PLANNING REPORT NUMBER 29

A REGIONAL WASTEWATER SLUDGE MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN

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CAMP DRESSER & McKEE INC.

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Special acknowledgement is due Lyman F. Wible, P.E., SEWRPC Water Quality Program Coordinator, and Robert P. Biebel, P.E., SEWRPC Sanitary Engineer, for their contributions to this report.

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Prepared by Camp Dresser & McKee Inc.
for the
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July 1978

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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July 3, 1978

STATEMENT OF THE CHAIRMAN

A significant proportion of the cost of wastewater treatment is in the cost of handling and disposing of residual solids—called sludges—which are generated by the treatment process. As the level of wastewater treatment is improved to meet the legally established water quality objectives, the amount of sludge generated and the cost of its handling and disposal may be expected to increase. The sludges are rich in plant nutrients and can be beneficially returned to the land, thus closing the environmental cycle. Consequently, the management of wastewater treatment sludges presents a challenge not only to the fiscal responsibilities of the local units of government concerned but also to their obligation to properly manage the natural resource base.

In a large metropolitan region such as southeastern Wisconsin, with its mixed urban and rural land use pattern, the intelligent management of both wastewater sludges and land resources requires full understanding of the complexities which face both the generator of the sludges and those who make benefit from their reuse. In recognition of these facts, the Regional Planning Commission in 1975, as a part of its areawide water quality management planning program for southeastern Wisconsin, undertook the preparation of a regional sludge management plan. The work was funded by the U. S. Environmental Protection Agency and was conducted with the assistance of a Technical Advisory Committee composed of local planning and public works officials, county agricultural agents and public health officials, representatives of certain concerned state and federal agencies, sanitary engineers from the major universities within the Region, representatives of industry, and concerned citizens. The technical work involved was carried out by the Commission staff with the assistance of a consulting engineering firm over an approximate two-year period.

The regional sludge management system plan set forth herein contains specific recommendations for the management and disposal of four major categories of wastewater sludges: municipal sewage treatment plant sludges; industrial wastewater pretreatment and treatment plant sludges; municipal water supply treatment plant sludges; and septic tank and holding tank wastes. The report presents information on the amounts and characteristics of sludges generated within the Region; existing means of sludge handling and disposal; alternative means of handling and disposal of the amounts and kinds of sludges which can be expected to be generated within the Region to the plan design year 2000; the general geographic configurations for multijurisdictional sludge management programs; the probable sensitivity of local sludge management decisions to results of the combined sewer overflow abatement studies underway within the Region; and the potential effects of sludge management decisions on the natural resource base. The report recommends the best plan from among the alternatives evaluated, namely, land spreading, together with certain auxiliary recommendations, including contaminant monitoring and reduction and standby sanitary landfill requirements.

The findings and recommendations set forth in this report should be useful to local units of government, land management agencies, and private individuals who may benefit by utilization of wastewater sludges, as well as to the urban and rural residents of the Region who have both a right and an obligation to be informed about the problems inherent in the management of wastewater sludges. This is particularly true because of the important implications which sludge management and disposal have for sound land use development and land management within the Region and the attendant heavy responsibility of local units of government.

Several important goals are to be attained through the implementation of the recommended regional sludge management plan including: the more effective guidance of land use and land management decisions; achievement of established air and water quality objectives; protection of the natural resource base and the public health; maintenance of the productivity of agricultural land; recovery and utilization of valuable resources; and the most efficient use of the financial resources which must be devoted to sludge management.

As is true of all of the Commission's work, the regional sludge management system plan is entirely advisory to the local, state, and federal units and agencies of government concerned. Consistent with previous Commission practice, this report contains a chapter outlining the specific actions required by these various governmental units and agencies to implement the recommended plan.

In its continuing role as a center for coordination of plan implementation activities within the Region, the Commission stands ready to provide such assistance as may be requested of it by the various interests involved in implementing the recommended regional sludge management system plan, a plan which should serve the Region well as an important point of departure and source of technical information for the making of land use and sludge management decisions over the next decade.

Respectfully submitted,

George C. Berteau
Chairman

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CDM

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planners, & management consultants

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December 23, 1977

Mr. Kurt W. Bauer, Executive Director
Southeastern Wisconsin Regional
Planning Commission
916 N. East Avenue
Old Courthouse
Waukesha, WI 53186

Dear Mr. Bauer:

In accordance with the agreement between Camp Dresser & McKee Inc. and the Southeastern Wisconsin Regional Planning Commission, dated November 9, 1976, as amended, we are pleased to submit our report entitled "A Regional Sludge Management Plan for Southeastern Wisconsin."

This report incorporates comments received from the Sludge Management Subcommittee, the Technical Advisory Committee, the Planning and Research Committee, and the Commission Staff. In addition, findings have been presented at a series of public meetings and have been reviewed with the Wisconsin Department of Natural Resources.

It has been a pleasure to work with you and your staff in preparing this report and we trust that it will serve as a flexible and useful guide in realizing a sound sludge management plan in Southeastern Wisconsin.

Very truly yours,

CAMP DRESSER & McKEE INC.

David R. Horsefield

David R. Horsefield
Senior Vice President

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Chapter I

INTRODUCTION

The comprehensive areawide sludge management planning program for southeastern Wisconsin presents a unique opportunity to consider wastewater-generated solids as an important resource rather than as a potential problem. The many sludge processing, transportation, and utilization or disposal alternatives available offer a wide range of choices leading to realization of this resource while minimizing problems associated with disposal. This report also affords the opportunity to expand and enhance the concepts and understanding of the nutrient and energy value of municipal and industrial wastewater sludge, while effectively limiting the negative aspects through application of proper engineering, management, and education. The current wastewater sludge management practice in the Region will be improved through the positive, comprehensive regional planning approach.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) represents an attempt to provide the necessary areawide planning services for one of the large urbanizing regions of the nation. The Commission was created in August 1960, under the provisions of Section 66.945 of the Wisconsin Statutes, to serve and assist local, state, and federal units of government in planning for the orderly and economical development of southeastern Wisconsin. The role of the Commission is entirely advisory, and participation by local units of government in the work of the Commission is on a voluntary, cooperative basis. The Commission itself is composed of 21 citizen members, three from each county within the Region, who serve without pay.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in the state enabling legislation. The Commission is authorized to employ experts and a staff as necessary for the execution of its responsibilities. Basic funds necessary to support Commission operations are provided by the member counties, the budget being apportioned among the several counties on the basis of relative equalized valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government for the purpose of accomplishing its objectives, and is authorized to deal directly with the state and federal government for this purpose. The organizational structure of the Commission and its relationship to the constituent units and agencies of government existing or operating within the Region is shown in Figure 1.

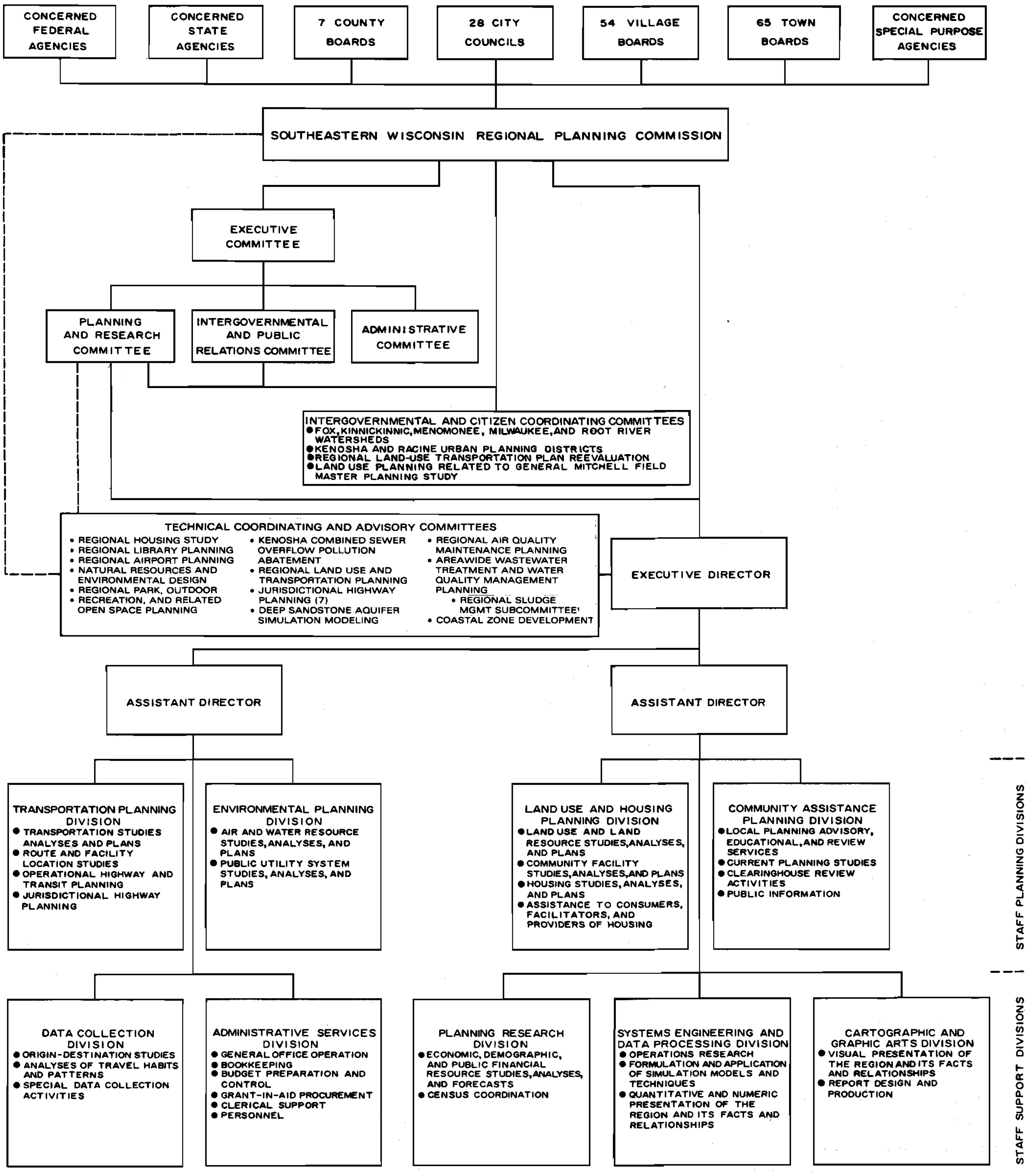
THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha counties in southeastern Wisconsin. Exclusive of Lake Michigan, these seven counties have a total area of 2,689 square miles, and together comprise about 5 percent of the total area of the State of Wisconsin. About 40 percent of the state population, however, resides within these seven counties, which contain three of the eight and one-half standard metropolitan statistical areas in the state. The Region contains approximately one-half of all the tangible wealth in the State of Wisconsin as measured by equalized valuation, and represents the greatest wealth-producing area of the state, with about 42 percent of the state labor force employed within the Region. It contributes about twice as much in state taxes as it receives in state aids. The seven-county Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 natural watersheds. The Region has been subject to rapid population growth and urbanization, and in the decade from 1960 to 1970, accounted for 40 percent of the total population increase in the entire state.

Geographically the Region appears to have good prospects for continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, as well as being an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within a 250-mile radius of the Region, and over 35 million people reside within this radius, an increase of nearly 5 million persons over the 1960 level.

Figure 1

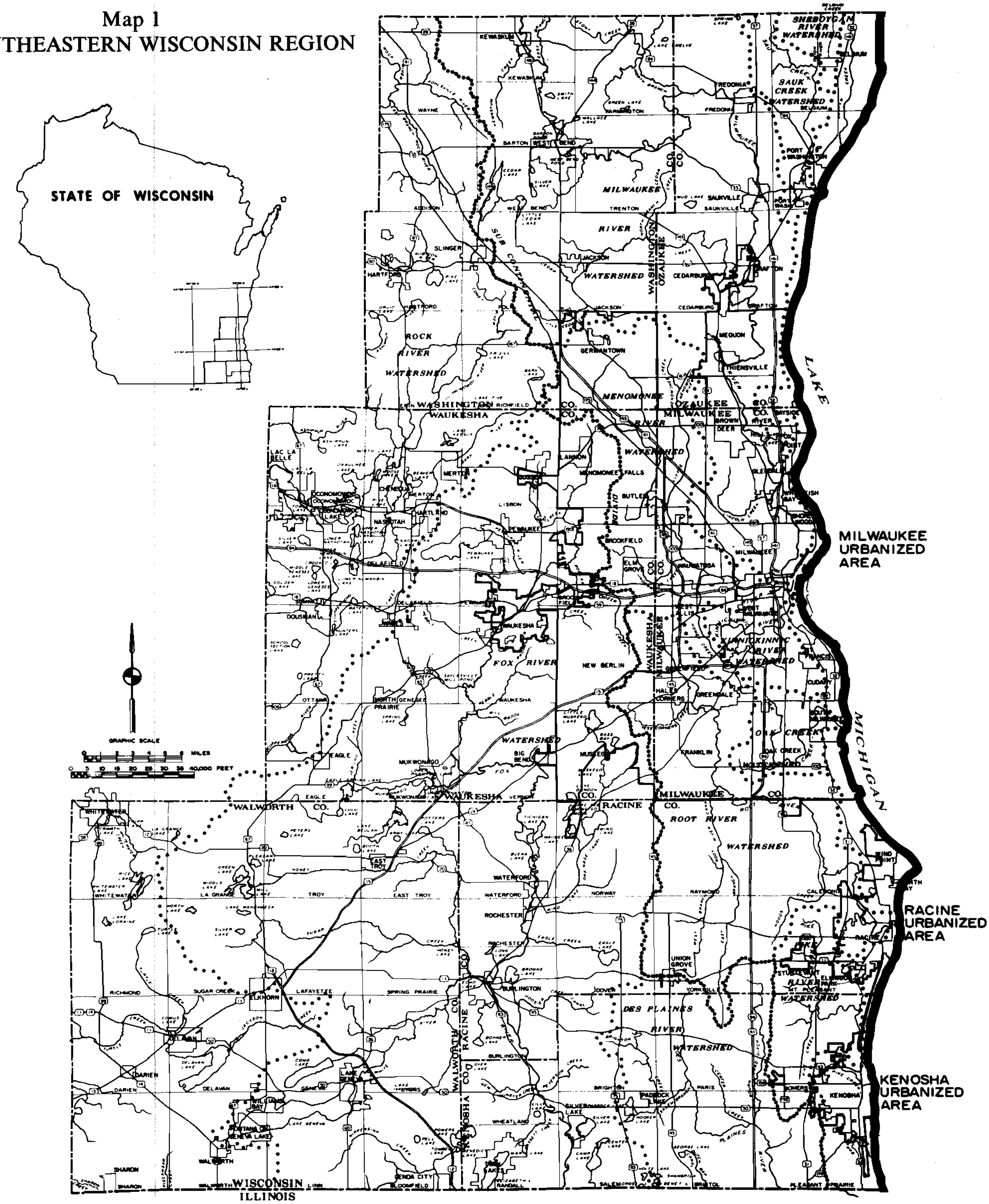
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION ORGANIZATIONAL STRUCTURE



Also serves in an advisory role to the total solids management facilities planning effort of the Metropolitan Sewerage District of the County of Milwaukee.

Source: SEWRPC

Map 1
THE SOUTHEASTERN WISCONSIN REGION



The seven-county southeastern Wisconsin planning Region comprises a total area of about 2,689 square miles, or about 5 percent of the total land and inland water area of Wisconsin. The Region contains, however, about 40 percent of the state's population and about one-half of the tangible wealth in Wisconsin, as measured by equalized property valuation. The Region contains 154 general purpose local units of government and encompasses all or part of 11 major watersheds.

Source: SEWRPC. Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, Volume I, Inventory Findings, 1975, page 4.

The importance of the resource base of the seven-county Region to significant elements of the areawide sludge management system planning effort is discussed briefly below[1].

Consideration of the elements of the natural resource base cannot be overemphasized, since areawide sludge management system development, by its impacts on that base, has the potential to either degrade or to protect and enhance the natural heritage and environmental quality of the Region. Furthermore, the economic costs attendant to the planning, design, construction, and operation of areawide sludge management systems are, in part, a function of how well such systems are interfaced with the natural resource base. The most important factors considered in this respect are climate and soils as these have the most direct impact on wastewater sludge management system planning. Climate determines most directly the methods and timing of sludge application to land, while soils help determine crop types and allowable application rates. The important man-made features of the Region include its land use pattern, its public utility networks, and its transportation system. Together with the population residing in and the economic activities taking place within the Region, these features might be thought of as the socioeconomic base of the Region.

The ease with which outdoor construction and maintenance activities can be carried out is temperature dependent, and therefore annual temperature variations enter into the planning and scheduling of such activities. Seasonal temperature changes affect the amount of heat energy needed for sludge digesters at wastewater treatment plants. Seasonal temperatures also determine the kinds and intensities of the agricultural uses to which the lands may be put, and, consequently, the periods over which sludge spreading might be most desirable.

The kind and amount of precipitation that might be expected to occur within the Region influences the nature of man's activities in general, and particularly wastewater sludge management system design, construction, operation, and maintenance. For example, some existing sewerage system problems, such as overflows from combined sewers in certain urban areas, are the direct result of precipitation events. Rainfall events might also cause separate sanitary sewerage systems to surcharge and overflow to surface water courses, and might require wastewater treatment plants to bypass large volumes of untreated wastewater solids in excess of the hydraulic capacity of the plants. Such surcharging of separate sanitary sewerage systems is caused by the entry of excessive quantities of rain, snowmelt, and groundwater into the sanitary sewers via manholes, building sewers, building downspouts, and foundation drain connections, and by infiltration through faulty sewer pipe joints, manhole structures, and cracked pipes. Precipitation influences the level of local groundwaters, and therefore might preclude sludge application from areas that otherwise would not be limited. Flood plains are also unsuitable because of frequent inundation that could result in a potential source of water pollution had sludge been recently spread. Heavy rains may wash surface-applied sludge into drainage ways and water courses. It may also cause a more rapid transmission of soil or spread sludge constituents to the groundwater table. Spreading methods must be designed to account for these factors.

Snow cover, particularly early in the winter season, significantly influences the depth and duration of frozen ground which in turn affects engineered works involving extensive excavation and underground construction and the incorporation of sludge solids into the soil. Sludge cannot be plowed into frozen ground and may, if surface-applied, mix with rainwater and runoff from the frozen crust to the nearest drainage path or stream. Following a spring thaw, the surface soils may be wet and soft, and heavy spreading equipment could cause damage to fields at this time. Accumulated snow depth at a particular location and time is primarily dependent on antecedent snowfall, rainfall, and temperature characteristics, and the amount of solar radiation. Rainfall is relatively unimportant as a melting agent but can, because of compaction effects, significantly affect the depth of snow cover on the ground.

Anticipated frost conditions influence the design of engineered works in that structures and facilities are designed to prevent the accumulation of water and, therefore, the formation of damaging frost (as in the case of pavements and retaining walls or structures), or else facilities are designed to be partially or completely located below the frost susceptible zone in the soil (as in the case of foundations and water mains). For example, in order to avoid or minimize the danger of structual damage, foundation footings must be placed deep enough in the ground to be below that zone in which the soil may be expected to contract, expand, or shift due to frost action. Wastewater sludges cannot be injected or plowed into frozen ground.

[1]*See SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, Volume I, Inventory Findings.*

The magnitude and annual variation in evaporation from water surfaces and the relation of that evaporation to precipitation is of importance to wastewater treatment plant operation primarily because of its implications for the design and operation of sludge drying beds or sludge drying lagoons. Digested sludge is spread on the drying beds which are normally open to the atmosphere, constructed of graded layers of gravel or crushed stone, and provided with an underdrain system. Dewatering occurs by the dual processes of filtration through the porous material and evaporation to the atmosphere.

Wind also accelerates evaporation and, thus, sludge drying beds and lagoons should be designed, located, and oriented so as to maximize the evaporation and, therefore, the sludge drying process. Potential undesirable wind effects, which can be precluded or at least minimized by careful engineering, planning, design, and operation of wastewater treatment facilities, includes transmission of odorous gases into urban areas.

The amount of daylight influences, to some extent, the crop growth cycle and therefore fertilizer requirements. When fertilizer requirements are high, it may be that the amount of hours during which sludge can be spread is limited by daylight visibility.

The nature of soils within southeastern Wisconsin has been determined primarily by the interaction of the parent glacial deposits covering the Region, and by topography, climate, plants, animals, and time. Within each soil profile the effects of these soil-forming factors are reflected in the transformation of soil material in place, chemical removal of soil components by leaching or physical removal by wind or water erosion, additions by chemical precipitation or by physical deposition, and transfer of some components from one part of the soil profile to another. Soil type is a primary determinant (along with market considerations) in crop patterns and directly influences the suitability of a given site for sludge application. Soil type directly determines the desirable rate of sludge application on a clear field planned for a given crop type. Also of particular significance are permeability of the most restricting layer above 3 feet (the depth to bedrock) and groundwater levels.

Surface water resources, consisting of lakes, streams, and associated floodlands, form the singularly most important element of the natural resource base of the Region. Their contribution to the economic development of the Region, to recreational activity, and to the aesthetic quality of the Region is immeasurable. Groundwater resources of southeastern Wisconsin are closely interrelated with the surface water resources, inasmuch as they sustain lake levels and provide the base flow of streams. The groundwater resources, along with Lake Michigan, constitute the major sources of supply for domestic, municipal, and industrial water users.

According to SEWRPC land use inventory data as of 1975, natural wetlands within the Region were being lost at a rate of approximately 220[1] acres per year between 1963 and 1970. Most of the loss in wetland area has been the result of conversion to agricultural[2] and urban use through drainage modifications. There has been increased public interest in the recreational use of more desirable open-water wetlands in recent years and as a result, a slight increase has occurred in the acreage of open-water wetlands that are subject to public control. Recognizing the many environmental attributes of wetland areas and also the severe limitations they present for any form of wastewater sludge management system, planning and design should seek to protect the best remaining wetlands in the Region by discouraging costly (both in monetary and environmental terms) wetland draining, filling, and urbanization.

Consideration has been given to historical changes in the demographic, economic, and financial resource bases of the Region. Both short- and long-term data on the changes in regional population and economic activity levels indicate that the fundamental trend toward growth and urbanization in the Region, which has been uninterrupted over a period of more than 130 years, might be expected to continue over the foreseeable future. The most recent data on population and economic activity levels, both nationally and for the Region, do indicate, however, that the scale, if not the character, of this growth and urbanization process is changing. The change appears to be in the direction of lower population growth rates.

The migration trends have been reversed in many of the large metropolitan areas of the United States, from high rates of in-migration during the 1950s to high rates of out-migration during the 1960s. This reversal has also occurred within the Region, particularly within Milwaukee County. Moreover, birthrates, nationally

[1]*SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, Volume I, Inventory Findings, 1975, page 136.*

[2]*Records of the Agricultural Stabilization and Conservation Service of the U.S.D.A. indicate that during 1976 in excess of 200 acres was cost shared for installation of drainage facilities in wetlands.*

and within the Region, have reached the lowest level since the 1930s. These trends in migration and natural increase might be only short-term in nature, but even so will have long-term effects on the future growth and development of the Region.

The character of the urbanization process in the Region is continuing to change from the traditional growth pattern that was centered on the older and larger central cities to a diffused pattern of development, with dispersal of population and economic activity accompanied by some declines in population levels of the central cities and older first-ring suburbs.

This trend has resulted in a reduction in available agricultural acreage and in a reduction of suitable landspreading sites for wastewater sludge. Because most wastewater treatment plants are sited near the population centers, urban sprawl tends to increase the distances to suitable application sites. It also results in greater haul times or distances through populated areas and might inhibit acceptability of sludge application because of fears or objections of the farmer's neighbors. This diffusion of urban growth might be expected to continue into the foreseeable future.

The traditional means of financing the majority of local government services—property tax revenues—are expected to continue into the foreseeable future. The most recent data on these revenue sources indicate that the proportion of total local government revenues provided by property tax levies is diminishing. This is due, in part, to public pressure on local elected officials to stabilize or reduce local property tax rates, especially in light of smaller increases in value of the property tax base upon which property taxes are levied. This has resulted in a shift toward other revenue sources, particularly public utilities, to provide needed additional municipal revenues. Federally mandated user charge/industrial cost recovery systems will be an increasingly important source of funds for wastewater sludge management systems.

This shift toward public utilities has provided another major source of local government revenues which can be expected to continue in proportion to the urbanization process, since these revenues are derived directly from the users of public facilities and services such as sludge management systems. In addition to the new revenue source provided by public utilities, shared tax receipts from state and federal sources have recently been used as a direct offset to property tax levies, effectively reducing the property tax rates in many of the Region's communities. This trend in the use of shared tax receipts is expected to continue, especially in those communities which are at or approaching their tax levy limits.

COMMISSION WORK PROGRAMS

The commission has undertaken a series of work programs resulting in a collection of published reports. The reports published as of March 17, 1977, are listed in the Appendix. Those that are considered especially important to the areawide sludge management planning program are discussed briefly below.

Land Use-Transportation Study

The first major work program of the Commission actually directed toward preparing long-range development plans was a regional land use-transportation study, initiated in January 1963 and completed in December 1966. The findings and recommendations have been published in the three-volume SEWRPC Planning Report No. 7, Regional Land Use-Transportation Study; in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin; and five supporting technical reports.

Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, Volume 1, Inventory Findings was completed in April 1975.

Information developed during these study efforts was used to estimate transportation costs between various sludge processing and utilization or disposal sites. Maps, developed from information pertaining to land use and soils, indicate the location and extent of sites suitable for land application of wastewater sludges.

Regional Sanitary Sewerage System Planning Program

Recognizing the importance of sanitary sewerage to regional development, the Commission in 1969 initiated a regional sanitary sewerage system planning program. This program was completed in May 1974 with the formal adoption of the plan by the Commission (see SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin). Technical and policy guidance in preparing the regional sanitary sewerage system plan was provided by an advisory committee of 24 distinguished public works officials and sanitary engineers representing the major universities and certain state and federal, as well as local, units of government within the Region.

Briefly, the recommended regional sanitary sewerage system plan is comprised of five major elements: sewer service areas, wastewater treatment facilities, trunk sewers, abatement of combined sewer overflows, and auxiliary elements applicable in general to all recommended wastewater conveyance and treatment systems. With respect to sewer areas, the plan recommends that centralized sanitary sewer service be extended to a total of 670 square miles, or about 25 percent of the Region. With respect to wastewater treatment facilities, the plan recommends that wastewater treatment be provided to a total of 52 public facilities, and that in order to meet the established water use objectives and supporting water quality standards, 41 of the 52 facilities provide an advanced level of treatment with resulting higher sludge loads. Twenty-two existing public wastewater treatment facilities and 29 existing private wastewater treatment facilities would be abandoned upon implementation of the plan. The plan recommends the general alignment and approximate size of those intercommunity trunk sewers required to extend trunk sewer service from the recommended treatment plant into the recommended sewer service areas, as well as to permit the relocation of certain wastewater treatment facilities and the abandonment of other wastewater treatment facilities.

With respect to the abatement of pollution from combined sewer overflows, the plan recommends implementation of the Milwaukee River watershed plan recommendation to conduct a preliminary engineering study, including further consideration of the construction of a combination deep tunnel mined storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows in Milwaukee County. In the Kenosha and Racine area, the plan recommends that definitive recommendations (concerning those remaining combined sewer areas which should be separated and those which should receive specialized wastewater treatment facilities) be held in abeyance until the completion of combined sewer overflow research and demonstration studies in those communities. Finally, the plan includes several auxiliary plan elements, including the mounting of clear water elimination efforts; the elimination of nearly 600 known points of wastewater flow relief in the Region; the full metering of all wastewater flows, including bypassed flows; the undertaking of special studies for sludge handling, disposal, or recycling; and the conduct of a continuing water quality monitoring program.

The sanitary sewerage system plan affects the areawide wastewater sludge management study inasmuch as it includes recommendations for locations, sizes, and levels of treatment at wastewater treatment plants in the region. This information then provides a basis for projecting future sludge generation.

THE REGIONAL WASTEWATER SLUDGE MANAGEMENT PLANNING PROGRAM FOR SOUTHEASTERN WISCONSIN-STUDY OBJECTIVES

The areawide water quality planning program for southeastern Wisconsin is intended to update, extend, and refine previous studies and plans completed by the Commission, to fully meet the requirements of Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500).

More specifically, the areawide water quality planning program for southeastern Wisconsin will provide for full integration with regional land use planning; provide for the conduct of refined areawide point and nonpoint source pollution abatement plan elements through revision and refinement, as may be found necessary, of the previously prepared and adopted comprehensive watershed plans and regional sanitary sewerage system plan; prepare a practical areawide sludge management plan element, building upon previous Commission plan implementation recommendations with respect to land use development and water quality management; conduct, within the purview of an areawide water quality planning program, subarea planning for municipal sludge management facilities anticipated to be constructed within a five-year period following completion of the Section 208 plan; and to provide for the establishment of a continuing areawide water quality planning program for southeastern Wisconsin.

With regard to wastewater sludge management, the overall objective is to determine through careful, detailed study the most cost-effective and environmentally suitable alternatives for the treatment, processing, storage, transportation and ultimate disposal or utilization of sludges originating from area wastewaters. Plan development has at its core an effective system of evaluation based on consideration of the following specific factors:

1. Atmospheric Resources: Potential degradation of the region's atmospheric resources, local air movement patterns, temperature changes, and climate variations.

2. Costs: The capital costs of construction, as well as operation and maintenance costs, included to the planning horizon year 2000.

3. Cultural Factors: Life styles, public welfare, public health and safety, employment, popu-

lation characteristics, transportation demands, aesthetic values, historical or archaeological sites.

4. Earth Resources: Terrestrial, nonbiological constituents such as minerals, energy resources, soil, or other related subfactors.

5. Flora and Fauna: The impact of a management system on the biological community, and preservation of local ecological balance.

6. Land Use: Land availability for sludge management and competing land uses.

7. System Adaptability: Flexibility and ease of modification to meet varying future loads, institutionally and financially implementable, ease of operation and maintenance, and proven effectiveness.

8. Water Resources: The potential degradation of ground and surface waters through discharge and runoff and relation to water quality standards.

Sensitivity to public concerns was maintained during the course of selection and design of the system. An extensive program to inform the public and consider their concerns was undertaken. These concerns inclusive of: land spreading equipment for sludge, soil compaction, odor, health and safety, buffer zones, recycling of resources, toxic metals and availability of technical information, have been incorporated in the analysis and in the development of the recommended program[1].

The wastewater sludge management planning effort for southeastern Wisconsin provides a mechanism for the establishment of a continuing areawide sludge management planning and management program for the Region. It has been Commission policy to provide such continuing planning efforts so as to monitor development and provide a basis for future plan reappraisal, updating and refinement.

Development of Study Design and Initiation of Study

Section 208 of the Federal Water Pollution Control Act Amendments of 1972, provides for the development and implementation of areawide water quality management planning programs within the nation's major metropolitan areas (later expanded to also include areas outside of major metropolitan areas). In response to this Congressional Act, and in accordance with its statutory areawide planning responsibilities and the findings and recommendations of its previous water quality planning efforts, the Southeastern Wisconsin Regional Planning Commission requested the Governor of the State of Wisconsin to designate the seven-county Southeastern Wisconsin Region as a water quality management planning area and the Southeastern Wisconsin Regional Planning Commission as the water quality management planning agency for that area, all pursuant to the procedural requirements set forth in Section 208 of the Act. Substantiating information relating to the planning area and planning agency designations was set forth in a document prepared by the Commission in the Spring of 1974[2].

On September 27, 1974, Governor Patrick J. Lucey formally designated the seven-county Southeastern Wisconsin Region and the Southeastern Wisconsin Regional Planning Commission pursuant to the terms of Section 208 of the Act. This designation was made after a public hearing concerning the matter held jointly by the Wisconsin Department of Natural Resources and the Southeastern Wisconsin Regional Planning Commission of June 18, 1974. On December 26, 1974, the Administrator of the U.S. Environmental Protection Agency formally approved the two designations and authorized the Commission to proceed with the preparation of an application for federal funds in support of the conduct of the proposed areawide water quality and management planning program for the Region.

On March 6, 1975, the Southeastern Wisconsin Regional Planning Commission authorized the preparation of the necessary study design for the proposed areawide management planning program, such study design being envisioned as the basic supporting document for a federal grant application for the program. In addition, the Commission acted to create a Technical and Citizens Advisory Committee on Areawide Water Quality Planning and Management. This Committee is comprised of federal, state, and local public officials; knowledgeable engineers and planners; and concerned citizen leaders from throughout the Region. The Commission charged the Committee with assisting the Commission in the formulation of the areawide water quality planning and management program, and

[1]*A summary of comments and concerns voiced at public meetings is presented in Appendix M.*

[2]*See "Substantiating Information for Area and Planning Agency Designation Under Section 208 of the Federal Water Pollution Control Act and Amendments, 1972," SEWRPC and Wisconsin Departments of Natural Resources and Administration, May 1974.*

with monitoring the conduct of that program once it is mounted.

Accordingly, the study design provided a working outline of the areawide water quality management planning program for the Region and set forth a recommended time schedule, budget, and organizational structure for the program.

The consultant for the areawide wastewater sludge management program was formally contracted on November 9, 1976, and the solids management portion of the areawide water quality management planning program was thus initiated. Prior to this time, much background information and data were collected by the Commission staff through their inventory program. This information included detailed questionnaires on municipal and industrial wastewater treatment plants, data from SEWPRC files, previous planning and technical reports, and data development from previously collected materials specifically for use in this study. When sludge quality data were deemed inadequate, samples were collected and analyzed cooperatively by DNR and SEWRPC staffs. The consultant for the state-of-the-art studies completed the document entitled "Sludge Treatment and Disposal Alternatives and Cost Information" on November 30, 1976.

Relationship of This Study to Metropolitan Sewerage District Study

The facilities planning effort of the Metropolitan Sewerage District of the County of Milwaukee, being conducted under Section 201 of the Federal Water Pollution Control Act Amendments of 1972, is intimately related to the areawide water quality planning program study effort, particularly in the area of solids management. Therefore, recommendations of both studies must be consistent. The recommendations presented in this study will form the basis for facility planning efforts.

An inventory and economic analysis of the present and projected regional, national, and international markets for the sale of possible recovered sludge products such as an organic fertilizer, a composted sludge soil conditioner, or other potentially economic products of recovered sludge was prepared jointly under the 201 facilities planning effort of the Metropolitan Sewerage District and as part of this study. The marketing analysis included an evaluation of the price elasticity of the product; and identification and discussion of the conditions under which the above-cited recovered sludge products would behave as a competitive substitute for synthetically prepared fertilizer or soil conditioners; a review of the market response to Milorganite during the period of elevated energy costs following 1973; and an identification of the size and characteristics of the potential markets for each of the feasibly produced by-products. Specific consideration was given to the potential changes in major industrial processes within the Region as they may affect the amounts and characteristics of the sludges generated. An example would be changes in the Milwaukee treatment plant sludges resulting from modifications which could take place in Milwaukee's brewing industry because of increased waste recovery or pretreatment practices. A summary of the results of this market investigation is incorporated in this report as Chapter IV.

Relationship of This Study to Other Major Studies Underway in the Program

The Combined Sewer Overflow Study for Milwaukee—In 1975, the Metropolitan Sewerage District began evaluating several alternative solutions for the abatement of combined sewer overflow (CSO) pollution in Milwaukee's rivers. The four most feasible alternatives considered were: end-of-pipe treatment; sewer separation; instream treatment; and conveyance/storage and gradual treatment.

Of the four alternatives, conveyance/storage and gradual treatment was selected by the District as the preferred method to combat this pollution problem. This alternative consists of a system of pipelines leading to approximately 21 drop shafts constructed within street rights-of-way for collection of sewer overflow. The drop shafts, about 350 feet deep, would connect to a tunnel system where conveyance and storage of the overflow would be provided. Storage would also be provided in a central cavern from which wastewater would be pumped to a surface treatment system located near the Jones Island Treatment facilities. The system would be sized to eliminate virtually all of the 50 overflows that now occur during a year. Only very large storms would cause the system to overflow.

The relationship of this proposed CSO solution to the areawide wastewater sludge management study is important since additional quantities of stormwater solids would be captured in the storage facility and generated by the CSO surface treatment system. These additional quantities of sludge would require proper processing, utilization or disposal, and sludge management designs for future facilities should account for this load.

The Combined Sewer Overflow Study for the City of Kenosha—This combined sewer overflow study was initiated in the Spring of 1977, and scheduled for completion after completion of the areawide water quality management planning program. However, some stormwater sludges might originate from implementation of certain recommendations, and the recommendations of the areawide wastewater sludge management plan must be flexible in order to accommodate such sludges.

In preparing the prospectus for this overflow study it was clearly indicated that surface water pollution is a problem in the Kenosha area. Public concern about the problem is centered on the extent of pollution and its effect on the use of Lake Michigan beaches in the area and upon Lake Michigan as a source of water supply for the area. Available information further indicated that the pollution problem is generally associated with periods of wet weather, and therefore, in part, with separate and combined sewer overflows and stormwater runoff.

Existing data clearly show that the major sources of water pollution in this study area consist of municipal wastewater treatment plants, industrial and institutional waste treatment plants, overflows from both separate and combined sewers, and urban and agricultural runoff. Plans have been prepared which, if implemented, would lead to the abatement or elimination of the pollution in the study area from the municipal, industrial, and institutional wastewater treatment plants. Those plans also recommend that preliminary engineering studies be undertaken to determine the most cost-effective means of eliminating all separate sanitary sewer overflows and all combined sewer overflows in the study area. Thus, if the adopted plan recommendations were fully carried out, all point sources of pollution in the study area would eventually be abated or eliminated; and the only remaining known source of surface water pollution in the study area would be agricultural and urban stormwater runoff. The city is currently carrying out a facility plan to evaluate nonpoint source pollution and infiltration/inflow.

The Combined Sewer Overflow Study for the City of Racine–The purpose of the comprehensive study is to determine the environmental impact of combined sewer overflows on the Root River, to compare dollar costs to pollutant reduction and resultant water quality, and to develop a program for abatement of the overflows. Inherent in the purpose for the study is the acceptance of the water use objectives and supporting water quality standards set forth by the Southeastern Wisconsin Regional Planning Commission Report No. 9, A Comprehensive Plan for the Root River Watershed. This study was initiated in March 1977 and results are not yet available. However, additional sludge quantities originating in potential structural solutions to the combined sewer overflow problem might result.

Section 201 Facilities Planning in Southeastern Wisconsin

There are a number of 201 facilities planning projects already funded or committed by the Wisconsin Department of Natural Resources within the Southeastern Wisconsin Region. It is the intent of the areawide water quality management planning program to fully integrate the results of these 201 facilities planning efforts in the areawide plan, and to coordinate the preparation of such plans as necessary. Of particular importance is the facilities planning project now underway to determine the most cost-effective solution to the problems of abating pollution from combined sewer overflows in the Milwaukee area. This facilities planning project, a preliminary engineering study, is being carried out with a Section 201 grant in accordance with a prospectus prepared by the Regional Planning Commission for the Metropolitan Sewerage District. In addition to including already funded or committed facilities plans in the areawide program, it was an objective of the areawide planning effort to include additional plans for those remaining recommended waste treatment facilities that will likely be needed within five years from the time of completion of the areawide plan. Federal Section 208 financial limitations preclude the actual conduct of facilities planning with Section 208 monies. Accordingly, all necessary facilities planning will be conducted with available Section 201 monies. All Section 201 work programs are subject to review and monitoring by the Commission as the areawide planning agency in order to assure full coordination with the areawide planning effort.

Facilities plans or simply engineering design reports were available for most wastewater treatment plants in the study area. These reports proved to be invaluable for development of the recommendations under the Regional sludge management planning effort. In particular, these reports contained important details on processing unit design criteria, wastewater and sludge characteristics, and plant siting, as well as local preferences and facility costs. It was found that, in general, the approach at the local level was sound and the recommendations made in this report are compatible with the results of other planning efforts in the Region.

ORGANIZATION FOR THE REGIONAL WASTEWATER SLUDGE MANAGEMENT PLANNING PROGRAM FOR SOUTHEASTERN WISCONSIN-STAFF

The staff function throughout the project included review and evaluation of the consultant's plan of work; the collection of data for use by the consultant in all phases of the work; calling of meetings of the sludge management subcommittee of the technical advisory committee; the review and coordination of staff and consultant activities; and other ongoing project management activities. All phases of coordination were achieved through exchange of information, periodic interagency staff meetings, and advisory committee membership.

Technical Advisory Committee on Areawide Water Quality Management Planning

The basic purpose of the Technical Advisory Committee on Areawide Water Quality Management Planning was to actively involve, through technical level representatives and elected officials, the various governmental, business, and technical agencies and universities within the Region in the planning process, and to thereby assist the Commission in determining and coordinating basic technical policy involved in the conduct of the proposed program and in the resultant areawide plans and implementation measures. Membership of this committee was comprised of senior-level technical representatives of appropriate federal, state, and local areas of government, including representatives of industries concerned with treatment and management. The committee also includes other major wastewater treatment management agencies; county planners; universities; the U.S. Environmental Protection Agency; the U.S. Soil Conservation Service, U.S. Department of Agriculture; and the League of Women Voters. This Committee had a particularly important role in directing and overseeing all technical work involved in preparing the areawide plan and, in general, formulating technical policy direction for the study. In addition, the Committee members were called upon to assist in familiarizing the political, business, industrial, and private citizen leadership within the Region with the areawide planning program and its findings and recommendations, and in fostering understanding of basic wastewater treatment planning objectives and implementation procedures.

Sludge Management Study Subcommittee of the Technical Advisory Committee

This subcommittee was composed of members of the Technical Advisory Committee and was formed specifically to oversee the sludge management study portion of the areawide water quality management planning program. Because of the size and scope of the areawide water quality management planning program, the formation of a subcommittee of knowledgeable participants was a valuable, worthwhile undertaking. This committee met as necessary throughout the course of the study to review the work by SEWRPC staff and the consultant and to provide needed advice and consent to various procedures and approaches.

The subcommittee also served in an advisory capacity to review work conducted for the Metropolitan Sewerage District of the County of Milwaukee in preparation of the facilities planning study for total solids management. This approach provided for continuity and consistency between the two study efforts. Mr. Robert J. Borchardt, Chief Engineer and General Manager of the District, served as acting committee chairman.

University of Wisconsin Extension

The interplay between the Southeastern Wisconsin Regional Planning Commission's ongoing mechanisms for public involvement and the University Extension's assumed responsibilities for public involvement in the 208 areawide water quality management planning program merged a diverse coalition of information and resources. The comprehensive physical planning functions of SEWRPC and the physical setting within which the public participation program was undertaken makes available to the cooperating University Extension Agent, current, accurate information relevant to the areawide water quality management planning efforts. This information was utilized in designing and conducting educational programs by the University of Wisconsin Extension Service (UWEX) in cooperation with SEWRPC. These programs were designed to inform and involve local elected and appointed officials, and interested and affected citizens about the areawide water quality management planning program; the responsibilities of local governments in water quality management; the communication channels available for citizens and officials in the planning process; the role of governments and citizens in plan adoption and implementation; and the availability of future educational programs to address problems or concerns they may have.

The University of Wisconsin Extension was contracted to design and implement the public involvement program for the entire areawide water quality management planning efforts. In assuming these responsibilities the agent in charge of this program became the liaison with the Citizens Advisory Panel for Public

Participation. The liaison agent thus served in an education role with the Citizens Advisory Panel presenting accurate information while assuming a neutral attitude toward specific elements of the planning program. This role has been most effective in the sludge management planning program element by developing public awareness and interest in sludge management.

Citizens Advisory Panel for Public Participation
The Citizens Advisory Panel for Public Participation involved interested and affected citizens and representatives of a wide variety of organizations. The purposes of this committee were to provide guidance to the Commission and the University Extension agent in charge of the areawide water quality management planning program in the conduct of the public participation program, and to improve communications between the Technical Advisory Committee for areawide water quality management planning program and the interested or affected citizens.

Consultants
Camp Dresser & McKee Inc. was retained to undertake most of the analytical work effort required to complete the areawide wastewater sludge management program for Southeastern Wisconsin. Because of the vast size and scope of the program, employment of such a consultant was necessary to supplement existing and shared staff at SEWRPC. In addition, Arthur D. Little Inc. was subcontracted to undertake an economic analysis of recovered sludge products; and Sommer Frey Laboratories, Inc., was retained by the Regional Planning Commission to conduct laboratory analyses of sludge samples collected for the Regional Planning Commission by the Southeast District staff of the Wisconsin Department of Natural Resources. Camp Dresser & McKee Inc. was also retained to undertake the 201 facilities planning program for the Metropolitan Sewerage District, in order to provide proper and complete interface between the two studies. Because the sludge load at the Jones Island and South Shore plants represents a majority of that produced in the study area, such an approach is reasonable.

STATUTORY AND ADMINISTRATIVE SIGNIFICANCE OF AREAWIDE WASTEWATER SLUDGE MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN

Under the provisions of Section 208 of the 1972 Amendments to the Federal Water Pollution Control Act, the Southeastern Wisconsin Regional Planning Commission, as the officially designated areawide water quality planning agency, was committed to undertake the preparation of a regional wastewater sludge management system plan, in accordance with the approved Study Design for the Areawide Water Quality Planning and Management Program.

Since the period during which the study design for the areawide water quality planning program was developed, the Metropolitan Sewerage District of the County of Milwaukee accelerated implementation of its "Master Plan" for the development of facilities to provide adequate collection, transmission, and treatment facilities for sanitary sewage within the service area of the sewerage district, inclusive of solids handling facilities. For this reason, the facilities planning activity for solids handling at the Jones Island and South Shore Sewage Treatment Plants, conducted under the provisions of Section 201 of the 1972 Act amendments was conducted during the same general time period as the systems planning for regional wastewater sludge management in southeastern Wisconsin. Both the Metropolitan Sewerage District staff and the staff of the Regional Planning Commission agreed that the development of the facility plan for solids handling for the Metropolitan Sewerage District and the development of the Regional Wastewater Sludge Management Systems Plan should be fully coordinated during the concurrent periods of preparation. This coordination was enhanced by using a common consultant, by recognizing the interrelationship of the two study efforts from the very beginning of the two planning processes, and by using the same membership on the subcommittee involved in the studies. By those mechanisms, duplication of work effort was avoided and fully integrated study results achieved in the two planning activities.

Many other communities also have undertaken or are currently involved in 201 facilities planning efforts throughout the seven county Region. To provide the most complete data base possible, review of available results of this planning was undertaken during the data gathering effort for this areawide sludge management study. Most published documents contained design criteria related to sludge processing, transportation, and utilization or disposal.

Under the Wisconsin Pollutant Discharge Elimination System (WPDES), permits are required for all wastewater discharges to surface waters from identifiable point sources. Beginning in 1977, permits for municipal treatment plants issued under WPDES contained expanded sludge management requirements generally consisting of: submittal of a sludge management plan by the permit-holder, evaluation of sludge storage facilities, a description of sludge characteristics, a description of mode of sludge transportation, information about the ultimate disposal site and maintenance of records for each disposal site. Previous WPDES permits had required only monitoring, reporting and record keeping for wastewater treatment plant operations and effluent discharges, average sludge volumes, type of sludge treatment prior to disposal, means of disposal and location of disposal site. These permits are a key element in the National Pollutant Discharge Elimination System. The findings and recommendations of this study may be expected to influence the permit development through the definition of sludge quality and the development of recommended utilization or disposal techniques and standards related to that quality.

FORMAT OF PLANNING PROCESS

The major findings and recommendations of the areawide wastewater sludge management study are documented and presented in this report.

The basic format was to employ a seven-step planning process developed by the Commission, through which the principal functional relationships existing in the Region that affect sludges could be accurately described, and the effect of different courses of action with respect to areawide sludge management tested and evaluated. The steps involved in this planning process are: 1) study organization and design; 2) formulation of objectives, principles, and standards; 3) inventory, or data collection, and review; 4) analyses and forecasts; 5) preparation, test, and public evaluation of alternative plans; 6) plan selection and adoption; and 7) plan implementation, including the establishment of a continuing planning process and the preparation of precise facility plans.

Chapter II

BASIC CONCEPTS AND PRINCIPLES

INTRODUCTION

This sludge management planning study for the southeastern Wisconsin region is needed to address problems of sludge generation, processing, transport, and utilization (or as a last resort, disposal) which are regional in scope. Furthermore, it is important that possibilities for utilization of the region's sludge outside of the region be evaluated.

As described in this study, sludges are considered to include the aqueous suspensions of residual solids generated through the treatment of municipal or industrial wastewaters, and of such a nature and concentration as to require special considerations in their disposal. A stabilized sludge is considered to be a sludge which has been treated at a wastewater treatment plant, to remove the highly volatile portion of the sludge, to degrade organic toxicants and to kill or inactivate pathogenic organisms.

The single most important concept developed in this study is that wastewater sludge is a resource which must be managed more effectively than it has been in the past. The concept of disposal has ignored the energy, nutrient, and other value of sludge by focusing on its undesirable properties. With proper control and utilization, sludge can become a safe and valuable resource and might provide the opportunity to reclaim lands now of marginal value.

This regional study provides a forum for input of public opinion, provides for a consistent regional awareness, and may result in a positive view of sludge as a resource rather than a problem. Sludge application to lands is a subject of regional scope. Both rural and urban people and lands are involved in the overall effort associated with production, processing, and utilization of this resource. An enlightened view toward the subject can only be developed on a regional level.

THE GEOGRAPHIC PLANNING UNIT

Wastewater sludge management system planning must be accomplished on a regional basis. Land use patterns—which determine the amount and spatial distribution of sludges generated—develop over an entire urban region in response to basic social and economic forces, without regard to artificial corporate limit lines or natural watershed boundaries. Sludge management facilities, in turn, determine to a degree the capacity of an area to support such land uses. These facilities may cross not only corporate limits, but also watershed boundaries. Thus, sludge management systems planning may not be accomplished successfully within the context of a single municipality or county if the municipality or county is part of a larger urban complex. Nor can such planning be accomplished successfully solely within natural watershed areas.

Unlike some public service systems such as transportation facilities, sludge handling and disposal facilities and procedures need not form a single integrated system over an entire urbanizing region. Rather, they may form subsystems related to existing urban concentrations and natural watershed boundaries, provided that such subsystems are fully coordinated on a regional basis. Although sludge handling and disposal facilities and practices may cross minor watershed boundaries, the watershed must be recognized as an important factor. Existing urban concentrations with well-developed utility systems must also be recognized as an important influence on the development of Regional sludge management systems. This is necessary if maximum use is to be made of the capacity of these systems and the public capital invested in them.

Planning relating to wastewater sludges could conceivably be carried out on the basis of various geographic units, including areas defined by governmental jurisdictions, economic linkages, or watershed boundaries. None of these are perfect as planning units. For example, there are many advantages to selection of the county as a sludge management planning unit, since many problems relating to both rural and urban development as well as to natural resource conservation are traditionally county oriented. However, groundwater and surface water divides do not necessarily coincide with county boundaries and therefore planning for groundwater use and protection must incorporate both intrawatershed and interwatershed considerations. Agricultural practices and crop patterns are most often related to soils, groundwater, geology, and topography rather than political boundaries. However, major local divisions regarding public acceptance of land and wastewater management are made by political units at the county and town levels of government.

Nevertheless, the regional planning effort must eventually focus on the individual wastewater treatment facility. In addition, the area of influence of the individual sludge management systems may overlap in various ways, and local people can often best identify with their own plant's unique feature. The plants can accurately be related back to the regional level through the common problems and features that generally govern sludge utilization.

Each sludge has its own special characteristics related to the wastes originating in the community. Those particular characteristics, especially heavy metals, are directly related to the local manmade features and economy and as such affect the alternatives for sludge disposal. Thus, it makes good sense to focus on individual plants when dealing with sludge quality and source control.

Treatment plants may quite naturally be identified as sited within a particular county. However, the exact area of influence is a function of individual practice. Sludge may be trucked 30 or more miles to a landfill or land application site. Individual plants might, therefore, be in competition for remote application sites in some instances. This relates most strongly to the need for regional planning.

The urbanizing region must form the basic geographic unit for wastewater sludge management system planning to assure coordination of related subsystems. However, the planning effort must recognize the existence of subregional planning areas relating both to existing sludge handling and disposal systems, and potential management units. The need to coordinate sludge management system development in an urbanizing region to effect economies in providing such facilities, and to protect the natural resource base may dictate the need to adjust and change the delineation of such areas for a more efficient overall system.

BASIC PRINCIPLES

Based on these considerations, seven principles were formulated which form the basis for the planning process applied in the regional sludge management system planning program:

1. Sludge management system planning must be regional in scope, recognizing subregional planning areas related to existing systems, potential management agencies, natural watershed boundaries, and urban concentrations with well-developed sewerage systems and related sludge handling systems. The existence of extra-regional relationships must also be recognized. Sludge from areas adjacent to the Region's boundaries may be processed at wastewater treatment plants near those boundaries; e.g. Whitewater, Oconomowoc and Hartford may accept some septic wastes from outside the Region. Sludges from these treatment plants may also be utilized on farmland in near-by areas outside the Region.

2. Sludge management system planning must be compatible with land use planning. The population distribution and land use patterns determine the amount and spatial distribution of sludges to be accommodated by the system. The system, in turn, is an important element of the sanitary sewerage utilities which service the land use pattern.

3. Land use, wastewater treatment facility and sludge management planning must recognize the existence of a limited natural resource base to which rural and urban development must be adjusted to ensure the continuation of a pleasant and habitable environment. Sludge management systems must have minimum negative environmental impact and assist in attaining areawide land use, air quality, and water quality.

4. Sludge management facilities must be planned as integrated systems or coordinated subsystems. The capacity of each proposed facility in the total system or subsystem must be carefully fitted to present and probable future sludge loadings. The performance of the proposed facilities and the effects on the rest of the system must be quantitatively determined and evaluated.

5. Primary emphasis should be placed on regional solutions to sludge management problems. The export of sludge products, with their attendant nutrient and economic value, to other regions should be considered only after the Regional market capacity and environmental capacity has been fully utilized.

6. Sludge should be treated as a resource, which can, with proper management and control,

provide a valuable energy source at a wastewater treatment plant or a valuable nutrient supplement or soil conditioner for land application. Constituents, such as valuable trace elements or harmful toxic substances, should be fully evaluated.

7. Sludge management systems must have public acceptance to be viable or implementable.

THE SLUDGE MANAGEMENT PLANNING PROCESS

The Commission has developed a seven-step planning process which was utilized by the consultant in the development of this sludge management plan. The planning process not only provides for the integration of the complex planning and engineering studies required to prepare a comprehensive plan, but also provides a means whereby the various private and public interests concerned might actively participate in the plan preparation. The process thus provides a mechanism for resolving actual and potential conflicts between such interests; a forum in which the various interests might better understand the various interrelated problems of the planning area and the alternative solutions available for such problems; and finally, a means whereby all planning area interests might become committed to implementation of the best alternative for the resolution of the problems.

The seven steps involved in this sludge management planning process are: 1) study design, 2) formulation of objectives and standards, 3) inventory, 4) analysis and projections, 5) alternative program formulation, 6) program test and evaluation, and 7) program selection and adoption.

Following this process, the first step of the regional sludge management study consisted of the development of a study design and work schedule for all the work elements of the study. The second step consisted of the identification of wastewater sludge management objectives and supporting principles and standards to be used in the evaluation of alternative regional sludge utilization or disposal system plans. The third step consisted of the assembly of the basic data required for the identification, quantification, and analysis of the existing wastewater sludge disposal within the Region, and the analysis of the assembled data, in order to define the existing and probable future sludge disposal problem in the Region. The fourth step consisted of the formation of alternative system plans for the disposal of wastewater treatment sludges, generated and forecast to be generated within the Region by the year 2000. As the fifth step, the alternatives were screened to identify those which are technically, economically, and institutionally feasible, given the objectives and standards formulated in the study. A deeper evaluation of the economic, social, and environmental costs and benefits conducted for those alternatives that survive the screening was the sixth step. The seventh step of the investigation consisted of the selection of the recommended areawide system plan from among the alternatives evaluated in the sixth step together with a description and identification of necessary implementation measures.

Study Design

Every planning program must be founded in a formal structure or study design so that the program may be carried out in a smooth, logical, manner. The study design must follow through the content of the data gathering operations, define the geographic area for which data will be gathered and plans prepared, outline the manner in which the data collected are to be processed and analyzed, specify requirements for forecasts and forecast accuracy, and define the nature of the plans to be prepared and the criteria to be used in their evaluation and adoption. Such a study design was prepared, followed and modified as necessary during the conduct of this study to assure timely and efficient completion of the work.

Formulation of Objectives and Standards

In its most basic sense, planning is a rational process for establishing and meeting objectives. In order for defined objectives to be useful in the wastewater sludge management planning process, the objectives to be defined must not only be clearly stated and logical but must also be related in a demonstrable way to alternative physical development proposals. The objectives must be clearly relatable to physical systems planning so that a choice can be made from among the alternative plans in order to select that plan which meets the agreed-upon objectives. Logically conceived and well-expressed objectives may be translated into facility design standards to provide the basis for physical plan development. Because the formulation of objectives and standards involves both technical and nontechnical policy determinations, all objectives and standards were carefully reviewed and adopted by the Sludge Management Study Subcommittee of the Technical Advisory Committee.

The objectives and standards range from general development goals for the Region as a whole, some of which were superimposed on the study from the regional land-use transportation planning program and the regional sanitary sewerage system planning program, to engineering and planning analytical procedures and design criteria covering siting of facilities; application of sludges to agricultural lands; and economic and financial analyses.

Inventory

Reliable basic planning and engineering data collected on a uniform, areawide basis are absolutely essential to the formulation of workable development plans.

The necessary data for this study were largely collected through questionnaire forms, review of prior publications, perusal of agency files, personnel interviews with private citizens and public officials, committee meetings of staff and technical advisors, and original field investigations.

Analysis and Projections

Inventories provide factual information about historical and present situations, but analyses and projections are necessary to provide estimates of future needs for sludge processing, transport and disposal facilities. These future needs must be determined from a sequence of interlocking forecasts. Economic activity and population forecasts enable determination of future growth within the Region, which, in turn, can be translated into future demands for land, other resources, and sludge management facilities. These future demands can then be compared with the existing supply and plans formulated to meet deficiencies.

The Metropolitan Sewerage District of the County of Milwaukee has of necessity prepared and maintained technical information on the processing, utilization, and disposal of sludge from the wastewater treatment facilities under its management. Studies of sludge handling equipment have been conducted by several communities for their specific existing installations.

Alternative Program Formulation

Alternative program formulation or design forms the heart of the planning process. The most well-conceived objective; the most sophisticated data collection, processing, and analysis operations; and the most accurate forecasts are of little value if they do not ultimately result in sound plans. The outputs of each of the three previously described planning operations—formulation of objectives and standards, inventory, and forecast—become inputs to the design problems of plan synthesis.

Program Test and Evaluation

If the plans in the design stage of the planning process are to be realized in terms of actual facility development, some measures must be applied to quantitatively test alternative plans in advance of their adoption and implementation. Devices used to test and evaluate the plans range from the use of computer simulation programs to interagency meetings and public hearings. Plan test and evaluation demonstrates which alternative plan or portions of plans are technically sound, economically and financially feasible, environmentally sound, and politically realistic.

Program Selection and Adoption

The general approach utilized for the selection of one plan from among alternatives is to proceed through the use of the sludge management subcommittee of the technical advisory committee, interagency meetings, and public informational meetings and hearings to a final decision and plan adoption by the Commission in accordance with the provisions of the state enabling legislation. The role of the Commission is to certify the adopted plan to federal, state, and local units of government and private sector for their consideration and action. The final decisive step to be taken in the process is the acceptance or rejection of the certified plan by local governmental units concerned, and subsequent plan implementation by public and private action. Therefore, plan selection and adoption must be founded in the active involvement of the various governmental bodies, technical agencies, and private interest groups concerned with development in the Region. The use of advisory committees and both formal and informal hearings is a most practical and effective procedure for achieving such involvement in the planning process, and of openly arriving at agreement among the affected governmental bodies and agencies on objectives and on a final areawide wastewater sludge management plan which can be cooperatively adopted and jointly implemented.

Chapter III

EXISTING SLUDGE MANAGEMENT SYSTEMS

INTRODUCTION

On an average day in 1975, the public wastewater treatment plants of the Southeastern Wisconsin Region processed approximately 290 million gallons (mil gal.) of wastewater, composed of domestic and industrial wastes, as well as storm and ground waters which enter the sewerage systems from foundation and roof drains and through leaking pipes and appurtenances. Of this total approximately 210 mgd is treated by the facilities of the Metropolitan Sewerage District of the County of Milwaukee. The solid materials which are contained in wastewaters and which can be removed in wastewater treatment processes, include solids generated by both industrial pretreatment and municipal sources. Requirements for higher levels of wastewater treatment, combined with anticipated population growth in the Region, are expected to cause increased rates of sludge production through year 2000. The recent addition of phosphorus removal at most large wastewater treatment plants in the Region has increased the quantity of solids contained in wastewater treatment plant sludges.

Aged and partially digested sludges of a different nature originate from septic tanks and holding tanks that currently serve about 15 percent of the resident population of the seven-county region. Contents of such tanks are periodically discharged to municipal systems, where possible.

The use of holding tanks has increased within the Region in areas where groundwater tables, soil conditions, and lot sizes prohibit the use of septic tanks and attendant leaching fields, and where public facilities are not currently available. Unlike sludge or septage, the material from holding tanks is essentially stale, raw domestic wastewater. After being held temporarily—from a few days to a month or more—these unconcentrated wastes are pumped from the holding tank into a sanitary transport truck for disposal into a municipal treatment system or onto a field.

Given proper treatment, concentrated wastewater solids can be made to yield rich organic and chemical fractions to benefit human use as in the production of methane (a byproduct of sludge digestion), in the production of fertilizers or soil conditioners, and in land reclamation. Federal, state, and local units of government recognize the potential resource value of these wastewater residuals and accordingly are exploring methods to utilize sludge. On the other hand, if managed improperly, wastewater sludge can provide excessive nutrients to accelerate eutrophication of surface waters, produce foul and obnoxious odors, or irreparably pollute groundwater. Sludge improperly applied to land might also destroy the productivity of soil by overloading it with heavy metals and other toxic pollutants.

Disposal of sludge has historically been one of the most neglected aspects of wastewater treatment plant design and operation. Considerable effort has been concentrated on developing techniques and methods for in-plant sludge handling and sludge reduction, but to date less effort has been directed at techniques and methods for final use or disposal of sludge. Federal and state insistence on proper sludge management is causing a rapid improvement to this situation.

Studies conducted in conjunction with development of the regional sanitary sewerage system plan indicated that about half of the municipal wastewater treatment plants within the Region (32) use sludge drying beds or sludge lagoons to dewater sludge, with the dewatered residue being trucked to sanitary landfill sites or plowed into farmlands and otherwise utilized for soil improvement (landspreading). It is not unusual for dewatered or dried sludge to be used on parklands or by home gardeners. Small plants located in rural areas generally spread liquid digested sludge on nearby farmlands. Some larger municipal plants use more complex sludge reduction and disposal techniques, including incineration and commercial fertilizer manufacturing along with landspreading. Since 1926, the Jones Island wastewater treatment plant has converted raw, dewatered wastewater sludge into a commercial fertilizer sold under the trade name "Milorganite," an early example of the desirable recycling of waste materials. South Shore wastewater treatment plant sludge is now being dewatered in storage lagoons for utilization by landspreading.

In addition to the publicly owned treatment facilities, there are privately owned facilities which serve isolated enclaves of residential urban development within the Region. Privately owned facilities often utilize landfill or landspreading for final disposal. An additional source of sludge is that which may be generated during the treatment of combined sewer overflows or during stream dredging work that will take place in the future.

About 80 facilities are currently operated in the Region for the pretreatment of industrial wastewaters, prior to their discharge to municipally owned sewerage systems. Many of the waste treatment residues generated thereby are transported and disposed of on solid waste sites also containing other types of wastes. Certain landfills are licensed to accept hazardous and toxic wastes from these sources.

Inventory Procedures

An inventory of existing sludge management systems was undertaken to develop a data base on which to formulate alternative systems described in Chapter IX. Essential to this inventory is the collection and evaluation of data on these existing systems.

The collection of data on wastewater sludge management systems was accomplished by first assembling all available data and reviewing the NR101 forms. The Wisconsin Department of Natural Resources industrial waste reporting and monitoring program, as specified in Chapter NR 101 of the Wisconsin Administrative Code and as established in Chapter 144.45 of the Wisconsin Statutes. Inventory questionnaires were then prepared and distributed and these were followed up by meetings and telephone conversations. The inventory questionnaires were developed by SEWRPC staff as part of the overall areawide water quality management planning inventory work. The comprehensive questionnaire for wastewater treatment and sludge management at municipal and private wastewater treatment plants and the similar, less detailed, questionnaire for industrial dischargers are appended. Data are presented for year 1975, the base year for data utilized in this report.

An effort was made to obtain actual design criteria on every major structural component at the 21 major municipal wastewater treatment plants identified in this chapter. Other treatment plants were reviewed as to plant type and size. Detailed plans, specifications, and other data were obtained for the MSD-Jones Island and MSD-South Shore wastewater treatment plants in Milwaukee under the current total solids management 201 facilities planning effort. This information has all been utilized in developing the inventory data base presented herein.

Definition of terms, adopted for use in presenting the inventories, analyses, alternative sludge management plans, and recommended plan in this report, are appended.

INVENTORY FINDINGS—GENERAL

The inventory findings are presented below for municipal wastewater sludge management facilities, water treatment plant sludge management facilities, industrial wastewater sludge management, and septic and holding tank wastes. For the sake of efficiency in the conduct of the Regional Wastewater Sludge Management Planning Program, the most detailed level of analysis was reserved for the 25 major municipally-owned sewage treatment plants or other municipally owned sewage treatment plants, having a design flow reported in 1970 as being in excess of 0.5 mgd, or selected to represent a category of sewage treatment plants other than major plants. Specifically, the categories of activated sludge and trickling filter plants, with and without phosphorus removal are addressed. Other factors considered were the potential for abandonment, the potential for joint treatment with other existing treatment plants or planned service areas, and the spatial distribution of the facilities. The resulting emphasis on the 21 municipal sewage treatment plants which are individually addressed, proved to be justified, since 90 percent and 91 percent of the total raw sludge solids—inclusive of those generated from municipal sewage treatment plants, private sewage treatment plants, industries, septic systems, and water treatment plants—estimated for 1975 and anticipated by year 2000, respectively, are associated with these facilities, as demonstrated in Table 56. Table 1 summarizes the inventory findings for all wastewater sludge management systems in the Region.

INVENTORY FINDINGS—MUNICIPAL FACILITIES

Below are descriptions of sludge processing, transportation, and utilization or disposal facilities associated with each of the 21 major wastewater treatment plants in the study area. Each description consists of brief introductory material on the plant and process and is followed by more detailed information on existing practice along with flows, loads, and design criteria. This is accompanied by a brief tabulation of flows and loads which compares the approximate values for 1975 with the known plant design criteria. Known future facilities planning is also discussed. Flow and load data were generally derived from DNR records for 1975, supplemented by further data from SEWRPC and DNR files.

TABLE 1

SUMMARY OF SLUDGE GENERATION SOURCES IN REGION—1975

Facility	Raw Sludge Quantity Produced in 1975 (lb/day dry solids)
Major Municipal Facilities	693,200
Other Municipal Facilities	7,035
Private Facilities	3,500
Industrial Facilities	
Tanneries	5,400
Metal Plating	7,300
Metal Machining	34,200
Food Processing	2,800
Battery Manufacturing	(<100)
Truck and Car Wash Operations	200
Power Plants	—
Water Treatment Plants	25,157
Septic and Holding Tanks[1]	(12,400)
Total	778,792

[1]*Discharged to municipal wastewater treatment plants; value is included in municipal quantities and in total sludge quantity.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The year 1975 populations were estimated by SEWRPC, while plant design criteria were obtained from reports and studies by others, visits to plant sites, and discussion with local consultants. Industries considered were generally those contributing a flow of more than 10,000 gal./day to the municipal facilities as reported in the NR 101 program. The main objective of this section is to document the current area sludge management situation in the Region, to indicate the relative useful life and capacity of the existing sludge processing facilities, and to provide a data base upon which a sound sludge management program can be based.

Table 2 is an overview of the current processing, transport, and disposal/utilization practices in the Southeastern Wisconsin Region. This is followed by a site map (see Map 2). Other municipal facilities are addressed by category, and industries contributing wastewater are listed in the appendix.

MSD—Jones Island

The Jones Island activated sludge wastewater treatment plant includes phosphorus removal and has a hydraulic capacity of 200 mgd. The facility consists of a West Plant built in 1926 with a capacity of 85 mgd and an East Plant with a capacity of 115 mgd. The East Plant was placed in operation in two stages; the first stage, about 60 percent of the total capacity, in 1935 and the second stage, about 40 percent of the total capacity, in 1952. The service area includes portions of the City of Milwaukee and surrounding communities.

Sludge processing consists of: thickening, chemical conditioning with ferric chloride ($FeCl_3$), dewatering on vacuum filters, and drying in rotary drum dryers. The final product of sludge processing is sold primarily as the organic fertilizer Milorganite.

Monitoring of plant effluent during 1975 showed effluent limitations, set by DNR permit, were fully met during January only. At wastewater flows above 140 mgd and influent BOD_5 about 350 mg/l, the Milorganite plant cannot handle the waste sludge loadings from the clarifiers; the sludge blanket level then increases to the level of the weir and flows over into the plant effluent. These solids will be captured in the future when currently planned facilities are completed. At 140 mgd and current organic loadings, 100 percent dryer utilization is necessary. The facilities, with an allowance for adequate down-time, cannot handle current loadings. It is obvious that 100 percent dryer utilization is not possible because dryers must be removed from service for routine maintenance, which factor reduces the maximum allowable flow capacity with adequate solids handling, by the existing plant, from 140 to approximately 125 mgd. During 1975, filter utilization was equivalent to 18.6 filters per day, and dryer utilization was equivalent to 9.2 dryers per day.

The average 1975 flow at Jones Island was 137.1 mgd and contained approximately 485,140 lb/day BOD_5 and 431,067 lb/day SS. Industry contributes approximately 25% of the influent flow; significant industries are listed in Appendix D. The estimated population served by the combined facilities of Jones Island and South Shore was approximately 1,118,900. Plant data are shown in Table 3.

Waste sludge is thickened in six gravity thickeners, four with diameters of 43 feet and two with diameters of 98 feet; depth is 15 feet for all six thickeners. The sludge is next conditioned with $FeCl_3$. Thickened sludge is dewatered on 24 rotating-drum vacuum filters: 23 have diameters of 13 ft and a 16-ft face and

TABLE 2 SLUDGE MANAGEMENT IN THE REGION - 1975

Wastewater Treatment Facility	Wastewater Treatment Processes		Sludge Processing Options											Transport Options			Utilization/Disposal Options							
	Existing	Proposed	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Wet Oxidation	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail	Pipeline	Incineration/Pyrolysis	Landfilling	Land Spreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
MSD - Jones Island	AS-C		E					E	E				E	E	E								E	
MSD - South Shore	AS-C		E			E					E			E				E	E					
Racine	AS-C					E		E	E					E				E	E					
Kenosha	AS-C		E			E		E		E				E					E					
Waukesha	TF-C	TF/AS-C	Po			E Po					E Po									E Po				
West Bend	AS-C	TF/AS-C	Po			E Po		Po	Po		E			E				Po	E Po					
South Milwaukee	AS-C					E Po	E	Po		Po[2]	E	E		E				E Po	E	E				
Whitewater	TF/AS	RBC	Po			E Po		Po		Po[2]		E		E				Po	E	Po				
Oconomowoc	AS		E			E		E	E		E	E		E				E	E					
Burlington	AS-C			E	E	E		E						E					E					
Walworth Co. MSD[3]	AS/TF	TF	Po			E Po						E		E Po				E	Po					
Brookfield	AS-C				E[1]			E		E				E			E	E						
Port Washington	AS-C				E	E								E					E					
Grafton	AS-C				E	E								E					E					
Cedarburg	AS/TF-C		E			E					E	E		E					E					
Hartford	AS-C				E							E Po		E					E					
Twin Lakes	TF/AS-C				E	E						E		E					E	E				
Williams Bay	AS		E			E						E		E					E					
West Racine Co. MSD	AS-C	AS-C			E Po	Po						E Po		E					E Po					
Hartland-Delafield	AS	RBC				E Po					E Po	Po		E Po					E					
Union Grove	AS-C	AS/RBC-C			Po	E					E	Po		E Po				E	Po					

Notes:
[1]Used as a holding tank
[2]Belt filter press
[3]Delavan and Elkhorn

E = Existing
Po = Proposed by others
AS = Activated sludge

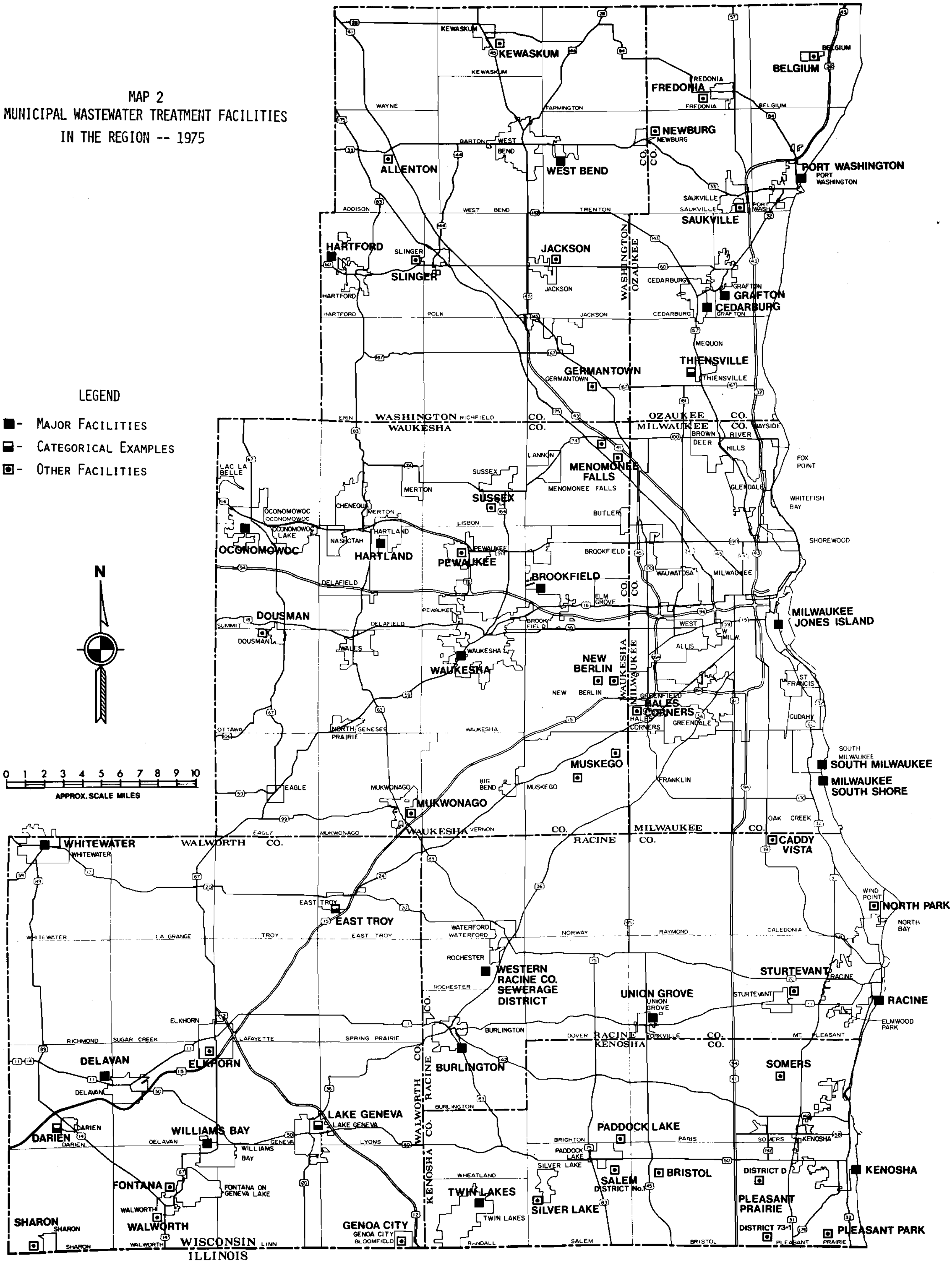
TF = Trickling filter
RBC = Biocontactor
C = Chemical addition

Source: Camp Dresser & McKee Inc. and SEWRPC

one has a diameter of 13 ft and a 14-ft face. Before vacuum filtration, the solids content of the sludge is approximately 1.5 percent and after filtration it is approximately 14 percent. Filtered sludge is dried on 10 indirect-direct counterflow, rotary-drum dryers. Dryer feed is manually controlled to approximately 1 part wet sludge and 1 part dryer recycle. Hot air for drying is provided by exhaust waste heat from the gas turbines supplemented by natural gas or fuel oil. When the plant was designed, the dryers were coal fired; this was changed later to natural gas, supplementing that from the power house turbines. Currently, approximately three-quarters of the heat for drying originates from the gas turbines used to generate electrical power and represents the indirect fired source. The balance of the heat for drying is by burning of natural gas at the head of the dryer and represents the direct-fired source. The recent gas shortage necessitated a shift to fuel oil and increased drying costs. Solids content of the dried sludge is 95 to 98 percent. Dried sludge is classified in gyratory screens to produce an evenly graded particle size between 11 and 60 mesh. Oversize particles are crushed in a cage mill and returned to the dryers. Undersized particles are first pelletized and then granulated prior to secondary screening. The secondary screens produce recycle, product and dust. The dust is bagged and sold as "Milorganite F". The final product, Milorganite, is either bagged or sold in bulk.

There is a need for dryers, filters, and related equipment to process sludges and allow adequate down-time for existing units: currently, additional dryers and additional filters are to be designed for this purpose. A Section 201 Facilities Plan has been prepared by the

MAP 2
MUNICIPAL WASTEWATER TREATMENT FACILITIES
IN THE REGION -- 1975



SOURCE: CAMP DRESSER & MCKEE INC. AND SEWRPC

District to determine an efficient way to abate pollution of Lake Michigan. A total Solids Management Plan is currently contracted for the consultant which will form part of the 201 facilities plan.

TABLE 3

SELECTED OPERATING AND DESIGN DATA—
MSD—JONES ISLAND WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	137.1	200
Population	1,018,900[2]	N/A[5]
Unit Flow (gpcd)	208[3]	N/A
Sludge Solids (lb/day)	386,000[4]	N/A
BOD_5 (lb/day)	485,140	N/A
SS (lb/day)	431,067	417,000

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Total Sewer Service Area Population.*

[3]*Total Sewer Service Area Unit Flow.*

[4]*416,000 lb/day with $FeCl_3$ addition.*
Average Milorganite Production of 363,000 lb/day.

[5]*Not available.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

MSD—South Shore

The Metropolitan Sewerage District's South Shore Wastewater Treatment Plant is a 120-mgd activated sludge facility with phosphorus removal. The original 60-mgd plant, built in 1968, was a primary treatment plant; in 1974, this plant was upgraded to 120 mgd with activated sludge secondary treatment being added. The current facilities are located on "made" land consisting of sand fill behind a double steel-walled breakwater. The service area includes portions of the City of Milwaukee and surrounding communities, except the City of South Milwaukee.

Monitoring of plant effluent in 1975 showed that effluent conditions of the discharge permit were not met during 11 months. High sludge blankets in the final clarifiers, brought about by problems with pumping and sludge thickening, caused spewing of sludge solids into effluent channels. Perhaps the most limiting feature in the operation is the lack of adequate digester capacity, due to addition of the secondary treatment portion. Liquid is decanted from the lagoons and recycled to the head of the plant.

Waste-activated sludge is treated in air-flotation thickeners. It may then either be combined with primary sludge entering the two-stage anaerobic digesters or be digested separately. After digestion, sludge is pumped to lagoons for holding prior to ultimate use by land-spreading.

Waste pickling liquor, used to aid phosphorus removal, is added either in the aeration basins or in the grit channels ahead of the primary settling basins.

Plant data for South Shore and data for combined flows to South Shore and Jones Island are shown in Table 4. The industry list in Appendix D contains all discharges known to have flows over 10,000 gpd filed under section NR101 of the Wisconsin Administrative Codes.

TABLE 4

SELECTED OPERATING AND DESIGN DATA—
MSD—SOUTH SHORE WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	73.7	120
Population	1,018,900[2]	N/A[5]
Unit Flow (gpcd)	208[3]	N/A
Sludge Solids (lb/day)	196,000	N/A
BOD_5 (lb/day)	184,419	300,000[4]
SS (lb/day)	268,606	288,000[4]

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Total Sewer Service Area Population.*

[3]*Total Service Area Unit Flow.*

[4]*O&M Manual for South Shore.*
Raw Wastewater: 300 mg/l BOD_5 and 290 mg/l SS.

[5]*Not available, Draft O&M Manual does not clearly define.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 73.7 mgd and contained approximately 184,419 lb/day BOD_5 and 268,606 lb/day SS. Industry contributes approximately 17% of the influent flow.

Waste-activated sludge flows to dissolved air-flotation thickeners, designed to concentrate sludge from approximately 0.5 percent solids to 4 percent solids. Six thickeners are used, and the original design data for each are:

Effeetive surface area ....1,620 sq ft
Loading rate................................8.54 lb/sf/day
Solids handling (dry basis).......13,850 lb/day
Maximum gross loading...........16,300 lb/day
Design capacity with
  coagulant aid ....20-40 lb/sf/day
Polyelectrolyte addition ....5-10 lb/ton dry solids

Primary and secondary sludges may be combined before anaerobic digestion or each may be digested separately. Six fixed-cover, primary digesters are followed by two secondary digesters with floating covers which provide gas storage and partial liquid solids separation. Sludge in the primary digesters is heated by waste heat from the generator building through a system of internal coils and external sludge heat exchangers, with the objective of maintaining the sludge at approximately 90°F. Methane from the digesters is used to power engines for the blowers serving the aeration basins and for power generation. The existing digesters were designed for the original 60-mgd primary plant and are being used for the current 120-mgd plant without alteration. Design data for the digestion system are indicated:

Primary: 6 at 200,000 cubic feet each
Secondary: 2 at 200,000 cubic feet each
Total Volume: 1,600,000 cubic feet or
  12,000,000 gal. at 20 feet
  side water depth (swd)
Detention time at design sludge flow of 935,000 gpd.
  Primary only: 9.1 days (6 digesters)
  Primary plus Secondary: 12.1 days (8 digesters)

Digester sludge is stored in six lagoons prior to being utilized by land-spreading. The original four lagoons cover an area of 600,000 sq ft and have a capacity of 8,000,000 cu ft when filled. Two temporary lagoons of irregular shape adjoining a residential area additionally cover an approximate area of 371,500 sq ft and have a capacity of 7,250,000 cu ft when filled. A contractor withdraws sludge from these lagoons for spreading at DNR approved sites during times when the ground is not frozen.

Two small incinerators are under construction; these will be used to burn coarse screenings, grit, and scum. Additional heating for the existing digesters is underway and is especially critical during winter. Also underway is an experiment with various polymers to aid dewatering in the lagoons.

City of Racine

The City of Racine is served by an activated sludge wastewater treatment plant including phosphorus removal consisting of a primary plant built in 1938 and a secondary plant built in 1965. This facility is being modified and enlarged to handle a future average daily flow of 30.0 mgd. The new plant will also provide for phosphorus removal. The modifications will permit continued operation of the secondary treatment process as either a Kraus Nitrified Sludge Interchange Process or a contact stabilization activated sludge process. Current modifications are arranged to accommodate future expansion to 48 mgd. Plant data are given in Table 5.

TABLE 5

SELECTED OPERATING AND DESIGN DATA—
CITY OF RACINE WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	19.69	30.0
Population	116,500	141,000
Unit Flow (gpcd)	169	212.8
Sludge Solids (lb/day)	18,000[2]	76,500
BOD_5 (lb/day)	16,042	49,800
SS (lb/day)	19,748	61,200

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Estimate based on detailed operating data in the 1973 Annual Report.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The area served by this treatment plant includes the City of Racine, the Towns of Mt. Pleasant and Caledonia, and the Village of North Bay. The 1975 average wastewater flow was 19.69 mgd and contained 16,042 lb/day BOD_5 and 19,748 lb/day SS. Industry contributes approximately 15% of the influent flow; signficant industries contributing flow are listed in Appendix D. The estimated 1975 population served was 116,500.

Modifications to the existing plant currently nearing completion will provide primary digestion in two high-rate digesters each fitted for gas recirculation. Sludge will be pumped through heat exchangers prior to entering the digesters. In addition, external sludge heat exchangers will be provided to maintain digester contents at a uniform operating temperature of 95°F. The primary digesters have a combined volume of 266,000 cu ft and are sized at 1.89 cu ft/capita. The loading rate is 0.179 lb volatile solids/day/cu ft. Sludge detention time at design flow will be 7.3 days.

The secondary digester (under construction) will be a new tank with a 60-ft diameter and a volume of 445,000 gal. After digestion, sludge will be stored in an existing fixed-cover digester which will provide storage for 333,000 gal., or 3.2 days of sludge. Sludge is conditioned with lime and $FeCl_3$ prior to the vacuum filtration units. The two older units plus one new unit will provide a total capacity of 6,600 lb/hr at an application rate of 6 lb dry solids/hr/sf. The total filter surface area is 1,100 sq ft.

The sludge cake leaving the filter has a solids content of approximately 24 percent and is trucked to the Glenn Oakes' sanitary landfill. Some sludge cake is applied to agricultural land.

Current expansion of the treatment plant is nearing completion and no other known plans exist for future facilities. Studies of combined sewer overflows might lead to recommendations resulting in increased future solids loadings at the wastewater treatment plant.

City of Kenosha

Kenosha's activated sludge wastewater treatment plant has a design capacity of 18.0 mgd (annual average flow). A primary treatment plant built in 1940 is operated in tandem with a secondary treatment plant built in 1967. The waste-activated sludge is treated in a dissolved air-flotation thickener before being combined with the raw sludge flowing to the anaerobic digesters. The digested sludge is conditioned with ferric chloride and lime to aid dewatering in a filter press. Final disposal consists of trucking to farms for landspreading. Raw sludge from the Somers, Pleasant Prairie, Pleasant Park, and Salem wastewater treatment plants is trucked to Kenosha for processing.

In 1971, a biosorption treatment system with a capacity of 20 mgd was added to provide biological treatment of combined sewer overflows during periods of rainfall. In 1972, phosphorus removal facilities were completed and placed in operation; approximately 85 percent removal of phosphorus is achieved. Population, flow, and load data are presented in Table 6.

TABLE 6

SELECTED OPERATING AND DESIGN DATA—
CITY OF KENOSHA WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	18.44	18.0/23.0[2]
Population	89,500	103,000
Unit Flow (gpcd)	206	180
Sludge Solids (lb/day)	35,800	51,400
BOD_5 (lb/day)	18,030	18,000
SS (lb/day)	31,152	25,000

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Annual average flow/peak daily flow.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 18.44 mgd and contained approximately 18,030 lb/day BOD_5 and 31,152 lb/day SS. Industries contribute approximately 40% of the influent flow; significant dischargers are listed in Appendix D. The estimated population served was 89,500.

The dissolved air-flotation sludge thickeners are designed to concentrate the secondary sludge from 5,000 to 10,000 mg/1 and have a design loading of 10 lb/day with a net surface area of 2,000 sq ft.

The anaerobic digesters consist of two first-stage units with volumes of 80,000 cu ft and 108,400 cu ft respectively, and one second-stage unit with a volume of 80,000 cu ft. Total digester volume is 268,400 cu ft. Design loading on a total solids basis is 0.138 lb/cu ft/day and on a volatile solids basis is 0.095 lb/cu ft/day. Detention time is 32 to 38 days. A fourth digester is being added and has a volume of 65,500 cu ft.

Prior to dewatering on the filter press, sludge is conditioned with lime and ferric chloride to aid the dewatering process. The system is designed for a supply of liquid $FeCl^3$ concentrate (approximately 40 percent $FeCl_3$ solution) which is diluted to the necessary application level in an agitated dilution tank. From here it is pumped into the main sludge flow and mixed in a mixing tank. The lime system is designed to use hydrated lime, received in a 1,500-cu ft bin and mixed in an agitated dilution tank, to give a 10 percent milk of lime solution fed at the required rate to the main sludge flow in a mixer.

The chemical conditioning system was designed on the basis of an addition of 12 percent lime and 3 percent ferric chloride. However, performance tests on the filter press sludge dewatering facilities showed that lime dosing requirements of 17 percent and ferric chloride dosing of 2.7 percent were needed to meet the dewatering parameters of the filter press. It should also be noted that the current rate of lime dosing is above the 20 percent level; however, the minimal lime dosage for proper operation may be slightly lower. Conditioned sludge enters a 500-gal. feed pressure vessel prior to the filter press units.

The filter press operation consists of two units, each 4 ft by 4 ft and containing 72—1-in. trays; design capacity is 105,000 lb dry solids/week operating 16 hr/day, 5 days a week. For utilization, dewatered sludge is trucked to farms, stockpiled, and spread by farmers. Currently, the demand for sludge is higher than the supply.

The Kenosha Water Utility is undertaking facilities planning for combined sewer overflow abatement studies with the assistance of a consultant. The objective is to determine the most cost-effective method for water pollution control for the City of Kenosha and adjacent areas.

City of Waukesha

Wastewater treatment at Waukesha is currently provided by an 8.5-mgd two-stage trickling filter system including phosphorus removal. Collected sludges are digested anaerobically, pumped to lagoons where drying occurs, and shredded for use as a soil conditioner. Plant data are shown in Table 7. A facilities planning study calls for upgrading of the plant to 16-mgd capacity and addition of chemical flocculation and dual-media filters.

TABLE 7

SELECTED OPERATING AND DESIGN DATA—
CITY OF WAUKESHA WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd)	9.9	8.5	16
Population	49,000	43,500	65,000
Unit Flow (gpcd)	202	195	246
Sludge Solids (lb/day)	21,000	N/A[3]	N/A[3]
BOD_5 (lb/day)	13,280	N/A[3]	20,000
SS (lb/day)	12,584	N/A[3]	22,000

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*A facilities plan has been completed for expansion of the existing facilities; this proposed addition has been considered in the development of a sludge management plan (Chapter IX and X).*

[3]*Not presented in plant design criteria.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 9.9 mgd and contained approximately 12,584 lb/day SS and 13,280 lb/day BOD_5. Industries contribute approximately 36% of the influent flow; significant dischargers are listed in Appendix D. Estimated residential population served was 49,000 (1975), with a significant industrial load.

The existing plant contains the following sludge processing equipment:

Digesters:
- Primary — 1-65 ft diam x 21.75 ft swd
  1-55 ft diam x 20 ft swd (4.7 cu ft/cap.)
- Secondary — 1-50 ft diam x 18.5 ft swd
  1-55 ft diam x 14.5 ft + 14.5 ft deep cone

Lagoons: 3.5 acres (0.08 Ac/1,000 cap.)

From the lagoons, the dried sludge is shredded in a portable shredder on-site. All sludge is given away as a soil conditioner to the public, the Department of Public Works, and to the Park Board.

It is proposed by the City's consultant that the existing facilities be paralleled by either a similar unit with a capacity of 8 mgd, or by a primary and secondary treatment facility of the conventional activated sludge type with a capacity of 8 mgd. In the former, the combined wastewater discharge would be treated only by chemicals in flocculation and coagulation basins prior to rapid sand filtration, disinfection, and discharge to the river. In the latter, the wastewater discharge combined with that of the existing facilities would be treated in nitrification and aeration and settling basins, before chemical flocculation and settling in coagulation basins, rapid sand filtration, and disinfection.

The combined treatment plant will be capable of accepting an average daily flow of 16 mgd, with a maximum hydraulic capacity of 28 mgd.

Sludge handling at the proposed 8-mgd trickling filter wastewater plant would consist of two digesters with 80-ft diameters and 20-ft swd sized at 6.2 cubic feet per capita, and 40 acre-feet of lagoons for storage and drying sludge prior to removal for use as a soil conditioner. With the 8-mgd activated sludge addition, the same equipment is proposed with the addition of two sludge thickeners (20 ft by 75 ft) and a solids loading of 10 lb/sf/day.

It should be noted that the future plans assume that the current high demand for sludge, which exceeds production, will continue in the future.

<u>City of West Bend</u>
West Bend is currently served by a 2.5-mgd activated sludge wastewater treatment facility placed into operation in 1966. In the future, SEWRPC estimates the service area will be expanded to include: Wallace Lake, Little Cedar Lake, Big Cedar Lake, and Silver Lake. Currently, none of these areas are served by wastewater treatment plants.

Waste pickle liquor is currently being added prior to the primary settling tank for phosphorus removal. Waste-activated sludge is then returned to the primary clarifiers; the combined primary and waste-activated sludge flows from the primary clarifiers to two heated anaerobic digesters. After digestion, sludge is pumped to tank trucks for utilization by landspreading. Currently, three separate farms are used, each approximately 15 miles from the plant. Plant data are shown in Table 8.

TABLE 8

SELECTED OPERATING AND DESIGN DATA—
CITY OF WEST BEND WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd)	3.70	2.50	9.0
Population	21,000	25,000	48,500
Unit Flow (gpcd)	176	100	186
Sludge Solids (lb/day)	6,000	5,000	17,650
BOD_5 (lb/day)	3,200	4,250	13,000
SS (lb/day)	7,992	5,000	15,220

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*
[2]*A facilities plan has been completed for expansion of the existing facilities; this proposed addition has been considered in the development of a sludge management plant (Chapters IX and X).*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 average flow was 3.70 mgd and contained approximately 3,200 lb/day BOD_5 and 7,992 lb/day SS. The estimated population served is 21,000. Industry contributes approximately 36% of the influent flow; significant dischargers are listed in Appendix D.

Current sludge handling consists of two anaerobic digesters. Sludge is then pumped either directly to tank trucks for landspreading or to lagoons for drying. The lagoons are cleaned once a year.

A 9.0-mgd wastewater treatment facility, to include current as well as future flows and designed to serve until year 2000, has been proposed by the City's consultant. The plant will be located adjacent to existing facilities. Wastewater treatment will be by a two-stage trickling filter followed by aeration and effluent filtration. Waste pickle liquor is to be added to the aerated grit chambers for phosphorus removal. Sludge treatment will consist of all sludge being gravity thickened to about 5.5 percent solids in two tanks sized at 11 lb/sq ft and capable of handling 17,650 lb/day. Following thickening, sludge will be anaerobically digested in four tanks with a total volume of 242,755 cu ft and a detention time of 47 days. Digested sludge will be dewatered on two 400-sq ft vacuum filters, each with a diameter of 8 ft and a length of 16 ft. The solids loading rate is 1,600 lb/hr, and filters will be operated for 8 hr/day. Sludge will then be landfilled at the City landfill, due to high concentrations of heavy metals. The consultant also recommended a source control program to isolate and eliminate the current high concentrations of cadmium; liquid sludge could then be spread safely on farmland.

City of South Milwaukee

South Milwaukee operates an activated sludge wastewater treatment facility including phosphorus removal located between 5th Avenue and Lake Michigan. The 1975 connected population was 23,400 persons, and the 1975 average daily flow was 2.7 mgd. Industry contributes approximately 18% of the influent flow: significant dischargers are listed in Appendix D.

Design capacity of the plant is 6.0 mgd. The principal components of the existing plant include: mechanically cleaned grit chambers, screens, primary clarifiers, primary pumping, aeration tanks, secondary clarifiers, and a chlorine contact tank. Effluent is discharged to Lake Michigan. The plant data are presented in Table 9.

TABLE 9

SELECTED OPERATING AND DESIGN DATA—
CITY OF SOUTH MILWAUKEE WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	2.7	6.0
Population	23,400	32,000
Unit Flow (gpcd)	115	187.5
Sludge Solids (lb/day)	4,600	2,680[2]
BOD_5 (lb/day)	3,490	12,510
SS (lb/day)	3,715	13,761

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Excess sludge is hauled.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

Waste-activated sludge is returned to the primary clarifier. All sludge is then anaerobically digested and disposed of by three methods. During 1975 the plant averaged 1.9 tons of digested sludge per day. About 65 percent of this digested sludge was wet-air oxidized. The resulting ash and wastewater were discharged to a lagoon for settling. The lagoon supernatant, which averages about 6,000 mg/l BOD_5 was returned to the head of the plant. This Zimpro unit, which was constructed in 1964, is operated on a batch basis. This unit has been difficult to maintain and considerable amounts of natural gas are also required.

During 1975 about 8 percent of the digested sludge was dried on sludge drying beds. The sludge was allowed to dry from 3.3 percent solids to about 50 percent solids in 25 to 35 days. Reportedly, most of the dried sludge is picked up and used by the public.

The third method utilizes contract hauling of liquid digested sludge (at 3.3 percent solids) to landspreading.

The city's consultant estimates that current digested sludge solids (1975) are 688 ton/year, or 0.161 lb/cap./day.

Since November 1976, polymers have been added to the digestion system between the first and second stages. This has been effective in increasing the sludge solids concentration and reducing the solids in the digester supernatant. As a result of this increase in solids concentration, the plant is now able to handle all its sludge in the Zimpro Wet Air Oxidation system and is not hauling sludge to land application.

According to projections by SEWRPC, the residential population of South Milwaukee may be expected to decrease slightly in the next 25 years. Average daily wastewater flow in the year 2000 is expected to be about 2.8 mgd.

R.W. Nicholson, Consulting Engineers, submitted a sludge processing study to the city in December 1975. Five alternative sludge disposal techniques were investigated. As of this time, an alternative has not been selected by the city. The five methods are: 1) thicken sludge with a dissolved air flotation thickener and, thus, make existing facilities adequate; 2) continue current methods; 3) City hauling to farmland application; 4) increase sludge bed capacity; 5) mechanical thickening (belt filter press) and landfill disposal. The latter is considered by the consultant to be most feasible.

City of Whitewater

Whitewater is currently served by a 2.5-mgd wastewater treatment plant consisting of the parallel operation of a 1937 trickling filter plant and a 1967 activated sludge plant. Data are shown in Table 10 for a proposed 3.65-mgd plant.

TABLE 10

SELECTED OPERATING AND DESIGN DATA— CITY OF WHITEWATER WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd) . .	1.14	2.50	3.65
Population	11,000	N/A[3]	36,500
Unit Flow (gpcd)	104	N/A	100
Sludge Solids (lb/day)	3,700	N/A	12,410
BOD_5 (lb/day)	4,350	6,080	11,425
SS (lb/day)	2,667	N/A	10,800

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*A facilities plan has been completed for construction of a new wastewater treatment plant; this proposed facility has been considered in the development of a sludge management plan (Chapters IX and X).*

[3]*Not presented in available plant design criteria, population equivalent at 35,750.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

In 1975, the average flow was 1.14 mgd and contained approximately 4,350 lb/day BOD_5 and 2,667 lb/day SS. Estimated population served is 11,000. Industry contributes approximately 28% of the influent flow; significant dischargers are listed in appendix D. Of the contributing industries Hawthorn-Mellody Farms adopted a treatment program for its wastes in 1973. (Water Engineering Associates' report, May 1972, concludes that the waste flows from Foremost Foods is a "small contributor hydraulically and on a BOD basis," and that the university's discharge is low in BOD and essentially equal to domestic BOD.)

Sludge is treated in a two-stage anaerobic digester with the second stage serving as storage. Sludge from both the trickling filter and activated sludge plant is treated in this digester. Sludge can then either be dried on sand beds and stockpiled for farmer use (optional) or spread (on agricultural lands) by tank trucks drawing directly from the digester.

A facilities plan by Robinson and Associates, presented in October 1975, contained a proposal that the existing wastewater treatment facilities be abandoned and a new 3.65-mgd plant of the fixed film contacter process with anaerobic digestion of sludge be built at a new site. Design values for this plant are based on a flow of 100 (gpcd), 0.17 lb/cap./day BOD_5 and 0.2 lb/cap./day SS. Sludge handling would consist of anaerobic digestion followed by a belt filter press and disposal in a DNR-approved landfill adjacent to the facility (it would also be available to the public or could be landspread). The anaerobic digester would be fitted for recovery of methane to be used in power generation. The primary sludge is expected to total 6,480 lb/day with 5.0 percent solids and 78 percent volatile solids; secondary sludge 5,930 lb/day at 0.64 lb BOD_5 with 3.5 percent solids and 78 percent volatile solids. The digester is designed to handle 80 lb volatile suspended solids (VSS)/1,000 cf/day and has a volume of 139,000 cu ft.

City of Oconomowoc

Oconomowoc is currently served by a 1.5-mgd trickling filter wastewater treatment plant built in 1935. In 1962, the City's consultant prepared a report on revisions and improvements to the existing plant; however, none of the suggested revisions were instituted. In 1970, a facilities plan for a new 4.0-mgd wastewater treatment plant of the activated sludge type was prepared by consultants. Implementation of this plan was also delayed; then, a 1974 infiltration/inflow analysis proposed that this plant be constructed as planned and that the sewer system be renovated to remove approximately 50 percent of the existing peak infiltration/inflow. This plan has been adopted and the wastewater treatment plant is expected to be operational in the spring of 1977. Plant data are shown in Table 11.

The 1975 flow was 1.903 mgd and contained approximately 3,640 lb/day BOD_5 and 2,857 lb/day SS. Industry contributes approximately 30% of the influent flow; significant dischargers are listed in Appendix D. The estimated population served is 11,100.

Existing sludge handling at the trickling filter plant consists of anaerobic digestion of the combined primary sludge and scum, and secondary sludge followed by drying on sand beds or storage in lagoons. Dried sludge is hauled by truck for ultimate utilization at an

TABLE 11

SELECTED OPERATING AND DESIGN DATA—
CITY OF OCONOMOWOC WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	1.903	4.02
Population	11,100	29,500
Unit Flow (gpcd)	171	136
Sludge Solids (lb/day)	2,400	N/A
BOD_5 (lb/day)	3,640	8,340
SS (lb/day)	2,857	6,670

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

apple orchard and as a soil amendment at construction sites.

Sludge handling at the activated sludge plant under construction is by thickening in two dissolved air flotation units, each with a surface area of 450 sq ft. Thickened sludge is anaerobically digested in two two-stage digesters: primary digesters have a total volume of 86,000 cu ft, and secondary digesters have a total volume of 43,340 cu ft. The digested sludge could be loaded in tank trucks for landspreading in good weather or could be conditioned with lime and dewatered on two vacuum filters, each with a 10-ft diam. and a 10-ft drum face. The sludge will then be trucked to a landfill.

Studies of infiltration/inflow conditions, completed by the City's consultant in 1974, conclude that a sewer system evaluation survey and consequent program for removal of approximately 50 percent of the infiltration/inflow would extend the life of the treatment plant under construction to 1995. No other known plans exist for future facilities.

City of Burlington

Existing wastewater treatment facilities in Burlington consist of a 2.5-mgd "contact stabilization" activated sludge plant including phosphorus removal. This plant is a combination of an older 1-mgd trickling filter plant converted and upgraded in 1972 to a 1.5-mgd activated sludge plant plus a 1-mgd factory-built activated sludge plant. Plant data are shown in Table 12.

TABLE 12

SELECTED OPERATING AND DESIGN DATA—
CITY OF BURLINGTON WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	1.48	2.5
Population	10,800	25,000
Unit Flow (gpcd)	137	100
Sludge Solids (lb/day)	2,440	N/A
BOD_5 (lb/day)	2,550	5,000
SS (lb/day)	1,753	N/A

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

In 1975, treatment plant flow was 1.48 mgd and contained approximately 2,550 lb/day BOD_5 and 1,753 lb/day SS. Estimated population served was 10,800. Industries contribute approximately 10% of the influent flow; significant dischargers are listed in Appendix D.

Waste-activated sludge is digested in the heated primary and secondary (gas-mixing) digesters of the earlier trickling filter plant which have a design capacity of 43,240 cu ft, or 4.32 cu ft per person; a converted primary settling tank with a design capacity of 15,000 cu ft, or 3.0 cu ft per person; and a new aerobic digester with a design BOD_5 loading of 2,000 lb/day.

Digested sludge is transported in a 3,200-gal. tank truck and disposed of by spreading on grass runways at an airport.

The City has recently purchased a basket centrifuge capable of concentrating 1,750 lb/day of 1.6 percent sludge to approximately 10 percent solids. The sludge will then be hauled to farms and stockpiled; farm owners will do the spreading under guidance of treatment plant personnel and a proposed monitoring program.

Walworth County Metropolitan Sewerage District

The Walworth County Metropolitan Sewerage District formed in 1975 consists of: the Delavan Lake Sanitary District, Elkhorn, and the Walworth County Institutions. The City of Delavan has a 1.0-mgd trickling filter wastewater treatment plant, built in 1950 with repairs in 1975, which services only the City of Delavan. Lake Lawn Lodge, located within the sanitary district, has its own 0.1-mgd activated sludge wastewater treatment facility. Elkhorn is served by a 0.5-mgd trickling filter wastewater treatment plant built in 1949. The Walworth County Institutions are served by a 0.23-mgd activated sludge wastewater treatment plant constructed in 1963. Plant data are presented in Tables 13 and 14.

The 1975 flow to the City of Delavan treatment plant was 0.59 mgd and contained approximately 528 lb/day BOD_5 and 793 lb/day SS. The estimated population served is 5,800. Industry contributes approximately 25% of the influent flow; significant contributors are listed in Appendix D. Primary and secondary sludge is anaerobically digested and trucked to local farms for liquid spreading.

The 1975 flow to the Elkhorn treatment facility was 0.69 mgd and contained approximately 770 lb/day BOD_5 and 650 lb/day SS. The estimated population served is 4,400, with no significant industrial loading. Primary and secondary sludge is combined for anaerobic digesting; it is then dewatered on drying beds and the solids removed for land application.

Lake Lawn Lodge, a major resort complex, has a compact activated sludge wastewater plant which will be abandoned when the sewerage system reaches this location. For the week of 14 August 1976, the flow was 0.137 mgd with approximately 239 lb/day BOD_5 and 232 lb/day SS.

TABLE 13

SELECTED OPERATING AND DESIGN DATA—CITY OF DELAVAN AND CITY OF ELKHORN—WALWORTH COUNTY METROPOLITAN SEWAGE DISTRICT

	City of Delavan		City of Elkhorn	
	Reported Operating Data For 1975	Existing Design[1]	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	0.59	1.0	0.69	0.5
Population	5,800	10,000	4,400	N/A
Unit Flow (gpcd)	102	100	157	N/A
Sludge Solids (lb/day)	230	N/A	N/A	N/A
BOD_5 (lb/day)	528	N/A	770	1,513
SS (lb/day)	793	N/A	650	N/A

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The Walworth County Institutions are also served by their own wastewater treatment plant which will be abandoned when sewer connections are available. For the same week in August 1976, their flow was 0.081 mgd with 151 lb/day BOD_5 and 152 lb/day SS. The 1963 treatment plant uses the activated sludge process. Methods of sludge disposal are not known.

The 201 facilities plan for wastewater treatment by Jensen & Johnson, Inc., Elkhorn, Wisconsin, dated 8 October 1976, recommended that the existing trickling filter wastewater treatment plant in Delavan be paralleled by a new trickling filter plant. The combined facility would then serve all of the Walworth County Metropolitan Sewerage District. Design data are shown in Table 14.

Sludge treatment would consist of a single gravity thickener with chemical addition to treat the combined sludge of both plants. Sludge would then flow to a two-stage anaerobic digester with a volume of 56,500 cu ft (60-ft diam; 20-ft swd). The methane given off during digestion would be used as a fuel to heat the digester. Sludge would then be stored in three storage tanks with a total volume of 1.2 mil gal. designed for storage of 150 days of sludge. Disposal would be by land-spreading. Jensen & Johnson, Inc. recommended that the county formulate a sludge management program.

City of Brookfield

A 5.0-mgd contact stabilization activated sludge wastewater treatment plant including phosphorus removal is currently serving the western half of Brookfield which lies in the Fox River drainage basin. The communities of Lannon, Menomonee Falls, Sussex, and Pewaukee are currently planned to be served. Sludge is also received from the City of New Berlin's two wastewater treatment plants.

In 1975, the plant flow rate was 2.487 mgd; the service area population was 16,200, with no significant industrial loading. The wastewater contained 3,310 lb/day BOD_5 and 4,045 lb/day SS. Plant data are shown in Table 15.

Waste-activated sludge is combined with primary sludge prior to entering an aerobic digester with a capacity of 32,300 cu ft. This digester is currently being used as an aerated storage tank prior to a precoat tank where it is treated with $FeCl_3$. It is then conditioned with lime and ash and enters a Passavant

TABLE 14

SUMMARY OF PROPOSED DESIGN DATA—WALWORTH COUNTY METROPOLITAN SEWER DISTRICT

	City of Delavan	Elkhorn, Delavan Lake Sanitary District, Walworth County Institutions	Proposed Design
Population	8,600	21,900	30,500
Flows			
Average	1.0 mgd	2.6 mgd	3.6 mgd
Peak	2,090 gpm	5,410 gpm	7,500 gpm
Minimum	0.30 mgd	0.70 mgd	1.00 mgd
Loadings			
Biochemical Oxygen Demand	1,460 lb/day	4,160 lb/day	5,620 lb/day
Suspended Solids	1,720 lb/day	4,795 lb/day	6,515 lb/day
Phosphorus	85 lb/day	215 lb/day	300 lb/day
Total Kjeldahl Nitrogen	292 lb/day	758 lb/day	1,050 lb/day

Source: Jensen & Johnson, Inc.

TABLE 15

SELECTED OPERATING AND DESIGN DATA—
CITY OF BROOKFIELD WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd) ..	2.487	5.0	10.0
Population	16,200	22,000	—
Unit Flow (gpcd)	153	228	—
Sludge Solids (lb/day)	5,300	N/A	—
BOD_5 (lb/day)	3,310	3,665	—
SS (lb/day)	4,045	N/A	—

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Future facilities are being considered for a proposed design flow of 10 mgd. No facilities planning has been initiated at this time.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

filter press with a capacity of 530 lb/hr dry solids. One part ash is added for every two parts sludge, and to this is added 5 percent $FeCl_3$ and 15 percent lime. The press operates 16 hr/day and can process 42,500 lb/week dry solids. The sludge is dewatered to a 45 to 50 percent solids filter cake. (This filter press can be expanded to dewater 85,000 lb/week dry solids.) The sludge cake is conveyed to a 5-hearth incinerator capable of handling 2,700 lb/hour of filter press sludge at 45 percent solids. The incinerator might also operate 16 hr/day with 75 percent excess air and a gas outlet temperature of 800° -1,000°F. The heat requirement is 10,000 BTU/lb volatile content of entering sludge.

Sludge disposal consists of trucking the ash to a landfill site. The incinerator may be by passed and the filter cake trucked directly to a landfill.

The present plant came on line in January 1974. Future facilities are being planned for.

City of Port Washington
Port Washington is currently served by a 1.25-mgd activated sludge wastewater treatment plant including phosphorus removal consisting of a 1-mgd primary plant built in 1955, upgraded in 1972 to 1.25 mgd secondary treatment. Primary sludge is anaerobically digested while secondary sludge is treated in an aerobic digester. Plant data are shown in Table 16.

TABLE 16

SELECTED OPERATING AND DESIGN DATA—
CITY OF PORT WASHINGTON WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	1.7	1.25
Population	9,500	12,500
Unit Flow (gpcd)	179	100
Sludge Solids (lb/day)	1,800	2,565
BOD_5 (lb/day)	1,740	2,130
SS (lb/day)	2,407	2,500

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

In 1975, flow to the treatment plant was 1.7 mgd and contained approximately 1,740 lb/day BOD_5 and 2,407 lb/day SS. The estimated population served was 9,500. Industry contributes approximately 5% of the influent flow; significant contributors are shown in Appendix D.

The anaerobic digester has a volume of 16,900 cu ft in the primary unit and 15,900 cu ft in the secondary unit. The solids loading is 72 lb volatile SS/day/1,000 cu ft, and the detention time is 47 days. The aerobic digester has a volume of 28,800 cu ft sized at 3.0 cu ft/cap. and a detention time of 27.5 day.

Sludge from both digesters is trucked in liquid form to farmlands for spreading; currently, there are no known plans for future facilities.

City of Cedarburg
Cedarburg is served by a 3.0-mgd trickling filter/

activated sludge wastewater treatment plant with phosphorus removal. The plant is a combination of a 1960 1.0-mgd trickling filter plant and a 1971 2.0-mgd activated sludge plant operated in series to provide design flow of 3.0 mgd. Plant data are shown in Table 17.

TABLE 17

SELECTED OPERATING AND DESIGN DATA—
CITY OF CEDARBURG WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	1.41	3.0
Population	10,400	20,000
Unit Flow (gpcd)	136	150
Sludge Solids (lb/day)	2,000	3,100 (volatile solids)
BOD_5 (lb/day)	1,340	5,000
SS (lb/day)	1,811	6,250

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 1.41 mgd and contained approximately 1,340 lb/day BOD_5 and 1,811 lb/day SS. The estimated population served is 10,400. Industry contributes approximately 13% of the influent flow; significant contributors are shown in Appendix D.

Sludge from final sedimentation tanks is treated in a thickener and phosphate stripper with a volume of 12,600 cu ft sized at 715 gal./sq ft/day. From here, sludge is recycled to the head of the aeration tanks; the excess is wasted, combined with raw sludge, and flows to two heated anaerobic digesters with gas mixing. The digesters consist of two 27,000-cu ft tanks; one built in 1960, the second in 1970. From here, sludge flows to lagoons with a total volume of 33,200 cu ft (3.5 ft depth and area of 9,500 sq ft) before being hauled in tank trucks to farms for spreading.

In addition, overflow from the thickener/stripper is flocculated with the supernatant of the digesters and settled in a precipitation tank of 6,850 cu ft, with a one hour detention time and maximum inflow of 1.2 mgd. Sludge from precipitation also flows to the lagoons. One small sand bed serves as an emergency storage area. Sludge may be hauled directly from digesters and landspread.

As reported in the discussion of the Village of Grafton treatment plant, a facilities plan is being initiated.

Village of Grafton

A 1.0-mgd contact stabilization activated sludge wastewater treatment plant with phosphorus removal serves the Village of Grafton. Plant data are presented in Table 18.

TABLE 18

SELECTED OPERATING AND DESIGN DATA—
VILLAGE OF GRAFTON WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	0.88	1.0
Population	8,800	9,400
Unit Flow (gpcd)	100	106
Sludge Solids (lb/day)	2,600	1,320
BOD_5 (lb/day)	1,015	1,881
SS (lb/day)	1,898	1,881

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 0.88 mgd and contained approximately 1,015 lb/day BOD_5 and 1,898 lb/day SS. The estimated population of the service area was 8,800. It is reported that industry contributes approximately 26% of the influent flow; significant contributors are shown in Appendix D.

An aerobic digester is included as part of an activated sludge contact stabilization tank. This aerobic digester has a volume of 25,000 cu ft sized at 3.2 cu ft/cap. The secondary sludge is treated in this aerobic digester. Primary sludge is treated in an anaerobic digester consisting of two tanks, one with a volume of 13,750 cu ft and the other of 12,900 cu ft. The BOD_5 loading limit of these digesters is 80 lb/1,000/cu ft/day. Primary and secondary sludges are processed, handled and disposed of separately.

Sludge utilization consists of trucking to farmlands for spreading. A 201 facility plan has been initiated for the Village of Grafton, the City of Cedarburg, and the Towns Grafton and Cedarburg.

City of Hartford

The City of Hartford, Washington County, has a 2.0-mgd secondary treatment facility including phosphorus removal that was placed in operation in 1974. Future service will probably be extended to include Pike Lake. Plant data are shown in Table 19.

TABLE 19

SELECTED OPERATING AND DESIGN DATA— CITY OF HARTFORD WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	1.37	2.0
Population	7,600	10,000
Unit Flow (gpcd)	180	200
Sludge Solids (lb/day)	1,990	N/A
BOD_5 (lb/day)	2,121	10,000[2]
SS (lb/day)	2,811	11,465[2]

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Designed to accommodate industrial wastes.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The raw wastewater received at the plant is relatively strong, particularly due to industrial wastes. Additionally, a resident population of 7,600 persons (1975) was served. The 1975 flow was 1.37 mgd with 2,811 lb/day SS and 2,121 lb/day BOD_5. Industry contributes approximately 40% of the influent flow; significant contributors are listed in Appendix D. Quantities of sludges generated in the pretreatment of beet processing wastes at local industries were not available.

Waste-activated sludge is collected from the aeration tanks and placed in the two aerobic digesters. Digester decant is returned to the aeration tanks. (There are no primary settling tanks.) Each aerobic digester has a 340,000-gal. capacity. From the aerobic digesters, the sludge may be pumped to one of six drying beds, each being 7,400 sq ft in area, with bed underflow returned to the head end of the treatment plant. Sludge is handled directly from the aerobic digesters in a 2,100-gal. tank truck when spreading on farmland is feasible. Otherwise, it is dried on the drying beds where a front-end loader and dump truck extract it for use by the Department of Public Works as compost material.

Future sludge production will be affected by the degree of industrial pretreatment; however, it is not likely to be higher on a per capita basis than it is at present.

Twin Lakes-Kenosha County

Twin Lakes is currently served by a 0.82-mgd wastewater treatment facility including phosphorus removal consisting of a 0.32-mgd trickling filter plant built in 1958 and a 0.5-mgd activated sludge plant completed in 1972. Plant data are shown in Table 20.

The 1975 flow was 0.41 mgd and contained approximately 740 lb/day BOD_5 and 1,091 lb/day SS. The estimated population served was 3,400 (1975) with no known industrial load. Waste-activated sludge is treated in an aerobic digester prior to treatment in anaerobic digesters. The aerobic digester was designed on the basis of 2.8 cu ft per capita for a total volume of 14,000 cu ft. Along with the activated sludge portion built in 1972, a new anaerobic digester was added which is now the primary digester—the earlier digester was converted to a secondary digester. The primary digester has a capacity of 25,100 cu ft. This was designed on a basis of 2.5 cu ft per capita and a loading of 80 lb/1,000 cu ft/day. In the summer, sludge is dried on two beds, each with an area of 4,000 sq ft and designed on the basis of 1.75 sq ft per capita. The combined capacity was rated at 4,600 persons. During winter weather the sludge is drawn off from the digesters and trucked to a holding lagoon; from there, it is removed and spread on farmland during favorable weather conditions. Dried sludge from the beds is stockpiled for pickup by area residents.

Currently, there are no known plans being developed for new facilities; however, the activated sludge portion of the plant was designed with a provision for a future addition of parallel units.

TABLE 20

SELECTED OPERATING AND DESIGN DATA—VILLAGE OF TWIN LAKES WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	0.41	0.82
Population	3,400	8,200
Unit Flow (gpcd)	120	100
Sludge Solids (lb/day)	600	N/A[2]
BOD_5 (lb/day)	470	850[3]
SS (lb/day)	1,091	N/A

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Not provided in original design criteria.*

[3]*Data for activated sludge portion of plant only (5,000 design pop.).*

Source: Camp Dresser & McKee Inc. and SEWRPC.

Williams Bay

An activated sludge wastewater treatment facility with a capacity of 0.787 mgd is currently serving the Village of Williams Bay. Plant data are shown in Table 21.

The December 1975 flow was 0.196 mgd and contained approximately 206 lb/day BOD_5 and 93 lb/day SS. The estimated population served was 1,700 (1975), with no industrial load. Waste-activated sludge is thickened in a 24-ft circular tank with a 7-ft swd. The thickener is designed for loadings of 8 lb solids/sq ft/day and 500 gal/sq ft/day. The maximum mixed liquor SS from the aeration tank is 4,000 mg/1, and waste flow is 10 percent total flow. Allowable loadings are 3,616 lb solids/day and 226,000 gal./day. Thickened sludge is combined with primary sludge before being digested in an anaerobic digester with a capacity of 10,750 cu ft and a 26-day detention time. Sludge from the digester, totaling approximately 139,140 wet lb/year, is spread on 4 drying beds with a combined area of 3,780 sq ft. Five applications of 8 in. deep sludge per year account for 12,600 cu ft of sludge. The remaining 24,600 cu ft is picked up for utilization by residents. There are no known plans for future facilities.

TABLE 21

SELECTED OPERATING AND DESIGN DATA—VILLAGE OF WILLIAMS BAY WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]
Average Flow (mgd)	0.196[1]	0.787
Population	1,700	6,500
Unit Flow (gpcd)	115	121
Sludge Solids (lb/day)	100	564
BOD_5 (lb/day)	206[2]	1,100
SS (lb/day)	93[2]	N/A[3]

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*Partial Data: for month of December only.*

[3]*Not provided in original design criteria.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

Western Racine County Sewerage District

The sewerage district is currently served by a 0.5-mgd contact stability wastewater treatment plant including phosphorous removal. This plant is proposed to be upgraded to 1.0 mgd capacity by addition of parallel units. Plant data are shown in Table 22. Probable future service areas include Waterford-Rochester and Tichigan Lake.

The 1975 flow was 0.244 mgd and contained approximately 403 lb/day SS and 329 lb/day BOD_5. The estimated population served was 3,400 (1975), with no industrial load. Approximately 300 lb/day of sludge solids currently require disposal.

The existing plant contains a 15,000-cu ft aerobic digester which is equivalent to 3 cu ft per capita at a de-

TABLE 22

SELECTED OPERATING AND DESIGN DATA— WESTERN RACINE COUNTY SEWERAGE DISTRICT WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd)	0.244	0.5	1.0
Population	3,400	5,000	9,700
Unit Flow (gpcd)	72	100	103
Sludge Solids (lb/day)	300	N/A	(1,700)[3]
BOD_5 (lb/day)	329	850	1,649
SS (lb/day)	403	N/A	2,037

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*A facilities plan has been completed for expansion of the existing facilities; this proposed addition has been considered in the development of a sludge management plan (Chapters IX and X).*

[3]*To primary digester.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

sign population of 5,000. The digested sludge is hauled by tank truck and spread at several farms in the area.

It is proposed by others that the existing contact stabilization plant be paralleled by a similar unit. Aerobic digestion will be provided in a 14,000 cu ft tank (2.8 cu ft/cap.). Sludge drying beds are proposed for a population of 10,000 on the basis of 1.2 sq ft/cap. This is to be accomplished by providing five beds—50 ft by 20 ft. Dried sludge would be landspread. A primary anaerobic digester is proposed for 10,000 persons, with a second at some future date. The design solids load is approximately 1,700 lb/day to the digester.

Delafield-Hartland

The Delafield-Hartland Water Pollution Control Commission is designed to provide for the wastewater treatment needs of the City of Delafield, the Village of Hartland, and portions of the Town of Delafield, Village of Nashotah, and the Town of Summit (around Nemahbin Lakes). Existing wastewater treatment facilities within the service area is a 0.35-mgd activated sludge plant (built in 1962) in the Village of Hartland.

The facilities plan completed in July 1976 by the Commission's consultant recommended a new joint treatment facility for Hartland-Delafield and abandonment of the existing Hartland facility. Other communities within the Commission's service area do not have wastewater treatment facilities. Plant data are shown in Table 23.

TABLE 23

SELECTED OPERATING AND DESIGN DATA— DELAFIELD-HARTLAND WATER POLLUTION CONTROL COMMISSION WASTE WATER TREATMENT PLANT

	Reported Operating Data For 1975[1]	Existing Design[2]	Proposed Design[3]
Average Flow (mgd)	0.40	0.35	2.2
Population	4,400	3,500	22,000
Unit Flow (gpcd)	91	100	100
Sludge Solids (lb/day)	1,100	N/A	4,330
BOD_5 (lb/day)	335	700	3,670
SS (lb/day)	403	N/A	4,587

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*City of Hartland only.*

[3]*A facilities plan has been completed for a new wastewater treatment facility. This proposed plant has been considered in the development of a sludge management plan (Chapters IX and X).*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow at the Hartland treatment plant was 0.40 mgd and contained approximately 335 lb/day BOD_5 and 403 lb/day SS. The estimated population served was 4,400, with no industrial load. Sludge handling includes anaerobic digestion with final disposal in lagoons.

The proposed wastewater treatment facility for the Delafield-Hartland region includes primary settling tanks, rotating biological contactors, final clarifiers, sand filters, and contact basins. Primary and secondary sludges will be combined prior to a two-stage anaerobic digester. The first stage will be a covered, mixed and heated tank fitted for methane recovery. The second stage will consist of an unmixed tank with a floating cover; this unit provides additional stabilization and solids concentration. Sludge will then flow to drying lagoons for dewatering. Each of the two proposed lagoon cells will be capable of holding one year's production of sludge. An underdrain collection system will return liquor to the primary clarifiers. Final disposal will be by seasonal application of dried solids to agricultural lands. Also proposed is a management program for monitoring sludge quality and soil application rates.

Village of Union Grove

Union Grove is currently served by a 0.3-mgd conventional activated sludge wastewater treatment plant including phosphorus removal. This plant is soon to be replaced by a new 1-mgd activated sludge plant including phosphorus removal, effluent filtration, and nitrogen removal. Plant data are shown in Table 24.

TABLE 24

SELECTED OPERATING AND DESIGN DATA—
VILLAGE OF UNION GROVE WASTEWATER TREATMENT PLANT

	Reported Operating Data For 1975	Existing Design[1]	Proposed Design[2]
Average Flow (mgd) . .	0.428	0.3	1.0
Population	3,200	3,000	6,500
Unit Flow (gpcd)	134	100	154
Sludge Solids (lb/day)	1,220	N/A	N/A[3]
BOD_5 (lb/day)	696	510	1,205
SS (lb/day)	725	N/A	N/A

[1]*Design data reported in this table are taken from the official and approved data, where available, as reported in the facilities plan for the existing treatment plant. Actual operating characteristics and capacities are reported in Chapter V.*

[2]*A new wastewater treatment plant has been designed and is under construction. This new facility has been considered in the sludge management plan (Chapters IX and X).*

[3]*Not provided in original design criteria.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The 1975 flow was 0.428 mgd and contained approximately 725 lb/day SS and 696 lb/day BOD_5. The estimated population served is 3,200 (1975), with no known industrial waste load. The estimated solids currently disposed of is approximately 1,216 lb/day or 0.38 lb/cap./day at 3,200 persons.

The existing plant has conventional primary clarifiers and activated sludge with anaerobic sludge digestion. The digested sludge is removed by tank truck and stored in a lagoon near the plant. When the lagoon is full (estimated to be about every 10 years), the sludge is dredged and landfilled. Sludge volume from the digestion process currently averages about 38,400 gal./month.

Sludge processing and disposal facilities at the proposed plant will consist of aerobic digestion tanks, sludge pumping to drying beds with dewatered sludge to sanitary landfill, or possibly to land application. The aerobic digestion tanks will be 21,600 cu ft with 40.2 lb oxygen consumed/hr from air, and the eight sludge drying beds will be 100 by 25 for a total of 20,000 sq ft.

INVENTORY FINDINGS—OTHER MUNICIPAL FACILITIES

The above-described 21 major plants are responsible for production of greater than 95 percent of the municipal sludge in the seven-county region. While the other 40 municipal plants in the Region must be considered, it was most convenient to group them in two categories: trickling filter plants and activated sludge plants. These plants contribute less than 5 percent of the municipal sludge in the Region. Private wastewater treatment facilities in the Region are listed and described in Table 28.

City of Lake Geneva
(Example: Trickling Filter Plant
with Phosphorus Removal)

The City of Lake Geneva is currently served by a 1.1-mgd trickling filter wastewater treatment plant. The plant is included here as an example of a trickling filter plant because it is one of the few of the smaller trickling filter plants which has advanced waste treatment for phosphorus removal. The original plant was constructed in 1930; extensive modifications were completed in 1966. Construction of phosphorus removal facilities and a chlorine contact tank was completed in 1976. The existing plant is designed to handle the wastewater flow from a population of 11,400 people on the basis of 100 gallons per person per day. Sludge handling facilities are designed for 2260 lb/day of sludge solids and 1890 lb/day of BOD_5.

The 1975 flow was 0.74-mgd and contained approximately 780 lb/day BOD_5 and 920 lb/day SS. The estimated population served is 5700 with no significant industrial load.

Sludge from the primary and secondary clarifiers is treated in an anaerobic digester. Sludge is hauled by tank truck to a landspreading site at the old City dump. In the future, as part of the 1977 WPDES discharge permit, this spread sludge may have to be incorporated into the soil after spreading.

East Troy
(Example: Trickling Filter Plant without Phosphorus Removal)
East Troy is currently served by a 0.32-mgd trickling filter wastewater treatment facility not including phosphorus removal. Sludge is anaerobically digested, dried on drying beds, and landspread. Liquid sludge is also trucked for spreading on an airport.

In 1975, the plant flow rate was recorded as 0.25 mgd and contained approximately 219 lb/day BOD_5 and 133 lb/day SS. Other small trickling filter plants are listed in Table 25.

TABLE 25

OTHER MUNICIPAL FACILITIES TRICKLING FILTER PLANTS — 1975[2]

Plant Name	Hydraulic Loading (mgd) Design	Hydraulic Loading (mgd) 1975	BOD_5 Loadings lb/day Design	BOD_5 Loadings lb/day 1975	Sludge Processing	Sludge Disposal
Elkhorn	0.5[1]	0.69	1,513	770	Anaerobic Digester, Drying bed	Trucked to city landfill; landspread.
Hales Corners (MSD)	0.6[1]	0.52	1,330	740	Anaerobic Digester, Drying bed	Removal by private users; landspread.
Menomonee Falls (Pilgrim Road)	1.9[1]	1.4	935	830	Aerobic Digester, Anaerobic Digester, Drying bed	Land spreading; landfill.
Mukwonago	0.22	0.44	485	422	Anaerobic Digester, Drying bed	Liquid and dry spreading on farmland.
Sharon	0.15	0.08	40	48	Anaerobic Digester	Liquid trucked to farms for spreading.
Sturtevant	0.25[1]	0.53	425	614	Anaerobic Digester, Drying bed	Tank truck to farmland or city landfill.
Sussex	0.3	0.47	510	558	Anaerobic Digester, Drying bed	Liquid trucked to farms.
East Troy	0.32	0.25	480	220	Anaerobic Digester, Drying bed	Liquid trucked to airport for spreading.
Saukville	0.30	0.29	430	312	Anaerobic Digester, Drying bed	Land spreading.

TABLE 25

OTHER MUNICIPAL FACILITIES TRICKLING FILTER PLANTS — 1975[2] (continued)

Caddy Vista	0.25[1]	0.09	—	161	Anaerobic Digester, Drying bed	Land spreading; land filling.
Lake Geneva	1.10	0.74	1,890	776	Anaerobic Digester, Drying bed	Land spreading.
Genoa City	0.12	0.07	200	77	Anaerobic Digester, Drying bed	Land spreading.
Fontana	0.40	0.52	—	291	Anaerobic Digester	Land spreading.
Jackson	0.03	0.26	400	311	Anaerobic Digester, Drying bed	Land spreading.
Slinger	0.15	0.15	792	159	Anaerobic Digester, Drying bed	Land spreading.
Pewaukee	0.75	0.30	1,595	509	Aerobic Digester, Anaerobic Digester	Land spreading, land filling.
Walworth	0.15	—	1,480	—	Anaerobic Digester, Drying bed	Land spreading.

[1]*To be abandoned.*
[2]*See City of Lake Geneva and Village of East Troy for descriptions of trickling filter wastewater treatment plants.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

Village of Thiensville
(Example: Activated Sludge Plant
with Phosphorus Removal)

Thiensville is currently served by a 0.34-mgd activated sludge wastewater treatment plant constructed in 1952, and later upgraded to include phosphorus removal. Although it is scheduled for abandonment in accordance with the recommendations of the Regional Sanitary Sewerage System Plan, it is included here as an example of an activated sludge plant which has advanced waste treatment for phosphorus removal. Sludge from the primary clarifiers is anaerobically digested in a primary digester fitted for gas recovery. Waste-activated sludge can be treated separately in a secondary digester or can be combined with primary sludge. Digested sludge can be drawn from each digester and pumped to drying beds.

The 1975 average daily flow was 0.40 mgd and contained approximately 435 lb/day BOD_5 and 634 lb/day SS. The estimated population served was 3,850, with no industrial flow.

Current sludge handling consists of two anaerobic digesters which can be used as a first and second stage combination or as two separate units–one for primary sludge and one for waste-activated sludge. Sludge is then pumped to drying beds for dewatering prior to being trucked to a landspreading site. Sludge can also be stored in the second digester and drawn off to a tank truck.

Village of Darien
(Example: Activated Sludge Plant
without Phosphorus Removal)

The Village of Darien is currently served by a 0.15-mgd activated sludge wastewater treatment plant constructed in 1970. The plant is designed for a population of 1500 on the basis of 100 gallons per capita per day.

The 1975 average daily flow was 0.14-mgd and contained approximately 142 lb/day BOD_5 and 139 lb/day SS. The estimated population served was 1060 with industrial flow from a small Brass Works and Plastics Manufacturer (neither company was required to file a NR101 form).

Current sludge handling consists of aerobic digestion followed by land-spreading on farm land and Village owned property. Sludge is hauled by tank truck and incorporated into the soil.

Other small activated sludge plants are listed in Table 26.

TABLE 26

OTHER MUNICIPAL FACILITIES ACTIVATED SLUDGE PLANTS — 1975[2]

Plant Name	Hydraulic Loading (mgd) Design	Hydraulic Loading (mgd) 1975	BOD_5 Loadings lb/day Design	BOD_5 Loadings lb/day 1975	Sludge Processing	Sludge Disposal
Belgium	0.07	0.07	—	122	Anaerobic Digester, Drying bed	Tank truck to land spreading site.
Bristol Utility District	0.08	.07	270	90	Aerobic Digester	Tank truck to disposal site in Burlington.
Darien	0.15	0.14	255	142	Aerobic Digester	Tank truck to farmland for spreading.
Fredonia	0.12	0.28	200	305	Anaerobic Digester, Drying bed	Land spreading.
Menomonee Falls (Lily Road)	1.0[1]	0.7	1,700	637	Aerobic Digester, Lagoon	Land spreading; landfill.
Salem Utility District No. 1 (Facility Plan)	1.5	0.8	1,657	—	Anaerobic Digester	Hauling by contractor, to Kenosha
North Park Sanitary District	2.0[1]	1.13	3,400	914	Anaerobic Digester, Drying bed	Tank truck to land spreading.
Salem Utility District	0.3[1]	0.08	510	79	Aerobic Digester	Tank truck to Kenosha treatment plant.
Somers Utility District	0.03	0.06	—	100	Aerated Holding tank	Tank truck to Kenosha treatment plant.
Thiensville	0.24[1]	0.57	—	333	Aerobic Digester, Anaerobic Digester, Drying bed	Land spreading.
Allenton	0.1	0.08	170	263	Anaerobic Digestion, Drying bed	Tank truck to land spreading.

TABLE 26

OTHER MUNICIPAL FACILITIES ACTIVATED SLUDGE PLANTS — 1975[2] (continued)

Dousman	0.12	0.11	200	98	Aerobic Digester	Tank truck to land spreading and land filling.
Kewaskum	0.5	0.32	1,800	966	Aerobic Digester	Tank truck to land spreading.
City of Muskego — Northeast	0.5[1]	0.34	1,000	462	Aerobic Digester, Drying beds	Tank truck and front-end loader to land spreading.
Silver Lake	0.30	0.15	510	59	Aerobic Digestion	Contract land spreading.
Pleasant Prairie Utility District D	0.13	0.10	—	97	Aerobic Digestion	Haul to Kenosha Plant.
Pleasant Prairie Sanitary District 73-1	0.40	0.03	800	30	Aerobic Digestion	Haul to Kenosha Plant.
Pleasant Park Utility Co.	0.06	—	—	—	Aerobic Digestion	Haul to Kenosha Plant.
Paddock Lake	0.40	0.17	—	138	Anaerobic Digestion	Land spreading.
Rawson Homes Sewer and Water Trust	0.04[1]	—	67	—	—	—
Germantown	1.00[1]	0.80	1,700	193	Aerobic Digestion	Contract landfilling land spreading.
Village of Newburg	0.08	0.07	136	144	Aerobic Digestion	Land spreading.
New Berlin Regal Manor	0.35	0.13	500	215	Aerobic Digestion, Drying beds	Land spreading.
Green Ridge (Not in operation)	0.10	0.08	—	135	Aerobic Digestion	Land spreading.

[1]*To be abandoned.*
[2]*See Thiensville and Darien for descriptions of activated sludge treatment plants.*
Source: Camp Dresser & McKee Inc. and SEWRPC.

TABLE 27

OTHER MUNICIPAL FACILITIES — LAGOON TREATMENT

Plant Name	Hydraulic Loading — mgd		BOD_5 — Loadings lb/day		Sludge Processing	Sludge Disposal
	Design	1975	Design	1975		
Big Muskego Lake	0.70[1]	0.58	1,400	532	Lagoon	Land spreading

[1]*To be abandoned.*

NOTE: In addition to the above listed treatment plants (Tables 25, 26, and 27) facilities are proposed by others for: Town of Dover-Eagle Lake Sewer Utility District, Town of Norway Sanitary District No. 1 (under construction) and an addition is proposed for the Town of Somers Sanitary District No. 2.

TABLE 28

PRIVATE WASTEWATER TREATMENT PLANTS - 1975

Plant Name	Design Flow mgd	Actual Flow-1975 mgd	BOD_5 Loading lb/day	Processing	Sludge Handling/ Utilization
Paramski Mobile Home Park	-	-	-	Extended Aeration	Storage-Land
Howard Johnson Motor Lodge and Restaurant	-	0.049	40	Activated Sludge	Storage-Land
Brightondale County Park	-	0.002	176	Activated Sludge	Anaerobic Digestion-Land
American Motors Corporation Truck Service Facility[2]	-	-	-	Activated Sludge	Storage-Land
Wheatland Mobile Home Park	-	-	-	Contact Stabilization	Storage-Land
Wisconsin Department of Transportation--Tourist Information Center[1]	-	-	-	Septic Tank	Storage-Land
Sienadale Motherhouse	-	-	-	Extended Aeration	Storage-Land
George Connolly Development (Under Construction)	.034	-	-	Extended Aeration	Storage-Land
Kenosha Packing Co.[2]	-	-	-	Ridge and Furrow	-
Highway 100 Drive In Theater[1,3]	-	-	-	Septic Tank	Storage-Land
Union Oil Highway 100 Truck Stop	-	-	-	Extended Aeration	-
Wisconsin Electric Power Company (Oak Creek)	-	-	-	Extended Aeration	-
Sisters of Notre Dame School[3]	.04	.0145	-	Activated Sludge	Storage-Land
Port Country Club[1]	-	-	-	Septic Tank	Storage-Land
Chalet on the Lake[3]	-	-	-	Primary Clarifier	Anaerobic Digestion-Land
Cedar Valley Cheese Factory[2]	-	-	-	Spray Irrigation	-
Justo Foods Company (not in operation)[2]	-	-	-	Soil Absorption	-
Krier Preserving Company[2]	-	-	-	Lagoon	-
S & R Cheese Corporation[1,2]	-	-	-	Septic Tank	-
Federal Foods, Inc.[2,3]	-	-	-	Lagoon	-
Wisconsin Southern Colony Training School	.45	0.180	675	Contact Stabilization	Drying Beds Anaerobic Digestion-Land
Holy Redeemer College	-	0.008	6	Extended Aeration	Storage-Land

TABLE 28

PRIVATE WASTEWATER TREATMENT PLANTS - 1975 (continued)

St. Bonaventure Prep School	-	-	-	Contact Stabilization	Storage
C & D Foods, Inc.[2]	-	-	-	Activated Sludge	-
Fonk's Mobile Home Park No. 1	-	-	-	Extended Aeration	Storage
Fonk's Mobile Home Park No. 2	-	-	-	Extended Aeration	Storage
Franks Pure Food Company[2]	-	-	-	Lagoon	-
Grove Duck Farm[2]	-	-	-	Lagoon	-
J. I. Case Company[2]	-	-	-	Chemical Treatment	-
Meeter Brothers Company[2]	-	-	-	Lagoon	-
Packaging Corporation of America	-	-	-	Extended Aeration	-
Pekin Duck Company[2]	-	-	-	Spray Irrigation	-
Racine County Highway and Park Commission	.0015	-	-	Activated Sludge	-
Downey Duck Co. Inc.[2]	-	-	-	Lagoon, Spray Irrigation	-
Lakeland Nursing Home (Walworth County Institutions)	.08	0.070	87	Activated Sludge	Storage-Land
Country Estates	-	0.015	19	Extended Aeration	Storage-Land
Playboy Club Hotel	-	-	-	Contact Stabilization	Aerobic Digestion-Storage-Land
Slovak Sokol Camp	-	-	-	Activated Sludge	-
Walworth County Institutions	-	-	-	-	-
Lake Lawn Lodge	0.05	0.070	47	Activated Sludge	Anaerobic Digestion-Storage-Land
Kikkomon Foods Inc.	-	-	-	Aerobic Digestor, Lagoon	-
Libby, McNeill & Libby--Darien[2]	-	-	-	Lagoon	-
Paiser Produce Company (not in operation)[2]	-	-	-	Lagoon	-
Lake Geneva Interlaken Resort Village	.125	.027	-	Contact Stabilization	Storage-Land
Walworth County Correctional Center (not in operation)	-	-	-	Activated Sludge	-
Wisconsin Dairies Cooperative--Genoa City[2]	-	-	-	Activated Sludge	-
Wisconsin Department of Trans-portation--East Troy Area	-	-	-	Contact Stabilization	Aerobic Digestion Contract Pickup
Cedar Lake Rest Home	-	-	-	Contact Stabilization	Storage-Land
Level Valley Dairy[2]	-	-	-	Extended Aeration	Storage-Land
Libby, McNeill & Libby-Jackson[2]	-	-	-	Lagoon	-
Libby, McNeill & Libby-Hartford[2]	-	-	-	Lagoon	-
National Farmers Association Slinger Transfer Station[2]	-	-	-	Ridge and Furrow	-
Pike Lake State Park	-	-	-	Lagoon	-
New Berlin Memorial Hospital	-	0.260	498	Activated Sludge	Storage-Land
Cleveland Heights School--New Berlin[1]	-	0.005	-	Septic Tank	Storage-Land
New Berlin High School[1]	-	0.018	-	Septic Tank	Land
Highway 24 Outdoor Theater[1,3]	-	-	-	Septic Tank	-
Wisconsin School for Boys - Wales	-	-	-	Contract Stabilization	Aerobic Digestion-Drying Beds
Steeplechase Inn	-	-	-	Extended Aeration	Storage-Land
Gipes-Hillside Apartments	-	-	-	Activated Sludge	-

TABLE 28

PRIVATE WASTEWATER TREATMENT PLANTS - 1975 (Continued)

Oakton Manor--Tumblebrook Golf Course	-	-	-	Primary Clarifier	-
Rainbow Springs Resort (not in operation)	-	-	-	Activated Sludge	Aerobic Digestion
St. John's Military Academy (Delafield)	-	-	-	Septic Tank	Storage-Land
Willow Springs Mobile Home Park	-	-	-	Soil Absorption	-
Muskego Rendering Company[2]	-	-	-	Lagoon	-
Mammoth Springs Canning Company[2]	-	-	-	Spray Irrigation	-
Brookfield Central High School[3]	-	-	-	Septic Tank, Sand Filter	-

[1] These septic systems have been included in sections throughout the text describing septage.

[2] These industrial pretreatment facilities have been included in the categories of industries, their sludges are described as Industrial Pretreatment Sludges in Chapters IX and X.

[3] Recommended to be abandoned in the Regional Sanitary Sewer System.

Note: Dash indicates that data was not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

INVENTORY FINDINGS-INDUSTRIAL FACILITIES

Industrial wastewater treatment and sludge handling facilities for specific industrial categories are described in the following sections. Information regarding each type of wastewater treatment and disposal method was derived from data obtained by SEWRPC. Data on chemical composition and flow rates were compiled from industrial monitoring (NR101) data on file at SEWRPC. In nearly every case, monitoring procedures, techniques, and frequency of sampling were not included with the data, and accuracy of the compiled data could not be taken into account in descriptions presented herein.

Industrial operations described include: tanneries, metal plating and metal machining industries, food processing industries, battery manufacturing, power generation facilities, and truck and car washing operations. A number of plants appear to have both metal plating and metal machining operations. Tables 29 through 34 should be considered representative rather than complete.

Tanneries

Most tanneries within the study area employ some type of wastewater treatment prior to discharge to a wastewater treatment system. In most cases, treatment consists of screening and, in a few cases, screening plus a settling basin. One tannery has added chemical precipitation and sludge dewatering equipment to its wastewater treatment operation. Screenings and sludges are usually hauled to a sanitary landfill without further processing.

From the SEWRPC Treatment Facility and Sludge Handling Practices Survey, it was found that approximately 6,000 gal./day of tannery and rendering sludge is currently produced by those industries which responded. Of the 17 questionnaires mailed, 8 were returned. The total produced is estimated to be approximately 12,700 gal./day with 5,400 lb/day dry sludge solids. The remainder of the solids produced are discharged to sewerage systems.

Wastewater entering the treatment system can fluctuate widely in pH and in the number of lb/day of chemicals as shown in Table 29. It might be observed that the pH ranges from a low of 3.3 for some plants to a high of 12.4 for others. In addition, large amounts of the following were indicated in the wastewaters of several tanneries: chromium, chloride, sulfate, oils, fats and grease, SS, and BOD_5.

Metal Plating Operations

Metal plating industries in the study area usually treat wastewaters prior to discharge to the sanitary sewer. A few companies use only pH adjustment, but the majoriy have settling basins and chemical precipitation with pH adjustment. A small number have also added screening and reverse osmosis. In those plating industries where compressors are used, most have oil separators for treating cooling water. Sludge generated by treatment processes is usually taken to a landfill by private haulers; however, a few companies reportedly discharge sludge to nearby sanitary sewers. In a few cases, sludge is lagooned or dewatered prior to ultimate disposal at a landfill. From the SEWRPC Treatment Facility and Sludge Handling Practice Survey, it was found that approximately 12,000 gal./day of sludge is produced by those industries which responded. Of the 50 questionnaires mailed, 35 were returned. The total produced is estimated at 17,100 gal./day which contains 7,300 lb/day dry solids.

TABLE 29

TANNERIES IN REGION - 1975

Company	Receiving System	Average Wastewater Flow mgd	pH Range	Maximum Load in Wastewater Discharge (lb/day)									
				BOD_5	Suspended Solids	Oils, Fats, Grease	Ammonia	Nitrogen (Kjeldahl)	Phosphorus	Sulfate	Chloride	Chromium	Others
A.F. Gallun & Sons Corp.	Milwaukee	0.5	6.8-9.2	3,033	3,513	1,490			15	2,780	6,043	138	
Badger State Tanning	Milwaukee	0.034	3.9-5.8	745	285	68.2			2.3	297		1.1	
Blackhawk Tanning*	Milwaukee	0.11	3.4-7.2	414	434	456			12.5	313	754	25	Cadmium 0.76
Cudahy Tanning	Milwaukee	0.39	5.7-11.2	9,260	5,580	749			28.8	9,000	2,736	67	
Flagg Tanning	Milwaukee	0.60	5.3-12.2	5,548	4,679	7,909			25	382	6,800	125	
Gebhardt-Vogel*	Milwaukee	0.18	4.1-11.8	3,037	5,242	1,023			8.47	4,156	2,733	233.8	
Gebhardt-Vogel	Milwaukee	0.126	5.2-7.5	928	453	295			1.47	1,249	306	42.2	
General Split Corp.	Milwaukee	0.509	3.3-9.4	4,742	4,309	212			52	520	1,414	135	Zinc 12.5
Great Lakes Tanning	Milwaukee	0.12	4.3-8.9	660	250	42.4			6.5	430	2,600	1.1	
Law Tanning	Milwaukee	0.133	4.5-6.8	635	972	3.4			2.8	702	608	13.5	
Midwest Tanning*	South Milwaukee	0.14	7.3-12.4	5,081	11,564	473	315	469	35	3,539	7,219	263	
Pfister-Vogel*	Milwaukee	1.4	8.9-10.7	18,900	43,000	6,390				20,200	37,000	1,675	
Rapco Leather Co.	South Milwaukee	0.07	8.0-12.4	336	553	42	41	147	1.19	490	6,305	16.8	
Seidel Tanning*	Milwaukee	0.25	5.5-11.5	130	186	82.2			2.5	130	230	2.9	
Spencer Leathers	Milwaukee	0.364	3.5-11.3	3,262	6,825	108			6.3	5,250	13,500	63.7	
Thiel Tanning	Milwaukee	0.095	6.3-11.9	372	372	1,313			0.0	436	1,484	1.5	
W.B. Place & Company*	Hartford	0.12	-9.6	1,960	1,095	209	194	309	3.2	1,770	479	79	

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.
* Wastewater is pretreated prior to discharge(Source: SEWRPC Treatment Facility and Sludge Handling Survey).

Source: Wisconsin DNR and SEWRPC.

TABLE 30

METAL PLATING IN REGION - 1975

Company	Receiving System	Average Wastewater Flow mgd	Maximum Load in Wastewater Discharge (lb/day)										
			Cadmium	Cyanide	Copper	Chromium	Nickel	Zinc	Lead	Fluoride	Phosphorus	Chlorides	Sulfates
Snap on Tools *	Kenosha	0.488				14.5	7.3				11	207	666
Master Lock	Milwaukee	0.943	41.8	108.7	6.6	8.7	70.6	4.24		10.4	115	258	387
Industrial Cylinders	Milwaukee	0.422	0.84		0.42	2.96		1.69	275		68.5	271	1,324
Pressed Steel Tank	Milwaukee	0.726			0.73	0.77		12.3			10.43	1,389	1,612
Inryco Inc.	Milwaukee	0.23			0.1723	5.69		85			16.8	92	38
Ladish Co. *	Milwaukee	2.03			2.06	1.8	14.2	1.4		8.2	62.5	372	1,468
Electro Coatings	Milwaukee	0.22				17.6	1.5		0.15		0.08	4.4	6.4
Finishing & Plating Service *	Kenosha	0.73	0.35	0.16	0.1	0.2	0.07	1.45	0.07		3.7	75	
Milwaukee Plating	Milwaukee	0.16	0.84	0.08	0.03	5.3	0.33	10.0	0.14	1.7	0.06	169	58.1
Modern Plating	Milwaukee	0.0073		7.1	3.0	6.9	4.9	0.7			0.4	2.1	28.7
Murray Metal Plating Works	Milwaukee	0.13		0.04	0.27	21.62	36.4			1.4	2.8	29.7	128
National Plating	Milwaukee	0.018	0.08	1.35	0.38	1.31	.34	1.31	0.008	0.14	0.003	7.4	12.9
Oconomowoc Electroplating	Waukesha	0.017		4.96		0.16		0.16			0.018	179	28.4
Plating Engineering	Milwaukee	0.062	0.0	0.12	0.47	1.61	12.72	0.03	0.0		0.27		60
Printing Developments	Racine	0.0023		2.25	23	6.3		24.8		157		756	
Racine Plating	Racine	0.24	17.3	456.8	252	9.23	22.7	13.5	.225	29.3	2.46	639	562
Reliable Plating Works *	Milwaukee	0.043				13.6	0.005				0.05	145	55
S.K. Williams *	Milwaukee	0.03	.02	25.11	0.1		2.0	0.6		18.5	0.9	301	626
Shephard Plating *	Racine	0.18	0.74	3.1	2.98	2.6	1.04	3.12		0.15	0.74	33	52
Wisconsin Plating Works	Racine	0.049	0.0	1.2	1.3	1.6	2.1	6	0.0		5.7	54	18
Acme Galvanizing	Milwaukee	0.34	2.08	2.9	0.46	19.5	3.24	118	0.13	3.94	2.2	58	1,354
Metal Coatings *	Milwaukee	0.017	0.15	1.0	6.2	0.0	0.0	7.0	0.0		0.09	48	14
Wright Metal Processors	Milwaukee	0.04				0.14	1.07	5.4		0.5	0.71	10	10.2
Amron Corp. *	Waukesha	0.735	0.0	0.26	10.2	17.8	0.19		0.0	41.3	1.50	4,489	362
MacWhyte Co.	Kenosha	0.475		0.0	1.6	7.9	1.2	51.4	0.8		13.06	1,780	4,155
Briggs & Stratton Corp. *	Milwaukee	0.045		1.18	.39	0.434	0.29	0.76	0.044		0.201	4.52	2.82

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.
* Wastewater is pretreated prior to discharge (Source: SEWRPC Treatment Facility and Sludge Handling Survey).

Source: Wisconsin DNR and SEWRPC.

TABLE 31

METAL MACHINING IN REGION - 1975

Company	Receiving System	Average Wastewater Flow mgd	Maximum Load in Wastewater Discharge (lb/day)								
			Suspended Solids	Oils Fats Grease	Cadmium	Cyanide	Copper	Chromium	Nickel	Zinc	Lead
Teledyne Wisconsin Motor*	Milwaukee	.071	14	12	-	-	-	0.0	0.0	0.02	0.0
Waukesha Engine	Waukesha	0.43	300	203	-	-	0.18	0.11	0.1	0.6	-
Bucyrus-Erie Co.	Milwaukee	0.52	194	127	0.0	0.04	0.0	0.0	0.0	0.66	0.0
Rexnord Inc.	Milwaukee	0.23	154	48	-	0.0	0.36	0.06	0.39	1.87	1.37
Rexnord Inc. Construction Mach.	Milwaukee	0.633	58.4	10.9	-	-	0.06	0.02	0.03	0.33	0.01
Twin Disc Inc.	Racine	0.01	195	6	0.0	0.0	0.025	0.01	0.03	0.06	0.01
RTE Corp.	Waukesha	0.1	26.2	4.2	-	0.001	0.014	0.53	0.01	0.016	0.0
Allis Chalmers	Milwaukee	0.1	78.3	16.1	0.124	0.011	17.4	1.36	0.0	2.24	0.0
Allen-Bradley*	Milwaukee	2.75	420	-	1.11	21.44	26.62	5.21	1.1	3.3	1.4
Cutler Hammer	Milwaukee	0.033	15.9	1.0	-	-	0.03	0.09	0.84	2.2	-
Oster Corp.	Milwaukee	0.05	29	13	-	-	0.0	4.54	0.0	0.01	0.0
GMC AC Spark Plug Div.*	Milwaukee	0.42	774	254	0.0	0.11	0.0	0.32	0.28	0.47	0.16
American Motors Lakefront	Kenosha	0.98	18,953	15,770	0.67	-	2.6	7.88	111	10.77	2.6
American Motors Main Plant*	Kenosha	2.8	5,742	18,364	-	-	7.0	3.9	13.8	28.8	2.2
A.O. Smith*	Milwaukee	2.26	1,452	646	-	-	1.8	.71	.32	61.3	.65
Harley-Davidson Motor Co. Inc.*	Milwaukee	0.075	233	100	-	0.0	0.0	0.0	0.0	4.2	0.0
Motor Castings	Milwaukee	0.018	70.9	2.8	-	-	0.26	.04	0.0	19.6	0.9
Allied Smelting	Milwaukee	0.003	625	20.5	-	-	.007	-	-	-	15
Anaconda Co.	Kenosha	1.00	93.4	900.7	0.0	0.0	6.6	0.0	0.0	3.3	1.6
Acme Die Casting	Racine	0.430	28.0	23.2	-	-	-	-	-	4.2	-
Mercury Marine	Cedarburg	0.005	32.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milwaukee Die Casting	Milwaukee	0.024	37.2	68.4	-	-	0.05	0.01	0.002	0.16	0.01
American Can *	Milwaukee	0.16	246.9	29.3	0.0	0.003	0.015	0.0	0.0	0.06	0.0
J. Schlitz Container *	Milwaukee	0.125	1,376	1,553	-	-	0.052	58.5	0.0	0.114	0.031
Miller Brewing Container Co.	Milwaukee	0.073	110	64	-	-	0.13	2.3	0.2	0.17	0.1
Briggs & Stratton *	Milwaukee	1.288	692.2	643.2	0.0	8.5	7.21	27	8.8	18	0.28
Chrysler Outboard *	Hartford	0.17	432.7	0.0	-	-	0.0	2.26	0.0	0.0	0.0
Evinrude Motors #1 *	Milwaukee	0.6	175	10	16.75	19.5	1.7	11.4	5.5	2.4	-
Evinrude Motors #5 *	Milwaukee	0.02	456	23.4	-	0.005	0.085	-	-	.14	-
Mercury Marine	Cedarburg	0.179	392	1.7	0.0	-	0.0	0.8	0.0	0.2	0.0
Tecumseh Products Co.	Grafton	0.081	86.5	10.0	-	-	0.05	0.02	0.02	0.18	0.14

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.
* Wastewater is pretreated prior to discharge (Source: SEWRPC Treatment FAcility and Sludge Handling Survey).

Source: Wisconsin DNR and SEWRPC.

TABLE 32

FOOD PROCESSING IN REGION - 1975

Company	Receiving System	Average Wastewater Flow mgd	Maximum Load in Wastewater Discharge (lb/day) BOD$_5$	Suspended Solids	Oils Fats Grease	Nitrogen Kjeldahl	Ammonia	Phosphorus	Sulfates	Chlorides
				Meat Processing						
C & D Foods Inc.	Land Disposal Spray Irrigation	0.052	414	15,881	-	3,604	102	540	408	213
Downy Duck Co. *	Land Disposal Spray Irrigation	0.045	21	29	5	126	94	42.4	84.1	65.8
Grove Duck Farm *	W. Br. Root River	0.025	16.7	273	11.3	32.4	9.7	7.0	170	28.4
Pekin Duck Farm *	Land Disposal Spray Irrigation	0.006	270	336	7.5	134	110	31.5	31	62
Kenosha Packing *	Land Disposal Ridge Furrow	0.232	184.5	42	29	7.8	4.4	1.29	80	15.5
Patrick Cudahy	Milwaukee	2.2	2,468	15,631	7,656	1,274	276	274	808	8,510
Peck Meat Packing	Milwaukee	0.2	6,660	10,100	7,790	460	-	2.14	200	144
Strauss Bros. Packing Co. Inc.	Milwaukee	0.023	30	15	0.14	9.10	3.96	0.52	36.5	32.1
Wisconsin Packing	Milwaukee	0.2	3,100	1,830	610	19.2	230	41.1	71	100
Armour & Co.	New Berlin	.015	484	85	299	38.4	3.2	107	0.0	586
Fred Usinger	Milwaukee	0.1197	1,866	200	879	-	-	2.8	52.6	931.2
Kenosha Packing *	Kenosha	0.146	170	31	6,688	-	-	7.2	72.9	173.9
Klement Sausage	Milwaukee	0.0686	270	40.5	30.5	6.4	0.9	1.0	12.1	85.3
Natural Casing	Hartford	0.0218	448	43	27	20	-	3.8	-	2,900
Uncle August Sausage Co.	Milwaukee	0.044	64	33	24	-	0.2	1.6	-	-
				Dairy Processing - Milk & Cheese						
Weisel & Co.	Milwaukee	0.117	842	82.7	73.8	0.29	0.178	4.14	1.33	26.6
Level Valley Dairy *	Cedar Creek	0.094	42.5	37.2	31.54	3.94	1.68	25.23	94.62	55.2
Cedar Valley Cheese	Land Disposal	0.025	-	-	4.54	-	-	9.24	105	32.3
Foremost Foods Co.	Whitewater	0.043	249	9.7	5.1	12.2	0.0	2.5	14.9	71.8
Bordon Inc.	Milwaukee	0.482	5,402	406.2	339	-	-	114	68	253
Hawthorn-Mellody Farms	Waukesha	0.016	308	113	50.0	15	4	1.2	15.0	54.0
Fairmount Foods	Kewaskum	0.09	615.7	219	100.4	25.86	5.72	0.96	33.8	1,948
Gehl Guernsey Farms	Milwaukee	0.038	349	91.2	21.6	-	-	2.7	72.9	11.2
Hawthorn-Mellody Farms	Whitewater	0.241	3,010	1,500	420	128	.7	140	73	3.1
Pabst Farms *	Land Application Spray Irrigation	0.364	783	456	327	83.2	0.81	32.5	36	89.0
Carnation Co.	Oconomowoc	0.10	1540	388	57	-	-	-	-	-
				Vegetable Processing **						
Krier Preserving *	Land Application Spray Irrigation	0.550	275.2	275.2	238.5	-	-	76.4	-	183.5
Libby, McNeil, Libby *	Hartford	0.01	22,571	13,643	280	9,475	395	163	1,909	5,473
Libby, McNeil, Libby *	Land Application Spray Irrigation	0.142	4,944	890	51	134	29	47.4	1,711	10,040
Ocean Spray * Cranberries	Kenosha	0.59	6,872	637	12	-	.49	15	124	137
Jewett & Holsum Foods	Waukesha	0.09	255	47	25	-	-	5.94	75	1,083

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.
* Wastewater is pretreated prior to discharge (Source: SEWRPC Treatment Facility and Sludge Handling Survey).
** Vegetable peelings and washings are usually spread on land but are considered a solid waste.

Source: Wisconsin DNR and SEWRPC.

TABLE 33

BREWERIES IN REGION - 1975

Company Name	Receiving System	Average Wastewater Flow mgd	Maximum Load in Wastewater Discharge (lb/day)			
			BOD_5	Suspended Solids	Nitrogen Kjeldahl	Phosphorus
Jos Schlitz Brewing Co.	Milwaukee	4.6	95,600	65,400	2340	240
Miller Brewing Co.	Milwaukee	5.6	41,700**	18,000**	-	278**
Pabst Brewing Co.	Milwaukee	5.1	74,000	53,500	-	306

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.

* Wastewater is pretreated prior to discharge (Source: SEWRPC Treatment Facility and Sludge Handling Survey).

** Average Values not reported -- Maximum Values reported here.

Source: Wisconsin DNR and SEWRPC.

TABLE 34

TRUCK AND CAR WASH OPERATIONS IN REGION - 1975

Company Name	Receiving System	Average Wastewater Flow mgd	Maximum Load in Wastewater Discharge (lb/day)			
			Suspended Solids	Oils Grease	Phosphorus	Chloride
Capital Court Car Wash	Milwaukee	0.012	15.0	5.3	0.12	21.0
DJ & K Enterprises	Milwaukee	0.01	17.0	1.9	0.10	20.0
Imperial Car Wash Inc.	Milwaukee	0.0115	36.0	2.3	3.5	0.757
Magic Car Wash Inc.	Milwaukee	0.0091	60.94	3.6	1.9	0.884
Suburban Car Wash	Milwaukee	0.0149	14.18	1.99	0.0995	1.442
Willows Car Wash	Milwaukee	0.011	20	4.7	0.04	7.8
Your Car Wash	Kenosha	0.012	-	3.7	2.33	4.8

Note: Plants listed have daily flows in excess of 10,000 gal/day or toxic substances in their wastewaters.

* Wastewater is pretreated prior to discharge (Source: SEWRPC Treatment Facility and Sludge Handling Survey).

Source: Wisconsin DNR and SEWRPC.

Wastewater entering a sanitary sewer contains significant concentrations of metals used in the plating operations. (For analysis data see Table 30). Two industries in particular appear to contribute high concentrations of a number of metals and toxic materials. Master Lock, in Milwaukee, has wastewaters with amounts of cadmium, cyanide, nickel, and phosphorus. Racine Plating, in Racine, has wastewaters with concentrations of cadmium, cyanide, copper, chromium, nickel, and zinc. Other companies with concentrations of particular chemicals are listed below:

Cyanide.....S.K. Williams
Copper.......Printing Developments Inc.
Chromium.Reliable Plating, Acme Galvanizing, Amron Corp., Snap-on-Tools, Electro Coatings, Murry Metal Plating Works
Nickel.........Ladish Co., Murry Metal Plating, Electro Coatings
Zinc............Printing Developments, Acme Galvanizing, MacWhyte, Inryco Inc.
Lead...........Industrial Cylinders

Metal Machining Operations

In metal machining industries, wastewater results mostly from washing of machined parts and from cooling. The wastewaters are high in SS (sand, grit, buffing compounds, etc.) and in oils and grease (die lubes and drawing oils). Almost all industries treat their wastewater before discharging to the sanitary sewer. In the majority of cases, treatment consists of settling basins, pH adjustment, and oil separation. Some industries also use screens or filters, chemical precipitation, and sludge dewatering in combination with the above treatment. In most cases, sludge is hauled to a landfill by a private hauler.

From the SEWRPC Treatment Facility and Sludge Handling Practices Survey, of the 39 questionnaires mailed, 13 were returned. It was found that approximately 52,000 gal./day of sludge is generated. However, 38,000 gal./day was at one facility from wet-type dust collectors. The total is estimated at 80,000 gal./day, containing 34,200 lb/day dry solids.

Wastewater entering a sanitary sewer is characteristically high in both SS and oils and grease (see Table 31 for data). Particular industries which appear to have large amounts of SS and/or oils and grease in their wastewater are Allied Smelting, Anaconda Co., American Can, Schlitz Container Div., Briggs & Stratton, Chrysler Outboard, Evinrude Motors, Mercury Marine, Waukesha Engine, Allen-Bradley, GMC-AC Spark Plug Div., American Motors, and A.O. Smith. Sources of apparent high concentrations of other metals are listed below:

Cadmium .....Evinrude Motors Plant# 1
Cyanide ....Evinrude Motors Plant # 1, Allen-Bradley
Copper ....Allis Chalmers, Allen-Bradley
Chromium......Schlitz Container Div., Briggs & Stratton, Envirude Motors Plant # 1
Nickel.............American Motors
Zinc................Motor Castings, American Motors, A.O. Smith

Food Processing

From the SEWRPC Treatment Facility and Sludge Handling Practices Survey, it was found that 3,800 gal./day of sludge is produced by those responding industries. Of the 65 questionnaires mailed, 33 were returned. The total is estimated at 6,500 gal./day containing 2,800 lb/day dry solids. Data are presented in Table 32.

Milk Processing–In the milk processing industry, wastewater results from cooling water, milk evaporation, and washing of equipment. At Level Valley Dairy, the wastewater is treated biologically and the sludge landfilled. At the Pabst Farms, wastewater is first sent to a settling basin with the resulting sludge lagooned at the farm. At other farms wastes are discharged directly to a sanitary sewer. Wastewaters appear to be high in BOD_5, particularly Borden Inc. and Hawthorn-Mellody Farms; suspended solids, Borden Inc., Fairmont Foods, Hawthorn-Mellody Farms, and Pabst Farms; and oils and fats, Borden Inc., Fairmont Foods, Hawthorn-Mellody Farms, and Pabst Farms.

Cheese Processing–In cheese processing, wastewaters come from sanitation of processing equipment and the evaporation of whey. In most cases the wastewater is discharged directly to the sanitary sewer; however, the Oak cheese factory does treat some wastes in seepage beds.

Wastewater from cheese processing are similar to those from milk processing and are high in BOD_5, SS, and oils and fats.

Meat Processing–In the meat processing industries, wastewater results from sanitation of processing equipment, from cooling water, and from cooking wastes. At the Kenosha Packing Co., wastewater is treated in an Imhoff tank followed by evaporation in a ridge and furrow system. At other processing plants, wastewater is discharged directly to the sanitary sewer. At the Pekin Duck Farm and the Downy Duck Company, wastewater from washdown and drinking waters is settled, screened, and lagooned, with final disposal by spray irrigation and landspreading of sludge.

Wastewater from Patrick Cudahy and Peck Meat Packing appears to have extremely high levels of BOD_5, SS, and fats and grease. Other plants which appear to have high levels of other materials in their wastewaters are:

SS ....C&D Foods
Grease and Fat............Kenosha Packing
Nitrogen (Kjeldahl).....C&D Foods, Patrick Cudahy
Ammonia.....C&D Foods, Pekin Duck Farm, Patrick Cudahy, Wisconsin Packing
Phosphorus..C&D Foods, Patrick Cudahy, Armour
Sulfates.........C&D Foods, Patrick Cudahy
Chlorides......Patrick Cudahy, Kenosha Packing

Vegetable Processing—Vegetable processing industry wastewater results from washing and cooking and from sanitary cleaning of processing equipment. Krier Preserving Co. and Libby McNeill & Libby screen their wastes prior to lagooning, and wastewater is applied to the land by spray irrigation. Sludge at Krier is incorporated into the soil; sludge at Libby remains in the lagoon. Frank Pure Foods and Meeter Bros. & Co. utilize stabilizing lagoons to treat processing wastewater; lagoons are cleaned annually. Mammoth Springs Canning uses lagoons and spray irrigation. Other processing industries discharge directly to the sanitary sewer.

Brewing Industry
Wastewater from the three major breweries in the Region—Joseph Schlitz, Miller and Pabst—is discharged to the treatment plants of the Milwaukee Metropolitan Sewage District. Wastewater characteristics are shown in Table 33. As can be seen, these wastewaters are high in BOD_5 and suspended solids. Solid wastes generated as a by-product of brewing are sold as animal feed by each of the three breweries. These wastes are not considered to be sludges. No significant amount of sludge is generated at these breweries. The high quantities of BOD_5 and SS present in the brewery wastewaters are believed to contribute to the high nitrogen content of the "Milorganite" produced at the MSD-Jones Island treatment plant.

Battery Manufacturing Operations
Wastewater from battery manufacturing at the Globe-Union Teutonia Plant results from cleaning of acid spillage from floors, rinsing of ceramic parts, and process cooling water. Wastewater is passed through a settling tank and is treated for pH adjustment. Sludges that contain lead and lead sulfate are recycled. Sludge quantities (for disposal from the plant) average 1 gal./day. Treated wastewater is discharged to the sanitary sewer and contains small amounts of lead, sulfates ammonia, and nitrogen (kjeldahl).

Truck and Car Wash Operations
Wastewater from car washing operations contains road dirt, oils, salts, and soaps. In some cases, a settling basin is used prior to discharge to the sanitary sewer for removal of SS. Ultimate disposal is by private hauler to a landfill. From the SEWRPC Treatment Facility and Sludge Handling Practices Survey, of the 9 questionnaires mailed, 3 were returned, it was found that 50 gal./day of sludge is produced containing 183 lb/day dry solids. Data are presented in Table 34. Fruehauf Corp. uses a sump pit and septic system; NFO Slinger Receiving uses septic tanks plus ridge and furrow disposal. All others discharge untreated wash water directly to the sewerage system. Both Magic Car Wash and Modern Car Wash appear to discharge comparatively high amounts of SS. Modern Car Wash wastewater also appears to have large amounts of phosphorus and chloride.

Power Plants
The largest volume of wastewater flowing from a power plant is process cooling water. In this region, the generating stations for Wisconsin Electric Power Company discharge their cooling water directly to surface waters. No known wastewater treatment equipment is used; however, there are plans for complying with the WPDES effluent limitations.

Other wastewaters result from floor drainage, boiler blowdown, and boiler feedwater treatment. These wastes contain SS, chlorides, and sulfates, currently combined with the effluent cooling water. Sanitary wastewater and small volumes of some process waters flow to the sanitary sewers at only a few power plants.

INVENTORY FINDINGS— WATER TREATMENT PLANT SLUDGES

Water treatment plants within the study area utilize either alum coagulation or filtration for SS removal. Sludges generated by these processes are disposed of by direct discharge to a sanitary sewer (see Table 35) or are hauled to an approved landfill (see Table 36). In some cases, sludges are sent to a settling basin or a holding tank prior to ultimate disposal; however, no other treatment methods are used. Table 37 indicates current and anticipated modes of processing and disposal at each plant.

The large treatment plants serving major cities use alum coagulants. Most of these plants are either currently connected to the sanitary sewer or have plans to construct connections in the near future. Only the North Shore filtration plant, which uses a landfill, and Cudahy, which uses a settling lagoon, do not have plans to connect to the sanitary sewer. Kenosha and Racine both utilize sedimentation basins which are emptied two or three times a year directly to the sanitary sewer. The Linwood and Howard plants in Milwaukee will discharge their wastes at a controlled rate. The water treatment plant in South Milwaukee discharges at a controlled rate of 2,000 gal./day for six months each year from its storage/settling tanks.

Those treatment plants which utilize sand, charcoal, or pressure filters generally treat their water to remove iron. Backwash waters usually go to a holding tank or reservoir for settling; sludges are then discharged to either a sanitary sewer, a landfill site, or to drying beds followed by landfilling. Exceptions are Whitewater, which uses a marsh for some backwash waters, and Williams Bay, which trucks to a gravel pit.

TABLE 35

WATER TREATMENT PLANTS DISCHARGING TO A SANITARY SEWERAGE SYSTEM

Plant Name	Estimated Sludge Volume for Final Disposal gal./day[1]	Estimated Total Solids for Final Disposal lb/day dry
Village of Menomonee Falls[4]	19,700	5
City of Oak Creek	32,800	—[2]
City of Milwaukee Linwood Avenue Plant[4]	60,000	7,670
City of Milwaukee Howard Avenue Plant[4]	90,000	5,070
City of South Milwaukee[5]	2,000	1,830
City of Kenosha[4]	5,000	3,060
City of Racine[4]	24,100	4,820
City of Port Washington	10,000	—[2]
City of Whitewater	9,300[3]	14
Village of Genoa City	620	3
City of Oconomowoc	1,860	—[2]
		22,472

[1]*Sludge volumes reduced to daily averages, although discharges might occur at high rates at less frequent intervals.*
[2]*Data not available.*
[3]*Portion of sludge is also discharged to a marsh.*
[4]*Design and/or construction of connection to sanitary sewerage system in progress.*
[5]*6 months/year.*

Source: Camp Dresser & McKee Inc.

TABLE 36

WATER TREATMENT PLANTS DISCHARGING TO A LANDFILL OR OTHER DISPOSAL

Plant Name	Disposal Site	Estimated Sludge Volume for Final Disposal gal./day[1]	Estimated Total Solids for Final Disposal lb/day dry
North Shore Water Utility[2]	Landfill	960	1,460
City of Cudahy	Lagoon	—[4]	—[4]
City of Lake Geneva	Landfill	10,000	—[4]
Village of Williams Bay	Gravel pit	410	1,219
City of Elkhorn	Landfill	15	—[3]
City of Whitewater	Marsh[3]	8,600	5
Village of Darien	Landfill	2,300	1
			2,685

[1]*Sludge volumes reduced to daily averages, although discharges might occur at high rates at less frequent intervals.*
[2]*Contemplating discharge to the sanitary sewerage system.*
[3]*Portion of sludge is discharged to sanitary sewerage system.*
[4]*Data not available.*

Source: Camp Dresser & McKee Inc.

TABLE 37

WATER TREATMENT PLANT SLUDGES

Plant Name	Sludge Type	Sludge Processing	Existing/ Proposed	Sludge Disposal	Existing/ Proposed	Not to WWTP	Disposal Continuous/Batch
Village of Menomonee Water Treatment Plant	Pressure Filter Backwash	No Treatment (None proposed)	E	Sanitary Sewer Permit date 1/1/77 (Not yet operational)	E		
City of Oak Creek	Alum	No Treatment (None proposed)	E	Sanitary Sewer to South Shore WWTP since 11/74	E		
North Shore Water Utility Filtration Plant	Alum	1 Lagoon 2 Additional Lagoons Polymer added to Lagoons (experimental)	E P P	To Glendale Landfill (closed) New landfill for spring 1977 Connection to WWTP	E P P	* *	Batch (Excavation of Lagoons)
City of Milwaukee Linnwood Avenue Plant	Alum	Settling Tank (No Treatment) Experimenting w/Polymers	E P	To Lake Michigan To Sanitary Sewer (July or Sept. 1977)	E P	*	Controlled Rate
City of Milwaukee Howard Avenue Plant	Alum	Settling Basin (No Treatment) Experimenting w/Polymers	E P	To Lake Michigan To Sanitary Sewer (Under construction)	E P	*	Controlled Rate
City of Cudahy	Alum	Settling Tanks No Treatment	E	To Lagoons design life - 15 yrs.	E	*	

TABLE 37

WATER TREATMENT PLANT SLUDGES (Continued)

Plant Name	Sludge Type	Sludge Processing	Existing/ Proposed	Sludge Disposal	Existing/ Proposed	Not to WWTP	Disposal Continuous/Batch
City of South Milwaukee Water Treatment	Filter Plant w/Alum	No Treatment Settling/Holding Tank	E	To Sanitary Sewer Pumping to begin after spring thaw Alt.-Solids from Storage/Settling Tank to landfill Alt.-Filter Bed to dry sludge prior to land-fill	E		Controlled Discharge 2,000 gal/day for 6 mo/year
City of Kenosha	Alum	No Treatment; backwash water & basin sludge to Lake Michigan	E	To Lake Michigan	E	*	
		Building retention basin for backwash water with daily or weekly discharge to Sanitary Sewer No Alternative Plans if sanitary sewer connection does not work out	P	Connecting to sanitary sewer in 6 months	P		Backwash Water Daily or Weekly Sedimentation Basin sludge once every 6 months
City of Racine	Alum	No Treatment		To Lake Michigan	E	*	
		Settling Basin for sludge	E	Contract signed for connection to sanitary sewer-completion Date Oct. 1977	P		Discharge from Basin 3 times per year
City of Oconomowoc	Filters for Iron & Rust Removal on Well #5 only	No Treatment (Well #5 not in use at present; Plans existing for re-drilling) (Future treatment need unknown)	E	Backwash Water to sanitary sewer	E		Batch - 12,000 to 14,000 gallons once per week at off-peak hours
City of Port Washington	Sand Filtration w/Lime Addition New Plant 1971	No Treatment Backwash water to clarifier Sludge to settling tank	E	To Sanitary Sewer	E		Batch-Clarifier Solids - 2 times per week Sludge Solids - 2 times per year
City of Lake Geneva	Pressure Filter for Iron Removal	No Treatment Backwash to reservoir	P	To Sanitary Sewer (ending)	E		
				Solids in reservoir cleaned monthly to be buried on site or trucked to Greidanus Landfill	P	*	Monthly cleaning or reservoir
Village of Williams Bay	Lime/Alum Treatment	No Treatment Directly to covered sand drying beds No Future Plans	E	Beds cleaned with front end loader & trucked to gravel pit with DNR permit	E	*	Winter - one bed once every 2 or 3 weeks Summer - one bed once every week
City of Elkhorn	Iron Removal via Filters	No Treatment Holding/Settling Tank for backwash	E	Settling trucked to City Landfill	E	*	Batch Cleaned once per year 5,000 gallons
City of Whitewater	Sand Filters for Iron Removal	No Treatment No Holding Tanks	E	Backwash from 2 Filters to sanitary sewer	E		Batch Backwash once per week for 1-1.5 hours and 60-70,000 gallons
		Contemplating new well if iron still present w/holding tank for backwash	P	Backwash from one filter flows directly to marsh through sewer line	E	*	
Village of Genoa City	Sand & Charcoal Filters for iron removal	No Treatment No Holding Tanks	E	Backwash directly to sanitary sewer; Connected 6/76	E		Batch Backwash once every 2 or 3 weeks approximately 13,000 gallons
Village of Darien	Iron Removal via Filters	No Treatment Holding Tank for backwash water	E	Settlings have been accumulating in tank for 2 years & are not deep enough yet to require removal	E		

Source: Camp Dresser & McKee Inc. and SEWRPC.

SEPTIC AND HOLDING TANK WASTES

An estimated total of 240,000 persons in the Region, or about 14 percent of the total Region population, rely on about 69,000 individual wastewater disposal systems for domestic wastewater disposal. About 24,000 of these persons live on farms. The remaining 217,000 persons constitute urban dwellers living generally throughout the rural and rural-urban fringe areas of the Region. About 139,000 of the 217,000 urban dwellers live within urbanizing areas of the Region, however, and within potential service areas of centralized sanitary sewer systems. The area currently devoted to urban land uses within the Region, but unserved by sanitary sewerage facilities, is estimated to total from 61 to 85 square miles (23 to 21 percent of the currently urbanized area of the Region), depending upon the definition used for the term "urban development."[1]

The estimated amount of dry sludge solids produced by these septic systems is 12,400 lb/day. This is based on the assumption that all systems are cleaned regularly and properly. In as much as all systems are probably not cleaned on a regular basis, this might be considered a conservatively high figure. Those persons living on farms are quite likely to apply the septage directly to their own land (12,400 lb/day is less than 2 percent of the total dry solids produced by large wastewater treatment facilities). This per capita solids production is about 0.05 lb/day, as opposed to average raw sludge production of municipal origin of about 0.25 lb/cap./day.

SUMMARY

The presentation of existing sludge management systems and those known to be planned by others was organized by discussing each of the 21 major municipal wastewater treatment plants individually and other sources of sludges by category. Because the plan recommendations will emphasize the 21 major plants, detailed information is presented on structural components and sludge quantities currently generated or projected for the future. Other wastewater treatment plants, industrial pretreatment sludges, and water treatment plant sludges were addressed on a categorical level. This data base will be used to project sludge quantities through the year 2000 (Chapter V) and to develop the alternatives for screening (Chapter IX).

TABLE 38

SUMMARY OF SLUDGE GENERATION — 1975

Facility Type		Raw Sludge Quantity Produced in Tons/Day
Major Municipal Plants		346.6
Other Municipal and Private Plants		5.3
Industries		25.0
Water Treatment Plants		12.6[1]
Septic and Holding Tanks	(6.2)[2]	
Total:		389.5

[1]*Some discharge to municipal wastewater treatment plants.*
[2]*Quantity shown for information only; included in municipal plant totals above.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

The total quantity of dry solids produced by the 21 major plants (see Table 38) was found to be approximately 347 ton/day. Other wastewater treatment plants produced approximately 5.3 ton/day and water treatment plants approximately 12.6 ton/day. Total industrial sludge quantities, based upon a survey of 180 industrial operations to which 51% responded, were estimated to amount to about 25.0 ton/day for the categories of industries. Sludge quality characteristics are discussed in Chapter V. The total amount of sludge solids currently generated by these named categories was found to be approximately 390 ton/day. Additional information on sludge quantities are also found in Chapter V. Quantities of sludge expected from treatment of combined sewer overflows and stream bottom dredgings are not yet available.

[1]*Urban development from a historical perspective includes those general areas of the Region wherein houses or other buildings have been constructed in relatively compact groups or where a closely spaced network of minor streets has been constructed, thereby indicating a concentration of residential, commercial, industrial, governmental, or institutional land uses. The continuity of such development is considered interrupted only if a quarter mile or more of nonurban type land uses, such as agriculture, woodlands, or wetlands prevailed, and the above conditions were generally absent. By contrast, precise quantification of urban land uses, irrespective of spatial continuity, can be established by detailed examination of the Commission aerial photographs. These two alternative approaches result in a range of urban development estimates. (SEWRPC, "A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000", April 1975, page 170.)*

Chapter IV

MARKET ANALYSIS OF RECOVERED SLUDGE PRODUCTS

INTRODUCTION

The purpose of this chapter is to present an analysis of existing and future markets for recovered sludge products and the dollar value of the products. A detailed analysis was prepared by Arthur D. Little, Inc.[1] This analysis discusses markets and marketing considerations for Milorganite and sludge compost, as well as liquid or cake sludge (digested). Information on sludge-derived energy was developed by Camp Dresser & McKee Inc.

Related information pertaining to sludge quality and land area required and available for spreading of sludges may be found in Chapters V and IX. As stated in more detail in Chapter V, sludge contains valuable nutrients and has properties enabling it to serve as an excellent soil conditioner.

The dollar value applied to sludge as a result of the analyses of this chapter may be viewed in two ways. First, the dollar value may be considered as a credit to the concept of utilization of recovered sludge products and, thus, represents a benefit to society. The second view is to consider the dollar value of a recovered sludge product as a possible sale value. This dollar value would then be applied as a credit in the economic analysis. The dollar value is only applicable in the economic analysis, if the marketing program is successful.

Much of the success of any market program will depend on product marketability in terms of the consumer's acceptance of the product. When discussing sludge utilization with the farming community, a person (possibly from the Soil Conservation Service) with an understanding of normal farming practices should be involved. On the other hand, when discussing sludge utilization with nonfarm rural homeowners, a person with a nonfarm background may be most suitable.

Sludge contains 1 to 99 percent water and is comprised of the solid matter which is generated by the wastewater treatment process. This solid matter consists mainly of biodegradable organic materials such as proteins, carbohydrates, and fats which will decompose to yield plant nutrients such as nitrogen (N), phosphorus (P), potassium (K) and a number of micronutrients, and inorganic materials such as silica. Other persistent and potentially harmful materials such as heavy metals (cadmium, lead, mercury, etc.) and polychlorinated biphenyls (PCBs) may also be present in sludge (Chapter V contains further discussion of sludge characteristics). The attractiveness of sludge utilization in agriculture is, therefore, dependent on the relative importance attached to the various beneficial and potentially harmful constituents of the product, as well as other factors, as discussed in this chapter.

A sludge product is not generally considered a "fertilizer" unless it contains more than about 2 percent nitrogen by weight. At nitrogen levels below about 1 percent, the product is more properly termed either a "soil conditioner" or "soil amendment." Available nitrogen is a common basis of comparison between various products. Available nitrogen determines the amount of dry sludge solids to be spread per acre for a given crop type. Department of Natural Resources regulations refer to guidelines regarding the use of sludges.

The Wisconsin fertilizer law (Wisconsin Statute 94.64) specifically excludes sewage sludge from the definition of fertilizer. However, a product manufactured (processed, granulated, compounded, produced, mixed, blended or altered[1]) from fertilizer material (any substance containing nitrogen, phosphorus or potassium or any recognized plant nutrient, which is used as a fertilizer or for compounding mixed fertilizers[2]), is considered to be a fertilizer under the law. For example, a lagooned sludge applied to farmland would not be a fertilizer whereas a heat dried sludge product would be considered as a fertilizer. Two additional considerations are: first, if the nitrogen plus phosphorus plus potassium content is less than 24%, a special permit is needed and the product must be labeled as a specialty

[1]*Arthur D. Little, Inc. Evaluation of Markets for Municipal Sludge Products Produced in Southeastern Wisconsin," Cambridge, MA, July 1977.*

[1]*From Wisconsin Fertilizer Law 94.64(b).*

[2]*From Wisconsin Fertilizer Law 94.64(h).*

fertilizer. The second consideration is that it is the view of the Wisconsin Department of Agriculture that sewage sludge products that are not sold (except for reasonable administration fees) do not fall under the fertilizer law. In this developing area, it is reasonable to expect that as sludge products become more common, the fertilizer laws might change.

MILORGANITE MARKETS AND MARKETING

Of the three sludge-based products examined in detail in this study, namely Milorganite, compost, and liquid or cake sludge, Milorganite is the product with which there is the greatest marketing experience. Indeed, the production of Milorganite represents the most prominent pioneering effort in the U.S. relative to large-scale wastewater sludge utilization. No other sludge products have had the success of Milorganite, in terms of market size or retail price obtained.

Product Characteristics

Milorganite is the brand name for the heat-dried activated sludge product which has been produced at the Jones Island facility of the Metropolitan Sewerage District of the County of Milwaukee since 1926. Milorganite consists of waste activated sludge from the wastewater treatment process which is thickened by gravity, dewatered on vacuum filters, and dried in rotary dryers (see description of MSD-Jones Island plant in Chapter III). The dried product is screened so that a uniform size range is obtained, which makes spreading easier. Only Houston, Texas, Los Angeles, California, and Largo, Florida, sell similar type products. Milorganite currently has a guaranteed N-P-K (nitrogen-phosphoric acid-potassium) analysis of 6-2-0. The product was originally sold to fertilizer manufacturers, until the early 1930s, when a distribution system was established which encouraged sales to golf courses. During World War II, when nitrogen fertilizers were scarce, significant home and garden markets for Milorganite were established.

In the past several decades, commercial fertilizers designed specifically for turf and garden applications have emerged as competitive products. Despite the emergence of these commercial fertilizers, Milorganite was still used by a large share of professional turf managers through much of this period.

Two important reasons for Milorganite popularity among current users are its characteristic nonburning and long-lasting qualities. Milorganite has a uniform particle size, contains many secondary and micronutrients essential to healthy plant growth, and is, therefore, a unique product.

One threat to Milorganite quality is the possibility of an increase in its ash (inert) content or, conversely, a reduction in its available fertilizer value, as defined in terms of N-P-K. Changes in the character and composition of the solids in the influent wastewater at MSD-Jones Island because of industrial process changes, high loads, or inert material such as water treatment plant sludge could have such an impact as to result in a reduced market value.

Characterization of Current Markets

Milorganite is sold nationwide through a group of 71 distributors. From 1962 through 1976, annual shipments ranged from 65,500 to 94,000 tons, and Milorganite sales were greatest in the five east-north central states of Wisconsin, Illinois, Indiana, Michigan, and Ohio. The mid-atlantic states are also important Milorganite markets. It is interesting to note that, while Milorganite sales have been at a relatively constant and low level in the other regions, sales have been increasing in the mid-atlantic region at the expense of the east-north central region.

Annual Milorganite production and shipments peaked in 1966 and 1967, respectively, and have declined in recent years to a level of about 70 thousand tons. Review of the monthly production and shipment data suggests that seasonality has not been a major problem in recent years. This is largely because of the current successful Milorganite marketing program which has been designed to reduce seasonal demand swings by serving geographically diverse markets and offering off-season discounts.

Until the mid 1960s, approximately 70 percent of Milorganite sales were made to the professional turf market, with the remaining 30 percent to the retail home and garden market. In the last several years, the markets have tended to equalize, largely because of increasing cost pressures on professional turf managers and a slowdown in the rate of growth of U.S. golf facilities. Home lawn and garden application now account for about 43 percent of Milorganite sales, and it is estimated that, within the lawn and garden segment, about 75 percent of the product is used on lawns and 25 percent on flower beds and in gardens. Distribution between institutional and dealer, or retail, sales varies considerably by geographic region within the U.S.

Estimated Total Potential U.S. Market Size

The current total annual U.S. market potential for Milorganite or similar commercial nonfarm products is estimated to be approximately 5.8 million tons (see Table 39), assuming that such products could supply 100 percent of all nonfarm U.S. fertilizer nitrogen

TABLE 39

ESTIMATED CURRENT TOTAL U.S. MARKET POTENTIAL FOR MILORGANITE-TYPE PRODUCTS

Land Use	Potential Market In[1] Terms of Milorganite-Type Products	Realistic Market Share	Realistic Market Size	Percentage of Total
	(1,000 tons)	(percentage)	(1,000 tons)	
Single-family residences	3,290	10	329	46
Multi-family residences	107	10	11	2
Residential: under development	205	15	31	4
Golf courses	677	20	135	19
Parks and recreation	410	10	41	6
Parks: areas under development	11	15	2	—
Highways: under development	28	15	4	1
Sod and nursery farms	477	15	72	10
Institutional buildings	430	15	65	9
Commercial buildings	153	15	23	3
Total	5,788	—	713	100

[1]*Potential market represents an estimate of the total land area in each category now being fertilized. This information was derived from data from 1976 U.S. Statistical Abstract and "The Non-Farm Market," Prestwich and Messerly, Farm Chemicals, November 1976.*

Source: Arthur D. Little, Inc., estimates.

needs. Over 50 percent of this market consists of the lawns surrounding single-family homes. Combined golf course, sod and nursery farms, and nursery use represents another 20 percent. Other significant markets are areas under development and parks and recreation areas (including institutional greens and athletic fields).

This annual market potential for Milorganite (or similar products) is based on estimates of the amount of nitrogen applied annually in nonfarm areas. These in turn were derived from data on the amount of fertilizer sold to nonfarm consumers.

The amount of nonfarm land currently fertilized annually in the U.S. is estimated to be approximately 6 million acres. If 100 percent of the sites in each land-use category were fertilized, the total number of fertilized acres would double to over 12 million, with attendant doubling of the potential market to 11.6 million tons per year. It is, for example, estimated that no more than one-half of the home lawns in the U.S. are currently fertilized. This large segment of home owners, who could perhaps be persuaded to use a sludge-based fertilizer, represents a second market potential for these products but is considered to be a less reliable market, because this segment does not now fertilize.

Currently, a potential consumption level of approximately 700 thousand tons per year of sludge-based fertilizer products is reasonable—assuming that the material is competitive to existing products in terms of price and that it is readily available and receives moderate promotion. As indicated in the table, lawns and flower beds of single-family residences account for nearly half of this market. Golf courses are next in importance at approximately one-fifth of the national total market, followed in descending order by sod farms and nurseries (10 percent), institutions (9 percent), and parks and recreation areas (6 percent).

Overall nonfarm fertilizer market growth is expected to average 3 to 4 percent per annum during the next 10 years; although, the increasing share of this market served by sludge-based products may lead to more rapid growth potential for sludge-based products for this segment.

Marketing Considerations

With current Milorganite production at 70 thousand tons and a potential national consumption level of 700 thousand tons, based on a realistic market shown in Table 39, the potential market for Milorganite-type products is significantly larger than the current supply of this product. Nevertheless, there is no reliable way to determine *a priori* what share of this potential market a product such as Milorgantie may attain under various marketing approaches or slight changes in product character. While it would be helpful to quantify the price elasticity for Milorganite, to understand the effect of a price change on product demand, this is not possible because of a lack of sufficient price and demand data for both Milorganite and competitive products. Qualitatively speaking, one would expect the price elasticity for Milorganite to be relatively low, because many consumers seem to view it as a relatively unique and valuable product.

Generally, few Milorganite distributors, dealers, or customers are in favor of changing either the product or its distribution. Based on this consideration, as well as the risk inherent in changing elements of the current successful marketing approach, it is reasoned that Milorganite should not be augmented with chemical fertilizers or other adulterants. A change would result in complications with no benefit.

Several obstacles to the continued sale of Milorganite at current levels have been identified. The three most important are: (a) the typical Milorganite consumer is an older person, (b) there is expected continued commercialization of competitive sludge-based products by other major municipalities, and (c) the heavy metals content of Milorganite, which could result in adverse packaging requirements or other limitations.

These problems do not imply that Milorganite manufacture is not a viable option for sludge utilization. The first two problems identified above may be minimized through the development of an appropriate promotional strategy. The third obstacle may be lessened by the control or pretreatment of industrial wastes or perhaps by research directed toward examination of the toxicity of certain constituents found in sludge. This latter problem is common to most large municipal operations and, thus, Milwaukee is by no means alone.

If the problems are dealt with successfully, it is believed that the sale of Milorganite could be doubled (over current levels) in the next five years and beyond. Doubling of Milorganite production would require a completely new region-wide production facility and extensive operating modifications. In determining the best marketing approach leading to an expanded market, it is suggested that a series of test market programs be designed to consider the effects of such variables as product physical and chemical character, product price, package size and style, and level of advertising and promotion expense.

COMPOST MARKETS AND MARKETING

Production of compost is one of the process train options which is being examined under the Total Solids Management Study for the District, and construction of a 10-ton-per-week pilot compost facility at the MSD-South Shore Wastewater Treatment Plant is proposed. This section discusses compost product characteristics, examines the characteristics of existing markets for compost and similar soil amendment products, and then presents an estimate of the potential market for compost in the Region. The section concludes with a discussion of compost marketing considerations.

Product Characteristics

Composting is a method of converting wastewater sludge or other organic material to a solid product for use as a soil amendment by nonfarm consumers. Properly composted material is relatively free of pathogens, weed seeds, and odors, although any of these may be a problem in certain areas, and measures must be taken to address these factors.

Compost generally contains approximately 1 percent nitrogen and less than 1 percent phosphorus and potassium. As a soil amendment, or topdressing, compost improves soil tilth, supports beneficial microbiological activity, and adds primary-secondary-and micro-nutrients to the soil.

As with Milorganite or digested sludge, heavy metals may also be a problem with compost. Because of the lower total nitrogen content of compost, relative to Milorganite or other sludge products, heavy metals are more likely to be the limiting factor restricting the bulk application of compost to a given area of land. While consideration of municipal wastewater sludge composting is currently in vogue because of success at three U.S. sites, actual experience in both compost processing and marketing in this country is quite limited compared to Milorganite or digested sludge.

Characterization of Current Markets

Relatively little information is available on the current market for compost in the Region. Therefore, reliance was placed on examination of the sale and use of similar products such as topsoil, peat, and manure. These products are sold in bulk or in bags to various professional and home consumers.

Homeowners generally use soil amendments for landscaping projects such as putting in a new lawn, planting trees, shrubs, and flowers, or upgrading the quality of their garden's soil. Professional users include schools, cemeteries, parks, sod farms, nurseries, and landscape contractors. The use of soil amendments ranges from a few cubic yards for an individual homeowner to several thousand tons per year by professionals. Typical retail prices for bagged soil amendments are $2.00 to $4.75 for a 50 lb bag or $80.00 to $190.00/ton (see Table 40).

Estimated Potential Region Market Size

The estimated potential for compost use in the Region is approximately 18,000 wet tons per year. Approximately 20 percent of this market potential is in the single-family residential segments for use by current home owners who are now purchasing fertilizer at least once a year for lawns, gardens, and flower beds. Fifty percent of the potential consists of areas under development such as residences, parks, and highways, and another 20 percent consists of commercial establishments such as golf courses, sod farms, and nurseries. The remaining potential for compost use lies with parks and recreation areas, including institutional parks and athletic fields, and to a small extent, multifamily residences.

People who do not currently fertilize their lawns are unlikely potential compost users, because application of compost may require even more time and effort than fertilizer application.

TABLE 40

TYPICAL PRICES FOR BAGGED SOIL AMENDMENTS

Product (percent N)	Bag Size (lb)	Price ($/bag)	Equivalent Price ($/ton)
Michigan peat	50	2.00	80.00
Topsoil	50	2.00	80.00
Composted cow manure (1 percent)	40	3.00	150.00
Shredded hardwood bark .	50	4.75	190.00
Nitrohumus[1] (0.8 percent)	50	1.80	72.00

[1]*Brand name for composted sludge product sold by Kellogg Supply Company, Los Angeles, California.*

Source: Arthur D. Little, Inc.

The market size estimates were also based on the known nitrogen requirements for specific fertilizer areas (for example, up to 10 lb per 1,000 sq ft for golf course tees) and on the percentage of that requirement which could be met through the application of compost. Because compost contains only about 1 percent nitrogen, the entire nitrogen requirement of some areas cannot be met with compost. Some additional fertilizer use would still be necessary in these cases.

It is estimated that compost could be applied to levels up to 100 lb per 1,000 sq ft (0.03 in. deep). At this rate, it would provide 1 lb of nitrogen per 1,000 sq ft, or roughly 40 percent of the nitrogen requirement for average lawns.

Marketing Considerations

Seasonality will be a significant problem in marketing compost in the Region. Compost will potentially be in high demand between April and September but demand is likely to be low during the remainder of the year. Various incentives may be used to try to balance demand, such as free delivery.

Demand for compost in the Region will depend largely on the initial publicity and promotional effort during introduction of a characteristically satisfactory product. For reasonable demand to exist, potential consumers must: (a) have a clear concept of the product, (b) have easy access to the product, and (c) realize that benefits of using the product outweigh the associated costs.

Demand will largely depend on its perceived value as a soil conditioner. There are not enough data available to quantitatively determine the price elasticity of compost, but qualitatively one would expect the price elasticity to be relatively high, in view of the variety of similar soil amendments (see Table 40) already on the market.

The operation of a pilot compost facility at the MSD-South Shore plant will provide the District with an opportunity to try various marketing approaches to determine their effect on compost demand. By observing the changes in demand which occur with various price levels and promotional expenditures, it should be possible to determine an optimal strategy for creating the desired level of demand at minimum cost.

Several possible approaches to distribution are: public pickup with customer supplying the container, bag, or bulk container; public pickup of a bagged product or containerized product; and delivery of bulk loads to bulk users.

LIQUID AND CAKE SLUDGE MARKETS

Digested liquid or cake sludge products are a third alternative. Such products are now being extensively utilized on agricultural land in the Region and the state. Liquid sludge is that material which may be pumped and usually contains up to about 10 to 12 percent solids by weight; it is more or less a freely flowing material. Cake sludge must be scooped or shovelled and does not flow freely. Cake sludge may contain up to 45 percent solids by weight. This section discusses the potential for sale of these products to agriculture. It describes the characteristics of the products and their application, compares them to commercial fertilizers and fertilization practices, and provides estimates of market shares obtainable at several price levels.

Product Characteristics

Physical Form—Sludges now being produced in the Region are either slurries or cake with low to medium solids contents. Either a slurry, which is handled as a liquid, or a cake, which is handled as a solid, can be acceptable as a fertilizer and soil amendment for agriculture. Slurries have the advantage that they can be pumped and are therefore easy to transfer from storage to truck and, if necessary, from the truck to storage and/or to application equipment. Application equipment is available. Major disadvantages are in transportation costs, particularly when long distances are required, because of large quantities of water. Also, there is a maximum amount of liquid which can be applied to the land at any one pass, depending on soil conditions. More sludge may be required than can be incorporated in one pass without significant puddling and running of material. Thus, it may be necessary to make more than one pass over the field. In the spring, when much of the sludge must be applied, time is a critical element, and the farmer does not wish to have delays in tilling and planting. Compaction of the soil is of concern, and the farmer prefers to have as little disturbance by heavy equipment as possible.

Metals that are secondary or micronutrients are present in sludge and are recognized as being vital to healthy plant growth. Soils deficient in these micronutrients can benefit from the application of sludge containing appropriate concentrations of these metals. On the other hand, sludge containing relatively high concentrations of these or other metals may cause excessive concentrations to accumulate in the soil, reaching levels which may be toxic to plants. Research indicates that heavy metals such as cadmium should not be an immediate problem when sludge application rates are limited to the level at which the crop will effectively use available nitrogen in the sludge. Further discussion of this subject may be found in appropriate sections of Chapters V, VIII, and IX.

Sludge as a Soil Conditioner—Sludge has the property of improving the physical condition of many soils, particularly sandy soils and soils lacking organic content. This advantage of sludge tends to be more pronounced in the western part of the state, where the improvement in the soil's humus content is most noticeable. Nevertheless, the addition of sludge to soils in the Region is viewed by farmers as a practice that improves soil tilth as well as a soil's ability to absorb water and hold nutrients. These improved soil properties help to reduce erosion and runoff.

While farmers appreciate the soil improvement properties, they are not likely to pay money for these properties alone. The lack of a commercial market for animal manures is ample evidence to substantiate this belief. Even farmers that spread manure produced on their own farms are as much interested in disposing of it as in improving their soil. Only if it is scientifically documented, that quantitatively defined better crops or yields result, will it be possible to sell sludge to farmers at more than its nutrient value.

Special Application Problems—Concern over surface spreading of sludges has been expressed by the DNR and EPA, as well as other agencies. Surface spreading without incorporation may result in perceived odors, in runoff during heavy rains, and in nitrogen volatilization. The solution is to turn the material under the soil during or immediately following application or inject the material into the soil, which, however, increases the cost of application. Row crops restrict the applications to early spring and late fall, placing an extreme seasonal peak on operations.

Most plants in the Region produce relatively little sludge and, therefore, little nitrogen. Of the 21 major existing plants, ten are expected to produce 10 or fewer tons per year of effective nitrogen, each by the year 2,000, and only two might produce in excess of 56 tons. These quantities are small when compared with the nitrogen fertilizer requirements of agriculture. In the year ending 30 June 1976, 171,200 tons of commercial fertilizer nitrogen were consumed in Wisconsin in farm and nonfarm applications. The most recent information on fertilizer applications by county was developed in the U.S. Census of Agriculture of 1974. These data indicate that the seven county Region accounted for 9.2 percent of the total fertilizer used in the state in 1974. Assuming that nitrogen use correlates with total fertilizer use and that the seven county Region maintained its share of the state total in 1975/76, nitrogen consumption was 15,800 tons in the Region in 1975/76. Taking the Region as a single entity, the total available nitrogen from all municipal sludges is equivalent to roughly 6 to 14 percent of the fertilizer nitrogen consumption, the variable being the type of process trains for sludge handling developed for the MSD-Jones Island and MSD-South Shore plants.

Fertilizer Practices—While phosphorus and potassium will generally stay in the soil where placed, nitrogen is more soluble and will leach out. If nitrogen is applied too early, particularly in the fall, there is a danger that it will be lost before the plant can use it. Corn needs nitrogen most when it is producing grain. Thus, there are advantages to delaying nitrogen application until after the seeds have germinated. This, however, requires two applications of fertilizers: one for mixtures high in phosphorus and potassium and another for nitrogen.

According to the Wisconsin Department of Agriculture in Wisconsin in 1975 and 1976, about one-third of all fertilizers were spread in the fall and two-thirds in the spring. Fall applications of nitrogen were not as prevalent as of phosphate and potash. Twenty-eight percent of the nitrogen was applied between July 1 and December 31, compared to 35 percent of the phosphate and 38 percent of the potash. The prevalence of spring application is a result of the desire to place fertilizers in the row with the seed and a reluctance to commit funds over the winter. In some cases, the farmer is not certain what crop will be planted and will wait until spring to obtain a better estimate of crop prices.

The majority (83 percent) of fertilizers in Wisconsin are sold in bulk, both solid and liquid. About 20 percent of fertilizer tonnage is moved as liquid, most of this being anhydrous ammonia and nitrogen solutions. The use of liquid mixed fertilizers is increasing in popularity.

The use of bulk fertilizer saves in bagging, transportation, and handling costs and enables the custom blending of fertilizers to the farmer's particular specifications. In this case, the farmer is not constrained to a limited number of prepared mixtures and can blend fertilizer to meet specific soil and crop needs. Many farmers test the soil annually to determine nutrient levels.

Market Value of Sludge To Farmers—There is little experience in the sale of sludge to farmers. Sludge from the Osseo plant in western Wisconsin is sold for $2.00 per load (1,000 gallons) plus 10 cents per mile for hauling. Otherwise, in nearly all cases, it is given away or farmers are paid to accept it. For a product with so little commercial experience, and where a market price has not been tested, product value must be estimated on the basis of intrinsic worth. Assuming sludge provides the same effects as commercial fertilizers in feeding growing plants, a farmer will be willing to pay as much as for an equivalent amount of commercial fertilizer. As additional benefits accrue, such as improved soil texture or improved crop yields, because of the presence of other elements not contained in commercial fertilizers, the farmer might even be willing to pay more for sludge than the equivalent value of a commercial fertilizer. On the other hand, if the use of sludge is troublesome because it interferes with standard farming practices, because of paperwork and red tape or poor community relations, the intrinsic worth of the sludge would have to be discounted. There is sufficient experience to realize that there may be significant procedural and community relations problems associated with the spreading of sludge. Additional study is needed to quantitatively compare long-term crop yields, actual soils improvement, and degree of interference with the farmer's normal practices. Large-scale spreading is being conducted from the MSD-South Shore plant, which indicates that the interference with farming practices is not severe.

Assuming, however, that the sludge does give equivalent or better benefits than commercial fertilizers and that the administrative and regulatory problems can be solved by the suppliers or applicators of the sludge, the expected maximum price would be comparable to that of commercial fertilizers on the basis of nutrient value.

Fertilizer prices are unstable. Overcapacity on a worldwide basis during the late 1960s and early 1970s resulted in severe competition and depressed prices. Prices then increased dramatically in 1974 as a result of unforeseen shortages and higher energy costs. These recent higher prices encouraged fertilizer producers to add new capacity and discouraged consumption. Currently, the trend is downward; anhydrous ammonia, which sold at an average of $252.50/ton in 1975, has recently been selling at $205. Solid nitrogen products, which were selling at just under $500 per ton of nitrogen in 1975, are now being quoted at $356. Phosphate prices have also declined significantly from their 1975 highs. Fertilizer prices for spring 1977 were used to estimate the value of sludge products in Table 41.

Because of the considerable cost of applying bulk sludge products versus concentrated commercial fertilizers, estimates were made of the value of both commercial fertilizers and sludge as applied to the field. The nutrient application rates were based on using 100 lb per acre of nitrogen. Recommended application rates in Wisconsin are as high as 180 lb N per acre in some cases; but, in fact, current application rates are on the average about 100 lb. Phosphate and potash application rates were assumed to be proportional to nitrogen in relationship to these elements' use on agriculture in all of Wisconsin.

Fertilizer delivery and application methods and costs are quite variable. General practice in Wisconsin is for the distributor to deliver the material to the farm. The farmer will then spread the material himself, using his own equipment or equipment rented from the dealer. When the farmer does the application, associated costs depend on how the farmer values the costs of labor and of equipment operation and maintenance.

Typical dealer charges are $2.00 per ton for delivery and an additional $3.50 per ton for spreader rental, if the farmer does his own spreading. Assuming 350 lb of fertilizer per acre is an average application rate, delivery and spreader rental charges amount to $0.96 per acre. A local dealer quoted custom application of fertilizers, including delivery, of $1.75 per acre. Assuming that this price was set to make it attractive to the farmers, it probably represents a reasonable estimate of delivery and application costs which must be added to the base price of the fertilizer.

Delivery and application costs in Table 41 are based on applying all three nutrients at the same time at a cost of $1.75 per acre. Because sludge generally has adequate phosphate content, the value to the farmer would be equal to the amount of phosphate he planned to put in the field. A farmer will not likely pay extra for phosphate beyond that required. The sludges have minimal quantities of potash. This implies, then, that the farmer will have to apply potash separately. Therefore, the value of the potash applied was deducted from the cost of fertilizer applied to obtain the value of the sludge. Delivery and application costs for potash will be somewhat less than the $1.75 per acre, but not proportionately less. Thus, the value to farmers of the sludge, using today's prices for fertilizers, would be $29.50 per acre, as derived in Part I of Table 41.

The value per unit weight or volume of sludge will depend on the nutrient content. This, in turn, depends on the nutrient content of the contained solids and on the solids content. Both of these factors are highly variable. Values per ton of dry solids and per thousand gallons are provided in Part II of Table 41 for different combinations of solids and nitrogen concentrations. Based on about 900 to 2,000 tons of nitrogen available in area sludges, this represents a maximum value of about $530,000 to $1,200,000 per annum at spring 1977 prices.

<u>Effect of Price on Market Size</u>—Because of the nature of sludges, the difficulty in applying them without interfering with normal farming practices, permits required, and restrictions placed on farmers who use sludges by local, state, and federal authorities, prices for these sludges will have a very significant influence on market penetration. However, such relationships have not been significant in fertilizers as such. Fertilizers are important enough to crop yields and a small enough part of the total cost of farming that even moderately significant price changes have not resulted in statistically significant changes in consumption patterns. Only when fertilizer prices doubled and tripled a few years ago was there found a significant market resistance to higher prices. Because of the factors stated above, it is believed that the lack of sensitivity will not be the case with sludge products and that, even if applied at no cost, a large number of farmers will refuse to use them. Furthermore, if prices at or near fertilizer values are charged it is doubtful that many farmers will use them.

TABLE 41

MAXIMUM AGRICULTURAL VALUE OF WASTEWATER SLUDGE PRODUCTS AS FERTILIZER

I. Value per acre

Nutrient	Application Rate (lb/acre)	Spring, 1977 Price ($/lb)	Value ($/acre)
N	100	$0.178	$17.80
P_2O_5	70	0.160	11.20
K_2O	120	0.077	9.24
Delivery and application			1.75
Cost of fertilizer applied			$39.99
K_2O values not present in sludge		$9.24	
Delivery and application		$1.25	—$10.49
Net value of sludge			$29.50

II. Value per unit of volume and per unit of weight

Effective Nitrogen Contents of Dry Solids	Value $/Ton Dry Solids	Value $/Thousand Gallons at Percentage Solids Concentration			
		2 percent	15 percent	20 percent	40 percent
0.3 percent	$ 1.77	$0.30	$ 2.36	$ 3.18	$ 6.90
1.0 percent	5.90	0.99	7.86	10.62	23.00
2.0 percent	11.80	1.98	15.72	21.23	45.99
3.0 percent	17.70	2.97	23.58	31.85	68.99
5.0 percent	29.50	4.95	39.30	53.08	114.98

Source: Arthur D. Little, Inc.

In most counties, the treatment plants are expected to produce sludges containing nitrogen equivalent to less than 2 percent of the total nitrogen consumption in the county. After sufficient experience is gained in using the sludges to determine that crop yields can be achieved similar to those using commercial fertilizers, probably all of the sludges could be sold at a delivered and applied price of approximately two-thirds that of commercial fertilizers, or $400 per ton of effective nitrogen. However, the spreading of all sludges from the two large Milwaukee plants would require achieving a market share of nitrogen equivalent to from 6 to 14 percent of total use of nitrogen on all crops in the Region in 1975/76. When it is considered that much of the land is not suitable for sludge spreading for one reason or another, the market share relative to the available land must be much larger still.

Total corn acreage in the seven southeastern Wisconsin counties is 279,000 acres.[1] Because of grade, cropping practices, soils, and the need for buffer zones, probably about two-thirds of this area is not suitable for spreading sludges, leaving about 90,000 acres in corn as an available market share. Currently, the average annual application rate is approximately 100 lb of nitrogen per acre, or a total of 4,500 tons of nitrogen on the available 90,000 acres. Nitrogen application rates have been increasing and are expected to continue to increase in the future, probably to 125 lb per acre in 1980 and could even reach 200 lb per acre by 1990, as crop varieties and general agricultural practices improve. It is possible that these application rates could increase further beyond 1990, but this would require significant improvements in corn varieties and agricultural practices, to accompany and complement the increased fertilizer application rate. Thus, the total potential market until the year 2000 is estimated to increase to 9,000 tons of nitrogen per year, as shown in Table 42.

[1] *"1976 Wisconsin Agricultural Statistics," from Wisconsin Statistical Reporting Service, Madison, WI.*

The available nitrogen from all of the large plants in southeastern Wisconsin will increase with time, approximately as shown on the previously mentioned table. This indicates that from about 1990 to the year 2000, all of the plants will need to serve from 13 to 15 percent of the total available market at a minimum and from 31 to 33 percent at a maximum.

While no one can predict with accuracy a price/volume relationship 10 to 20 years forward for a product for which there has been very little practical experience, it is believed that with education relative to safety and application rates, perhaps 50 percent of the potential farmers will use sludges. However, it is doubtful that farmers will purchase it at a price equal to that of commercial fertilizers. Considering this, the following price/volume relationship has been prepared, which indicates that at a price of one-half to two-thirds of the price of commercial fertilizers as applied to the soil, 10 to 15 percent of the market might be penetrated. As the price approaches zero, from 30 to 50 percent of the market might be penetrated. However, such a market is actually quite a bit larger than it might seem. As shown in Table 43, if the sludge is given away, it may be possible to increase the application rate per acre so that effectively the sludge market share is in the range of 45 to 75 percent, so long as by doing so, limits for heavy metals or for the leaching of nitrogen into groundwaters are not exceeded. Today that would mean that instead of spreading 100 lb per acre, it would be possible to spread 150 lb of nitrogen per acre. As farming practices improve, recommended

TABLE 42

NITROGEN AVAILABLE IN SLUDGES

			Available in Sludges[1]			
	Average Annual N Application Rate	Potential Market (Tons N)	Tons N		Percentage of Potential Market	
			Min.	Max.	Min.	Max.
1975	100 lb/acre	4,500	—	—	—	—
1980	125	5,625	962	2,186	17	39
1990	200	9,000	1,200	2,800	13	31
2000	200	9,000	1,332	3,006	15	33

[1] *The difference between the minimums and maximums is related to options open for different sludge process trains at MSD-Jones Island and MSD-South Shore.*

Source: Arthur D. Little, Inc.

application rates of nitrogen are likely also to increase, and these recommendations could conceivably reach 300 lb per acre in the future.

It can be seen, then, that if the maximum amount of nitrogen-containing sludges are to be produced (in which case, over 30 percent of the available market must be penetrated), and if there is competition in all counties in the Region from the MSD plants, it will be necessary to provide the farmer with the sludge completely applied at zero cost. On the other hand, if the minimum amount is produced and made available in the Region, in which case 13 to 17 percent of the market must be penetrated, it may be possible to charge from $100 to $300 per ton of effective nitrogen. Furthermore, if the MSD plants are able to dispose of their sludges in some other manner, leaving the entire market to the smaller plants, a price of up to $400 per ton of effective nitrogen might be charged.

TABLE 43

ESTIMATED MARKET PROPORTION FOR SLUDGE PRODUCTS

Applied Price (dollar/Ton N)	Share of Available Market (percentage)
590	0
400	10
300	15
100	20-30
0	45-75

Source: Arthur D. Little, Inc.

Marketing Aspects

In promoting the land application of sludge, consideration must be given to the attitudes towards this practice by both farmers and nonfarm rural residents.

Farmers—Farmers are generally favorably inclined towards the use of sludge as long as this practice does not significantly disrupt normal farming operations. Many farmers report an improvement in their soil in terms of structure, tilth, and fertility. In western Wisconsin, where soils are quite sandy, noticeably visual results have been reported, even with one application of sludge. This is an ideal type of evidence to influence the decision to use sludge. Demonstrated cost effectiveness at agricultural experiment stations and word-of-mouth advertising are also viable methods for promoting landspreading of sludge.

In developing the market for sludge as a fertilizer and soil conditioner, it is important to have extension agents or others with agricultural back-grounds work with the farmers to provide the technical information which will be requested relating to nutrient content, heavy metal content, odor, and other concerns. Where a careful job of preselling has been done, especially in predominantly rural areas, the demand for sludge normally exceeds the supply.

Nonfarm Rural Residents—One of the greatest problems in dealing with the land application of sludge in rural areas with a significant population of nonfarm residents is the objection to this practice which develops among these residents. These objections are often based on highly conservative health and safety considerations, although some towns have recently banned sludge spreading simply on the basis of aesthetics. Much will depend on the pressures and information brought to members of the governing boards of the various units of government in southeastern Wisconsin.

A program of public education is essential, to point out the advantages of sludge spreading and also to allay unfounded fears relating to the health and safety of the practice. Public participation meetings represent one approach to educating the public. A more effective, although admittedly more costly, approach is to talk individually to the nonfarm rural residents who are likely to be affected by sludge application in their town or who have expressed opposition to this concept, although no direct effect may be apparent. In this case, the nonfarm rural residents of a given area are best approached by individuals with interests and backgrounds similar to their own. Such administrative costs are included in the analyses of Chapter IX.

In working with both farmers and nonfarm rural residents, it is important to emphasize the benefits to all concerned and to correct any wrong impressions concerning the safety and health of this practice. Because odor is the most common reason for objection on the part of nonfarm rural residents, careful attention to application techniques and timing is important. To promote cooperation, coordination, and understanding, a joint meeting between the farmer, potentially affected nonfarm residents, and representatives of the state or the wastewater treatment plant would be beneficial. With proper attention to the interests and concerns of the several parties impacted by sludge spreading, the categorical banning of this practice should not be a problem.

MARKETS FOR ENERGY DERIVED FROM WASTEWATER TREATMENT PLANT SOLIDS

Attention is currently being directed to several areas of interest regarding energy utilization at municipal wastewater treatment plants. These facilities are often large consumers of purchased electricity and fossil fuels. Increased cost and diminished supply of these conventional energy sources has led to investigation of energy consumption, and the potential for energy production using recovered waste products at treatment plants. Because of their relatively large size, the MSD-Jones Island and MSD-South Shore plants have been investigated for the purpose of characterizing and quantifying the potential for recovering, utilizing, or marketing energy from residual or waste solids. Specifically, the question is whether there is potential to generate a significant quantity of energy in a marketable form and, if so, to identify uses or markets for this commodity.

Energy studies include the following considerations:

1. sources of energy for wastewater treatment operations including outside electric power, natural gas, coal, and fuel oil

2. allocation of these conventional energy forms to various processes within the treatment plants

3. conservation of purchased power and fossil fuels by such measures as the addition of waste heat recovery equipment

4. utilization of the energy potential of various waste products, such as electric power generation from sludge digester gas or combustion of sludge with energy recovery for heating or drying purposes.

Operating Data—The tabulation of 1976 energy data in Table 44 for both of the MSD treatment plants indicates the current level of consumption of conventional fossil-fuel derived energy. These energy forms include electric power purchased from a private utility, and natural gas and fuel oil purchased from private fuel suppliers. Most of the purchased fuel is used for on-site electric power generation at the treatment plants. This is accomplished by the use of gas turbines at MSD-Jones Island and gas engines at MSD-South Shore.

Energy Conservation—The two treatment plants which can be considered here are leaders in energy conservation, as demonstrated by the following systems:

1. The MSD-Jones Island plant recovers waste heat from gas turbine generator exhaust for use in sludge dryers

2. The MSD-South Shore plant generates roughly 50 percent of the total treatment plant electrical load from generator sets fueled by sludge digester gas.

TABLE 44

PURCHASED ENERGY

	Jones Island Plant	South Shore Plant
Electric power (purchased) . .	(10,700,000 kwh) 36,500 million Btu	(3,200,000 kwh) 10,900 million Btu
Natural gas and fuel oil (purchased) . .	2,362,600 million Btu*	47,300 million Btu*
Total . . .	2,399,100 million Btu	58,200 million Btu

**Most of this fuel is used for onsite power generation.*

Source: Camp Dresser & McKee Inc.

Additional Energy Potential—There are two principal alternatives for the planning of further energy recovery systems, namely offsite marketing to bulk energy consumers and inplant utilization. The source of this energy would be the residual solids from treatment processes, which currently are either converted to Milorganite, land spread, or disposed of at landfills. There are several forms which this energy could assume, in concept, for offsite market consumption. Each has a constraint of limitation which characterizes this energy as somewhat different from the more conventional alternatives and hence, in practice, affects the market value. Each of these forms and its distinguishing characteristics are listed below:

1. Sell the solids as a fuel supplement for use in large, solid-fuel boilers such as coal-fired electric utility boilers. The problem with this alternative is that treatment plant solids have a relatively low unit heating value because of high moisture content and have a variable chemical composition which represents some

jeopardy to the continuous reliable operation of power boilers. For example, the heating value per lb of wet sludge (40 percent solids) is typically around one-seventh the value of residual oil and one-fifth the value of coal. In short, electric utilities have expressed a distinct preference not to handle this fuel.

2. Produce and sell a fuel gas by pyrolizing the solids in equipment which is currently under development for this application. However, the operating experience of this equipment is limited, and the fuel gas has a relatively short distribution distance to the consumer. This constraint arises from the consumption of energy to compress this low Btu gas, if pipeline transmission is a part of the system. Similarly, storage of this fuel is impractical, because the heating value per cubic ft is approximately one-twentieth that of natural gas, as determined from autogenous pyrolysis of sludge at demonstration scale. Therefore, the ideal usage or purchase schedule should be uniform around the clock, to correspond with the schedule of fuel gas generation from sludge processing. Preliminary findings show Milorganite (sludge) energy usage at about 36 percent of total processing. The energy used to produce a synthetic fertilizer of a 6-2-0 formulation would be 352,800 million Btu at 70,000 tons of product per year.

3. Produce steam from solids through pyrolysis or incineration for sale to a bulk consumer. For offsite marketing, this alternative shares the limitation of establishing the nearby (within 1 mile) round-the-clock consumer which characterized the fuel gas system, because there is a limitation on distribution piping and no storage capability.

4. Produce electric power as a further refinement of steam production, thereby optimizing the acceptability of the energy form and reducing the distribution problem by not requiring a nearby consumer. However, three problems remain. One is that the total generating capacity would be quite small relative to a central station, thereby creating a reluctance on the part of an electric utility to purchase this energy and manage its transmission. Second, during offpeak hours, this energy competes with low-cost nuclear and coal plans, hence, has a reduced wholesale market value much of the time. Third, a public power generating facility would, in effect, be entering competition with private utilities.

Although the markets for offsite energy are characterized by obstacles to implementation, there is a potential for utilization which is logical and compatible with the solids quantities and characteristics. This is inplant use, which could assume a variety of forms, as described above, and as specified by allocation to various treatment processes.

For example, if all sludge which is currently used in Milorganite production or for landspreading (a total of approximately 300 tons per day on a dry solids basis) were to instead be thermally processed to produce electric power, the resultant energy (approximately 58 million kilowatt-hours annually) would represent roughly 60 percent of the electric power which currently is either purchased directly or generated from purchased fossil fuel, for these two treatment plants.

Electric power generation represents one concept for energy recovery from sludge, which provides a quantitative comparison of energy inherent in the sludge and energy consumed in the wastewater treatment plants. In practice, however, the recovered energy might include process steam or dryer heat in the form of flue gas, as well as electric power, based on considerations of highest energy value, equipment reliability, and availability of fossil fuels. On the basis of 1976 energy costs to the MSD treatment plants, the total amount of energy contained in current sludge quantities would have the approximate replacement value of $2,030,000 in purchased electric power or $2,060,000 in purchased natural gas. These costs are expected to increase in the future.

In summary, there is in concept no excess energy from solids available for offsite marketing, if the treatment plants themselves are given priority for this energy. It is a matter for detailed facilities planning to determine the specific forms and allocations of the various components of energy within each plant.

Energy Recovery Potential Summary—The two principal alternatives for further energy recovery at the two Metropolitan Sewerage District Plants are: (1) offsite marketing and (2) inplant utilization. Several market areas are listed below:

1. Sell the sludge as a fuel supplement for use in solid fuel boilers such as coal-fired utility boilers. Wisconsin Electric has not expressed an interest in this concept because of the low fuel value and variable fuel composition of the

available material.

2. Produce and sell a fuel gas from pyrolized solids. The operating experience with this equipment is limited and of questionable success, and the product is of a low heat value which imposes a short distribution distance and limits the potential market.

3. Produce steam by incineration or pyrolysis and sell to a bulk purchaser. A round-the-clock consumer within 1 mile of the plant is required to make this alternative attractive.

4. Produce electric power as a further refinement of steam production. With the relatively small generating capacity of this station, it is unlikely that a utility market could be developed for this power, in view of the transmission management problem and other related economic problems.

Given the various constraints summarized above, the potential for inplant utilization of recovered energy appears far greater than sale to offsite users. Preliminary computations indicate that approximately 60 percent of the electric power which currently is either generated onsite or purchased by the MSD could be produced onsite by the fuel value of the existing solids. Thus, it would appear that the two District treatment plants, even with improvements and full recovery of energy from sludge, will remain energy consumers, dependent on outside sources for a portion of the energy supply. The total amount of energy contained in the sludge is equivalent to about $2 million in natural gas or electricity at 1976 market prices. The same conclusion holds for other wastewater treatment plants in the study area. The total quantity of raw municipal sludge solids generated by all plants other than MSD-Jones Island and MSD-South Shore in 1975 is about 59 tons/day. If all this sludge were properly anaerobically digested, it would yield approximately 830,000 cu ft of digester gas per day with an annual value based on 1976 natural gas prices of about $130,000. This represents a recovered sludge product for inplant use. Nevertheless, consideration should be given, in any treatment plant modifications, to maximizing the recovery of energy from sludge and conserving energy use.

SUMMARY

The three products considered in detail and discussed above are Milorganite, compost, and liquid or cake sludge. Table 45 shows the relative potential markets for these products and other important factors. The strongest approach would be to spread the product volume over several market sectors, not expecting any one market to take the full amount. Energy derived from sludge should be used within the wastewater treatment plants, because there is not enough available for offsite sale. Therefore, there is no offsite market for energy sale. If all or a portion of the sludge generated at the two Milwaukee wastewater treatment plants or

TABLE 45

SUMMARY OF SLUDGE PRODUCT MARKET CONSIDERATIONS

	Milorganite	Compost	Liquid or Cake Sludge
Major use	Professional and home turf or lawn	Professional and home landscaping	Farm
Market location	National	Regional	Regional
Market size	Adequate for MSD	Adequate for MSD-South Shore	Marginally adequate for entire region
Price elasticity	Moderate	High	Very high
Augmented product	Not recommended	Not recommended	Not recommended
Seasonality	Moderately high	High	Very high

Source: Arthur D. Little, Inc.

other large plants were converted to energy, the sludge available to market would be accordingly reduced or eliminated. It should also be recognized that competing forms of chemical fertilizers require large expenditures of energy in their production.

Strategy to market the sludge-derived products in terms of packaging, promotional literature, field salesmen, points of distribution, etc. must be developed by the wastewater facilities districts, cities, counties, towns, and villages. Formal strategy, as related to Milorganite, depends on the needs of the District. Conflict between the three listed products should be avoided, because they are produced and marketed as complementary materials.

Chapter V

SLUDGE CHARACTERISTICS

INTRODUCTION

The large quantities and varying characteristics of municipal and industrial sludges generated in the Region can create serious problems for disposal or utilization; therefore, an analysis of the nutrient content and chemical constituents of these sludges is essential to evaluation of regional alternatives. Sludges generated within the Region have varying physical and chemical characteristics because of the type of customer served and the wastewater treatment processes used by plants in the Region.

Analytical data on sludge from plant records and a supplemental sampling conducted by SEWRPC and DNR were used to establish the characteristics of sludges being generated at the treatment plants in the Region. The results of the analyses which follow indicate that the concentration of chemicals in the sludges vary widely from plant to plant and within the samples from individual plants. Such variations are considered normal and are caused primarily by intermittent flows from various industrial users, differences in municipal and industrial wastes entering a plant daily and weekly, infiltration/inflow entering the sewerage system and spot sampling procedures utilized.

Sludge quantities expected by the year 2000 at the municipal facilities, described herein, are discussed at the conclusion of this chapter. Quantity projections for industrial sludges, septage, and holding tank wastes are also presented. Additional sources of sludge within the Region are located primarily within the service area of the Metropolitan Sewerage District of the County of Milwaukee. They are combined sewer overflows and stream bottom sediments.

With this knowledge of sludge quantities and characteristics, it was possible to develop treatment and utilization or disposal options consistent with guidelines and regulations governing each option (see Chapter VI).

Utilization/disposal options, such as land application in its various forms (liquid or solid spreading, composting, soil conditioner/fertilizer), landfilling, incineration or pyrolysis present problems such as: health hazards, odors, ground and surface water pollution and air pollution in different degrees depending on the option considered and on the chemical constituents present in the sludge. Since land application of sludge is now extensively practiced in the Region, and, for most facilities is likely to continue (see Chapters IX and X), each major category of sludge constituent and the constraints affecting land application are discussed in detail. For the other possible disposal options, the problems associated with these same constituents are also discussed in this chapter.

CHARACTERISTICS OF MUNICIPAL SLUDGES

The principal sludge quality characteristics are chemical, nutrient, organic and moisture content. The chemical and nutrient content of sludges are discussed in detail because sludges in this Region are widely used as a source of nutrients for crops. Landspreading is a cost-effective approach to the utilization/disposal question; however, crops can be sensitive to these quality characteristics of sludges. Data on sludge quality are presented in Appendix E. It should be kept in mind that municipal sludges are affected by industrial waste discharges to municipal wastewater treatment plants. Regulatory requirements for industrial waste discharges to municipal systems are being developed and are discussed in Chapter VI.

Heavy Metals

The heavy metals in wastewater sludges may present serious health hazards to humans and animals whether sludge is applied to land for its value as a soil conditioner or fertilizer or whether it is burned for its energy value.

Relative to land application some of the heavy metals are essential plant nutrients (copper and zinc) and, if the available concentrations of these elements are too low, crop yields may be reduced. However, an overabundance of these metals or the presence of other nonessential toxic metals (cadmium, lead, and mercury) above certain concentrations may result in toxicity to plants. Heavy metals may be taken up by plants and concentrated within various plant parts; and, therefore, these toxic metals may be passed along to humans directly or indirectly via herbivorous animals. Mercury and lead are usually not a problem with land application because plant selectivity and chelating agents in the soil tend to limit their mobility and incorporation in plants. However, cadmium is much more mobile in soil and is more readily available for plant uptake.

Introduction of heavy metals to the soil by landspreading or landfilling may result in groundwater contamination. Soils with shallow depth to bedrock, high permeability rates, or short vertical distances to groundwater should be avoided. At landfill sites, decomposition of the organic matter in sludge will gradually lower the pH and dissolve heavy metals resulting in the need for leachate collection and treatment.

Surface water contamination by heavy metals can occur from surface run-off. To minimize contamination by this means sludge should be incorporated promptly into the soil, and site topography should be relatively flat. Cadmium (along with PCB's and pesticides) may represent the greatest hazard to humans, because of its easy uptake by many plants and its mobility in soils at reduced pH levels. The interrelations of heavy metals and their concentration in higher levels of the food chain are not yet completely understood. Prediction of acceptable and safe levels for sludge applicaton depends on various soil attributes, including pH (degree of acidity or alkalinity), humus content, moisture, nutrient level, and plant uptake rates. As a result, the safety of sludge application to land is of concern to home gardeners and farmers utilizing sludge for growing edible crops.

Guidelines on land application of sludge, as discussed below, may sometimes not apply where lands are publicly owned and agricultural use will not be practiced. When privately owned land is not now intended for agricultural use, the possibility of its future agricultural use remains. Thus, limitations presented by various researchers and in Technical Bulletin No. 88 are generally considered to apply to all privately-owned land and publicly owned land.

For disposal by incineration and pyrolysis, the heavy metals (cadmium, chromium, lead, zinc, and mercury) which are generally at low concentrations in the sludge can occur at high concentration within the submicron particle stream which passes through air pollution control devices. Since these particles and heavy metals can be deposited in the innermost regions of the human respiratory system, toxic effects may be manifested in the human respiratory tract[1].

[1]*Natusch, D.F.S., Wallace, J.R., and Evans, C.A., Jr., 1974. "Toxic Trace Elements: Preferential Concentration in Respirable Particulates," Science, 183: 202-204.*

Sidestream treatment of scrubber water from air pollution control equipment on incinerators and pyrolysis units is necessary because the scrubber water may contain small amounts of some heavy metals. These sidestreams can be treated separately by flocculation and sedimentation. Ash resulting from incineration or pyrolysis of sludge containing heavy metals may contain relatively high concentrations of such metals requiring carefully controlled disposal or utilization.

Content of Heavy Metals in Sludges—All wastewater sludges produced in the U.S. contain heavy metals though concentrations vary considerably. Those which pose varying dangers to the environment include cadmium, chromium, copper, lead, mercury, nickel, and zinc. The potential toxicity of these metals is illustrated in Table 46. As discussed later, these metals do not all accumulate in plants to the same degree.

TABLE 46

POTENTIAL TOXICITY OF HEAVY METALS

	Essential to		Potential Toxicity to	
Element	Plants	Animals	Plants[1]	Animals
Cadmium (Cd)	No	No	Moderate	High[2]
Chromium (Cr)	No	No	Low	Low
Copper (Cu)	Yes	Yes	High	Moderate
Lead (Pb)	No	No	Low	High[2]
Mercury (Hg)	No	No	Low	High[2]
Nickel (Ni)	No	Yes	High	Moderate
Zinc (Zn)	Yes	Yes	Moderate	Low

[1]*When metal is applied to soil.*
[2]*Cumulative effects.*

Source: Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin (Dept. of Natural Resources), Technical Bulletin No. 88, Madison, Wisconsin, 1975.

Heavy metal concentrations can vary seasonally, weekly, daily, and even hourly within sludges generated by a single service area. Sludges generated in this Region are discussed below, and concentrations are presented on a dry solids basis. Those treatment facilities which, based on the available data[2], appear to have sludges

[2]*Sludge Quality Sampling Data are given for each major municipal plant in Appendix E.*

containing concentrations above what are normally found in the Region have been indicated.

1. Cadmium. The average value for the data is approximately 25 mg/kg dry solids, and the range was from 1 to 977 mg/kg. MSD-Jones Island, MSD-South Shore, Hartford, Kenosha, Twin Lakes, Whitewater, Racine, and West Bend plant sludges show relatively high concentrations.

2. Chromium. The average value for the data is approximately 200 mg/kg, and the range was from 30 to 18,000 mg/kg. MSD-Jones Island, MSD-South Shore, Cedarburg, Oconomowoc, Waukesha, South Milwaukee, and Hartford plant sludges show relatively high concentrations.

3. Copper. The average value for the data is approximately 450 mg/kg, and the range was from 300 to 4,000 mg/kg. MSD-South Shore, Cedarburg, Kenosha, and Waukesha plant sludges show relatively high concentrations.

4. Lead. The average value for the data is approximately 300 mg/kg, and the range was from 50 to 4,400 mg/kg. Racine, MSD-Jones Island, MSD-South Shore, and West Bend show relatively high concentrations.

5. Mercury. The average value for the data is approximately 9 mg/kg, and the range was from 0.1 to 75 mg/kg. Whitewater, Oconomowoc, Burlington, and Hartland show relatively high concentrations.

6. Nickel. The average value for the data is approximately 60 mg/kg, and the range was from 13 to 780 mg/kg. It appeared that Kenosha and MSD-South Shore plants have relatively high concentrations.

7. Zinc. The average value for the data is approximately 1,800 mg/kg, and the range was from 600 to 6,000 mg/kg. Kenosha, Oconomowoc, Racine, Twin Lakes, Waukesha, and MSD-South Shore have relatively high concentrations.

Interaction With Soils—Physical and chemical properties of soil play a major role in determining suitable sludge application rates. However, the chemical interactions between soil and sludge remain unclear. Based on heavy metal uptake by plants, the allowable rate of applications appears to be related to four principal phenomena: (1) ion exchange, (2) adsorption, (3) precipitation, and (4) complexation or chelation. Specific soil-plant relations which influence metal uptake include pH, cation exchange capacity (CEC), total phosphorus, organic matter, reversion in soil, crop variety and species, plant components (root, stem, leaf, seed), and plant age. Soil pH, which can be regulated, greatly affects metal uptake. In general, the higher the pH, the more immobile metals become.

Cation exchange capacity (CEC) affects metal retention by the soil, thereby limiting availability to plants. Because the concentration of metals which can be retained in this manner is quite variable, a comprehensive evaluation of soil CEC is necessary to establish allowable metal loadings. Heavy-metal fixation is achieved by a stabilization process which reduces the mobility of a cation (positively charged particle). CEC refers to the exchange capacity of both the organic fraction within the soil and the colloidal fraction. Because wastewater sludges contain a large volume of organic substances, the availability of heavy metals to plants might actually be reduced, although the sludge itself contains additional quantities of heavy metals. This appears to be especially true of copper and nickel.

Phosphorus readily combines with numerous metals to hold them in the soil, thus limiting their availability to plants. High concentrations of phosphates might also result in iron deficiencies (chlorosis), in combination with excessive levels of copper and nickel. Phosphates are not totally selective in their binding reactions and can fix much of the available iron. In addition, overfertilization with phosphates might enrich surface waters, leading to eutrophication problems.

Organic matter in the soil might limit the availability of heavy metals by chelation; that is, by binding heavy metals in complexes which are not readily utilized by plants. These complexes might be more mobile in soil, if they are soluble. Chelation might be more useful in binding heavy metals than simple cation exchange.

It has been noted that heavy metals can become immobilized in soil by the slow process of "reversion" (whereby toxic metals "revert" to forms less available to plants). The mechanics of this process are generally poorly understood, but reversion has been postulated to be a solid state diffusion of metal into crystalline material, including the clay and organic fraction of the soil.

Interaction With Plants—Certain concentrations of heavy metals are toxic to plants, and thus crop selection is an important consideration in land application of sludges. Of the metals contained in wastewater sludge, only copper, nickel, and zinc appear to have serious toxic effects. However, there is some evidence to show that cadmium has an effect on certain types of soybeans. In addition to the above, background levels of metals, as well as the level or degree of binding agents present in the soil, must be known. Interactions among copper, nickel, and zinc and reactions with other soil constitutents (clay, phosphates, organic matter) are not always predictable, and secondary effects on the availability of other metals, principally iron, must be considered.

Hinesly et al[1] indicated that allowable application rates of heavy metals might be higher than those determined by other researchers. Hinesly reported no adverse effects on corn crop yields of metal concentrations previously assumed to be deleterious. Segregation of heavy metals by certain plant species is an important factor in establishing loading rates. Interaction with higher levels of the food chain must also be considered and is particularly important to industrial farming operations.

Crop Uptake-Food Chain Concentration—Plants require certain nutrients to sustain growth. These nutrients are utilized via a number of complex processes, and heavy metals are frequently introduced with them. If the metals are not required for growth, they may be stored or concentrated within a specific segment of the plant. The location and extent of these concentrations are important in the total food chain system.

Heavy metals in the stem or fruit may accumulate in the animal (or human) which eats the plant. Cadmium is normally concentrated within liver and kidney tissues. Lead and mercury, although not taken up as rapidly by plants as cadmium, also accumulate in various human organs. Although small quantities generally do not pose a threat to health, continued ingestion of affected foods might prove hazardous. Over a period of time, this accumulation might cause deterioration of liver and kidney functions. The process of metal concentration makes humans and animals much more susceptible over a long period of time to various metal toxicities. Unfortunately, the mechanisms which concentrate metals, and to what degree, are not yet fully understood.

[1]*Hinesly, T.D., Braids, O.C., Molina, J.E., Dick, R.I., Jones, R.L., Meyer, R.C., and Welch, L.F., 1972. "Agricultural Benefits and Environmental Changes Resulting from the Use of Digested Sludge on Field Crops," Grant No. 001-UZ-0080.*

Crop Selection and Segregation—Segregation of heavy metals within the plant might limit their concentration in the food chain. Some plant species concentrate toxic heavy metals within certain parts (stem, root, fruit, etc.). If the marketable portion of the plant concentrated heavy metals, its utility for sludge application sites would be severely limited or nonexistent. For these purposes, the "useful" portion of the plant should be relatively metal-free. Of course, the eventual disposal of the nonuseful portion of the plant containing the concentrated heavy metals could return such metals to the soil.

Heavy metal uptake by plants, and subsequent concentration in humans and animals, can be somewhat controlled by careful selection of plants for the application site. Not all plant species respond to heavy metals in the same manner. Tolerance levels, uptake quantities, and segregating operations vary significantly. The ideal crop is one which will exclude or introduce the lowest levels of toxic and nonessential heavy metals to the food chain. Factors relevant to this selection are discussed below.

For a long-term program, plant species which are not adversely affected by heavy metals (as measured by crop yield reductions and heavy-metal uptake) are desirable. To consume as much of the excess nutrients introduced with the sludge as possible, maximum growth is required. Tolerance level, crop yield, and nutrient uptake must be considered in crop selection. The best possible return is essential, to keep sludge application costs low. Crop tolerance and potential yield are critical variables in this respect.

Crops very sensitive to toxic metals include the beet family, turnips, kale, mustard, and tomatoes. Beans, cabbage, and collards are less sensitive. Corn, small grains, and soybeans are moderately tolerant. Of particular importance in the selection of crops for growth on sludge amended soils is the selectivity of the plant itself, i.e. certain parts of the plant—stem, leaves, seeds—may not concentrate the toxic metals. Of the crops mentioned above, corn is the best for use on sludge-amended soil; it has a high nitrogen uptake and the heavy metals, particularly cadmium, are assimilated into the stem and leaves, rather than into the kernels. The most tolerant of all species are the grasses. In this Region grasses include the species of brome grass, timothy, canary grass, sudan grass, and red clover.

The ultimate use of the proposed crop must be considered. For example, grain crops are raised primarily for their fruit, as opposed to alfalfa, which is raised for its stem, leaf, and fruit. Some crops, such as forest crops, are not ingested by humans or domestic animals and would not directly affect the human food chain.

Application of sludges to lands which might be used to grow crops must be accomplished so as to ensure that cropland resources are protected and harmful contaminants are not accumulated in the human food chain. Pasture crops should not be consumed by animals while these crops are physically contaminated by sludge.

Evaluation and selection of the ultimate crops depend on the above considerations, as well as harvest procedures, length of time the site is to be utilized, and price per quantity produced (profitability).

Surface Water Contamination—Heavy metals in wastewater sludges can enter surface waters, if:

1. sludge is applied to steep slopes subjected to rapid runoff rates

2. sludge is applied to sites close to surface waters (rivers, lakes, streams)

3. sludge is applied to soil shortly before or during rainy periods, if not injected

4. sludge is applied to soil with a high percentage of liquid.

Heavy metals may have toxic effects on aquatic biological communities and are highly susceptible to uptake. The threat to humans is again present by food chain concentration.

Groundwater Contamination—Application of wastewater sludges containing heavy metals might contaminate groundwater sources. Processes which bind or fix metals to soil also play a major role in controlling groundwater contamination. Each type of soil has a limited capacity to receive and bind heavy metals. Soil properties discussed previously include cation exchange capacity, pH, organic matter, and phosphorus form and availability. Ultimate migration of these metals through the soil depends on such factors as depth of soil to groundwater, nature of soil, humus content, quantity of metals applied, length of sludge receiving period, and time (season) of application.

Groundwater contamination is usually not observable for some time, unless the application rates are inordinate. Contamination of large aquifers might not become apparent for years, with irreversible effects. Soil pH again appears to play a significant role in limiting heavy metal breakthrough to the groundwater system. It has been found that heavy metals are more mobile in the soil and available to plants when soil pH drops below 6.5.

Heavy Metal Application Criteria—Currently, allowable safe sludge application rates are highly controversial in the U.S. A number of individuals have attempted to establish formulas for limiting heavy metal application to land sites. Chumbley[1] proposed a "zinc equivalent" formula, based on the relative toxicities of zinc, copper, and nickel. He established that copper was twice as toxic and nickel eight times as toxic as zinc. Chumbley also proposed that no more than 250 ppm (Zn equivalent) of toxic metals be added to the soil in any 30-year period. This formula does not fully consider the wide variance in tolerance of plant species or the many factors which affect binding of these metals to soils.

The National Swedish Board of Health and Welfare limits sludge application rates to 0.5 ton/acre/year. This policy might not be warranted, based on experience in the U.S.

Chaney[2] incorporated soil sorption (absorption and adsorption) properties in his formula and proposed to limit the total zinc equivalent to 5 percent of the soil CEC. The U.S. EPA subsequently incorporated this criterion, with minimal alterations, in early drafts of the proposed technical bulletin on Municipal Sludge Management. The equation published by EPA to calculate maximum metal equivalent loadings in relation to metal toxicities to plants is:

[1]*Chumbley, C.G., 1971. "Permissible Levels of Toxic Metals in Sewage Used on Agricultural Land," A.D.A.S. Advisory Paper No. 10, Ministry of Agriculture, Fisheries, and Food, Wolverhampton, England.*

[2]*Chaney, Rufus L., 1973. "Crop and Food Chain Effects of Toxic Elements in Sludges and Effluents, "Proc. of the Joint Conf. on Recycling Municipal Sludges and Effluents on Land, EPA, USDA, and NASULGC: 129-141.*

Metal Equivalents per ton of sludge =

$$\frac{32{,}700 \times \text{CEC}}{(\text{ppm Zn}) + 2\,(\text{ppm Cu}) + 4\,(\text{ppm Ni}) - 200}$$

where

CEC = cation exchange capacity of soil, milliequivalents/100 g
ppm = mg metal per kg dry weight of sludge
denominator = Zn equivalents, taking into account higher plant toxicities of Cu and Ni

According to Technical Bulletin No. 88[1] this equation is, "difficult to use because of the inherent variability of sludges with source and time." However, it can readily be modified to a more usable form permitting calculation of total metal loadings on a lb/acre basis as:

Total allowable metal equivalent loading = 65 × (CEC) lb/acre and metal equivalents in pound per ton of sludge can be calculated from:

Metal Equivalents per ton of sludge =

$$\frac{(\text{ppm Zn}) + 2\,(\text{ppm Cu}) + 4\,(\text{ppm Ni})}{500}$$

Under Technical Bulletin No. 88, total sludge loading for a particular site is an accounting of the yearly metal loadings expressed as lb/acre of metal equivalents. The resulting site lifetime for sludge application can then be computed using these assumptions from the total metal equivalent allowable on the soil's cation exchange capacity and the amount of metal equivalents applied with the sludge each year.

In addition to these total metal equivalents limitations, Cd additions must be limited to a maximum of 2 lb/acre/yr with a total site lifetime maximum of 20 lb/acre. The recommended maximum of 2 lb/acre/yr is based on the results of an experimental sludge application program in Wisconsin. The findings show that concentrations above 2 lb/acre of sludge-derived cadmium cause a marked increase in the cadmium content of the vegetative tissue of certain crops grown on these plots.

[1]*Department of Natural Resources, "Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin," Technical Bulletin No. 88, Madison, Wisconsin, 1975.*

Hinesly et al[1], working with sludges from the highly industrial metropolitan area of Chicago (with Cd concentrations of 200 to 600 mg/kg– far above the limit suggested by EPA in the draft technical bulletin Municipal Sludge Management), did not find their application to be detrimental. Loading rates based on Chaney's zinc equivalent were surpassed by 4.5 to 6.4 times, without apparent phytotoxicity.

EPA subsequently published a draft document, Municipal Sludge Management: Environmental Factors[2], for public comment, which is currently under EPA review. This document did not present the zinc-equivalent formulation. Instead, the document states in Section 2-4.2:

> "... Because of the wide variety of conditions that can affect the level of heavy metals that may be toxic to plants or taken up by the crop and eventually consumed by humans as part of their diet, absolute numerical limitations are not appropriate. It is recommended that the project conform to any limitations established by FDA or USDA. Where a sludge relatively high in heavy metals content is used, the following measures are prudent:
>
> Reduce heavy metals contamination in the sludge by pretreatment of wastewaters from industrial users;
>
> Maintain a high pH (above 6.5) in the combined sludge and soil;
>
> Concentrate on growing grain crops as opposed to leafy vegetables;
>
> Intensify monitoring of heavy metals in the sludge, soil, and plant tissues ..."

After reviewing an early draft of the EPA technical report, the USDA had submitted comments to the Office of Management and Budget on Section 2-4.2. The comments were as follows:

> "2-4.2. Protection of Agricultural Lands. The following interim criteria are based on recom-

[1]*Hinesly, 1972. "Agricultural Benefits and Environmental Changes Resulting from the Use of Digested Sludges on Field Crops."*

[2]*Environmental Protection Agency (EPA), 1976. Municipal Sludge Management: Environmental Factors, Federal Register, Vol. 41, No. 108.*

mendations of the U.S. Department of Agriculture. These limits are based on experiments directed at the determination of levels of heavy metals which are toxic to plants or absorbed by plants. Because of the great uncertainty concerning the appropriate level of intake by humans of these heavy metals as part of their diet, EPA cannot say that these levels constitute the appropriate levels for human intake. To the extent, however, that the limits represent an attempt to keep the levels of heavy metals in foods at a lower point than would otherwise be the case, these limits will make a contribution to the protection of public health. There will be two categories of land application of sludge; (1) Application to privately owned land (hereafter denoted privately owned land) and (2) Application to land dedicated to sludge application, e.g., publicly owned or leased land (hereafter denoted publicly controlled land.).

I. Application criteria for privately owned land. No greater amount of sludge borne metals may be applied than those shown below:

Maximum Cumulative Sludge Metal Applications for Privately Owned Land

Metal	Soil Cation Exchange Capacity (meg/100g)* 0-5	5-15	>15
	(Maximum metal addition, kg/ha[1])		
Zn	250	500	1,000
Cu	125	250	500
Ni	50	100	200
Cd	5	10	20
Pd	500	1,000	2,000

*(Determined on unsludged soil using the method utilizing pH 7 ammonium acetate for a weighted average to a depth of 50 cm.)

It is suggested that sludges having cadmium contents greater than 25 mg/kg (dry weight) should not be applied to privately owned land unless their Cd/Zn is <0.015[1]. Annual rates of sludge application on land should be the lower of the following two values (1 or 2):

1. Nitrogen requirement of the crop (inorganic N + 20% organic N).

   a. When incorporated, sludge should be applied at no more than 100% of the crop requirement for N.

   b. When surface applied, sludge should be added at no more than 150% of the crop requirement for N.

2. Cadmium loadings on land should not exceed 1 kg/ha/yr (0.89 lb/acre/yr) from liquid sludge and not more than 2 kg/ha/yr (1.78 lb/acre/yr) from dewatered sludge.

Sludge having a cadmium content greater than 1.5 percent of its zinc content should not be applied on a continuing basis unless there is an abatement program to reduce the quantities of cadmium in the sludge to an acceptable level. These metal additions apply to soils that are adjusted to pH 6.5 or greater thereafter (soil pH determined by 1:1 water, or equivalent method).

Growing leafy vegetables on sludge treated land is not recommended without monitoring the metal content of the crop.

Sludge should not be applied to soils with less than 50 cm (20 in.) of depth.

II. Application criteria for publicly controlled land. On publicly controlled land, up to 5 times the amounts of sludge-borne metals listed in the above table may be applied if the sludge is mixed into the 0-15 cm surface soil. Where deeper incorporation is practiced, proportionally higher total metal applications may be made. These metal applications apply only to soils that are adjusted to pH 6.5 or greater when sludge is applied.

[1]*kg/ha is equal to 0.89 lb/acre.*

[1]*Only one area sludge, with cadmium above 25 mg/kg had a cadmium/zinc ratio less than 0.015.*

If the sludge metal application rates exceed those recommended for privately owned land, metal analyses shall be provided to purchasers of marketed products. Purchasers may wish to consult the appropriate state and federal agencies concerning the relevance of these analyses.

These comments and recommendations are based on best available information and should be subject to revision as new information becomes available."

Sludge Suitable for Land Application—As noted in the previous section, Hinesly et al[1] have applied sludges with high concentrations of heavy metals. Many authorities recommend, however, that concentration of heavy metals in the sludge be limited, in addition to limiting the accumulation in the soils.

CDM met with Dr. Rufus L. Chaney of USDA in June 1976 to discuss USDA's views on sludges suitable for land application. According to Chaney, sludges recommended for application to privately owned land (whether used for agriculture or not) would not exceed any of the criteria presented in Table 47. However, sludges having concentrations up to 150 percent of these values could be applied to land, if there is an abatement program to control sources of heavy-metal addition to sewer systems. This presumes the abatement program would be successfully carried out.

The number of plants in the Region exceeding the Chaney criteria, based on available sludge data, are shown in Table 47. In general, if these criteria were accepted by the federal government and EPA as guidelines or regulations governing metal concentrations in sludge applied to land, source control programs would be necessary in many systems tributary to treatment plants in the Region.

Source Control—The heavy metals in municipal sewage sludge originate from industrial wastes, stormwater runoff, combined sewage, and the background levels present in domestic wastes. The industrial component of sludge may be reduced with an effective program of source control and the stormwater component of sludge generated at a plant may be increased through separation, control and/or treatment of combined sewer flows. (Currently, sludge containing heavy metals and other materials resulting from sanitary sewage and surface runoff is entering waterways from combined sewers during storm events causing overflow.) However, the background levels of heavy metals present in domestic wastes cannot be estimated.

[1]*Hinesly, 1972. "Agricultural Benefits and Environmental Changes Resulting from the Use of Digested Sludge on Field Crops."*

Municipalities with high levels of heavy metals in their systems (as shown in Table 47 and in the Sludge Quality Monitoring Data in the Appendix) should consider a program of industrial source control. Under such a program industrial discharges might be reduced by in-plant process changes or a pretreatment system for concentrating and recovering the valuable heavy metals.

The Metropolitan Sewerage District of the County of Milwaukee has completed a sampling program for heavy metals in several areas that are residential. A preliminary evaluation of the cadmium data shows that the residential contribution is slightly higher than the levels found in other cities (e.g., New York, Pittsburgh, and Muncie, Ind). Additional analysis of background levels of heavy metals is currently being prepared as part of the District's Total Solids Management Program. The District is also conducting a heavy metals source categorization study within its service area.

TABLE 47

PLANTS WITH HEAVY METALS IN EXCESS OF 1976 CHANEY RECOMMENDED CRITERIA

Element	Recommended Criteria	Number of Major Plants (21) in Excess	Number of Other Plants (12) in Excess
Zn	2,500 mg/kg	6	6
Cu	1,000 mg/kg	4	6
Ni	200 mg/kg	2	2
Cd	25 mg/kg	8	8
Cd/Zn	1.0 ratio	11	5
Pb	1,000 mg/kg	4	3
Hg	10 mg/kg	4	1
Cr	1,000 mg/kg	7	3

Source: Camp Dresser & McKee Inc.

Note: Facilities with heavy metals concentrations in excess of these amounts as indicated above can be found in the Sludge Quality Monitoring Data in Appendix E.

Nutrients

Wastewater sludges contain a number of basic nutrients such as nitrogen, phosphorus, potassium, and trace elements necessary for plant growth. Land application thus has obvious merit, because sludge cannot merely be disposed of but utilized and recycled to the environment in a safe and proper manner. The following paragraphs discuss the physical and chemical properties of nutrients contained in wastewater sludge.

Substances commonly grouped under the heading "nutrients" are quite diverse in nature and form. The extent to which each is required by plants varies. Nutrients obtained from the soil by plants include: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, manganese, copper, zinc, boron, and molybdenum (specific plants might require other elements as well). Deficiencies in any of these elements can inhibit growth in certain plants.

Nitrogen–Digested urban sludges typically contain two to five percent nitrogen (by weight of dry solids), which is one of the most critical elements for plant growth. In this Region, sludges were found to contain approximately 11.6 to 96.2 mg/g total nitrogen, or 1.2 to 9.6 percent. Milorganite contains 6 percent organic nitrogen and is considered an excellent soil conditioning fertilizer. The amounts and chemical forms of nitrogen available to plants depend on the following factors:

mineralization	denitrification processes
nitrification	immobilization
fixation	cation exchange
adsorption	weather conditions
volatilization	soil type
plant uptake	plant species

As a result, nitrogen loading rates are difficult to determine. Proper levels should be determined by monitoring the groundwater for any accumulation of NO_3-N, which can pose a health hazard to persons or animals obtaining their water supply from this source. However, once nitrates are found by conventional well testing of ground waters from the saturated zone, it is too late to prevent the nitrogen loading problem at that concentration, although prompt discontinuation of land spreading would halt further elevation of these levels. To circumvent this inadequacy in monitoring, a suction lysimeter can be used on a soil sample to determine the approximate quantity of nitrogen actually in the unsaturated zone of the soil. Excessive levels of NO_3-N can cause methemoglobinemia, which reduces the oxygen-carrying capacity of the blood. Current drinking water standards limit nitrate concentrations to less than 45 mg/l (10 mg/l NO_3-N).

Nitrogen in sludges is present in two forms: organic nitrogen (organic N) and free ammonium (NH_4+). Evidence indicates that 20 to 50 percent of nitrogen in digested sludge is in the ammonium (NH_4+) form. The ammonium can be chemically oxidized by autotrophic bacteria to the nitrate-nitrogen form which can be utilized by plants. However, the method of sludge application (surface-spreading or incorporation into the soil) has a major bearing on the total available ammonia nitrogen. If sludge is surface-spread, under favorable conditions, as much as 50 percent of the free ammonium can be volatilized after six days and thus lost as a plant nutrient. Organic nitrogen is slowly released by bacterial decomposition to the ammonium from which can then be oxidized to the nitrate form.

Nitrate-nitrogen is utilized by plants and soil bacteria to produce new cellular material. Excess nitrates are subject to denitrification within the soil, in the absence of free oxygen, thus freeing nitrogen to the atmosphere. Any remaining nitrates can be leached from the soil and enter groundwater or surface waters as contaminants. Figure 2 presents the nitrogen cycle in the environment.

The sludge application rate calculations described in Technical Bulletin No. 88 are also guidelines based on annual crop nitrogen requirements.

Maximum nitrogen loading rates can be estimated for specific soils and crops from the information on nitrogen uptake by crops from Wisconsin soils presented in that bulletin.

Nitrogen requirements vary considerably for different crops, as do allowable nitrogen loadings to prevent groundwater contamination. Backup data prepared by USDA for its draft recommendations on land application of sludges to the Office of Management and Budget[1], estimate that, in general, a requirement of 200 lb/acre of nitrogen would be satisfied by a loading of about 10 dry ton/acre of sludge cake and about 3.3 dry ton/acre of liquid digested sludge. Differences in loading rates are attributable to the nitrogen content of the liquid removed in dewatering. Even after a loading rate is established and implemented, a groundwater monitoring program should be instituted, to ensure that excessive break-through by nitrates does

[1] *United States Department of Agriculture (USDA) Suggested Draft of Section 2-4.2 of Environmental Protection Agency (EPA), 1976, Municipal Sludge Management: Environmental Factors, Federal Register, Vol. 41, No. 108.*

not occur. Groundwater must be monitored for an extended period of time because of its slow passage through the soil.

Phosphorus—Analyses of sludge in this Region indicate a wide range of concentrations from 8 to 111 mg/g, or 0.8 to 11.1 percent. This is in large measure due to the range in phosphorus removal efficiencies at the several plants sampled. Milorganite contains about 2 percent phosphorus. Phosphorus in wastewater sludges is generally present as calcium, aluminum, iron, and magnesium phosphate.

If the concentration of phosphorus is high, this element can form precipitates with zinc, iron, magnesium, and molybdenum, making them unavailable to plants. Phosphorus applied to the soil will react with and precipitate alumium and iron if soil pH is low, or precipitate calcium if soil pH is high. Phosphorus precipitates are so insoluble that they are largely held in the upper layers of the soil (if sludge is surface-applied) with little or no movement to groundwater.

Overapplication of phosphorus can cause overfertilization, which might result in toxic effects and contamination of surface waters. Should phosphorus enter surface waters in excessive quantities, along with soil particles carried in surface runoff, it might cause a response similar to that of nitrogen (eutrophication).

Heavy loadings of phosphorus in wastewater sludges usually do not pose a long-term threat to groundwater, because phosphorus is highly reactive and quickly combines with other elements in the soil to form less mobile, more stable compounds. Also, because of its high degree of reactivity with various soil metals, phosphorus might limit the availability of certain heavy metals to plant uptake. Phosphates are known to reduce the availability of zinc for example, thereby limiting its toxic concentration. Excess phosphorus, coupled with low soil pH, can increase its reaction with iron resulting in chlorosis (iron deficiency) in plants. This problem is a short-term problem which can be remedied by adding lime to the soil.

Although heavy loadings of phosphorus in wastewater sludges might not pose a threat to groundwater, surface-spreading of sludges might cause some phosphates to move to surface waters.

In one study[1], sludge was applied at a rate of 120 ton/acre/year, to determine phosphorus uptake by plants. The percentage of phosphorus removed appeared to be directly related to the volume of sludge. Soil analysis revealed that, even at the high loading rate, phosphorus was confined to the upper layers, effectively reducing any threat to groundwater.

Potassium—Potassium (K) is an essential plant nutrient. Because wastewater sludges contain only a limited quantity of this element, supplementary amounts may be required, to ensure maximum crop yield from application sites. The appropriate quantity will depend on crop demands, sludge content, and soil characteristics. The amount of potassium in the soil can limit the uptake of nitrogen; if there is insufficient potassium to support the desired healthy plant growth, then nitrogen will not be used at the calculated or projected rate by the crop. Milorganite contains approximately 0.2 percent potassium.

Inorganic Salts

Ions typically involved in the exchange reactions within soil include: Ca^{++}, Mg^{++}, K^+, Na^+, $S^=$, and Cl^-. Characteristically, salts of these ions are quite mobile and may enter groundwater via continual leaching processes. The potential hazard of increasing groundwater salt levels depends entirely on the quantities applied to land. If high salt effluents are tributary to a wastewater treatment plant (such as from vegetable canneries or from surface runoff especially during winter), seed germination might be inhibited when these sludges are applied shortly after seeding. Careful monitoring of sludges can identify those not suitable for land application.

Pathogens

Wastewater sludges contain pathogenic organisms which can be classified into four groups; viruses, bacteria, protozoa, and intestinal worms. Pasteurization, composting, heat drying, and lime treatment of sludge can reduce these organisms, as can simple storage of sludge for a period of time (however, no method eliminates pathogens entirely).

Pathogens are also effectively removed in the soil by filtration, sorption-inactivation, and die-off. Their movement is typically restricted to a few feet from the point of application, unless the soil is very coarse or contains cracks and channels. There is little danger of disease transmission to humans or animals by landspreading of well-digested or stabilized wastewater sludges.

To minimize the hazards associated with pathogens, sludge may be incorporated into the soil immediately,

[1]*King, L.D., and Morris, H.D., 1973. "Land Disposal of Liquid Sewage Sludge: IV. Effect of Soil Phosphorus, Potassium, Calcium, Magnesium, and Sodium," J. Environ. Quality, 2:411-451.*

or as soon after application as possible. Restricted access to the site might also merit some consideration. Guidelines, by the Wisconsin Department of Natural Resources in Technical Bulletin No. 88 to protect surface water, groundwater, and crops from pathogenic organisms, include:

1. Raw sludge should not be applied to agricultural land.

2. There should be at least 2 ft, and preferably more than 4 ft, of soil between the sludge application zone and bedrock, any impermeable layer, or the water table.

3. Sludge should not be applied to soil in the year the soil is used for any root vegetables or other vegetables which are consumed uncooked.

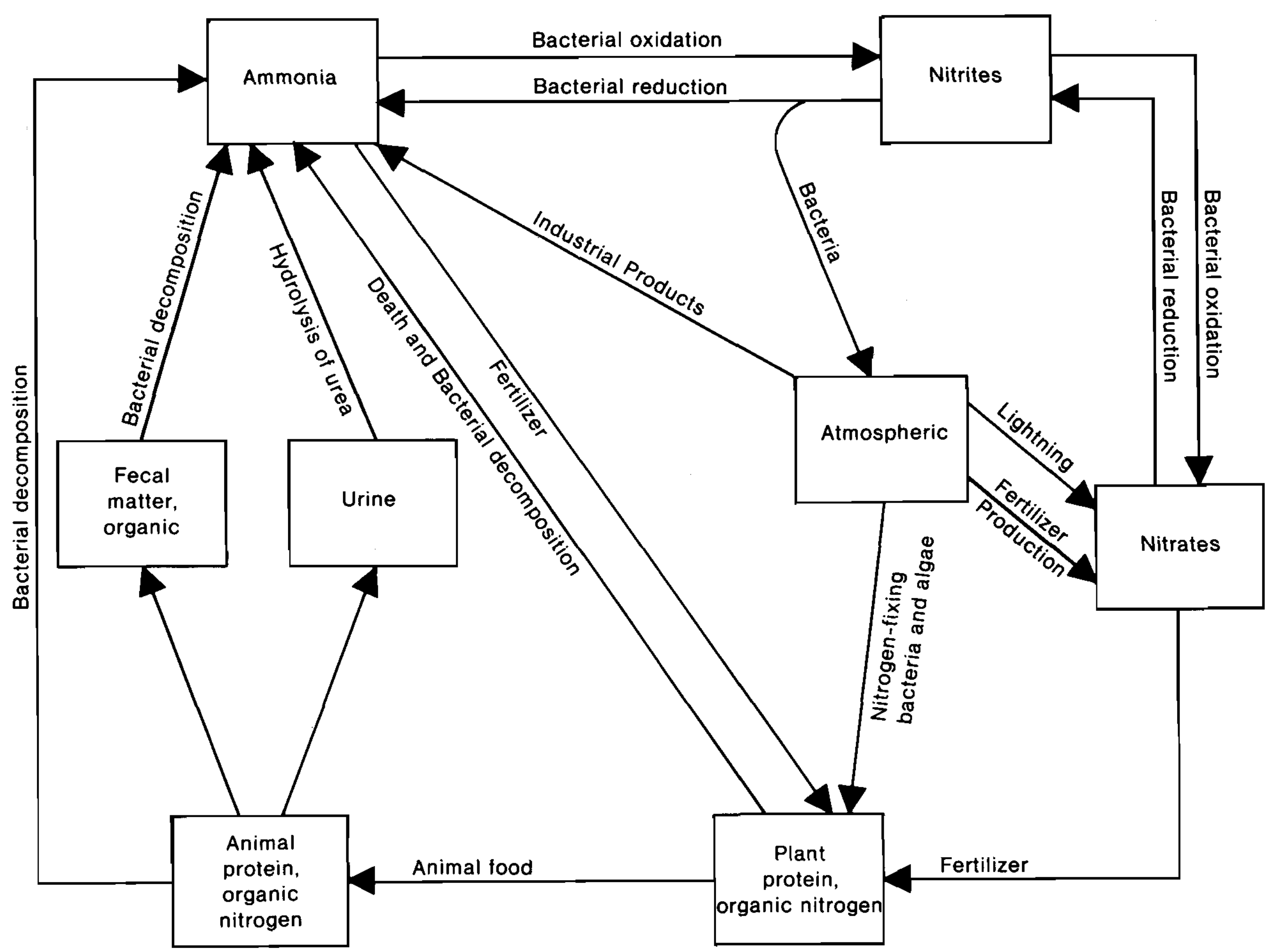
4. If sludge is applied to the surface, runoff should be minimized by contour strips and terraces.

5. Pastureland should not be grazed by milk cows for at least 2 months after sludge application. Other animals should not graze for at least 2 weeks after sludge application.

6. Green-crop forage should not be harvested for feed to milk cows for 2 months, or other animals for at least 2 weeks, after sludge application.

7. To ensure adequate protection of water supplies the sludge application site should be a minimum of 1,000 ft from the nearest public water supply well and 500 ft from the nearest private water supply well.

Figure 2 Nitrogen Cycle



Source: Camp Dresser & McKee Inc.

Polychlorinated Biphenyls
PCBs were measured in area wastewater sludges and the data are appended. Concentrations are low, but the materials are persistent and could pose long-term hazards to the soil or surface (and subsurface) water supplies. Moreover, spills of toxicants to the sewer systems could result in high toxic levels in the sludges. Wisconsin Department of Natural Resources chapter NR157 "establishes procedures for storage, collection, transportation, processing and final disposal of PCBs and products containing PCBs taken out of service for disposal."

Sludges should be monitored regularly, to detect the occurrence of excessive loads of toxic substances. If a problem were discovered, contaminated sludges could be destroyed by combustion or disposed of in landfills to accept hazardous materials, to prevent further mobility of the toxicants. The closest known incinerators approved by the U.S. Environmental Protection Agency are in Bridgeport, N.J., Deer Park, Texas, and Baton Rouge, La.; however, a potential site exists in Detroit, Michigan. The Pereless Cement Co. has incinerated PCBs with cement in its kiln and is interested in continuing this practice. The closest approved landfill sites are in Sheffield and Willsonville, Illinois.

Energy Potential of Sludge
The energy stored within the volatile portion of sludge might be utilized to reduce plant operating costs. One source of this energy is the methane gas produced during the anaerobic digestion process. Digestion can produce approximately 15 cu ft of gas per pound of volatiles destroyed. The heat value of this gas is approximately 600 BTU per cu ft[1].

A second source of energy is recovery of the heat value (or caloric value) of the sludge by burning either pure sludge or some combination of sludge and solid waste (refuse derived fuel) in an incinerator or pyrolysis unit. The combustible elements of sewage sludge are carbon, hydrogen, and sulfur; these elements are chemically combined in the organic sludge as grease, carbohydrates, and protein. The average characteristics of sewage solids and their heating values are given in Table 48.

If the heat value of the sludge is too low or the water content of the sludge is too high, auxiliary fuel will be necessary to sustain combustion. This auxiliary fuel requirement can be supplied by mixing refuse derived fuel, or fossil fuels, with the sludge. Heat energy can be recovered from the hot flue gases leaving the incinerator in a waste heat boiler and used to generate electricity and meet heating requirements throughout the plant. When the pyrolysis mode is used for burning, the exhaust gas can be burned in an afterburner and the energy recovered as direct fired heat, steam, or electricity.

[1]*Camp Dresser & McKee Inc. and Alexander Potter Associates, Phase 2 Report of Technical Investigation of Alternatives for New York - New Jersey Metropolitan Area Sewage Sludge Disposal Management Program, June 1976.*

TABLE 48

AVERAGE FUEL CHARACTERISTICS OF SEWAGE SLUDGE

Material	Combustibles Percent	Ash Percent	BTU/lb
Grease and scum	88.5	11.5	16,750
Raw sewage solids	74.0	26.0	10,285
Fine screenings	86.4	13.6	8,990
Ground garbage	84.8	15.2	8,245
Digested sewage solids and ground garbage	49.6	50.4	8,020
Digested sludge	59.6	40.4	5,290
Grit	30.2	69.8	4,000

Source: Rubel, Fred N., Incineration of Solid Wastes, Pollution Technology Review No. 13; 1974, Noyes Data Corporation.

CHARACTERISTICS OF INDUSTRIAL SLUDGES

Data on the characteristics of industrial sludges were compiled from surveys and a sampling program conducted by SEWRPC in conjunction with the Wisconsin DNR. The best information was available from the results of the sampling program. Specific industries were chosen on the basis of: product diversity, knowledge of the manufacturing processes used, and a description in an earlier survey of the sludge byproducts produced. The industries were further screened to represent categories selected in the "Study Memorandum for a Regional Wastewater Sludge Management Plan" and listed in the Classified Directory of Wisconsin Manufacturers 1973 Edition. Sludges from Food Processing industries can be spread on the land after they have been stabilized (digested). Sludges from other categories of industries may contain harmful chemicals toxic to plants, animals or humans. These sludges are usually landfilled at an approved site. (See recommendations in Chapters IX and X.) Also, many industrial wastewaters contain substances which are toxic to the microorganisms present in secondary treatment processes. Industrial pretreatment can prevent upsets to these biological processes, and result in the concentration of the undesirable chemicals in a relatively small volume of sludge to be carefully disposed.

Tanneries
The sample from W. B. Place & Co. in Hartford was very high in chromium and sodium when compared to municipal sludges. Nitrogen, phosphorus, and other metals were comparable to municipal sludge concentrations. This sludge and that from other tanneries with the chrome tanning process may not be suitable for land application because of high chromium concentrations.

Metal Plating and Metal Machining Operations
S. K. Williams was sampled. This is a metal plating operation producing a sludge high in concentrations of nickel, sodium and aluminum.

American Can Co. contained high concentrations of aluminum, sodium, and zinc.

American Motors' (Kenosha) sludge did not exhibit any significantly high concentrations in comparison to municipal sludge.

J. I. Case, Clausen, sludge did not exhibit any significantly high concentrations in comparison to municipal sludge.

Trent Tube sludge had high concentrations of chromium, magnesium, and nickel.

Food Processing
The sludge from Patrick Cudahy was low in all constituents sampled and would present no spreading problem. Among the subcategories selected for sampling, samples were not taken at vegetable canning, milk processing, or cheese processing industries because there was no sample sludge available.

Battery Manufacturing
The sludge sample from Globe Union was low in lead and cadmium and would present no particular problem.

Truck and Car Wash Operations
No sludge samples were taken from industries within this category. NR101 analyses are included in Chapter III.

Power Plants
For this category attempts to obtain sludge samples were unsuccessful in the abbreviated work period of the Regional Wastewater Sludge Management Planning Program.

Characteristics of Septage
Between April 15, 1976 and December 31, 1976, data on the strength of septage and holding tank wastes received at the MSD-Jones Island and MSD-South Shore treatment plants were collected by the laboratory staff of the Sewerage Commission. Five categories were sampled: Chemical Toilets, Residential Septage, Commercial Septage, Residential Holding Tanks and Commercial Holding Tanks. The results of the analysis for BOD, Suspended Solids and pH are indicated in Table 49. Based upon the type of waste and the method of sample collection, the averages could be high dependent upon when the sample was collected during the discharge period. Wide ranges in the data collected indicate a variable waste and that some samples may not be representative. Typical values for septage characteristics can be found in the State-of-the-Art Report on Sludge Treatment and Disposal.

TABLE 49

CHARACTERISTICS OF SEPTAGE AND HOLDING TANK WASTES[1]

Source	pH Geometric Mean	BOD mg/l Geometric Mean	Suspended Solids mg/l Geometric Mean
Chemical Toilet	8.0	5,220	7,890
Residential Septage	6.6	4,650	17,770
Commercial Septage	6.8	2,350	6,640
Residential Holding Tank	7.2	780	2,800
Commercial Holding Tank	7.4	426	780

[1]*Data collected by the Metropolitan Sewerage District laboratory staff from samples collected by drivers of trucks discharging these wastes at the MSD-Jones Island or MSD-South Shore treatment plants.*

MUNICIPAL SLUDGE QUANTITY PROJECTIONS

This section describes the sludge quantity projections derived by CDM for this study. Some quantities for 1975 (shown in Table 50) are considered quite reliable,

TABLE 50

LARGE WASTEWATER TREATMENT PLANTS

Estimated Raw Sludge Production
(lb/day dry solids)

Plant	Current*	2000
MSD-Jones Island (Milwaukee)	386,000	417,000
MSD-South Shore (Milwaukee)	196,000	285,000
Racine	18,000	60,100
Kenosha	35,800	47,300
Waukesha	18,900	28,500
West Bend	6,000	17,600
South Milwaukee	4,900	4,900
Whitewater	3,700	8,100
Oconomowoc	2,400	9,600
Burlington	2,300	4,500
Walworth Co. MSD	2,200	4,500
Brookfield	5,300	19,600
Port Washington	1,800	4,000
Cedarburg	2,000	4,400
Grafton	2,600	4,500
Hartford	2,000	3,900
Twin Lakes	600	1,900
Williams Bay	100	500
Western Racine Co. MSD	300	1,700
Hartland-Delafield	1,100	4,300
Union Grove	1,200	2,000
Total	693,200	933,900
	(346.6 ton/day)	(466.9 ton/day)

Source: Camp Dresser & McKee Inc.

**Based on 1975 flows and loads.*

as they are based on long-term data or detailed facilities planning work. Other quantities are based on the type of treatment process and existing and projected BOD_5 and SS loadings. All solids values are presented as dry solids.

The amount of sludge generated depends on three primary factors, as follows:

1. Amount of wastewater processed at a treatment facility
2. Strength of the wastewater processed
3. Type and level of treatment provided, including sludge process utilized.

When long-term operating data for a treatment plant was not available and detailed facilities planning had not yet been done, sludge quantities and required unit sizes were calculated from a mass balance. The mass balance is a theoretical computation of the amount and concentration of the sludges, based on the existing unit processes at the treatment plant under consideration because the required capacities of unit processes and sludge quantities depend on the type and level of treatment at the plant and on the recycled sidestreams. Process performance, such as solids capture and moisture content of the solids stream, directly affect the required capacities of process equipment downstream. Liquid sidestreams returned from a process to the head of the treatment plant or to secondary treatment can significantly affect the loading on subsequent unit processes. Mass balances were calculated for existing and possible future process schematics to determine capacities, sludge loading on each unit process and the quantity of sludge produced at the treatment plant.

The municipal sludge quantity projections discussed in this section do not include sludges resulting from combined sewer overflow control and treatment or river dredgings. Quantities of such sludges which may be generated by combined sewer overflow programs now being planned in Milwaukee, Kenosha, and Racine have not yet been determined; however, projections based on information presently available from the studies for Milwaukee are presented in Chapter IX and are included in costs for treating these sludges. The CSO studies in Racine and Kenosha are not yet to a point where figures can be presented for approximate CSO solids quantity. Also, the Milwaukee data does not include possible solids generated as a result of the 5/5 effluent guidelines pending as a result of the Illinois Federal Court case. Septage and holding tank wastes are discussed in other sections of this chapter, but their resultant sludge quantities are included in the municipal projections inasmuch as they ultimately are processed at such facilities.

Anticipated Growth Assumption

Projections of future sludge quantities were made by increasing the domestic-commercial load in proportion to the projected (by SEWRPC) population increase and holding the industrial component constant at its present level unless information was available suggesting specific increases or decreases. Industrial growth is anticipated for the Region as discussed in Chapter I, but it is expected that the imposition of User Charges and Industrial Cost Recovery (UC/ICR) programs will tend to minimize sludge generation, probably through in-plant process changes. Imposition of a UC/ICR program should have no effect on industries not on municipal systems; in this case, discharge permit requirements will govern.

Where a consultant for a municipality had estimated future sludge production, these numbers were generally favored, with appropriate adjustments to the latest estimated sewered population for year 2000. In addition to existing industries, projections of future industrial activity were considered. It has been suggested that the municipal per capita load should be increased in the future. However, information for Waukesha and several other plants showed no discernable upward trend in the last decade. In addition, future septage and holding tank waste loads were considered in accordance with the Regional Sanitary Sewerage System Plan.

All sludge quantity values contained herein are annual average values. Peaking on a monthly or daily basis was accounted for in the unit design criteria and cost functions utilized. The peaking values for Jones Island and South Shore will be investigated in detail under the facilities planning effort. Table 51 presents a summary of flows and loads in the most recent year of record (1976) for the Jones Island facility. This table indicates the seasonal flow, load, chemical addition, and other factors which affect sludge and Milorganite production at that plant.

Major Municipal Wastewater Treatment Plants

MSD-Jones Island—The original design data for the Jones Island plant was not available for review. However, considerable data has been collected on plant operations and raw wastewater loads by the MSD. This data was utilized to develop a range of sludge quantity projections for the Jones Island plant. A range of values is considered to serve better for comparative purposes than an absolute projection, as wastewater might be diverted to either Jones Island or South Shore resulting in a mix of possible flows and, therefore, loads and sludge quantities.

The 1975 waste sludge load was about 386,000 lb/day, and it was estimated that roughly 36,600 lb/day more would have been captured had the permit conditions been met and no bypassing had occurred. The low-range condition for year 2000 was based on an industrial load discharge held constant at the 1975 level with most of the diversion area flow going to South Shore. It was estimated that 417,000 lb/day[1] would be generated, as under this condition the maximum flow condition would be occurring at South Shore. The high range load for year 2000 was with Jones Island at about 200 mgd capacity with most of the diversion area flow accepted there. Based on this condition, the estimated projected sludge load was 580,000 lb/day[1] for year 2000 at Jones Island. Estimates of combined sewer overflows solids[2] as of July, 1977 show a maximum load of 857,000 lb/day and an average load from April through October of 10,700,000 lbs. These values represent projections, based on study to date, of solids from storm sewers requiring further treatment by thickening and dewatering.

MSD-South Shore—As with Jones Island, considerable data was available on the existing plant. A corresponding range of sludge projections was derived for South Shore to account for diversion of flows. The 1975 waste-activated and primary sludge was found to be approximately 196,000 lb/day. Had all permit conditions been met, the estimated load would have been about 241,000 lb/day. The low-range loading in year 2000, corresponding to the high-range loading at Jones Island, was estimated to be 122,000 lb/day[1]. The high-range loading in year 2000, corresponding to the low-range loading at Jones Island, was estimated to be approximately 285,000 lb/day[1]. The total load of the two plants would be about 702,000 lb/day[1] in year 2000.

Racine—With actual operating data and a consultant's report, it was estimated that the current (1975) sludge load would have been approximately 25,400 lb/day with the new plant on line. The year 2000 load was similarly estimated at 60,100 lb/day.

The Thirty-Sixth Annual Report for 1973 (the latest available at the time of data compilation) contained detailed information on sludge management practice

[1] *Does not include solids contained in combined sewer overflows.*

[2] *Projections, Stevens, Thompson and Runyan Inc. to Metropolitan Sewerage District, July 8, 1977.*

at that time. The connected population in 1973 was 118,700 persons, with an influent suspended solids load of 23,970 lb/day. According to the report, approximately 6,650 lb/day of these solids were removed. The reported raw sludge produced was 90,090 gal/day at 7.48 percent solids. The load of dry sludge solids off the vacuum filter was 9,310 lb/day, with 1,160 lb/day lime and 100 lb/day ferric chloride having been added prior to filtering. Phosphorus removal, with pickle liquor as a chemical coagulant, was the practice throughout most of 1973, having started in March of that year.

The 1975 influent suspended solids was 19,748 lb/day, with 6,800 lb/day being removed, indicating a drop in the influent suspended solids load (compared to 1973). Note that the suspended solids loads for 1970, 1971, 1972, and 1973 were respectively 22,570 lb/day, 19,590 lb/day, 22,130 lb/day, and 23,970 lb/day. This indicates that no apparent increase in solids loading took place even though there was some increase in sewered population.

Design criteria for the recent plant expansion[1] are based on a design population of 141,000 persons and

[1]*Consoer, Townsend & Associates, Consulting Engineers, "Engineering Report on Wastewater Treatment Facilities for City of Racine, Wisconsin," Chicago, Illinois, October 1970.*

TABLE 51

JONES ISLAND WASTEWATER TREATMENT PLANT—PLANT FLOW AND LOAD ESTIMATES—1976

Months	"Estimated"[1] Average Monthly Flows and Loads Entering the Jones Island Treatment Plant			Measured Screened Average Monthly Flows and Loads Entering Activated Sludge Plant			Milorganite Production
(1976)	Flow mgd	BOD lb/day	SS lb/day	Flow mgd	BOD lb/day	SS lb/day	lb/day
January	109.9	437,000	324,000	106.1	384,000	298,000	358,000
February	151.1	574,000	426,000	134.0	392,000	314,000	423,000
March	184.9	447,000	387,000	167.3	394,000	332,000	431,000
April	160.3	405,000	364,000	156.6	359,000	333,000	383,000
May	155.3	416,000	346,000	151.1	361,000	329,000	406,000
June	144.4	363,000	348,000	144.7	355,000	377,000	424,000
July	144.8	350,000	353,000	141.1	365,000	364,000	402,000
August	144.4	370,000	348,000	147.6	418,000	388,000	403,000
September	137.9	374,000	374,000	131.9	359,000	387,000	370,000
October	134.6	355,000	430,000	127.4	347,000	421,000	367,000
November	120.3	312,000	314,000	111.9	298,000	323,000	382,000
December	106.0	348,000	305,000	105.8	321,000	299,000	359,000
Yearly Ave. by Month	141.2	401,000	366,000	135.5	369,000	353,000	393,000
Ratio of Maximum to Average	1.31	1.43	1.17	1.23	1.13	1.19	1.10

Average Yearly Waste-Activated Sludge to Solids Processing Facilities (lb/day) ... 428,000

With $FeCl_3$ addition (lb/day) ... 467,000

[1]*Actual measurements not taken.*

Source: Jones Island Purification — Analytical Data.

58,400 lb/day dry suspended solids removed from the wastewater. The plant is designed to accommodate an average wastewater flow of 30 mgd. The dry suspended solids removed, coupled with 9,700 lb/day of biological sludge and 8,400 lb/day of phosphorus sludge, gives the total design raw solids load to sludge processing of 76,500 lb/day.

Based on a solids balance and the 1975 influent suspended solids and phosphorus loadings, the raw sludge solids load to the new plant could range from 18,000 to 29,000 lb/day. An earlier design report[1] contained lower estimates, which fall within this expected range. Those figures were adopted for this study (estimated 1974 sludge load, 25,400 lb/day, and estimated year 2000 sludge load, 60,100 lb/day). The projected year 2000 load is, therefore, 369 lb/day raw sludge/1,000 population.

Kenosha—From actual operating data, the 1975 load was estimated to be 35,800 lb/day. The year 2000 load was estimated to be 47,300 lb/day.

The 1975 Annual Report of the Kenosha Water Utility was reviewed and found to contain thorough information on solids handling in the wastewater treatment plant. This information indicated that the current raw sludge solids loading was approximately 35,800 lb/day. The information on the solids balance at this plant was quite complete and all values compared well with what might be expected on a theoretical basis. The reported thickened waste-activated sludge solids was 13,740 lb/day, while the total sludge to the filter press was 18,590 lb/day. (Phosphorus removal was accomplished by addition of waste pickle liquor.) The total suspended solids entering the plant in 1975 was 31,152 lb/day, with 27,680 lb/day removed.

The influent suspended solids for 1971, 1972, 1973, 1974, and 1975 were respectively 20,490 lb/day, 20,710 lb/day, 22,053 lb/day, 24,639 lb/day, and 31,152 lb/day, illustrating an upward trend over this short period of time.

Design criteria of this plant were based on a yearly average suspended solids loading of 25,000 lb/day, with 40,000 lb/day expected on the maximum day.[2] Sludge sent to the digesters was estimated at 26,000 lb/day—13,700 lb/day from the primary treatment portion and 12,300 lb/day from the secondary treatment portion.

[1]*Consoer, Townsend & Associates, "Engineering Report on Sewage Treatment Facilities for the City of Racine, Wisconsin," Chicago, Illinois, January 1964.*

[2]*Alvord, Burdick & Howson "Water Pollution Control Plant Design Criteria and Operational Capacity, Kenosha, Wisconsin."*

Accepting the reported 1975 solids balance as accurate, the year 2000 load was projected at 47,300 lb/day, or 346 lb/day raw sludge/1,000 population.

Waukesha—From plant operating data, sludge quantities were computed using EPA "Process Design Manual for Phosphorus Removal." Sludge solids loads were estimated at 18,900 lb/day in 1975 and 28,500 lb/day in year 2000.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire was available for Waukesha. The estimated total quantity of raw primary and secondary sludge was 21,000 lb/day. However, the consultant's[1] design report gave detailed information on suspended solids loading to the plant since 1962. The design suspended solids concentration selected by the consultant was 165 mg/l and, while the concentrations have varied over the last 15 years, there has been no discernable upward trend (165 mg/l was only exceeded once on an annual basis during the time period considered). The 1975 suspended solids load was 12,584 lb/day, and phosphorus removal was being accomplished with alum addition.

The design suspended solids loading at the proposed plant is 22,020 lb/day. At 98 percent removal, this represents 21,580 lb/day of suspended solids removed at the design flow of 16 mgd. Using solids balance computations it was estimated that the current raw sludge solids loading is approximately 18,900 lb/day. This was projected to 28,500 lb/day in year 2000, based on the proposed plant processes. This represents 354 lb/day raw sludge/1,000 population.

West Bend—The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire for West Bend indicated that the sludge production from all processes was estimated to be 10,940 lb/day. However, the total suspended solids load to the plant in 1975 was 7,992 lb/day, with 7,420 lb/day reported removal.

The recent facilities plan contains complete estimates of future sludge quantities which appear to be reasonable and well documented[2]. The projected value for year 2000 is 17,630 lb/day or 354 lb/day of raw sludge/1,000 population. Utilizing the available data, values were computed for 1975 on the basis of a solids balance. Approximately 6,000 lb/day was the calculated value.

[1]*Alvord, Burdick & Howson, "Report on Sewage Treatment for Waukesha, Wisconsin," Chicago, 1974.*

[2]*Donohue & Associates, Inc. "West Bend Facilities Plan," Sheboygan, Wisconsin, December 1975.*

South Milwaukee—From plant operating data and solids balance computations, the raw sludge load was estimated at 4,900 lb/day for both 1975 and 2000.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire indicated that an estimated 4,000 lb/day of raw sludge are produced at the South Milwaukee wastewater treatment plant. The consultant's report[1] contained an estimate of 3,770 lb/day of digested sludge solids that required disposal. During the 1975 annual period, total suspended solids in the influent was 3,715 lb/day, with 3,470 lb/day being removed. Based on these data, a solids balance indicated that the raw sludge produced is approximately 4,900 lb/day. As no growth is expected here, this value was held constant through year 2000. This is 214 lb/day raw sludge/1,000 population.

Whitewater—A current raw sludge load of 3,700 lb/day was calculated from plant operating data and a solids balance. A year 2000 load of 8,100 lb/day was based on the consultant's report supplemented by the 1975 population estimates which now show a lower growth rate through year 2000 than the earlier 1970 forecasts.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire indicated the current total suspended solids load in the plant influent at 2,667 lb/day, with 1,890 lb/day removed.

The design criteria for the new plant, currently in the design phase[2], is an influent suspended solids load of 10,800 lb/day. The total raw sludge solids produced is estimated (by the consultant) at 12,410 lb/day. While the design report is very thorough, the projected service area population was initially estimated at 26,550, versus SEWRPC's design horizon value of 18,050. For the year 2000, sludge quantities were adjusted from 12,410 lb/day to 8,100 lb/day to reflect this difference.

Oconomowoc—An estimated production of 2,400 lb/day (1975) and 9,600 lb/day (2000) raw sludge was computed from plant operating data and a mass balance.

Operating records from the DNR files show the total influent suspended solids to the Oconomowoc plant in 1975 as 2,857 lb/day; 1,780 lb/day was removed.

[1]*R.W. Nicholson, "Report on Phosphorus Removal and Sludge Handling and Disposal at the South Milwaukee Wastewater Treatment Plant, South Milwaukee," December 1975.*

[2]*Robinson & Associates, "Facilities Plan for Whitewater," Brookfield Wisconsin, October 1975.*

The new Oconomowoc wastewater treatment plant will soon be completed.[1] Design criteria were based on a population of 29,500 and a raw suspended solids loading of 6,670 lb/day. Based on current operating data and a solids balance, sludge projections were 2,400 lb/day for year 1975 and 9,600 lb/day for year 2000.

Burlington—A raw sludge load of 2,300 lb/day (1975) and 4,500 lb/day (2000) was computed from plant operating data and a mass balance.

SEWRPC's Treatment Facility and Sludge Handling Practices Questionnaire indicated that the raw sludge load is approximately 2,440 lb/day. The raw suspended solids load to the plant is 1,753 lb/day, with 1,680 lb/day removed. The design report[2] indicated that the raw suspended solids concentration in October 1968 was 170 mg/l. (The concentration during October 1975 was 167 mg/l, indicating no increase.) Phosphorus removal is currently being practiced by the addition of pickle liquor.

Walworth County MSD—An estimate 2,200 lb/day (1975) and 4,500 lb/day (2000) were computed from a consultant's report with adjustments for the latest population projections.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire for Delavan indicated 230 lb/day of dry sludge solids. The DNR records indicate that the total suspended solids in 1975 was 793 lb/day, with 700 lb/day removed. The design report[3] for the new regional plant contained an estimated digested solids of 4,645 lb/day, for an estimated year 2000 population of 30,500. The estimated total suspended solids load at the design condition is 6,520 lb/day. With appropriate adjustments to the consultant's values, based on SEWRPC's latest population projections, the values of 2,200 lb/day (1975) and 4,500 lb/day (2000) were arrived at. There is no known major industrial contribution.

Brookfield—A 1975 raw sludge production of 5,300 lb/day is reported in the plant operating records, while 19,600 lb/day raw sludge in year 2000 was estimated.

[1]*Donohue & Associates, Inc., "Report for Wastewater Treatment Facilities for the City of Oconomowoc, Wisconsin." Sheboygan, Wisconsin, October 1970.*

[2]*Hoganson & Robers, Inc., "Engineering Study for Revising Sewage Treatment Plant, City of Burlington," Burlington, Wisconsin, July 1969.*

[3]*Jensen & Johnson Inc., "Facilities Plan for Wastewater Treatment Works-Walworth Co. Metro. Sewerage Dist.," Walworth Co., Wisconsin, October 1976.*

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire reported the raw sludge load as 5,300 lb/day dry sludge solids. The influent suspended solids load was reported at 4,045 lb/day, with 3,510 lb/day removed by the wastewater treatment plant.

Since the load reported on the plant questionnaire checked closely with a mass balance calculation, the year 2000 value of 19,600 lb/day was estimated by using the mass balance value of 280 lb/day sludge per 1,000 population. This assumes activated sludge secondary treatment and chemical addition for phosphorus removal.

Port Washington–1,800 lb/day of raw sludge is reported in 1975 plant operating records and in SEWRPC's Treatment Facility and Sludge Handling Practices Questionnaire. From this value and the projected year 2000 population, a raw sludge quantity of 4,000 lb/day was estimated for year 2000.

There is no organic loading from industry allowed for in the design criteria[1]; the raw sludge solids load to the primary digester is estimated at 1,750 lb/day from primary treatment (for a total of 2,565 lb/day at a design population of 12,500 persons). This figure is based on a raw influent suspended solids load of 2,500 lb/day. At an estimated year 2000 population of 13,500 persons, sludge production was estimated to be 4,000 lb/day or approximately 280 lb/day per 1,000 population. This value assumes activated sludge treatment with chemical addition for phosphorus removal.

Cedarburg–Cedarburg values, estimated from actual operating records and the consultant's reports, were 2,000 lb/day raw sludge (1975) and 4,400 lb/day raw sludge (2000).

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire and DNR file data indicated that the digested sludge was approximately 950 lb/day to 1,200 lb/day in 1975. The influent suspended solids load was 1,811 lb/day, with 1,530 lb/day removed.

The existing plant was designed[2] on the basis of 20,000 persons and 250 mg/l suspended solids. The digesters were designed to handle 3,100 lb/day volatile solids with phosphorus removal.

[1]*Donohue & Associates, Inc., "Port Washington Design Criteria," Sheboygan, Wisconsin.*

[2]*R.W. Nicholson, "Report to the City of Cedarburg, Wisconsin, on Wastewater Treatment Revisions," South Milwaukee, Wisconsin, 1970.*

The 1975 raw sludge value from above was accepted as reasonably accurate, and the year 2000 value was projected to 4,400 lb/day by proportion of the population increase and a greater degree of phosphorus removal. This is 230 lb/day/1,000 population.

Grafton–Raw sludge values at Grafton were estimated from plant operating data and a mass balance at 2,600 lb/day (1975) and 4,500 lb/day (2000).

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire stated the current raw sludge dry solids load at 2,600 lb/day. The influent suspended solids load is 1,898 lb/day with 1,780 lb/day removed. The existing plant is designed[1] for a population of 9,400, with 924 lb/day suspended solids removed in the primary clarifier.

Hartford–The raw sludge quantity for Hartford was 2,000 lb/day (1975), from plant operating records.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire indicated that 1,990 lb/day raw sludge solids were produced in 1975.

The 1975 raw sludge load was used to compute the projected year 2000 raw sludge value of 3,900 lb/day. As the industrial load to this plant is very high, future industrial pretreatment could have a significant effect.

Twin Lakes–Amounts of 600 lb/day (1975) and 1,900 lb/day (2000) were based on plant operating records and a mass balance performed on the plant.

Plant operating records in the DNR files indicate influent suspended solids of 1,091 lb/day with removal at 510 lb/day. Plant design criteria were not based on influent suspended solids loadings, and 1975 operating data were incomplete. The estimated sludge load (for 1975) of 600 lb/day was estimated from the operating records, while that for year 2000 (1,900 lb/day) was estimated on the basis of 244 lb/day/1,000 population (representing activated sludge with phosphorus removal).

Williams Bay–The values for Williams Bay were based on consultant's report values corrected for the most recent SEWRPC population projections: 100 lb/day (1975) and 500 lb/day (2000).

The reported operating data indicated a suspended solids load of 93 lb/day, with 85 lb/day being removed.

[1]*Donohue & Associates, "Grafton Design Data," 1R68.*

The plant was designed[1] for digester loads of 352 lb/day during nine winter months and 865 lb/day during three summer months. The design population was 6,500 peak. The average sludge load to the digester was 564 lb/day.

Based on the suspended solids removed in 1975, a sludge quantity of 100 lb/day for 1975 was estimated. The SEWRPC year 2000 population was 7,100, which includes an estimated seasonal population of 2,500. The design value of 564 lb/day was rounded to 500 lb/day, because of the seasonal variations in sewered population.

Western Racine County-MSD—A 1975 raw sludge quantity of 300 lb/day is reported in operating records. The projected year 2000 value of 1,700 lb/day is reported in the consultant's report[2]. That design report for additional plant units was based on a solids load to the digester of 1,700 lb/day for a year 2000 population of 10,000.

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire, which agrees with the operating records, report a raw sludge production of 300 lb/day.

Phosphorus removal was started in 1976, and there is no known industrial contribution.

Hartland-Delafield—The 1975 value of 1,100 lb/day and the year 2000 value of 4,300 lb/day were reported in the consultant's report.

The sludge handling portion of the new facility is designed for a raw sludge load of 4,330 lb/day (249 lb/day at 1,000 population). This value was accepted for this study. A base value of 1,100 lb/day was estimated for 1975 from SEWRPC's population estimates and the values in the above report. There is no known industrial contribution to this planned facility.

Union Grove—A raw sludge quantity of 1,200 lb/day for 1975 was estimated from plant records; a value of 2,000 lb/day in year 2000 was estimated from a mass balance.

[1]*Jensen & Johnson, Inc. "Design Criteria for Additions to the Existing Wastewater Treatment Plant Village of Williams Bay, Walworth County, Wisconsin," Elkhorn, Wisconsin, July 1967.*

[2]*Jensen & Johnson, Inc. "Engineering Report on the Addition to the Wastewater Treatment Plant of the Western Racine County Sewage District," Elkhorn, Wisconsin, August 1973.*

The SEWRPC Treatment Facility and Sludge Handling Practices Questionnaire indicated a raw sludge production of 1,220 lb/day. The influent suspended solids was 725 lb/day, and 696 lb/day were removed. However, data was for four months only.

Design criteria[1] for the soon to be constructed facility does not directly state the unit design values on the basis of sludge solids loadings. The 1,200 lb/day from the questionnaire appeared reasonable for the current load. Based on the plant design and SEWRPC's population estimates, a value of 2,000 lb/day (323 lb/day/1,000 population) was selected for year 2000.

Other Municipal Wastewater Treatment Plants (Flow < 0.5 mgd)

The amount of sludge generated by the other municipal wastewater treatment plants is a minor amount when compared to the amount produced at the large wastewater treatment plants discussed above. The 40 smaller facilities produced only 1.01 percent as much sludge as was generated at the major plants in 1975 (see Table 52). However, when sludge production is examined by county, it can be seen that these smaller plants generate significant portions of the total in Walworth, Washington, and Ozaukee counties. In the more populated counties of Racine, Kenosha, Milwaukee, and Waukesha, most small plants have been or are expected to be consolidated into larger treatment plants. The remaining small plants in these counties generate minor quantities of sludge when compared to major plants. Sludge quantities were estimated by mass balances typical of the categories being considered.

In Walworth County, sludge from other treatment plants is 40.4 percent of the sludge generated at the major plants in this county and 28.8 percent of the total sludge. In Washington County, these small plants produce 17.7 percent, when compared to the sludge produced by the major plants, and 15.0 percent of the total. In Ozaukee County, the smaller plants produce 16.6 percent, when compared to the sludge produced at the major plants, and 14.2 percent of the total. Table 52 lists data by plant type and county.

These calculations show that the smaller municipal treatment plants produce a significant proportion of sludge in the less populated counties and therefore are considered in the evaluation of selected sludge management alternatives in Chapter IX.

[1]*Robers & Boyd Inc., "Final Unit and Equipment Design Report," June 1976.*

TABLE 52

ESTIMATED RAW SLUDGE PRODUCTION OF ALL MUNICIPAL TREATMENT PLANTS IN REGION

County	1975 Sludge Production (lb/day dry solids)			2000 Sludge Production (lb/day dry solids)		
	Major Plants	Other Plants	% of Major Plants	Major Plants	Other Plants	% of Major Plants
Walworth	6,000	2,425	40.4	13,100	5,545	42.3
Racine	21,800	negligible	negligible	68,300	330	0.48
Kenosha	36,400	1,335	3.67	49,200	3,325	6.76
Washington	8,000	1,415	17.7	21,500	4,480	20.8
Ozaukee	6,400	1,060	16.6	12,900	2,210	17.1
Waukesha	27,700	800	2.89	62,000	1,940	3.13
Milwaukee	586,900	negligible	negligible	706,900	negligible	negligible
Total	693,200	7,035	1.01	933,900	17,800	1.91

Source: Camp Dresser & McKee Inc.

Private Wastewater Treatment Plants

The amount of sludge which could be produced by the design flow of the private wastewater treatment plants in the seven counties of Southeastern Wisconsin is insignificant when compared to the amount produced by the large public facilities (see Table 53). When sewage sludge production is examined by county, only Walworth County shows a significant percentage of sludge produced at private facilities.

Calculations determining sludge production at private facilities were based on the design flow and not on actual 1975 or projected year 2000 flow. The data given are the maximum amount of sludge that can be efficiently produced by each plant but do not indicate when this level will be reached as no data was available to make meaningful projections.

Water Treatment Plants

Sludges generated at water treatment plants currently amount to approximately 25,200 lb/day. 22,500 lb/day enter sanitary sewerage systems, while 2,700 lb/day are removed to disposal sites. These sludges are also discussed in Chapters III and IX and in the State-of-the-Art Study on Sludge Treatment and Disposal. By year 2000, these water treatment plants are expected to generate approximately 30,000 lb/day of sludge solids.

THE EFFECT OF CHANGING PROJECTIONS OF FUTURE CONDITIONS

The intent of this discussion is to address the effect of future conditions that may result in an increase or decrease of the predicted sludge solids loads at the area wastewater treatment plants. This is a three step discussion, the first step addressing possible changes in population. (Population change is the single most important factor in future sludge quantity estimates.) The second step addresses other factors affecting the total pounds of dry sludge solids produced (i.e., potential per capita solids load changes, errors introduced by solids balance assumptions, the effect of trucking-in septic and holding tank wastes, and future plant process changes). The third step was to compute an estimated variance in the projected quantities which can then be applied to predicted sludge solids generation, and then, in turn, compared to variance in plant process train costs to see if the alternative future condition might possibly favor process trains other than those selected.

In 1966 the Commission adopted a regional land use plan for southeastern Wisconsin. Recently, the Commission completed a full revision of the plan for design year 2000. Two alternative preliminary plans were initially considered in the development of the proposed plan for the year 2000. Each of the alternative preliminary plans depicted a spatial distribution of land based on common, new projections of increased regional population levels to the year 2000. Following review of the two alternative plans, the centralized plan was selected by the Commission for refinement and detailing. In general, the centralized land use plan embodies the same basic concepts relating to the spatial distribution and density of land uses as those established in the preparation of the initial regional land use plan for 1990. More specifically, the plan embodies the following three basic concepts:

TABLE 53

PRIVATE TREATMENT FACILITIES
ESTIMATED RAW SLUDGE PRODUCTION

County	Private Plants Sludge Production (lb/day dry solids)		Sludge Production (Design Percentage of Major Municipal Plants)	
	1975	Design	1975	2000
Walworth	1,414	1,636	27.3	12.5
Racine	885	1,024	4.7	1.5
Kenosha	150	174	0.48	0.35
Washington	N.A.[1]	N.A.	N.A.	N.A.
Ozaukee	88	102	1.6	0.79
Waukesha	936	1,083	3.9	1.8
Milwaukee	27	31	N.A.	N.A.
Total	3,500	4,050	0.58	0.43

[1]*Not Available.*

Source: Camp Dresser & McKee Inc.

1. New urban development within the Region should be encouraged to occur only in areas contiguous to existing urban development, readily served by centralized public sanitary sewerage and water supply facilities; covered by soils well suited to urban development and the attendant construction of facilities and structures; not located in areas of natural hazards such as floodlands; and should occur at densities which are sufficient to support the maintenance of urban mass transit systems and the development of planned neighborhood units.

2. All delineated primary environmental corridors, which encompass the best remaining elements of the natural resource base and the environmentally sensitive areas within southeastern Wisconsin, should be preserved in essentially natural open use.

3. To maximum extent possible, prime agricultural lands in the Region should be preserved in agricultural use in order to assure the maximum continuing production of food and fiber for existing and future generations of the residents of the Region; to protect the scenic and cultural heritage of the Region; and to enhance the overall quality of the environment.

Of the major elements of the controlled centralization alternative land use plan, the most important to the preparation of the areawide wastewater sludge management plan is that almost all of the urban land use development (approximately 96 percent) and almost all of the population (97 percent) are proposed to be served by public sanitary sewerage and water supply facilities. This would result in a total of about 630 square miles (about 92 percent of all urban development in the Region) and of 2,093,500 persons (about 94 percent of the total population of the Region) being served by centralized public utilities by the year 2000 under the proposed land use plan.

Population projections for the Region to the year 2000 are shown in five year increments in Table 54. In the preparation of these population projections, independent projections were made of resident population levels to the year 2000 by SEWRPC using four different demographic techniques. Using these techniques, a total of 18 different population projections were prepared, each based upon different assumptions concerning trends in fertility, migration, and mortality rates. These projections ranged from a probable low of 1.97 million persons to a probable high of 2.43 million

TABLE 54

POPULATION PROJECTIONS

County	1970	1975	1980	1985	1990	1995	2000	Population Change 1970-2000	% Change 1970-2000
Kenosha	117,917	127,800	139,200	149,800	159,900	167,800	174,800	56,883	48.2
Milwaukee	1,054,249	1,028,300	1,014,500	1,015,000	1,022,200	1,041,400	1,049,600	-4,649	-0.4
Ozaukee	54,461	65,300	76,200	86,800	97,400	106,000	114,000	59,539	109.3
Racine	107,838	177,400	185,600	195,500	203,600	211,400	217,700	46,862	27.4
Walworth	63,444	69,000	74,700	80,500	86,600	93,300	99,600	36,156	57.0
Washington	63,839	77,300	90,900	103,900	117,600	129,800	143,000	76,161	124.0
Waukesha	231,338	262,200	292,300	322,600	356,600	390,200	420,600	189,262	81.8
Region	1,756,086	1,807,300	1,873,400	1,954,100	2,043,900	2,139,900	2,219,300	463,214	26.4

Source: U.S. Bureau of the Census and SEWRPC.

persons. The population projections were compared with independent employment forecasts and a single population estimate selected as the forecast value with the assistance of the appropriate Technical Advisory Committees.

This procedure produced a projected median total population for the Region of about 2.22 million persons by the year 2000. The projected population level is based on an assumed reduction in the fertility rates to below replacement level by 1980, followed by a gradual increase to replacement level by the year 2000; and on an assumed halt of out-migration from the Region by 1985, with no substantial net in- or out-migration occurring thereafter. Recently projected regional population level is about 460,000 persons below the level used to design the original land use and transportation plans (over a decade ago) and the regional sanitary sewerage system plan. This reduction in population might be expected to have an impact on the need for public works facilities within the Region, including sludge management facilities.

As discussed above, the year 2000 population projections ranged from a low of 1.97 million to a high of 2.43 million, with a value of 2.22 million persons as a best estimate.

A problem at small, remote plants is the high seasonal population during three or four summer months, resulting in high solids loadings for those summer periods. However, the average per capita loading is likely to be less than for other permanently settled areas.

Extensive wastewater quality data were not available for some plants, and mass balance estimates of solids quantities were made. These theoretical and empirical relationships are always subject to some discrepancy because all wastewaters are chemically different. Future plant process changes might also result in small changes in solids loading, particularly due to differences in the point of application of chemicals and the type of chemicals used. Future wasteload allocations might also have some effect.

Based on the above, a reasonable approach is to compound an estimated percentage change per year over the study life. For this comparison, 0.5 percent per year was chosen. This represents an overall change from 1975 to 2000 of plus or minus 13.3 percent. This factor, coupled with the range of population projections, was used to arrive at a potential variance for year 2000 of 27.7 percent lower than predicted to 24.1 percent higher than predicted. This is an overall range of 45.8 percent from low to high projections. While this is a substantial variation, it is highly unlikely that a change of this magnitude will cause one process train to outweigh another in costs or feasibility. Cost functions representing individual processes or process trains all have similar economies-of-scale, and the plots of cost functions quite often run parallel to each other. Therefore, relative costs of process trains will not vary substantially over a wide range of solids loading. Any feasible, flexible process can be readily expanded and varying future conditions would only affect the timing of the future expansion.

The most important conclusion to be drawn from the above discussion is that all new plants should be built on sites with extra area. The increase is slight in overall plant costs to purchase the extra site area needed to facilitate future expansion of facilities (including any on site disposal). Additional site area should be acquired sufficiently early to also facilitate expansion of existing plants which conform to the long-range sewerage program for the Region.

INDUSTRIAL SLUDGE QUANTITY PROJECTIONS

The industrial inventory data gathered by SEWRPC in conjunction with the Wisconsin DNR gives detailed information on specific industries within the categories discussed earlier. Sludge quantity projections for the year 2000 based on these surveys, employment projections, and new federal regulations were considered as too speculative and subject to gross error. First, significant error would be introduced by projecting from a single sample, or two or three samples, to a value representative of a complete category. Second, new regulations for user charges and industrial cost recovery programs required in federally funded works may force industries to re-examine their current practice and seek methods of reducing the total waste load discharged to the municipal systems. And, third, estimates of future industrial growth in the Region, based on employment projections[1] suggest a 25 percent growth between 1975 and year 2000. Each of these potential inputs to the projection leads in a different direction rather than pointing to a common estimate. For these reasons industrial sludge quantities were held constant at their present level in all categories and no specific information for a specific category suggested otherwise. Quantities are shown in Table 55. (If wastewater limitations are tightened for industrial discharges, industrial wastewater from pretreatment will be much easier to treat in the municipal system and will produce much less sludge.)

In addition to the quantities shown in Table 55, further information on both industrial sludges and wastewater loads from industry is presented in Chapter III. Brewery wastes in Milwaukee, for example, are discharged directly to the sewerage system. Of the municipal sludge quantities for 1975, shown in Table 50, it is estimated that about 324,000 lb/day is of industrial origin.

[1] *The Economy of Southeastern Wisconsin, SEWRPC Technical Report Number 10, pp. 57-70.*

TABLE 55

INDUSTRIAL SLUDGE QUANTITIES BY CATEGORY

Category	Estimated Quantity in lb/day
Tanneries	5,400
Metal plating operations	7,300
Metal machining operations	34,200
Food processing operations	2,800
Battery manufacturing operations	(<100)
Truck and car wash operations	200
Power plants	—
Total	49,900

Source: Camp Dresser & McKee Inc. and SEWRPC.

SEPTAGE AND HOLDING TANK QUANTITY PROJECTIONS

The construction of public sanitary sewerage facilities has not fully kept pace with the rapid urbanization of the Region, and this has been a contributing factor to the widespread use of onsite soil absorption wastewater disposal systems including mound systems which are reported have similar septage characteristics as septic tanks. An estimated total of 240,000 persons in the Region, or about 14 percent of the total Region population, rely on such septic tank wastewater disposal systems for domestic wastewater disposal. About 24,000 of these persons live on farms. The remaining 217,000 persons constitute urban dwellers living generally throughout the rural and rural-urban fringe areas of the Region.

The estimated amount of dry sludge solids produced by these septic systems is about 12,400 lb/day, or less than 2 percent of the regional total. It should be noted here that although septage appears to be an insignificant proportion of the overall sludge production in this Region, it is by no means a simple problem to deal with. Septage is a high strength waste, i.e. high in BOD and Suspended Solids, which can upset the biological organisms in secondary treatment processes. Typical ranges are 2,500-20,000 mg/l BOD_5 and 2,500-100,000 mg/l SS. Typical values for raw domestic wastewater are 150 mg/l BOD_5 and 170 mg/l SS. The value 12,400 lb/day is based on the assumption that all systems are cleaned properly every 3 to 5 years. In as much as all systems are probably not cleaned on a regular basis, this might be considered a conservatively high figure. In year 2000, it is estimated that no more than 122,000 persons will be served by septic or holding tanks versus the current total of 240,000. Thus, the load in year 2000 will be approximately 5,600 lb/day, which is less than 1 percent of the estimated load to large public facilities.

Although the approximate location and number of septic tanks, mound systems and holding tanks is known, there is no reliable, detailed data available on the disposal practices of these wastes. Wastes currently being delivered to a public wastewater treatment plant are known and recorded by the operators, but such data at other disposal sites are uncertain. If full control of disposal practices were achieved, the impact of these wastes and solids loads would be felt most at the smaller treatment plants. It is generally considered that no more than about 10 percent of the daily volume of flow received by a treatment plant should result from septic and holding tank pumpage. Septage particularly is highly concentrated and in excessive amounts can upset biological treatment processes. Holding tank wastes, while relatively dilute, are also stale and may create operating problems. The maximum quantities of such wastes received in the future by each treatment plant in the Region should be governed by the proportion which can be processed without upsetting biological treatment processes. Study will be needed at each facility to determine the correct proportion which can be accepted.

SUMMARY

The above chapter presents the available data on sludge quantity and quality, a discussion of how this quality impacts the use-value of sludge, and a discussion of future sludge quantities projected to year 2000. Of the sludge quality criteria, greatest attention was paid to nutrients and heavy metals found in Region sludges from both municipal and industrial facilities. For the 21 major plants, an increase of about 35 percent between year 1975 and year 2000 was calculated. Projections for other plants, private plants, and industrial categories were also produced.

The estimated sludge quantities for all categories in 1975 and 2000 are shown in Table 56.

TABLE 56

SUMMARY OF ESTIMATED SLUDGE QUANTITIES IN THE REGION[1]

Category	Raw Sludge Solids (lb/day) 1975	Raw Sludge Solids (lb/day) 2000
Municipal		
Major plants	693,200	933,900
Other plants	7,000	17,800
Industries	49,900	49,900
Private plants	3,500	4,100
Water treatment plants	25,200	25,200
Total[2]	778,800	1,030,900

[1]*Quantities of combined sewer overflow solids and river bottom sediments cannot be estimated with precision; however, approximate costs for treating combined sewer overflows for Milwaukee have been estimated and are included under the projections for MSD-Jones Island in this Chapter and in Chapter IX.*

[2]*Sludges from water treatment plants are also partially included in municipal plant values. See solid production estimates, also see Table 98.*

Source: Camp Dresser & McKee Inc.

Chapter VI

REGULATORY CONSIDERATIONS

INTRODUCTION

The purpose of this chapter is to outline the major regulatory considerations that govern alternative sludge management plan screening and selection. Implementation and funding considerations are addressed further in Chapter XI. The regulatory considerations at the local or areawide level are more closely associated with the plan implementation while those at the state and federal level are more generally associated with the particular structural techniques available for processing, transportation, and disposal or utilization of sludges. Planning Report No. 16, published by the Southeastern Wisconsin Regional Planning Commission, provides an additional source for information on regulating agencies and laws.

Local level agencies are the cities, villages, towns, sanitary, and utility districts. These agencies are responsible for providing adequate service to their constituents through construction at appropriate intervals and through continued operation and maintenance of their particular facilities. They are most directly responsible to the local electorate and must live with the day-to-day problems of facility operation and maintenance. Under Wisconsin Statutes, these local agencies may also become involved in providing centralized sanitary sewer service and they have responsibilities for land use management.

Areawide agencies are: townships, counties (including soil and water conservation districts and the University of Wisconsin Extension Service), county health agencies, Metropolitan Sewerage District of the County of Milwaukee, other metropolitan sewerage districts, joint sewerage commissions, cooperative contract commissions, comprehensive river basin districts, and the Southeastern Wisconsin Regional Planning Commission. These agencies have a wide range of responsibilities, but they all have a common charge in that they must overview a large area and undertake long-term planning for wastewater and sludge management facilities. Statutory provisions exist for these agencies to have specific planning or plan implementation powers relating to regional sanitary sewerage system plans.

State level agencies with regulatory responsibility are: Department of Natural Resources, Department of Health and Social Services, and the Department of Administration. These agencies have either general or specific planning authority and certain plan implementation powers relating to regional sanitary sewerage system plans. This level of agencies serves to normalize the efforts of the various local and areawide agencies toward a common level or goal such that all must make comparable efforts in environmental protection. Such agencies can formulate standards and guidelines applicable to the particular environment of the State of Wisconsin. In addition, the Lake Michigan Enforcement Conference has made recommendations concerning sludge management. Federal agencies are: Environmental Protection Agency, the Department of the Interior, the Department of Agriculture, the Food and Drug Administration, and the Army Corps of Engineers. In addition, all proposed federally funded wastewater treatment facilities must be in compliance with the National Environmental Policy Act of 1969, the Council on Environmental Quality Guidelines for Preparation of Environmental Impact Statements dated 1 August 1973, and the Environmental Protection Agency's Final Regulations for Preparation of Environmental Impact Statements dated 14 April 1975.

The National Environmental Policy Act of 1969 requires a detailed statement covering:

1. The environmental impact of the proposed action
2. Any adverse environmental effects which cannot be avoided should the proposal be implemented
3. Alternatives to the proposed action
4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity
5. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

The Wisconsin Environment Policy Act is essentially the same as the National Act with the addition of:

6. An analysis of the economic impact of the proposed project including both advantages and disadvantages

7. A public hearing must be held for the proposed project if an impact statement is prepared.

LOCAL AGENCIES

Cities, Villages, and Towns

Cities have specific authority under Section 62.18 of the Wisconsin Statutes to provide for sewer service and to construct, operate, and maintain an entire sanitary sewerage system. Under this statute, cities are allowed to establish within the city limits special sewerage districts and levy special sewerage district taxes therein for improvements. By direct reference in Section 61.39, of the Wisconsin Statutes, villages are given identical powers as cities with respect to establishing sanitary sewerage systems and special sewerage districts. Additional authority to regulate by ordinance any conditions bearing upon the health, safety, and welfare of the community; to regulate wastewater quality discharged to the sewerage system from commercial or industrial sources and require pretreatment if necessary; and to regulate land use through zoning are provided in other Wisconsin Statutes.

There are 16 cities and villages in the study area which have exercised these powers to operate and maintain a sanitary sewerage system with a large wastewater treatment plant, as defined in Chapter III. There are an additional 25 cities and villages which also exercise these powers to operate and maintain small wastewater treatment plants. Under their police powers, cities and villages also could exercise regulatory authority over the use or disposal of sludge, including water treatment sludges, within their boundaries. They are as follows:

1. City of Kenosha—Management of the City of Kenosha sanitary sewerage system is under the direction of the City of Kenosha Water Utility and the City Council. The Utility is governed by a six-member Board of Water Commissioners appointed by the Mayor and subject to confirmation by the City Council. In practice, all of the members of the Board of Water Commissioners are also aldermen and concurrently serve as the Public Works Committee of the Kenosha City Council. Day-to-day administration of the sanitary sewerage system is provided by the staff of the Water Pollution Control Division of the Kenosha Water Utility and the City Public Works Department.

   Financing of the City of Kenosha sanitary sewerage system is provided through a combination of general taxes and sewer service charges based on water consumption.

2. Village of Twin Lakes—Management of the Village of Twin Lakes sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Sewer Committee of the Village Board. Operation and maintenance of the system are financed through a monthly service charge.

3. City of South Milwaukee—Management of the City of South Milwaukee sanitary sewerage system is under the direction of a five-member Sewerage Commission elected by the City Council. Day-to-day administration of the system is provided by the Superintendent of the sewage treatment plant. Financing of the system is provided through the general property tax.

4. City of Port Washington—Management of the City of Port Washington sanitary sewerage system is under the direction of the Board of Public Works, a committee of the City Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided through a combination of general taxes and sewer service charges based on water consumption.

5. City of Cedarburg—Management of the City of Cedarburg sanitary sewerage system is under the direction of a five-member Board of Public Works. Day-to-day administration of the system is provided by the wastewater treatment plant superintendent. Financing is provided through a combination of general taxes and sewer service charges based on water consumption.

6. Village of Grafton—Management of the Village of Grafton sanitary sewerage system is under the direction of a five-member Sewer and Water Commission. Day-to-day administration of this system is provided by the staff

of the Commission. Financing of the system is provided through a sewer service charge.

7. City of Burlington—Management of the City of Burlington sanitary sewerage system is under the direction of the Mayor and City Council. Day-to-day administration of the system is provided through the general property tax.

8. City of Racine—Management of the City of Racine sanitary sewerage system is under the direction of the Wastewater Commission of the City of Racine. Day-to-day administration of the system is provided by the staff of the wastewater utility of the City of Racine, headed by the General Manager of the Water and Wastewater Utilities. The city also maintains and staffs an air pollution department.

   Local financing of the City of Racine sanitary sewerage system is provided both through the property tax and through funds provided under contractual agreements with other municipalities and special purpose districts.

9. Village of Union Grove—Management of the Village of Union Grove sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided both through the property tax and through a sewer service charge. The charge is based on water consumption.

10. City of Whitewater—Management of the City of Whitewater sanitary sewerage system is under the direction of the City Manager and Common Council. Day-to-day administration of the system is provided by the City Manager. Financing of the system is provided through the general property tax and a sewer service charge based on water consumption.

11. Village of Williams Bay—Management of the Village of Williams Bay sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided through a sewer service charge based on water consumption.

12. City of Hartford—Management of the City of Hartford sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided both through a sewer service charge based on water consumption and through a general property tax levy.

13. City of West Bend—Management of the City of West Bend sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Water and Sewer Department of the city, headed by the City Engineer. Financing of the system is provided through a sewer service charge based on water consumption.

14. City of Brookfield—Management of the City of Brookfield sanitary sewerage system is under the direction of a five-member sewer utility board including the Mayor and Public Works Director. Day-to-day administration of the system is provided by the Director of Public Works and the Utility Superintendent. Financing of the system is provided through both a sewer service charge and a general property tax levy.

15. City of Oconomowoc—Management of the City of Oconomowoc sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided through the general property tax and a sewer service charge based on water consumption.

16. City of Waukesha—Management of the City of Waukesha sanitary sewerage system is under the direction of the Mayor and Common Council advised by the Board of Public Works. Day-to-day administration of the system is provided by the Director of Public Works and the Sewage Plant Superintendent. Financing of the system is provided through the general property tax.

Communities have in the past effectively prevented the disposal of sludge within their boundaries by several means. Racine County until recently had rigorous administrative procedures, the Towns of Waukesha and Summit imposed temporary bans which have been lifted, and the City of Oak Creek expressed its opposition. Currently no formal bans are in effect within the Region.

Sanitary and Utility Districts

Within the framework of sewerage and utility districts, local government units may retain certain responsibilities such as constructing, operating, and maintaining that portion of the sanitary sewerage system that serves the local area, assessing and collecting sewer service charges or taxes to finance their portion of the total cost of the overall district operation, regulate by ordinance any condition bearing upon the health, safety, and welfare of the community, and regulate by ordinance local land use.

Within the Region there were 41 active, legally established town sanitary and utility districts in 1970, as described in Planning Report 16.

There are 10 districts which presently operate or have under construction a wastewater treatment plant. These include the Town of Bristol Utility District No. 1, Town of Dover Eagle Lake Sanitary District, Town of Norway Sanitary District No. 1, Town of Pleasant Prairie Sanitary District 73-1, Town of Pleasant Prairie Sewer Utility District D, Town of Salem Sewer Utility District No. 1, Town of Somers Utility District No. 1, Caddy Vista Sanitary District, Allenton Sanitary District, and the North Park Sanitary District.

AREAWIDE AGENCIES

The Wisconsin Statutes provide several methods by which local units of government may jointly provide sewer service through special purpose districts. Three such districts meeting the statutory criteria are: Metropolitan Sewerage District of the County of Milwaukee, Western Racine County Metropolitan Sewerage District, and Walworth County Metropolitan Sewerage District.

Metropolitan Sewerage District of the County of Milwaukee

The largest of these special purpose districts is the Metropolitan Sewerage District of the County of Milwaukee which was established and operates under the provisions of Section 59.96 of the Wisconsin Statues.

Management of the Milwaukee Metropolitan sewerage system is under the direction of both the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee. These two commissions act jointly in all matters affecting the Metropolitan Sewerage District. The Sewerage Commission of the City of Milwaukee consists of five members who are appointed by the Mayor, subject to confirmation by the Common Council. The Metropolitan Sewerage Commission of the County of Milwaukee consists of three members all appointed by the Governor. One member is certified to the Governor by the Sewerage Commission of the City of Milwaukee and one member is certified to the Governor by the Wisconsin Department of Natural Resources. The Governor must appoint to the Commission those persons certified. The Governor appoints the third member on his own motion, with the limitation that the member be a resident within the drainage area of Milwaukee County but outside of the City of Milwaukee. Day-to-day administration of the Milwaukee-Metropolitan sanitary sewerage system is provided by a joint staff headed by a Chief Engineer and General Manager.

The Metropolitan Sewerage Commission has the power to plan and construct main sewers; pumping and temporary disposal facilities for the collection and transmission of domestic, industrial, and other sanitary sewage to and into the intercepting sewers of the District; and may improve any watercourse within the District by deepening, widening, or otherwise changing the same where, in the judgment of the Commission, it may be necessary in order to carry off surface or drainage waters. The Metropolitan Sewerage Commission, however, may only exercise its powers within the District and outside of the City of Milwaukee. The Sewerage Commission of the City of Milwaukee, on the other hand, is empowered to construct, operate, and maintain treatment facilities and main and intercepting sewers within its jurisdictional area, which is the City of Milwaukee. The Sewerage Commission of the City of Milwaukee also may improve watercourses within the city.

In order to coordinate the activities of the two Commissions, the Wisconsin Statutes provide that the Metropolitan Sewerage Commission must secure the approval of the Sewerage Commission of the City of Milwaukee before it is empowered to engage in any work and, when it has completed the work it proposes to do, it then conveys title of the facilities to the Sewerage Commission of the City of Milwaukee for operation and maintenance. In addition, the rules of the Sewerage Commissions adopted pursuant to State Statutes further require that all towns, cities, and villages lying within the District or under service agreements with the District submit local sewerage system and construction plans for approval to the Sewerage Commission of the City of Milwaukee before they may connect to the main and intercepting sewers owned by the District. The two Commissions have the power to promulgate and enforce reasonable rules for the supervision, protection, management, and utilization of the entire sewerage system.

Financing of the District is accomplished through charges to the municipalities served who in turn bill their users. A User Charge/Industrial Cost Recovery (UC/ICR) program is currently being developed. Under Chapter 59.96 of the Wisconsin Statutes, the District may raise funds through the imposition of a tax levy by the Milwaukee County Board of Supervisors or through the issuance of Metropolitan Sewerage Bonds by the county, pursuant to a funding request initiated by the District.

Western Racine County Metropolitan Sewerage District

This district is made up of the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1. Management of the sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by the commission itself. Financing of the system is provided by the two villages and the town utility district which contribute sewage to the District. Each collects a sewer service charge from the residents.

Walworth County Metropolitan Sewerage District

The District is made up of the Delavan Lake Sanitary District, the Cities of Delavan and Elkhorn, and the Walworth County Institutions. The wastewater treatment facility is not on line at this time but management of the sanitary sewerage system will be by commission. Day-to-day administration of the system will be provided by the Commission. Financing of the system will be split between the District, city, and institutions, based on sewage volumes.

Cooperative Contract Commissions

Section 66.30 of the Wisconsin Statutes permits the joint exercise by municipalities, which includes cities and villages by definition, of any power or duty required of, or authorized to, such municipality by statute. To exercise any power, such as the transmission, treatment, and disposal of sanitary sewage, the municipalities have to create a commission by contract. Three formal cooperative contract commissions have been created to date in this Region: Underwood Sewerage Commission, jointly created by contract between the City of Brookfield and the Village of Elm Grove; the Menomonee South Sewerage Commission, jointly created by contract between the City of Brookfield and the Village of Menomonee Falls; and the Delafield-Hartland Water Pollution Control Commission, jointly formed by contract between the City of Delafield and the Village of Hartland.

Soil and Water Conservation Districts

Soil and water conservation districts (SWCD) are special purpose units of government which derive their authority from Chapter 92 (Wisconsin Statutes). The basic legislative policy surrounding the creation of these districts is "To provide for the conservation of the soil and soil resources of this state, and for the control and prevention of soil erosion, and for the prevention of floodwater and sediment damages, and for furthering agricultural phases of the conservation, development, utilization and control of water . . . and promote the health, safety, and general welfare of the people of this state."

SWCDs are created by county boards after it is determined that the conservation of soil, water, or related resources presents a problem of public concern and that a substantial proportion of the land occupiers of the county favor such a district. After an SWCD is created, the county agricultural and extension committee supervises the SWCD. The geographic jurisdiction of the SWCD corresponds to the county that created the district.

SWCDs have the authority to carry out certain regulatory responsibilities pertaining to planning, construction, and operation of nonpoint source pollution facilities in accordance with Section 92.09, land use regulation. To date this authority has not been exercised and programs have been entirely voluntary. An SWCD may carry out preventative and control measures after obtaining the approval of the land occupiers. The measures may include, but are not limited to, "engineering operations such as terraces, terrace outlets, soil-saving dams, sediment traps, dikes, ponds, diversion channels, and other necessary structures."

Any regulatory authority possessed by the SWCD is limited to those areas of the district lying outside the incorporated areas. In addition, any county included in the regional planning program shall promote plans which are not at variance with regional plans, such as those prepared by the Southeastern Wisconsin Regional Planning Commission. SWCDs receive financial aid and administrative support from, and are subject to review by, the state board of the SWCDs. The SWCD annual work programs and long-range plans within the southeastern Wisconsin region are subject to review by SEWRPC.

The Soil and Water Conservation Districts have memoranda of understanding with the University of Wisconsin Extension Service, the Soil Conservation Service and the Agricultural Stabilization and Conservation Service under which these other agencies provide technical assistance and program development assistance to the Soil and Water Conservation Districts.

County and Township Governments

County and Town governments have regulatory authority over landspreading and sewage treatment plant locations by their authorities to control land use. Their powers of zoning allow them to regulate activities and behavior which may affect the health or safety of their inhabitants. Also, Counties and Townships have powers to examine and regulate septic tank systems. These powers are exercised through the town or county health agencies which have the authority to inspect and permit septic systems. It is possible that these powers (zoning and health and safety) could be expanded to regulate the land application of wastewater sludges.

Regional Planning Commission

In addition to these areawide districts and commissions; the Southeastern Wisconsin Regional Planning Commission (SEWRPC) represents the effort to provide necessary areawide planning services within the seven-county Southeastern Wisconsin Region. The Commission was created in August 1960, under provision of Section 66.945 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in planning for orderly and economic development in southeastern Wisconsin. The Commission's role is entirely advisory and participation by local units of government in its work is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region, who serve without monetary compensation.

Under Section 208(b)(2)(j) of PL 92-500 an areawide plan prepared by SEWRPC shall include "a process to control the disposition of all residual waste generated in such area which could affect water quality . . ." The areawide plan must be compatible with discharge permits issued by the Wisconsin Department of Natural Resources. Under Chapter 147.02 of the Wisconsin Statues, the disposal of sludge from a treatment works is declared unlawful unless done under the terms of a permit issued by the Department of Natural Resources. The Commission reviews all waste treatment management (facility) plans prepared under section 201 for consistency with the regional plan.

STATE AGENCIES

Department of Natural Resources

Responsibility for water pollution, solid waste, and air pollution control in Wisconsin is centered in the Department of Natural Resources (DNR). Pursuant to the State Water Resources act of 1965, the Department of Natural Resources acts as the central unit of state government to protect, maintain, and improve the quality and management of the ground and surface waters of the state. To this end, the Department must:

1. Formulate long-range comprehensive water resources plans for each region of the state
2. Formulate plans and programs for the prevention and abatement of water pollution and for the maintenance and improvement of water quality
3. Adopt rules setting standards of water quality which must be related to the different uses to which the waters may be put
4. Issue general orders for the construction, installation, use and operation of systems for preventing pollution
5. Issue orders to municipal units of government and private corporations to secure appropriate operating results at sewage treatment facilities in order to control water pollution
6. Investigate and inspect as necessary to assure compliance with pollution abatement orders
7. Conduct research and demonstration projects on sewerage and waste treatment matters
8. Enter into agreements with other states relative to pollution control of intrastate waters and to carry out such agreements by appropriate orders to owners of waste sources
9. Establish examining programs for the certification of wastewater treatment plant operators
10. Order the installation of a sanitary sewerage system within a specified time upon finding that the absence of a municipal sanitary sewerage system tends to create a nuisance or menace to public health
11. Administer a financial assistance program for the construction of pollution prevention and abatement facilities.

The University of Wisconsin Soil Science Department and the Department of Natural Resources in 1975 jointly prepared Technical Bulletin No. 88, "Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin." This publication gives guidelines for applying processed sewage sludge to agricultural and forest lands and assists DNR staff in the granting of discharge permits. These guidelines are discussed in detail in Chapter V.

Pursuant to sections 144.43 and 144.44 of the Wisconsin Statutes, the Department of Natural Resources is charged with preparing and adopting minimum standards for the location, design, construction, sanitation, operation and maintenance of solid waste disposal sites and facilities. Such sites or facilities must be licensed annually, and the department may collect a fee for administration.

Pursuant to Chapter 144 of the Wisconsin Statutes, the Department of Natural Resources is charged with organizing a comprehensive program to enhance the quality, management, and protection of the air resources of the state; creating an air pollution advisory council; making rules; providing for penalties and appropriate funds.

The following is a listing and brief summary of related chapters of the "Wisconsin Administrative Code—Rules of Department of Natural Resources Environmental Protection," and other rules and guidelines:

1. Chapter NR 3—Sets requirements for public participation under the pollutant discharge elimination system.

2. Chapters NR 102, 103, and 104—Set water quality standards for Wisconsin surface waters.

3. Chapter NR 110—Sets forth standards for all new or modified sewage facilities, excluding industrial waste treatment facilities. Special attention is paid to "sludge handling and disposal" and "land disposal of effluent." Recommended handling and disposal processes will conform to this chapter. A 1977 amendment to NR110.27—NR110.27(6)—states that "a sludge management plan shall be developed by each owner of a wastewater treatment plant and submitted to the department pursuant to the conditions imposed in the WPDES permits." In addition, "the owner of the wastewater treatment plant shall be responsible for the implementation of the approved sludge management activities." The department "shall evaluate the management plans on the basis of recommendations in Wisconsin department of Natural Resources (DNR) technical bulletin No. 88."

4. Chapter NR 113—Sets regulations for disposal of solids from septic tanks, seepage pits, grease traps, privies, and disposal of liquid industrial wastes.

5. Chapter NR 151—Provides standards for industrial and domestic solids waste handling and disposal including storage licensing, collection, transportation, processing, incineration, land disposal, composting, and air curtain destructor, salvage, and scrap metal processing.

6. Chapter NR 154—Sets air pollution control standards.

7. Chapter NR157—Establishes procedures for storage, collection, transportation, processing and final disposal of PCBs and products containing PCBs taken out of service for disposal. This chapter does not apply to sludges containing only small amounts of PCBs.

8. Chapters NR 200 through NR 297—Set requirements for filing applications for discharge permits, define categories of point source for which effluent standards and standards of performance are to be adopted, and establish effluent limitations for publicly-owned treatment works and privately-owned domestic sewage treatment works.

9. Department of Natural Resources Technical Bulletin No. 88—Is a guideline for the application of wastewater sludge to agricultural land in Wisconsin.

Wisconsin Department of Health and Social Services, Division of Health

Sections 144.03 and 145.02(1) of the Wisconsin Statutes specify the Department's authority to establish standards regarding private domestic sewage treatment and disposal systems and septic tank systems.

The Department of Administration

The Department is directed by Section 16.95 to promote the development and wise use of natural and human resources of the state through a system of comprehensive long-range planning. The Office of State

Planning and Energy executes this responsibility.

Lake Michigan Enforcement Conference
This Enforcement Conference was originally established under Section 10 of the Federal Water Pollution Control Act of 1948; however, the precise legal status of its measures is not clear under the Amendments of 1972. Its measures have been fully integrated into the state's water pollution control effort, and a number of recommendations of the conference are of significance to sanitary sewerage system planning in the Lake Michigan Basin. Recommendations specifically affecting sludge management planning include:

1. Waste treatment is to be provided by all municipalities to achieve at least 80 percent reduction of total phosphorus. This action was to be substantially accomplished by December 1972.

2. Combined storm and sanitary sewers are to be separated in coordination with all urban reconstruction projects and prohibited in all new developments, except where other techniques can be applied to control pollution from combined sewer overflows. Pollution from combined sewers is to be controlled by July 1977.

3. Discharge of treatable industrial wastes to municipal sewage systems, following needed preliminary treatment, is to be encouraged.

4. Prohibition of the dumping of polluted material into Lake Michigan is to be accomplished as soon as possible.

Lake Michigan effluent limitations were subsequently established by court action. On October 16, 1973 officials of the cities of Racine and Kenosha signed a settlement to a Lake Michigan pollution law suit brought by the State of Illinois which would commit the cities to provide higher levels of waste treatment at their sewage treatment facilities and eliminate pollution from combined sewer overflows. The agreement is binding on Racine and Kenosha only if all necessary federal and state funds are made available and only if all other municipalities discharging effluent in Lake Michigan are also required to meet these treatment standards. Effluent limitations for Racine and Kenosha were established as follows:

Effluent Limitation	By 12/31/76	By 12/31/77	By 7/1/79
BOD_5	20 mg/l (monthly avg.)	10 mg/l (monthly avg.)	4 mg/l (monthly avg.)
Suspended Solids	20 mg/l (monthly avg.)	10 mg/l (monthly avg.)	5 mg/l (monthly avg.)
Phosphorus .	1 mg/l (monthly avg.)	1 mg/l (monthly avg.)	1 mg/l (monthly avg.)

The city of South Milwaukee has reached an agreement which is similar to that of Racine and Kenosha. The present effluent discharge from South Milwaukee's wastewater treatment facilities is meeting the 10 mg/l BOD_5 10 mg/l suspended solids and 1 mg/l phosphorus discharge limit set for 12/31/77 in the above table.

In the recent decision of the Federal court case involving the Metropolitan Milwaukee Sewerage District, effluent limitations of 5 mg/l BOD_5 5 mg/l suspended solids and 1 mg/l phosphorus were set. It was not specified whether these values were monthly averages, and, at this writing, no compliance schedule had been adopted. Also, the condition of available federal and state funding was not included. A final judgement on effluent limitations and a compliance schedule is expected in late 1977.

FEDERAL AGENCIES

Environmental Protection Agency
The Environmental Protection Agency's role in wastewater treatment and sludge management results from its authority under the following acts: Federal Water Pollution Act of 1970, Public Law 84-660-Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500; Resource Conservation and Recovery Act of 1976, Public Law 94-580; Safe Drinking Water Act of 1974, Public Law 93-523; Toxic Substances Control Act, Public Law 94-469; and the Clean Air Amendments of 1970, Public Law 91-604. The Federal Water Pollution Control Act Amendments of 1972 extensively revised the earlier Act of 1970 and is currently the principal federal water quality legislation.

The Federal Water Pollution Control Act Amendments of 1972
The amendments of 1972 are divided into five broad titles and administered by the United States Environmental Protection Agency. This Act is discussed below:

Title I deals with research and related programs and includes Congressional declaration of goals and policy for water quality.

Title II deals broadly with federal grants for the construction of waste treatment works. One of the major provisions in this title is found in Section 208 and deals with the development and implementation of areawide waste treatment management plans. Such plans are intended to become the basis upon which the Environmental Protection Agency approves grants to local units of government for the construction of waste treatment works. Any area-wide plan prepared under the Section 208 planning process must include recommendations for the control of the disposition of all residual wastes generated in the planning area which may affect water quality, such as sludge. This report is an attempt to meet that requirement.

Title III deals with water quality standards, effluent limitations, and enforcement. The major provisions are those in Section 301 which establish a deadline of 1 July 1977 for the enactment of specific effluent limitations for all point sources of water pollution other than publicly-owned treatment works. Such limitations must require the application of the best practical water pollution control technology currently available, as defined by the Environmental Protection Agency Administrator. In addition, any waste source which discharges into a publicly-owned treatment works must comply with applicable pretreatment requirements also to be established by the Environmental Protection Agency Administrator. In addition, Section 301 provides that any waste source must meet any more stringent effluent limitation as required to implement any applicable water-use objective and supporting standard established pursuant to any state law or regulation or any other federal law or regulation. Section 301 further provides that no later than 1 July 1983, effluent limitations for point sources of water pollution, other than publicly-owned treatment works, must require the application of the best available technology that will result in further progress toward the national goal of eliminating the discharge of all pollutants.

Section 302 of the Act provides authority for the Environmental Protection Agency Administrator to set even more stringent effluent limitations for point sources or groups of point sources of water pollution upon a specific finding that the effluent limitations established under Section 301 (relating to the 1983 goals) would not result in the attainment or maintenance of that water quality in a specific portion of the navigable waters which would protect public water supplies, accommodate agricultural and industrial uses and the protection and propagation of a balanced fish and wildlife population, and allow human recreational activities in and on the water. No authority is given in this section to the states, indicating that upon specific findings, the Environmental Protection Agency Administrator can apply direct federal action to assure the achievement of water-use objectives and supporting water quality standards.

Section 402 of the Act provides authority for the Environmental Protection Agency to delegate to the States authority for administering a permit program which will carry out the objectives of this Act and to issue permits for discharges into navigable waters within the jurisdiction of the State.

As part of the continuing state planning process discussed below, each state is required by Section 303(e) of the Act to identify any waters within its boundary for which effluent limitations required under Section 301 are not stringent enough to achieve applicable adopted water-use objectives and supporting water quality standards. The state is then required to establish a priority ranking for such waters, taking into account the severity of the pollution and the uses proposed to be made of the waters. For each identified water, the state is then to establish a total maximum daily load for appropriate pollutants. Such a daily load is to be established at a level necessary to implement the water quality standards.

Finally, with respect to water quality standards and effluent limitations, Section 304 of the Act grants to the Environmental Protection Agency Administrator the authority to develop appropriate guidelines applicable to the establishment of the aforementioned water quality standards and effluent limitations. These guidelines include the following:

1. The development and publication of criteria for water quality accurately reflecting the latest scientific knowledge on the kind and extent of identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water; on the concentration and dispersal of pollutants in any body of water; on the concentration and dispersal of pollutants through biological, physical, and chemical processes; and on the effects of pollutants on biological community diversity, productivity, and stability.

2. The development and publication of information on factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters; on the factors necessary for the protection and propagation of fish life for classes and categories of receiving waters and to allow recreational activities

in and on the waters; on the measurement and classification of water quality; and on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

3. The preparation and publication of regulations providing guidelines for adopting or revising effluent limitations.

4. The development and publication of information relating to the degree of effluent reduction attainable through the application of secondary waste treatment; information on alternative waste treatment management techniques and systems; and information for identifying and evaluating the nature and extent of nonpoint sources of pollution and the processes, procedures, and methods needed to control pollution from such sources.

5. The preparation and publication of guidelines for the pretreatment of pollutants determined not susceptible to treatment by publicly-owned treatment works.

6. The preparation and publication of guidelines for establishing test procedures for the analysis of pollutants.

7. The preparation and publication of guidelines for the establishment of uniform application forms and other minimum requirements for the acquisition of information from owners and operators of point sources of pollution.

8. The preparation and publication of guidelines establishing the minimum procedural and related elements of any state permit program for waste discharges including monitoring requirements, reporting requirements, and enforcement provisions.

In accordance with Section 304, Environmental Protection Agency requirements and guidelines on particulates and opacity, mercury, and polychlorinated biphenyls from sludge incinerators are expected to apply to new facilities in the study area. Federal requirements do not mention exhaust temperature limits. The applicable publications are:

1. EPA New Source Performance Standards (40 CFR 60)

2. EPA Regulations on National Emissions Standards for Hazardous Air Pollutants (40 CFR 61)

3. EPA Technical Bulletin on Municipal Sludge Management Federal Register, Volume H, No. 108.

Section 306 of the Act provides, for the first time, national standards of performance with respect to the discharge of pollutants. The Environmental Protection Agency Administrator is required to publish a list of categories of pollution sources and regulations establishing federal standards of performance for newly established sources of pollution within each industrial category. The term "standard of performance" is defined to mean a standard for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated water pollution control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 307 of the new Act requires the Environmental Protection Agency Administrator to establish toxic and pretreatment effluent standards. Any state or local pretreatment requirements that are not in conflict with any national pretreatment standards are allowed to remain in effect. This section also specifies that individual industrial users of municipal waste treatment plants are not to be required to obtain a discharge permit under Section 402 of the Act, as discussed below. Any such discharge permit issued to a municipal waste treatment plant must, however, identify any industrial contributors and the quality and quantity of effluent introduced by them. Finally, industrial users must give notice of any change in the quality or quantity of effluent discharged into a municipal sewerage system to the state or federal agency issuing a permit for a publicly-owned treatment works, so that that agency will have an opportunity to examine the impact of the proposed discharge so as to determine whether there might be a violation of the municipal waste discharge permit.

Section 308 of the Act requires the Environmental Protection Agency Administrator or a state, upon approval of the Administrator, to establish an effective monitoring system related to all point sources of pollution.

Title IV deals with permits and licenses, Section 402 establishes a national pollutant discharge elimination system. Under this system, the Environmental Protection Agency Administrator or a state, upon approval of the Environmental Protection Agency Administrator, may issue permits for the discharge of any pollutant, or combination of pollutants, upon condition that the discharge will either meet all applicable effluent limitations or, prior to the taking of necessary implementing actions relating to effluent limitations, such additional conditions as the Administrator determines are necessary to carry out the provisions of the Act. The intent of the permit system is to include in the permit, where appropriate, a schedule of compliance which will set forth the dates by which implementation of various stages of the requirements imposed in the permit shall be achieved.

Section 405 of the Act prohibits the disposal of sewage sludge in any manner which could result in any pollutant from the sludge entering the navigable waters of the United States.

Finally, Title V of the Act includes general provisions relating to administration of the Act.

Congress has currently not approved additional funding and reform of the 1972 law; however, the program is still under review by both the House and Senate.

Sludge technical bulletin "Municipal Sludge Management: Environmental Factors," printed several times in draft form for review and comment, is about to be published in final form. The document has been developed with substantial assistance from both the U.S.D.A. and the U.S.F.D.A., under Public Law 92-500. The bulletin addresses only those factors important to the environmental acceptability of particular sludge management options and does so in a general manner, because the constraints are quite site specific. This bulletin should not be construed to be a regulatory document.

<u>The Resource Conservation and Recovery Act of 1976</u>—This Act (Public Law 94-580) is to provide technical and financial assistance for the development of management plans and facilities for the recovery of energy and other resources from discarded materials and for the safe disposal of discarded materials and to regulate the management of hazardous waste. The solid waste management plans (including resource recovery and resource conservation systems) are to promote improved solid waste management techniques, new and improved solid waste management techniques, new and improved methods of collection, separation and recovery of solid waste and the environmentally safe disposal of nonrecoverable residues. The Act prohibits future open dumping on the land and requires the conversion of existing open dumps to facilities which do not pose a danger to the environment. The Act regulates the treatment, storage, transportation and disposal of hazardous wastes which have adverse effects on health and the environment. The Act provides for the promulgation of guidelines for solid waste collection, transport, separation, recovery and disposal practices and systems.

Under this Act, the term solid waste refers to "sludges from waste treatment plants," and the Office of Solid Waste Management and Planning of the Environmental Protection Agency will have regulatory responsibility for sludges generated at municipal wastewater treatment plants. This Office is preparing guidelines for the land disposal of sludge; these guidelines will be mandatory for federal facilities and advisory for states.

Under this Act solid waste management plans should consider municipal sludges as one of the "solid wastes" in planning for resource recovery facilities or disposal sites. Municipal sludges spread on land are to be considered as part of the overall plan and spreading is to be carried out in conformance with federal and state guidelines.

Solid waste management regions are to be established in each state for the purpose of carrying out the solid waste management plans. Agencies will be designated to develop and implement the state solid waste plan. Regional or local agencies may be responsible for developing and implementing specific plans for their area in accordance with the state plan. Where feasible, designation of the agency for the affected area designated under Section 208 of the Federal Water Pollution Control Act shall be considered.

<u>The Safe Drinking Water Act</u>—Under this Act, Public Law 93-523, National Drinking Water Regulations will be established and enforced for all public drinking water supplies. The law also provides for a regulatory program to protect underground drinking water sources from careless injection of pollution. The following regulations will be promulgated:

1. National Interim and revised Primary Drinking Water Regulations

2. Special Monitoring for Organic Chemicals Regulations (part of the above regulations)

3. Regulations covering radioactivity levels will be promulgated at a later date and shall be part of the Interim Primary Drinking Water Regulations

4. National Interim Primary Drinking Water Implementation Regulations

5. Underground Injection Control Program Regulations

6. State Public Water System Supervision Program Grant Regulations

7. Grants for Underground Injection Control Program

8. National Secondary Drinking Water Regulations

9. Revised Primary Drinking Water Regulations.

On 24 June 1977 the Interim Primary Drinking Water Regulations will become official. The maximum contaminant levels for inorganic chemicals, e.g., Cadmium 0.010, Chromium 0.05, Lead 0.05, Mercury 0.002 mg/l, etc., may affect the permitted effluent concentrations of these substances, when the receiving water serves as a source of drinking water.

The Clean Air Act Amendments of 1970—Public Law 91-604, as amended by Public Law 92-157, Public Law 93-15, and Public Law 93-319, requires measures be taken to control emission sources and to achieve and maintain acceptable pollutant levels. The Environmental Protection Agency is currently developing ambient air standards on a pollutant-by-pollutant basis. Standards for several pollutants have been set and others for less critical pollutants are still being developed. Also, under this act, the Environmental Protection Agency has compiled a handbook of expectations and minimum levels of emissions on a process-specific basis. Each state is to adopt or improve these expectations as standards applying to specific processes regulating emission rates. In Wisconsin, the Department of Natural Resources under NR 154, Air Pollution Control, and NR 155, Ambient Air Quality, has set rules to maintain standards of air quality. These rules affect levels of pollution from sludge incinerators and pyrolysis units.

The Toxic Substances Control Act of 1976—Public Law 94-469, is being implemented by the Environmental Protection Agency. A program will be developed for testing short and long-term hazards of new chemical products. The act requires the Environmental Protection Agency to rule on whether the chemical products have been adequately tested for both short and long-term hazards. Any new chemical which is to be placed on the market after 11 December 1977 must be tested and approved.

U.S. Food and Drug Administration
The Food and Drug Administration (FDA), while supporting the use of treated sewage sludge on agricultural lands, has issued a set of recommendations to protect food crops from potentially dangerous levels of polychlorinated biphenyls (PCB), cadmium, lead, pathogens, and other contaminants. The FDA's comments to the EPA about their proposed technical bulletin suggest limiting the amount of cadmium to 20 parts per million (ppm), lead to 1,000 ppm, and PCBs to 10 ppm. (See Chapter V discussion of heavy metals.) In addition, crops which are customarily eaten raw should not be planted within three years from the last sludge application. Crops commonly mixed with other foods before cooking (corn, potatoes) should not be grown on sludge-fertilized land unless soil tests show that there is no danger; and, sludge should not be applied directly to crops when there is a danger of it remaining on or in the food. The FDA also suggests limits on the total amount of sludge which can be applied to the same plot of land.

U.S. Department of the Interior Geological Survey
This agency conducts continuing programs with respect to water resources appraisal and monitoring. These programs are particularly important to carrying out continuing stream gauging efforts which provide necessary input to streamflow analysis. These inputs also affect sanitary sewerage system plans and consequently the characteristics and quantities of the solids which must be removed from wastewater before discharge to streams. The Geological Survey also provides information on groundwater and depth to groundwater and can be called upon to aid in the analysis of potential spreading sites.

U.S. Department of Agriculture
This agency, through the Soil Conservation Service, provides technical information on soils and soils' analysis necessary to the preparation of a land application program. The Soil and Water Conservation Districts have local directive responsibility over programs related to the planning and carrying out of works of improvement for soil and water conservation. These local districts can play a significant role in any land application program by disseminating information to the local farmers and by supplying site information and monitoring of spreading operations.

The USDA is conducting a field demonstration program for composting sludge from wastewater treatment plants. This program is continuing at the Beltsville field station.

The USDAs role in sludge management is handled through the Cooperative Extension Services' programs in each community and through the technical support activities of the Agricultural Stabilization and Conservation Service, and the Soil Conservation Service.

U.S. Army Corps of Engineers

The Army Corps of Engineers continues to review all permits for waste outfalls discharging to navigable waters. The scope of the Corps of Engineers review is one relating to the interference of such outfalls with anchorage and navigation in and on navigable waters. The Corps of Engineers also has authority under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 to consult with and provide technical assistance to states and areawide planning agencies in the development of areawide waste treatment management plans for urban areas.

SUMMARY

Local government units, such as cities and villages, and areawide agencies, such as the metropolitan sewerage districts, are given authority to construct, finance, operate, and maintain sewage treatment systems through the Wisconsin Statutes. Under their police powers, cities, and villages could exercise regulatory authority over the management, use and disposal of sludge within their boundaries. In addition, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) is given responsibility for areawide planning through the Wisconsin Statutes and Federal Law, PL 92-500. At the state level, the Department of Natural Resources has primary responsibility for environmental quality. In the federal government the Environmental Protection Agency is the primary regulatory agency for environmental quality.

These regulatory structures influenced the consideration of screening methodologies presented in Chapter VIII and the development and screening of alternatives presented in Chapter IX. The methodologies for plan implementation in Chapter XI reflect, most directly, the regulatory authority of the responsible agencies and point out the agencies which may be of prime importance to plan implementation.

Chapter VII

WASTEWATER SLUDGE MANAGEMENT SYSTEM DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

Planning is a rational process for formulating and meeting objectives. The formulation of objectives is, therefore, an essential task which must be undertaken before plans can be prepared. The formulation of objectives for organizations whose functions are directed primarily at a single purpose and, therefore, are direct and clearcut is a relatively easy task. The Region, however, is composed of many diverse interests; consequently, the formulation of objectives for the preparation of advisory, comprehensive regional development plans is a very difficult task.

Soundly conceived regional development objectives should incorporate the combined knowledge of many people who are informed about the Region and should be established by duly elected or appointed representatives legally assigned this task, assisted by planning technicians and engineers. This is particularly important because of the value system implications inherent in any set of development objectives. The act of participation by duly elected or appointed public officials and by citizen leaders in the overall regional planning program is implicit in the structure and organization of the Southeastern Wisconsin Regional Planning Commission itself. Moreover, the Commission very early in its existence recognized that the task of guiding the broad spectrum of related public and private development programs, which would influence and be influenced by a comprehensive regional planning program, would require an even broader opportunity for the active participation of public officials and private interest groups in the regional planning process. In light of this recognition, the Commission has provided for the establishment of a number of advisory committees to assist the Commission and its staff in the conduct of the regional planning program. The Technical Advisory Committee on Areawide Water Quality Management Planning is only one of many advisory committees which have contributed to the formulation of objectives toward which the advisory structure of regional plan elements has been directed. Others include the Intergovernmental Coordinating Committee on Regional Land Use-Transportation Planning and the Technical Coordinating and Advisory Committee on Regional Land Use-Transportation Planning, which jointly contributed to the formulation of the land use and transportation development objectives; the Root River, Fox River, Milwaukee River, and Menomonee River Watershed Committees, which contributed to the formulation of water use and water control facility objectives for their respective watersheds; and the Technical Advisory Committee on Regional Sanitary Sewerage System Planning, which contributed to the formulation of sanitary sewerage system development objectives.

This chapter sets forth the regional development objectives, principles, and standards relevant to wastewater sludge management which have been adopted by the Commission under other regional planning programs after careful review and recommendation by the advisory committees concerned. In addition, a series of new objectives, principles, and standards relating directly to the development of a regional wastewater sludge management system is presented.

BASIC CONCEPTS AND DEFINITIONS

The term "objective" is subject to a wide range of interpretation and application and is closely linked to other terms often used in planning work equally subject to a wide range of interpretation and application. The following definitions have, therefore, been adopted in order to provide a common frame of reference:

1. Objective: a goal or end toward the attainment of which plans and policies are directed.

2. Principle: a fundamental, primary, or generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: a criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: a design which seeks to achieve the agreed-upon objectives.

5. Policy: a rule or course of action used to ensure plan implementation.

6. Program: a coordinated series of policies and actions to carry out a plan.

Although this chapter deals with the first three of these terms, an understanding of the interrelationship of the foregoing definitions and the basic concepts which they represent is essential to the following discussion of development objectives, principles, and standards.

DEVELOPMENT OF OBJECTIVES

Objectives, in order to be useful in the comprehensive regional planning process, must be logically sound and related in a demonstrable and measurable way to alternative physical development proposals. This is necessary because it is the legal duty and function of the Commission to prepare a comprehensive plan for the physical development of the Region and, more particularly, because it is the purpose of the regional areawide water quality management planning program to prepare certain key elements of such a plan, including a regional wastewater sludge management system plan. Only if the objectives are clearly relatable to physical development and only if they are subject to objective test, can an intelligent choice be made from alternative plans in order to select the one plan or combination of plans which best meets the agreed-upon objectives.

Under its various planning programs the Commission has postulated a set of specific regional development objectives which are directly relatable to physical development plans and can be at least crudely quantified. The quantification is facilitated by complementing each specific objective with a set of quantifiable planning standards which are, in turn, directly relatable to a planning principle which supports the chosen objective. Planning principles thus augment each specific objective by asserting its inherent validity as an objective.

In its planning efforts to date, the Commission has adopted, after careful review and recommendation by advisory and coordinating committees, nine specific regional land use development objectives, seven specific regional transportation system development objectives, four specific water control facility development objectives, and four specific sanitary sewerage system development objectives. These specific development objectives, together with their supporting principles and standards, are set forth in full in previous Commission planning reports.[1]

Land Use Development Objectives

Seven of the nine specific regional land use development objectives already adopted by the Commission under previous planning programs are applicable to the regional wastewater sludge management system planning effort, and are hereby recommended for reaffirmation as development objectives under this planning program. These are:

1. A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.

2. A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

3. A spatial distribution of the various land uses which will result in the protection and wise use of the natural resources of the Region including its soils, inland lakes and streams, wetlands, woodlands, and wildlife.

4. A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economic provision of transportation, utility, and public facility services.

5. The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive.

6. The preservation, development, and redevelopment of a variety of suitable industrial and commercial sites, both in terms of physical characteristics and location.

7. The preservation and provision of open space to enhance the total quality of the regional environment, maximize essential natural resource availability, give form and structure to urban development, and facilitate the ultimate attainment of a balanced year-round outdoor recreation program providing a full range of facilities for all age groups.

8. The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture; provide a reserve or hold-

[1] *See SEWRPC Planning Report No. 25, "Land Use-Transportation Study, Forecasts and Alternative Plans—2000, Volume II," SEWRPC Planning Reports Nos. 9, 12, 13, and 26, "Comprehensive Plans for the Root, Fox, Milwaukee, and Menomonee River Watersheds," respectively, and SEWRPC Planning Report No. 16, "A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin."*

ing zone for future needs; and ensure the preservation of those unique rural areas which provide wildlife habitat and which are essential to shape and order urban development.

In addition to the foregoing specific regional land use development objectives, the following specific land use and surface and groundwater development objective was recommended for adoption as an additional development objective for the Milwaukee River watershed, in the development of a comprehensive plan for this watershed, and is hereby reaffirmed and recommended for consideration as a development objective for the regional wastewater sludge management systems planning program:

9. The attainment of good soil and water conservation practices in order to reduce stormwater runoff, soil erosion, and stream and lake sedimentation, pollution, and eutrophication.

Water Control Facility Development Objectives

One of the four water control facility development objectives already adopted by the Commission, under its comprehensive watershed planning programs, is applicable to the regional sludge management system planning effort and is hereby recommended for reaffirmation as specific development objectives for the regional wastewater sludge management system planning program:

1. Attainment of sound groundwater resource development and protective practices to minimize the possibility of pollution and depletion of the groundwater resources.

The three additional objectives formulated under the watershed programs deal with stream and lake water quality for each particular watershed and with the development of drainage and flood control structures. These objectives have been recognized in the development of similar objectives for the Region as a whole under the regional sanitary sewerage system planning program and the areawide water quality management planning program.

Sanitary Sewerage System Planning Objectives

The four specific regional sanitary sewerage system development objectives already adopted by the Commission under its sanitary sewerage system plan are applicable to the regional sludge management systems planning effort, and are hereby recommended for reaffirmation as development objectives under the regional wastewater sludge management system planning program. These are:

1. The development of sanitary sewerage systems which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated sanitary waste disposal demand generated by the existing and proposed land uses.

2. The development of sanitary systems so as to meet established water use objectives and supporting water quality standards.

3. The development of sanitary sewerage systems that are properly related to and will enhance the overall quality of the natural and manmade environments.

4. The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

Wastewater Sludge Management Systems' Development Objectives

The following six specific development objectives for regional wastewater sludge management system planning have been developed under this program and are recommended for adoption as additional development objectives for the Region.

1. The development of a regional wastewater sludge management system which will effectively support the existing regional development pattern and serve to aid in the implementation of the regional land use plan, while meeting the anticipated wastewater sludge management needs generated by the existing and proposed land uses.

2. The development of a regional wastewater sludge management system which will meet established air and water use objectives and supporting standards; which will not result in pollution of the land, impairing its desirable uses; and which will be properly related to the natural resource base and enhance the overall quality of the environment in the Region.

3. The development of a regional wastewater sludge management system which will effectively protect the public health within the Region.

4. The development of a regional wastewater sludge management system which will help to

maintain or enhance the productivity of agricultural land within the Region.

5. The development of a regional wastewater sludge management system which will maximize the recovery and utilization of resources in the handling and disposal of wastewater sludges.

6. The development of a regional wastewater sludge management system which is both economical and efficient, meeting all other objectives at the lowest cost possible.

PRINCIPLES AND STANDARDS

Complementing each of the foregoing specific land use, water control, sanitary sewerage system, and sludge management system development objectives is a planning principle and a set of planning standards. These, as they apply to land use, water control facility, and sanitary sewerage system development, are set forth in other Commission reports already cited. In so far as these objectives, principles, and standards relate to the design, testing, and evaluation of alternative sludge management systems, the objectives will be deemed to have been met if the sludge management plans are found to be consistent with the adopted regional land use and sanitary sewerage system plans, and with the several watershed development plans.

It should be noted that the planning standards herein recommended fall into two groups: comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. Absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values. Standards should not only aid in the development, testing, and evaluation of sanitary sewerage system plans but also in development, testing, and evaluation of local land use and public utility plans and in the development of plan implementation.

SUMMARY

The task of formulating objectives and standards to be used in plan design and evaluation is a difficult but necessary part of the planning process. It is readily conceded that regional plan elements must advance development proposals which are physically feasible, economically sound, aesthetically pleasing, and conducive to the promotion of public health and safety. The agreement on development objectives beyond such generalities, however, becomes more difficult to achieve because the definition of specific development objectives and supporting standards inevitably involves value judgments. Nevertheless, it is essential to state such objectives for the development of a regional wastewater sludge management system and to quantify them, insofar as possible, through standards in order to provide the framework through which alternative regional wastewater sludge management system plans can be prepared and evaluated. Moreover, so that the regional wastewater sludge management system plan will form an integral part of the overall framework of long-range plans for the development of the Region, the regional wastewater sludge management system objectives must be compatible with other regional development objectives. Therefore, the regional wastewater sludge management system development objectives and supporting principles and standards, as set forth in this chapter, are based upon previously adopted regional development objectives, supplementing these only as required to meet the specific needs of the regional wastewater sludge management system planning program.

Six new development objectives, together with supporting principles and standards, were formulated under the regional wastewater sludge management system planning program. Together with the land use and related water control facility and regional sanitary sewerage system development objectives previously established under related Commission work programs, these development objectives, principles, and standards provide the basic framework within which the alternative regional wastewater sludge management systems were formulated and a recommended regional wastewater sludge management system plan synthesized. (See Table 57.)

TABLE 57

WASTEWATER SLUDGE MANAGEMENT SYSTEM PLANNING OBJECTIVES, PRINCIPLES, AND STANDARDS[1]

OBJECTIVE NO. 1

The development of a regional wastewater sludge management system which will effectively support the existing regional development pattern and serve to aid in the implementation of the regional land use plan while meeting the anticipated wastewater sludge management needs generated by the existing and proposed land uses.

PRINCIPLE

The generation of sludges is an unavoidable result of the treatment of wastewaters from residential, commercial, industrial, institutional, and other intensive land uses in an industrialized society. Such generation creates a need for land for treatment and application—a need which should be accommodated properly within the overall existing and desirable future land use pattern of the Region.

STANDARDS

1. To assure a continuing potential for sludge application on land, the spatial arrangement of suitable land uses should be compatible with the spatial arrangement of existing and planned urban land use, to provide at least 60 acres of suitable and accessible agricultural or silvicultural land per 1,000 residents.

2. Sludge processing and utilization facilities should be sized and located so as to efficiently and effectively serve the recommended future land use pattern of the Region, as well as the existing land use pattern within the Region.

3. Systems for processing and disposal of sludge should be available at a reasonable cost to all owners or operators of publicly or privately owned sanitary or combined storm and sanitary or industrial sewage treatment plants, stormwater treatment facilities, large[2] industrial wastewater pretreatment facilities, on-site sewage treatment systems, or holding tanks.

4. The location of new and replacement wastewater sludge processing, storage, and handling facilities should be properly related to the existing and proposed future urban development pattern, as reflected in the adopted regional land use plan and any community or neighborhood unit development plans prepared pursuant to and consistent with the regional land use plan; and, more specifically, should be located only in areas designated for industrial or public utility areas.

5. The location of new and replacement wastewater sludge utilization sites should be properly related to the existing and proposed future urban development patterns as reflected in the adopted regional land use plan in existence at the time of disposal, as reflected in local community plans and zoning prepared pursuant to and consistent with the regional land use planning objectives, principles, and standards; and should, more specifically, be located only in areas designated for agricultural, woodland, industrial, utility, transportation, or specially managed park and recreation uses.

OBJECTIVE NO. 2

The development of a regional wastewater sludge management system which will meet established air and water use objectives and supporting standards; which will not result in pollution of the land, impairing its desirable uses; and which will be properly related to the natural resource base and enhance the overall quality of the environment in the Region.

[1] *The standards presented here serve multiple roles. First they are used by the Commission to compare the suitability and relative performance of physical plan alternative. Second, they are technical standards advised by the Commission for use by local units of government. In this role, standards may be considered minimum standards by local units of government which desire to impose more stringent limitations on waste management activities.*

[2] *Large industrial pretreatment facilities are defined as those treating at least 10,000 gal. per day of waste.*

PRINCIPLE

Wastewater sludges contain physical, chemical, and biological substances which could potentially present a threat to human health and to the chemical, biological, and ecological integrity of the air, water, and land of the Region; and to desirable uses of these and other elements of the underlying and sustaining natural resource base.

STANDARDS

1. Wastewater sludges should be treated and utilized only in a manner compatible with and supportive of the water use objectives and supporting water quality standards for the surface waters of the Region; and, sludge application shall be conducted only on lands where good soil and water conservation practices are implemented in order to avoid pollution of lakes and streams.

2. Operations conducted for land utilization of solid or liquid sludges should provide for a minimum of six months of sludge storage, should be performed only on lands where good soil and water conservation practices are implemented, should be properly timed and performed to account for meteorological conditions—inclusive of moisture and temperature—and, where feasible, should include incorporating the sludge into the soil immediately following application in order to avoid pollution of lakes and streams.

3. Wastewater sludge application should occur only on suitable soils, as identified in detailed soil survey maps.

4. The continuous or recurring application of wastewater sludges to land or in sanitary landfills should be avoided unless the recurring land area has been carefully selected, designed, operated, and monitored to avoid creation of a pollution or a public health hazard in the groundwaters of the Region.

5. Incineration of wastewater sludges shall be practiced in such a manner as to assure that the air quality standards will be maintained within the Region.

6. New and replacement installations for wastewater sludge treatment, handling, storage, and disposal, as well as additions to existing facilities and operations, should be located outside of the 100-year recurrence interval floodplains of the Region. If, in order to maximize the use of existing facilities, it is necessary to use floodplain lands for wastewater sludge treatment, handling, or storage, the facilities should be located outside of the floodway so as not to increase the 100-year recurrence interval flood stage and should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage, so as to assure adequate protection against flood damage and avoid disruption of the processes of wastewater handling and disposal during flood periods. In the event that a floodway has not been established, or if it is necessary to encroach upon an approved floodway, the hydraulic effect of such encroachment shall be evaluated on the basis of an equal degree of encroachment for a significant reach on both sides of the stream, and the degree of encroachment shall be limited so as not to raise the peak stage of the 100-year recurrence interval flood by more than 0.5 feet.

7. Existing wastewater sludge storage and handling facilities located in the 100-year recurrence interval flood plain should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and avoid disruption of wastewater sludge management processes during flood periods.

OBJECTIVE NO. 3

The development of a regional wastewater sludge management system which will effectively protect the public health within the Region.

PRINCIPLE

Sanitary wastewater sludges contain pathogenic organisms and toxic substances harmful to human and other life. The improper handling and disposal of such sludges might, therefore, create serious public health hazards.

STANDARDS

1. All sludges derived from sanitary wastes to be handled, stored, or land-applied off the wastewater treatment site, or in any other way allowing for substantial, noncontrolled public contact, should be digested, heated, or otherwise processed to reduce the hazard from pathogenic organisms.

2. Wastewater sludge storage facilities and landfills used for sludge application should be provided with protective fencing, suitable buffer zones, and evergreen plantings for visual screening.

3. Wastewater sludge land application sites should be located a minimum of 1,000 feet from the nearest public water supply well and 200 feet from the nearest private water supply well when sludge is incorporated into soil immediately after spreading.

4. No sludges should be applied on land to be used in the same or following year for the production of root crops intended for direct and uncooked consumption by humans, or directly onto trees bearing fruit which is to be consumed uncooked by humans.

5. Animal grazing or the harvesting of silage or other animal feed crops should be avoided on land where sludge has recently been spread.

6. The soil pH at sludge application sites should be maintained at 6.5 or greater in order to minimize uptake of cadmium and other heavy metals by plants.

7. Toxic and hazardous substances which would be present in harmful quantities in wastewater sludges must be reduced to acceptable levels by pretreatment of the contributing wastewater to make the sludges amenable to safe handling and disposal.

OBJECTIVE NO. 4

The development of a regional wastewater sludge management system which will help to maintain or enhance the productivity of agricultural land within the Region.

PRINCIPLE

As one of the most important renewable natural resources in the Region, soil, with its complex chemical and living organic characteristics, constitutes a particularly valuable and increasingly precious resource. Except on engineered sites, designed specifically and only for the purpose, sludge application practices should not preclude the continued and essentially unconstrained use of the prime agricultural lands of southeastern Wisconsin for the safe and healthful production of food and fiber.

STANDARDS

1. Long-term sludge utilization activities should not limit the capacity of the land for the production of food and fibers and should not be located on prime agricultural lands, as identified in the regional land use plan.

2. Soil and sludge tests should be utilized together in the analysis of sludge application sites to avoid damage to the long-term productivity of the land, through the addition of sludges of known characteristics.

3. Written records of wastewater sludges applied to land should be maintained for long-term reference for the analysis of the total loadings which have been applied.

OBJECTIVE NO. 5

The development of a regional wastewater sludge management system which will maximize the recovery and utilization of resources in the handling and disposal of wastewater sludges.

PRINCIPLE

A substantial amount of energy is expended in the conduct of activities which precede and cause the generation of sludge, which then contains natural organic substances and concentrated chemicals and thereby presents an opportunity to reduce the net resources needed to conduct the activities of human society and economy within the Region.

STANDARDS

1. Wastewater sludge management systems should be designed and developed wherever feasible in coordination with the design and construction of solid waste disposal facilities.

2. Where technically feasible, consideration should be given to the reclamation, from wastewater sludges, of substances having economic value, or to the use of pretreatment of wastewaters to remove substances having economic value prior to discharge of those substances to sewerage systems.

3. Wastewater sludge management systems should be designed and developed to provide for maximum use of the organic and nutrient components of sludge through application to enhance soil fertility.

OBJECTIVE NO. 6

The development of a regional wastewater sludge management system which is both economical and efficient, meeting all other objectives at the lowest cost possible.

PRINCIPLE

The total resources of the Region are limited and any undue investment in wastewater sludge handling and utilization systems must occur at the expense of other public and private investment; total wastewater sludge management systems' costs, therefore, should be minimized while meeting, to the maximum extent practicable, all of the other system development operations.

STANDARDS

1. The sum of wastewater sludge management system operating and capital investment costs, inclusive of any revenues received from resource recovery, should be minimized.

2. Maximum feasible use should be made of all existing and committed wastewater sludge management facilities. Such facilities should be supplemented with additional facilities only as necessary, to meet the anticipated wastewater sludge demand generated by substantial implementation of the regional land use plan and the regional sanitary sewerage system plan, while meeting pertinent water quality use objectives and standards.

3. The use of new or improved methods for wastewater sludge handling and utilization should be allowed and encouraged if such methods are adequately monitored in a suitable environmental sampling program; offer economies in operational costs; or, by their superior performance, lead to the achievement of air quality and water quality standards at lesser costs, providing they do not detract from the achievement of other objectives set forth herein.

4. The development of wastewater sludge handling and utilization processes and facilities should be conducted in such a manner as to allow the maximum feasible flexibility in the provision of technical alternatives for sludge handling and utilization and should always provide, as a temporary measure and as a possible future alternative, at least one alternative to the primary method of sludge disposal.

5. When technically feasible and otherwise acceptable, the application of wastewater sludge on land should utilize existing public lands in order to minimize land acquisition or easement costs.

6. Wherever possible, wastewater sludge handling and utilization systems should be designed and developed concurrently with power generation facilities, in order to effect engineering and construction economies as well as to assure the separate function and integrity of wastewater sludge management systems and power generation facilities.

Chapter VIII

ENGINEERING DESIGN CRITERIA AND ANALYTICAL PROCEDURES

INTRODUCTION

Techniques are described in this chapter for sludge processing, transportation, and utilization/disposal, together with techniques for analysis and screening of alternatives leading to the selection of the recommended regional sludge management system plan.

The first section of this chapter is developed utilizing, as a basis, the State-Of-The-Art studies completed for the Commission by Stanley Consultants Inc. and is directed toward system component feasibility and design criteria. Advantages and disadvantages of each component or unit operation are discussed. The purpose of this discussion is to present the character of each unit operation prior to the combination of these various unit operations into processing, transport, and utilization/disposal trains for the development of areawide wastewater sludge management system plan alternatives.

The second section of this chapter describes the factors for consideration in the screening of alternatives. Each factor is discussed and an environmental assessment matrix is presented. The advantage of a matrix or a check list is consistency in analysis and the assurance that major factors are not overlooked.

DISCUSSION OF TECHNIQUES FOR SLUDGE PROCESSING, TRANSPORTATION, AND UTILIZATION/DISPOSAL

Sludge processing is currently being studied by many consulting engineers, agencies, and manufacturers, and these studies are resulting in the development of new techniques for sludge processing. It is prudent for an areawide system's level study to consider such developments as well as those methods that have been thoroughly tested and in use for a number of years. Sludge processing, transportation, utilization, and disposal techniques for consideration in the alternatives analysis are listed below. The list of processes is presented in Table 58 based on previous State-Of-The-Art studies completed by Stanley Consultants Inc., SEWRPC, and further review of the various unit processes, both those found most feasible in other areas and those currently utilized in the study area (as discussed in Chapter III). Also shown in Table 58 are the number of major plants in the Region currently utilizing the listed processes.

TABLE 58

TECHNIQUES FOR SLUDGE PROCESSING, TRANSPORTATION, AND UTILIZATION/DISPOSAL

Technique	Number in Use at 21 Major Plants
Processing	
Thickening (Gravity/Flotation)	6
Centrifugation	1
Aerobic Digestion	7
Anaerobic Digestion	15
Wet Air Oxidation	1
Chemical Conditioning	6
Vacuum Filter	3
Filter Press	2
Drying Lagoon	6
Sand Beds	8
Transport	
Truck	21
Rail	1
Pipeline	0
Barge	0
Utilization/Disposal	
Incineration/Pyrolysis (ash to landfill)	1
Landfilling	6
Landspreading	15
Public Pickup	3
Composting	0
Soil Conditioner	0
Organic Fertilizer	1

Source: SEWRPC and Camp Dresser & McKee Inc.

<u>Thickening (Gravity/Flotation)</u>

The term thickening will be used to describe an increase in solids concentration, whether it occurs as the objective of a separate process or as a secondary effect of a process provided essentially for a different purpose. Thickeners are used in wastewater treatment plants where solids must be concentrated to increase the efficiency of further treatment. Thickening is economically attractive because considerable volume reduction is achieved with even modest increases in solids concentration. One percent solids sludge concentrated to two percent solids will represent a volume reduction of 50 percent. The same sludge concentrated to 5 percent solids will be only 20 percent of the original volume. Such volume reductions will result in considerable savings in haul costs. For example, anaerobic sludge digesters are designed on the basis of solids retention, and a thicker sludge will allow for a reduction in the required digester volume. The proper location of the thickener in a wastewater treatment plant is important. If the sludge is to be digested, thickening a blend of raw primary and waste-activated sludge seems, in some cases, to be efficient. On the other hand, if raw primary and secondary sludges are to be dewatered and incinerated, sludges might be thickened separately and blended immediately before dewatering. The thickening characteristics of a particular sludge are highly dependent on waste source and type of solids entering the treatment plant as well as the treatment process. Characteristics are also dependent on the location of chemical addition for phosphorus removal. Blending of raw primary and waste-activated sludge prior to thickening and digestion allows one to use a single type of thickener and results in a fairly uniform sludge feed to the anaerobic digesters. Dewatering, as necessary, would follow digestion. Gravity thickening might be found to work best on raw primary sludge, while flotation thickening might be found to work best on raw waste-activated sludge. These two sludges, thickened separately and efficiently, might then be blended prior to dewatering and incineration. There are no hard and fast rules and careful study and pilot work is necessary prior to final design. Plant size is also a factor. It might be best, in a small plant, to simply use a gravity thickener because it is fairly simple and easy to operate.

It is necessary to distinguish between sludge thickening and sludge dewatering. Thickening is defined as the concentrations of sludge to less than 10 percent solids. Such sludge, depending on its type, might still be pumpable by conventional means.

Gravity Thickening–Gravity thickening is the most common sludge concentration process in use at wastewater treatment plants. Suspended solids particles with sufficient settling velocity can be separated from water by maintaining gentle flocculation. Gravity thickeners usually follow gravity clarifiers (sometimes in the same unit), but emphasis in the former is on removing water from solids rather than, as in the latter, solids from water. In thickening, the predominant mechanism is settling of a sludge blanket rather than the free settling typical of clarification. An advantage of gravity thickening is its simplicity.

In a primary clarifier, settled solids can thicken sufficiently under the right conditions without further treatment. However, a clarifier following a biological treatment process must handle much lighter solids, and, therefore, accomplishes a lesser degree of thickening. Sludge from a trickling filter plant will normally be concentrated to about 3 to 6 percent by weight. Activated sludge rarely concentrates to more than 0.5 to 1.5 percent in final clarifiers.

To thicken the primary or mixture of primary and secondary sludges further, either before digestion or dewatering, sludge can be pumped to a separate gravity thickener. These units have hydraulic loadings of about 200 to 500 gpd/sf. Solids loadings are about 5 to 20 lb/day/sf. Retention time cannot be too long if the liquid temperature is (for example) 80°F or higher, because anaerobic conditions quickly develop with resultant gas formation and sludge flotation. Gravity thickening is generally ineffective for waste-activated sludge. It can often only increase the solids concentration from about 0.5 to 1.5 percent to 2.5 to 4 percent by weight. Also, if nitrates are present, denitrification could occur with the release of nitrogen as bubbles, resulting in the floating of biological sludge floc. Chlorination of sludge in the thickener is frequently used to suppress or delay anaerobic conditions and denitrification, as well as to control odors.

Mixing of primary and activated sludges for thickening solves many problems associated with activated sludge. Concentration of 5 to 8 percent by weight might be obtained with combined sludges.

The design basis of most thickeners is expressed in terms of solids loading as lb solids/day/sf. Some typical design values are given below, for various sludges. (The liquid overflow sidestream from thickeners is returned to the plant after the primary clarifier.)

TABLE 59
THICKENER LOADING RATES

	lb/day/sf
Activated sludge	5
Trickling filter humus	10
Raw primary sludge	20
Raw primary & activated sludge	10

Source: Camp Dresser & McKee Inc.

Pressurized-Air Flotation—Flotation, like gravity settling, can be and has been used for clarification or removal of suspended solids from the main wastewater stream. Like gravity settling, it has been adopted for thickening waste sludges, especially organic sludges (such as waste-activated sludge), that do not thicken readily by gravity settling. To accomplish good thickening, and also to have a relatively clear underflow, raw sludge is frequently "conditioned" with either an organic or inorganic coagulant (an example is the South Shore plant).

The particular flotation process described here is referred to as dissolved-air or pressurized-air flotation (shown schematically on Figure 3). A volume of relatively clear water (usually the underflow) is pressurized to 40 to 80 psi, and air is injected into the pressurized liquid. This pressurized liquid is then released to the flotation basin (about 3 to 4 psi) and mixed with raw sludge. The drop in pressure causes microscopic air bubbles to come out of the solution and attach themselves to the sludge particles, or floc, resulting in rapid flotation. Waste-activated sludge, having a concentration (as it comes from the final clarifier) of 0.5 to 1.5 percent by weight of solids, can be readily thickened to about 4 to 5 percent. Captured suspended solids can range from 83 to 99 percent, depending on loading and usage of polymers. Such flotation thickening of activated sludge can also be used ahead of anaerobic digestion.

It has been found that the weight of air dissolved averages about 1 percent of the dry solids applied. Solids loading might range from 10 to 20 lb/day/sf. Some activated sludge might require a polymer for the higher loading. The hydraulic loading should not exceed 1.0 gpm/sf. (The above mentioned criteria are for thickening of waste-activated sludge.) One of the advantages of using air flotation for sludge thickening, especially activated sludge, is that the system is kept aerobic. This eliminates septic action and "gassing" in the sludge, which frequently occurs in gravity-type thickeners due to anaerobic decomposition.

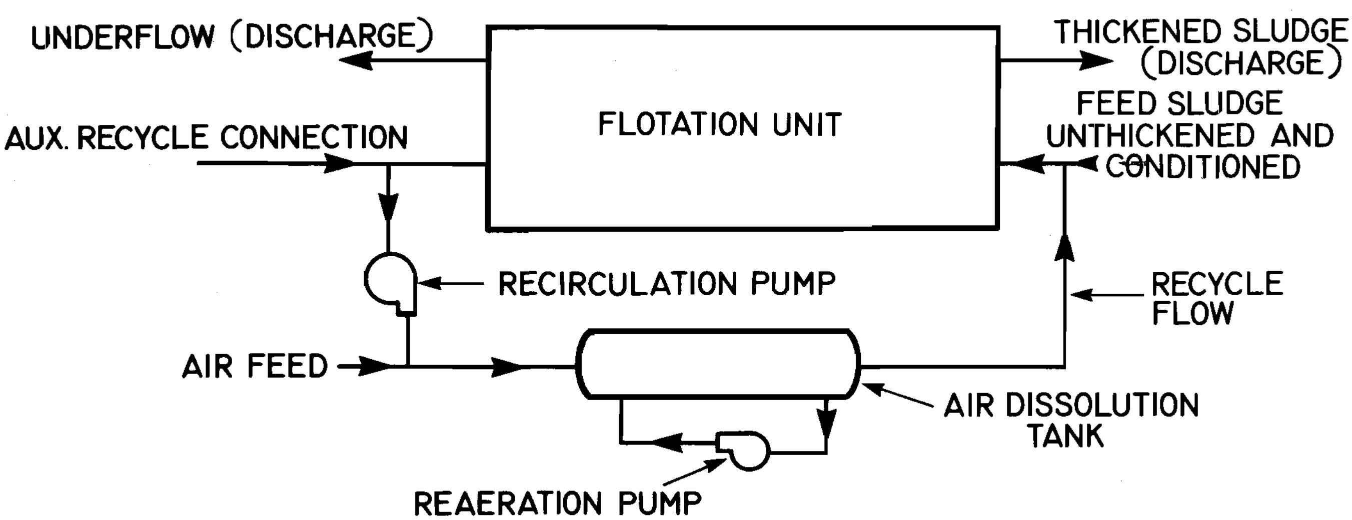
Flotation can be used to thicken various types of sludges, including inorganic sludges such as metal hydroxides. Bench-scale test units are available for testing of any sludge to determine the necessary design parameters for sludges which are different from those normally produced in a domestic wastewater treatment plant. Flotation thickener liquor can be recycled to the secondary plant.

Aerobic Digestion

Aerobic digestion is the separate aeration of primary sludge, waste biological sludge, or a combination of primary and biological sludges in an open tank.

Aerobic digestion is less sensitive to toxicity than anaerobic digestion. Normally, a 10-to 15-day retention time is sufficient to stabilize the sludge and accomplish

FIGURE 3
SCHEMATIC DIAGRAM OF
DISSOLVED AIR FLOTATION SYSTEM
FOR SLUDGE THICKENING



Source: EPA Process Deisgn Manual for Sludge Treatment and Disposal a reduction in volatile solids of about 30 to 55 percent. If the temperature of the liquid drops to about 40°F, retention time should be increased to 25 to 30 days. Biological oxidation generates heat and, for thick sludges having a high volatile content, excessive temperatures can be produced if heat loss from the unit is insufficient. Dewatering characteristics of aerobically digested sludge are usually similar to those of anaerobically digested sludge.

The principal operating cost is the power required for aeration. Sludge is supplied with oxygen so that a dissolved oxygen concentration of at least 1 mg/l exists in all portions of the basin. Aeration can be accomplished by means of compressed air (or oxygen) and porous diffusers, surface-type mechanical aerators or by submerged turbines supplied with compressed air. However, with relatively thick sludges, it is often not possible to dissolve and distribute oxygen throughout the entire sludge mass unless a mechanical device is used.

The oxygen requirements are about 10 mg/l/hr/1,000 mg/l of volatile solids in the digester. However, if primary sludge is digested with secondary sludge, oxygen requirements will increase by 50 to 100 percent above the 10-mg/l/hr figure. If compressed air is used with porous diffusers, about 25 to 35 cfs (min)/1,000 cu ft of digester volume should be sufficient.

As with anaerobic digestion, when the liquid portion is returned to the treatment plant it results in a pollutant load which would not be imposed if the sludge had not been "digested." In the case of aerobic digestion, there is very little BOD load imposed but the nonbiodegradable or poorly biodegradable organic solubles (as measured by COD or TOC) are increased. More importantly, a large portion of nitrogen and phosphorus is solubilized and oxidized to nitrates and phosphates, resulting in increased costs if they are to be removed from the effluent. Fine suspended solids in the supernatant can be fairly high, because prolonged aeration causes deflocculation.

With primary sludge, it is possible for grit and other heavy inert solids to enter the unit. Therefore, the basin must be designed for easy cleaning and removal of heavy solids not kept in suspension.

It is good practice to have at least two basins so that one could be out of service for a few days with some digestion still achieved in the second basin. Also, the second basin can serve the same function as the second-stage anaerobic digester tank (i.e., accomplish liquid-solids separation), but be equipped with aeration so that in an emergency it can perform as a digester.

The process is easy to control and not prone to upset. Power costs for mixing and aeration are high, however, and there is no gas produced.

Because aerobic digestion has high power costs and because use of anaerobic digester gas has become more cost-effective for larger plants, aerobic digestion is often limited to smaller treatment plants (up to about 5 mgd).

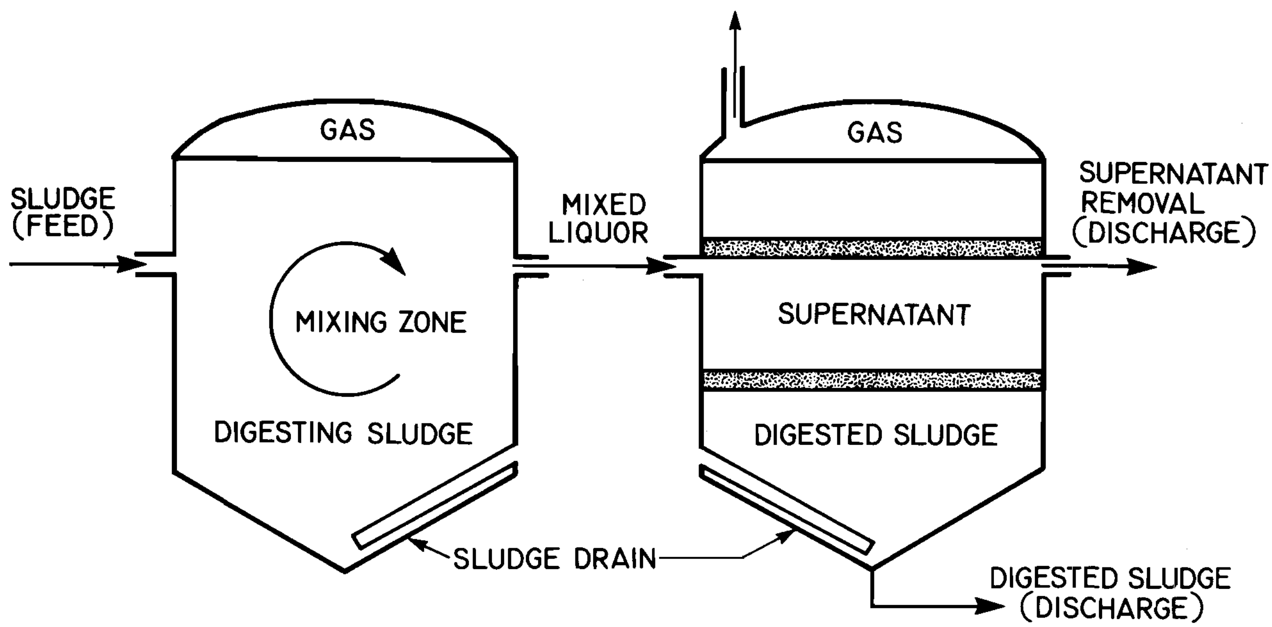
Anaerobic Digestion

This process is used at many wastewater treatment facilities in the study area. Although the process is subject to operational difficulties and can return a high-strength sidestream in the form of supernatant or filtrate, anaerobic digestion stabilizes sludge and thus prepares it for land application. In addition, gas produced can be used to heat buildings and, in sufficiently large installations, power direct-drive equipment or produce electricity. (A typical two-stage system is illustrated on Figure 4.) Costs will be based on completely mixed primary digesters having a 20-day detention time and an allowance of credit for the use of digester gas.

Anaerobic digestion involves biological decomposition of organic material in an environment devoid of dissolved oxygen. Decomposition results from activities of two major groups of bacteria. One group is the "acid-formers," many of which are facultative. In the absence of free dissolved oxygen, they convert carbohydrates, fats, and proteins to organic acids, alcohols, and CO_2. Amino acids are broken down to ammonia. The other group is the methane bacteria which convert organic acids and alcohols to methane and CO_2. These latter bacteria are somewhat slow-growing and sensitive to various toxicants, such as heavy metals and chlorinated hydrocarbons. They cannot grow in the presence of any free oxygen in the liquid, and their optimum temperature is between 85° and 95°F. Below 70°F, their activity practically ceases. Acid-formers are not nearly as sensitive to an adverse environment.

Thorough anaerobic digestion reduces volatile matter by 40 to 65 percent, and the remaining solids settle out. Their concentration by weight is not much less than their concentration in the raw sludge fed to the digester; in fact, it is frequently higher. Anaerobic digesters must be operated at a temperature of 85° to 95°F; this requires heating. Anaerobic digestion can take place in either a single-stage or two-stage unit. In the two-stage system, liquid in the first-stage unit, where the active biological decomposition takes place, is usually continuously mixed by gas-lift circulation, a pumped recirculation system, or mechanical mixers. In

FIGURE 4
SCHEMATIC DIAGRAM OF
TWO-STAGE ANAEROBIC DIGESTION SYSTEM
FOR SOLIDS REDUCTION AND METHANE PRODUCTION



Source: EPA Process Design Manual for Sludge Treatment and Disposal

the second-stage unit, there is no direct requirement for heating or mixing, although equipment should be provided for operational flexibility. Instead, a quiescent condition is provided which leads to the settling out of solids and formation of a supernatant. In general, the digestion proceeds for about 30 to 60 days. After equilibrium, solids are allowed to settle and are periodically removed for dewatering. Under current practice, the supernatant is normally sent back to the biological treatment plant because it is high in BOD, fine suspended solids, and nutrients; however, such practice must not degrade the final effluent, otherwise the supernatant should be given proper separate treatment. Settleable solids can be dewatered on sand beds without further conditioning, though for dewatering by mechanical equipment digested sludge is further conditioned by chemicals or heat.

Anaerobic digesters are susceptible to upsets, primarily due to sensitivity of the methane-forming organisms to variations in environment and toxicants in the sludge. Heavy metals, phenolics, and chlorinated hydrocarbons inhibit the action of these organisms, resulting in an accumulation of organic acids and a resultant drop in pH.

Digester design criteria depend on sufficient time and proper solids loading. Inflow solids concentration to the digester determines which factor is critical. Typical critical values are 30 days hydraulic detention time and a maximum loading of 0.075 lb/cu ft/day of volatile solids.

High-rate digestion of primary and activated sludge has been successfully practiced, but proper operating and monitoring practices, such as complete mixing of the digester contents, uniform feeding, and frequent monitoring of volatile acid, alkalinity, and pH are important in obtaining a stable operation. The loading for high-rate digestion is 0.10 to 0.40 lb of volatile solids per cu ft/day, and the hydraulic detention time is 15 to 20 days. The completely mixed contents are generally discharged into a second unit for supernatant separation.

From a practical operational standpoint, one of the most common and troublesome problems of anaerobic digesters is cleaning the grit and other heavy solids that accumulate at the bottom. If solids are not removed they gradually decrease the digester volume. Good digester mixing is desirable and will reduce the frequency of cleaning.

Cleaning of the digester might put the unit out of operation for several days. The two-stage system provides a means of continuing digestion at a smaller plant when there is only one primary digester in operation. It has generally been noted that a better quality supernatant and better overall operation, as far as solids settling is concerned, are obtained if two-stage digestion is used. Considering the frequent upsets and other problems that digesters are prone to, it is an expense that is worthwhile, especially for high-rate digester systems.

Heat Conditioning

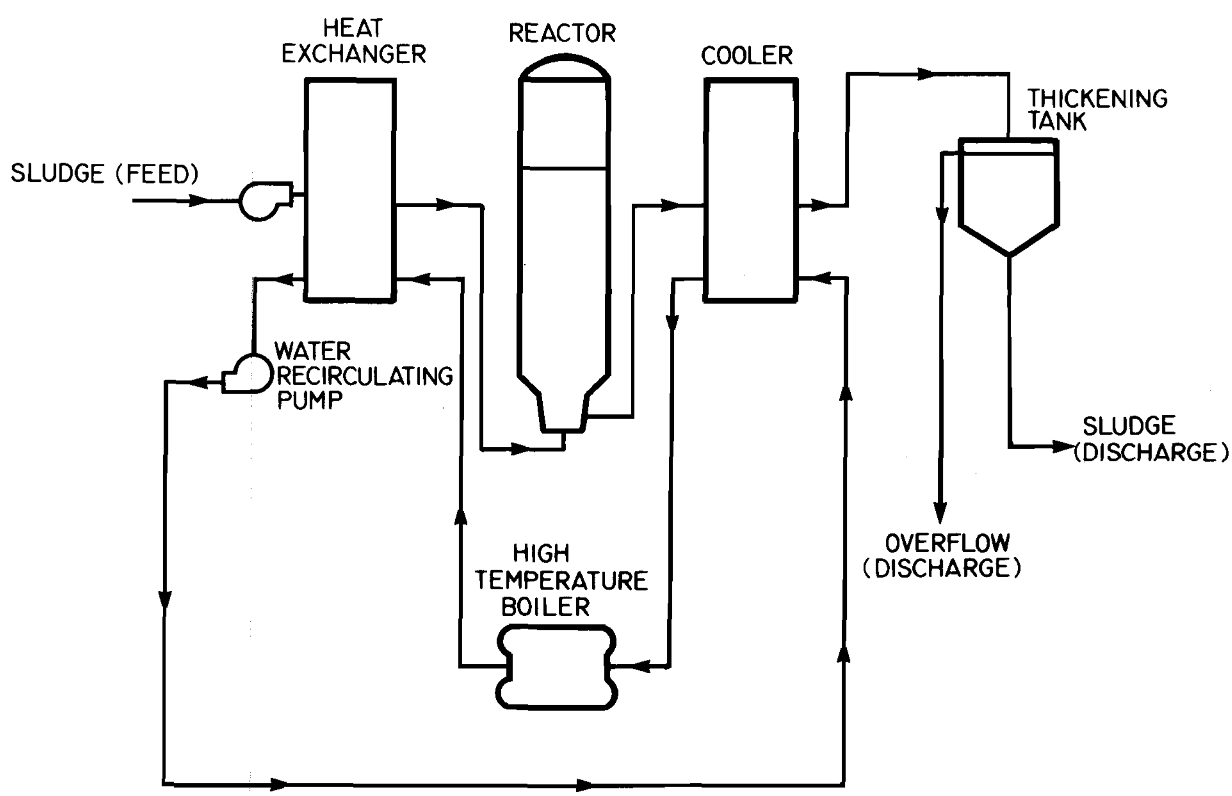
It is generally acknowledged that heat treatment of sludges, especially those containing a large percentage of organic matter, will improve its dewaterability without the use of conditioning chemicals. Wastewater sludge can be classified as being, to a large degree, a colloidal-gel system, and heating allows entrapped water to escape the gel structure.

Basically, this process involves heating partially thickened sludge in a closed reactor to a temperature of 350° to 400°F at a pressure of about 200 to 250 psi, and holding it under these conditions for about 30 minutes (see Figure 5). It should be emphasized that this process is not comparable to the so-called "wet air oxidation" process, since end results are entirely different.

Dewaterability is improved by the solubilizing and hydrolyzing of the smaller and more highly hydrated sludge particles which then end up in the cooking liquor. While analysis of this liquor from domestic wastewater sludges indicates that the breakdown products are mostly organic acids, sugars, polysaccharides, amino acids, and ammonia, the exact composition of the liquor is not well-defined. Some investigators have found the liquor to be highly polluted and to contain a high portion of nonbiodegradable matter.

It is reported that returning of untreated liquor to the aeration tank in an activated sludge system can repre-

FIGURE 5
SCHEMATIC DIAGRAM OF
HEAT CONDITIONING SYSTEM



Source: Camp Dresser & McKee Inc.

sent 30 to 50 percent of the BOD_5 and solids loading to the aeration unit.

Some of the heat is recovered via exchangers that heat the incoming sludge by use of heat from the conditioned sludge. The product is discharged to decant tanks where it thickens to about 10 percent solids.

This process requires a considerable amount of fuel and electricity, and produces very strong sidestreams from the decant tanks and from the filtrate. Moreover, capital and operating costs are high and odor and maintenance problems may be experienced. If the sludge is to be incinerated or pyrolyzed, then heat conditioning would reduce fuel use because of the drier cake and because inorganic conditioning chemicals, which would otherwise be used, decrease the fuel value of the sludge.

When total systems costs, including the additional costs for sidestream treatment, are evaluated, heat conditioning systems cost about the same to considerably more than systems with chemical conditioning.

Wet Air (High-Pressure) Oxidation

In the wet air oxidation process, organic compounds in sludge are chemically oxidized in the aqueous phase with dissolved oxygen in a specially designed reactor at temperatures of about 300° to 700°F and pressures from 1,000 to 1,750 psi. The degree of oxidation achieved in the process can vary considerably, depending on sludge characteristics, temperature, and detention time. In practice, the process is designed to reduce COD by 70 to 80 percent. Wet air oxidation of sludge produces a sterile, stable product that readily dewaters and filters. Oxidized sludge is thickened and dewatered, usually by settling, vacuum filtration, centrifugation, or a combination of these methods.

Wet air oxidation is especially suited to the treatment of dilute waste liquors and sludges which are difficult to dewater. This is because no preliminary dewatering or drying is required in marked contrast to incineration. Oxidation of most organic compounds is achieved under high pressure (1,000 to 1,750 psi) at temperatures of 300° to 700°F. These temperatures are relatively low compared to temperatures of 1,500°F or more required for complete conventional incineration at atmospheric pressure. Air pollution is controlled because the oxidation takes place in water and no fly ash, sulfur dioxide, or nitrogen oxides are formed. The remaining liquid is sterile and has a high concentration of inert and organic matter, both in suspension and solution. The COD of the liquid can vary from 10,000 to 20,000 mg/l, depending on degree of oxidation achieved and nature of the solids in the raw sludge. This residual carbonaceous matter is present mainly as fatty acids. The organic nitrogen is converted to ammonia, which is not oxidized, and remains in solution because, at the pH in the reactor, all of it is ionized. The concentration of ammonia can vary from 1,000 to 1,800 mg/l. The BOD_5 in the liquor ranges from 20 to 50 percent of the COD, and reported values of BOD range from 2,000 to 10,000 mg/l; this liquid sidestream requires treatment.

Gases from wet oxidation can be odorous, and therefore a catalytic burner is recommended. Also, for the process to be economical, the large amount of energy supplied to compress the air to the required high pressure should be recovered in a gas turbine.

Chemical Conditioning

Conditioning with lime and/or ferric chloride or with polymers precedes many mechanical dewatering operations. Currently, in the Region, only five wastewater treatment plants (MSD-Jones Island, Kenosha, Brookfield, Burlington, and Racine) employ mechanical dewatering, although use of such equipment might become more prevalent in the future.

Generally, dosages of 15 percent lime and 5 percent ferric chloride have been used for raw sludge, and 19 percent lime and 6 percent ferric chloride for anaerobically digested sludge.

Raw sludge is that received directly from the treatment plant units and is readily putresible. Digested sludge is stabilized by biological activity and is not subject to much further degradation.

Chemical conditioning is used to break down the colloidal-gelatinous structure of the wastewater sludge which makes it difficult to separate water from the solids. By adding certain chemical flocculants, "bound" water can be separated from the solids with much less effort and cost. The inorganic chemicals used for such conditioning are alum, ferrous sulfate and ferric chloride, and lime. Alum is used primarily to agglomerate the fine floc of an activated sludge to aid thickening. Ferric sulfate is generally used with lime. The most widely used inorganic conditioner is a combination of ferric chloride and lime. The pH is raised from 10.5 to 12.5 and good conditioning is obtained. The high pH causes many pathogenic organisms to die and would be expected to result in the inactivation of many viruses. Precipitated ferric hydroxide is aided in conditioning the sludge by calcium carbonate precipitation from the calcium alkalinity in the water and the CO_2 thus adding weight to aid in thickening light sludges.

A great many of the new organic polyelectrolytes, especially of the cationic type, are effective flocculants and conditioners. Their use typically adds less than 1 percent to the dry solids.

Many sludges, that do not dewater readily without a large amount of conditioning chemicals, can be dewatered easily on vacuum filters by adding a "filter aid" such as diatomite, fly ash from coal-fired power plants, or sludge incinerator ash.

Lime Stabilization—The addition of lime in sufficient quantities as to maintain a high pH (between 11.0 and 12.0), stabilizes sludge and destroys pathogenic bacteria. Lime stabilized sludges dewater well on sandbeds without odor problems. Sludge filterability can be improved with the use of lime; however, caution is required when sludge cake disposal to land is practiced. Disposal in thick layers could create a situation where the pH might fall to near 7 prior to full drying of the sludge, causing regrowth of organisms and resulting in noxious conditions. Essentially, no organic destruction occurs with lime treatment. The key factor for assuring a proper stabilization process is the maintenance of a pH of about 11.0 for a sufficient time. Recent studies indicate that the pH should remain above 11.0 for over two weeks.

The following table gives the approximate lime dose requirement, for various sludge types, to keep the pH above 11 for at least two weeks.

TABLE 60

LIME STABILIZATION DOSES

Type	Dose (lb $Ca(OH)_2$/ton sludge solids)
Primary sludge	200 - 300
Septic tank sludge	200 - 600
Biological sludge	600 - 1,000
Al sludge (secondary precipitation)	800 - 1,200
Al sludge (secondary precipitation) + Primary sludge (SS_{AL}: SS_{Prim} = 1:1)	500 - 800
Fe sludge (secondary precipitation)	700 - 1,200

Source: EPA

Chlorine Stabilization—This commercially available process uses heavy doses of chlorine (about 2,000 mg/l) for sludge stabilization. This sludge dewaters well on drying beds and has excellent long-term stability.

Chlorine-stabilized sludges are somewhat difficult to dewater on vacuum filters, because the low pH (about 2) interferes with the action of the chemical conditioners. Test results indicate that the pH should be greater than 4 to allow for acceptable conditioning. The low pH, coupled with the production of high concentrations of chloramines, make the sludge difficult to dispose of in the environment.

Oxygen Stabilization (Biological)—Biological stabilization with oxygen is similar to aerobic digestion except that pure oxygen is used instead of air. Commercially available systems stabilize sludge up to 5 percent solids. Such thick sludge produces considerable biological energy, resulting in an elevated temperature and thus more rapid metabolic activity.

Pasteurization—Pasteurization implies heating to a specific temperature for a time period that will render harmless, or destroy, undesirable organisms in sludge. It is reported that pasteurization of digested sludge at 70°C (158°F) for one-half hour destroys pathogens found in sludge, and that direct steam injection is more efficient than indirect heat transfer.

Pasteurization has been applied in Europe for disinfection of sludge prior to landspreading.

Elutriation—Elutriation is essentially a washing process once widely used for conditioning anaerobically digested sludges prior to further conditioning with metal salt. The process involves countercurrent or concurrent extraction of soluble alkaline carbonates and phosphates, as well as fine sludge particles from the sludge, by dilution with treatment plant effluent and resettling. Principal purposes of the process are to reduce chemical requirements and produce a more readily dewaterable sludge. With the advent of higher levels of secondary treatment and consequent activated sludges; the sludge going to elutriation contains a large amount of fine particles. The process, therefore, will produce a very dirty elutriate and a heavy recirculation load unless flocculants are used.

Dewatering

Vacuum Filter—Vacuum filters are used extensively throughout the United States. Within the study area, the MSD-Jones Island and Racine plants have vacuum filters, and they have been proposed for several other plants. Vacuum filters can dewater sludge to a range of

15 to 25 percent solids depending on sludge characteristics and conditioning method. Chemical use is about the same as filter presses, although sometimes polymers might be added. Figure 6 illustrates a typical arrangement.

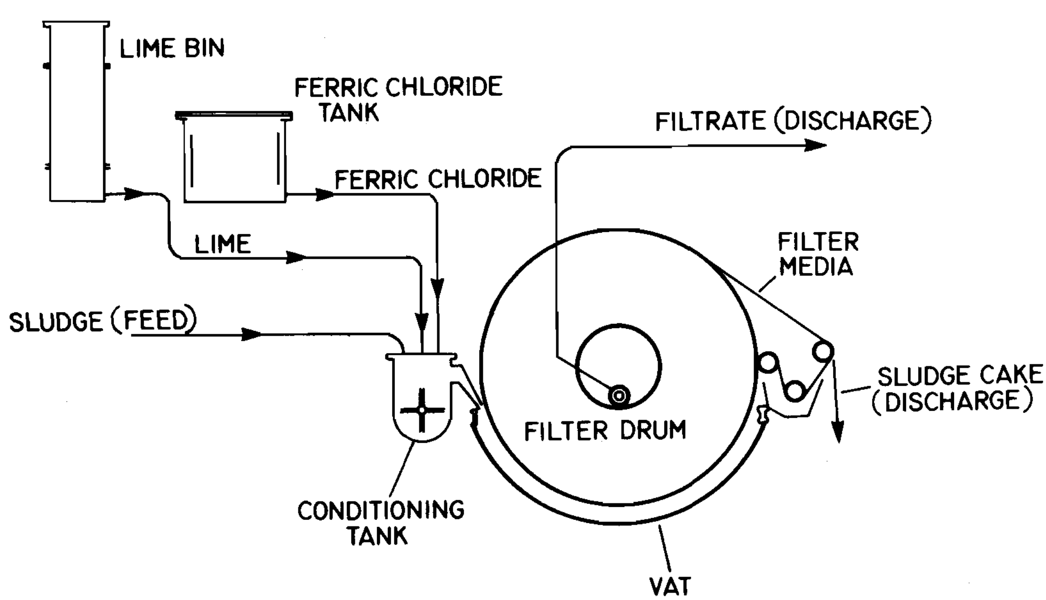
The rotary drum type of vacuum filter has been widely used for sludge dewatering. Basically, there are two types: the stainlesss steel coil filter (Racine) and the belt filter, which uses a belt of fabric (usually synthetic) as the filtering medium (MSD-Jones Island). The chemical and physical character of the filtrate is largely dependent on the sludge conditioning process used. Vacuum filters will, as a rule, capture a much higher proportion of suspended solids and produce a drier cake than centrifuges.

It is difficult to characterize filtrate from vacuum filters because of the many variables that affect filtrate quality. These variables include sludge type, degree and method of conditioning, type of filter media, amount of vacuum applied, and sludge application rates. Wherever possible, filter leaf tests should be made to determine cake and filtrate characteristics.

All types of municipal wastewater sludges—raw, digested, primary, activated, trickling filter, and mixtures—can be dewatered by vacuum filtration. In general, it has been observed that sludge filtration rates (pounds per square foot per hour) increase as solids input concentration increases. This is because the hydraulic loading that is possible per unit of filter area (gallons per square foot per hour) is generally constant with cake thickness. Input solids concentration should be no greater than about 10 percent; at a greater value, chemical conditioning and sludge distribution on the filter drum are hampered.

Because vacuum filters, except in the largest plants, might be operated only for 8 hours a day, 5 or 6 days a week, thickened sludge must be stored during periods when the vacuum filters are not operating. This is done by installing sufficient capcacity holding tanks between the thickening operation and the vacuum filters. Plants having digesters would not need holding tanks, as the digesters will also serve this purpose.

FIGURE 6
SCHEMATIC DIAGRAM OF
ROTARY DRUM VACUUM FILTER SYSTEM
FOR SLUDGE DEWATERING



Source: EPA Process Design Manual for Sludge Treatment and Disposal

The solids content in the dewatered cake may be 15 to 20 percent for activated sludge and 20 to 25 percent for raw primary sludges and well-digested sludges. Filtrate from vacuum filtering, as far as suspended solids and BOD are concerned, is almost entirely dependent on the type of conditioning used. Filtrate flow is normally about 0.5 to 1.0 percent of the plant flow (depending on the prethickening of the sludge). The BOD_5 and suspended solids will usually be removed by the secondary treatment if they are recycled back to the head end of the plant.

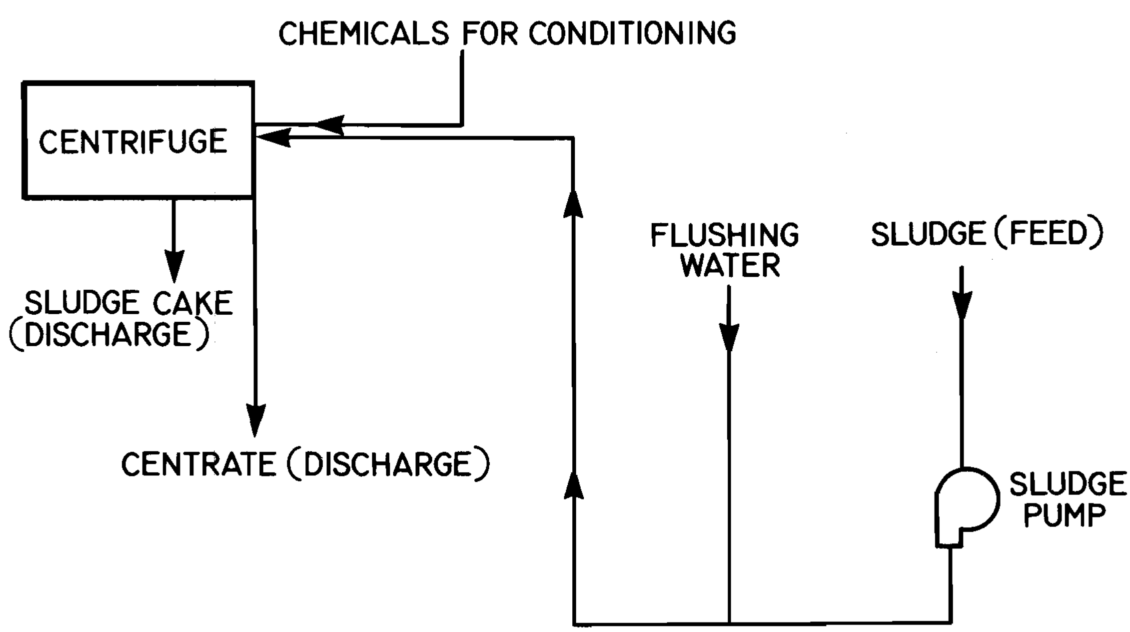
Centrifugation—Centrifuges have been used primarily in the wastewater treatment field for sludge dewatering; however, one type of centrifuge, known as the disk or nozzle type, is coming into use for thickening of activated sludge. The disk-type centrifuge has been used for many years in the chemical process industry, but its use for sludge thickening is relatively new and only a few installations exist. Its current use is limited to waste-activated sludge. The thickening efficiency of the disk centrifuge is comparable to that of the pressurized air-flotation system. Principal advantages of the disk centrifuge are compactness, overall lower costs, and possible improved solids capture without chemicals. However, there is a risk of clogging if proper screening equipment is not used and maintained ahead of the centrifuge, and operational problems have been experienced. A typical system is illustrated on Figure 7.

The centrate can be returned to the aeration basins if evidence indicates that the solids can be entrained in the main portion of the MLSS. Operational problems must be carefully evaluated prior to application of this process.

The unit generally used for wastewater sludge dewatering is the horizontal solid bowl centrifuge. It operates on a continuous basis and can produce a sludge cake of 10 to 25 percent solids, depending on the type of sludge and conditioning received.

Advantages of centrifuges over vacuum filters are less space and, sometimes, lower overall costs. However, in general, the solids capture is not as good as with vacuum filters unless optimum chemical conditioning is used, and then the cake invariably is not as dry (i.e., a dry cake results in less solids capture). The centrate with suspended solids that have not been removed is

FIGURE 7
SCHEMATIC DIAGRAM OF
CENTRIFUGE SYSTEM
FOR SLUDGE THICKENING



Source: EPA Process Design Manual for Sludge Treatment and Disposal typically returned to the head of the treatment plant.

Centrifuges tend to classify solids: that is, remove the larger, denser solids and leave the finer, lighter colloidal solids in the centrate. These solids are usually very fine and few will settle in, for example, a primary clarifier. If the concentration is excessive, such recycle can cause a buildup of fine solids in the system with eventual discharge in plant effluent. If chemical coagulation is employed, either in the primary treatment or in the secondary treatment, then such solids will become coagulated and settle out with the other solids in the final clarifier. Biological secondary processes might not capture all such fine solids, and therefore chemical coagulants might be necessary.

Frequently, activated sludge or sludge from trickling filters is mixed with primary sludge and the mixture is dewatered in the solid bowl centrifuge. It is important that the primary sludge be free of grit, or there will be rapid wearing of the metal lining of the bowl. Even with a standard grit removal facility, it is common to use a cyclone to degrit primary sludge before it is sent to the centrifuge.

A cyclone is a mechanical device used to separate grit from sludge by centrifugal action. The sludge is pumped through a circular casting at high velocity and grit is thereby separated. The separated grit drops into a sump and can be dewatered by a slow moving screw conveyor. The degritted sludge is discharged from a center tube on the circular casting. This center tube also contains a flow control device which serves to regulate the amount of grit separated.

A vertical solid bowl centrifuge, which has recently been extensively tested, is known as the "basket type." It is batch operated, with intermittent removal of the cake, and has a high degree of solids capture; batch operation can be highly automated. The horizontal bowl and basket type can be used in series—the basket type unit being the final one. In the basket type (when the unit is stopped) a knife moves down into the vertical bowl to cut the cake, which then falls to the open machine bottom.

Effects of returning centrate to the treatment plant vary according to the type of sludge being dewatered. Little has been documented regarding effects of returned centrate. There is currently only one treatment plant in the study area (Burlington) which has a centrifuge. Polymers are normally used for sludge conditioning. Dosages range from 0 to 10 lb/ton of dry solids, depending on sludge characteristics and operating variables.

For determining cost-effective sludge processing alternatives for individual plants, centrifuges were only considered in the case of the existing Burlington unit. However, centrifuges might be substituted for vacuum filters (in most cases) with little change in overall economics.

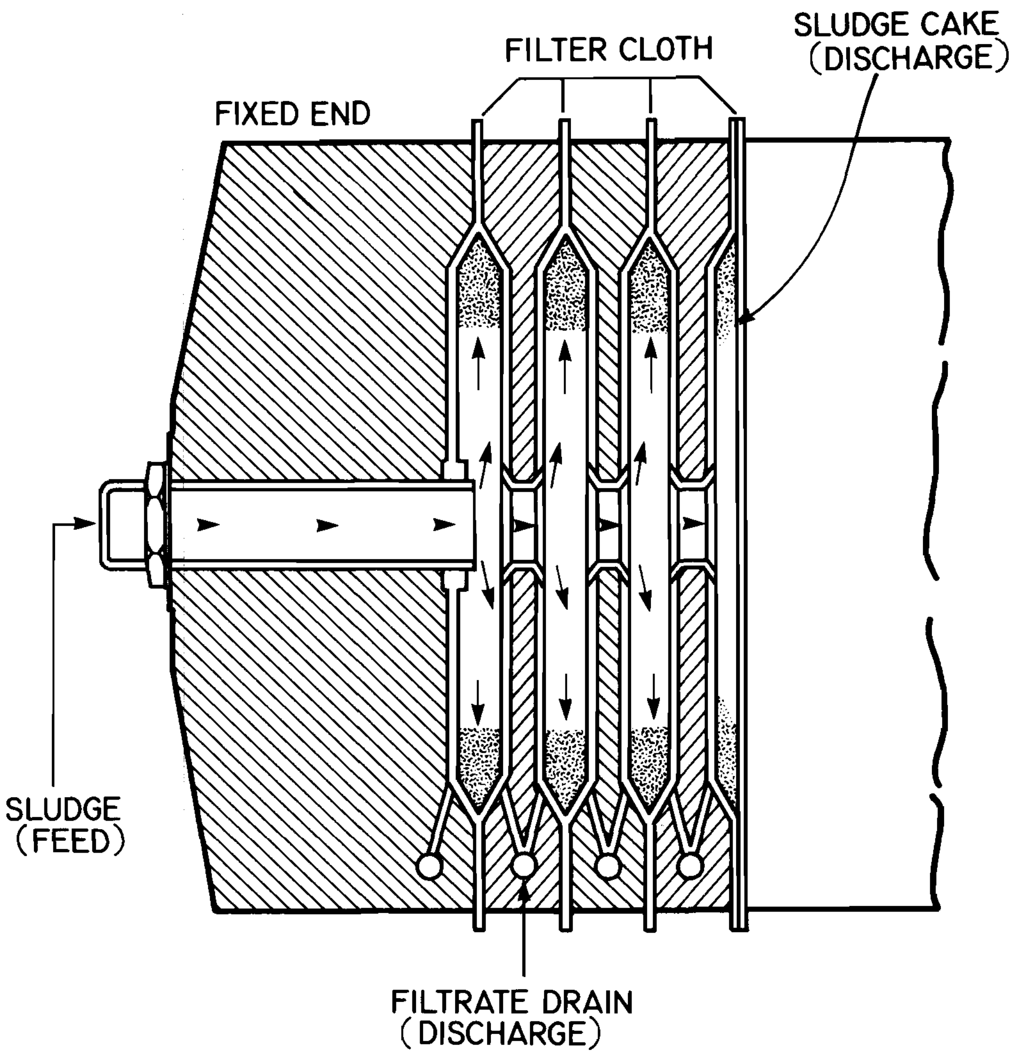
Filter Presses—The standard filter press (pressure leaf filter) has been used for many years in the chemical process industry for dewatering slurries. It consists of "leaves" covered with some type of porous fabric (shown on Figure 8.) These leaves or plates form a series of chambers, sludge is retained between the fabric on both sides of the leaf. These plates are first pushed together and compressed by hydraulic or mechanical pressure (exerted on the ends of the series of plates) to prevent leakage. Drainage ports in the plates are provided for the liquid to escape. Pressure is imposed by pumping in the sludge which is retained between the filter fabrics. The final pressure can amount to several hundred psi, though usually for wastewater sludge it is about 100 to 225 psi.

These presses have, in recent years, become highly automated, although they basically perform as a batch operation. After the sludge pumped into the chambers has been retained (for a predetermined time) at the maximum pressure, the plates are pulled apart and the cake is allowed to fall away from the fabric, normally onto a conveyor belt below the press. The automation of the presses has greatly increased its possible application to wastewater sludge dewatering.

Filter presses are in operation at Brookfield and Kenosha. In the United States there are about 15 operating installations, with several more planned. Filter presses can dewater sludge to a range of 35 to 65 percent dry solids, depending on sludge characteristics and conditioning method. When ash and chemicals are used for conditioning, solids usually exceed 45 percent. Chemicals alone produce sludge cakes with 35 to 45 percent solids content. Typical chemical dosages are 3 to 7 percent ferric chloride and 15 to 20 percent lime. When ash is used as a conditioning agent, chemical usage is somewhat reduced. The liquid side-stream from a filter press is generally, for comparable sludges and conditioning, similar to that from a vacuum filter.

Belt Filter Presses—Belt filter presses have been installed at only a few treatment facilities in the United States. There are no belt filters now in operation in the study area; however, several plants have pilot tested one manufacturer's unit. The cake consistency for belt filter presses is about the same as vacuum filters or centrifuges. Polymers are normally used for condi-

FIGURE 8
SCHEMATIC DIAGRAM
SECTION OF FILTER PRESS SYSTEM
FOR SLUDGE DEWATERING



Source: EPA Process Design Manual for Sludge Treatment and Disposal

tioning with dosages being very dependent on sludge characteristics. Costs were not developed for belt filter presses but could be expected to fall in the same range as costs for vacuum filters or centrifuges of comparable capacity.

Lagoons–Lagoon dewatering is a land intensive, relatively simple process that is used at some plants in the Region. The lagoons are operated to promote stratification and allow supernatant draw-off. Polymers are sometimes used to quicken the dewatering process. Depending on the degree of sludge digestion and other factors, lagoons frequently are odorous.

Protection of groundwater resources is of utmost importance. Within the Region, lagoons are normally cleaned on a yearly basis.

Lagoons are sometimes designed as digesters. In order to achieve thorough digestion in lagoons, about three years detention time is required with no sludge addition during the final year. These lagoons are only feasible where inexpensive land is available. They are known to produce foul odors, particularly during the spring or a disturbance by excavation or pumping. Such lagoons would only be acceptable at very remote locations, generally too far from the source of sludge generation to be of much value.

Major design factors include climate, subsoil permeability, lagoon depth, loading rates, and sludge characteristics. Design should provide for uniform distribution of sludge and for decanting of supernatant to speed the drying process.

Sand Beds–Sand drying beds for sludge dewatering are commonly used at treatment plants throughout the study area. At some installations they are used parallel to, or as a backup, to, other dewatering or disposal methods. For optimum utilization of the beds, operators in the region usually dry sludge for about two weeks to a consistency of 15 to 20 percent solids. Although sludge is sometimes left to dry up to 50 percent solids, where bed capacity is available, weather conditions severely limit the number of applications per year. Residence times of greater than one month are common during colder weather. Normally, sludge is digested but not conditioned prior to discharge to drying beds. Polymers have been used in attempts to shorten the drying time or produce a drier cake.

Dewatering on sand beds is by drainage and evaporation. The proportion of removal water by drainage might vary from 20 to 85 percent. Most drainage is usually accomplished in the first two days on the bed; subsequently, evaporation is the principal effect. After a few days, the sludge cake shrinks horizontally, producing cracks at the surface which expose additional sludge surface area and also enhance drainage. The liquid draining from the sludge is often returned to the treatment plant. Though its volume is small, if the sludge being dried has been digested, the drainage contains a high concentration of soluble organic matter, ammonium compounds or nitrates, and phosphates. After sufficient dewatering, the sludge is removed by hand shovel or by a mechanical scraper. Only light weight equipment can be used because heavy wheel loads will damage the underdrain system.

Important parameters affecting sand bed design and use are: climatic conditions, depth of sludge layer, sludge characteristics, and the underdrain system.

Drying beds are inexpensive and simple to operate. Their disadvantages are the area required, potential nuisance problems, susceptibility to adverse weather, and that sludge must be well-digested or conditioned before dewatering.

Advantages of enclosed drying beds are: reduced area requirements, protection from rain and cold, control of odors and insects, and improved appearance. Disadvantages are the construction and maintenance costs and the problems regarding use of any mechanical equipment in a relatively small enclosure. Good ventilation is essential to promote evaporation.

Transportation

Truck–Transportation of sludge by truck is used almost exclusively in the Region and several concerns specialize in handling of liquid wastes and sludges. Some of these companies have negotiated contracts with municipalities for trucking to landfills or land application sites.

Trucking offers the greatest flexibility of all modes of transportation being considered. Access to and within a treatment plant site is usually adequate for hauling sludge by the truckload. In contrast, most plants do not have access to either rail or barge and use of these modes would require an intermediate step involving trucks or pipeline. Liquid sludges are hauled in various sizes of tank trucks with the truck quite often serving as the spreading or application vehicle. Dewatered sludges are containerized (like Kenosha's) or handled by dump truck (such as Racine's). Containerization is a type of short-term storage option whereby the filter press sludge from a two-shift operation is spread by a single vehicle in one shift.

A disadvantage of trucking is its impact on the environment. Because only a small volume can be handled at a time, the resulting frequency of hauling causes increased traffic congestion and roadway damage and is particularly detrimental if the trucks must pass through a residential neighborhood. Also, trucking uses much more energy than the other transportation alternatives and contributes to air and noise pollution.

Rail–Sludge can be transported by rail as a liquid or dewatered cake. In Chicago, liquid sludge is hauled in railroad tank cars to some disposal areas.

The economics of transportation by rail depend on the amount of sludge, loading and unloading requirements, route, connections required, condition of the tracks, and train speed. Railway tariffs are complex and contingent on source and destination.

Rail transport is more advantageous than trucking in that less energy would be used for a train of tank cars than individual trucks and less air and noise pollution would result. The magnitude of this advantage would depend on the volume of sludge to be handled. Moreover, use of trains would reduce truck traffic between sludge processing, utilization, or disposal sites.

Milorganite is the only sludge currently shipped by rail within the Region.

Pipeline—Transport of liquid sludge by pipeline from wastewater treatment plants to remote land application sites might be achieved with cost savings over other forms of transport.

Economics of pumping sludge via pipeline from treatment plants to application sites are considered later in this report. Costs are largely dependent on sludge production rate and the area through which pipelines must be built.

Pipelines should be sized for a friction loss of about 1.6 times the loss for water and velocities of between 3 and 5 fps. These values are within the normal design limits. Storage at the point of origin would provide some standby capacity. In the event of a long shutdown, backup trucking or barging might be necessary. In especially sensitive areas, twin pipelines could be built, increasing construction costs by about 50 percent.

Barging—Barging is a possible transportation option between docking facilities along Lake Michigan at wastewater treatment plants and at land disposal sites. At the MSD-Jones Island treatment plant, barges might be able to utilize facilities presently available in the harbor; however, at all other facilities (MSD-South Shore, Racine, Kenosha, South Milwaukee and Port Washington) newly constructed docking facilities would be required.

Barging may be more sensitive to weather conditions than other modes of transportation. Weather forecasts predicting severe storms or high winds can delay schedules as can severe ice conditions. The economics of barging is sensitive to the availability of tugs, the time required for docking under different conditions, channel conditions, vessel size and speed, loading rate and bridges or gates along the proposed route. Also, the availability of spreading sites along the lakefront or near docking facilities is critical to the economics of barging. Barging provides more flexibility of operation than the use of pipelines since the destination can be varied.

Because of the flexibility and ease of operation (compared to other methods), small plants will likely continue to use gas or diesel trucks for most of their hauling. Rail haul generally becomes competitive with trucking when distances exceed about 50 miles. Barging is generally less expensive than either rail or truck for transportation north or south along the lakeshore if proper facilities for docking are available.

Incineration

Since the municipal wastewater solids and sludge (including grit and skimmings) that are generated contain a large portion of organic matter, the burning of such sludge is a logical final stabilization process. If skimmings are incinerated, a mix tank might be necessary to prevent hot spots and damage to the incinerator; however, an ash remains for final disposal. Whether or not the combustion is self-supporting depends on the calorific value of the solids and the accomplished degree of dewatering. Incinerators are always provided with auxiliary fuel for use when needed—such as during startups. Domestic wastewater sludge, dewatered to a solids content greater than 30 percent, may permit self-supporting combustion. Although either raw or digested sludge can be incinerated, raw sludge is preferable because of its greater calorific value.

Wastewater sludge incineration has been practiced for many years and is being considered in urban areas as sludge volumes increase and as land areas for alternative operations become scarce. Also, the development of greatly improved designs with regard to control of air pollution and possible recovery of heat have increased the use of incineration. However, it is a relatively expensive process in terms of both investment and operating cost. The incineration process must not produce objectionable smoke, odor, or other atmospheric pollutants.

Incineration achieves volume and weight reduction and solids sterilization. The resulting ash will be 15 to 45 percent of the original sludge solids weight (depending on the volatile solids concentration of the feed sludge and chemicals added during previous treatment stages) and the volume, assuming a 25 percent solids cake as feed, will be about 10 percent. The two most common types of sludge incinerators are the multiple hearth and fluidized bed. A less common type is the flash drying and burning unit (rotary kiln).

Incineration of wastewater sludge might be divided conceptually into two major phases: drying and combustion. In drying, sludge cake is heated to above 212°F, water is evaporated, and temperature of the water vapor is increased to that of the incinerator exit gas temperature. For sludge entering with 25 percent dry solids, a typical heat requirement for this drying operation is about 4,000 BTU/lb of dry solids. In some incinerators, drying and burning occur sequentially, while in others, both take place in the same chamber. The latter method is characteristic of the fluidized bed unit, the former is characteristic of the multiple hearth unit. In combustion, virtually all of the recoverable heat released might be required to meet demands of the drying process. Equipment, therefore, should be designed and operated to achieve maximum practical combustion efficiency. Usually, auxiliary fuel (gas or oil) is provided for startup and for use if the cake should become too wet.

Combustion of the sludge is followed by cooling and scrubbing of the gases to remove fly ash and any unburned particles. Usually, the ash is quenched with plant effluent. In all incinerators there is a possibility of a furnace explosion. Most frequently, explosive conditions are created by allowing unburned fuel and air to accumulate within the furnace, or by feeding highly volatile liquids with a large excess of air. Progressive ignition of sludge and air, as they are introduced into the furnace, is the best insurance against furnace explosions. Proper purging procedures, prior to light-off of a cold furnace, are essential to prevent the possibility of an explosion on startup.

Pyrolysis

True pyrolysis involves heating of organic matter in the complete absence of oxygen. The term "destructive distillation" is used when wood is subjected to this treatment to produce methanol. Depending on the nature of the organic matter, decomposition of sludge by pyrolysis (at temperatures varying from 900° to over 1,700°F) produces compounds such as: char, tars, various liquids, and gases such as hydrogen, carbon monoxide, carbon dioxide, methane, and ethane.

As far as wastewater sludge is concerned, because it must be dewatered to a degree comparable to that required for complete incineration, there does not appear to be much economic or technical justification for using pyrolysis, unless a useful byproduct can be recovered (such as char) which can be used in place of expensive activated carbon for adsorbing a large portion of the soluble organic matter in clarified wastewater effluent.

The term pyrolysis is often used to include not only complete pyrolysis but also thermal destruction in an oxygen deficient atmosphere. Recent analysis and research, particularly at central Contra Costa County, California, indicate that this modified pyrolysis (in an oxygen deficient atmosphere) in multiple-hearth furnaces might be superior to conventional incineration in terms of thermal efficiencies and emissions to the atmosphere. (A typical arrangement is shown on Figure 9.)

Incineration or Pyrolysis–There is currently only one incinerator in operation for burning dewatered sludge in the SEWRPC area (at Brookfield).

Recent analysis and research indicate that pyrolysis in multiple-hearth furnaces will be superior to incineration. In incineration, excess air is introduced into a furnace to insure that sufficient oxygen is available for essentially complete combustion at an adequate rate. In true pyrolysis, decomposition of organic matter–as, for example, in charcoal production–is obtained by heating in the complete absence of oxygen, but the term pyrolysis is often used to include thermal destruction in an oxygen deficient atmosphere.

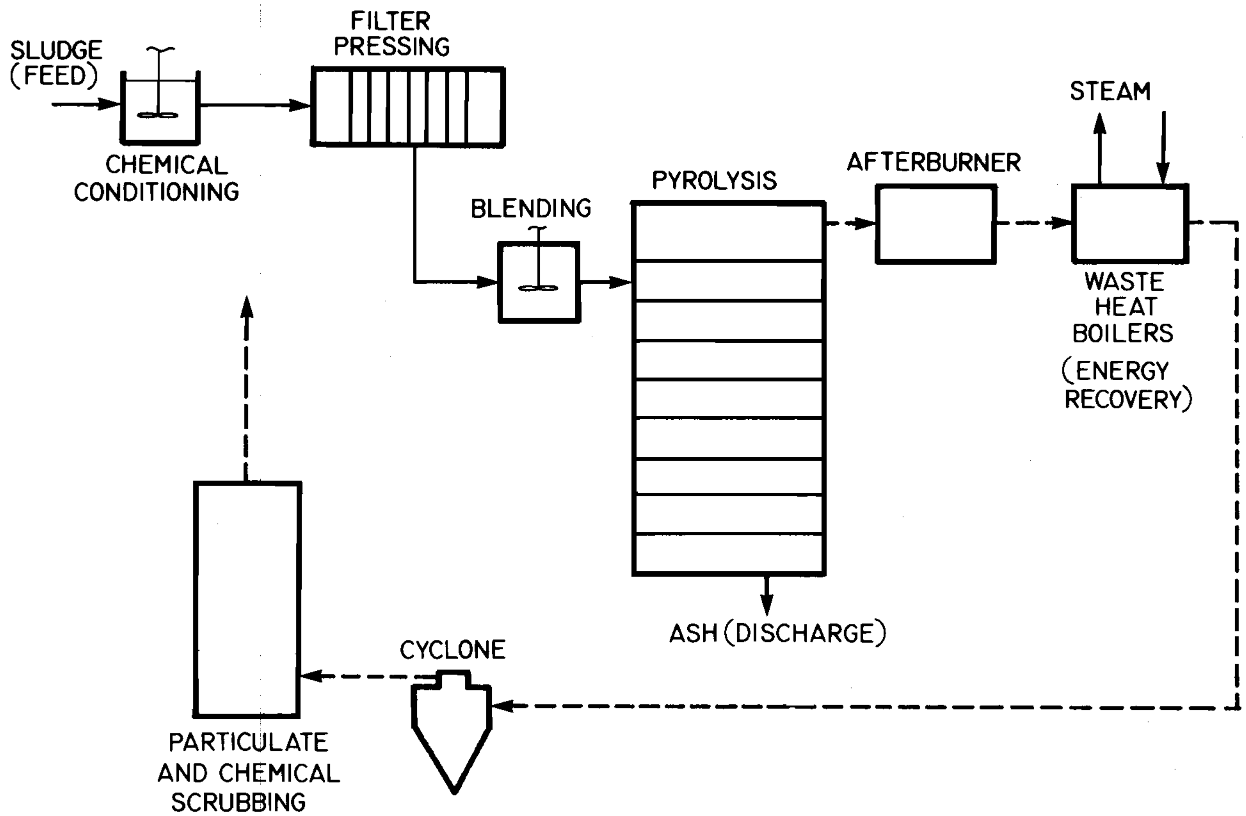
The large volumes of air required for incineration are heated in the process from ambient temperature up to the furnace's exhaust temperature and have to be cleansed after use to decrease emissions to the atmosphere. Pyrolysis is less expensive in these two areas. Because less air is used with pyrolysis (and can be further reduced by using oxygen), less heat is wasted in heating air, and thus pyrolysis is thermally more efficient. The smaller volume of air also means that air pollution control equipment can be smaller. Furthermore, preliminary research indicates that particulate emissions from pyrolysis will be less because the lower gas velocities in a furnace should suspend less ash.

Pyrolysis costs will allow for high-energy wet scrubbers to reduce particulate levels to less than 1.3 lb/ton pyrolyzed, in accordance with the EPA New Source Performance Standards (40 CFR, part 60). Installation would be designed to allow for exhaust temperatures of about 1,400°F, in order to insure virtually complete combustion of materials that volatilize at lower temperatures (such as odor-producing compounds and chlorinated hydrocarbons). For large volumes, it might be cost-effective to recover heat from the afterburner in order to produce heat and power.

Raw sludge with low ash content dewatered on filter presses to over 30 percent solids may be autogenous (capable of self-sustaining combustion). Digested sludge with high ash content and less than 30 percent solids probably will not be autogenous; and vacuum filter sludges will not be capable of sustaining 1,400°F exhaust temperatures.

Fuel oil may be used where necessary to sustain pyrol-

FIGURE 9
SCHEMATIC DIAGRAM OF
SLUDGE DEWATERING AND PYROLYSIS SYSTEM
FOR SOLIDS REDUCTION AND HEAT RECOVERY



Source: Camp Dresser & McKee Inc.

ysis and to serve as a pilot fuel for the afterburner. Recent studies indicate, however, that refuse-derived fuel can be used with sludges that are not autogenous and that continuous ignition is not required in an afterburner. Exact figures for these fuel amounts are not available and could be expected to vary widely with sludge characteristics.

Landfilling

Stabilized sludge containing no free water can be satisfactorily disposed of in a sanitary landfill either alone or in a mixture with municipal solid waste. Sludge with free water must be blended with refuse. A sanitary landfill should be managed so that wastes are systematically deposited and covered with earth to control environmental impacts within defined limits. Placement of incinerator ash or stabilized sludge cake in a sanitary landfill can be an acceptable procedure when adequate land is available, and site location and operational precautions prevent the creation of nuisance conditions or health hazards. Prior to placing sludge in a landfill, it should be sufficiently dewatered to minimize the quantity of free water present. Leachate and runoff from a sanitary landfill should be minimized and, when necessary, collected through a system of underdrains and suitably treated to prevent pollution of ground and surface waters.

Landspreading

Application of digested, or digested-dewatered sludge on cropland has been increasing considerably in recent years and is an important method of utilization in the study area. In addition, Milorganite, after processing as described below under sludge drying, is utilized on land.

Rather than being considered fertilizers, domestic wastewater sludges are commonly considered soil conditioners or soil builders. Soil conditioning provides agglomeration, soil structure stability, pore volume, permeability, air and moisture holding capacity, and the ability to withstand crusting, leaching, and erosion. Although sludges provide some of the needed chemical nutrients, conventional chemical fertilizers normally will still be required to provide the optimum combination of nutrients for most crops.

Since digestion does not guarantee destruction of all pathogenic organisms, appropriate measures should be taken to prevent health hazards in applying liquid sludge to land. Other factors of concern are the effects of nitrogen compounds and heavy metals (Cu, Zn, Pb, Cd, Ni, Mn, Mg), especially zinc, copper and nickel, because they can be toxic to plant life in sufficient concentrations. Sludge characteristics are discussed in detail in Chapter V.

Soil is composed of mineral matter, organic matter, microorganisms, solutions, and air. The soil's assimilative capacity hinges on its ability to filter, buffer, and absorb a sludge's constituents. It chemically and biologically transforms materials and supports plants which use the applied nutrients. Desirable soil properties for sludge assimilation are:

- —Depth
- —High infiltration and percolation capacity
- —Fine enough texture to have high water and nutrient holding capacity
- —Good drainability and aeration
- —Neutral or alkaline pH.

Technical Bulletin No. 88 is the Wisconsin DNR guideline for agricultural landspreading in the study area. As noted in Chapter I, detailed soils mapping has been completed for the Region.

Sludge might be spread and incorporated, as shown on Figure 10 simply spread or sprayed on the surface for later plowing. Sludge left on the surface loses some of its nitrogen through volatilization, and thus there is a loss of fertilizer value. This is, however, the approach of most farmers in that animal manures may lay on the surface for some days before incorporation. Further discussion on agricultural use of sludges is given in Chapter V and IX.

Except for the sludge from MSD-Jones Island, most of the Region's sludge is eventually applied to land for agricultural use. Wastewater treatment plants that do not apply sludge in the winter either lagoon sludge or stockpile sludge cake. Odors are generated in the spring, but the sludge piles are removed expeditiously, so that the nuisance is short lived. It appears that land application will continue to be a viable alternative for many of the area's plants. Many of these plants are removed from residential areas or can stockpile sludge cake at acceptable distances from homes, thus mitigating odor problems.

Public Pickup

Rather than haul and spread, some plants in the Region allow public pickup of lagoon or sand bed dried sludge. The sludge has undergone digestion and drying which would amount to at least a month's detention. With proper digestion, risk of health hazard for either drying bed or lagooned sludge is minimal. Such a method of disposal is obviously inexpensive from the viewpoint of the sewerage authority. However, there is no control over application methods or rates of application. Public pickup is an acceptable utilization/disposal method provided educational data or proper labeling is provided. It is important to provide the information to the public in a positive manner, and it should include a simple description of the material, where the material should be used, and at what rate it should be applied.

Some sludges are used by departments of public works and park boards for spreading on publicly held lands.

Composting

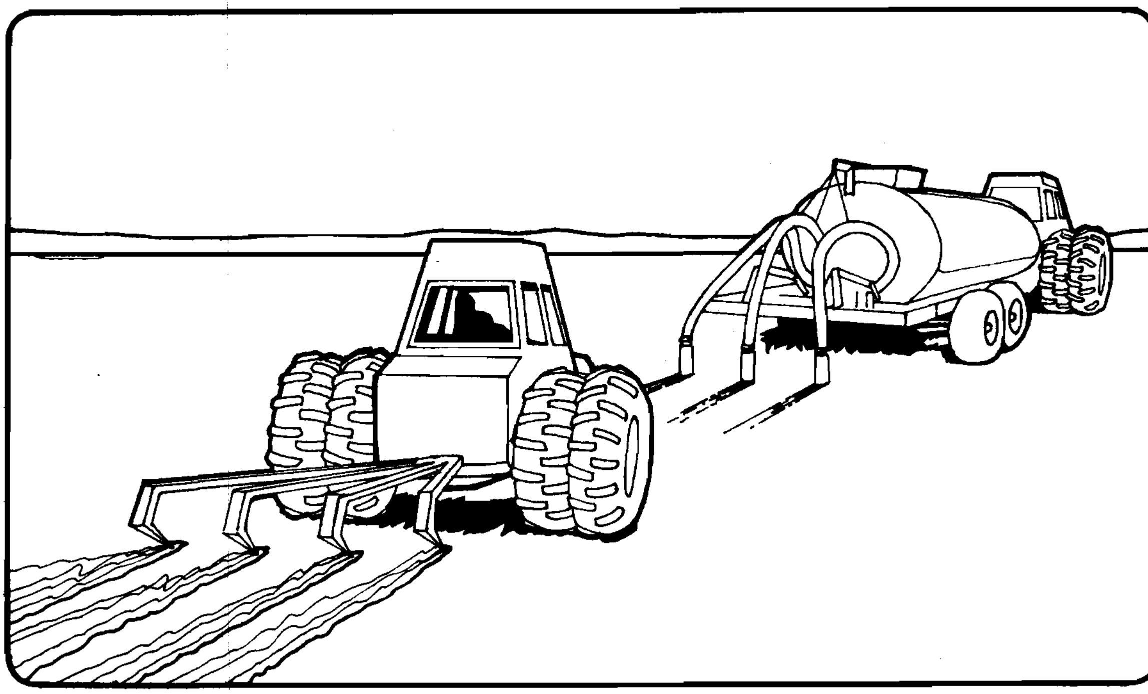
The Beltsville, MD, research facilities of the US Department of Agriculture have developed composting methods that have also been found effective in winter tests conducted in Durham, NH, and Bangor, ME. These techniques are being considered for demonstration at the MSD-South Shore plant.

Compost has a low nitrogen value (typically 1 to 2 percent nitrogen) and thus is more suitable as soil conditioner than as fertilizer. Composting is advantageous in metropolitan areas where the major use is for lawns and flower beds, and the product can be stored over the winter without causing noxious odors when the piles are broken in the spring. Compost consistency is desirable in that it is dry and easily spread.

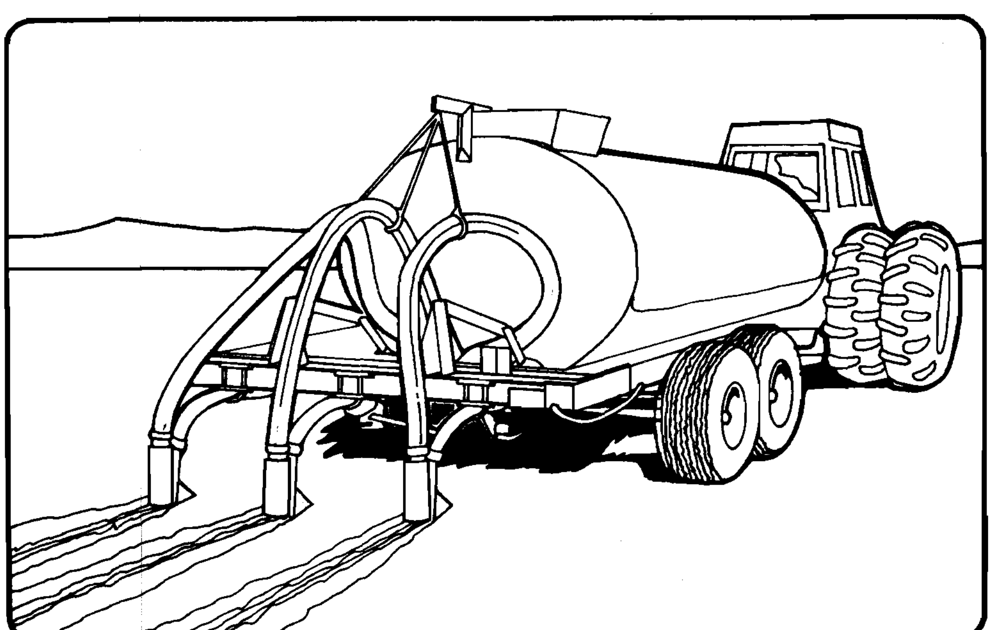
Composted wastes reach temperatures of 140° to 170°F for extended periods of time, killing or inactivating pathogens.

Composting of sludge, either separately or with municipal solid wastes, has not been widely applied in North America. A primary problem may have been the absence or inability to develop a market for the stable

FIGURE 10
LAND SPREADING SYSTEM



SURFACE SPREADING
FOLLOWED BY INCORPORATION



INCORPORATION DURING SPREADING

Source: Camp Dresser & McKee Inc.

product.

A system recently investigated by the Agricultural Research Service, USDA, uses blowers to draw air through the prepared compost pile. Perforated pipes under the pile are connected to a fan. Gases removed from the pile are scrubbed by passing them through another pile of previously stabilized and screened compost. Estimated total land area required for this system is 1.0 to 1.3 acres per dry ton.

A pilot composting program to investigate the feasibility of composting sewage sludge from the MSD-South Shore treatment plant will begin in the fall of 1977. The objectives are to evaluate methods and costs of composting; odors associated with composting and means of controling these odors, and marketing of the compost.

The sludge is completely stabilized and does not attract rodents or insects. It can thus be readily disposed of on land or used as a soil conditioner. Because the process is aerobic, a large portion of the ammonia is either oxidized to nitrates or goes off as a gas.

Composting systems generally fall into three categories: pile, windrows, and mechanized (or enclosed) systems.

Sequential steps usually involved in composting are:

Preparation—Sludge that is composted without the inclusion of solid waste fractions must be blended with some bulking material, if windrows are used. This bulking material can be soil, sawdust, wood chips, dried sludge, refuse or other suitable material. If a mechanical aeration system is used, bulking agent requirements are less severe. For proper waste digestion, a moisture content between 45 and 65 percent by wet weight is desirable. A potential advantage exists when combined sludge—solid waste composting is practiced, because digested sludge can provide nutrients and requisite moisture to the solid waste fraction; normal sludge to refuse ratios of roughly 0.50 to 1.00, by weight, are employed. However, odor problems may result.

Digestion—The digestion period is characterized by rapid decomposition. Air is supplied by periodic turnings in windrow-type operations while in mechanical systems, forced draft or agitation in long screw conveyors is utilized. The period of digestion is normally about six weeks for windrows and several days in mechanical aeration systems.

Curing—This period is characterized by a slowing of the decomposition rate. The temperature drops back to normal and the process is brought to completion. This takes about two or more windrow weeks or two to four weeks for mechanical systems.

Finishing—If municipal solid waste fractions containing nondigestible debris have been included, some sort of screening or other removal procedure might be necessary. Builder material of other type also has to be removed.

Sludge Drying

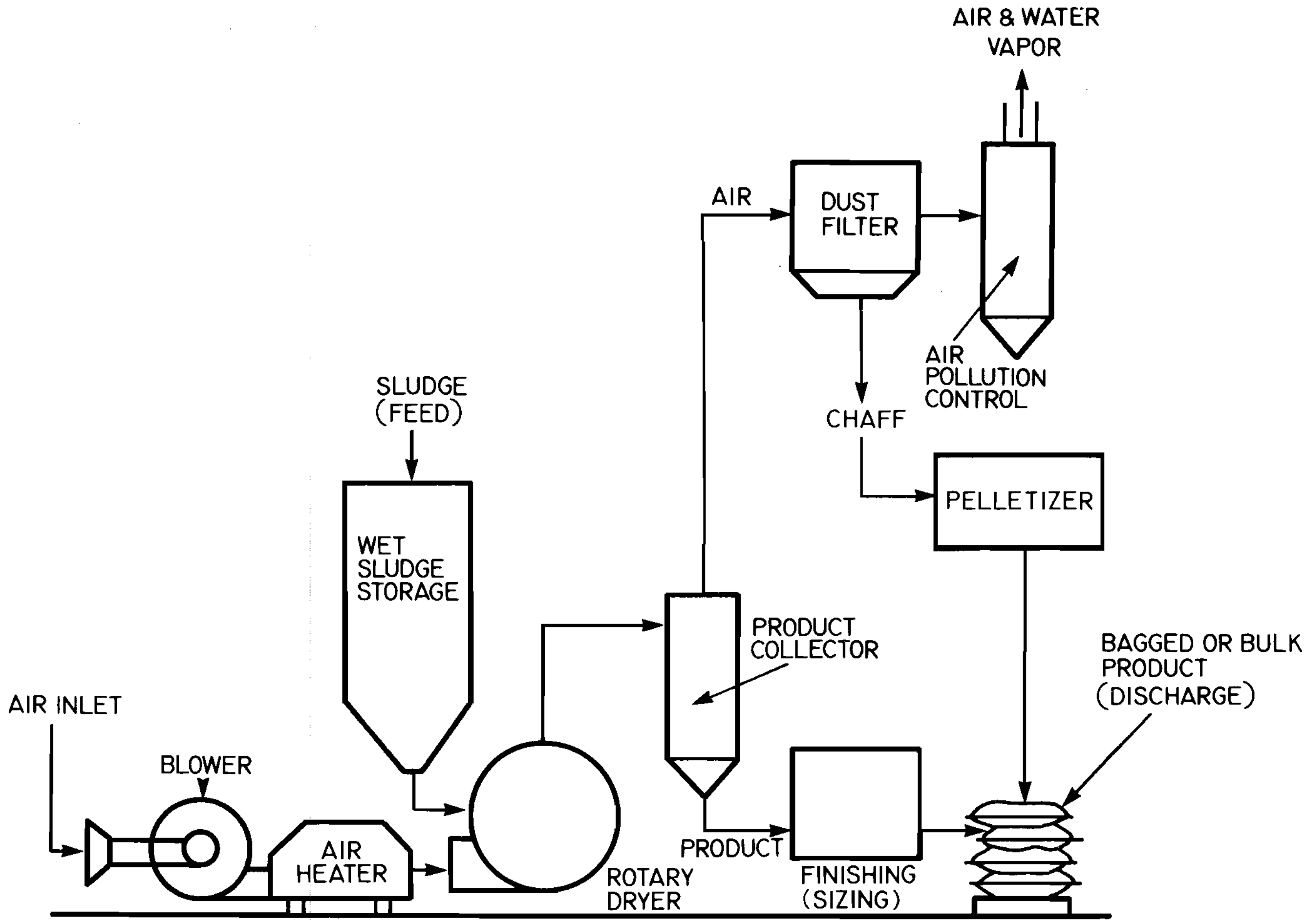
Currently, only the MSD-Jones Island facility employs sludge drying for the production of organic fertilizer, under the name Milorganite. This operation, in general, consists of a thickening step, a dewatering step and a drying step. Following drying, the sludge particles are screened and may be bagged or sold in bulk. These operations usually employ vacuum filters or belt filter presses for dewatering with the addition of various conditioning chemicals. Dryers are commonly of the rotary type and may be fired with natural gas, fuel oil, or coal. The dryers at Jones Island are rotary; other types are flash dryers and jet mills. Flash dryers utilize a cage mill where the water vapor is "flashed." This is essentially a rotary dryer only the unit is smaller. Jet mills have no moving parts and rely on the gas stream forces to convey and classify the solids simultaneously. At MSD-Jones Island, 75 percent of the required heat for the drying is waste heat from the power house.

The future of sludge drying depends on the value of the product on the open market, which helps to offset the high cost of drying. The price evaluation analysis of Chapter IV addresses this question.

ANALYSIS TECHNIQUES

In Chapter IX, six sludge management system alternatives are presented with options for sludge processing, transportation, utilization, and disposal. In order to narrow the number of alternatives and the number of sludge processing, transportation, utilization, and disposal options contained within these alternatives, it was necessary to develop a list of factors for a screening system. Listed below are the factors and related considerations explaining the methods of application of the factor considerations for ruling out alternatives and the options contained therein. The factors were selected based on groupings used in similar studies and were reviewed by the Technical Advisory Committee. Prior work in the State-Of-The-Art studies insured that

FIGURE 11
SCHEMATIC DIAGRAM OF
SLUDGE DRYING SYSTEM



Source EPA Process Design Manual for Sludge Treatment and Disposal

no technically unfeasible processing, transportation, utilization, or disposal options were involved in the alternatives development.

The six alternatives were first screened by considering costs and technical factors related to options within each of the alternatives. Similar, less detailed considerations were applied to categories of sludges. The options within the alternatives were also screened considering non-cost factors. Finally, the apparently most feasible, recommended alternative was reviewed and discussed taking these factors into account. This material is presented in Chapter IX.

Discussion of Factors

Evaluation of potential sludge management options is based on a number of factors which contribute to the overall effectiveness of a given system. To compare the merits or disadvantages of a number of alternatives, the factors which play important roles must be identified and defined. Factors to be considered include a wide range of topics which may or may not directly relate to each other.

The determined assessment factors of this study fall within eight major classifications, and are as follows:

Atmospheric Resources
Costs
Cultural Factors
Earth Resources
Flora and Fauna

Land Use
System Feasibility (including flexibility)
Water Resources

This group of factors was selected because each group identifies a separate area of concern, yet the number of factors is limited. To further evaluate specific components of a given factor, a more comprehensive breakdown is possible. The following sections address those characteristics which are specifically assessed within each of the eight major factors.

Atmospheric Resources—This factor is important in the assessment of sludge processing alternatives, because a number of the options to be considered might directly affect the atmospheric resources of the region. Sludge incineration (or related procedures) could produce serious hazards should operation failures or inadequacies result. Transport of sludges involves burning of fossil fuels, a topic of primary concern involving overall air quality. Promotion of improved or degraded air quality by a particular option, either directly or indirectly, will bear heavily on that option's total acceptability. Other concerns which may or may not be involved include air movement patterns, temperature changes, and/or climatic variations.

Costs—This factor is important in that it details the funds that must be made available over the planning period to carry out identified alternatives.

The capital and operation and maintenance costs will be a large portion of the total monies required for handling area wastewaters and will have an impact on local budgets.

Cultural Factors—Man's role in the decision process is not limited to the siting and design activities as they directly relate to the proposed action or project, but rather relate directly and indirectly with the activities of man not involved with sludge treatment. This factor is quite critical because it specifically deals with the human element. Our lifestyles and public welfare are all part of the cultural element. A wide diversity of subfactors can be identified which must be evaluated in terms of the proposed action. Public health and safety, employment, population characteristics, transportation demands, aesthetic values, historical or archaeological significance and more, all enter into the assessment of the cultural factor. Man's perception of the proposed action is critical and often viewed by how it might change some aspect of the cultural condition.

Earth Resources—The treatment and disposal of municipal sewage sludges is important in terms of earth resources. This factor has been defined (for purposes of this study) to be composed of those materials which include terrestrial nonbiological constituents such as minerals, energy resources, soil, or various other related subfactors. The ultimate disposal of sludge will have a distinct impact on earth resources because the options under consideration for this study will directly impact this segment of the environment.

Flora and Fauna—Vegetation and wildlife characteristics are important factors to be examined because they collectively interact and link man with the natural environment. By studying the characteristics of the biological community, one can determine a great deal about the welfare of the system. Hazards or actions potentially dangerous to man's welfare might be reflected by the biota as an early warning that might allow for some sort of mitigative course of action to be implemented. It is a reasonable assumption that a condition which adversely impacts the well-being of the vegetative and wildlife community also might adversely affect the welfare of the human environment. Not only will the biological community warn us of potential hazards but it will also directly contribute to the mitigation of adverse conditions.

Land Use—This factor is critical when considering that the total quantity of land available is limited. Any actions proposed by man which might commit a portion of that total resource to a limited long-term use is important.

Lands have often undergone changing uses with little attention paid to future needs and beneficial alternative uses. Recognition of this problem will help to minimize future adverse impacts. Structural solutions should be in conformance with Region land use planning goals.

System Feasibility—The basic feasibility criteria are that a system be technically sound and of proven performance; flexible, in order to meet uncertain future demands; and institutionally acceptable to those who bear the costs and reap the potential benefits.

All systems given serious consideration must be technically sound and be of proven performance capability. Should a system be difficult to operate or unable to meet permit criteria due to poor process selection, it might be the consequence of poor planning. Performance must be proven by past successful experience or by thorough, unbiased pilot testing over a reasonably long period of time. Systems must be flexible in that they might have to be modified to meet future demands. These future demands might arrive as changing loads due to new air and water quality or other standards, or simply due to a change in the amount and type of waste. New air and water quality standards might force system modifications or, due to modifications in related systems processes, result in load changes that must be met. A new emissions standard might necessitate much additional, expensive equipment for an existing incinerator, while the requirement of effluent filtration at a wastewater treatment plant might result in an increase in sludge load. Loads on the wastewater treatment plants might change as the result of unanticipated population or industrial activity. The wastewater characteristics might also change due to changing lifestyles, changing industrial production technology, or reduced loading brought about as the result of a new user charge/ industrial cost recovery system. Selected alternatives must be able to be modified or expanded in a relatively easy manner. The system must be capable of standing the test of alternative futures.

The system selected must be institutionally acceptable and must have the support of the existing and near future public attitudes. The system must be functional in the eyes of current governing bodies and voters at large, and must be within the bounds of the law. This points to a continuation of current practice within existing institutional boundaries. The established boundaries need not be violated unless other significant benefits are attainable.

Another factor is the availability of men and materials to operate the systems. Plants which use less material derived from scarce resources, such as natural gas, might be favored. Similarly, those processes that recover heat, fertilizer, or methane gas might also be favored.

Water Resources—This last factor might be more closely associated than the others with sludge collection, transport, processing, and disposal. Historically, water has served as the primary medium for the movement of wastes from one location to another. Man is increasingly dependent on the fresh water resource. Both surface and groundwater resources are subject to the effects of various actions. Subfactors of particular concern for this study include water quality, recharge or withdrawal potential, flooding, and eutrophication.

Cost Analysis Techniques

The alternative regional sludge management system plans, identified in Chapter IX, were evaluated and compared both by economic analysis procedures and through the identification and consideration of several non-economic factors. The economic analysis and evaluation, carried out by techincal staff at Camp Dresser & McKee Inc. during the planning program, is described below and was performed in accordance with the methods used by SEWRPC.

No attempt was made to calculate monetary benefits for meeting the statutory requirements and the regional development objectives. Benefit-cost ratios were not, therefore, calculated. If monetary benefits are created (in other sectors such as recreation or agriculture) from the multiple-purpose use of elements of sludge management plans, these benefits might be used to reduce the economic cost of that element and the plan of which it is a part. Material in the price evaluation analysis in Chapter IV was viewed in this light.

Economic evaluations conducted under the planning program included the selection of a design period and an economic life; an interest rate; depreciation and salvage values; and various costs, including construction, capital, present worth, and equivalent annual costs.

Design Period and Economic Life—The physical life of a property is that period between the original acquisition and final disposal of the property. The physical life of a given property is usually longer than its economic life. The economic life is defined as the period after which the incremental benefits from continued use no longer exceed the incremental cost of the operation. In the economic analyses conducted under the sludge management system planning program, the time period over which the facility is totally depreciated is made equal to the economic life.

The planning period for the regional sludge management planning program was selected to end at year 2000. This planning period is also in line with Federal Guidelines. It is recognized, however, that the design economic life of some facilities exceeds that of the planning period. For purposes of economic analysis, lives of plant process trains were estimated at 30 years. An exception to this were sludge application sites where the site life is governed by sludge and soil characteristics.

While the planning period is through year 2000, the economic analysis period extended over the longest economic life of components of the regional sludge management system plan. This 30 year analysis period is based on the longest useful service life of process equipment given in the "Cost-Effectiveness Analysis Guidelines" Title 40, Chapter 1 of the Environmental Protection Agency. Although this analysis period differs from the 50 year analysis period used in the Sanitary Sewerage System planning program, it is based on the same set of criteria, since the analysis period equals the service life of the longest component life. For sludge handling and processing this is 30 years. It should be noted here that all process equipment considered in this study is designed and sized to handle the loadings projected through the year 2000. Cost computations under the sludge management study assume that construction of major system elements would begin in 1979-1980. All costs, however, are expressed as August 1976 values (Engineering New Record Construction Cost Index 2445).

Following the principles of sound engineering economic analyses, no escalation of costs for construction, operation, maintenance, or replacement was considered. In the economic evaluations, provisions for the replacement of shorter-lived components are incorporated in total economic costs through the selection of an economic life. The economic analyses of alternatives assumes replacement of facilities at specific life intervals. Therefore, relative economic comparisons will result in the same conclusions. A salvage value was credited to facilities whose economic life extended beyond the year 2010 or where a landspreading site was abandoned.

Interest Rate—An interest rate of 6% was used in all of the economic analyses in accordance with SEWRPC practice. A value of 6% is considered reasonable because it represents the approximate rate to citizens on conservative investments and, therefore, is representative of the cost to the individual of foregoing opportunities for investment elsewhere. For the recommended alternative, a value of 6⅜% will also be used as per Federal Guidelines. The difference between these two rates is slight and of no real consequence.

Depreciation and Salvage Values—For the purposes of economic analyses, it was assumed that all facilities would depreciate at an average annual rate over the economic life. At the end of economic life, it was generally assumed that no value remained; thus, no salvage values were included in the economic analysis except for those facilities with an economic life extending beyond the year 2010. An exception to this is land used for sludge spreading.

Construction/Capital Cost—The construction costs of all facilities included in the regional wastewater sludge management system plan were estimated from the series of cost curves. These construction costs were multiplied in the economic analysis by a factor of 1.35 to obtain capital costs. The additional 35 percent of the estimated construction costs is added to account for unforeseen items in the cost estimates (contingencies), engineering and legal fees, administrative costs, and financing costs. The multiplier was derived by SEWRPC as shown below:

TABLE 61

CONSTRUCTION COST MULTIPLIER

Construction Cost	=				1.0
Contingencies	=				0.15
Subtotal					1.15
Engineering	=	1.15	× 0.08	=	0.092
Legal and Administrative	=	1.15	× 0.02	=	0.023
Interest during Construction	=	1.15	× 0.045	=	0.052
Subtotal					1.317
Financing	=	1.317	× 0.03	=	0.039
Total (rounded)					1.35

Present Worth and Annual Costs—Four terms are commonly used in preparing economic analyses of important engineering projects. These are the single payment present worth factor (PWF), the uniform series present worth factor (SPWF), the gradient present worth factor (GPWF), and the capital recovery factor (CRF).

The single payment present worth factor converts the cost of a single expenditure at some future time to a value at present or close to present. The uniform annual series present worth factor converts a series of uniform annual payments to equivalent present value. Where annual payments are increasing by a fixed amount per year, the gradient present worth factor is used to determine the present value of the series. This factor, multiplied by the gradient (annual increase), is added to the present worth of a series of payments equal to the first year's payment to obtain total present worth. In 10-year series, the gradient is equal to the difference between the 10th year cost and the first year cost divided by the time base minus one year. The divisor is always one less than the series length because the amount of the gradient is zero for the first period. This method was applied to wastewater treatment plant operation and maintenance costs, assuming that they increase in a straight line from the costs at the initial operating flow to the maximum at plant capacity. After the facility is operating at capacity, the present worth of operation and maintenance costs is calculated as the present worth of uniform annual series starting at a point in the future equal to the gradient time base.

The present worth of future single, uniform, or nonuniform annual series payments is always less than the absolute value of the single payment or the sum of the annual payments. The capital recovery factor converts a lump payment at the beginning of a period into a series of uniform annual payments over the length of the period. The sum of these uniform annual payments is always greater than the lump payment.

The following is an example of the use of present worth and annual cost analyses:

Assume that a sludge processing plant is proposed with gravity thickening of 2.25 ton/day capacity and a lagoon with 1.7 ton/day capacity is to be designed and constructed for operation to start-up during 1980. In addition, an anaerobic digester of 0.5 ton/day capacity is to be designed and constructed for operation beginning in 1989. The capital cost of phase one is $261,900, and land cost of phase one is $2930. Capital cost of phase two is $270,000. The operation and maintenance during the initial year is $61,560, and in year 2000 is $87,615. The present worth and average annual cost of this plant for a 20 year operation period is computed as follows: mid-point of construction is 1980, start up year is 1981.

ANNUAL COSTS (AVERAGE) TO YEAR 2000

Capital Cost × CRF (30 yr.)
531,900 × 0.07265 = $ 38,643

Land Cost × Interest Rate
2,930 × 0.0600 = 176

$[OM_2 + OM_1] \div 2$
[87,615 + 61,560] ÷ 2 = 74,590

Total Average Annual Cost = $113,410

PRESENT WORTH ANALYSIS AT 6% INTEREST RATE

Capital Cost (p_1) × pwf (N_1) $N_1 = 1980 - 1976 = 4$
$261,900 × .7921 = $ 207,450

Land Cost (p_1) × pwf (N_1)
$ 2,930 × .7921 = 2,320

Capital Cost (p_2) × pwf (N_2) $N_2 = 1989 - 1976 = 13$
$270,000 × .4688 = 126,576

Land Cost (p_2) × pwf (N_2)
$ 0 × = 0

Less pw of Land Salvage:

Land Cost (p_1) × pwf ($N^* + 30$) $N^* = 5 + 13 - 4 = 14$
$ 2,930 × .073 = (214)

Land Cost (p_2) × pwf ($n_1 + N_2 - N_1 + 30$)
$ 0 × = (0)

$OM_1 \times \text{spwf}(n_2) \times \text{pwf}(n_1)$ $n_2 = 19 = 2000 - 1981$; $n_1 = 5 = 1981 - 1976$
61,560 × 11.158 × .7473 = 513,310

$\frac{OM_2 - OM_1}{n_2 - 1} \times \text{gpwf}(n_2) \times \text{pwf}(n_1)$
$\frac{26,055}{18}$ × 81.308 × .7473 = 87,950

$OM_2 \times \text{spwf}(n_3)^{**} \times \text{pwf}(n_1 + n_2)$ $n_3 = 30 - n_2 + (N_2 - N_1) = 20$
87,615 × 11.47 × .2470 = 248,220

Total Present Worth August, 1976 = $1,185,610

*$N = n_1$ for single phase const., $n_1 + N_2 - N_1$ for two phase const.

**$n_3 = 30 - n_2$ for single phase const., $30 - n_2 + N_2 - N_1$ for two phase const.

Environmental Assessment Process

Two of the above assessment factors are not included in this assessment because they do not directly relate to environmental or noneconomic considerations; these categories are costs and system feasibility. Analysis of these two factors has been conducted individually. This is important because costs of a proposed action directly influence its feasibility. The opposite statement also is true because a more complex system and environmental requirements might demand higher costs. Evaluation of these characteristics is basically a comparative analysis of total cost and is discussed in Chapter IX.

The relative importance of each impact is not the same for each segment of the environment for a given proposed action.

The environmental assessment process utilized for this project has been specially designed to meet the requirements imposed by project goals and objectives.

The first step in the assessment, related to the alternatives development, identifies each of the sludge management options and scores them utilizing an environmental assessment matrix developed for this project (see Figure 12). The matrix is composed of two groups of factors, each represented on an axis of the matrix. The top axis, or row, lists those actions which might produce an impact on some aspect of the existing environment. Six environmental factors are represented along the left margin, or column, axis. A grid system is formed from the two axes which provides a space for each possible interaction.

To use the matrix, a single sludge management option must first be identified for consideration. Next, consideration is given to actions which might cause an impact on the environment. Determine whether or not the impact is positive or negative and enter the appropriate sign (+ or -) in the proper space. Should an impact not be clearly positive or negative, enter a (o) in the space to signify that some impact is possible but no definition of its net result is possible at the time, based on available knowledge. After having gone through the entire matrix, all potential impacts will have been identified.

To establish a means of determining the relative importance or weight for each potential impact, a system of assigning weights to each of the eight screening factors was utilized. Rating of the screening factors is indicated in Table 62.

Once all of the impact interaction points have been identified and appropriate values assigned, the weighted value for that group must be applied to determine a weighted score for each impact. Impacts which are positive should be assigned a +1 value, negative impacts should be assigned a -1 value. For those potential impacts which are not distinctively positive or negative, a zero value should be assigned. The weight factor within each of the appropriate categories should then be multiplied by the impact values. After all weight factors are applied, each column and row can be totaled to obtain a net sum which value might be either positive, negative, or zero. Net sums are then totaled to arrive at a matrix value which represents the result of the total environmental assessment matrix calculation.

An inventory of interactions must be prepared for use in the environmental scoring equation. First, all points of impact identified on the matrix are totaled—this will include all positive, negative, and zero interactions. Then the number of interactions that are positive and negative are determined. At this point, four numbers will have been determined for a given sludge management option. For example:

1) matrix total score, 10.4
2) total number of interactions, 10

TABLE 62

RATING OF SCREENING FACTORS

Factor	Importance Rating (Weight)
Atmospheric Resources	10.3
Costs	13.2
Cultural Factors	10.9
Earth Resources	11.3
Flora & Fauna	12.8
Land Use	10.7
System Feasibility	13.0
Water Resources	17.8
Total	100.0

Source: Camp Dresser & McKee Inc. and the Regional Wastewater Sludge Management Planning Subcommittee.

FIGURE 12
ENVIRONMENTAL ASSESSMENT MATRIX

ASSOCIATED ACTIONS POTENTIALLY CAUSING ENVIRONMENTAL IMPACT

EXISTING ENVIRONMENT	Weight Factor	Processing			Resource Recovery			Traffic Demands			Sludge Emplacement And Treatment			Ecological Change			Developmental Land Transformation			Column Total
Earth Resources																				
Water Resources																				
Atmospheric Resources																				
Flora & Fauna																				
Land Use																				
Cultural Factors																				
Column Total																				

Matrix Total

Source: Camp Dresser & McKee Inc.

3) number of positive interactions, 4
4) number of negative interactions, 6.

These numbers are then utilized in the equation shown in Table 63, resulting in an environmental score. This would equal -1.56 for the example numbers.

TABLE 63

ENVIRONMENTAL SCORING EQUATION

$$E = \frac{\text{matrix total score}}{\text{total potential impact interactions}} \times \frac{\pm \text{ impact interactions}}{\pm \text{ impact interactions}}$$

If the matrix total is positive, then use:

$$\frac{\text{number of } + \text{ impact interactions}}{\text{number of } - \text{ impact interactions}}$$

If the matrix total is negative, then use:

$$\frac{\text{number of } - \text{ impact interactions}}{\text{number of } + \text{ impact interactions}}$$

All computations are made utilizing weighted values.

E = Environmental Score

Source: Camp Dresser & McKee Inc.

The environmental score is used to compare sludge management options under consideration for this study. The utility of the comparisons drawn from examining the various values is limited by the general assumptions necessarily made for the assessment. Scores which are obtained reflect only the relative merits of the process without any consideration of specific site characteristics. The scores generated at this point are utilized only as a guide in the further assessment of more specifically defined site options.

The last step of the assessment process is to present the best sludge processing/utilization plans for the entire Region. This is necessary because the problems that are associated with this activity are frequently regional in significance. In some alternatives, individual sludge processing sites must rely on associations with distant sites to meet total processing goals. This is especially true of regions which include large developed urban areas.

SUMMARY

The above discussion contains basic descriptions of wastewater sludge management system unit operations which represent the current state of technology. Factors to be considered in the selection of unit operation process trains and the relative importance of factors considered in the alternatives development and screening are described. This information is background material to the systems development of Chapter IX. The alternative screening factor discussion serves to indicate those factors which are considered to be most important for consideration in selection of recommended process trains for regional wastewater sludge management systems. A number of potential regional plans are considered in this report. Each alternative is reviewed noting the options proposed for each individual site. Regional objectives were compared with each alternative's merits. This regional perspective is important because duplication of effort and unnecessary expenses might be effectively minimized and extra-regional alternatives may be properly considered. An objective weighting system is developed which permits disciplined utilization of the matrix and assists in applying sound judgment to the screening of alternatives and selection of a recommended regional sludge management system.

In Chapter IX, the six alternative systems for the large wastewater treatment plants are developed. These are then subjected to a two-step cost analysis using the cost analysis techniques. The various sludge management options developed under these alternatives are also screened through the environmental assessment process. Categories of facilities' sludges are tested in a more general fashion. Finally, the recommended alternative is related to the various factors.

Chapter IX

ALTERNATIVE AREAWIDE SLUDGE MANAGEMENT SYSTEM PLANS

INTRODUCTION

Alternative areawide plans for the management of municipal wastewater sludges, industrial wastewater sludges, water supply treatment plant sludges, septic tank sludges, and holding tank wastes are presented in this chapter. The evaluations and resulting recommendations for sludge treatment and utilization/disposal are based on: existing sludge management systems (Chapter III), the market value of recovered sludge products (Chapter IV), sludge characteristics and quantity projections (Chapter V), regulations governing sludge processing and end-use (Chapter VI) objectives, principles and standards (Chapter VII), and unit operations for processing, transporting, and utilizing sludges (Chapter VIII). Sludges resulting from the anticipated treatment of combined sewer overflows are also discussed. The analysis leading to the recommended plan takes into account not only the dollar costs of construction and operation but also noneconomic factors, including environmental and energy considerations.

AREAWIDE SLUDGE MANAGEMENT SYSTEMS

In a broad sense, the sludge management problems of the Southeastern Wisconsin Region may be segregated into distinct elements. In the discussion that follows, the term "alternatives" refers to the overall processing and geographic management alternatives illustrated on Maps 3 through 8. Options refers to the processing, transportation, utilization, and disposal unit operations discussed in Chapter VIII, while process train options refers to combinations of unit operations (options) as functional sludge handling systems within the six geographic alternatives. The distinct elements of these geographic alternatives are:

1. Sludge generated by the Metropolitan Sewerage District Jones Island and South Shore Plants
2. Sludge generated by all other plants in the Region
3. Industrial wastewater sludge
4. Water treatment plant sludge
5. Septage and holding tank wastes.

The geographic alternatives considered herein for the 59 municipal wastewater treatment plants located outside the Metropolitan Sewerage District of the County of Milwaukee resolve themselves readily into local or at most subregional arrangements. However, the great quantity of District sludge requires that combinations of Regional and extra-Regional utilization/disposal options be considered, along with sophisticated, large-scale processing options, including energy recovery.

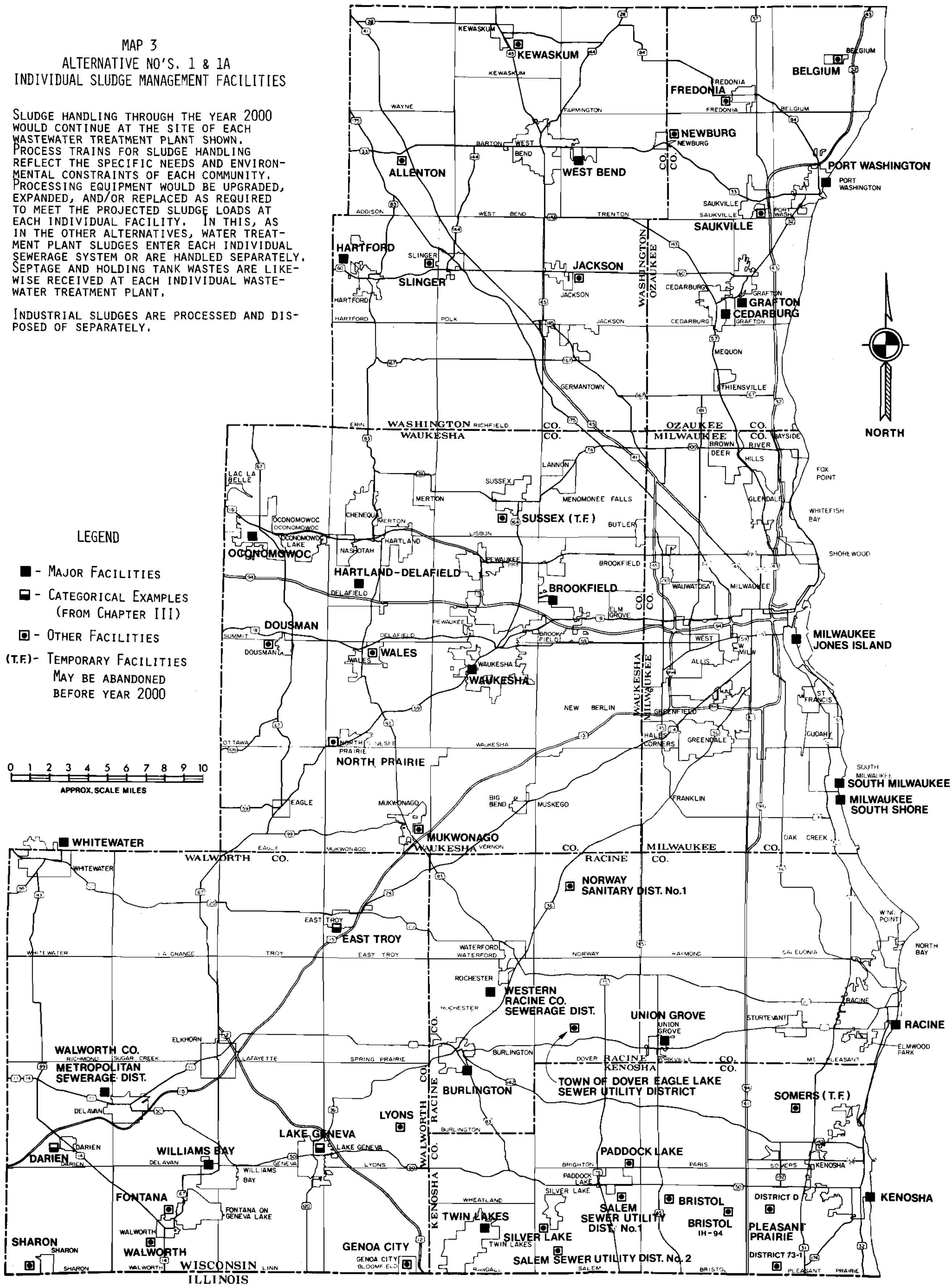
Industrial wastewater sludges are generally not compatible with processing of municipal sludges and have been considered separately. Most water treatment plant sludges and septage and holding tank wastes currently enter municipal sewerage systems and are thus components of municipal sludge. This concept is illustrated on Figure 12A.

Six geographic alternatives for processing and management of the municipal wastewater treatment plants in the Region were developed to investigate the least cost and most environmentally acceptable means of treating and utilizing the current and forecast amounts of wastewater sludges. The alternatives range from separate treatment and utilization by each municipal facility, to combined treatment at a single, central facility for processing and disposing of all sludge from the Region. The six alternative geographic systems are further comprised of multiple series of process train options which may in turn be made up of a multiple series of unit process options. The screening contained herein addresses approximately 300 possible combinations. Many other combinations were eliminated by work in the State-of-the-Art study. The basic unit process options were described in Chapter VIII. Selection criteria for developing the six alternatives were: the cost and effectiveness reported in the study of the State-of-the-Art of wastewater sludge management, review of the process alternatives selected in that study, proximity of sludge generation sites, the transportation networks, and haul distances. The alternatives consider the advantages to be gained by processing sludge in

MAP 3
ALTERNATIVE NO'S. 1 & 1A
INDIVIDUAL SLUDGE MANAGEMENT FACILITIES

SLUDGE HANDLING THROUGH THE YEAR 2000 WOULD CONTINUE AT THE SITE OF EACH WASTEWATER TREATMENT PLANT SHOWN. PROCESS TRAINS FOR SLUDGE HANDLING REFLECT THE SPECIFIC NEEDS AND ENVIRONMENTAL CONSTRAINTS OF EACH COMMUNITY. PROCESSING EQUIPMENT WOULD BE UPGRADED, EXPANDED, AND/OR REPLACED AS REQUIRED TO MEET THE PROJECTED SLUDGE LOADS AT EACH INDIVIDUAL FACILITY. IN THIS, AS IN THE OTHER ALTERNATIVES, WATER TREATMENT PLANT SLUDGES ENTER EACH INDIVIDUAL SEWERAGE SYSTEM OR ARE HANDLED SEPARATELY. SEPTAGE AND HOLDING TANK WASTES ARE LIKEWISE RECEIVED AT EACH INDIVIDUAL WASTEWATER TREATMENT PLANT.

INDUSTRIAL SLUDGES ARE PROCESSED AND DISPOSED OF SEPARATELY.



SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

MAP 4
ALTERNATIVE No. 2
SUBREGIONAL SLUDGE MANAGEMENT FACILITIES
(SIX SUBREGIONAL FACILITIES)

THIS ALTERNATIVE CONSIDERS THE OPTION OF COMBINED SLUDGE PROCESSING AT A REGIONAL SOLIDS HANDLING FACILITY FOR EACH OF THE COMBINATIONS PRESENTED. THIS ALTERNATIVE ALSO REPRESENTS JOINT LANDSPREADING ON RURAL SITES AND WOULD BE A MANAGEMENT SYSTEM WHERE COSTS SAVINGS COULD RESULT FROM MORE EFFICIENT USE OF SPREADING EQUIPMENT AND MORE EFFECTIVE MONITORING OF THE SPREADING SITE. COMBINATIONS OF LARGE SLUDGE MANAGEMENT FACILITIES CONSIDERED ARE:

PORT WASHINGTON - GRAFTON - CEDARBURG,

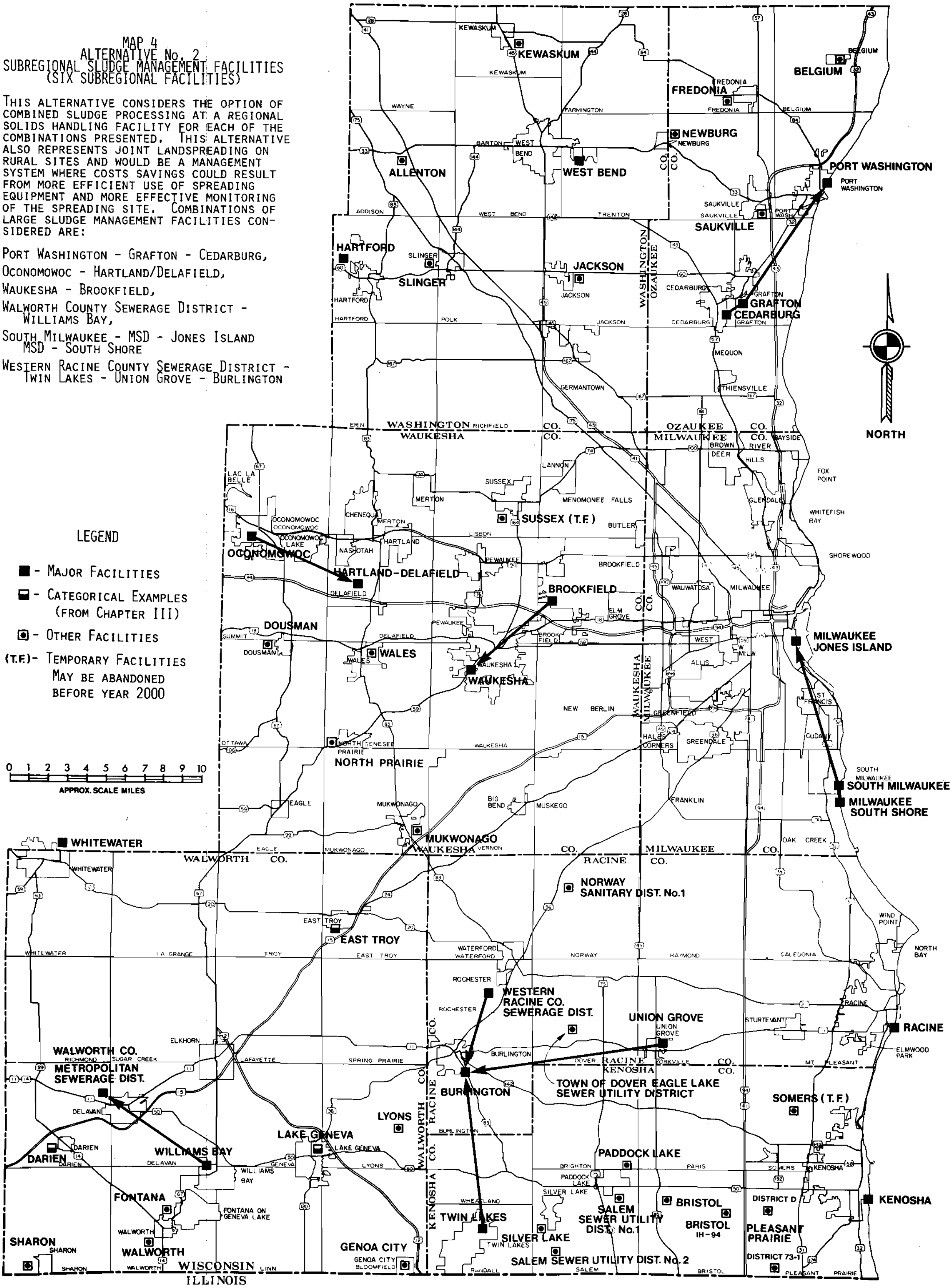
OCONOMOWOC - HARTLAND/DELAFIELD,

WAUKESHA - BROOKFIELD,

WALWORTH COUNTY SEWERAGE DISTRICT - WILLIAMS BAY,

SOUTH MILWAUKEE - MSD - JONES ISLAND MSD - SOUTH SHORE

WESTERN RACINE COUNTY SEWERAGE DISTRICT - TWIN LAKES - UNION GROVE - BURLINGTON



SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

MAP 5
ALTERNATIVE NO. 3
SUBREGIONAL SLUDGE MANAGMENT FACILITIES
(FOUR SUBREGIONAL FACILITIES)

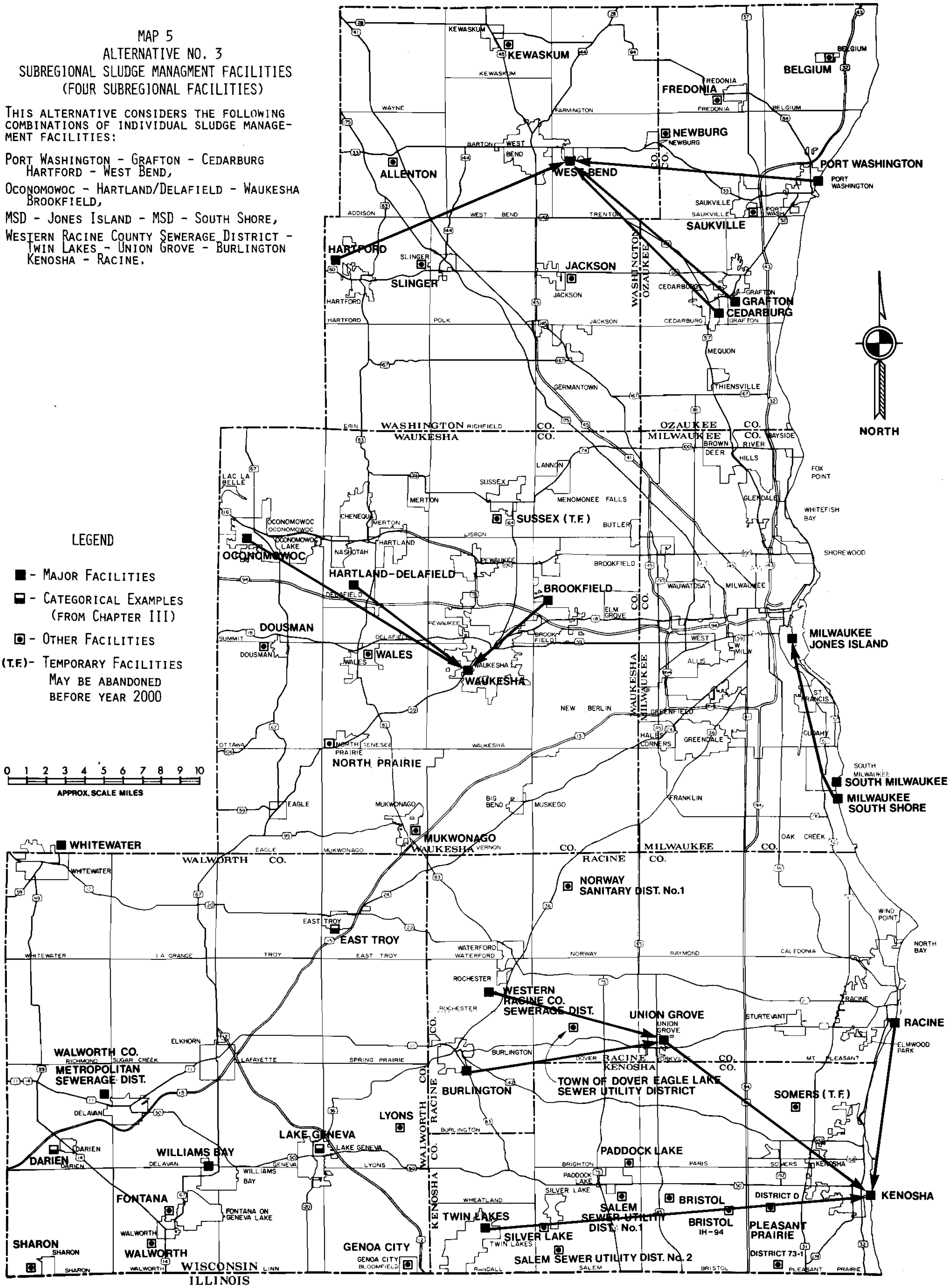
THIS ALTERNATIVE CONSIDERS THE FOLLOWING COMBINATIONS OF INDIVIDUAL SLUDGE MANAGEMENT FACILITIES:

PORT WASHINGTON - GRAFTON - CEDARBURG HARTFORD - WEST BEND,

OCONOMOWOC - HARTLAND/DELAFIELD - WAUKESHA BROOKFIELD,

MSD - JONES ISLAND - MSD - SOUTH SHORE,

WESTERN RACINE COUNTY SEWERAGE DISTRICT - TWIN LAKES - UNION GROVE - BURLINGTON KENOSHA - RACINE.



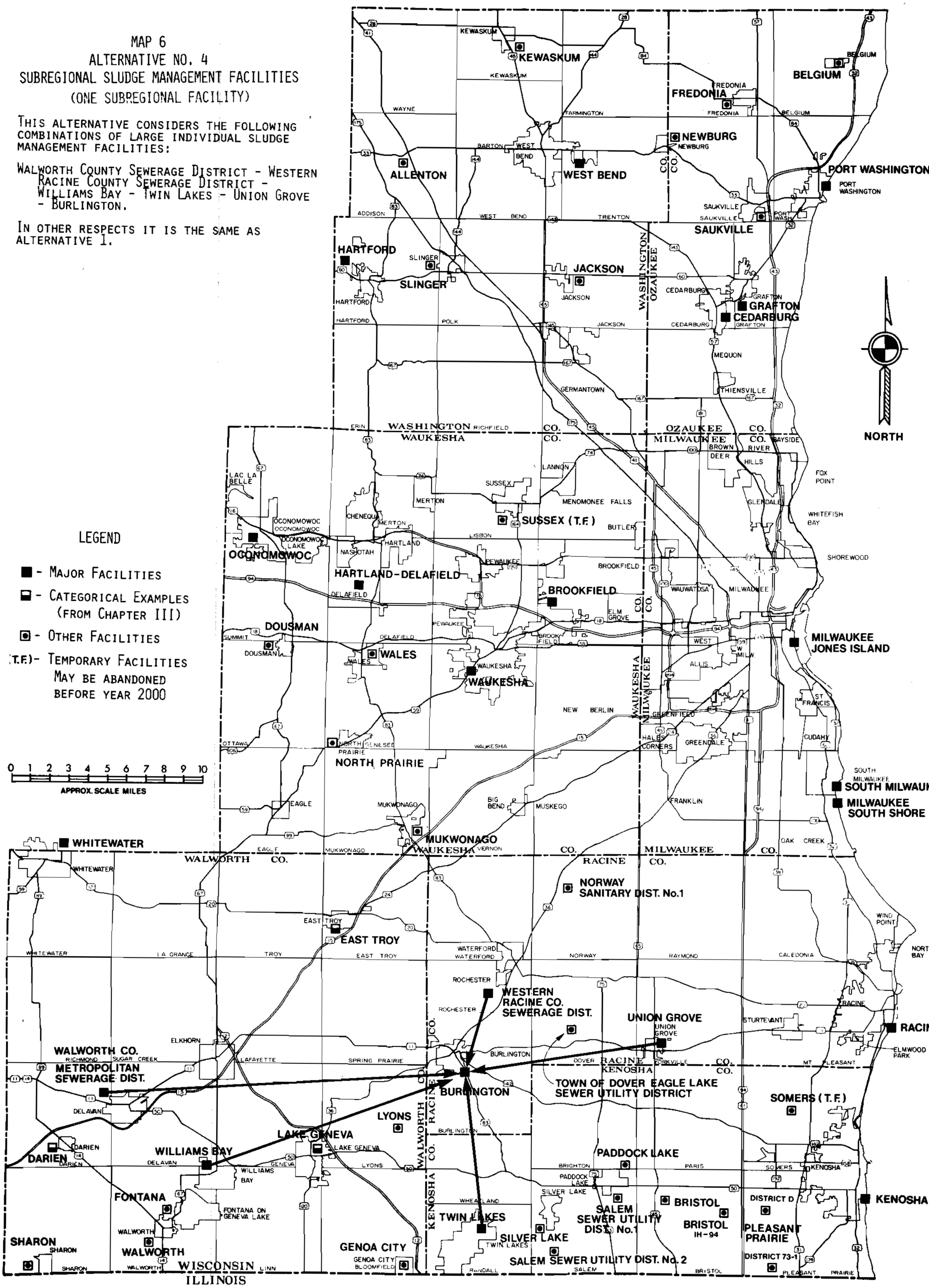
SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

MAP 6
ALTERNATIVE NO. 4
SUBREGIONAL SLUDGE MANAGEMENT FACILITIES
(ONE SUBREGIONAL FACILITY)

THIS ALTERNATIVE CONSIDERS THE FOLLOWING COMBINATIONS OF LARGE INDIVIDUAL SLUDGE MANAGEMENT FACILITIES:

WALWORTH COUNTY SEWERAGE DISTRICT - WESTERN RACINE COUNTY SEWERAGE DISTRICT - WILLIAMS BAY - TWIN LAKES - UNION GROVE - BURLINGTON.

IN OTHER RESPECTS IT IS THE SAME AS ALTERNATIVE 1.



LEGEND

- ■ - MAJOR FACILITIES
- ⊟ - CATEGORICAL EXAMPLES (FROM CHAPTER III)
- ▣ - OTHER FACILITIES
- (T.F.)- TEMPORARY FACILITIES MAY BE ABANDONED BEFORE YEAR 2000

SOURCE: CAMP DRESSER & McKEE, INC. AND SEWRPC

MAP 7

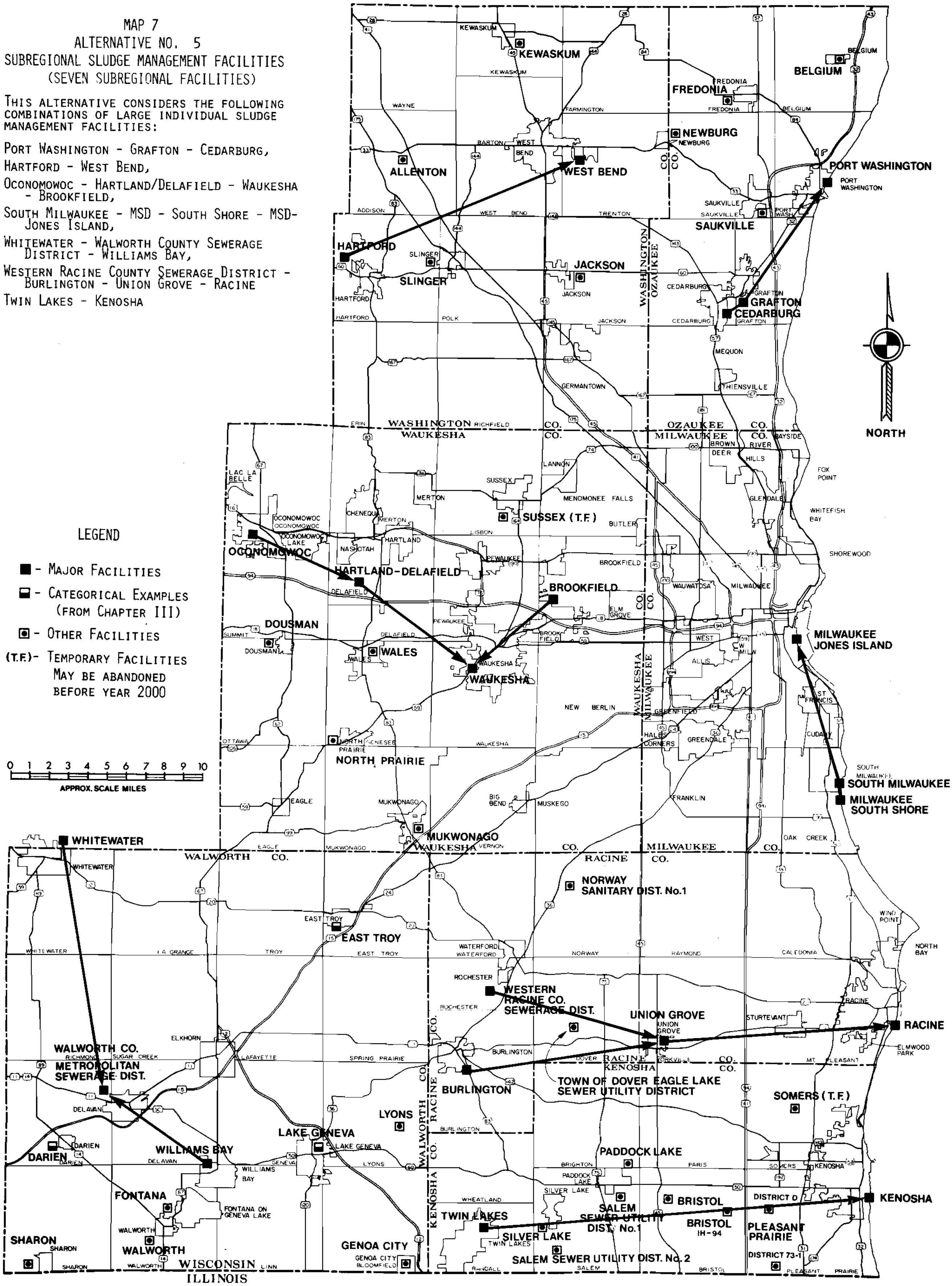
ALTERNATIVE NO. 5

SUBREGIONAL SLUDGE MANAGEMENT FACILITIES

(SEVEN SUBREGIONAL FACILITIES)

THIS ALTERNATIVE CONSIDERS THE FOLLOWING COMBINATIONS OF LARGE INDIVIDUAL SLUDGE MANAGEMENT FACILITIES:

PORT WASHINGTON - GRAFTON - CEDARBURG,
HARTFORD - WEST BEND,
OCONOMOWOC - HARTLAND/DELAFIELD - WAUKESHA - BROOKFIELD,
SOUTH MILWAUKEE - MSD - SOUTH SHORE - MSD-JONES ISLAND,
WHITEWATER - WALWORTH COUNTY SEWERAGE DISTRICT - WILLIAMS BAY,
WESTERN RACINE COUNTY SEWERAGE DISTRICT - BURLINGTON - UNION GROVE - RACINE
TWIN LAKES - KENOSHA



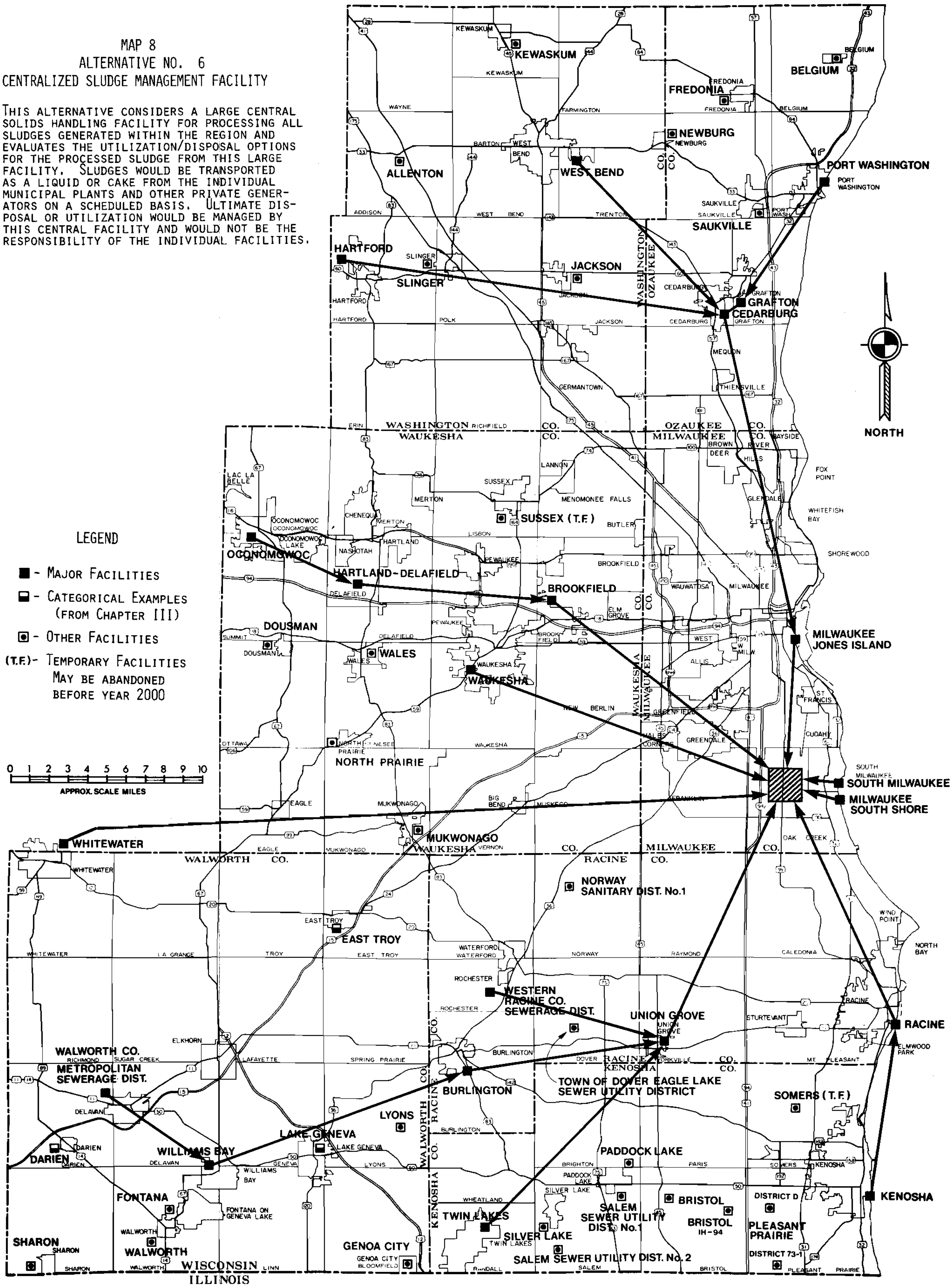
SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

MAP 8

ALTERNATIVE NO. 6

CENTRALIZED SLUDGE MANAGEMENT FACILITY

THIS ALTERNATIVE CONSIDERS A LARGE CENTRAL SOLIDS HANDLING FACILITY FOR PROCESSING ALL SLUDGES GENERATED WITHIN THE REGION AND EVALUATES THE UTILIZATION/DISPOSAL OPTIONS FOR THE PROCESSED SLUDGE FROM THIS LARGE FACILITY. SLUDGES WOULD BE TRANSPORTED AS A LIQUID OR CAKE FROM THE INDIVIDUAL MUNICIPAL PLANTS AND OTHER PRIVATE GENERATORS ON A SCHEDULED BASIS. ULTIMATE DISPOSAL OR UTILIZATION WOULD BE MANAGED BY THIS CENTRAL FACILITY AND WOULD NOT BE THE RESPONSIBILITY OF THE INDIVIDUAL FACILITIES.



LEGEND

- ■ - MAJOR FACILITIES
- ⊟ - CATEGORICAL EXAMPLES (FROM CHAPTER III)
- ⊡ - OTHER FACILITIES
- (T.F.) - TEMPORARY FACILITIES MAY BE ABANDONED BEFORE YEAR 2000

SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

Regional facilities where economies may result through greater efficiency and optimum use of equipment, and the advantages to be gained through Regional management of utilization/disposal methods. In Washington, Walworth, and Ozaukee counties, sludges from both the major and other plants were used in evaluating the costs of treatment and utilization/disposal for the geographic alternatives. These quantities were used in these three counties because the other facilities produce a significant portion of the total sludge generated by municipal treatment plants in those counties. For the other counties, only the sludge quantities generated at the major facilities were used in the calculations.

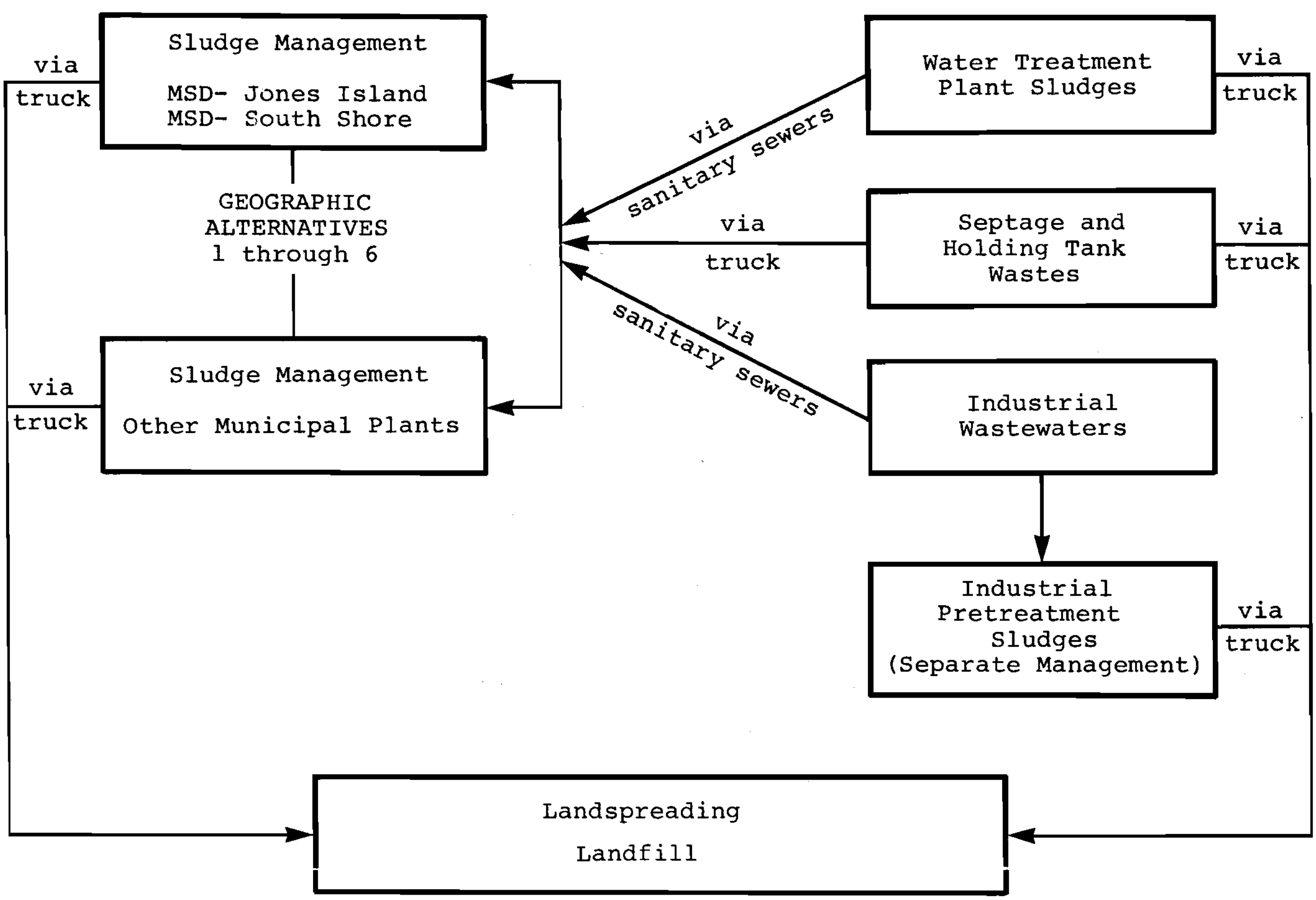
Because both MSD-Jones Island and MSD-South Shore wastewater treatment plants have an immediate need for additional solids handling capacity, both interim and long-term solutions are necessary for each plant. The interim solutions are planned to be operating within three to five years, and the mechanical equipment may be compatible with the long-term year 2000 solution. Additional dryers and filters are proposed for MSD-Jones Island to maintain plant capacity.

Detailed zone-to-zone travel distances developed by SEWRPC for year 2000 conditions were used to estimate the cost of transportation.

The age and capacity of existing sludge processing equipment was evaluated and compared to the projected loading in year 2000, and a process train developed in accordance with the utilization potential, e.g., landspreading and existing (or proposed) equipment capabilities.

FIGURE 12A

CONCEPTUAL DIAGRAM OF
SLUDGE ELEMENTS INTERACTION



Geographic Alternative 1—Individual Facilities
Sludge handling through the year 2000 would continue at the site of each wastewater treatment plant. (See Map 3) Process trains for sludge handling reflect the specific needs and environmental constraints of each community. Processing equipment would be upgraded, expanded, and/or replaced as required to meet the projected sludge loads at each individual facility. In this, as in the other alternatives, water treatment plant sludges enter each individual sewerage system[1] or are handled separately. Septage and holding tank wastes are likewise received at each individual wastewater treatment plant.

Industrial sludges are treated and disposed of separately in each alternative.

Geographic Alternative 2—Subregional Facilities
This alternative (see Map 4) considers the option of combined sludge processing at a regional solids handling facility for each of the combinations presented below. This alternative and others below also represent joint landspreading on rural sites and would thus be a management system where costs savings could result from more efficient use of spreading equipment and more effective monitoring of the spreading site. Combinations of major sludge management facilities considered are:

Port Washington—Grafton—Cedarburg,
Oconomowoc—Hartland/Delafield,
Waukesha—Brookfield,
Walworth County Sewerage District —Williams Bay,
South Milwaukee—MSD-Jones Island —MSD-South Shore,
Western Racine County Sewerage District—Twin Lakes— Union Grove—Burlington.

Geographic Alternative 3—Subregional Facilities
This alternative (see Map 5) considers the following combinations of major individual sludge management facilities:

Port Washington—Grafton—Cedarburg —Hartford—West Bend,
Oconomowoc—Hartland/Delafield —Waukesha—Brookfield,
MSD-Jones Island—MSD-South Shore,
Western Racine County Sewerage District—Twin Lakes—Union Grove— Burlington—Kenosha—Racine.

[1]*Water treatment plant sludges do not appear to affect treatment plant biological processes when bled to sewer system at a controlled rate. Treatment of these sludges may be cheaper when done in conjunction with waste water treatment if there is a collection system in close proximity to the water treatment plant.*

Geographic Alternative 4—Subregional Facilities
This alternative (see Map 6) considers the following combinations of major individual sludge management facilities:

Walworth County Sewerage District —Western Racine County Sewerage District—Williams Bay—Twin Lakes —Union Grove—Burlington.

In other respects it is the same as Alternative 1.

Geographic Alternative 5—Countywide Facilities
This alternative (see Map 7) considers the following combinations of major individual sludge management facilities:

Port Washington—Grafton—Cedarburg,
Hartford—West Bend,
Oconomowoc—Hartland/Delafield —Waukesha—Brookfield,
South Milwaukee—MSD-South Shore —MSD-Jones Island,
Whitewater—Walworth County Sewerage District—Williams Bay,
Western Racine County Sewerage District—Burlington—Union Grove—Racine,
Twin Lakes—Kenosha.

Geographic Alternative 6—Centralized Facility
This alternative considers a major central solids handling facility for processing all municipal sludges generated within the Region and evaluates the utilization/disposal options for the processed sludge from this major facility (see Map 8). Sludges would be transported as a liquid or cake from the individual municipal plants and other private generators on a scheduled basis. Ultimate disposal or utilization would be managed by this central facility and would not be the responsibility of the individual facilities.

AGRICULTURAL LAND APPLICATION OF MUNICIPAL SLUDGES

Application of municipal wastewater sludges to agricultural land is a key element in the above alternatives. The objectives, principles, and standards in Chapter VII emphasize land application as a desirable utilization method while minimizing negative impacts that might result from such a practice. Existing sludge management systems with agricultural land application are described in Chapter III and sludge quality as related to land application, is discussed in Chapter V. This section summarizes the analysis of land-spreading which is presented in detail in Appendix F.

The landspreading analysis is based on the guidelines presented in Department of Natural Resources Technical Bulletin No. 88 entitled Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin. This document is incorporated, by reference, into the Wisconsin Administrative Code as one evaluation criteria for sludge management plans. Using the procedures in Technical Bulletin No. 88 will result in a recommended application rate expressed in dry tons of sludge per acre. Also generated by the recommended procedures will be the total applications of sludge in dry tons per acre or the maximum number of applications at the given rate. The following factors are required as inputs to the Bulletin No. 88 procedures:

1. Sludge quality analysis including percent organic nitrogen, percent ammonia nitrogen, heavy metal concentrations in mg/kg for zinc, nickel, copper and cadmium

2. Crop yield potential of the soil

3. Physical limitations of the soil

4. Chemical limitations of the soil

5. Application method

6. Crop grown.

It is the interaction among the various values for these factors that determines the amount of land required for application of sludge. The analyses presented in Appendix F were designed to show the range of possible outcomes that could result for different input conditions encountered in this Region now and as projected through the year 2000. This range is considered to include all likely future conditions. Appendix tables F-20 and F-21 indicate under which conditions and for which treatment plants land application of sludge is a viable long-range (through the year 2000) utilization option. For the other plants, landspreading is generally a viable option under all analyzed conditions. For the major plants and those with high concentrations of heavy metals, landspreading is a viable option only when conditions are changed to one or more of the following:

1. Metal concentrations in the sludge are reduced

2. Spreading on crops (soils) requiring higher levels of nitrogen

3. Utilizing soils with moderate limitations in addition to soils with slight limitations, thereby effectively increasing land for spreading

4. Utilizing more farmland for land application of sludge.

The actual amount of land required for the long-term application of sludge for a plant or for all plants in total will be a function of the conditions that will actually exist in the future. It is also likely that conditions will not remain constant over time. For example, as source control is implemented, the number of applications permitted (total sludge loadings) will be increasing and, therefore, cumulative land requirements will be decreasing. The analyses in appendix F assume constant conditions (both with and without source control) over the study period. Analysis of variable condition situations can be undertaken only when future conditions such as contaminant control programs and implementation schedules are determined.

Two maps have been prepared which, based on the analyses in Appendix F, show the preferred or "primary land application zones" for each municipal treatment plant in the Region to meet anticipated year 2000 sludge loads. The shaded areas on the maps represent the zones which would serve treatment plants located therein. The farmlands located within the designated zones and which contain suitable soils with slight to moderate limitations (see Appendix F) would continue their primary food production function and, upon agreement, also would provide a sludge utilization function.

Map 9 shows the primary land application zones for sludge from each of the municipal treatment plants in the Region for the average sludge conditions listed in Table F-2 with the spreading occurring on crops with low yields (low nitrogen requirements). In total, the land required for a long-term land application program (through the year 2000) under these conditions is from 69,000 acres to 103,000 acres depending on in-plant treatment options and allocations of diversion flows to the Milwaukee Metropolitan Sewerage District facilities. The primary land application zones, shown on the map, include an area about twice that which is required to account for lands that are physically suitable for land application of sludge but are unavailable due to factors such as farmer preference, surrounding land uses, and community objectives. Table 64 summarizes the land required for land application and the land available in the entire region.

Map 10 shows the primary land application zone for sludge from each of the municipal treatment plants in the Region if a strict heavy metals control program were in effect for the entire study period. Table 64 also summarizes the land required under these conditions. Under these conditions or any other conditions, the situation could occur where a treatment plant has satisfied its long-term land requirements for land application sites yet suitable and available land remains in its primary land application zones. If this situation were to occur, the extra land in the primary zone for the local plant should be made available, subject to all required local and state approvals to other municipal treatment plants in the Region that have not been able to satisfy their land requirements in their designated primary zone. This process could work by reserving the right of first refusal to utilize a specific available suitable land application site to the sludge from the local treatment plant in whose zone the site is situated. If the local plant does not reserve all the land within its zone for its own use, the land would then be available to the other treatment plants after a reasonable period and subject to the required local and state approvals. The reservations of the use of suitable land for sludge land application should only extend to twice the area of land required under applicable regulations and required to meet approved projections of sludge quality and quantity. If a treatment plant cannot obtain the use of enough suitable land for application in its primary zone, the municipality should then seek suitable lands in adjacent areas subject to the right of first refusal outlined above.

TABLE 64

SUMMARY OF LAND AVAILABLE FOR APPLICATION OF SLUDGE TO AGRICULTURAL LAND

	Conditions of Load			
	Range for Average Sludge Quality and "Poor" Crop Yield		Range for Contaminant Controlled Sludge Quality and "Better" Crop Yield	
Source of Sludge	Acres Required			
MSD-Jones Island and MSD-South Shore[1]	39,125	72,857	27,563	48,933
Other Major Plants	28,381	28,381	14,933	14,933
Other Plants	1,500	1,500	1,000	1,000
Total	69,006	102,738 (worst case)	43,496	64,648
Total Slight and Moderate Limitations Acres Existing in Region	358,000	358,000	358,000	358,000

[1]*Does not include combined sewer overflow solids land application or the effect of 5 mg/l BOD_5 and SS effluent criteria.*

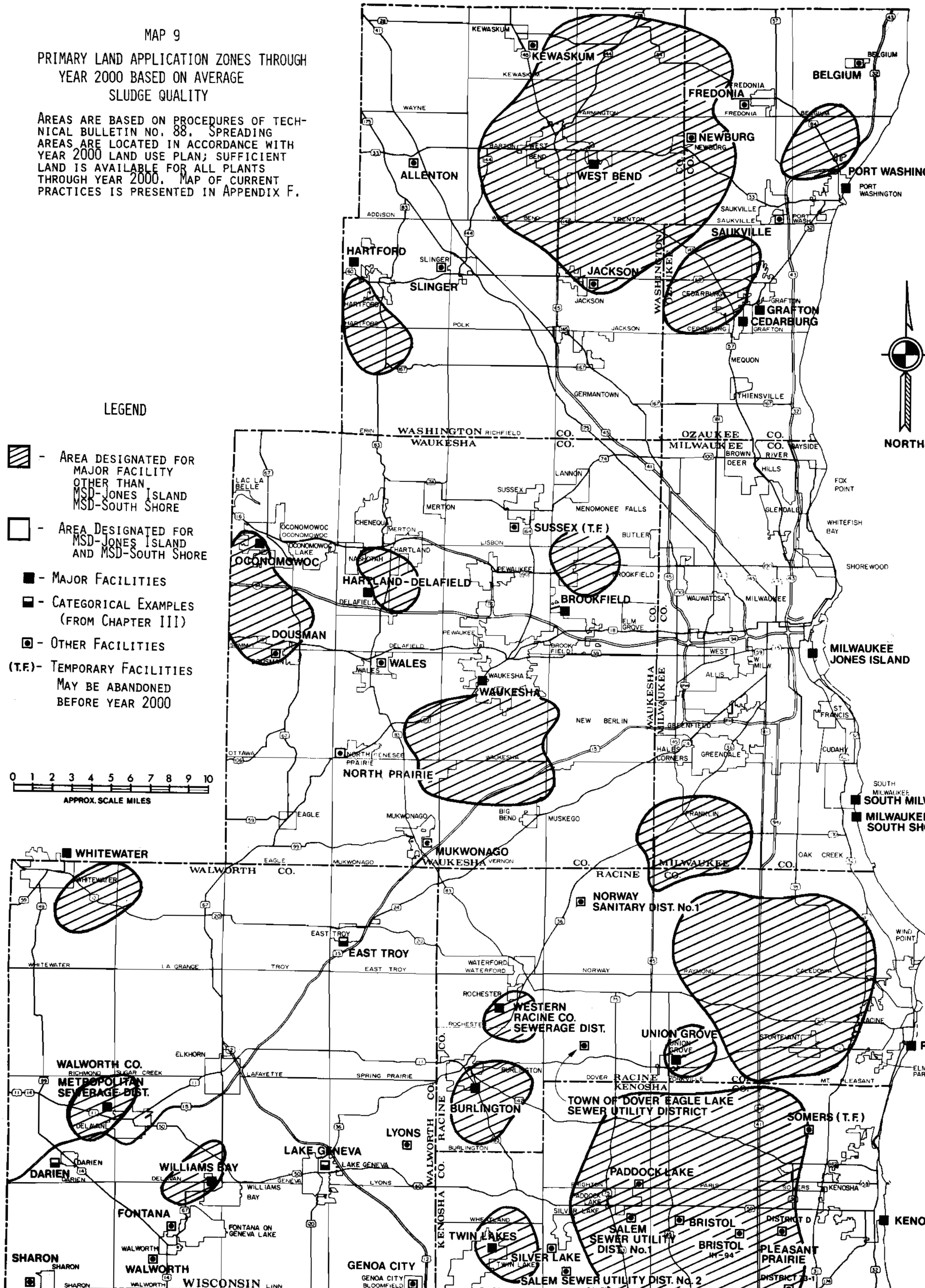
Note: Discussion of assumptions and limitations in Appendix F.

Source: Camp Dresser & McKee Inc.

MAP 9

PRIMARY LAND APPLICATION ZONES THROUGH YEAR 2000 BASED ON AVERAGE SLUDGE QUALITY

AREAS ARE BASED ON PROCEDURES OF TECHNICAL BULLETIN NO. 88. SPREADING AREAS ARE LOCATED IN ACCORDANCE WITH YEAR 2000 LAND USE PLAN; SUFFICIENT LAND IS AVAILABLE FOR ALL PLANTS THROUGH YEAR 2000. MAP OF CURRENT PRACTICES IS PRESENTED IN APPENDIX F.

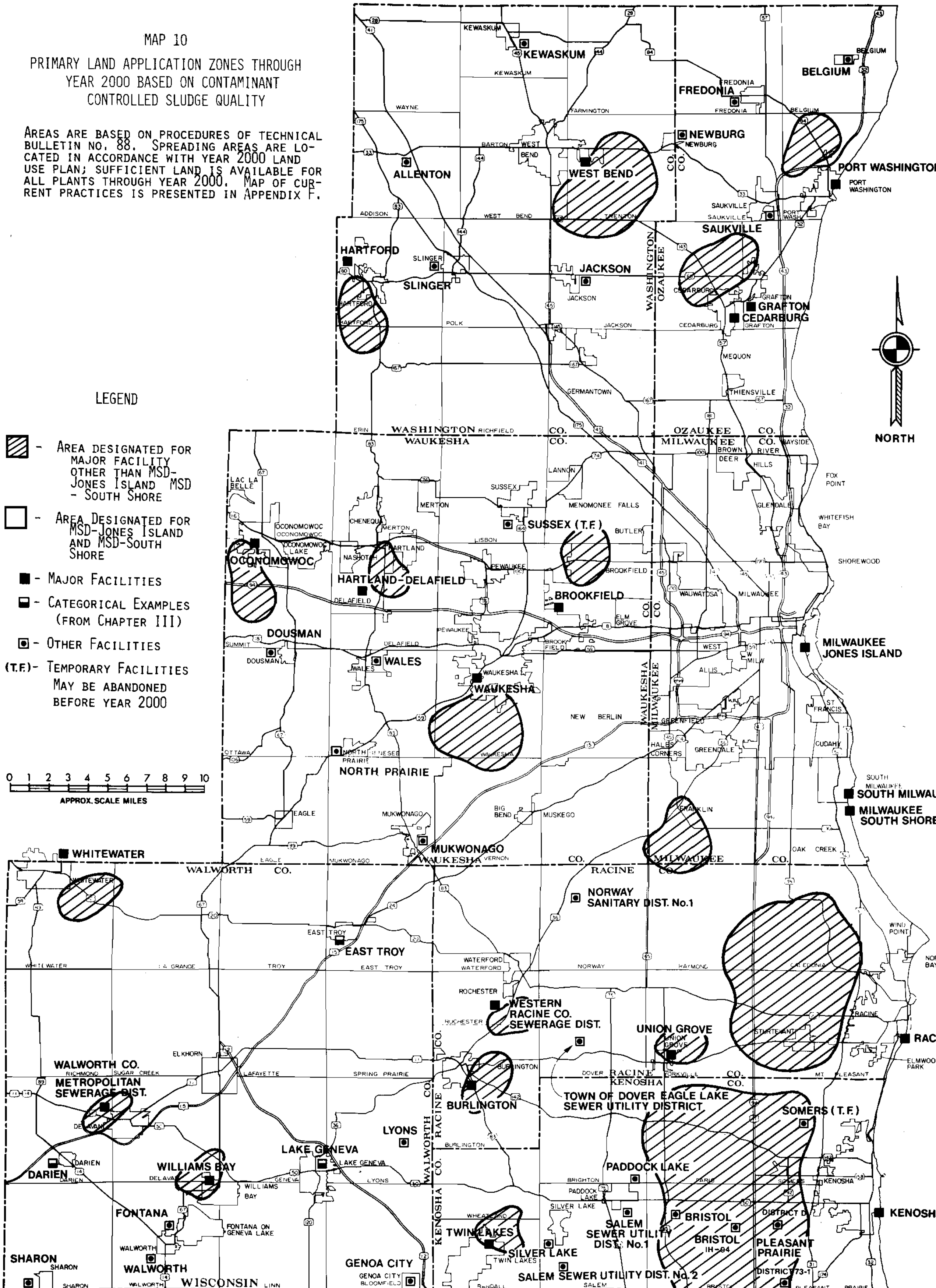


SOURCE: CAMP DRESSER & McKEE, INC. AND SEWRPC

MAP 10

PRIMARY LAND APPLICATION ZONES THROUGH YEAR 2000 BASED ON CONTAMINANT CONTROLLED SLUDGE QUALITY

AREAS ARE BASED ON PROCEDURES OF TECHNICAL BULLETIN NO. 88. SPREADING AREAS ARE LOCATED IN ACCORDANCE WITH YEAR 2000 LAND USE PLAN; SUFFICIENT LAND IS AVAILABLE FOR ALL PLANTS THROUGH YEAR 2000. MAP OF CURRENT PRACTICES IS PRESENTED IN APPENDIX F.



LEGEND

- [hatched box] - AREA DESIGNATED FOR MAJOR FACILITY OTHER THAN MSD-JONES ISLAND MSD - SOUTH SHORE
- [open box] - AREA DESIGNATED FOR MSD-JONES ISLAND AND MSD-SOUTH SHORE
- ■ - MAJOR FACILITIES
- ⊟ - CATEGORICAL EXAMPLES (FROM CHAPTER III)
- ⊡ - OTHER FACILITIES
- (T.F.) - TEMPORARY FACILITIES MAY BE ABANDONED BEFORE YEAR 2000

SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

The maps presented indicate the primary land application zones for two sets of conditions. If a different set of conditions were to exist, then the map would have to be revised to reflect these changes.

SCREENING OF SLUDGE MANAGEMENT SYSTEMS

The potential sludge management systems presented above as Geographic Alternatives 1 through 6 were analyzed in two steps. The system defined as Alternative 1 was analyzed to determine which process options and process train options were most feasible based on costs per ton of raw sludge input. Likewise, the systems defined as Alternatives 2, 3, and 4 were analyzed to determine which process options and process train options were most feasible based on costs per ton of raw sludge input. This process train option screening was then combined with a present worth analysis of the apparent more feasible process train options for Alternatives 1 through 6. The present worth methodology utilized is described in Chapter VIII. The first step involved preliminary process train comparisons and the selection of a feasible process for the large plants, and the second step involved a present worth analysis. For the MSD-Jones Island and MSD-South Shore treatment plants, potentially feasible process options were analyzed by a present worth analysis. Screening and selection is continuing as part of the Districts' Total Solids Management facilities planning program.

The capacities of all existing sludge handling equipment and all sludge handling equipment proposed by others for the 21 major plants was determined from the available data on design criteria and operating characteristics. Projected sludge quantities were compared with these capacities, and future needs established with the aid of a general sludge solids mass balance. Future levels of wastewater treatment were based on Planning Report No. 16 and available facilities plans. More stringent effluent requirements for plants discharging to Lake Michigan may soon take effect. The mass balance helped quantify the amount of sludge entering each unit. It was assumed that chemicals would be used for phosphorus removal, and the balance was used to establish the operating conditions which would result in appropriate processing for each unit operation.

Each geographic alternative is made up of a series of process trains, one or more associated with each wastewater treatment plant, which is in turn made up of a series of unit processes.

For each major treatment plant, several possible process trains for supplementing existing capacities were subjected to a screening process which eliminated the most costly and least feasible process trains. Considerations included the existing process equipment, equipment proposed by other consultants, the ability of existing equipment to successfully meet the needs of the community or sewerage district, the age of the units, and the restrictions imposed by the site and surrounding land uses. For example, the least costly expansion of sludge dewatering capacity appears to be lagoons; however, lagoons were considered to be inappropriate where residential areas would be near treatment plant sites. In these cases, an alternate, feasible, low cost process was chosen. Incineration is generally more costly than land application. In addition, incinerators would be difficult to operate at other treatment plants and were considered only for MSD-Jones Island, MSD-South Shore, Racine, Kenosha and continuation at Brookfield. This is supported by the previous State-of-the-Art studies.

Capital, operation, and maintenance costs for the process trains and alternate processes were prepared using cost curves based on information available in the State-of-the-Art study for unit processes discussed in Chapter VIII.

Costs of process trains were compared for each individual plant size and the most economical process trains were selected. For each process train selected, capital and operation and maintenance costs and present worth values were calculated as described in Chapter VIII. Further process discussion and costs are appended to this chapter.

Cost curves are presented in more detail in appendices G and H. All costs presented below are on the basis of dry weight of raw sludge solids.

Geographic Alternative 1 and 1A

Process trains evaluated for each large plant, including MSD-Jones Island and MSD-South Shore, and associated relative costs are discussed below (digestion costs are also included).

The acres required for landspreading, and the location and acres available for landspreading, are shown in Table 65.

Sludge handling costs include sludge processing, transportation to spreading or landfill sites, and spreading costs. The spreading costs were calculated in two different ways to facilitate comparison of final disposal management alternatives. Under Alternative 1, it was assumed that the farmer would be spreading the sludge, and spreading costs include only the cost of on-site storage. Under Alternative 1A, it was assumed that spreading would be done by treatment plant personnel; storage costs at the treatment plant were included where necessary. The plant processing capital cost does not change under these two designations; sludge processing remains unchanged. Potential process options for Jones Island and South Shore plants were evaluated solely by present worth analyses.

TABLE 65

COMPARISON OF ACRES AVAILABLE TO ACRES REQUIRED FOR LANDSPREADING

Plant	Towns	Total Suitable Acres Potentially Available[1]	Total Acres Required[2]
Jones Island and/or South Shore	East Troy	4,815	16,946 to 62,050
	Lafayette	4,569	—
	Spring Prairie	4,874	7,316 to 29,055
	Troy	8,058	—
	Mukwonago	5,839	—
	Vernon	5,399	—
Total		33,554	7,316 to 73,637
Racine	Caledonia (W)	—	—
	Caledonia (E)	—	—
	Mt. Pleasant (W)	—	—
	Raymond	—	—
	Yorkville	—	—
Total		23,559[3]	4,220
Kenosha	Bristol	—	—
	Paris	—	—
	Pleasant Prairie	—	—
	Somers (W)	—	—
Total		18,616[3]	9,097

Grafton and Cedarburg	Cedarburg	5,327[3]	861
Hartford	Hartford	5,161[3]	265
Twin Lakes	Randall	3,541[3]	129
Williams Bay	Geneva	1,984	28
Western Racine Co. MSD	Rochester	4,539[3]	64
Hartland/Delafield	Delafield	5,318[3]	151
Union Grove	Dover	4,372[3]	63
Waukesha	Pewaukee	4,168[3]	3,463
West Bend	Farmington	5,389	—
	Trenton	5,377	—
Total		10,766	6,522
South Milwaukee	Franklin	5,465[3]	441
Whitewater	Whitewater	3,019	1,260
Oconomowoc	Oconomowoc	4,771[3]	1,382
Burlington	Burlington	2,842[3]	Data not available
Walworth Co. MSD	Darien	12,179	—
	Delavan	7,228	—
Total		19,407	237
Brookfield	Brookfield	1,618[3]	198
Port Washington	Saukville	5,169[3]	Data not available

[1]*Does not include severely limited soils, man-made land or land classified as urban.*

[2]*See Appendix F.*

[3]*Assumes only a portion of the suitable land for sludge application. Based upon an average percentage, of the land being in fields large enough and sufficiently remote to provide buffer zones, taken from a detailed analysis of specific townships and the land inventoried by SEWRPC as having either slight or moderate limitations for sludge application.*

Source: SEWRPC and Camp Dresser & McKee Inc.

MSD-Jones Island Assumptions for Screening of Options—Assumptions made for the cost estimates for the MSD-Jones Island plant alternatives are 1) continuation of a 3 shift/day, 7 day/week operation for sludge handling processes; 2) 1.77 percent solids (1975 average) feed to the vacuum filters from the sludge thickening tanks; 3) heat recovery from all pyrolysis units and gas recovery from all potential anaerobic digestion units; 4) average revenue from the Milorganite operation at $61 per ton of dry solids; 5) availability of landfilling and landspreading sites within a 50-mile haul distance from the Jones Island plant.

Current loading of the vacuum filtration units of 1.4 lb/hr/sf and an allowance of 10 of the existing 24 vacuum filters for standby and backup units were used as a basis for calculating sludge dewatering capacity of the Jones Island system. Aerobic digestion was considered and ruled out due to high costs. Space allowance for vacuum filtration is approximately 625 sq ft, and a total of 18 units could be housed in the machinery shop of the filter building. Specifications for the three existing sludge dryers in the dryer building extension required an evaporating capacity of 8,000 lbs of water per hour per dryer. This specification was used to more accurately determine the number of additional, similar dryer units needed to dry the excess sludge quantities. Allowances of one dryer for every five existing or new dryer units was made to serve as a backup for breakdown or maintenance shutdown of operating dryer units. In order to determine building construction costs for additional dryer units, a space requirement of approximately 3,000 sq ft was used per dryer unit (including conveyors, crawl space, and air pollution and dust separating equipment).

A solids mass balance was calculated for each process train considered for the Jones Island treatment plant. A mass balance is a simple accounting of the amount of dry sludge solids into and out of each unit process in the process train. This mass balance accounts for such occurrences as increased sludge quantities resulting from chemical conditioning, solids returned to the plant in sidestream withdrawal from vacuum filtration units as well as anaerobic digesters, and residue production in pyrolysis units. The balance serves to size the unit process components.

Excess sludge quantities delivered to the MSD treatment plants, as a result of the combined sewer overflow study recommendations, are not included in these comparative cost estimates.

The capital cost of the entire combined sewer overflow abatement procedures is estimated to be about $350 million. Costs will also increase if it becomes necessary to meet an effluent criteria of 5 mg/l for both BOD_5 and suspended solids.

Process Options (MSD-Jones Island)—There are three groups of proposed sludge dewatering and final utilization/disposal options for the Jones Island treatment plant. In the interim, Milorganite production will continue at Jones Island. The three groups according to the methods of final sludge use are: 1) increased Milorganite production, 2) phase out of Milorganite production with increased landspreading or landfilling of dewatered sludge or ash, and 3) a combination of continued Milorganite production and excess sludge dewatered for separate utilization/disposal.

The low to high range production Milorganite process trains (1-1, 1-2, and 1-3, as referenced in Table 66) involve a refurbishing of the Milorganite process and expanded dewatering capacity through the use of additional vacuum filters, centrifuges or filter presses, and dryers. The low and high range sludge loads for each of the MSD plants refer to the possible load shift between plants by the shift of the diversion area wastewater flows. The objective of these alternatives is to dewater and dry increased sludge quantities generated by higher plant flows and increased plant solids capture, while maintaining a full capacity production Milorganite operation.

The Milorganite process is essentially being replaced over time under the operation and maintenance program. Should the cost of energy continue to rise at a rate higher than general inflation, the ordering of relative costs of the process trains may shift dramatically.

Process trains 1-5, 1-6, and 1-7 involve dewatering and/or digestion of all waste-activated sludge from the Jones Island plant with final disposal by means of incineration/pyrolysis (including energy recovery) with ash landfill or by means of landspreading or landfilling. The basis of these alternatives is the assumption that Milorganite production would be gradually phased out and finally abandoned.

This option represents replacement of the existing program with a less energy-intensive process. This may be the favored approach should energy costs continue to rise as expected.

The remaining process trains 1-4, 1-8, and 1-9 deal with a combination of continued Milorganite production based on the capabilities of the existing plant with excess sludge handled separately. This separate treatment of excess sludge consists of either 1) dewatering

TABLE 66
MSD-JONES ISLAND PROCESS TRAINS CONSIDERED

Wastewater Treatment Facility	Wastewater Treatment Processes		Sludge Processing Options										Transport Options				Utilization/Disposal Options								Remarks
Jones Island Plant	Exist	Proposed	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Chemical Conditioning	Vacuum Filter	Filter Press	Lagoon	Sand Beds	Sludge Dryers	Truck	Rail	Barge	Pipeline	Incineration / Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	"Milorganite" Organic Fertilizer	Other	
Option 1-1	AS		Pe				Pe	Pe,P				Pe,P	E	Pe									Pe		Full Milorganite Production Maintained
1-2	AS		Pe				Pe	Pe	P			Pe	E	Pe									Pe		
1-3	AS		Pe				Pe	E	P			Pe	E	Pe									Pe		
1-4	AS		Pe				Pe	Pe	P			Pe	E,P	Pe			P	P					Pe		Partial Milorganite Production
1-5	AS		Pe				Pe	E				E	E,P	E			P	P					E		Abandon all Milorganite Production
1-6	AS		Pe			P	Pe	P,E				E	E,P	E				P	P				E		
1-7	AS		Pe			P	Pe	E	P			E	E,P	E				P	P				E		
1-8	AS		Pe			P	Pe	Pe,P				Pe	E,P	Pe				P	P				Pe		Partial Milorganite Production
1-9	AS		Pe			P	Pe	Pe	P			Pe	E,P	Pe				P	P				Pe		
																				P	P				

Notes

E = Existing
P = Considered by CDM
Pe = Considered by CDM to use Existing Process
AS = Activated Sludge

1. Does not include consideration of:
   a. Refurbish or replacement of wastewater treatment plant units.
   b. Higher levels of thickening prior to vacuum filtration.

Source: Camp Dresser & McKee Inc.

the sludge by filter presses followed by incineration/pyrolysis (including energy recovery) with landfill ash disposal or, 2) anaerobic sludge digestion with subsequent dewatering alternatives and landspreading or landfilling of the dewatered cake. These process trains would be desirable for implementing several management options, thus anticipating changing technology and government regulations.

Screening of Process Trains (MSD-Jones Island)—Present worth costs, based on operation and maintenance and capital costs for sludge dewatering and disposal, were calculated for the various alternatives over the planning period. For the low-range projected sludge loading for the year 2000, the present worth costs of dewatering and disposal ranged from $28.0 to $108.8 million for all nine options.

Based on the high projected sludge loading (based on full hydraulic plant capacity) by the year 2000, the range of present worth costs was $35.8 to $176.8 million, which includes all nine process train options. Following this initial screening, it was decided that no single option or series of options should be entirely eliminated. The process train option with the lowest cost per ton included landspreading as final utilization for all sludge generated at the MSD-Jones Island plant. Gas or heat recovery from unit processes such as anaerobic digesters and pyrolysis reduced the sludge handling costs by $3 to $10 per ton of dry solids for sludge quantities projected both from the low and high level projections.

Examination of potential future energy costs and their effect on the MSD-Jones Island plant process train options gave much weight to waste heat/gas recovery as a screening factor. Sludge drying is an energy intensive process compared to digestion and dewatering with landfilling or landspreading or compared to incineration/pyrolysis. Other factors to be reviewed, in more depth in order to screen out some of the options, include 1) refurbish and repair of plant structures to keep the plant operable through the year 2000, 2) levels of backup systems and bypass capabilities where needed for the proposed alternatives, and 3) a higher degree of thickening the waste-activated sludge before dewatering and subsequent cost savings to sludge dewatering. Estimated costs for MSD-Jones Island are shown in Table 67.

MSD-South Shore Assumptions for Screening of Process Trains—Various process trains were considered (shown in Table 68) and have been costed based on the following assumptions:

1. Use of the existing lagoons is not desirable for the long-term solution, because of problems associated with such facilities

2. Alternatives are to use existing land if possible, because of the lack of availability of major land areas and the high land values in the vicinity of the plant

3. Construction would be completed by 1987

4. A 14-mile haul distance, for disposal, based on a theoretical haul to a major landfill in Racine County

5. Addition of gas benefits from the anaerobic digestion process and the equipment to utilize the gas

6. Addition of heat recovery benefits from the pyrolysis process

7. The addition of estimated sludge storage costs of $2.50 per dry ton of solids to the land-spreading costs.

Screening of Process Trains (MSD-South Shore)—Process Train 1-1 considers addition of gravity thickeners to the primary sludge stream prior to the existing digesters and to increase the detention time in these digesters. The digested sludge would be sent to the existing lagoons for thickening to approximately 14 percent solids and then hauled by truck to a land-spreading site. This process train has been given a low rating for the year 2000, because of the sludge holding lagoon.

Process Train 1-2 considers to have gravity thickeners added to the primary sludge stream, but the lagoon is to be eliminated. Because of the larger sludge volumes

TABLE 67

ESTIMATED RANGE OF COSTS FOR
MSD-JONES ISLAND PROCESS TRAIN OPTIONS CONSIDERED

	Low Range Sludge Load	High Range Sludge Load
Capital	$ 5,510,000[4]-$33,690,000	$ 8,670,000[4]-$46,750,000
Operation and Maintenance (Includes all transportation related costs.)	2,170,000 - 3,010,000	3,160,000 - 3,780,000
Present Worth	28,000,000 - 48,700,000	35,800,000 - 65,600,000

Necessary demolition and addition of thickeners estimated to range from 6 to 8 million dollars present worth.

Energy cost inflation may increase high range upper limit to $176,800,000 present worth based on increase in cost of fuel at 13 percent per year. This is due to energy costs rising faster than the general rate of inflation. Final mix of processing options also dependent on available sludge products market. Amounts shown include the revenue from Milorganite sales.

[1]*Demolition costs of existing plant works not included. Relative costs for region-wide comparison. These do not represent a recommendation.*

[2]*Costs of new thickeners or wastewater treatment plant works not included.*

[3]*Based on effluent from wastewater treatment plant of 30 mg/l BOD_5 and 30 mg/l SS.*

[4]*Assumes maintenance of existing drying and dewatering operations.*

Note: Discount Rate at 6%, ENR Construction Cost Index 2445.

Source: Camp Dresser & McKee Inc.

TABLE 68
MSD-SOUTH SHORE PROCESS TRAINS CONSIDERED

Wastewater Treatment Facility South Shore	Wastewater Treatment Processes: Exist	Wastewater Treatment Processes: Proposed	Sludge Processing Options: Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Chemical Conditioning	Vacuum Filter	Filter Press	Lagoon	Sand Beds	Other (Aerated Lagoon)	Transport Options: Truck	Rail	Pipeline	Utilization/Disposal Options: Incineration/Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
Process Train 1-1	AS		PE P			PE P				PE			PE				E	E P					
1-2	AS		PE P			PE P				E			PE				E	E P					
1-3	AS		PE P			PE P				PE			PE				E	P E					
1-4	AS		PE P			PE P				E			PE				E	P E					
1-5	AS		PE			PE P	P	P		E			PE				PE	E					
1-6	AS		PE P			PE P	P	P		E			PE				PE	E					
1-7	AS		PE			E	P	P		E			PE				PE	E					
1-8	AS		PE P			E	P	P		E			PE				PE	E					
1-9	AS		PE			PE P	P		P	E			PE			P	PE	E					
1-10	AS		PE			PE P	P		P	E			PE				PE	E					
1-11	AS		PE P			PE P	P		P	E			PE			P	PE	E					
1-12	AS		PE P			PE P	P		P	E			PE				PE	E					
1-13	AS		PE			E	P		P	E			PE			P	PE	E					
1-14	AS		PE			E	P		P	E			PE				PE	E					
																			P	P			

NOTES:

E = Existing P = Considered by CDM
C = Chemical Addition AS = Activated Sludge

Source: Camp Dresser & McKee Inc.

to be hauled and spread, the cost of this solution is high, when compared to 1-1.

Process Train 1-3 considers gravity thickeners after the existing digesters to thicken the sludge to 9 percent solids and reduce the volume to the lagoon; sludge would be hauled by truck and landspread. This process train has been given a low rating for the year 2000, because of the sludge holding lagoon.

Process Train 1-4 is considered as having gravity thickeners after the existing digesters with the lagoon eliminated. Changes in sludge quantities between the thickener and the lagoon are not as severe as in 1-2; therefore, sludge handling costs have not increased significantly.

Process Train 1-5 considers vacuum filters after digestion. The dewatered sludge would be hauled by truck and landfilled. Additional digesters would be added for the final solution.

Process Train 1-6 considers gravity thickeners on the primary sludge stream to the digesters and vacuum filters after digestion. The dewatered sludge would be hauled in a truck and landfilled. Additional digesters would be added for a final solution.

Process Train 1-7 considers vacuum filters on undigested sludge. The dewatered raw sludge would be hauled in a truck and landfilled. Due to the larger sludge volumes to be hauled and landfilled, the cost for this solution is high compared to 1-5 and 1-6.

Process Train 1-8 considers gravity thickeners on the primary sludge stream and vacuum filters on undigested sludge. The dewatered raw sludge would be hauled by truck and landfilled. Due to the larger sludge volumes to be hauled and landfilled, the cost is high when compared to 1-5 and 1-6.

Process Train 1-9 considers filter presses and incineration/pyrolysis after digestion. The ash would be hauled by truck and landfilled. The incineration/pyrolysis unit may have a relatively long construction time.

Process Train 1-10 considers filter presses after digestion without incineration/pyrolysis. Sludge would be landfilled.

Process Train 1-11 considers gravity thickeners on the primary sludge stream prior to the digesters. The digested sludge would be sent to filter presses and an incineration/pyrolysis unit. The final product is to be hauled by truck and landfilled. The incineration/pyrolysis unit process may have a relatively long construction time.

Process Train 1-12 considers gravity thickeners on the primary sludge stream flowing to the digesters. The digested sludge would be sent to filter presses and landspread.

Process Train 1-13 considers filter presses and an incineration/pyrolysis unit for undigested sludge. The ash is to be hauled by truck and landfilled. The pyrolysis unit may have a relatively long construction time.

Process Train 1-14 considers filter presses for undigested sludge. Due to the larger sludge volumes to be hauled and landfilled, the cost is increased over 1-10.

Processing the sludge from the South Milwaukee treatment plant with the sludge from the MSD-South Shore treatment plant, which appears to be economical, will not have a significant effect on costs of MSD-South Shore. Additional unlisted process or transportation options might still be considered for both the interim and the long-term solution (i.e., sludge drying, composting, barge, pipeline). The long-term combination of processes at MSD-Jones Island and MSD-South Shore also depend on the results of marketing studies regarding organic fertilizer and compost.

A pilot composting operation has been proposed to be undertaken at MSD-South Shore to investigate the feasibility of this unit operation for sludge processing and utilization. If markets are available, this option could supplement the existing sludge facilities.

Table 69 lists the sludge handling costs for the long-range solution. Present worths for the various process train options range from approximately $4,900,000 to approximately $28,700,000 for the long-range solution. These costs were determined from cost functions developed by Camp Dresser & McKee Inc. Alternatives 3 and 6 consider combinations of Jones Island and

TABLE 69

ESTIMATED RANGE OF COSTS FOR
MSD-SOUTH SHORE PROCESS TRAIN OPTIONS CONSIDERED
(Long Term Solution Costs Only)

	Low Range	High Range
Capital	$2,100,000[4]-$11,700,000	$3,780,000[4]-$21,060,000
Operation and Maintenance (Includes all transportation related costs.)	300,000 - 930,000	546,000 - 1,670,000
Present Worth	4,900,000 - 16,000,000	8,900,000 - 28,700,000

Note: Discount Rate at 6%, Engineering News Record Construction Cost Index at 2445.
[1]*Relative costs for region wide comparison. These do not represent a recommendation.*
[2]*Based on effluent BOD_5/SS at 30 mg/l/30 mg/l.*
[3]*Final mix of processing options dependent on available sludge products market.*
[4]*Assumes continued use of existing thickeners, digesters, and lagoons.*

Source: Camp Dresser & McKee Inc.

South Shore which are discussed further below.

For MSD-Jones Island and MSD-South Shore, consideration was given to sludge transport between the two sites and to transport to remote land application sites (see Table 70). It is considered in this analysis that sludge with 5 percent solids content is suitable for pipeline or barge transport and 20 percent sludge is suitable for truck transport.

For comparison of haul (about 15 miles) between plants, a value of 82 tons/day was selected, this being the difference in the high and low ranges at the plants by year 2000. Truck haul of 5 percent solids was estimated to be about $540,000/year, pipeline at about $300,000/year at 5 percent solids, and barge haul at about $190,000/year at 5 percent solids. Truck haul of 20 percent solids was about $190,000/year. Therefore, it would appear that if it becomes desirable to transport sludge, truck and barging are the favored approaches; they are also the more flexible modes.

For comparison of in-region versus out-of-region transport of sludge, sites in Sheboygan (about 87 miles) and Columbia (about 85 miles) counties (agricultural areas) were compared to sites in Walworth County (about 40 miles). A round figure of 200 tons/day was selected for comparative purposes, this being the low range value used in comparison of Jones Island process train options. The total cost of pipeline or truck transport to a central point located in Walworth County would cost about $1,600,000/year and $1,000,000/year, respectively. The truck sludge cake would be 20 percent solids and the pipeline sludge at 5 percent solids. Trucking at 5 percent solids is $4,400,000/year. Transport into Columbia County would be about $3,600,000/year by pipeline and $1,800,000/year by truck or an increase of $2,000,000/year to $800,000/year over haul to Walworth County. Barging and trucking to Sheboygan County is estimated at $2,000,000/year, while pipeline to this location is estimated at $3,600,000/year or an increase of $1,000,000 to $2,600,000/year over transport to Walworth County. Overall, the increased lower costs for the extra haul is $800,000 to $1,000,000/year. From 1980 to 2000, this represents a present worth (1976 dollars) of $7,200,000 to $9,100,000.

Transport at an even greater distance, by pipeline, to central Adams County (about 125 miles) would result in an annual cost of $6,200,000/year, or an increase of $5,200,000/year over transport to Walworth County. From 1980 to 2000, this represents a present worth (1976 dollars) of $47,300,000.

It thus appears that truck transport of cake sludge is

TABLE 70

ESTIMATED TOTAL ANNUAL TRANSPORTATION COSTS

	Pipeline	Truck	Barge
Between Jones Island and South Shore	$ 300,000	$ 190,000	$190,000
To Walworth Co.	$1,600,000	$1,000,000	—
To Sheboygan Co.	$3,600,000	$2,000,000[1]	
To Columbia Co.	$3,600,000	$1,800,000	—
To Adams Co.	$6,200,000	—	—

[1]*Includes cost of barging with trucking from transfer point to application site.*

Note: Discount Rate at 6%, ENR at 2445.

Source: Camp Dresser & McKee Inc.

favored on a general cost basis over pipeline transport of liquid sludge. This is mainly due to the high initial capital cost of pipeline construction with the associated works. The main non-cost advantage of trucking is its flexibility. (See also Appendices H and K.)

For MSD-Jones Island, it was decided to retain all nine process train options for further consideration, with a preference expressed toward parallel or dual-process trains inclusive of digestion-dewatering-land-spreading-landfilling and Milorganite production. For MSD-South Shore, those alternatives retained for further consideration include digestion-dewatering-land-spreading-landfilling, composting, and dewatering with incineration/pyrolysis. Lagoons, land application of liquid sludge (<5 percent solids), and landfilling of raw sludge were ruled out. This leaves about five process train options for MSD-South Shore.

For the following reasons it was not possible to select a final mix of process trains for MSD-Jones Island and MSD-South Shore at this time:

1. Final decisions, requiring a detailed facilities planning analysis, are necessary to determine the future usefulness of major existing equipment items.

2. The wastewater stream characteristics are unique due to the high industrial load, which dominates; therefore, extensive pilot testing of

new facilities is necessary before selection can be made.

3. Experience shows the differences between costs of different large-scale sludge management process trains are not as great as the cost differences between process train options for small scale operations; therefore, more detailed studies of unit processes and process trains are necessary.

4. Analysis of compost production and marketing require detailed data to be made available through the facilities planning process.

5. The rate of sludge production in the MSD-system is more variable than in other large systems due to the high industrial proportion of the flow.

6. Parallel studies involving user charges/industrial cost recovery, infiltration/inflow, and combined sewer overflow abatement when complete, will provide important relevant information.

Based on preliminary information presented in the "Combined Sewer Overflow Pollution Abatement"[1] report, solids handling for combined sewer overflows was based on a load of 120 tons/day dry solids. Based on incineration and landfilling of dewatered solids received from the treatment facilities, the estimated capital cost of facilities to treat these CSO treatment plant sludges solids is $12,000,000 to $22,000,000.

In a suit brought under the Federal common law nuisance, Illinois alleged that Milwaukee wastewaters contaminated the potable water supply used by Illinois residents. Federal Judge John S. Grady, in his ruling on the case, has ordered Milwaukee to build "a hydraulically adequate collection system" and to meet a level of treatment such that the effluent contains no more than 5 mg/l BOD and 5 mg/l suspended solids. Increased sludge loads are not expected to affect the list of process train options recommended.

Racine—The expansion program currently nearing completion at Racine's wastewater treatment plant was designed for expected sludge quantities in the year 1980. Consequently, the existing plus new digester capacity would require expansion to meet year 2000 requirements. Sludge thickening facilities which can aid digester operation have not been planned at this time. Existing vacuum filters will have adequate future capacity to year 2000, if operation is extended to 50 hours per week. Ultimate disposal sites include a landfill at an approximate 5-mile haul distance and suitable farm spreading sites at less than 25 miles.

The following process train options for meeting projected year 2000 conditions were investigated.

Option 1 considers that the digester capacity is increased to meet year 2000 requirements. The digested sludge would be dewatered by vacuum fillers and transported to either a landfill (1B) or landspreading sites (1A). The costs of this option with landfilling is estimated to be about $89/ton of raw sludge processed; landspreading is about $74/ton.

The need for expansion of digesters, as calculated from differences between existing capacities, new capacities, and year 2000 requirements, should be reevaluated at the 201 facilities planning level, after the operating data and characteristics of the new equipment become available. The current method of hauling processed sludge cake by truck should be continued.

Option 2 assumes that the digester capacity would not be expanded, but excess raw sludge would be blended with the digester sludge, dewatered on vacuum filters, and reduced by pyrolysis. Ash would be transported to a landfill. The cost of this option is about $110/ton which is substantially higher than Option 1. Furthermore, the pyrolysis of vacuum filter cake would require supplementary fuel which is not included in the above costs. The amount of fuel needed would vary with the proportions of raw and digested sludge and the fuel value of the sludge. It is estimated to add about $10/ton to the cost of processing.

The most feasible approach would be to use the existing and newly constructed facilities with expansion (as required) of the digesters, and with ultimate utilization by landspreading (1A). Disposal by landfilling would be the next most feasible method, in case of adverse conditions for landspreading. Thickening primary sludge by gravity and waste-activated sludge with dissolved air flotation is possible to improve the operating characteristics of digesters and expand their capacity.

Ultimate utilization by either option, spreading by the treatment plant or by the farmer, is acceptable. Lower costs do appear to be associated with storage sites at the farms combined with the farmer doing his own spreading. However, the actual methods must be nego-

[1]*Stevens, Thompson & Runyan, Inc., "Phase Two—Interim Report—Combined Sewer Overflow Pollution Abatement," for Metropolitan Sewerage District of the County of Milwaukee.*

tiated between the treatment plant and individual farmers. As a backup to spreading, the existing landfilling agreement would be continued.

Kenosha—This plant provides anaerobic digestion and dewatering by filter presses for present day requirements. Based on a 20-day detention time, "primary" digesters have a capacity of 26,400 lb/day; existing filter presses have a capacity of 24,200 lb/day. The nearest landfilling is approximately 8 miles away, and there are suitable landspreading sites at less than 10 miles distance. General cost curves indicate lagooning as the least expensive dewatering method prior to landspreading. However, lagooning has been investigated by others[1] and found to be not acceptable, due to the location of the plant, and is therefore not considered here. The following process options were investigated.

Option 1 assumes that both digesters and filter presses are expanded for year 2000 requirements. Ultimate disposal would be by landspreading. The cost of this option is about $82/ton of raw sludge processed.

Option 2 is the same as Option 1 except vacuum filters would be installed for expansion of dewatering capacity. The cost of this option is about $84/ton and, therefore, does not give a cost saving compared to Option 1. No other major differences between these options are evident. The increased cost of hauling, due to the larger volume of wetter cake, is accounted for.

Option 3 again utilizes additional digester capacity; however, the dewatering capacity would not be expanded and the excess liquid sludge would be trucked to a landspreading site. The cost of this option is about $82/ton.

Option 4 assumes that the existing digester capacity would not be increased. The mixture of digested sludge and excess raw sludge would be dewatered with expanded filter press equipment. This would be followed by pyrolysis and ash disposal to landfill. The cost of this option is about $142/ton, which is well above the other options. The fuel cost would be about $10/ton.

The cost of Option 1 is the same as Option 3; however, it does have the advantage of producing a well dewatered cake which could be diverted to a landfill site more economically than liquid sludge.

[1]*Communication with City of Kenosha, 11/76.*

The above analysis shows that the least cost would be incurred through expansion of the existing equipment with additional new units (Option 1).

The existing dissolved-air flotation thickener should be retained to treat waste-activated sludge; additional thickener capacity, probably in the form of a gravity thickener, should be considered for primary sludge. Additional anaerobic digestion capacity should be provided with new units, and additional filter press needs met by installing a third press in the space provided in the existing building. Hauling filter cake by truck should be continued as should ultimate utilization by landspreading. The least costly method is to provide storage facilities at the farm site and allow the farmer to apply the sludge when needed. However, the actual method used will have to be agreed upon by both the farmer and the City. As a backup alternative, sludge can be trucked to a landfill site.

Waukesha—Sludge volumes projected for the year 2000 indicated that expansion of the existing facilities will be required in the near future. A facilities plan, prepared by the City's consultant, presents two alternatives or options for meeting anticipated conditions in the year 1990.

If sludge thickeners are used, the expansion of the anaerobic digester capacity proposed by the City's consultant should be sufficient through the year 2000. The proposed lagoon capacity, sufficient for the 1990 sludge flow, might need to be slightly expanded to meet the needs in the year 2000. Because of differences in the design years (1990 in the facilities plan vs. 2000 in this study) and variations in the selected operating parameters, projected capacities required to handle future conditions differ slightly.

Currently, dewatered lagooned sludge (about 30 percent solids) is given away as a soil conditioner to the public, the Department of Public Works, and the Park Board; the current demand is greater than supply. This operation shifts the costs of ultimate disposal to the users. If there should, for some reason, be no future demand for the dried sludge, the general cost curves indicate that lagooning and landspreading would be the most feasible option, even at hauling distances up to 25 miles. Suitable landspreading sites are available at a distance of less than 10 miles. At a 10-mile hauling distance, the cost of digestion, lagooning, drying, and landspreading would be about $76/dry ton of raw sludge handled.

Thickeners installed prior to digestion should improve the efficiency of the digesters; gravity thickeners would appear to be most effective for primary sludge, while dissolved-air flotation would be most effective for waste-activated sludge.

One method would be that the current system of public pickup of dried sludge be continued. However, this method could be supplemented by truck hauling to farm spreading sites where areas could be developed for storage, prior to spreading by the farmer. This alternate method assures that sludge cake will not build up at the treatment plant storage facilities. In adverse weather, a backup alternative to landspreading is landfilling of the dewatered lagooned cake. Public pickup is a desirable utilization option and should be encouraged at all sites.

West Bend—The City's consultant has prepared a facilities plan recommending expansion of both the wastewater treatment and sludge handling portions of the existing facility, if it is to adequately treat the projected volumes through the year 2000.

Proposed addition of gravity thickeners, anaerobic digesters, and vacuum filters will meet year 2000 requirements (14.25 tpd raw sludge). The capacity of the existing lagoons is well below present day requirements. Currently, the major method of ultimate utilization is landspreading of liquid sludge to farms at about 15 miles distance. However, based on 1975 data, the sludge appears to contain high concentrations of heavy metals; and therefore, land application would not be permitted without contaminant control. Capacity of the existing nearby landfill is almost exhausted; distance to other landfills is at least 20 miles. The following dewatering/disposal options were considered.

Option 1 assumes that the concentrations of heavy metals would be reduced to acceptable levels through source control. Anaerobic digesters and lagoons would be utilized to meet year 2000 requirements. Ultimate disposal would be by landspreading at a hauling distance of about 25 miles. Year 2000 costs for this option would be about $96/dry ton of raw sludge.

Option 2A is the same as Option 1, except vacuum filters would be utilized for dewatering. The cost would be about $112/ton of raw sludge.

Option 2B assumes that heavy metals would be received by the plant; therefore, only landfilling would be acceptable. Vacuum filtration would be utilized for dewatering, following anaerobic digestion; a hauling distance of about 25 miles to landfill is assumed. The cost would be about $133/ton of raw sludge.

Option 3A is the same as Option 1, except for the use of filter presses for dewatering. The cost of this option would be about $121/ton of raw sludge, filter presses generally being more expensive than vacuum filters.

Option 3B is the same as Option 2B, except filter presses would be utilized for dewatering. The cost of this option would be about $130/ton of raw sludge.

Because the treatment plant site is adjacent to a housing development, Option 1, utilizing dewatering lagoons, is ruled out. The existing lagoons are located at the far end of the present site away from houses; however, due to their small size and the fact that expansion would require land nearer the housing, abandonment is suggested.

Without contaminant control of heavy metals discharged by industry, Option 3B (filter presses) is about the same as Option 2B (vacuum filters). With source control, Option 2A (vacuum filters) is significantly more economical than Option 3A (filter presses). Therefore, use of vacuum filters is the most feasible and flexible option because it would offer cost savings should source control be implemented.

Ultimate disposal of the dewatered sludge by landfilling is recommended by the City's consultant because of the high cadmium content of the sludge. This recommendation is supported as is the recommendation that a program for control of cadmium be instituted at the industries whose effluent is high in heavy metals. Prior to source control, the lower cost landspreading option should only be used as a backup alternative to landfilling and, in addition, a strict monitoring and site management program may be necessary. With contaminant control, landspreading of filter cake by farmers from on-site storage areas would be the least costly disposal alternative assuming that an agreement between the farmers and the City can be negotiated.

In both the landfilling and landspreading options, hauling dewatered sludge by truck from the plant site is feasible.

South Milwaukee—The projected raw sludge volumes of 2.45/dry tons per day (tpd) are essentially the same in the year 2000 as they are today.

Existing digester capacity is well above the requirements if sludge thickening is utilized. Currently, polymers are being added to the digesters; good solid-liquid separation is being achieved and all solids can be handled in the wet air oxidation unit. The City Manager is pleased with this process change and feels that it is working well; landspreading of liquid sludge is no longer required. However, the wet air oxidation unit is old, and according to the consultant's report, the unit is difficult to operate, and has about 25 percent downtime. With 25 percent downtime, it can handle about 2.1 tpd, which is sufficient to process the estimated digested sludge quantity of 1.9 tpd. Conditioned sludge from this unit is currently settled in a storage lagoon. The existing sand beds can handle only about 350 lb/day of sludge.

The following process train options were investigated.

Option 1 assumes that sludge would be digested, and wet-oxidized, and that liquid ash from the lagoon, with about 5 percent solids, would be trucked 10 miles to a land-application site. The existing sand beds would be utilized to their capacity, and dried sludge would be picked-up by the public. The cost of this option is about $176/dry ton of raw sludge, and does not include capital cost of the wet-oxidation unit and the existing storage lagoon. Also, the sand bed drying costs are excluded from this and following options, because it is common to all and would not affect comparisons. The cost of rehabilitation of the old unit would add at least $20/dry ton to the above cost.

Option 2 assumes that the wet-oxidation unit would be abandoned. Digested sludge would be dewatered in new lagoons and dried on existing sand beds. Dried sludge would be trucked to landspreading sites about 10 miles away. The cost of this option would be about $144/dry ton of raw sludge.

Option 3 is the same as Option 2, except no new dewatering facilities would be provided and liquid digested sludge would be trucked to land-spreading sites. The cost of this option would be about $152/dry ton of raw sludge.

Option 4 is the same as Option 2, except vacuum filters would be used for dewatering. The cost of this option would be about $162/dry ton of raw sludge. This analysis indicates there is no benefit to continuation of the operation of the wet air oxidation unit and eventually this unit may be abandoned.

Analysis indicates that utilizing lagoons followed by landspreading (Option 2) is the least costly option. The next least costly option is the use of vacuum filters, which is environmentally more acceptable and provides a cake suitable for landfilling, and which is more desirable for filling than a liquid sludge. Due to the proximity of residential areas to the treatment plant, expansion of the present lagoons does not appear to be a feasible dewatering option.

The City's consultant recommended chemical conditioning followed by belt filter presses for dewatering. A pilot study was conducted at the South Milwaukee plant, and results indicate that belt presses could be successfully operated at this plant. Construction costs for these units are similar to those for vacuum filters, but their operating costs might be slightly lower. Therefore, belt filter presses would be suitable for South Milwaukee instead of vacuum filters under option 4.

The existing sand beds might be retained, as they currently serve as a source of dried sludge for use by local residents. This is a practice that might be continued. However, expansion was not considered as sand bed costs are higher than some other options as shown in Appendix G.

Ultimate utilization of filter cake by landspreading appears best for South Milwaukee. Where possible, it is believed that spreading should be done by the farmer according to his needs. This would help to prevent conflicts between the timing of the treatment plant's need to spread sludge and the timing of crop growth cycles. Hauling sludge by truck can give the greatest flexibility in ultimate disposal methods and is recommended. As a backup to landspreading, a suitable landfill site should be available.

It might also be possible for South Milwaukee to digest its sludge onsite followed by hauling to the South Shore plant for further processing. The cost of this option is estimated to be $105/dry ton.

The operating characteristics of the existing digesters might be improved by thickening the sludge prior to digestion.

Whitewater—Projected sludge volumes for the year 2000 show significant increases above the present level and require additional capacity at the current treatment plant. A facilities plan completed by the City's consultant proposed that the existing plant be abandoned and a new facility be built at a new site to meet future requirements. This plan has been accepted and the plant is now in the design stage. Sludge hauling will consist of thickeners, anaerobic digesters, chemical conditioning, and belt filter presses followed by landfilling. The analysis developed in this study supports the recommendation of thickening primary and secondary sludge in a gravity thickener prior to anaerobic digestion. Since the consultant chose a belt filter press on the basis of a satisfactory pilot program at the existing plant, that recommendation was followed in this study. On the basis of those tests, the belt press at this plant appeared to be slightly less costly to operate than vacuum filters.

The proposed digester and belt filter press will meet estimated requirements beyond year 2000. Suitable landspreading and landfilling sites appear to be available at distances less than 5 miles.

Based on operation of the proposed digestion/dewatering equipment, Option 1A with landspreading would cost about $138/dry ton of raw sludge and Option 1B with landfilling would cost about $159/ton of raw sludge.

The current system of hauling sludge cake by truck appears to give the most flexibility and should be continued. Landspreading appears to be the lowest cost option for this plant and is favored. Landfilling, as proposed by the consultant, is also a viable alternative particularly as backup for landspreading.

Oconomowoc—The City of Oconomowoc is currently building a new wastewater treatment plant which will be capable of treating the projected sludge quantities in the year 2000. The sludge processing units recommended by the City's consultant and supported by the findings of this analysis are thickening, anaerobic digestion, chemical conditioning, and vacuum filtration.

Landspreading sites are at distances of less than 5 miles; a landfill site is at a distance of less than 10 miles. Landspreading of liquid digested sludge and landfilling of filter cake have been proposed for future operation. With the estimated digested sludge quantities of 0.9 tpd in 1975 and 3.6 tpd in year 2000, the general cost curves indicate that landspreading of vacuum filter cake, rather than digested 5 percent sludge, would be more economical once the vacuum filters are installed. (See cost curve for vacuum filtration option not including vacuum filter capital cost.) Option 1A with landspreading of filter cake would cost about $134/dry ton of raw sludge; Option 1B with landfilling would cost about $156/ton of raw sludge.

Truck transportation of dewatered sludge appears to offer the most flexibility, and the consultant's recommendation is supported. Because of the apparent availability of good land (with few limitations for spreading) in the vicinity of the treatment plant, landspreading is a viable alternative for ultimate utilization.

The least costly method of landspreading might result through provision of storage facilities at accepting farms followed by farmer spreading. However, the actual method used will be dependent on the willingness of the farmer and needs of the treatment plant. Landfilling would serve as a backup process during times when landspreading cannot be practiced.

Burlington—Existing aerobic and anaerobic digesters in the three plants are sufficient for year 2000 requirements. The existing dewatering facilities consist of sand beds and a basket centrifuge which are estimated to have capacity to handle 1981 flows and loads. Suitable landspreading sites are at distances of less than 10 miles. Currently, dewatered sludge is trucked to farms. The City landfill is only a short distance from the treatment plant and has an estimated site lifetime of about 10 years.

Because the possibility of expansion at the present site is limited by surrounding land use and due to the site proximity to industrial and residential areas, drying lagoons are not recommended for future dewatering requirements. The following process options are considered for year 2000 requirements.

Option 1A assumes that ultimate disposal of 5 percent liquid sludge in excess of the capacity of existing dewatering facilities would be made by trucking and landspreading. The cost of this option would be about $165/dry ton of raw sludge processed.

Option 1B assumes that a new centrifuge would be added to supplement the existing dewatering facilities; cost of this option would be about $226/ton of raw sludge.

This analysis indicates that the least costly mode of future operation is landspreading of liquid digested sludge in excess of the capacity of the existing centrifuge and sand beds. However, actual costs for operation of the existing basket centrifuge are being evaluated by the City's consultant as more data becomes available. If it proves to be relatively economical, another basket centrifuge could be added. The City has been most thorough in their approach to sludge handling and continues to make improvements to their system.[1]

Thickening of sludge before digestion would improve

[1]*Pietila, K. A., and Zacharias, D. R., "Full Scale Study of Sludge Processing and Land Disposal Utilization Centrifugation for Dewatering," Milwaukee, Wisconsin, May 1977.*

efficiency and reduce costs of liquid sludge hauling. Continued use of the existing sand beds will provide dried sludge for public pickup.

The current system of trucking dewatered sludge to farms should be continued; however, proper storage areas should be provided at the farms for controlling run-off and to allow the farmers to spread at their convenience. Landfilling at the City landfill should be considered as a backup alternative.

Walworth County Metropolitan Sewerage District—Based on sludge projections, the capacity of existing facilities in Delavan and the area (included in the Sewerage District) require expansion to adequately treat the projected year 2000 sludge quantities. A facilities plan for expanding Delavan's current treatment plant, to meet projected needs of the Walworth County Sewerage District through the design year 2000, was completed by the District's consultant in October 1976. This plan proposes expansion of the existing Delavan treatment plant with a parallel process followed by sludge treatment in gravity thickeners and anaerobic digesters. Holding tanks (aerated) for liquid sludge would provide 150 days (approximately 5 months) storage, and sludge would be spread in liquid form on near-by farms.

The proposed anaerobic digesters are sufficient for approximately 1995 requirements, based on assumed operating parameters. The suitable landspreading sites are at distances of less than 5 miles. At 2.25 tpd (year 2000) raw sludge production (Option 1A with landspreading of liquid sludge) would cost about $156/dry ton of raw sludge and Option 1B with lagoons would cost about $149/ton of raw sludge. Due to the location of the treatment plant, adjacent to a school and residential area, lagoons are not desirable. Therefore, Option 1A is the most feasible. This study supports the findings of the consultant that Option 1A is the lowest cost, suitable alternative. Gravity thickening would improve the operation of the digesters; anaerobic digestion is considered to be the most suitable choice. Because of the nearness of spreading sites and available storage tanks (resulting from expansion), storage of liquid sludge is an acceptable option for this plant. Utilization by truck hauling and landspreading during good weather is favored.

A future option at a somewhat higher cost is to use vacuum filters; utilization under this option would include truck hauling to on-site storage facilities followed by individual farmer application. An advantage of vacuum filters is the availability of the backup disposal alternative of landfilling of sludge cake.

Brookfield—The existing wastewater treatment plant serving the western part of Brookfield was completed in 1974, and was designed as an interim facility pending full implementation of a recommended upper Fox River Watershed Sanitary Sewerage System Plan. The plant was designed to treat the anticipated flows through 1980; therefore, expansion of the existing capacity will soon be required. The plant currently utilizes filter pressing and incineration for sludge disposal with ash disposal at a landfill. The filter press would not meet future requirements.

Currently, the incinerator is being operated at less than half of its capacity. By operating at capacity 24 hours per day, 7 days a week, the existing unit should be capable of handling projected sludge volumes until about year 2000 under the watershed system.

Average hauling distance to landspreading sites is less than 10 miles, and the landfill site is at a distance of 11 miles. Process train options were investigated and are presented below.

Option 1 assumes that the existing filter press would be expanded for year 2000 requirements and the incinerator would be operated continuously. Cost of this option would be about $180/dry ton of raw sludge processed, including the amortized capital cost of the existing incinerator.

Under Option 1, expansion of the filter press capacity through the addition of a second unit would be required. A difficulty might arise with emissions from the incinerator stack if the incinerator is operated continuously. Should this be the case, the loading might be reduced with the excess filter cake bypassing the incinerator and, thereafter, being combined with the ash for hauling to a suitable landfill. However, it should be noted that the undigested sludge might be considered a hazardous material by DNR and would require special handling and a disposal site licensed to accept such material.

Option 2 assumes that the existing filter press and the incinerator would be utilized up to the capacity of the filter press. Excess sludge would be digested in a new anaerobic digester, dewatered by new lagoons, and utilized by landspreading. Cost of this option would be about $177/ton of raw sludge.

Option 3 assumes that the existing incinerator would be abandoned. All sludge would be digested in a new anaerobic digester; dewatering, in addition to the existing filter press, would be provided by new lagoons. All dewatered sludge would be hauled to landspreading sites. Cost of this option would be about $172/ton, including amortized capital cost of the abandoned incinerator.

Thickening should be added prior to the filter presses as a means of improving their operation. Chemical conditioning (without ash recycle) should be tested and, if successful, utilized to reduce the load on the presses.

Port Washington—Sludge projections for the City of Port Washington show that loads will be about twice the current level by the year 2000. Some expansion of the existing sludge handling facilities will be required. Capacity of the existing anaerobic digesters is sufficient to treat the projected year 2000 sludge quantities. In this operating mode, existing aerobic digesters would not be used and could be converted to storage or other uses. Continued operation of aerobic digesters might result in higher operation and maintenance costs for the City.

Currently, there are no dewatering facilities and liquid sludge is utilized by landspreading; suitable landspreading sites are at distances of about 5 miles from the plant. The following process train options were investigated.

Option 1 assumes that no dewatering facilities would be added and landspreading of liquid sludge by truck hauling would be continued. The cost of this option would be about $167/dry ton of raw sludge processed.

Option 2 would add solids lagoons, and cake sludge would be trucked to landspreading sites. The cost of this option is about $160/ton.

Option 3 assumes that vacuum filters would be utilized for dewatering, and sludge would be trucked to landspreading sites. The cost of this option would be about $180/ton.

Option 2 (utilizing solids lagoons) is the least costly process train. However, there is limited area at the plant site for lagoon construction. Lagoons could be located near the spreading sites rather than at the wastewater treatment plant site. In this case, the cost would increase to about $164/ton, which remains less costly than liquid sludge hauling and spreading. Because of this, lagoons are favored; as a backup option, landfilling could be used.

If a solids lagoon at a remote location is unacceptable to the City, landspreading of liquid sludge (Option 1) could be continued as long as it is practical, and vacuum filters (Option 3) could be installed if, for any reason, landspreading of liquid sludge cannot be continued.

Grafton—Sludge quantity projections for the year 2000 show significant increases over current levels. At the projected load, expansion of the existing digesters will be necessary before 1990. In evaluating alternatives to meet these needs, it was found that the operating characteristics of digesters at this plant might be improved through addition of a gravity thickener. In order to expand the digestion capacity, it appears that anaerobic digesters would be the least costly. However, it should be pointed out that aerobic digesters are easier to operate than the more efficient, yet sometimes more troublesome, anaerobic digesters.

One potentially feasible option is to use the excess digester capacity available at the nearby Cedarburg plant. This way, capacity beyond year 2000 requirements for both plants could be provided. This option should be evaluated in detail at the facilities planning level.

Currently, the plant has no dewatering facilities, and ultimate disposal is by landspreading of liquid sludge. Suitable landspreading sites are at distances of less than 5 miles.

Because of adjacent residential and commercial development, solids lagoons located at the plant site do not appear feasible. In addition, land for expansion is very limited at the current site. Therefore, only remotely located solids lagoons can be considered. The following process options were investigated to meet projected requirements in year 2000.

Option 1 assumes that anaerobic digester capacity would be expanded. Ultimate disposal would be by landspreading of liquid digested sludge. Cost of this option would be about $225/ton of raw sludge processed.

Option 2 assumes that anaerobic digestion capacity would be expanded and liquid digested sludge would be trucked about 5 miles to new solids lagoons constructed near landspreading sites. Dried sludge would be spread by farmers. Cost of this option would be about $227/ton of raw sludge processed.

Option 3 assumes that vacuum filters would be utilized for dewatering digested sludge. Sludge cake would be trucked to landspreading sites. Cost of this option would be about $238/ton of raw sludge processed.

This analysis indicates that Option 1, with landspreading of liquid sludge, would cost about the same as Option 2 utilizing solids lagoons. However, Option 2 is more desirable as it would provide a flexible ultimate disposal operation because sludge can be diverted to a landfill site when landspreading is not possible.

Cedarburg—Cedarburg sludge projections for the year 2000 show an increase to 2.2 tpd of raw sludge. A capacity analysis of the existing units indicates that the gravity thickener and anaerobic digester have sufficient additional capacity to treat future sludge loads well beyond year 2000. Therefore, the best future alternative appears to be continuation of the present mode of operation. However, existing lagoons and sand beds have a capacity of only 210 lb/day and 60 lb/day respectively, and therefore dewatering and ultimate disposal options should be evaluated.

Expansion of existing lagoons at the plant site does not appear feasible because of potential odor problems. Therefore, only remotely located lagoons (preferably near landspreading sites) could be considered. Suitable landspreading sites are at distances of less than 5 miles.

The following process train options for year 2000 requirements were considered.

Option 1 assumes that dewatering facilities would not be constructed and liquid digested sludge would be trucked to landspreading sites. Cost of this option would be about $154/dry ton of raw sludge processed.

Option 2 assumes that liquid digested sludge would be trucked about 5 miles to new solids lagoons, and utilization would be by landspreading. Cost of this option would be about $155/ton.

Option 3 assumes that vacuum filters would be utilized for dewatering digested sludge, and utilization would be by landspreading. Cost of this option would be about $166/ton.

It appears that Option 2 is the most desirable, as it has about the same cost as Option 1 but also provides a sludge cake which can be landfilled when necessary. Vacuum filters at the plant site should be considered as an alternative to lagoons.

Hartford—Projected raw wastewater flows for the year 2000 exceed the capacity of the existing Hartford treatment plant, and an expansion program will have to be undertaken. Sludge projections for the year 2000 indicate that the capacities of some units of the sludge handling portion of the plant will also require expansion.

Existing aerobic digesters are adequate well beyond the year 2000 requirements (1.95 tpd raw sludge). They appear to be working well in the current system which accepts industrial wastewater from a tannery. Anaerobic digesters probably would not function well with the tannery wastes due to the high levels of chromium.

Existing sand beds are sufficient to dewater all of the present day digested sludge volume. Currently, part of the liquid digested sludge is spread on farmland by tank truck. The landspreading sites are at distances of less than 5 miles. General cost curves indicate that costs of hauling and landspreading of 3 percent sludge (estimated concentration from aerobic digestion) is higher than costs of landspreading the dried sludge from existing sand beds (when capital amortized cost of existing sand beds are excluded). Therefore, the current practice of hauling liquid sludge is relatively uneconomical. For future requirements, in excess of current dewatering capacity. Option 1 (with landspreading of liquid sludge) would cost about $224/ton of raw sludge and Option 2 (with landspreading of lagoon dried sludge) would cost about $208/ton.

The treatment plant site in Hartford is surrounded by agricultural land and is far from residential development. Expansion land does not appear to be limiting in this case, and it seems that the best dewatering method would be to construct a solids lagoon at the plant site. If the existing sand beds are satisfactory, the lagoon would supplement their capacity. If the current system is too expensive or unsatisfactory for other reasons, larger solids lagoons could be used to replace the existing sand beds.

Following dewatering, truck hauling of sludge cake would allow the greatest flexibility. For landspreading, which appears to be the best ultimate utilization option, proper storage of sludge cake at the farm, followed by farmer spreading according to his needs, might result in the least conflicts. However, spreading by treatment plant personnel might prove to be more acceptable.

In the event that solids lagoons are not feasible, the next lowest cost options are hauling of liquid digested sludge and vacuum filtration.

Twin Lakes—Wastewater flows to the treatment plant at Twin Lakes, projected through the year 2000, indicate that expansion will be required. Sludge quantities' estimates for the same period show moderate increases and require some changes in current processes to adequately treat projected amounts.

The current operating mode utilizes both aerobic and anaerobic digestion. Because the capacity of the anaerobic digesters is more than sufficient to meet projected needs (0.95 tpd raw sludge in year 2000), it seems reasonable to discontinue operation of the aerobic digesters. This is supported by the high operating costs of aerobic digesters and by the redundancy of retreating aerobically digested sludge in anaerobic digesters. This "double" system might be unnecessary and costly. The aerobic digester may be used as an aerated holding tank.

Existing sand beds can handle only 0.13 tons per day of digested sludge, and suitable landspreading sites are at distances of less than 10 miles. The following process train options were investigated.

Option 1 assumes ultimate disposal by landspreading of liquid digested sludge in excess of the capacity of the existing sand beds. This option would cost about $240/dry ton of raw sludge processed.

Option 2 would utilize solids lagoons to supplement the existing sand beds; dried sludge would be trucked to landspreading sites. Cost of this option would be about $226/ton of raw sludge.

Because the treatment plant is in an isolated location away from residential areas, lagoons (Option 2) is the preferred dewatering method. The cost may be lower, storage is provided, and dewatered cake can be spread by farmers or by the treatment plant. Spreading by the farmer from storage facilities at his farm appears to be the best method of final utilization. An alternative to this method is to have the treatment plant personnel spread the sludge for the farmer. An evaluation of the conflicts and efficiency of each method would be necessary before a responsible choice could be made. Landfilling of sludge cake could also serve as an alternative, if spreading is not possible. The municipal landfill at Twin Lakes would appear to be suitable and has an expected lifetime of more than 10 years.

To improve operating characteristics of the anaerobic digester, a gravity thickener could be added to the current process train, possibly in the aerobic digestion space. This addition would become more effective as the digester reaches its capacity and might extend the useful life of the system. The current sand beds should be retained as a source of sludge for local residents.

Williams Bay—Projected sludge volumes for the Williams Bay wastewater treatment plant indicate that the current capacity of the sludge handling processes will, for the most part, be adequate through the year 2000. Thickening of waste-activated sludge in the existing thickener should be continued and should remain adequate throughout the planning period. The existing anaerobic digester should also have adequate capacity, if the present mode of operation continues. Existing sludge drying beds would meet dewatering requirements to year 1990, and either liquid sludge disposal or additional dewatering facilities would then be required.

Proximity of residential areas to the treatment plant site does not make solids lagoons feasible; however, remotely located solids lagoons might be considered.

The following process train options were considered for the year 2000 requirements.

Option 1 assumes that liquid sludge, in excess of the existing sand beds, will be trucked to landspreading sites. Cost of this option would be about $326/dry ton.

Option 2 assumes that excess liquid digested sludge would be trucked to new solids lagoons located near landspreading sites; dried sludge would be spread by the farmers. Cost of this option would also be about $326/ton.

Because the cost of these options are the same and either one could be implemented, new dewatering facilities would not be needed until 1990. Until that time, existing plant sand beds are sufficient to provide dried sludge for residents, for hauling and landspreading to farmland, or for landfilling.

Western Racine County MSD—Projected wastewater flows for the Western Racine County MSD show that expansion of the existing facilities will be required. An engineering report has been prepared by the District's consultant presenting an expansion program which includes sludge handling facilities.

The primary anaerobic digester proposed by the consultant is sufficient for year 2000 digestion requirements for both primary and waste-activated sludge (0.85 tpd in year 2000). For this reason, it is felt that the existing aerobic digesters should be bypassed. In addition, the operating costs of aerobic digesters are considerably higher than for anaerobic digesters, and cost savings may result from using only the proposed anaerobic digester. Aerobic units can then be used to meet other expansion needs, possibly as sludge thickeners or aerated holding tanks. The proposed sand beds would be sufficient until about 1983. Suitable land application sites are at distances of less than 5 miles.

The following process train options were investigated for year 2000 requirements.

Option 1 assumes that liquid digested sludge, in excess of the capacity of the sand beds, and dried sludge would be trucked to landspreading sites. Cost of this option would be about $238/dry ton of raw sludge processed.

Option 2 would utilize solids lagoons to supplement the sand beds and dried sludge would be trucked to landspreading sites. Cost of this option would be about $199/ton.

Option 2, utilizing solids lagoons, appears more feasible, and is supported by the availability of land at the plant site. The use of landspreading and truck hauling to the spreading sites has been found by both studies to be the most feasible choice for this plant. A backup alternative is to landfill the dried sludge cake, when landspreading is not possible.

The operating parameters of digesters can generally be improved by thickening the sludge prior to digestion. In this case, gravity thickeners should be considered as an appropriate method.

Hartland-Delafield—Consultants for the Hartland-Delafield Water Pollution Control Commission recommend that a new rotating biological contactor wastewater treatment plant be built at a new site. This plant will utilize anaerobic digesters and solids lagoons. Sludge projections and proposed sludge handling capacities (estimated by the consultant) are supported by the findings of this study.

Although the proposed digester capacity appears to be adequate to treat the expected sludge quantities through the year 2000 (2.15 tpd raw sludge), the addition of a gravity thickener prior to the digester could improve the operating characteristics of the digester and extend its capacity. It is felt that this alternative should be evaluated as part of the proposed sludge handling process.

Suitable landspreading sites are located at distances of about 5 miles. Cost of digestion, dewatering by lagoons, and truck hauling to landspreading sites would be about $152/ton of raw sludge processed.

Transportation of dewatered sludge by truck will allow the treatment plant the greatest flexibility in ultimate utilization/disposal options. For this plant, landspreading appears to be the best option, and it is felt to be the most practical alternative by both the Commission's consultant and the analysis of this study. Should landspreading be discontinued for any reason, landfilling at a site in Delafield could be used as the backup alternative.

Union Grove—The existing wastewater treatment plant in Union Grove will be abandoned when construction of a new plant, recently advertised for bids, is completed. The proposed sludge handling process uses aerobic digestion followed by sand bed dewatering and landspreading. Although it is felt that anaerobic digestion is the less costly stabilization process, aerobic digestion is an easier process to operate in relatively small plants.

Consideration of the anticipated operating characteristics of the treatment plant indicates that additional capacity for digestion and dewatering might be necessary before the year 2000. The digester might need expansion by about 1984. The proposed sand beds have a capacity of about 0.3 tons per day. For the digesters and sand beds, the particular operating characteristics of the installed units and the sludge flows from wastewater treatment processes should be evaluated after operation begins. With actual operating data in hand, capacities can be established more precisely and future needs compared with existing unit sizes.

Suitable landspreading sites (based on Technical Bulletin No. 88) are at distances of less than 5 miles. For future requirements, the following process train options were investigated.

Option 1 assumes that the aerobic digesters would be expanded and liquid sludge, in excess of the capacity of sand beds, and dried sludge from sand beds would be trucked to landspreading sites. Cost of this option would be about $283/dry ton of raw sludge processed.

Option 2 assumes solids lagoons would supplement the sand beds and dried sludge will be trucked to landspreading sites. Cost of this option would be about $245/ton.

Addition of lagoons to supplement the drying beds and landspreading appears to be the most feasible option. Landfilling would be a backup option.

Other Wastewater Treatment Plant Sludges—For other wastewater treatment plants, the most significant considerations are costs and ease of operation. Complicated features that might make the small facility difficult and expensive to operate should be avoided. It appears that the most reasonable process options to consider include the use of gravity thickening, anaerobic digestion, lagoon storage, sand beds and trucking of liquid sludge for landspreading, or public pickup of lagooned dewatered sludge with landspreading of the excess sludge. These contentions are based on review of the process train cost functions and general information on the various available processes. Other plants in the Region are listed in Table 71.

Gravity thickening might be used prior to anaerobic digestion, and is a reasonably simple process to operate and should not create any problems. For very small trickling filter or activated sludge facilities (less than 0.1 mgd) it is simpler to allow for the extra digester volume rather than building and operating a thickener. Anaerobic digesters are generally less costly than aerobic; however, aerobic digesters are simpler to operate. Anaerobic digestion process is sensitive to shock loadings (more likely to occur at small plants); therefore, aerobic digester use is favored. Sludge from digestion might be held in drying lagoons for storage and volume reduction prior to landspreading or public pickup. Sludge might also be stored in liquid form and applied to land as a liquid. The local landfill might serve as a backup disposal option. Contract hauling of liquid sludge to large facilities should also be considered in the facilities plan.

It is important to provide adequate capacity to handle peak loads and shutdowns; this is often improperly addressed in small plant design. For even small plants, provision should be made for parallel sludge digesters and standby sludge pumping capacity. Peak wastewater flows should be used as the basis to project peak sludge loads and facilities should be capable of accepting these peaks.

Most small plants have adequate land available within less than 5 miles and some may only require a single farm for all the sludge generated.

All other wastewater treatment plants are listed in Table 71 and those to be abandoned are noted. The total sludge load from these plants is only 1.6 percent (1975) of that from the large plants.

The capital cost for these plants is estimated to be $1,300,000.

Sludge hauling to disposal might be contracted for with private haulers; and, if the hauler has storage capacity, the plant might be able to effect short-term storage in the digester volume—at least while the plant is operating below design capacity.

TABLE 71

OTHER PLANTS IN REGION

Plant Name	Plant Name
Elkhorn[1]	City of Muskego[1] (Contact stabilization w/polishing lagoon) (Northeast)
Hales Corners (MSD)[1]	Silver Lake
Menomonee Falls[1] (Pilgrim Road)	Pleasant Prairie Sewer Utility District D[1]
Mukwonago	Pleasant Prairie Sanitary District No. 73-1
Sharon	Pleasant Park Utility Co.[1]
Sturtevant[1]	Paddock Lake
Sussex (T.F.)[2]	Rawson Homes Sewer and Water Trust[1]
East Troy	Germantown[1]
Saukville	Village of Newburg
City of Muskego (Big Muskego Lake Plant)[1]	Belgium
Caddy Vista[1]	Bristol Utility District No. 1
Lake Geneva	Darien
Genoa City	Fredonia
Fontana	Menomonee Falls[1] (Lily Road)
Jackson	Salem Utility District No. 1
Slinger	North Park Sanitary District[1]
Pewaukee[1]	Somers Utility District (T.F.)[2]
Walworth	
New Berlin[1] Regal Manor	
Thiensville[1]	
Allenton	
Dousman	
Kewaskum	

Note: In addition to the above-listed treatment plants facilities are under construction for Town of Dover, Eagle Lake Sewer Utility District, Town of Norway Sanitary District No. 1. An addition is proposed for the Town of Somers Sanitary District No. 2. Other plants which are proposed under the recommended regional land use plan are to be located at the Villages of North Prairie and Wales, the Town of Salem Utility District No. 2, the Town of Bristol proposed IH-94 and the Town of Lyons.

[1]*To be abandoned.*

[2]*Temporary facilities — may be abandoned before year 2000.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

Scheduling of sludge hauling and spreading should be carefully considered in the normal sequence of plant operation so that sludge may be properly applied to agricultural lands, without spreading during unsuited weather conditions.

Costs of Alternative 1 and 1A—For each of the large treatment plants, the present worth (including capital, operation, and maintenance) and capital costs of the sludge handling processes selected (see Table 72) in the above screening were calculated. (These are shown in Table 73.) These costs include sludge processing, truck transportation to spreading sites, and spreading costs. The spreading costs were calculated in two different ways to facilitate comparison of final disposal management alternatives. Under Alternative 1, it was assumed that the farmer would be spreading the sludge, and spreading costs include only the cost of on-site storage. Under Alternative 1-A, it was assumed that spreading would be done by treatment plant personnel; storage costs at the treatment plant were included where necessary. The plant processing capital cost does not change under these two designations; sludge processing remains unchanged. Associated backup landfill sites are shown in Table 74.

Geographic Alternative 2
(Subregional Sludge Management)
Port Washington, Grafton, Cedarburg—Joint landspreading of lagoon dried sludge cake from an intermediate application location between the plants might result in savings for each of these plants. For this particular combination it might also be advantageous to have a joint drying lagoon at or near the spreading sites. This is possible because remote lagoons for each plant are already necessitated by restrictions at the plant sites. However, under this mode, consideration must be given to the effects of distance on the trans-

TABLE 72
SCREENED SLUDGE MANAGEMENT PROCESSES
ALTERNATIVES 1 AND 1A

ALTERNATIVE #1	Sludge Processing Options											Transport Options			Utilization/Disposal Options							
Wastewater Treatment Facility	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail/Barge	Pipeline	Incineration/ Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
MSD-Jones Island	PE			P		PE	PE P	P			P PE E	P PE E	PE E	P	P	P	P	P		P	PE E	
MSD-South Shore	PE	P		P PE		P	P	P	E			PE	P	P	P	P	E P	P	P	P		
Brookfield	P		E**			PE		PE				PE			PE	PE						
Port Washington	P		E	PE		A	A		P*			PE				B	PE					
Grafton	P		PE	E		A	A		P*			PE				B	PE					
Cedarburg	PE			PE		A	A		P*E	PE		PE				B	PE					
Grafton/Cedarburg	PE			PE		A	A		P*E	E		PE		P		B	PE					
Hartford	P		PE			A	A		P	PE		PE				B	PE					

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process

Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank

2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

TABLE 72
SCREENED SLUDGE MANAGEMENT PROCESSES
ALTERNATIVES 1 AND 1A (continued)

ALTERNATIVE #1	Sludge Processing Options											Transport Options			Utilization/Disposal Options							
Wastewater Treatment Facility	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail/Barge	Pipeline	Incineration/ Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
Twin Lakes	P		E	PE		A	A		P	PE		PE				B	PE	PE				
Williams Bay	PE			PE		A	A		P*	PE		PE				B	PE					
Western Racine	P		Po E	P Po		A	A		P	P Po E		PE				B	P Po E					
Hartland-Delafield	P			P Po		A	A		P Po			P Po				B	P Po					
Union Grove			P Po	E		A	A		E	P PoE		P Po E				BE	P Po					
Racine	P			PE		PE	PE					PE				BE	PE					
Kenosha	PE			PE		PE		PE				PE				B	PE					
Waukesha	P Po			P Po E					P Po E			P				B	P	P Po E				
West Bend	P Po			P Po E		P Po	P Po		E			E P Po				P Po	BEPo					
South Milwaukee	P			Po P E	E[2]	P Po	P	Po[1]	E	PE		PE				BE	PE	PE				
Whitewater	P Po			P Po		P Po		P[1] Po[1]				PE				P Po	PE	Po				
Oconomowoc	PE			PE		PE	PE					PE				BE	PE					
Burlington	P	PE	E	PE		PE				E		PE				B	PE					
Walworth County	P Po			PE Po		A	A			E		Po PE				E	P Po					

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process

Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank
2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

TABLE 73

ALTERNATIVES 1 AND 1A COSTS[2] FOR MAJOR PLANTS

Treatment Plant	Present Worth (Including Operation and Maintenance) Capital Cost (Dollars)	Present Worth Treatment Hauling Storage (Dollars)	Present Worth Treatment Hauling Storage Spreading (Dollars)	Average Annual Cost 1976-2000 Treatment Hauling Storage (Dollars)	Average Annual Cost 1976-2000 Treatment Hauling Storage Spreading (Dollars)
MSD Jones Island[1] (low range sludge load)[3]	—	29,900,000	30,800,000	3,140,000	3,240,000
MSD South Shore[1] (high range sludge load)[3]	—	28,700,000	31,300,000	2,700,000	2,900,000
Racine	4,523,000	5,957,000	6,118,000	570,000	586,000
Kenosha	3,193,000	4,921,000	5,084,000	464,000	480,000
Waukesha	2,946,000	3,356,000	3,541,000	313,000	331,000
West Bend	2,484,000	3,313,000	2,975,000	310,000	277,000
South Milwaukee	365,000	657,000	685,000	62,000	65,000
Whitewater	2,255,000	2,236,000	2,265,000	210,000	213,000
Oconomowoc	—	601,000	642,000	48,000	51,000
Burlington	344,000	789,000	809,000	75,000	77,000
Walworth Co. MSD	1,438,000	1,448,000	1,448,000	134,000	134,000
Brookfield	1,080,000	2,332,000	3,251,000	209,000	322,000
Port Washington	247,000	688,000	728,000	63,000	67,000
Cedarburg	100,000	318,000	361,000	29,000	33,000
Grafton	532,000	1,146,000	1,194,000	108,000	112,000
Hartford	63,000	1,019,000	1,057,000	93,000	97,000
Twin Lakes	167,000	289,000	309,000	26,000	28,000

[1]*Relative costs for region wide comparison. These do not represent a recommendation. See* Tables 68 and 70.

[2]*ENR 2445, Discount Rate @ 6%, includes Engineering and Contingencies.*

[3]*See Chapter V for explanation of sludge load ranges. The above is based on the diversion area going to South Shore.*

Williams Bay	19,000	93,000	101,000	8,000	9,000
Western Racine Co. MSD[4]	938,000	835,000	856,000	77,000	79,000
Hartland-Delafield	1,519,000	1,492,000	1,532,000	130,000	134,000
Union Grove	0	768,000	782,000	63,000	64,000
Total	—	90,858,000	95,838,000	8,832,000	9,299,000

[4]*Delavan-Elkhorn.*

Source: Camp Dresser & McKee Inc.

portation costs of liquid sludge. If distances to the selected sites are greater than about 15 miles, vacuum filters should be considered at one or more of the plants as a dewatering option and their costs compared to the costs of solids lagoons.

As a backup, landfilling should be considered, possibly at a site in Grafton, for disposal of sludge cake during adverse weather.

Oconomowoc, Hartland-Delafield—For this combination, joint landspreading at an intermediate site appears feasible and might result in some savings in disposal costs. Changes in sludge processing should not be necessary at either plant. During adverse weather or crop-growth cycles, a backup landfill option at a site near Delafield should be considered.

Waukesha, Brookfield—It is anticipated that joint landspreading at an intermediate site might reduce costs of the separate landspreading programs. However, with this proposed combination, Waukesha should continue to make sludge available for public pickup by area residents. In the case of Brookfield, some changes in the anticipated plant expansion would be required. Under the current-operating mode, Brookfield dewaters raw sludge in a filter press and incinerates the cake. It is felt that this process should be retained, but, since state guidelines suggest that sewage sludge spread on land be stabilized, future plant expansion should include digestion. The treatment option thought to result in the lowest costs is anaerobic digestion followed by solids lagoons. Only the lagoon sludge cake should be spread in the joint program. The backup option of landfilling at the site (used by Brookfield for its incinerator ash) should also be considered for times when landspreading is not possible.

South Milwaukee, MSD-Jones Island, MSD-South Shore—A joint landspreading program for these plants should consider truck transportation to spreading sites, because this could give them the greatest flexibility in operation. A pipeline to the general area of the spreading sites might also be feasible but could result in operational problems if sites are changed.

Also, it is quite possible that many sites would have to be used; this would depend on the available backup alternatives and on the possibility that landspreading be used only for meeting emergencies arising from equipment breakdowns. As a backup alternative to landspreading, landfilling at selected sites should be considered.

Walworth County-Metropolitan Sewerage District, Williams Bay—In this joint spreading program, Walworth County will continue to spread liquid sludge directly from holding tanks, unless the distances to the joint sites are long and the consequent hauling costs become higher than the costs of dewatering and hauling sludge cake. In this case, it appears less costly to use vacuum filters; lagoons are not possible because of the nearness of residential areas. For Williams Bay, the current processes should be adequate. As a backup to the joint spreading site, a landfill site should be readily available for emergency use during periods of adverse weather or crop-growth cycles.

Western Racine, Twin Lakes, Union Grove, Burlington—With this combination, it is possible for each plant to lower their sludge processing/disposal costs through utilization of a joint site. Because the site might be closer to some plants than to others, costs for equipment might be allocated so that results are mutually agreeable for each community. Union Grove, Twin Lakes, and Western Racine should consider continuing their practice of making sludge, dried on sand beds, available to the public.

The capital and present worth costs for the above alternatives are summarized in Table 75.

TABLE 74

BACK-UP LANDFILL SITES FOR LANDSPREADING

Treatment Plant	Possible Existing Back-up Landfill	Distance (One Way) In Miles
MSD-Jones Island and MSD-South Shore	Oakes	14
	Lauer	31
Racine	Oakes	4
Kenosha	Oakes	14
Waukesha	Delafield (Nichols)	9
West Bend	Lauer	21
South Milwaukee	Oakes	15
Whitewater	Tate (new site)	3
Oconomowoc	Delafield	9
Burlington	Burlington	2
Walworth County MSD	Greidanus	4
Brookfield	Delafield	11
Port Washington	Saukville	6
Grafton	Saukville	5
	Lauer	13
Cedarburg	Saukville	6
	Lauer	12
Hartford	Delafield	22
Twin Lakes	Twin Lakes	1
Williams Bay	Baker	8
Western Racine County MSD	Burlington	4
Hartland-Delafield	Delafield	3
Union Grove	Oakes	10

Source: Camp Dresser & McKee Inc. and Southeastern District Wisconsin Department of Natural Resources — Solid Waste Management.

Geographic Alternative 3
(Subregional Sludge Management)
Port Washington, Grafton, Cedarburg, Hartford, West Bend—With the possible exception of West Bend, this combination for a joint landspreading operation could result in cost savings for each plant involved. It should be recalled that savings are in landspreading costs only. Consequently, a centrally located site or possibly two sites appears to be the wisest choice. Also, the backup landfilling site, or sites, should be central or reasonably convenient to all plants.

In this possible combination, consideration should be given to the costs of the remote lagoons suggested in Alternative 1 for Grafton, Cedarburg, and Port Washington. Joint solids lagoons (e.g., between Grafton and Cedarburg) might result in economies-of-scale. Haul distances and costs to these remote lagoons are a significant factor in their overall value to the treatment plant. Longer distances or potential problems in maintaining these remote lagoons might increase the value of using vacuum filters.

For West Bend to be included in the spreading scheme, a program of source control for cadmium may have to be initiated. Current high levels of cadmium in the sludge at West Bend would reduce site lifetime and require that new land be located every few years.

Oconomowoc, Hartland-Delafield, Waukesha, Brookfield—As with the other joint schemes, savings could result in this case through combined-use and/or leasing of spreading sites or equipment. The largest per ton savings could result for Hartland/Delafield and Waukesha; Brookfield and Oconomowoc could gain small savings. However, distances to the selected spreading sites could be an equalizer as could plant size; larger plants save less on a per ton basis, but might realize larger overall savings resulting from their larger tonnages. Distances from the plant to the joint site should also reflect haul costs.

Waukesha should continue its current program of making dried sludge available to local residents. Brookfield, to participate in the joint spreading scheme, will have to take into account an alternative processing train for plant expansion which includes digestion.

MSD-South Shore, MSD-Jones Island—A joint landspreading scheme with backup landfill sites could be a possible option for ultimate disposal. However, large tracts of land would be required and haul distances will be fairly long. Sludge processing at MSD-South Shore could include such processes as thickening,

TABLE 75

ESTIMATED COSTS FOR ALTERNATIVE 2
FOR MAJOR PLANTS

Treatment Plant	Capital Cost	Present Worth (Dollars) (Including Operation and Maintenance): Treatment, Haul, Storage	Land Application	Total
	(Dollars)			
Port Washington	$ 247,000	$ 688,000		
Grafton	532,000	1,146,000		
Cedarburg	100,000	318,000		
Subtotal		2,152,000	$ 113,000	$ 2,256,000
West Bend	2,484,000			2,975,000
Hartford	63,000			
Oconomowoc	—	601,000		
Hartland/Delafield	1,519,000	1,492,000		1,057,000
Subtotal		2,093,000	64,000	2,157,000
Waukesha	2,946,000	3,356,000		
Brookfield	2,518,000	2,332,000		
Subtotal		5,688,000	109,000	5,797,000
South Milwaukee	365,000	657,000		
MSD-South Shore	—	28,700,000		
MSD-Jones Island	—	29,900,000		
Subtotal		59,257,000	2,413,000	61,670,000
Whitewater	2,255,000			2,265,000
Walworth Co. MSD	1,438,000	1,448,000		
Williams Bay	19,000	93,000		
Subtotal		1,541,000	71,000	1,612,000
Western Racine Co. MSD	938,000	835,000		
Burlington	344,000	789,000		
Union Grove	—	768,000		
Twin Lakes	167,000	289,000		
Subtotal		2,681,000	38,000	2,719,000
Racine	4,523,000			6,118,000
Kenosha	3,193,000			5,084,000
Total				$93,710,000

Note: Discount Rate at 6%, ENR at 2445.

Source: Camp Dresser & McKee Inc.

anaerobic digestion, and solids lagoons. MSD-Jones Island sludges could be processed in thickeners, anaerobic digesters, and vacuum filters. Transportation by truck appears best, because of its flexibility, although pipelines might also prove feasible.

Western Racine County Metropolitan Sewerage District, Twin Lakes, Union Grove, Burlington, Kenosha, Racine—For this combination of wide-spread plants, diverse spreading areas might be necessary; however, savings can still result for all plants. Again, the situation exists where larger cost savings, per ton of raw sludge, occur for the other plants. The selected locations can take these differences into account and equalize savings among the plants through haul costs.

Sludge processing at all plants should remain unchanged from Alternative 1; backup landfill sites should be available. Those plants which have public pickup should continue this practice and might wish to encourage its expansion. The capital and present worth costs for the above alternative are summarized in Table 76.

Geographic Alternative 4
(Subregional Sludge Management)
Walworth County, Williams Bay, Western Racine, Twin Lakes, Union Grove, Burlington—The combination of these plants for the purpose of joint landspreading could result in savings to all plants over the costs of individual landspreading schemes. Savings gained by this larger grouping appear to be a little larger than for the separate groups examined under Alternative 2. One or possibly two joint sites located by taking into account both savings differentials between plants and equipment needs would appear best. A backup landfill site or sites would also be required.

Because the proposed Walworth County treatment plant includes holding tanks and spreading of liquid sludge, the higher hauling costs under this alternative would affect its possible savings. Also, the equipment required for spreading liquid sludge is not compatible with equipment for spreading the drier cake from the other plants. Consequently, the alternative method of vacuum filter dewatering could become more feasible for Walworth County.

Twin Lakes should continue its current program of having dried sludge available for use by residents. The capital and present worth costs for the above alternative are summarized in Table 77.

Geographic Alternatives 2, 3, and 4—
Combined Processing Facilities

Regional incineration/pyrolysis plants could receive and process all the sludge from participating member plants.

Heat drying for fertilizer production is limited to MSD-Jones Island and possibly to transported sludge from MSD-South Shore.

The economic screening of process train options in Alternative no. 1 above indicated that new installations of pyrolysis facilities at individual plants would be costlier than those process train options which involve digestion, dewatering, and landspreading or landfilling; for Alternatives 2, 3, and 4 economies-of-scale may favor regional pyrolysis plants. General cost curves (in dollars per dry ton of raw sludge as a function of plant size) were developed for pyrolysis and landspreading options (as shown on Figure 13). The process train options are:

Option A1 = Filter press (raw sludge) & pyrolysis & ash disposal

Option A2 = Anaerobic digestion & filter press & pyrolysis & ash disposal

Option B1 = Anaerobic digestion & vacuum filter & landspreading

Option B2 = Anaerobic digestion & vacuum filter & landfilling.

For the pyrolysis options A1 and A2, it was assumed that the dewatering facilities would be located at individual plants and the dewatered sludge transported a maximum distance of 5 miles to a common pyrolysis plant; ash would be transported no more than 5 miles to a landfill site.

For the landspreading option B1, all sludge would be anaerobically digested and dewatered by vacuum filters and transported a minimum distance of 10 miles to common landspreading sites. No credit was given for the capital cost of existing digesters and dewatering equipment. Even though these conditions are biased in favor of pyrolysis, results clearly indicate that regional pyrolysis options would be far more costly than those options oriented toward landspreading of sludges from individual plants.

A further consideration is the use of joint facilities (processing) for dewatering and/or storage prior to land application or landfilling of sludge. This suggests that once sludge has been thickened and/or digested at the existing plant sites, liquid sludge (now about 5

TABLE 76

ESTIMATED COSTS FOR ALTERNATIVE 3
FOR MAJOR PLANTS

Treatment Plant	Capital Cost (Dollars)	Present Worth (Dollars) (Including Operation and Maintenance): Treatment, Haul, Storage	Land Application	Total
Port Washington	$ 247,000	$ 688,000		
Grafton	532,000	1,146,000		
Cedarburg	100,000	318,000		
West Bend	2,484,000	3,313,000		
Hartford	65,000	1,019,000		
Subtotal		6,484,000	$ 235,000	$ 6,719,000
Oconomowoc	—	601,000		
Hartland/Delafield	1,519,000	1,492,000		
Brookfield	2,518,000	2,332,000		
Waukesha	2,946,000	3,356,000		
Subtotal		7,781,000	183,000	7,964,000
South Milwaukee	365,000			685,000
MSD-South Shore	—	28,700,000		
MSD-Jones Island	—	29,900,000		
Subtotal		58,600,000	2,413,000	61,013,000
Western Racine Co. MSD	938,000	835,000		
Burlington	344,000	789,000		
Twin Lakes	167,000	289,000		
Union Grove	—	768,000		
Racine	4,523,000	5,957,000		
Kenosha	3,193,000	4,921,000		
Subtotal		13,559,000	318,000	13,877,000
Whitewater	2,255,000			2,265,000
Walworth Co. MSD	1,438,000			1,448,000
Williams Bay	19,000			93,000
Total				$94,064,000

Note: Discount Rate at 6%, ENR at 2445.

Source: Camp Dresser & McKee Inc.

TABLE 77
ESTIMATED COSTS FOR ALTERNATIVE 4
FOR MAJOR PLANTS

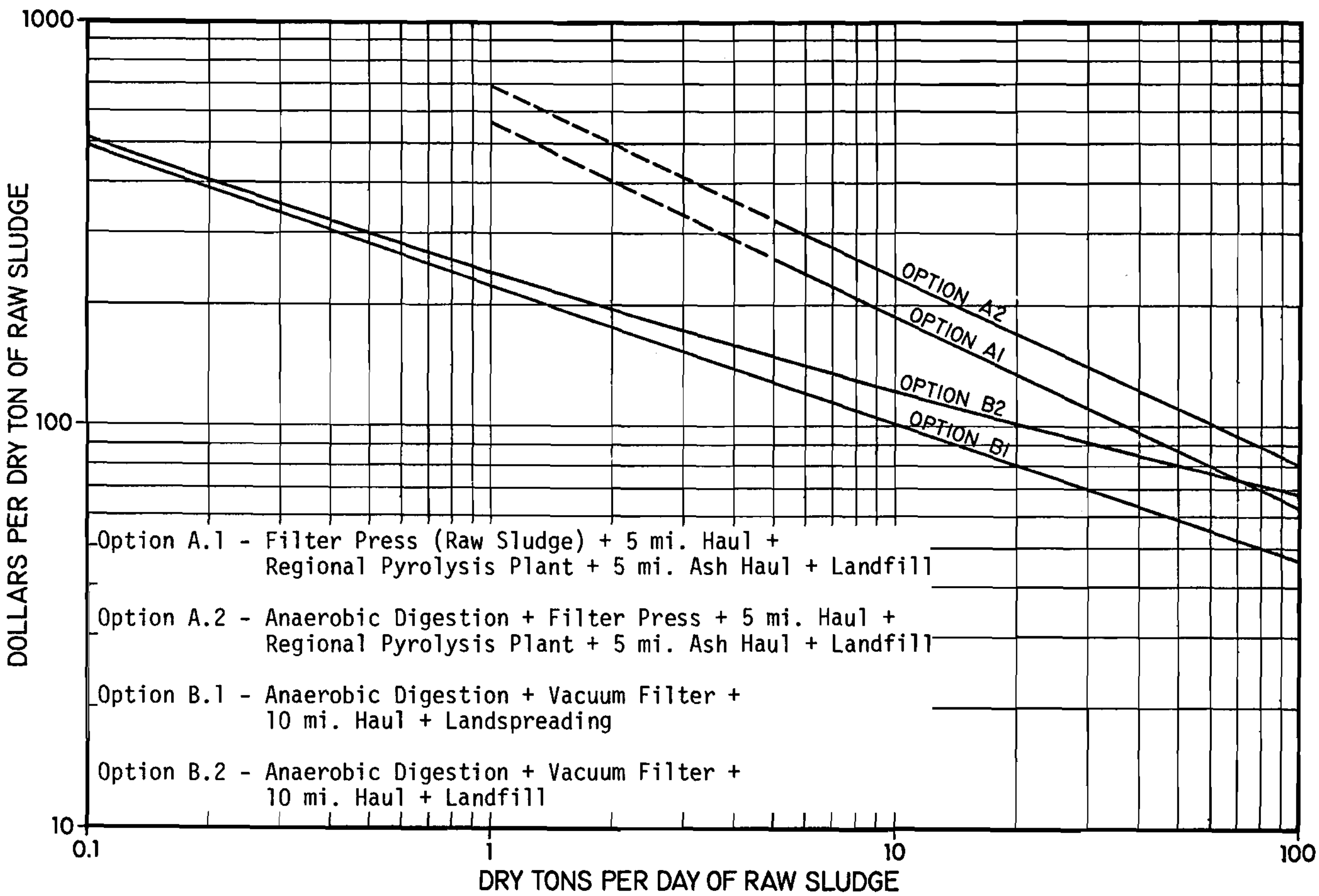
Treatment Plant	Capital Cost	Present Worth (Dollars) (Including Operation and Maintenance)		
		Treatment, Haul, Storage	Land Application	Total
	(Dollars)			
Port Washington	$ 247,000			$ 728,000
Grafton	532,000			1,194,000
Cedarburg	100,000			361,000
West Bend	2,484,000			2,975,000
Hartford	63,000			1,057,000
Oconomowoc	—			642,000
Hartland/Delafield	1,519,000			1,532,000
Waukesha	2,946,000			3,541,000
Brookfield	2,518,000			3,251,000
South Milwaukee	365,000			685,000
MSD-South Shore	—			31,300,000
MSD-Jones Island	—			30,800,000
Whitewater	2,255,000			2,265,000
Walworth Co. MSD	1,438,000	$ 1,448,000		
Williams Bay	19,000	93,000		
Twin Lakes	167,000	289,000		
Western Racine Co. MSD	938,000	835,000		
Burlington	344,000	789,000		
Union Grove	—	768,000		
Subtotal		4,222,000	$50,000	4,272,000
Racine	4,523,000			6,118,000
Kenosha	3,193,000			5,084,000
Total				$95,805,000

Note: Discount Rate at 6%, ENR at 2445.
Source: Camp Dresser & McKee Inc.

percent solids) might be transported to a common dewatering/storage facility. The thickening and digestion process evens out the sludge load and provides necessary storage capacity and volume reduction prior to hauling. All large plants currently have sludge digesters except for Jones Island.

Investigation of cost curves indicates that facilities with lagoons or vacuum filters are generally the least expensive of several considered. Liquid sludge might thus be hauled to a common processing site for dewatering and storage prior to land application or landfilling. A 5- to 10-mile haul of 5 percent solids sludge costs between about $9 and $14/dry ton. Cost savings due to economies-of-scale for lagoons and vacuum filters are about $10/day ton and $20/dry ton, respectively, from a 1- to a 10-ton/day plant. Operating costs for existing vacuum filters exhibit about a $10/dry ton differential over this same range. Therefore, plants would have to be within 5 miles haul to gain economic advantage at a 1 to 10 size ratio. The dewatering processes simply do not exhibit sufficient

FIGURE 13
TOTAL COST OF PROCESS TRAIN OPTIONS
PYROLYSIS VS. LANDSPREADING OR LANDFILLING



Source: Camp Dresser & McKee Inc.

economies-of-scale to offset the transportation costs. Remote lagoons from some plants were considered above.

A further consideration is the composting of dewatered sludge for stabilization and solids reduction prior to land application as a soils conditioner. Composting offers no economic advantage for plants with close land suitable for spreading of cake or liquid sludge. In addition, nutrient value of the sludge is reduced during the composting process. However, where sludge must be hauled long distances to suitable application sites, composting and public pickup may be an attractive alternative for a metropolitan area. Marketing studies are required as the operation is very site-specific.

Screening of Process Trains—Costs for Options A1, A2, and B1 are given for each plant and regional group of plants in Table 78. Average sludge quantities between years 1975 and 2000 were used for all options. (Costs for Option B2 are not tabulated since disposal by landfill would be for short periods only, and as a back-up when landspreading is not possible due to adverse conditions.) In all cases, the landspreading option is more economical than the pyrolysis option.

Joint structural systems for Alternatives 2, 3, and 4 do not appear feasible.

TABLE 78
RELATIVE COST COMPARISON OF PROCESS OPTIONS FOR ALTERNATIVES 2,3,&4

	Raw Sludge Production (tons per day)			Option A.1 Relative Cost $		Option A.2 Relative Cost $		Option B.1 Relative Cost $	
	1975	2000	Average	per ton	per day	per ton	per day	per ton	per day
ALTERNATIVE 2									
Port Washington	0.90	2.00	1.45	-	-			195	283
Grafton-Cedarburg	2.30	4.45	3.38	-	-			146	493
Regional Total			4.83	265	1,280	330	1,594	161	776*
Brookfield	2.65	9.8	6.23	-	-	-	-	119	741
Waukesha	9.45	14.25	11.85	-	-	-	-	96	1,138
Regional Total			18.08	140	2,531	518	3,218	104	1,879*
Western Racine	0.15	0.85	0.5	-	-	-	-	280	140
Burlington	1.15	2.25	1.7	-	-	-	-	185	315
Twin Lakes	0.30	0.95	0.63	-	-	-	-	260	164
Union Grove	0.60	1.00	0.80	-	-	-	-	240	192
Regional Total			3.63	305	1,107	380	1,379	223	811*
Williams Bay	0.05	0.25	0.15	-	-	-	-	430	65
Walworth	1.10	2.25	1.68	-	-	-	-	185	311
Regional Total			1.83	422	772	520	952	205	376*
Hartland-Delafield	0.55	2.15	1.35	-	-	-	-	200	270
Oconomowoc	1.20	4.80	3.00	-	-	-	-	152	456
Regional Total			4.35	275	1,196	345	1,501	167	726*
ALTERNATIVE 3									
Port Washington	0.90	2.00	1.45	-	-	-	-	195	283
Grafton-Cedarburg	2.30	4.45	3.38	-	-	-	-	146	493
West Bend	3.00	8.80	5.90	-	-	-	-	121	714
Hartford	1.00	1.95	1.48	-	-	-	-	195	289
Regional Total			12.21	170	2,076	215	2,625	146	1,779*
Brookfield	2.65	9.8	6.23	-	-	-	-	119	741
Waukesha	9.45	14.25	11.85	-	-	-	-	96	1,138
Hartland-Delafield	0.55	2.15	1.35	-	-	-	-	200	270
Oconomowoc	1.20	4.80	3.00	-	-	-	-	152	456
Regional Total			22.43	128	2,871	160	3,589	116	2,605*
Racine	12.7	30.05	21.38	-	-	-	-	78	1,668
Kenosha	17.9	23.65	20.78	-	-	-	-	79	1,642
Union Grove	0.60	1.00	0.80	-	-	-	-	240	192
Western Racine	0.15	0.85	0.5	-	-	-	-	280	140
Burlington	1.15	2.25	1.70	-	-	-	-	185	315
Twin Lakes	0.30	0.95	0.63	-	-	-	-	260	164
Regional Total			45.79	91	4,167	115	5,266	90	4,121*
ALTERNATIVE 4									
Western Racine	0.15	0.85	0.5	-	-	-	-	280	140
Union Grove	0.60	1.00	0.80	-	-	-	-	240	192
Twin Lakes	0.30	0.95	0.63	-	-	-	-	260	164
Williams Bay	0.05	0.25	0.15	-	-	-	-	430	65
Walworth	1.10	2.25	1.68	-	-	-	-	185	311
Regional Total			3.76	300	1,128	375	1,410	232	872*

Source: Camp Dresser & McKee Inc.

*Indicates lowest relative cost.

Geographic Alternative 5
(Subregional Sludge Management)
Port Washington, Grafton, Cedarburg—(See discussion of this grouping under Alternative 2.)

Hartford, West Bend—By combining the individual landspreading programs of these two treatment plants, some actual cost savings for Hartford could result. The benefit to West Bend would come from the increased efficiency of the spreading option.

In any landspreading scheme involving West Bend, it is suggested that a program for contaminant control of cadmium be initiated. Sludge processing trains at both plants could otherwise remain as described under Alternative 1.

Oconomowoc, Hartland/Delafield, Waukesha, Brookfield—(See discussion of this grouping under Alternative 3.)

South Milwaukee, MSD-South Shore, MSD-Jones Island—(See discussion of this grouping under Alternative 2.)

Whitewater, Walworth County, Williams Bay—A joint landspreading scheme for this combination of treatment plants, with the required backup landfill, appears feasible with centrally located sites. Costs savings could result for each plant involved, and spreading equipment would be used more efficiently.

Sludge processing at the Whitewater treatment plant would remain essentially the same as described under Alternative 1. However, sludge treatment at Williams Bay and Walworth County might require some changes under the joint scheme. Locating Williams Bay's lagoon at a joint spreading site could reduce the overall flexibility of the system and affect its inherent ability to move easily from one site to another. This choice could also increase the hauling costs, thereby reducing the savings gained from entering the joint scheme. However, a joint lagoon used by both Walworth County and Williams Bay could be located so as to be convenient to both plants. This option would serve Walworth County since their sludge is not dewatered under the Alternative 1 option and would, therefore, be incompatible with the cake from the other two plants. The choice of a joint solids lagoon is acceptable for these two plants and its location could be considered independently of the joint spreading sites.

Individually, a solids lagoon on a site away from residential areas but near the Williams Bay plant would be a possibility. For Walworth County, vacuum filtration might prove best and least expensive in the joint spreading scheme.

Western Racine, Burlington, Union Grove, Racine—Combinations of large and small treatment plants, such as proposed here, can reduce the costs of landspreading for all plants; however, savings are much larger for the other plants. Because hauling costs are lower for these other plants, the selected sites should be closer to the major plants. For these plants, no changes appear necessary in the proposed sludge processing schemes described in Alternative 1.

Twin Lakes, Kenosha—By combining a major treatment plant with a nearby smaller plant in a joint landspreading scheme, savings for the small plant could be significant. However, the overall effect on the larger plant appears to be small when compared to its other costs. One consideration which can be quite important is the cost of hauling sludge. Costs should be about equal on a dollar-per-ton basis for both major and other plants, but the much greater tonnage hauled from the large plant makes a centrally located spreading site too costly. The other plant would have to be willing to spend more on hauling to a site chosen for its convenience to the major plant, in return for savings on spreading costs.

Sludge processing trains at both plants can remain as described in Alternative 1. The capital and present worth costs for the above alternative are summarized in Table 79.

Geographic Alternative 6
(Centralized Sludge Management)
In this alternative, all sludge would be hauled by truck to a central incineration/pyrolysis unit located adjacent to the existing MSD-Jones Island treatment plant. Sludge processing would be continued at each individual plant in essentially the same manner as described under Alternative 1, except for those cases described below. The advantages gained appear in the economies-of-scale for disposal by incineration/pyrolysis and landfilling. Landfilling and landspreading would serve as a backup in emergencies. Hauling by truck would provide some flexibility in picking up sludge cake from storage areas at the various plants.

Sludge processing for MSD-Jones Island would be done at the regional plant which would have thickeners, chemical conditioning, and filter presses prior to incineration/pyrolysis.

For Port Washington, Grafton, and Cedarburg solids lagoons do not appear necessary; sludge could be

TABLE 79

ESTIMATED COSTS FOR ALTERNATIVE 5
FOR MAJOR PLANTS

Treatment Plant	Capital Cost (Dollars)	Present Worth (Dollars) (Including Operation and Maintenance): Treatment, Haul, Storage	Land Application	Total
Port Washington	$ 247,000	$ 688,000		
Grafton	532,000	1,146,000		
Cedarburg	100,000	318,000		
Subtotal		2,152,000	$ 113,000	$ 2,265,000
West Bend	2,484,000	3,313,000		
Hartford	63,000	1,019,000		
Subtotal		4,332,000	108,000	4,440,000
Oconomowoc	—	601,000		
Hartland/Delafield	1,519,000	1,492,000		
Brookfield	2,518,000	2,332,000		
Waukesha	2,946,000	3,356,000		
Subtotal		7,781,000	183,000	7,964,000
South Milwaukee	365,000	657,000		
MSD-South Shore	—	28,700,000		
MSD-Jones Island	—	29,900,000		
Subtotal		59,257,000	2,413,000	61,670,000
Whitewater	2,255,000	2,236,000		
Walworth Co. MSD	1,438,000	1,448,000		
Williams Bay	19,000	93,000		
Subtotal		3,777,000	122,000	3,899,000
Western Racine Co. MSD	938,000	835,000		
Burlington	344,000	789,000		
Union Grove	—	768,000		
Racine	4,523,000	5,957,000		
Subtotal		8,349,000	191,000	8,540,000
Twin Lakes	167,000	289,000		
Kenosha	3,193,000	4,921,000		
Subtotal		5,210,000	159,000	5,369,000
Total				$94,147,000

Note: Discount Rate at 6%, ENR at 2445.

Source: Camp Dresser & McKee Inc.

hauled as a liquid. Brookfield could abandon its incinerator and haul raw filter press sludge cake. South Milwaukee could abandon its wet air oxidation unit and haul liquid sludge or select either vacuum filters or trucking with MSD-South Shore. For Williams Bay, the remote solids lagoons do not appear necessary, and its liquid sludge could be hauled with that from Walworth County. Liquid sludges hauled to the central facility would be processed with the MSD-Jones Island sludges.

In general, costs for this alternative were found to be much higher than for any of the other options and instead of savings, significant additional costs would be incurred.

The regional facility could be located elsewhere, but this would then require intermediate transport of the MSD-Jones Island sludge, with higher costs incurred.

It would also be a difficult task to pull all municipal units together and to effect appropriate agreements for mutual satisfaction. The capital and present worth costs for this alternative are summarized in Table 80.

TABLE 80

ESTIMATED COSTS OF ALTERNATIVE 6 FOR MAJOR PLANTS

Present Worth Dollars			
Individual Facilities	Haul to Regional Site	Regional Site	Total
$29,761,000	$27,500,000	$67,867,000	$125,128,000

Note: Discount Rate at 6%, ENR 2445.

Source: Camp Dresser & McKee Inc.

Comparison of Alternatives

Table 81 shows the total present worth values and capital costs for each previously described alternative. All present worth values for Alternatives 1 through 5 are within 6 percent of one another and these values are essentially equal. Only Alternative 6 is significantly different; it shows a 38 percent increase in costs over the other solutions. Thus, there does not appear to be any significant advantage in regionalization of facilities. The marginal economies provided by Alternatives 2 through 5, in relation to Alternative 1, are due to joint land application management systems.

TABLE 81

SUMMARY—ALTERNATIVE COSTS (DOLLARS)

Alternative	Present[1] Worth	Capital[2] Cost	Present Worth % greater than least cost alternative
1	$ 90,858,000	$39,154,000	—
1A	95,838,000	39,154,000	6%
2	93,710,000	40,592,000	3%
3	94,064,000	40,592,000	4%
4	95,805,000	40,592,000	6%
5	94,147,000	40,592,000	4%
6	125,128,000	47,600,000	38%

[1]*Including Operation and Maintenance.*
[2]*Costs for MSD-Jones Island and MSD-South Shore included only for comparative purposes.*

Note: Discount Rate at 6%, ENR 2445.

Source: Camp Dresser & McKee Inc.

Selected Alternative

Alternative no. 1 is characterized by an individual plant management system. Each sludge treatment plant would function independently with its sludge processing and sludge utilization practices. No centralization of facilities for common treatment is suggested. The individual plants will be managed by the local municipality or authority with higher, more complex agencies taking a regulatory overview of their operation. Under the selected alternative, individual facilities would be constructed to accommodate the processing of sludges, with the possible exception of MSD-Jones Island/MSD-South Shore/South Milwaukee and Grafton/Cedarburg.

The unit costs in dollars per dry ton of raw sludge solids for the process train options considered for Alternative no. 1 are presented in Table 82. In general, the least costly and preferred process trains involve digestion, dewatering, truck hauling, and land application.

TABLE 82
BASIC COMPARISON OF PROCESS TRAINS
FOR ALTERNATIVE 1 FOR 19 LARGE PLANTS

Wastewater Treatment Facility	Process Train Option	Options: Aerobic Digestion	Anaerobic Digestion	Vacuum Filter	Filter Press	Dewatering Lagoon	Sand Bed	Incineration/ Pyrolysis	Truck Hauling	Land-spreading	Landfill	Wet Air Oxidation	Centrifuge	Relative Cost/ Dry Ton of Raw Sludge Processed
MSD- Jones Island	1-9		●	0 ●	●	Rotary Dryer ●		●	0 ●	●	0 ●			-
MSD- South Shore	1-14		0 ●	●	●	0		●	0 ●	0 ●	0 ●			-
Racine	1 A		0 ●	0					25	●c				74*
	1 B		0 ●	0					5		●c			89
	2		0	0				●	5		●a			110
Kenosha	1		0 ●		0 ●				10	●c				82*
	2		0 ●	●	0				10	●c				84
	3		0 ●		0				10 10	●c/●L				82
	4		0		0 ●			●	8		●a			142
Waukesha	1		0			0			10	●				76*
West Bend	1		0 ●			0 0			25	●c				96
	2 A		0 ●	●		⊠			25	●c				112*
	2 B		0 ●	●		⊠			25		●			133
	3 A		0 ●		●	⊠			25	●c				121
	3 B		0 ●		●	⊠			25		●			130
South Milwaukee	1		0				0+		10	●L		0		176
	2		0			●	0+		10	●c		⊠		144
	3		0				0+		10	●L		⊠		152
	4		0	●			0+		10	●c		⊠		162*
Whitewater	1 A		0		0				5	●c				138*
	1 B		0		0				5		●			159
Oconomowoc	1 A		0		0				5	●				134*
	1 B		0		0				10		●			156
Burlington	1 A		0				0+		10	●c/●L			0+	165*
	1 B		0				0+		10	●c			0+ ●	226
Walworth	1 A		0						5	●L				156*
	1 B		0			●			5	●c				149

TABLE 82 (continued)
BASIC COMPARISON OF PROCESS TRAINS
FOR ALTERNATIVE 1 FOR 19 LARGE PLANTS

Wastewater Treatment Facility	Process Train Option	Options												Relative Cost/ Dry Ton of Raw Sludge Processed
		Aerobic Digestion	Anaerobic Digestion	Vacuum Filter	Filter Press	Dewatering Lagoon	Sand Bed	Incineration/ Pyrolysis	Truck Hauling	Land-spreading	Landfill			
Brookfield	1				0 ●			0	11		●a			180*
	2		●		0	●			11 10	●c	0a			177*
	3		●		0	●		⊠	10	●c				172*
Port Washington	1		0						5	●c				167*
	2		0			●			5	●L				160*
	3		0	●						●c				180
Grafton	1		0●						5	●L				225
	2		0●			0			5	●c				227*
	3		0●	●										238
Cedarburg	1		0			0+	0+		5	●L				154
	2		0			0+ ●	0+			●c				155*
	3		0	●		0+	0+							166
Hartford	1	0					0+		5	●L/●c				224
	2	0				●	0+		5	●c				208*
Twin Lakes	1	0	0				0+		10	●L				240
	2	0	0			●	0+		10	●c				226*
Williams Bay	1		0				0+		5	●L				326*
	2						0+		5	●c				326*
West Racine	1		0				0+		5	●c/●L				238
	2		0			●	0+		5	●c				199*
Hartland-Delafield	1		0			0			5	●c				152*
Union Grove	1	0 ●					0+		5,5	●L/●c				283
	2		●			●	0+		5	●c				245

Notes

0 - Existing, under construction or planned for construction.
● - Process option to meet year 2000 requirements.
⊠ - Option to be abandoned
c - Sludge cake
L - Liquid sludge
a - ash

* - Least cost acceptable approach.
\+ - Common to all process trains. Portion of sludge handled in these facilities are not included in costs.

ENR Construction Cost Index 2445 (August 1976)

Source: Camp Dresser & McKee Inc.

INDUSTRIAL WASTEWATER SLUDGES

The following discussion addresses, by category, several types of industrial wastewater treatment and disposal of resulting sludges. This discussion indicates the type of processing and disposal options available that may be applicable to the Region. Most sludges containing metals or toxics could be placed in landfills specially designed for this purpose; others may be landspread.

Discussion of heavy metals originating from industries discharging to the sewerage system of the Metropolitan Sewerage District of the County of Milwaukee is appended. Existing sludge quantities are presented in Chapter III and future quantities and sludge quality are discussed in Chapter V. The handling of industrial pretreatment sludges has been superimposed on the municipal system alternatives as essentially an independent entity.

Tannery Sludges

Inventory data for 1975, as shown in Table 83, show 17 tanneries operating in the Region. Eight of these facilities reported pretreating their wastewater. All 17 facilities are expected to generate an estimated 2.7 dry tons per day of solids in the year 2000. At this rate they will require about 108 cubic feet per day of landfill volume with a sludge solids concentration of 25 percent.

There are a large number of tanneries in the Region as shown in Chapter III. Milwaukee is one of the large tanning areas of the nation. The mode of treatment of tannery wastes depends on what type of tannery is involved and what processes are used. In general, there are three types of tanning processes: chrome, vegetable, and alum. There are a few tanneries that use all three processes. The treatment processes used and the results obtained from an EPA study are valuable because the data obtained are considered highly reliable.[1]

Equalization was found to be necessary because of the 5-day work week and batch discharges. In general, the treatment plant consisted of coagulation, sedimentation, and a completely mixed activated-sludge process, followed by final clarification. Since chrome tanning and vegetable tanning liquors have different characteristics, they were kept segregated before equalization. Chrome liquor is treated with lime only, while the vegetable liquor must have its pH raised with lime and also be coagulated with alum. The alum tanning liquor was used for adjusting pH at this tannery and an anionic polymer for coagulation was used before sedimentation. Suspended solids in both the chrome and vegetable tanning liquor (after the above treatment) were settled in a common primary clarifier.

After sedimentation, wastewater flows to the activated-sludge plant. (The COD was about 1,000 mg/l and the BOD was about 600 mg/l.) (In the unsettled waste, the BOD/COD ratio was 0.35.) The final effluent did not meet the discharge requirements, primarily due to the 200 mg/l of suspended solids in the final clarifier effluent; however, certain modifications in operation of the activated sludge plant were expected to improve this. As a result, the effluent BOD was about 100 mg/l instead of the desired 25 mg/l that laboratory tests indicated could be obtained. The total dissolved solids (TDS) were very high, about 13,000 mg/l, but this did not inhibit biological activity. However, the discharge of such a high TDS into certain receiving waters would not be acceptable. The total chromium was only 0.4 mg/l, with hexavalent type 0.01 mg/l in the effluent. The resultant sludges were combined in a thickener, dewatered, and disposed of in a landfill.

Generally, unhairing operations are done with high-lime sulfide liquors. There is a process for recovering the sulfide by acidifing the liquor after screening and releasing H_2S gas, which is collected in NaOH solution. Usually tannery wastes have high sulfides. The unhairing liquors can be coagulated and flocculated by treatment with an anionic polymer followed by cationic polymer and an inorganic salt. After settling, volatile suspended solids are reduced by 98 percent with 56 percent COD reduction.[1]

The first operation in tanneries receiving salt-preserved hides is to process them through a "beam-house" where defleshing and unhairing takes place. After unhairing the hides are further soaked in lime water. These so-called "beam-house" liquid wastes must be screened to remove the fleshings and hair; tanning and coloring follows. Before this, however, the hides must be pickled with sulfuric acid. In chrome tanning, a complex salt of chromium is used which reacts with the protein in the hides. Chromium is all in the trivalent form, thus, it can be removed by precipitation with lime.

Camp Dresser & McKee Inc. ran a pilot plant for the

[1] *"Secondary Treatment of Wastes from a Multiple-Purpose Tannery," E.L. Thackson, 28th Purdue Industrial Wastes Conference, 1973, p. 881.*

[1] *Cooper, J. E. et al., "Effect of Flocculants on Sedimentation of Organic Solids in Tannery Unhairing Effluents," Jour. Amer. Leather Chem. Assn., 70, 18, 1975.*

TABLE 83
GENERAL RECOMMENDATIONS
DISPOSAL OF INDUSTRIAL PRETREATMENT SLUDGES

Industrial Category	Sludge Disposal Option[1]	Dry Tons/Day	Volume of Landfill Required In Cubic Feet/Day (at 25% solids)	Acres of Land Required For Spreading Till Year 2000	Number of Facilities Reporting[3]	Number of and Percentage of Facilities with Pretreatment Reported		Number of Facilities Listed Under NR101
Tannery Sludges	Landfill	2.7	108		8	8	100	17
Metal Plating	Landfill	3.7	148		35	25	71	50
Metal Machining	Landfill or Incineration	17.1	684		39	22	56	39
Milk processing and other dairy wastes sludges	Landfill or landspreading[2]							
Meat processing	Landfill or landspreading[2]	1.4	56	∿500	33	20	61	65
Vegetable processing wastes sludges	Landfill or landspreading[2]							
Battery manufacturing wastes sludges	Landfill	0			1	1	100	2
Truck and Car Wash Operations	Landfill	0.1	neg.		9	6	67	9
Power plants wastes sludges	Landfill	0			1	0	0	1
		25.0	996					

[1]Sludge not discharged to municipal system. Landfills licensed by Wisconsin DNR to accept hazardous and toxic wastes. These are Metro Disposal Service Inc. - Franklin, Land Reclamation Ltd. (Oakes), and United Waste Systems (Lauer).

[2]Following stabilization (digestion).

[3]SEWRPC Questionnaire Form

Source: Camp Dresser & McKee Inc.

A.C. Lawrence Leather Co. of South Paris, Maine, which is a chrome tannery. The study was funded by FWPCA (predecessor to EPA) and a report published (ORD-5) in 1969. The "beam-house" wastes were screened and then were mixed with the acid-tanning wastes. The mixture was treated in a reactor-clarifier unit with flue gas to keep the pH at about 9.0-9.5. This permitted biological action in the next step but did not release H_2S from the sulfides present. The clarified wastes (after carbonation) were treated in an activated sludge plant. Entering BOD, which is present in the tanning waste, varied from about 500 to 3,000 mg/l. The pH was reduced in the aeration basin to about 7, by the CO_2 produced by the biological action on the organics.

Sulfides were oxidized in the activated sludge process. The chromium present in the influent to the pilot plant varied from 15 to 85 mg/l; some was removed in the primary settling basin, some in the carbonation reactor-settler, and the remainder in the activated sludge plant. Tests indicated that chromium up to concentrations of 100 mg/l did not interfere with the activated sludge process.

All sludges had appreciable chromium (0.6-1.3 percent on a dry basis); waste-activated sludge had up to 0.55 percent chromium. The pilot plant produced an excellent effluent with an average BOD of 32 mg/l.

In vegetable tanning, extracts of wood, bark, etc. are used, primarily in the manufacturing of sole leather. Processes preceding the tanning are similar to those for chrome tanning, and the discarded vegetable tanning liquor will have a BOD of 2,500-3,500 mg/l and a pH of 4-5.5. Many tanneries use both the chrome and vegetable processes. The vegetable tanning liquor has a low pH which must be raised with lime addition using spent lime solution.

Treatment of tannery wastes with municipal wastes is possible and practiced at several localities. The most extensive of such installations is at the joint Gloversville-Johnstown, N.Y., plant[1]; 22 tanneries in this area have their wastes treated at this plant. Extensive pilot plant tests showed that activated sludge could be used to treat the tannery wastes and domestic wastewater and obtain up to 85 percent BOD reductions when the

[1]*Nemerow, N. L. and Armstrong, R., "Combined Tannery and Municipal Waste Treatment: Johnston-Gloversville, N.Y.," 21st Purdue Ind. Waste Conf., 1966, p. 447.*

volume ratio of wastewater to tannery waste was about 5:1. It was established, as elsewhere, that where combined treatment is used, waste equalization is necessary at the tannery, and screening is necessary for removal of fleshings and hair. Pilot plant studies indicated that the sludge could be anaerobically digested, though there was a reduction of gas production to about 9 cu ft from 12 to 15 cu ft per lb volatile solids destroyed. The amount of chromium in this combined sludge was not clearly stated.

The other major combined treatment facility is at Grand Haven, Michigan, where a pretreated chrome waste is blended with domestic wastewater at a ratio of about 3:1; the resulting BOD is 320 mg/l. The lime "beam-house" wastes were blended with the chrome wastes resulting in precipitation of most of the chromium. Coagulating chemicals, ferric chloride, and lime are added to the mixture, mixed and flocculated, then settled in primary clarifiers. This was followed by activated sludge treatment and final clarification. The large quantities of sludge produced are thickened in gravity units, heat treated, dewatered on vacuum filters, and incinerated.

Anaerobic digestion of sludge produced from treating chrome tanning wastes will not be successful as the chromium will interfere with proper growth of the methane formers. Aerobic organisms are apparently not affected by the chromium. The City of Hartford wastewater treatment plant uses an aerobic digestor to treat sludges from a mixed municipal-industrial wastewater containing a tannery discharge. Also, certain industrial detergents are frequently used in tanning operations which adversely affect the methane-forming organisms.

While the chrome liquor from the chrome tanning process may receive treatment in the activated sludge process, sludges containing high levels of chromium are unacceptable for landspreading. The most feasible approach appears to be, in general, to thicken, dewater, and landfill such sludge at a site suitably designed and licensed to accept the material. Incineration of the sludge prior to landfilling is not believed to be cost effective for the quantities generated in the study area.

Metal Plating Wastes Sludges

Inventory data for 1975, as shown in Table 83, show 50 metal plating facilities operating in the Region. Twenty-five of these facilities reported pretreating their wastewater. All 50 facilities are expected to generate an estimated 3.7 dry tons per day of solids in the year 2000. At this rate, they will require about 148 cubic feet per day of landfill volume with a sludge solids concentration of 25 percent.

After metal parts have been formed or fabricated, the surface finishing usually involves stripping, removal of undesirable oxides, cleaning, and plating. The total wastes produced, while not large in volume, can be hazardous due to their toxic metal content. Contaminants are usually acids and metals such as chromium, cadmium, copper, nickel, tin, and cyanides. Various organic cleaning compounds and grease and oil are also present in the wastes. In general, in a plating operation there are two sources of wastes—batches of plating solutions and rinsing waters.

The original stripping is done in baths consisting of solutions of sulfuric, nitric, and hydrochloric acids; sometimes alkaline baths of sodium sulfide, cyanide, and hydroxide are used. Cleaning is carried out with various organic solvents, emulsifiers, and wetting agents.

The character and strength of plating wastes vary considerably, depending on type of plating and rinsing used. The total plant waste can be either acidic or alkaline. Cyanide and alkaline cleaning baths result in highly alkaline wastes, while the opposite is true for chromate baths.

Treatments of plating wastes by physical and chemical means are designed primarily to accomplish: (1) removal of cyanides, (2) removal of chromium, and (3) removal of all other metals, oils, and greases.

Cyanide-bearing wastes are treated by the alkaline-chlorination process which involves addition of a chlorine gas to a high pH waste. Sufficient alkalinity, lime or caustic, is added to raise the pH to 11.0. This assures complete oxidation of the cyanide. This can take as long as 24 hours if complex metal cyanides are present.

Chromium-plating waste treatment is by reduction and precipitation, which involves reducing the hexavalent chromium to the trivalent state, using reducing agents such as ferrous sulfate, SO_2, or $NaHSO_3$. Sufficient mineral acid should be present to combine with the reduced chromium. After the reduction process is complete, an alkali (usually lime) is added to neutralize the acid and precipitate trivalent chromium as the hydroxide.

Other metal, oil, and grease bearing wastes are neutralized and precipitated as hydroxides; oils and greases are usually absorbed on the metal hydroxides. The resulting sludges are very light, voluminous, and difficult to dewater. They are disposed of in controlled landfills suitable for receiving hazardous materials.

Some of the larger plating plants recover the metals by use of ion exchange for reuse. Its best use is on rinse waters, since they have little foreign matter.

Most treatments of plating wastes are carried out in batch systems, since tests can be made on a treated batch to determine if it is suitable for dumping to the sewer. Though some large plants have continuous systems, complex monitoring is essential. Cyanide oxidation is always carried out in a batch system.

One of the greatest ever-present dangers in regard to plating operations is the accidental dumping of solutions. Some states require a container or holding tank to hold the entire volume of a process solution, due to accidental dumping. This is particularly true for the more toxic solutions such as cyanide and chromic acid plating vats. It should also be done for cadmium plating solutions since it is the most toxic metal as far as animal and human health is concerned. Various diluting devices and alarms should be used to determine if there are leakages of toxic solutions into the plant wastewater.

The quality restrictions of various discharges into municipal sewers might not be as severe as direct discharges into receiving waters, storm drains, or sewers. A secondary municipal treatment plant can remove, by physical and biological adsorption, precipitation, and oxidation, an appreciable amount of the toxic metals and cyanides. However, direct or indirect discharges into receiving waters must meet the effluent requirements set up by EPA for drinking water standards.

On the other hand, in many cases, some of the removed metal remains in the sludge required for final disposal. Metals' removal in the municipal plant might preclude land application of the sludge materials. Thus, the best approach, if possible, is to pretreat onsite to generate a small quantity of high strength sludge. This could then be disposed of in a properly controlled landfill. The more material that can be reclaimed or recycled the better the overall results.

Metal Finishing and Machining Wastes Sludges

Inventory data for 1975, as shown in Table 83, show 39 metal finishing and machining facilities operating in the Region. Twenty-two of these facilities reported pretreating their wastewater. All 39 facilities are expected to generate an estimated 17.1 dry tons per day of solids in the year 2000. At this rate they will require about 684 cubic feet per day of landfill volume with a sludge solids concentration of 25 percent.

Wastewaters originate from plants whose operations involve metal removal, welding, brazing, soldering, degreasing, machining, heat treating, and surface coating (other than plating).

Machining of metals involves use of coolants, cutting oils, and lubricants. Lubricating oils can be skimmed off the top of separator tanks while metal chips and fines are taken off from the bottom. Such separators are similar to separation tanks used in oil refineries. Machining and fabricating plants produce considerable amounts of wastewater containing soluble oils, usually used as coolants, and these may be mixed with emulsifying agents and various metal cleaners. The treatment of these wastes is either batch or continuous. For plants producing less than 2,000 gpd, batch treatment is (usually) more economical. Batch treatment should always be used if the wastewater contains toxic materials which must be removed before the tank contents are discharged to a sewerage system.

The treatment of wastewaters containing soluble oils is accomplished by adding acid or alum, or both, until the pH is reduced causing the emulsion to break. The free oil is decanted and the remaining water is neutralized with lime or caustic. Neutralization with lime will result in precipitation of insoluble calcium salts, which might be desirable, instead of keeping them solubilized as sodium salts. Sludge resulting from lime treatment should be dewatered and disposed of in a sanitary landfill.

Air flotation can be used for removing soluble oil resulting from the cracking of emulsion. Using acid or an alkali, the entire mass is saturated with air under pressure. The formed chemical floc, which is rich in oil, floats to the top, and after skimming may be readily incinerated in specially designed units to handle high BTU liquids.

Surface finishing by grinding or abrasive operations produce concentrations of particles in the 15 micron size. Air cyclones and wet scrubbers have been used to clean up the emitted air. Any resulting sludge should be disposed of in a landfill.

As noted above, sludges from chemical precipitation and lime neutralization should be disposed of in a sanitary landfill. Oils separated by air flotation might best be disposed of by burning in an incinerator specially designed to handle high BTU liquids. Such units are known to be located in Minneapolis and Springfield, Illinois.

Food Processing Waste Sludges

Inventory data for 1975, as shown in Table 83, show 65 food processing facilities operating in the Region. Twenty of these facilities reported pretreating their wastewater. All 65 facilities are expected to generate an estimated 1.4 dry tons per day of solids in the year 2000. At this rate they will require about 56 cubic feet per day of landfill volume with a sludge solids concentration of 25 percent.

Milk Processing and other Dairy Waste Sludges—Milk and other dairy wastes are readily treated by biological processes, since all essential nutrients are present. If municipal treatment plants are properly designed, these wastes should be quite amendable to biological treatment; however, because these are released in batches which may have high or low pH or concentrated high phosphate detergents, equalization is essential. Because these wastes putrefy rapidly, holding tanks should be aerated. Such equalization should be done at the milk or cheese processing plant. Depending on the source of wastewater, unless it is a very dilute wash water, BOD values over 1,000 mg/l (and in some cases, several thousand mg/l) should be expected.

If milk or dairy wastes are a large fraction of the municipal wastewater, it may be more economical to treat the wastes separately, such as in an extended aeration plant, in order to keep the sludge production to a minimum.

If the waste must be treated separately, a two-stage treatment would be most economical in order to reduce the high initial BOD to an acceptable value for discharge (i.e., high and low loaded activated sludge stages).

The sludge produced can be disposed of in a manner similar to that from treatment of ordinary municipal wastewater. Landspreading would be the most economical method.

Meat Processing Wastes Sludges—Meat processing involves the cooking, curing, canning, and freezing of meat from slaughter houses. Fairly strong wastes are produced and some by-product recovery is normally practiced. If the wastes are to be released to a municipal sewer, some pretreatment and equalization is desirable and necessary. The pretreatments practiced are screening, sedimentation, and flotation. The solids removed by such pretreatment processes must be disposed of, usually by conversion to by-products, by the processing plant. The escape of large amounts of grease can be disastrous to the operation and the sludge characteristics of a municipal activated sludge plant.

Meat processing plant wastes will have BOD values from 200 to 800 mg/l and an equal amount of suspended solids; the grease can amount to 100-300 mg/l.

Proper design of primary equipment for removal of grease and suspended solids is very important. After that, the activated sludge process can be used to achieve 90-95 percent removal of the soluble organic matter. However, unless long aeration periods are used, the effluent ammonia will be high, i.e., 30-50 mg/l.

Air flotation can effectively thicken the waste-activated sludge. In some large plants the waste-activated sludge, which may average about 50 percent protein, has been used as an animal feed supplement. Grease skimmings may be returned to the rendering department for salvage.

Small processing plants have used anaerobic lagoons for pretreatment of their wastes before discharging into a municipal wastewater treatment plant. The waste sludge, given proper digestion, may be dewatered and disposed of in a landfill or utilized for landspreading.

Vegetable Processing Wastes Sludges—A wide variety of vegetables and fruits are processed in Wisconsin. In general, the processing consists of screening out the peelings or outer surfaces. This is a standard procedure and various methods are used by processing plants to screen out these solids. This leaves a liquid of fairly high BOD. For example, such washing liquids can have BOD values as follows:

Apples:	2,500 mg/l
Cherries:	1,700 mg/l
Others:	1,400 mg/l

The most difficult part of treating such canning or processing liquids is their seasonal nature. Hartford has decided to accept such seasonal loads and designed the treatment plant accordingly.

Elsewhere aerated lagoons have been used to handle such seasonal loads which occur during the summer. For example, a 5-series lagoon system in New York State reduced the apple wastewater BOD by about 95 percent within 15 days. Such lagoons of the facultative-type produce little sludge for wasting, which is one of their advantages.

Practically all vegetable and fruit canning wastes are grossly deficient in nitrogen and phosphorus which must be added for biological treatment of the wastewater. Treatments using high-rate trickling filters, biodiscs, or the activated sludge process require the largest amount of addition of such nutrients. Such treatments also produce the largest amount of waste sludge that must be processed and disposed of.

The initial primary treatment normally involves use of vibratory screens to remove the large particles; this is a problem to be handled by the processing plant.

Spray irrigation on wasteland and agricultural land has been used successfully at several locations for disposing of the soluble organics in the wastewater.

The frozen food industry produces a strong waste at a pH of 10-12, because caustic is used in peeling operations. However, aerobic treatment of these wastes, in aerated lagoons or by use of the activated sludge process or some modification of it, has been successful, due to self-neutralization by the CO_2 generated in the long aeration time needed to combat the high strength of the waste.

Though chemical treatment has been used in the past (usually lime and an iron salt or alum), it is no longer extensively practiced because of the large quantities produced of a difficult to process and handle sludge; a BOD reduction of only 40 to 50 percent is obtained. However, it is still used (in some cases) as a pretreatment, prior to discharge into a municipal sewer system. Waste sludges may be dewatered and landfilled or applied by landspreading to agricultural land.

Battery Manufacturing Wastes Sludges

Inventory data for 1975, as shown in Table 83, show 2 battery manufacturing facilities operating in the Region. One of these facilities reported pretreating their wastewater. Both facilities are expected to generate only a small quantity of dry solids per day in the year 2000. At this rate, they will require only a very small volume of landfill space at a sludge solids concentration of 25 percent.

The constituents in wastes from battery manufacturing plants depend on the types of batteries produced. Manufacturing of dry-cell batteries might result in the discharge of toxic metals such as zinc, cadmium, and nickel. The largest amount of wastes are generated by the lead-acid battery manufacturing industry. About 50 million such batteries are manufactured annually in plants having daily production of 250 to over 12,000 units. The primary raw materials used are lead and sulfuric acid.[1]

The nickel-cadmium battery industry is growing, and there have been some cases of discharge of wastewaters with high concentrations of cadmium[2]. All such wastewaters must be treated with lime to precipitate the cadmium (and other metals present such as zinc and nickel). The resulting sludge must be treated as a hazardous solid waste and disposed of in a hazardous waste landfill. Perhaps some recovery operation is possible, though currently its economics are questionable.

Lead-acid batteries are produced in two forms: wet and dry. The plate design and manufacture is identical for both types. The wet type, after plate placement, is filled with a low concentration sulfuric acid and charged. After this initial charge, the low concentration acid is dumped and replaced with a higher concentration acid. In the dry type, the plates receive the initial charge before assembly; they are then washed free of acid and dried. After assembly, the batteries are shipped without acid which increases their shelf life. Acid is added after the battery is sold, and it is then fully charged.

The battery plates are made by first fabricating a lead wire frame or grid. The pure lead is converted to the oxide by mixing in a special ball-milling machine with water and acid to form a paste, which consists of lead sulfate, oxide, and pure lead. This paste is applied to the grid in a thin film to form the battery plate. This pasted plate is cured and the metallic lead is oxidized.

Wastewater is produced in the pasting operation and contains dissolved lead and suspended lead compounds. The paste is flushed to a sedimentation sump and the water off the top is recycled. This wastewater is alkaline and has a pH of about 11.

In wet battery manufacturing, there are several washing operations, and the wash water contains sulfuric acid and dissolved lead. The dry charge production area can produce a large volume of wastewater containing high concentrations of waste acid, having a pH of about 2.0 and suspended and dissolved lead.

[1] *"Waste Lead Oxide Treatment from Lead-Acid Battery Manufacturing Wastewater," C.J. Crandall, Proc. of 29th Conf. of Purdue Ind. Wastes, 1974, p. 194.*

[2] *"Fish Caught Near a Battery Plant on Hudson Contain Up to 1,000 Times Normal Cadmium," New York Times, 13 June 1971.*

Composite wastewater discharges from lead-acid battery manufacturing plants are typically low in pH and contain high amounts of dissolved and suspended lead compounds. Wastewater production varies from 10-80 gal. per battery, depending on in-plant recycling and reuse.

The Illinois Institute of Technology has made a study of battery plant waste neutralization at eight plants; wastewaters averaged about 24 mg/l lead. Neutralization was accomplished with either hydrated lime, caustic soda, or ammonia. The lowest cost process was that using lime. The biggest problem was disposal of the large amount of lead-contaminated, calcium-sulfate sludge. Caustic soda does not produce sludge, but the dissolved solids are very high. The plant using ammonia had the highest effluent lead concentration—1.9 mg/l of dissolved lead and 22 mg/l of suspended lead. After neutralization, final treatment by coagulation-flocculation, sedimentation, and filtration is necessary. Ferric sulfate and polymers are effective coagulants to use. It should be noted that none of the above neutralization processes are really satisfactory in all respects.

In studying a process for limiting total lead to 1 mg/l in the plant effluent and limiting sulfate concentration to 400 mg/l, the following approach has been tested in a pilot plant and involves mixing the acidic waste stream with waste lead oxide, which is usually available in sufficient quantity at the plant because it is generated in the manufacturing process. This results in the formation of various insoluble lead sulfates as the pH of the solution is raised; sulfate ions are precipitated, lead is precipitated, and the total dissolved solids concentration is thereby reduced. However, the soluble lead and colloidal lead particles are not completely removed so as to meet the 1 mg/l limit, even after sand or coal filtration. By adding either sodium phosphate or sodium carbonate, however, a precipitate is formed with the remaining lead, which can be filtered out, therefore achieving the 1 mg/l limit.

It is apparent that relatively costly treatment is necessary if a lead-acid battery plant is to discharge an effluent low in soluble and insoluble lead. The resulting solids must then be managed as hazardous wastes; but lead may be recovered from the solids.

Truck and Car Washing System Sludges

Inventory data for 1975, as shown in Table 83 show 9 truck and car washing facilities operating in the Region. Six of these facilities reported pretreating their wastewater. All 9 facilities are expected to generate an estimated 0.1 dry tons per day of solids in the year 2000. At this rate, they will require only a very small volume of landfill space at a sludge solids concentration of 25 percent.

The materials to be disposed of from such systems are primarily oil and grease, sand, and grit. Such systems can be large facilities (such as maintained at Army bases) and the standard commercial washrack for private vehicles. All such washracks have a collecting tank underneath, designed so that the solids can settle to an apex. The oils and greases are solubilized by the detergents used; suspended solids are the principal solids to be disposed of. The solids are either pumped out and hauled to a landfill as a liquid suspension or, in some installations, a cyclone is used for dewatering. It depends on installation size and local requirements.

Some recycling of water is practiced in water-short areas for the initial flush. However, the final rinse must be low in dissolved solids, to prevent streaking.

Solids produced per car can vary from 0.5 lb during summer to 5 lb during winter. In the northern climates, due to road salt, the chlorides can buildup very rapidly (up to several thousand mg/l), and thus frequent dumping of the collection tank water to the sewer is necessary.

Unless the accumulated settled solids are dumped into sanitary sewers, no problems should result at the treatment plants from the operation of such car and truck washing facilities. The oils and greases are minimal and no unusual compounds are used as is done in airplane washing operations. Sludge and grit from pretreatment should be hauled to landfills for burial.

Power Plant Waste Sludges

In the Region, all power plants are of the fossil-fuel type. The principal solids produced at this type of facility are the bottom ash and the fly-ash collected by scrubbers. Presently, no scrubbers are used and other wastes are principally solid wastes and not sludges.

Blowdowns from cooling towers and boilers can include many compounds used as algicides and various boiler-tube cleaning and corrosion control compounds. These are normally all soluble. However, solids do accumulate in the cooling tower sump, because of dust in the air. Some boiler blowdowns have precipitated sludge, but this has not been a problem in this Region

Disposal of ashes and blowdown solids in landfills can cause serious degradation of the groundwater, if the landfill is not properly located, engineered, and monitored. The heavy metal concentration of fly-ash, bottom ash, and blowdown solids can be high. Values reported in the literature are as follows:

Toxic Heavy Metal	mg/kg (dry basis)
Arsenic	10-250
Cadmium	0.01-15
Chromium	80-150
Mercury	0.15-2
Nickel	110-250
Selenium	3-75
Vanadium	100-300
Titanium	5,000-20,000

Vanadium is present in fuel oil. For instance, the New England Power Company, at its power plant near Boston, could meet its effluent discharge permit by treating the sluice water and other discharges (sea water) by raising the pH to 9 with lime and removing all heavy metals except vanadium and nickel. By raising the pH to 9.5, nickel could be precipitated but not vanadium. Some oils have vanadium concentrations up to 150 mg/l which escape with the flue gas as a particulate. The raw sluice water from the electrostatic precipitators had 60 mg/l of vanadium; the discharge permit required treatment to 0.8 mg/l.

Laboratory studies indicate that the vanadium could be absorbed on ferric hydroxide precipitates. The process adopted involves adding ferric chloride for the vanadium absorption and then raising the pH with lime to insure precipitation of the nickel. The mixture is then filtered. The resulting solids must be either processed for vanadium recovery (as is done elsewhere) or disposed of in a controlled landfill. Certain vanadium compounds apparently are sufficiently soluble at higher pH levels so that the required values in effluents discharged to receiving waters cannot be attained by mere treatment with lime.

Utilities using coal in their power plants generate immense quantities of fly-ash, bottom ash, and wet-scrubber sludge. Fly-ash has found various uses (such as concrete additive). There are also other commercial applications for fly-ash and bottom ash. Wet-scrubber ash will increase tremendously in years to come as electric utilities convert from oil to coal and install SO_2 removal systems. It has been estimated that by 1980 there will be 35 million dry tons per year of wet-scrubber sludge, due to use of lime-limestone for SO_2 removal. This is about four times the total sludge generated by a U.S. population of 250 million from primary and secondary treatment of their wastewater. Studies are in progress to find some use for this sludge, possibly as some sort of structural material, especially for road building. If to the above figure of 35 million tons is added the coal ash, the figure becomes about 120 million tons, or about 14 times the total sewage sludge on a dry basis.

For each 1 percent of sulfur in coal, it is estimated that the lime-limestone scrubbing system will produce 160 lb of sludge, or 8 percent of the weight of the coal.

Disposal of all this sludge on the land is necessary and studies are in progress. One approach is to mix the sludge with sewage sludge for use on barren land.

Summary

Table 83 summarizes the disposal options for several categories of industrial pretreatment sludges. For industrial sludges containing metals, the best apparent option for most plants would be to recycle where possible; the remaining sludge could then be disposed of in an approved landfill. (Private concerns devoted to materials recycle may serve well in this regard.) Food processing wastes that do not contain metals or toxics could be landspread in the same manner as municipal sludges. Major industries in the Region are discussed in Chapter III.

It is stressed that industrial sludges are highly variable in character and often unlike municipal sludges. Therefore, separate, categorical treatment is required. The total capital cost of improved facilities, which follows from the recommendations of Table 83, is estimated to be approximately $3,000,000. This is only the sludge handling portion and in no way includes pretreatment of wastewaters or inplant modifications or other than the defined categories.

SLUDGE DISPOSAL IN CONJUNCTION WITH REFUSE SYSTEMS OR ELECTRIC UTILITY OPERATIONS

On 16 January 1975, the City of Milwaukee signed a 15-year contract with the Americology Division of American Can Company for the construction and operation of a 1,200-ton per day resource recovery plant. This plant will process about 270,000 tons per year of city solid wastes, and about 50 to 60 percent will be recovered as combustible fuel product to be fired (following a testing program) as a supplemental boiler fuel by Wisconsin Electric Power Company (WE). This is essentially all of the solid waste for which the city has responsibility. The plant is expected to be in full operation by early summer of 1977.

Two sludge disposal alternatives related to refuse processing have been considered. One is the direct firing of sludge with refuse in WE boilers and the other is use of either refuse derived fuel (RDF) or residues produced by the Americology plant as an energy source for sludge processing.

WE will evaluate the characteristics of RDF produced by the Americology plant and the effects of burning it in WE boilers. Based on the test results, specifications for the RDF will be developed by WE and Americology. Additions of sludges to the RDF or separate firing would require a new test program, and WE has currently indicated a reluctance to proceed with new tests. The effects of the introduction of sludge into utility boilers are not known, and it is probable that a test program would be required to provide information on air emissions, ash quality and quantity, slagging, boiler tube corrosion, and a number of other items. Because of its position as an electric utility, any significant effort required by WE to investigate the burning of sludge would undoubtedly require some external means of funding. In view of the uncertainties associated with a program of direct firing of sludge in WE boilers, further investigation of this alternative is considered unjustified at this time.

The RDF produced from Milwaukee refuse is to be fired in WE boilers. However, after successful operation of the plant with refuse from Milwaukee, Americology plans to secure additional solid waste from communities outside Milwaukee. RDF produced from these other communities is not obligated to WE at this time. Nominal capacity of the plant is about 1,500 tons per day; about 1,000 tons per day is required to service the Milwaukee contract. Therefore, in the future, Americology might have as much as 300 tons per day of RDF available for sale in addition to the RDF provided to WE. (RDF produced amounts to about 60 percent of the weight of incoming solid wastes and has a heating value of about 7,000 BTU per pound.) Also, the residues from the plant are expected to amount to up to 20 percent of the incoming wastes by weight, and will have a heating value of about 5,000 BTU per pound. The other 20 percent consists of recovered materials such as ferrous metals. Americology is now trying to market the residues produced from Milwaukee wastes. Either residues or RDF produced from wastes originating outside Milwaukee could be available as a fuel for sludge processing.

In summary, the Americology plant might produce as much as 100 tons per day of residue (at about 5,000 BTU per pound) and about 300 tons per day of RDF (at about 7,000 BTU per pound) which will be available on the open market. Use of either Americology plant residue or RDF as a fuel for sludge processing depends on negotiating an acceptable contract with Americology. Therefore, further investigation of alternatives using these fuels must include consideration of the status of Americology operations and planning, particularly proposed schedules.

It is anticipated recycling regions may be established throughout the State by the Wisconsin Solid Waste Recycling Authority in the next 10 years. Such centers may utilize refuse-derived fuel to provide steam or electricity to industry. Contracts for facilities in the Region might be awarded as early as November 1979. Takeover of the Americology facility by the Wisconsin Solid Waste Recycling Authority, in some capacity, is also a possibility. Given proper markets for sludge-derived products, the Authority may someday engage in the production and marketing of dried sludge or compost.

WATER TREATMENT PLANT SLUDGES

The four basic types of water treatment plant wastes generated in the study area are alum, lime, iron sludges, and brine from ion-exchange softeners. Alum sludge is generated by the treatment of surface water with alum to remove the suspended solids. Most of the solids are removed in a clarifier and the supernatant can be filtered to polish the final water to the consumer. The clarifier sludge is gelatinous and has a high affinity for water. Solids in the filter backwash have similar characteristics.

Lime sludge is generated by the treatment of surface or well waters with slaked lime to remove solids and/or soften the water. Most of the solids are removed in a reactor-clarifier, and the supernatant can be filtered and stabilized with carbon dioxide to polish the water to the consumer. The clarifier sludge is primarily calcium-carbonate and magnesium-hydroxide and has a high pH. It is nongelatinous and easily dewatered. Solids in the filter backwash have similar characteristics.

Iron sludge is generated by the filtration of well water with sand filters after aeration, to remove insoluble ferric compounds. Solids content of the iron sludges is very small when compared to alum and lime sludges. Ion-exchange brine from the regeneration of ion-exchange softeners has a high pH, high alkalinity, and few solids. It is composed of mostly calcium and magnesium salts.

Disposal methods include:

1. Reclamation of chemicals–Recalcination of lime sludges is the most common example of

reclamation. It occurs when heat is applied to calcium-carbonate, leaving calcium-oxide, which may be returned to the water softening process, and carbon dioxide, which may be used for stabilization of the softened water or the separation of magnesium sludge from the calcium-carbonate sludge in the reclamation process. A by-product of the reaction is a magnesium-carbonate solution, which may be sent to the wastewater system at a controlled rate.

Acidic recovery of alum from sludges can be accomplished by exposure of the sludge to sulfuric acid, which destroys the aluminum hydroxide complexes and allows rapid dewatering and settling of the solids. Flotation thickening of the sludge is required prior to the acid treatment.

(Neither of these examples are believed to be economical for Milwaukee.)

2. Direct use of sludges–Water treatment plant sludges have been used as soil stabilizers when mixed with fly ash, soil conditioners, plasticizers in clays, and fillers in such diverse products as toothpaste, rubber products, and paint. Not all of these endeavors have been successful and no permanent market for those materials has ever been established.

3. Incineration–Incineration of alum sludges is possible, but it is energy-intensive and is the source of offensive odors.

4. Landfill–Sludges that have been dewatered are useful as a backfill material or might be deposited in approved landfills. Dewatering methods might include filter presses, vacuum filters, centrifuges, and exposure to the atmosphere in drying lagoons or sand beds. Alum sludges require more time and/or effort to dewater than lime sludges or iron sludges. Polymer addition and flotation thickening might be beneficial for alum sludge. Alum sludges are usually dewatered to 35 percent dry solids; lime and iron sludges are usually dewatered to 50 percent dry solids. The water plant size is very important in determining the most economical dewatering method.

5. Landspreading–Lime sludges might be used to neutralize the acidic pH in farm soils. Spreading may occur only during certain seasons and, therefore, sludge must be stored until the farmland is ready for liming.

6. Discharge to the sewerage system–Water treatment plant sludges may be discharged to the sewerage system, if there is proper prevention of a cross-connection between the sewerage system and the potable water system. Sludge must be discharged at a constant rate or the wastewater treatment plant must be of sufficient size to prevent "slugs" at the plant. The section of the sewerage system carrying the sludge must be thoroughly cleaned on a regular basis to prevent decrease in capacity of the sewerage system or blockage (especially important for lime sludges), and sludge must be compatible with the wastewater treatment plant's biological, chemical, and sludge handling processes. Alum and lime sludges, in general, improve the removal of solids in the primary clarifier, but high lime dosages might have an adverse effect on the anaerobic digestion of the primary sludge. Iron sludges, in general, have little effect on the wastewater plant, because of the low amount of solids in the iron sludge. Brine from ion-exchange units can be accepted at wastewater plants, if it is discharged at a low rate.

Eleven water treatment plants discharge or soon will discharge to a sanitary sewerage system, and seven water treatment plants discharge to a landfill or other disposal. The discussion below summarizes the average daily volume of sludge, weight of dry solids being disposed of from these sites, and disposal method (based on information supplied by each water treatment plant in 1976).

About 11.3 tons/day dry solids enter or soon will enter a municipal wastewater treatment facility while about 1.3 tons/day dry solids are disposed of by other means.

Menomonee Falls water treatment plant uses pressure filters after aeration to remove iron from well water. 19,700 gal./day of sludge and 5 lb/day of solids are collected from the backwash of the filters to be discharged to the sanitary sewerage system on completion of the necessary controls and sewer connections at the water treatment plant.

Oak Creek water treatment plant uses alum for coagulation and filtration to remove suspended solids from lake water. 32,800 gal./day of sludge is collected from the clarifiers and is discharged to the sanitary sewerage system. The filter backwash water is settled and the supernatant is recycled; settled solids from the backwash are sent to the sanitary sewerage system.

Linnwood Avenue (Milwaukee) water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 60,000 gal./day of sludge and 7,670 lb/day of solids are collected from the clarifiers and is to be discharged to the sanitary sewerage system on completion of the necessary controls and sewer connections at the water treatment plant. The filter backwash water is to be recycled.

Howard Avenue (Milwaukee) water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 90,000 gal./day of sludge and 5,070 lb/day of solids are collected from the clarifiers for discharge to the sanitary sewerage system on completion of the necessary controls and sewer connection at the water treatment plant. The filter backwash water is to be recycled.

South Milwaukee water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 2,000 gal./day of sludge and 1,830 lb/day of dry solids are collected from the clarifiers and backwash of the filters and are discharged to the sanitary sewage system for six months per year. During the other six months, the sludge is held in a settling basin and the settled solids are landfilled.

Kenosha water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 5,000 gal./day of sludge and 3,060 lb/day of solids are collected from the clarifiers to be discharged to the sanitary sewerage system. The backwash is to be discharged to a settling basin with the overflow to the sanitary sewerage system and the settled solids will be landfilled.

Racine water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 24,100 gal./day of sludge and 4,820 lb/day of solids are collected from the clarifiers and is to be discharged to the sanitary sewerage system on completion of the necessary controls and sewer connections at the water treatment plant. The filter backwash water is to be recycled.

Port Washington water treatment plant uses alum for coagulation and filters to reduce solids from the lake water. 10,000 gal./day of sludge is collected from the clarifiers and filter backwash. Sludge and backwash is discharged to a settling basin and the resultant sludge is sent to the sanitary sewerage system. The clear supernatant is discharged to Lake Michigan.

Whitewater water treatment plant uses sand filters to remove iron from well water. 9,300 gal./day of sludge and 14 lb/day of solids are collected from the backwash of two filters and are discharged to the sanitary sewerage system. 8,600 gal./day of sludge and 5 lb/day of solids are generated from the backwash of one filter and are discharged to a marsh area.

Genoa City water treatment plant uses sand and charcoal filters to remove iron from well water. 620 gal./day of sludge and 3 lb/day of solids are collected from the backwash of the filters and are discharged to the sanitary sewerage system.

Oconomowoc water treatment plant uses filters to remove iron from well water. 1,860 gal./day of sludge is collected from the backwash of the filters and is discharged to the sanitary sewerage system.

North Shore water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. 960 gal./day of sludge and 1,460 lb/day of solids are collected from the clarifiers and are discharged to a drying lagoon. Polymers are used to aid the drying process. Solids are landfilled after drying. The filter backwash water is recycled.

Cudahy water treatment plant uses alum for coagulation and filters to remove suspended solids from lake water. The sludge collected from the clarifier is discharged to a lagoon with a fifteen year life remaining. The filter backwash water is recycled.

Lake Geneva water treatment plant uses pressure filters to remove iron from well water. Less than 10,000 gal./day sludge and 4 lb/day of solids are collected from the backwash of the filters and are discharged to a settling basin. The settled solids are landfilled. The supernatant is discharged to the White River.

Williams Bay water treatment plant uses lime to soften raw water and remove iron and manganese. 410 gal./day of sludge and 1,219 lb/day of solids are collected from the clarifiers and are discharged to drying beds. The dry solids are hauled to a gravel pit.

Elkhorn water treatment plant uses filters to remove iron from well water and ion-exchange units for softening. 15 gal./day of sludge is collected from the backwash of the filters and is discharged to a settling basin. The settled solids are landfilled. The supernatant is discharged to the storm sewer system.

Darien water treatment plant uses filters to remove iron from well water. 2,300 gal./day of sludge and less than 1 lb of solids are collected from the backwash of the filters and are discharged to a settling basin. The supernatant is discharged to Turtle Creek. The settled solids are to be hauled to a landfill when sufficient accumulation warrants.

Water treatment plant sludges that are discharged to the sanitary sewerage systems do not represent a large portion of the total solids being handled at area wastewater treatment plants and this is generally expected to continue through the year 2000. However, some of the available data are not considered to be very precise and the effect of these sludges on the individual units or overall performance at the wastewater treatment plants must be carefully evaluated in facilities planning programs to determine if the sludges have any adverse effects on the wastewater treatment plant operations.

The quantity of water treatment plant sludges is expected to increase from 25,200 lb/day to 30,000 lb/day sludge solids. This increase is not expected to cause operational problems at wastewater treatment plants, and it is expected that the wastewater treatment plants will be able to handle this modest increase without difficulty.

Those water treatment plants that are able to continue the landfill of sludge through year 2000 present no foreseeable problems, given that the landfills are properly operated and maintained.

SEPTIC TANK SLUDGES AND HOLDING TANK WASTES

There are few proven wastewater treatment methods which can be used to neutralize the polluting potential of the high BOD_5 and suspended solids concentrations of septic tank sludges. Sewage treatment plant operations have observed upsets and deterioration of effluent quality resulting from the direct addition of septage to the treatment plant. By controlling the rate of addition of septage, and thereby diluting the septage in the influent sewage, effects on the treatment processes can be minimized. The three primary parameters in developing dilution criteria are: suspended solids, oxygen demand, and (if from industry) toxic chemical concentrations. The type of treatment at the wastewater treatment plant dictates the degree of dilution required. It is the secondary biological processes (especially activated sludge) which are most susceptible to upset; plants with primary clarifiers are affected less because the clarifiers can dampen the shock loadings. In plants without primary clarifiers, dilution requirements are more critical and should be monitored more closely. Equalization tanks may be most applicable in these plants. Dilution should limit solids increases in the mixed liquor to 10% to 15%[1], to prevent substantial upset to the biological equilibrium. Small treatment plants are more susceptible to upset than large facilities for two reasons: 1) their low flows do not provide much dilution and 2) treatment often consists of aeration without prior primary settling.

Examination of the oxygenation capacity of small activated sludge facilities indicates that a facility may not have the aeration capacity to handle the intermittent septage loads delivered to the plant by private contractors. And even when the aeration capacity is sufficient to maintain the desired aerobic conditions, the sludge-handling facilities often do not have sufficient capacity. Addition of sludge with 30,000 to 40,000 mg/l solids to the aeration tank of an activated sludge facility would shorten the designed sludge retention period. This can decrease the dewaterability of the sludge and hence decrease the effectiveness of the solids concentration process.

It does not appear practical or economically feasible to design a central facility or modify an existing treatment plant[2] to treat septic tank wastes as long as there are enough area treatment plants to handle this load. Eight plants are currently known to accept septage on a regular basis.

Handling of septage and holding tank wastes at the treatment plants should consist of pretreatment and storage prior to dilution in the influent sewage. Coarse screens are necessary to remove large items such as bottles, cans, rocks, etc. Comminution or grinding is necessary for rags, plastic bags, and organic solids. These facilities are necessary at plants where these operations are not used for influent sewage. At larger plants, the septage can be added prior to these primary treatment processes. Both operations help prevent excessive wear and breakdown of plant equipment. Adequate wash down facilities should be provided to clean unloading areas and keep down odors. The problem of odor can be effectively controlled by aeration of the storage tank. Aerobic treatment with detention times of one day are sufficient in most cases to reduce the odor to the earthy odor of activated sludge.

[1]*Smith, S.A., and Wilson, J.C., "Trucked Wastes: More Uniform Approach Needed," Water and Wastes Engineering, March 1973, pp 48-57.*

[2]*Costs are lower when septage is handled as allocated. Also to operate and maintain an additional treatment facility in the Region is not in accord with the Regional Sanitary Sewerage System Plan.*

It is recommended that septage and holding tank wastes be treated at a wastewater treatment plant along with the other wastewaters received by the plant. Treatment plants in the region should recover costs through disposal fees to private haulers.

If septage is allocated to wastewater treatment plants based on approximately equal overload distance splits, all plants would be able to handle the additional loads. In almost all cases, the flow from septage is less than one percent of the average daily plant flow. In no case is the volume of septage greater than two percent of the average daily flow. (See Table 84.) However, to treat these allocated septic tank sludges, slug loads that could upset the biological organisms in the plant must be avoided. It is recommended that all plants accepting septage consider aerated holding tank capacities to allow dilution of the septage in the influent flow. The cost of equalization tanks is small. Actual dilutions should be coordinated with influent flow so that septage does not at any time exceed about five percent of the influent flow.

It should be noted that the allocated areas were not based on equal travel times or equal "over the road" distances to the various treatment plants. Consequently, the amount of septage being delivered to a treatment plant may vary by as much as ten to fifteen percent above or below the allocated amount. The loadings given in Table 84 have been rounded off to take into account these possible variations. As the number of persons served by septic tanks will be reduced in the future as sewerage service becomes available to more remote areas, the percent allocations will be reduced.

A more balanced division of septage service areas is shown in Map 11. This mapping is based on loads and transportation routes and should be used to guide the treatment of septage by area plants.

The trickling filter treatment process is not as susceptible as the activated sludge process to shock loadings, and, therefore, requires less careful monitoring of septage dilution rates.

SUMMARY OF COSTS OF SLUDGE HANDLING

This section contains further description and presentation of the costs associated with the plan elements appearing most feasible as a result of the screening process. The costs associated with the 21 major wastewater treatment plants are presented individually, while categories of plants are addressed in a general manner. A

TABLE 84

SEPTAGE LOAD ALLOCATION

Treatment Plant	Total Plant Flow MGD 1975	Allocated[1] Septage Flow MGD 1975	% Septage
Kenosha Co.			
Kenosha	18.44	0.0003	0.002
Twin Lakes	0.41	0.0006	0.15
Paddock Lake	0.17	0.0001	0.06
Silver Lake	0.15	0.0005	0.33
Pleasant Prairie (UD #D)	0.10	0.0004	0.40
Salem (SD #1)	0.08	0.00009	0.11
Bristol (UD #1)	0.07	0.0004	0.57
Somers (UL #2)	0.06	0.0008	1.3
Pleasant Park	—	0.0005	—
Pleasant Prairie (UD #73-1)	—	0.0001	—
Milwaukee Co.			
MSD-Jones Island	137.0	0.0	0.0
MSD-South Shore	73.7	0.0015	0.002
MSD-Hales Corners	0.52	0.0016	0.3
South Milwaukee	2.67	0.00002	0.0008
Ozaukee Co.			
Port Washington	1.70	0.0001	0.006
Cedarburg	1.41	0.0006	0.04
Grafton	0.88	0.0005	0.06
Thiensville	0.57	0.0009	0.16
Saukville	0.29	0.0005	0.17

TABLE 84

SEPTAGE LOAD ALLOCATION (CONTINUED)

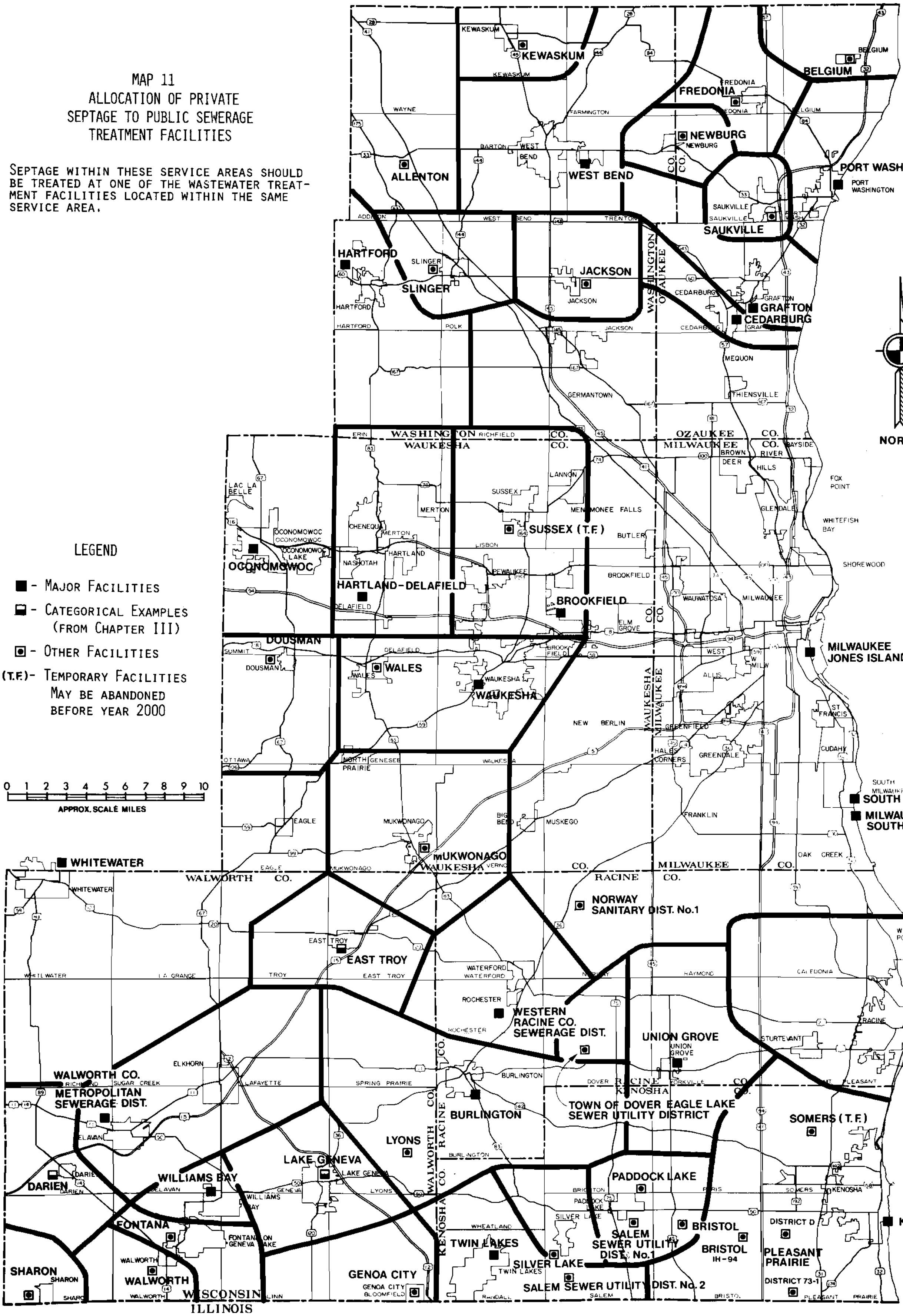
Treatment Plant	Total Plant Flow MGD 1975	Allocated[1] Septage Flow MGD 1975	% Septage
Fredonia	0.28	0.0003	0.11
Belgium	0.07	0.0002	0.29
Racine Co.			
Racine	19.69	0.00007	0.0004
Burlington	1.48	0.001	0.07
North Park (SD)	1.13	0.0003	0.03
Sturtevant	0.53	0.0009	0.17
Union Grove	0.43	0.0007	0.16
Western Racine County (SD)	0.24	0.0004	0.17
Caddy Vista (SD)	0.09	0.001	1.1
Walworth Co.			
Whitewater	1.14	0.0004	0.04
Lake Geneva	0.74	0.001	0.14
Elkhorn	0.69	0.0007	0.10
Delavan	0.59	0.0006	0.10
Fontana	0.52	0.0004	0.08
East Troy	0.25	0.0006	0.24
Williams Bay	0.20	0.0007	0.35
Darien	0.14	0.0002	0.14
Sharon	0.08	0.00009	0.11
Walworth	—	0.0001	—
Genoa	0.07	0.0006	0.86
Washington Co.			
West Bend	3.7	0.001	0.03
Hartford	1.37	0.0002	0.02
Germantown	0.80	0.0015	0.19
Kewaskum	0.32	0.0005	0.16
Jackson	0.26	0.0006	0.23
Slinger	0.15	0.001	0.67
Allenton (SD #1)	0.08	0.0005	0.63
Village of Newburg	0.07	0.0004	0.57
Waukesha Co.			
Waukesha	9.92	0.0015	0.015
Brookfield	2.48	0.002	0.08
Oconomowoc	1.90	0.0012	0.06
Menomonee Falls Pilgrim Road	1.40	0.0036	0.26
Menomonee Falls Lilly Road	0.70	—	—
Muskego (Big Muskego)	0.58	0.0011	0.19
Sussex	0.47	0.0019	0.40
Mukwonago	0.44	0.0012	0.27
Hartland	0.43	0.0023	0.53
Muskego (NE)	0.34	—	—
Pewaukee	0.30	0.001	0.33
New Berlin	0.13	0.0023	1.8
Dousman	0.11	0.0012	1.1

[1]*Based on "Allocation of Private Septage to Sewerage Facilities" SEWRPC Inventory Memo No. 16, 208 Study Volume No. 1900.*

Source: Camp Dresser & McKee Inc. and SEWRPC.

MAP 11
ALLOCATION OF PRIVATE SEPTAGE TO PUBLIC SEWERAGE TREATMENT FACILITIES

SEPTAGE WITHIN THESE SERVICE AREAS SHOULD BE TREATED AT ONE OF THE WASTEWATER TREATMENT FACILITIES LOCATED WITHIN THE SAME SERVICE AREA.



SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

portion of this section addresses the selected plan costs in terms of local costs incurred as an average over the study period. The best way to translate the costs into a more meaningful number is to present them on a per person and per household basis with federal and state aid and industrial cost recovery deducted. These values are not exact, but do give a good indication of the impact felt at the local level and show where this impact might be greatest. The costs do not include existing bonded indebtedness.

The local cost for sludge processing and utilization for each of the 21 major facilities was determined on the basis of the 75 percent federal aid for capital cost of construction and related planning and design. All operation and maintenance costs were assumed to be paid with local revenues. By deducting the grant-in aid portion, the resultant value represents the total local cost. To finance the local share of the capital costs, an average bonding rate of 6% was used in conjunction with the standard bond term of 20 years. The payment of capital improvements would be spread from the time of construction, generally 1978-1983, through about the year 2000. Operating costs for the proposed plan are for the same period. This analysis normalizes all of the costs and allows comparison between the various systems. However, it does not address the problem of outstanding bonds or debts. Because the interest rate is held constant, it does not reflect the local variations in the communities bond rating, and it does not address the total costs incurred by residents for all municipal services. It does pose the question of willingness to pay for the proposed management plan. After reviewing the costs, one can weight the improvement in environmental protection against the cost, and thereby judge the value of the sludge management system plan. Environmental considerations are further discussed in the Appendix.

Another factor considered was industrial user charges. It has generally been found that facilities accepting industrial wastes have sludge productions in excess of 0.25 lb/capita/day. Therefore, this value was used as a conversion factor for adjusting capital and operation and maintenance costs. For example, if the per capita sludge production at a plant was estimated at a value greater than 0.25 lb/capita/day, that portion above this value was deducted as a cost expected to be paid by the industry. The adjusted average annual cost was then divided by the population served to give the cost per person, then converted to a cost per household based on the Region's projected (1990) average number of persons per household.

For the categories of small facilities, the annual average cost was based on the type of wastewater treatment for a given average daily flow rate. The costs developed here are given at a general Region level and will vary from plant to plant.

For industrial facilities, it is necessary to consider the tonnage treated and refer to the cost curves for a per ton cost and an average annual cost. These facilities vary; dollar per ton costs will generally range from $40 to $120.

Table 85 presents the values computed for Alternative no. 1 for each of the large facilities. Costs for 19 of the 21 major plants (as previously discussed) represent a recommended approach to processing, transportation, and utilization. As can be seen, costs of sludge handling might be substantial, and especially for categories of other plants.

Similar or higher costs are incurred by industrial facilities and water treatment plants, however, these costs cannot be directly related to the same basis (see Tables 86 and 87).

This analysis shows that the apparent least expensive, most feasible system with optimum utilization and recycling of recovered sludge products is still costly.

NONECONOMIC CONSIDERATIONS INVOLVED IN SELECTION OF UTILIZATION/DISPOSAL OPTIONS

For purposes of environmental assessment, a distinction must be made between study alternatives and process/utilization options. The geographic alternatives evaluated consist of various groupings and locations of treatment plants which would be joined by a common treatment function or management program. The actual treatment process employed at the plants might be quite similar from one alternative to the next. The environmental effects associated with each alternative are far more sensitive to the process train options selected than to a specific geographic alternative. In cases where a specific sludge treatment process and utilization option is directly linked to a geographic alternative, the environmental assessment associated with the option might be more alternative-specific. An example of this situation would be where one large pyrolysis unit is proposed for a group of local sludge production facilities. Variations in treatment plant groupings are not as important in environmental impact matters as are the process options proposed for various sludge production sites. Specific discussion of factors considered is presented in Appendix K.

TABLE 85

LOCAL COSTS FOR SLUDGE MANAGEMENT—
19 MAJOR PLANTS

Plant Name	Adjusted Average Annual Cost (w/o industrial component)	Average Cost per Person per Year	Average Cost per Household per Year
Racine	$340,100	$1.50	$ 5.00
Kenosha	301,500	1.70	5.20
Waukesha	137,200	1.70	5.80
West Bend	113,800	3.50	11.80
South Milwaukee	43,800	1.60	4.20
Whitewater	56,100	3.60	11.20
Oconomowoc	48,200	1.70	5.80
Burlington	13,000	0.90	2.80
Walworth Co. MSD	61,200	2.70	8.30
Brookfield	154,200	1.70	6.00
Port Washington	50,500	4.10	14.30
Cedarburg	23,800	1.70	5.80
Grafton	60,800	5.70	20.00
Hartford	72,200	7.20	24.30
Twin Lakes	13,100	3.10	9.70
Williams Bay	7,200	1.10	3.40
Western Racine Co. MSD	29,300	3.40	11.00
Hartland-Delafield	52,900	2.90	10.40
Union Grove	63,000	6.50	21.00

Note: ENR 2445.

Source: Camp Dresser & McKee Inc.

Sludge processing/utilization options which lend themselves to centralized facilities might include pyrolysis/landfill, incineration/landfill, and production of commercial organic fertilizers or soil conditioners.

These options require construction of additional facilities. Implementation of any regional plant grouping alternative would require an additional level of management. Additional transportation of sludges would be required to bring the sludge from individual treatment plants to a central facility. This increased transportation demand would impose a number of environmental impacts on the Region including:

Increased consumption of energy resources

Increased emissions to the atmosphere

Additional wear and volume on existing transport routes

Potential construction requirements of roads, rail lines, or pipelines, depending on transport mode utilized

Increased potential for spills or leaks of sludge material during loading and transport operations

Commitment of transport resources, manpower, and construction resources

Required large capacity landfill sites for pyrolysis/incineration options

Commitment of land for structural development.

The capacity for conversion from one sludge utilization option to another is an important consideration. Options requiring the development of large processing facilities require a number of resources. Conversion would represent a loss or waste of those resources; consequently, there is limited flexibility to change. The capacity to initiate new systems or techniques in sludge management are important and might increase as new federal and state regulations are developed and implemented. The status of existing regulations is unclear and no rigid standards have been promulgated.

The recommended alternative with individualized management and process/utilization is readily adapted to alterations. The management of land application programs is as easily conducted on a local level as on a more sophisticated regional level. Ideally, sites receiving sludges will be located close to treatment facilities to reduce transportation costs and environmental impact.

Discussion of specific environmental impacts will be in terms of sludge process/utilization options proposed under the selected alternative. Individual sludge processing plants will be grouped in terms of the recommended sludge utilization process to be used. This is an effective method to discuss the resultant impacts, because similarities exist among the plants.

TABLE 86

LOCAL COSTS — OTHER TREATMENT PLANTS

Treatment Plant Category	Adjusted Average Annual Cost (w/o industrial component)	Cost per Person per Year	Cost per Household per Year
Trickling Filter			
0.5 mgd	$57,200	$17.30	$ 51.10
0.25 mgd	36,100	21.20	62.70
0.1 mgd	20,100	30.00	88.50
Activated Sludge			
0.5 mgd	64,000	19.40	57.20
0.25 mgd	38,700	22.80	67.20
0.1 mgd	24,500	36.60	108.00

Note: ENR 2445.

Source: Camp Dresser & McKee Inc.

Land Application
This utilization option appears most feasible for the majority of the major treatment plants (14) within the Region as well as for other plants, private plants and the food processing industrial categories. Land application is the practice of spreading sludge on land for the purpose of providing nutrients to sustain crop growth and productivity. The actual practice of spreading sludges on agricultural lands is not new. The majority of the treatment plants through the state are engaged in some form of land application. A number of methods can be used to spread the sludge which may be in a variety of forms. Composting sludges is one method of preparing sludges for land application.

The land application alternative option is related to the public pickup and organic fertilizer options (de-

TABLE 87

INDUSTRIAL TREATMENT UNIT COSTS
USED FOR TOTAL COST ESTIMATE

Industrial Treatment Plant	Total Cost $/ton	$/year
	Vacuum Filter and hauling and landspreading	
0.1 tpd	100	3,700
1.0 tpd	66	24,100
10.0 tpd	45	164,300
	Vacuum Filter and hauling and landfilling	
0.1 tpd	120	4,400
1.0 tpd	90	32,900
10.0 tpd	68	248,200

Note: ENR 2445.

Source: Camp Dresser & McKee Inc.

scribed below) in that sludge is being used as a fertilizer and soil conditioner. Sludges, in most cases, will be applied in a rather moist form so that a substantial quantity of water will be applied along with the sludge. This is important during periods when rainfall levels are insufficient to fulfill crop requirements.

Rates of application will be based on maximum crop uptake rates of nutrients as recommended in the Department of Natural Resources Technical Bulletin No. 88. This publication is now in the process of being adopted as part of the Wisconsin Administrative Code. All sites which are to receive sludges must first be approved by DNR field representatives. All sludge utilization systems will likely be required to monitor sludge quality, soil characteristics, and groundwater and plant uptake rates. The rates established for nitrogen by the DNR Bulletin are designed to provide the maximum requirement for optimum crop yield. Consideration is given to type of crop being cultivated, soil characteristics, and sludge nutrient content, as well as mineralization rates. Phosphorus concentrations within the typical wastewater sludge are more than sufficient to supply crop nutrient requirements. Potassium levels are low and some additional application of commercial fertilizer might be advisable.

Environmental impacts associated with land application are derived from three sources: transportation, application, and storage. The constituents of the sludge which are of concern include: metals, nutrients, and pathogens.

Sludges produced at the treatment plants must be transported to the fields for spreading. Truck transportation of the processed sludge would be the most effective method of transfer because trucks are highly flexible to destination or route changes and can begin transport immediately.

The movement of the vehicles along local roadways will impose certain demands on exising road systems. Truck traffic will contribute to increased road congestion and to road surface wear. Impacts can be reduced by minimizing the distance to spreading sites and by scheduling transport during times when traffic loads are light.

Vehicles utilized to haul sludge will contribute to the degradation of air quality throughout the Region. The level of deterioration in air quality will depend on the number of trucks transporting sludge along a specific corridor and on the existing air quality along that corridor. The trucks will emit quantities of particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons.

Usage of trucks for sludge transfer will result in the expenditure of transportation resources including equipment, roads, and fuel. Energy resources will be burned to operate trucks and field tractors during application periods.

The agricultural utilization of sludge as a fertilizer and soil conditioner is typically a seasonal event. Fertilizer is usually applied in the spring or fall during planting or after harvesting. This results in high demand of sludge during short periods of time and low demands during the rest of the year; it also necessitates the need for storage of sludges for extended periods of time. Facilities to store sludge must be adequate to accommodate the production volume accumulated over the winter months when the ground surface is frozen or flooded. Location of the storage facilities might pose a nuisance hazard to individuals located in adjacent areas. Storage might be accomplished by utilizing a lagoon or by some form of dry storage. Odor problems might occur if unstable sludges are exposed prematurely. To minimize these problems, a careful management policy must be followed.

Wastewater sludges contain a number of various pathogenic organisms which can potentially affect human health. The treatment process removes or destroys the great majority of these organisms, but total removal is nearly impossible. However, hazard to the general public is quite remote provided adequate precautions are taken.

Application of wastewater sludges to agricultural fields results in beneficial impacts. Organic matter contained in sludge improves the soil environment for crop growth. Slow decomposition of the organic matter contributes nutrients (especially nitrogen, phosphorus, and potassium) to growing plants, insuring a continuous supply of nutrients to crops throughout the growing season. Organic matter also improves the soil's capacity to retain water for plant growth. Crops require specific quantities of various nutrients to grow and mature properly. At the proper application rate, application of sludge to the land will supply adequate quantities of nutrients without surpassing the plant's assimulative capacity.

Adverse impacts of nutrient-sludge application to land are primarily associated with the nitrogen content since phosphorus is rapidly combined in the upper layers of the soil in relatively immobile forms.

Nitrogen in excess of crop demand is potentially hazardous to the human environment because contamination of groundwater resources might occur. Of primary concern is the potential for nitrate poisoning of individuals or animals which drink contaminated water. This condition, formally recognized as methemoglobinemia, affects individuals by reducing the oxygen-carrying capacity of the blood. Pregnant women and small children are particularly susceptible. Site-specific characteristics important in determining the ultimate availability of nitrogen include mineralization, application method, storage time, volitilization, residual soil nitrogen, crop type, and climatic weather conditions.

Nutrients applied on land might adversely affect surface water quality due to runoff. Phosphorus and nitrogen enhance algal blooms which contribute to increased eutrophication of the resource. Careful management of application rates and periods of application will minimize problems associated with nutrients. Site-specific evaluations of proposed application sites will determine their acceptability for sludge spreading. Sites with extreme slopes or direct drainage to surface water bodies are inappropriate for sludge application.

Sludge application on land might also contribute heavy metals to water resources, vegetation, and food chains. Food chains are composed of a group of living organisms which directly interact as a result of feeding habits. For instance, minnows feed on small invertebrate or vegetative life forms. Small fish in turn consume the minnows. The food chain is further expanded when larger fish consume the little ones. Man becomes a part of the food chain when he eats the fish. In this example, man is participating at the highest level in the chain. Food chains are in reality much more complex because individual animals can participate at more than one level.

Of primary concern is the potential for food chain accumulation of toxic heavy metals. Concentration of some heavy metals tends to increase with each higher level of the food chain in a process called bioaccumulation. While toxic levels of certain metals might cause disfunction of some body organs and lead to illness or death, symptoms may not appear immediately following consumption due to the slow accumulation process. Metals of concern are those which accumulate in plant tissues without impairing growth and development. Contaminated crops are then harvested and fed to domestic livestock or might be directly consumed by man. Cadmium appears to be the most hazardous of all. To overcome this health concern, there will be monitoring of sludge quality, soil, and crop tissues.

Other concerns associated with heavy metals, in conjunction with sludge fertilization, include plant toxicity (phytotoxicity) and water resource contamination.

Potential metal contamination of water resources is determined by the capacity of soil to bind metals in upper horizons, thereby, reducing the metals' mobility. Binding of the metals in the soil will prevent their migration to surface and groundwater resources.

Energy and fertilizer resources are closely associated because the commercial production of nitrogen fertilizers requires the consumption of natural gas. Use of wastewater sludges for agricultural crop production represents the recycling of a natural resource. The significance of this benefit might become more important as national fertilizer and energy resources become limited. National policy appears to be moving toward a more-conscientious management of all our natural resources; consequently, the optimum recovery of nutrients from wastewater sludges is most desirable.

The implementation of a landspreading program will require that some measures of site control be developed to limit foraging livestock or human contact with fields shortly after sludge application. Fencing or barriers might be required. In addition, close monitoring over an extended period of time will provide a substantial measure of safety to the system.

High Rate Land Application

A review of soils and groundwater information in the Region failed to yield a site where sludge could be applied at high rates without a high risk of groundwater contamination. High rate land application was, therefore, ruled out of consideration.

Soils where high rate spplication could be practiced would be sandy gravelly soils which have a high risk of groundwater contamination from nitrogen. These soils would require a leachate collection system and may require additional site preparation to seal the area to prevent leachate from reaching groundwaters. Sites where such site preparation is undertaken should be limited in size to areas where very high rate application would be possible; the site would then serve as a sludge landfill.

Public Pickup

The public pickup alternative allows the general public to "pick up" the stablilized processed sludge at a distribution location for use as a soil conditioner and fertilizer on private lands. The sludge may be given away or sold at a nominal fee. This sale may be subject to a tax of about $0.10 per ton at some future date.

This sludge utilization option was evaluated as being the most desirable in terms of environmental considerations based on results utilizing the environmental assessment matrix described in Chapter VIII. Three locations currently have a similar program in effect. The potential for more treatment plants to become involved in a public pickup operation is quite good and should be encouraged. Implementation of this system is generally limited by the public relations effort required to inform area residents of sludge availability and recommended usage. Pilot pickup studies might induce other communities to implement similar pickup programs.

Environmentally, public pickup is a very attractive method of utilizing sludges. The environmental benefits of adding sludge nutrients and organics to the soil are considerable and are similar to those of the landspreading option. Both options use the processed sludge as a fertilizer and soil conditioner. Those impacts, relating to nutrients, pathogens and heavy metals (as discussed under land application), are applicable to the public pickup system.

The nature of a public pickup program does not allow control over application rates and locations, and very little monitoring of application sites is expected. To promote public safety, a program for public pickup should include readily available information to potential users on appropriate application rates and methods. Assistance for the public in these matters should be readily available.

Implementation of a public pickup program will require adequate storage facilities to stabilize raw sludges. The storage facilities will also accommodate processed sludge during periods when public demand is low or insufficient to remove total daily output. This storage and stabilization process can cause odor and air quality problems, should processing actions not function effectively. Buffer zones can be established to protect the public welfare.

Sludges do not need to be transported by the sanitary sewerage system management agency provided the public is picking up the sludge at the treatment facility. Impacts resulting from spills and/or leaks can be mitigated by strict loading and hauling regulations. Spills will likely be small because the quantity of material being hauled is limited by the vehicle sizes used.

A public pickup program might impinge on the aesthetic qualities near the treatment facility, if proper housekeeping procedures are not followed. Messy and untidy facilities might present undesirable conditions and affect the acceptability of the program.

Organic Fertilizer Production

Continued production of organic fertilizer for sale on the retail market is being considered as a sludge utilization option at MSD-Jones Island.

An evaluation of the organic fertilizer alternative, utilizing the environmental assessment matrix, ranked it second to the public pickup option. The two options are dependent on direct public utilization and demand for the sludge product. Because the market for organic fertilizers is somewhat larger than that of public pickup, transportation impacts play a slightly greater role. Also, processing facilities will result in additional environmental impacts. Impacts directly related to processing structures include the commitment of land areas to industrial development, surfacing and paving of adjacent areas, and consumption of natural gas and/or fuel oil for drying. The construction of the buildings and parking areas will commit construction resources such as cement, steel, etc., as well as manpower and equipment.

Incineration—Pyrolysis with Ash Landfill

This option groups together the incineration and pyrolysis treatments which both burn sludges using high temperatures. Landfill disposal of the remaining ash is required. The primary differences between the two processes, which make pyrolysis more attractive environmentally, relate to air quality and energy resource recovery.

Pyrolysis is designed to recover energy from the sludge which, in turn, is used to support the unit's operation. This characteristic conserves energy resources which would otherwise be consumed in the conventional incineration process.

Air quality also has been a problem with sludge incineration facilities. Consequently, the environmental rating for air quality is more positive for the pyrolysis method than for incineration. Pyrolysis systems, however, are relatively new and problems have occurred in at least one existing facility. An experimental unit in Baltimore, Maryland, has been plagued by mechanical difficulties. The designer of the facility has withdrawn support of the unit and recommended it be converted to a conventional incineration system.

Only one site has been found to be feasible for a sludge incineration system; this system is located in Brookfield. The Jones Island and South Shore sites have not been ruled out at this time.

The incineration process requires substantial volumes of energy resources to process the wastewater sludge. This burning process will contribute to the total loadings of pollutants found in the atmospheric resources within the Region.

Pathogens found in the sludge will be destroyed as a result of incineration and pyrolysis.

Residual ash will have concentrations of various metals at levels above those found in preincineration sludge. This ash, lacking nutrient value, will require landfill disposal. The use of the landfill site will present other environmental impacts. The development of acceptable, licensed landfill requires that a substantial level of manpower and resources be expended to prepare a site for ash disposal. A land area will be committed to use, effectively removing that area from further optional use or development for an extended period of time.

Special provisions must be made to insure that metals contained within the ash do not escape from the landfill site and enter the surface or groundwater resources. The potential for water resource contamination from a landfill site is great because the hazardous metals have been concentrated within a small area. DNR regulations on landfill development and operation are designed to mitigate the hazard of leakage.

The disadvantage of sludge combustion is that sludge nutrients and organic matter are not recycled. In addition, the combustion process requires the consumption of energy to destroy the agriculturally beneficial substances.

Transportation impacts from the combination options are similar to those for land application but to a lesser degree, because the volume of ash requiring transport to the landfill is considerably smaller than the volume of processed sludge that must be transported to the land application sites.

Landfill

Landfilling of wastewater sludges with or without municipal refuse is not as attractive environmentally as the land application options already discussed, primarily because the resource value of the sludge is lost through disposal. The treatment plant located in West Bend, Wisconsin, is the only facility recommended for landfilling because of reported high levels of cadmium in the sludge. Landfilling is regulated by Chapter NR 151 of the Wisconsin Administrative Code.[1]

Environmental impacts associated with the disposal of wastewater sludges in sanitary landfills are quite varied. Land is committed to long-term use as a fill site which precludes most other land-use options. The size of the landfill relates directly to the quantity and moisture content of the sludge being disposed.

The recycling value of the sludge nutrients for crop production is lost in landfilling. Nitrogen, phosphorus, and potassium contained in the sludge will be buried, while commercial fertilizers will continue to be used on agricultural lands at the expense of large quantities of energy required in commercial fertilizer production.

The landfill site will concentrate the hazardous constituents of sludge in a confined area. Spills or leaks might occur and expose the surrounding environment to high concentrations of metals and pathogens. Health and environmental hazards attributable to landfill seepage include: ground or surface water contamination by metals and nutrients, pathogen transfer from the site to adjacent areas, surface water eutrophication, and increased sediment in aquatic resources.

A number of preventive measures are possible which will efficiently reduce the hazards of landfilling sludges. Extensive site preparation prior to landfilling can be conducted to seal the site against leakage and hazards. Natural drainage patterns can be adjusted to prevent the transfer of toxic or hazardous materials to surface waters. Rigid operating controls must be observed to insure that the landfill site is capable of accommodating all materials in an environmentally acceptable manner. Landfill management must be performed conscientiously to protect the public's long-term interests.

Resources utilized in the operation of the landfill site will be committed for the term of site usage. Site barriers or fences, machinery, site lining material, top soil, and labor will be expended. Some of these resources have already been committed in existing landfills. Transportation impacts are virtually the same as those described for landspreading. However, landfills are less susceptible to shut down than landspreading and considerably less dependent on climate or season.

The long-term goal of any municipality or sewerage district should not include the landfilling of municipal sludges as the sole available utilization/disposal process. Methods for improving sludge quality should be implemented when feasible so that the sludge becomes more amenable to land application. This would allow a conversion from landfilling to landspreading with minimal complications. Sludge quality monitoring is critical in meeting this objective because sludge quality is subject to frequent variation.

Other Sludge Processing Plants

There are a number of other treatment plants within the Region which have been evaluated by category. Most plants serve small communities and do not contain industrial wastes. Determination of the best sludge management program for these plants should be done on an individual basis, considering existing loads and utilization practice. In most cases it is anticipated that some form of land application be utilized. Since the level of most industrial effluents is low, the hazards of heavy metals are reduced. Land required to accommodate sludge loads from these plants is minimal, and readily available within short transport distances. En-

[1]*SANITARY LANDFILL. Sanitary landfill is a type of land disposal operation involving the disposal of solid waste on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the solid waste to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation, or at such more frequent intervals as may be necessary.*

vironmental impacts are similar to those described for land application of major plants but the magnitude of the impacts is much less. The public pickup process/utilization option might be ideal for small treatment plant use. Should sludges with high metals be produced at any of the small communities, landfill might also be needed.

Industrial Wastes—Contaminant Control

The selection of an individual plant sludge utilization option is dependent on sludge quality. Generally, municipalities with little or no industrial development do not have any problem with land application of their sludges since the heavy metals are not found in high concentrations. In cases where industries are contributing substantial flows to the system, some increased concentrations of toxic materials will likely occur. The removal of these toxic materials at the treatment plant may not be practical because of the high volume of sludge being processed and the diversty of materials being received. Typically, each industry or factory has special effluent characteristics which narrow the number of target constituents to be removed. Special equipment designed to extract these toxic substances may be more effective when operating at the point where the concentrations of toxic materials are high, namely, at the source contributing the toxic substances. Such contaminant control might be necessary to accomplish the goals of effective wastewater treatment. Industry may be required to pretreat its wastewater if the waste is a source of municipal plant process upset.

Not all industrial sludges or wastes are unacceptable for land application. Food processing industries usually produce a sludge or waste effluent which is high in organic matter content. This material is very desirable for land application. Brewery wastes may be considered as an animal feed supplement because of the high nutrient content. Such wastes are currently utilized in this way.

Industrial sludges produced as a result of pretreatment programs must be evaluated, as are public treatment facilities, in terms of sludge utilization options. Those which appear worthy of nutrient recycling should be managed in a similar manner and applied to the land.

Industrial sludges that are hazardous or toxic must be handled in a manner which will protect the public welfare.

CONFORMANCE WITH THE OBJECTIVES, PRINCIPLES, AND STANDARDS

The recommended plan meets the six objectives and supporting principles and standards presented in Chapter VII.

There is adequate land available for agricultural use of processed wastewater sludge, but this land is by no means abundant when such qualitative factors as farmer and community acceptance are considered. Therefore, conservation of available land is necessary (Objective 1—Standard 1). The recommended regional wastewater sludge management system utilizes existing facilities and future sites that appear to be consistent with the desired future land-use pattern, as well as the existing pattern within the Region (Standard 2). It does not appear that the facilities will impose an unreasonable cost to the homeowners or industries in the Region, but there is by no means a cheap solution (Standard 3). Replacement facilities are located at existing sites while new facilities are consistent with the regional land use plan insofar as the designated areas are delineated. Sludge disposal sites are located on existing and designated future agricultural areas and landfill sites are those with long expected useful lives.

Objective no. 2 encompasses seven supporting standards that address environmental and public health aspects of sludge disposal. The landspreading sites and backup landfills were selected based on consideration of detailed soil maps by SEWRPC, aerial photos, crop patterns, and previous reports. Proper storage facilities, conservation practices, and incorporation of sludge into the soil were designed in the process train development. Burning of sludges was considered in the incineration/pyrolysis option and was ruled out for all but Brookfield and possibly MSD-Jones Island and MSD-South Shore. Costs include the incorporation of air pollution control equipment to meet emissions standards. Costs are adequate to cover the required flood protection for new or replacement structures.

Objective no. 3 relates directly to the public health of the Region and is directed to the proper processing and handling of sludges to avoid harm from pathogenic organisms or toxic substances that may be harmful to humans or other life forms. All sludges to be applied to agricultural land for soil amendment purposes will have undergone digestion. Protective buffer zones were included in the costs of land and site development. The assessment of land available for agricultural use incorporates Standards 3 through 6 and these are simply part of the plan recommendation. Pretreatment of industrial discharges or treatment of sludge is recommended to reduce the threat from toxic and hazardous substances. Where these substances have been identified and isolated, they may be landfilled at a specially designed site.

Objective no. 4 calls for the maintenance of the productivity of agricultural land in the region. The recommended plan is based on the practices of Technical Bulletin No. 88, which is believed to offer adequate protection (Standard 1). Testing of sites is called for in Appendix F while a standard system of record keeping and sludge testing is called for in Chapter XI.

Objective no. 5 calls for the maximum recovery and utilization of resources contained within the sludge. Other than common landfilling, it does not appear that sludge management systems can combine functions with other solid waste disposal facilities (Standard 1). Substances of economic value are reclaimed in the form of methane gas from anaerobic digestion, nutrients and organic materials are added to the soil during land application, and should incineration/pyrolysis be practiced at MSD-Jones Island or MSD-South Shore, heat would be recovered (Standard 2). The plan makes maximum use of the organic and nutrient components of the sludge for soil amendment purposes (Standard 3).

Objective no. 6 stated that all objectives should be met by a system that is both economical and efficient. The recommended plan represents a low cost solution (Standard 1) and makes maximum feasible use of all existing and committed wastewater sludge management facilities (Standard 2) by making maximum use of existing plant process equipment with remaining life. Various methods of wastewater sludge handling and disposal were presented in Chapter VIII and address the need for consideration of the various methodologies (Standard 3). Each plant has presented for it a backup system and the plan is quite flexible, given the large number of independent systems and several process train options for MSD-Jones Island and MSD-South Shore (Standard 4). It is not recommended to purchase large tracts of land for application of wastewater sludge due to high cost (Standard 5). The recommended plan calls for sludge processing facilities that are sited along with the wastewater treatment facilities recommended in Planning Report no. 16 and in the several available facilities plans. This is particularly reasonable when one considers the generation and recovery of methane gas from anaerobic digestion processes for use in other plant units, the desirability to concentrate and stabilize the sludge prior to transportation, and the desirability to use public pickup for removal and utilization of stabilized, dewatered sludge cake (Standard 6).

CONCLUSIONS

Screening and analysis of potential Regional management systems for wastewater sludges from the 21 major municipal treatment plants and other municipal plants, as well as industrial wastewater sludges, water treatment plant sludges, and septage and holding tank wastes, have been discussed above. Based upon this evaluation of alternatives, the following conclusions have been reached:

1. There is no significant advantage in physically consolidating the 21 major plants or the other plants into subregional systems or a centralized Regional system. Other small systems should consider joint land application approaches to minimize costs. Joint sludge management associations of South Milwaukee with MSD-South Shore and Grafton with Cedarburg should be considered further.

2. Alternative 1, including a combination of process trains for the MSD-Jones Island and MSD-South Shore plants, is selected as the basic configuration of the Regional sludge management plan because:

   a. Maximum local control is provided

   b. Sludge produced by most plants may be utilized or disposed of close by

   c. It is the least cost system

   d. Maximum use is made of existing and planned structural facilities

   e. It is consistent with the objectives, principles, and standards (Chapter VII)

   f. It provides for extensive reuse and recycling of valuable materials in the sludge

   g. Public health is protected

   h. Productivity of agricultural land is maintained

3. The Region is fortunate in that most major sludge generators are close to land application sites, and Milorganite has an established national market.

4. With the exception of the MSD-Jones Island

and MSD-South Shore plants, municipal treatment plants including West Bend should effect sludge utilization through landspreading. Public pickup of stabilized sludge products is desirable and should be encouraged.

5. Sludge disposal facilities for all plants should in any event include designated landfills to be used in emergencies or when acceptance and demand do not equal production (see conclusions 8 and 14 below). Maximum use of the fertilizer, soil conditioner, or energy value of all sludge should be practiced, with disposal of sludges to landfills minimized.

6. The ultimate responsibility for and the core of a successful Regional program lies with the local management agencies. Each operating agency or sludge generator should commit itself to a program of site selection in cooperation with its neighbors both within and outside the Region.

7. Adequate suitable land must be made available to implement the Regional sludge management program, including required landfills, through the year 2000 and beyond. To assure that land is available when it is required, it is essential that management agencies begin immediately a coordinated program to develop public support leading to agreements with land owners for easement, lease and/or site acquisition as appropriate and SEWRPC should coordinate such a program. It is important in this context that each community recognize its long-term interdependence with others in the Region to solve the common problem of providing environmentally sound sludge utilization.

8. In the event of severe climatic or other limitation of land application techniques, it is necessary to have available backup landfills. Although the locations and types of waste accepted for the 88 sanitary landfills in the Region are a matter of public record, as of 1975 only three were licensed by the Wisconsin Department of Natural Resources to accept sludges and toxic and hazardous materials. It is not known how much additional landfill capacity suitable for sludge disposal is available in existing or potential sites. Accordingly, in order to assure adequate capacity of landfills in the Region for sewage sludge management, it is recommended that a Regional solid waste management plan be formulated to provide direction in the utilization or disposal of all solid wastes including sludge.

9. The optimum long-term process mix at the MSD-Jones Island and MSD-South Shore plants will depend on detailed facilities planning (currently underway) of economic, environmental, and energy factors and on the results of the marketing strategy for sludge-derived products from these facilities. Evaluation should include consideration of continued heat drying, incineration/pyrolysis, digestion, landspreading, landfilling, composting and combinations of these processes to provide flexibility in meeting future technological and regulatory changes. The production of heat-dried activated sludge should continue, on an interim basis at least, pending full implementation of the total solids management plan.

10. Evaluations of processing, transporting and utilization/disposal of sludge from the MSD-Jones Island Plant consider that combined sewer overflow sludge will be generated and handled in separate treatment facilities. Development of CSO facilities plans by the District may necessitate reevaluation of MSD-Jones Island and MSD-South Shore recommendations based upon separate treatment facilities.

11. In 33 (of 83 total) townships in the Region, there are about 172,000 acres of land currently suitable for land application of sludge. This acreage is 170 to 260 percent of that required for the agricultural application of all sludge generated by municipal treatment plants in the Region through the year 2000. The actual available acreage will depend on farmer and community acceptance. Farmer acceptance will depend to a large extent on the convenience and manner of application. Also, the regulations governing the land application of wastewater sludges are still in the developmental stage and rates may be established by the Environmental Protection Agency and other agencies in the future. The above acreages are based on current Wisconsin guidelines. (See Appendix F.)

    Certain heavy metals limitations suggested to EPA by the Department of Agriculture would, if adopted, not allow land application by 14 of the 21 major plants, based on available sludge quality data and the assumption of a moderately successful contaminant control program. An examination of the pattern of heavy metals values indicated that for the other seven major plants, two or three heavy metals are generally above the suggested limits, while for the other smaller plants, typically only one or two of the metals are above the suggested limits. Thus, while contaminant control programs are desirable, under such strict limitations they might not be sufficient to enable landspreading to be considered for all of the plants.

12. Maps 9 and 10 indicate lands that should be utilized for landspreading by each individual wastewater treatment facility to minimize transportation of sludge throughout the Region.

13. High-rate land application of sludge could be practiced where land will not be used, in the future, for agricultural purposes. Sites with suitable soils which, according to the SEWRPC year 2000 land use plan, are expected to be urbanized, represent such lands in this Region. However, there is insufficient acreage of land in the Region suited to high-rate land disposal at a low risk to make this option a viable long-range alternative for Southeastern Wisconsin.

14. Many sludges resulting from separate pretreatment of industrial wastewaters contain heavy metals or other contaminants and, unless concentrations are reduced to nonhazardous levels, should be disposed of only in licensed hazardous and toxic wastes landfills. Three such landfills exist in the Region; however, these sites have limited capacity for such wastes. As part of a Regional solid waste management planning study additional site requirements should be evaluated as a top priority item.

15. A variety of contaminant control strategies should be considered to reduce contaminant levels to those which will allow use of all feasible solids management processes including landspreading. Such strategies should include control of contaminants in raw materials being used by industry, in-plant industrial process change, pre-treatment by industry, monitoring of suspected sources of contaminants, sidestream treatment at treatment facilities, and disposal at landfill sites licensed to receive such materials.

16. Some industrial wastewaters in the Region contain concentrations of contaminants which result in high levels of these contaminants in municipal wastewater sludges. When such industrial wastewaters are discharged directly to municipal systems, these contaminants appear in the municipal sludge to be disposed of in licensed hazardous waste disposed sites.

17. Sludge disposal/utilization in conjunction with solid waste/refuse systems or electric utility operation does not appear feasible with presently available technology. However, joint utilization for power generation should be considered in the future.

18. Pipeline transport of sludge to land application sites does not appear to offer advantages over trucking.

19. Water treatment plant sludges do not generally present a serious future problem and may be discharged at uniform rates to municipal wastewater collection systems, where they are close-by, or dewatered at water treatment plants and landfilled.

20. Septage should be accepted at the local wastewater treatment plants. Properly equalized septage should not upset treatment processes. Map 11 shows local areas which may be served by each wastewater treatment plant.

21. It is not desirable nor is it economically or environmentally justified to export liquid or cake sludge from the Region on a large scale.

Chapter X

RECOMMENDED REGIONAL SLUDGE MANAGEMENT SYSTEM PLAN

INTRODUCTION

The purpose of this chapter is to present and summarize the recommended plan formulated through the analyses presented in Chapter IX. The recommended plan consists of sludge management system plan recommendations for the 21 major wastewater treatment facilities and for categories of other types of sludges[1] in the region; namely, other wastewater treatment plant sludges, industrial facility sludges, water treatment plant sludges, leachates, and septage and holding tank wastes.

The recommended plan (defined as geographic Alternative 1) was selected after consideration of the economic and noneconomic factors related to feasible options for processing, transportation, utilization, and disposal of sludge. The approach included a consideration of all important factors, i.e. costs and technical feasibility and noneconomic factors (primarily environmental). Systems which appeared most technically feasible and least expensive also rated high on the environmental scale, and hence, no major conflicts developed between economics and environmental considerations. Specific resolution of the exact techniques of sludge spreading for land application and responsibility for each phase of the spreading operation will have to be reviewed on a case by case basis and approved by the Wisconsin Department of Natural Resources. While it is relatively simple and inexpensive for wastewater treatment plant personnel to haul loads of sludge to a nearby farm, some farmers find their existing spreading equipment improperly designed to handle municipal sludge. Therefore, a plant might have to provide for spreading in order to convince the farmer to accept the material. These uncertainties must be resolved during facilities planning efforts.

The ultimate responsibility for undertaking the necessary detailed planning, engineering and construction of wastewater sludge processing, transportation and disposal or utilization lies with the local management agency. While guidance from UWEX, SEWRPC, DNR, and others is available, facilities plan formulation and application site selection are the responsibility of the local agency.

Under each geographic alternative, a number of process train options are available for each plant. Similarly, within each process train, a number of specific unit operations are available. This three level definition of plan recommendations is necessary because of the many components to be addressed.

Specific information on the existing wastewater treatment and sludge management systems was presented in Chapter III. The market analysis for alternative municipal wastewater sludge products was presented in Chapter IV and, for purposes of Regional sludge management alternatives assessment, indicated an adequate national market potential for the heat-dried activated sludge from the MSD-Jones Island plant in the turf management and home lawn market; a modest regional market potential for composted sludge from the MSD-South Shore plant; and a generally adequate but highly seasonal and highly elastic regional market potential for liquid or cake sludge from the entire region in the farm market. Chapter V set forth sludge quality characteristics and the projections of sludge quantities. Chapter VI was a discussion of basic regulatory considerations, Chapter VII contained the objectives, principles, and standards, and Chapter VIII, the design criteria and analytical procedures. The material in these chapters formed the basis for the alternatives analysis in Chapter IX. The basic alternatives for consideration were developed using the material presented in Chapters III and VIII. Analysis techniques applied were those listed in Chapter VIII, while further measures of plan suitability were provided by Chapters IV, VI, and VII. The sludge quantity projections in Chapter V allowed for sizing of plan components.

An analysis of application of sludges to agricultural lands is contained in Appendix F. The land acreage required for application of sludge under various conditions of sludge load and quality is presented and the implications of contaminant control and regulatory constraints addressed.

[1]*Solids from treatment of combined sewer overflows are discussed under the major wastewater treatment facility where they occur.*

RECOMMENDATIONS FOR MAJOR MUNICIPAL WASTEWATER TREATMENT PLANT SLUDGES

The recommendation for wastewater sludge management for the major wastewater treatment facilities is presented in Tables 88 and 89. Table 88 shows the relationship between the recommended processing, transportation and utilization options labelled "P" and the presently existing facilities and operations labelled "E"; also shown are alternate processing options and backup utilization/disposal options to the recommended plan. Table 89 identifies the recommended processing facilities to be constructed at 19 of the 21 major facilities, their required additional capacity, start-up year and expected lifetime. The recommendations for both the MSD-Jones Island and MSD-South Shore wastewater treatment plants are that consideration be given in the ongoing Total Solids Program to evaluating and implementing a combination of two or more of the process trains considered in this sludge management plan.

Landfilling is the ultimate disposal process in the event that land application or other utilization/disposal options are limited. However, presently there is insufficient available landfill volume if large volumes of sludge should have to be landfilled for extended periods of time. Long term, areawide solid waste management planning is required to assure availability of adequate environmentally acceptable fill sites. The worst case would be a failure of some large segment of the plan, caused by climatic conditions, regulatory constraint or public opposition to land application.

In general, the recommended plan calls for each plant to operate, maintain, and construct its own facilities as necessary. This is a least cost, acceptable, feasible approach. In addition, joint spreading of sludges from more than one plant at the same site or sites may in some instances result in cost savings and should be considered on a case by case basis. Joint landfilling operations also should be considered with other operating agencies; however, cost effects upon the Regional plan would not be significant. Where public pickup of stabilized sludge may be successfully practiced, it should be fully encouraged, otherwise the municipality or district will have to haul and, in some cases, spread the sludge on farm fields.

Plants with anaerobic digestions for sludge stabilization will have digester gas available for in-plant use. Since anaerobic digestion is a process option compatible with reuse of sludge through landspreading, digestion allows further recovery and reuse of the waste material.

Contaminant control or sludge treatment programs for heavy metals and toxics should be developed, implemented, and enforced where such action will assure acceptable sludge quality for long-term land application. These programs are most appropriate for major facilities as these facilities are the source of most of the metals loading. Consideration of cadmium contamination is the most critical element of contaminant control program development.

The program management and overview will be discussed under implementation in Chapter XI. However, it is evident that an information storage and retrieval system must be developed so that a complete record of where, when, and in what amount sludge has been applied to land is clearly documented. This documentation should be part of the records transferred to new land owners so that the history of sludge application will be known and can, therefore, be considered in future land uses. A form for complaint receipt and resolution for all sludge management problems at the local level should be maintained to help minimize problems.

The following summarizes the recommendations for major facilities in the Region as outlined in Table 89.

MSD-Jones Island—There are two groups of proposed sludge processing and final utilization/disposal options for the Jones Island treatment plant which require detailed evaluation (see Table 88 and 90): 1) continued Milorganite production with additional sludge processed and disposed of or utilized separately, and 2) phase out of Milorganite production with all sludge processed and disposed of or utilized separately.

The process trains including continued Milorganite production include an incremental sludge quantity to be handled separately. This separate treatment of incremental sludge quantities consists of either: 1) dewatering followed by incineration/pyrolysis with landfill residue disposal, 2) anaerobic sludge digestion with subsequent dewatering and landspreading or landfilling of the dewatered cake, or 3) the full production of Milorganite with renovation of the facilities, with expanded dewatering and drying capacity. These process trains recognize the possibility of maintaining a production of Milorganite at some level while addressing the possibility that the demand for Milorganite may be subject to market and regulatory constraints. Thus, it appears desirable to maintain flexibility by implementing more than one process train.

Process trains including phaseout of Milorganite production involve dewatering of all thickened waste-activated sludge from the Jones Island plant, with final

TABLE 88
SELECTED PROCESSES FOR REGIONAL SLUDGE MANAGEMENT

ALTERNATIVE #1	Sludge Processing Options											Transport Options			Utilization/Disposal Options							
Wastewater Treatment Facility	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail/Barge	Pipeline	Incineration/ Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
MSD-Jones Island	PE			P		PE	PE P	P			P PE E	P PE E	PE E	P	P	P	P	P		P	PE E	
MSD-South Shore	PE	P		P PE		P	P	P	E			PE	P	P	P	P	E P	P	P	P		
Brookfield	P		E**			PE		PE				PE			PE	PE						
Port Washington	P		E	PE		A	A		P*			PE				B	PE					
Grafton	P		PE	E		A	A		P*			PE				B	PE					
Cedarburg	PE			PE		A	A		P*E	PE		PE				B	PE					
Grafton/Cedarburg	PE			PE		A	A		P*E	E		PE		P		B	PE					
Hartford	P		PE			A	A		P	PE		PE				B	PE					
West Bend	P Po			P Po E		P Po	P Po		E			E P Po				P Po	BEPo					
South Milwaukee	P			Po P E	E[2]	P Po	P	Po[1]	E	PE		PE				BE	PE	PE				
Whitewater	P Po			P Po		P Po		P[1] Po[1]				PE				P Po	PE	Po				
Oconomowoc	PE			PE		PE	PE					PE				BE	PE					
Burlington	P	PE	E	PE		PE				E		PE				B	PE					
Walworth County	P Po			PE Po		A	A			E		Po PE				E	P Po					

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process

Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank

2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

TABLE 88
SELECTED PROCESSES FOR REGIONAL SLUDGE MANAGEMENT (continued)

ALTERNATIVE #1

Wastewater Treatment Facility	Sludge Processing Options: Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Transport Options: Truck	Rail/Barge	Pipeline	Utilization/Disposal Options: Incineration/Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
Twin Lakes	P		E	PE		A	A		P	PE		PE				B	PE	PE				
Williams Bay	PE			PE		A	A		P*	PE		PE				B	PE					
Western Racine	P		Po E	P Po		A	A		P	P Po E		PE				B	P Po E					
Hartland-Delafield	P			P Po		A	A		P Po			P Po				B	P Po					
Union Grove			P Po	E		A	A		E	P PoE		P Po E				BE	P Po					
Racine	P			PE		PE	PE					PE				BE	PE					
Kenosha	PE			PE		PE		PE				PE				B	PE					
Waukesha	P Po			P Po E					P Po E			P				B	P	P Po E				

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process
Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank
2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

disposal utilization by means of incineration/pyrolysis with residue landfill or anaerobic digestion with dewatering and landspreading or landfilling. These process trains recognize that Milorganite production may be gradually phased out and ultimately abandoned as a method of sludge handling.

MSD-South Shore– It is recommended that all sludge generated at the MSD-South Shore Treatment Plant be thickened by dissolved-air flotation. It should then be either: 1) digested, dewatered, and landspread or landfilled; 2) dewatered and composted, and/or 3) dewatered, incinerated/pyrolyzed, and the residue landfilled.

In addition, combining the sludge from the South Milwaukee Treatment plant with the sludge from the MSD-South Shore treatment plant appears to be economical. Transportation options between the MSD-South Shore and Jones Island plants which should be considered for both the interim and the long-term solutions are barge, rail, and pipeline. Storage facilities prior to ultimate disposal or utilization will depend on the process trains selected, at the facilities planning level, for both the interim and long-term solutions. A combination of process trains is recommended to deal with changing technology, regulatory considerations, and economics or energy and marketing.

Brookfield—Thickeners should be considered prior to the filter presses as a means of improving their operation. Expansion of the filter press capacity through the addition of a second unit is required and is recomended. Continued use of the present incinerator is possible through the year 2000 and ultimate disposal of ash should be landfilling.

Port Washington—Thickeners should be added prior to digestion. Digestion should be continued in the existing anaerobic units which will have adequate capacity through year 2000 with use of the proposed thickeners. Sludge lagoons located near landspreading sites are recommended. Transportation should be by truck as at present.

Grafton–Facilities planning for both Cedarburg and Grafton is currently underway. The economic advantages point to separate sludge management. If the Village of Grafton decides to continue with the present system of independent sludge management, gravity thickeners should be considered for addition to the plant prior to digestion and consideration should be given to increasing the digestion capacity. Lagoons located near landspreading sites should be considered. Hauling sludge from the treatment plant and from the lagoon should be by truck as at present.

Cedarburg–Facilities planning for both Grafton and Cedarburg is currently underway. It is economically advantageous for sludge from the Cedarburg plant to be managed separately from that of Grafton. If the City decides to continue with an independent sludge management program, capacities of the existing gravity thickeners and anerobic digesters are adequate through year 2000. Additional lagoon capacity at a site near landspreading operations should be considered. Transportation of sludge should be by truck as at present.

Hartford–Existing sludge processing facilities are adequate through the year 2000 with the exception of dewatering. Expansion of the dewatering capacity of the existing sand beds with a lagoon is recommended. Truck hauling to landspreading sites should be continued as at present.

Twin Lakes–A gravity thickener should be added to the existing process train to improve the operating characteristics of the anaerobic digester. Additional capacity in the form of lagoons should be added. Ultimate utilization through expansion of the present program of public pickup should be supplemented, if necessary, by landspreading. Transportation should be by truck.

Williams Bay–The present capacity of sludge handling with the exception of dewatering is adequate through the year 2000. A lagoon should be added in 1990 to supplement the existing sand beds. The lagoon should be constructed near landspreading sites, and transportation should be by truck.

Western Racine County MSD–Expansion of the existing sludge handling facilities is required. The recommended train is: gravity thickening, anaerobic diges-

TABLE 90

RECOMMENDATIONS FOR FACILITY PLANNING EVALUATION FOR THE METROPOLITAN SEWERAGE DISTRICT OF THE COUNTY OF MILWAUKEE

MSD-Jones Island Plant

Sludge processing facilities evaluation:

1. With Milorganite Production
   Thickening by gravity
   Chemical conditioning
   Dewatering with drying for Milorganite and:
   A. Incineration/Pyrolysis followed by residue landfilling and/or
   B. Anaerobic digestion prior to dewatering followed by landspreading or landfilling or
   C. No other processing.
2. With No Milorganite Production
   Thickening by gravity and/or dissolved-air flotation with:
   A. Dewatering and Incineration/Pyrolysis with residue landfilling and/or
   B. Anaerobic digestion with dewatering and landspreading or landfilling.

MSD-South Shore Plant

Sludge processing facilities evaluation of thickening by dissolved-air flotation with:

1. Anaerobic digestion, chemical conditioning and dewatering with landspreading or landfilling and /or
2. Dewatering, Composting and/or
3. Dewatering, Incineration/Pyrolysis with residue landfilling.

NOTES:

1. If effluent requirements are changed to 5 mg/l BOD_5 and 5 mg/l suspended solids, these recommendations are not expected to change. Recommendations to be evaluated under MSD Total Solids Management Program.
2. Backup system to all those shown is transport of sludge to landfill.
3. Evaluation should include transportation of sludge between plants in the MSD Total Solids Management Program.
4. Development of CSO facilities plans by the District may necessitate reevaluation of the above recommendations.

Source: Camp Dresser & McKee Inc.

TABLE 89

PROCESSING FACILITIES TO BE CONSTRUCTED FOR YEAR 2000 AT 19 OF 21 MAJOR PLANTS

Processing Facility	Required Additional Solids Capacity (dry tons per day)	Date of Approximate Startup	Date of Approximate End of Useful Life
Racine			
Gravity Thickener (Primary)	24.0	1982	2012
Dissolved Air Flotation Thickening (Secondary)	6.0	1982	2012
Anaerobic Digester	18.6	1982	2012
Kenosha			
Gravity Thickener (Primary)	11.8	1981	2011
Anaerobic Digester	10.5	1981	2011
Waukesha			
Gravity Thickener (Primary)	10.3	1981	2011
Dissolved Air Flotation Thickening (Secondary)	4.0	1981	2011
Anaerobic Digester	5.9	1981	2011
Lagoon	6.0	1981	2011
West Bend			
Gravity Thickener (Primary)	8.8	1981	2011
Anaerobic Digester	4.5	1981	2011
Vacuum Filters	6.6	1981	2011
South Milwaukee			
Gravity Thickeners	2.5	1981	2011
Vacuum Filters	1.7	1981	2011
Whitewater			
Dissolved Air Flotation Thickening	4.0	1982	2012

TABLE 89 (CONTINUED)

PROCESSING FACILITIES TO BE CONSTRUCTED FOR YEAR 2000 AT 19 OF 21 MAJOR PLANTS

Anaerobic Digesters	4.9	1982	2012
Belt Filter Presses	3.0	1982	2012
<u>Oconomowoc</u>			
Plant under construction	0	1977	2007
<u>Burlington</u>			
Gravity Thickeners	2.3	1981	2011
Centrifuge	0.7	1981	1996
<u>Walworth County MSD</u>			
Gravity Thickeners	2.3	1981	2011
Anaerobic Digesters	2.3	1981	2011
Holding Tanks (Aerated)	(150 days)	1981	2011
<u>Brookfield</u>			
Gravity Thickener	9.8	1980	2010
Filter Press	5.6	1980	2010
<u>Port Washington</u>			
Gravity Thickener	2.0	1980	2010
Lagoon	1.5	1980	2010
<u>Cedarburg</u>			
Lagoon	1.6	1980	2010
<u>Grafton</u>			
Gravity Thickeners	2.3	1981	2011
Anaerobic Digester	1.3	1989	2019
Lagoon	1.7	1981	2011

TABLE 89 (CONTINUED)

PROCESSING FACILITIES TO BE CONSTRUCTED FOR YEAR 2000 AT 19 OF 21 MAJOR PLANTS

Hartford			
Lagoon	0.8	1980	2010
Twin Lakes			
Gravity Thickener	1.0	1980	2010
Lagoon	0.6	1980	2010
Williams Bay			
Lagoon	0.2	1990	2020
Western Racine County MSD			
Gravity Thickener	0.9	1981	2011
Anaerobic Digester	0.9	1981	2011
Lagoon	0.7	1983	2013
Hartland/Delafield			
Gravity Thickener	2.2	1980	2010
Anaerobic Digesters	2.2	1980	2010
Lagoon	1.6	1980	2010
Union Grove			
Aerobic Digester	1.0	1979	2009
Lagoon	0.8	1979	2009

Source: Camp Dresser & McKee Inc.

tion and lagoons. Ultimate utilization should be by landspreading, and transportation to spreading sites should be by truck as at present.

Hartland/Delafield—A new wastewater treatment facility has been proposed by the Commission's consultant. Their recommendations include anaerobic digestion followed by lagoons. The findings of this study support those recommendations; however, it is felt that the addition of a gravity thickener prior to digestion would improve the sludge handling process. Ultimate utilization by landspreading is recommended as is transportation by truck.

Union Grove—A new wastewater treatment plant is being constructed which includes aerobic digestion followed by sand bed dewatering. An evaluation of the operating characteristics and capacities after startup will determine, more precisely, future needs. Should additional capacity be required later in the planning period, aerobic digestion and lagoons should be added to the present process train. Ultimate utilization should be by landspreading, and transportation of sludge should be by truck.

Racine—Continued use of the existing process train; use of existing and newly constructed facilities with expansion (as required) of the digesters. Thickening, prior to digestion, is recommended for consideration; new construction would include gravity thickeners for primary sludge and dissolved-air flotation thickeners for secondary sludge. For final utilization, sludge cake is to be trucked to landspreading sites.

Kenosha—Continued use of the existing process train. Expansion of the existing anaerobic digester capacity with additional new units. Expansion of the thickener capacity with a gravity thickener for primary sludge. Ultimate use of sludge should be by landspreading and transportation by truck to the spreading site.

Waukesha—Expansion of the present facilities as proposed by the City's consultant in their Facilities Plan with digestion and lagoons. Additional processing by thickening is recommended for consideration: gravity thickeners for primary sludge and dissolved-air flotation thickeners for secondary sludge. Utilization through the present public pick-up program should be continued.

West Bend—Upgrading of existing treatment plant and sludge handling facilities with new construction recommended by the City's consultant includes gravity thickening, anaerobic digestion and vacuum filters. Ultimate disposal should be by landfilling at a landfill where sludges with high concentrations of heavy metals can be accepted unless sludge quality can be improved through a program of contaminant control or sidestream recovery.

South Milwaukee—Trucking sludge to the MSD-South Shore plant is less expensive than constructing additional sludge processing and utilization facilities, as shown in Chapter IX.

If the City decides to continue an independent sludge management program, it should consider the use of gravity thickeners prior to the existing digesters, and following digestion, dewatering by vacuum filtration. Ultimate utilization by landspreading appears best, and transportation to spreading sites by truck will provide the most flexibility.

Whitewater—Sludge handling by thickening (dissolved-air flotation type), anaerobic digestion, chemical conditioning and belt filter presses, as designed by the City's consultant, is supported and recommended. Ultimate utilization should be by truck hauling to landspreading sites.

Oconomowoc—The wastewater treatment facility under construction will be capable of handling projected sludge loads through the year 2000. Sludge processing includes: dissolved-air flotation thickening, anaerobic digestion, chemical conditioning and vacuum filtration. Ultimate utilization by truck hauling to land application sites is recommended.

Burlington—Sludge thickening by gravity is recommended to be considered for improving sludge handling efficiencies and reducing treatment costs. Expansion of the centrifuge capacity may be economical if the present unit proves satisfactory; however, the least costly mode of future operation may also be to landspread liquid sludge in excess of the centrifuge and sand bed capacity. Trucking sludge to landspreading sites should be continued.

Walworth County MSD—The facilities plan prepared by the District's consultant proposed gravity thickening, anaerobic digestion and holding tanks followed by truck hauling and liquid landspreading. The findings of the consultant are supported by this study and are recommended.

Plants with anaerobic digestion for sludge reduction and stabilization will have available for in-plant use digester gas. Since anerobic digestion is a process option compatible with reuse of sludge through landspreading, digestion allows further recovery and reuse of the waste material.

Cost of Recommended Plan—Major Facilities

The estimated total cost of the recommended plan for 19 of the 21 major facilities is shown in Table 91. Table 91 presents the estimated capital cost, operation and maintenance cost, present worth cost and average annual cost of the facilities described in Tables 88 and 89.

RECOMMENDATIONS FOR CATEGORIES OF FACILITIES SLUDGES

Other Wastewater Treatment Sludges

Table 92 summarizes the recommendation for other wastewater treatment plants. Many of the general recommendations made for major facilities apply to this category. The alternative process trains developed from these process, transport, and utilization/disposal unit process options are feasible and provide a least cost approach. It should be remembered that the best process in a small plant is most often that which is the simple and least subject to upset due to shock loads. Final utilization through land application is most desirable. Septage and holding tank wastes may be accepted at all municipal plants provided proper control of flow is practiced.

Industrial Wastewater Treatment Plant Sludges

Table 93 summarizes the general recommendations for industrial pretreatment sludges. Recycle of materials within industries should be encouraged to reduce the material entering the pre-treatment process and the sewerage system, to recover valuable materials where possible, and to reduce the quantities of waste materials entering the environment. With proper pretreatment, source control, or other contaminant control measures, industries presently discharging to a municipal treatment facility, as indicated in Chapter III, may continue to do so; however, the operator of a municipal treatment plant should receive prior notice of any major industrial process change which might affect the existing treatment. Those sludges containing large amounts of heavy metals or toxics such as to preclude landspreading should be landfilled at approved sites with proper groundwater and surface water protection. The three landfills in the Region licensed to accept toxic and hazardous wastes have limited future capacity for these wastes; additional site requirements should be evaluated as a top priority matter. Incineration may be cost-effective for some metals machining sludges.

Municipal sludges are not usually considered as toxic and hazardous wastes; however, a special permit is required if a landfill is to accept sludge. In municipalities where there is little or no industry, sludge should not have a high concentration of heavy metals or other toxic substances. These municipal sludges present few problems. Where industries which have toxic wastes exist in the sewer service area, three possibilities exist for a sludge that may require special permits and special considerations in its disposal:

1. The industry pretreats and has a sludge which could be classified as toxic or hazardous—no toxic material enters the municipal sludge.

2. The industry partially pretreats; both the industry and the municipality may have a sludge that could be classified as toxic and hazardous requiring special considerations in its disposal.

3. The industry does not pretreat—the industry has no sludge but the municipality may have a sludge that could be classified as toxic and hazardous requiring special considerations in its disposal.

Water Treatment Plant Sludges

Water treatment plant sludges may be discharged to the nearest sewerage system if rates are controlled to avoid upsets at the wastewater treatment plant. Water treatment plant sludges do not appear to present a serious future problem. If no Sewerage System is available these sludges may be dewatered and disposed of in landfills.

Leachate Collection, Treatment, and Disposal

All landfills, and particularly those accepting hazardous and toxic wastes, should be designed to minimize the production of leachate and for the protection of groundwater. Leachate that may be produced must be collected and treated before discharge to nearby water courses. Treatment may be provided at a municipal wastewater facility or at a self-contained onsite facility. Although the location, and type of waste accepted at the 88 sanitary landfills in the Region are a matter of public record, as of 1975 only three were licensed by the Wisconsin Department of Natural Resources to accept sludge and toxic and hazardous materials. It is not known how much additional landfill capacity suitable for sludge disposal is available in existing or potential sites. Accordingly, in order to assure adequate capacity of landfills in the Region as a back-up system for sewage sludge management, it is recommended that a regional solid waste management plan be formulated to provide direction in the utilization or disposal of all solid wastes including sludge.

TABLE 91

TOTAL COST OF RECOMMENDED SLUDGE MANAGEMENT PLAN FOR THE MAJOR FACILITIES[1]

Treatment Plant	Estimated Capital Cost	Estimated 1st Year Operations & Maintenance Cost	Estimated Average Annual Cost[2]
MSD-Jones Island[3]	$ 59,000,000 to $ 98,000,000	—	—
MSD-South Shore[4]		—	—
Racine	$ 4,523,000	$ 196,000	$ 570,000
Kenosha	3,193,000	214,000	464,000
Waukesha	2,946,000	90,000	313,000
West Bend	2,484,000	90,000	310,000
South Milwaukee	365,000	36,000	62,000
Whitewater	2,255,000	38,000	210,000
Oconomowoc	—	29,000	48,000
Burlington	344,000	45,000	75,000
Walworth Co. MSD	1,438,000	24,000	134,000
Brookfield	1,080,000	93,000	209,000
Port Washington	247,000	16,000	63,000
Cedarburg	100,000	17,000	29,000
Grafton	532,000	62,000	108,000
Hartford	63,000	79,000	94,000
Twin Lakes	167,000	11,000	26,000
Williams Bay	19,000	5,000	8,000
Western Racine Co. MSD	938,000	7,000	77,000
Hartland-Delafield	1,519,000	12,000	130,000
Union Grove	—	56,000	63,000
Total	$ 81,213,000 to $120,213,000	$1,120,000	$2,993,000

[1]*ENR Construction Cost Index 2445 (August 1976).*
[2]*Amortization of capital cost at 6⅜% plus Operation & Maintenance Cost.*
[3]*Refer to Table 67.*
[4]*Refer to Table 69.*

Source: Camp Dresser & McKee Inc.

Septage and Holding Tank Wastes

All municipal plants in the Region appear capable of receiving controlled quantities of septage and holding tank wastes. Map 11 contains a future allocation of septage to plants in the Region.

It is recommended that municipal treatment plants receive no more than 10 percent of their average influent flow from septage and holding tank wastes. Such wastes preferably should be discharged from tank trucks directly into aerated holding tanks for metered introduction to the plant influent as a percentage of the influent flow rate. In this way, shock loads will be minimized, which is especially important with activated-sludge-type plants. The number and size of tank trucks discharging wastes to a plant should be closely monitored by the plant operator to avoid overloading. The haul distance is not considered to be overriding inasmuch as economics and convenience govern the area serviced by haulers for discharge to a given facility.

SUMMARY

The manner in which the above recommendations may be implemented, especially those for the major facilities, are considered in Chapter XI. The entire study is summarized in Chapter XII. Future sludge management consists of continued processing at existing plant sites, see Map 12, using anaerobic digestion for methane recovery where costs favor it. The processed sludge should be hauled by truck and applied to agricultural land. For land application, the Department of Natural Resources Technical Bulletin No. 88 is to be used as a guideline, and it was used as the baseline condition for this analysis. If higher rates of application of sludge to agricultural land should be accepted as the result of future research, the systems level recommendations of this report would remain the same. Sludges containing heavy metals or toxics exceeding allowable limits for landspreading may be processed in an independent facility especially designed for this purpose or may be disposed of in a hazardous and toxic wastes landfill. The recommendations support resource conservation and recycling of the valuable material contained in the sludge and provide appropriate protection to the environment from harmful constituents or poor management.

TABLE 92

RECOMMENDATIONS FOR OTHER WASTEWATER TREATMENT PLANTS FOR SLUDGE PROCESSING, TRANSPORTATION AND UTILIZATION

PROCESSING OPTIONS

Gravity Thickening
Anaerobic Digestion
Lagoons
Vacuum Filters
Sand Beds

TRANSPORTATION OPTIONS

Truck

UTILIZATION/DISPOSAL OPTIONS

Landspreading
Public Pickup
Landfilling (generally as a backup)

Note: Specific process train options for each plant to be determined in facilities plans.

Source: Camp Dresser & McKee Inc.

TABLE 93

GENERAL RECOMMENDATIONS—DISPOSAL OF INDUSTRIAL PRETREATMENT SLUDGES

Industrial Category	Sludge Disposal Option[1]
Tannery Sludges	Landfill
Metal Plating	Landfill
Metal Machining	Landfill or incineration
Milk Processing and other dairy wastes sludges	Landfill or landspreading[2]
Meat Processing	Landfill or landspreading[2]
Vegetable processing wastes sludges	Landfill or landspreading[2]
Battery manufacturing wastes sludges	Landfill
Truck and Car Wash Operations	Landfill
Power Plants wastes sludges	Landfill

[1]*Sludge not discharged to municipal system. Landfills licensed by Wisconsin DNR to accept hazardous and toxic wastes. These are currently Metro Disposal Service Inc.—Franklin, Land Reclamation Ltd. (Oakes) and United Waste Systems (Lauer).*
[2]*Following stabilization (digestion).*

Source: Camp Dresser & McKee Inc.

Chapter XI

PLAN IMPLEMENTATION

INTRODUCTION

The implementation of a regional sludge management system plan will be dependent on three key factors: plan adoption and coordination, cooperation and communication between the various governmental agencies which will implement the plan, and the availability and utilization of financial resources.

The coordination of public review and coordination of plan adoption is the responsibility of the designated areawide planning agency, SEWRPC. SEWRPC coordinates the reviews of the Technical Advisory Committee and the public. After the draft sludge management plan is released, SEWRPC will coordinate public hearings on the plan. The membership of SEWRPC's Commission will assist communication channels between the agencies designated to carry out the plan at the local level. The extent of financial resources is the least certain portion of plan implementation since it is highly dependent on the availability and amount of state and federal grant funds as well as bond elections, and city, town and village council votes on rate structures and increases.

When the areawide sludge management plan is approved by the Governor, expected during the winter/spring of 1978, the Governor will designate two types of agencies with specific charters related to carrying out the plan: (1) management agencies at the local level for carrying out design, construction and operation aspects of the plan; (2) an areawide planning agency at the regional level to continue the regional planning process.

The institutional relationship between areawide planning and local implementation is designed to ensure the following benefits:

1. The management aspects of each detailed plan at the local level, including facilities plans, are not in conflict with each other and represent the most cost effective regional sludge management system.
2. Day-to-day implementation remains at the local level with technical assistance, coordination, reporting and collection of data being maintained on a regional level to ensure harmony with all aspects of other Local and Region programs (for example, transportation and land use).
3. Because of requirements of Public Law 92-500 (Federal Water Pollution Control Act Amendments of 1972), regarding areawide goals, a local government is assured that similar activities in adjacent areas are compatible and one plan will not be adversely impacted by another.

The establishment of a continuing planning process is an important goal of areawide sludge management planning. The sludge management program, as one portion of the areawide plan, has the two-fold goal of meeting all other aspects of regional planning. In order to effect this goal, the coordination of the institutional aspects of the plan is of primary importance. The following management/financial questions will be addressed in this chapter:

1. Who is responsible for each aspect of the plan?
2. How will the communication and dissemination of information take place?
3. How will the planning process be updated and continued?
4. What are the potential financial resources for funding the plan?

BASIC CONCEPTS AND PRINCIPLES

Management and regulatory agencies will be selected and designated based upon two criteria:

1. Suitability for carrying out specific responsibilities involving the need for an agency at the appropriate level of government and with the necessary specific power.
2. An institutional need exists for which a specific agency has the most appropriate re-

sources. That is, does this agency deal with problems or requirements of a similar nature and might it be beneficial to give it somewhat broader duties?

Once the areawide plan is adopted, the responsibility for the development of facilities plans and for carrying out the design, construction, and operation will be at the local level. Inasmuch as none of the 21 major municipal treatment plants or any of the other plants are expected to be abandoned in favor of consolidated facilities, except as may be determined in currently ongoing facilities plans such as those for the Metropolitan Sewerage District of the County of Milwaukee or for Cedarburg and Grafton, it is apparent that local ownership responsibility will probably continue to reside in existing agencies. Operational responsibility, particularly for the other plants, may, however, be consolidated into a smaller number of governmental agencies to improve and facilitate proper operation and maintenance of the plant. Although some day-to-day implementation may be the responsibility of contracted sludge haulers, ultimate responsibility will still rest with the local government entity contracting the work. Present institutional responsibilities for each community are listed in Chapter VI Regulatory Considerations.

The management and control regulation aspects of the plan will be the responsibility of a statewide agency carrying out specific guidelines of the federal government promulgated through the Environmental Protection Agency. The Department of Natural Resources, Environmental Protection Division will be responsible for licensing, permitting and some monitoring aspects of plan implementation. The DNR maintains district offices. The Southeastern Wisconsin Office of DNR is located in Wauwatosa.

Historically, the Soil and Water Conservation Districts have not been given specific responsibility for any aspect of wastewater sludge management. To date, their input at public meetings has been most valuable in ascertaining current local concerns, public education needs and the current acceptability of different sludge management practices. The SWCD's are supported by University of Wisconsin Extension Agents, District Conservationists of the Soil Conservation Service, county and state funded personnel and the county USDA Agricultural Stabilization and Conservation Service staffs.

Other federal agencies whose programs and planning functions relate to the sludge management plan include the Department of Housing and Urban Development, particularly through their flood control and insurance program. A second federal agency whose planning and funding activities could affect plan implementation is the U.S. Department of Agriculture's Farmers' Home Administration Water and Waste Program which issues grants for water and wastewater projects in the Region. A third federal agency, the Economic Development Administration, Department of Commerce, through the Public Works Employment Act issues grants for qualifying projects.

The coordination of "other federal program" planning activities and the sludge management program will be the responsibility of SEWRPC through the A-95 project review process. This federal requirement was initiated to be carried out at the regional or areawide level to ensure the compatibility of all planning elements in a region. This review is required prior to all federal and state grant awards. In 1975, SEWRPC reviewed 373 applications for state and federal loans or grants totaling $155 million. Plans which conflict with regional objectives or which duplicate other efforts do not receive approval.

It is important to keep in mind that the sludge management program is one of 4 major planning elements of the comprehensive areawide water quality management planning program. The other three major elements are:

1. A plan element for eliminating pollution from point sources

2. A plan element for eliminating pollution from non-point sources

3. A plan element for water quality management, including the designation of land and wastewater management agencies.

The sludge management planning program must be integrated with the other three major plan elements. The technical assistance necessary to achieve the necessary high level of communication between the management and implementation agencies with responsibility for individual plan elements can best be provided through SEWRPC. The successful implementation of the program will rely not only upon fitting the pieces together, but in making it work once it is adopted. Public understanding and acceptance must, therefore, be achieved during the plan selection process.

Plan adoption and integration, discussed in more detail later in this chapter, will begin with public hearings. These hearings will determine which sludge management plan each individual community is to accept and implement. Two aspects of the plan are separable and yet dependent; sludge processing and sludge utilization/disposal. While utilization/disposal practices are dependent upon type and quality of sludge, the utilization/disposal method itself is likely to be the key issue in plan adoption, unless the public is fully informed as to the consequences of these practices. Therefore, one key element in the planning process will be the success of the public participation process which was begun prior to the selection procedure (discussed in Chapter XII).

Since a fairly conservative approach to sludge utilization is suggested by DNR through Technical Bulletin No. 88, it is believed that public acceptance will be easily obtained, if the monitoring program is understood.

Plan integration by local management agencies is scheduled to begin early in 1978. The responsibility for updating and adjusting the plan is expected to be given to SEWRPC.

The delineation of who ought to control or regulate land application of sludge and how, is currently the subject of additions to the Wisconsin Administrative Code for the Department of Natural Resources. DNR is recommending a permit process which follows the guidelines of Technical Bulletin No. 88 and is similar to the current WPDES permit process.

PLAN IMPLEMENTATION ORGANIZATIONS

Technical Advisory Committees

The Technical Coordinating and Advisory Committees of the SEWRPC number 14; one is the Committee on Areawide Water Quality Management. One subcommittee of this TAC is the Regional Sludge Management Subcommittee. The development of sludge management plan objectives and standards was reviewed by this subcommittee. In the implementation of the plan itself, this subcommittee may act as a communications clearing house for disseminating and developing important public education materials. To date, members of this subcommittee have been present at public meetings and have maintained important channels of communication within SEWRPC and the Commission. The TAC's subcommittees are an important resource in the communication of plan goals and objectives to the public-at-large. A Citizens Advisory Committee for Public Participation has also been established. This committee has given guidance to the Commission and extension agents on the conduct of the public participation program. If this committee is continued after plan adoption, it can give the same valuable input as to the conduct of the public information and education program.

Local Level Agencies

Cities—Several cities have undertaken to provide the sanitary wastewater utility function, an authority granted to cities by Wisconsin statute. The sludge management portion of the sewerage system will be a city responsibility in Kenosha, South Milwaukee, Port Washington, Cedarburg, Whitewater, Burlington, Racine, Hartford, West Bend, Oconomowoc, Brookfield, Waukesha, Lake Geneva, Muskego and New Berlin.

Each city will be responsible for preparing a detailed sludge management plan including appropriate monitoring, as set forth in detail in Appendix F, in conjunction with a facilities plan. In the case where the city is the owner/operator, management is usually under the direction of the mayor and council with day-to-day operations supervised by the director of public works and plant superintendent. The specific institutional arrangement in each city is given in Chapter VI, Regulatory Considerations.

Whether the disposal of sludge is contracted to a hauling firm or handled by the utility itself, currently proposed DNR sludge management guidelines will make the treatment plant operator, rather than contractors, responsible for the compliance with newly proposed DNR rules on safe transportation, handling and application of sludge. Thus, plan implementation will place some new responsibilities on local agencies; i.e. self-monitoring, self-enforcement and record-keeping, and reporting to DNR. Similarly, if sludge is hauled to a regional processing or a regional application site, the treatment plant operator will still be responsible for the processing at the local plant and for the hauling to a regional site.

Villages—Several villages have elected to exercise their power to establish sewerage districts for sewerage systems including Twin Lakes, Grafton, Union Grove, and Williams Bay. As with cities, each of the 28 villages will be responsible for preparing a detailed facilities plan including a specific sludge management plan portion. These plans will be reviewed by DNR according to new regulations which became effective on July 1, 1977.

As with cities, villages will retain more responsibility for self-monitoring, enforcement and reporting under a new permit structure.

Towns—A number of towns have established special town sanitary or utility districts to provide for centralized sanitary sewer service in urban portions of the towns. Each of these special sanitary or utility districts will be responsible for facilities plan development in the same manner as cities and villages.

One of the keys to plan implementation at the local level could be interrelationships between other community functions performed at this level such as zoning and land use controls (from setbacks to greenbelt zoning to nuisance control). Because local governments are empowered to carry out plans for the protection and safety of the public, as well as given powers of eminent domain, the judicious use of these powers may enhance the acceptability of sludge management plans and may provide much needed assurance of future land availability. Since the cities, villages and towns do not constitute the major part of Regional sludge production, the availability of land within these governmental jurisdictions for application of sludges from local facilities is not expected to be a major problem factor in plan implementation. Far more important and controversial may be land availability for the acceptance of sludge from outside a particular jurisdiction. Because these local units have the basic responsibility for land use and land management decisions, it will be necessary for each of them to identify sound and locally acceptable methods of sludge utilization, so that all of the agencies which must manage wastewater treatment facilities can conduct their sludge management programs in accordance with the recommendations, objectives and principles embodied in this recommended regional plan. While this plan identifies technically sound methods of sludge utilization, each local unit of government as a generator of sludge, or as the manager of a land resource needed for sludge utilization, must review the local conditions to assure that project planning and implementation also incorporate local preferences and desires. In addition, the local level agency is responsible for having a suitable back-up system which can be implemented if required by adverse conditions, e.g. bad weather which prevents land spreading, or local resistance to land spreading, and which can then adequately handle any sludges from the local treatment plant. A worst possible condition should be considered and a workable back-up system identified for that possibility.

This successful interjurisdictional transfer of sludge may be best accomplished, at the outset, by an adequate public education program coupled with an intensified public officials information program. A series of explicit policies and agreements could then be expected to evolve as more local experience and intergovernmental cooperation in sludge managment is achieved. Currently, no overriding public objection has been raised although South Milwaukee and MSD-South Shore exported large amounts of sludge through and to other communities in 1975-1976. However, the large scale sludge application operation for MSD-South Shore is still fairly new.

Sanitary and Utility Districts—The sanitary and utility districts are responsible for seven other treatment plants that will generally be subject to the same restrictions discussed for villages above.

Areawide Level Agencies

Metropolitan Sewerage District of the County of Milwaukee—Under Section 59.96 of the Wisconsin Statutes, the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee together act as agents for the District.

The centralized system developed and operated by the commissions comprises the largest system in the study area serving most of the population within the District's service area boundaries (194 square miles). The District's powers were discussed in detail in Chapter VI.

The District is engaged in completing a comprehensive 201 Facilities Plan which will go into much greater detail in evaluating alternative solids management programs for both the MSD-Jones Island and MSD-South Shore Wastewater Treatment Plants. The District's plans are dependent upon further alternatives analysis during the ongoing facilities planning process. The District is also undertaking facilities planning studies relative to combined sewer overflow abatement, which will provide input to this evaluation.

The responsibility for day-to-day plan implementation, as in the case of cities noted above, will be with each commission, after satisfying the requirements set out in legislative terms for receipt of approval from each separate commission body.

Western Racine County Metropolitan Sewerage District and Walworth County Metropolitan Sewerage District—Since each of these metropolitan districts falls outside the category of 500,000 population criteria required to qualify under the Wisconsin Statutes, these districts retain no special powers. Chapter VI identified commissions as the day-to-day administrators for plan implementation in the metropolitan districts. Financing through service charges insures power for implementation of the facilities portions of the plan. (Walworth County has no facilities as of this time.)

Day-to-Day implementation responsibilities will be similar to cities and villages, with answerability to a commission rather than a mayor/council. Each district will be required to develop a detailed sludge management plan, file for permits from DNR, and will be responsible for self-monitoring, self-enforcement, recordkeeping and reporting at regular intervals to DNR.

Joint Sewerage Commissions–The alignment of two or more sewerage agencies for cooperative sludge management plans is a potential institutional arrangement under several of the plan alternatives. Several management agencies may join to create a joint commission for the transport and landfill or land application of sludge. The cost effectiveness of the various alternative groupings was discussed in Chapter IX. It is shown that joint management agencies are not expected to result in substantial cost savings.

Cooperative Contract Commissions–Three formal cooperative contract commissions are of interest. They are: Underwood Sewerage Commission, which includes the City of Brookfield and the Village of Elm Grove; the Menomonee South Sewerage Commission, which includes the City of Brookfield and the Village of Menomonee Falls (the City of Brookfield also has its own district), and the Delafield-Hartland Water Pollution Control Commission, which includes the City of Delafield and the Village of Hartland. Each of these cooperative contract commissions will have the same implementation responsibilities as any city or village, to draw up a detailed plan, obtain permits as necessary and to secure funding.

Comprehensive River Basin Districts–(none currently exist in the Region) Plan implementation for the river basin districts would be an indirect or advisory function. The districts might review elements of the plan, particularly sludge disposal plans, to ensure that water and groundwater resources are adequateley protected. River basin plans in the form of Section 303(e) of Public Law 92-500 studies must be consulted in the formulation of specific elements of areawide plans, to ensure compatability. Consistency with basin plans would be maintained by the areawide plan.

Southeastern Wisconsin Regional Planning Commission–The SEWRPC will play a direct role in plan implementation in the coordination of plan review and adoption, the review of detailed management plans, the collection of data, the dissemination of information and the annual update and review of plan implementation. The regional role of SEWRPC is key to the successful management of both information and resources.

The following roles are suggested as important to plan implementation:

1. Technical assistance to local agencies in formulating detailed sludge management plans and preparing grant applications.

2. A-95 clearing house review of all plans applying for federal grant assistance.

3. Provision of technical and educational materials and technical assistance at public meetings for local agencies, the Soil and Water Conservation Districts, the DNR and the organization of public hearings, workshops and seminars.

4. Development, dissemination and compilation of annual progress reports for plan implementation. Publication in the annual report together with plan updates for the other three elements of the areawide planning process.

5. Review of new or expanded project proposals.

The SEWRPC should review each agency or municipality sludge management plan proposal to determine:

1. Extent to which the project is consistent with the overall areawide sludge management system plan.

2. Extent to which the project duplicates, conflicts, or requires coordination with other projects.

State Level Agencies

Wisconsin Department of Natural Resources–Generally, the responsibility for pollution discharge elimination is governed by Chapter 174, "Pollution Discharge Elimination" of Wisconsin State Statutes. This chapter grants to the Department of Natural Resources "all authority necessary to establish, administer, and maintain a state pollutant discharge elimination system to effectuate the policy set forth under sub (1) and consistent with all the requirements of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500.

The Department of Natural Resources has instituted the Wisconsin Pollutant Discharge Elimination System (WPDES). Under WPDES all owners and operators of sewage treatment works must obtain permits for the discharge of treated wastewater effluents. The Wisconsin Administrative Code sets down the rules and guidelines under which this system operated including pretreatment standards and other standards of performance.

The DNR, also under the provisions of Chapter 147, is authorized to administer and maintain a state pollutant discharge elimination system to effectuate the policy that the discharge of toxic pollutants in toxic amounts is prohibited and, therefore, pollutant discharges must be closely and carefully monitored. Under 147.02 it is stated, "The disposal of any pollutant into any waters of the state or the disposal of sludge from a treatment work by any person shall be unlawful unless such disposal is done under a permit issued by the department."

The District and DNR reached agreement in May 1977 which committed the District to proceeding with a water pollution abatement program estimated to cost at least $670 million. This agreement included funding commitments as well as a sewer connection limitation in the service area.

The current practices, with regard to sludge disposal on land, fall into two major categories, landfilling and land application. The DNR has started a detailed inventory and approval process of sludge disposal.

The processes for obtaining licenses and the proposed process for permits is shown schematically in Figure 14 on the following page.

Landfilling Requirements–In order for sludge to be disposed at a landfill site, the sludge must meet certain quality criteria and/or be placed in a landfill which is certified to receive toxic or hazardous wastes (usually in a confined area) in compliance with sections of the code (NR 151.12(7)). The chemical and trade names of all wastes, names and addresses of initial transporters and sources, average quarterly quantities in pounds and gallons, etc. The stipulations of an operator's license may include, for instance, the quantities of household or residential refuse to be mixed with sludge, particularly those sludges with a high liquid content. In the case of a landfill disposal, the treatment plant operator, or sludge generator, must report type, quality, and quantity of the sludge to the Municipal Wastewater Section, DNR. One problem which may arise in making sludge management decisions is the limited availability of sanitary landfill disposal sites to year 2000.

Land Application Requirements–Land application was administered by an informal permit process which has been formalized by changes in the administrative code. Current practice is for the owner to inform the DNR of the site location and characteristics including soils analysis. DNR personnel inspect the site, conduct spot monitoring, and issue a letter of approval or disapproval. The DNR currently has one staff position in the Region plus five additional field staff to perform followup monitoring and inspection. Efforts to date have been concentrated on the MSD-South Shore Plant sludge application activities. (This plant produces nearly two-thirds of the total regional amount of sludge which is not sold as fertilizer.)

The new permit process will administer, in a more formalized way, the application of sludge on land. The permit application for requesting site approval will include a discharge fact sheet and will follow the guidelines set forth in Technical Bulletin No. 88, "Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin." The proposed process was given schematically in Figure 14.

The new permit process for sludge application to land is incorporated with the current WPDES permit system. As a minimum, the DNR will receive all necessary data in the form of a permit application. The data will be reviewed in accordance with the conservative guidelines set forth in Technical Bulletin No. 88, and permit stipulations will be issued (transportation, method of applications, strength and quantity, maintenance of sludge quality parameters, such as amount of nitrogen, percent liquid). DNR also has stipulations for licensing composting operations in NR 151.13.

The DNR, of necessity, requires operators to report at specified intervals (usually dependent on initial quality, industrial users, etc.). The DNR will make changes in permit requirements based upon any change in either sludge quality or regulations. The responsibility for meeting permits conditions will be the operators', however, the DNR will perform some on-site checks, perhaps once or twice per year as an enforcement measure. This program of enforcement could potentially be run in cooperation with the Soil and Water Conservation Districts, SEWRPC, or both.

Consolidation of regional data for areawide waste management is important. Therefore, a system of exchanging data between DNR and SEWRPC must be developed. Since both agencies are working cooperatively in the area of water quality monitoring for the areawide program, effecting a formalized system of re-

FIGURE 14

PERMITS & APPLICATION PROCEDURES FOR PUBLIC AND PRIVATE SLUDGE MANAGEMENT

Case 1. Sludge Application to Land

Local Agency or Owner	Contents of Permit Application	State Agency
Prepares Sludge Management Program[1] for submittal to DNR	Provision for Storage Sludge/Characteristics/Mode of Transport/Description of Disposal Site: depth of groundwater length of period available frequency and months ownership incorporation	DNR accepts or rejects local plan on the basis of relevant State and Federal Guidelines. If permit is denied, it is returned to local agency for revision.

Case 2. Sludge Disposal to a Landfill Site

Local Agency or Landfill Operator	Contents of License Application	State Agency (DNR)
Prepares a report on Landfill Operation for submittal to DNR	Provision for Storage Sludge/Characteristics/Mode of Transport/Description of Disposal Site: depth of groundwater length of period available frequency and months ownership incorporation Population & Area/Site Characteristics/Location of Hazardous Waste Areas/Operation Plan/ Groundwater Monitoring/Soils Borings/Compacting/ Other Provisions of NR 151	Acceptance/Denial of Plan (If denied, return to agency for revision.)

[1]*In Case 1. guidelines follow Technical Bulletin No. 88. In Case 2. guidelines are contained within Wisconsin Admin. Code Chapter NR 151, Solid Waste Management, and NR 110.27, Sewerage Systems, Sludge Handling and Disposal.*

Source: Camp Dresser & McKee Inc. and Wisconsin Department of Natural Resources.

porting between the two agencies should be easily accomplished.

A schematic diagram of management agency relationships both actual and proposed is shown in Figure 15. This diagram illustrates the following:

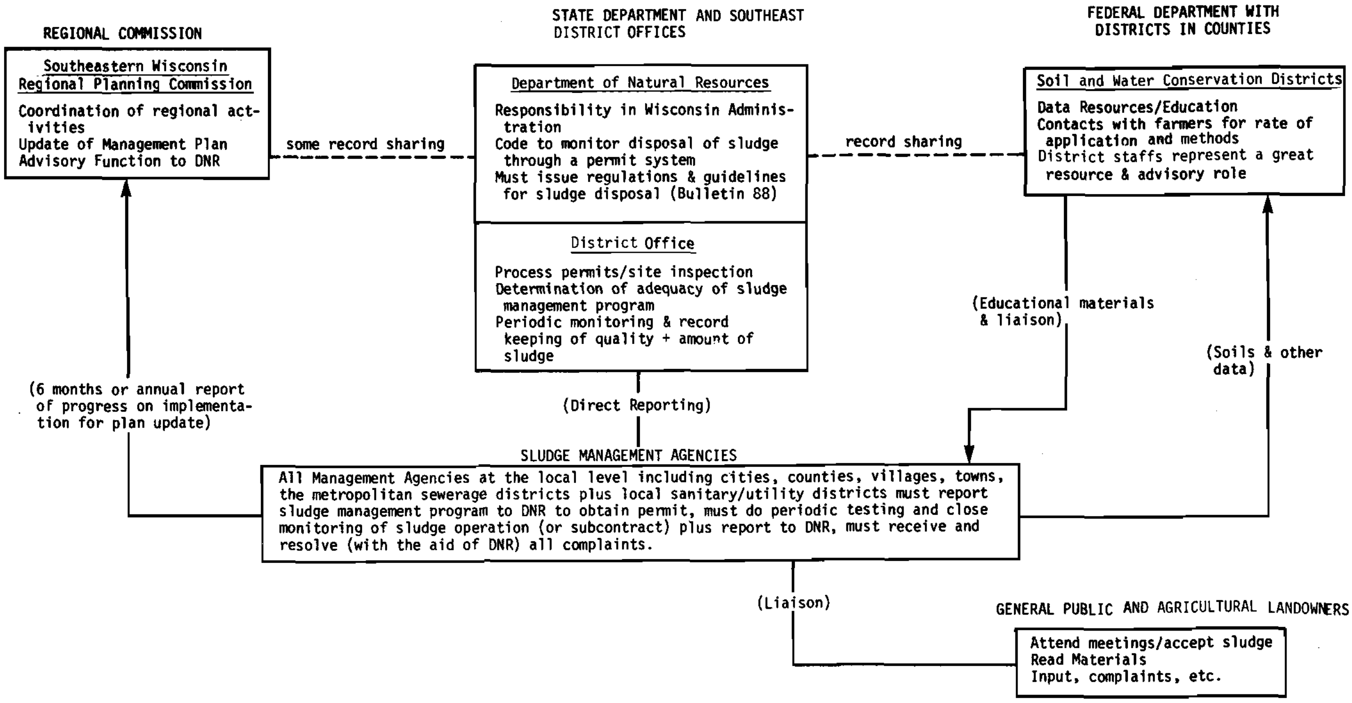
1. DNR is the regulatory and enforcement agency for wastewater treatment plants including sludge management.

2. SEWRPC is the regional planning coordinating and facilitating agency and has the potential to apply technical assistance to facilitate implementation.

3. Soil and Water Conservation Districts have valuable contacts and data resources. In addition, their mission with regard to agricultural practices makes them ideally suited to carry out an advisory and assistance role and to provide valuable liaison with the public and specifically, agricultural landowners. In addition, SWCD's can provide records (soils data) which could prevent duplication of effort. SEWRPC has interpreted the soils maps making determination of suitability for land application sites.

4. Much of the implementation responsibility has been placed at the local level where it can

FIGURE 15
AGENCY INTERRELATIONSHIPS



Source: Camp Dresser & McKee Inc.

most effectively and efficiently be carried out.

Other Sludge Management Regulatory Requirements—One plant, Brookfield, incinerates its dewatered sludge. Incineration requires a permit under NR 154, "Air Pollution Control," and must meet specific ambient air standards. No open burning is permitted in the Region. Any incineration or pyrolysis units that might be recommended for either the MSD-Jones Island or MSD-South Shore plants would likewise be under these requirements.

The production and marketing of the fertilizer Milorganite may come under further federal regulation along with many other similar products produced elsewhere. Since a large portion of the sludge produced in the region is from the MSD-Jones Island plant and is sold as fertilizer, any major change in regulatory requirements could have far-reaching effects on the Region's sludge management program.

The public pickup of sludge for fertilizer or soil conditioner is monitored at this time and may be regulated by some form of sludge application permit or reporting form.

Computerized Systems—The DNR and SEWRPC currently keep many records and data files in a centralized computer bank. It is recommended that the records and cumulative outputs of the sludge management implementation program be computerized for easy reference and compilation. The following is a list of data which might provide useful regional information.

1. Methods and rates of application.

2. Percent of site use/unused.

3. Quality and monitoring frequency.

All this data could be beneficially displayed through composite mapping. If records are accurate, possible problem areas could be identified without an extensive monitoring program.

Wisconsin Department of Health and Social Services Division of Health—The Division of Health of the Wisconsin Department of Health and Social Services currently has no direct responsibility or participatory role in areawide sludge management system planning or within the Environmental Protection Division of DNR.

In many states, the Department of Health participates in important research related to settling regulations. In fact, some departments in those agencies are responsible for setting water quality effluent and sludge disposal regulations. The DNR could perhaps utilize the resources expertise and manpower of the Wisconsin Division of Health, particularly in the area of developing sludge management techniques.

Wisconsin Solid Waste Recycling Authority—The Wisconsin Solid Waste Recycling Authority, created under Chapter 305 of the Laws of 1973, coordinates all solid waste recycling activities within specified recycling regions. Region III in Southeastern Wisconsin includes Milwaukee, Ozaukee, Washington and Waukesha Counties. The recycling Authority is a corporation established by the state government as an operating agency without regulatory or licensing authority. It is the policy of the Authority to provide effective systems and facilities for solid waste management, recycling and disposal and to develop, finance, design, construct and operate these facilities for the benefit of the people and municipalities of the state. The Authority has the power to: coordinate all solid waste recycling activities within the established recycling regions, to require any person capable of being effectively served by the facilities of the Authority to make use of such facilities pursuant to s.499.16, and to establish a program of research and development of processes to effect the recycling of resources from solid waste and of markets and new products for the resources reclaimed thereby.

Sewage sludge and industrial waste sludges are not included in the list of materials to be handled by the facilities of the Recycling Authority. However, the Authority is willing to accept these sludges if markets can be found for the combined RDF/sludge or processed sludge material. In the Southeastern Wisconsin region it may be possible to enter into agreements with the Recycling Authority under which the Authority would process and market sewage sludges at their recycling facilities. Such agreements are dependent on the marketing and potential profitability of the final product.

Federal Level Agencies

U.S. Environmental Protection Agency—The U.S. EPA is responsible for the overall project administration of grants issued under Public Law 92-500. The areawide water quality management planning program is one program administered under this law. SEWRPC is responsible for reporting to the EPA as to plan progress and implementation and for ensuring that all regulations and guidelines issued by EPA for air and water quality are met within the program. Within the program certain timeframes for meeting standards are set (as stated and stipulated by the pollution discharge permits) which carry stiff penalties when not met.

Amendments to the Water Pollution Control Act, Public Law 92-500 have been held up due to disagreements over funding between the House and Senate. At stake is the funding available through the EPA for construction of wastewater collection and treatment systems. However, program regulations for the construction grants program specify that any states who do not obligate all of their allotments will have the balance reapportioned among the other states. Current figures show that a substantial number of states and a large amount of money could be involved in the competition for funds.

One requirement which is of particular significance for the sludge management program is "The Industrial Cost Recovery Guidelines." These guidelines stipulate that for all treatment works facilities grants, that portion of the federal grant which serves industry must be recovered. Fifty percent is to be returned to the federal government and the rest is to be reinvested in a capital improvements program. Therefore, any owner or operator receiving federal grant assistance for capital facilities, must assess what part of the total improvements serve industry and must adjust service charges accordingly.

Several plants in the study area rely upon ad valorem taxes to finance the operation and maintenance costs of their systems. Under EPA guidelines, all grantees receiving federal grant assistance must draw up user charge structures which base costs and rates charged upon the total use of each class of user within a system. The most common form of user charge relies upon winter quarter water consumption as a measure of sewage flow. Several districts or management agencies will be required to adjust their current rate structures in order to ensure grant eligibility. The use of ad valorem taxes to finance operation and maintenance costs has been ruled by the Controller General (GAO Memo July 12, 1974) as not meeting EPA guidelines for user charge requirements. Of the 21 major facilities in the study area, 9 meet their operating costs through ad valorem taxes.

U.S. Department of Agriculture, Farmers Home Administration—The USDA Farmer's Home Administration administers a water and waste disposal loan program under the Rural Development Act of 1973. The total allotment for the State of Wisconsin in fiscal year 1977 was $13.9 million for loans and $4.9 million for grants. The amount varies yearly depending upon the Congressional budget request. Loans are generally issued in the form of general obligation bonds.

Economic Development Administration, Department of Commerce—The Economic Development Administration, through the Public Works Employment Act, issues grants for qualifying projects. The EDA has several special assistance programs to promote economic development. Recently, another $4 billion has been allocated under the Local Public Works Act of 1972. This money is to be awarded during June-July 1977 and projects must be ready to construct within 90 days.

PLAN ADOPTION AND INTEGRATION

Local Level Agencies/Areawide Level Agencies
During early 1978, meetings will be held for public officials and the public on the plan (see Chapter XII and Appendix). The various sludge management alternatives will be presented for receiving public input, critique and plan selection. Although Alternative 1 was selected in Chapter IX, a combination of options is expected to result depending upon the perceived advantages or disadvantages to the various regional associations. Cost-effectiveness is not the sole evaluation criteria; public acceptability and environmental soundness are also important. Once a plan is agreed to and adopted, final integration will be both a local and an areawide responsibility.

Each local management agency will be responsible for preparing a detailed plan. Each of these plans will be reviewed at the areawide planning level to ensure compatibility with other agency plans. Integration of these efforts with other areawide planning will be effected by coordination of facility plans with sludge management system plans. This must be accomplished at the local level.

Assistance to local management agencies in planning and implementation may come from UWEX, SEWRPC and private consulting engineers and planners.

State Level Agencies
The DNR will be more directly involved in plan integration than plan adoption, although DNR's participation at the public meetings this fall will provide valuable input.

The DNR will review all detailed sludge management plans of local agencies and will, after approval, issue permits and permit stipulations to these agencies. The Governor is expected to adopt the final areawide sludge management planning program sometime during the Spring of 1978. Once accepted, it will become the plan to which other plans will be compared.

Federal Level Agencies
The Environmental Protection Agency (EPA) does keep abreast of progress on the various elements of the areawide water quality management planning program by reviewing drafts as they are prepared. Their input and review is cumulative and no formal adoption will be made prior to presentation to the Governor.

EPA will have reviewed and commented on portions of the draft prior to presentation to the Governor. However, the Regional Administrator will not approve/disapprove or conditionally approve the plan until after it has been signed by the Governor of Wisconsin.

SUBSEQUENT ADJUSTMENT OF THE PLAN

Subsequent adjustment of the plan will be the responsibility of the regional planning agency, as the designated areawide 208 management agency.

After final adoption of the plan, annual updates will be prepared to reflect:

1. Subsequent 201 Facilities Planning.
2. Additions or deletions to the plan.
3. Progress of plan implementation activities.
4. Progress toward meeting the stated goals or policies set forth in the plan.

This annual plan update may be reported in the Annual Report of SEWRPC with more in-depth plan updates prepared at 3-5 year intervals. The length and amount of data in the plan prohibit a complete annual rewrite and publication of the plan.

IMPLEMENTATION SCHEDULES

The requirements for construction and the associated costs incurred for each of the 21 major wastewater treatment plant sludge facilities are discussed in Chapter IX. Construction dates used in the economic analysis were developed based on the capacity of existing facilities and the projected sludge quantities of Chapter V.

Those locations with immediate needs for improvements are the MSD-Jones Island and MSD-South Shore plants of the Metropolitan Sewerage District of the County of Milwaukee, Waukesha, West Bend, Whitewater, Walworth County MSD, Western Racine County MSD and Hartland-Delafield. Those plants believed to require improvements during the planning period are: Racine, Kenosha, South Milwaukee, Burlington, Brookfield, Port Washington, Grafton, Cedarburg, Hartford, Twin Lakes and Williams Bay. Oconomowoc and Union Grove plant improvements currently under construction will be adequate throughout the planning period. All costs given in Chapter IX are at August 1976 values. Inflationary trends will increase costs over time, but the relative values from plant to plant will remain the same.

For the categories of other facilities, a construction period of 8 to 24 months should be anticipated for sludge handling facilities. Prior to construction, a 201 Facilities Planning stage of 4 to 12 months and a Design stage of 8 to 14 months should be included. In addition, EPA approval for design and construction grants may require as much as 6 to 10 months. Therefore, planning and design should be initiated about 2 to 4 years prior to the time additional capacity is needed.

Implementation of Auxiliary Plan Elements

Combined Sewer Overflows–Studies carried out by the Regional Planning Commission indicate that combined sewer overflows are a problem only in the older, central areas of Milwaukee, Racine, and Kenosha. The Milwaukee River watershed plan recommended that a preliminary engineering study begin and further consideration be given to the construction of a combined deep tunnel storage/flow-through treatment system. A report by the Metropolitan Sewerage District's consultant will present recommendations for abatement of the combined sewer overflows in Milwaukee. In both Racine and Kenosha, research and demonstration studies of the combined sewer overflows have been initiated. Specific recommendations concerning which of the remaining combined sewer areas should be separated and which should receive specialized treatment facilities have not been completed at this time.

Abatement of combined sewer overflows can result in increased solids loads at the existing treatment facilities. These increases may require expansion of sludge handling capacities and increased costs for sludge management/utilization. When specific recommendations are available, predictions can be made concerning the actual effect on the existing sludge handling processes and the costs associated with treating the additional flows.

Industrial Source Control–The EPA has established regulations of pretreatment standards for introduction of pollutants into publicly-owned treatment works for those pollutants determined not to be susceptible to treatment by such works or which would interfere with the operation of such treatment works. The pretreatment standards specify a time for compliance for elimination of the listed pollutants and are established to prevent the discharge of the designated substances.

The implementation of a User Charge/Industrial Cost Recovery (UC/ICR) program under Public Law 92-500 will, in some cases, change the economics of industrial pretreatment in favor of reducing the quantity and/or strength of the discharged industrial wastewater. Because the primary variable in wastewater characteristics is the industrial wastewater contribution, the nature of these reductions can affect both the quantity and quality of the sludge processed and utilized. Certain substances such as the heavy metals have a deleterious effect on the quality of sludge and limit its uses.

The speed of any implementation program is dictated either by law, good planning or by the economics of recovery.

Landfill Upgrading, Design and Construction

For most of the proposed facilities sludge utilization as a low grade fertilizer and soil conditioner appears to be the most feasible method. However, as a backup for periods of bad weather due to crop cycles or in the event of a change in sludge quality due to industrial waste, landfilling has been recommended. Landfilling has also been recommended for some industrial wastes and water treatment plant sludges. For most of the large facilities a landfill site with an average site lifetime of 10 years exists at less than a 15-mile, one-way, haul distance. Of these sites, three–Oakes, Lauer, and Metro Disposal Service–are licensed to accept hazardous and toxic wastes. However, capacities and useful lives of many sites are limited if long term landfilling of large quantities of sludges were necessary.

FINANCIAL AND TECHNICAL ASSISTANCE

Financial Assistance

Financial assistance falls under the following major categories: grants-in-aid, borrowing and sewer service charges. Only major sources of funding will be addressed in this section. (Sources of financial assistance for sanitary sewerage systems are discussed in detail in SEWRPC's Planning Report No. 16, Chapter XIV. Sewer service charges for each of the large treatment plants are discussed in Chapter VI.) There are a number of special grant programs for economically depressed areas, "boom" town areas and others, for which special kinds of funds may be sought–including funds for major capital improvements; however, these special sources are not expected to be a major source of revenue.

Grants-in-aid

Under Public Law 92-500, the Environmental Protection Agency provides construction grants for waste treatment works. (Title II) "The award of these grants creates a contractual obligation of the United States for payment of the Federal share" (75 percent) "of the construction costs of such works."

Grant awards are made based upon a state allocation and the state priority listing of projects. Priorities are based upon a project's contribution to the overall water pollution abatement program. Each project is given a cumulative score based upon several factors: river basin score, project score, health hazard score, assimilative capacity score, phosphorus control score and population score.

If a project is included in the regional facility priority list, and if after review and priority assignment a project is not funded in that year, it will automatically be included in the regional priority list the following year, unless later studies or reviews indicate that the project is no longer advisable. Project seniority will not necessarily have a bearing on year-to-year priority ranking. Once each year the state will review new projects, in conjunction with plan update process, for inclusion in the priority list.

Federal grants-in-aid may also be obtained from the U.S. Department of Commerce through its Economic Development Administration. The State of Wisconsin administers grants-in-aid under Chapter NR 125, for the construction of sanitary sewage treatment facilities and sanitary sewage collection systems serving municipalities. According to officials from DNR, the amount of state grants has, in the past, been up to 15 percent of the project costs (generally 5 percent with an additional 10 percent for tertiary treatment facilities) which, when 75 percent is federally funded, leaves between 10 and 20 percent to be raised by the local agency. The receipt of a federal grant does not ensure a "matching" fund from the state, however, the state does rely on the state priorities system for determination of needs, which is the same priority system under which funds are administered. State funds' availability for the future plan implementation is indeterminate at this time.

Borrowing

The local share of project-related capital costs is often covered through municipal bonds, either general obligation or revenue. General obligation bonds are dependent upon the credit rating of the municipality and are guaranteed by the ad valorem tax structure of that municipality. They are backed by the full taxing power of a community. General obligation bonds may be issued for up to a 20-year repayment period (a State of Wisconsin limitation). Revenue bonds are guaranteed by the rate structure or revenues of a particular project. A rate is to include bond principal and interest payments. Often a reserve amount equal to all or a portion of the next annual payment is required to be held in reserve to ensure payment (or is negotiable). Revenue bonds may be issued for longer than a 20-year period, however, 20-year bonds are the general practice, according to a Milwaukee bank investment office.

The ability of a community to borrow depends upon their rating in the bond market. Older communities and those with high property tax values usually receive better ratings than newer, growing communities, especially those which have no previously-established credit rating. Bonds are not issued to pay any operations and maintenance costs. The purpose of bonds is to incur long-term debt when capital costs are best paid by spreading payments over a long-term period. Utility districts which are outside the municipal government can obtain revenue bonds only.

The Farmer's Home Administration will sometimes buy bonds where a municipality has been unsuccessful in the traditional bonding markets.

Sewer Service Charges

All wastewater systems receiving federal grants must rely upon user charges for operation and maintenance of publicly owned treatment works. The federal guidelines are contained in Appendix B of Chapter 40, Part 35 (Federal Register Vol. 39, No. 29 Monday February 11, 1974). Under these guidelines, a grant applicant must show that: the applicant "has adapted or will adapt a system of charges to assure that each recipient will pay its proportionate share of operation and maintenance including replacement."

The user charge system must provide also for industrial cost recovery for that portion of the federal grant allocable to industrial waste capacity. Repayment must be made to the federal government of 50 percent of project-related capital costs for the capacity reserved for industry (over a period not to exceed 30 years, or the useful life of the facility, whichever is less). Forty percent of the recovered funds must be retained and used for grant eligible construction and 10 percent may be used at the grantee's discretion, except that such funds may not be used to pay for general operation and maintenance costs or to provide rebates to industrial users for costs incurred by those users through implementation of user charge or industrial cost recovery systems.

The controller general has ruled that the use of ad valorem taxes to finance operations and maintenance costs does not conform to EPA guidelines. Nearly half of the current management agencies in the Region will be required to change their present funding systems since they rely, wholly or in part, upon ad valorem taxes.

Technical Assistance

The implementation phase will require:

1. Detailed sludge management (facility) plans from each management agency.

2. Public education programs.

3. Grant applications, bonding and formulation of rate structures.

Technical assistance in the preparation of sludge management plans and permit applications is provided by the DNR through its district offices, consulting engineers or, in the case of the smaller agencies, by the District engineers themselves. The regional planning agency does not normally provide this type of technical assistance, although this agency will be able to identify any conflicts in the plans of agencies as they compile the detailed management plans. Once the new permit procedures are released, the DNR may find that one or two information assistance persons are needed to answer questions/problems. The Soil and Water Conservation Districts may be able to provide valuable soils data to those agencies selecting specific land application sites for sludge.

The public education portion of technical assistance would best be provided at public meetings and seminars, which local officials are encouraged to attend. The DNR would be a logical source of materials and resource people to attend and to answer questions concerning sludge management. The Soil and Water Conservation Districts have located and invited interested individuals to attend public information meetings during the areawide sludge management study effort, and their continued support in establishing and continuing public informational efforts would be important to program success. In addition, the SWCDs with established ties between farmers and agricultural programs, will be important conduits of new information regarding sludge management and the fertilizer/soil builder benefits. The SWCDs should be kept as fully informed and involved as possible throughout program implementation.

SUMMARY

This chapter has described the financial and technical assistance available to the agencies responsible for the various stages of plan implementation and has outlined the agencies responsible for plan review and for coordination with other areawide plans. In addition, agencies requiring special permits and imposing regulations on the proposed plan systems have been reviewed.

The critical phases in the implementation are: adoption, detailed planning, funding, construction management, and operation and maintenance. The critical level of government for plan implementation is the local boards, councils and commissions, and the metropolitan sewerage commissions which are responsible for the ownership, the day-to-day management and operation and the financing of the sewerage facilities. The most important phases for these agencies are summarized below.

Local Level

Common Councils and Village Boards–The common councils and village boards through their public works and utilities departments are the existing wastewater management agencies. It is the responsibility upon referral to and upon recommendation of the local plan commission, that each council and board as appropriate:

1. Adopt the recommended areawide water quality management plan as a guide to future facility development in their community.

2. Review and adopt the implementation schedule incorporated in that plan.

3. Apply for Grants-in-aid, establish an industrial cost recovery program where appropriate, and appropriate or borrow the additional monies needed for facilities planning and construction.

4. Initiate facilities planning and construction as appropriate for their community such that the implementation schedule is met.

5. Review the operational characteristics and maintenance of their facilities to determine if the facility is being operated in accordance with the standards outlined in that plan, particularly those governing sludge utilization on land.

6. Keep accurate records of operation, especially land application programs where testing and monitoring of application sites is required.

7. Obtain and comply with the various permits governing operation and management, particularly utilization of sludge on land.

8. Adopt a procedure for receiving and investigating complaints.

9. Develop agreements for treatment of septage and land application of sludges with adjacent governing units.

Planning Commissions of Cities, Villages and Towns—It is recommended that the planning commissions of all cities, villages and towns within the Region:

1. Adopt the areawide water quality management plan as a guide to future facility development and certify such adoption to the local governing body.

2. Integrate the areawide plan into local master plans.

3. Adopt zoning and/or land use ordinances dictating acceptable sludge application procedures and sites.

Areawide Level

Metropolitan Sewerage District of the County of Milwaukee—The District will be responsible for adopting a detailed sludge management plan as a part of the areawide water quality management plan, and is responsible for its implementation through its sewerage commissions acting in cooperation. The District is engaged in facilities planning including a total solids management plan. The District is responsible for the same details of plan implementation—Financing, Facilities Planning, Construction, Operation and Maintenance, Compliance with Permits and Land Application Regulations,—as other local agencies.

Other Areawide Agencies—The Western Racine County Sewerage Commission, the Delafield-Hartland Water Pollution Control Commission, the Underwood Sewer Commission, the Menomonee-South Sewerage Commission and other future joint sewerage commissions have responsibilities similar to those of the Metropolitan Sewerage District of the County of Milwaukee and the local common councils and village boards.

Regional Planning Commission—The major role of the Southeastern Wisconsin Regional Planning Commission is to coordinate the adopted plan among local agencies and with other areawide planning programs, and to disseminate information through educational programs and public meetings, on technical, regulatory and financial assistance available to the implementation and operating agencies.

The following roles are suggested as being significant to successful plan implementation:

1. Technical assistance to local agencies in formulating detailed sludge management plans and preparing grant applications.

2. Provision of adequate educational materials necessary for detailed plan development, e.g. financial assistance available application procedures, regulations governing aspects of plan and permit application procedures.

3. Review of all projects and plans to determine consistency with areawide water quality management plan and to eliminate duplication of or conflict with other plan elements.

4. Annual review and update of plan elements.

Potential Regional Management Functions by Regional or Subregional Agencies

Regional and subregional treatment of sludge at a facility serving two or more wastewater treatment plants was determined, in Chapter IX, to be uneconomical, however, regional or subregional management agencies could be advantageous for this Region. Such a regional or subregional agency on a county or watershed basis could provide several valuable services and eliminate costly duplication of efforts in small communities as follows:

Centralized Administration—Centralized administration could provide some essential functions to the proper functioning of treatment processes and monitoring of sludge utilization. First of all, a professional staff could be supported; properly trained permanent operating and management personnel are essential if the complex operations of a treatment plant are to be maintained in top condition. These individuals can demand high salaries and usually cannot be supported by small communities. The monitoring and record keeping required for discharge permits and land application of sludge could be simplified and more efficiently administered.

The history of any land application site would be known, particularly the quantities of heavy metals previously applied, and spreading operations by more than one facility at the same site could be more easily monitored. Site lifetimes could be closely monitored and future spreading sites identified and held ready to meet new acreage requirements.

Centralized Laboratory Facilities—A principal laboratory could be centrally located and all major and routine laboratory functions provided for all facilities. Sampling stations for collecting and running emergency tests when needed would be provided at other locations, but all routine control samples would be picked up at the plants, refrigerated and brought to the central laboratory where a completely equipped laboratory would be maintained with a highly skilled staff.

Maintenance—All routine maintenance work could be performed by a special services staff. This would centralize supervision, responsibility, control scheduling and skilled personnel. These combined functions would justify the payment of salaries adequate to attract and retain competent, qualified employees. A central stockroom under audit control would result in efficient handling of all supplies, tools and inventory.

A continuous in-service training program could be sponsored. This would be of great value in up-grading the number and skills of plant operating and maintenance personnel.

Because of the advantages of regional or subregional management agencies in the successful implementation of a sludge management plan, it is recommended that such agencies be considered as part of the overall water quality management plan. In addition, should sludge management become the responsibility of a single agency serving several treatment plants, a joint commission could be formed to ensure equitable representation in the management decisions for that particular region or subregion.

Chapter XII

SUMMARY AND CONCLUSIONS

INTRODUCTION

This chapter summarizes the entire planning report, presents the study findings and recommendations and describes the general flow and content of the study. Overall plan costs, public reaction, and recommended implementation of plan components are presented.

It was first necessary to establish a baseline condition and the basic principles by which the study would be undertaken as presented in Chapters I and II. Stressed in Chapter I are the needs for regional planning, the Regional Planning Commission, the Regional Planning Concept, and Commission work programs. Also presented in Chapter I are the study objectives, including the relationship to other studies, and the organization of staff and consultants who participated in various phases of the study. Chapter II stressed the basic principles and concepts by which the study was undertaken and summarized the sludge management planning process. The seven steps involved in this planning process are: 1) study design, 2) formulation of objectives and standards, 3) inventory, 4) analysis and projections, 5) alternative program formulation, 6) program test and evaluation, and 7) program selection and adoption.

BASIC PRINCIPLES

Several basic principles were formulated to guide the planning process as applied in the Regional sludge management system planning program:

1. Sludge management system planning must be regional in scope, recognizing subregional planning areas related to existing systems, potential management agencies, natural watershed boundaries, and urban concentrations with well-developed sewerage systems and related sludge handling systems.

2. Sludge management system planning must be compatible with land use planning. The population distribution and land-use patterns determine the amount and spatial distribution of sludges to be accommodated by the system. The system, in turn, is an important element of the public utilities which service the land-use pattern.

3. Land use, wastewater treatment facility, and sludge management planning must recognize the existence of a limited natural resource base to which rural and urban development must be adjusted to ensure the continuation of a pleasant and habitable environment. Sludge management systems must have minimum negative environmental impact and assist in attaining areawide land use, air quality, and water quality objectives.

4. Sludge management facilities must be planned as integrated systems or coordinated subsystems. The capacity of each proposed facility in the total system or subsystem must be carefully fitted to present and probable future sludge loadings. The performance of the proposed facilities and the effects on the rest of the system must be quantitatively determined and evaluated.

5. Primary emphasis should be placed on Region solutions to sludge management system development problems related to the environment. The export of sludge management problems to other regions should be considered only after careful evaluation of environmental impacts. This is not to say that sales of highly refined sludge products should be restricted to the Region.

6. Sludge should be treated as a resource which can, with proper management and control, provide a valuable energy source at a wastewater treatment plant or a valuable nutrient supplement or soil conditioner for land application. Harmful constituents, such as heavy metals and other toxic substances, should be subject to control.

7. Sludge management systems must have public acceptance to be viable or implementable.

INVENTORY FINDINGS

The inventory findings are presented in Chapters III, IV, and V. Chapter III details the existing sludge management systems in the Region, Chapter IV contains the marketing analysis, and Chapter V contains sludge quality and quantity information. In formulating a plan, the starting point is the existing system (Chapter III), and the existing material quantity and quality (Chapter V). Criteria affecting alternatives development continues in Chapters V, VI, and VII, which contain further inventory information.

Chapter I noted the important regional features in the formulation of alternatives–surface and groundwater resources, environmental corridors, climate, geology, and soils. The most important manmade features considered were the transportation network, land-use development patterns, and the strength and size of the regional economy.

The natural and manmade features information was used to determine where sludge could best be land-applied, the impact of climate on sludge processing plant design and construction, and the environmental effects of the various processing, transportation, and utilization or disposal options. The transportation network information was used to determine distances and travel times for sludge hauling.

Land-use development patterns show where available agricultural land is located and possible future trends, while the strength of the regional economy indicates ability to pay for the recommended plan.

Chapter III findings of greatest significance were data on existing sludge quantities, existing treatment facility and sludge handling practices, design criteria, actual unit sizes, condition, age, and design data for future facilities planning. Existing systems at specific treatment facilities are often the most feasible, least cost systems that would be best for the study area in the future. On a cost basis alone, existing capital equipment often carries a good deal of weight in the economic analysis. Existing management systems form the basis for an improved or more clearly defined system to meet plan objectives. Existing sludge quantities were needed to form the basis of projections of future quantities; existing unit sizes, condition, and management practices serve as a starting point to develop alternatives that must interface with the existing system.

The objectives, principles, and standards formulated and presented in Chapter VII tempered the overall plan development and the technical and management recommendations. The six objectives call for a system that is economical, safe from an environmental, public health, and agricultural standpoint, supports desired development patterns, and maximizes resource recovery. The six objectives are presented in Table 95. Data pertaining to the market value of sludge is presented in Chapter IV. In general, the market for Milorganite could rise to twice the present sales level under the proper promotional program. The market for liquid and cake sludge is limited by available land in agricultural use with acceptable features for sludge spreading, but it does appear that a market is available for all sludge if it is given away. The compost market appears to be the most limiting and can serve as a utilization option for only a limited portion of the Region sludge.

The presentation of existing sludge management systems and those known to be planned by others was organized by discussing each of the 21 major municipal wastewater treatment plants individually and other sources of sludge by category. As the plan recommendations for the 21 major plants are the most specific, detailed information was presented in structural components and sludge quantities currently generated or projected for the future at these facilities. Other wastewater treatment plants, industrial pretreatment sludges, and water treatment plant sludges were addressed on a categorical level as these sludges, when handled independent of the municipal plants, total 42 tons raw sludge solids per day or less than 10 percent of all sludge generated. Septage and holding tank wastes and leachate were also addressed categorically.

The inventory findings for the major facilities are summarized in Table 96 which shows process trains currently utilized and proposed by others. The existing and projected sludge quantities generated by these major facilities are shown in Table 97.

Table 98 shows the total quantity of dry solids produced in the Region in 1975. The total quantity of dry solids produced by the 21 major plants in 1975 was found to be approximately 347 tons/day. Other wastewater treatment plants produced approximately 5.3 tons/day and water treatment plants approximately 12.6 tons/day. Industrial sludge produced was approximately 25 tons/day. Industrial sludge produced was approximately 25 tons/day and septic and holding tank wastes at approximatley 6.2 tons/day.

Sludge quality data summaries are shown in Table 99. This table presents only that information related to the 21 major plants, and many of the values are averages of several data points. Most of this data is based on sampling conducted in December 1976.

TABLE 95 WASTEWATER SLUDGE MANAGEMENT SYSTEM DEVELOPMENT OBJECTIVES

Objective No. 1

The development of a regional wastewater sludge management system which will effectively support the existing regional development pattern and serve to aid in the implementation of the regional land use plan while meeting the anticipated wastewater sludge handling and disposal needs generated by the existing and proposed land uses.

Objective No. 2

The development of a regional wastewater sludge management system which will meet established air and water use objectives and supporting standards; which will not result in pollution of the land, rendering it unfit for desirable uses; and which will be properly related to the natural resource base and enhance the overall quality of the environment in the Region.

Objective No. 3

The development of a regional wastewater sludge management system which will effectively protect the public health within the Region.

Objective No. 4

The development of a regional wastewater sludge management system which will help to maintain the productivity of agricultural land within the Region.

Objective No. 5

The development of a regional wastewater sludge management system which will maximize the recovery and utilization of resources in the handling and disposal of wastewater sludges.

Objective No. 6

The development of a regional wastewater sludge management system which is both economical and efficient, meeting all other objectives at the lowest cost possible.

Source: Camp Dresser & McKee Inc. and SEWRPC.

DESIGN CRITERIA

The unit operations for the structural alternatives for sludge processing, transportation and utilization, or disposal must be based on sound design criteria. The design criteria are presented in Chapter VIII and are in agreement with the process criteria given in SEWRPC Technical Reports. Further criteria related to land application of processing of wastewater sludges are presented in Chapter V.

A number of sludge processing options were given serious consideration in this study. Those processes chosen have been successfully proven at other locations and the selection effort focused primarily on the least cost, site-specific, acceptable processes. Various methods of transportation and utilization or disposal were also considered. The methods considered have all been tested extensively except for the pyrolysis processing option. While limited information indicates that pyrolysis shows promise over conventional incineration, a broad base of operational data on many sludge types simply is not available at this time. Pyrolysis should, however, be considered as a long-range option for larger facilities.

In conjunction with the design criteria, cost curves for the unit processes were developed in State-of-the-Art studies. In addition, costs related to site-specific factors such as land costs, existing equipment integration, and age and condition of existing facilities were taken into account. Noneconomic factors were also considered and may be summarized as: atmospheric resources, cultural factors, earth resources, flora and fauna, land use, system feasibility, and water resources.

TABLE 96
SLUDGE MANAGEMENT IN THE REGION - 1975

Wastewater Treatment Facility	Wastewater Treatment Processes		Sludge Processing Options											Transport Options			Utilization/Disposal Options							
	Existing	Proposed	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Wet Oxidation	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail	Pipeline	Incineration/Pyrolysis	Landfilling	Land Spreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
MSD - Jones Island	AS-C		E					E	E				E	E	E								E	
MSD - South Shore	AS-C		E			E					E			E				E	E					
Racine	AS-C					E		E	E					E				E	E					
Kenosha	AS-C		E			E		E		E				E					E					
Waukesha	TF-C	TF/AS-C	Po			E Po					E Po									E Po				
West Bend	AS-C	TF/AS-C	Po			E Po		Po	Po		E			E				Po	E Po					
South Milwaukee	AS-C					E Po	E	Po		Po[2]	E	E		E				E Po	E	E				
Whitewater	TF/AS	RBC	Po			E Po		Po		Po[2]		E		E				Po	E	Po				
Oconomowoc	AS		E			E		E	E		E	E		E				E	E					
Burlington	AS-C			E	E	E		E						E					E					
Walworth Co. MSD[3]	AS/TF	TF	Po			E Po						E		E Po				E	Po					
Brookfield	AS-C				E[1]			E		E				E			E	E						
Port Washington	AS-C				E	E								E					E					
Grafton	AS-C				E	E								E					E					
Cedarburg	AS/TF-C		E			E					E	E		E					E					
Hartford	AS-C				E							E Po		E					E					
Twin Lakes	TF/AS-C				E	E						E		E					E	E				
Williams Bay	AS		E			E						E		E					E					
West Racine Co. MSD	AS-C	AS-C			E Po	Po						E Po		E					E Po					
Hartland-Delafield	AS	RBC				E Po					E Po	Po		E Po					E					
Union Grove	AS-C	AS/RBC-C			Po	E					E	Po		E Po				E	Po					

Notes:
[1]Used as a holding tank
[2]Belt filter press
[3]Delavan and Elkhorn

E = Existing
Po = Proposed by others
AS = Activated sludge

TF = Trickling filter
RBC = Biocontactor
C = Chemical addition

Source: Camp Dresser & McKee Inc. and SEWRPC

ALTERNATIVE PLANS

Six geographic alternative system plans for the 21 major facilities were developed on a geographical basis for consideration and application of screening factors.

Under each geographic alternative system plan, a number of process train options are available for each plant. Also, within each process train, a number of unit operations are available. When all these components are compounded, the total number of different systems considered is approximately 300. Alternative 1 considered each plant processing its own sludge in much the same manner as occurs today. Alternatives 2, 3, and 4 represented various subregional combinations of facilities while Alternative 5 represented countywide facilities from the standpoint of organizational feasibility on the county level. Alternative 6 represented a complete regional system for the entire study area. Under each of the alternative systems, a number of processing, transportation, and utilization/disposal options were considered. Combinations of existing process functions or unit operations could then be compared to an array of future possibilities. The 40 other municipal wastewater treatment plants were considered to be integral parts of each alternative. In addition, extra-regional landspreading alternatives were investigated and found to be economically unfeasible at this time.

Based on the evaluation of alternative plans, a modification of Alternative 1 is recommended as the Regional Sludge Management Plan.

TABLE 97
MAJOR WASTEWATER TREATMENT PLANTS
Average Estimated Raw Sludge Production
(lb/day dry solids)

Plant	Current[1]	2000
MSD-Jones Island (low range)[2]	386,000	417,000
MSD-South Shore (high range)[2]	196,000	285,000
Racine	18,000	60,100
Kenosha	35,800	47,300
Waukesha	18,900	28,500
West Bend	6,000	17,600
South Milwaukee	4,900	4,900
Whitewater	3,700	8,100
Oconomowoc	2,400	9,600
Burlington	2,300	4,500
Walworth Co. MSD	2,200	4,500
Brookfield	5,300	19,600
Port Washington	1,800	4,000
Grafton	2,600	4,500
Cedarburg	2,000	4,400
Hartford	2,000	3,900
Twin Lakes	600	1,900
Williams Bay	100	500
Western Racine Co. MSD	300	1,700
Hartland-Delafield	1,100	4,300
Union Grove	1,200	2,000
Total	693,200	933,900
	(347 tons/day)	(467 tons/day)

[1]*Based on 1975 flows and loads.*
[2]*Diversion area flows to MSD-South Shore resulting in high range sludge loads at that facility.*

Source: Camp Dresser & McKee Inc.

RECOMMENDED PLAN

Major Wastewater Treatment Plant Sludges

The recommendations for wastewater sludge management for 19 of the 21 major facilities are shown in Table 100. A specific recommendation has been made for all major municipal plants. These recommendations are in general agreement with the results of previous planning efforts.

For the MSD-Jones Island and South Shore plants, it is recommended herein that a number of processing, transportation and utilization options be evaluated by the District. Such an evaluation is now being performed for the District by CDM in the total solids

TABLE 98
ESTIMATED SLUDGE PRODUCTION IN THE REGION—1975

Source		Quantity (dry tons/day)	% of Total
Major Wastewater Treatment Plants		347.0[1]	92.1
Other Wastewater Treatment Plants (Including private works)		5.3	1.0
Industrial Sludges		25.0	6.6
Water Treatment Plants	(11.3)[2]	1.3	0.3
Septic and Holding Tank Wastes	(6.2[1])[2]	—	—
Total[3]		376.9	100.0

[1]*Raw Sludge Quantities.*
[2]*Sludges discharged to municipal wastewater treatment plants.*
[3]*Estimates for combined sewer overflow solids and stream bottom sediments unavailable.*

Source: Camp Dresser & McKee Inc.

TABLE 99

SUMMARY OF WASTEWATER SLUDGE QUALITY DATA
MAJOR PLANTS

Plant	Total N%	Organic N%	Ammonia N%	Zn (mg/Kg dry solids)	Ni (mg/Kg dry solids)	Cu (mg/Kg dry solids)	Cd (mg/Kg dry solids)
MSD-Jones Island (raw sludge)	6.9	4.6	2.3	2946	158	434	241
MSD-South Shore	3	2	1	4300	700	950	41
Racine	1.5	1.45	0.05	3112	139	569	96
Kenosha	2.1	1.5	0.6	3800	442	2580	28
Waukesha	1.87	1.65	0.22	5390	133	1350	15
West Bend	3.23	2.11	1.12	2428	533	833	977
South Milwaukee	5.9	4.5	1.4	756	92	560	9
Whitewater	9.5	5.2	4.3	1100	88	571	26
Oconomowoc	6.0	4.2	1.8	5110	140	658	19
Burlington	—	—	0.69	1080	343	560	9
Walworth Co. MSD	4.2	3.1	1.1	620	37	113	13
Brookfield	1.15	1.13	0.02	1120	44	432	12
Port Washington	2.34	1.62	0.72	1140	—	—	—
Grafton	—	—	—	—	—	—	—
Cedarburg	4.45	3.01	1.44	1900	39	1340	18
Hartford	5.7	4.4	1.3	1680	98	412	57
Twin Lakes	5.24	3.79	1.45	2910	112	360	32
Williams Bay	6.1	5.5	0.6	1040	36	530	14
Western Racine Co. MSD	1.4	1.32	0.8	1514	23	334	6
Hartland-Delafield	2.56	1.76	0.8	993	21	360	10
Union Grove	1.4	1.0	0.4	1030	24	370	9

See: Appendix E.

Source: Camp Dresser & McKee Inc. and SEWRPC.

TABLE 100
SELECTED PROCESSES FOR REGIONAL SLUDGE MANAGEMENT

ALTERNATIVE #1	Sludge Processing Options											Transport Options			Utilization/Disposal Options							
Wastewater Treatment Facility	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail/Barge	Pipeline	Incineration/ Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
MSD-Jones Island	PE			P		PE	PE P	P			P PE E	P PE E	PE E	P	P	P	P	P		P	PE E	
MSD-South Shore	PE	P		P PE		P	P	P	E			PE	P	P	P	P	E P	P	P	P		
Brookfield	P		E**			PE		PE				PE			PE	PE						
Port Washington	P		E	PE		A	A		P*			PE				B	PE					
Grafton	P		PE	E		A	A		P*			PE				B	PE					
Cedarburg	PE			PE		A	A		P*E	PE		PE				B	PE					
Grafton/Cedarburg	PE			PE		A	A		P*E	E		PE		P		B	PE					
Hartford	P		PE			A	A		P	PE		PE				B	PE					
West Bend	P Po			P Po E		P Po	P Po		E			E P Po				P Po	BEPo					
South Milwaukee	P			Po P E	E[2]	P Po	P	Po[1]	E	PE		PE				BE	PE	PE				
Whitewater	P Po			P Po		P Po		P[1]Po[1]				PE				P Po	PE	Po				
Oconomowoc	PE			PE		PE	PE					PE				BE	PE					
Burlington	P	PE	E	PE		PE				E		PE				B	PE					
Walworth County	P Po			PE Po		A	A			E		Po PE				E	P Po					

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process
Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank
2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

TABLE 100
SELECTED PROCESSES FOR REGIONAL SLUDGE MANAGEMENT (continued)

ALTERNATIVE #1	Sludge Processing Options											Transport Options			Utilization/Disposal Options							
Wastewater Treatment Facility	Thickening Gravity/Flotation	Centrifuge	Aerobic Digestion	Anaerobic Digestion	Heat Treatment	Chemical Conditioning	Vacuum Filter	Filter Press	Drying Lagoon	Sand Beds	Sludge Dryers	Truck	Rail/Barge	Pipeline	Incineration/ Pyrolysis	Landfilling	Landspreading	Public Pickup	Composting	Soil Conditioner	Organic Fertilizer	Other
Twin Lakes	P		E	PE		A	A		P	PE		PE				B	PE	PE				
Williams Bay	PE			PE		A	A		P*	PE		PE				B	PE					
Western Racine	P		Po E	P Po		A	A		P	P Po E		PE				B	P Po E					
Hartland-Delafield	P			P Po		A	A		P Po			P Po				B	P Po					
Union Grove			P Po	E		A	A		E	P PoE		P Po E				BE	P Po					
Racine	P			PE		PE	PE					PE				BE	PE					
Kenosha	PE			PE		PE		PE				PE				B	PE					
Waukesha	P Po			P Po E					P Po E			P				B	P	P Po E				

A = Alternate Process
P = Considered by CDM
E = Existing
B = Backup Process
Po = Proposed by Others
1 = Belt Filter Press
* = Lagoon at remote location
** = To be used as a holding tank
2 = Wet air oxidation

Source: Camp Dresser & McKee Inc.

management study. Because of the uncertainties of future technological and regulatory changes as well as increasing energy costs, reduced availability of conventional energy sources (natural gas and fuel oil), limited availability of suitable land for disposal, and increased environmental concern on the part of the public, it is recommended that the District consider the implementation of several combinations of options as shown in Table 101, as part of its overall long-term solids management strategy. A combination of process train options will provide a stronger, more reliable system for a major portion of the sludge generated in the Region. The maximum capital cost of facilities for the MSD-Jones Island and MSD-South Shore facilities was estimated to be $59,000,000 to $98,000,000 for the planning period for a mix of three remaining process trains inclusive of thickening costs, transportation capital costs, and complete sludge process replacement. The plan to be developed for the District will specifically recommend such combinations. Furthermore, the District should implement immediate short-term measures (such as in-plant process changes, additional filters and dryers) to enable it to meet discharge requirements imposed by the Wisconsin Department of Natural Resources.

With the exception of the MSD-Jones Island and MSD-South Shore plants, municipal plants including West Bend should primarily effect sludge utilization through landspreading. Public pickup is desirable and should be encouraged. Backup facilities should include designated landfills, to be used in emergencies or when acceptance and demand do not equal production. Maximum use of the fertilizer, soil conditioner, or energy value of all sludges should be practiced. This Region is fortunate in that most major sludge generators are close to land application sites, and Milorganite has an established national market.

As there is limited landfill capacity available, a com-

TABLE 101

RECOMMENDATIONS FOR FACILITY PLANNING EVALUATION
FOR THE METROPOLITAN SEWERAGE DISTRICT
OF THE COUNTY OF MILWAUKEE

MSD-Jones Island Plant

Sludge processing facilities evaluation:

1. With Milorganite Production
   Thickening by gravity
   Chemical conditioning
   Dewatering with drying for Milorganite and:
   A. Incineration/Pyrolysis followed by residue landfilling and/or
   B. Anaerobic digestion prior to dewatering followed by landspreading or landfilling or
   C. No other processing.
2. With No Milorganite Production
   Thickening by gravity and/or dissolved-air flotation with:
   A. Dewatering and Incineration/Pyrolysis with residue landfilling and/or
   B. Anaerobic digestion with dewatering and landspreading or landfilling.

MSD-South Shore Plant

Sludge processing facilities evaluation of thickening by dissolved-air flotation with:

1. Anaerobic digestion, chemical conditioning and dewatering with landspreading or landfilling and /or
2. Dewatering, Composting and/or
3. Dewatering, Incineration/Pyrolysis with residue landfilling.

NOTES:

1. If effluent requirements are changed to 5 mg/l BOD_5 and 5 mg/l suspended solids, these recommendations are not expected to change. Recommendations to be evaluated under MSD Total Solids Management Program.
2. Backup system to all those shown is transport of sludge to landfill.
3. Evaluation should include transportation of sludge between plants in the MSD Total Solids Management Program.
4. Development of CSO facilities plans by the District may necessitate reevaluation of the above recommendations.

Source: Camp Dresser & McKee Inc.

prehensive solid waste management plan should be developed for the Region as a first step in the addition of needed capacity. Although the locations, and types of waste accepted for 88 sanitary landfills in the Region are a matter of public record, as of 1975 only three were licensed by the Department of Natural Resources to accept sludge, and toxic and hazardous materials. It is not known how much additional landfill capacity suitable for sludge disposal is available in existing or potential sites. Accordingly, in order to assure adequate capacity of landfills in the Region for sewage sludge management, it is recommended that a regional solid waste management plan be formulated to provide direction in the utilization or disposal of all solid wastes including sludge.

For South Milwaukee, it was found economically advantageous for its wastewater treatment plant sludge to be hauled to the MSD-South Shore plant for dewatering and disposal/utilization.

A detailed facilities plan is currently being prepared for Cedarburg and Grafton. However, it was found in this regional study that it is economically advantageous for each city to pursue an independent sludge management program assuming that they continue to operate separate treatment facilities. If the facilities plan analysis indicates that combination of treatment facilities is appropriate, then joint sludge management is required. The economic and environmental analysis performed in the facilities planning study should determine whether, from an overall, facilities standpoint, the two plants should remain separate or be consolidated.

The estimated cost of the recommended plan for 19 of the 21 major facilities are shown in Table 102. This table shows the total capital cost, operation and maintenance, total present worth cost, and the average annual cost.

Contaminant control programs for heavy metals and toxics should be developed, implemented, and enforced by each agency responsible for a wastewater treatment plant receiving such materials as part of the strategy to insure acceptable sludge quality for long-term land or other application. An additional element of this strategy is to investigate the possibility of sludge treatment for metals removal within the overall plant processing operations.

In 33 most suitable (of 83) townships in the Region, there are about 172,000 acres of land currently suitable for land application of sludge. This is 170 to 260 per-

TABLE 102

TOTAL COST OF RECOMMENDED SLUDGE MANAGEMENT PLAN FOR THE MAJOR FACILITIES[1]

Treatment Plant	Estimated Capital Cost	Estimated 1st Year Operations & Maintenance Cost	Estimated Average Annual Cost[2]
MSD-Jones Island[3]	$ 59,000,000 to	—	—
MSD-South Shore[4]	$ 98,000,000	—	—
Racine	$ 4,523,000	$ 196,000	$ 570,000
Kenosha	3,193,000	214,000	464,000
Waukesha	2,946,000	90,000	313,000
West Bend	2,484,000	90,000	310,000
South Milwaukee	365,000	36,000	62,000
Whitewater	2,255,000	38,000	210,000
Oconomowoc	—	29,000	48,000
Burlington	344,000	45,000	75,000
Walworth Co. MSD	1,438,000	24,000	134,000
Brookfield	1,080,000	93,000	209,000
Port Washington	247,000	16,000	63,000
Cedarburg	100,000	17,000	29,000
Grafton	532,000	62,000	108,000
Hartford	63,000	79,000	94,000
Twin Lakes	167,000	11,000	26,000
Williams Bay	19,000	5,000	8,000
Western Racine Co. MSD	938,000	7,000	77,000
Hartland-Delafield	1,519,000	12,000	130,000
Union Grove	—	56,000	63,000
Total	$ 81,213,000 to $120,213,000	$1,120,000	$2,993,000

[1]*ENR Construction Cost Index 2445 (August 1976).*
[2]*Amortization of capital cost at 6-3/8% plus Operation & Maintenance Cost.*
[3]*Refer to Table 67.*
[4]*Refer to Table 69.*

Source: Camp Dresser & McKee Inc.

cent of the total acreage required for the agricultural application of municipal sludge over an approximate 20-year period. The actual available acreage will depend on farmer and community acceptance. Also, the regulations governing the land application of wastewater sludges are still in the developmental stage and rates may be set by Environmental Protection Agency in the future. The above acreages are based on current Wisconsin guidelines.

Certain heavy metals limitations suggested to EPA by the Department of Agriculture would if adopted, only allow land application by seven large plants, based on available sludge quality data and the assumption of a moderately successful contaminant control program. An examination of the pattern of heavy metals values indicated that for the large plants, currently two or three heavy metals are above the suggested limits, while for the other plants, typically only one or two of the metals are above the suggested limits. Under such strict limitations, even a mandatory contaminant control program might not enable landspreading to be considered for a majority of the plants.

High-rate land application of sludge could be practiced where land will not be used in the future, for agricultural purposes. Sites with suitable soils which, according to the SEWRPC year 2000 land use plan, are expected to be urbanized, represent such lands in this Region. However, there is not a sufficient quantity of land suited to highrate land disposal at a low risk to make this option a viable long-range alternative for Southeastern Wisconsin.

Adequate suitable land must be made available to implement the Regional sludge management program including required landfills, through the year 2000 and beyond. To assure that land is available when it is required, it is essential that SEWRPC encourage its members to start immediately a coordinated program to develop public support leading to agreements with land owners and/or site acquisitions as appropriate. It is important in this context that each community recognize its longterm interdependence with others in the Region to solve the common problem of providing environmentally sound, sludge utilization. Backup sludge disposal facilities for all plants should include designated landfills to be used in emergencies or when acceptance and demand do not equal production. Maximum use of the fertilizer, soil conditioner, or energy value of all sludge should be practiced, with disposal of sludges to landfills minimized.

Other Wastewater Treatment Plant Sludges

Table 103 summarizes the recommendations for other municipal wastewater treatment plants in the Region. The alternative process trains shown are generally feasible and provide a least-cost approach. It should be remembered that the best process in a small plant is most often that which is the simplest and least subject to upset by shock loads. Final sludge utilization would be through land application.

TABLE 103

RECOMMENDATIONS FOR OTHER WASTEWATER TREATMENT PLANTS FOR SLUDGE PROCESSING, TRANSPORTATION AND UTILIZATION

PROCESSING OPTIONS

Gravity Thickening
Anaerobic Digestion
Lagoons
Vacuum Filters
Sand Beds

TRANSPORTATION OPTIONS

Truck

UTILIZATION/DISPOSAL OPTIONS

Landspreading
Public Pickup
Landfilling (generally as a backup)

Note: Specific process drain options for each plant to be determined in facilities plans.

Source: Camp Dresser & McKee Inc.

The total estimated capital costs of sludge processing, transportation and utilization facilities for all the 40 other treatment plants in the Region through the year 2000 are presented in Table 105.

Septage and Holding Tank Wastes

At present, there are an estimated 69,000 septic tank systems and an undetermined number of wastewater holding tanks located in the Region. Based upon available data, less than one percent of the average flow to municipal treatment plants results from the discharge of septage and holding tank wastes.

It is recommended that municipal treatment plants receive no more than 10 percent of their average influent flow from septage and holding tank wastes. Such wastes should be discharged from tank trucks directly

TABLE 104

GENERAL RECOMMENDATIONS—DISPOSAL OF INDUSTRIAL PRETREATMENT SLUDGES

Industrial Category	Sludge Disposal Option[1]
Tannery Sludges	Landfill
Metal Plating	Landfill
Metal Machining	Landfill or incineration
Milk Processing and other dairy wastes sludges	Landfill or landspreading[2]
Meat Processing	Landfill or landspreading[2]
Vegetable processing wastes sludges	Landfill or landspreading[2]
Battery manufacturing wastes sludges	Landfill
Truck and Car Wash Operations	Landfill
Power Plants wastes sludges	Landfill

[1]*Sludge not discharged to municipal system. Landfills licensed by Wisconsin DNR to accept hazardous and toxic wastes. These are currently Metro Disposal Service Inc.—Franklin, Land Reclamation Ltd. (Oakes) and United Waste Systems (Lauer).*

[2]*Following stabilization (digestion).*

Source: Camp Dresser & McKee Inc.

into aerated holding tanks for metered introduction to the plant influent as a percentage of the influent flow rate. In this way, shock loads will be minimized. The number and size of tank trucks discharging wastes to a plant should be closely monitored by the plant operator to avoid overloading. The haul distance is not considered to be the decisive factor since economics and convenience govern the area serviced by haulers for discharge to a given facility.

Industrial Wastewater Treatment Plant Sludges

Table 104 summarizes the general recommendations for industrial pretreatment sludges. Recycle of materials within all industrial plants should be encouraged to reduce the materials entering the pretreatment process and the sewerage system, to recover valuable materials where possible, and to reduce the quantities of waste materials entering the environment. Those sludges containing heavy metals or toxics in such concentrations as to preclude groundwater and surface water protection, should be landfilled in hazardous and toxic waste landfills or be further processed to reduce concentrations.

Many sludges resulting from separate pretreatment of industrial wastewaters contain heavy metals or other contaminants and, unless concentrations are reduced to nonhazardous levels, should be disposed of only in licensed hazardous and toxic wastes landfills. Three such landfills exist in the Region; however, these sites have limited capacity for such wastes. As part of a Regional solid waste management study additional site requirements should be evaluated.

A variety of contaminant control strategies should be considered to reduce contaminant levels to those which will allow use of all feasible solids management processes including landspreading. Such strategies should include control of contaminants in raw materials be used by industry, inplant industrial process change, pre-treatment by industry, monitoring of suspected sources of contaminants, sidestream treatment at treatment facilities, and disposal at landfill sites licensed to receive such materials.

Some industrial wastewaters in the Region contain concentrations of contaminants which result in high levels of these contaminants in municipal wastewater sludges. Municipal sludges are not usually considered as toxic and hazardous wastes; however, a special permit is required if a landfill is to accept sludge. In municipalities where there is little or no industry, sludge should not have a high concentration of heavy metals or other toxic substances. These municipal sludges present few problems. Where industries which have toxic wastes exist in the sewer service area three possibilities exist for a sludge that may require special permits and special considerations in its disposal:

1. The industry pretreats and has a sludge which could be classified as toxic or hazardous–no toxic material enters the municipal sludge.

2. The industry partially pretreats; both the industry and the municipality may have a sludge that could be classified as toxic and hazardous requiring special considerations in its disposal.

3. The industry does not pretreat–the industry has no sludge but the municipality may have a sludge that could be classified as toxic and hazardous requiring special considerations in its disposal.

TABLE 105

APPROXIMATE TOTAL CAPITAL COST OF RECOMMENDED PLAN FOR THE REGION THROUGH YEAR 2000

Facility Type[1]	Estimated Total Capital Cost[2]
MSD-Jones Island and MSD-South Shore[3]	$59,000,000 to $98,000,000
Other Major Plants (Alternative 1)	22,200,000
Other Plants	1,300,000
Industrial Categories[4]	3,000,000
Total for Combined Sewer Overflow Solids[5]	$12,000,000 to $22,000,000
Total for Stream Bottom Sediments	Unknown
Total Program Costs	$97,500,000 to $146,500,000

[1]*Septic and holding tank wastes accepted at municipal facilities. Most water treatment plant sludges accepted at municipal facilities.*

[2]*ENR Construction Cost Index 2445 (August, 1976 Base).*

[3]*These costs do not reflect the additional costs that would be required if advanced wastewater treatment is implemented to meet 5 mg/l BOD_5 and 5 mg/l SS effluent standards.*

[4]*This value does not include costs for major in-plant process changes instituted to reduce contaminant levels in wastewaters.*

[5]*Includes only sludge handling facilities required to comply with Department of Natural Resources Stipulation. Does not include increased solids expected from compliance with 5/5 effluent standards.*

Source: Camp Dresser & McKee Inc.

Leachate Collection, Treatment and Disposal

All landfills, particularly those accepting hazardous and toxic wastes, should be designed to minimize the production of leachate and for the protection of groundwater. Leachate that may be produced must be collected and treated before discharge to nearby water courses. Treatment may be provided at a municipal wastewater facility or at a self-contained on-site facility.

Water Treatment Plant Sludges

Water treatment plant sludges may be discharged to the nearest sewerage system if rates are controlled to avoid upsets at the wastewater treatment plant. This is the current practice for about 90 percent of this load. Otherwise, these sludges may be dewatered and disposed of in landfills.

Water treatment plant sludges do not generally present a serious future problem and may be discharged at uniform rates to municipal wastewater collection systems, where they are close-by, or dewatered at water treatment plants and landfilled.

Combined Sewer Overflow and Stream Bottom Sediments

The estimated cost shown in Table 105 for handling sludges originating from combined sewer overflows, has been estimated by the Metropolitan Sewerage District of the County of Milwaukee. The estimated cost for facilities required to process stream bottom sediments is not known at this time, because estimates of quantities have not been made, and processing requirements are not fully determined. It is expected that preliminary layouts, and estimated quantities and costs of required facilities will be prepared under the combined sewer overflow study presently being conducted by the District.

Cost of Recommended Plan

The estimated total cost of the recommended plan for the Region is presented in Table 105. The major municipal facilities will account for about 93 percent of the total public expenditure required. The costs shown for the MSD-Jones Island and MSD-South Shore plants represent an expected upper limit figure while those for categories of small plants and industries are based on groupings of categories of facilities.

Public Participation in Plan Development

The public was invited to participate in the development of the Regional sludge management plan through a variety of citizen participation activities including newsletters, workshop meetings, telephone networks, and citizen advisory panels. The overall purpose of these activities was to keep the public informed on the progress and interim results of the study and to solicit comments and input from the public.

SEWRPC published a series of monographs on water quality management. The February 1977 issue of "Update" was devoted to sludge management (copy in Appendix L). "Update" is mailed periodically to a large cross section of citizens and officials in the Region. The lead article in the SEWRPC general newsletter of January-February 1977 also contained a discussion of sludge management. The newsletter is mailed to all elected officials in the Region as well as others interested in regional planning matters. The highlight of this newsletter article was a centerfold, color map showing the current method of utilization of sludge within the Region.

As part of the overall public participation program being carried out by SEWRPC, three subregional sludge management alternatives workshops were held in early 1977. The purpose of the meetings was to present preliminary alternatives for Regional sludge management so that persons attending the meetings could offer opinions and suggest alterations that might ultimately render final recommendations more implementable. The intent was to get input prior to final alternative selection and this was fulfilled.

Participants in the subregional meetings included farmers, treatment plant operators, public officials, representatives of environmental groups, and local citizenry. Participants were also invited through news releases and by the University of Wisconsin Extension Service. The county agricultural extension agents were instrumental in encouraging participation. The meetings were subdivided for discussions into the four major aspects of the planning effort: sludge processing, transportation, utilization, and management. The major issues raised at these meetings were:

- sludge storage both at the treatment plant and spreading sites
- buffer zones between spreading sites and adjoining land uses
- heavy metal content of sludges
- fertilizer value of sludge
- landspreading equipment state-of-the-art
- sludge incineration and energy recovery
- farmer experience with land application
- public acceptance of land application
- composting.

In general, those in attendance at these meetings expressed support for the use of sludge as a soil additive. A more detailed summary of the workshops can be found in the Appendix.

Another element in the SEWRPC's public participation program for water quality management was an Educational Telephone Network utilized on 24 March 1977. This two-way audio hookup between central locations in each county in the Region permitted interested citizens and officials to interact with the SEWRPC staff and representatives of CDM.

A more formalized and periodic method of citizen participation is the Citizen Advisory Panel composed of environmental groups, representatives of businesses and industries, engineers, and others. This group has met several times during the duration of the sludge management study. They have reviewed the study's progress during alternative development and screening phases. The group also toured the MSD-South Shore treatment plant including its sludge handling facilities.

The Regional Sludge Management Subcommittee of the Technical Advisory Committee for Areawide Wastewater Treatment and Water Quality Management Planning has provided continuing review of this plan throughout its development.

IMPLEMENTATION

Plan implementation will occur in several phases and will require coordination and communication between several levels of agencies. The critical phases to successful implementation are: adoption, detailed planning, funding, construction, and operation and maintenance of the sludge management facilities. The critical level of government is the local boards, councils and commissions, the metropolitan sewage commissions, and, in particular, the Metropolitan Sewerage Commission of the County of Milwaukee. These agencies must coordinate their planning with areawide agencies: county boards and the Regional Planning Commission; state agencies, particularly the Department of Natural Resources, the Department of Health and Social Services; and federal agencies, Environmental Protection Agency, Department of Housing and Urban Development, the USDA Farmers Home Administration and the Department of Commerce Economic Development Administration. Each of these overseeing agencies plays a vital role in the successful implementation of the plan and provides technical and/financial assistance to the local agency. Without coordination and communication between these agencies, implementation of the plan may not be possible.

The Regional Planning Commission can provide assistance in facilitating the necessary coordination between levels of government and between this portion of the water quality management plan and other Regional planning efforts. In addition, information on governing regulations, permit procedures, restrictions and monitoring requirements is available through the Regional Planning Commission.

Regional management agencies could provide several valuable services, especially to small communities, and eliminate costly duplication of efforts in sludge utilization programs. Centralized administration and record keeping, laboratory services, maintenance services and a training program could prove to be advantages in the successful implementation of a sludge management plan. A regional management agency such as this, should be considered as part of the implementation program.

The ultimate responsibility for program development and site selection lies with the local management agencies. Provision must be made for adequate backup systems and interaction with neighboring communities. Sludge is a product and its utilization must be promoted by the local agency.

PUBLIC REACTION TO RECOMMENDED PLAN

As an integral part of its seven-step planning process, the Commission considers its plan evaluation and plan selection process to be critical in the development of sound regional plan elements. The general approach used by the Commission in all of its planning programs for the selection of a recommended plan from among alternatives is to proceed through the use of advisory committees, interagency meetings, public informational meetings, and public hearings to a final decision and plan adoption by the Commissioners themselves. Because the selection and adoption of a plan necessarily involves both technical and non-technical policy determinations, such a process must actively involve the various governmental, technical and private interests concerned. This active involvement is particularly important in light of the advisory role of the Commission in shaping regional development. These mechanisms combine in a generally applied process – which varies according to the needs of the specific interests and subject matter – used as a means of devising, selecting, modifying and eventually arriving at agreement on the development plans. These plans can then be jointly adopted and cooperatively implemented by all of the parties involved.

As an integral part of the regional wastewater sludge management planning program, three subregional sludge management workshops attended by more than 120 persons were held as informational meetings early in 1977, as described above. In addition, a full-day conference on sludge management was held on March 15, 1978, in the Waukesha County Exposition Center, with workshops for subregional areas in the afternoon, and a formal public hearing during the evening. The purpose was to more fully inform the public officials and the private landowners, persons involved in the transportation and application of sludges, and interested citizens about the findings and recommendations of the regional wastewater sludge management planning program, and to obtain public reaction to the plan recommended by the consultant, the staff and the Technical Advisory Committee on the Areawide Wastewater Treatment and Water Quality Management Planning, as well as by the Regional Sludge Management Planning Subcommittee thereof. The Regional Conference and associated hearing were widely announced with notices sent to about 2,400 potentially interested individuals and organizations included on the Commission Newsletter mailing list, and to 3,500 interested persons and organizations included on the special areawide water quality management planning program mailing list. In addition, news releases were issued to all daily and weekly newspapers, and to radio and television stations serving the Region; and special notices were provided through the University of Wisconsin Extension Service offices in each of the seven counties in the Region. A summary of the inventory, analysis, and forecast findings of the regional wastewater sludge management planning development plans considered, and of the recommended Regional Wastewater Sludge Management Plan was presented in SEWRPC Newsletter, Volume 18, No. 1, which was made available at the Regional Conference and the public hearing, and was widely disseminated throughout the Region.

The details and the summary minutes of the Regional Conference as well as the transcript of the public hearing along with a description of the notification procedures utilized by the Commission are published in the *Proceedings of the Tenth Regional Planning Conference,* published in June, 1978, approximately 200 pages in length. These proceedings were made available for review by the Commissioners for their consideration prior to the final adoption of the recommended plan.

One additional informational meeting was held on March 20, 1978 at the request of the representatives of the Wisconsin Liquid Waste Carriers Association, Inc. The purpose of this meeting was to provide a more detailed explanation of the implications and potential effects of the recommended Regional Wastewater Sludge Management Plan, for the handling and disposal of septage and holding tank wastes at the municipal sewage treatment plants within the Region.

More than 210 persons registered and attended the Regional Conference and the afternoon workshops, while 38 persons participated in the public hearing. The record of the proceedings indicates that local government and public reaction were displayed towards a few of the recommendations contained in the plan, while either passive or positive reactions were indicated for most of the plan recommendations. The specific public reactions to the recommended Regional wastewater sludge management plan are more specifically summarized below, together with the Commission response thereto. The plan contains recommendations for the management and disposal of municipal sewage treatment plant sludges, private sewage treatment plant sludges, industrial wastewater treatment facilities sludges, water supply treatment plant sludges, leachate, and septage and holding tank wastes. Of these, only the plan element for municipal sewage treatment plant sludges and the plan element for the management of septage and holding tank wastes, were the subjects of significant public reaction, except that the auxiliary plan element related to environmental sampling program recommendations was the subject of requests for the development of additional details.

Municipal Sewage Treatment Plant Sludge
Management Plan Element

During the course of the Regional Conference, the associated workshops during the day, and the formal hearing held in the evening, the Commission received reactions to the specific plan recommendations regarding individual municipal wastewater treatment facilities. The following comments present a brief summary of the comments raised by local officials and the general public, and the pertinent responses to the individual comments. The comments are organized by treatment plant as they are listed in the recommended plan as set forth in Chapter X, and are presented in like sequence, along with introductory comments of a general nature regarding the responsibility for sludge management.

Responsibility for Sludge Management—In each of the four afternoon workshops, and in the public hearing itself, an important general issue was raised as to who should be responsible for the safety of land application as a means of sludge management, and particularly for avoiding over-application. The direct response—offered repeatedly during the day—was that the sludge generator has the responsibility. The Commission staff concluded from the questions reflected in the Conference Proceedings, that amplification was needed on this point of the plan. The protection of the environment is ultimately a matter of public health and safety and therefore befalls every self-directing adult. However, the management of wastewater sludge, including the processing, transport, re-use, or disposal resides morally, technically, and economically in the sludge generator. The generator knows the source, composition, environmental and human health effect and cost components of a given sludge. Accordingly, the functions suitable to be performed or caused to be performed by the sludge generator includes, but is not limited to the following:

1. The testing and recording of pertinent physical, chemical, bacteriological, and viral characteristics of the sludges.

2. The development and implementation of a local sludge management plan, as well as the obtaining of pertinent federal, state, regional, and local approvals thereof. This includes the establishment of explicit intergovernmental cooperation between the sludge generator and the civil town, village or city responsible for the local land use decisions. In this regard, the pertinent county soil and water conservation district may also be especially helpful as an involved governmental unit.

3. The review, monitoring evaluation and reporting of results of proposed and current sludge management techniques, including such matters as identifying and obtaining approvals for land application or burial sites; such matters as actually applying the sludges; and such matters as sampling the soil, crops, surface water, groundwater or air, as appropriate. Thus, the sludge generator should bear some responsibility for the long-term land management actions of the land owners.

In addition, the plan recommends that procedure and data handling capability be developed by the Commission itself to record for long-term use, the sites, amounts and characteristics of land-applied sludges. This is a very important recommendation designed to avoid multiple or excessive applications of sludges beyond those intended in the original approval for land application on a given land parcel. This auxiliary plan element is also intended to assist local units of government in their operational responsibilities—as noted above—for long-term land management by farm operators.

Milwaukee Metropolitan Sewerage District—Jones Island and South Shore Plants—For the Jones Island plant, the plan recommended that four primary sludge management processes be examined in detail in the ongoing facilities planning program in order to determine which of the four, or which combinations thereof will provide the most cost-effective resolution to the sludge management problems of this plant. The four alternatives include: (1) continued Milorganite production; (2) dewatering, incineration and landfill of residue; (3) digestion, dewatering and land application in partially dried form; and (4) digestion, dewatering and landfill.

For the South Shore plant two or more of four alternatives were recommended to be chosen on the basis of more detailed analyses to be conducted in the facilities planning program. For the South Shore plant the four primary processes to be examined included: (1) dewatering, incineration and landfill of residue; (2) digestion, dewatering and land application in partially dried form; (3) digestion, dewatering and landfill; and (4) dewatering, composting, and marketing of the compost.

Importantly the system plan recommends that the facilities planning process determine for both of these plants the relative cost effectiveness of transporting sludge for potential processing and management jointly, in order to effect possible economies of scale. In general, and specifically in the case of the treatment facilities of the Milwaukee Metropolitan Sewerage Commissions, the recommended Regional Sludge Management Plan placed special emphasis on the land application of sludges for utilization by agricultural activities.

Three general issues were raised in regard to these recommendations. A representative of the Citizens for Better Environment, Mr. William Forcade; a representative of the general citizenry and environmentalists and a resident of the City of Franklin, Mr. Edward D. Jurasinski; and the Chairman of the Town of Waukesha, Mr. Wilson L. Wright, all indicated concern regarding the levels of toxic and hazardous substances in the sludges applied to lands utilized for crops which enter the food chain, and for the long-term protection of the capacity of the soils for the production of safe foodstuffs. One of Mr. Wright's concerns related to organic chemicals, specifically polybrominated biphenyls (PBB); while Mr. Forcade and Mr. Jurasinski expressed concern about cadmium and other heavy metals present in sludges. Also, the Commission received written communications from a representative of the Metropolitan Sewerage Commissions, Mr. Wayne St. John. While endorsing the recommended plan as a suitable and comprehensive document for sludge management, Mr. St. John emphasized the need for flexibility for the District in maintaining landfill as a possible element of the total solids management system for the Metropolitan Sewerage Commissions. Finally, Mr. Donald K. Bulley, a resident of the City of South Milwaukee submitted a letter during the comment period after the hearing, requesting recognition and evaluation of odor problems associated with sludge lagoons.

As indicated by the record of the proceedings of the Regional Conference and the record of the hearing, the general reaction to the proposed sludge utilization on agricultural land was favorable. Without exception, this favorable response was conditioned on the stated assumption that careful management including sampling and involvement of regulatory agencies was a required integral element of such a solution. Mr. Forcade and Mr. Jurasinski both indicated their concern that management of sludges be carefully regulated and controlled, and be limited in cases where heavy metals are unusally high. Mr. Forcade noted that the Food and Drug Administration of the U. S. Department of Agriculture had issued recommendations for sludge characteristics for application on specific crops, and observed further that some chemical characteristics for the sludges in the Region were reported in Commission studies to be as high as 50 times the recommended concentrations.

Upon further research, the Commission staff concluded that Mr. Forcade's reference was to the U. S. Department of Agriculture (USDA) review comments (discussed on pages 77 through 80 of this report) as considered in the U. S. Environmental Protection Agency (EPA) proposed regulations for 40 CFR Part 257, "Solid Waste Disposal Facilities: Criteria for Classification" published on February 6, 1978. For tobacco, leafy vegetables and root crops, the USDA had recommended and EPA proposed a limit of 25 milligrams per kilogram of cadmium in the sludge. For other crops, the proposed regulations indicated that a maximum loading of 2 kilograms per hectare per year (1.78 pounds per acre per year) should be considered in the application of municipal sewage sludges, with a more stringent limit of 0.5 kilograms per hectare per year (0.445 pounds per acre per year) by 1985.

It should be noted that tobacco, leafy vegetables, and root crops would not be considered suitable for application of sludges under the Commission's Sludge Management Development Objective Number Three and the supporting principles and standards as set forth in Chapter VII of this report. For the maximum annual loading discussed, it should be noted that the sludges in the Region generally exhibit sufficiently low levels of cadmium that the annual loading limit would be dictated by nitrogen content rather than the cadmium concentrations. Moreover, the analysis of data indicates that this could also be expected to be true in 1985, when the maximum annual application rate of cadmium will be reduced to 0.5 kilogram per hectare per year. It is further noted that the limitations of the ultimate loading rates for cadmium range from 5 to 20 kilograms per hectare, depending on the cation exchange capacity of the soils, just as assumed in the Commission analyses in this report. All of these requirements, with exception of the more stringent—but still unconstraining—1985 maximum annual loading rate for cadmium, were considered in the development of the sludge management plan set forth in this report, and as noted above, are not affected by the newly published requirements.

Mr. Jurasinski's questions regarding the levels of the industrial chemicals polybrominated biphenyls (PBB's) and Polychlorinated biphenyls (PCB's) were addressed during the conference, as noted in the published proceedings. More specifically, Professor Arthur E. Peterson of the University of Wisconsin—Madison, School of Agriculture, cited the analysis of PBB's by Dr. Lee Jacobs of the University of Michigan Extension Service; and assured the conference participants that there is no indication of a problem with PBB's in sludges in Wisconsin. Moreover, the levels of PCB's in sludges were tested for in 24 municipal sewage treatment plants, as set forth in Appendix E on page 315 of this report, and found to be unusually low—in a range of 0.01 to 70 micrograms per kilogram, and about a factor of ten below the typical ranges observed in other sludges in the United States.

The representatives of the Metropolitan Sewerage District and the Sewerage Commissions of the City and County of Milwaukee indicated that the possibility for landfill application should be kept in active consideration for the facilities planning analysis. Clarifying language was added to the relevant sections of the plan analyses and recommendations. As noted above in the recommendations for the Milwaukee plants, this possibility is recommended to remain an active one, with the only condition being the recommended plan emphasis upon the reuse of sludge resources wherever possible.

In a meeting of April 20, 1978, the Regional Sludge Management Planning Subcommittee reviewed the public reactions to the plan findings and recommendations, as well as the Commission staff's proposed changes to respond to those public reactions. The Subcommittee acknowledged the expressed public concerns, and endorsed the proposed changes reported in this section. The Subcommittee also reacted to further information obtained by Mr. Edward P. DePreter on April 17, 1978. Mr. DePreter, as the manager of wastewater sludge land application for the Druml Company, the contractor hauling sludge from the South Shore sewage treatment plant, attended a meeting sponsored by the U. S. Environmental Protection Agency (EPA) regarding sludge management policies. Mr. DePreter advised the Subcommittee of the potential discussed at the EPA meeting, that the maximum allowable cadmium concentration of 25 mg/kg in sludge—as set forth in requirements described above—may be extended in federal agency policies, to include not only application to lands used for tobacco, leafy vegetables, and root crops, but to all agricultural land applications of sludge. Such a policy would have a potentially adverse effect upon the viability of agricultural land application for many sludges generated, and for most of the volume of sludge generated in the Region, as noted on page 257 of the report. The possibility apparently would not preclude forest land application of sludge. Although the information represents only informal comments of federal agency employees, the Subcommittee requested that the plan should explicitly address the possibility, by stating that properly designed and operated sanitary landfills should be used for disposal of such sludges, where land application is precluded. This back-up alternative had been addressed at numerous points in this report, but would become a primary sludge management technique.

Based on the letter comments of Mr. Donald K. Bulley, the Commission staff reviewed the plan recommendations pertaining to the use of sludge lagoons. On page 129, the report discusses odor problems associated with operation of lagoon storage. Odors are also addressed among the "aesthetic" considerations and cultural factors described for plan evaluation on page 138. In the discussion of alternatives for the South Shore sewage treatment plant, the plan indicates in pages 163 and following, that the long-term use of the existing lagoons has compelling disadvantages, and therefore should not be pursued. For some of the 21 large sewage treatment plants, properly designed—and in many cases "remote"—lagoon storage is recommended. These include Waukesha, Port Washington, Cedarburg, Grafton, Hartford, Twin Lakes, Williams Bay, Western Racine, Delafield-Hartland, and Union Grove. For these facilities, as well as for the smaller and categorically-addressed facilities, it is noted that the facilities planning activities are recommended to provide the actual design specifications. However, the regional plan does identify performance criteria which constrains the facilities plan recommendations. As noted on pages 383 through 389, adequately sized, and properly operated and maintained sludge management facilities and procedures should avoid major odor problems. This section can be related to the discussion of the South Shore sewage treatment plant on page 23 of the report, indicating inadequate digester capacity at the South Shore plant.

Perhaps most important, site-specific facilities plans must be reviewed and approved by the Commission based on the objectives, principles, and standards of adopted regional plan elements. For the regional wastewater sludge management plan, this includes the location of facilities only near compatible land uses, and the requirement for full stabilization of sludges, as discussed in Table 57 on page 114.

For the reasons discussed above, the Commission concluded that the recommended plan includes consideration of odor problems to the degree appropriate for an areawide plan. Moreover, the recommended plan provides suitable performance criteria for review of odor-related considerations properly addressed in the site specific facilities plans and the Wisconsin Pollutant Discharge Elimination System discharge permits, developed pursuant to the Federal Water Pollution Control Act.

City of Racine—Representatives of the Racine County Planning and Zoning Department expressed concern about handling problems associated with the sludge, which is approximately 20 percent solids. Although the solids thickening and dewatering process as utilized serve to reduce the transportation cost, the agricultural representatives from Racine and Kenosha Counties indicated that this causes problems for spreading. Apparently when loaded into conventional solid manure spreaders, the sludges did not have sufficient shear strength to be unloaded by the action of the mechanical "flights" or "slats" which convey the solids for distribution to the spreading mechanisms at the rear of the device. Rather the slats seemed to pass under the sludges and required instead manual unloading of the sludge. Several alternatives were offered by the farmers and the representatives of the sewerage system operating agencies in attendance. One was for the sludge to be left to dry for a significant period of time—as much as one year. Another alternative was to apply the sludges in liquid form without dewatering. The Commission concluded that the logical interim recommendation for this situation is for liquid application in specific cases where partially dewatered sludge application problems become apparent, meanwhile pursuing the development of more compatible combinations of sludge processing and spreading equipment. Pending the availability of such a solution, it was concluded that Racine and other generators of problem sludge should take the responsibility for sludge application, if they choose to continue to dewater the sludge prior to application.

City of West Bend—Concern was expressed by the representatives of the City of West Bend that the high cadmium levels reported in this planning report for the sludge from the sewage treatment plant of the City, would require landfill disposal. Because no approved landfill is currently available to the City of West Bend, it was observed that immediate plan implementation was not feasible. Moreover, it was noted that there was reason to believe that cadmium levels had been reduced since the Commission sampling had been conducted. Accordingly, an amended recommendation is presented here, for the City of West Bend to proceed concurrently with 1) continued land application of the sludge following carefully the sludge sampling and the metals-loading limits recommendations of this plan, and 2) the further reduction of the high cadmium concentrations in the sludges by a source identification and reduction program. In addition it is recommended that soil and crop testing be undertaken for any agricultural lands which have been previously subject to heavy or repeated applications of sludge from the City sewage treatment plant. The conduct of an industrial survey to identify the cadmium sources and abate them at the earliest possible opportunity, should be undertaken immediately by the City Public Works Department. In both activities, the Commission can provide technical staff assistance, most especially in the provision of detailed soil survey data and supportive interpretive ratings of soil suitability for sanitary landfill. It is further recommended that the Wisconsin Department of Natural Resources provide staff assistance as requested by the City in both of the above recommended activities.

City of Oconomowoc—A question was raised during the workshops regarding the criteria for selection of the recommended primary land application zones for the City of Oconomowoc. Mr. William D. Rogan, Chairman of the Waukesha County University of Wisconsin Extension office, inquired as to the choice of the agricultural lands south of the City for the primary application zone, when agricultural lands are more plentiful to the north of the City. Based on this recommendation, the Commission staff reviewed the allocations for the City of Oconomowoc, as well as for other communities, and amended the spatial arrangement of the primary land application zones for the sewage treatment plants. The revised application zones as well as a summary depiction of the recommended regional sludge management systems plan are set forth on Map 12.

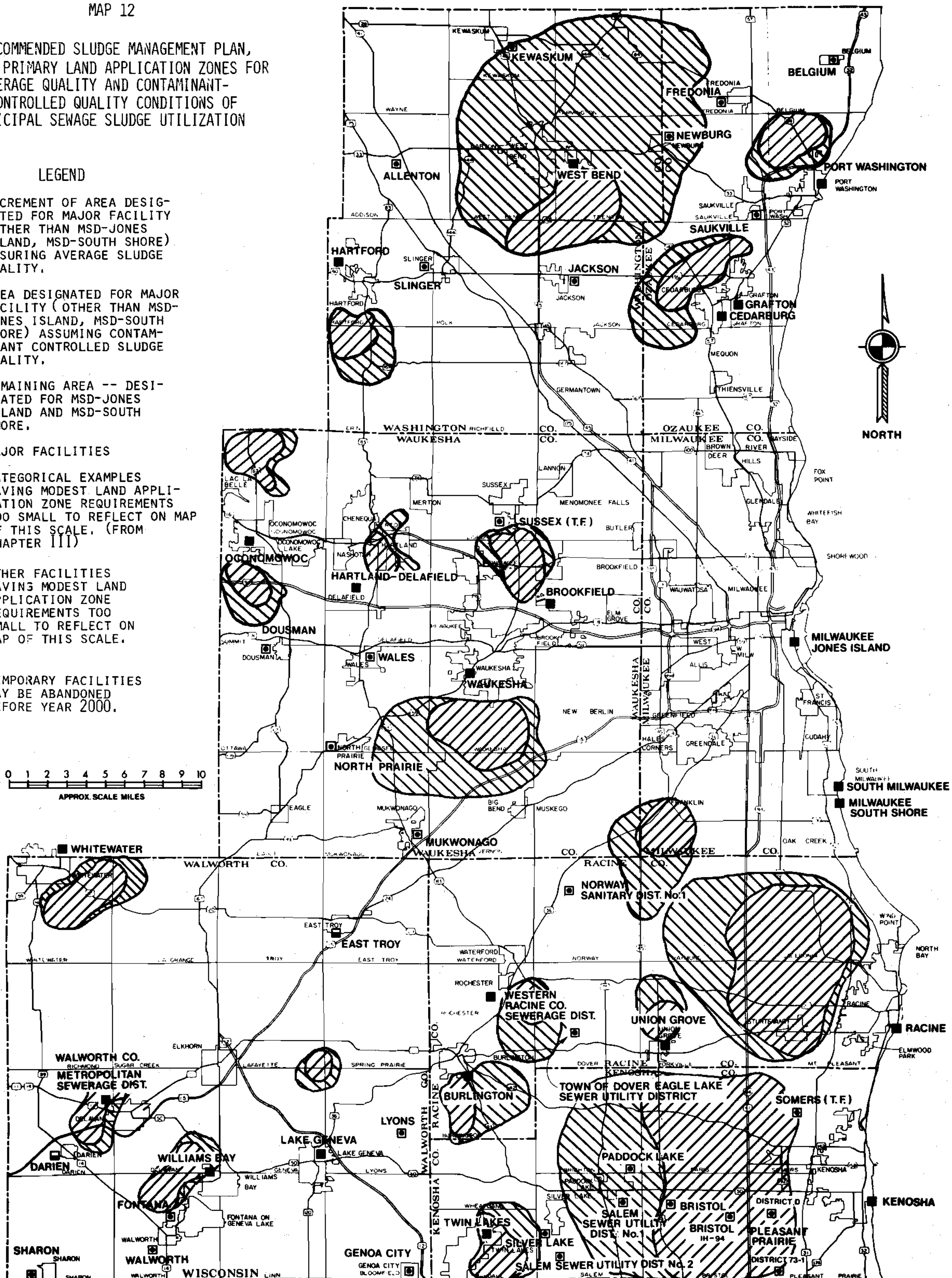
City of Brookfield—Representatives of the City of Brookfield inquired as to the potential availability of agricultural land for sludge application from their facility, and recommended that the Commission consider identification of sufficient lands for sludge application by the City. On review, the Commission staff concluded that the preliminary recommendation for continued utilization of the sludge incinerator at the City

MAP 12

RECOMMENDED SLUDGE MANAGEMENT PLAN, WITH PRIMARY LAND APPLICATION ZONES FOR AVERAGE QUALITY AND CONTAMINANT-CONTROLLED QUALITY CONDITIONS OF MUNICIPAL SEWAGE SLUDGE UTILIZATION

LEGEND

- INCREMENT OF AREA DESIGNATED FOR MAJOR FACILITY (OTHER THAN MSD-JONES ISLAND, MSD-SOUTH SHORE) ASSURING AVERAGE SLUDGE QUALITY.
- AREA DESIGNATED FOR MAJOR FACILITY (OTHER THAN MSD-JONES ISLAND, MSD-SOUTH SHORE) ASSUMING CONTAMINANT CONTROLLED SLUDGE QUALITY.
- REMAINING AREA -- DESIGNATED FOR MSD-JONES ISLAND AND MSD-SOUTH SHORE.
- ■ - MAJOR FACILITIES
- CATEGORICAL EXAMPLES HAVING MODEST LAND APPLICATION ZONE REQUIREMENTS TOO SMALL TO REFLECT ON MAP OF THIS SCALE. (FROM CHAPTER III)
- OTHER FACILITIES HAVING MODEST LAND APPLICATION ZONE REQUIREMENTS TOO SMALL TO REFLECT ON MAP OF THIS SCALE.
- (T.F.) - TEMPORARY FACILITIES MAY BE ABANDONED BEFORE YEAR 2000.



Sludge processing and handling through the year 2000 would continue at the site of each wastewater treatment plant. Process trains for sludge handling are recommended so as to reflect the specific needs and environmental constraints of each community. Processing equipment would be upgraded, expanded, or replaced as required to meet the projected sludge loads at each individual facility. Water treatment plant sludges are recommended to be handled in centralized sewerage systems whenever centralized sanitary sewerage service is available. Septage and holding tank wastes are likewise received at each individual wastewater treatment plant. Industrial wastewater sludges are recommended processed and disposed of separately.

The delineation of land application zones shown above reflects public comments on land application zones presented in Maps 9 and 10 of this report, following the Regional Conference and Hearing. The locations and extent of the areas are based on procedures of Technical Bulletin No. 88, and the detailed interpretive soils mapping. The specific spreading areas are located in accordance with the Commission recommended year 2000 land use plan. The study findings indicate that sufficient land is available for all plants through year 2000. Map of current land application practices is presented in Appendix F, and provides a comparison showing that the recommended land application zones would result in reduced sludge transportation costs.

Source: SEWRPC.

of Brookfield sewage treatment plant to the year 2000 would require seven days a week of three-shift operation, would be inconsistent with normal operating shift procedures, and would preclude sufficient preventive maintenance opportunity. Therefore, the Commission staff recommends that the City of Brookfield utilize not only its existing incinerator and associated sludge processing, but also the application of dewatered and digested sludge on suitable agricultural lands within the primary land application zone for the City of Brookfield as identified on Map 12, and based on the land application analyses of alternating and the summary table presented on page 331.

The Village of Grafton—Subsequent to the Regional Conference and associated hearing, written comments were received from the Grafton Water and Wastewater Commission, by letter dated March 17, 1978, signed by Mr. James Wilson, Utility Engineer. The letter offered comments pertaining to basic inventory data. The comments have been incorporated as appropriate in the final printed version of this report. The letter further observed that the detailed facilities planning activities of the Water and Wastewater Commission had concluded that sludge dewatering by use of a horizontal belt press were particularly cost effective and low in energy requirements. The letter indicated that the costs would be considerably less than for other types of dewatering equipment, and requested that these findings be taken into account in the preparation of final report. It should be noted that the preliminary recommended regional plan for sludge management at the Grafton sewage treatment plant considered only lagoon drying or vacuum filtration as alternative sludge dewatering techniques and did not provide for evaluation of the belt filter press. Because the analysis of the Water and Wastewater Commission had been conducted with very specific cost estimates for horizontal belt presses for the Village of Grafton sewage treatment plant, and the recommendations of the engineering analyses had been undertaken in a plan implementation action, the Commission adopted the locally proposed action as a sub-element of the regional wastewater sludge management plan.

Williams Bay—During the Regional Conference, questions were raised in the Walworth County workshop regarding the anticipated five-fold increase in sludge generation rates at the Village of Williams Bay sewage treatment plant. Commission staff confirmed these estimates, as set forth on page 90 in Chapter V of this report. It is anticipated that sludge generation rates will increase because of increased treatment levels and increased wastewater loads, reflective in part of an increase in the area served by the Village. This results in an approximately five-fold increase from 100 dry pounds per day to 500 dry pounds per day, over the period 1975 to the year 2000 at the Village of Williams Bay sewage treatment plant.

Lake Geneva—Subsequent to the Regional Conference on Wastewater Sludge Management, and the official public hearing, questions arose regarding the analysis of alternatives for the City of Lake Geneva. It should be noted that the City of Lake Geneva had the only trickling filter sewage treatment plant with phosphorus removal of any significant size within the Region and therefore, was chosen as an example of this category of treatment facility. However, this resulted in an analysis of only a limited range of alternatives, since the smaller plants which were treated categorically in the recommended regional sludge management plan, were afforded a less detailed treatment and discussion than were the facilities which were discussed individually. Because of the current and anticipated future importance of the City of Lake Geneva wastewater treatment facility, it was concluded that additional details should be developed concerning plan alternatives at this facility. Accordingly, the following discussion of sludge management alternatives was developed as a parallel to the discussions set forth in Chapter IX for individual sewage treatment plants.

Current sludge volumes of approximately 0.7 dry tons per day are estimated to increase to approximately 3.9 dry tons per day by year 2000 and will require additional capacity at the existing treatment plant. A facilities plan is currently under development by the City's consultant. Sludge handling currently consists of anaerobic digestion from the primary and secondary clarifiers, with tank truck transportation of the sludge to a single purpose landfill site, formerly used by the City for refuse disposal. Based on the locally proposed plan as approved in the 1977 WPDES discharge permit, incorporation of the sludge into the soil is expected to be undertaken in the future.

In light of the findings of the analysis of alternative plans for the Region, as set forth on page 191 in Chapter IX, it may be concluded that the City of Lake Geneva sewage treatment plant, like other municipal wastewater treatment facilities of the Region, can be analyzed individually with no major economies of scale to be achieved in joint sludge management with other nearby facilities. If the facilities planning effort scheduled for completion in 1978 should indicate joint wastewater treatment with some or all of the nearby sanitary sewerage systems of the Village of Fontana, Williams Bay and Walworth, then the sludge management arrangement should also be jointly conducted.

The following sludge management alternatives were considered for the City of Lake Geneva sewage treatment plant. Option 1 assumes the use of gravity thickness, anaerobic digesters, vacuum or belt filter press, truck transport, and land spreading. The cost of this option would be about $190 per dry ton of raw sludge. Option 2 assumes the use of the same processes, except that landfill would be utilized rather than land spreading. Option 2 is estimated at a cost of about $205 per dry ton of raw sludge. Option 3 would also include gravity thickening and anaerobic digestion, but would also involve truck haul, remote storage lagoons, and landspreading. The cost is estimated at about $181 per dry ton of raw sludge.

Based on the cost data developed, Option 3 is recommended as the most cost effective. This option is indicated not only by the costs, but also by the objectives, principles and standards which favor the recycling aspects of land application; and by location of the existing sewage treatment facility which is in proximity to urban residential areas and favors remote storage. It should be noted that Option 1 is estimated at within 5 percent of the cost of Option 3, and offers flexibility of operation and better back-up capability, should future regulations preclude landspreading. Therefore, Option 1 is also a viable approach to sludge management at Lake Geneva.

The selected process train—providing for gravity thickening, anaerobic digestion, truck hauling of liquid sludge, lagoon storage, and spreading on agricultural land—has an estimated 30-year present worth of $1,126,000 for capital, and operation and maintenance costs. The average annual cost for the period 1976 through 2000 is estimated at $105,000 per year. If the sludge is spread by farm operators, the present worth for capital and operation and maintenance costs is estimated at $1,092,000 with about $102,000 estimated for the average annual cost.

Septage and Holding Tank Wastes Management Plan Element

During the Regional Conference and the official hearing, verbal and written questions, respectively, were presented regarding the plan recommendations pertaining to septage and holding tank wastes. In a letter addressed to Mr. George C. Berteau, Commission Chairman, from Mr. James W. Morgan, Executive Secretary of the Wisconsin Liquid Waste Carriers Association, Inc., detailed written comments including six issues were presented, discussed below and are incorporated in the Conference Proceedings. First, the letter expressed concern that the existing and forecast amounts of septage may be underestimated. Second, the Association questioned whether the discharge of septage to currently overloaded sewage treatment plants was preferable to land application which is commonly practiced. Third, the letter identified the difficulty of implementation of septage discharge to municipal wastewater treatment plants. Fourth, the Association reiterated the need for public understanding of the importance of sludge management as discussed in this report. Fifth, the Association called for an understanding of the urban-rural interactions necessary for sound management of sludges and septage wastes, because of the mutual benefits to each of the two interests. This mutual understanding was suggested to be necessary to avoid the development of private facilities for treatment of hauled liquid wastes. Finally, the Association suggested that proper maintenance of private, onsite sewage disposal systems is essential to ensure the adequate protection of the environment, and encouraged the Commission to address this problem in the planning program.

The Commission staff reviewed the recommendations and offers the following comments in response:

1. Estimated Amounts of Septage—Of the total estimated amount of sludges generated within the Region as of 1975, septage was found to constitute an estimated 6.2 tons per day, or 1.6 percent of the total and therefore constitutes a problem of relatively modest proportion, compared to the need for sound management of municipal and other wastewater sludges generated in the Region. In order to estimate the amounts of septage and holding tank wastes generated, the Commission staff assumed 0.05 pounds of dry solids per capita per day from the range of 0.03 to 0.08 pounds per day as reported in SEWRPC Technical Report No. 18, *State of the Art of Water Pollution Control in Southeastern Wisconsin*, Vol. I, "Point Sources." Multiplying this value times the estimated population of 244,000 persons currently served by privately-owned onsite sewage disposal system, results in a total volume estimate of 12,400 pounds per day. This estimate assumes that all septic tanks are properly maintained and frequently pumped, and that solids do not pass in significant amounts from the septic tanks into the drain field or other means of effluent disposal. Upon reconsideration, the Commission staff concluded that the planning report incorporates the best available estimate of the amounts of septage generated. It should be noted that representatives of the Liquid Waste Carriers Association agreed, during the

subsequent meeting of March 20, 1978, when their letter comments were discussed with the Commission staff, and the basis for the estimate was explained.

2. Surface Spreading of Septage—The Association noted that surface spreading is a common approach to septage disposal, and probably is used for the majority of the septage in the Region. It was suggested that surface spreading would be far less expensive than hauling septage to sewage treatment plants. The Association noted that—differing from holding tank wastes—septage has a higher solids content, is more organically stabilized and is less likely to reach lakes or streams as surface runoff. Although it is recognized that the current practices frequently include the land application of septage by surface spreading by sanitary haulers within the Region, the Commission staff concluded upon careful review that the recommendation of the plan as presented at the public hearing should stand. There are two major reasons for this. First, as set forth in Objective No. 3, Standard No. 1, in Chapter VII of this report, it was recommended by the Subcommittee on Regional Wastewater Sludge Management and duly adopted by the Technical Advisory Committee on Areawide Wastewater Treatment and Water Quality Management Planning that no undigested or partially stabilized sludges should be land-applied within the Region. Since septage can include the raw sewage from the immediately previous day's use of the septage system, such wastes cannot be deemed fully stabilized without discontinuation of the use of the system by the homeowner prior to pumping. Even under these circumstances, the wastes would have been stabilized only by an anaerobic process and would continue to degrade and decompose in a noxious manner when exposed to the atmosphere during field spreading.

   Second, it was noted that the highly mixed urban/rural land uses within the Southeastern Wisconsin Region create a significant potential for public contact and the public health hazard as well as for the creation of nuisance conditions from field spread septage, as well as potential confusion to the lay public over the application of septage as opposed to holding tank wastes, and portable toilet wastes—which are even higher strength wastes—included in that category. It is noted that holding tank and toilet wastes are all deemed suitable only for disposal in sanitary sewage treatment plants, in the opinion of both the Commission and the sanitary haulers' organization. The Commission staff did deem it useful to clarify the conditions under which discharge of septage or holding tank wastes to a sewage treatment facility would be appropriate. Accordingly, it is hereby recommended that any sewage treatment plants for which the achievement of Wisconsin Pollutant Discharge Elimination System permit requirements would be significantly degraded by discharge of septage or holding tank wastes would not accept such wastes.

3. Septage and Holding Tank Wastes' Acceptance at Sewage Treatment Plants—As set forth in Table 106, only nineteen sewage treatment plants in the Region are reported to accept any hauled sanitary wastes at the current time. Consequently, the plan recommendation for disposal at each plant may be difficult to implement.

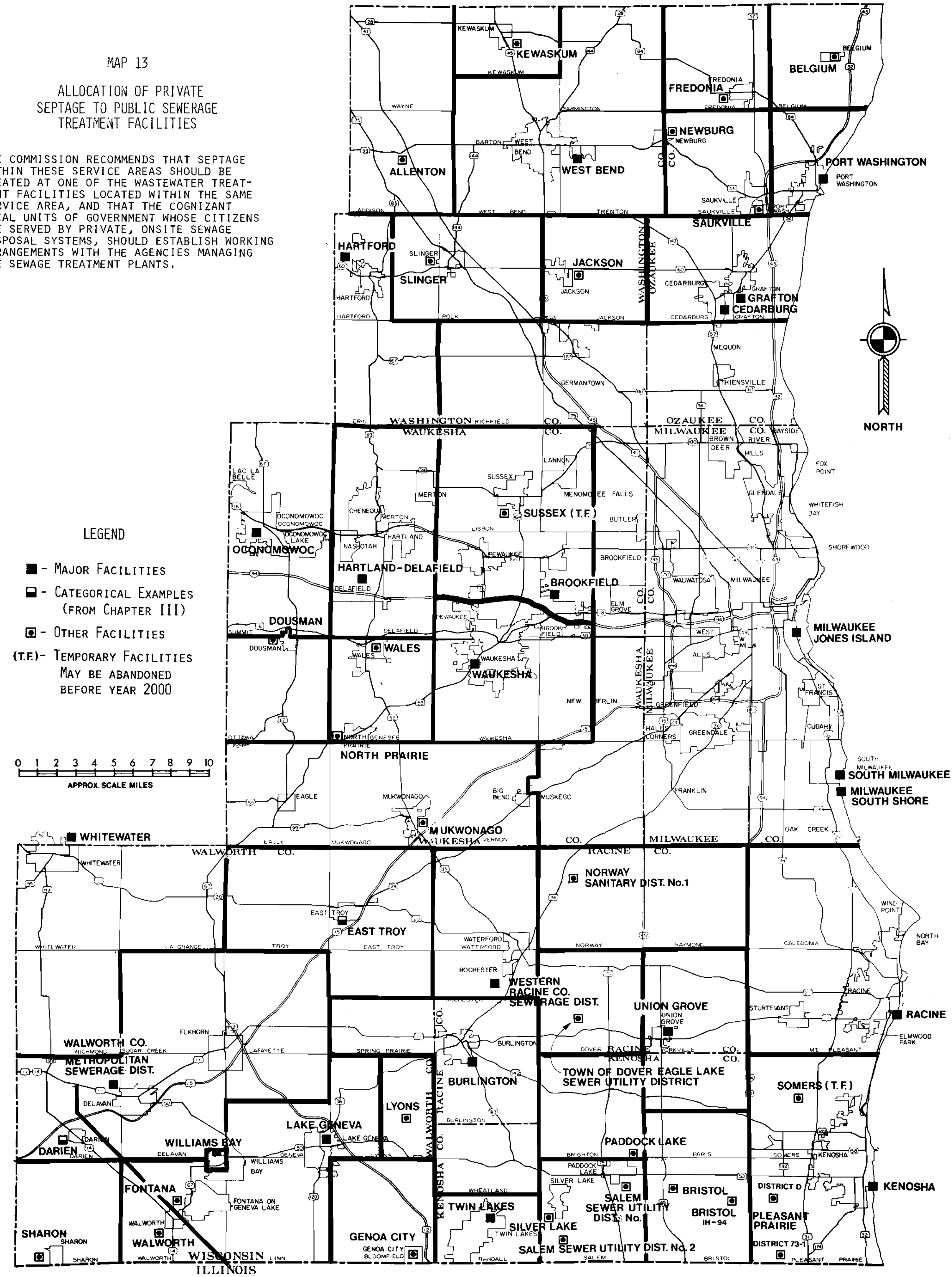
   Representatives of the Association noted that they had found some success in "trade-off" arrangements regarding the planned application of sludges in certain townships, along with the cooperative agreement for septage to be hauled to the wastewater treatment facility generating the sludge. This was recommended as one means for plan implementation, and is endorsed by the Commission. To this end the recommended spatial allocation of septage and holding tank wastes to specific sewage treatment plants has been revised as reflected in Map 13 to reflect a correlation between the primary zones of land application and the areas of septage contribution for a given treatment plant, and to reflect the importance of civil town boundaries as limits of a cohesive political unit bargaining on behalf of local residents relying on private onsite disposal systems. In addition to identifying specific areas, the map recognizes the spatial relationship between the land areas of the Region and the associated governmental units as potential primary sources of septage and hauling tank wastes, and simultaneously, as land application zones for municipal sewage sludge.

4. Public Information and Education—The Commission staff accepts and endorses the recom-

MAP 13

ALLOCATION OF PRIVATE SEPTAGE TO PUBLIC SEWERAGE TREATMENT FACILITIES

THE COMMISSION RECOMMENDS THAT SEPTAGE WITHIN THESE SERVICE AREAS SHOULD BE TREATED AT ONE OF THE WASTEWATER TREATMENT FACILITIES LOCATED WITHIN THE SAME SERVICE AREA, AND THAT THE COGNIZANT LOCAL UNITS OF GOVERNMENT WHOSE CITIZENS ARE SERVED BY PRIVATE, ONSITE SEWAGE DISPOSAL SYSTEMS, SHOULD ESTABLISH WORKING ARRANGEMENTS WITH THE AGENCIES MANAGING THE SEWAGE TREATMENT PLANTS.



SOURCE: CAMP DRESSER & MCKEE, INC. AND SEWRPC

TABLE 106

MUNICIPAL SEWAGE TREATMENT PLANTS
ACCEPTING SEPTAGE OR HOLDING TANK WASTES
IN THE REGION

Municipal Sewage Treatment Plant	Plants Accepting Septage or Holding Tank Wastes: in 1975 As Reported in SEWRPC Sanitary Sewerage System Questionnaire	in 1978 As Reported By Wisconsin Liquid Waste Haulers Association
Kenosha Co.		
Kenosha	X	X
Twin Lakes	—[1]	—
Milwaukee Co.		
MSD-Jones Island	X	X
MSD-South Shore	X	X
Ozaukee Co.		
Port Washington	X[2]	X
Cedarburg	X[3]	X
Grafton	X[4]	X
Racine Co.		
Racine	X	—
Burlington	—	X
Walworth Co.		
(None reported to accept hauled wastes routinely)		
Whitewater	—[5]	—
Washington Co.		
West Bend	—[6]	—
Hartford	—	X
Germantown	X[7]	X
Kewaskum	—	X
Waukesha Co.		
Waukesha	X	X
Brookfield	—[8]	X
Oconomowoc	—	X
Menomonee Falls-Pilgrim Road	—[9]	—
Menomonee Falls-Lilly Road	—[9]	—
Muskego-Big Muskego	X[10]	X
Muskego-Northeast	X[11]	—

Source: Wisconsin Liquid Waste Carriers Association, and SEWRPC.

[1]*Reportedly considering future acceptance of hauled wastes.*
[2]*"Minor amounts only" reported in questionnaire.*
[3]*"Residential only" as of August 1976 reported in questionnaire.*
[4]*Septage-1500 gal/month; holding tank wastes-75,000 gal/month.*
[5]*Reported to accept wastes from one holding tank in summer, about 55 gal/week.*
[6]*Reportedly intending to accept hauled wastes at some future time.*
[7]*Reported to accept 4700 gal/day of holding tank wastes, but no septage.*
[8]*Reported to have made provisions in case it became necessary at some future time to accept hauled wastes.*
[9]*Accepts hauled wastes "rarely" or "seldom."*
[10]*Reportedly accepts an estimated 6000 gal/week.*
[11]*Reportedly accepts no septage, but holding tank wastes at 15,000 gal/day.*

mendations of the Wisconsin Liquid Waste Carriers Association regarding the importance of public education, an issue raised repeatedly in the meetings of the Sludge Management Subcommittee of the Technical Advisory Committee on Areawide Wastewater and Water Quality Management Planning.

5. Private Alternatives for Septage and Holding Tank Wastes Treatment—The Liquid Waste Carriers Association noted the importance of the intergovernmental agreements, cited in paragraphs 2 and 3 above, but expressed further concern: if such intergovernmental arrangements cannot be suitably established, the Association indicated that, as a private interest group, it may seek approval for the development of a septage treatment facility which would comprise essentially a new industrial point source of water pollution. This would be in conflict with the identified point sources of water pollution provided for in the recommended plans of the Commission. The Commission appreciates the need for a suitable septage disposal arrangement and discourages the development of a parochial and private facility, designed exclusively for septage disposal.

6. Proper Operation and Maintenance of Onsite Disposal Systems—Finally, the Commission notes the importance of proper maintenance of onsite sewage disposal systems and concurs with the sanitary haulers that this issue is indeed an important one for areawide water quality management. As such, the subject is suitable for discussion in the nonpoint pollution source control element of the areawide water quality management plan, rather than

regional wastewater sludge management element. Accordingly, the Commission refers interested parties to the recommendations contained in Chapters X, XI, XII and XIII of SEWRPC Planning Report No. 30, *An Areawide Water Quality Management Plan for Southeastern Wisconsin* with regard to the management of onsite sewage disposal systems.

It should be noted that the Liquid Waste Carriers Association, before presenting their letter of comment at the official hearing and in subsequent communications, generally encourage the adoption of the Regional Wastewater Sludge Management Plan, subject to the incorporation of the considerations they raised. They also expressed their optimism that with proper public educational efforts, sound sludge management could quickly resolve sludge management problems.

Auxiliary Plan Elements—Environmental Sampling in Sludge Management

During the workshop for Milwaukee and Waukesha Counties, Mr. Michael D. Doran, representing John Strand & Associates, an engineering firm, questioned whether the potential costs of the recommended sampling upon the local wastewater sludge management agencies had been considered. The Commission staff noted at the workshop that during the progress of plan development, recommended monitoring requirements of the Wisconsin Department of Natural Resources had steadily increased. Accordingly, what had been assumed as negligible cost factors at the start of the plan development period had become potentially important issues in plan implementation by the time the plan had been developed. In response to the expressed concerns, the Commission staff reviewed the details of the cost estimates of the recommended sampling. As set forth on page 347 in Appendix F of the report, the estimated average cost for a typical site of sludge application may be about $1,000 the first year and $300 for each year thereafter, for sludge, soil, crop, groundwater and storm water runoff sampling.

Given these general costs, typical sludge characteristics and site, and the likelihood of situations requiring different levels of sampling intensity, the Commission developed cost factors to be included in the alternative evaluations of the areawide sludge management plan. For the one-time costs associated with site evaluation prior to land application, the amortized costs of groundwater test well installation, groundwater sampling, and soil tests are estimated at an average cost of $0.44 per dry ton of sludge applied. For the ensuing annual costs of soil, crop, and groundwater testing as recommended in Appendix F, the average cost is estimated at $0.64 per dry ton. The total cost of $1.08 per dry ton of land-applied sludge was therefore incorporated in the operation and maintenance costs presented in Table 73 on page 180. It should be emphasized that the resulting costs are above and beyond the sampling of wastewater required as part of sound operation and maintenance of sewage treatment facilities.

Concluding Comment—Public Reaction

In summary, it may be concluded that the public reaction to the preliminary regional wastewater sludge management plan recommendation, although mixed, was generally very favorable. In reviewing all the comments, opinions, and data presented at the meeting as well as the hearing held concerning the plan recommendations, the Commission determined to accept the recommendations as set forth in this chapter reflective of the major changes made in response to public comments.

SUMMARY

Implementation of the recommended plan presented above, if properly carried out, will provide for sound wastewater sludge management in the study area through the year 2000 and beyond, see Map 12.

Based on the investigations and analyses conducted for this study as described herein, a prime conclusion is that the present sludge management systems in the Southeastern Wisconsin Region are basically sound in concept from a technological viewpoint. From an environmental viewpoint, the Region has been and continues to be among the leaders in the United States in sludge management practices and public awareness. Milorganite production, distribution and use is a prime example of waste recycling. The extensive practice of landspreading of sludge in the Region is another example of recycling. However, aging and overutilized facilities, heavy metals and toxic wastes, and changing government regulations and citizen attitudes have rendered various aspects of the existing systems inadequate. As technology and governmental regulations, environmental and energy requirements, and knowledge of the effects of toxic materials change the concept of recycling and reuse should not change; however, the processing, transportation and utilization techniques followed must adapt to these changing conditions. The Regional sludge management plan recommended in this report meets these conditions by recognizing the need for maximum resource conservation and reuse. Sludge is thus considered as a resource to be properly utilized rather than an undesirable material to be disposed of.

APPENDIX

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Appendix A

PUBLICATIONS LIST[1]

NUMBER	PLANNING REPORTS
1	Regional Planning Systems Study (12-62, 73pp).
2	Regional Planning Base Mapping Program (7-63, 23pp).
3	The Economy of Southeastern Wisconsin (7-63, 175pp).
4	The Population of Southeastern Wisconsin (7-63, 100pp).
5	Natural Resources of Southeastern Wisconsin (7-63, 100pp).
6	The Public Utilities of Southeastern Wisconsin (7-63, 90pp).
7	The Regional Land Use-Transportation Study Volume One, Inventory Findings—1963 (5-65, 192pp). Volume Two, Forecasts and Alternative Plans—1990 (10-66, 256pp). Volume Three, Recommended Regional Land Use-Transportation Plans—1990 (11-66, 208pp).
8	Soils of Southeastern Wisconsin (6-66, 403pp).
9	A Comprehensive Plan for the Root River Watershed (9-66, 286pp).
10	A Comprehensive Plan for the Kenosha Planning District Volume One (2-67, 309pp). Volume Two (2-67, 227pp).
11	A Jurisdictional Highway System Plan for Milwaukee County (3-69, 130pp).
12	A Comprehensive Plan for the Fox River Watershed Volume 1, Inventory Findings and Forecasts (4-69, 445pp). Volume 2, Alternative Plans and Recommended Plan (2-70, 497pp).
13	A Comprehensive Plan for the Milwaukee River Watershed Volume 1, Inventory Findings and Forecasts (12-70, 514pp). Volume 2, Alternative Plans and Recommended Plan (10-71, 625pp).
14	A Comprehensive Plan for the Racine Urban Planning District Volume 1, Inventory Findings and Forecasts (12-70, 265pp). Volume 2, The Recommended Comprehensive Plan (10-72, 114pp). Volume 3, Model Plan Implementation Ordinance (9-72, 240pp).
15	A Jurisdictional Highway System Plan for Walworth County (10-72, 131pp).
16	A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin (2-74, 809pp).
17	A Jurisdictional Highway System Plan for Ozaukee County (12-73, 145pp).
18	A Jurisdictional Highway System Plan for Waukesha County (1-74, 171pp).

[1]*As of 17 March 1977.*

19 A Library Facilities and Services Plan for Southeastern Wisconsin (7-74, 163pp).

20 A Regional Housing Plan for Southeastern Wisconsin (2-75, 489pp).

21 A Regional Airport System Plan for Southeastern Wisconsin (12-75, 556pp).

22 A Jurisdictional Highway System Plan for Racine County (2-75, 129pp).

23 A Jurisdictional Highway System Plan for Washington County (10-74, 137pp).

24 A Jurisdictional Highway System Plan for Kenosha County (4-75, 133pp).

25 A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000
Volume 1, Inventory Findings (4-75, 414pp).

26 A Comprehensive Plan for the Menomonee River Watershed
Volume 1, Inventory Findings and Forecasts (10-76, 481pp).
Volume 2, Alternative Plans and Recommended Plan (10-76, 429pp).

NUMBER COMMUNITY ASSISTANCE PLANNING REPORTS

1 Residential, Commercial, and Industrial Neighborhoods, City of Burlington & Environs (2-73, 96pp).

2 Alternative Land Use & Sanitary Sewerage System Plans for Town of Raymond-1990 (1-74, 62pp).

3 Racine Area Transit Development Program 1975-1979 (6-74, 170pp).

4 Floodland Zoning Report for the Rubicon River, City of Hartford, Washington County, Wisconsin (12-74, 80pp).

5 Drainage and Water Level Control Plan for the Waterford-Rochester-Wind Lake Area of the Lower Fox River Watershed (5-75, 60pp).

6 A Uniform Street Naming and Property Numbering System, Racine County, Wisconsin (11-75, 52pp).

7 Kenosha Area Transit Development Program: 1976-1980 (3-76, 88pp).

8 Analysis of the Deployment of Paramedic Emergency Medical Services in Milwaukee County (4-76, 11pp).

9 Floodland Information Report for the Pewaukee River (10-76, 43pp).

10 The Land Use and Arterial Street System Plans, Village of Jackson, Washington County (12-76, 49pp).

11 Floodland Information Report for Sussex Creek and Willow Springs Creek.

12 Waukesha Area Transit Development Program 1977-1981 (1-77, 108pp).

NUMBER	PLANNING GUIDES
1	Land Development Guide (11-63, 96pp).
2	Official Mapping Guide (2-64, 52pp).
3	Zoning Guide (4-64, 158pp).
4	Organization of Planning Agencies (8-64, 86pp).
5	Floodland and Shoreland Development Guide (1-69, 199pp).
6	Soils Development Guide (8-69, 247pp).

NUMBER	TECHNICAL REPORTS
1	Potential Parks and Related Open Spaces (9-65, 32pp).
2	Water Law in Southeastern Wisconsin (1-66, 92pp).
3	A Mathematical Approach to Urban Design (1-66, 58pp).
4	Water Quality and Flow of Streams in Southeastern Wisconsin (4-67, 342pp).
5	A Regional Economic Simulation Model (10-65, 50pp).
6	Planning Law in Southeastern Wisconsin (10-66, 120pp).
7	Horizontal and Vertical Survey Control in Southeastern Wisconsin (1-68, 155pp).
8	A Land Use Plan Design Model Volume 1, Model Development (1-68, 102pp). Volume 2, Model Test (10-69, 91pp). Volume 3, Final Report (4-73, 102pp).
9	Residential Land Subdivision in Southeastern Wisconsin (9-71, 86pp).
10	The Economy of Southeastern Wisconsin (12-72, 90pp).
11	The Population of Southeastern Wisconsin (12-72, 98pp).
12	A Short Range Action Housing Program for Southeastern Wisconsin (6-72, 64pp).
13	A Survey of Public Opinion in Southeastern Wisconsin-1972 (9-72, 64pp).
14	An Industrial Park Cost-Revenue Analysis in Southeastern Wisconsin—1975 (6-75, 52pp).

15 Household Response to Motor Fuel Shortages and Higher Prices in Southeastern Wisconsin (8-76, 34pp).

16 Digital Computer Model of the Sandstone Aquifer in Southeastern Wisconsin (4-76, 46pp).

18 State of the Art of Water Pollution Control Southeastern Wisconsin Volume 4, Rural Storm Water Runoff (12-76, 50pp).

20 Carpooling in the Metropolitan Milwaukee Area (3-77, 55pp).

Appendix B

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53186 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

August 20, 1976

To Owners and Operators of Selected Industries in Southeastern Wisconsin:

As you may know, the Southeastern Wisconsin Regional Planning Commission is presently involved in an areawide water quality planning and management program. This program must address not only the kinds and levels of wastewater treatment required to achieve state and federally adopted water quality objectives but also the best means of disposing of sludges produced by the required wastewater treatment.

Certain industries operate wastewater pretreatment facilities which produce both clearwater effluents and by-product sludges. Information pertaining to the quantities and composition of these sludges is essential to the proper completion of the planning program. For the purpose of the planning program sludges are defined as acqueous suspensions of residual solids generated through the treatment of municipal or industrial wastewaters, and of such a nature and concentration as to require special considerations in their disposal. Please note that it is the Commission's intent to gather information pertaining to generation and disposal of only wastewater sludges and not of refuse material which is bulky, dry or solid.

To provide the necessary information, the Commission is undertaking an inventory of municipal and industrial wastewater treatment facility sludge production and disposal practices. Data is being requested from a representative sample of firms in the tanning; metal plating; machining; milk, meat, cheese and vegetable processing; and battery manufacturing industries; and from power plants and car and truck wash operations. For the above stated reasons the Commission would very much appreciate your assistance by the completion of the enclosed questionnaire. A self-addressed Commission envelope is also enclosed for your convenience.

Should you have any questions concerning this matter, please contact Mr. Jeffrey D. Cowee of the Commission staff at (414) 547-6721, extension 255.

Sincerely,

Kurt W. Bauer
Executive Director

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53186 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

October 5, 1976

To all Privately-Owned Wastewater Treatment Facility Owners and Operators:

Dear Sir:

As you may know, the Southeastern Wisconsin Regional Planning Commission is presently involved in an Areawide Water Quality Management Planning Program, pursuant to the provisions of Section 208 of the 1972 Amendments of the Federal Water Pollution Control Act. The purpose of this program is to determine surface water quality conditions, pollution sources, and the alternative actions which may be taken to achieve state and federally adopted water quality objectives.

Because wastewater treatment facilities produce both clearwater effluents and by-product sludges as a result of treatment, information pertaining to sludge quantities, composition and handling practices constitutes an important input to this planning program. Accordingly, the Commission is undertaking an inventory of relevant plant characteristics and sludge handling practices within the Region. As a part of this inventory, we would very much appreciate your assistance by completing the enclosed questionnaire and returning it to the Commission offices by November 1, 1976. Your cooperation in this matter will be greatly appreciated.

Should you have any questions concerning this matter, please contact Mr. Jeffrey D. Cowee of the Commission staff directly at (414) 547-6721, extension 255.

Sincerely,

Kurt W. Bauer
Executive Director

TREATMENT FACILITY AND SLUDGE HANDLING PRACTICES SURVEY
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
AREAWIDE WATER QUALITY MANAGEMENT PROGRAM

Industry Name: ____

Contact Name: ______________________________ Phone: __________

PLEASE COMPLETE THE INFORMATION BELOW:

1. Types of processes that generate wastewater at your plant: ______________

____

____

2. Do you treat the wastewater prior to discharge? ______________________

3. Type of wastewater treatment employed (blacken box):

☐ settling basin or tank
☐ sand filter
☐ oil separator
☐ screening
☐ lagooning
☐ chemical precipitation
☐ biological treatment
☐ pH adjustment
☐ sludge dewatering
☐ other, please specify: ____

____

4. Maximum number of gallons of wastewater discharged in one day: ________ gallons

5. Average number of gallons of wastewater discharged in one day: ________ gallons

6. Average quantity of treatment sludge generated in one day: ___________ gallons

7. Brief chemical analysis of sludge, if available: ______________________

____

8. Average quantity of other high strength liquid wastes generated per day:

__________ gallons

9. Brief chemical analysis of other high strength liquid wastes, if available:

____

10. Ultimate sludge disposal (blacken appropriate box):

☐ not applicable
☐ commercial recycling
☐ discharge to sanitary sewer
☐ lagoon
☐ landfill or dump
☐ internal recycling
☐ discharge to storm sewer
☐ other, please specify: ____

Name and location of disposal site or name of hauler: ______________________

____

Thank you.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53186 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

August 2, 1976

Dear Sir:

As you probably know, the Southeastern Wisconsin Regional Planning Commission is presently involved in an Areawide Water Quality Planning and Management (208) Program. The purpose of this program is to determine surface water quality conditions, pollution sources, and the alternative actions which may be taken to achieve state and federally adopted water quality objectives. Because sewage treatment facilities produce both clearwater effluents and by-product sludges as a result of treatment, information pertaining to sludge quantities, composition and handling practices constitutes an important input to this planning program. Accordingly, the Commission is undertaking an inventory of relevant plant characteristics and sludge handling practices within the Region. As a part of this inventory, we would very much appreciate your allowing us to arrange for an interview with the appropriate person on your staff, to review the enclosed questionnaire. We are aware that such detailed questionnaires place a burden on your staff. Therefore, a member of the Commission staff will contact you to arrange an interview and to complete the questionnaire for you. Your cooperation in this matter will be greatly appreciated.

Should you have any questions concerning this matter, please contact Mr. Jeffrey D. Cowee of the Commission staff directly at (414) 547-6721, extension 255.

Sincerely,

Kurt W. Bauer
Executive Director

TREATMENT FACILITY AND SLUDGE HANDLING PRACTICES QUESTIONNAIRE
FOR
SECTION 208 STATE OF THE ART OF WASTEWATER MANAGEMENT STUDY

Facility Name: ______________________ Date: ____________

Interviewee: ______________________ Interviewer: ____________

Interviewee Title: ______________________

Operating Agency: ______________________ Phone No.: ____________

Facility Location: ______________________

Communities Served: ______________________

I. GENERAL PLANT DESCRIPTION

A. Type of treatment provided: ______________________

B. Level of treatment provided: ______________________

C. Date of original plant construction: ______________________

D. Date and type of major modifications: ______________________

E. Number of connections: ______________________

F. Is the WDNR Design Schematic correct? ______________________

II. DISCHARGE DESCRIPTION

A. Number of discharge points: ______________________

B. Location: ______________________

C. Receiving body: ______________________

D. Does the facility have bypass capability? ______________________

E. How often does this occur? ______________________

III. EFFLUENT DISINFECTION CAPABILITIES

A. Does the facility have the capability to disinfect? ______________________

B. Is the facility currently disinfecting? ______________________

C. What types of disinfection are used? ______________________

D. What type and quantity of chemical is applied in lb./day? ______________________

____

E. What is the effluent residual chlorine level in mg/l? ________

IV. SEPTAGE

A. Does your plant or collection system receive discharges from septic tanks or sewage holding tanks? ________

B. What are the quantities?

1. Septic tank pumpage: ________

2. Holding tank pumpage: ________

V. INDUSTRIAL WASTES

A. Is your plant designed to receive industrial wastes? ________

B. Is your plant currently receiving such wastes? ________

C. What is the design flow for the industrial component of the influent (mgd)?

____

D. What is the average daily flow of the industrial contribution (mgd)? ________

____

E. What types of industrial plants? ________

VI. DESIGN CAPACITY

A. Population: ________ Average daily hydraulic (mgd): ________

B. Peak daily hydraulic (mgd): ________

C. Average daily organic (lb. $CBOD_5$/day): ________

D. Population equivalent: ________

E. Solids handling capacity (lb./day): ________

VII. EXISTING LOADINGS (1975)

A. Population: ________ Average daily hydraulic (mgd): ________

B. Peak daily hydraulic (mgd): ________

Peak hourly hydraulic (mgd): ________

C. Average daily organic (lb. $CBOD_5$/day): ________

D. Population equivalent: ________

E. Average daily suspended solids (mg/l): ________

F. Days in 1975 in which flow exceeded meter capacity: ____________________

Plant: ____________________

VIII. SLUDGE PRODUCTION

A. Primary treatment:

1. Average quantity of grit produced in dry lb./day:* ____________

2. Average quantity of sludge produced in dry lb./day:* ____________

3. What is the percent solids?* ____________

B. Secondary treatment:

1. What quantity of sludge is produced in dry lb./day?* ____________

2. What is the percent solids?* ____________

C. Advanced wastewater treatment or phosphorus removal:

1. What quantity of sludge is produced in dry lb./day?* ____________

2. What is the percent solids?* ____________

IX. SLUDGE DISPOSAL

A. Estimation of final quantity: ____________

B. Estimation of percent solids: ____________

C. How is the sludge stored during holding for disposal? ____________

D. On the average, how long is the sludge stored before disposal? ____________

E. How is the sludge transported away from the facility? ____________

F. What is the cost of transportation? ____________

G. What is the location of disposal? ____________

H. What is the method of disposal at that site? ____________

I. Describe the handling methods and equipment that are used on the treatment plant site and in the transport of the sludges away from the site.

J. What are the costs of these procedures? ____________

* Under average daily flow conditions-i.e., average amounts generated.

K. Describe the equipment and sludge handling methods that are employed at the disposal site.

L. What are the costs of these processes at the disposal site?

1. Capital: ______
2. Operation and maintenance: ______
3. Labor: ______
4. Materials: ______
5. Other: ______

VI. SLUDGE SOLIDS CHARACTERISTICS, IF AVAILABLE

A. Nutrient concentrations (percent), if available:

1. Total nitrogen: ______
2. Ammonia nitrogen: ______
3. Nitrate nitrogen: ______
4. Total phosphorus: ______
5. Total potassium: ______
6. Other: ______

B. Heavy metal (mg/l), if available:

1. Arsenic: ______
2. Cadmium: ______
3. Copper: ______
4. Chromium: ______
5. Lead: ______
6. Mercury: ______
7. Nickel: ______
8. Zinc: ______
9. Other: ______

C. Any other available data:

1. pH: ______________________________

2. Viral content: ______________________________

3. MFFCC: ______________________________

4. Pathogens: ______________________________

Appendix C

DEFINITION OF TERMS

The following list of definitions of terms related to sanitary sewerage systems includes and expands upon the definitions developed by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning and published in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974. The original list of definitions of terms set forth in Planning Report No. 16 was expanded to include terms utilized in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volumes 1 and 2; and SEWRPC Planning Report No. 29, A Regional Sludge Management Plan for Southeastern Wisconsin. The additional definitions were derived from the following sources: Preliminary Draft of SEWRPC Planning Report No. 29—Chapter IV, Areawide Wastewater Sludge Management Planning Program, Camp Dresser and McKee, 1977; Glossary Water and Wastewater Control Engineering, APHA, ASCE, AWWA, NPCF, 1969; Process Design Manual for Carbon Adsorption, USEPA, 1973; Environmental Engineers Handbook—Volume 1—Water Pollution, 1974; Wastewater Engineering, Collection, Treatment, Disposal, 1972.

Activated Carbon Adsorption—The process which involves the accumulation or concentration of substances on an activated carbon surface. Adsorption of substances in wastewater onto activated carbon can occur as a result of two separate properties of the wastewater-activated carbon system: (1) the low solubility of a particular solute in the wastewater; and (2) a high affinity of a particular solute in the wastewater for the activated carbon.

Activated Sludge Process—A biological waste treatment process in which a mixture of sewage and activated sludge is agitated and aerated in a tank to oxidize the organic matter in the sewage. The activated sludge, which consists of a growth of zoogleal organisms, is subsequently separated from the treated sewage by sedimentation and wasted or returned to the process as needed.

Aeration, Extended—A modification of the activated sludge process which provides for aerobic sludge digestion within the aeration system.

Aeration, Step—A procedure for adding increments of settled sewage along the line of flow in the aeration tanks of an activated sludge sewage treatment plant.

Appurtenances—Appliances or auxiliary structures comprising an integral part of a sewerage system, such as manholes, manhole covers, ladders, frames, and screens to provide for ventilation, inspection, and maintenance of the sewerage system, as well as specialized structures for conveying sewage, such as depressed siphons and junctions.

Bypass—A flow relief device by which sanitary sewers entering a lift station, pumping station, or sewage treatment plant can discharge a portion or all of their flow, by gravity, directly into a receiving body of surface water to alleviate sewer surcharge; also a flow relief device by which intercepting or main sewers can discharge a portion or all of their flow, by gravity, into a receiving body of surface water to alleviate surcharging of intercepting or main sewers.

Centrate—The liquid extracted from a sludge in a centrifuge used either for thickening or dewatering. Its composition depends on the physical and/or chemical treatment of the sludge, the centrifugal force used in the unit, and the design of the centrifuge.

Centrifuge—A mechanical unit in which centrifugal force is used to separate solids from water.

Chlorination—The application of chlorine to sewage effluent generally for disinfection.

Clarifier—A unit of which the primary purpose is to secure clarification of waste water such as sedimentation tanks or basins.

Clarification—Any process or combination of processes the primary purpose of which is to reduce the concentration of suspended matter in a liquid.

Composting—A process using aerobic thermophillic organisms to stabilize dewatered sludge; usually placed in piles and mixed with material such as wood chips, leaves, and other organic matter to keep the pile aerobic. The piles can be artificially aerated.

Conditioning of Sludges–A process used to aid in releasing liquid from sludges. It consists of treating the sludges with various chemicals or subjecting them to physical conditioning such as heating or cooling, or processing them biologically.

Contact Stabilization Process–A modification of the activated sludge process in which raw sewage is aerated with a high concentration of activated sludge for a relatively short period of time to obtain CBOD removal by absorption, the solids being subsequently removed by sedimentation, and transferred to a stabilization tank where aeration is continued to further oxidize and condition the sludge before reintroduction to the raw sewage flow.

Crossover–A flow relief device by which sanitary sewers discharge a portion of their flow, by gravity, into storm sewers during periods of sanitary sewer surcharge or by which combined sewers discharge a portion of their flow, by gravity, into storm sewers to alleviate sanitary or combined sewer surcharge.

Design Capacity, Average Hydraulic–The average influent sewage flow at which a sewage treatment plant will operate at design pollutant removal efficiencies.

Design Capacity, Organic–The average biochemical oxygen demand of the influent sewage, expressed as pounds of $CBOD_5$ per day, which the sewage treatment plant is designed to treat.

Design Capacity, Peak Hydraulic–The maximum influent sewage flow for which the plant is designed to operate without flooding; pollutant removal is still performed under this flow condition but at a much lower efficiency than the design efficiency.

Dewatering–The removal of additional liquid so that thickened sludge attains properties of a solid–that is, it can be shoveled, conveyed on a sloping belt, and handled by typical solids handling methods. Such dewatered sludge is usually in the form of a "cake" such as that produced by a centrifuge, vacuum filter, or filter press.

Digestion, Aerobic–The decomposition of organic matter in the presence of elemental oxygen.

Digestion, Anaerobic–The decomposition of organic matter resulting in gasification, liquification, and mineralization through the action of microorganisms in the absence of elemental oxygen.

Fertilizer–A material of known nitrogen, phosphorus, and potash content which is applied to land for the purpose of increasing plant growth by increased availability of known chemicals. The chemical content is commonly expressed as a three-number sequence (such as 20-10-5) denoting relative weights of N, P_2O_5, and K_2O.

Filter Backwash Waters–The water resulting from backwashing for removal of solids retained by granular media filters which are used to physically remove suspended solids from wastewater treatment plant effluents.

Filter Press–A mechanical press for separation of water from sludge solids.

Filtrates–The liquid extracted from a sludge in vacuum filters, filter presses, belt filters, and other devices in which liquid is separated from solids by applying a differential force across a porous fabric, screen, or other medium.

Filtration–The process of passing a liquid through a filtering medium consisting of granular material, such as sand, magnetite, anthracite, garnet, activated carbon or diatomaceous earth, finely woven cloth, unglazed porcelain, or specially prepared paper, to remove suspended or colloidal matter.

Fixed-Growth Media Biological Treatment Processes–A general categorization of processes such as trickling filters and rotating biological contactors.

Flash Mixer–A device for quickly dispersing chemicals uniformly throughout a liquid.

Force Main–A pipeline joining the discharge of a pumping station with a point of gravity flow designed to transmit sewage under pressure flow throughout its length.

Grit Chamber–A detention chamber designed to reduce the velocity of the influent sewage to permit the removal of coarse minerals from organic solids by differential sedimentation.

Heat Treatment or Conditioning–The application of heat and pressure to sludge to make the sludge more amenable to dewatering.

Holding Tank–An onsite storage tank for short-term storage of sewage as part of a sewage disposal process whereby the wastes are periodically removed from the tank and transported by tank truck to a suitable treatment and discharge facility. The systems are generally only utilized where centralized sanitary sewerage service is unavailable and soils are not suitable for septic systems installation and use.

Incinerator—A mechanical device for controlled combustion. Special designs may be used to incinerate or to maximize energy recovery or volume reduction, or destruction of toxic or hazardous materials.

Infiltration—The water entering a sanitary sewerage system from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow—The water discharged into a sanitary sewerage system from such sources as, but not limited to, roof leaders, cellar, yard, and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross-connections from storm sewers and combined sewers, catch basins. Inflow consists of storm water runoff, street wash waters, and other forms of surface drainage and does not include, and is distinguished from, infiltration.

Intercepting Structure—A structure designed to intercept all dry-weather sanitary sewage flow in a combined sewer and a proportionate amount of the mixed storm water and sanitary sewage flow during periods of rainfall or snowmelt and discharge such flows to an intercepting sewer.

Sludge Lagoon—A bermed or ponded area for the storage and partial dewatering of wastewater sludge.

Leachate—The liquid that is produced from landfills due to organic decomposition, dewatering of sludge, and rain water.

Loading, Average Hydraulic—The arithmetic average of the total metered daily flow at a sewage treatment plant for any selected year.

Loading, Peak Hydraulic—The greatest total daily sewage flow received by a treatment plant in any selected year.

Microstrainer—An extremely fine rotating screen for the removal of very small suspended solids in sewage.

Multimedia Filter—A treatment unit utilized to process wastewater by passing the liquid through a multiple of three media—usually combinations of sand, anthracite, activated carbon, weighted sperical resin beds, and garnet—for the removal of suspended or colloidal matter.

Neutralization—The reaction of acid or alkali with an opposite reagent until the concentrations of hydrogen and hydroxyl ions in the solution are approximately equal.

Nitrification—The conversion of nitrogenous matter—primarily ammonia—into nitrates by bacteria.

Package Plant—A relatively small, usually prefabricated, sewage treatment plant.

Polishing Lagoon—An unaerated lagoon designed and intended to upgrade or stabilize secondary, tertiary, or advanced wastewater treatment process effluent by natural oxidation of organic matter and settling.

Population Equivalent—The existing or design organic loading to a sewage treatment plant expressed in population and based on an average normal domestic sewage strength and flow.[1]

Precipitation—The phenomenon that occurs when a substance held in solution in a liquid passes out of solution into solid form.

Pretreatment—The conditioning of a waste at its source before discharge to remove or to neutralize substances injurious to sewers and treatment processes or to effect a partial reduction in load on the treatment process. The term generally applies to the conditioning of industrial wastes before discharge to municipal sewerage systems.

Private Sanitary Sewerage System—A waste water disposal system providing conveyance, treatment, and final disposal for wastes from users who have agreed-upon rights to the benefits of the facility which is owned and operated by an individual owner, either a private business or a public institution.

Public Sanitary Sewerage System—A wastewater disposal system providing conveyance, treatment, and final disposal for wastes from users who all have equal rights to the benefits of the utility which is owned and operated by a legally established governmental body.

[1] *In the regional sanitary sewerage system planning program the average sewage strength was assumed to be 200 mg/l of $CBOD_5$ and the average domestic sewage flow was assumed to be 125 gallons per capita per day. This concentration and daily per capita flow are equivalent to 0.21 pound of $CBOD_5$/capita/day. The population equivalent was computed for either the existing or design loading by dividing the daily $CBOD_5$ loading in pounds by 0.21 pound of $CBOD_5$/capita/day. The computation of equivalent population can also be based on suspended solids by dividing the daily suspended solids loading in pounds by 0.21 pound suspended solids/capita/day.*

Pyrolysis–A process for heating sludge so that the organic matter present decomposes into burnable gases, liquids similar to petroleum, and char. The process is carried on in the absence of air or with an air supply which is for combustion.

Reverse Osmosis–The process in which a solution is pressurized to a degree greater than the osmotic pressure of the solvent, causing it to pass through a membrane, carrying only reduced levels of the chemical constituents of the solution.

Sand Drying Beds–A layer of sand contained between low level concrete or wooden walls, underlaid by a system of drains. Sludge is placed or poured on the bed and partially dewatered by air drying and filtration of the liquid through the sand into the underdrains for return to the treatment plant.

Screening–The removal of floating and suspended solids in sewage by straining through racks or screens.

Sedimentation–The process of subsidence and deposition of the suspended matter in sewage by gravity, usually accomplished by reducing the velocity of the sewage below the point at which it can carry suspended matter. Primary sedimentation occurs in a complete sewage treatment process before biological or chemical treatment; secondary sedimentation occurs after such treatment.

Septic System (Mound Type)–A septic system which incorporates as a drain field, granular material placed on a mound above the existing grade and receiving pumped septic tank effluent for discharge to the inside of the mounded bed through tile levees. The granular material allows the liquid to be lifted to the surface by capillary action to evaporate or be used by vegetation atop the mound, or allows the liquid to infiltrate the underlying soil after undergoing some filtration within the mound.

Septic Tank–A settling tank in which organic solids are settled and decomposed by anaerobic bacterial action, with the settled sludge being an immediate contact with sewage flowing through the tank. The treated sewage is then discharged to the groundwater reservoir by underground tile lines.

Sewage–The spent water of a community consisting of a combination of liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, or storm water which may be unintentionally present.

Sewage Lagoon–A shallow body of water containing partially treated sewage in which aerobic stabilization occurs.

Sewage Treatment Plant–An arrangement of devices and structures for treating sewage in order to remove or alter its objectionable constituents and thus render it less offensive or dangerous.

Sewage Treatment Plant Efficiency–The ratio of the amount of pollutant removed by the sewage treatment plant to the amount of pollutant in the influent sewage expressed in percent.

Sewer–A pipe or conduit, generally closed but not normally flowing under pressure, for carrying sewage.

Sewer, Branch–A common sewer receiving sewage from two or more lateral sewers serving relatively small tributary drainage areas.

Sewer, Building–A private sewer conveying sewage from a single building to a common sewer; also called house connection.

Sewer, Combined–A common sewer intended to carry sanitary sewage, with component domestic, commercial, and industrial wastes, at all times, and which, during periods of rainfall or snowmelt, is intended to also carry storm water runoff from streets and other sources.

Sewer, Common–A sewer in which all abutters have equal rights; also called public sewer.

Sewer, Intercepting–A common sewer that receives dry-weather sanitary sewage flows from a combined sewer system and predetermined proportionate amounts of the mixed storm water and sanitary sewage flows during periods of rainfall or snowmelt and conducts these flows to a point of treatment or disposal.

Sewer, Lateral–A common sewer discharging into a branch or other common sewer and having no other common sewer tributary to it.

Sewer, Main–A common sewer which receives flows from many lateral and branch sewers serving relatively large tributary drainage areas for conveyance to a treatment plant; also called trunk sewer.

Sewer, Outfall–A sewer that receives flows from a collection system or from a treatment plant and conveys the untreated or treated waste flows to a point of discharge into a receiving body of surface water.

Sewer, Relief—A common sewer built to carry the flows in excess of the capacity of an existing sewer, thus relieving surcharging of the latter.

Sewer, Sanitary—A common sewer which carries sewage flows from residences, commercial buildings and institutions, certain types of liquid wastes from industrial plants, together with minor amounts of storm, surface, and ground waters that are not intentionally admitted.

Sewer, Storm—A common sewer which carries surface water and storm water runoff from open areas, rooftops, streets, and other sources, including street wash and other wash waters, but from which sanitary sewage or industrial wastes are specifically excluded.

Sewerage System—A system of piping, treatment facilities, and appurtenances, for collecting, conveying and treating wastewater.

Skimmings—The material that is skimmed from the surface of clarifier basins including liquid, such as oil, floating grease and other debris.

Sludge—An aqueous suspension of residual solids generated through the treatment of a municipal or industrial wastewater, and of such a nature and concentration as to require special consideration for disposal. Industrial residuals having economic value without significant processing are not included under this definition.

Soil Conditioner—A material which, when applied to land, increases the ability of the soil to absorb water and hold nutrients as well as improving soil tilth.

Stabilization Lagoon—A shallow pond for storage of wastewater before discharge. Such lagoons may serve only to detain and equalize wastewater composition before regulated discharge to a stream, but often they are used for biological oxidation.

Stabilization Pond—A type of oxidation pond in which biological oxidation of organic matter is affected by natural or artificially accelerated transfer of oxygen to the water from air.

Station, Lift—A relatively small sewage pumping installation designed to lift sewage from a gravity flow sewer to a higher elevation when the continuance of the gravity flow sewer would involve excessive depths of trench, or designed to lift sewage from areas too low to drain into available sewers. Lift stations normally discharge through relatively short force mains to gravity flow points located at or very near the lift station.

Station, Portable Pumping—A point of flow relief at which flows from surcharged sanitary sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of portable pumping units.

Station, Pumping—A relative large sewage pumping installation designed not only to lift sewage to a higher elevation but also to convey it through force mains to gravity flow points located relatively long distances from the pumping station.

Station, Relief Pumping—A flow relief device by which flows from surcharged main sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of permanent lift or pumping stations.

Supernatant—The liquid that is decanted from an anaerobic or aerobic digester and which generally contains a high concentration of suspended and dissolved organic matter plus inorganics such as ammonium compounds, phosphates, heavy metals, bicarbonates of calcium, and magnesium, as well as various types of pathogens.

Thickening—Process for concentrating sludges up to a maximum of about 10 percent solids content.

Treatment, Advanced—This may be defined as additional physical and chemical treatment to provide removal of additional constituents, particularly phosphorus and nitrogen compounds, by such means as chemical coagulation, sedimentation, charcoal filtration, and aeration. Although advanced treatment is traditionally conceived of as following secondary treatment or as combined with tertiary treatment, it can be performed following primary treatment or as an integral part of secondary treatment. Advanced treatment may remove 90 percent or more of the raw influent phosphorus and may remove up to 90 percent of the raw influent nitrogen, or effect up to 95 percent reduction in the oxygen demand of ammonia in the sewage treatment plant influent by coverting the ammonia compounds to nitrate.

Treatment, Auxiliary—This may be defined as a treatment measure used in combination with all other treatment methods, and includes, for example, effluent aeration and disinfection by chlorination.

Treatment, Primary—This may be defined as physical treatment of raw sewage in which the coarser floating and settable solids are removed by screening and sedimentation. Primary treatment normally provides 50 to 60 percent reduction of the influent suspended matter and 25 to 35 percent reduction of the influent carbonaceous biochemical oxygen-demanding organic matter ($CBOD_{ult}$). It removes little or no colloidal and dissolved matter.

Treatment, Secondary—This may be defined as biological treatment of the effluent from primary treatment, in which additional oxygen-demanding organic matter is removed by trickling filters or activated sludge tanks and additional sedimentation. Secondary treatment normally provides up to 90 percent removal of the raw influent suspended matter and 75 to 95 percent removal of the raw influent $CBOD_{ult}$. Secondary treatment facilities can be designed and operated to also remove 30 to 50 percent of the raw influent nitrogenous biochemical oxygen demand ($NBOD_{ult}$) and 30 to 40 percent of the raw influent phosphorus content of the influent sewage.

Treatment, Tertiary—This may be defined as physical and biological treatment of the effluent from secondary treatment, in which additional oxygen-demanding matter is removed by use of shallow detention ponds to provide additional biochemical treatment and settling of solids of filtration using sand or mechanical filters. Tertiary treatment normally provides up to 99 percent removal of the raw influent suspended matter and 95 to 97 percent of the raw influent $CBPD_{ult}$.

Trickling Filter Process—A biological waste treatment process in which sewage is applied in spray form from nozzles or other distribution devices over a filter consisting of an artificial bed of coarse material, such as broken stone, through which the sewage trickles to underdrains, giving opportunity for the formation of zoogleal slimes which clarify and oxidize the sewage.

Vacuum Filter—A filter consisting of a cylindrical metal drum covered with cloth or other media revolving on a horizontal axis with partial submergence in liquid sludge. A vacuum is maintained under the media to extract moisture from the sludge which adheres to the cloth or media and is scraped off continuously for disposal.

Wet Air Oxidation—A method of sludge disposal that involves oxidation under pressure, at high temperatures.

Appendix D

INDUSTRIES CONTRIBUTING WASTEWATER TO LARGE MUNICIPAL PLANTS

MSD-JONES ISLAND AND SOUTH SHORE

Industry Name	SIC Code[1]
Acme Galvanizing, Inc.	3471
Adelman Laundry & Cleaners, Inc.—E C	7211
Adelman Laundry & Cleaners, Inc.—HUM	7211
Allen-Bradley	3622
Allis Chalmers Corp.—Hawley Division	3613
Allis Chalmers Corp.—W. Allis Manufacturing Operations	3523
Alton Box Co. Container Division	2653
American Can Co.	3411
American Industrial Service Co.	7218
American Linen Supply	7213
American Motors Corp.—Milwaukee	3711
AMPCO—Pittsburgh Corporation	3362
Appleton Electric Co.—Lighting Division	3643
Aqua-Chem., Inc.—North Plant 1	3829
Aqua-Chem., Inc.—North Plant 2	3829
Babcock & Wilcox—Tubular Prod. Div.	3312
Badger Meter, Inc.	3824
Badger State Tanning Corp.	3111
Blackhawk Tanning Co.	3111
Borden, Inc.	2026
Brady, W.H. Co.—Glendale Ave. Plant	2641
Briggs & Stratton Corp.—Milwaukee Plant	3499
Briggs & Stratton Corp.—Wauwatosa Plant	3519
Buckley Laundry Co., Inc.	7211
Bucyrus-Erie Company	3532
Capitol Car Wash	7542
Carrie Shortening Corp.	2076
Caterpillar Tractor Company	3531
Charter Wire	3315
CHR Hansens Laboratory, Inc.	2869
Coca-Cola Bottling Co. of Wisconsin	2086
Continental Baking Co., ITT	2051:3
Cooper, Peter Corp.	2891
Crown Zellerbach—Gaylord Container	2653
Cudahy Tanning Co., Inc.	3111
Cutler-Hammer, Inc.—Industrial Systems	3622
Cutler-Hammer, Inc.—Specialty Products Division	3643
DJ & K Enterprises, Inc.	7542
Eaton Corp.	3462
Electro-Coatings, Inc.	3471
Erie Manufacturing Co., Inc.	3822
Everbrite Electric Sign Co., Inc.	3993

[1]*For conversion of SIC codes to categories of industry refer to the State-of-the-Art report on Point Source Wastewater Control, SEWRPC, 1977, and Standard Industrial Classification Manual, Executive Office of the President—Office of Budget, Prepared by the Statistical Policy Division, U.S. Government Printing Office, Washington D.C. Stock No. 4101-0066.*

Evinrude Motors–Plants 2, 5 & F	3519
Evinrude Motors–Plant 5	3519
Evinrude Motors & Research–Plant 1	3519
Falk Corporation–Plant 1	3566
Federal Malleable Div.–Chromalloy	3322
Findley Adhesives, Inc.–Plant 1	2891
Findley Adhesives, Inc.–Plant 2	2891
Flagg Tanning Corp.	3111
Froedtert Malt Corp.	2083
GMC Spark Plug Division	3694
GMC Delco Electronics Division	3674
Gallun, A.F. & Sons Corp.	3111
Gebhardt-Vogel Tanning Co.	3111
Gehl Guernsey Farms, Inc.	2023
Geisers Potato Chip Company	2099
General Electric Co.–Dishwasher Division	3634
General Electric Co. Radiology System	3693
General Split Corp.	3111
Geuder Paeschke Frey	3469
Globe-Union, Inc.–Admin. & Res. Park Bldg.	3691
Globe-Union, Inc.–Hopkins Plant	3671
Globe-Union, Inc.–Keefe Ave. Plant	3691
Globe-Union, Inc.–Teutonia Plant	3691
Globe-Union, Inc.–Villard Plant	3671
Grace, W.R. & Co.	2066:1
Grafs Beverages, Inc.	2086
Great Lakes Tanning Co.	3111
Grede Foundries, Inc.	3325
Harley-Davidson Motor Co., Inc.–Capitol Drive	3751
Harley-Davidson Motor Co., Inc.–W. Juneau Ave.	3751
Harnischfeger Corp.	3536
Heil Co. Bulk Trailer Division	3713
Heil Co. Solid Waste System & Truck Equipment	3713
Hentzen Chemical Coatings, Inc.	2851
Hercules, Inc.–Milwaukee Plant	2860
Hide Service Corp.	3111
Hoerner Waldorf Corp.	2653
Howe's (Mrs.) Food Products, Inc.	2099
Howmet Corp.–Crucible Steel Casting	3325
Huber Supreme Metal Treating Co.	7692
Imperial Car Wash, Inc.	7542
Industrial Cylinders Co.	3443
Industrial Towel and Uniform	7218
Inland Container Corp.	2653
Inryco, Inc.	3444
Johnson Controls, Inc.	3822
Johnston, Robert A. Co.	2065
Keiding, Inc.	2646
Kerr-McGee Chemical Corp.	2491
Klement Sausage Co., Inc.	2031
Krause Milling Co.	2041
Kurth Malting Corporation	2083
Ladish Company	3462
Law Tanning Co.	3111
Longview Fibre Company Downing Box	2653

Magic Car Wash, Inc.	7542
Mandel Co.	2795
Master Lock Co.–N. 32nd St.	3429
Maynard Steel Casting Company	3325
McGraw-Edison Power Systems Division	3699
Mead Corp.–Milwaukee Containers Division	2653
Mellowes Co. Div. Charter Mfg. Co., Inc.	3315
Merrell National Laboratories	2834
Metal Coatings, Inc.	3479
Mickey's Linen & Towel Supply, Inc.	7211
Miller Brewing Co.–Can Plant	3411
Miller Brewing Co.–Milwaukee Plant	2082
Milprint, Inc.	2649
Milsco Manufacturing Company	3523
Milwaukee Die Casting Co. Inc.	3361
Milwaukee Dye & Bleaching Co.	2262
Milwaukee Electric Tool Corp.	3546
Milwaukee Forge	3462
Milwaukee Plating Co.	3471
Milwaukee Solvay Coke Co.	3312
Milwaukee Tallow Co., Inc.	2077
Milwaukee Valve Co., Inc.	3494
Milwaukee Wire Products, Inc.	3496
Modern Car Wash, Inc.	7542
Modern Plating Co.	3471
Motor Castings Co.–Plant 1	3321
Motor Castings Co.–Plant 2	3321
Murray Metal Plating Works, Inc.	3471
National Plating Co., Inc.	3471
Newspapers, Inc.	2711
Oster Corp.	3634
PPG Industries	2851
Pabst Brewing Co.	2082
Patrick Cudahy (Wisconsin), Inc.	2011
Peck Meat Packing Corp.–East Plant	2011
Peck Meat Packing Corp.–Main Plant	2011
Peck Meat Packing Corp.–Moobattue	2011
Peerless Overall Cleaners, Inc.	7218
Perfex Div.–McQuay-Perfex, Inc.	3433
Perlick Company, Inc.	3585
Pfister & Vogel Tanning Co. (Beatrice Foods Co.)	3111
Pfizer, Inc.	2099
Pho-tronics, Inc.	3679
Plating Engineering Co.	3471
Pressed Steel Tank Co.	3443
Rapco Leather Co. (Beatrice Foods Co.)	3111
Reliable Plating Works, Inc.	3471
Rexford Paper Co., Inc.	2641
Rexnord, Inc. Construction/Machinery Division	3566
Rexnord, Inc. Nordberg Machinery Group	3532
Schlitz, Jos. Brewing Co.	2082
Schlitz, Jos. Brewing Co.–Container Division	3411
Seidel Tanning Corp.	3111
Seven-Up Milwaukee, Inc.	2086
Singer (The) Company Controls Division	3822

Smith, A.O. Corp.	3714
South Side Laundry & Dry Cleaners	7211
Southeastern Wisconsin Products Co.	2099
Spencer Leathers Wisconsin	3111
Spic and Span, Inc.	7211
Splinter Pickle Co., Inc.	2035
Square D Company	3622
Strauss Bros. Packing Co., Inc.	2011
Suburban Car Wash, Inc.	7542
Teledyne Wisconsin Motor	3519
Thiele Tanning Co.	3111
Uncle August Sausage Co., Inc.	2013
Universal Foods Corp.–Red Star Yeast Division	2099
Usinger, Fred, Inc.	2013
Utility Products Co.	3317
Veterans Linen Supply Co.	7213
Wayne Chemical	2851
Weisel & Company	2013
Western HDWR Specialty Manufacturing	3471
Williams, S.K. Co.	3471
Willows Car Wash, Inc.	7542
Wisconsin Cuneo Press, Inc.	2752
Wisconsin Electric Power–Commerce Station	4911
Wisconsin Electric Power–East Wells Station	4911
Wisconsin Electric Power–Valley Station	4911
Wisconsin Leather Co.	3111
Wisconsin Packing Co.–Butler	2011
Wisconsin Packing Co.–Milwaukee	2011
Wright Metal Processors, Inc.	3479

RACINE

Acme Die Casting Corp.	3361
Beecham, Inc.	2023
Esb, Inc. Wisconsin Division	3692
Evans Products Co.	3325
Jacobsen Manufacturing Co.	3524
JI Case Co. Tractor Plant	3523
Modine Mfg. Co.	3433
Murphy Products Co., Inc.	2048
Printing Developments, Inc.	3471
Racine Plating Co.	3471
Rexnord, Inc. Fluid Power	3599
S.C. Johnson & Sons, Inc.	2842
Seven-Up Bottling, Inc.	2086
Shepard Plating Co.	3471
St. Mary's Hospital	8062
Twin Disc, Inc.	3566
Walker Mfg. Co.	3714
Western Publishing Co.	2731
Wisconsin Plating Works	3471
Young Radiator Co.	3714

KENOSHA

American Motors Corp.–Lake Front and Main Plants	3711
Anaconda Company–Brass	3351
Coca-Cola Bottling Co.	2086
Eaton Corp. Industrial Drivers Div.	3566
Finishing & Plating Service	3471
Frost Co.	3432
Jerry's Forest Park Car Wash	7542
Jockey International	2322
Kenosha Laundry Co.	7211
Kenosha Packing Co.–Ren	2013
MacWhyte Company	3496
Ocean Spray Cranberries	2033
Pepsi-Cola Bottling Co.	2086
Snap-on Tools Corp.	3423
St. Catherine's Hospital	8062
Your Car Wash, Inc.	7542

WAUKESHA

Amron Corp.	3489
Carnation Co. Instant Prod.	2099
E.F. Brewer Co.	3471
Globe Skate Corp.	3944
Hawthorn–Mellody Farm (Dairy)	2024
Jewett & Holsum Foods	2035
Milwaukee Chaplet & Mfg.	3559
Milwaukee Electric Tool	3546
Mirro Aluminum Co. Plant #8	3444
Oconomowoc Electroplating	3471
Pho-Tronics, Inc.	3679
Quality Aluminum Casting	3361
RTE Corporation North & Lincoln Plants	3612
W.A. Krueger Co.	2732
Waukesha Engine Division	3519

WEST BEND

Amity Leather Products	3172
Bermico Company	2646
Gehl Company	3523
West Bend Company	3634

SOUTH MILWAUKEE

Appleton Electric	3643
Bucyrus Erie	3522
Everbrite Sign	3993
McGraw Edison	3699
Midwest Tanning	3111
Rapco Leather	3111

WHITEWATER

Alpha Casting, Inc.	3321
Foremost Foods Dairy Plant	2023
Hawthorn-Mellody Farms Dairy Plant	2026

OCONOMOWOC

Carnation Co. Instant Products	2099

BURLINGTON

Associated Milk Producers	2026
Burlington Brass Works	3432
Nestle Company Inc.	2066

WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT

Bunker Ramo Corp.	3829

PORT WASHINGTON

Outdoor Power Equipment Co.	3524
Simplicity Manufacturing Co.	3542

CEDARBURG

Mercury Marine	3519
Pioneer Container	2653

GRAFTON

Badger Mill	2281
Est. Company	3361
Tecumseh Products Co.	3519

HARTFORD

Libby McNeill & Libby	2033
Chrysler Outboard	3519
International Stamping	3714
Broan Manufacturing	3634
W.B. Place	3111

Source: NR101 Inventories by Department of Natural Resources.

Appendix E

Wastewater Sludge Characteristics

The data summaries presented herein are divided into two groups; municipal wastewater treatment plant sludges and industrial sludges. The data for Jones Island was extensive and a representative sample is included herein. The Metropolitan Sewerage District has collected data for its plant at Jones Island since 1926. Recent data (1976) is presented herein. Averages (mean), maximum, minimum, and median (mid-point) values are given to enable a review of the ranges that occur. At other plants, all data obtained are presented. Those samples analyzed especially for the area-wide wastewater sludge management plant are presented as well as those collected from other sources.

Sludge Quality Sampling Data
MSD - Jones Island
(all quantities in mg/kg dry solids)

Constituents	Source: West Plant[1] Date: Average 1975 Location: Return Sludge	Source: West Plant[1] Date: Average 1976 Location: Return Sludge
Percent Solids		1.38
Total Nitrogen	69,000[2]	66,700[5]
Ammonia Nitrogen	23,000[2]	
Nitrate Nitrogen		
Total Phosphorus		38,400
Total Potassium		
Copper	246	306
Zinc	1,270	820
Nickel	106	138
Chromium	7,250	5,860
Lead	690	520
Cadmium	94	97
Arsenic		
Mercury		
Calcium	13,950[3]	
Magnesium	4,588	
Sodium		
Aluminum	4,970	
Iron	33,860[4]	37,300[5]
pH		
PCB	10 - 25[6]	

Source: MSD - Jones Island Plant Records

1. Considered representative of Milorganite.
2. Months of February through May only
3. Month of February only.
4. Months of January through May only.
5. Months of January through November only
6. Represents a general range of results from samples tested by various agencies. Actual sample results show some apparent discrepancies between testing agencies.

Sludge Quality Sampling Data
MSD - South Shore
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 1976 Mean Spreading Season Location: Lagoon Sludge	Source: Treatment Plant Date: 1975 Mean Spreading Season Location: Lagoon Sludge	Source: DNR Files Date: 5/5/76 Location: Berger Farm
Percent Solids	13.7	11.8	
Total Nitrogen	27,800	28,800	
Ammonia Nitrogen			
Nitrate Nitrogen			
Total Phosphorus	25,100	27,800	
Total Potassium	990	910	
Copper	944	963	1,200
Zinc	4,309	4,688	4,400
Nickel	697	744	800
Chromium	12,450	13,325	15,000
Lead	1,061	1,336	950
Cadmium	41	51	50
Arsenic			
Mercury			2.6
Calcium			
Magnesium			
Sodium			
Aluminum	6,940		
Iron	36,875	37,440	
pH	7.3		
PCB			

Source: MSD - South Shore Plant Records

Sludge Quality Sampling Data
MSD-South Shore
(all quantities in mg/kg dry solids)

Constituents	Source: Sommer-Frey Lab. Date: 8/8/75 Location: Lagoons	Source: DNR Files Date: 1/31/77 Location: Lagoons	Source: Date: Location:
Percent Solids	3.96		
Total Nitrogen	78,700		
Ammonia Nitrogen	51,600		
Nitrate Nitrogen			
Total Phosphorus	104,600		
Total Potassium	1,130		
Copper	499		
Zinc	1,082		
Nickel	511.7		
Chromium	2,665		
Lead	1,194		
Cadmium	64.7		
Arsenic			
Mercury	2.85		
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron			
pH			
PCB		9.0 to 20.0[1]	

Source: MSD - South Shore Plant Records

1. Range of six samples

Sludge Quality Sampling Data
Kenosha
(all quantities in mg/kg dry solids)

Constituents	Source: Donohue & Assoc. Date: 3/18/76 Location: Filter Press, Sludge Cake	Source: Donohue & Assoc. Date: 3/19/76 Location: Filter Press, Sludge Cake	Source: Donohue & Assoc. Date: 3/22/76 Location: Filter Press, Sludge Cake
Percent Solids	38.5	46.1	52.5
Total Nitrogen	27,500	19,300	20,800
Ammonia Nitrogen	320	650	420
Nitrate Nitrogen			
Total Phosphorus	11,000	15,800	10,500
Total Potassium	820	770	650
Copper	1,340	1,388	1,219
Zinc	3,356	3,774	3,352
Nickel	224	195	171
Chromium	670	629	495
Lead	462	425	381
Cadmium	24.8	21.6	20.6
Arsenic	2.24	6.70	3.41
Mercury	<.0002	2.11	3.8
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron			
pH	12.25	12.30	12.28

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Kenosha
(all quantities in mg/kg dry solids)

Constituents	Source: Donohue & Assoc. Date: 3/23/76 Location: Filter Press, Sludge Cake	Source: Donohue & Assoc. Date: 3/29/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 4/19/76 Location: Filter Press, Sludge Cake
Percent Solids	49.0	37.2	
Total Nitrogen	19,900	17,300	
Ammonia Nitrogen	530	1,400	700
Nitrate Nitrogen			
Total Phosphorus	8,600	11,300	27,100
Total Potassium	640	680	
Copper	1,265	1,210	4,034
Zinc	3,265	3,226	1,175
Nickel	167	140	299
Chromium	510	538	652
Lead	383	366	
Cadmium	22	20.4	42
Arsenic	3.29	0.793	
Mercury	.89	0.121	
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron			70,389
pH	12.3	12.20	

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Kenosha

(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 4/26/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 5/3/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 5/12/76 Location: Filter Press, Sludge Cake
Percent Solids			
Total Nitrogen			
Ammonia Nitrogen	2,600	1,900	900
Nitrate Nitrogen			
Total Phosphorus	24,300	25,400	17,800
Total Potassium			
Copper	1,985	1,866	1,610
Zinc	1,120	1,018	1,121
Nickel	334	302	326
Chromium	668	566	412
Lead			
Cadmium	45		33
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron	72,706	65,950	72,657
pH			

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Kenosha

(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 6/7/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 6/21/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 6/25/76 Location: Filter Press, Sludge Cake
Percent Solids			
Total Nitrogen			
Ammonia Nitrogen	3,100		
Nitrate Nitrogen			
Total Phosphorus	23,500	25,600	6,400
Total Potassium	3,700	1,400	1,100
Copper	2,919	3,298	3,170
Zinc	5,840	4,850	5,207
Nickel	730	776	679
Chromium	730	1,164	905
Lead			
Cadmium		19	23
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron	47,436	42,103	26,488
pH			

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data

Kenosha

(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 6/28/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 6/29/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 6/30/76 Location: Filter Press, Sludge Cake
Percent Solids			
Total Nitrogen			
Ammonia Nitrogen	1,700	1,700	1,600
Nitrate Nitrogen			
Total Phosphorus	22,000	9,600	8,600
Total Potassium	1,300	1,900	1,300
Copper	3,419	3,366	3,758
Zinc	5,128	5,048	5,073
Nickel	641	631	752
Chromium	855	841	1,127
Lead			
Cadmium	21	21	19
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron	31,410	28,818	34,386
pH			

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data

Kenosha

(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 7/1/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 7/2/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 7/6/76 Location: Filter Press, Sludge Cake
Percent Solids			
Total Nitrogen			
Ammonia Nitrogen	1,100	1,600	
Nitrate Nitrogen			
Total Phosphorus	9,800	10,600	18,700
Total Potassium		2,000	1,400
Copper		3,088	2,911
Zinc		4,529	4,366
Nickel		618	485
Chromium		823	647
Lead			
Cadmium		20	32
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron		15,438	24,741
pH			

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Racine
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 1976 Grab sample Location: Filtered Sludge
Percent Solids	
Total Nitrogen	
Ammonia Nitrogen	530
Nitrate Nitrogen	
Total Phosphorus	59,000
Total Potassium	625
Copper	445
Zinc	2,265
Nickel	125
Chromium	570
Lead	1,390
Cadmium	145
Arsenic	4.45
Mercury	1.85
Calcium	
Magnesium	
Sodium	
Aluminum	
Iron	78,165
pH	9.0

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sample Data
Kenosha
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 7/7/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 7/12/76 Location: Filter Press, Sludge Cake	Source: Treatment Plant Date: 7/13/76 Location: Filter Press, Sludge Cake
Percent Solids			
Total Nitrogen			
Ammonia Nitrogen			
Nitrate Nitrogen			
Total Phosphorus	16,300	29,600	17,900
Total Potassium	1,600	1,900	1,600
Copper	2,908	3,543	3,110
Zinc	4,470	4,849	4,276
Nickel	447	559	583
Chromium	894	1,119	972
Lead			
Cadmium	20	37	39
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			
Iron	17,662	34,875	25,656
pH			

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data

West Bend

(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: July, 1975 Grab Location: Anaerobic Digester Discharge
Percent Solids	6.3
Total Nitrogen	21,140
Ammonia Nitrogen	11,240
Nitrate Nitrogen	146
Total Phosphorus	36,700
Total Potassium	529
Copper	833
Zinc	2,430
Nickel	533
Chromium	992
Lead	2,381
Cadmium [a]	977 [a]
Arsenic	11.1
Mercury	1.22
Calcium	
Magnesium	15,130
Sodium	
Aluminum	
Iron	39,680
pH	7.4

[a] A later (October, 1977) sludge sample result reported by City of West Bend treatment plant personnel contained a cadmium level of 92.5 mg/kg on a dry solids basis indicating a possible reduction in cadmium content from 1975 to 1977. It was noted that one potential source of cadmium has been eliminated since 1975.

SOURCE: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
South Milwaukee
(all quantities in mg/kg dry solids)

Constituents	Source: Sommer-Frey Labs, Inc. Date: 8/20/76 Location: Digester Discharge	Source: Nalco Chemical Co. Date: 9/9/76 Location: Digester Composite
Percent Solids	4.29	3.1
Total Nitrogen	44,100	74,200
Ammonia Nitrogen	16,300	12,490
Nitrate Nitrogen		6.5
Total Phosphorus	37,800	32,260
Total Potassium	980	1,520
Copper	475.5	645
Zinc	706.29	806.5
Nickel	144.76	38.7
Chromium	15,543	20,000
Lead	218.41	264.5
Cadmium	1.93	16.13
Arsenic	7.90	71.0
Mercury	1.93	2.1
Calcium		
Magnesium		
Sodium		
Aluminum		
Iron		
pH	7.0	7.1

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Burlington
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 1975 Location: Unknown
Percent Solids	0.67
Total Nitrogen	
Ammonia Nitrogen	690
Nitrate Nitrogen	3
Total Phosphorus	30,450
Total Potassium	7,100
Copper	560
Zinc	1,080
Nickel	343
Chromium	637
Lead	313
Cadmium	8.95
Arsenic	1.79
Mercury	75
Calcium	
Magnesium	
Sodium	
Aluminum	
Iron	
pH	

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Delavan
(Walworth Co. MSD)
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: Unknown Location: Sludge*
Percent Solids	9.3
Total Nitrogen	45,000
Ammonia Nitrogen	8,000
Nitrate Nitrogen	
Total Phosphorus	8,000
Total Potassium	14,000
Copper	320.1
Zinc	362.1
Nickel	65.2
Chromium	84.7
Lead	98.5
Cadmium	43
Arsenic	1
Mercury	0.1
Calcium	
Magnesium	
Sodium	
Aluminum	
Iron	
pH	6.9

*Data Assumed Given As Dry Basis.

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Elkhorn
(Walworth Co. MSD)
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: Unknown Location: Unknown
Percent Solids	4.1
Total Nitrogen	33,000
Ammonia Nitrogen	13,000
Nitrate Nitrogen	
Total Phosphorus	10,000
Total Potassium	3,000
Copper	0.3
Zinc	1,400
Nickel	50
Chromium	50
Lead	0.5
Cadmium	1
Arsenic	
Mercury	
Calcium	
Magnesium	
Sodium	
Aluminum	
Iron	
pH	6.9

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Port Washington
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 1975 Location: Aerobic Sludge*
Percent Solids	
Total Nitrogen	23,400
Ammonia Nitrogen	7,200
Nitrate Nitrogen	310
Total Phosphorus	111,000
Total Potassium	40,500
Copper	373
Zinc	1,140
Nickel	
Chromium	398
Lead	
Cadmium	
Arsenic	
Mercury	
Calcium	31,400
Magnesium	12,800
Sodium	8,400
Aluminum	11,800
Iron	156,000
pH	

*Data Assumed Given As Dry Basis.
Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Grafton
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant Date: 1976 Location: Aerobic Sludge	Source: Treatment Plant Date: 1976 Location: Anaerobic Sludge
Percent Solids	1.75	5.0
Total Nitrogen		
Ammonia Nitrogen	30	3,600
Nitrate Nitrogen		
Total Phosphorus		
Total Potassium	91,430	60,000
Copper	550	275
Zinc	2,100	1,475
Nickel	12.5	26.3
Chromium	1,325	450
Lead	475	325
Cadmium	120	10
Arsenic		
Mercury		
Calcium		
Magnesium		
Sodium		
Aluminum		
Iron		
pH	6.9	7.0

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Western Racine Co.
(all quantities in mg/kg dry solids)

Constituents	Source: Treatment Plant* Date: Unknown Location: Unknown
Percent Solids	1.75
Total Nitrogen	14,000
Ammonia Nitrogen	800
Nitrate Nitrogen	
Total Phosphorus	8,000
Total Potassium	200
Copper	334
Zinc	1,514
Nickel	23
Chromium	29
Lead	257
Cadmium	5.7
Arsenic	0.57
Mercury	0.11
Calcium	
Magnesium	
Sodium	
Aluminum	
Iron	
pH	7.05

*Data Assumed Given As Dry Basis.

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data
Hartland
(all quantities in mg/kg dry solids)

Constituents	Source: Facilities Plan Date: 5/13/76 Location: Digested Sludge*
Percent Solids	6.57
Total Nitrogen	24,200
Ammonia Nitrogen	11,900
Nitrate Nitrogen	1,600
Total Phosphorus	36,200
Total Potassium	20,400
Copper	500
Zinc	1,400
Nickel	18
Chromium	100
Lead	130
Cadmium	14.9
Arsenic	4.7
Mercury	4.1
Calcium	52,800
Magnesium	13,800
Sodium	8,300
Aluminum	44,400
Iron	11,300
pH	

*Data Assumed Given As Dry Basis.

Source: Southeastern Wisconsin Regional Planning Commission File Data.

Sludge Quality Sampling Data

Tanneries
(all quantities in mg/kg dry solids)

Constituents	Source: Midwest Tanning Date: Location: Plant	Source: W.B. Place & Company Date: Location: In Plant
Percent Solids		
Total Nitrogen		10,000
Ammonia Nitrogen	390	
Nitrate Nitrogen		
Total Phosphorus		2,500
Total Potassium		10,000
Copper		290,000
Zinc		
Nickel		
Chromium	320	
Lead		
Cadmium		
Arsenic		
Mercury		
Calcium	9,320 (as $CaCO_3$)	42,200
Magnesium		2,740
Sodium		3,120
Aluminum		19,200
Iron		17,100
pH		

Source: Southeastern Wisconsin Regional Planning Commission Inventory Data.

Sludge Quality Sampling Data
Metal Machining
(all quantities in mg/kg dry solids)

Constituents	Source: Colt Industries Date: Location: In Plant	Source: Young Radiator Co. Date: Location: In Plant
Percent Solids		
Total Nitrogen		
Ammonia Nitrogen		
Nitrate Nitrogen		
Total Phosphorus		
Total Potassium		
Copper	1,000	6,000
Zinc		66,400
Nickel	1,000	
Chromium	20,000	
Lead		7,700
Cadmium		
Arsenic		
Mercury		
Calcium	20,000	
Magnesium	1,000	
Sodium		
Aluminum	10,000	
Iron	20,000	25,500
pH		

Source: Southeastern Wisconsin Regional Planning Commission Inventory Data.

Sludge Quality Sampling Data
Food Processing
(all quantities in mg/kg dry solids)

Constituents	Source: Holsum Foods Date: Location: In Plant	Source: Level Valley Dairy Date: Location: In Plant	Source: Jos. Schlitz Cont. Div. Date: Location: In Plant
Percent Solids		1.5	
Total Nitrogen		1,000	
Ammonia Nitrogen			
Nitrate Nitrogen			
Total Phosphorus	64,700	450	
Total Potassium		11.0	
Copper			1.2
Zinc	1,500		
Nickel			
Chromium			
Lead			0.2
Cadmium			0.42
Arsenic			
Mercury			
Calcium			
Magnesium			
Sodium			
Aluminum			3,000
Iron			113
pH		7.7	

Source: Southeastern Wisconsin Regional Planning Commission Inventory Data.

SLUDGE QUALITY SAMPLING DATA
MUNICIPAL WASTEWATER TREATMENT PLANTS

(All Quantities in mg/kg dry solids)
(except for PCB which is in ug/kg dry solids)

Constituents

	Sample Location	Calcium	Copper	Iron	Lead	Magnesium	Mercury	Nickel	Potassium	Sodium	Zinc
Allenton	Primary & Waste Activated Sludge	53,781	3,970	24,300	440	19,300	3.9	99.0	2,920	11,250	1,590
Bristol	Aerobic Digester	33,137	650	19,050	250	8,860	3.3	108.0	5,550	16,150	3,730
Brookfield	Pressure Filter	104,365	432	101,800	125	6,010	0.0	44.3	378	1,958	1,120
Cedarburg	Anaerobic Digester	36,449	1,340	8,200	337	6,290	2.4	39.0	3,490	8,750	1,900
East Troy	Anaerobic Digester	90,570	746	23,970	320	16,940	2.7	320.0	6,550	35,700	1,650
Fontana	Drying Bed	31,605	1,300	21,570	250	9,550	0.0	51.0	2,170	3,070	3,510
Genoa City	Drying Bed	59,818	768	2,120	69	2,780	1.7	8.7	226	376	356
Hartford	Aerobic Digester	25,772	412	52,100	917	8,040	1.6	98.0	5,620	20,100	1,680
Hartland	Lagoon	36,498	220	3,990	94	3,480	0.0	23.8	590	1,040	586
Jackson	Anaerobic Digester	48,797	440	15,178	228	19,124	2.1	75.9	7,285	21,249	36,427
Kenosha	Filter Press	86,385	2,830	57,100	550	4,790	0.1	223.0	471	482	4,780
Kewaskum	Aerobic Digester	56,368	333	97,200	3,750	13,780	1.4	194.0	4,280	12,000	1,340
Lake Geneva	Anaerobic Digester	47,743	841	14,100	270	8,790	1.1	71.0	2,330	10,250	4,610
Mukwonago	Anaerobic Digester	57,960	380	5,330	0	17,620	0.0	116.0	9,040	48,300	1,200
Oconomowoc	Anaerobic Digester	45,870	658	14,800	427	6,480	20.2	140.0	3,110	8,760	5,710
Paddock Lake	Anaerobic Digester	30,360	1,490	26,200	710	21,400	0.0	690.0	8,700	42,600	5,900
Pewaukee	Drying Bed	22,215	825	31,300	4,930	7,850	167.0	50.0	1,250	1,820	7,340
Racine	Vacuum Filter	164,575	461	85,579	2,139	9,216	0.1	103.0	658	889	3,293
Silver Lake	Aerobic Digester	32,043	500	21,800	320	8,200	0.0	147.0	2,760	12,800	9,290
Twin Lakes	Anaerobic Digester	35,120	360	57,900	240	6,780	0.8	112.0	2,190	8,740	2,910
Union Grove	Lagoon	32,662	370	7,020	306	5,140	trace	24.5	5,920	2,650	1,030
Waukesha	Sludge Piles	53,289	1,350	15,200	565	7,740	0.4	133.0	691	1,006	5,390
Whitewater	Anaerobic Digester	43,952	571	10,100	396	11,160	19.3	88.0	6,420	20,300	1,100
Williams Bay	Drying Bed	13,741	530	10,090	203	4,320	0.0	36.4	720	620	1,040

Source: Southeastern Wisconsin Regional Planning Commission; Samples taken December 9-21, 1976

SLUDGE QUALITY SAMPLING DATA
MUNICIPAL WASTEWATER TREATMENT PLANTS

(All quantities in mg/kg dry solids)
(except for PCB which is in ug/kg dry solids)

Constituents

	Sample Location	Kjeldahl Nitrogen	Ammonia Nitrogen	Nitrate Nitrogen	Total Phosphorus	Arsenic	Aluminum	Cadmium	Chromium	Polychlorinated Biphenyls
Allenton	Primary & Waste Activated Sludge	45,670	7,243	1,100	24,132	22.0	1,600	66.0	1,570	69.5
Briston	Aerobic Digester	61,800	1,560	2,870	23,262	0.0	5,880	33.0	83	42.25
Brookfield	Pressure Filter	11,498	208	145	318	7.6	2,490	12.1	55	0.14
Cedarburg	Anaerobic Digester	44,470	14,400	2,130	39,486	0.0	65,600	18.0	1,470	trace
East Troy	Anaerobic Digester	130,300	51,600	3,380	88,892	0.0	1,600	96.0	210	trace
Fontana	Drying Bed	20,070	919	788	9,555	0.0	4,780	14.7	1,210	0.07
Genoa City	Drying Ben	20,780	2,450	360	3,487	1.4	1,140	2.1	172	8.13
Hartford	Aerobic Digester	57,060	1,290	2,830	38,013	0.5	2,100	57.0	10,800	0.06
Hartland	Lagoon	26,590	3,740	467	11,670	0.0	10,500	5.5	19	0.98
Jackson	Anaerobic Digester	93,673	46,008	888	13,787	0.0	1,594	45.5	266	trace
Kenosha	Filter Press	24,070	982	33	7,984	25.5	2,880	51.3	654	0.09
Kewaskum	Aerobic Digester	32,100	617	1,970	65,294	2.8	1,350	140.0	860	0.08
Lake Geneva	Anaerobic Digester	48,670	20,350	928	57,872	7.1	43,400	27.0	270	0.02
Mukwonago	Anaerobic Digester	126,000	72,450	5,060	52,318	0.0	2,320	162.0	230	0.40
Oconomowoc	Anaerobic Digester	60,020	17,640	2,730	24,458	0.3	3,720	19.2	1,600	0.02
Paddock Lake	Anaerobic Digester	134,100	75,220	1,730	25,028	0.0	2,970	202.0	273	3.55
Pewaukee	Drying Bed	20,000	2,083	555	7,670	3.4	8,250	14.3	2,060	2.38
Racine	Vacuum Filter	16,876	3,343	44	1,371	0.4	7,406	44.4	493	3.01*
Silver Lake	Aerobic Digester	60,240	2,400	923	22,616	0.0	830	19.0	64	0.01
Twin Lakes	Anaerobic Digester	52,400	14,470	607	41,238	80.0	63,900	32.0	100	1.0
Union Grove	Lagoon	14,130	3,649	52	10,955	1.2	11,000	9.4	80	0.02
Waukesha	Sludge Piles	18,320	2,220	349	8,247	0.0	6,340	15.2	1,430	0.01
Whitewater	Anaerobic Digester	94,670	43,410	1,503	34,608	8.8	1,050	26.0	246	0.09
Williams Bay	Drying Bed	60,810	6,990	245	8,052	0.0	2,160	13.6	46	14.06

Source: Southeastern Wisconsin Regional Planning Commission; Samples taken December 9-21, 1976

*median value of three samples

SLUDGE QUALITY SAMPLING DATA
INDUSTRIAL WASTEWATER TREATMENT PLANTS

Constituents

Sample Location		Kjeldahl Nitrogen (mg/kg)	Ammonia Nitrogen (mg/kg)	Nitrate Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Arsenic (mg/kg)	Aluminum (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)
American Motors	Holding Tank	1,691	64.9	49	131	0.3	1,300	0.6	10
Butler Lime & Cement	Drying Bed	182	13.0	46	446	4.3	5,780	1.4	10
Falk Corp., Canal St.	Sludge Thickener	532	25.3	36	298	2.1	4,850	2.7	37
Globe Union	55 gal. Drums	102	51.4	9	20	0.1	11	0.7	1
Hotpoint	Drying Bed	729	9.7	845	66	143.0	1,790	2.6	2
J. I. Case, Clausen	Vacuum Press, Screens	336	20.0	11	353	6.1	670	14.2	25
Patrick Cudahy	Drying Bed	12,550	28.8	23	1,584	0.0	80	0.3	2
P P Glass, Oak Creek	Settling Tank	2,520	1,570	71	7,860	0.0	10,340	2.1	224
S. C. Johnson, Waxdale	Vacuum Filter	3,378	209	48	739	0.0	1,590	2.8	6
S. K. Williams	Holding Tank	1,046	88.7	2,424	716	48.9	33,500	135.0	2,170
Trent Tube	Holding Tank	5,180	374	7,168	4,594	0.0	1,090	43.0	15,300
W. B. Place, Hartford	Settling Basin	38,340	4,480	235	2,112	4.5	3,280	57.0	46,600
American Can Co.	Settling Basin	12,040	1,820	612	5,044	16.8	172,800	20.0	87

Sample Location		Calcium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Magnesium (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Potassium (mg/kg)	Sodium (mg/kg)	Zinc (mg/kg)	PCBs (µg/kg)
American Motors	Holding Tank	487	7.8	795	13	56	0.0	7.5	412	750	146	13.31
Butler Lime & Cement	Drying Bed	92,976	9.7	5,200	17	7,980	0.1	16.1	422	269	933	0.01
Falk Corp., Canal St.	Sludge Thickener	1,414	19.0	4,730	11	1,160	0.0	20.0	260	443	15	3.38
Globe Union	55 gal. Drums	143	5.3	19	14	20	0.0	1.1	9	122	203	3.21
Hotpoint	Drying Bed	346	1.6	61	57	95	0.0	4.4	28,900	35,200	401	0.05
J. I. Case, Clausen	Vacuum Press, Screens	2,346	43.9	5,680	520	1,420	0.0	11.6	435	254	1,711	0.03
Patrick Cudahy	Drying Bed	4,830	4.9	520	8	215	0.0	13.8	92	265	77	0.61
P P Glass, Oak Creek	Settling Tank	6,498	23.1	3,980	300	398	147.0	145.0	217	47,900	2,180	0.14
S. C. Johnson, Waxdale	Vacuum Filter	766	5.3	293	19	43	0.0	2.8	40	858	663	0.09
S. K. Williams	Holding Tank	948	1,410.	3,120	1,650	847	0.0	11,010	639	12,690	994	0.04
Trent Tube	Holding Tank	247,568	242	69,100	86	33,700	0.9	11,500	222	6,070	158	21.30
W. B. Place, Hartford	Settling Basin	68,795	56	1,610	750	5,370	0.5	54	417	34,200	154	1.98
American Can Co.	Settling Basin	22,866	170	10,100	270	4,170	1.3	170	1,260	82,050	172,800	2.02

Source: Southeastern Wisconsin Regional Planning Commission Samples taken December 9-21, 1976

Appendix F

LAND REQUIRED FOR AGRICULTURAL SPREADING OF SLUDGES

In examining the alternative of land application of sludge it is important to determine the amount of land required by each facility over the study period. If the land required is greater than that which is available, then the landspreading alternative must be modified or eliminated for some facilities, although it might appear to be a viable alternative by all other measures. On the other hand, if enough suitable land is available within reasonable haul distances of the treatment plants, the landspreading alternative should be further considered and evaluated. Land application of sludge is extensively practiced in the Region. Current (1975) spending sites are located on Figure F-1.

METHODOLOGY

Land application of sludges is addressed by the Wisconsin Department of Natural Resources through its Technical Bulletin No. 88 entitled, Guidelines For The Application of Wastewater Sludge To Agricultural Land In Wisconsin. In addition to presenting a theoretical background, Technical Bulletin No. 88 offers practical guides for determining the sludge application rate and maximum total loadings which are considered safe in Wisconsin. The guidelines in Technical Bulletin No. 88, as of 1 July 1977, are incorporated into the Wisconsin Administrative Code through reference (NR 101.27 (6)). Because Technical Bulletin 88 is conservative in its recommendations, it use would assure that sludge would be applied to the land at safe maximum loads. If, in the future, it is determined that more sludge could be applied than permitted under Technical Bulletin No. 88 guidelines, no harm would have been done and sludge could be reapplied to the previously used fields. In addition, this systems level analysis of Regional alternatives would then be subject only to the development of an even more cost-effective solution.

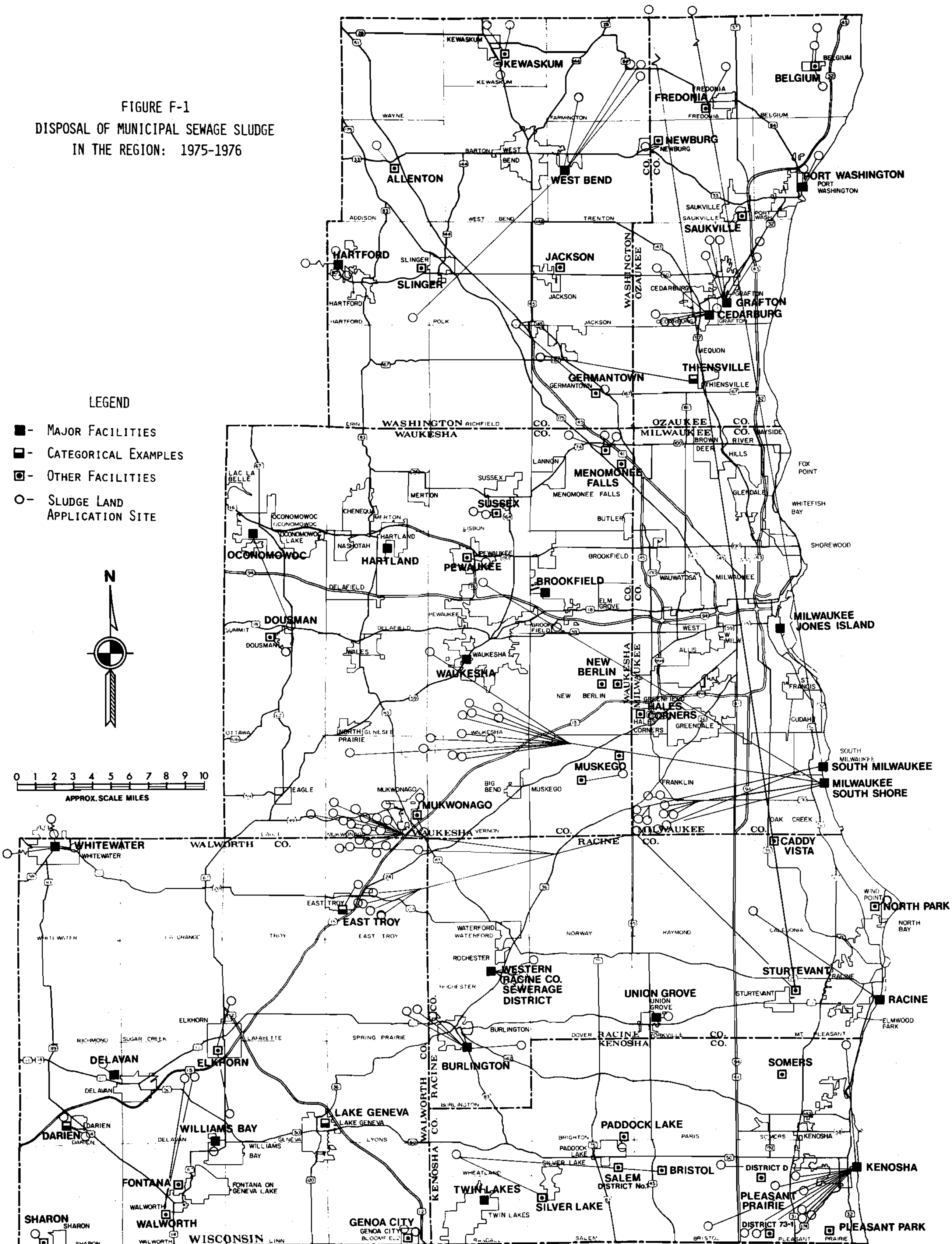
Based on this bulletin and the objectives, principles, and standards contained in Chapter VII, sludge from each of the large plant alternatives was analyzed to determine its guideline application rate and maximum total loading. In performing this analysis, the following assumptions were utilized:

1. The procedures of DNR Technical Bulletin No. 88 are used
2. The sludge is applied to the surface and immediately incorporated into the soil or injected into the soil
3. The soil is a sand or loam with an organic matter content of 21-30 tons per acre ("poor soil")
4. The crop grown is corn.

Assumptions 1, 2, and 3 are conservative in that they generate low estimates of permissible sludge application rates and the number of applications per spreading site (total loadings) is limited; and, therefore, land requirements are high. Assumption 2 has the effect of increasing the land requirements from 20 to 40 percent for most plants, as compared to surface application in which ammonia-nitrogen is lost to the air. The practice of incoporation is encouraged by Technical Bulletin No. 88 and is consistent with the objectives, principles, and standards for sludge disposal. The assumption of a poor soil has the effect of increasing the land requirement by 20 to 30 percent for most plants. Assuming corn is grown on the lands that have been treated with sludge had the effect of minimizing the negative impacts of heavy metals[1]: This is because heavy metals that enter the plant tend to concentrate in places other than the corn kernel. The net result of combining the effects of the assumptions is an overestimate of about 40 to 70 percent in the computation of land required, compared to the most favorable conditions. An underlying concept in the development of Technical Bulletin 88 was that sludge application rates would not exceed the level which would supply the required nitrogen to the crop being grown. By not exceeding

[1] *This assumes that the corn is not used for silage.*

FIGURE F-1
DISPOSAL OF MUNICIPAL SEWAGE SLUDGE
IN THE REGION: 1975-1976



SOURCE: CAMP DRESSER & McKEE INC. AND SEWRPC the nitrogen uptake rate, maximum benefits can be achieved from the nutrients in the sludge. An additional benefit of limiting the sludge application rate to the nitrogen uptake rate is that excess nitrogen would not be leached into surface or groundwater supplies. The crop nitrogen requirements used in Technical Bulletin 88 are standard recommendations for Wisconsin. The US EPA, in various publications, has used crop nitrogen requirements that are moderately higher. There is also some limited experimental research to indicate that sludge application at rates higher than the nitrogen uptake rate has the effect of increasing crop yield without contamination of surface or groundwater.

ANALYSIS RESULTS

Results of an analysis based on the above assumption is reported in Table F-1. The analysis uses (as inputs) the levels of nutrients and heavy metals derived from the sludge analyses in appendix E. The number of acres required for landspreading is based on the calculated sludge application rate, number of applications reported in Table F-1 and the sludge loads reported in Table F-2.

To determine the cumulative land requirements for the land application of a sludge over the study period, the following formula was developed:

Cumulative Acres Needed =

$$I + (N\text{-}1)g + (I \times C)$$

$$+ [(N\text{-}CL\text{-}1)g]_{N>CL+1} + [(N\text{-}2CL\text{-}1)g]_{N>2CL+1}$$

$$+ \ldots + [(N\text{-}iCL\text{-}1)g]_{N>iCL+1}$$

Where: I = Acres required in first year.

N = Year of need. (N = 1 for first year, N = 2 for second year, etc.)

g = Additional acres required each year due to growth in sludge volume.

CL = Number of applications or cycle length.

C = Application cycle number where:

N/CL	
$0<N/CL<1$	0
$1<N/CL\leq 2$	1
$2<N/CL\leq 3$	2
$3<N/CL\leq 4$	3
$i<N/CL\leq (i+1)$	i

and where it is assumed that:

1. The application rate is constant
2. Applications to the same land are in consecutive years
3. The number of applications (CL) is a whole number

TABLE F-1
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES
AVERAGE SLUDGE QUALITY - POOR SOIL

Plant	Application Rate Tons/Acre	Number of Applications Per Site	Total Acres Required to Year 2000
Jones Island[1]	1.4	29	
Alternative 1-6 - Min.			41,714
Max.			58,139
Alternative 1-7 - Min.			44,582
Max.			62,050
Alternative 1-8 - Min.			16,946
Max.			32,589
Alternative 1-9 - Min.			18,250
Max.			34,675
South Shore	3.3	8	
Min.			7,316
Max.			29,055
Racine	10.4	5	4,220
Kenosha	5.5	4	9,097
Waukesha	8.5	3	3,463
West Bend	1.0	10	6,522
South Milwaukee	1.9	57	441
Whitewater	0.9	107	1,260
Oconomowoc	1.7	19	1,382
Burlington[2]	NA	NA	NA
Walworth Co. MSD	2.6	95	237
Brookfield[3]	16.0	7	198
Port Washington[2]	NA	NA	NA
Cedarburg	2.2	23	411
Grafton	NA	NA	NA
Hartford	2.0	42	265
Twin Lakes	2.0	29	129
Williams Bay	2.4	45	28
Western Racine Co. MSD	4.3	25	64
Hartland-Delafield	3.9	34	151
Union Grove	7.5	17	63
Total			67,506 to 101,238

Assumptions:
a) Average sludge analysis - see Appendix E
b) "Poor" Soil - Sand or loam with an organic matter content of 21-30 tons/acre
c) Corn Crop
d) DNR Technical Bulletin No. 88 Procedures

Notes: [1]Jones Island alternatives assume landspreading starts in 1983.
[2]NA - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.

Source: Camp Dresser & McKee Inc.

TABLE F-2

DIGESTED SLUDGE QUANTITIES FOR USE IN LANDSPREADING

Plant	Sludge Load Tons/Year in 1975 (year if not 1975)	Sludge Load Tons/Year in 2000
Jones Island (see note)		
Alternative 1-6 - Min.	55,115 (1983)	58,400
Max.	62,415 (1983)	81,395
Alternative 1-7 - Min.	58,765 (1983)	62,415
Max.	66,430 (1983)	86,870
Alternative 1-8 - Min.	20,075 (1983)	23,725
Max.	26,280 (1983)	45,625
Alternative 1-9 - Min.	21,535 (1983)	25,550
Max.	28,105 (1983)	48,545
South Shore (see note)		
Min.	2,847	8,979
Max.	22,338	25,477
Racine	4,345	10,284
Kenosha	6,125	8,092
Waukesha	2,587	3,901
West Bend	1,027	3,011
South Milwaukee	838	838
Whitewater	506	1,109
Oconomowoc	411	1,643
Burlington	315	616
Walworth Co. MSD	301	616
Brookfield	0 (1978)	1,518
Port Washington	246	548
Cedarburg	275	602
Grafton	356	616
Hartford	274	534
Twin Lakes	82	260
Williams Bay	14	68
Western Racine Co. MSD	41	233
Hartland-Delafield	151	589
Union Grove	164	274

Note: Minimum and maximum flows based on extent of diversion area served

Source: Camp Dresser & McKee Inc.

4. Growth in sludge volume is a constant amount each year.

The land actively being spread upon in any year is equal to

$$I+(N-1)g$$

Results of applying the cumulative acres formulas are also reported in Table F-1.

As the nutrient and heavy metal data reported in appendix E consist of relatively few samples for most plants, and given the inherent variability of sludge composition, the possibility exists that there could be considerable variance between the sludge quality data and actual conditions at many plants. Therefore, a further analysis was conducted assuming a 50 percent increase of all nutrient and heavy metal levels (as reported in Table F-3). The results of this analysis are reported in Table F-4. In addition, an analysis was performed for all plants which had unusually high levels of one or more metals. In this analysis it was assumed that contaminant control would reduce the metal concentrations to 150 percent of the limit recommended by the USDA as shown in Table F-5. The results of this analysis are reported in Table F-6.

The above analyses all assume a sand or loam soil with 21 to 30 tons per acre of organic matter. This "poor" yielding soil is a "worst case" assumption. Table F-7 shows the results of an analysis using the average quality sludges performed on the assumption of a "better yielding" soil consisting of a sandy loam with 21 to 30 tons per acre of organic matter. Table F-8 shows the same analysis for the contaminant controlled sludge.

For the case of the Jones Island, South Shore, and West Bend treatment plants, three special analyses were conducted, due to the high level of nitrogen and/or heavy metal reported in their sludges. The first of these analyses shows the effects of applying the sludge to the land surface without incorporation. Under this application method, some of the ammonia-nitrogen vaporizes and is not available for plant uptake. The second analysis shows the effect of reducing the nitrogen in the sludge; this 50 percent reduction might occur with the implementation of various processing or storage options.

Both of the above analyses assume a "better" soil consisting of a sandy loam with 20 to 30 tons per acre of organic matter. A third analysis was conducted assuming both a reduction of 50 percent in the nitrogen level and contaminant control for heavy metals. This analysis assumed a "poor" soil. The results of these analyses are reported in Table F-9.

Table F-10 is a summary of the above analyses showing the cumulative acres required over the study period for each plant under each set of assumptions.

In interpreting the results of the analyses reported in Table F-10, the effect of the length of the study period should be clearly understood. The horizon year for this study is the year 2000. In the case of some plants where sludges can be spread 20 to 25 times on one site, a large amount of new (previously not used for landspreading of sludge) land has to be committed for spreading just before the end of the study period. In fact, this new land could last well past the horizon year. For example, the land required for spreading the sludge from the Oconomowoc treatment plant and the effects of the number of applications permitted per site is shown in Table F-11.

TABLE F-3
DEGRADED SLUDGE QUALITY DATA
AVERAGE DATA INCREASED BY FIFTY PERCENT

Plant	% Organic Nitrogen	% Ammonia Nitrogen	Zinc mg/kg	Nickel mg/kg	Copper mg/kg	Cadmium mg/kg
Jones Island	6.9	3.45	4,446	237	651	361.5
South Shore	3	1.5	6,450	1,050	1,425	61.5
Racine	2.18	0.075	4,668	208.5	853.5	144
Kenosha	2.25	0.9	5,700	663	3,870	42
Waukesha	2.475	0.33	8,085	200	2,025	22.8
West Bend	3.165	1.68	3,642	800	1,249.5	1,465.5
South Milwaukee	6.75	2.1	1,134	138	840	13.5
Whitewater	7.8	6.45	1,650	132	856.5	39
Oconomowoc	6.3	2.7	8,565	210	987	28.8
Burlington	NA	1.035	1,620	514.5	846	13.43
Walworth Co. MSD	4.65	1.65	930	55.5	169.5	19.5
Brookfield	1.695	0.03	1,680	66.45	648	18.5
Port Washington[1]	2.43	1.08	1,710	NA	NA	NA
Cedarburg	4.515	2.16	2,850	58.5	2,010	27
Grafton	NA[1]	NA	NA	NA	NA	NA
Hartford	6.6	1.95	2,520	147	618	85.5
Twin Lakes	5.685	2.175	4,365	168	540	48
Williams Bay	8.25	0.9	1,560	54.6	795	20.4
Western Racine Co. MSD	1.98	1.2	2,271	34.5	501	8.55
Hartland-Delafield	2.64	1.2	1,489.5	31.5	540	15.3
Union Grove	1.5	0.6	1,545	36.75	555	14.1

Notes: [1]NA - Not available due to lack of basic data.

Source: Camp Dresser & McKee Inc.
SEWRPC.

TABLE F-4
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES
DEGRADED SLUDGE QUALITY, POOR SOIL

Plant		Application Rate Tons/Acre	Number of Applications Per Site	Total Acres Required to Year 2000
Jones Island[1]				
Alternative 1-6 -	Min.	1.4	19	NCL[4]
	Max.			NCL
Alternative 1-7 -	Min.			NCL
	Max.			NCL
Alternative 1-8 -	Min.			16,946
	Max.			NCL
Alternative 1-9 -	Min.			18,250
	Max.			NCL
South Shore				
	Min.	2.2	8	10,974
	Max.			43,582
Racine		6.9	5	6,360
Kenosha		NCL	NCL	NCL
Waukesha		4.4	4	5,203
West Bend		NCL	NCL	NCL
South Milwaukee		1.3	57	645
Whitewater		0.6	108	1,912
Oconomowoc		1.1	19	2,136
Burlington[2]		NA	NA	NA
Walworth Co. MSD		1.7	96	362
Brookfield[3]		10.6	7	299
Port Washington[2]		NA	NA	NA
Cedarburg		1.5	23	602
Grafton		NA	NA	NA
Hartford		1.34	42	396
Twin Lakes		1.35	29	193
Williams Bay		1.6	45	43
Western Racine Co. MSD		2.9	25	96
Hartland-Delafield		2.5	35	236
Union Grove		5.0	17	95

Assumptions:
a) Degraded sludge analysis, see Table F-3.
b) "Poor" Soil - Sand or loam with an organic matter content of 21-30 tons/acre
c) Corn Crop
d) DNR Technical Bulletin No. 88 Procedures

Notes:
[1]Jones Island alternatives assume landspreading starts in 1983.
[2]NA - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.
[4]NCL - Not calculated - landspreading for this plant eliminated under less or as restrictive assumptions.

Source: Camp Dresser & McKee Inc.

TABLE F-5

CONTAMINANT CONTROLLED SLUDGE QUALITY DATA (CONTROLLED VALUES UNDERLINED)

Plant	Organic Nitrogen %	Ammonia Nitrogen %	Zinc mg/kg	Nickel mg/kg	Copper mg/kg	Cadmium mg/kg
Jones Island	4.6	2.3	2,964	237	650	<u>37.5</u>
South Shore	2	1	<u>3,750</u>	<u>300</u>	950	<u>37.5</u>
Racine						
Kenosha	1.5	0.6	<u>3,750</u>	<u>300</u>	<u>1,500</u>	28
Waukesha	1.65	0.22	<u>3,750</u>	133	1,350	15.2
West Bend	2.11	1.12	2,428	<u>300</u>	833	<u>37.5</u>
Suggested USDA limit	—	—	2,500	200	1,000	25
150% of limit	—	—	3,750	300	1,500	37.5

Source: Camp Dresser & McKee Inc./USDA.

TABLE F-6
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES
CONTAMINANT CONTROLLED SLUDGE QUALITY, POOR SOIL

Plant		Application Rate Tons/Acre	Number of Applications Per Site	Total Acres Required to Year 2000
Jones Island[1]		NCL	NCL	
Alternative 1-6 -	Min.			NCL
	Max.			NCL
Alternative 1-7 -	Min.			NCL
	Max.			
Alternative 1-8 -	Min.			NCL
	Max.			NCL
Alternative 1-9 -	Min.			NCL
	Max.			NCL
South Shore		3.25	11	
	Min.			5,798
	Max.			22,242
Racine		NCM	NCM	NCM
Kenosha		5.0	6	7,148
Waukesha		8.4	4	2,725
West Bend		3.0	15	1,611
South Milwaukee		NCM	NCM	NCM
Whitewater		NCM	NCM	NCM
Oconomowoc		NCM	NCM	NCM
Burlington[2]		NA	NA	NA
Walworth Co. MSD		NCM	NCM	NCM
Brookfield[3]		NCM	NCM	NCM
Port Washington[2]		NA	NA	NA
Cedarburg		NCM	NCM	NCM
Grafton		NA	NA	NA
Hartford		NCM	NCM	NCM
Twin Lakes		NCM	NCM	NCM
Williams Bay		NCM	NCM	NCM
Western Racine Co. MSD		NCM	NCM	NCM
Hartland-Delafield		NCM	NCM	NCM
Union Grove		NCM	NCM	NCM

Assumptions:
a) Contaminant controlled sludge analysis - see Table F-5
b) "Poor" Soil - Sand or loam with an organic matter content of 21-30 tons/acre
c) Corn Crop
d) DNR Technical Bulletin No. 88 Procedures

Notes:
[1]Jones Island alternatives assume landspreading starts in 1983.
[2]NA - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.
[4]NCL - Not calculated - landspreading for this plant eliminated under less or as restrictive assumptions.
[5]NCM - Non-calculated - landspreading for this plant possible under more or as restrictive assumptions.

Source: Camp Dresser & McKee Inc.

TABLE F-7
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES
CONTAMINANT CONTROLLED SLUDGE QUALITY, BETTER SOIL

Plant		Application Rate Tons/Acre	Number of Applications Per Site	Total Acres Required to Year 2000
Jones Island[1]		1.98	21	
Alternative 1-6 -	Min.			29,495
	Max.			41,109
Alternative 1-7 -	Min.			31,523
	Max.			43,874
Alternative 1-8 -	Min.			11,982
	Max.			23,043
Alternative 1-9 -	Min.			12,904
	Max.			24,518
South Shore		4.5	8	
	Min.			5,365
	Max.			21,307
Racine		NCM	NCM	NCM
Kenosha		7.5	4	6,671
Waukesha		11.8	3	2,494
West Bend		1.0	10	6,522
South Milwaukee		NCM	NCM	NCM
Whitewater		NCM	NCM	NCM
Oconomowoc		NCM	NCM	NCM
Burlington[2]		NCM	NCM	NCM
Walworth Co. MSD		NCM	NCM	NCM
Brookfield[3]		NCM	NCM	NCM
Port Washington[2]		NA	NA	NA
Cedarburg		NCM	NCM	NCM
Grafton		NA	NA	NA
Hartford[2]		NCM	NCM	NCM
Twin Lakes		NCM	NCM	NCM
Williams Bay		NCM	NCM	NCM
Western Racine Co. MSD		NCM	NCM	NCM
Hartland-Delafield		NCM	NCM	NCM
Union Grove		NCM	NCM	NCM

Assumptions:
a) Average sludge analysis - see Appendix E
b) "Better" soil - Sandy loam with an organic matter content of 21-30 tons/acre
c) Corn Crop
d) DNR Technical Bulletin No. 88 Procedures

Notes:
[1]Jones Island alternatives assume landspreading starts in 1983.
[2]NA - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.
[4]NCL - Not calculated - landspreading for this plant eliminated under less or as restrictive assumptions.
[5]NCM - Non-calculated - landspreading for this plant possible under more or as restrictive assumptions.

Source: Camp Dresser & McKee Inc.

TABLE F-8
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES
CONTAMINANT CONTROLLED SLUDGE QUALITY, BETTER SOIL

Plant		Application Rate Tons/Acre	Number of Applications Per Site	Total Acres Required to Year 2000
Jones Island[1]		1.95	37	
Alternative 1-6 -	Min.			29,949
	Max.			41,741
Alternative 1-7 -	Min.			32,008
	Max.			44,549
Alternative 1-8 -	Min.			12,167
	Max.			23,397
Alternative 1-9 -	Min.			13,103
	Max.			24,894
South Shore		4.7	10	
	Min.			4,166
	Max.			15,460
Racine		17.0	4	3,061
Kenosha		6.8	6	5,256
Waukesha		11.7	4	1,957
West Bend		4.1	15	1,178
South Milwaukee		2.7	54	310
Whitewater		1.23	107	902
Oconomowoc		2.39	24	880
Burlington[2]		NA	NA	NA
Walworth Co. MSD		3.6	90	171
Brookfield[3]		21.4	7	148
Port Washington[2]		NA	NA	NA
Cedarburg		3.1	22	296
Grafton		NA	NA	NA
Hartford		2.8	40	191
Twin Lakes		2.8	28	93
Williams Bay		3.3	43	21
Western Racine Co. MSD		6.1	23	47
Hartland-Delafield		5.4	33	109
Union Grove		10.3	16	46

Assumptions:
a) Contaminant controlled sludge analysis - see Table F-5.
b) "Better" Soil - Sandy loam with an organic matter content of 21-30 tons/acre
c) Corn Crop
d) DNR Technical Bulletin No. 88 Procedures

Notes:
[1]Jones Island alternatives assume landspreading starts in 1983.
[2]NA - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.

Source: Camp Dresser & McKee Inc.

TABLE F-9a

LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES AVERAGE SLUDGE QUALITY, BETTER SOIL

Plant	Application Rate Tons/Acre	Number of Applications per Site	Total Acres Required to the year 2000
Jones Island[1]	2.9	14	
Alternative 1-6 Min.			39,343
Max.			50,745
1-7 Min.			42,008
Max.			54,106
1-8 Min.			15,326
Max.			25,961
1-9 Min.			16,481
Max.			27,645
South Shore	6.7	5	
Min.			5,295
Max.			21,410
West Bend	1.02	10	6,522

Assumptions: *1) Average sludge analysis — see appendix E.*
2) "Better" soil — sandy loam with an organic matter content of 21-30 tons/acre.
3) Corn crop.
4) DNR Technical Bulletin No. 88 Procedures.
5) Surface application — no incorporation.

TABLE F-9b

LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES REDUCED NITROGEN SLUDGE QUALITY, BETTER SOIL

Plant	Application Rate Tons/Acre	Number of Applications per Site	Total Acres Required to the year 2000
Jones Island[1]	7.15	10	
Alternative 1-6 Min.			27,679
Max.			36,536
1-7 Min.			29,562
Max.			38,968
1-8 Min.			10,916
Max.			19,248
1-9 Min.			11,744
Max.			20,498
South Shore	9.0	4	
Min.			4,694
Max.			18,644
West Bend	1.02	10	6,522

Assumptions: *1) Reduced nitrogen sludge analysis.*
2) "Better" soil — sandy loam with an organic matter content of 21-30 tons/acre.
3) Corn crop.
4) DNR Technical Bulletin No. 88 Procedures.

TABLE F-9c

LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGES REDUCED NITROGEN PLUS CONTAMINANT CONTROLLED SLUDGE QUALITY, POOR SOIL

Plant	Application Rate Tons/Acre	Number of Applications per Site	Total Acres Required to the year 2000
Jones Island[1]	2.8	18	
Alternative 1-6 Min.			20,857
Max.			29,020
1-7 Min.			22,291
Max.			31,025
1-8 Min.			8,397
Max.			15,295
1-9 Min.			9,125
Max.			17,338
South Shore	6.5	5	
Min.			5,458
Max.			22,068
West Bend	5.9	7	1,476

Assumptions: *1) Reduced nitrogen plus contaminant controlled sludge analysis.*
2) "Poor" soil — sand or loam with an organic matter content or 21-30 tons/acre.
3) Corn crop.
4) DNR Technical Bulletin No. 88.

[1]Jones Island alternatives assume landspreading starts in 1983.

Source: Camp Dresser & McKee Inc.

TABLE F-10
SUMMARY OF LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER SLUDGE THROUGH THE YEAR 2000

Plant	Sludge Quality Crop Yield From Table	Degraded "Poor" F-4	Average "Poor" F-1	Average "Better" F-7	Contaminant Control "Poor" F-6	Contaminant Control "Better" F-8	Average[6] "Better" F-9a	Nitrogen Control "Better" F-9b	Nitrogen & Contaminant Control "Poor" F-9c
Jones Island[1)]									
Alternative									
1-6 - Min.		NCL[4]	41,714	29,495	NCL	29,949	39,343	27,679	20,557
Max.		NCL	58,139	41,109	NCL	41,741	50,745	36,536	29,070
1-7 - Min.		NCL	44,582	31,623	NCL	32,008	42,008	29,562	22,291
Max.		NCL	62,050	43,874	NCL	44,549	54,106	38,968	31,025
1-8 - Min.		16,946	16,946	11,982	NCL	12,167	15,326	10,916	8,397
Max.		NCL	32,589	23,043	NCL	23,397	25,961	19,246	16,295
1-9 - Min.		18,250	18,250	12,904	NCL	13,103	16,481	11,744	9,125
Max.		NCL	34,675	24,518	NCL	24,894	27,675	20,498	17,338
South Shore									
Min.		10,974	7,316	5,365	5,798	4,166	5,295	4,694	5,458
Max.		43,582	29,055	21,307	22,242	15,460	21,410	18,644	22,068
Racine		6,360	4,220	NCM	NCM	3,061	NCM	NCM	NCM
Kenosha		NCL	9,097	6,671	7,148	5,256	NCM	NCM	NCM
Waukesha		5,203	3,463	2,494	2,725	1,957	NCM	NCM	NCM
West Bend		NCL	6,522	6,522	1,611	1,178	6,522	6,522	1,476
South Milwaukee		645	411	NCM	NCM	310	NCM	NCM	NCM
Whitewater		1,912	1,260	NCM	NCM	902	NCM	NCM	NCM
Oconomowoc		2,136	1,382	NCM	NCM	880	NCM	NCM	NCM
Burlington[2]		NA	NA	NA	NA	NA	NA	NA	NA
Walworth Co. MSD		362	237	NCM	NCM	171	NCM	NCM	NCM
Brookfield[3]		299	198	NCM	NCM	148	NCM	NCM	NCM
Port Washington[2]		NA	NA	NA	NA	NA	NA	NA	NA
Grafton and Cedarburg		NA/602	NA/411	NA/NCM	NA/NCM	NA/296	NA/NCM	NA/NCM	NA/NCM
Hartford		396	265	NCM	NCM	191	NCM	NCM	NCM
Twin Lakes		193	129	NCM	NCM	93	NCM	NCM	NCM
Williams Bay		43	28	NCM	NCM	21	NCM	NCM	NCM
Western Racine Co. MSD		96	64	NCM	NCM	47	NCM	NCM	NCM
Hartland-Delafield		236	151	NCM	NCM	109	NCM	NCM	NCM
Union Grove		95	63	NCM	NCM	46	NCM	NCM	NCM

Notes:
1) Jones Island alternatives assume landspreading starts in 1983.
2) NA - Not available due to lack of basic data.
3) Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.
4) NCL - Not calculated - landspreading for this plant eliminated under less restrictive assumptions.
5) NCM - Non-calculated-landspreading for this plant possible under more restrictive assumptions.
6) Surface applied.

Source: Camp Dresser & McKee Inc.

TABLE F-11
LAND REQUIRED FOR AGRICULTURAL USE OF WASTEWATER
SLUDGE FROM THE OCONOMOWOC PLANT

Year	N	Acres Required This Year	Total Acres To Date	
1975	1	242	242	
1976	2	271	271	
1977	3	300	300	
1978	4	324	324	
1979	5	358	358	
1980	6	387	387	
1981	7	416	416	
1982	8	445	445	
1983	9	474	474	
1984	10	503	503	
1985	11	532	532	
1986	12	561	561	
1987	13	590	590	
1988	14	619	619	
1989	15	648	648	
1990	16	677	677	
1991	17	706	706	
1992	18	735	735	
1993	19	764	764	
1994	20	793	1,034	- Large Com-
1995	21	822	1,092	mitment of
1996	22	851	1,150	New Land
1997	23	880	1,208	
1998	24	908	1,266	
1999	25	937	1,324	
2000	26	966	1,382	

Number of applications per site: 19

Assumptions:
a) Average Sludge Analysis - see Appendix E
b) "Poor soil - sand or loam with an organic matter content of 21-30 tons/acre
c) Corn crop
d) DNR Technical Bulletin No. 88 Procedures

Source: Camp Dresser & McKee Inc.

The above analyses were conducted using the procedures in Wisconsin Department of Natural Resources Technical Bulletin No. 88. Although the federal government has not, as of this writing, officially adopted requlations governing land application of wastewater sludges, the U.S. Department of Agriculture has recommended to the Environmental Protection Agency (EPA) certain draft standards as reported in Chapter V. To compare the impact of rigid federal regulations, if adopted, the land required for spreading the sludge at each plant was calculated using proposed federal procedures. Results of this analysis indicate that, in general, less land would be required for landspreading. However, some plants would require substantially more land. The Department of Agriculture procedures also contain upper limits for certain sludge constituents. They recommend that sludges between 100 and 150 percent of the limits be spread only if there is an approved contaminant control program in effect. Under no circumstance should sludges over 150 percent of the limit be spread. Values for each of the average sludges under study and the upset limits are reported in Table F-12. Application of such a standard would eliminate all but seven plants from landspreading, if an assumed moderate contaminant control program were in effect. Without a contaminant control program, only two plants would be eligible for landspreading. Table F-13 and F-14 report the same analysis for the degraded and contaminant controlled sludges. An examination of the pattern of values above the limits reveals that, for the other plants, two or three of the heavy metals are above the recommended limits. For the other plants, typically only one or two of the metals ae above the recommended limits. If such strict limits were imposed as a regulation, the landspreading alternative could be severely reduced in its scope. Under such regulations, it becomes mandatory to have a strict, major contaminant control program in effect if landspreading is to be considered.

A review of the procedures currently being proposed by the Illinois EPA was also conducted. The Illinois procedure for estimating available nitrogen in sludge yields a higher application rate than Technical Bulletin 88's procedure during the first year and lower application rates during following years. Illinois addresses the question of heavy metals by stating that, for nonindustrialized communities, heavy metals should not be a problem if application procedures are followed. However, total sludge loadings are limited to 100 tons per acre without a complete soil analysis and special permit. Cadmium loadings are restricted to 0.3 lb/acre/year compared to 2 lb/acre/year recommended in Technical Bulletin 88. Total cadmium loadings are proposed to be limited by the Illinois EPA to 6 lb per acre for cadmium/zinc ratios less than 0.01 and to 3 lb for ratios greater than 0.01. Technical Bulletin 88 limits total cadmium loads to 20 lb per acre.

Sludge application rates, an order of magnitude higher than those recommended in Technical Bulletin No. 88, have been used in other areas. For example, in Fulton County, Illinois:[1]

> Sludge Application to strip-mined land is authorized on a rate scale of 75 dry tons per acre for the first year, and 25 tons per acre for the following years. Because sludge application rates must be modified according to climatic and cropping conditions, maximum spreading rates are seldom reached. For the coming year (1977), sludge will be incorporated at a maximum rate of 25 dry tons per acre in five to six applications to non-cropped land. Cropped land will receive approximately half that amount (12.5 dry tons per acre) in three applications (two pre-planting and one post-harvest). Sludge application rates and their effect on a specific soil type must be studied under actual conditions, because inadequate data exists to accurately predict effects.
>
> The possible effects of increasing application rates or accumulation of sludge in the fields on groundwater nitrogen levels cannot be assessed at this early stage of project development. Data are not sufficient for analysis of trends, and long-term monitoring of groundwater quality is required to establish the relationship between project operations and the nitrite and nitrate nitrogen level. Study of the movements of labeled nitrogen compounds or isotopes in the soil and in the groundwater system would assist in this assessment.

[1] *"Draft Environmental Impact Statement—Sludge Disposal and Land Reclamation in Fulton County, Illinois," Chicago, Illinois, June 1976.*

TABLE F-12
1975/76 AVERAGE SLUDGE QUALITY DATA OVER SUGGESTED USDA LIMITS

Plant	% Cadmium/ Zinc	Lead (mg/kg)	Mercury (mg/kg)	Chrome (mg/kg)	Zinc (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	Cadmium (mg/kg)
Jones Island	8.13*	699	NA[2]	6,640*	2,964+	158	434	241*
South Shore	0.95	1,100+	2.73	1.064+	4,300*	700*	850	41*
Racine	3.08*	332	4.64	722	3,112+	139	569	96*
Kenosha	0.74	428	1.16	756	3,800*	442*	2,580*	28.0+
Waukesha	0.28	565	.35	1.430	5,390*	133	1,350+	15.2
West Bend	10.24*	2,381	1.22	992	2,428	533*	833	977*
South Milwaukee	1.19+	241	2.02	17,772*	755	92	560	9.0
Whitewater	2.36*	396	19.3*	246	1,100	88	511	26+
Oconomowoc	0.34	427	20.2*	1,600*	5,110*	140	658	19.2
Burlington	0.82	313	75.0*	637	1,080	343*	560	8.95
Walworth Co. MSD	2.1 *	47	0.1	113	620	37	113	13
Brookfield	1.08+	125	0	55	1,120	44.3	432	12.1
Port Washington	NA	NA	NA	398	1,140	NA	NA	NA
Cedarburg	0.95	337	2.4	1,470+	1,900	39	1,340	18
Grafton	NA	NA	NA	NA	NA	NA	NA	NA
Hartford	3.39*	917	1.55	10,800*	1,680	98	412	57*
Twin Lakes	1.10+	240	0.8	100	2,910+	112	360	32+
Williams Bay	1.31+	203	0	46	1,040	36.4	530	13.6
Western Racine Co. MSD	0.38	2.57	0.11	29	1,514	23	334	5.7
Hartland-Delafield	1.03+	112	13.95+	60	993	21	360	10.2
Union Grove	0.91	306	0.04	796	1,030	24.5	370	9.4
+Exceeds limit[1]	1.0	1,000	10	1,000	2,500	200	1,000	25
*Exceeds 150% limit	1.5	1,500	15	1,500	3,750	300	1,500	37.5

Notes:

[1]Suggested by USDA - See Chapter V.

[2]NA - Not Available.

Source: Camp Dresser & McKee Inc.
SEWRPC

TABLE F-13
DEGRADED SLUDGE QUALITY DATA OVER RECOMMENDED USDA LIMITS

Plant	% Cadmium/ Zinc	(mg/kg) Lead	Mercury	Chrome	Zinc	Nickel	Copper	Cadmium
Jones Island	8.13*	1,048+	NA[2]	9,960*	4,446*	237+	651	361.5*
South Shore	0.95	1,650*	4.09	1,596*	6,450*	1,050*	1,425+	61.5*
Racine	3.08*	498	6.96	1,083+	4,665*	208.5+	853.5	144*
Kenosha	0.74	642	1.65	1,134+	5,700*	663*	3,870*	47*
Waukesha	0.28	847	0.52	2,145*	8,085*	200+	2,025*	22.8
West Bend	40.24*	3,571*	1.83	1,486+	3,642+	800*	1,249.5+	1,465.5*
South Milwaukee	1.19+	361	3.03	26,658*	1,134	138	840	13.5
Whitewater	2.36*	594	28.95*	369	1,650	132	856.5	39
Oconomowoc	0.34	640	30.3*	2,400*	8,565	210+	987	28.8+
Burlington	0.82	469	112.5*	955	1,620	514.5*	840	8.95
Walworth Co. MSD	2.1 *	70	0.15	169	930	55.5	169.5	19.5
Brookfield	1.08+	187	0	82	1,680	66.45	648	18.15
Port Washington	NA	NA	NA	597	1,716	NA	NA	NA
Cedarburg	0.95	505	3.6	2,205*	2,850	58.5	2,010*	27.0
Grafton	NA	NA	NA	NA	NA	NA	NA	NA
Hartford	3.39*	1,375+	2.32	16,200*	2,520+	147	618	85.5*
Twin Lakes	1.10+	360	1.2	150	4,365*	168	540	48*
Williams Bay	1.31+	304	0	69	1,560	54.6	795	20.4
Western Racine Co. MSD	0.38	385	0.16	43.5	2,271	34.5	501	8.55
Hartland-Delafield	1.03+	168	20.92*	90	1,489.5	31.5	546	15.3
Union Grove	0.91	459	0.06	1,194+	1,545	36.75	555	14.1
+Exceeds limit[1]	1.0	1,000	10	1,000	2,500	200	1,000	25.0
*Exceeds 150% limit	1.5	1,500	15	1,500	3,750	300	1,500	37.5

Notes:
[1]Suggested by USDA - See Chapter V.
[2]NA - Not Available.

Source: Camp Dresser & McKee Inc.
SEWRPC

TABLE F-14

ESTIMATED CONTAMINANT CONTROLLED QUALITY DATA OVER SUGGESTED USDA LIMITS

Plant	Percent Cadmium/ Zinc	Lead	Mercury	Chrome	Zinc	Nickel	Copper	Cadmium
Jones Island	1.26	699	NA[2]	6,640*	2,964+	158	434	37.5+
South Shore	1.00	1,100	2.73	1,064	3,750+	300+	950	37.5+
Kenosha	0.75	428	1.16	756	3,750+	300+	1,500+	28.0+
Waukesha	0.41	565	.35	1,430	3,750+	133	1,350+	15.2
West Bend	1.54*	2,381*	1.22	992	2,428+	300+	833	37.5+
+ Limit	1.0	1,000	10	1,000	2,500	200	1,000	25
* 150 limit	1.5	1,500	15	1,500	3,750	300	1,500	37.5

[1]*Recommended by USDA — see Chapter V.*
[2]*NA — Not available.*

Source: Camp Dresser & McKee Inc.
Southeastern Wisconsin Regional Planning Commission.

Authorization of an application rate on the order of 12.5 ton/acre/year, as mentioned above, would result in a land requirement for the study area plants of 0.07 to 0.8 times that of using the criteria of Technical Bulletin No. 88. However, the risk of groundwater contamination is substantially increased. Groundwater quality should be monitored and, in the case of nitrogen breakthrough, application rates should be immediately reduced.

A review of soils and groundwater information in the Region failed to yield a site where sludge could be applied at high rates without a high risk of groundwater contamination and high rate application is therefore ruled out of consideration. Soils where high rate application could be practiced would be sandy gravelly soils which have a high risk of groundwater contamination from nitrogen. These soils would require a leachate collection system and may require additional site preparation to seal the area to prevent any leachate from reaching groundwaters. The cost of such preparation for large acreage sites is extremely high. Sites where such site preparation is undertaken should be limited in size to areas where very high rate application would be possible; this site would then serve as a sludge landfill.

LAND AVAILABLE FOR AGRICULTURAL SPREADING OF SLUDGES

As previously stated, land application of wastewater sludges is a viable disposal alternative only if enough suitable land is available. To determine if such land is available for spreading, a three-step procedure was followed. First was a preliminary determination of land availability, second was a detailed determination of land availability, and the last step was a comparision of land available to land required.

ANALYSIS RESULTS

The preliminary determination was made by selecting townships for spreading each treatment plant's sludge based on current spreading practices. Haul distances were kept within the range of existing hauls.

For the other plants, the township containing the plant or an adjacent township was selected. In the case of larger plants requiring several townships, locations were selected based on current practice, predominant land-use types, and haul distances.

Following the selection of townships for land application in Step 1, a detailed examination of land availability was conducted. For land to be considered available for land application of sludge, it had to meet the following criteria:

1. Soil type must be classified as having slight limitation[1] for sludge application based on DNR Technical Bulletin No. 88 guidelines (see Table F-15).

2. Land must be a working farm field which can be identified easily during normal farm operations

3. There can be no surface drainage or runoff problems.

Lands that are classified as moderate limitations or that have apparent surface drainage problems were also identified during the analysis. Prior to sludge application to these lands, detailed on-site inspection and soils evaluations would have to be made to determine the suitability of the site.

The procedure used to determine the farmland available was as follows: First, the soils maps for the township were color-coded to indicate soils of slight limitations, soils of slight limitations but with apparent surface drainage problems, and soils of moderate limitations.[2] Next, aerial photographs were examined to locate farm fields in each soil limitation grouping. Fields covering two or more limitation groups were classified according to the most limiting group. The third step was to determine the acreages of the identified fields. This procedure was used on a case study basis on 12 of the 33 townships identified in the preliminary analysis. Results of this case study analysis were extended to cover the remaining 21 townships and are reported in Table F-16.

The third major step in the procedure was to compare the land available with the land required to spread the sludge from each plant. The results of this comparison for the average sludge on a poor soil are reported in Table F-17. As can be seen in Table F-17, the percentage of required land that is available varies widely in each soil grouping. For example, farmfields classified as slight limitation amount to only 17 percent of the land required for Kenosha where as they constitute over 3,300 percent of the requirement for the Walworth County facilities. For the plants listed in Table F-17, when on farms classified as having slight limitations. Typically, whereas the larger plants must utilize slight limitation soils with surface drainage problems and moderate limitation soils to meet their land requirements.

An expansion of the analysis in Table F-17 to land available in the entire region is shown in Table F-19. Table F-17 assumes that landspreading would only occur in the 33 townships identified in Table F-16. Table F-19 considers the land that is suitable for sludge application in all 83 townships in the region. If all suitable lands of slight and moderate limitations were used to spread contaminant controlled sludge on high yielding crops, there would be from 5.6 to 8.4 times the land required actually available on farms.

Table F-20 indicates which sludges can be spread under each set of assumptions. The effect of extending landspreading beyond the 33 selected townships to the entire region and possibly beyond is reported in Table F-21. The underlying assumption in Table F-21 is a doubling of the available land assumed in

[1]*Soil limitations used in Technical Bulletin No. 88 refer to the physical properties of the soils as they relate to landspreading. The terms "poor" and "better" soils used earlier in this appendix distinguish soils based on their chemical properties and agricultural yield potential. Soils with slight limitations are not necessarily "better" soils or "poor" soils. All combinations of limitations and crop potential can exist.*

[2]*Coded maps are available from SEWRPC.*

TABLE F-15
SOIL LIMITATIONS FOR SEWAGE SLUDGE APPLICATION TO AGRICULTURAL LAND AT NITROGEN FERTILIZER RATES.

Soils Features Affecting Use	Degree of soil limitation: Slight	Moderate	Severe
Slope*	Less than 6%	6 to 12%	More than 12%
Depth to seasonal water table **	More than 4 ft	2 to 4 ft	Less than 2 ft
Flooding & ponding	None	None	Occasional to frequent
Depth to bedrock **	More than 4 ft	2 to 4 ft	Less than 2 ft
Permeability of most restricting layer above 3 ft	0.6 to 2.0 in./hr	2.0 to 6.0 in./hr 0.2 to 0.6 in./hr	Less than 0.2 in./hr More than 6 in./hr
Available water capacity	More than 6 in.	3 to 6 in.	Less than 3 in.

* Slope is an important factor in determining the runoff that is likely to occur. Most soils on 0 to 6 percent slopes will have very slow or slow runoff; soils on 6 to 12 percent slopes generally have medium runoff; and soils on steeper slopes generally have rapid to very rapid runoff.

** Measured at depth of application.

Source: DNR Technical Bulletin No. 88 - Table 28.

TABLE F-16
LAND AVAILABLE FOR SPREADING OF WASTEWATER SLUDGES

Plant	Townships	All Locations: Acres Slight Limitations[a]	Acres Moderate Limitations[a]	Total[1] Acres	Classified Farm Fields: Acres Slight Limitations[b]	Acres Slight Limitations With Problems[2b]	Acres Moderate Limitations[b]	Total[1] Acres	% of Total Land on Farm Fields
Jones Island or South Shore	East Troy	11,747	4,376	16,123	1,093	528	3,194	4,815	29.9
	Lafayette	14,783	1,155	15,938	1,973	499	2,097	4,569	28.7
	Spring Prairie	16,637	1,386	18,023	2,039	1,639	1,196	4,874	27.0
	Troy	10,492	4,790	15,282	4,136	2,218	1,704	8,058	52.7
	Mukwonago	11,299	5,765	17,064	1,316	348	4,175	5,839	34.2
	Vernon	12,061	3,943	16,004	609	43	4,747	5,399	33.7
Total		77,019	21,415	98,434	11,166	5,275	17,113	33,554	34.1
Racine	Caledonia (W)	4,116	15,549	19,665	-	-	-	-	-
	Caledonia (E)	1,535	4,243	5,778	-	-	-	-	-
	Mt. Pleasant (W)	3,705	13,894	17,599	-	-	-	-	-
	Raymond	4,754	12,451	17,205	-	-	-	-	-
	Yorkville	3,471	14,811	18,282	-	-	-	-	-
Total		17,581	60,948	78,529	1,785[3]	704[3]	21,070[3]	23,559[3]	30.0
Kenosha	Bristol	3,929	12,479	16,408	-	-	-	-	-
	Paris	5,533	10,375	15,908	-	-	-	-	-
	Pleasant Prairie	3,017	9,285	12,302	-	-	-	-	-
	Sommers (W)	3,441	13,996	17,437	-	-	-	-	-
Total		15,920	46,135	62,055	1,592[3]	637[3]	16,387[3]	18,616[3]	30.0

Notes: 1 Does not include severely limited soils, man-made land or land classified as urban.
2 Defined as slight limitation soils with apparent surface drainage or runoff problems.
3 Estimated.

Sources: a SEWRPC.
b Camp Dresser & McKee Inc.

TABLE F-16 (continued)
LAND AVAILABLE FOR SPREADING OF WASTEWATER SLUDGES

Plant	Townships	All Locations: Acres Slight Limitations[a]	Acres Moderate Limitations[a]	Total[1] Acres	Classified Farm Fields: Acres Slight Limitations[b]	Acres Slight Limitations With Problems[2b]	Acres Moderate Limitations[b]	Total[1] Acres	% of Total Land on Farm Fields
Grafton and Cedarburg	Cedarburg	8,532	9,224	17,756	853[3]	341[3]	4,133[3]	5,327[3]	30.0
Hartford	Hartford	16,025	1,178	17,203	1,603[3]	641[3]	2,917[3]	5,161[3]	30.0
Twin Lakes	Randall	7,818	3,985	11,803	782[3]	313[3]	2,446[3]	3,541[3]	30.0
Williams Bay	Geneva	11,096	4,623	15,719	245	564	1,175	1,984	12.6
Western Racine Co. MSD	Rochester	6,878	8,253	15,131	688[3]	275[3]	3,576[3]	4,539[3]	30.0
Hartland/Delfield	Delafield	12,363	5,365	17,728	1,236[3]	371[3]	3,711[3]	5,318[3]	30.0
Union Grove	Dover	2,776	11,797	14,573	278[3]	111[3]	3,983[3]	4,372[3]	30.0
Total		272,836	240,661	513,497	42,170	20,106	107,961	170,237	33.5

Notes: 1 Does not include severely limited soils, man-made land or land classified as urban.
2 Defined as slight limitation soils with apparent surface drainage or runoff problems.
3 Estimated.

Sources: a SEWRPC.
b Camp Dresser & McKee Inc.

TABLE F-16 (continued)
LAND AVAILABLE FOR SPREADING OF WASTEWATER SLUDGES

Plant	Townships	All Locations: Acres Slight Limitations[a]	Acres Moderate Limitations[a]	Total[1] Acres	Classified Farm Fields: Acres Slight Limitations[b]	Acres Slight Limitations With Problems[2b]	Acres Moderate Limitations[b]	Total[1] Acres	% of Total Land on Farm Fields
Waukesha	Pewaukee	12,969	926	13,895	1,297[3]	389[3]	2,482[3]	4,168[3]	30.0
West Bend	Farmington	8,471	9,882	18,353	862	223	4,304	5,389	29.4
	Trenton	6,491	10,896	17,387	809	311	4,257	5,377	30.9
Total		14,962	20,778	35,740	1,671	534	8,561	10,766	30.1
South Milwaukee	Franklin	1,614	16,602	18,216	161[3]	65[3]	5,239[3]	5,465[3]	30.0
Whitewater	Whitewater	6,915	5,301	12,216	1,447	522	1,050	3,019	24.7
Oconomowoc	Oconomowoc	12,628	3,274	15,902	1,263[3]	379[3]	3,129[3]	4,771[3]	30.0
Burlington	Burlington	3,056	6,418	9,474	306[3]	122[3]	2,414[3]	2,842[3]	30.0
Walworth Co. MSD	Darien	18,723	1,156	19,879	5,182	6,140	857	12,179	61.3
	Delavan	16,159	462	16,621	2,692	2,396	2,140	7,228	43.5
Total		34,882	1,618	36,500	7,874	8,536	2,997	19,407	53.2
Brookfield	Brookfield	3,282	2,110	5,392	230[3]	66[3]	1,322[3]	1,618[3]	30.0
Port Washington	Saukville	6,520	10,711	17,231	652[3]	261[3]	4,256[3]	5,169[3]	30.0

Notes: 1 Does not include severely limited soils, man-made land or land classified as urban.
2 Defined as slight limitation soils with apparent surface drainage or runoff problems.
3 Estimated.

Sources: a SEWRPC.
b Camp Dresser & McKee Inc.

TABLE F-17
COMPARISON OF AVAILABLE LAND TO REQUIRED LAND FOR LANDSPREADING WASTEWATER SLUDGES
OF CONTAMINANT CONTROLLED QUALITY ON BETTER SOILS

Plant	Acres Required Through the Year 2000[5]	Farm Fields Classified As: Slight Limitations Available Acres	Slight Limitations % of Required That is Available	Slight Limitations with Problems[4] Available Acres	Slight Limitations with Problems[4] % of Required That is Available	Total Slight % of Required That is Available	Moderate Limitations Available Acres	Moderate Limitations % of Required That is Available	Total % of Required That is Available
Jones Island[1]									
Alternative 1-6 Min	29,949	11,166	37	5,275	18	55	17,113	57	112
Max	41,741	11,166	27	5,275	13	40	17,113	41	81
1-7 Min	32,008	11,166	35	5,275	16	51	17,113	53	104
Max	44,549	11,166	25	5,275	12	37	17,113	38	75
1-8 Min	12,167	11,166	92	5,275	43	135	17,113	141	276
Max	23,397	11,166	48	5,275	23	71	17,113	73	144
1-9 Min	13,103	11,166	85	5,275	40	125	17,113	131	256
Max	24,894	11,166	45	5,275	21	66	17,113	69	135
South Shore									
Min	4,166	11,166	268	5,275	127	395	17,113	411	806
Max	15,460	11,166	72	5,275	34	106	17,113	111	217
Racine	3,061	1,785	58	704	23	81	21,070	688	769
Kenosha	5,256	1,592	30	637	12	42	10,387	198	240
Waukesha	1,957	1,297	66	389	20	86	2,482	126	212
West Bend	1,178	1,672	142	534	45	187	8,561	727	914
South Milwaukee	310	161	52	65	21	73	5,239	1,690	1,763
Whitewater	902	1,447	160	522	58	218	1,050	116	334
Oconomowoc	880	1,263	144	379	43	187	3,129	356	543
Burlington[2]	N/A	306	N/A	122	N/A	N/A	2,414	N/A	N/A
Walworth	171	7,874	4,605	8,536	4,992	9,597	2,997	1,753	11,350
Brookfield[3]	148	230	155	66	45	200	1,322	893	1,093
Port Washington[2]	N/A	652	N/A	261	N/A	N/A	4,256	N/A	N/A
Grafton and Cedarburg	563[6]	853	152	341	61	213	4,133	734	947
Hartford	191	1,603	839	641	336	1,175	2,917	1,527	2,702
Twin Lakes	93	782	841	313	337	1,178	2,446	2,630	3,808
Williams Bay	21	245	1,167	564	2,687	3,854	1,175	5,595	9,449
Western Racine	47	688	1,464	275	585	2,049	3,576	7,609	9,658
Hartland - Delafield	109	1,236	1,134	311	285	1,419	3,711	3,404	4,823
Union Grove	46	278	604	111	241	845	3,983	8,659	9,504
Total	42,496 to 63,648	42,170	99 to 66	20,116	47 to 32	146 to 98	109,736	258 to 172	404 to 270

Assumptions: a Contaminant controlled
b Better soil

Notes: [1]Jones Island alternatives assume landspreading starts in 1983.
[2]N/A - Not available due to lack of basic data.
[3]Brookfield assumes incineration continues and landspreading handles excess sludge after 1978.
[4]Defined as slight limitation soils with apparent surface drainage or runoff problems.
[5]From Table F-1.
[6]Assumes Grafton's sludge has similar characteristics to that of Cedarburg's and spread jointly.

TABLE F-19
SUMMARY OF LAND AVAILABLE FOR APPLICATION OF SLUDGE TO AGRICULTURAL LAND

Area in Acres

Conditions of Sludge Load	Average Sludge Quality and "Poor" Crop Yield: Minimum	Average Sludge Quality and "Poor" Crop Yield: Maximum	Contaminant Controlled Sludge Quality and "Better" Crop Yield: Minimum	Contaminant Controlled Sludge Quality and "Better" Crop Yield: Maximum
Area Required				
MSD-Jones Island and MSD-South Shore .	39,125	72,857	27,563	48,933
Other Large Plants . .	28,381	28,381	14,933	14,933
Other Plants	1,500	1,500	1,000	1,000
TOTAL	69,006	102,738	43,496	64,648
Total Slight and Moderate Limitations Acres Available in Region	358,000	358,000	358,000	358,000

Source: Camp Dresser & McKee Inc.

TABLE F-20
APPLICABILITY OF WASTEWATER SLUDGES TO AGRICULTURAL USE OF AVERAGE QUALITY, POOR SOILS
(THROUGH YEAR 2000)

Sludge Quality	Degraded	Degraded	Average	Average	Average	Average	Contaminant Control	Contaminant Control	Nitrogen Control	Average	Nitrogen & Contaminant Control
Limitations	Slight Soils	All Soils	Slight Soils	Total Slight	All Soils[4]	All Soils	All Soils	All Soils	All Soils	All Soils	All Soils
Crop Yield	Poor	Poor	Poor	Poor	Poor	Better	Poor	Better	Better	Better	Poor
Plant											
Jones Island											
Alternative I-6											
Min	No	No	No	No	No	No	No	No	No	No	No
Max	No	No	No	No	No	No	No	No	No	No	No
Alternative I-7											
Min	No	No	No	No	No	No	No	No	No	No	No
Max	No	No	No	No	No	No	No	No	No	No	No
Alternative I-8											
Min	No	No	No	No	No	Yes	No	Yes	Yes	No	Yes
Max	No	No	No	No	No	No	No	No	No	No	No
Alternative I-9											
Min	No	No	No	No	No	Yes	No	Yes	Yes	No	Yes
Max	No	No	No	No	No	No	No	No	No	No	No
South Shore											
Min	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Max	No	No	No	No	No	No	No	No	No	No	No
Racine	No	Yes	No	No	Yes	Yes	Yes	Yes	-	-	-
Kenosha	No	No	No	No	No	Yes	Yes	Yes	-	-	-
Waukesha	No	No	No	No	No[1]	Yes[1]	Yes[1]	Yes	-	-	-
West Bend	No	No	No	No	No	No	Yes	Yes	No	No	Yes
South Milwaukee	No	Yes	No	No	Yes	Yes	Yes	Yes	-	-	-
Whitewater	No	Yes	No	Yes	Yes	Yes	Yes	Yes	-	-	-
Oconomowoc	No	Yes	No	Yes	Yes	Yes	Yes	Yes	-	-	-
Burlington	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Walworth Co. MSD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Brookfield	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Port Washington	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Grafton and Cedarburg[3]	No	Yes	No	Yes	Yes	Yes	Yes	Yes	-	-	-
Hartford	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Twin Lakes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Williams Bay	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Western Racine Co. MSD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Hartland-Delafield	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Union Grove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-

Notes:
1 "Yes" if public pickup continues.
2 Surface applied.
3 Assumes Grafton's sludge has similar characteristics to that of Cedarburg's and spread jointly
4 All slight soils plus all moderate soils from Table F-16

Assumptions: Long term - the year 2000.
Jones Island and South Shore would use lame lands, therefore only one of the two plants can spread

Source: Camp Dresser & McKee, Inc.

TABLE F-21
APPLICABILITY OF WASTEWATER SLUDGES TO AGRICULTURAL USE
THROUGH YEAR 2000 FOR DOUBLE LAND AVAILABILITY

Sludge Quality	Degraded	Degraded	Average	Average	Average	Average	Control	Control	Nitrogen Control	Average	Nitrogen and Contaminant Control
Limitations	Slight Soils	All Soils	Slight Soils	Total Slight	All Soils[4]	All Soils	All Soils	All Soils	All Soils	All Soils	All Soils
Crop Yield	Poor	Poor	Poor	Poor	Poor	Better	Poor	Better	Better	Better	Poor
Plant											
Jones Island											
Alternative 1-6											
Minimum	No	No	No	No	No	Yes[1]	No	Yes[1]	Yes[1]	No	Yes[1]
Maximum	No	No	No	No	No	No	No	No	No	No	Yes[1]
Alternative 1-7											
Minimum	No	No	No	No	No	No	No	No	Yes	No	Yes[1]
Maximum	No	No	No	No	No	No	No	No	No	No	Yes
Alternative 1-8											
Minimum	No	Yes[1]	No	No	Yes[1]	Yes	Yes[1]	Yes	Yes	Yes[1]	Yes
Maximum	No	No	No	No	No	Yes[1]	No	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Alternative 1-9											
Minimum	No	Yes[1]	No	No	Yes[1]	Yes	Yes[1]	Yes	Yes	Yes[1]	Yes
Maximum	No	No	No	No	No	Yes[1]	No	Yes[1]	Yes[1]	Yes[1]	Yes[1]
South Shore											
Minimum	No	Yes	Yes[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum	No	No	No	No	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Racine	No	Yes	No	No	Yes	Yes	Yes	Yes	-	-	-
Kenosha	No	No	No	No	Yes[1]	Yes	Yes	Yes	-	-	-
Waukesha	No	No	No	No	Yes[1]	Yes	Yes	Yes	-	-	-
West Bend	No	No	No	No	Yes[1]	Yes[1]	Yes	Yes	Yes[1]	Yes[1]	Yes[1]
South Milwaukee	No	Yes	No	Yes[1]	Yes	Yes	Yes	Yes	-	-	-
Whitewater	Yes[1]	Yes	Yes[1]	Yes	Yes	Yes	Yes	Yes	-	-	-
Oconomowoc	Yes[1]	Yes	Yes[1]	Yes	Yes	Yes	Yes	Yes	-	-	-
Burlington	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Walworth Co. MSD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Brookfield	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Port Washington	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Grafton & Cedarburg[3]	Yes	Yes	Yes[1]	Yes	Yes	Yes	Yes	Yes	-	-	-
Hartford	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Twin Lakes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Williams Bay	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Western Racine Co. MSD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Hartland-Delafield	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Union Grove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-

Notes:

[1] Change from Table IX-A-18.

[2] Surface applied.

[3] Assumes Grafton's sludge has similar characteristics to that of Cedarburg's and spread jointly.

[4] All slight soils plus all moderate soils from Table F-16

Assumptions: Long term - the year 2000.
Jones Island and South Shore would use same lands.
Double land availability.

Source: Camp Dresser & McKee Inc.

Table F-20. For a plant to be listed as spreadable in either Table F-20 or F-21, an amount of land greater than that required by a factor of about two must be available. The factor varies according to the amount of land required. For the smaller plants a factor less than two might be acceptable, whereas a factor of greater than two is required for the larger plants. This factor accounts for suitable lands that cannot be used for landspreading due to farmer or community nonacceptance, drainage or runoff problems, future land use, noncorn acreage, and buffer zones.

BUFFER ZONES

As noted above, the imposition of buffer zones for land application sites will reduce the amount of land available for utilizing sludge. The amount of this reduction is a function of the buffer zone sizes, land uses surrounding the application site, and site size and dimensions. Table F-22 lists the buffer zones contained in various guidelines or regulations. Also listed in Table F-22 is a recommended set of buffer zones. The setback from a roadway is designed to keep the sludge out of the drainage ditch or curb of the roadway. (This recommendation is only a guideline.) The buffer-zone guides should be used only after a full on-site inspection has been made to evaluate the needs of a particular site.

TABLE F-22

BUFFER ZONES

Minimum Distance From	Wisconsin Domestic Wastes NR 113	Technical Bulletin No. 88	Proposed Illinois EPA	Recommended
Uphill[1] from ditch, dry run, pond, lake, stream, flowage, or flood plain				
Slope 6-12%	500 feet	100 feet	200 feet[4]	100 feet
0-6%	100 feet	100 feet	200 feet[4]	100 feet
Well or reservoir	200 feet	500 feet[6]	150 feet	500 feet
Public well	1,000 feet	1,000 feet	—	1,000 feet
Property line	50 feet	—	—	None
Residence, business, or recreational area	500 feet	500 feet[3]	20 feet[2]	500 feet[5]
Closest edge of traveled portion of public road or within fence	—	—	10 feet	10 feet

[1]*Downhill minimum distance is 10 feet.*
[2]*Occupied dwelling.*
[3]*Residence (may be reduced if sludge is incorporated in the soil.)*
[4]*Surface water.*
[5]*Does not apply to farmers own home or water supply.*
[6]*May be reduced to 200 feet if sludge is incorporated in the soil.*

Source: Camp Dresser & McKee Inc.

FARMER ACCEPTANCE

Farmer acceptance of a sludge land application program is important to its success. If the farmers do not accept the sludge then there is no land available, even if there might be suitable soils on the farm. Experience to date in the southeastern Wisconsin region and around the country indicates a high degree of farmer acceptance. At the inception of a new program of landspreading, farmer acceptance might be low. However, as the program proceeds and the benefits of land application can be seen locally, farmer acceptance increases. In some cases, the farmers will take all the sludge they can get to satisfy their fertilizer requirements.

COMMUNITY ACCEPTANCE

Community acceptance is difficult to generalize because of the range of attitudes that the public holds; community reactions to sludge land application programs vary from total rejection to full support. Negative reactions run higher in newer suburban communities without a strong agrarian base. Traditional agricultural communities tend to support land application programs. Often the arguments in a community center on the fertilizer value of the sludge versus the real or perceived environmental and health problems. Resolution of this argument can only occur through local discussion of the facts and local decisions based on a public information program which explains the bene/ts and possible negative impacts of the landspreading program.

FUTURE LAND USE

Future land use impacts land availability in that suitable farmland might be removed from the available land pool due to development. The magnitude of this reduction in the available land pool is unknown. It is a function of the amount of development, its pattern, and specific site and timing. However, it must be recognized that some nonquantifiable amounts of land will be developed over the study period and will, therefore, be unavailable for landspreading.

NONCORN ACREAGE

The analysis of the land required for spreading sludges assumed that corn would be the crop grown. The amount of suitable land available for sludge application would be reduced by the amount of these lands devoted to the noncorn crops (oats, soybeans, and hays), either on a rotation or continuous crop basis.

This analysis indicates that given proper quality control, there is enough land within reasonable haul distances of all treatment plants for spreading of sludges. However, this is only true with strict contaminant control and considerations of land in Jefferson and Dodge counties. The question which remains is that of application rate and number of applications. Many thousands of acres are required by the application rates computed following guideline values in Technical Bulletin No. 88. (The other end of the spectrum is ordinary landfilling.) Higher application rates might be feasible at a few sites, but there is always the danger of groundwater contamination. If sludges are to be spread at higher rates, monitoring, such as described below, should be required. The intensity of monitoring should be increased with increased rates of sludge application above the guideline values in Technical Bulletin No. 88.

MONITORING APPLICATION SITES

The basis criteria that should be addressed when designing a sludge application monitoring program are:

1. The program must adequately determine the ecological effects on the natural environment
2. The contributions of the components from sludge to the natural environment must be determined
3. The cost/feasibility of conducting the monitoring program must be determined.

Each of these topics should be considered on an individual site basis, since the geography and hydrogeologic characteristics will vary between sites.

In addition to these criteria, the following criteria from Technical Bulletin No. 88 were considered in the design of the typical monitoring program:

1. The site meets the qualifications outlined in the section on site selection, and runoff is minimized
2. Sludge is being added at fertilizer nitrogen rates and nutrient recycling by use of grain, forage, or vegetable crops is being practiced
3. Sludge is digested or otherwise treated so that pathogen levels are minimal
4. Metals and phosphorus are tightly sorbed in the surface soil.

Thus, using recommended practices, ground and surface water contamination can be expected to be essentially at "background" levels; that is, no greater than might occur if commercial fertilizers or animal manures were used rather than sludge.

The following are recommendations for monitoring intensity which is variable with the extent of site use.

1. Occasional use: Sludge applied at a maximum once every two to three years as part of a normal rotation. This use requires a soil test every three years to ensure that phosphorus, potassium, and pH are adequate for maximum crop yields. Analysis of selected plant material for cadmium, after three sludge applications, should be conducted. Spot checking of any nearby surface waters should be conducted to assure that the application practices are successful in the prevention of water pollution.

2. Continuous use: Sludge applied yearly on private, leased, or community-owned land. This use also requires a soil test for potassium, pH level, and plant tissue monitoring to evaluate nutrient status and metal uptake. Plant analyses should include cadmium, copper, manganese, nickel, zinc, and boron. Each site receiving sludge should have soil tests and plant tissue testing on an annual basis.

The plant integrates various soil and environmental variables involved in the mobility of elements in the soil. Therefore, plant tissue analysis will provide the most sensitive and accurate assessment of heavy metal problems. The drawback to plant analysis is that, if a problem is indicated, it might be too late to apply remedial action.

Table F-23 lists the range in elemental composition normally encountered in samples of plant tissue in the field. Suggested tolerance levels given are preliminary values, at this time, and are for succulent vegetative tissue only.

The tolerance levels suggested in Table F-23 assume that:

1. The same tolerance levels can be used for the common agronomic crops

2. The designated plant part and stage of development will be used

3. The municipal sludges and effluents are being recycled or used as fertilizer. This implies a rate of application commensurate with crop needs

4. The land is productive agricultural land to be used for crop production for generations to come

5. Many of the noxious compounds in the wastes become immobile when added to the soil and will remain there indefinitely

6. The crop will probably absorb a part of any toxic heavy metal or noxious compound added to the soil

7. The tolerance level includes an acceptable safety factor. Therefore, the suggested levels are only one-half, or less, of the values the literature suggested as being toxic levels for animals; plant levels at which appreciable transfer of the element from the vegetative portion of the plant to the grain occurs; and the level known to be toxic to the plant itself.

In addition to plant analyses, research on metals extractable from the soil as related to plant toxicity and uptake are currently being evaluated to recommend a "toxic" range of DTPA-extractable Zn, Cu, Ni, and Cd in soil. This will be useful in monitoring the site and predicting possible problems before they occur.

TABLE F-23

RANGE IN NORMAL ELEMENTAL COMPOSITION AND SUGGESTED TOLERANCE LEVEL FOR VARIOUS ELEMENTS IN SUCCULENT VEGETATIVE TISSUE* OF AGRONOMIC CROPS, LEGUMES AND GRASSES (MELSTED, 1973).

Element	Normal Range (ug/g)	Suggested Maximum Tolerance Level (ug/g)
Cadmium	0.05 - 0.2	3.
Cobalt	0.01 - 0.3	5.
Copper	3. - 40.	150.
Manganese	15. -150.	300.
Mercury	0.001- 0.01	0.04
Nickel	0.01 - 1.0	3.
Lead	0.1 - 5.0	10.
Zinc	15. -150.	350.
Arsenic	0.01 - 0.1	2.
Boron	7. - 75.	150.
Molybdenum	0.2 - 1.0	3.
Selenium	0.05 - 2.0	3.
Vanadium	0.1 - 1.0	2.

**Values are for corn leaves at or opposite and below ear level at tassel stage; soybeans — the youngest mature leaves and petioles on the plant after first pod formation; legumes — upper stem cutting in early flower stage; cereals — the whole plants at boot stage; grasses — while plants at early hay stage. All plant samples should be washed with deionized-distilled water before drying to remove any solution or a weak acid solution before the final washing with deionized-distilled water. Samples should be dried (65° C) as quickly as possible, ground, and stored for analysis. If the undried samples cannot be processed immediately, they would be placed in polyethylene bags and stored under refrigeration. Preparation for analysis involves: 1) wet digestion. For all elements except N and B. Digest in boiling nitric-perchloric acids. Treatment with NF may be necessary for recovery of some of the heavy metals from the silica which precipitates in the digest. 2) Dry ashing. At low temperature (450 to 500° C). Dissolve ash in HCL. This is the only method to be used for B analysis. Not suitable for Hg, S, Se, As, Ag, Fe, Sb, and N. 3) Kjeldahl (H_2SO_4) digestion. For total N, P, and K.*

Source: Technical Bulletin No. 88.

TABLE F-24

PARAMETERS TO BE MEASURED AT SITES WITH POSSIBLE GROUNDWATER QUALITY PROBLEMS WHILE APPLYING SLUDGE AT RATES EXCEEDING CROP NITROGEN UPTAKE REQUIREMENTS

Hydrogeological:

1. groundwater elevations;
2. sample analyzed for permeability and porosity from drill cuttings;
3. drilling log maintained as to soil type, depth of horizons, etc.

Chemical Analysis in Soil: (As per Tech. Bull. No. 88)

Potassium (K)	Phosphorus
pH	

Chemical Analysis in Groundwater:

Copper*	Total Phosphorus
Zinc*	Ammonia nitrogen
Cadmium*	Nitrate — Nitrogen
Nickel*	Fecal Coliform
Arsenic*	Total Potassium
Mercury*	
Chromium*	
Lead*	

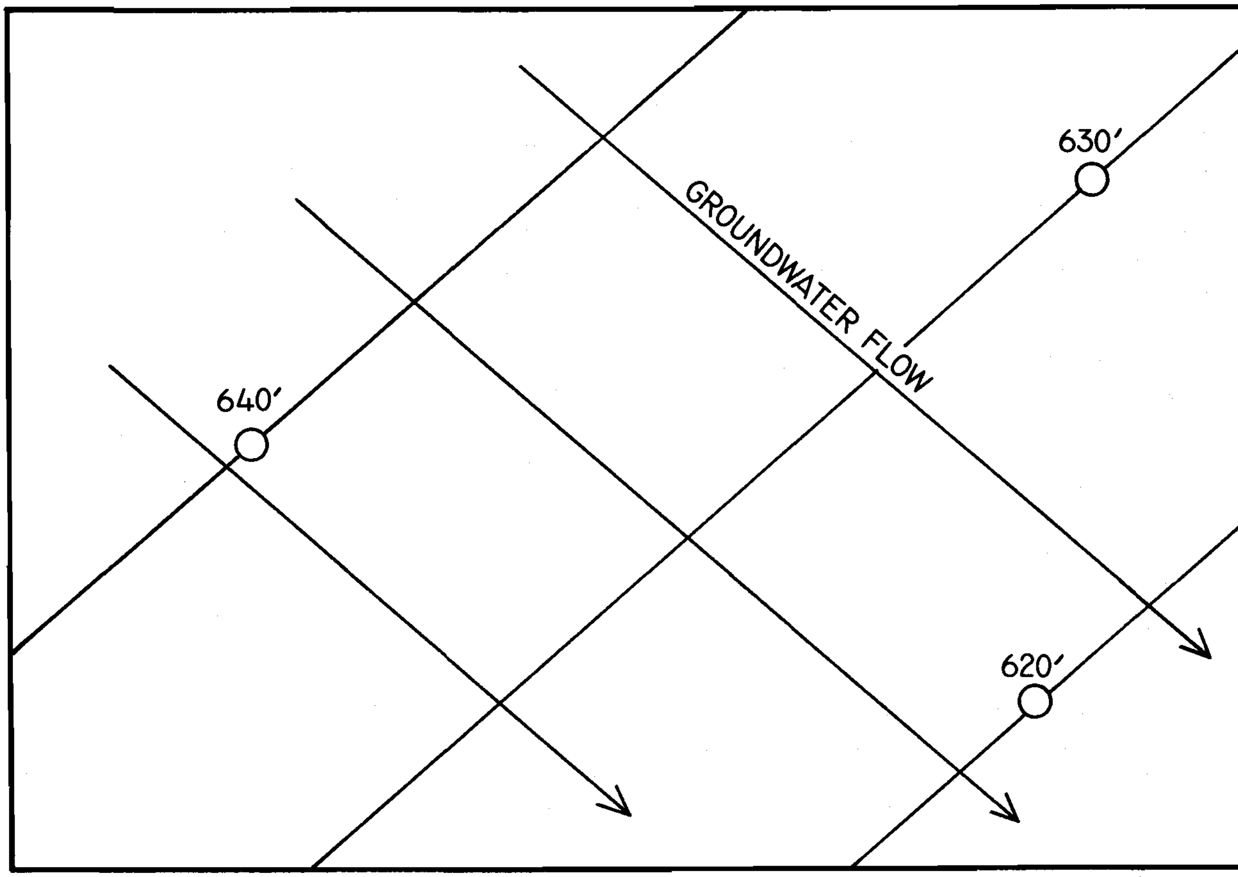
Chemical Analysis in Plant Tissue: (Not normally required)

Cadmium	Mercury
Copper	Lead
Manganese	Arsenic
Nickel	Molybdenum
Zinc	Selenium
Boron	Vanadium
Cobalt	

Source: DNR Technical Bulletin No. 88 and Camp Dresser & McKee Inc.

If the site is within one watershed, contains relatively low relief (less than 12 percent), does not have an extensively irregular shape, and will not border or is not within near proximity to surface water in the drainage pattern from the site, the following monitoring program might be applied.

FIGURE F-2
RECOMMENDED PLACEMENT OF SAMPLING WELLS AT SITE
TO BE USED FOR SLUDGE APPLICATION



Source: Camp Dresser & McKee Inc.

Three sampling wells placed 5-10 feet below the water table will be sufficient to monitor the direction of groundwater flow and will serve as sampling wells for metallic, nitrogen, and phosphorus parameters (see Figure F-2 for well placement configuration on the site parcel and Table F-24 for monitoring parameters). These wells must be backfilled with silica sand to prevent leachates from entering around the well casing. Only PVC pipe and PVC well points can be used to ensure no metallic ion addition from a metal well pipe. Each well must be surveyed in and groundwater elevations monitored to determine direction of flow. The frequency of sampling should be once every three years, based upon the criteria that the sludge is applied yearly and that the site is undergoing continuous use. The higher the sludge loading rates above an estimated fertilizer rate, the more frequent monitoring is required. During times when groundwater elevations are taken, groundwater samples (to be analyzed for chemical parameters) will be collected.

The cost of the above described monitoring program would be approximately $1,000 for the first year and $300 for each additional test year. The costs have been included in the total system costs presented in Chapter IX. These costs are minimal and would have to be scaled if sludge were applied at excessively high rates, applied to limited soils, and/or applied to maximum levels for heavy metals above the recommended limits. As a minimum, a broadened program would have to include testing of each sludge application site each year as appropriate. Also ground and surface water monitoring should be extended beyond the immediate application site to detect if any of the aforementioned pollutants had entered the associated environment.

Appendix G

DISCUSSION OF GENERAL PROCESS TRAIN OPTIONS AND SCREENING OF UNIT PROCESSES

Under the processing options, reasonable alternatives to those currently practiced generally amount to further thickening, dewatering, or digestion which results in solids or volume reduction. Volume reduction reduces handling and transport costs and is necessary prior to drying for organic fertilizer production and to some measure in incineration/pyrolysis. The objective of this systems analysis is to find the most cost-effective association of dewatering/transport options. A further consideration is that some forms of mechanical thickening/dewatering might not be reasonable at other plants employing limited operations personnel.

Under processing options possible transportation savings and those which are necessary for the utilization/disposal options were examined. Table G-1 illustrates the relationship of some basic components.

Truck haul is likely to remain the most feasible transport option (excluding the major facilities). Pipelines are very site-specific and could present such maintenance problems as clogging, wear in pumps, and freezing. However, if land application for MSD-Jones Island and MSD-South Shore takes place it will then become necessary to further compare pipelines to truck haul. A subregional or regional landspreading alternative might well allow for a better trained staff, economies-of-scale, and a larger inventory of available sites. Conversely, there is a loss of independence by the owners of individual facilities.

Analysis of regional solutions incorporated consideration of sludge loads from other plants, in Walworth, Washington, and Ozaukee counties. As noted in Chapter V, small plants in these counties represent a substantial portion of the total load. Where landspreading is to function as a primary or a backup utilization or disposal option, a reasonable backlog of land must be available.

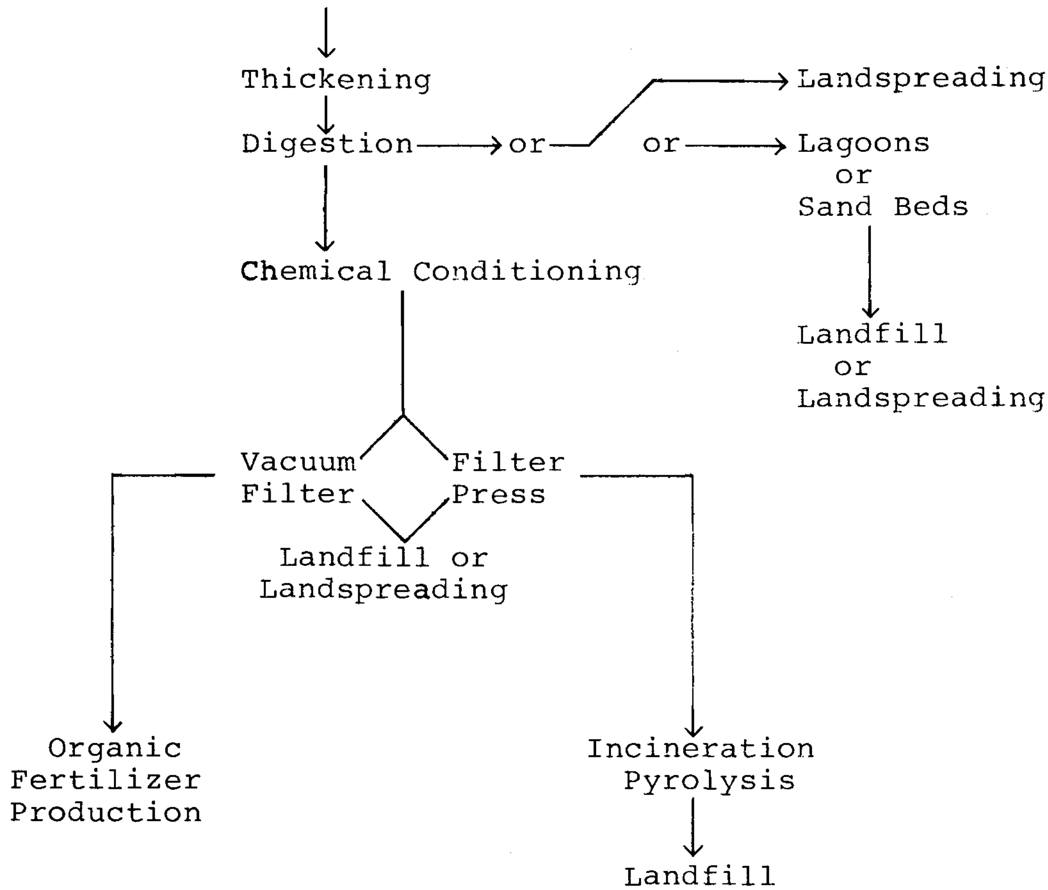
Due credit was given to all existing facilities in the economic analysis, especially as regards digestion and dewatering equipment. Land costs are very site-specific and were factored into the economic analysis. Average 1975 parcel prices in the particular county were used as a basis for such costing. As stated in Chapter VIII, the "washout" principle applies to the present worth analysis and inflationary trends are thus factored out. The planning period is a minimum of 20 years, according to Federal Guidelines, and the planning horizon in this study is year 2000. In general, with this study complete in 1977, plans and specification for new facilities could be completed by 1978-1981 and construction could be completed by 1979 to 1983.

Landspreading is currently the favored approach to utilization/disposal at most plants. Where heavy metals, other toxics, or site limitations preclude spreading, landfilling is the option most often used. The subregional systems involving small plants consider that several small plants purchase and operate a truck or combine site monitoring efforts.

Where a rapid increase in population and sludge production was predicted for a plant service area, staged facilities as per Federal Guidelines were considered. This avoids unnecessary expense given that actual increases are lower than predicted.

In case of operational discontinuity of plant components, it was necessary to provide for backup facilities. These can be in two forms; either parallel units or another more simplistic form of disposal (or storage). Parallel units are useful where complex mechanical equipment might require routine maintenance for periods, while the availability of a more simplistic form of disposal is perhaps advisable when it might be less costly than the additional complex units. Maintenance of standby units should not impose a substantial cost burden.

TABLE G-1
PROCESS TRAINS



It is pertinent to briefly address some of the major plants and issues before delving into the process trains that might afford solutions.

The first issue is energy. In order to dewater or to dry sludge, heat or pressure must be applied, either to pump out, squeeze out, or to evaporate the water from the sludge to make a material of such consistency as will be most economical to transport. Dewatering may be accomplished with sand beds, lagoons, vacuum filters, and filter presses. Drying may be accomplished in rotary dryers. The second issue is product character. This is mainly the handleability factor, either as it relates to transport or to spreading. The problem of long-term acceptability of process and product, intermittent handling and disposal methods, alteration, maintenance, ease of operation, and salvageability must be addressed.

Existing process equipment, site location, and state-of-the-art information often suggests a direction be taken for a given plant or group of plants. A final solution for Jones Island might recommend a continuation of Milorganite production. Other possibilities are incineration/pyrolysis on-site or at a new site or landspreading.

Continued Milorganite production suggests the refurbishing of old units with more efficient dewatering. Incineration/pyrolysis could be phased-in as the Milorganite process is wound-down. Land adjacent to the plant in the old tank farm might be used. Landspreading might be possible with transportation over the interstate system to rural sites or possibly via rail haul to rural sites; digestion and dewatering would be the considered processes under this mode of utilization.

Either continued Milorganite production or incineration/pyrolysis suggests that some backup land-spreading area might be desirable. Pyrolysis residue could go to one of several existing landfill sites or possibly to a new site designed for this purpose.

An immediate need at South Shore is to reduce the volume of sludge by thickening and dewatering and thereby reduce handling and transportation to utilization/disposal sites. Gravity thickening for the primary sludge and vacuum filters (or filter presses) after the digesters (with chemical conditioning) might be appropriate. New mechanical equipment should complement a final solution. Composting may be feasible.

If the disposal option should be incineration/pyrolysis, then preparatory digestion is not desired. However, the existing digestion units could serve as standby storage facilities to backup the other processing units. Other solutions could incorporate interim modifications as suggested above or some sort of organic fertilizer production. Because of the large volume, landfilling at a large, controlled site might also be a reasonable alternative.

Racine has a new vacuum filter to backup the two older filters and these should be adequate throughout the planning period. The question is what to do with the digested-dewatered sludge: incineration/pyrolysis, landfilling, or landspreading? Incineration/pyrolysis might be viable only if local landfills are for some reason unavailable and landspreading is ruled out. A subregional site near Racine could be located south of the existing site.

The filter press operation at Kenosha will be expanded as necessary to accommodate the future increased sludge load. Landspreading might be a future approach, but pyrolysis or landfilling are alternatives. A subregional site near Kenosha could be located south of the existing site.

While the plant for Waukesha, proposed by the consultant, will certainly be adequate for some time, further consideration of more sophisticated dewatering methods was appropriate. This is especially important in assessing a subregional utilization/disposal option (where transportation costs become important). Public pickup seems to be sufficient and might well continue to be so.

In addition to the facilities for West Bend (proposed by the City's consultant) it might be possible to effect economies by further dewatering prior to landfilling or landspreading. In general, possible use of pyrolysis for a Washington-Ozaukee county regional facility was considered.

Dewatering improvements comparable to those proposed by others were considered for South Milwaukee as was inclusion in a subregional grouping.

Dewatering improvements for Whitewater were considered as were transport to a common site in a subregional alternative.

The alternatives for other plants generally involved more dewatering versus transport costs to landspreading or landfilling sites. Regional spreading facilties or haul to regional processing facilities were given general consideration.

SLUDGE THICKENING

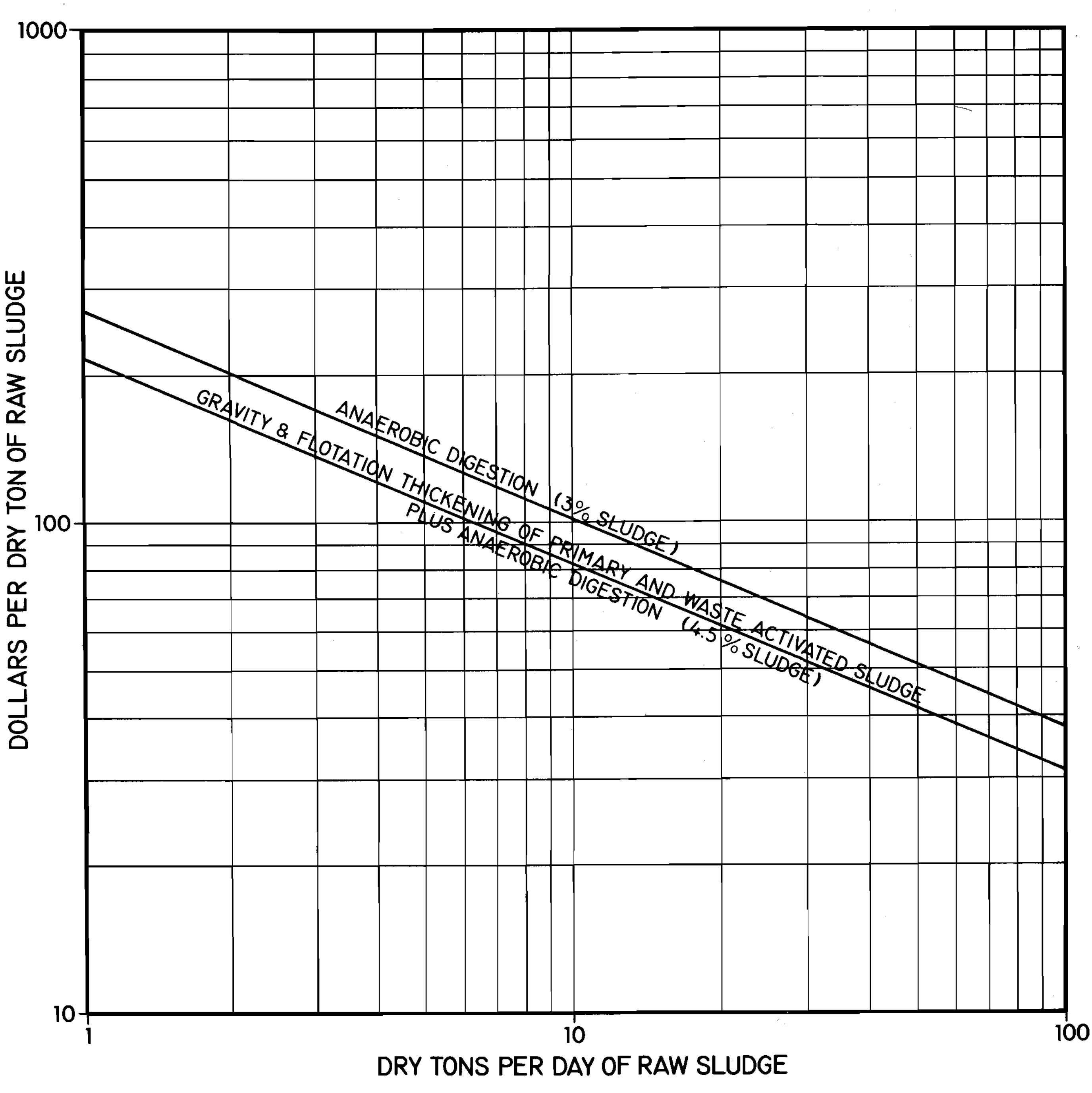
Figure G-1 demonstrates the feasibility of sludge thickening. The higher curve represents the cost of anaerobic digestion without utilizing sludge thickening. The lower curve represents the combined cost of sludge thickening and anaerobic digestion. Further economies would result due to increased efficiency in dewatering and transportation. Therefore, it was concluded that all plants should utilize sludge thickening.

Digestion

Figure G-2 represents a comparision of anaerobic and aerobic digestion total costs, and indicates the

FIGURE G-1

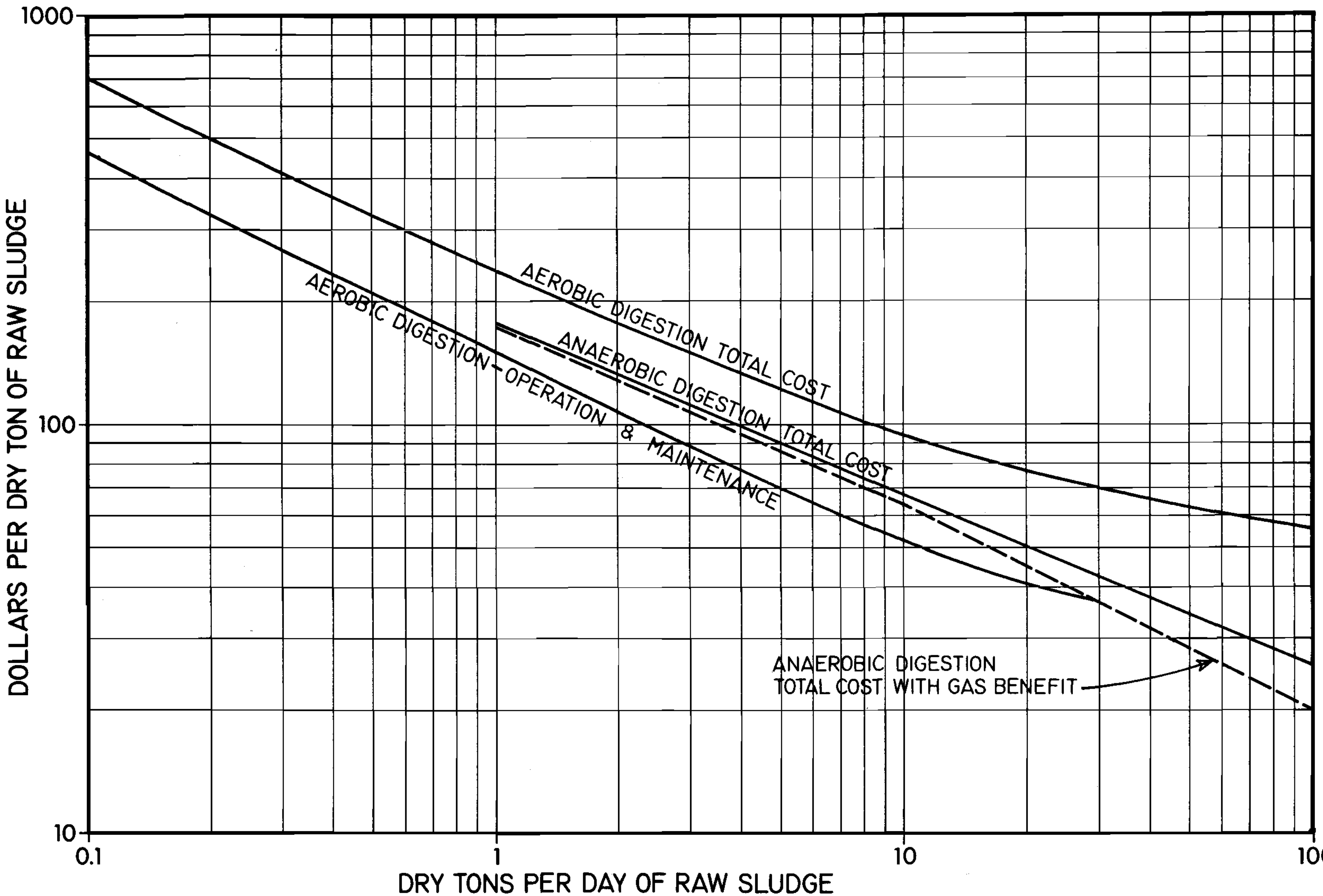
COSTS OF THICKENING



Source: Camp Dresser & McKee Inc.

FIGURE G-2

WASTEWATER SLUDGE DIGESTION COSTS



Source: Camp Dresser & McKee Inc.

cost savings of anaerobic digestion. The operation and maintenance cost for aerobic digestion is also represented and is lower than the total cost of anaerobic digestion up to sludge loadings of about 30 tons per day. Therefore, it would not be economical to replace existing aerobic digesters with new anaerobic digesters up to this loading.

ALTERNATIVE 1

General Cost Curves

Figure G-3 shows the relative composite costs of dewatering, truck hauling, and landspreading of digested sludge for various dewatering options. Costs of hauling and landspreading of liquid digested sludge are also indicated for comparison. For preliminary screening purposes, it was established that sludge cake would be stored by the treatment plant but spread by the farmers. These costs are given in terms of hauling distances at 5-, 10-, and 25-mile intervals. Costs are based on operation and maintenance plus amortized cost of capital expenditures.

The curves indicate that utilization of drying lagoons would result in the lowest overall costs. Other dewatering options are, ranked in the order of increasing costs, vacuum filter, filter press, and sand beds. The high costs of sand beds are due primarily to the required low allowable sludge loading rates of sludges resulting from phosphorus precipitation. Hauling of liquid digested sludge to landspreading sites becomes competitive with hauling of cake sludge following processing by new vacuum filters up to a digested sludge quantity of about 55 tons per day at a 5-mile hauling distance. However, dewatering by vacuum filtration has the advantage of allowing for greater ease of diverting the sludge to landfill sites when landspreading of liquid sludge cannot be continued. The figure also shows the costs of some dewatering/utilization options exclusive of the capital cost of dewatering equipment; i.e., they show only operation and maintenance costs. The purpose of these curves is to allow an investigation of bypassing existing dewatering equipment in a plant and utilization of liquid sludge. For example, the operation and maintenance costs for a vacuum filter is less than disposal of liquid sludge (3 to 5 percent) and therefore, existing vacuum filters should not be bypassed, rather they should be fully utilized.

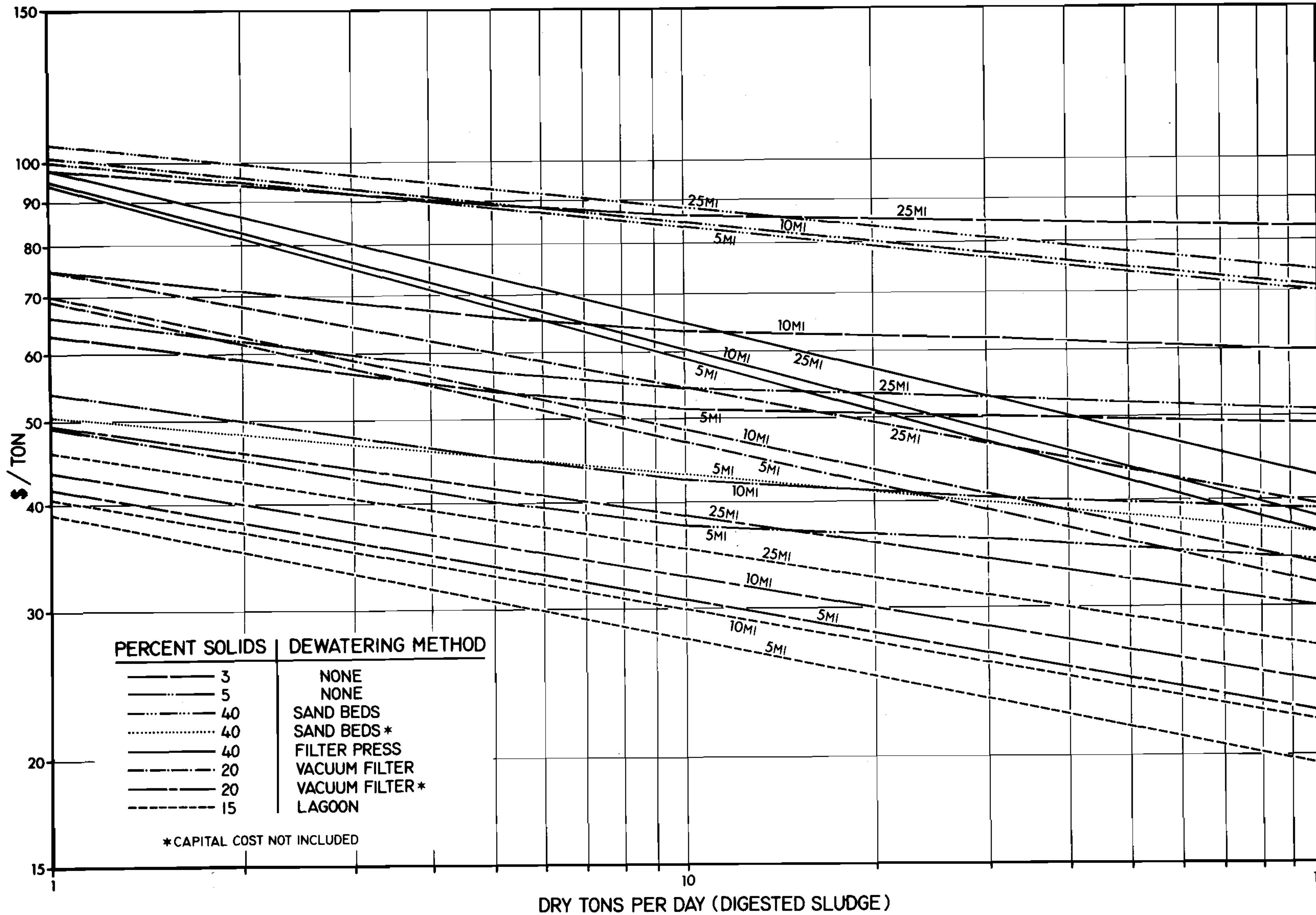
The cost of dewatering/disposal process trains terminating with landfill rather than landspreading can be obtained by adding a cost of \$37.5/ton of digested sludge for lagoon dried sludge, \$28.1/ton of digested sludge for vacuum filter cake, and \$12.5/ton of digested sludge for filter press cake to the values given in Figure G-3.

Figure G-4 gives total cost of filter pressing and pyrolysis of digested and raw sludges. Figure G-5 gives total cost of ash disposal to landfill in terms of hauling distances. These two curves were utilized to develop total cost of process trains, including the pyrolysis option.

Chapters III and V should be referred to for estimated and projected sludge quantities and capacity of existing facilities. The comparative costs for Alternative no. 1 are based on year 2000 sludge quantities only. The relative cost of the various options would not change appreciably within the range of sludge quantities generated by each plant between the present day and year 2000.

A further consideration is the composting of dewatered sludge for stabilization and solids reduction prior to land application as a soils conditioner. Composting offers no economic advantage for plants with close land suitable for spreading of cake or liquid sludge. In addition, nutrient value of the sludge is reduced during the composting process. However, where sludge must be hauled long distances to suitable application sites, composting and public pickup may be an attractive alternative for a metropolitan area. Marketing studies are required as the operation is very site-specific.

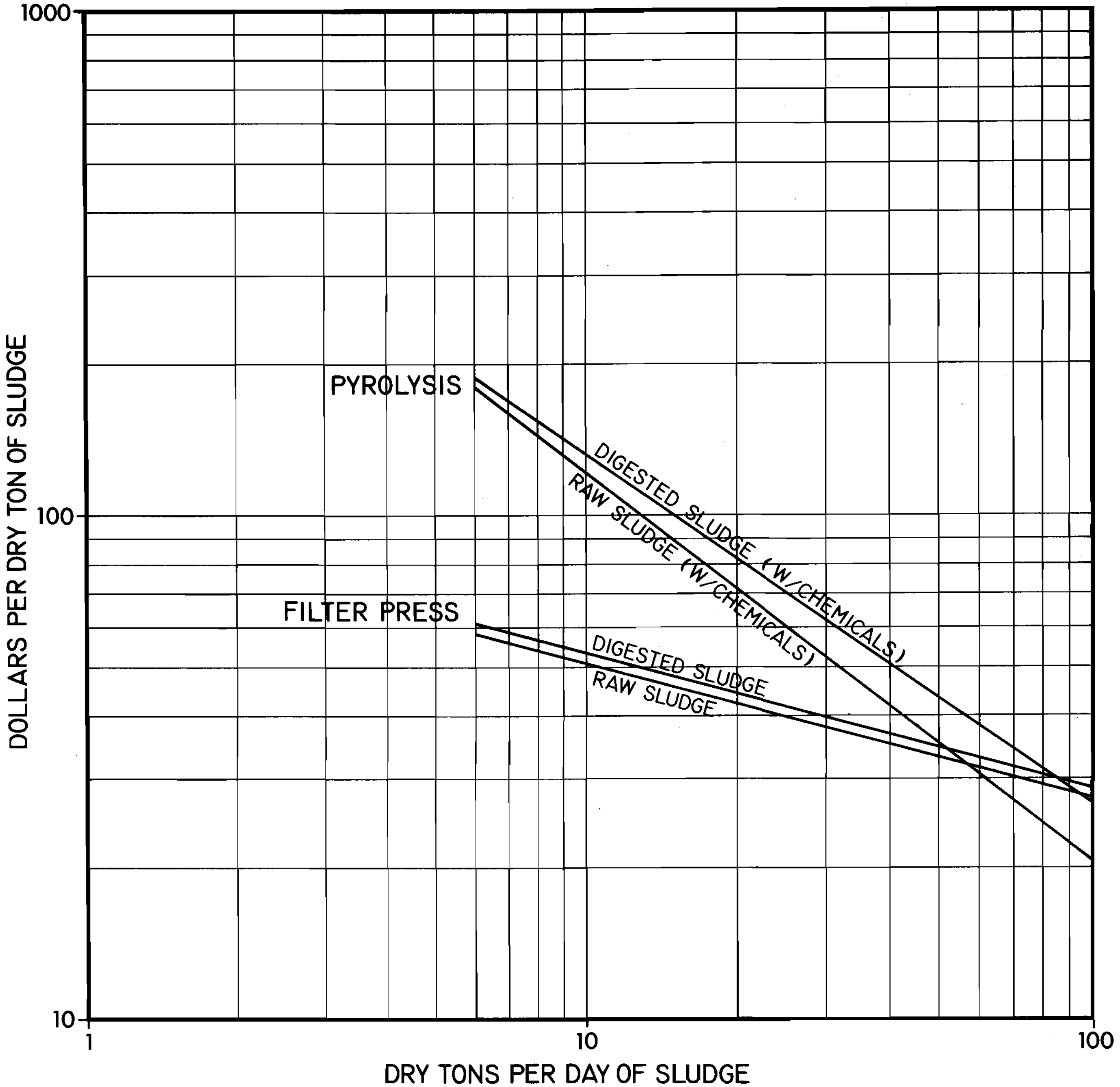
FIGURE G-3
TOTAL COST OF DEWATERING, TRUCK HAULING AND LANDSPREADING PROCESS TRAINS



Source: Camp Dresser & McKee Inc.

FIGURE G-4

TOTAL COST OF
FILTER PRESS AND PYROLYSIS



Source: Camp Dresser & McKee Inc.

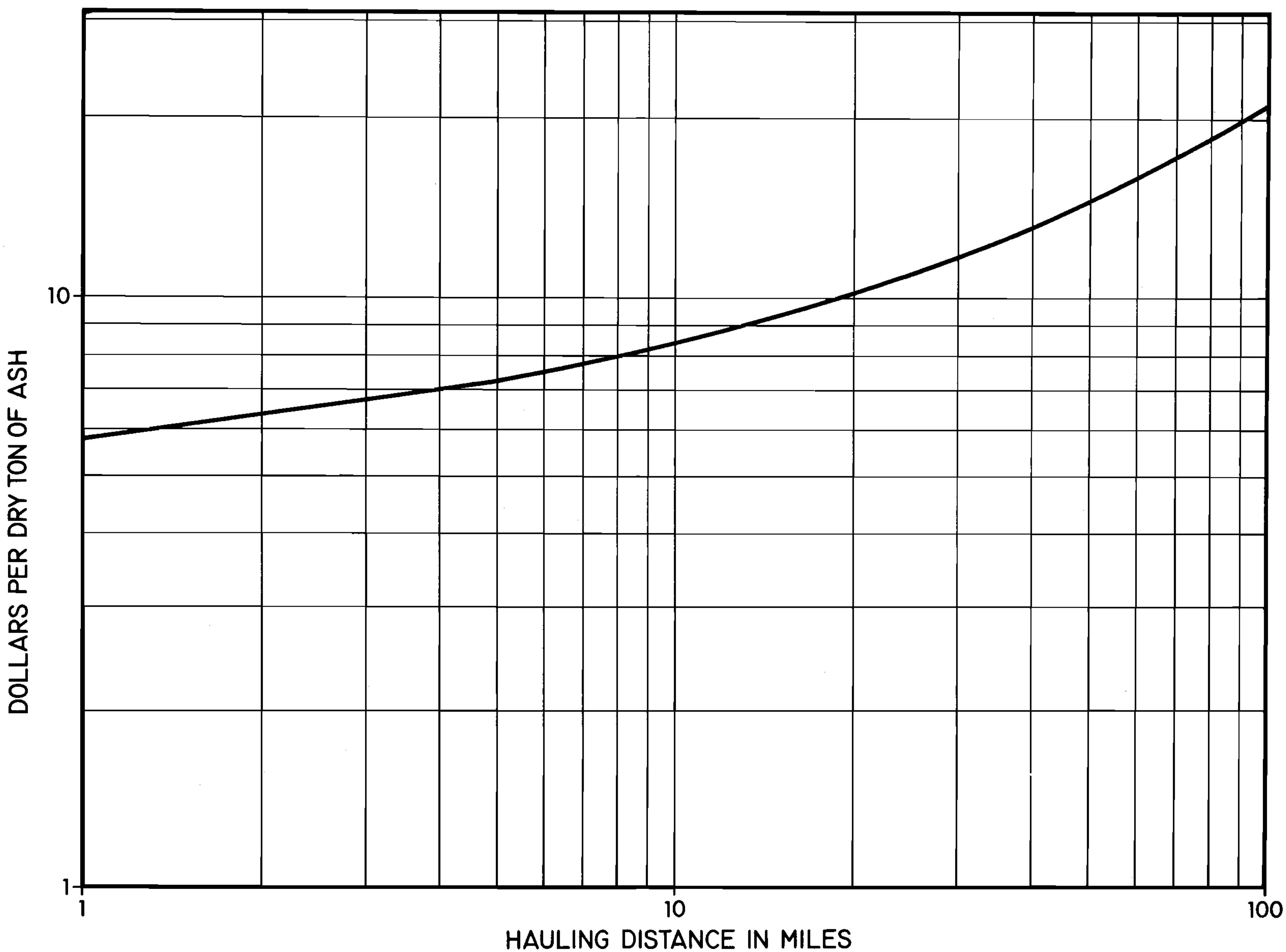


FIGURE G-5
TOTAL COST OF
ASH HANDLING AND SANITARY LANDFILLING

Source: Camp Dresser & McKee Inc.

Appendix H

SLUDGE TRANSPORTATION

As there is available land for application of sludge outside of the study area, it has been suggested that sludge be rail hauled, trucked, or barged to remote locations. While there is no technical reason why this cannot be accomplished, there are significant increases in costs which must be examined on consideration of such a scheme. Values presented in the above analyses were for haul distances largely confined within the seven-county study area. Costs of hauling sludge at several distances are shown in Table H-1.

These costs were developed from cost curves of the state-of-the-art studies and other sources. For long hauls (beyond 50 miles), it is expected that barging and rail haul would be less expensive than trucking. As stated in Chapter VIII, barging requires proper docking facilities which might not be available where desired; substantial costs could be associated with the construction of these facilities.

Costs of pipeline transportation of 5 percent sludge were developed and compared with truck hauling costs of liquid and dewatered sludge.

It was assumed that a single force main with cement lined cast-iron pipe will be utilized to provide low friction losses. The minimum allowed diameter was assumed to be 4 in.; assumed velocities were a minimum of 3 fps and a maximum of 5 fps. The sludge pump station costs were based on use of open impeller-type pumps. Pumps were used in series when it was necessary to develop high total dynamic heads. Booster pumping stations were assumed to be located at such intervals that the maximum operating pressure would not exceed 350 psi. Figure H-1 shows a comparison of pipeline transport and truck hauling costs of 5 percent sludge.

The figure indicates that pipeline transportation costs ($/ton of digested sludge) increase rapidly with increase in transportation distances and tend to decrease at higher sludge loadings. In any case, costs of transportation by pipeline generally are significantly higher than truck hauling of liquid sludge. Pipeline transport begins to be competitive with truck hauling of 5 percent sludge at 35 tpd, but at less than a 4-mile haul distance.

Relatively high costs at low sludge quantities are due to under utilization of the minimum 4-in. force main size, as a few hours of operation is sufficient to transport the daily sludge quantity. Therefore, high capital expenditure for a relatively small amount of sludge would be required. Comparison of costs of pipeline transport versus dewatered sludge truck hauling can be made when dewatering costs and ultimate disposal costs are included in the comparison. Such a comparison was carried out. It was determined that overall costs of hauling and landspreading of lagoon dried sludge was far more economical than pipeline transport and landspreading of liquid sludge within a wide range of sludge quantities.

Pipeline transport and landspreading of liquid sludge begins to be competitive with hauling and landspreading of vacuum filter dried sludge at about a 5-mile hauling distance, but at sludge quantities of 20 tons per day or more.

In the analysis, pipeline transport of liquid sludge was not generally considered because the highest quantities of digested sludge projected for plants (other than Jones Island and South Shore) is about 30 tons per day (at the Racine plant).

TABLE H-1

GENERAL ESTIMATED INCREMENTAL TRANSPORTATION COSTS FOR SLUDGE TRUCKING

Haul Distance Miles	Cost, Dollars/Dry Ton 5 Percent Solids	20 Percent Solids	40 Percent Solids
20	$22.00	$ 8.00	$ 6.40
40	35.00	13.50	10.00
80	56.00	24.00	17.00
100	67.00	29.00	20.00

FOR SLUDGE BARGING

Haul Distance Miles	Cost, Dollars/Dry Ton 5 Percent Solids
20	$18.00
40	26.00
80	45.00
100	55.00

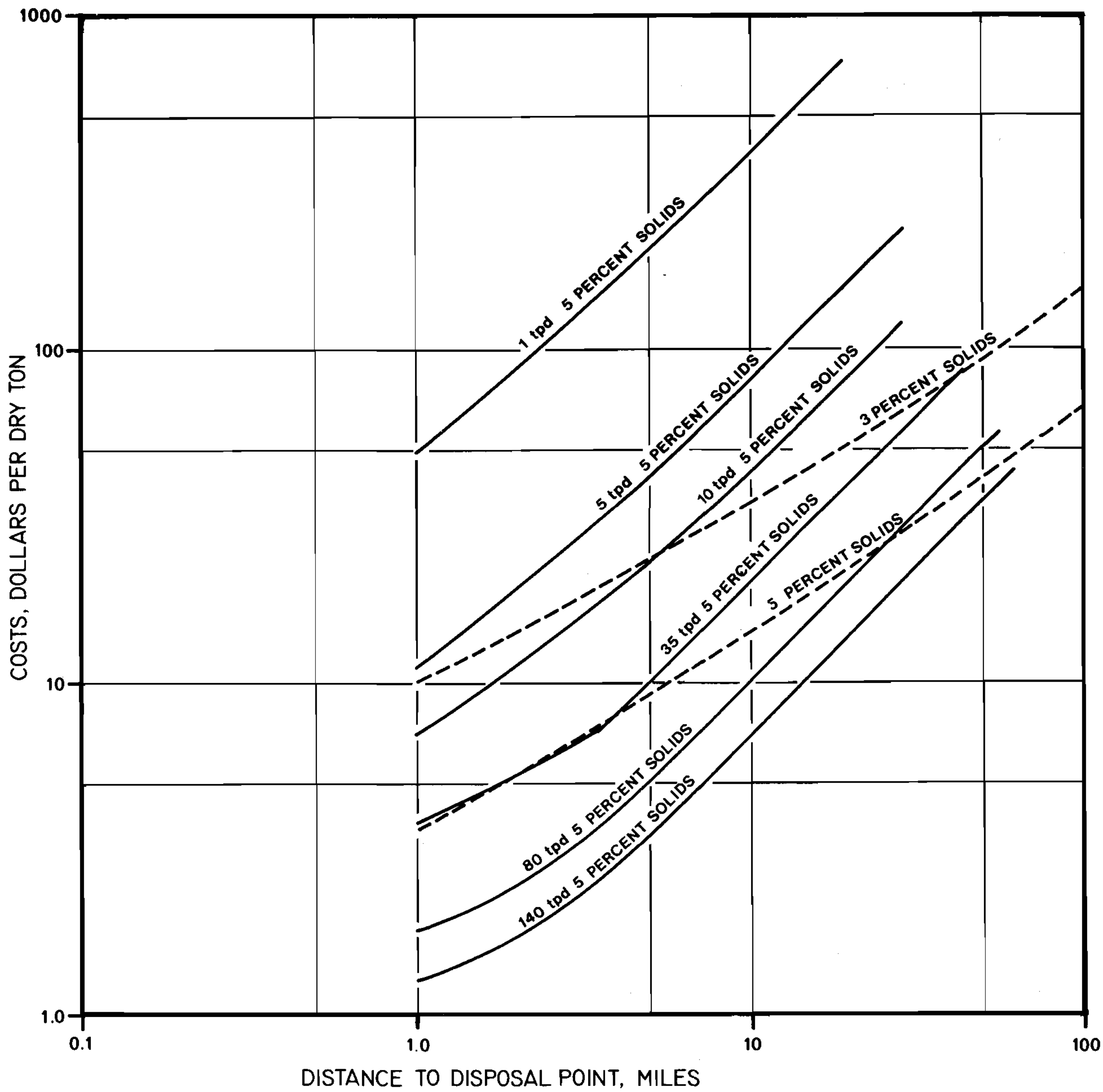
FOR RAIL HAULING

Haul Distance Miles	Cost, Dollars/Dry Ton 35 Percent Solids
20	$30.00
40	33.00
80	40.00
100	43.00

ENR 2445

Source: Camp Dresser & McKee Inc.

FIGURE H-1
ESTIMATED SLUDGE[1] HAULING
TOTAL COSTS



________ Pipeline

---------- Truck

[1]Tons per day (tpd) digested sludge

Source: Pipeline Cost - Camp Dresser & McKee Inc.
Trucking Cost - State-of-the-Art Studies

Appendix I

INDUSTRIAL COMPONENT OF HEAVY METALS AT THE MSD-JONES ISLAND AND MSD-SOUTH SHORE WASTEWATER TREATMENT PLANTS

Chapter V presents a comprehensive discussion of heavy metals in sludges, the general effects of these metals, and the limiting of some concentrations of these metals in sludges for various utilization or disposal alternatives.

The following section is devoted specifically to heavy metals at the MSD-Jones Island and MSD-South Shore wastewater treatment plants, the sources of these metals, and possible levels of control. While the discussion will concentrate on cadmium and zinc, because these constituents are most important in terms of continued Milorganite production and distribution, other heavy metals whose levels are significant will also be considered.

It is reasonable to address Jones Island and South Shore in detail because greater than 80 percent of the total municipal sludge in the study area is generated at these facilities. These metals quantities represent greater than 80 percent of the metals in the total municipal plant load in the study area.

Heavy metals discharged to the wastewater treatment plants arrive in domestic, industrial, and combined wastewater flows. The largest contribution of heavy metals to the wastewater treatment plants is the industrial component. According to data collected in 1976 by the State of Wisconsin's NR 101 Program, of a total of 207 industries (or industrial-type discharges such as laundries and hospitals) classified under this program, 122 contained at least one heavy metal in their wastewater discharges to the MSD wastewater treatment plants. While the NR 101 Program does not cover every single industrial discharge, it was the most comprehensive listing available. Table I-1 is a tabulation of the heavy metals discharges by type of industry. Tables I-3 through I-8 are tabulations of data by size of discharge per heavy metal. The NR 101 program data shown in the tables represent average values of pounds per day discharged, where this value was available. The maximum values were utilized where average values were not given. Thus, the values may generally be considered to be on the high side. These tabulations illustrate a wide array of industrial discharges of heavy metals with the metals load in lb/day indicated.

The MSD has conducted its own laboratory tests for some various industries believed to be discharging cadmium to the Jones Island Wastewater Treatment Plant. Using the data from these tests, and combining it with the NR 101 data described above, an approximate daily range of 30 to 47 lb of cadmium discharged by industry into the MSD sewerage system was developed. The range in individual values was substantial when compared to the NR 101 values.

DOMESTIC FLOW

Some test data exists to allow approximate quantification of the heavy metals components of the nonindustrial portion of flow to the Jones Island and the South Shore plants. Other urbanized areas have studied this problem and some of the results of these studies for New York, Pittsburgh, and Muncie are presented in Table I-9.

These values are from urbanized industrial cities with combined wastewater systems. Of note is the high percentages from residential flows for the metals under consideration.

The characteristics of the MSD system are probably similar to those of New York and Pittsburgh. Table I-10 illustrates values of residential "background" levels for heavy metals in the influents to the District's two wastewater treatment plants, assuming the average tabulated per capita values and an MSD population of about 1,074,000.

A single test by the MSD for cadmium indicated that the domestic contribution was 0.018 mg/l. This

TABLE I-1
HEAVY METALS DISCHARGED BY INDUSTRY TO MSD SYSTEM
(As Listed by DNR In NR101 Program)

SIC Code	Type of Industry	No. of Industries Listed By NR101	Cd No. of Industries Discharging	Cd lb/day	Cu No.	Cu lb/day	Ni No.	Ni lb/day	Zn No.	Zn lb/day	Cr No.	Cr lb/day	Pb No.	Pb lb/day	Phenols No.	Phenols lb/day	Other
20	Food & kindred products	29	1	5.5	5	38.7	-	-	11	116.7	2	25.8	3	4.5	3	8.4	Boron:3 @ 38.2 lb/day Mn:1 @ 2.2 lb/day An:1 @ 0.7 lb/day
22	Textiles	1	-	-	-	-	-	-	1	0.5	-	-	-	-	1	0.1	Boron:@ 1.2 lb/day Barium:@ 8.7 lb/day
24	Wood & wood products	1	-	-	-	-	1	0.3	1	0.1	-	-	1	0.1	1	0.8	-
25	Wood furniture	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Paper	12	2	0.2	5	11.1	2	5.1	6	44.1	8	21.5	8	68.5	1	1.9	Boron:5 @ 8.1 lb/day Barium:1 @ 0.4 lb/day PCB:1 @ 0.1 lb/day Cn:1 @ 0.5 lb/day
27	Printing & publish	4	-	-	2	0.5	1	0.2	2	10.6	3	3.0	-	-	-	-	Boron:2 @ 2.2 lb/day
28	Chemicals	9	-	-	2	6.6	1	0.2	6	101.4	4	1,200.0	1	51.0	4	59.1	Boron:2 @ 8.6 lb/day Mn:2 @ 9.4 lb/day Selenium:1 @ 2.0 lb/day Cobalt:1 @ 5.5 lb/day
29	Petroleum	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Leather	16	1	0.8	2	3.9	1	0.3	7	21.6	16	2,516.0	1	2.0	-	-	Mn:2 @ 9.3 lb/day
32	Glass, stone, & ceramic	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	Primary metals product	19	1	0.2	2	0.6	-	-	5	23.0	1	0.1	2	15.9	2	731.1	Mn:2 @ 1.0 lb/day
34	Fabricated metals	29	7	45.8	15	21.2	13	110.0	22	274.9	19	168.0	5	275.5	-	-	Born:3 @ 5.8 lb/day Mn:8 @5.8 lb/day Cyanide:2 @ 108.8 lb/day
35	Non-elec. machinery	20	1	16.8	8	10.9	5	17.4	9	25.2	6	46.9	3	1.8	3	0.9	Mn:3 @ 4.2 lb/day Boron:4 @ 4.9 lb/day
36	Elec. machinery	18	6	15.6	9	67.0	10	21.6	10	48.2	8	32.5	7	8.3	4	3.6	Boron:4 @ 13.9 lb/day Mn:1 @ 0.5 lb/day Cyanide:3 @ 3.3 lb/day
37	Transportation equip.	8	-	-	2	1.9	2	5.0	3	68.3	2	0.9	2	0.8	1	0.6	Mn:1 @ 9.6 lb/day Boron:1 @ 34.6 lb/day Arsenic:1 @ 0.2 lb/day
38	Meas. instruments	7	1	0.3	5	28.0	3	0.3	5	11.2	4	54.4	2	0.9	1	0.4	Boron:3 @ 29.8 lb/day
39	Miscellaneous mfg.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72 75 80	Laundries Hospitals & Carwashes	21	-	-	1	0.9	1	0.4	9	3.5	1	1.5	2	0.2	-	-	Barium:2 @ 8.9 lb/day
		201	20	85.2	58	191.3	40	160.8	97	749.3	74	4,070.6	37	429.5	21	806.9	

Source: Camp Dresser & McKee Inc.

TABLE I-2

SUMMARY OF NR 101 TABULATIONS OF HEAVY METALS DISCHARGED TO THE MSD SYSTEM

Metal	lb/day
Cadmium	85
Copper	191
Nickel	161
Zinc	749
Chromium	4,071
Lead	430
Mercury	—

Source: Camp Dresser & McKee Inc.

TABLE I-3

PLANTS DISCHARGING CADMIUM

			Cumulative		
Range of Cadmium Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	No. of Plants	lb/Day Discharged	Percent of Total Discharged In lb/Day
0					
	16	1.1			
.5			16	1.1	1.3
	3	2.4			
1			19	3.5	4.1
	1	1.1			
2			20	4.6	5.4
	2	4.8			
3			22	9.4	11.0
	—	—			
4			22	9.4	11.0
	—	—			
5			22	9.4	11.0
	1	5.5			
10			23	14.9	17.5
	2	28.5			
20			25	43.4	50.9
	1	41.8			
50			26	85.2	100
	—	—			
100					
Total	26	85.2			

Source: Camp Dresser & McKee Inc.

TABLE I-4

PLANTS DISCHARGING COPPER

			Cumulative		
Range of Copper Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	No. of Plants	lb/Day Discharged	Percent of Total Discharged In lb/Day
0					
	30	7.1			
.5			30	7.1	3.1
	5	3.0			
1			35	10.1	5.3
	4	5.9			
2			44	28.9	15.10
	5	12.9			
3			44	28.9	15.10
	—	—			
4			46	38.2	20.0
	2	9.3			
5			52	79.4	41.5
	6	41.2			
10			56	137.7	72.0
	4	58.3			
20			58	191.3	100
	2	53.6			
50					
	—	—			
Total	58	191.3			

Source: Camp Dresser & McKee Inc.

TABLE I-5
PLANTS DISCHARGING NICKEL

			Cumulative		
Range of Nickel Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	No. of Plants	lb/Day Discharged	Percent of Total Discharged In lb/Day
0					
	21	4.7			
.5			21	4.7	2.9
	1	0.8			
1			22	5.5	3.4
	4	5.8			
2			26	11.3	7.0
	1	2.4			
3			27	13.7	8.5
	3	6.3			
4			30	20.0	12.4
	4	18.8			
5			34	38.8	24.1
	2	14.3			
10			36	53.1	33
	3	37.1			
20			39	90.2	56.1
	—	—			
50			40	160.8	100
	1	70.6			
100					
Total	40	160.8			

Source: Camp Dresser & McKee Inc.

TABLE I-6
PLANTS DISCHARGING ZINC

Range of Zinc Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	Cumulative No. of Plants	Cumulative lb/Day Discharged	Cumulative Percent of Total Discharged In lb/Day
0					
	44	11.1			
.5			44	11.1	1.5
	11	7.8			
1			55	18.9	2.5
	8	12.8			
2			63	31.7	4.2
	6	14.8			
3			69	46.5	6.2
	2	6.6			
4			71	53.1	7.1
	5	20.8			
5			76	73.9	9.9
	3	17.9			
10			79	91.8	12.3
	8	124.7			
20			87	216.5	28.9
	5	137.3			
50			92	353.8	47.2
	4	277.1			
100			96	630.9	84.2
	1	118.4			
150			97	749.3	100
Total	97	749.3			

Source: Camp Dresser & McKee Inc.

TABLE I-7

PLANTS DISCHARGING CHROMIUM

			Cumulative		
Range of Chromium Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	No. of Plants	lb/Day Discharged	Percent of Total Discharged In lb/Day
0			17	3.8	0.001
	17	3.8			
.5			22	7.4	0.002
	5	3.6			
1			34	24.8	0.06
	12	17.4			
2			39	37.2	0.09
	5	12.4			
3			42	46.9	1.1
	3	9.7			
4			44	55.7	1.4
	2	8.8			
5			51	98.2	2.4
	7	42.5			
10			58	207.9	5.1
	7	109.7			
20			64	384.8	9.5
	6	176.9			
50			68	630.6	15.5
	4	245.8			
100			71	1,028.6	25.3
	3	398			
150			74	4,070.6	100
	3	3,042			
>150					
Total	75	4,070.6			

Source: Camp Dresser & McKee Inc.

TABLE I-8

PLANTS DISCHARGING LEAD

Range of Lead Discharged In lb/Day	No. of Plants	lb/Day Discharged In Range	Cumulative No. of Plants	Cumulative lb/Day Discharged	Cumulative Percent of Total Discharged In lb/Day
0			20	3.6	0.8
	20	3.6			
.5			23	5.8	1.4
	3	2.2			
1			26	9.7	2.3
	3	3.9			
2			28	13.7	3.2
	2	4.0			
3			29	17.5	4.1
	1	3.8			
4			29	17.5	4.1
	—	—			
5			31	30.3	7.1
	2	12.8			
10			34	77.3	18.0
	3	47			
20			35	103.6	24.1
	1	26.3			
50			36	154.6	36.0
	1	51			
100			36	154.6	36.0
	—	—			
150			37	429.5	100
	1	274.9			
>150					
Total	37	429.5			

Source: Camp Dresser & McKee Inc.

TABLE I-9

RESIDENTIAL CONTRICUTION OF HEAVY METALS IN SEWAGE FROM URBAN AREAS

	METAL																	
	Cd			Cr			Cu			Pb			Ni			Zn		
Urban Area	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
New York, NY ...	38	0.019	0.016	27	0.09	0.08	38	0.21	0.18	NA	—	—	34	0.09	0.08	16	0.25	0.21
Pittsburgh, PA ..	63	0.013	0.011	23	0.022	0.018	96	0.12	0.10	63	0.075	0.062	19	0.014	0.012	32	0.20	0.167
Muncie, IN	NA	0.007	0.006	3	0.008	0.007	36	0.12	0.10	10	0.12	0.10	13	0.024	0.020	27	0.25	0.21

1 — % of total contributed to plant from Residential Flows.
2 — mg/kg value.
3 — # day/1,000 persons.
NA — Value not available.

Source: J. A. Davis III, J. Jackson, "Heavy Metals in Wastewater In Three Urban Areas," Jour. Water Poll. Control Fed., 47:2292, 1975.

TABLE I-10

RESIDENTIAL HEAVY METAL CONTRIBUTIONS TO
WASTEWATER TREATMENT PLANTS

Typical Condition	Cu	Cr	Ni	Zn	Cd	Pb
Using Pittsburgh	12	19	107	67	13	179
Using Average of Pittsburgh and N.Y.	15	54	150	67	49	203
Using Average of three Urban Areas	12	58	137	87	31	211

Source: Camp Dresser & McKee Inc.

test was conducted in an area that was strictly residential. Applying this concentration to the system for the influent exclusive of industrial process discharge, 1976 average for industrial process water was approximately 30.7 mgd at Jones Island and 11.7 mgd for South Shore, according to preliminary data from the MSD's current UC/ICR study. The contribution to the Jones Island plant influent was about 17 lb/day with about 8 lb/day to South Shore. This results in a total of 25 lb/day and a per 1,000 population contribution of 0.023 lb.

This value per 1,000 population is somewhat higher than shown in Table I-9 for the three similar urban areas. However, the value may be high due to the application of concentration given by a single test to all wastes, excluding only nonindustrial process discharges. Application to flow from only the residential population could drop the value from 50 to 60 percent of the totals shown for the system. Thus, a very approximate total for the MSD system for only the residential contribution of cadmium would be about 15 lb/day with about 10 lb currently going to Jones Island. (The range could be considered 15 to 25 lb/day.)

COMBINED WASTEWATER FLOWS

Heavy metals will be found in runoff from urban areas. The EPA has conducted and sponsored a wide-ranging program over the last 10 years in part, to determine the characteristics of pollutants added to waterways by combined wastewater and stormwater flows.

The significance of the pollutants in combined wastewater is in the incremental values added to these normally found in the average dry weather flows. The impact of these pollutants will be felt mainly at the Jones Island facility, because the entire combined system can be made tributary to this plant.

Any combined flows not diverted and allowed through the Jones Island facility for treatment above the dry-weather flow totals will carry incremental pollutants, because of the runoff to the combined system. Significant amounts of metals could be included in these combined flows. Table I-11 illustrates some typical average values of heavy metals in runoff of midwestern cities. The amount of material per million gallons is also shown.

The impact on plant effluent and sludge of the values in lb per million gallons shown are significant, if the nature of the operation of the Jones Island facility is considered. In 1976 this plant treated an average daily flow of approximately 141 mgd. The hydraulic capacity is approximately 200 mgd. Diversion of flows at the plant and overflows in the system begin to occur when rainfall is greater than 0.1 inches. This is estimated to have occurred in about 50 instances in 1976. In the future, the Jones Island plant might treat as much flow as is hydraulically feasible, up to about 200 mgd. Over an annual period, many pounds of additional heavy metals might thus be removed at the plant. The quantities are especially significant for cadmium because of the sensitivity of the cadmium concentrations in the sludges processed for Milorganite.

EFFECTS OF HEAVY METALS ON TREATMENT PLANT OPERATIONS

Heavy metals sometimes affect wastewater treatment plant operations by interfering with biological processes. The Metropolitan Sewerage District has not experienced problems of this kind, and there is no evidence of biological upsets. If they have occurred, they appear to be of very small significance, and the plants seem to have an overabundance of solids in their activated sludge portions to make up any deficiencies caused by the toxic action of heavy metals or slugs of material.

The problem of heavy metals discharged to the plants is most sensitive in the area of metals in the sludges processed for fertilizer, especially the quantities of cadmium and zinc.

Current data and information as to application rates of sludges to land and the environmental effects of these practices are discussed in Chapter V. The list below represents preliminary information collected

TABLE I-11

METALS CONCENTRATIONS

Heavy Metal	Estimated Concentration in Runoff (mg/l)	lb per Million Gallons (lb)
Cadmium	0.03	0.25
Copper	0.10	0.80
Nickel	0.14	1.2
Zinc	0.40	3.3
Chromium	0.08	0.7
Lead	1.3	10.8

Source: Camp Dresser & McKee Inc.

by CDM in correspondence with the U.S. Department of Agriculture. These data indicate sludges should not be applied to private land with concentrations of materials greater than those shown:

Element	mg/kg
Cd	25
Cu	1,000
Ni	200
Zn	2,500
Cr	1,000
Pb	1,000
Hg	10

The Cd/Zn ratio should not be greater than 10 percent (values up to 150 percent of those shown could be allowed, provided an abatement program to cause pretreatment of metals is underway with its goal being to reduce the values to those shown). The following discussion will be predicated to the above criteria.

The past testing procedures afford a much greater data base for heavy metals at the Jones Island plant than are available for South Shore. Very approximate data for Jones Island and South Shore sludges are shown in the first two columns of Table I-12. The Jones Island data are averages of analyses of daily samples for 1975. The sludge samples tested were taken just prior to the sludge being discharged to the thickeners (i.e., prior to the Milorganite producing facilities). The South Shore samples were from composited sludge samples taken from the sludge lagoons over a three-month period in late 1976.

An attempt was made to produce a mass balance of heavy metals at the MSD facilities (see Table I-12). However, the data apparently were too approximate and the assumptions too wide, to produce meaningful results. A more comprehensive program, now underway, is required to compute a mass balance. Further discussion of this program will be made later in this section.

The table does illustrate that the values for Cd and Zn and the Cd/Zn ratio is much higher than the

TABLE I-12

APPROXIMATE SLUDGE QUANTITIES FROM VARIOUS DATA SOURCES

	Jones Island[2]		South Shore[2]		Approximate Totals in Plant Sludges	Industrial Totals From DNR 101 Values	Background[1]	Total Using Assumed plus NR 101 Values
	mg/g	lb/day	mg/g	lb/day	lb/day	lb/day	lb/day	lb/day
Cd	0.16	62	0.062	12	73	85	14	99
Cu	0.45	174	1.0	200	371	191	14	205
Ni	0.13	50	0.73	146	195	161	140	301
Zn	0.15	579	3.6	720	1,240	769	62	831
Cr	6.64	2,563	10.64	2,128	4,651	4,071	49	4,120
Pb	0.70	270	1.1	220	486	810	189	999
Hg	0.003	1	0.005	1	2	—	—	—
Total					7,018			6,558

[1]*Background values for Cd as given by preliminary test data. Other background and per capita values are shown for New York and Pittsburgh, shown in Table IX-D-9.*

[2]*Jones Island and South Shore mg/g data as given by MSD, and assuming 193 tons/day at Jones Island, and 98 tons/day at South Shore as the sludge quantities.*

Source: Camp Dresser & McKee Inc.

current allowables being quoted by the U.S. Department of Agriculture.

The rough comparisons illustrate that source control of heavy metals discharges (especially for Cd, Zn, and Cr) is desirable in the future, if the quantities of Cd and Zn in the Milorganite are limited.

Further, steps will be taken as part of the ongoing facilities planning solids management study to quantify, as closely as possible, the metals discharged to the plant. This more complete set of analyses will illustrate where the big discharges are and allow levels of removals to be set.

ADDITIONAL DATA AND TESTING REQUIRED

The quantification of heavy metals, primarily the Cd and Zn values, being discharged to the MSD systems is required to determine (1) the effect of contaminant controls in the industries involved (in terms of number of installations) and (2) the levels of removals required for various metals discharged.

As previously discussed, the industrial sources of heavy metals contribute by far the greatest levels of metals to the wastewater system. Thus, the testing program should be the most extensive of the programs run outside of the treatment facilities themselves. NR 101 data for 1977 will be utilized to establish which industries are the largest potential dischargers of heavy metals to the system. The NR 101 results should be verified by independent testing over a one-or two-day period.

According to data provided, between 55 and 60 industries contribute approximately 75 percent of the total industrial discharge to the system. These industries should first be checked against NR 101 data, to determine which of these large industrial dischargers should be tested for heavy metals discharge (only Cd and Zn if a limited testing program is desired). Other industries discharging large Cd and Zn values should be evaluated.

The existing testing procedures have already yielded substantial results which will supplement the complete testing program outlined above. Analysis of available data from the existing program will be completed before further testing is undertaken.

Appendix J

LEACHATE PREVENTION, CONTROL, AND TREATMENT/DISPOSAL

The disposal of waste materials by landfilling is under the regulatory auspices of the DNR. Many area landfills receive both municipal and industrial wastes. "Municipal" Solid Wastes are essentially wastes resulting from municipal, community, trade, business, and recreational activities; all other solid wastes are categorized as "industrial." In some situations, industry has selected lagooning and land application as a viable alternative. Industrial wastes may additionally be "hazardous" or "toxic" meaning that they may be toxic, corrosive, flammable, or irritating in nature and likely to cause substantial personal injury, serious illness, or harm to human and other living organisms. A portion of a typical scale record at an area landfill is shown in Table J-1.

Because the disposal of municipal or industrial sludges[1] by landfilling, lagooning, or land application deals with waste material applied on or into the ground, there is a high potential of contaminating groundwater and/or surface water supplies with noxious materials. Control measures can be implemented to reduce or eliminate these hazards. Sanitary and industrial landfills, if properly operated, are efficient methods of burying solid wastes in a manner which minimizes public health and environmental hazards. This Region's present landfills do not have abundant capacity, and planning for solid waste management may be necessary.

The lagooning or ponding of liquid industrial wastes is a versatile treatment/disposal technique which may serve to: 1) settle and remove suspended solids; 2) store wastewater; 3) biologically treat wastes; and, 4) reduce waste volume by evaporation. Groundwater and surface water supplies adjacent to industrial lagoons must be protected from contamination. Contamination can occur when the lagoon interior permits transfer of pollutants to the groundwater, or, if the lagoon is situated such that runoff is diverted through the lagoon, pollutants can enter surface waters.

Landspreading of organic, biodegradable industrial wastewater and sludges can be an environmentally sound waste management practice if proper control measures are implemented. Among the important control methods are those which prevent the interaction between waste material and groundwater/surface water supplies.

The DNR has various regulations and in-house guidelines which provide direction in control methods for reducing the potential groundwater/surface water contamination from all solid waste land disposal activities. In general, on-site control methods must include procedures which will isolate the waste material from adjacent groundwater and surface water supplies. Surface water runoff should be diverted from disposal sites to minimize infiltration into the disposal site. (Increasing the moisture content of the waste material normally increases the rate of decomposition of the waste.) As the moisture content increases, leachate might leave the waste and, if conditions allow, might enter the nearby groundwater or surface water regime.

The composition of the leachate varies widely with the type of source waste and normally contains high concentrations of soluble chemical and biological substances which have the potential to cause water pollution problems.

In the Region there is a large number of sludge disposal sites which involve landfilling, lagooning, and/or land application. Landfilling of industrial sludge and solid waste is a common disposal method utilized in the study area and represents a potential for water pollution from industrial sludge disposal activities.

[1]*These sludges should have a moisture content such that they are compatible with the landfill operation. (A wet runny material will interfere with operations.)*

TABLE J-1

PORTION OF TYPICAL RECORD OF MATERIAL
DELIVERED TO A LANDFILL

Date	Description of the Waste Received
9/5/75	Sludge Waste Wax Machine Oil Oil
9/6/75	Soluble Wash Oil Paint Sludge
9/8/75	Sludge Cutting Oil Paint Sludge
9/9/75	Paint Sludge Oil Sludge Machine Oil Sludge
9/10/75	Sludge Paint Thinner Acid Water Sludge

Source: Glenn Oakes' Landfill, Racine County.

The three largest landfill operations in the area that appear to be capable of accepting most types of sludges are:

1. Lauer II–Waste Management–Washington County
2. Franklin–Metro Disposal Service–Milwaukee County
3. Land Reclamation, Ltd.–Glenn Oakes–Racine County

However, these 3 sites have limited availability and remaining useful life. There are many other smaller sites which are permitted by DNR to accept various types of solid wastes. However, a good many of these sites have only a few years remaining life or are subject to re-engineering.

ASSOCIATED WATER POLLUTANTS

Water pollutants resulting from the landfilling of solid waste and sludge are generated as stormwater runoff interacts with the waste material at the disposal site surface, or by precipitation and/or runoff which migrates vertically through the decomposing waste material, forming leachate. This might be supplemented or aggravated by moisture from a watery sludge. The constituency of the leachate and the surface water runoff might vary widely, depending on the waste composition.

The volume of leachate flowing from a landfill depends on the quantity of moisture which contacts the waste material and the quantity which subsequently flows out of the disposal area. Some general estimates indicated that from one-quarter to one-third of the incident rainfall might percolate through the vertical sections of a landfill site. The physical, chemical, and biological interaction of this retained moisture with the waste material over a relatively long period of time produces leachate, characteristically high in concentrations of constituents, which might cause water pollution. These pollutants are typically characterized as biochemical oxygen demand (BOD), chemical oxygen demand (COD), iron, chlorides, hardness, and alkalinity. Various toxic chemicals and heavy metals are often present at high concentrations. Data which is typical of the composition of leachate from general municipal solid waste is presented in Table J-2. This table demonstrates the tendency for the concentrations of certain leachate constituents to decrease with the increasing age of landfilling (see columns 4, 5, and 6 in Table J-2). However, by the time the landfill ages, most of the damage has been done.

TABLE J-2
TYPICAL LEACHATE COMPOSITION[1]

Constituent	1	2	3	4	5	6
pH	5.6	5.9	8.3			
Total hardness ($CaCO_2$)	8,120	3,260	537		8,700	500
Iron total	305	336	219	1,000		
Sodium	1,805	350	600			
Potassium	1,860	655	no result			
Sulfate	630	1,220	99		940	24
Chloride	2,240	no result	300	2,000	1,000	220
Nitrate	no result	5	18			
Alkalinity as $CaCO_2$	8,100	1,710	1,290			
Ammonia nitrogen	815	141	no result			
Organic nitrogen	550	152	no result			
COD	no result	7,130	no result	750,000		
BOD	32,400	7,050	no result	720,000		
Total dissolved solids	no result	9,190	2,000		11,254	2,075

[1]No age of fill specified for Sources 1-3, Source 4 is initial leachate composition, 5 is from 3-year-old fill, 6 is from 15-year-old fill. All concentrations are mg/l.

Source: U.S. Environmental Protection Agency, Office of Air and Water Program, "Ground Water Pollution from Subsurface Excavations," Washington, D.C., 1973.

The volume of surface water through a disposal site is the incident rainfall and adjacent sources of runoff (which may be routed through the disposal site) less the volume of water which is percolated into the soil. The quality of the surface runoff interacting a waste disposal site will vary widely, depending on the composition of the exposed waste material. Generally, constitutent concentrations in superficial surface runoff are less than the corresponding leachate concentrations because of short reaction times and relatively large surface runoff volumes.

CONTROL MEASURES FOR LEACHATE

As outlined above, control measures which minimize the pollution of groundwater and surface water at solid waste and sludge disposal sites are those methods which exclude water from the disposal site, prevent leachate or waste material from percolating to groundwater, or which intercept and collect leachate or waste material for purposes of subjecting it to chemical or biological treatment. Although most of the control methods presented below are, in principle, applicable to either landfilling, lagooning, or land application, the following discussion will be oriented primarily to the disposal method of landfilling. Additional control procedures dealing specifically with land application and lagooning of sludges may be found in Technical Bulletin No. 88 and Administrative Code Regulations.

SEPARATION OF WASTES

In existing situations, the potential of a landfill to pollute groundwater is generally limited somewhat by requiring the separation at the source of the wastes which are unacceptable for a given landfill site. This is accomplished by enforcing restrictions on materials for disposal by licensing each landfill as to what materials it may accept. For the most part, necessary control measures are encompassed in the existing DNR regulations.

SITE SELECTION FOR PROPOSED LANDFILLS

The best control measure for a proposed landfill is a suitable site location determined by preliminary engineering and hydrogeologic evaluations. To minimize the potential for groundwater contamination from leachate migration, evaluations of a landfill site should include analyses of such important site characteristics as: 1) the soil's permeability, filtration, adsorptive, and buffering capacities; 2) the distance to groundwater; and 3) the groundwater movement pattern and rate. For large proposed landfill operations, the DNR requires such evaluations before a permit is approved. Approximate costs for such investigation services are presented in Table J-3. These are general costs only and might be expected to vary from site to site.

TABLE J-3

COSTS OF SANITARY LANDFILL PERMIT APPLICATIONS
(In thousands of dollars)

	Design Capacity in Tons Per Day			
Item	40	100	300	Greater than 300
Engineering design[1]	12	18	25	30[1]
Survey	6	8	10	10
Borings	5	8	15	25
Legal Work	4	6	10	10[1]

[1]*When an environmental impact statement is required and/or unfavorable hydrogeological conditions are encountered, site development costs may be increased substantially, perhaps even dwarfing expected engineering design costs.*

Source: Hoskius, Thomas et al, "Disposal Related Non-Point Source Analysis, prepared for Texas Water Quality Board, Austin, Texas, 1976.

Generally, the selection of a landfill site should include an assessment of the following points: 1) the geology of the site should provide low relief to minimize the erosion potential; impervious stable rock formations, such as sedimentary rock formations, are preferable; 2) the bottom of the landfill should be well above the historical high groundwater table, and flood plains, shore lands, and groundwater recharge areas must be avoided; significant hydraulic connection between the site and standing or flowing surface water should be absent; and 3) homogeneous host soils of low permeability and high sorption capacity, alkaline pH, and high cation exchange capacity are preferable.

CONTROL OF WATER POLLUTION FROM LANDFILL SITES

Even the best reasonable choice among alternative landfill sites may require that control techniques be implemented to assure protection of ground and surface waters.

These techniques include:

1. Utilization of impermeable liners to retain leachate for treatment
2. Surface water diversion, collection, and treatment
3. Water quality monitoring.

Impermeable Liners

If the natural soil structure at the best available site does not provide suitable groundwater protection, then the use of an installed impermeable liner must be considered. Materials used for liners range from imported soils to synthetic (often petroleum based) materials. Table J-4 presents descriptions and estimated costs of liners composed of soils, admixture materials, and asphalt, while Table J-5 presents similar information for polymeric liners made of plastics and rubbers. Generally, the "soils" liners presented in Table J-4 are more durable and less costly than the "polymeric" liners of Table J-5; however, the polymeric liners provide greater protection to groundwater as they are not likely to open under stress. Liners containing asphalt are not recommended for industrial applications where asphalt might be susceptible to deterioration by solvents.

Leachate Collection and Treatment

The use of an impermeable liner requires that provisions be made for the removal of the fluids contained in the waste material. The accumulated leachate should be removed by a drainage and collection system which involves a network of perforated pipes, risers, and pumps. For the case of existing landfills or old dump areas that are creating a water quality problem, the polluted groundwater in or near the fill area might be captured by well points.

Once the leachate has been removed and collected it is necessary to provide treatment to produce an environmentally acceptable discharge. Leachate may be suitably treated by conventional waste treatment processes, including aerobic and anaerobic biological reactors, carbon adsorption, and ion exchange. Laboratory studies have indicated that leachate may be added to domestic wastewater in an extended aeration activated-sludge plant, providing that the additional waste flow does not exceed about five percent by volume. Aeration tank capacity and solids handling are key plant components in this regard. Costs associated with the processes required for separate treatment of leachate are not well documented, but they would be similar to those estimated for treatment of point sources presented in the state-of-the-art reports. It should be emphasized that systems designed solely to collect and treat leachate are expensive and should be carefully considered in predesign studies.

Surface Runoff Control and Treatment

To prevent surface water from entering the landfill site, it may be necessary to utilize a collection system to transmit upland drainage from the fill area and to open channels, berms, and dikes to divert runoff from surrounding areas. Low-cost, portable drainage channels are available as bolt-together half-sections of corrugated steel pipe. A completed landfill site should be capped with an impervious liner to minimize infiltration and production of leachate.

Treatment of surface water runoff collected within the landfill site may be necessary if the water quality of downstream water supplies is apt to be degraded by eroding cover material and runoff contaminated by waste material. Required treatment might be as simple as a detention basin to remove settleable solids, or might involve conventional treatment processes such as those for treatment of leachate.

TABLE J-4

ESTIMATES OF COSTS[1] OF POTENTIAL LINERS FOR SANITARY LANDFILLS, ADMIXTURE MATERIALS, AND ASPHALT MEMBRANES

Type	Installed Cost
Soil + Bentonite 9 lb/sq yd (1 psf)	$0.72
Soil cement 6-in. thick + sealer (2 coats — each) 0.25 gal./sq yd	1.25
Soil asphalt 6-in. thick + sealer (2 coats — each) 0.25 gal./sq yd	1.25
Asphalt concrete — Dense-graded paving with sealer coat (Hot mix — 4-in. thick)	2.35-3.25
Asphalt concrete — Hydraulic (Hot mix — 4-in. thick)	3.00-4.20
Bituminous seal (catalytically blown asphalt) 1 gal./sq yd	1.50-2.00
Asphalt emulsion on mat (polypropylene mat sprayed with asphalt emulsion)	1.26-1.87

[1]*Costs in dollars per square yard.*

Source: Hoskius, Thomas et al., "Disposal Related Non-Point Source Analysis," prepared for Texas Water Quality Board Austin, Texas, 1976.

TABLE J-5

PRELIMINARY ESTIMATE OF COSTS[1] OF POTENTIAL LINERS FOR SANITARY LANDFILLS: POLYMERIC MEMBRANES — PLASTICS AND RUBBERS — UNREINFORCED

Item	Thickness (mil)	Price of roll goods	Installed Costs[2]
Butyl rubber	31.3 (1/32")	$2.25	$3.25-$4.00
Chlorinated polyethylene (CPE)	20	1.58	2.43- 3.24
Chlorosulfonated polyethylene	20	1.66	2.88- 3.06
Ethylene propylene rubber (EPDM)	46.9 (3/64")	2.42	2.65- 3.42
Neoprene	62.5 (1/16")	2.97	4.41- 5.40
Polyethylene film	10	0.36	0.90- 1.44
Polyvinyl chloride	20	0.90	1.17- 2.16

[1]*Costs in dollars per square yard.*

[2]*Soil cover not included; membranes require some soil cover, cost of which can range from $0.10 to 0.50/sq. yd. per ft. of depth.*

Source: Hoskius, Thomas et al., "Disposal Related Non-Point Source Analysis," prepared for Texas Water Quality Board Austin, Texas, 1976.

Water Quality Monitoring

Routine sampling and environmental surveillance are necessary in the disposal of hazardous wastes, to quickly identify system failures and facilitate remedial action before water supplies become degraded. Prior to the deposition of waste material, baseline data would have been obtained and used to define site characteristics such as hydrologic budget and ground and surface water quality, flow, and use patterns. Sampling point distributions and monitoring procedures will be determined by the geological, hydrological, and chemical intricacies of the site. The interface between soils with different permeabilities will often be the critical plain of groundwater or leachate movement, and should be monitored as a potential leachate pathway. The water quality of tributary flows upstream and downstream of the disposal site should be sampled periodically to detect the degree of surface water pollution.

Lysimeters, observation wells, earth restivity measurements, and core samples are techniques which might be used to measure changes in soil and groundwater conditions. Observation wells and lysimeters down gradient from a landfill area and at different depths are recommended to collect representative samples of leachate activity in the soil profile. Earth resistivity techniques are used to measure the extent of leachate escape from a landfill site. Core sampling from saturated and unsaturated zones are used for a positive identification and movement of chemical constituent concentrations. Because changes in water quality may occur over a relatively long period of time, particularly in groundwater supplies, an effective monitoring program should continue through the life of the disposal operation and should be continued after site closure. Movement of mounded fill sites should also be monitored if the possibilities of slope sloughing exist.

Operation Controls

There are certain operational controls which will help minimize the potential ground and surface water contamination from the disposal of wastes by landfilling. Among these are the following:

1. Provide continuing maintenance of the graded, finished fill cover by filling and regrading the fill surface as shrinkage, which causes cracks or depressions, occurs

2. Seed the completed fill surface with a high transpiration cover crop, but avoid overirrigation of plants

3. In disposal operations where the solid, liquid, and semi-liquid wastes are involved, and admixing of liquid wastes are involved, admixing of liquid wastes and sludges with relatively dry absorbent wastes should be practiced to reduce the possibility of leachate streams or pockets adjacent to unnecessarily dry areas (this is the practice at some major sites).

Summary

Review of available capacity in existing and proposed landfills indicates a shortage of satisfactory sites for sludge disposal. Landfilling is the recommended backup system to landspreading and the requirement of adequate landfill capacity is part of the plan reommendations. It is also apparent that an overall solid waste management plan must be developed for the region that will consider sludge along with all other solid wastes.

Appendix K

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PROCESSING, TRANSPORTATION, AND UTILIZATION/DISPOSAL OPTIONS

INTRODUCTION

In addition to costs and technical feasibility and the compatibility with the objectives, principles, and standards, it is necessary to consider the process train options from an environmental assessment standpoint. The key actions considered below are energy, fertilizer application, waste recycling, transportation, landfilling, storage, liquid effluent discharge, stack and exhaust emissions, insect control, spills and leaks, operation failure, surfacing or paving, surface excavation, site and buildings, and barriers.

The matrix is based on the interaction of information on two axes. The one along the top of the matrix describes potential impact-causing actions, and the other is located at the left margin and represents some segments of the existing environment. To identify potential impacts for a given alternative process train, it is necessary to review the actions displayed at the top of the matrix and to decide which may be a result of the proposed alternative. The next step is to examine each action in relation to the environmental characteristics listed in the left margin and to mark the appropriate box in the matrix. After all boxes have been marked, each interaction is reviewed to determine whether the resulting impact will be positive +1, negative -1, or potentially both (which may balance to 0).

Seven processing-utilization/disposal options were assessed with this matrix. The impact identification and evaluation logic for each of the identified interactions used for all project alternatives are discussed in the following text. The potential action resulting in an impact is listed first, followed by descriptive material. The results of application of the matrix to given process train alternatives follows.

FACTORS CONSIDERED

The utilization of the environmental assessment matrix discussed in Chapter VIII assumes certain constant values are maintained from one option evaluation to the next. This section describes the logic behind the impact identification and how the value determinations were made.

ENERGY GENERATION–ENERGY RESOURCES

This matrix interaction pertains to the impact upon energy resources of energy generation due to a proposed action. With energy production, the impact upon energy resources will be positive because the demand for the resource will be reduced. This would be a resource-conserving action of identifiable merit.

ENERGY GENERATION–EMPLOYMENT

The production of energy will require manpower, thereby increasing the employment base. This is regarded as a positive impact when related to cultural conditions. The goal of our society has traditionally been to maintain high employment, ultimately reaching for a full-employment situation.

FERTILIZATION APPLICATION (ORGANIC)–SOILS

The application of organic materials contained within wastewater sludges will have a variety of impacts upon the various segments of the existing environment. The impact evaluations for this specific matrix interaction are based on the value of the organics contained within sludge. These materials have a distinct beneficial use and any impact evaluation considers optimization of the potential benefit. Any misuse or nonusage of the material is viewed in adverse terms.

FERTILIZATION APPLICATION (ORGANIC)–ENERGY RESOURCES

The production of organic fertilizers and other substitutes utilizes large amounts of energy. The proper use of these nutrients in the sludge will constitute a savings in energy since less commercial fertilizer will be used and, consequently, less will be manufactured. Conversely, losses of this natural fertilizer through sludge disposal (i.e., in a landfill) would indirectly require the expenditure of energy resources to produce substitute commercial fertilizer. Costs for transporting and the associated environmental impacts are basically the same.

FERTILIZATION APPLICATION (ORGANIC)–SURFACE WATER

The application of organic fertilizers to the soil may result in pollutant transport to the surface water resource. Determination of relative impact depends upon the hazard to water quality, the benefits of water holding capacity, and site drainage potential.

FERTILIZATION APPLICATION (ORGANIC)–GROUNDWATER

In cases where sludge is applied to the land, the organic material may pose some hazard to groundwater resources. The relative impact, however, may, in many instances, be quite limited. Groundwater contamination might result when groundwater resources are at shallow depths or when soil conditions permit a rapid movement of pollutants through the soil column.

FERTILIZATION APPLICATION (ORGANIC)–CROPS

The application of organic materials to the soil will have a beneficial impact upon crops. The organic fertilizer added to the soil will enhance crop production resulting in greater benefits to the grower. Other benefits which might relate to increased vegetative productivity include a greater forage base for native wildlife species that may find the croplands a food resource. Greater crop or vegetative productivity might also increase the extent or quality of various wildlife habitats.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–SOILS

The trace elements and nutrients commonly contained in wastewater sludges enhance soil quality for agricultural uses. The trace elements are needed for optimum growth and development, along with a number of nutrients.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–SURFACE WATER

The recycling of trace elements (heavy metals) and nutrients might pose a hazard to surface water resources. These nutrient materials, when carried to a water body, are rapidly utilized by aquatic plants for increased production, possibly resulting in eutrophic conditions. The metals are often assimilated into plant and animal tissues creating potential health problems. Metal uptake occurs initially at low levels of the food chain, but health problems may occur as the metals become concentrated throughout the chain. When assessing the potential impact, consideration for controlling application rate and materials becomes very important. Properly managed systems will not endanger the quality of surface water resources.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–GROUNDWATER

Trace elements and nutrients associated with wastewater sludges may adversely affect groundwater resources. This is critical since man is dependent on these waters as a source for a large portion of his drinking water. The quality of groundwater directly affects human health and safety. Problems are caused by trace elements leaching through the upper soil profile to the groundwater. The soil, along with the vegetative cover, is capable of holding a limited quantity of these elements within the upper horizon;

however, the assimilative capacity of the soil might be exceeded. Proper management of the sludge, such as supplying enough trace elements or other nutrients to meet crop demands and soil holding capacities, will mitigate groundwater contamination.

Site evaluations must be made to determine the soil condition and depth of soil to groundwater. Soils with channels or fractures in underlying bedrock should be avoided.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–CROPS

The addition of trace elements and nutrients to crop production sites can be very profitable by increasing crop yields. Increased crop production may be offset, however, if heavy metals become highly concentrated and cause a reduction in yield. Phytotoxic effects result when soil and geographical conditions favor the assimilation of excess quantities of toxic metals by a particular crop. Assessing the degree of phytotoxicity is difficult without detailed site-specific information. A number of variables are important in determining the potential for plant toxicity. Crop type, soils, application rate, soil conditioning, rainfall, and season of application are examples of some of these variables. Generally, the addition of trace elements and nutrients to agricultural systems is considered favorable, provided proper site planning and control is practied.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–FOOD CHAINS

Exposure of excess heavy metals to agronomic crops enhances the potential for bioaccumulation of toxic substances within the food chain. The current majority of sludges produced contain excess quantities of various metals and other materials which pose a health and safety hazard to the natural food chain. Man is not exempt from these hazards for he is a component of the chain. Man is, however, somewhat fortunate in that he can selectively choose the level at which he desires to interact. Our society, in general, interacts at a number of levels within this complex food system.

Crops cultivated on sludge-amended soil generally take up quantities of metals in excess of normal background levels. A hazard exists when this uptake rate is sufficient to cause illness or even death to those persons consuming the contaminated crop.

When assessing impact, consideration of the potential hazard must be made assuming sound management policies are to be followed. If not, a negative value is warranted due to the uncertainty. This does not mean that a hazard will actually result, but only that the potential is significant enough to bear concern.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–HEALTH AND SAFETY

Health and safety is considered in terms of human welfare. Potential health problems result from the recycling of nutrients and toxic heavy metals. Heavy metals, when consumed and concentrated in man, can cause a number of health problems. The metals will often concentrate in body organs and tissues. As concentrations increase, body functions might become impaired. The effects of accumulating large quantities of metals are not usually acute. Long periods of time usually lapse before toxic levels are reached.

Nitrogen contamination of groundwater resources also might pose a health hazard to man. Nitrate poisoning might occur when sufficient quantities of nitrate leach to groundwater and are subsequently utilized by man or other animals. This illness, known as methemoglobinemia, causes a reduction in the oxygen-carrying capacity of the blood and may result in suffocation. Infants or unborn children are particularly susceptible. The potential for these conditions to occur can be effectively reduced through sound management of sludge disposal options.

WASTE RECYCLING (TRACE ELEMENTS AND NUTRIENTS)–MONITORING CONTROL

The extent to which the impacts occur is dependent on the intensity of sludge disposal management and control. This matrix interaction expresses the value of a rigid monitoring and control system for sludge disposal alternatives. Those alternatives which lend themselves to rigid control are assigned a positive value, while those with no control over application actions are assigned a negative value.

TRANSPORTATION–ENERGY RESOURCES

The transport of sludges to disposal sites will probably be accomplished by truck. All options require transportation and will be assigned a negative value since energy resources will be consumed by those vehicles. Transport options such as rail, barge, and pipeline will consume energy as well.

TRANSPORTATION–AIR QUALITY

This matrix interaction relates to the preceding one in that those options requiring direct transportation of sludges to disposal sites will have an adverse impact upon air quality. The burning of fossil fuel by internal combustion engines contributes to the degradation of ambient air quality. The significance or degree of this impact is directly linked to the engine's operating efficiency and the distance traveled.

TRANSPORTATION–ODOR

Transportation of wastewater sludges from treatment sites to disposal locations may cause odors that will infringe upon individuals inhabiting the perimeter of the transport route. Odors may also be generated from vehicle exhaust. It is the perception and evaluation of that odor by people which determines its objectability. (What is tolerable to one person may be entirely offensive to another.) One's cultural or social position may play an important role in determining the perception of various odors.

TRANSPORTATION–NOISE

Noise will be associated with the movement of sludges, largely by truck, to disposal sites. This is true of all alternatives requiring transportation. Levels of noise produced are dependent on truck operating efficiency and distance traveled. Noise exposure will also depend on the route utilized and the population density along that route. Noise is considered a cultural factor since its significance, like odor, is subject to individual interpretations and values.

TRANSPORTATION–HEALTH AND SAFETY

The transportation of sludges by truck or other means will pose two principal health and safety hazards to the general public. The first is a safety factor as a result of increased truck traffic on the roadways. The increased traffic will contribute to the risks experienced by both motor vehicle passengers as well as pedestrians.

The other hazard is the potential exposure to the general public of hazardous materials, contained in the sludges, as a result of leaks or accidents. This risk is dependent on the nature of the sludge and the way in which the sludge is transported. Mitigative means are available to sufficiently reduce the hazards associated with sludge transfer by whatever means.

TRANSPORTATION–EMPLOYMENT

Employment must be expanded, particularly in the trucking industry, to accommodate the quantity of sludge requiring transportation. In addition, a concommitant increase in supporting service employment opportunities will occur. The sludge water content and volume produced, as well as distance to be hauled, will have a direct bearing upon the employment benefits.

TRANSPORTATION–TRANSPORTATION NETWORK

Trucking of sludges will impose a greater demand on and use of existing transportation facilities and networks. The increased usage will mean that the damage and wear on the transportation systems will be greater. The demand created by this disposal activity is not anticipated to require large-scale network expansion projects. Some minor accommodations, however, might be necessary to facilitate the movement of trucks from public road systems to disposal sites. Other transport means will also imapct existing systems.

LANDFILL–COMPACTION AND SETTLING

Wastewater sludges disposed in landfills might produce an unstable soils condition in the landfill area. A period of time and exposure to natural elements such as rainfall, frost, and thawing contribute to the stabilization of a landfill site. Because this process occurs over a period of several years, the site is effectively limited from a number of land use options. Special provisions to provide extra measures of erosion protection might be required.

LANDFILL–STABILITY

As briefly mentioned in the preceding paragraph, the landfilling of sludge materials might produce an unstable site condition. The potential for sinks, erosion, and slides is increased. High moisture content sludges might require land periods of time to dry further contributing to site instability. Activities which may occur on the surface of such a facility are quite limited. Long periods of time are required before suitable levels of stability are attained; special construction procedures must be implemented to develop this sort of site.

LANDFILL–SURFACE WATER

Landfill sites are particularly susceptible to erosion as a result of rapid surface water runoff. Typically, the landfill sites are not well vegetated which contributes to erosion potential. The materials contained within the sludge are concentrated at a landfill site in such a manner as to pose additional hazard to surface water resources. Heavy metals and nutrients are of particular concern once they enter the surface water as they promote eutrophic conditions and encourage bioaccumulation of toxic substances. Special landfill site operating procedures must be implemented to reduce the associated hazards to surface waters.

LANDFILL–GROUNDWATER

The operation of a sanitary landfill site is designed to accommodate the disposal of a variety of potentially hazardous materials in a manner which protects the public welfare. Contamination of groundwater resources may occur through improper construction or maintenance. Such contamination may occur as a result of poor site preparations, which fail to seal the site properly, or due to leakage through the seal. Because the sludge has been placed in a compact area, the potential for local contamination is enhanced.

LANDFILL–DISEASE INSECT VECTORS

Sludge disposal in landfill sites must be conducted under specific handling procedures to assure public safety. Spills outside the dump area or improperly covered sludges might support various disease-carrying animal and insect pests.

LANDFILL–AGRICULTURAL

The disposal of sludges to landfill sites eliminates their beneficial use in providing nutrients to agricultural lands. As fertilizers and soil conditioners become increasingly scarce and costly, some marginal agricultural lands may be taken out of production. The use of sludges on such areas could make them more productive and substantially more attractive for agricultural use.

In some cases, landfill sites may be developed on agricultural lands. This activity would permanently remove that acreage from further crop production.

LANDFILL–ODOR

Landfill sites receiving unstable sludges might create odor problems for persons residing or engaged in activities near the disposal site. In addition, odors from machinery and trucks operating on-site might also be present.

STORAGE (DRY OR LAGOON)–SURFACE WATER RESOURCES

Because daily production of sludges cannot be disposed immediately, storage facilities will be required. Small plants which handle limited quantities of sludge might find it economical to store sludges for an extended period. Large plants might need to store sludge for several months. Storage of sludges creates potential adverse impacts. Spills and leaks might contaminate surface water resources.

STORAGE (DRY OR LAGOON)–GROUNDWATER RESOURCES

The environmental impacts associated with groundwater resources are much the same as those identified for a permanent sanitary landfill site. Leaks or improper site preparation are the predominate causes of contamination. The risk is perhaps not as great with this sort of facility because the quantities and time periods required to hold sludge are not as great as those for the landfill. The fact that a hazard does exist, however, warrants proper consideration and identification of that impact.

STORAGE (DRY OR LAGOON)–AIR QUALITY

The confinement of sludge within a designed storage structure might result in air quality degradation. Large lagoons might contribute gases or aerosols to the atmosphere which reduce air quality downwind of the facility. Dry storage might become hazardous or a nuisance during windy periods, as dust and debris originating from the exposed sludge might be transported considerable distances.

STORAGE (DRY OR LAGOON)–OPEN SPACE

Storage facilities might occupy large areas of open-space land. Collectively, the facilities needed throughout the region represent a sizeable area. Any reduction in available open-space land, particularly in or around metropolitan areas, diminishes land use flexibility. Those areas utilized as storage sites will exclude other potential activities.

STORAGE (DRY OR LAGOON)–AESTHETICS

Aesthetics impacts are difficult to evaluate. The abstract definition and values attached to aesthetics are diverse and vary widely from person to person. This matrix interaction (storage vs. aesthetics) generally assumes that an open area probably existed prior to storage facility development and is probably more desirable than a sludge storage lagoon or dry sludge pile, building, or other structure.

STORAGE (DRY OR LAGOON)–ODOR

It is contended that current technology can eliminate odor problems resulting from sludge storage. A number of cases have been reported in various parts of the country where storage operations resulted in complaints of offensive odors. This assessment assumes some odor generation from sludge storage. The perceived level of odor will depend on the population surrounding the storage site.

STORAGE (DRY OR LAGOON)–HEALTH AND SAFETY

Storage is a temporary holding operation prior to future use or disposal. Health and safety problems might arise should pathogenic organisms survive treatment processes. These organisms may, under certain conditions, infect a host and cause some discomfort or illness. The numbers of viable pathogens in sludge is variable. Danger to public welfare is quite remote, provided adequate safeguards are established. For instance, long-term storage will reduce the number of microorganisms. This assessment assumes that storage creates a potential health hazard and, therefore, a negative impact.

LIQUID EFFLUENT DISCHARGE–SURFACE WATER RESOURCES

The treatment of liquid wastes by wastewater processing plants will result in some solids being discharged into surface water resources. The levels of solids which enter the water are significantly reduced as a result of the treatment process. This action, assessed as being adverse, might, under special situations, enhance water quality. Detailed site-specific data are necessary to evaluate the degree of this impact. Potential problems associated with this factor include eutrophication of surface water resources and bioaccumulation of toxic materials.

LIQUID EFFLUENT DISCHARGE–AQUATIC PLANTS

Substances carried in effluent waters will stimulate aquatic plant growth, thereby accelerating eutrophication. The cyclic process of plant growth, decomposition, and regrowth contributes to the aging of surface waters.

LIQUID EFFLUENT DISCHARGE–FISHES AND SHELLFISH

Not only are aquatic plants influenced by effluent waters but the animal constituents are also affected. Stimulated plant growth might be beneficial to certain species but typically are not so to intolerant indicator species. Other materials such as metals and toxins carried into the system may accumulate in animals causing illness, retarded growth, reproduction failure, or death. Fish and shellfish feed on a variety of substances which increase the bioaccumulation hazard.

LIQUID EFFLUENT DISCHARGE–BENTHIC ORGANISMS

Benthic communities are susceptible to the same hazards as described for fishes. Toxic substances found in the effluent may result in similar consequences within this community. Benthic organisms are further significant because they are often fed on by the larger fishes which contribute to the food chain contamination problem.

LIQUID EFFLUENT DISCHARGE–HEALTH AND SAFETY

The health and safety of the public might be jeopardized by consuming food stuffs collected from a contaminated aquatic environment or by utilizing a polluted waterbody as a source of drinking water. Most citizens are served by a water treatment facility to reduce the hazard, but a polluted fresh water resource will result in increased costs to those individuals being served.

FERTILIZATION (REDUCTION IN COMMERCIAL PRODUCTION)–MINERAL RESOURCES

Sludge contains quantities of nutrients and trace elements that may be used by plants for growth and development. Application of sludge to agricultural land should reduce the demand for artificial fertilizers. Production of commercial fertilizer will impact mineral resources which are mined to supply raw materials for the commercial fertilizer industry.

FERTILIZATION (REDUCTION IN COMMERCIAL PRODUCTION)–ENERGY RESOURCES

The same principles described in the previous paragraph apply to this interaction point. The emphasis, however, is somewhat different. The production of commercial fertilizer is energy intensive. Nitrogen fertilizer production, for instance, requires the utilization of large quantities of natural gas. Energy conservation may become mandatory as long as energy demand exceeds supply. The use of natural fertilizers in place of commercial fertilizers is an energy consuming practice.

WASTE CONTROL (AUXILIARY SCRUBBERS)–ENERGY RESOURCES

The need for scrubbers to meet air quality standards will mean the consumption of additional energy. Sludge management alternatives which demand excessive energy consumption may be viewed unfavorably as energy demands grow and energy resources become more restricted. Decision makers reviewing this type of alternative should evaluate these options in view of anticipated future energy needs.

STACK AND EXHAUST EMISSIONS–AIR QUALITY

The burning of sludges in any manner will deteriorate the existing air quality. This problem may reach over a broad area due to widespread dispersion of air pollutants. Some areas of the southeastern Wisconsin region are exceeding air quality standards and, consequently, any additional loading might not be permitted. A negative impact assessment value is warranted for any alternatives which contribute to the deterioration of air quality.

STACK AND EXHAUST EMISSIONS–SCENIC VIEWS & VISTAS (AESTHETICS)

Large stacks from sludge combustion facilities, as well as smoke emitted from the stacks, might impinge upon the aesthetic qualities of the surrounding landscape.

STACK AND EXHAUST EMISSIONS–ODOR

Odors resulting from operational failures or inefficient combustion would be objectionable to individuals exposed to the odors. Public opposition to such conditions can become quite severe with many legal entanglements. While all sludge management alternatives can be designed to mitigate odors, some alternatives are more susceptible to the generation of "perceived" odors.

STACK AND EXHAUST EMISSIONS–HEALTH AND SAFETY

Any increased atmospheric loading of pollutants such as particulates or gases may increase the risk to public health. Many individuals suffer from chronic respiratory ailments which become irritated and intolerable under degraded air quality conditions. Air quality in southeastern Wisconsin has improved markedly during the past decade. Any sludge management alternative which deteriorates the improved air quality is negatively viewed.

INSECT CONTROL–HEALTH AND SAFETY

Several of the sludge management alternatives may produce conditions which are favorable to the breeding and production of insects. Insects can be disease vectors as well as a general nuisance to nearby residents. Prevention of insects can be accomplished through the implementation of sound control measures, such as reducing the potential for ponding.

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)–SURFACE WATER RESOURCES

The threat of spilling or leaking of sludge during its transportation to and from the treatment facilities is viewed adversely because of the potential for surface water contamination. This includes transportation of raw wastewater to subregional and regional processing centers, transportation of treated sludge to disposal or application sites, and the transportation of ash to disposal sites following sludge combustion. Spills or leaks would probably be most commonly associated with loading or unloading activities and, to a lesser extent, during actual transport.

The impact associated with surface waters is similar to those described for fertilization of sludges to croplands. Eutrophication of lakes and streams and bioaccumulation of toxic metals within aquatic organisms are primary concerns. Actual impacts are considered limited since the quantity of material lost would be minimal under most circumstances.

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)–GROUNDWATER RESOURCES

Impacts associated with groundwater contamination as a result of spillage of sludge during transportation are similar to the hazards imposed from nutrient and trace element recycling. Heavy metals and nitrogen loadings in excess of safe concentrations may result. Small quantities of spilled sludge will not present serious problems to the groundwater. Spills which exceed the assimilative capacity of the exposed vegetation or which are not carried away by surface waters may result in groundwater contamination. Situations which offer the possibility of spillage or leakage are assigned negative impact values.

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)–AIR QUALITY

Sludges which are lost by the transportation vehicles may contribute to the reduction of local air quality, particularly if dry sludges are hauled in open trucks. Fine particles are readily carried by the wind for considerable distances. Spills along roadways or at transfer points may also be subject to wind transport.

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)
–SCENIC VIEWS & VISTAS (AESTHETICS)

Spillage of sludge along the transportation route may reduce the aesthetic quality of adjacent areas. The degree of impact will be related to the area character where the spill occurs (e.g., spills in residential areas may affect the short-term aesthetic environment more than a spill in an unpopulated area).

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)–ODOR

The spillage of wastewater sludges along transportation routes and at transfer locations may result in nuisance odors. This situation, like previous odor problems, is quite subjective and will impact various individuals differently.

SPILLS AND LEAKS (TRANSPORTATION ACCIDENTS)–HEALTH AND SAFETY

A public health hazard may exist for individuals utilizing roadways on which spills have occurred. Organisms within the sludge are capable of infecting individuals which come in contact with it. Nutrients and heavy metals may contaminate water supplies. The degree of a given hazard depends a great deal on the quality and quantity of the sludge itself. There is considerable need for care in transporting sludges.

OPERATIONAL FAILURE–SURFACE WATER RESOURCES

Operational failure of the treatment plant may result in the discharge of untreated wastewater into surface water bodies. Such a discharge may result in eutrophic enhancement of the water resource due to the introduction of excessive levels of nutrients.

OPERATIONAL FAILURE–AQUATIC PLANTS

The nutrient wastewater discharge to surface waters may lead to increased growth of aquatic plants.

Toxic substances may be taken up by aquatic plants causing food chain hazards. The increased plant growth and subsequent die-off result in the rapid eutrophication of the water resource and typically suppress dissolved oxygen levels during time of high BOD and low flow.

OPERATION FAILURE–FISH AND SHELLFISH

The discharge of sludge into fresh water ecosystems can severely reduce oxygen levels necessary for life support of fishes and shellfish. Depressed oxygen levels may cause fishes to migrate to more favorable areas or to perish through suffocation.

Toxic substances in the sludge might accumulate in aquatic organisms and impair their vitality.

OPERATIONAL FAILURE–BENTHIC ORGANISMS

The adverse effects discussed in the preceding paragraph also apply to the benthic community. Bottom-dwelling organisms depend on sufficient oxygen levels to sustain life, and lowering dissolved oxygen levels will cause intolerant species to perish. Benthic organisms are relatively immobile so out-mitration is not possible.

OPERATIONAL FAILURE–SCENIC VIEWS & VISTAS (AESTHETICS)

The passage of wastes to surface waters as a result of operational failures may cause discoloration of the waters, increased turbidity, fish kills, excessive algal blooms, or contribute free-floating debris to the aquatic system. The impact upon scenic and aesthetic values may be quite severe.

OPERATIONAL FAILURE–ODOR

Odors may be produced by failing treatment operations because sludges might not be completely stabilized allowing offensive gases to be produced.

In cases where sludge enters nearby water systems, odors may result directly from the sludge in the water or indirectly as decomposition of algal material and other aquatic biota occurs. Odor problems can become widespread and are difficult to contain as wind and water movements will transport the odors over long distances.

OPERATIONAL FAILURE–HEALTH AND SAFETY

Failure of the treatment plant to effectively handle all sludges and/or effluents will impose a health and safety risk to the public. The public may be exposed to higher levels of pathogens and/or toxic substances in the sludge and in the contaminated water systems.

EXOTIC FLORA AND FAUNA INTRODUCTION–MICROFLORA AND FAUNA

The addition of sludges to agricultural lands may cause a typical species of microorganisms to be introduced to the soil environment. This occurs because most sludges contain a remnant population of microorganisms despite the extensive treatment processes which are designed to destroy them. The introduction of these species and the consequent population change may adversely impact the soil micro-ecosystem by altering soil processes, such as mineral transformations.

MODIFICATION OF HABITAT (STRUCTURAL)–OPEN SPACE QUALITIES

This matrix interaction addresses the adverse impact of changing open-space habitats to nonvegetative environments through the construction of buildings and other facilities. A number of the alternatives under consideration would require the additional construction of new or expanded facilities which directly reduce open-space areas and indirectly impact the aesthetic quality of others.

ALTERATION OF DRAINAGE–DEPOSITION

The filling of disposal landfill sites will alter the natural pattern of surface water runoff. An accurate evaluation of the potential impacts is only possible under site-specific terms, but general factors can be examined utilizing the matrix assessment system. Whenever deposition occurs, the drainage situation may be modified. Deflection of the waters to other pathways or reduction in the flow capacity might occur. This may cause increased erosion problems since the stability of the fill material is low. In general, changes of natural drainage systems are assumed to be adverse.

ALTERATION OF DRAINAGE–SURFACE WATER RESOURCES

Changes of natural drainage from sludge disposal may adversely affect adjacent surface waters. Increased turbidity levels are likely as runoff waters out.

Nutrients entering surface waters will contribute to long-term degradation of water quality.

SURFACE OR PAVING–MINERAL RESOURCES

Any alternative under consideration which calls for the surfacing and/or paving of the land will require that certain mineral resources (e.g., stone, sand, gravel) be expended to produce the surfacing materials. While these resources are not in short supply, they are limited in terms of ease of accessibility and transportation costs. Once the materials have been utilized for a project, they are in most cases lost for further use.

SURFACE OR PAVING–CONSTRUCTION MATERIAL

The consumption of mineral resources for surfacing and paving activities will also be accompanied by the utilization of various other construction materials. Asphalt, cement, wood materials, and steel will be utilized.

SURFACE OR PAVING–TEMPERATURE

The surfacing or paving of large areas will cause a microclimatic change in temperatures immediately around the surfaced area. Individually, these changes are not significant in terms of a region's general climate, but collectively such changes may influence the regional climate. Large paved sites will experience slightly higher temperatures during daylight times when radiational heating occurs. This elevated temperature may increase the rate of snow and ice melt contributing runoff water to drainage systems at times of the year when the system may be frozen and inoperative.

SURFACING OR PAVING–OPEN SPACE QUALITIES

Paving areas to provide access to buildings or for parking may remove open space from future-use options. All vegetation will be removed and future uses or activities on the site will be reduced.

NOISE AND VIBRATION–NOISE

Construction and plant operation will increase the noise levels in areas adjacent to the activity. Trucks moving sludge or construction materials will elevate noise levels. The type of surrounding land-use patterns will influence the tolerance level to noise.

SURFACE EXCAVATION–SOILS

Construction activities will require excavation. Excavation will drastically disrupt the natural characteristics of the soil. The valuable top horizon which is so important for sustaining vegetative growth may be entirely removed or buried below mineral soils which have little agronomic value. The character of this upper horizon has been developed over many years and is not easily restored by natural processes.

Restoration procedures are available to return a disturbed area to some level of productivity, but the costs are often high and complete restoration to the original level is impossible.

SURFACE EXCAVATION–LAND FORM

The purpose of surface excavation is to alter the natural land form in order to facilitate various development projects. The values associated with the existing (at times natural) land form depend entirely upon individual interpretations regarding specific cases.

SURFACE EXCAVATION–EROSION

Disrupting the earth's surface will remove vegetation cover and expose soil to wind and water erosion. Excavation may also indirectly affect a number of other parameters such as surface water quality, sedimentation, and alteration of drainage patterns.

SURFACE EXCAVATION–AIR QUALITY

Impact assessments for this interaction point assume that equipment utilized to excavate the earth's surface will emit exhaust fumes which will contribute to the total loading of pollutants. Any option assessed which demands that excavation be conducted will adversely impact the atmospheric resource.

SURFACE EXCAVATION–NOISE

The operation of heavy earth-moving machinery will create temporary increases in the noise levels near the construction site.

INDUSTRIAL SITES AND BUILDINGS–CONSTRUCTION MATERIALS

The construction of new or expanded treatment and disposal facilities will require that a wide variety of construction materials be utilized.

Once these materials are incorporated into a facility, their reuse is substantially reduced. The commitment of large quantities of resources must be measured in terms of benefits over the long term, not as solutions to immediate problems.

INDUSTRIAL SITES AND BUILDINGS–SCENIC VIEWS AND VISTAS (AESTHETICS)

Construction of formal buildings and treatment facilities will reduce the aesthetic values of undeveloped natural areas. It is possible under special conditions for this development on man-altered sites to be viewed as a benefit to aesthetic values. Determinations of this sort of situation must be made at the specific site level.

INDUSTRIAL SITES AND BUILDINGS–EMPLOYMENT

To maintain a functional treatment and disposal system, a certain level of employment will be required. The increased employment related to sludge processing/disposal activities is viewed as a beneficial impact.

BARRIERS INCLUDING FENCES–CONSTRUCTION MATERIAL

The construction and operation of sludge processing and disposal facilities might require that barriers, such as fences, be installed at certain locations. Construction materials will be utilized in the erection of these barriers.

BARRIERS INCLUDING FENCES—BARRIERS

Fences create a barrier to free movement by wild, free-roaming wildlife species. Fences or other barriers may change movement patterns from feeding to rest areas and even exclude traditional feeding sites from further use.

In addition, fences may impose a safety risk for some animals as a result of collisions or entanglements with the barrier.

BARRIERS INCLUDING FENCES—SCENIC VIEWS AND VISTAS (AESTHETICS)

The use of fences at sludge handling facilities and at disposal sites may reduce the aesthetic quality relating to open views and vistas.

Conversely, fences or barriers in some cases may provide a screen to reduce the visibility of unsightly disposal or treatment facilities.

The general value of fences in terms of scenic views and aesthetic values is considered adverse as open-space characteristics might be diminished.

BARRIERS INCLUDING FENCING—HEALTH AND SAFETY

The use of fences and alternate barriers at sludge processing sites may enhance the measure of public benefit in terms of health or safety. Fences can prevent excess contact between man and pathogenic organisms remaining in sludges. Other operational hazards may be effectively reduced through the implementation of a fencing program.

Food chain hazards associated with bioaccumulation, due to forage animals consuming contaminated crops, can be reduced by controlling forage times and rates.

ELIMINATION OF FUTURE LAND USE OPTIONS—OPEN SPACES

Open-space lands are available for a wide variety of future uses. If, under a specific option, these open spaces are committed to a certain use, the remaining future uses are reduced. Such long-term commitment of land is viewed as a detrimental impact.

ANALYSIS RESULTS—ENVIRONMENTAL ASSESSMENT

Seven common processing-utilization/disposal options previously defined were evaluated using the environmental assessment matrix. The assessment for each option was conducted in general terms for the region plant sites. The results of this evaluation are the ranking of options in order of their environmental desirability. The rankings are discussed below:

1. Public pickup
2. Organic fertilizer production
3. Landspreading
4. Landfill—Landspreading
5. Pyrolysis—Landfill
6. Incineration—Landfill
7. Landfill

PUBLIC PICKUP

The utilization of sludge through some program which encourages public pickup appears to be the most favorable system in terms of environmental cost-benefit. The practive itself is actually a modified form of a landspreading system because the sludge is being used as a fertilizer and soil conditioner by those receiving the materials. The benefit that this option possesses over simple landspreading is the reduction of management and labor required by the municipality or wastewater district to achieve the disposal objective. Public pickup systems realize most of the benefits associated with landspreading, such as fertilizer and trace element recycling which contribute to increased crop productivity. Some additional benefits are also realized. A portion of sludges utilized under public pickup systems are applied to nonfood chain crops such as lawns, shrubbery, and flower gardens. This reduces any hazards associated with extensive agricultural projects which maximizes application rates to produce food chain crops.

The wastewater district also does not have to spend time and money or consider the environmental implications of transporting sludges to specific disposal sites. Indirectly, the transportation relates to the program but is not a primary factor in the utilization option evaluation.

Public pickup systems, if totally successful, do not require the maintenance of an application site. This is important because landfill sites or other alternatives have a number of adverse characteristics which may be avoided.

A public pickup system must insure that all sludges are completely stabilized and do not impose a health hazard. Storage of sludges (digesters and lagoons) for extended periods of time inactivates large numbers of pathogens.

Sludges should be tested for nutrient and metals content to determine what application rates are advisable. The public should be informed of hazards from excessive application, and recommendations for appropriate rates and usage should be offered to the consumer.

This option, while appearing to be quite attractive and desirable in this Region based upon the matrix evaluation, might be limited by sludge quality at specific plants and by the lack of public demand for this product. Public pickup programs are currently functioning on a limited basis within the southeastern Wisconsin region. In order to expand this option for future use, an extensive publicity effort will be required to inform the population of the fertilizers' availability and their potential uses.

Special loading equipment (such as conveyor belt loaders) placed on-site might enhance this option's desirability.

ORGANIC FERTILIZER PRODUCTION

Organic fertilizer production for commercial sale along with the production of soil conditioners is another form of landspreading. Milorganite production, as one example, achieves the benefit of landspreading systems but also has qualities similar to the public pickup option.

The potential of this option for future use depends on the saleability of the product within the open market. As commercial fertilizers become more costly to produce and energy supplies are further diminished, the benefits of organic fertilizers as a less expensive alternative may become more important.

A substantial amount of this sludge is applied to nonfood chain crops as are public pickup sludges. Common outlets for this product are garden supply centers catering to the suburban lawn care market.

Sludge quality should be monitored regularly. Each bag distributed for sale should offer specific recommendations for the proper methods and rates of application of the fertilizer.

LANDSPREADING

Landspreading of municipal wastewater sludges is ranked third, as a result of the matrix assessment. The objectives of this alternative are to dispose of sludges in an environmentally acceptable manner while recovering a number of sludge constituents through the natural vegetative growth cycle. Nutrients, particularly nitrogen and phosphorus, are found in high enough concentrations to be beneficial for increasing the productivity of the receiving plant or crop community. Trace elements also contained within the sludges provide the needed nourishment for optimum plant productivity. The application of sludge to agricultural lands is valuable in supplying fertilizers in place of commercially produced products which require a complex degree of processing and preparation prior to their usage.

Implementation of large-scale landspreading operations, while desirable, is conceptually vague at this time because regulatory guidelines by federal and state agencies are not well defined. Utilizing standards and guidelines currently suggested by various agencies might limit the loadings upon specific sites to levels which might restrict the feasibility of this alternative. This problem might also apply to public pickup and organic fertilizers.

Other obstacles to overcome prior to implementation of this alternative include logistical transportation problems, year-round marketing, storage, management, and recording of application sites with rates applied and years of application, and a variety of other study quality statistics.

Land ownership arrangements must also be worked out in cases where outright purchases might be considered. Less-than-fee simple contracts may also be evaluated.

LANDFILL–LANDSPREADING

This option combines two disposal processes and as a result is represented by characteristics of each individual alternative. Landspreading is proposed for all those sludges which are of sufficient quality to meet crop nutrient requirements without imposing toxic or food chain hazards. The quantity of sludge landspread will also directly relate to the available lands which might receive this material. Sludges not suitable or impractical for landspreading would be disposed of in a sanitary landfill facility. This combined alternative allows for some nutrient recocery but does not fully achieve landspreading goals. Those sludges which ultimately go to landfill sites are essentially lost in terms of their fertilization potential.

Hazards identified with both alternatives are applicable to this combined alternative.

PYROLYSIS–LANDFILL

The pyrolysis-landfill sludge disposal option is ranked fifth and combines a processing technique with a disposal method. The two factors must be combined since the pyrolysis process will create certain impacts upon the environment as will the resultant ash which will be disposed of in landfill sites. The nutrient content which is in the unprocessed sludge is lost as a result of the pyrolysis process.

Pyrolysis may contribute to the greater efficiency of sludge stabilization and pathogen removal but requires energy, not all of which is self-produced, and can contribute to air pollution.

Hazards associated with landfills are to some degree reduced because of the lower volume of ash disposed and its nutrient characteristics. Some metals are, however, further concentrated.

INCINERATION–LANDFILL

This option is similar to the pyrolysis-landfill option. A lower ranking occurs since incineration requires more energy consumption. This additional demand for energy is measured against the capability of pyrolysis units to recover a quantity of energy from its process. Air quality emissions have also been quite difficult to control.

LANDFILL

Landfilling is ranked as the least desirable method of sludge disposal because no attempt is made to reclaim sludge constituents which may benefit the environment. These materials, primarily the nutrients and trace elements, are lost once confined within the landfill site.

The environmental hazards associated with simple landfilling of sludge materials are quite varied. Surface water enrichment can occur when insufficient drainage measures have been taken. This situation results in the transport of nutrients to aquatic systems where deterioration of the system quality might occur.

Groundwater resources might be contaminated by nutrients and toxic materials should leaks occur in the landfill sealing structure. This is particularly important since the nature of landfill sites concentrate high quantities of hazardous material in confined areas. Rigid site control plans must be implemented at landfill sites to provide a measure of safety.

Landfill sites also restrict land-use options upon the site at the time of completion of landfill activities. The material placed in a landfill requires a period of time to settle and compact before a number of activities can occur on-site. Special construction procedures must be followed should structures be placed on these sites.

TRANSPORT

The four transport options considered for liquid, cake, dried sludge, or ash are truck, rail, barge, and pipeline. In addition to costs, a number of common non-economic variables must be addressed during an option consideration.

Barge and rail hauling generally applies only to MSD-Jones Island and MSD-South Shore, as other plants are not located near a waterway or rail line, or are too small to be considered for these options. Rail and barge haul would generally involve the use of established transportation corridors and would be expected to have a minimum impact, as the activity level would not be increased much above that already experienced in the corridors. Barges are reasonably flexible on the lake shore, while rail lines, except for abbreviated side tracking, would follow existing corridors. In contrast to barge or rail haul, requiring the use of established corridors, trucks may travel a myriad of roadways and, to a limited extent, the pathways and fields off the established public roadway. As there are no pipelines currently available for sludge transport, it is required that new pipeline corridors be established where this option is used. Pipelines require much capital investment, and disturbance due to construction may be high. Once in place, pipelines are inflexible. Overall, trucks appear to offer the most flexibility, and pipelines, the least.

Trucks and trains would be expected to create more noise and visual nuisance than barges or pipelines. Trucks are generally the most energy intensive mode. Trucks can be disturbing, as regards noise and aesthetics, when hauling is through residential areas. Thus, route choice is a critical factor.

A system of trucks, rail cars, or barges is less limited by component failure than a pipeline, but these three more labor intensive modes may be more vulnerable to labor unrest.

Near rural land application sites, it is unlikely that pipeline would be the sole means of transport. Spreading would still be accomplished by some mobile equipment. Therefore the pipeline competes with truck only for the long haul portion of the journey. Trucks, railcars, and barges are salvageable for other similar uses, while once built, a pipeline is committed for life.

Overall, trucks appear to be the most acceptable operating mode with supplemental rail or barge used where established corridors permit. Pipelines involve much unsalvageable capital investment except where transport is between processing components or where pipeline is in combination with trucking.

Update

Facts for Citizens Interested in Clean Water In Southeastern Wisconsin

February 1977

Sludge—not a very nice-sounding name. And besides that, sludge has traditionally been a problem, a bother and something to get rid of.

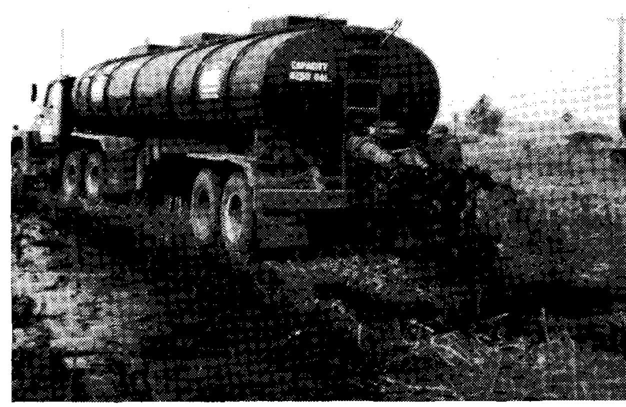
What is sludge?
Sludge is the solid matter left over when wastewater goes through treatment.

State and federal laws require that communities treat wastewater through a two- or three-step process. This wastewater comes from municipal sewage and industrial processes.

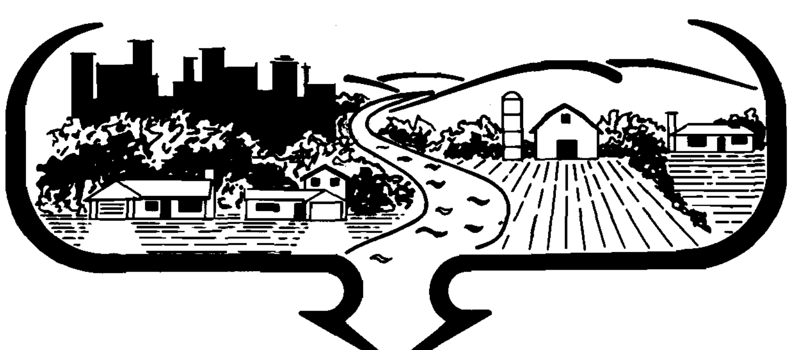
Most wastewater leaves the treatment process as effluent—essentially clear water with low concentrations of plant nutrients and other compounds. Disinfection methods are used to destroy disease organisms left in effluent, which is then discharged into a river or stream.

The solids taken out during the treatment process make up sludge. Sludge itself is still mostly water, and only 3 to 6 percent solids. But these solids contain valuable plant nutrients and other chemical elements and compounds.

So sludge, funny name or not, is attracting attention as a resource. Instead of disposing of sludge, people are considering an increase in the use of sludge as fertilizer—recycling the nutrients and organic matter in sludge instead of throwing them away.



Communities may find that applying sludge to farm land is the best sludge management alternative.



UNIVERSITY OF WISCONSIN EXTENSION PROGRAMS
Working With
THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Why the interest now?
There are several reasons. At this time, local governments along with the Southeastern Wisconsin Regional Planning Commission are dealing with alternatives and plans to clean up local waters—rivers, lakes, and streams. The federal Water Pollution Control Act—specifically section 208—guides these efforts.

A big part of the 208 clean water objectives is improving the treatment of wastewater. So with this upcoming increase in wastewater treatment, the quantity of sludge generated will increase as well.

In the past, communities disposed of sludge on land, in landfills, or through drying the sludge and then burning it in special incinerators. But new sites for landfilling are difficult to find, and incinerator fuels are now expensive. In addition, landfills pose the danger of contaminating groundwater, and some methods of incineration can cause air pollution.

Faced with the disposal of increasing amounts of sludge, communities are looking more and more to the alternative of applying sludge on farm land.

Sludge contains the major plant nutrients, nitrogen, phosphorus, and potassium, as well as trace elements.

The organic matter in sludge helps plants by improving the soil's physical condition and increases soil's ability to hold nutrients and absorb water.

And sludge benefits to plants extend beyond one growing season. As sludge breaks down, it releases nitrogen and other nutrients gradually, like a "slow release" fertilizer.

Put to the test
University of Wisconsin-Madison researchers from the Department of Soil Science recently tested sludge as a fertilizer for crops in several experiments. The researchers applied varying amounts of sludge to different soil types in different areas of the state.

Based on test results, the researchers drew this general conclusion: sludge application significantly improved the yields of corn, rye, and sorghum-sudan. The yields obtained using sludge as fertilizer were comparable to yields from commercial fertilizer.

Without additional application of sludge or fertilizer, the sludge plots gave significantly higher yields than commercial fertilizer plots the second year. This difference was due to sludge's slow release action.

The following table shows corn yields as affected by sludge at a Janesville, Wisconsin, testing site. Informal experiments by farmers in the Southeastern Wisconsin Region have found similar results.

Tons per Acre of Sludge (dry weight basis)[a]	1st Year (1972) bushels of corn/acre	2nd Year (1973)
0 Control	55	37
3.5	82	53
7.0	84	42
14.0	**101**	**44**
21.0	93	48
Water only[b]	64	45
Fertilizer[c]	**102**	**23**

[a] *Researchers applied sludge in late fall prior to planting the first year of corn. No additional sludge was applied.*

[b] *Water was applied at a rate equivalent to that applied with 10.5 tons per acre of sludge (3 acre-inches).*

[c] *Researchers treated plots once with 325 + 220 + 100 lbs/acre of N + P_2O_5 + K_2O commercial fertilizer prior to planting the first year of corn.*

Working sludge into the soil immediately after application minimizes odor.

Of 61 treatment plants in our area, about 50 spread at least part of their sludge on land. These plants include Kenosha, Milwaukee-South Shore, Hartford, and Waukesha.

Concerns and Limits

Odor. Along with the benefits of sludge as an agricultural fertilizer come some drawbacks. Sewage sludge often has an odor which some people find unpleasant. This can be greatly overcome by selecting fields away from populated areas and by immediately working the applied sludge into the soil, or using special equipment to inject the sludge directly into the soil. In addition, sludge is usually applied to each site only once during a year.

Heavy metals. Sludge also contains elements such as zinc, copper, nickel, arsenic, cadmium, and mercury, often from industrial wastewater. Plants need some of these as nutrients.

However, while low concentrations of trace nutrients are vital to plant growth, high concentrations—particularly of the heavy metals arsenic, cadmium, and mercury—may be toxic to plants or to the animals and humans that consume the plants. Whether concentrations of these elements become undesirably high in soil and plants due to sludge application depends on several factors: the amounts of elements in sludge, since this varies widely among communities; how often sludge is applied to one field, and how heavily sludge is applied.

Build-ups of heavy metals in soils and plants can be avoided by analyzing sludge for the concentrations of these elements and then controlling the amount of sludge applied to fields accordingly.

Disease-causing organisms. Wastewater treatment destroys up to 99.9 percent of all disease-causing organisms. Some organisms still remain in raw sludge. But after the sludge is stabilized, any remaining organisms die off or become inactive soon after sludge is applied to the soil. If farmers keep children and animals out of the fields for several weeks after applying the sludge, danger from these organisms is very minimal.

Soil compaction. Applying sludge to fields may give farmers another concern. Trucks and other equipment for sludge application are heavy, and may compact the soil. But if sludge is later worked into the soil as recommended, this will overcome any compaction problems. It's also best to avoid using sludge application equipment on overly wet soil.

Soil limitations. Some soils to avoid are those with steep slopes, high water tables or shallow bedrock, or very sandy soils. In these cases, sludge might contaminate surface water through runoff or pollute the groundwater.

Weather and Field location. Winter weather often prevents spreading operations, so facilities to store sludge are necessary. Also, farm fields should be relatively close to wastewater treatment plants where sludge originates, to minimize hauling expenses.

Is it worth it?

These problems and limitations need attention and careful consideration before applying sludge to farm fields is completely practical. But application to farm land might still be the most economical and directly beneficial way to manage sludge.

Not only does the general public save money through this alternative, but farmers save considerably, since commercial fertilizer costs have increased greatly. So land application offers communities a cheaper way to dispose of sludge and offers farmers a source of nutrients and organic matter for their soils and crops.

How does this affect the non-farmer?

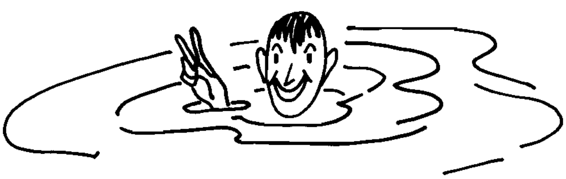
How communities manage sludge may mean several things to the non-farmer: will taxes increase due to costlier disposal methods? Will proper consideration be given to safe land application? Will scarce space be used as landfill sites? Is dewatering sludge and processing it as commercial fertilizer more efficient?

Ask your local officials about plans for sludge disposal in your community. Attend public meetings about sewage treatment for your community or meetings about water quality planning through your local University of Wisconsin-Extension office. Help to show your concern by submitting a written statement of your interests and opinions to your local officials.

If you have questions or desire more information about the Areawide Water Quality Management Plan in southeastern Wisconsin, contact:

Gary W. Jackson
UWEX Water Quality Education Agent
Southeastern Wisconsin Regional
Planning Commission
916 N. East Avenue
P. O. Box 769
Waukesha, Wisconsin 53186

Telephone 414/547-6721



Appendix M

SUMMARY OF COMMENTS MADE AT PUBLIC INPUT MEETING ON SLUDGE MANAGEMENT ALTERNATIVES

April 14, 1977
West Bend, Wisconsin

The first in a series of three public input meetings on Sludge Management Alternatives was held in West Bend, Wisconsin on April 14, 1977. In attendance at the meeting were about 40 people representing concerned citizens. Following an introduction by Maurice Houland, the Washington County University of Wisconsin Extension Agent and presentation by Gary Jackson, University of Wisconsin Extension Agent working in cooperation with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) Lyman Wible, SEWRPC 208 Project Coordinator, David R. Horsefield, Senior Vice President of Camp Dresser & McKee Inc. (CDM) and William Swanson, Project Engineer for CDM, questions and comments from the audience were accepted. Following below is a summary of the points raised.

1. After explaining that sludge is available everyday and up to six months of storage might be required if the sludge cannot be utilized immediately it was commented that farmers might be unwilling to take on the added responsibility of storing sludge.

2. Concern over buffer zones was raised by several individuals. Special concern was addressed to the buffer zones being considered for separating landspreading operations from residential properties.

3. In discussing the health and safety aspects of land application concern was raised over pathogenic organisms and heavy metals. The medical doctors in Hartford are concerned about Coliforms in sludge.

4. A representative of the League of Women Voters voiced the opinion that it appeared that SEWRPC was predisposed to landspreading as the final alternative and was not considering composting.

5. The local extension agent commented that sludge should be valued for its soil conditioning properties, not its nutrient content.

6. The definition of suitable land for sludge application was discussed.

7. A treatment plant operator indicated that he had more farmers willing to accept sludge than he had sludge to dispose of. However, the farmers are willing to accept sludge as it fits their croping schedule.

8. Another representative of the League of Women Voters asked about incineration of sludge and energy recovery. Additional questions were raised about ash disposal and air pollution.

9. There was discussion of the lack of regulations for controlling the landspreading of raw animal manure.

10. There was discussion on the cost of producing Milorganite and the advisability of committing energy resources to such a use in light of the growing energy shortages.

11. A farmer commented that farmers would not accept sludge until proven locally, maybe through a demonstration program.

12. In reference to incorporation of sludge, the treatment plant operators said local practice varied

from full incorporation to surface application without incorporation.

13. A farmer commented that he had sludge applied to his hay crop after the first cutting and attributed the second cutting to the water content of the sludge.

14. A farmer asked who was liable if a problem develops after using sludge, such as rendering land unfit for agricultural use.

15. The comment was made that more technical information had to be made available to local officials.

SUMMARY OF COMMENTS MADE AT PUBLIC INPUT MEETING ON SLUDGE MANAGEMENT ALTERNATIVES

April 26, 1977
Waukesha, Wisconsin

The second in a series of three public input meetings on Sludge Management Alternatives was held on April 26, 1977 in Waukesha, Wisconsin. In attendance at the meeting were about 30 people representing local units of government, farmers, and concerned citizens. The meeting was moderated by Gary Jackson, University of Wisconsin Extension agent working in Cooperation with Southeastern Wisconsin Regional Planning Commission (SEWRPC). Presentations were made by Lyman Wible, SEWRPC 208 Project Coordinator, David R. Horsefield, Senior Vice President of Camp Dresser & McKee Inc. (CDM) and William R. Swanson, Project Engineer fro CDM. Following the presentations, comments and questions from the audience were accepted and are summarized below.

1. A member of the audience asked who checks on land application operations and how often. Another person indicated that supervision of landspreading operations was a major concern of the public.

2. There was discussion as to who would issue variances to regulations on landspreading.

3. A comment was made about the impact of large sludge hauling trucks on rural roads.

4. A person in the audience asked what were the procedures used to select a landfill site.

5. A gentleman in the audience asked if the report being prepared by CDM would contain sludge quality data and analysis of the sludge for heavy metals, and will the report contain guidelines for the maximum levels of metals that are considered safe.

6. What restrictions exist on sludge use near waterways was asked.

7. A comment was made that fear of the unknown was a major problem with sludge use.

8. The energy value of sludge was questioned.

9. A member of the audience asked if the sludge management plan would dictate a single solution for the entire region or if there would be a diversity of methods proposed.

10. A concern over odor problems was raised.

11. A person asked about composting.

12. The land required for land application of sludges was asked about.

13. There was discussion of pretreatment of industrial wastes.

SUMMARY OF COMMENTS MADE AT PUBLIC INPUT MEETING ON SLUDGE MANAGEMENT ALTERNATIVES
April 28, 1977
Somers, Wisconsin

The last in a series of three public input meetings on Sludge Management Alternatives was held in Somers, Wisconsin on April 28, 1977. In attendance at the meeting were about 40 people representing local units of government, sewerage treatment plants, farmers, sludge haulers, and concerned citizens. Mr. Paul Jaeger, the Kenosha County University of Wisconsin Extension agent acted as the meeting moderator. Presentations were made by Gary Jackson, University of Wisconsin Extension Agent working in cooperation with the Southeastern Wisconsin Regional Planning Commission (SEWRPC), Lyman Wible, SEWRPC 208 Project Coordinator, David R. Horsefield, Senior Vice President of Camp Dresser & McKee (CDM) and William Swanson, Project Engineer for CDM. Following the presentations, questions and comments from the audience were accepted and are summarized below.

1. The effect or impact of the breweries on sludge was questioned.

2. A member of the audience asked about the odor associated with sludge.

3. There was discussion about a petition circulated last year concerning sludge on South Kenosha which was dumped and not incorporated.

4. Mr. Jaeger commented that the odor associated with sludge is comparable to other odors associated with farming.

5. A sludge hauler said that composting reduces the heavy metal problem by stabilizing the compounds. He added that some farmers work their crop schedules to fit the availability of sludge.

6. There was discussion of the handling of septic and holding tank wastes and industrial sludges.

7. A member of the audience asked if drying sludges was advisable to cut down on transportation costs.

8. A farmer commented that he had used sludge and that its beneficial effects were readily noticeable. In an informal test, he said that no harmful effects were noticed when he spread sludge near a pond. He added that spreading equipment was in need of improvement such as water tight trucks for hauling and a speed beater for the spreader. He suggested that the sewerage treatment plants provide the spreading equipment. A second farmer agreed with the comments on equipment.

9. A sewerage treatment plant operator said that the plants were trying to keep their costs down and providing spreading equipment would only increase costs.

10. A farmer commented that he would not accept sludge again unless the plant supplied the equipment.

11. The sludge hauler advocated the use of low loading rates until sludge quality improves.

12. The farmers in the audience commented that they had had no complaints about spreading sludge.

13. A local official said he received complaints when the sludge was not properly incorporated.

14. The use of sludge on vegetables and sweet corn was discussed.

15. A treatment plant operator said that tests on sludge after digestion were negative for salmonella.

16. A treatment plant operator said that he had no problem finding land for spreading if he went far enough away from the plant.

17. A sludge hauler commented that he was surprised at the lack of objection to sludge expressed at the meeting. He added that objections to sludge that had been raised elsewhere were based on fear of the unknown and are reduced with time and experiences.

18. A farmer commented that using sludge was too much work. The sludge tended to stick to the slats in the manure spreader. He also knew of a case where the sludge became too thick and greasy to spread.

19. A former fertilizer salesman indicated that Milorganite smells when wet.