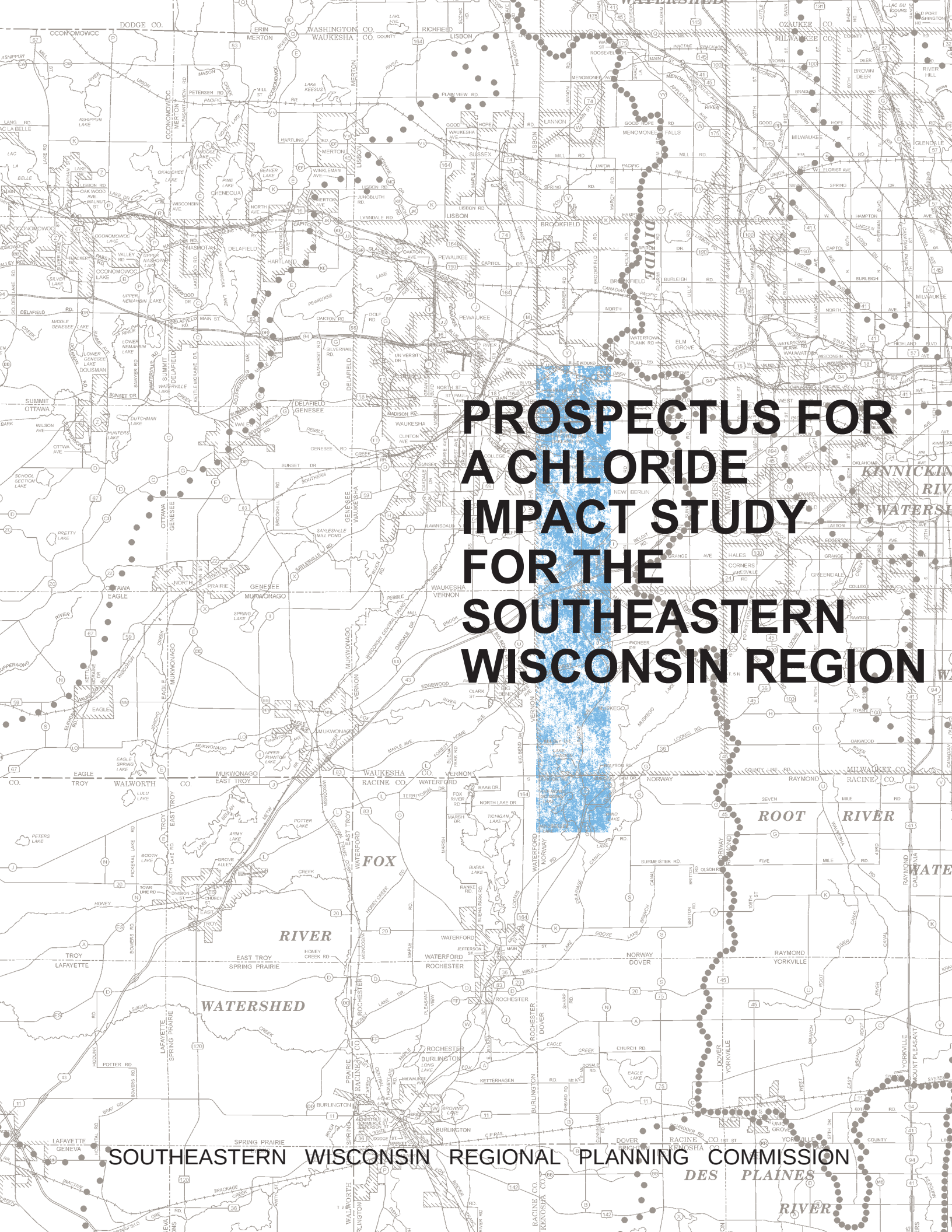

PROSPECTUS FOR A CHLORIDE IMPACT STUDY FOR THE SOUTHEASTERN WISCONSIN REGION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Dr. Thomas M. Slawski.....Chief Biologist

Special acknowledgment is due Dr. Joseph E. Boxhorn, Senior Planner; for his contributions to the preparation of this report.

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John Walker .....Center Director, U.S. Geological Survey

Thomas A. Wiza .....Director, Engineering and Public Works, City of Cedarburg

[1]*Prior to October 2015, Maureen A. McBroom, former Wisconsin Department of Natural Resources Stormwater Specialist, served on the Technical Advisory Committee.*

[2]*Prior to January 2016, Kevin M. Brunner, former Walworth County Director of Central Services, served on the Technical Advisory Committee.*

A CHLORIDE IMPACT STUDY FOR THE SOUTHEASTERN WISCONSIN REGION

Prepared by the

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

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Chapter I

INTRODUCTION

INTRODUCTION

At the Regional Planning Commission meeting held on March 19, 2014, Commissioner Nancy L. Russell, Chairman of the Walworth County Board, called attention to a growing public concern about the environmental impacts of the use of salt in winter road maintenance. She and Commissioner Charles L. Colman noted that this growing public concern was focused on the effects of the use of road salt on the surface and ground water resources of the area, particularly including inland lakes. At the conclusion of the discussion that ensued, it was the consensus of the Commission that the staff be directed to prepare a Prospectus for a comprehensive study of the environmental impacts of the use of road salt in winter road maintenance within the Region.[1] The prospectus, upon its completion and approval by the Commission, would be made available to the seven constituent county boards for their consideration.

The Commission direction to the staff recognized that public concern over the effects of the growing use of road salt has heightened in recent years, as evidenced by a number of national, state, and local study reports issued on the topic. The Commission further recognized that the issue affects all of the local units and agencies of governments—counties, cities, villages, and towns—constituting the Region, as well as certain State agencies and private enterprises. The Commission intended that the prospectus provide a focus for consideration of this issue by the interests concerned. The Commission subsequently acted to create a Technical Advisory Committee to assist in preparation of the prospectus. That Committee, the membership of which is set forth on the inside front cover of this document, worked with the Commission staff to produce this prospectus, which constitutes the Committee's recommendations to the Regional Planning Commission, the seven constituent county boards, the concerned local units of government, and the concerned State agencies.

During preparation of this prospectus, it became clear that other significant sources of chloride to the environment, in addition to road salt, must be considered under the proposed study. Thus, this prospectus is intended to specify the scope and content of a work program that would provide a comprehensive inventory of the historic and present sources of chloride loads to surface and groundwater resources; an assessment of the impacts

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[1] *During preparation of this prospectus, it became clear to the Commission staff that there are potentially several significant sources of chloride to the environment, including road salt. Thus, to adequately address the effects of chloride, the study would need to consider all significant sources of chloride. In recognition of that, the study title was changed to reflect a broader focus on chloride from multiple sources. The Commission Planning and Research Committee was notified of that change at its November 10, 2015, meeting, and the prospectus was presented to the full Commission at its December 2, 2015, quarterly meeting.*

of these loads on the environment, and in particular on the surface water and groundwater resources of the Region; identification of alternative means of achieving desired levels of management of sources of chloride; and the formulation of recommendations for abatement of the undesirable environmental impacts of the use of chloride. The work program is described in sufficient detail to permit the Commission, the seven constituent county boards, concerned State agencies, and local units and agencies of government to consider undertaking the study.

ABOUT THE COMMISSION

Authority

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) was established in 1960 under Section 66.945 (now Section 66.0309) of the Wisconsin Statutes as the official areawide planning agency for the urbanizing southeastern region of the State. The Commission was created to provide the basic information and planning services necessary to address problems which transcend the corporate boundaries and fiscal capabilities of the local units of government comprising the Region. Those problems include traffic congestion, flooding, air and water pollution, and changing land use, among others.

Area Served

The Commission serves the Southeastern Wisconsin Region, which consists of the seven counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha (see Map 1). These seven counties have an area of about 2,689 square miles, or about 5 percent of the total area of the State. These counties, however, have a resident population of over two million persons, or about 35 percent of the total population of the State, and contain about 1.2 million jobs, or also about 35 percent of the total employment of the State. The Region contains real property worth about $169 billion, or about 37 percent of all the tangible wealth of the State as measured by equalized valuation. There are 154 general-purpose local units of government in the Region, all of which participate in the work of the Commission.

Basic Concepts

Regional, or areawide, planning has become recognized as a necessary governmental function in all of the large metropolitan areas of the United States. This recognition stems from an awareness that problems of physical and economic development and of environmental deterioration transcend the geographic limits and fiscal capabilities of the local units of government comprising such large areas, and that sound resolution of these problems requires the cooperation of all units and agencies of government and of private interests as well.

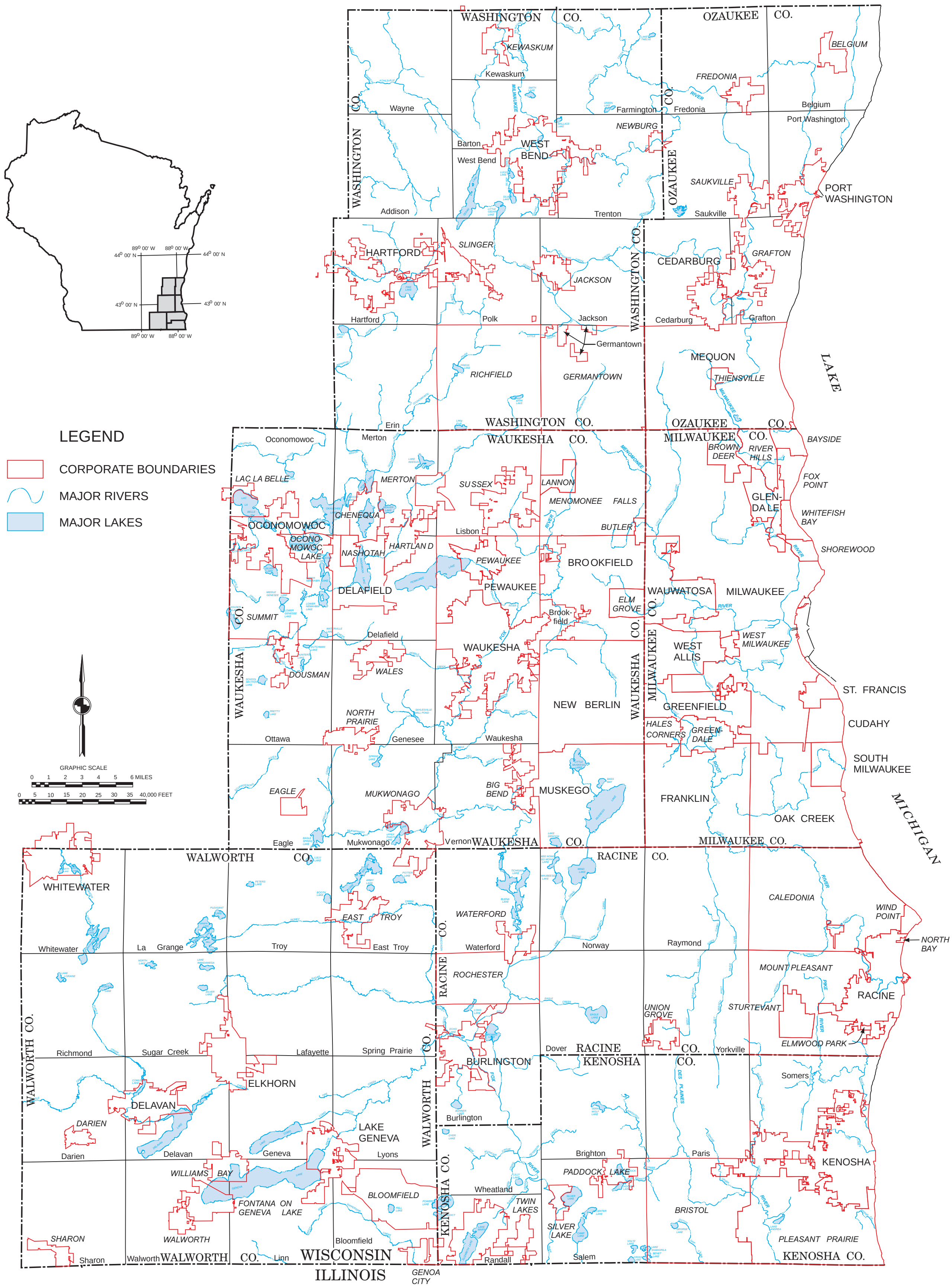
As used by the Commission, the term “region” means an area larger than a county but smaller than a state, united by economic interests, geography, and common developmental and environmental problems. A regional basis is necessary to provide a meaningful technical approach to the proper planning and design of such systems of public works as highway and transit, sewerage and water supply, and parks. A regional basis is also essential to provide a sound approach to the resolution of such environmental problems as flooding, air and water pollution, natural resource base deterioration, and changing land use.

Private as well as public interests are vitally affected by these kinds of areawide problems and by proposed solutions to these problems, and it appears neither desirable nor possible for any one level or agency of government to impose the decisions required to resolve these kinds of problems. Such decisions can better come from consensus among the public and private interests concerned, based on a common interest in the welfare of the entire Region. Regional planning is necessary to promote this consensus and the necessary cooperation among urban and rural; local, State, and Federal; and public and private interests. In this light, regional planning is not a substitute for Federal, State, county, or local public planning, or for private planning. Rather, regional planning is a vital supplement to such planning.

The work of the Commission is advisory in nature. Consequently, the regional planning program in Southeastern Wisconsin has emphasized the promotion of close cooperation among the various governmental agencies

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

concerned with land use development and with the development and operation of supporting public works facilities. The Commission believes that the highest form of areawide planning combines accurate data and competent technical analyses with the active participation of knowledgeable and concerned public officials and private citizens in the formulation of plans that address clearly identified problems. Such planning is intended to lead not only to a more efficient regional development pattern but also to a more desirable environment in which to live and work.

Basic Functions
The Commission conceives regional planning as having the following three basic functions:

- The collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis. The creation and use of such data can in and of itself contribute to better development decision-making in both the public and private sectors that operate in the Region.

- The preparation of a framework of long-range areawide plans for the physical development of the Region. Mandated by the State planning enabling legislation, the Commission places emphasis on the preparation of plans for land use and supporting transportation, utility, and community facilities.

- The provision of a center for coordinating day-to-day planning and plan implementation activities of all of the governments operating within the Region. Through this function, the Commission seeks to integrate regional and local plans and planning efforts and thereby to promote regional plan implementation.

Organization
The Commission consists of 21 members, three from each of the seven member counties. One Commissioner from each county is appointed or, in those counties where a County Executive appoints, confirmed by the County Board and by custom is an elected County Board Supervisor. The remaining two from each county are appointed by the Governor, one from a list prepared by the county. All appointments are for six-year terms.

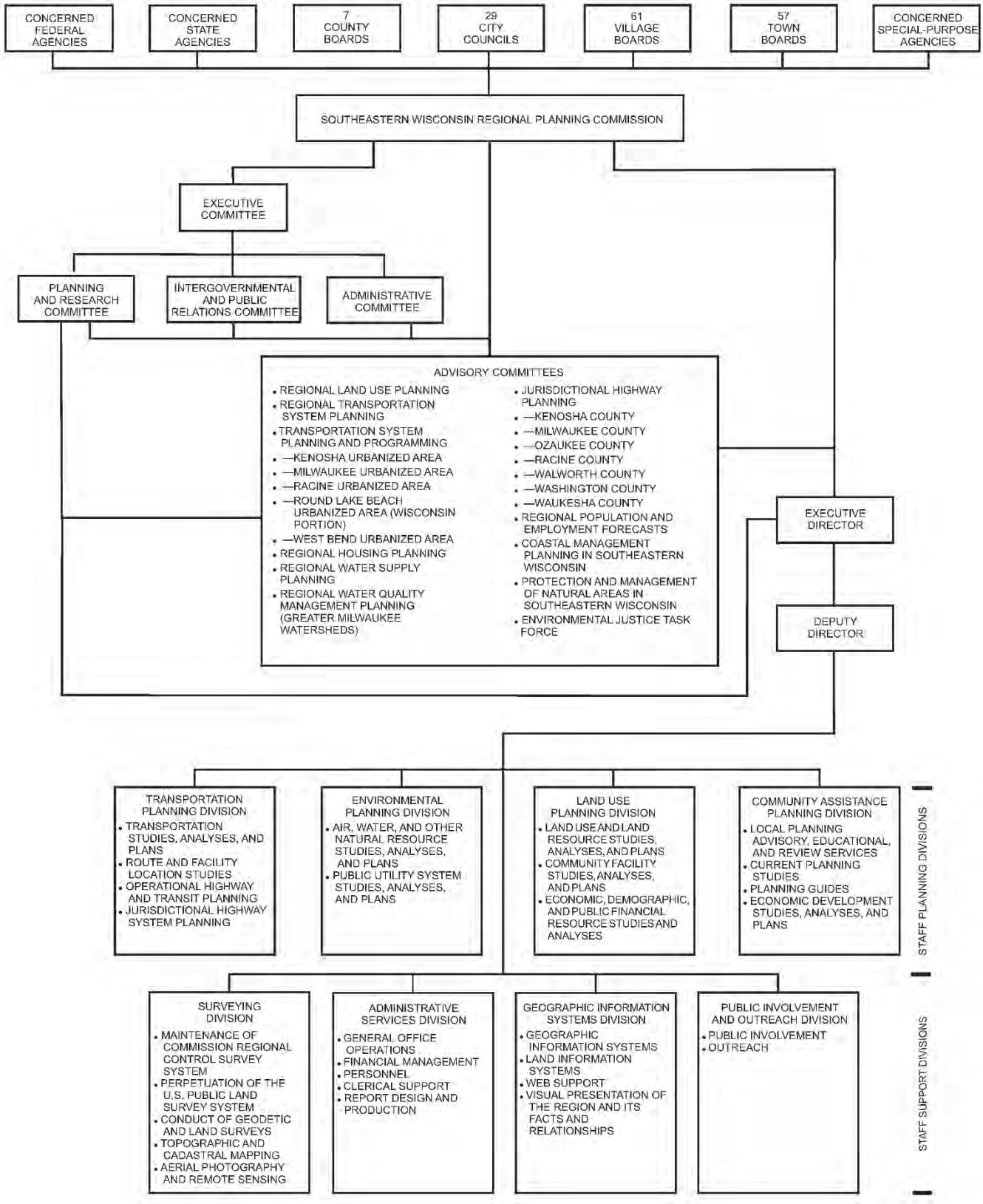
The Commission is assisted greatly in its work by Advisory Committees. These Committees include both elected and appointed public officials and interested citizens with knowledge in the Commission work program areas. The Committees perform a significant function in both the formulation and the execution of those work programs.

Staffing
The Commission prepares an annual work program which is reviewed and approved by Federal and State funding agencies. This work program is then carried out by a core staff of full-time professional, technical, and clerical personnel, supplemented by additional temporary staff and consultants as required by the various work programs under way. A Commission and staff organizational chart is provided in Figure 1.

Funding
Basic financial support for the Commission's work program is provided by a special property tax charge levied on local governmental units by the counties and apportioned on the basis of equalized valuation. These basic funds are supplemented by State and Federal aids.

Figure 1

SEWRPC ORGANIZATIONAL STRUCTURE: 2016



Source: SEWRPC.

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Chapter II

PURPOSE OF THE PROSPECTUS

The purpose of the prospectus is to explore the need for and recommend the means by which a technically sound and feasible regional chloride management program can be established for the Southeastern Wisconsin Region. The prospectus is intended to provide the information required to permit the levels, units, and agencies of government concerned to consider the benefits and costs of such a program and to determine the desirability of its execution.

More specifically, this Prospectus is intended to:

1. Establish the need for and purpose of a regional study of the environmental impacts of chloride on surface water and groundwater resources;

2. Identify the scope and content of the needed study, the work required to be undertaken to properly carry out the study, and to document the findings and recommendations of the study;

3. Recommend the most feasible means for organizing and accomplishing the required work;

4. Recommend a practical time sequence and schedule for the work; and

5. Recommend a budget for the required work program, including identification of potential sources of funding.

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Chapter III

NEED FOR STUDY

INTRODUCTION

Chloride loads to surface and groundwater resources can potentially come from several significant sources, including road salt applied for anti-icing and deicing of public and private roads, sidewalks and parking lots; water softening systems and other sources that discharge to sanitary sewers or private onsite wastewater treatment systems; salt storage areas; large agricultural feed lots; fertilizers; landfills; chemical manufacturing, and food processing. The proposed study will consider the relative magnitudes of chloride loads to the environment from those sources, and any other significant sources identified during the course of the study. Salt applied to roads is the most visible of the potential chloride sources, and thus, receives the most public attention.

The now widespread practice of providing snow-and-ice free dry pavement surfaces through enhanced winter road maintenance practices came into being in the mid-1950s. Prior to World War II, snow pack was generally permitted to accumulate on pavement surfaces, and it was common practice to utilize chains on automobile and truck wheels to provide traction. Later it was common to use studded tires for traction. Some urban residents placed their automobiles into winter storage, and utilized the well-developed streetcar, electric interurban railway, and steam railway systems for daily transportation. The shift to dry pavement winter road maintenance practices required the use of road salt to facilitate snow and ice removal from pavement surfaces.

As the number of lane miles of public streets and highways expanded within southeastern Wisconsin, as public expectations of safe, high-quality winter road operating conditions grew, and as the attendant use of road salt in winter road maintenance practices increased, public concern over the environmental impacts of the use of road salt developed. Road salt can damage metal and concrete, thereby affecting the condition of motor vehicles and the structural integrity of roadway pavements and street and highway bridges. Road salt can damage roadside vegetation, and change soil structure and fertility. Road salt in runoff, along with chloride from other sources as described above, enters streams and watercourses and accumulates in lakes, reservoirs, and wetlands, thereby harming aquatic plants and animals. Chloride from multiple sources, including road salt, may also enter and accumulate in groundwater. To the extent that chloride accumulates in surface and groundwater sources of drinking water, it may affect human health. There may also be considerations regarding consumers' perceptions of the taste of drinking water containing elevated levels of sodium and chloride. Wildlife is also prone to ill effects from ingesting chloride by drinking surface waters and, particularly by drinking runoff from snow and ice melt. Certain additives to road salt—such as ferrocyanide used to prevent caking—contribute to the water pollution. Water contaminated by chloride will settle in the deepest parts of lakes and reservoirs, leading to chemical stratification, impediment of annual turnover and mixing, and prevention of dissolved oxygen from reaching the lower layers of the waterbody which may become unable to support aquatic life.

Chloride Concentrations in Surface Waters

Data that could be used to characterize historical and existing chloride concentrations in surface waters of the Region are available from several sources. The earliest systematic sampling of surface waters in southeastern Wisconsin was conducted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) during a 14-month period extending from January 1964 through February 1965.[1] This study collected monthly samples at 87 sampling stations on 43 streams. Many of these samples were analyzed for chloride concentrations and/or specific conductance which can be used as a surrogate for chloride concentration. Following this study, the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources (WDNR) to undertake a continuing stream water quality monitoring program in the Region.[2] Between 1968 and 1975, this program regularly collected samples at the same sampling stations as the earlier study. At a few stations, data collection extended into 1976 and 1977. Many of the samples collected for this program were analyzed for chloride and/or specific conductance. The data collected as part of these studies can serve as a baseline for examination of trends in chloride concentrations in streams of the Region. Several other agencies and programs collect water quality monitoring data within the Region that include either chloride or specific conductance and make these data publicly available. Data collected by U.S. Geological Survey (USGS) are available in the USGS NWIS database. Data collected by the WDNR are available in both the WDNR SWIMS database and the U.S. Environmental Protection Agency (USEPA) STORET databases. Data collected by the Milwaukee Metropolitan Sewerage District (MMSD) are available in the MMSD/USGS Corridor Study Database.

The findings of several studies provide evidence that chloride concentrations have been increasing in surface waters of the Southeastern Wisconsin Region. Increases have been documented through long-term water quality monitoring of streams and rivers. Figure 2 shows chloride concentrations from samples collected at various times from spring through fall at nine water quality monitoring stations located along the Milwaukee River during the period 1975 through 2004.[3] The data from each of the eight monitoring stations for which long-term data sets are available show strong trends toward increasing concentrations of chloride in the River. Recent work suggests that this trend has continued beyond 2004. Figure 3 shows chloride concentrations from samples collected generally from spring through fall at nine water quality monitoring stations located along the Root River during the period 1964 through 2012.[4] The data show that chloride concentrations have increased at all four stations for which long-term data are available. Increases in chloride concentrations over time have been documented in other streams and rivers in the Region.[5]

The findings of a recent study suggest that there may be a widespread trend toward increasing chloride concentrations in streams of the northern United States.[6] This study examined 30 sites on 19 streams, including sites on the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers within the Southeastern Wisconsin Region

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[1]*SEWRPC Technical Report No. 4,* Water Quality and Flow of Streams in Southeastern Wisconsin, *November 1966.*

[2]*SEWRPC Technical Report No. 17,* Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975, *June 1978.*

[3]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

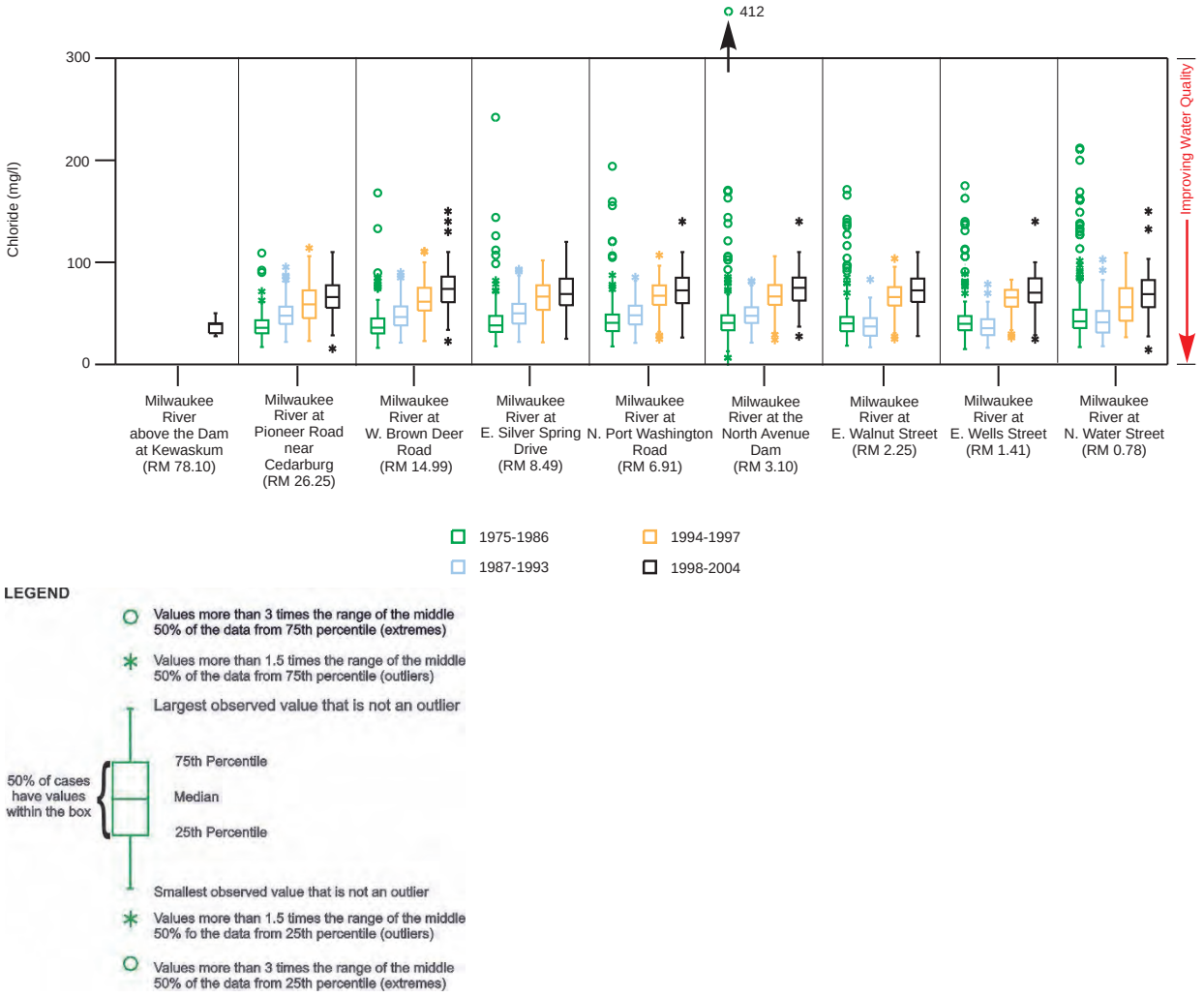
[4]*SEWRPC Community Assistance Planning Report No. 316,* A Restoration Plan for the Root River Watershed, *July 2014.*

[5]*SEWRPC Technical Report No. 39, op. cit.*

[6]*Steven R. Corsi, Laura A. De Cicco, Michelle A. Lutz, and Robert M. Hirsch, "River Chloride Trends in Snow-Affected Urban Watersheds: Increasing Concentrations Outpace Urban Growth Rate and Are Common Among All Seasons,"* Science of the Total Environment, *Volume 508, 2015, pages 488-497.*

Figure 2

CHLORIDE CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004



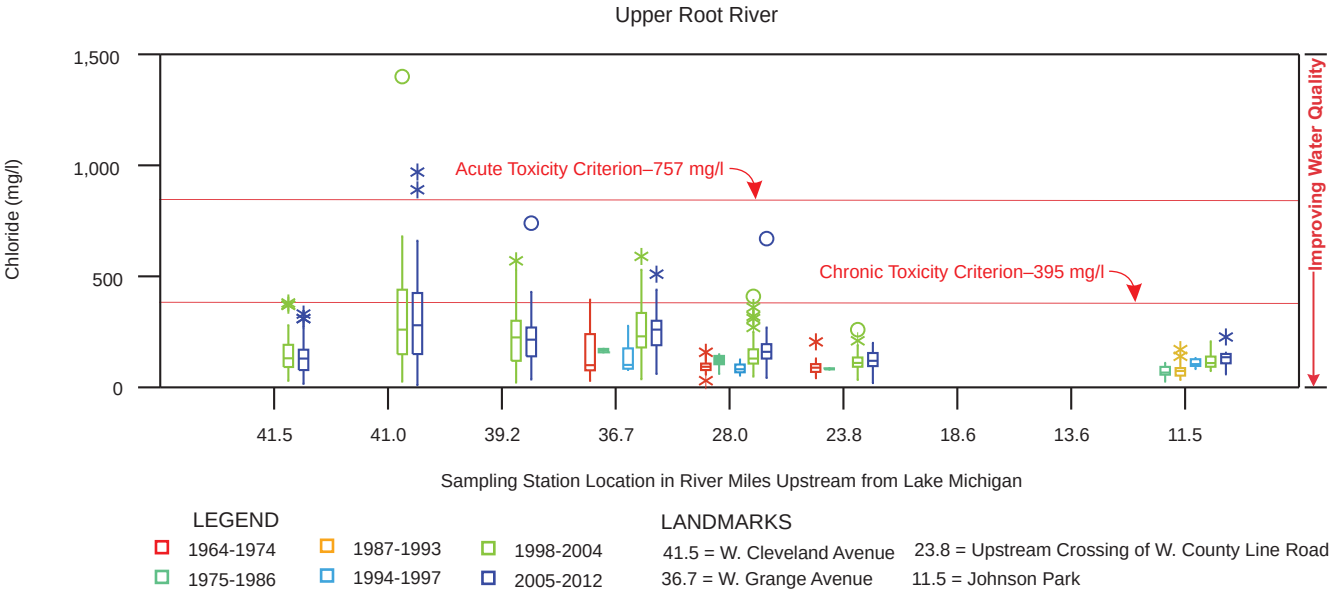
NOTE: The acute toxicity criterion for fish and aquatic life is 757 mg/l, and the chronic toxicity criterion for fish and aquatic life is 395 mg/l.

Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

and sites on the Des Plaines, Fox, and Rock Rivers located downstream from the Southeastern Wisconsin Region. The study examined trends in chloride concentrations over the period from 1980 through 2010 using statistical techniques which can account for the dependence of chloride concentrations upon season of the year and level of streamflow. The study found that chloride concentrations increased over time in most of the streams that were located in the northern United States that were examined. Increasing concentrations were documented in the Des Plaines, Fox, Kinnickinnic, Menomonee, Milwaukee, Rock, and Root Rivers. While the largest increases in chloride concentrations occurred during winter months, increases were found to occur in all seasons of the year. Instream chloride concentrations were related to the percent of urban land cover within the watershed, with higher concentrations being associated with higher percentages of urban land cover. The study also found that this relationship changed over time with chloride concentrations increasing at a faster rate than the rate of urbanization. In fact, the study found that for the same level of urban land cover, chloride concentrations from the

Figure 3

CHLORIDE CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE ROOT RIVER: 1964-2012



NOTE: See Figure 2 for description of symbols.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

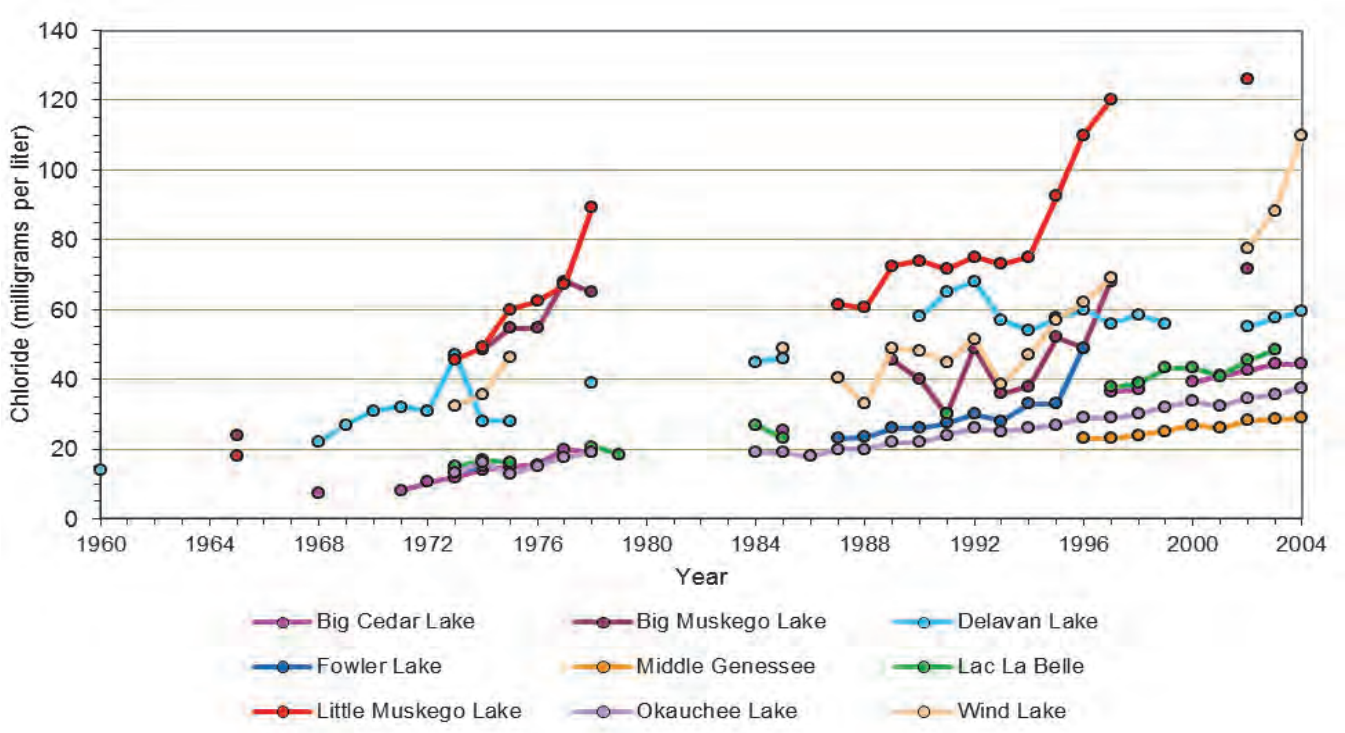
period 2006 through 2010 were about double those from the period 1990 through 1994. The study discussed several factors that could account for the changing relationship between chloride concentrations and percent urban land cover. It concluded that it is likely that some of this increase is due to increases in the amount of salt being applied per unit urban area, noting that the increase in road salt sales in the northern U.S. outpaced the rate of increase in urban land cover by about 40 percent over the study period. Finally, the study found that the relationship between urban land cover and the number of days that chloride concentrations would be expected to exceed the USEPA recommended chronic toxicity water quality criterion of 230 mg/l changed over the study period, with the number of exceedances for a particular percent urban land cover being greater during the latter portion of the study.

Similar increases in chloride concentrations have been observed in lakes located in the Region. Figure 4 shows chloride concentrations in samples collected from nine lakes during the period 1960 through 2004.[7] Increasing concentrations were observed in all nine lakes. In some lakes, the increase was dramatic. For example, concentrations of chloride in Little Muskego Lake increased from less than 20 milligrams per liter (mg/l) in 1962 to over 120 mg/l in 2001.

[7]*SEWRPC Community Assistance Planning Report No. 315,* A Water Resources Management Plan for the Village of Chenequa, Waukesha County, Wisconsin, *June 2014.*

Figure 4

CHLORIDE CONCENTRATIONS IN SELECTED LAKES WITHIN SOUTHEASTERN WISCONSIN



Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

Additional data are available indicating that chloride concentrations have increased over time in other streams and lakes and in groundwater in Southeastern Wisconsin, such as Oak Creek and Lincoln Creek,[8] the Milwaukee outer harbor,[9] the nearshore Lake Michigan area,[10] 31 additional Southeastern Wisconsin lakes,[11] and shallow groundwater at several monitoring wells in Southeastern Wisconsin.[12] Similar increases have been documented at other location in Wisconsin, including the Yahara lakes[13] and public water supply wells in the Madison area.[14]

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[8]*SEWRPC Technical Report No. 39*, op. cit.

[9]Ibid.

[10]Ibid.

[11]*Jeffrey A. Thornton, Thomas M. Slawski, and Hebin Lin, "Salinization: The Ultimate Threat to Temperate Lakes, with Particular Reference to Southeastern Wisconsin (USA),"* Chinese Journal of Oceanology and Limnology, *Volume 33, pages 1-15, 2015.*

[12]Ibid.

[13]*Richard C. Lathrop, "Chloride and Sodium Trends in the Yahara Lakes,"* Resource Management Findings, *No. 12, Wisconsin Department of Natural Resources, June 1988; Rick Wenta and Kristi Sorsa,* Road Salt 2013: Where's the Balance?, *Public Health Madison and Dane County, January 3, 2014.*

[14]*Rick Wenta and Kristi Sorsa 2014*, op. cit.

Table 1

PERIODS WHEN CALCULATED CHLORIDE CONCENTRATION IN STREAMS OF THE MENOMONEE RIVER WATERSHED EXCEEDED 1,400 MILLIGRAMS PER LITER FOR FOUR DAYS OR MORE: NOVEMBER 2008 TO JULY 2011

Stream	Length (days)	Calculated Chloride Concentrations (milligrams per liter)						
		Lowest Daily Minimum	Highest Daily Minimum	Lowest Daily Maximum	Highest Daily Maximum	Lowest Daily Mean	Highest Daily Mean	Average over the Period
Honey Creek at Wauwatosa								
December 6, 2008-December 13, 2008	8	1,715	3,348	2,724	6,589	1,998	4,630	3,448
January 8, 2009-January 12, 2009	5	1,417	3,087	2,223	4,230	1,882	3,577	2,613
January 18, 2009-January 22, 2009	5	1,420	1,613	1,969	2,727	1,733	2,179	1,917
February 9, 2010-February 14, 2010	6	1,504	2,266	1,972	4,775	1,734	3,021	2,519
February 17, 2010-March 2, 2010	14	1,410	3,326	1,751	6,227	1,577	4,266	2,421
December 22, 2010-December 25, 2010	4	1,566	5,718	2,226	7,933	1,842	6,590	3,742
January 11, 2011-January 21, 2011	11	1,613	3,904	2,383	7,679	2,092	6,227	3,522
January 28, 2011-February 15, 2011	19	1,456	3,504	2,001	5,573	1,725	3,904	2,542
February 21, 2011-February 28, 2011	8	1,929	2,680	2,963	4,448	2,426	3,831	3,024
Underwood Creek at Wauwatosa[b]								
February 21, 2011-March 1, 2011	9	1,413	1,940	1,649	2,869	1,507	2,383	1,833

[a]*Chloride concentrations were calculated from specific conductance using the regression equation from Corsi* et al. *(2010). The regression equation is based on data from 17 Wisconsin streams. The regression equation is* Cl = 0.363 X Sc – 271*, where Cl is the concentration of chloride in milligrams per liter and Sc is the specific conductance in microSiemens per centimeter. This equation is considered valid for chloride concentrations greater than 230 milligrams per liter, which is equivalent to a specific conductance of 1,380 in microSiemens per centimeter.*

[b]*Period of record at this site was February 12, 2010 through July 26, 2011.*

Source: SEWRPC.

Analyses in a recent study indicate that concentrations of chloride in some streams of the Region during the winter may be reaching levels capable of causing substantial toxic effects to aquatic organisms.[15] This study first reviewed the toxicology literature to assess the acute toxicity of sodium chloride to freshwater organisms. This assessment was based upon a standard toxicological measure, the LC50 in 96-hour toxicity tests.[16] While this review found that there is considerable variability among organisms in their sensitivity to chloride, with one exception, all the LC50s were equal to or greater than an equivalent chloride concentration of 1,400 milligrams chloride per liter (mg Cl^-/l). Two aspects of this threshold in LC50 values are significant. First, this threshold concentration is considerably greater than the State of Wisconsin's acute toxicity criterion for chloride of 757 mg Cl^-/l. Second, this threshold concentration represents a concentration at which populations of aquatic organisms are experiencing substantial toxic effects. Appreciable acute toxic effects may be expected to occur at concentrations that are lower than the LC50.

The study used continuous monitoring data for specific conductance collected at six sampling stations located along streams in the Menomonee River watershed to estimate chloride concentrations during the winter. These estimates were made using a regression relationship developed for Wisconsin streams by the U.S. Geological Survey.[17] At each of the stations, periods during which the daily minimum concentration of chloride exceeded 1,400 mg Cl^-/l for four days or more were identified. The results are shown in Table 1. At one monitoring station

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[15]*SEWRPC Memorandum Report No. 204*, Development of a Framework for a Watershed-Based Municipal Stormwater Permit for the Menomonee River Watershed, *January 2013.*

[16]*The LC50 is the concentration at which 50 percent of the test organism die over the duration of the test. A higher LC50 indicates lower toxicity to the organism, while a lower LC50 indicates greater sensitivity to the toxin.*

[17]*S.R. Corsi, D.J. Graczyk, S.W. Geis, N.L. Booth, and K.D. Richards, "A Fresh Look at Road Salt: Aquatic Toxicity and Water-Quality Impacts on Local, Regional, and National Scales,"* Environmental Science & Technology, *Volume 44, pages 40-46, 2010.*

along Honey Creek, nine periods were identified in which chloride concentrations exceeded this threshold for four or more days. At another monitoring station along Underwood Creek, one such period was identified. The length of these periods varied between four and 19 days. No such periods were identified at four other monitoring stations. The study reached two conclusions relative to chloride concentrations in streams. First, in some streams of the Region chloride concentrations during the winter road maintenance season appear to achieve and remain at levels that are associated with acute toxic effects for extended periods of time. Second, based on the size and location of the streams in which these periods of high chloride were identified, chloride concentrations may be expected to reach higher levels in smaller streams that are located in highly urbanized areas than they do in larger streams and streams located in less urbanized areas.

Acute toxicity is not the only toxic effect associated with chloride. Chronic exposures to elevated concentrations of chlorides have been shown to produce sublethal toxic effects in aquatic organisms. Examples of effects that have been reported include reductions in reproduction by water fleas,[18] oligochaete worms,[19] rotifers,[20] ciliates[21] and clams;[22] changes in the time needed to reach maturity in water fleas[23] and frogs;[24] reduced survival of fathead minnow eggs;[25] immobilization of zooplankton;[26] and reduced rates of seed germination in aquatic plants.[27]

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[18]*K.E. Biesinger and G. M. Christiensen, "Effects of Various Metals on Survival, Growth, Reproduction and Metabolism of Daphnia magna,"* Journal of the Fisheries Research Board of Canada, *Volume 29, pages 1691-1700,. 1972; W.J. Birge, J.A. Black, A.G. Westerman, T. W. Short, D.M. Bruser, and E.D. Wallingford,* "Recommendations on Numerical Values for Regulating Iron and Chloride Concentrations for the Purpose of Protecting Warmwater Species of Aquatic Life in the Commonwealth of Kentucky," *University of Kentucky, Lexington Kentucky, 1985; U.M. Cowgill and D.P. Milazzo, "The Sensitivities of Two Cladocerans to Water Quality Variables,"* Archiv für Hydrobiologie, *Volume 120, pages 155-196, 1990; J.R.F. Elphick, K.V. Bergh, and H. C. Bailey, "Chronic Toxicity of Chloride to Freshwater Species: Effects of Hardness and Implications for Water Quality Guidelines,"* Environmental Toxicology and Chemistry, *Volume 30, pages 239-246, 2011;and E.C. Freitas and O. Rocha, "Effects of Sodium and Potassium on Life History Parameters of Freshwater Cladoceran Pseudosida ramosa,"* Journal of the Brazilian Society of Ecotoxicology, *Volume 7, pages 85-91, 2012*

[19]*Elphick and others, 2011,* op. cit.

[20]*Ibid.*

[21]*D.L Cronkite, A.N. Gustafson, and B.F. Bauer, "Role of Protein Synthesis and Ninhydrin-positive Substances in Acclimation of* Paramecium tetraurelia *to high NaCl,"* Journal of Experimental Zoology, *Volume 233, pages 21-28, 1985.*

[22]*G.L. Mackie, "Effects of Pollutants on Natality of* Musculium secures *(Bivalvia: Pisidiidae),"* The Nautilus, *Volume 92, pages 25-33, 1978.*

[23]*Freitas and Rocha, 2012,* op. cit.

[24]*I. Gomez-Mestre and M. Tejedo, "Local Adaptation of an Anuran Amphibian to Osmotically Stressful Environments,"* Evolution, *Volume 57, pages 1889-1899, 2003; and D. Sanso and S.J. Hecnar, "Effects of a Road Deicing Salt (NaCl) on Larval Wood Frogs (Rana sylvatica),"* Environmental Pollution, *Volume 140, pages 247-256, 2006.*

[25]*Birge and others, 1985,* op. cit.

[26]*B.G. Anderson, "The Apparent Thresholds of Toxicity to* Daphnia magna *for Chloride when Added to Lake Erie Water,"* Transactions of the American Fisheries Society, *Volume 78, pages 96-113, 1948.*

[27]*J.W. Teeter, "Effects of Sodium Chloride on Sago Pondweed,"* Journal of Wildlife Management, *Volume 29, pages 838-845, 1965.*

Increases in chloride concentration can result in major changes to the structure and functioning of aquatic ecosystems. This can impact the biological communities present. For example, experimental additions of chlorides to a stream site resulted in reduced algal diversity and lower algal biomass relative to what was present at an upstream control site.[28] Similar changes have been documented in lakes. For example, increased chloride loading related to commercial and residential development resulted in chloride concentrations in Third Sister Lake in Michigan increasing from 19 milligrams per liter (mg/l) to 260 mg/l over an eight-year period. This concentration change led to reduced mixing in the lake and anoxia in bottom waters. Several biological changes accompanied this, including reduced rates of primary production, lower diversity of benthic invertebrate species, and markedly reduced densities of benthic invertebrates.[29]

Although the negative environmental impacts attendant to the introduction of chloride are significant and costly, a single characteristic of chloride by itself creates a need to study its use and effects. Chloride introduced to surface water and groundwater resources is not amenable to treatment—that is, removal—by the best management practices applicable to other forms of water pollution. Of even greater concern however, is the fact that there are no natural processes by which sodium and chloride ions contained in contaminated runoff or other discharges are broken down, metabolized, taken up, or otherwise removed from the environment. This means that chloride will accumulate over time in surface lakes and reservoirs and in groundwater, thereby constituting a significant threat to the future quality of life within the Region.

Under the Federal Clean Water Act, waterbodies that do not meet the applicable water quality standards are considered impaired. Section 303(d) of the Federal Clean Water Act requires that states periodically submit a list of impaired waters to the USEPA for approval. Wisconsin most recently submitted this list in 2014, and USEPA approved the list in June of 2015. As of 2014, five streams in the Southeastern Wisconsin Region were either listed as impaired or proposed for listing due to acute aquatic toxicity caused by high chloride concentrations. These five streams include:

- A 23.5-mile section of the Root River in Milwaukee, Racine, and Waukesha Counties, which was first listed as impaired in the 1998 impaired waters list;

- A 2.7-mile section of the Kinnickinnic River in Milwaukee County, which is proposed for listing on the 2014 impaired waters list;

- The entire 9.7-mile length of Lincoln Creek in Milwaukee County, which is proposed for listing on the 2014 impaired waters list;

- The entire 13.3-mile length of Oak Creek in Milwaukee County, which is proposed for listing on the 2014 impaired waters list; and

- The entire 0.9-mile length of an unnamed tributary to Ulao Creek in Ozaukee County, which is proposed for listing on the 2014 impaired waters list.

The Federal Clean Water Act also requires states to develop Total Maximum Daily Loads (TMDLs) to address waterbodies that are not meeting water quality standards. A TMDL includes both a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that

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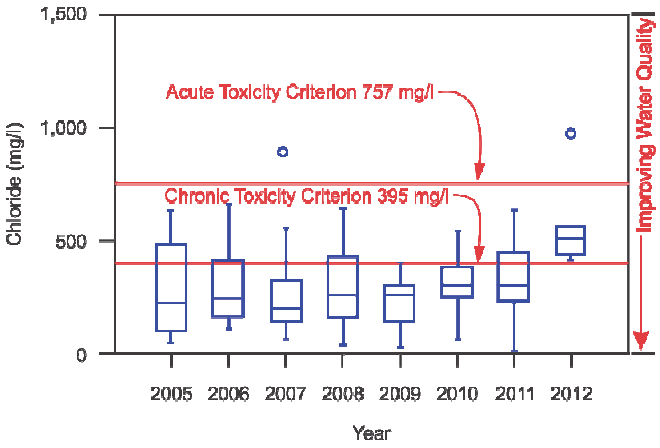
[28]*M.D. Dickman and M.B. Gochnauer, "Impacts of Sodium Chloride on the Microbiota of a Small Stream,"* Environmental Pollution, *Volume 77, pages 109-126, 1978.*

[29]*T.B. Bridgeman, C.D. Wallace, G.S. Carter, R. Carvajal, L.C. Schiesari, S. Aslam, E. Cloyd, D. Elder, A. Field, K.L. Schulz, P.M. Yurista, and G.W. Kling, " A Limnological Survey of Third Sister Lake, Michigan with Historical Comparisons,"* Lake and Reservoir Management, *Volume 16, pages 253-267, 2000.*

load among the various sources of that pollutant. The TMDL must also account for seasonal variations in water quality and include a margin of safety to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards. The TMDL allocates the allowable load between a **wasteload allocation for point sources** such as municipal wastewater treatment plants, industrial dischargers, concentrated animal feeding operations, and municipal separate storm sewer systems (MS4s); a **load allocation for nonpoint sources** such as agricultural sources, urban sources not covered under a discharge permit, and natural background loads; and a margin of safety. Wasteload allocations are implemented through limits established in discharge permits under the Wisconsin Pollutant Discharge Elimination System (WPDES). Load allocations are implemented through a wide variety of Federal, State, and local programs as well as voluntary action by citizens. Under the Federal Clean Water Act, TMDLs will eventually need to be developed for those waterbodies in the Region that are currently listed as impaired due to high chloride concentrations. TMDLs will also need to be developed for any other waterbodies in the Region that are added to the list in the future.

Figure 5

CHLORIDE CONCENTRATIONS AT THE SAMPLING STATION AT THE INTERSECTION OF W. NATIONAL AVENUE AND W. OKLAHOMA AVENUE (RM 41.0): 2005-2012



NOTE: See Figure 2 for description of symbols.

Source: Milwaukee Metropolitan Sewerage District.

Given that chloride concentrations are increasing in surface waters, additional waterbodies in the Region may be added to the impaired waters list in the future and TMDLs may be developed to address the chloride-related impairments in these waterbodies.

Chloride Concentrations in Groundwater

Monitoring data also suggest that chloride may be accumulating in groundwater. Figure 5 shows chloride concentrations in surface water samples collected from the Root River at the monitoring station located at the intersection of W. National Avenue and W. Oklahoma Avenue over the period 2005 through mid-2012. As described below, the high concentrations of chloride observed in surface water during 2012 may be the result of the drought conditions that affected southeastern Wisconsin during the late spring and summer of that year.

During 2012, the Region experienced abnormally dry conditions beginning in late May. These conditions progressed to moderate drought by late June and extreme drought by mid-July. Extreme drought conditions persisted through early August. Because of the low levels of precipitation that occurred during much of 2012, baseflow from groundwater most likely constituted a larger fraction of flow in the upper portions of the mainstem of the Root River than it would during years with normal or wet conditions.

An examination of the solubility properties of chloride and the rates at which groundwater moves can provide an explanation for the high chloride concentrations in the Root River during 2012. Chloride is highly soluble in water. When it is present in groundwater, it moves at the rate at which groundwater moves. These rates are considerably slower than the rates at which surface water flows. A consequence of this is that there may be a considerable time lag between a bit of chloride entering groundwater through infiltration and the same bit of chloride being discharged through baseflow into a surface waterbody. This also suggests that, with continued placement of chloride into the environment, a reservoir of chloride may accumulate in groundwater. Over time this will lead to an increase in the chloride concentration in groundwater and in water discharged from groundwater to surface waterbodies as baseflow. Thus, the likely explanation as to why chloride concentrations were high in the Root River during the drought conditions in 2012 is that the observed concentrations in the River were more reflective of concentrations in groundwater than they would be during a normal year.

NEEDS TO BE MET

A study of the environmental impacts of chloride should meet the following needs within the Region.

1. The provision of an accurate set of base-line data—or benchmark—describing the situations within the Region with respect to:

    a. The winter road maintenance practices followed by each of the State, county, and municipal agencies within the Region responsible for such maintenance. The data should include, for each agency, the number of lane miles of facility maintained; the maintenance practices followed; the road salt application rates used; and the total road salt used in the base year winter season. The data should be collected in a manner that permits analyses by areas and subareas, including counties, civil divisions, watersheds and subwatersheds, both in their entireties and various combinations of areas and subareas. To the extent feasible, the data should include salt use on public and private parking lots, drives, walks and other impervious surfaces.

    b. Chloride discharged to surface water and/or groundwater from wastewater treatment plants and private onsite wastewater treatment systems,[30] salt storage areas, large agricultural feed lots, fertilizers, landfills, chemical manufacturing, food processing, and any other potential chloride sources identified during the course of the proposed study.

    c. Surface water quality conditions within the Region in the base year with respect to chloride content. Data should be available by stream reach, wetland, reservoir, and importantly, by inland lakes within the Region.

    d. Ground water quality conditions within the Region in the base year with respect to chloride content.

2. The provision of an accurate record of historical data and trends relating to the use of road salt in winter road maintenance and on the related surface water and groundwater quality conditions. To the extent practicable, the data should be assembled for the same geographic areas used in the assembly of the base year conditions.

3. The assembly of pertinent surface water and groundwater objectives and standards related to human health, and to the maintenance of healthy fresh water aquatic plant and animal communities, as well as fertile soils and healthy terrestrial plant communities.

4. The preparation of reasonable long-range forecasts of the use of chloride that would potentially be discharged to surface water and groundwater resources within the Region.

5. The conduct of analyses to identify the particular surface water and groundwater resources that are being significantly impacted by the effects of the use of chloride, or which may be expected to be so impacted in the foreseeable future.

6. The assembly of a description of the state-of-the-art of activities affecting chloride in the environment, including particularly information on the technologies involved in the various practices, the performance of those practices, and the attendant costs.

7. The evaluation of alternative scenarios for reducing the use of road salt in winter road maintenance, for reducing chloride loads to the environment from other sources, and for abating the adverse effects of such use on the specific groundwater and surface water resources of the Region identified as exhibiting, or apt

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[30] *These discharges would include effluent from water softening systems.*

to exhibit in the foreseeable future, significant adverse effects from the introduction of chloride. This evaluation should include the development of recommendations for reducing the use of chloride where practicable and for abating the adverse effects associated with such use. The scenarios will be developed considering a) the amounts of salt and other deicing and anti-icing compounds applied to public and private facilities, b) substances that could be substituted for chlorides, c) emerging practices regarding anti-icing and pre-wetting agents, d) other operational modifications that may be identified during the course of the study, and e) legal and policy approaches to reduce the use of chloride where practicable.

Superficially considered, the foregoing list of needs may appear to be in part already met by data sets maintained within various public works and environmental protection agencies operating within the Region. The full value of meeting these needs, however, will be provided by the ability to analyze and evaluate the environmental impacts of the use of chloride in various geographic units—particularly watersheds—related to specific bodies of surface water within the Region and to areas of groundwater recharge.

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Chapter IV

WORK PROGRAM

INTRODUCTION

This chapter outlines the general scope and content of a study of the introduction of chloride in the environment and of the environmental impacts of such introduction within the Region. The outline is in sufficient detail to permit the development of cost estimates for budgetary purposes; to establish a practical time sequence and schedule for the necessary work; and to identify an organizational structure for the conduct of the work, including determination of staff requirements. The outline has, however, been kept deliberately general in order to permit latitude in the selection of specific procedures and techniques as work on the actual study proceeds.

The work outline is based upon the following assumptions:

1. That the study will, to the degree feasible, address contributions to the chloride content of the surface and groundwater resources of the Region from winter road maintenance activities, including salt runoff from sources other than public roadway impervious surface areas—such as privately owned walkways, driveways, and parking areas; wastewater treatment plants: onsite wastewater treatment and disposal facilities; salt storage areas; large feedlots; and landfills.

2. The study will investigate and, to the extent possible, define the relationship between the introduction of chloride from various sources and the chloride content of surface and groundwater within the Region.

3. That the geographic area of the study is to be the entire seven-county southeastern Wisconsin planning Region. The information developed in the study, however, is to be related to appropriate levels of geographic concern, including counties, and municipalities, and watersheds within those counties and municipalities.

4. That full use will be made of all available sources, studies, reports, and other data which may contribute to the information base to be developed in the study. Primary data collection efforts will be limited to those found necessary to provide an overall assessment of the status and impacts of chloride.

5. That the task of undertaking the study will require and receive the cooperation of all of the agencies responsible for winter road maintenance within the Region. Each such agency will need to make its data available for use in the study. It is assumed that any costs associated with the provision of such agency data will be borne by the providing agency.

STUDY DEVELOPMENT PROCESS

The study is proposed to employ a five step process: 1) detailed study design, 2) formulation of pertinent surface water and groundwater objectives and standards, 3) inventory, 4) analyses and forecasts, and 5) preparation of study findings and recommendations.

Detailed Study Design

Before beginning actual work, the proposed study must be designed in sufficient detail to assure maximum coordination between study participants, the efficient use of funds and personnel, a clear understanding of the various inventory and analytical tasks to be undertaken, and the ultimate advancement of the work toward the preparation of study findings and recommendations. To accomplish this, it will be necessary to prepare a design which sets forth clearly the detailed work procedures, staff assignments and requirements, and time schedules to be followed. It is recommended that the detailed design for the proposed study take the form of a series of staff memoranda. Each memorandum would set forth the methods and procedures to be followed in accomplishing each of the work steps. For each of the inventories proposed to be conducted, the staff memorandum should specify a set of inventory standards against which the completeness and accuracy of the existing inventory data kept by the operating agencies concerned would be determined. Each memorandum would specify in detail the information sought to be gathered; the manner in which the information is to be gathered, processed, and compiled; and the nature of the analytical work required to fulfill the study purpose. Each staff memorandum should specify the time and resources required to perform a particular work task. As each memorandum is completed, it should become a working guide for program progress review. Each staff memorandum should be reviewed and approved by the study advisory committee prior to the commencement of work operations.

Formulation of Objectives and Standards

The formulation of, and agreement upon, a set of surface water and groundwater quality objectives and standards related to human health, and to the maintenance of healthy freshwater aquatic plant and animal communities, as well as fertile soils and healthy terrestrial plant communities will be required. The objectives and standards are necessary as a basis of comparison with existing and forecast water quality conditions in order to assess the potential existence and severity of pollution problems. Potential attainment of the objectives and standards will be related to existing practices which introduce chloride to the environment, and may be expected to address public health and safety, surface water and groundwater quality,[1] and public works operational efficiency and effectiveness. Objectives and standards may have to be developed for stormwater and snowmelt runoff as well as for ambient quality conditions in lakes, streams, and groundwater.

Formulation of the necessary objectives and standards will be preceded by appropriate studies. The objectives and standards should reflect good current planning and engineering practice and be amenable to adoption by all levels, units, and agencies of government concerned and to implementation by the private and public sectors, where applicable.

Inventory

Reliable planning and engineering data available on a uniform, areawide basis are essential to the identification and understanding of environmental problems, and to the formulation of workable solutions to those problems. Consequently, inventory becomes the first operational step in any planning or engineering study concerning such

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[1]*The State of Wisconsin has promulgated surface and groundwater quality criteria for chloride concentrations, and those criteria will be incorporated in the standards established for the proposed study. In addition, a literature search will be conducted to obtain information on sodium and chloride concentrations associated with "aesthetic limits" for drinking water. At and beyond such limits, consumers note that the taste of drinking water is affected. Such limits are important considerations relative to water utilities using a groundwater source of water supply. The literature review will also seek to establish whether exceedance of "aesthetic limits" may have human health effects.*

problems. The data may either have to be collected, that is, obtained by direct measurement as part of the study, or may be available from secondary sources, that is, be obtainable from another agency which has originally collected the information. The following basic inventory operations will have to be conducted as part of the proposed study of the environmental impacts of chloride, and these operations will indirectly, or directly, assist in development of an accurate set of baseline data for the Region and its watersheds.

Base Maps and Aerial Photography

Essential to any consideration of the environmental impacts of chloride is knowledge of the topographic and cultural features of the study area. Such knowledge can best be acquired from topographic and cadastral maps of required scale and accuracy. Definitive information will be required on such natural features as relief; watershed boundaries; location of streams and watercourses, lakes, reservoirs, and wetlands; and upon such man-made features as civil division boundary lines, real property boundary lines, highways, railways, and principal buildings. In addition to topographic and cadastral maps, planning base maps will be required which permit information collected in the various inventory operations to be spatially located through application of geographic information system technology.

General Base Maps

General base maps of the Region will be required to provide a means for recording and presenting in graphic form the results of the study, as well as the relevant natural and man-made features of the Region. The Commission maintains a regional base mapping data set as part of its general regional planning program. Standard and customized base maps at various scales can be prepared from this data set, and the maps can be assembled by mosaic processes to cover various subareas of the Region and the Region as a whole. These base maps can be expanded or reduced in scale for use in various phases of the study and show, among other information: all major streams, lakes, and reservoirs; major watershed divides; all railways, streets and highways; all U.S. Public Land Survey system township, range, and section lines; and all civil division boundary lines. The mapping data set has been compiled to National Map Accuracy Standards utilizing the Wisconsin State Plane Coordinate Grid South Zone as the map projection. The regional base mapping data set is updated under the Commission's ongoing regional planning program, and the customized base maps prepared from these data will be made available to the study at no cost.

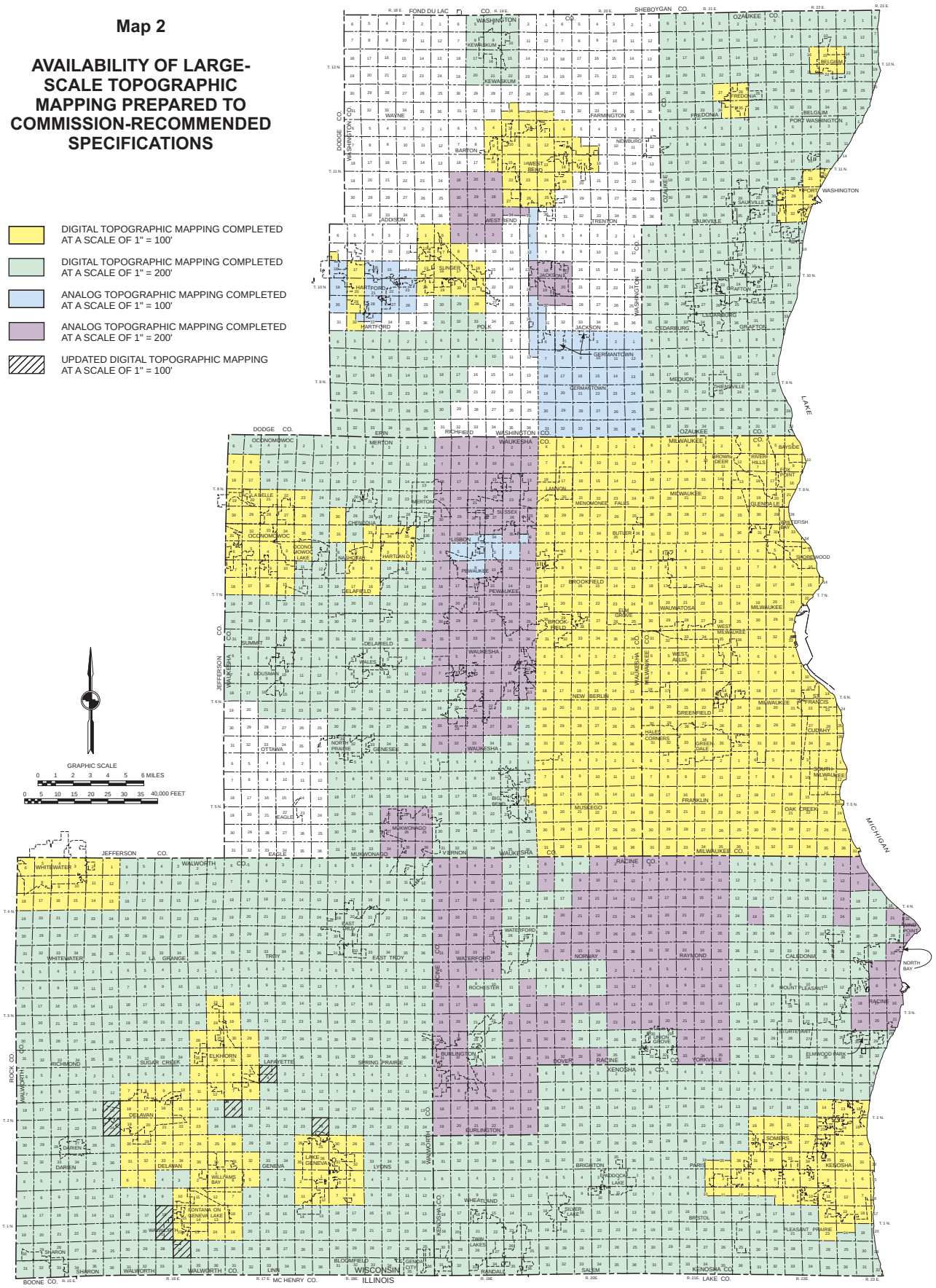
Topographic Maps

Large-scale—1 to 2,400 and 1 to 1,200—topographic maps will be necessary to the definition of the stormwater and snowmelt runoff patterns within the Region, and to assessment of the attendant potential effects of road salt use on the natural resource base. Since 1960, the Commission has assisted its constituent counties and municipalities in the acquisition of the necessary maps and has itself prepared such maps of subareas of the Region. The maps are based upon a monumented system of horizontal and vertical survey control which combines the U.S. Public Land Survey and State Plane Coordinate Systems, and which permits the accurate correlation of topographic data with real property boundary line data. The State Plane Coordinate System used is based upon the North American Datum of 1927. The vertical datum used is based upon the National Geodetic Vertical Datum of 1929, formerly known as the Mean Sea Level Datum. The large-scale topographic maps accurately show the planimetry of the mapped area—that is, the cultural and natural features of the area—including roadways, driveways, and other paved areas such as parking lots, railway trackage, and buildings. The maps also show the hypsometry of the mapped areas—that is, the relief—by contours normally having a two-foot vertical interval, but in some cases a one-foot interval. These maps provide essential input to the Commission water quality and quantity modeling program, to the delineation of the watershed and subwatershed boundaries, to the delineation of recommended areas for the provision of public sanitary sewer and water supply services, to the selection of specific sites and routes for various types of infrastructure facilities, and to the conduct of public works facilities planning and engineering efforts. As shown on Map 2, as of 2014, large-scale topographic maps have been prepared for a total of about 2,385 square miles, or about 89 percent of the total area of the seven-county Region. The currency of these maps varies with the subareas mapped, ranging from 1964 to 2014. The availability of these maps in digital and analog format is shown on Map 2.

Map 2

AVAILABILITY OF LARGE-SCALE TOPOGRAPHIC MAPPING PREPARED TO COMMISSION-RECOMMENDED SPECIFICATIONS

- DIGITAL TOPOGRAPHIC MAPPING COMPLETED AT A SCALE OF 1" = 100'
- DIGITAL TOPOGRAPHIC MAPPING COMPLETED AT A SCALE OF 1" = 200'
- ANALOG TOPOGRAPHIC MAPPING COMPLETED AT A SCALE OF 1" = 100'
- ANALOG TOPOGRAPHIC MAPPING COMPLETED AT A SCALE OF 1" = 200'
- UPDATED DIGITAL TOPOGRAPHIC MAPPING AT A SCALE OF 1" = 100'



Source: SEWRPC.

More recently, all of the counties comprising the Region have acquired current ground surface elevation data using LiDAR (Light Detection and Ranging). The LiDAR elevation data are based upon the Commission control survey network and are intended to meet National Map Accuracy Standards at planning scales of from 1 to 2400 to 1 to 1200. The LiDAR elevation data has been used to provide contour lines having a vertical interval of 1 foot or 2 feet, and these contour lines can be combined with 1 to 2400 and 1 to 1200 scale orthophotographs to provide quasi-topographic maps of any areas within the Region. The coverage and currency of this LiDAR mapping is shown on Map 3, and LiDAR-derived elevation contour mapping is shown on Map 4.

Cadastral Maps

Large-scale cadastral maps have been completed, and are continually maintained, by all of the counties and municipalities within the Region. Most, but not all, of the maps have been completed to Commission standards, and is referenced to the same horizontal control network as the attendant topographic maps. This cadastral mapping data can be used to prepare standard and customized cadastral maps at various scales, including 1:1200 scale and 1:2400 scale to complement the topographic maps. As shown on Map 5, cadastral maps prepared to Commission standards are available for about 2,041 square miles, or about 76 percent of the total area of the Region. These large-scale cadastral maps accurately show the location, arrangement, and dimensions of all real property boundary lines, including all street and other public rights-of-way; all existing land subdivisions; and the location and configuration of civil division boundaries. In the remaining 24 percent of the Region, cadastral maps have been prepared to local standards.

Aerial Photographs

Current aerial photography at appropriate scales will be required to provide certain types of detailed planimetric data as well as a medium for data analysis and plan preparation. Aerial photography also provides a basis for the collection of definitive current urban and rural land use data.

As part of its continuing regional planning program, the Commission has obtained ratioed and rectified aerial photographs at a scale of 1 to 4800 of the entire Region in 1963, 1967, and at five-year intervals thereafter from 1970 through 1990. The photography has been ratioed and rectified to fit the Commission horizontal survey control network in the Region. Since 1995, the aerial photography has been collected as orthophotography. Orthophotography is, in effect, ratioed and rectified aerial photography that is further enhanced by the removal of horizontal displacement caused by ground relief, thereby creating image products that approximate true maps.

New regional orthophotography was obtained in the spring of 2015. The acquisition project will provide imagery of the entire Region at a planning scale of 1 to 1200 with a pixel resolution of six inches. Some of the counties within the Region are also planning to obtain LiDAR data and LiDAR-derived elevation mapping in 2015 to complement the new orthophotography. The 2015 orthophotography, as well as all Commission historical aerial photography, will be made available for the study at no cost.

Land Information System

The Commission control survey network and the topographic and cadastral maps based upon that network provide the essential foundational elements for the creation of sound, computerized, parcel-based land information and public works management systems. The cadastral maps contain parcel identification numbers which provide the link between digital attribute data and the geographic locations, configuration, and areal extent of the attribute data concerned. The data that can be so linked to geographic location are virtually infinite, including, among others, parcel ownership, asset valuation, street address, existing and planned land use, soil type and properties, vegetation, flood hazard, and zoning, The cadastral maps also provide the basis for the preparation of accurate sanitary sewerage, stormwater management, water supply, and other utility system and facility maps, and the linkage of engineering data to those maps for use in public works management. The computer manipulable parcel-based land information systems should be particularly helpful to the conduct of the study by facilitating delineation of watershed and subwatershed boundaries; identifying flow paths from roadways and paved parking and other impervious areas to watercourses; and delineating areas of soils amenable to high infiltration and groundwater contamination. All of the seven counties comprising the Region have created, and maintain and operate, such land information systems, as have a number of municipalities within the Region and the Commission itself. These existing parcel-based land information and public works management systems will be available for use in the study.

Map 3

AVAILABILITY OF LiDAR AND ELEVATION DATA IN THE SOUTHEASTERN WISCONSIN REGION: 2013

LiDAR and Derived Elevation Data
Vector DTM files and/or raster DEM files, breaklines, mass points at accuracy of 1" = 100' scale.

LiDAR and Derived Elevation Data
Vector DTM files and/or raster DEM files, breaklines, mass points at accuracy of 1" = 200' scale.

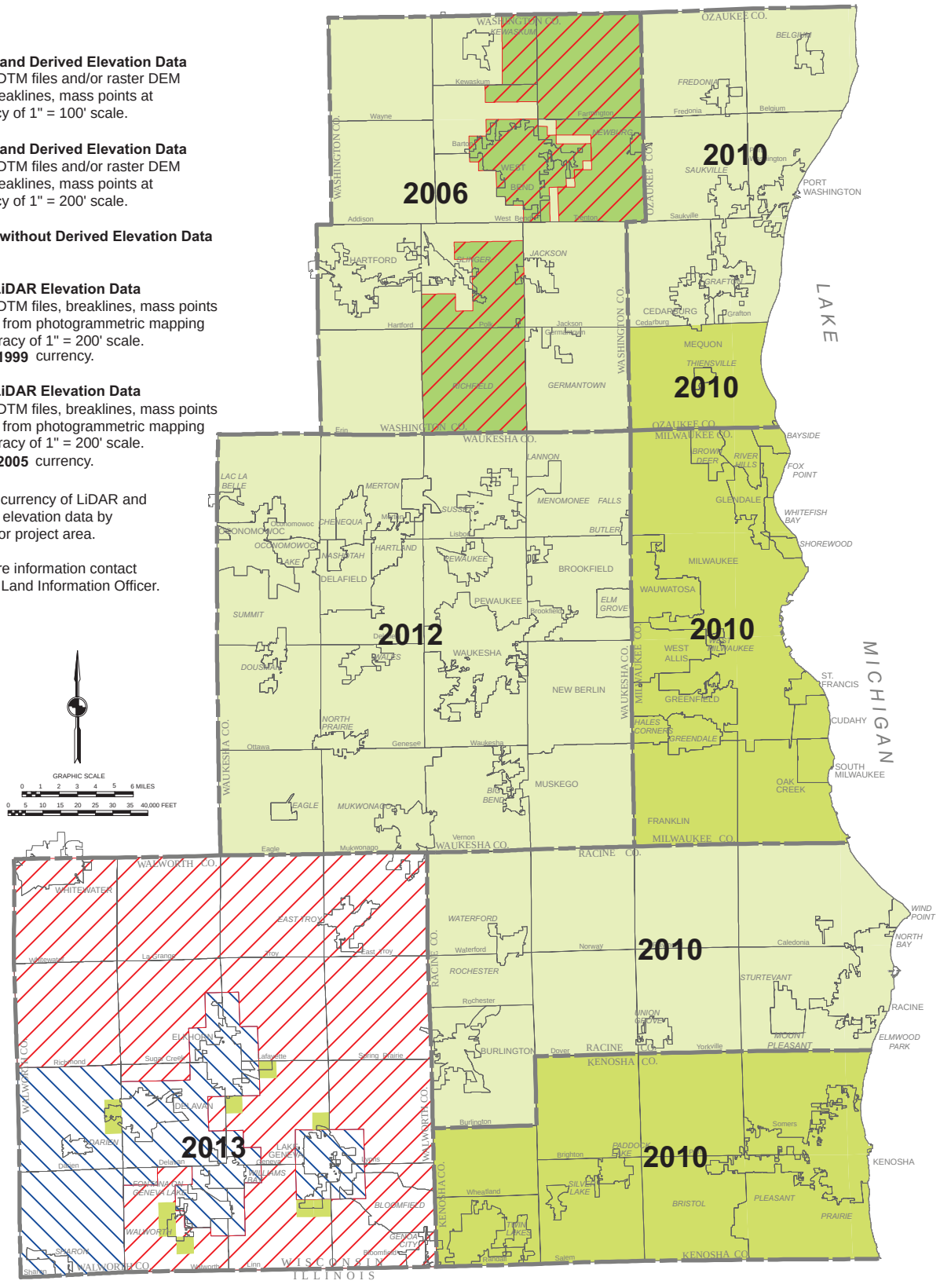
LiDAR without Derived Elevation Data

Non - LiDAR Elevation Data
Vector DTM files, breaklines, mass points derived from photogrammetric mapping at accuracy of 1" = 200' scale.
1994 - 1999 currency.

Non - LiDAR Elevation Data
Vector DTM files, breaklines, mass points derived from photogrammetric mapping at accuracy of 1" = 200' scale.
2000 - 2005 currency.

2010 Year of currency of LiDAR and derived elevation data by county or project area.

For more information contact County Land Information Officer.



Map 4

AVAILABILITY OF CONTOUR LINE DATA IN THE SOUTHEASTERN WISCONSIN REGION: 2013

Contour line data derived from LiDAR at accuracy of 1" = 100' scale.

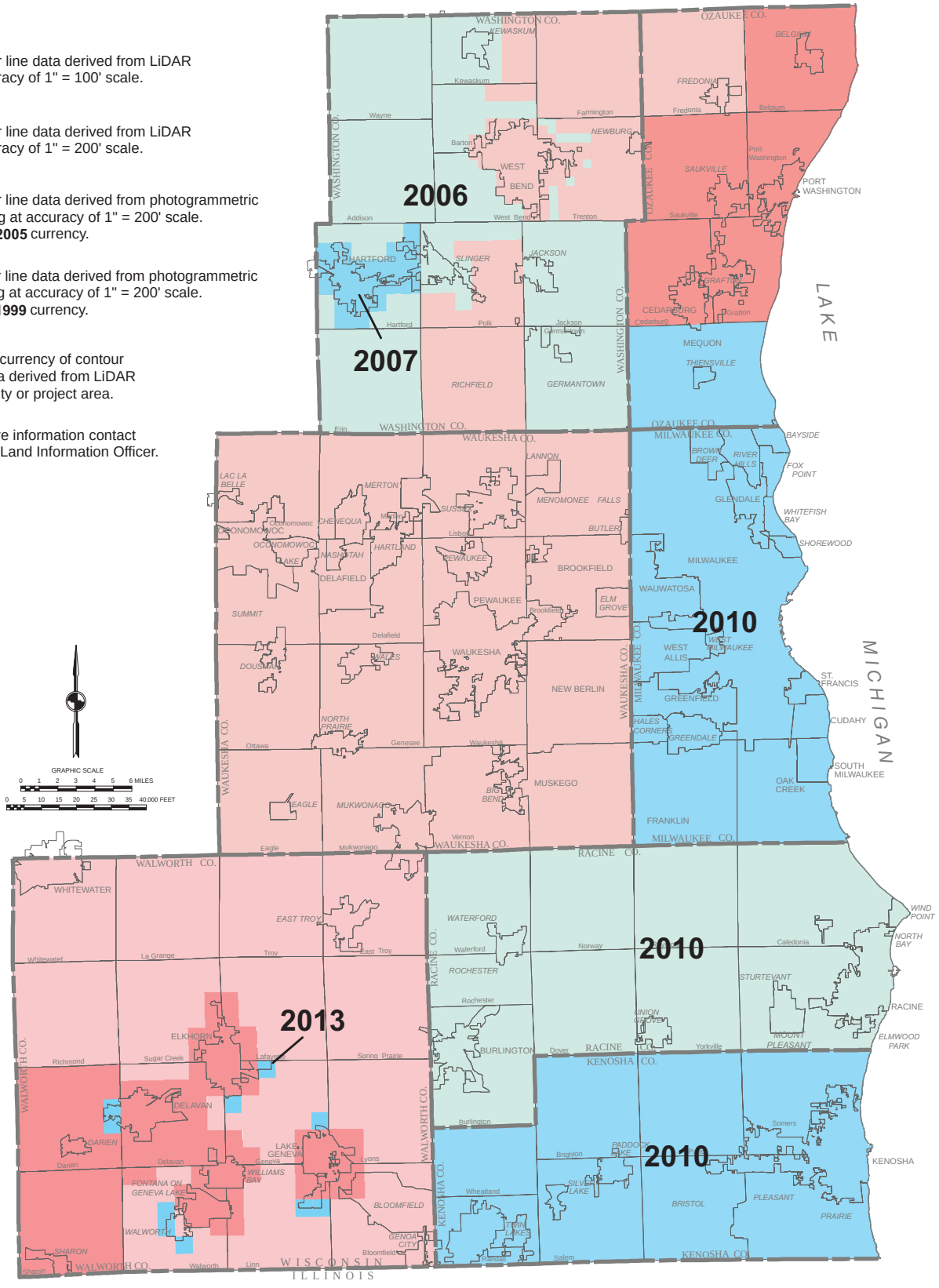
Contour line data derived from LiDAR at accuracy of 1" = 200' scale.

Contour line data derived from photogrammetric mapping at accuracy of 1" = 200' scale. **2000 - 2005** currency.

Contour line data derived from photogrammetric mapping at accuracy of 1" = 200' scale. **1994 - 1999** currency.

2010 Year of currency of contour line data derived from LiDAR by county or project area.

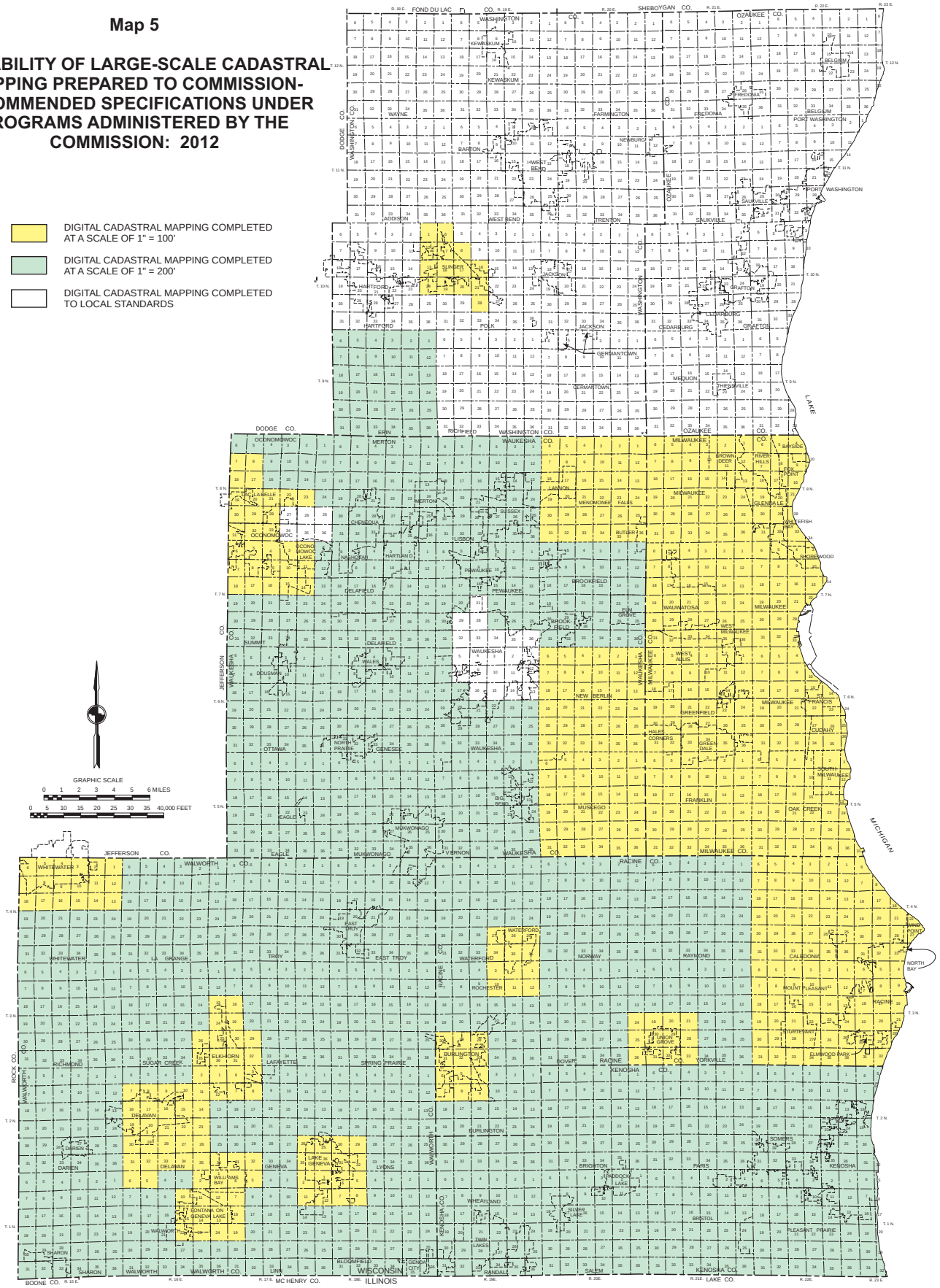
For more information contact County Land Information Officer.



Source: SEWRPC.

Map 5

AVAILABILITY OF LARGE-SCALE CADASTRAL MAPPING PREPARED TO COMMISSION-RECOMMENDED SPECIFICATIONS UNDER PROGRAMS ADMINISTERED BY THE COMMISSION: 2012



Source: SEWRPC.

State, County, and Municipal Road Maintenance Practices

An inventory will be conducted of 1) current and historical road anti-icing and deicing practices at the State, county, and municipal levels, and 2) salt and other deicing and anti-icing compound use by public agencies in winter road maintenance within the Region. This inventory will address the quantities of road salt and other deicing and anti-icing compounds applied and the distribution of the salt and associated chloride throughout the transportation system. It should be possible to collect the needed data by mail survey with, as necessary, telephone call and personal interview follow up.

Current and Historical Road Anti-Icing and Deicing Practices

Data on current and historical road anti-icing and deicing practices should be directly available from the agencies responsible for the maintenance operations. These agencies include the seven county highway or public works departments which are responsible for winter road maintenance of the State and county trunk highway systems within the Region; the street and highway or public works departments of the 147 cities, villages, and towns within the Region; and in some cases, special purpose agencies such as park and recreation departments, including the Wisconsin Department of Natural Resources.

Information will be collected on the various types of anti-icing and deicing agents applied over the past 20 years. As part of this effort, information will also be collected on the use of related snow and ice control practices that have the potential to affect surface and/or groundwater quality. Examples of these types of practices include the use and location of snow storage areas.[2]

Quantities Used

Data on the quantities of road salt and other deicing and anti-icing compounds used in winter road maintenance operations will also be obtained from the agencies responsible for maintenance. The quantities of road salt and other deicing and anti-icing compounds used in a designated base, or bench mark, year must be collated by the geographic areas for which each of the road maintenance agencies is responsible. At least 20 years of historical data should also be collected for each of the agencies and geographical areas concerned, along with pertinent changes in the service areas, in order to facilitate trend analyses. In addition to the two decades of historic data, and attempt will be made to obtain data on road salt and other deicing and anti-icing compounds used in 1965, a year in which the Commission conducted its first inventory of water quality conditions within the Region, obtaining accurate data on the chloride content of the streams and watercourses studied.[3] It should be possible to collect the needed data by mail survey with, as necessary, telephone call and personal interview follow-up.

Distribution

To permit analysis of the relationship of the use of road salt, other deicing and anti-icing compounds, and other sources of chloride to stream and inland lake water quality and to groundwater quality, data on the distribution of the road salt and other deicing and anti-icing compounds and on the locations of discharge from other sources of chloride used will be required. Data on application rates by jurisdictional and functional road classification will be

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[2]*Infiltration of melting snow from storage areas within designated wellhead protection areas could result in increases in chloride concentrations in groundwater used as a public water supply source. Thus, the location of snow storage areas relative to public water supply wellhead protection areas will be an important consideration in conducting the State, county, and municipal maintenance practice inventory. Municipal wellhead protection plans will be reviewed when evaluating the locations of snow storage areas relative to public water supply wells.*

[3]*See SEWRPC Technical Report No. 4,* Water Quality and Flow on Streams in Southeastern Wisconsin, *November, 1966.*

required—State, county, local—freeway, expressway, standard arterial, collector, land access, and other. A significant amount of data already exist within the Commission files with respect to the extent and the jurisdictional and functional classification of the street and highway network. For example, data on the center line mileage of street and highway facilities within the Region by jurisdictional and functional classification are routinely maintained by the Commission. An example of these data for calendar year 2011 are provided in Table 2.

For purposes of the study, center line mileage will have to be converted to lane mileage. Moreover, such mileage will have to be available for various geographic units including—in addition to counties and municipalities—watersheds and subwatersheds, permitting valid estimates to be made of road salt use in the base year and over time within these various geographic units. It should be possible to collate all of the data needed from Commission digital base files using computer-assisted techniques.

Salt Storage and Equipment Storage and Maintenance Practices
Data on practices related to the storage, transfer, and handling, of salt and related deicers and data related to the cleaning, storage, and maintenance of equipment used to transport and apply deicers will be obtained from the agencies responsible for winter road maintenance. These data will contribute to an assessment of the use of best management practices related to deicer storage and use in the Region

Private Facility Salt Use
An inventory of current and historical salt and other deicing and anti-icing compound use by private agencies in the winter maintenance of private parking areas and attendant walkways and driveways will be required. As is the case for public facility road salt, deicing, and anti-icing compound use, the inventory of such use on private facilities will have two components.

Quantities Used
Because of the large number and widely distributed characteristics of the facilities concerned, it will not be practical to obtain use data directly from the owner or operator of each facility. Instead, personal interview surveys of the major private snow and ice control firms which provide winter maintenance services to private facilities within the Region will have to be conducted to obtain needed data on quantities and application rates and practices. The data obtained from these interviews will be supplemented with information from personal interview surveys of the distributors and vendors that supply salt to snow and ice control firms and to the public. It should be possible to collect these data by telephone call and personal interview follow-up.

Distribution
To establish the distributive use of road salt and other deicing and anti-icing compounds in winter maintenance of private facilities, an inventory of automobile and truck parking and of bus, taxi, and truck terminal areas and of ancillary private walkways and driveways will be required. It should be possible to use the Commission's latest land use inventory to identify the location of all parking and loading areas providing accommodation for ten or more vehicles. This could be done using computer assisted technology. Having identified the location of parking and loading areas, the areal extent of the impervious areas concerned can then be determined by aerial photo interpretation using the Commission's latest large-scale, digital orthophotography. This distributive data will have to be compiled for the same geographic areas as those used in the compilation of data for the use of road salt and other deicing and anti-icing compounds by public agencies.

Climatological Data
Certain climatological data will have to be assembled for use in this study. These data should include definitive information on ambient air temperatures; precipitation, including annual and seasonal patterns and frequencies; data on snowfall accumulations, including seasonal patterns and frequencies; and data on frost depths within the planning area.

Table 2

STREETS AND HIGHWAYS IN THE SOUTHEASTERN WISCONSIN REGION BY FUNCTIONAL CLASSIFICATION, JURISDICTIONAL RESPONSIBILITY, AND COUNTY: 2011

County	Centerline Miles by Functional Class							
	Freeway				Standard Arterial			
	State	County	Local	Total	State	County	Local	Total
Kenosha	12.0	- -	- -	12.0	103.4	143.0	61.5	307.9
Milwaukee	66.4	- -	- -	66.4	185.0	85.9	451.1	722.0
Ozaukee	27.4	- -	- -	27.4	50.4	107.9	65.1	223.4
Racine	12.0	- -	- -	12.0	151.1	116.6	78.6	346.3
Walworth	50.0	- -	- -	50.0	155.8	178.6	48.1	382.5
Washington	42.7	- -	- -	42.7	143.6	145.4	74.9	363.9
Waukesha	58.7	- -	- -	58.7	175.4	356.8	162.4	694.6
Total	269.2	- -	- -	269.2	964.7	1,134.2	941.7	3,040.6

County	Centerline Miles by Functional Class							
	Collector/Land Access				Total			
	State	County	Local	Total	State	County	Local	Total
Kenosha	- -	114.4	656.0	770.4	115.4	257.4	717.5	1,090.3
Milwaukee	- -	59.6	2,166.8	2,226.4	251.4	145.5	2,617.9	3,014.8
Ozaukee	- -	46.5	643.3	689.8	77.8	154.4	708.4	940.6
Racine	- -	46.4	924.9	971.3	163.1	163.0	1,003.5	1,329.6
Walworth	- -	13.5	1,067.0	1,080.5	205.8	192.1	1,115.1	1,513.0
Washington	- -	40.6	1,088.3	1,129.3	186.3	186.0	1,163.6	1,535.9
Waukesha	- -	41.2	2,255.5	2,296.7	234.1	398.0	2,417.9	3,050.0
Total	- -	362.2	8,801.8	9,164.4	1,233.9	1,496.4	9,743.9	12,474.2

Source: SEWRPC.

Salt Storage and Equipment Storage and Maintenance Practices

Data on practices related to the storage, transfer, and handling, of salt and related deicers and data related to the cleaning, storage, and maintenance of equipment used to transport and apply deicers will be obtained from the agencies responsible for winter road maintenance. These data will contribute to an assessment of the use of best management practices related to deicer storage and use in the Region.

Much of the needed climatological information has been collated by the Regional Planning Commission from records of the National Weather Service and other agencies as part of the comprehensive regional planning program. Accordingly, only limited additional data collection activities are contemplated in this respect. All of the available data will be presented in a form suitable for study purposes.

Surface Water and Groundwater Quality Data

It is proposed to collate, and as may be found necessary collect, and analyze data on surface water and groundwater quality that is relevant to establishing the relative amounts of chloride present in the water resources of the Region.

Surface Water

The analysis of surface water quality data will focus on the collation and collection of instream and in-lake water data on specific conductance or chloride concentrations.[4,5] The collation of existing data will also include collation of data for those water quality constituents known to affect the toxicity of chloride to aquatic organisms.

Under certain circumstances, measurements of specific conductance may act as a useful surrogate for measurements of the concentrations of particular dissolved materials. For example, measurements of specific conductance may be able to provide indications of chloride concentrations in receiving waters. Analysis of data collected by the USGS suggests that there is a linear relationship between specific conductance and chloride concentration at higher values of conductance and chloride concentration.[6] This suggests that during periods when chloride is being carried into receiving waters by discharges of stormwater or snowmelt, ambient chloride concentrations could be estimated using specific conductance. The advantage to this is that specific conductance can be measured inexpensively in the field using a data logger or a hand-held meter, while measurements of chloride concentrations require chemical analysis.[7]

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[4]*Possible sources of existing specific conductance and/or chloride concentration data include the U.S. Geological Survey National Water Information System (NWIS), the U.S. Environmental Protection Agency Storage and Retrieval (STORET) database, the WDNR Surface Water Information System (SWIMS) database, the University of Wisconsin-Extension (UWEX) Water Action Volunteers Program (WAV), the Wisconsin Citizen Lake Monitoring Network (CLMN), Milwaukee Riverkeeper's volunteer stream monitoring program, and the Milwaukee Metropolitan Sewerage District water quality sampling program.*

[5]*Specific conductance measures the ability of water to conduct an electric current. Because this ability is affected by water temperature, conductance values are corrected to a standard temperature of 25 degrees Celsius (77 degrees Fahrenheit). This corrected value is referred to as specific conductance. Pure water is a poor conductor of electrical currents and exhibits low values of specific conductance (e.g., distilled water produced in a laboratory has a specific conductance in the range of 0.5 to 3.0 microSiemens per centimeter, a very low value). The ability of water to carry a current depends upon the presence of ions in the water, and on their chemical identities, total concentration, mobility, and electrical charge. Solutions of many inorganic compounds, such as salts, are relatively good conductors. As a result, specific conductance gives a measure of the concentration of dissolved solids in water, with higher values of specific conductance indicating higher concentrations of dissolved solids.*

[6]*Steven R. Corsi, David J. Graczyk, Steven W. Geis, Nathaniel L. Booth, and Kevin D Richards, "A Fresh Look at Road Salt: Aquatic Toxicity and Water-Quality Impacts on Local, Regional, and National Scales,"* Environmental Science & Technology, Volume 44, 2010.

[7]*Continued collection of both conductance and chloride data could be helpful in refining this relationship. Such a refinement could potentially allow for the substitution of conductance monitoring for some chloride monitoring with a potential cost savings. For the 2014 SEWRPC Root River watershed restoration planning effort, predicted chloride concentrations from the USGS regression equation were compared to actual Root River chloride conditions for specific conductance and chloride samples that were simultaneously collected. It was found that the USGS regression equation usually predicted higher concentrations based upon specific conductance than were observed in the Root River. The average difference between predicted and observed concentrations was about 24 percent of observed concentrations. The maximum difference was about 277 percent of the observed concentration.*

Historical Surface Water Quality Data
Possible sources of existing specific conductance and/or chloride concentration data include the U.S. Geological Survey (USGS) National Water Information System (NWIS), the U.S. Environmental Protection Agency (USEPA) Storage and Retrieval (STORET) database, the WDNR Surface Water Information System (SWIMS) database,[8] Milwaukee Riverkeeper's volunteer stream monitoring program, and the Milwaukee Metropolitan Sewerage District water quality sampling program. The Wisconsin Citizen Lake Monitoring Network (CLMN) may be another source of specific conductance and/or chloride concentration data, and the availability of such data would be determined under the proposed study.

Specific conductance data and/or chloride concentration data have been collected at various locations for more than 50 years. As noted previously, the Commission conducted its first inventory of water quality conditions within the Region in 1964 and 1965, obtaining accurate data on the chloride content of numerous streams.[9] Those sites were sampled over the following 10 to 13 years (see Map 6). Data from the other monitoring organizations mentioned above have been collected at various times and locations over the past 50 years. Readily-identified chloride concentration or specific conductance USGS and MMSD monitoring locations are shown on Map 7. Additional monitoring locations will be identified based on research to be conducted under the proposed study. The 118 USGS chloride and/or specific conductance monitoring sites range from those at which grab samples are collected to sites at which data are collected at five-minute intervals. The data are generally summarized as daily average, maximum, and minimum values. The MMSD currently collects monthly grab samples for chloride concentration and/or specific conductance at 97 locations. The MMSD also collects specific conductance at five-minute intervals at 21 sites.

Collation and Collection of Streamflow Data
Data will be collated, and as may be found necessary collected, on streamflows at the 39 continuous recording streamflow gaging stations within the Region that are operated by the USGS in partnership with local cooperators, including the Commission. Those 39 stations are shown on Map 8.

Collection of New Surface Water Quality Data
Past Commission studies have verified that there are few data available on instream, or in-lake, chloride concentrations or specific conductance levels during the winter. Therefore, under the proposed study, data loggers[10] would be deployed at perhaps 30 to 40 lake and stream locations to record conductivity and water temperature for adjustment of the conductivity values to a standard temperature of 25ºC over the course of one year, including the winter. To account for the effects of thermal and/or chemical stratification in lakes and deeper streams, it may be necessary to deploy multiple loggers in some of these waterbodies. The data collected by those loggers will establish an existing baseline condition regarding the chloride content of representative streams and lakes.

The collection of new specific conductance data will be targeted to those lakes and streams which might be expected to be most directly affected by chloride from road salt application or other potential sources, but it will also include some waterbodies that are judged to be less susceptible to chloride pollution, enabling the establishment of a baseline condition that is representative of a range of chloride impacts on the surface water resources of the Region. The following criteria will be applied in locating the new monitoring sites:

- New sites should be considered on streams or in lakes where chloride and/or specific conductance data are not currently being collected;

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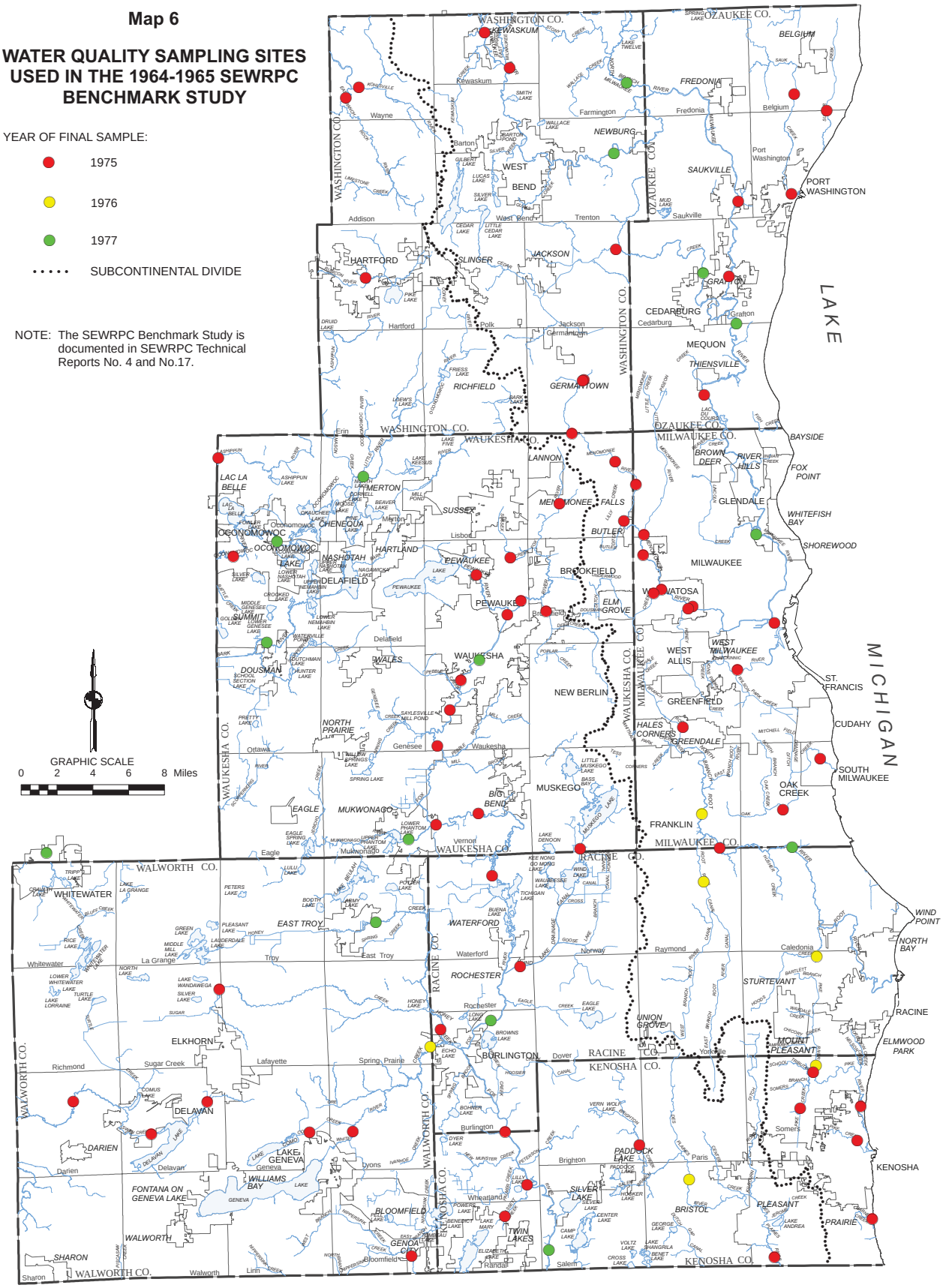
[8]*Data from the University of Wisconsin-Extension (UWEX) Water Action Volunteers Program (WAV) is being incorporated into the SWIMS database.*

[9]*SEWRPC Technical Report No. 4, op. cit.*

[10]*A data logger is a small, battery-operated probe that can be deployed in a lake or stream to record specific water quality constituent concentrations or magnitudes at a pre-programmed time interval. Following recovery of the logger, the recorded data can be downloaded to a computer.*

Map 6

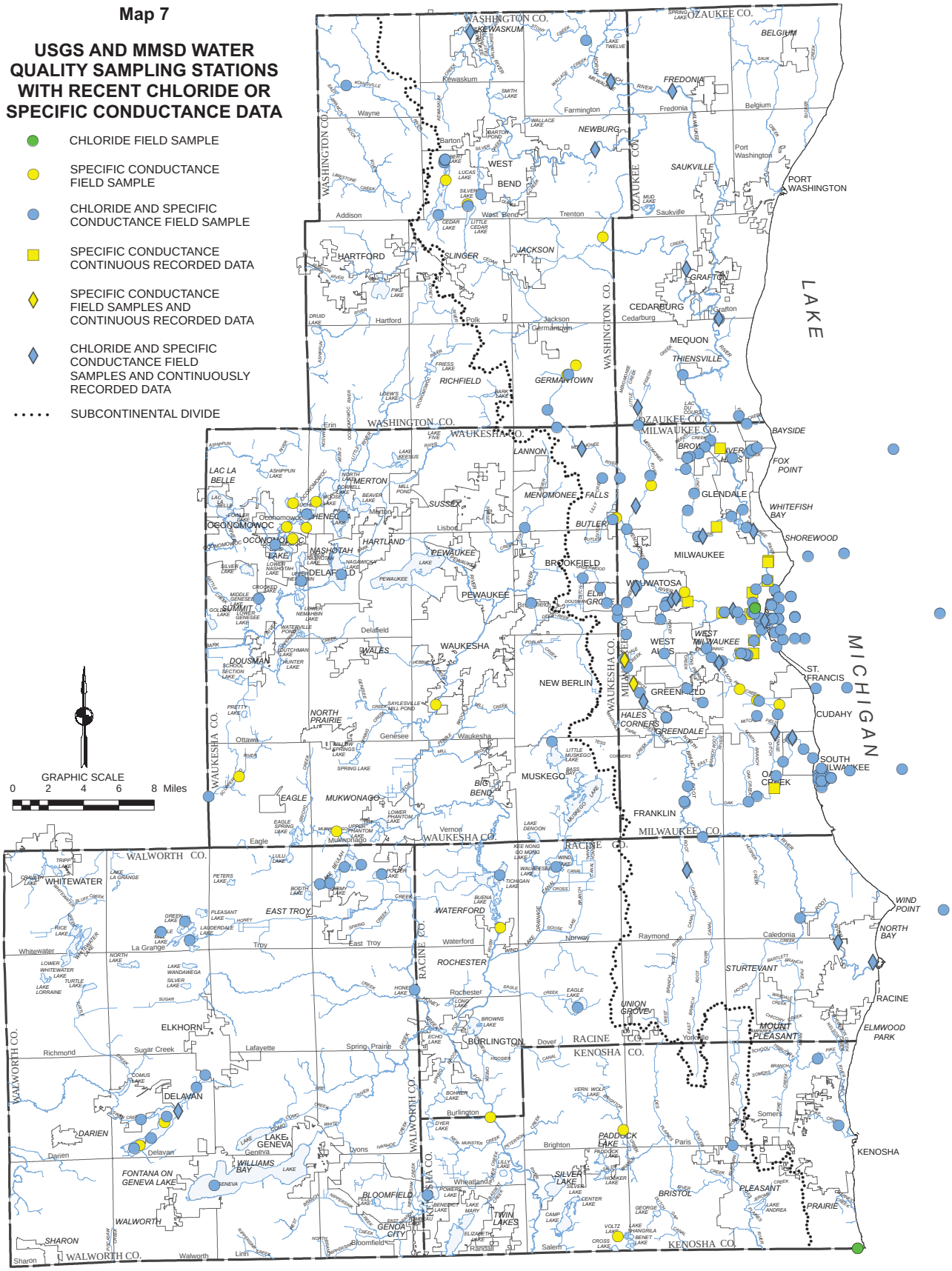
WATER QUALITY SAMPLING SITES USED IN THE 1964-1965 SEWRPC BENCHMARK STUDY



Source: SEWRPC.

Map 7

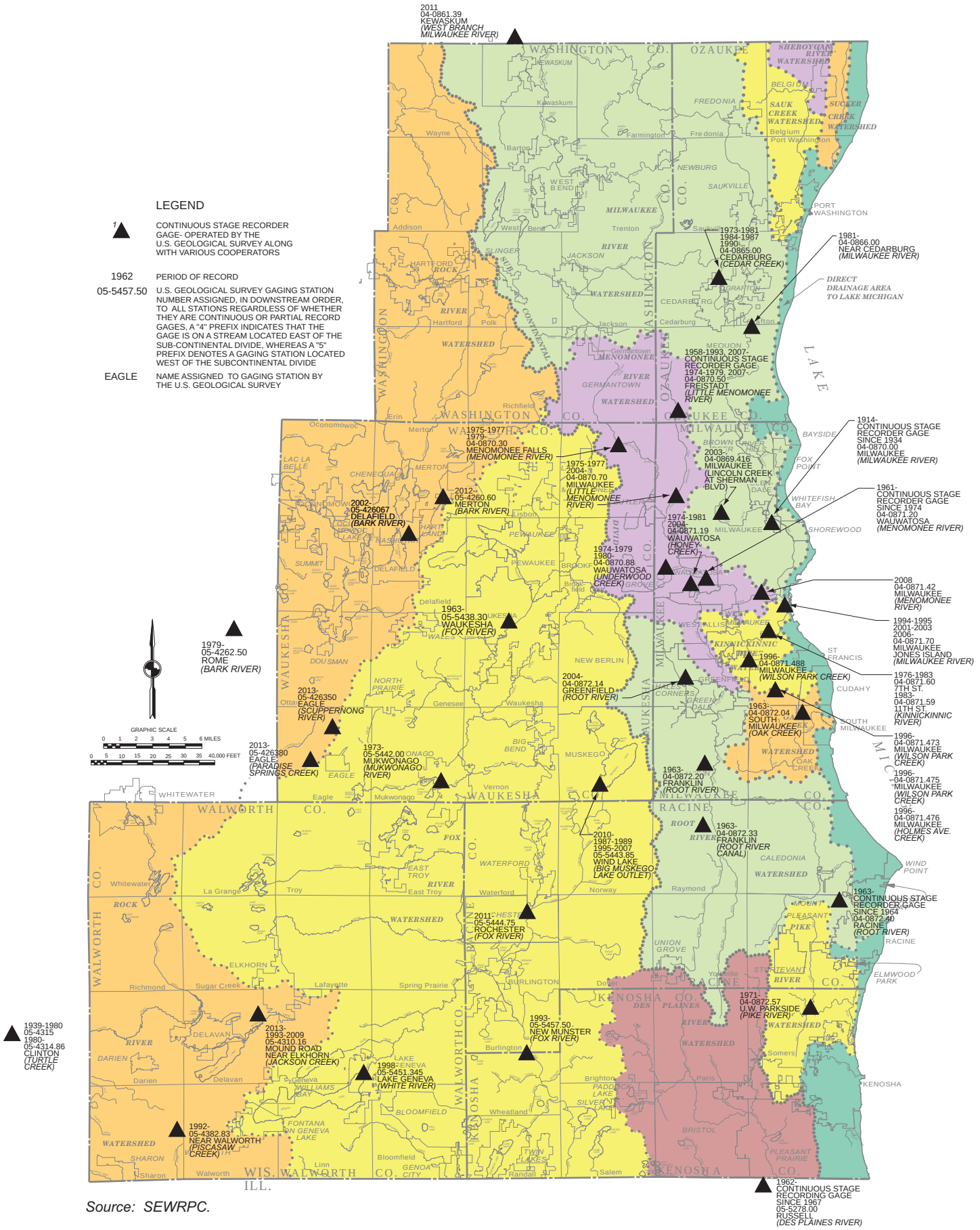
USGS AND MMSD WATER QUALITY SAMPLING STATIONS WITH RECENT CHLORIDE OR SPECIFIC CONDUCTANCE DATA



Source: U.S. Geological Survey, Milwaukee Metropolitan Sewerage District, and SEWRPC.

Map 8

LOCATIONS OF U.S. GEOLOGICAL SURVEY STREAM-GAGING STATIONS: 2013



Source: SEWRPC.

- New sites should be considered at locations where chloride and/or specific conductance data are currently collected during spring, summer, and fall, but not during the winter;
- New sites should be considered on a range of sizes of streams and rivers;
- New sites should be established to provide monitoring coverage throughout the Region and in every major watershed in the Region;
- New stream or river sites should be considered at, or near, the 39 existing USGS continuous recording streamflow gages in, or near, the Region;
- New lake sites should be selected to include seepage lakes, spring lakes, drained lakes, drainage lakes, and impoundments, if feasible; and
- New sites should be geographically distributed such that they represent locations where surface water runoff to streams comes from areas of low- medium, and high-density development.

The collection of new specific conductance data will be supplemented by collection of water samples from the stream and lake locations and depths at which the specific conductance data loggers are deployed. The samples will be sent to the Wisconsin State Laboratory of Hygiene (WSLH) for chemical analysis for concentrations of chloride, total hardness, sodium, potassium, and sulfate. WSLH analysis procedures for total hardness include determination of concentrations of magnesium and calcium. Collection of these data will enable the validation and refinement of the regression relationships between specific conductance and chloride on a site-specific basis.

Samples will be collected over a two-year period. In those waterbodies in which one logger is deployed, 20 samples will be collected. In those waterbodies in which multiple loggers are deployed, 20 samples will be collected at the site of one logger, and 10 samples at each other logger site. To validate the regression relationship, it is important that the samples collected at a site encompass the entire range of chloride and specific conductance values that occur there. To ensure that this range is obtained, some of the sampling will be conducted in response to specific events such as runoff events related to spring snowmelt.

The adequacy of the existing water quantity and quality stream gaging station network will be evaluated, and recommendations may be made for the installation, as may be found necessary or desirable, of additional stations.

Groundwater

It is proposed to obtain available WDNR records on chloride concentrations in well water throughout the Region, including available records on chloride concentrations in water in wells used to monitor landfills and hazardous waste facilities. The WDNR's Waste and Materials Management Program has collected environmental monitoring data from licensed landfills since the mid-1970s. These data are available through the Department's Groundwater and Environmental Monitoring System (GEMS) database. The records contained in the GEMS database cover analytical data for groundwater samples from monitoring wells at solid waste facilities, private drinking water supply wells around landfills, and a few hazardous waste facilities that have monitoring wells. In addition, the GEMS database contains records for surface water monitoring from landfills. While these data may not be representative of aquifer conditions, they may give insight as to the contribution of chloride from landfills to surface and groundwater.

Recent data on chloride concentrations in groundwater of the shallow aquifer and limited portions of the deep aquifer[11] will be used to establish a current baseline condition that can be 1) compared to drinking water

[11]*Data from wells developed in the shallow aquifer comprised of the sand and gravel aquifer and the dolomite aquifer (Silurian and Galena-Platteville formations) are pertinent to the evaluation of chlorides transmitted from the land surface to the groundwater. Throughout all but the extreme western portions of the Region, the shallow aquifer lies above the Maquoketa shale, which forms a relatively impermeable barrier between the shallow and deep aquifers. Data from wells developed in the deep, sandstone aquifer in the western parts of the Region where there is no shale layer separating the shallow and deep aquifers may also be of interest.*

standards, 2) compared to historical data to evaluate trends in chloride concentrations, and 3) analyzed along with historical chloride concentration data and past and existing land use information to identify possible sources of chloride in the groundwater. Generalized locations where shallow aquifer groundwater chloride concentrations data may be available are shown graphically on Map 9. A preliminary inventory of municipal wells indicates that approximately 133 wells may be sources of data on chloride concentrations in the groundwater. The municipal well data on groundwater chemistry will be supplemented with information from observation wells established by the USGS and information from private wells that has been submitted to the Center for Watershed Science and Education at the University of Wisconsin-Stevens Point.

Given the degree of dependency of much of the Southeastern Wisconsin Region upon groundwater as the primary source of supply, and the potential for contamination of the shallow aquifer supply by dissolved road salt that can infiltrate into the groundwater, or chloride from water softening systems that discharge to private onsite wastewater treatment systems that then discharge to the groundwater, definitive data compiled or developed under the 2010 SEWRPC regional water supply planning effort will be useful in accessing impacts on groundwater. Data from that planning effort is available on the hydrogeology of the groundwater aquifers underlying the Region, including data on the historical consumption of groundwater and the historical progression of water levels, or potentiometric surfaces, throughout the primary aquifers and the susceptibility of the aquifers to contamination. Because many lake levels, low streamflows, and wetland complexes are maintained by groundwater discharges, the relationships between the groundwaters and surface waters of the Region were also established under the 2010 planning program. In addition, the important groundwater recharge areas were delineated and mapped under the study, and that information is available for use in the chloride study.

In 2002, the Commission completed a cooperative project with the Wisconsin Geological and Natural History Survey for the conduct of a regional groundwater resource inventory and analysis.[12] Utilizing existing well logs and available geological survey and detailed soil survey data, definitive data were developed on such factors as depth to bedrock, depth to water table, groundwater flow patterns, potential for groundwater contamination, and sources of groundwater contamination. A series of county maps was developed at a compilation scale of 1:48000 presenting the results of the inventory and analysis, the mapped data being available in both hardcopy and digital format. The series included maps showing the topmost bedrock units and specifically the areal extent of the Maquoketa shale unit; depth to bedrock; bedrock outcrops; depth to water table, water table elevation; potentiometric surfaces for units deeper than the water table; the surfaces and thicknesses of the primary aquifers underlying the Region; hydrogeologic properties of the surficial deposits, and susceptibility of the shallow aquifer to contamination. The maps were based on carefully designed criteria to be useful in regional and local groundwater protection studies and related land use planning. The data and maps developed under the regional groundwater resource inventory and analysis will be available and adequate for use in the chloride impact study.

Land Use Data

Since certain land uses are important determinants of the potential stormwater and snowmelt runoff and indicators of discharges from private onsite wastewater treatment systems and attendant chloride pollution of 1) surface waters; 2) groundwater sources of water supply; and 3) stream, lake, and wetland baseflows derived from groundwater, a land use inventory will be required for the proposed study. Such an inventory must provide definitive data on the existing and probable future amount, type, intensity, and spatial distribution of the various land uses in sufficient detail to enable the establishment of historical patterns and trends.

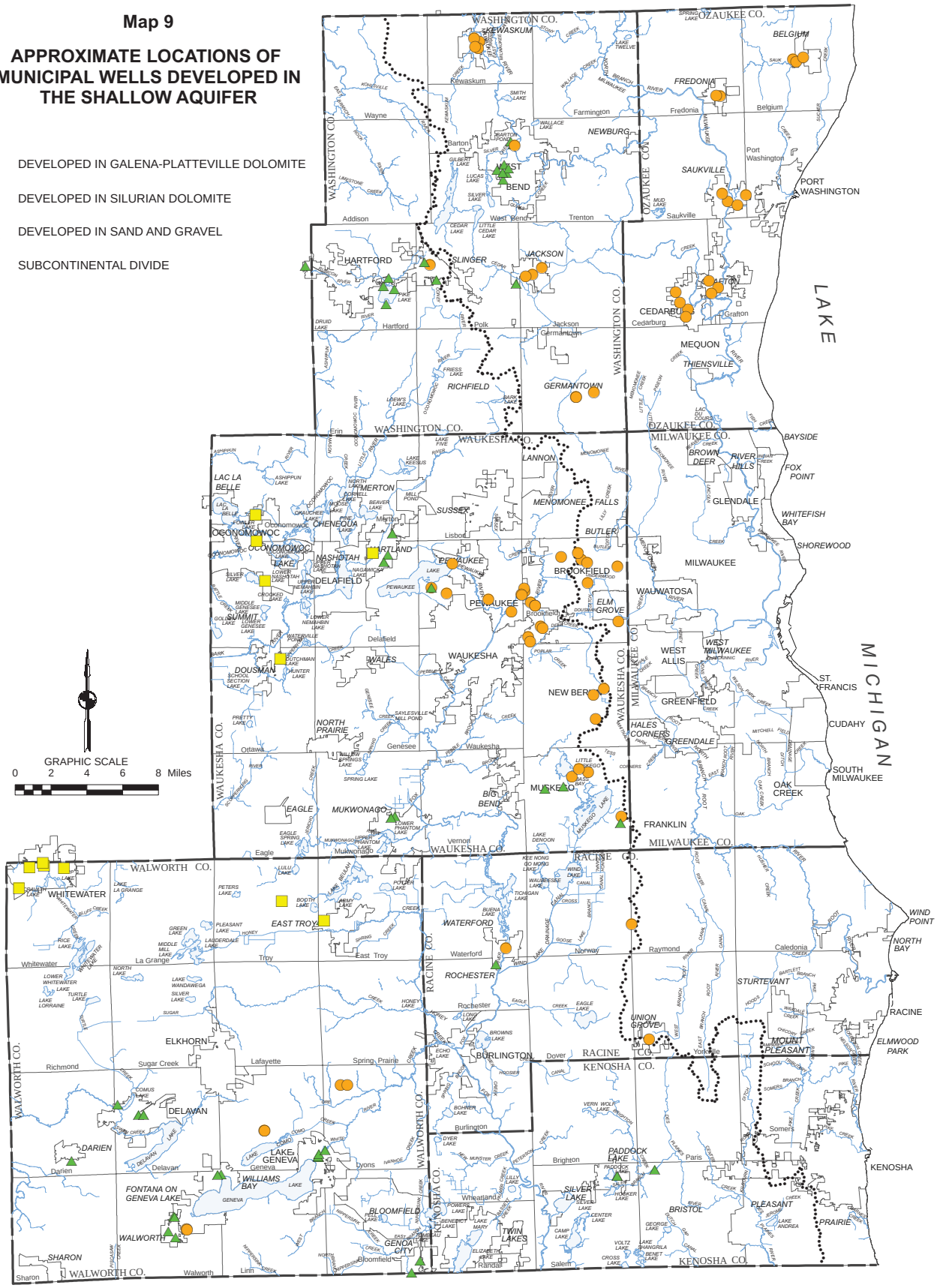
The Commission has periodically, since 1963, conducted definitive inventories of the existing land use patterns within the Region. The regional land use inventory provides data on 67 categories of land use. The most recent existing land use inventory reflects year 2010 conditions. The preparation of a year 2050 regional land use plan is

[12]*SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002*.

Map 9

APPROXIMATE LOCATIONS OF MUNICIPAL WELLS DEVELOPED IN THE SHALLOW AQUIFER

- DEVELOPED IN GALENA-PLATTEVILLE DOLOMITE
- DEVELOPED IN SILURIAN DOLOMITE
- DEVELOPED IN SAND AND GRAVEL
- SUBCONTINENTAL DIVIDE



Source: SEWRPC.

currently underway.[13] The land use plan will provide data on probable future land use patterns within the Region. The 2010 inventory and the 2050 plan information will be available for use in the proposed chloride impact study.

Natural Resource Base Data

Because of the potential for chloride use to impact the natural resource base of the Region, definitive data will be required on that natural resource base. The data should include information on the location, extent, and quality of wetland, woodland, and wildlife habitat areas within the Region, and on the location and extent of related park and open space reservations. The data should also include the identification of natural areas and critical species habitats requiring protection.

The Commission has, since 1963, periodically inventoried and mapped the woodland, wetland, and wildlife habitat areas of the Region and has identified natural areas and critical species habitats requiring protection and management. The Commission has also mapped all existing park and outdoor recreation sites within the Region, and has delineated Commission-defined environmental corridors within the Region. The environmental corridors encompass concentrations of natural resource elements, including woodlands, wetlands, wildlife habitats, surface waters and associated floodplains and shorelands, and sites having cultural and recreational value. Importantly, these corridors also encompass areas of both groundwater recharge and discharge within the Region. The corridors represent a composite of the best remaining elements of the natural resource base of the Region and the adopted regional land use plan recommends the preservation of these corridors in natural open uses. Such preservation is essential to the maintenance of a high level of environmental quality within the Region, to the protection of its natural heritage and beauty, and to the provision of invaluable opportunities for outdoor recreational and educational pursuits. The exclusion of urban development from these corridors will also help avoid the creation or intensification of such serious and costly problems as flood damages, water pollution, wet basements, building and pavement foundation failures, and excessive infiltration of clear water in sanitary sewerage systems.

The primary environmental corridors of the Region encompass an area of about 487 square miles, or 18 percent of the total area of the Region. The location, extent, and status of preservation of these corridors must be an important consideration in a regional chloride impact study.

Other Sources of Chloride Contamination of Surface Water and Groundwater

An inventory of the contribution of chlorides to the water resources of the Region from sources other than roads and parking areas will also be required. These sources include sewage treatment plants, onsite sewage treatment and disposal facilities, salt storage areas, large feedlots, and landfills.

Wastewater Treatment Plants

Currently there are 45 public wastewater treatment plants in operation within the Region. As shown on Map 10, 17 of these plants discharge treated effluent either directly to Lake Michigan or to streams tributary to Lake Michigan. The remaining 28 discharge treated effluent to streams, watercourses, and groundwater in the Fox and Rock River basins. In addition to the public wastewater treatment plants, there are still eight private wastewater treatment plants in operation within the Region that are regulated by the WDNR.[14] Of this total, one discharges treated effluent to a stream tributary to Lake Michigan, and seven discharge treated effluent to streams, watercourses, and wetlands, or to groundwater, in the Des Plaines, Fox, and Rock River basins and discharge treated effluent to the groundwater.

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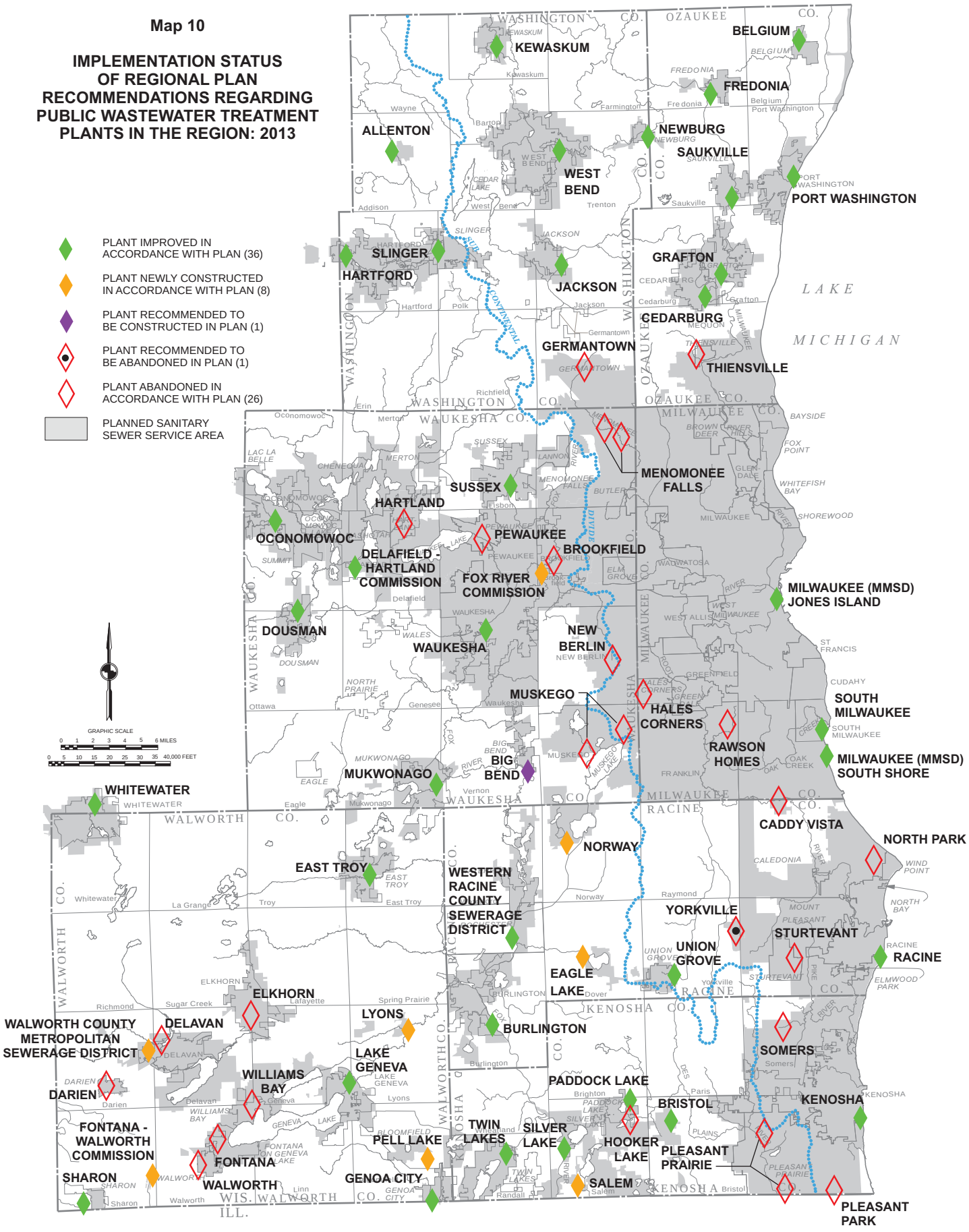
[13]*Demographic and economic studies required for regional land use, transportation, and public infrastructure system planning have been conducted periodically by the Commission since 1963. The historical and current resident population, household, and economic activity levels within the Region are all being considered in developing the regional land use plan for 2050.*

[14]*There may be other private sewage treatment plants that are now regulated by WDNR as industrial point sources. Those plants would be identified under the proposed study.*

Map 10

IMPLEMENTATION STATUS OF REGIONAL PLAN RECOMMENDATIONS REGARDING PUBLIC WASTEWATER TREATMENT PLANTS IN THE REGION: 2013



For the purpose of this study it will be necessary to obtain base year and historic discharges for these plants, and, where available, data on the chloride content of those discharges. The chloride content of the effluent may be expected to vary with such factors as the presence of water softener use in the area served, and with the type and volume of industrial waste discharges to the tributary sewerage systems. The sewage treatment plant operators are required by State law to file monthly reports with the Wisconsin Department of Natural Resources providing information on plant discharge and discharge quality, including chloride content. It will be necessary to collate these effluent flow and quality data from the State records for use in the study.

Private Onsite Wastewater Treatment Facilities

A significant amount of low density residential development exists within the Region. This type of development is generally served by onsite wastewater treatment and disposal facilities—septic tank systems—discharging to the groundwater reservoir. Using the Commission's land use inventory and state-of-the-art information concerning the chloride content of septic tank effluent, it should be possible to estimate the chloride contribution of septic tank systems to the groundwater reservoirs of the Region.

Miscellaneous Sources

A number of miscellaneous sources of salt contamination of surface water and groundwater exist within the Region. These include salt storage areas, large agricultural feed lots, and landfills. Using the Commission's land use inventory it should be possible to identify and locate these sources. A special survey of each identified source will then be necessary to establish the salt contribution of the sources to the surface or groundwater reservoirs of the Region.

It is also proposed to obtain effluent monitoring data submitted to the WDNR from facilities permitted to discharge to surface water or groundwater under the Wisconsin Pollutant Discharge Elimination System. While these data may not be representative of conditions within the receiving waters, they may be useful for estimating the magnitude of contributions of chloride to these waters from municipal wastewater treatment plants and industrial dischargers.

One factor that could inform the choice of which miscellaneous sources of salt contamination to consider in the proposed study is the available data on the uses of salt. The U.S. Geological Survey has compiled estimates of the national percentages of domestic consumption of salt devoted to various uses over the period 1995 through 2013. On average, the chemical industry accounts for about 42.0 percent of the domestic use of salt, and highway deicing is the next largest use, accounting for about 34.5 percent of domestic salt use. Sales to distributors, general industrial uses, food processing, agriculture, and primary water treatment range from about 1 to 8 percent of total domestic consumption. Depending upon the degree to which these uses of salt occur within the Region, it may be useful to consider including them in the inventories of sources of salt contamination to surface and ground waters. The following paragraphs present potential sources of salt contamination and some bases upon which to evaluate whether they should be included in the inventories.

As previously noted, on a national level chemical manufacturing constitutes the largest use of salt and brine. The uses in this industry consist mostly of brine used as chemical feedstock, primarily in the chlorine and caustic soda manufacturing sectors of this industry. Even with pretreatment of process water, these operations may be contributing chloride discharges to wastewater treatment plants.

Certain food processing activities use relatively large amounts of salt and brine. Examples of these include cheese making, sauerkraut manufacturing, meat curing, and pickling. Even with pretreatment of process water, these operations may be contributing chloride discharges to wastewater treatment plants.

The proposed study will include an inventory of chloride concentrations in sewage treatment plant influent and/or effluent, and in cases where concentrations are relatively high, additional inventories will be conducted as necessary to determine whether chemical manufacturing, food processing operations, or other activities or factors that could generate influent containing chloride contribute wastewater flow to the sewage treatment plant in question. Examples of potential sources of contributions of chlorides to wastewater treatment plants include wash

water from salt spreader trucks, runoff from salt storage areas, wastewater from car washes, hauled sanitary wastewater, wastewater from laundries, wastewater from potable water treatment at municipal drinking water facilities, reverse osmosis reject water, and infiltration and inflow into sanitary sewers.

Much of the salt used in the agricultural sector goes to manufacture fertilizers containing potassium chloride. Given the high solubility of this chemical, it is likely that much of the chloride applied to land in this form enters surface water or groundwater. Whether this source will need to be considered in the proposed study may be evaluated through discussions with staffs from county conservation departments, the local offices of the Natural Resources Conservation Service, and the University of Wisconsin-Extension. Such discussions should focus on determining whether there is significant use of fertilizers containing potassium chloride in the Region, or portions of the Region.

Potable water which has high levels of hardness is often treated through the use of water softeners that are recharged with salt and which generally discharge to wastewater treatment plants or to private onsite wastewater treatment systems. In the Southeastern Wisconsin Region, water softening is likely to be concentrated in areas that rely upon groundwater as a source of water supply. Chlorides from water softeners in areas served by wastewater treatment plants are not removed during the wastewater treatment process and they are discharged directly to surface waters. Chlorides from water softeners in areas served by private onsite wastewater treatment systems are not removed by the onsite systems and are discharged to the shallow groundwater aquifer. Those chlorides may eventually reach surface waters as baseflow. This source of chlorides to surface waters and groundwater will be evaluated through review of the sources of water supply in the Region and through development of estimates of the magnitude of chloride loads discharged to surface waters from wastewater treatment plant discharges[15] and to groundwater from private onsite wastewater treatment systems.[16]

Sources Not Included
Two natural sources of chloride contamination of ground and surface waters are proposed to be excluded from the study as relatively insignificant within the Region. These are: atmospheric deposition and the natural weathering of bedrock and surficial rocks and soils, including leeching from certain geologic deposits.

Analyses and Forecasts
Inventories provide factual information about historical and current situations. Analyses and forecasts prepared utilizing the inventory information are necessary to provide estimates of future conditions. With respect to use of chloride, these future conditions must be determined from a sequence of interlocking forecasts. Demographic and economic activity projections and forecasts provide estimates of future growth within the Region. These projections and forecasts can, in turn, be translated into future demands for the various types of land uses, which are used to develop land use plans. The planned land use pattern may be used to estimate the amount and spatial distribution of travel to be accommodated by the transportation system and the ability of various modes of transportation to serve travel demand cost-effectively. The planned configuration of the transportation system will be used to estimate various degrees of road salt use under possible alternative application scenarios. The planned land use distribution can be used, along with information on planned sanitary sewer service areas and on areas for which the water supply is to be provided by groundwater or surface water sources, to determine where water softening systems would be expected to be utilized and whether such systems would ultimately discharge to groundwater or to surface water.

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[15]*This would include review of chloride concentrations in wastewater treatment plant influent and/or effluent.*

[16]*See the preceding report subsections entitled "Wastewater Treatment Plants" and "Private Onsite Wastewater Treatment Facilities."*

Technical Analyses of Climatological, Surface Water, Groundwater, and Water Quality Inventory Data
Analyses of the climatological, surface water, groundwater, and water quality inventory data collated and collected under the program inventories will be required to establish functional relationships pertinent to the effects of chloride use on surface water and groundwater quality.

Climatological Data
The analyses of the climatological data should include consideration of 1) past winter precipitation data, including estimation of the number of snowfall or freezing rain events per year and of any annual trends in the number and intensity of such events, 2) past winter air temperature data, and 3) possible future winter snowfall and rainfall conditions incorporating the potential effects of climate change as projected through mid-century. The Commission has worked with the Climatic Research Center in the University of Wisconsin Nelson Institute for Environmental Studies on developing precipitation and air temperature data reflecting a range of possible mid-century climate change conditions in the Southeastern Wisconsin Region. That information, or appropriate updated information, may be applied in assessing mid-century conditions under the proposed study.

Surface Water, Groundwater, and Water Quality Data
As noted previously, surface water and groundwater quality data are available, and it is proposed to collect additional data on specific conductance and chloride concentrations. Significant effort will have to be expended to collate and analyze available specific conductance and chloride concentration data collected for streams, lakes, and groundwater aquifers. The data must be assembled in a form suitable for use in evaluating trends in concentrations; making comparisons to chronic and acute toxicity levels; and correlating the locations where data are available with possible road salt sources, or other salt sources.

The inventory and analyses of the surface water data should include the preparation of maps identifying lakes within the Region by type (i.e., seepage lakes, spring lakes, drained lakes, drainage lakes, and impoundments) and stream reaches to be given specific consideration under the study. The data collection and analyses should be limited to those lakes and streams which might be expected to be most directly affected by chloride.

Some of the required analyses have been completed by the Commission under its areawide water quality management and comprehensive watershed planning programs, and will only need to be reviewed for purposes of the proposed study. Other analyses will have to be conducted to account for additional data collected since those planning programs were completed.

Existing and Planned Land Use and Transportation System Data and Chloride Source Data
Land Use and Transportation System Data
The proposed study will utilize the latest existing (2010) land use and transportation system data and information on planned conditions as developed under the regional land use and transportation system plans prepared by the Commission and adopted by the Commission and by the county boards of the seven counties concerned. The Commission is in the process of updating the regional land use and transportation system plans to the design year 2050. It is proposed to use those plans, which are anticipated to be completed by mid-2016, as a source of needed land use and transportation system data in the chloride impact study. As noted previously, and elaborated upon below, the configuration of the land use pattern and transportation system can be used to estimate various degrees of chloride use under possible scenarios.

Road Salt Application Analyses and Forecasts
The Region will be divided into analysis areas to facilitate the evaluation of road salt loads and the impacts of those loads on surface water and groundwater resources. Those analysis areas will be delineated based on watershed, subwatershed, and subbasin boundaries, and consideration of the following factors:

- Locations of existing USGS continuous streamflow recording gages, some of which also measure specific conductance, and of new specific conductance measurement sites established under the study;
- State, county, and municipal road maintenance jurisdictional areas;

- Locations of potentially impacted lakes, streams, or rivers; and
- Locations of wastewater treatment plant discharges; and
- Locations of areas served by municipal separate storm sewer systems.

Within each of the analysis areas, existing and planned future lane miles of freeway, expressway, standard arterial, collector, and land access streets will be quantified, as will impervious areas other than streets and highways that are likely to be deiced,[17] and estimates of existing and probable future chloride loads to lakes and streams will be developed under the baseline condition and under several alternative winter road maintenance practices. For the baseline year, which will be established as the year for which lake, stream, and river chloride and/or specific conductance data were collected at the new sites established by the Commission for the study, annual road salt volumes applied will be estimated for each analysis area based upon 1) the lane miles of the various street and highway categories, 2) the road salt application rates reported by the various agencies responsible for winter road maintenance, 3) the number of salt application events, and 4) the number of passes over each section of highway or street during each event.[18] The total annual road salt application volume will be computed for each analysis area, combined with the totals for any other analysis areas in a given maintenance jurisdiction, and compared with the total road salt volume reported for that year by the maintenance agencies. If the computed and actual total road salt volumes are found to be in reasonable agreement, the approach for distributing road salt amounts over various parts of an analysis area will be used to develop forecasts of road salt application volumes under planned year 2050 conditions. If the estimated and actual volumes are not in good agreement, the estimation procedure will be iteratively refined to account for additional factors impacting the distribution of road salt until good agreement is reached between the estimated and actual totals.

In addition, estimates of deicing salt volumes applied to areas other than roads, will be made for the baseline year using data from the regional land use inventory and estimates of application rates obtained from surveys of organizations responsible for winter maintenance of such areas.

Projections of road salt application in the year 2050 will initially be made assuming current application practices applied to the planned lane miles associated with the recommended year 2050 street and highway system. County- and municipality-supplied data on the number of road salt application events over the past 20 years will be used to determine the annual average, minimum, and maximum number of events requiring salt application within each jurisdiction.[19] That procedure will be applied to estimating salt application volumes to roads and other areas under alternative future application scenarios, employing various approaches to salt application. Those alternative approaches will be selected based upon the results of an analysis of the state-of-the-art of winter road maintenance, conducted under the study as described below. In addition to estimating future salt application

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[17]*Such areas would include automobile and truck parking lots; bus, taxi, and truck terminal areas; and ancillary private walkways and driveways. A minimum size of such areas to be considered will be set in the study.*

[18]*To place this baseline year into historical context, weather and climate conditions during this year should be compared to those during the 20-year period for which deicing application data will be sought.*

[19]*Estimates will also be made of deicing salt volumes applied to areas other than roads.*

volumes under alternative approaches, consideration will also be given to how projected mid-century climate change conditions could affect the winter weather conditions and the frequency and intensity of snow and/or ice storms.[20]

Analyses and Forecasts of Other Chloride Sources
As noted above in the subsection entitled "Other Sources of Salt Contamination of Surface Water and Groundwater," the following potential source of chlorides other than road salt will be evaluated:

- Sewage treatment plants,
- Private onsite wastewater treatment systems,
- Salt storage areas,
- Large agricultural feed lots,
- Fertilizers,
- Landfills,
- Chemical manufacturing,
- Food processing, and
- Water softening.

Those sources for which the relative baseline year contributions of chlorides are found to be significant will also be included in the baseline year and alternative future forecasts and analyses of chlorides in surface water and groundwater. Future volumes of chloride from those "other significant sources" will be estimated based on current volumes adjusted to reflect incremental changes under 2050 planned land use and population forecasts.

Development of Instream or In-Lake Chloride Concentrations
The estimated baseline monthly road salt application volumes and the chloride volumes from other significant sources for each analysis area will be converted to estimates of monthly average chloride concentrations in streams, rivers, and lakes using monthly average streamflow determined from 1) measurements at one of the USGS streamflow gage locations shown on Map 6, 2) transposition of the monthly streamflow from a gaged reach to an upstream or downstream location, or 3) where available, simulated monthly average streamflow developed using one of the Commission continuous simulation hydrologic models.[21] For planned year 2050 land use conditions, the estimated monthly salt application volumes for each analysis area from both road salt and other significant sources will be converted to estimates of monthly average chloride concentrations by adjusting the streamflow data applied for baseline conditions to reflect potential additional runoff due to increases in

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[20]*As noted previously, the Commission has worked with the Climatic Research Center in the University of Wisconsin Nelson Institute for Environmental Studies on developing precipitation and air temperature data reflecting a range of possible mid-century climate change conditions in the Region. That data set will be examined to determine if it adequately represents the range of climate conditions pertinent to evaluation of projected winter weather changes. In general, climate scientists predict that under mid-century climate change conditions higher air temperatures, particular during night time hours, could result in more winter rain storms and fewer snow storms. Such a change in the normal winter weather regime could mean that there would be fewer events requiring road salt application for maintenance of safe driving conditions, but it could also mean that the road salt that is applied would be more quickly washed off the land surface into streams, rivers, and lakes when a winter rain event follows a snow or ice event for which road salt was applied.*

[21]*USEPA Hydrologic Simulation-Fortran (HSPF) continuous simulation models are available for the Des Plaines, Kinnickinnic, Menomonee, Pike, and Root River watersheds and the Oak Creek watershed.*

impervious area from the planned incremental urban development. Several approaches for making that adjustment may be considered, including using available continuous simulation hydrologic models to develop typical relationships between runoff volume and change in imperviousness. Those typical relationships would then be applied as appropriate throughout the Region.

The chloride volume that reaches surface waterbodies is a function of the amount transported from the land surface through snowmelt and/or rainfall, the amount that infiltrates into the ground and reaches surface waterbodies as interflow or as groundwater baseflow, and the amount discharged from sources other than those associated with road salt. The salt that is transported through subsurface interflow would be expected to reach receiving waters on a relatively short time frame; therefore, estimation of monthly volumes transported to surface waters would be expected to include the interflow component. In general, much of the infiltrated salt in solution that reaches the groundwater table would be expected to ultimately be transported to surface waters over a longer time frame than a month. The baseline instream and in-lake estimates of chloride concentrations computed from salt application and discharge volumes and measured or computed monthly streamflow would be compared to the chloride concentrations inferred from the relationship between specific conductance (measured) and chloride concentration. The salt volume reaching the waterbody would be adjusted to achieve reasonable agreement between observed and computed monthly average chloride concentrations. The difference between the total amount of chloride applied or discharged and the amount estimated to reach surface waters on a monthly time scale would be the amount that is transported to the groundwater, or temporarily retained on the land surface.[22,23]

Using the instream or in-lake chloride concentration estimates, which will be determined in a consistent manner, comparisons can be made between current baseline conditions, future conditions under various winter maintenance scenarios for roads and other impervious areas, and future conditions accounting for climate change. Those concentrations can also be compared to the chloride concentration standards for aquatic life and drinking water, and for aquatic and terrestrial vegetation.

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[22]*It would be anticipated that more road salt would be applied on a unit area basis in urban areas of dense development than in less densely-developed rural areas, and that the relative proportion of road salt transported to surface waters would be higher in more densely-developed areas with higher percentages of impervious surfaces. Thus, the analysis of relative amounts of road salt delivered to surface water and groundwater will appropriately distinguish between urban and rural tributary areas.*

[23]*An additional component of the chloride load to waterbodies would be from the chloride applied for anti-icing and deicing of paved surfaces that would reach sanitary sewers, and ultimately wastewater treatment plants, through infiltration and inflow. The magnitude of that component of the load would not be directly estimated, but it would be accounted for in the chloride loads from those treatment plants. The inflow component would generally enter sanitary sewers through surface connections such as manholes, and thus, would travel through the system and be discharged to waterbodies within a relatively short time. The infiltration component would be comprised of chloride that first infiltrates into the ground before infiltrating into a sanitary sewer. In relatively densely developed urban areas, the chloride load attributable to infiltration into sanitary sewers would reach those sewers on a short time frame (generally less than the monthly time frame to be used for the chloride mass balance analysis) given the spatial density of the sewer network. In certain less-densely developed areas served by sanitary sewers, and along the outer boundaries of densely-developed areas, there might be instances where chloride infiltrated into the ground would reach the groundwater table and travel more slowly to the sanitary sewer, perhaps on a time scale longer than one month. Such contributions might show up later in the winter maintenance period, or after winter. The magnitude of the loads reaching waterbodies on time frames greater than one month would be anticipated to be relatively small, but the possibility of chloride contributions from longer-term infiltration to sanitary sewers and from longer term groundwater inflow to waterbodies, will be taken into consideration during the mass balance analysis.*

SPECIAL CONSIDERATIONS RELATED TO FORECASTS AND ANALYSES FOR LAKES

The general analysis and forecast procedures for estimating chloride effects on surface waters as described in the preceding subsection of this prospectus will be applicable to lakes, but will be modified as necessary to account for the following:

- Consideration of the type of lake (i.e., seepage lake, spring lake, drained lake, drainage lake, or impoundment);
- The water residence time in the lake; and
- Recommendations developed under existing lake management plans.

General Analysis and Forecast Procedures Related to Groundwater

As described in the previous subsection on, "General Analysis and Forecast Procedures Related to Surface Waters," procedures will be applied to estimate the amount of chloride that is transported to the groundwater. Due to the limitations of the available data and the complexity of groundwater flow conditions, it is not considered feasible to estimate specific changes in chloride concentrations in groundwater over time. Rather, it is proposed to combine analyses of trends in chloride concentrations in groundwater based on historical measurements with estimates of the amounts of chloride transported to the groundwater under baseline and alternative future application scenarios to provide an assessment of the relative impacts on groundwater of the various application scenarios, and of the implications for public health.

Technical Analyses of Natural Resource Base Data

The Regional Planning Commission has adopted a regional natural areas and critical species habitat protection and management plan as an element of a comprehensive plan for the physical development of the Southeastern Wisconsin Region. This plan element is reflected in the adopted regional land use plan and pertinent data on woodlands, wildlife habitat, and on environmental corridors—like the socioeconomic and land use data—are available by U.S. Public Land Survey system one-quarter section. Therefore, the historical and current natural resource base data and plan proposals for the protection of the natural resource base of the Region are available in the Commission planning database in a form suitable for use in the proposed study.

The proximity of features comprising the natural resource data base to locations of existing or projected future road salt application will be used to identify critical natural resource areas that are being and/or could be adversely impacted by road salt application. The alternative winter road maintenance approaches will be evaluated relative to their potential to impact such areas, or to mitigate impacts on those areas.

Description of the State-of-the-Art of Activities Affecting Chloride in the Environment

A comprehensive state-of-the-art component will be developed that will examine various aspects of chloride sources in the environment. That component will a) analyze and evaluate what can be done to reduce the potential impacts of chloride on surface and groundwater resources, considering existing and emerging technologies and best practices, and b) lead to the development of recommendations. It will largely be based on an extensive search of both the technical literature and other appropriate sources and interviews of municipal public works staff and employees of private snow and ice control firms. It will address the following sources of chloride to the environment and will identify and evaluate the best practices and technologies for reducing chlorides from each of those sources.

- **Winter anti-icing and deicing by both the public and private sectors, including salt storage.** The toxicity and other environmental effects of road salt and various alternative road anti-icing and deicing substances will be evaluated.
- **Water softening**.
- **Municipal wastewater sources.**
- **Private onsite wastewater treatment systems.**
- **Other potentially significant sources such as large agricultural feed lots and fertilizers.**

In addition, the effects of chloride on transportation infrastructure will be described; regulatory requirements related to winter road maintenance will be reviewed;[24] and legal and policy aspects related to chloride in the environment and to approaches to mitigate the effects of chloride will be explored. Where appropriate, the performance of practices will be evaluated and cost information will be developed for various practices considered. The information developed under the state-of-the-art component will be applied in developing alternative scenarios.

Preparation of Study Findings and Recommendations

Several feasible chloride management scenarios will be developed and evaluated relative to the abatement of the adverse effects of road salt use and chloride discharges from other sources on the specific surface water and groundwater resources of the Region. Public and private entities responsible for winter maintenance of roads, parking lots, and ancillary features and for discharges of chloride from other sources can then consider incorporating some or all of the features of the alternatives into their maintenance program.

Each scenario must be quantitatively tested to establish the ability of the winter road maintenance features and other chloride management practices to cost-effectively meet public health and safety objectives, while reducing salt loads to stream and lakes and to groundwater. Each scenario will carry with it potential impacts on allocation of resources, public investment policies, and broadly defined community benefits and costs. Therefore, the related physical, economic, social, and legal impacts of the scenarios considered must be comparatively analyzed and presented in a clear, understandable form to elected public and municipal officials and interested citizens for evaluation. This would be done through a technical report documenting the study in detail and describing the corollary effects and broad benefits and costs of each scenario. The report would be subject to review by both the Advisory Committee formed by the Commission staff and tasked with guiding the development of the study (see Chapter I) and by the Commission itself.

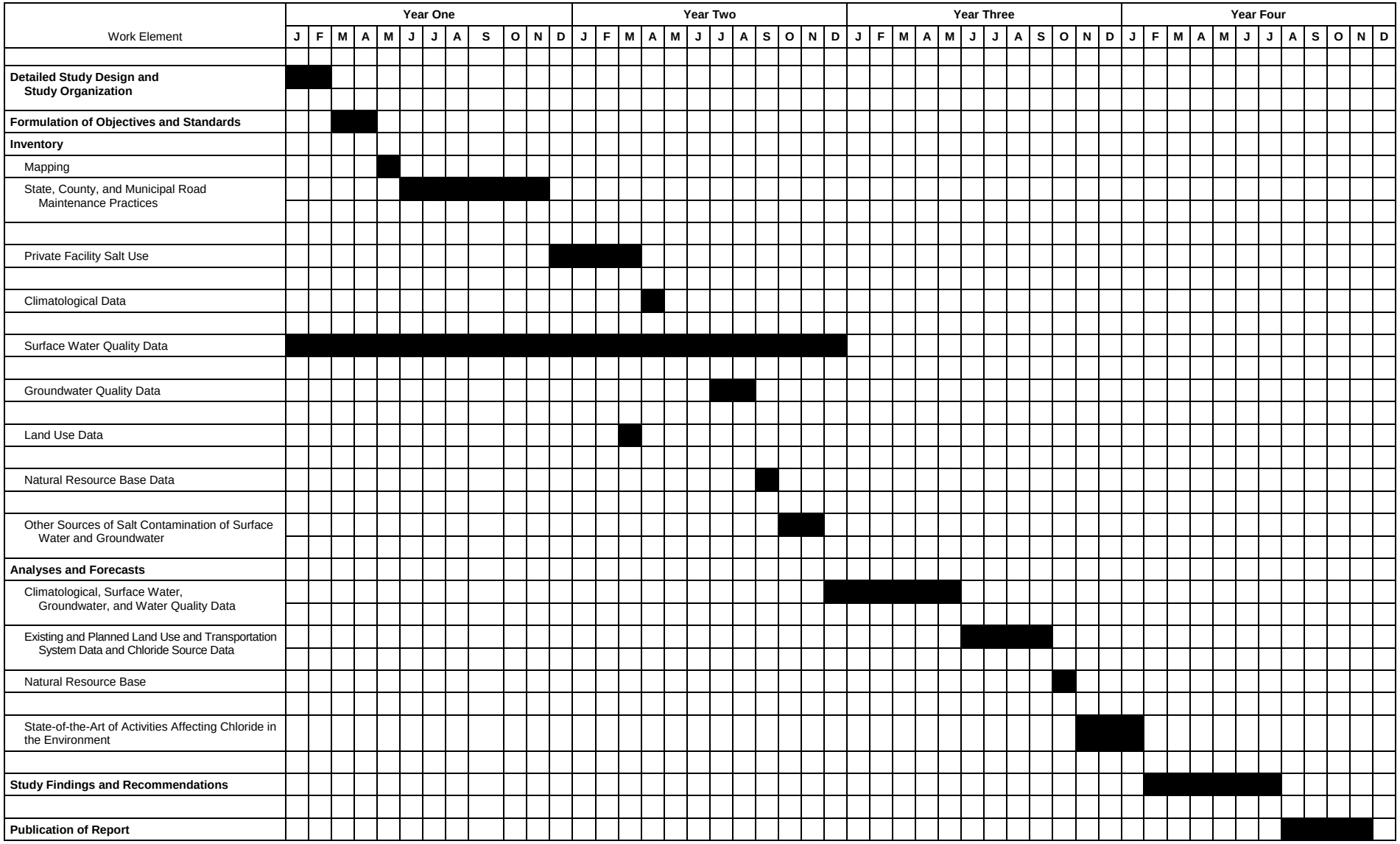
Additional documentation will be provided to make the findings and recommendations of the study available to a diverse audience. This additional documentation may take the form of an executive summary of the study, newsletters, and a dedicated page on the SEWPRC website.

As shown in Figure 6, it is estimated that this study would require a period of 48 months to complete. This schedule is subject to revision upon more detailed design of the various components of the study and is heavily dependent upon the cooperation of the agencies responsible for winter road maintenance and wastewater treatment within the Region and the agencies which have collected and are collecting surface water and groundwater quality data within the Region. The recommended study organization and the cost estimates presented in succeeding chapters of this prospectus are predicated in part upon this tentative time schedule.

[24]*Examples of issues to be addressed in this review include permit conditions related to winter road maintenance for municipal separate storm sewer systems and training programs and certification programs for winter road and parking lot maintenance personnel.*

Figure 6

TIMING OF MAJOR WORK ELEMENTS OF PROPOSED CHLORIDE STUDY



Chapter V

ORGANIZATION FOR STUDY

STAFF STRUCTURE

It is proposed that the study be carried out by the staff of the Commission. The conduct of the study would require the cooperation of the State, county, and municipal units and agencies of government responsible for winter road maintenance.

The recommended staff organization is indicated in Figure 7, as are preliminary functional designations of tasks. The Executive Director and the Deputy Director would have primary responsibility for program direction and coordination. All other aspects of the study would be carried out by the staff of the Environmental Planning Division with assistance from the Land Use Planning and Transportation Planning Divisions. The latter two divisions would provide data and data analyses relating to land use and street and highway system location and configuration.

The Wisconsin Department of Transportation and the county and municipal street and highway maintenance organizations operating within the Region would be asked to collate pertinent available data on street and highway lane mileage, on winter maintenance practices including attendant equipment, and on salt use.

COMMITTEE STRUCTURE

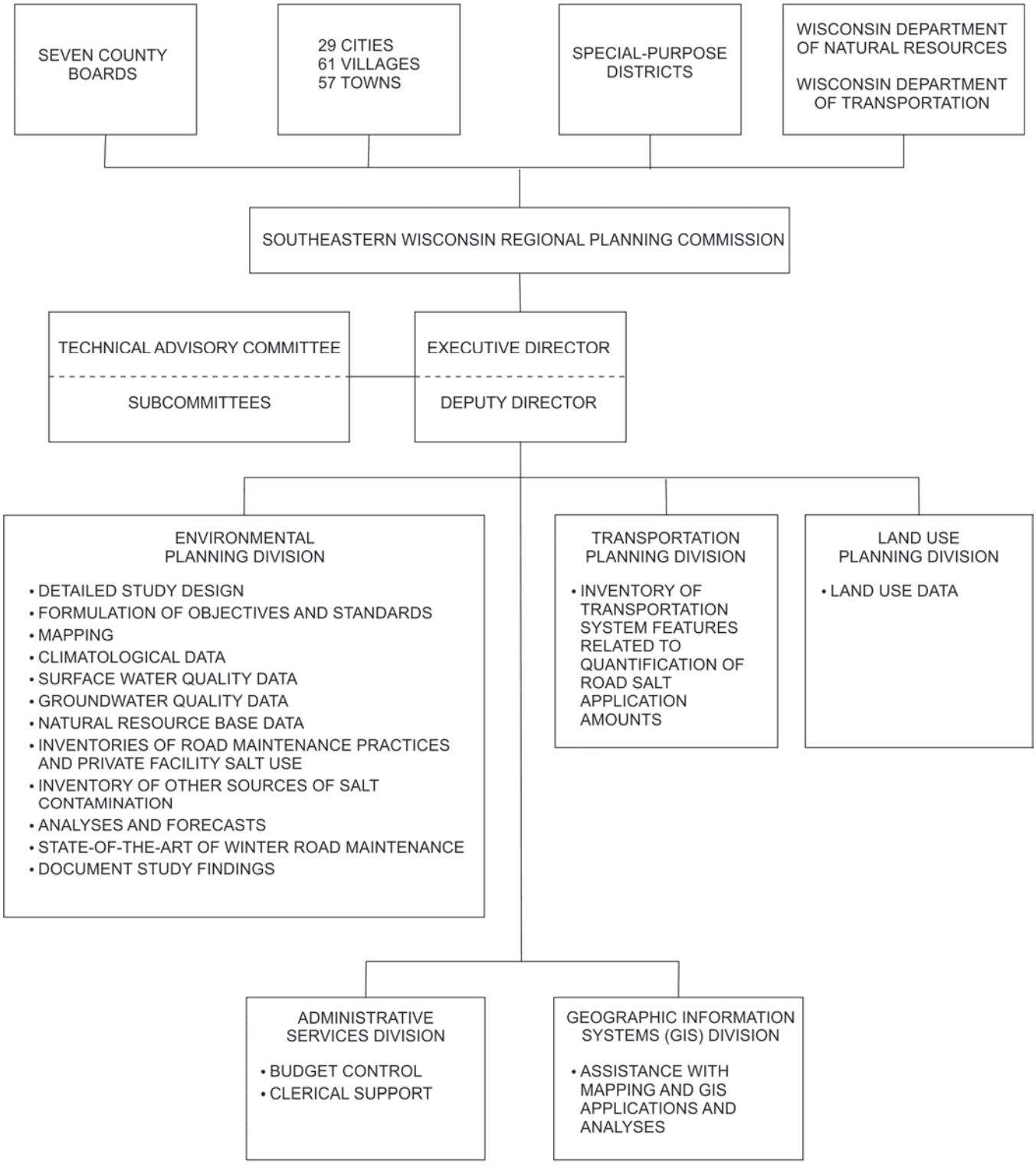
As shown in Figure 7, a technical advisory committee would be created by the Commission to oversee the conduct of the study. This committee would consist of those individuals who served on the advisory committee guiding the preparation of this prospectus—the membership of which is listed on the inside front cover of this prospectus—together with such additional members as may be determined to be needed to provide knowledgeable guidance in the conduct of the study. The membership of the technical advisory committee created to guide the conduct of the study should include, among others, representatives of the U.S. Environmental Protection Agency, the U.S. Geological Survey, the Wisconsin Department of Natural Resources, the Wisconsin Department of Transportation, the Wisconsin Geological and Natural History Survey, the Milwaukee Metropolitan Sewerage District, several counties and municipalities within the Region, environmental organizations, private business and development interests, and the academic community.

DOCUMENTATION

The findings and recommendations of the study would be documented in a Commission technical report. The preparation of the report would be the responsibility of the Commission staff subject to the review and approval by the technical advisory committee and ultimately by the Commission itself.

Figure 7

ORGANIZATIONAL STRUCTURE FOR PROPOSED CHLORIDE STUDY



Source: SEWRPC.

Chapter VI

COSTS AND BENEFITS OF THE STUDY

COST ESTIMATE

Estimated study costs are set forth in Table 3 and are based upon the scope of work, time schedule, and study organization recommended in this prospectus. The costs were calculated by estimating the staff time required to complete each work element, the hourly rate for each staff position anticipated to be assigned to the study, and the attendant overhead costs. Equipment and material costs are estimated to be about $33,000.

The total cost of the study is estimated to total $1.719 million, of which the Regional Planning Commission can contribute one-third in the form of in-kind services through its normal regional planning program. This leaves $1.146 million to be sought from other sources.

In any consideration of these cost estimates, it must be recognized that precise estimates cannot be made in the absence of a detailed study design. This is particularly true with respect to the analytical and scenario design phases of the work; since the depth and detail of the analyses required and the number and complexity of the scenarios to be considered will become apparent only as the work proceeds. Consequently, the cost estimates presented in Table 3 must be considered tentative with respect to the allocation of the total cost among the various work elements. Changes in this allocation must be expected as the work proceeds. Overall study costs, however, should not vary greatly from those estimated.

COST ALLOCATION

Because of the importance of salt use in winter road maintenance and the potentially adverse effect of such use on the transportation infrastructure and the water resources of the Region, and particularly on the inland lake, wetland, and groundwater resources of the area, it may be possible to obtain direct State funding for the conduct of the study. The state-of-the-art component and the study findings and recommendations would be applicable statewide and perhaps throughout the Midwestern United States. The applicability of the study beyond the Southeastern Wisconsin Region increases its value to the Wisconsin Department of Transportation (WisDOT) and the Wisconsin Department of Natural Resources (WDNR). Thus, a possible strategy for funding the study would be for WisDOT, WDNR, and SEWRPC to each provide one-third of the required funding, or approximately $573,000 each (see Table 4).

The WisDOT and WDNR representatives on the Technical Advisory Committee asked that additional sources of funding be pursued to reduce the costs to WisDOT, WDNR, and SEWRPC. Possible additional funding sources that will be considered include 1) the U.S. Environmental Protection Agency Great Lakes Restoration Initiative,

Table 3

REGIONAL CHLORIDE STUDY COST ESTIMATE

Work Element	Total Cost
A. Detailed Study Design and Organization	**$ 66,000**
B. Formulation of Objectives and Standards	**$ 39,000**
C. Inventory	
1. Mapping	$ 11,000
2. State, County, and Municipal Road Maintenance Practices	138,000
3. Private Facility Salt Use	92,000
4. Climatological Data	11,000
5. Surface Water Quality Data	367,000
6. Groundwater Quality Data	28,000
7. Land Use Data	24,000
8. Natural Resource Base Data	17,000
9. Other Sources of Salt Contamination of Surface Water and Groundwater	60,000
Subtotal	**$ 748,000**
D. Analyses and Forecasts	
1. Climatological, Surface Water, Groundwater, and Water Quality Data	$ 135,000
2. Existing and Planned Land Use and Transportation System Data, and Road Salt Application Data	159,000
3. Natural Resource Base	25,000
4. State-of-the-Art of Winter Road Maintenance	81,000
Subtotal	**$ 400,000**
E. Study Findings and Recommendations	**$ 130,000**
F. Publication of Report	**$ 50,000**
G. Travel, Contingencies, and Miscellaneous Expenses	**$ 286,000**
Total	**$1,719,000**

Source: SEWRPC.

Table 4

FUNDING STRATEGY FOR SOUTHEASTERN WISCONSIN REGIONAL CHLORIDE IMPACT STUDY IN THE ABSENCE OF SUPPLEMENTAL FUNDING FROM OTHER SOURCES

Agency	Year 1	Year 2	Year 3	Year 4	Total
SEWRPC	$167,418	$167,418	$119,083	$119,083	$ 573,002
WisDOT	$167,417	$167,416	$119,083	$119,083	$ 572,999
WDNR	$167,417	$167,416	$119,083	$119,083	$ 572,999
Total	$502,252	$502,250	$357,249	$357,249	$1,719,000

Source: SEWRPC.

2) Federal Highway Administration (FHWA) research funds, 3) the WisDOT State Planning and Research Program (80 percent funding from FHWA with the remainder provided by the State and SEWRPC), 4) the Fund for Lake Michigan, 5) municipalities that have municipal separate storm sewer system (MS4) permits from the State of Wisconsin under the Wisconsin Pollutant Discharge Elimination System (WPDES), 6) the Milwaukee

Metropolitan Sewerage District, 7) lake associations and river-oriented groups, and 8) the League of Wisconsin Municipalities. If funding is obtained from sources other than WisDOT, WDNR, and SEWRPC, the amount of that funding would be subtracted from the total study cost and the remaining amount would be divided equally between WisDOT, WDNR, and SEWRPC.[1]

BENEFITS OF THE STUDY

The study will provide multiple benefits to the Region and the State of Wisconsin by providing 1) an understanding of the levels of chloride in surface waters and groundwater; 2) an evaluation of historical and future trends in chloride loads and concentrations in surface water and groundwater; 3) quantification of the potential chloride contribution to surface water and groundwater from various sources, including segments of the interstate, state, and county highway systems; and 4) chloride management approaches that will help to maintain high quality surface water and groundwater resources, or to improve their quality, while also addressing public health and safety considerations and the Statewide economic benefits of adequate winter maintenance of roads. Specifically, the study will benefit the Southeastern Wisconsin Region, and the State of Wisconsin as a whole, through:

1. **The collection of valuable new instream and inlake water quality information, and the analysis of existing and new data to identify areas where chloride concentrations are at problem levels, or may reach problem levels in the future.** Existing data on specific conductance and chloride concentrations during the winter are relatively limited. The study will include collection of such data throughout the year, providing a more complete indication of annual variations in chloride concentrations. Existing information on chloride concentrations in groundwater will be collated from available records This analysis will also identify chloride concentration trends in surface water and groundwater.

2. **Establishment of sound, specific data on the amounts of chloride contributed to the environment from all significant sources within the Region.** This will provide valuable context regarding the relative contributions of chloride to the environment. The study will evaluate the estimated annual amounts of chloride applied to public roads relative to other sources, including wastewater treatment plants, private onsite wastewater treatment systems, salt storage areas, large agricultural feed lots, fertilizers, landfills, chemical manufacturing, food processing, and water softening.

3. **Analysis and evaluation of the potential impacts of chloride in the environment on surface and groundwater resources.** These analyses will be performed for existing and planned year 2050 land use conditions and will be performed at a subwatershed or subbasin geographic scale, recognizing municipal boundaries, that will enable the relative contributions of the various sources (e.g., road anti-icing and deicing, parking lot anti-icing and deicing, water softeners) to be estimated at that geographic scale. These analyses will provide useful information for evaluating effects of changes in land use on the amount of chloride in the environment, including the contributions from winter maintenance of roads and highways.

4. **Development of a comprehensive state-of-the-art component that will a) analyze and evaluate what can be done to reduce the potential impacts of chloride on surface and groundwater resources, considering existing and emerging technologies and best practices, and b) lead to the development of recommendations.** That component will largely be based on an extensive search of both the technical literature and other appropriate sources and on interviews of municipal public works staff and employees of private snow and ice control firms. It will address the following sources of chloride to the environment and will identify and evaluate the best practices and technologies for reducing chlorides from each of those sources.

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[1]*Any WisDOT or SEWRPC matching contributions that may be required for certain grants (e.g., from FHWA) would be treated as part of the WisDOT or SEWRPC equal cost shares.*

a) **Winter anti-icing and deicing by both the public and private sectors, including salt storage.** The toxicity and other environmental effects of road salt and various alternative road anti-icing and deicing substances will be evaluated.

b) **Water softening**.

c) **Municipal wastewater sources.**

d) **Private onsite wastewater treatment systems.**

e) **Other potentially significant sources such as large agricultural feed lots and fertilizers.**

In addition, the effects of chloride on transportation infrastructure will be described, regulatory requirements related to winter road maintenance will be reviewed, and legal and policy aspects related to chloride in the environment and to approaches to mitigate the effects of chloride will be explored. Where appropriate, the performance of practices will be evaluated and cost information will be developed for various practices considered. The information developed under the state-of-the-art component will be applied in developing alternative scenarios.

5. **Evaluation of alternative scenarios for reducing chlorides in the environment while protecting public health and safety.** These scenarios would address winter road maintenance, water softening, municipal wastewater treatment, private onsite wastewater treatment, and other identified significant chloride sources. The scenarios would be intended to reduce the adverse effects of chloride on surface water and groundwater quality and on transportation infrastructure. Applying information developed under the study on the relative magnitude of various sources of chloride within the Region and the effectiveness and cost of various measures to reduce chloride within the environment, the recommended scenarios would incorporate the most effective combinations of approaches to addressing identified chloride problems in terms of their sources and magnitudes.[2]

[2]*For example, the scenarios may include recommendations regarding 1) the use of alternative anti-icing and deicing materials and practices; 2) efficient water softener operation; and 3) policy approaches, such as providing legal protections against litigation related to private property deicing operations. Those recommendations would be developed in consideration of the need to protect public health and safety under winter driving conditions and through protection of the groundwater supply of potable water.*

Chapter VII

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

Chloride loads to surface and groundwater resources can potentially come from several significant sources, including road salt applied for anti-icing and deicing of public and private roads, sidewalks and parking lots; water softening systems and other sources that discharge to sanitary sewers or private onsite wastewater treatment systems; salt storage areas; large agricultural feed lots; fertilizers; landfills; chemical manufacturing, and food processing. The proposed study will consider the relative magnitudes of chloride loads to the environment from those sources, and any other significant sources identified during the course of the study. Salt applied to roads is the most visible of the potential chloride sources, and thus, receives the most public attention.

The now widespread practice of providing snow-and-ice free, dry street and highway pavement surfaces through enhanced winter road maintenance practices came into being in the mid-1950s. The shift to dry pavement winter road maintenance practices required the use of road salt to facilitate snow and ice removal from pavement surfaces. As the number of lane miles of public streets and highways expanded within southeastern Wisconsin, as public expectations of safe, high-quality winter road operating conditions grew, and as the attendant use of road salt in winter road maintenance practices increased, public concern over the environmental impacts of the use of road salt developed.

The public concern over the environmental impacts over the use of road salt was reflected in an action of the Regional Planning Commission taken at the Commission meeting held on March 19, 2014. At that meeting, Commissioner Nancy Russell, Chairman of the Walworth County Board, called attention to the growing public concern about the environmental impacts of the use of salt in winter road maintenance. She and Commissioner Charles L. Coleman noted that this growing public concern was focused on the effects on the winter resources of the area, particularly including the inland lakes and the groundwater. At the conclusion of the discussion of the issues, it was the consensus of the Commissioners, that the staff be directed to prepare a prospectus for a Commission study of the environmental impacts of the use of road salt in winter road maintenance within the Region. The prospectus, upon its completion and approval by the Commission, would be made available to the seven constituent County Boards and to the State agencies concerned for consideration.

NEED FOR STUDY

Road salt can damage metal and concrete, thereby affecting the condition of motor vehicles and the structural integrity of roadway pavements and street and highway bridges. Road salt can damage roadside vegetation, and change soil structure and fertility. Road salt in runoff, along with chloride from other sources as described in this prospectus, enters streams and watercourses and accumulates in lakes, reservoirs, and wetlands, thereby harming

aquatic plants and animals. Chloride from multiple sources, including road salt, may also enter and accumulate in groundwater. To the extent that chloride accumulates in surface and groundwater sources of drinking water, it may affect human health. There may also be considerations regarding consumers' perceptions of the taste of drinking water containing elevated levels of sodium and chloride. Wildlife is also prone to ill effects from ingesting chloride by drinking surface waters and, particularly by drinking runoff from snow and ice melt. Certain additives to road salt—such as ferrocyanide used to prevent caking—contribute to the water pollution. Water contaminated by chloride will settle in the deepest parts of lakes and reservoirs, leading to chemical stratification, impediment of annual turnover and mixing, and prevention of dissolved oxygen from reaching the lower layers of the waterbody which may become unable to support aquatic life.

Although the negative environmental impacts attendant to the use of chloride are significant and costly, a single characteristic of chloride by itself creates a need to study its use and effects. Chloride introduced to surface water and groundwater resources is not amenable to treatment—that is, removal—by the best management practices applicable to other forms of water pollution. Of even greater concern however, is the fact that there are no natural processes by which sodium and chloride ions contained in contaminated runoff or other discharges are broken down, metabolized, taken up, or otherwise removed from the environment. This means that chloride will accumulate over time in surface lakes and reservoirs and in groundwater, thereby constituting a significant threat to the future quality of life within the Region. This threat constitutes the basic need for a study of the effects of chloride on the surface and groundwater resources of the Region, particularly including its inland lakes.

PURPOSE OF STUDY

The primary purpose of the proposed study would be to investigate and, to the extent possible, define the relationship between significant sources of chloride to the environment and the chloride content of surface and groundwater within the Region. In addition, the study would:

- Provide an accurate set of baseline data—or benchmark—describing the situations within the Region with respect to :
  - The winter road maintenance practices followed by each of the State, county, and municipal agencies within the Region responsible for such maintenance;
  - Chloride discharged to surface water and/or groundwater from wastewater treatment plants and private onsite wastewater treatment systems,[1] salt storage areas, large agricultural feed lots, fertilizers, landfills, chemical manufacturing, food processing, and any other potential chloride sources identified during the course of the proposed study;
  - Surface water quality conditions within the Region in the base year with respect to chloride content. Data should be available for selected by stream reaches and inland lakes within the Region; and
  - Groundwater quality conditions within the Region in the base year with respect to chloride content.
- Provide an accurate record of the historical data and trends relating to the use of road salt in winter road maintenance and on the related surface water and groundwater quality conditions.
- Develop pertinent surface water and groundwater objectives and standards related to human health, and to the maintenance of healthy fresh water aquatic plant and animal communities, as well as fertile soils and healthy terrestrial plant communities.

[1]*These discharges would include effluent from water softening systems.*

Table 5

FUNDING STRATEGY FOR SOUTHEASTERN WISCONSIN REGIONAL CHLORIDE IMPACT STUDY IN THE ABSENCE OF SUPPLEMENTAL FUNDING FROM OTHER SOURCES

Agency	Year 1	Year 2	Year 3	Year 4	Total
SEWRPC	$167,418	$167,418	$119,083	$119,083	$ 573,002
WisDOT	$167,417	$167,416	$119,083	$119,083	$ 572,999
WDNR	$167,417	$167,416	$119,083	$119,083	$ 572,999
Total	$502,252	$502,250	$357,249	$357,249	$1,719,000

Source: SEWRPC.

- Develop reasonable long-range forecasts of the use of chloride that would potentially be discharged to surface water and groundwater resources within the Region.

- Conduct analyses to identify the particular surface water and groundwater resources that are being significantly impacted by the effects of the use of chloride, or which may be expected to be so impacted in the foreseeable future.

- Include a comprehensive state-of-the-art component that will examine various aspects of chloride sources in the environment, including information on the technologies involved in various practices to address chlorides, and the attendant costs.

- Evaluate alternative scenarios for reducing the use of road salt in winter road maintenance, for reducing chloride loads to the environment from other sources, and for abating the adverse effects of significant sources of chloride on vulnerable surface water and groundwater resources of the Region.[2]

Preparation of the needed chloride impact study is technologically feasible and, considering the importance of maintaining a safe water supply and protecting, or improving, the water quality of the surface water and groundwater resources of the Region to the continued social and economic development of Southeastern Wisconsin, is financially feasible.

The cost of cooperatively preparing a technically sound chloride impact study for the urbanizing Southeastern Wisconsin Region is estimated to total $1.719 million. Of this total cost, the Regional Planning Commission would provide one-third in the form of in-kind services. Because of the importance of salt use in winter road maintenance and the potentially adverse effect of such use on the transportation infrastructure and the water resources of the Region, and particularly on the inland lake, wetland, and groundwater resources of the area, it may be possible to obtain direct State funding for the conduct of the study. The state-of-the-art component and the study findings and recommendations would be applicable statewide and perhaps throughout the Midwestern United States. The applicability of the study beyond the Southeastern Wisconsin Region increases its value to the Wisconsin Department of Transportation (WisDOT) and the Wisconsin Department of Natural Resources (WDNR). Thus, a possible strategy for funding the study would be for WisDOT, WDNR, and SEWRPC to each provide one-third of the required funding, or approximately $573,000 each (see Table 5).

[2]*The scenarios will be developed considering a) the amounts of salt and other deicing and anti-icing compounds applied to public and private facilities, b) substances that could be substituted for chlorides, c) emerging practices regarding anti-icing and pre-wetting agents, d) other operational modifications that may be identified during the course of the study, and e) legal and policy approaches to reduce the use of chloride where practicable.*

The WisDOT and WDNR representatives on the Technical Advisory Committee asked that additional sources of funding be pursued to reduce the costs to WisDOT, WDNR, and SEWRPC. Possible additional funding sources that will be considered are listed in Chapter VI. The costs could be incurred over a four-year period.

In consideration of the foregoing, the Committee recommends that a chloride impact study be undertaken for the Southeastern Wisconsin Region, and that the scope, content, techniques, time sequence, staffing, committee structure, and funding strategy for the needed planning effort be as recommended in this prospectus. The Committee respectfully urges the Southeastern Wisconsin Regional Planning Commission to give careful consideration to this prospectus and to act favorably thereon.