Community Assistance Planning Report No. 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

PLAN RECOMMENDATIONS

[Note: Headings shown in blue indicate sections that have been previously reviewed by the Advisory Group and headings shown in red indicate sections that will be reviewed at a future Advisory Group Meeting]

6.1 INTRODUCTION

As noted in Chapter I, the purpose of the Oak Creek watershed restoration plan is to provide a set of specific, targeted recommendations that can be implemented over time to produce improvements relative to a set of focus issues related to conditions in the watershed. The recommendations address four focus areas: water quality, recreational access and use, habitat conditions, and targeted stormwater drainage and flooding issues. In addition, this plan addresses the status of the Oak Creek Mill Pond and the associated dam, considering their relationship to multiple focus issues. The improvements that would result from implementing the recommendations represent steps toward achieving the overall goal of restoring and improving the water resources and other natural resources of the Oak Creek watershed.

This watershed restoration plan was prepared in the context of the Southeastern Wisconsin Regional Planning Commission's (SEWRPC) regional water quality management plan update for the greater Milwaukee watersheds (RWQMPU),[1] which was prepared in coordination with, and largely incorporates, the

[1] *SEWRPC Planning Report No. 50,* A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, *December 2007.*

Milwaukee Metropolitan Sewerage District's (MMSD) 2020 facilities plan.[2] The recommendations of the RWQMPU as they pertain to the Oak Creek watershed and the status of their implementation are summarized in Chapter 2 of this report. In addition to addressing the recommendations of the RWQMPU, this watershed restoration plan also seeks to incorporate those elements of recent and ongoing watershed management programs and initiatives that are related to the restoration plan's focus areas and are consistent with and complement the goals of the RWQMPU. These programs and initiatives are also inventoried and reviewed in Chapter 2 of this report. This plan represents a refinement of the RWQMPU and enables successful implementation of recommendations at a smaller, 28-square mile watershed scale.

This chapter presents the recommended watershed restoration plan. This plan is designed to meet the goals presented in Chapter 5 of this report. Those goals consist of management objectives or steps related to the focus issues that must be achieved to meet the long-term goals established in the RWQMPU. The plan was also prepared to meet the U.S. Environmental Protection Agency's (USEPA) nine minimum elements for a watershed-based plan and to serve as a practical guide for the management of water resources within the Oak Creek watershed and for the management of the land surfaces that drain, directly and indirectly to Oak Creek and its tributaries. The plan includes both general recommendations related to the management of the watershed and a list of specific projects intended to contribute to meeting the management objectives established in Chapter 5. The general and specific types of recommendations made under this plan are described below.

Recommended Actions and Environmental Justice Populations

Improving equitable access to opportunity for all of the Region's residents is one of the important themes that guided the preparation and evaluation of recommendations throughout the VISION 2050 Recommended Regional Land Use and Transportation Plan.[3] As part of VISION 2050, Commission staff completed an equity analysis to evaluate whether the benefits and impacts of the recommended plan would be shared fairly and equitably among different populations in the Region. The equity analysis evaluated how areas with higher-than-average proportions of people of color, families in poverty, and people with disabilities (environmental justice populations) will be served by the recommendations made in the plan.[4]

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[2] *Milwaukee Metropolitan Sewerage District,* MMSD 2020 Facilities Plan, *June 2007.*

[3] *SEWRPC Planning Report No. 55,* VISION 2050, Volume III: Recommended Regional Land Use and Transportation Plan for Southeastern Wisconsin*, 2nd Edition, June 2020.*

[4] *Higher-than average proportions were determined relative to the Region as a whole.*

Each of the VISION 2050 land use recommendations was evaluated based on the degree to which the Region's environmental justice populations would receive a proportionate share of benefits or a disproportionate share of adverse impacts compared to the Region's population as a whole. The equity analysis concluded that all of the land use recommendations would have a positive impact on the Region's populations as a whole and none of the recommendations would have an adverse impact on environmental justice populations.[5]

According to Maps L.1 through L.5 in Appendix L of VISION 2050, portions of the Oak Creek watershed are home to areas with higher-than-average minority populations, families in poverty, and people with disabilities when compared to the Region as a whole. The land use recommendations provided in VISION 2050 were used as a foundation for developing both general and specific recommendations to address the four focus areas of this watershed restoration plan. It is through this framework that recommendations were developed with the goal of having a positive impact on the watershed's population as a whole, including environmental justice populations within the watershed. In particular, the following land use recommendations from VISON 2050 served as a foundation for developing this Oak Creek watershed restoration plan:

- Reserve land for parks and open space as residential neighborhoods are developed within urban service areas

- Preserve primary environmental corridors, secondary environmental corridors, isolated natural resource areas, natural areas, and critical species habitat sites to contribute to the health of the Region's natural resource base as well as that of the Region's residents

- Preserve areas with high groundwater recharge potential to protect the groundwater supply for those populations in the Region that depend on it for drinking water and for the Region-wide water quality and aquatic habitat benefits that groundwater provides to the baseflow of streams, rivers, and lakes

- Manage stormwater through compact development and sustainable development practices that minimize the total impervious surface coverage of new development, thus reducing future loads of pollutants delivered to the Region's streams, rivers, and lakes

[5] *See Appendix L of SEWRPC 2050,* op. cit.

- Target brownfield sites for redevelopment to revitalize underutilized or vacant properties

Many of the general and specific recommendations developed as part of this watershed restoration plan will also improve community resiliency to the impacts of climate change, improve access to outdoor recreational opportunities, and could have a positive impact on the overall health of the watershed's population as whole, including environmental justice populations.

General Recommendations

Unless otherwise indicated, general recommendations are intended to be applicable over the entire watershed. These recommendations provide guidance for the management of natural resources within the watershed with respect to a variety of general and specific factors and issues that contribute to the problems related to each of the focus areas. These problems are identified in Chapters 4 and 5. While general recommendations are presented for each focus area, it should be kept in mind that implementation of many of these recommendations will also have beneficial effects on other focus areas. For example, implementation of some urban stormwater management measures intended to address the water quality focus area by reducing the contributions of sediment to surface waters may also act to address the habitat focus area by reducing deposition of sediment in stream channels. It should be recognized that that placement of a recommendation within a focus area or within a category under a focus area is partially a matter of convenience of presentation.

In many instances, the general recommendations made for the Oak Creek watershed reflect recommendations that were made under the RWQMPU. Several of the general recommendations presented in this chapter consist of refinements of RWQMPU recommendations. These refinements reflect a number of factors, including specific conditions and circumstances in the Oak Creek watershed and additional data and knowledge that have become available since the release of the RWQMPU in 2007.

Specific Project Recommendations

This watershed restoration plan also presents recommendations for the implementation of specific projects. These projects represent specific actions that could be taken to partially implement the general recommendations discussed above. These projects are listed and summarized in Table 6.1 and their locations are shown on Maps 6.1 through 6.13.

The list of specific projects recommended in Table 6.1 was assembled from several sources. Many were suggested by members of the public at an August 30, 2016, meeting of stakeholders that was held to solicit such suggestions. Other projects were suggested in plans or engineering surveys and reports that were developed for local units of government that are located within the watershed. Additional projects were suggested during discussions with staff from State agencies, County and municipal departments, MMSD, and interested nongovernmental organizations. Many recommended projects were suggested by the findings of a field survey of stream physical conditions and instream habitat conducted by Commission staff along Oak Creek, the North Branch of Oak Creek, and a portion of the Mitchell Field Drainage Ditch.[6]

Table 6.1 summarizes several aspects of each recommended project. The summarized aspects include:

- Identification of the focus area or areas that the project addresses. It should be noted that many projects address more than one focus area. For example, while projects addressing streambank erosion directly address the habitat focus area, they also address the water quality focus area because eroding streambanks act as a source of sediment and total suspended solids (TSS) to streams.

- Description of the project site. This description includes a written description of the location, the municipality or municipalities in which the project site is located, and the owner of the site. Project locations are also shown on Maps 6.1 through 6.13.

- A brief description of the recommended management action.

- Estimates of annual pollutant load reductions that would result from implementing the project. These are given where they were either developed in modeling results presented in engineering reports or where enough information regarding the project was available to allow for the development of an estimate.

- Identification of the suggested party potentially responsible for implementing the recommended project.

- Estimates of capital and annual operation and maintenance (O&M) costs. These are given where they were available or where sufficient information about the project is available to develop an estimate. All costs are given in 2019 dollars.

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[6] *The results of these surveys are presented in Chapter 4 of this report.*

- Potential sources of funding and technical assistance that could be sought in order to facilitate implementation of the recommended project. Potential funding sources are indicated by the identification numbers used in the inventory tables given in this chapter.

- An indication of the priority that should be given to each project for implementation.

An important early step in developing and implementing the projects recommended in Table 6.1 and similar projects, will be to evaluate them for concerns that could affect implementation. Examples of considerations related to projects that should be evaluated include:

- Screening the project area for potential archeological sites in or near the project site

- Evaluating projects involving construction or excavation for conflicts with existing utilities

- Evaluating access to the project site for workers and equipment

- Evaluating the potential impact of the project on adjacent landscapes, channel conditions, and/or landowners

- Determining the best time of year for implementing the project

- Evaluating opportunities to combine multiple recommended projects into a single effort

Conducting such evaluations could reveal potential cost savings and allow implementing organizations to reduce potential undesirable impacts of construction, installation, or other implementation efforts.

Stormwater Management Pilot Projects

As part of the development of specific projects, preliminary screening was conducted to identify potential opportunities for implementing several selected types of stormwater management practices. Sites were identified at which a variety of practices could potentially be installed. These practices include:

- Installation of wet retention ponds.

- Daylighting of storm sewers in which existing storm sewers are removed and replaced with vegetated drainage swales.

- Installation of bioswales or bioretention basins in boulevard medians. In the first, grassed swales were installed in the medians. In the second, bioretention cells consisting of vegetated filters with engineered media and an underdrain were installed in the medians.

- Installation of pervious pavement in parking lots, parking lanes of parkway roads, and residential alleys.

Preliminary designs for each type of practice were developed for a few selected locations in the watershed to demonstrate the feasibility of these practices. These designs represent stormwater management pilot projects that could also be implemented at other locations within the watershed. As part of the preliminary design process, planning-level estimates of costs and pollutant load reductions were developed for these pilot projects. In some instances, multiple designs were done for the same pilot project type. It should be noted that implementation of any of these projects would require detailed site design and optimization.

This pilot project analysis provides several benefits. It demonstrates the feasibility of addressing issues related to stormwater in the Oak Creek watershed through the use of these practices. This analysis provides a screening of potential locations to consider for installing these practices. This screening analysis also provides information that may be useful for developing specific projects of these types in other locations throughout the watershed. This information includes estimates of the costs of installing and magnitudes of pollutant load reductions that might be achieved though implementation of these practices. Since the evaluation of some practices include examination of different sizes and alternative design configurations, these estimates may provide insight into how costs and performance may vary for different designs.

While the discussion in the following subsections focuses on the water quality benefits of implementing these practices, it should be kept in mind that the practices evaluated may also provide water quantity benefits. Such benefits may include reductions of peak runoff volume and the 1-percent-annual-probability peak discharge. Reductions in peak runoff volume may also lead to improved quality of instream and riparian habitat.

Several of the pilot projects discussed below are also included among the specific projects in Table 6.1. Several also serve as examples of types of projects recommended in later sections of this chapter related to water quality and water quantity.

Identification of Potential Project Locations

Potential locations for installing selected stormwater management practices are shown on Map 6.14. Locations where selected stormwater management practices could potentially be installed were identified using 2015 orthophotographs and 2010 topographic contours for Milwaukee County, subbasin maps from each municipality in the watershed, and available maps of storm sewer networks in each municipality. Opportunities for installing wet retention ponds were identified in existing residential subbasins that are not currently served by such ponds, where available open areas for installing a pond are present, and where stormwater currently drains directly into a nearby storm sewer system, drainage ditch, or waterbody. Opportunities for storm sewer daylighting projects were identified in locations where existing storm sewers lie under undeveloped land. Opportunities for installing bioswales or bioretention basins were identified for roadways that had medians. Opportunities for installing pervious pavement were identified in privately-owned parking lots covering at least one acre, parking lots of any size at churches and publicly owned facilities, parkway parking lanes, and residential alleys. It should be noted that detailed site investigations will be needed prior to development of stormwater management practices at any of these sites.

Pilot Project Design

Planning level designs were developed for pilot projects of each type. Wet retention ponds were developed for three locations in the watershed. Storm sewer daylighting projects were designed for two locations. Bioswale projects were designed for two boulevard median locations. Bioretention projects were designed for the same two locations. Pervious pavement projects were designed for two park and ride parking lots adjacent to IH-94, an alleyway in the City of South Milwaukee, and the Oak Creek Parkway in the City of South Milwaukee. Designs for the pervious pavement pilot projects also examined alternative designs in which different amounts of existing pavement were replaced with pervious pavement for scenarios where the pavement was directly and indirectly connected to storm sewers. The locations of the pilot projects are shown on Map 6.15.

The development the pilot projects included estimating average annual pollutant load reductions for TSS and total phosphorus that would result from project implementation. This was done using the Source Loading and Management Model for Windows (WinSLAMM). Land use and drainage area data from local community municipal separate storm sewer system (MS4) WinSLAMM model submissions were used to build the pilot project subbasin models where available. WinSLAMM is further described in the section on quantification of load reductions below.

Stormwater pilot project pollutant load reductions for fecal coliform bacteria were estimated using the modeled average annual per acre nonpoint source load for the subwatershed in which the pilot project was located[7] and a median value for the reduction of fecal coliform bacteria for the stormwater management practice as provided in the International Stormwater BMP Database.[8] It should be noted that performance data were not available for all of the stormwater management practices for which pilot projects were designed.

Planning level construction cost estimates were developed for each pilot project. Data for developing these estimates came from several sources, including the 2009 RSMeans Construction cost data, and recent project costs from the Wisconsin and Minnesota Departments of Transportation, MMSD, and the Cities of Cudahy, Milwaukee, Oak Creek, and Wauwatosa. The cost estimates for each project include an additional 40 percent contingency for engineering and permitting costs. All cost estimates were adjusted to 2019 dollars using the Engineering News-Record Construction Cost Index, averaging values from Chicago and Minneapolis.

Wet Retention Pond Pilot Projects

Three wet retention pond pilot projects were designed for locations in the Oak Creek watershed. The ponds varied in size, with permanent pool areas ranging between 0.74 and 3.30 acres (see Table 6.2). The subbasins draining to these pilot projects are shown on Map 6.15. These subbasins were selected to represent a range of contributing areas. Land use in pilot project subbasin L3-4 consists predominantly of multi-family residential, while land use in subbasins OC-472, O23-3, and O23-5 consists predominantly of medium density single family residential. Each of the selected subbasins have existing storm sewer networks that connect stormwater runoff directly to a nearby stream or drainage ditch. For each pilot project, the proposed wet retention pond was located near the outlet of the existing storm sewer system, just outside of the 1-percent-annual-probability floodplain (see Maps 6.16, 6.17, and 6.18).

Planning level costs and estimates of pollutant load reductions for the three wet retention pond pilot projects and the additional alternative are shown in Table 6.2. The proposed ponds serving subbasins L3-

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

[8] *J. Clary, J. Jones, M. Leisenring, P. Hobson, and E. Strecker,* International Stormwater BMP Database: 2016 Summary Statistics, *Water Environment & Reuse Foundation, 2017.*

4, O23-3 and O23-5, and OC-471 were each estimated to reduce TSS loads by about 80 to 84 percent and total phosphorus loads by about 54 to 60 percent.

Water quantity benefits were also estimated for these wet retention pilot projects. Based on the average for the pilot projects evaluated, wet retention ponds cost about $9,000 per cubic foot per second (cfs) reduction of runoff peak discharge or about $33,000 per acre of contributing drainage area to reduce current condition 1-percent-annual-probabilty peak discharge to 0.4 cfs per acre. The 0.4 cfs per acre discharge meets the City of Oak Creek's development and redevelopment stormwater requirements.

In addition to the retention pond projects discussed above, an alternative was evaluated in which runoff from subbasin OC-471 was routed to the pond proposed to serve subbasin OC-472. The size of the pond was not increased in this alternative because it was found that a larger pond was not feasible at the proposed project location. Load reductions for this alternative were estimated to be about 73 percent for TSS and 50 percent for total phosphorus. Preliminary analysis of this this alternative suggested that the capacity of existing storm sewers might be inadequate to convey flows from large storm events to the pond, and that during such events runoff from this subbasin might flow over land or through ditches into the Creek. Resolving this would require further detailed study. For the purposes of this plan, it was decided to address runoff from this subbasin through implementation of a different practice. (see the section on storm sewer daylighting pilot projects below).

Storm Sewer Daylighting Pilot Projects

Two storm sewer daylighting pilot projects were designed for locations in the Oak Creek watershed. These projects involve excavating and removing a section of storm sewer and replacing it with a grassed drainage swale. The subbasins served by these projects are shown on Map 6.15. Land use in both subbasins consists predominantly of medium density residential. The locations were selected to represent different-sized contributing areas and different drainage situations (see Table 6.3). A section of storm sewer in subbasin O18-5 runs parallel to E. Puetz Road and the public right-of-way could accommodate a grassed drainage swale (see Map 6.19). The situation in subbasin OC-471 is more complicated. The storm sewer network in this subbasin wraps around a subdivision and runs over 2,000 feet to the east to discharge to Oak Creek (see Map 6.20). Preliminary analysis indicated that this section of sewer was located too far underground for daylighting to be feasible. Because of this, an alternative approach was designed in which the current storm sewer would be truncated at the location where it turns to run eastward. A grassed drainage swale running north to Oak Creek would be constructed at the truncated location.

Planning level costs and estimates of pollutant load reductions for the storm sewer daylighting pilot projects are shown in Table 6.3. The proposed projects were estimated to reduce TSS loads by about 24 to 28 percent and total phosphorus loads by about 18 to 22 percent, with the project serving subbasin OC-471 achieving higher reduction percentages for both pollutants.

Bioswale Pilot Projects

Two bioswale pilot projects were designed for locations in the Oak Creek watershed. These were both located in medians of boulevards. The bioswales differed in size, with the smaller one being sited along W. Drexel Avenue to serve subbasin NB-42B (see Map 6.21) and the larger being sited along S. 20th Street to serve subbasin OC-451 (see Map 6.22). These sites and subbasins were selected to represent different contributing areas (see Table 6.4). The subbasins served by these projects are shown on Map 6.15. Both bioswales were designed to allow runoff to flow along the grassed swales and discharge into existing storm sewers located under the median.

For each bioswale, two alternative scenarios were examined. In the first, it was assumed that the bioswale treated runoff from the entire subbasin in which it would be located. In the second, it was assumed that the bioswale treated half of the runoff solely from the boulevard and not from the remaining areas of the subbasin. The second assumption is more conservative and may give a better representation of the likely performance of a bioswale located in a boulevard median.

Planning level costs and estimates of pollutant load reductions for the two bioswale pilot projects under both scenarios are shown in Table 6.4. Under the assumption that they would treat runoff from the entire subbasin, the bioswales were estimated to reduce TSS loads by about 24 to 41 percent and total phosphorus loads by about 21 to 33 percent. Under the assumption that they would treat runoff from half of the boulevard, the bioswales were estimated to reduce TSS loads by about 15 to 16 percent and total phosphorus loads by about 12 to 13 percent.

Bioretention Basin Pilot Projects

Two bioretention pilot projects were designed for locations in the Oak Creek watershed. These were both located in the same boulevard medians as the bioswale projects discussed in the previous section and serve the same subbasins (see Map 6.15).

The bioretention projects are designed to serve different sized subbasins, with subbasin NB-42B being substantially smaller than subbasin OC-451 (see Maps 6.21 and 6.22). These sites and subbasins were selected to represent different-sized contributing areas (see Table 6.5). Both bioswales were designed with engineered filter media and underdrains to drain excess water into the existing storm sewer system.

Like the bioswale projects, two alternative scenarios were examined for each bioretention project. In the first, it was assumed that the bioretention cell treated runoff from all of the subbasin in which it would be located. In the second scenario, it was assumed that the bioretention cell treated half of the runoff from the boulevard. The second assumption is more conservative and may give a better representation of the likely performance of bioretention located in a boulevard median.

Planning level costs and estimates of pollutant load reductions for the two bioretention pilot projects under both scenarios are shown in Table 6.5. Under the assumption that they would treat runoff from the entire subbasin, the bioretention cells were estimated to reduce TSS loads by about 50 to 86 percent and total phosphorus loads by about 44 to 77 percent. Under the assumption that they would treat runoff from half of the boulevard, the bioretention cells were estimated to reduce TSS loads by about 26 to 48 percent and total phosphorus loads by about 21 to 46 percent, with the project serving subbasin NB-42B achieving higher reduction percentages for both pollutants under both assumptions.

Parking Lot Pervious Pavement Pilot Projects

Two parking lot pervious pavement pilot projects were designed for locations in the Oak Creek watershed. These were both located in park and ride lots adjacent to IH-94 and W. College Avenue. The parking lots differed in size, with the smaller (N2-5C) being sited southwest of the intersection and the larger (Northeast Parking) being sited northeast of the intersection (see Map 6.15). Each parking lot consists of an indirectly connected impervious area where stormwater drains to pervious areas before entering storm sewer networks. The designs for both parking lot treatments included underdrains. For the southwestern lot, the entire N2-5C subbasin was modeled. For the northeastern lot, only the parking lot was modeled.

For each parking lot pervious pavement project, several alternatives were examined (see Table 6.6). The amount of the parking lot converted to pervious pavement varied, with alternatives ranging between 0.1 and 2.0 acres. In addition, for each alternative a hypothetical situation was examined in which the parking lot was directly connected to the storm sewer network. In all scenarios examined, the pervious pavement treated only runoff generated from the parking lots.

Performance of pervious pavements in these parking lots was evaluated differently. For the parking lot in the N2-5C subbasin, the modeling examined the effects on the entire subbasin which includes the park and ride lot as well as portions of W. College Avenue, IH-94, and open land areas. The modeling for the Northeast Parking area included only the parking area (see Table 6.6).

Planning level costs and estimates of pollutant load reductions for the alternative parking lot pervious pavement projects for both the indirect connection and direct connection scenarios are shown in Table 6.6. These costs and load reductions assume that restorative cleaning such as sweeping or vacuum cleaning is done annually. Estimated reductions of TSS and total phosphorus loads were larger as the amount of pervious pavement increased. Estimated load reductions were much higher in both lots in the hypothetical situation in which the lots were directly connected to the storm sewer system. This indicates that the efficiency of pervious pavement in reducing pollutant loads from parking lots is much higher when those lots are directly connected to storm sewer systems or discharge directly into adjacent waterbodies. Thus, installation of pervious pavement should be considered for use as a stormwater best management practice (BMP) in those situations.

Alleyway Pervious Pavement Pilot Project

One alleyway pervious pavement pilot project was designed for the Oak Creek watershed. This proposed project is located in subbasin OC40000 in the City of South Milwaukee (see Map 6.15). The drainage area for this subbasin is about 9.9 acres. Land use in this subbasin consists of mixed use residential. The project consists of installing a strip of pervious pavement down the center of the only alley in the subbasin. The alley is about 13 feet wide total. This project is designed to treat runoff originating only in the alley.

Four alternative designs were examined. These designs differ in the width of the pervious pavement strip that would be installed, with widths varying between one foot and four feet (see Table 6.7).

Planning level costs and estimates of pollutant load reductions for the alternative alleyway pervious projects are shown in Table 6.7. These costs and load reductions assume that restorative cleaning is done annually. Depending upon the width of the pervious pavement strip, reductions of TSS represent about 5 to 7 percent of subbasin totals. Reductions of total phosphorus represent about 3 to 4 percent of subbasin totals. These reductions are relatively small because most of the subbasin was not treated by the pervious pavement.

Oak Creek Parkway Parking Lane Pervious Pavement Pilot Project

One parkway parking lane pervious pavement pilot project was designed for the Oak Creek watershed. This proposed project is located in the section of parkway road in the City of South Milwaukee (see Map 6.15). In the project, strips of pervious pavement would be installed along the parking lanes adjacent to the curbs.

These strips would treat runoff originating on the parkway road only. The parkway road contributing area for the pilot project is about nine acres total.

Four alternative designs were examined. These designs differ in the width of the pervious pavement strip that would be installed, and whether strips were installed on only one side or both sides of the parkway road (see Table 6.8).

Planning level costs and estimates of pollutant load reductions for the alternative parking lane pervious projects are shown in Table 6.8. These costs and load reductions assume that restorative cleaning is done annually. Depending upon the number of pervious pavement strips installed and their widths, the strips were estimated to reduce TSS loads by about 34 to 89 percent and total phosphorus loads by about 33 to 86 percent. It should be noted that installing one-foot wide strips on both sides of the road resulted in greater pollutant load reductions than installing a two-foot wide strip on one side of the road.

Quantification of Load Reductions under the Recommended Watershed Restoration Plan

This watershed restoration plan has multiple objectives that are reflected in the four focus areas related to water quality, habitat, recreation, and flooding. Thus, consistent with the Federal Clean Water Act (CWA), the plan is designed to address the physical, chemical, and biological health of the watershed and its water resources. The plan is intended to provide a guide to improving water quality in the watershed over a ten-year period; however, because of 1) the long time scales needed for reductions in pollutant loads to be measurable in a complex natural system, and 2) limitations on the financial resources available for plan implementation, the plan will realistically be implemented over a time period longer than ten years. The plan recommendations include 1) specifically identified measures to advance the achievement of overall plan objectives in the near term and 2) somewhat more broadly targeted measures that would be implemented as opportunities arise over a longer time frame. For these reasons, the effects of various plan recommendations on reducing pollutant loads to the waterbodies in the watershed are addressed in several ways:

- For specific priority water quality improvement projects, the total phosphorus, total suspended solids, fecal coliform bacteria, and total nitrogen load reductions are estimated where feasible, enabling those reductions to be compared to the RWQMPU/watershed restoration plan target reductions set forth in Tables 5.2, 5.4, 5.6, and 5.9 in Chapter 5 of this report.

- Certain plan recommendations to improve water quality may be applicable to targeted stream reaches or areas of the watershed but are not specific enough for their load reduction potential to be practically quantified individually. However, those recommendations represent refinements of the recommendations from the RWQMPU, and their effects on reducing pollutant loads and instream concentrations are specifically represented within the USEPA HSPF water quality model developed under the RWQMPU. Thus, the potential water quality improvement effects of implementing those actions have been quantified at a more-detailed level than by simply estimating load reductions. This is because the loads have been combined with streamflows and routed through the watershed stream network, producing pollutant concentrations at multiple locations, which can readily be compared with regulatory water quality criteria.

- Other plan recommendations, particularly some of those targeted to habitat improvement, may be primarily directed to improving physical and biological conditions in the watershed consistent with the CWA. While in many cases these recommendations may produce ancillary water quality benefits, such benefits may not be directly quantifiable in terms of a pollutant load reduction.

To better refine estimates of pollutant load reductions for the Oak Creek watershed, the USEPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was applied to some specific project recommendations under this study.[9] STEPL employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various BMPs. STEPL provides a user-friendly Visual Basic interface to create a customized spreadsheet-based model in Microsoft Excel. It computes watershed surface runoff, nutrient loads, including total nitrogen, phosphorus, and 5-day biochemical oxygen demand (BOD_5); and sediment delivery based on various land uses and management practices. For each of the areas examined in the watershed using STEPL, the annual nutrient loading was calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using generalized BMP efficiencies. STEPL model results for pollutant loading and load reductions are shown in Table 6.1.

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[9] *Tetra Tech, Inc.,* User's Guide: Spreadsheet Tool for the Estimation of Pollutant Load, Version 4.4, *March 2018; more information on the STEPL model can be found at it.tetratech-ffx.com/steplweb/models$docs.htm.*

WinSLAMM was applied to other specific project recommendations to estimate pollutant load reductions in areas served by MS4s.[10] WinSLAMM is a proprietary model that evaluates nonpoint source pollutant loadings in urban areas using small storm hydrology. It determines the annual runoff from a series of normal rainfall events and calculates the pollutant loading created by these events. The model is also able to evaluate the effects of stormwater BMPs such as infiltration, biofiltration, street sweeping, wet retention ponds, grass swales, porous pavement, or catch basins to estimate how effectively these devices remove pollutants. It can compute surface runoff volume; and concentrations and loads of solids; nutrients such as total phosphorus, nitrate, and total Kjeldahl nitrogen; some metals such as cadmium, copper, lead, and zinc; and the polycyclic aromatic hydrocarbon (PAH) pyrene based on various land uses and management practices. The U.S. Geological Survey (USGS) has developed stormwater flow and pollutant concentration data for calibrating WinSLAMM for use in Wisconsin.[11] Nationally, WinSLAMM has been used for TMDL development, urban stormwater BMP and MS4 system design, and evaluating MS4 compliance with permit conditions. It is accepted for use by the WDNR for showing permit compliance from individual MS4s.

Load reductions for fecal coliform bacteria were estimated using the modeled average annual per acre nonpoint source load for the subwatershed in which the pilot project was located[12] and a median value for the reduction of fecal coliform bacteria for the stormwater management practice from the International Stormwater BMP Database.[13] It should be noted that performance data were not available for all stormwater management practices.

6.2 RECOMMENDED ACTIONS TO IMPROVE WATER QUALITY

Development of Recommendations to Improve Water Quality

As noted previously in this report, the Oak Creek watershed restoration plan was developed in the context of and refines and details the recommendations of the RWQMPU.[14] Chapter 2 of this watershed restoration plan summarizes 1) the recommendations of the RWQMPU as they relate to the Oak Creek watershed and

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[10] *PV & Associates,* WinSLAMM v. 10.2 User's Guide, *2014.*

[11] *U.S. Geological Survey,* WinSLAMM (Source Loading and Management Model: Parameter and Standard Land-Use Files for Wisconsin), *April 6, 2016, www.usgs.gov/software/winslamm.*

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

[13] *J. Clary, J. Jones, M. Leisenring, P. Hobson, and E. Strecker, 2017,* op. cit.

[14] *SEWRPC Planning Report No. 50,* op. cit.

2) the status of implementation of those recommendations within the watershed. The water quality recommendations of the RWQMPU were developed and evaluated through the use of a comprehensive, watershed-based calibrated and validated continuous water quality simulation model. This model work is described in Appendix L. The results of this model can be applied to estimate water quality improvements that would be expected from implementation of the recommended watershed restoration plan set forth in this chapter.

Recommended Actions to Reduce Stormwater Runoff Pollution

Recommended Urban Nonpoint Source Pollution Control Measures

The recommendations of the SEWRPC RWQMPU as they relate to urban nonpoint source pollution in the Oak Creek watershed were reviewed (see Chapter 2 of this report) and reevaluated under this watershed restoration planning effort. Based on that review and reevaluation, which included consideration of the additional water quality monitoring data collected since the RWQMPU was issued and recommendations that have already been implemented, the current applicability of the recommendations of the RWQMPU was confirmed. Thus, the following RWQMPU recommendations are reiterated with some refinements under this plan:

1. **It is recommended that urban nonpoint source controls be implemented that are consistent with, or more rigorous than the standards set forth in NR 151.** It should be noted that all of the municipalities in the watershed are required to meet the NR 151 standards to the maximum extent practicable under the conditions of their Wisconsin Pollutant Discharge Elimination System (WPDES) municipal stormwater discharge permits issued pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*. By implementing controls to meet the standards of NR 151, municipalities will address construction site erosion; stormwater pollution from areas of existing and planned urban development, redevelopment, and infill; and infiltration of stormwater runoff from areas of new development. Urban best management practices to be installed under this recommendation could include 1) runoff infiltration/evapotranspiration and/or pollutant filtration devices such as grassed swales, infiltration basins, bioretention facilities, rain gardens, green roofs, and porous pavement; 2) stormwater treatment facilities, such as wet retention basins, constructed wetlands, and sedimentation/flotation devices; and 3) maintenance practices such as vacuum sweeping of roads and parking lots. The benefits of full implementation of the urban performance standards set forth in NR 151 in the reduction of fecal coliform bacteria, total suspended solids, total phosphorus, and total nitrogen loads delivered to the streams of the watershed were explicitly represented in the water quality modeling analyses conducted for the RWQMPU. These results and the impact of the recent

changes in the enforcement of the urban performance standards in NR 151 are reflected in the pollutant loadings and water quality results presented in Chapter 5 of this report.

2. The RWQMPU recommended the implementation of coordinated programs to detect and eliminate illicit discharges to storm sewer systems and to control urban-sourced pathogens that are harmful to human health. As a refinement of this recommendation, **it is recommended that those municipalities in the watershed with municipal separate storm sewer systems (MS4s) regulated under the WPDES program modify their illicit discharge detection and elimination (IDDE) programs. Under this modification, some of the effort currently expended to monitor major outfalls that show no evidence of illicit discharges would be transferred to monitoring outfalls of any size that are considered likely to be conveying water contaminated with sanitary wastewater.** Because this recommendation targets the control of waterborne pathogens and the fecal indicator bacteria used to test for their likely presence, this recommendation is discussed later in this chapter in the subsection on "Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems." It should be noted that while this recommendation primarily targets pathogens and fecal indicator bacteria, implementation of it would also reduce inputs of nutrients to surface waters through MS4s.

3. **It is recommended that Milwaukee County and the municipalities in the watershed continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose. It is also recommended that the County and municipalities consider alternatives to current ice and snow control programs. It is further recommended that educational programs be implemented to provide information about 1) alternative ice and snow control measures on public and private properties and 2) optimal application rates in such areas. Educational programs should target both County and municipal staff, private applicators, and the general public.**

4. **It is recommended that information and education programs required under municipal WPDES stormwater discharge permits promote voluntary practices that optimize urban fertilizer application consistent with the requirements of WDNR Technical Standard No 1100, "Interim Turf Nutrient Management."** As a refinement of this recommendation from the RWQMPU, **it is recommended that these programs also promote voluntary compliance with the existing**

restrictions under Wisconsin Law on the sale, use, and display of fertilizers containing phosphorus.[15]

5. **It is recommended that all municipalities in the watershed have pet litter control ordinance requirements and that those requirements be enforced. Further measures to address pet litter should be considered on a site-specific basis in response to identified water quality problems resulting from pets.**

6. **It is recommended that existing litter and debris control programs along the urban streams of the watershed be continued and that opportunities to expand such efforts be explored.**

7. **It is recommended that installed stormwater BMPs be inspected at least annually to ensure that they are functioning as designed or are not deteriorating.**

Additional explanation regarding some of the approaches laid out in these recommendations is given in the subsections below. Specific projects recommended to address urban nonpoint source pollution are included in Table 6.1. The stormwater management pilot projects previously discussed in the section on specific projects also illustrate some of the approaches that can be taken to address urban nonpoint source pollution.

Post-Construction Monitoring and Maintenance of Stormwater Best Management Practices

Over this plan's implementation schedule, it will be important to monitor the functionality of stormwater BMPs implemented in the watershed periodically after their installation. Over time, BMPs can become less efficient at achieving designed pollutant reductions due to several factors. According to the USEPA, natural variability, lack of proper maintenance and unforeseen consequences are primary causes of BMP depreciation.[16] Considering how erratic and unpredictable weather patterns are increasingly becoming, checking BMPs in the watershed will be critical for assessing their performance. BMP performance data will be used to evaluate plan implementation, modeled load reduction estimates, and to help determine if substantial progress is or is not being made toward attaining water quality standards.

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[15] *These restrictions are set forth in Section 94.643 of the* Wisconsin Statutes

[16] *D.W. Meals and S.A. Dressing,* Technical Memorandum No. 1: Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, *Developed for the U.S. Environmental Protection Agency by Tetra Tech, Inc., October 2015, Available at www.epa.gov/sites/production/files/2015-10/documents/tech_memo_1_oct15.pdf.*

To ensure that stormwater BMPs continue to function as anticipated **it is recommended that Milwaukee County and the municipalities in the Oak Creek watershed develop systems for tracking and completing long-term maintenance of post-construction BMPs**. Such systems should include:

- An inventory of all municipally owned or operated BMPs. This inventory should include:
  - Each BMP's name, location, type, and year of construction.
  - A record drawing of each BMP.
  - An operation and maintenance plan for each BMP which includes procedures and a schedule for inspection.
- Written documentation of the municipality's ability to use privately-owned BMPs to meet the water quality requirements of their MS4 permit. Such documentation should include how the municipality is ensuring that these BMPs are being inspected and maintained.
- Written procedures used to track and enforce maintenance of stormwater management facilities that have been implemented to meet post-construction performance standards.
- Performance of long-term maintenance inspections at least once during each permit term.
- Documentation of inspections.
- A description of inspection and enforcement response procedures for addressing compliance issues with post-construction stormwater management performance standards.

<u>Green Infrastructure</u>

The Oak Creek watershed restoration plan encourages the use of green infrastructure to help manage stormwater. The USEPA defines green infrastructure as "an approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure management approaches and technologies capture, infiltrate, evapotranspire, and reuse stormwater to maintain or restore natural hydrologies."[17] This is an approach that helps store, convey, and use rainwater in more natural ways. Green infrastructure complements the gray infrastructure, such as sewer pipes, storage tunnels, and water reclamation facilities that have been, and will continue to be, the backbone for meeting water quality and flood management goals. While green infrastructure cannot entirely replace the capacity of gray infrastructure in urban areas, it can add supplemental capacity and pollutant removal.

A variety of green infrastructure practices have been developed over time. Descriptions, illustrations, and technical information regarding these practices are available in a number of recent references.[18] It should be noted that there is considerable diversity in the literature regarding the terminology used to refer to specific green infrastructure practices. For the purpose of this report, it is important to distinguish between several practices that are often referred to interchangeably. For this plan, the terms bioswale and bioretention cell refer to different practices. The former refers to a vegetated swale that water flows through, while the later refers to a vegetated cell with engineered media and an underdrain that water can filter through. Similarly, pervious pavement consists of concrete, asphalt, or pavers through which water can infiltrate, while permeable pavement consists of concrete or brick pavers separated by open joints through which water is able to infiltrate.

Municipal codes and ordinances have a broad impact on the use of green infrastructure. Depending on the code and ordinance specifics, they can provide incentives for, or present barriers to, the implementation of green infrastructure by the private and public sectors. Modifications to local codes, ordinances, and review processes can encourage municipalities, builders, and developers as well as property owners to implement green infrastructure practices. It would be beneficial for the municipalities in the Oak Creek watershed to review their codes to identify barriers to the implementation of green infrastructure practices within their jurisdictions. The results of such an audit could be used by municipalities in the consideration of revisions to their codes and ordinances that would remove barriers to the implementation of green infrastructure strategies.

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[17] *U.S. Environmental Protection Agency,* Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, *EPA 841-F-07-006, December 2007.*

[18] *See, for example, Milwaukee Metropolitan Sewerage District,* Fresh Coast Green Solutions: Weaving Milwaukee's Green & Grey Infrastructure into a Sustainable Future, *no date; Milwaukee Metropolitan Sewerage District,* Regional Green Infrastructure Plan, *June 2013; Milwaukee Metropolitan Sewerage District,* Green Infrastructure Standard Specifications and Plan Template Report, *October 2016; and Stormwater Solutions Engineering, LLC,* Green Infrastructure Operations & Maintenance Standards Guide, *Report to the Milwaukee Metropolitan Sewerage District, February 2020.*

A systematic review and audit of municipal codes and ordinances for barriers to green infrastructure implementation has recently been conducted for the Menomonee River watershed by MMSD, the Milwaukee County Environmental Services Division, the Southeastern Wisconsin Watersheds Trust (Sweet Water), and eight municipalities in the watershed. The Cities of Greenfield and Milwaukee, which are partially located in the Oak Creek watershed, are among the municipalities included in this review and audit of municipal codes. Similar reviews and audits were subsequently conducted for the Cities of Cudahy, Franklin, and Oak Creek with the involvement of Clean Wisconsin. **It is recommended that such an audit of municipal codes and ordinances for barriers to green infrastructure implementation be conducted for the City of South Milwaukee.** Based on the costs of the audits completed for the communities in the Menomonee River watershed, the total estimated cost of this audit is $10,500.

A consideration in the implementation of green infrastructure in urban areas is the presence of brownfields. Brownfields are abandoned, idle, or underused commercial or industrial properties. In some instances, the redevelopment and reuse of these properties is hindered by the presence of contamination related to previous activities. The presence of contaminated soils or other contamination on these sites can limit the use of some green infrastructure strategies. Specifically, the use of strategies that rely on infiltration of stormwater is generally not appropriate on brownfield sites, as they may facilitate the transportation of contaminants into groundwater. Green roofs, cisterns, and rain barrels would be the most appropriate strategies to use on these sites, although in some cases limited infiltration may be accomplished if uncontaminated fill is placed on a site, or runoff is directed to areas of uncontaminated soil. Information on brownfield areas in the watershed can be obtained from the WDNR.[19] A guidance document is available from the USEPA to assist communities, developers, and other stakeholders in determining the appropriateness of implementing stormwater management practices that promote infiltration at vacant parcels and brownfield sites.[20]

The stormwater management pilot projects previously discussed in the section on specific projects also provide additional information on some green infrastructure approaches that can be implemented in the Oak Creek watershed.

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[19] *Available on the WNDR website at: dnr.wi.gov/topic/Brownfields/WRRD.html.*

[20] *U.S. Environmental Protection Agency,* Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites, *EPA 905-F-13-001, July 2013.*

Green Infrastructure in the MMSD Planning Area

The MMSD has developed a green infrastructure plan for its planning area.[21] As shown on Map 6.23, this planning area includes all of the Oak Creek watershed except for the portions located in the City of South Milwaukee. In developing this GI plan, MMSD undertook a detailed data analysis of the opportunities and constraints for implementing green infrastructure strategies. Extensive data collection and mapping were conducted as part of this planning effort. These analyses include quantification of the numbers of roads, buildings, and parking lots in the planning area that can be treated with green infrastructure.

The objectives of the MMSD green infrastructure plan include:

- Capturing the first 0.5 inch of rainfall from impervious surfaces through green infrastructure
- Striving toward a rainwater harvest goal of capturing the first 0.25 gallon of rainwater per square foot of impervious area for reuse
- Complementing MMSD's Private Property Infiltration and Inflow Program and Integrated Regional Stormwater Management Program
- Helping municipalities and other entities prioritize green infrastructure actions
- Helping to meet receiving water quality standards by acknowledging watershed restoration plan recommendations
- Meeting MMSD's WPDES discharge permit requirements for green infrastructure volume capture

As part of its approach to meeting these objectives, the plan developed watershed-specific recommendations for the installation of green infrastructure over the plan implementation period of 2014 through 2035. These recommendations were based on individual characteristics of each watershed. Specific recommendations for the Oak Creek watershed are shown in Table 6.9.

When fully implemented, recommended green infrastructure strategies would capture an average of about 11,258 million gallons of stormwater in the portions of the Oak Creek watershed that are located within the

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[21] *Milwaukee Metropolitan Sewerage District, 2013* op. cit.

MMSD planning area each year. This would result in average annual loading reductions of about 854,100 pounds TSS and 2,970 pounds total phosphorus.[22] The capital costs of full implementation in the Oak Creek watershed are estimated as being $96.5 million.[23] The stormwater capture volumes, stormwater storage, and costs associated with full implementation of the recommendations for the watershed are broken down by green infrastructure strategy in Table 6.9.

The MMSD green infrastructure plan envisions that implementation of its recommendations will begin slowly with higher levels of implementation occurring later in its implementation period. The MMSD plan's timeline for achieving an equivalent 0.5-inch rainwater volume capture indicates that the plan envisions that about 12 percent of the green infrastructure strategies it recommends will be installed by the end of 2020 and about 77 percent of the green infrastructure strategies it recommends will be installed by the end of 2031. Table 6.10 shows the implementation benchmarks for the MMSD green infrastructure plan. Based on available information, green infrastructure practices to capture about 5.3 percent of the recommended capture volume were installed as of the end of 2018.[24]

As part of the Oak Creek watershed restoration plan, it is recommended that green infrastructure strategies be implemented within the portions of the Oak Creek watershed that are located within the MMSD planning area in accordance with and on the schedule given in the MMSD green infrastructure plan. This would require implementation of about 65 percent of the green infrastructure strategies recommended in the MMSD green infrastructure plan by the end of 2030 to achieve the level of implementation envisioned in that plan. The capital costs associated with this recommendation through 2030 are about $50.4 million. Implementation of green infrastructure through 2030 would result in the average annual capture of about 7,368 million gallons of stormwater and average annual loading reductions of about 560,000 pounds TSS and 1,940 pounds total phosphorus. Full implementation of the MMSD GI

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[22] *It is estimated that full implementation of the MMSD green infrastructure plan would result in average annual TSS load reductions of 15,109,000 pounds and average total phosphorus load reduction of 54,450 pounds in the entire MMSD planning area. To estimate the portion of these reductions that would occur in the Oak Creek watershed, the load reductions attributable to reduced combined sewer overflow volumes that would result from implementation of green infrastructure strategies was subtracted from the total load. The resulting amount was multiplied by the percentage of the impervious area in the MMSD planning area that is represented by impervious areas in the portion of the Oak Creek watershed in the MMSD planning area.*

[23] *All costs given in this section have been adjusted to 2019 dollars.*

[24] *Milwaukee Metropolitan Sewerage District,* 2050 Facilities Plan, Appendix 5D*, March 2021.*

green infrastructure plan in the Oak Creek watershed would result in average annual capture of about 11,258 million gallons of stormwater and average annual loading reductions of about 856,000 pounds of TSS and about 2,970 pounds of total phosphorus.

The MMSD green infrastructure plan notes that some areas within the Oak Creek watershed have characteristics that may limit the use of some green infrastructure strategies. These characteristics include areas having land slopes greater than 12 percent, areas where the depth to bedrock is less than six feet, areas where the depth to groundwater is less than six feet, small parcels in areas of high-density urban development, and areas where parcels have setbacks from the street right-of-way of less than 15 feet. The areas in the Oak Creek watershed that have these limitations are shown on Map 6.23. The plan specifically notes the presence of high groundwater at scattered locations adjacent to the mainstem of Oak Creek and the Mitchell Field Drainage Ditch within the City of Oak Creek. The MMSD plan indicates that the design of green infrastructure projects in these areas should include measures to protect groundwater quality. The plan also notes the presence of areas containing parcels with setbacks of less than 15 feet, mostly in the northern portion of the watershed in the Cities of Milwaukee and Oak Creek. It recommends the use of green infrastructure strategies that do not rely solely, or at all, on infiltration, such as green roofs, rain barrels, and cisterns, within these areas.[25]

The MMSD green infrastructure plan includes a prioritization of areas within the Oak Creek watershed for installation of green infrastructure. This prioritization identified subbasins of the surface water drainage system that presented the greatest opportunities for installation of green infrastructure and the greatest potential benefits from installing green infrastructure. This prioritization was conducted for the entire MMSD service area and was based on 11 factors, six of which were related to opportunities for installation of green infrastructure and five of which were related to potential benefits from installing green infrastructure. These factors include:

- Opportunities for green infrastructure implementation:
    - The presence and amount of vacant land in the subbasin
    - The presence and amount of potential redevelopment areas in the subbasin

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[25] *While rainwater collected in rain barrels and cisterns would ultimately be used to water vegetation, it is likely that much of the water applied would be transpired by plants.*

- The presence and amount of existing areas of green infrastructure in the subbasin
- The presence and amount of parks in the subbasin
- The presence and number of selective sewer separation opportunities in the subbasin[26]
- The presence and number of potential stream corridor restoration locations in the watershed

- Areas with multiple potential benefits from green infrastructure implementation:
  - Subbasins with high inflow to the Inline Storage System (deep tunnel)[27]
  - Subbasins containing areas of basement backups
  - Subbasins containing areas with potential drainage problems
  - Subbasins containing areas with potentially high inflow and infiltration into sanitary sewers
  - Subbasins located within high pollutant loading areas[28]

The analysis classified subbasins as having high, medium, or low priority for implementation of green infrastructure strategies. This classification is shown on Map 6.24 for the Oak Creek watershed. It identifies 22 subbasins as being high-priority areas, 36 subbasins as being medium-priority areas, and 15 subbasins as being low-priority areas for the implementation of green infrastructure strategies. The MMSD green infrastructure plan also uses these results to identify the 10 subbasins in the watershed with the highest priority for installation of green infrastructure strategies. These subbasins are shown on Map 6.25. **For the 2022-2031 implementation period of the Oak Creek watershed plan, it is recommended that efforts**

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[26] *This factor does not relate to the Oak Creek watershed because there are no combined sewers in the watershed.*

[27] *This factor does not relate to the Oak Creek watershed because no such areas were identified in the Oak Creek Watershed (see Figure A-3 in the MMSD green infrastructure plan).*

[28] *High pollutant loading areas were identified from the results of the calibrated water quality model that are presented in SEWPRC Planning Report No. 50,* op. cit.

to implement green infrastructure in the portions of the Oak Creek watershed located in the MMSD planning area give highest priority to installing green infrastructure projects in the 10 subbasins identified as high priority on Map 6.25.

Green Infrastructure in the City of South Milwaukee

While the City of South Milwaukee has not developed a green infrastructure plan, it has been conducting some green infrastructure installation activities. In 2013, the City developed an urban forestry plan that addresses the management of trees in street rights-of-way, city parks, and on other municipal properties.[29] This plan included an inventory of trees, tree stumps, and vacant planting sites. This inventory found 4,491 trees, 97 tree stumps, and 1,473 vacant planting sites in the areas examined.[30] The inventory also found that 745 of the trees counted were from species that are susceptible to emerald ash borer. It noted that this could increase the number of vacant planting sites to 2,218 if these trees are not chemically treated to prevent ash bore infestation. The plan recommended the City conduct some initial removals of ash and other trees in 2014 and 2015. It recommended that the City conduct routine removals of 40 trees per year and plant 125 trees per year in subsequent years. The estimated cost of this would be $91,700 per year, or $917,000 over the ten-year implementation period of this watershed restoration plan.

The presence of trees in urban areas can decrease the amount of stormwater runoff and pollutants that reach surface waters.[31] The roots and leaf litter from trees create soil conditions that promote the infiltration of rainwater into soil. Through their roots, trees take up water and nutrients reducing runoff. **It is recommended that the City of South Milwaukee continue to routinely remove damaged trees and plant additional trees in accordance with the schedule recommended in the City's urban forestry plan.**

Full implementation of this recommendation over this watershed restoration plan's ten-year implementation period would reduce the number of vacant planting sites in the City to 623, not counting any sites vacated due to removal of ash trees.

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[29] *Bluestem Forestry Consulting, Inc.,* City of South Milwaukee Urban Forestry Plan and Tree Inventory, *December 11, 2013.*

[30] *It should be noted that the trees in wooded areas owned by Milwaukee County were not included in the inventory.*

[31] *Center for Watershed Protection,* Making Urban Trees Count: A Project to Demonstrate the Role of Urban Trees in Achieving Regulatory Compliance for Clean Water, *December 2017.*

The inventory conducted as part of the South Milwaukee urban forestry plan also found that over 48 percent and 16 percent of the trees counted were members of the maple and ash species, respectively. In order to make the forest less susceptible to insect pests and plant diseases, the urban forestry plan recommended that no more than 10 percent of the forest should consist of members of any single genus and no more than five percent should consist of members of any single species. Because of this, **it is recommended that no ash trees be planted. In addition, it is recommended that no more maple trees be planted until these goals are met.** It should be noted that continuing to implement an urban tree-planting program would provide several benefits to the City. In addition to increasing infiltration and evapotranspiration of stormwater, additional trees would help to increase shade, lessen the impacts of urban heat island effects, provide habitat for many species of animals, filter fine particulates and other pollutants from air, mitigate climate change by sequestering carbon, and reduce the impact of climate changes providing shade and evaporative cooling.

Additional opportunities for the implementation of green infrastructure practices in the City of South Milwaukee were identified in the section above on stormwater management pilot projects. That section identified parking lots, alleyways, and sections of the Oak Creek parkway located in the City in which pervious pavement could potentially be installed. Some of the pilot projects analyzed in that section are included in the specific projects recommended in Table 6.1.

Maintenance of Green Infrastructure Practices

All stormwater management systems require maintenance. Proper operation and maintenance activities are essential to ensure that green infrastructure will continue to function properly; yield expected volume reduction, water quality, and environmental benefits; protect public safety; meet legal standards; and protect a communities' financial investment.

A recent assessment of green infrastructure maintenance in MMSD's service area documented a need for additional training and reference material on maintenance of green infrastructure practices.[32] In a survey conducted as part of this study, 14 out of the 20 respondents from local municipal staffs indicated that they would be interested in both a green infrastructure maintenance training workshop or course, and a training manual. The results of interviews conducted following the surveys suggested that the responses may have underestimated the need for training. Respondents indicated a desire for numerous resources, including

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[32] *Stormwater Solutions Engineering, LLC and Ruekert & Mielke, Inc.,* Green Infrastructure Maintenance: Analysis & Lessons Learned for Municipalities, *Report to the Milwaukee Metropolitan Sewerage District, March 2020.*

technical specifications, performance standards, levels of service, and assistance with or guidance for contract documents, bidding, and inspection. The study concluded that the populations that would benefit from training opportunities and reference material extend beyond municipal staff and include property owners, landscape maintenance contractors and staff, consultants, and homeowner associations.

Some reference material has recently been completed that will assist in addressing these training needs. MMSD recently issued a report providing guidance on operations and maintenance of 11 types of green infrastructure practices, including bioretention facilities, green roofs, native landscaping, constructed wetlands, rain gardens, and various types of permeable and pervious paving materials.[33] The document presents inspection and maintenance standards, provides detailed descriptions of maintenance tasks, and provides an expected maintenance schedule for each type of practice.

The assessment also noted that some of the communities surveyed expressed interest in opportunities for sharing resources for conducting green infrastructure inspection and maintenance. Areas of maintenance that could potentially be shared among municipalities include joint training activities, purchasing specialized equipment to maintain practices, hiring of seasonal staff or trained interns to inspect and maintain practices, and developing contracts to complete work on green infrastructure in multiple communities. The report pointed out that such cooperation could be organized through a number of structures including expansion of existing informal agreements among communities to include green infrastructure maintenance or as part of group MS4 permits. The structure and details of how to coordinate and manage such cooperative activities would need to be developed between participating organizations.

It is recommended that municipalities within the Oak Creek watershed track the locations, types, and frequencies of maintenance of green infrastructure within their jurisdictions. Municipalities and design staff should also design practices with maintenance in mind to ensure that they are accessible for inspection and maintenance and are also relatively easy to maintain.

It is recommended that MMSD provide additional education and training opportunities for green infrastructure maintenance. Such opportunities should be directed to a variety of audiences including private property owners, contractors, consultants, landscape and maintenance staff, and municipal designers and reviewers. Such opportunities should also promote existing resources such as MMSD's Green Vendor List, Planting Selection Tool, and Standard Green Infrastructure Plans and Specifications.

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[33] *Stormwater Solutions Engineering, LLC, 2020* op. cit.

Best Management Pilot Projects to Reduce Concentrations of

Dissolved Phosphorus Using Iron Enhancements

As discussed in Chapter 4, total phosphorus is comprised of two different forms of phosphorus: particulate phosphorus and dissolved phosphorus. BMPs that rely on physical processes, such as settling or filtering of material suspended in the water, will act to remove particulate phosphorus but have no effect on dissolved phosphorus. This is a problem because, on average, about 44 percent of total phosphorus in stormwater consists of dissolved phosphorus.[34] In addition, the percentage of total phosphorus consisting of dissolved phosphorus has increased over time in surface waters of the Oak Creek watershed (see Chapter 4 of this report). Given the high concentrations of total phosphorus present in Oak Creek and its tributaries, complying with the State's water quality criterion for total phosphorus will require the use of treatment approaches that remove dissolved phosphorus from stormwater or prevent it from entering waterways. This will require the use of processes that convert dissolved phosphorus to solid-phase forms that can be treated by conventional stormwater BMPs.

Potential methods for removing dissolved phosphorus from solution include precipitation of the phosphorus with calcium and adsorption of phosphorus to oxides or hydroxides of iron or aluminum. The phosphorus removal potentials of several materials containing one or more of these substances have been investigated for possible use as enhancements to BMPs to improve the removal of dissolved phosphorus from stormwater. These materials include drinking water treatment residuals such as alum sludge; slag from iron refining and steel making; bauxite tailings (*i.e.* red mud); zirconium; coal fly ash; crab shells; lithium, magnesium, or manganese-layered double hydroxides; aluminum hydroxide; calcareous sand; blast furnace dust; high calcium marble; clay; diatomaceous earth; and vermiculite. Many of these materials have been found to have limitations associated with them that reduce their potential for use as BMP enhancements. These limitations include changing the pH of treated water to unacceptable levels, consisting of or containing fine-grained material that will clog filters, consisting of materials that will dissolve and pass through filters, or leaching undesirable materials into treated water. Zero-valent or metallic iron, in forms such as steel wool, iron filings, and iron shavings, has been found to be effective at capturing dissolved phosphorus. It also meets several other practical requirements for use as a BMP enhancement. It is relatively inexpensive, safe to handle, and easy to place. In addition, it has a long potential life and may not clog filters as readily as some other materials. Iron-enhanced sand filters (IESFs) were developed and tested in

[34] *R. Pitt, A. Maestre, R. Morquecho, T. Brown, T. Schueler, K. Cappiella, and P. Sturm,* Evaluation of NPDES Phase 1 Municipal Stormwater Monitoring Data, *University of Alabama and Center for Water Protection, 2005.*

Minnesota and are currently accepted by the Minnesota Pollution Control Agency as a BMP for treating dissolved phosphorus in stormwater runoff.[35]

The main mechanism through which iron acts to remove dissolved phosphorus from water is the adsorption of phosphorus to the surfaces of iron oxides and hydroxides that form as iron corrodes, especially oxides and hydroxides in the form of the minerals hematite (Fe_2O_3) and goethite ($FeO(OH)$).[36] The iron in these compounds is in the ferric (Fe^{3+}) form. The surfaces on the iron oxides and hydroxides can fill up; however, new oxides and hydroxides will form as long as metallic iron is present and geochemical conditions within the filter are favorable for the formation of iron (III) oxides and hydroxides. The main conditions that affect formation of these compounds are oxidation-reduction potential and pH. Formation of iron (III) oxides and hydroxides requires that oxidizing conditions be present in the media. This means that it is important that air be able to reach the media and that the media be able to quickly dry out and achieve aerobic conditions between runoff events. This is accomplished by separating the filter from the surrounding soil with an impermeable liner to prevent intrusion of groundwater and including an underdrain in the filter that is placed above the elevation of downstream water levels.[37] In addition, it is recommended that IESFs be sized and constructed to drain and dry out within one to two days following a runoff event. Extended or constant inundation of the media results in anaerobic and reducing conditions. This drives the reduction of ferric iron to ferrous iron (Fe^{2+}), which is more soluble in water and does not adsorb phosphorus as well as ferric iron. This can result in release of adsorbed phosphorus from the media and into water.[38]

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[35] *Minnesota Pollution Control Agency, "Overview for Iron Enhanced Sand Filter," In:* Minnesota Pollution Control Manual, *stormwater.pca.state.mn.us/index.php/Overview_for_iron_enhanced_sand_filter, updated August 13, 2019.*

[36] *B.A. Fisher and J.M. Feinberg,* Formation Pathway for Iron Oxide Minerals and Geochemical Conditions for Phosphate Retention in Iron Enhanced Sand Filters, *Report to the Minnesota Stormwater Research Council, University of Minnesota Water Resources Center, November 25, 2019.*

[37] *A.J. Erickson and J.S. Gulliver,* Performance Assessment of an Iron-Enhanced Sand Filtration Trench for Capturing Dissolved Phosphorus, *Project Report No. 549, University of Minnesota St. Anthony Falls Laboratory, November 10, 2010.*

[38] *S.E. Rosenquist, W.C. Hession, M.J. Eick, and D.H. Vaughn, "Field Application of a Renewable Constructed Wetland Substrate for Phosphorus Removal,"* Journal of the American Water Resources Association, *volume 47, pages 800-812, 2011.*

Adsorption of phosphorus to iron oxides and hydroxides is also affected by pH.[39] In general, the amount of adsorption decreases as pH increases, with best adsorption occurring at moderately low pH.[40] Sufficient adsorption occurs in the pH ranges normally found in stormwater such that this should not reduce performance of an IESF; however, prior to installation of an IESF, it would be helpful to monitor the pH of the water to be treated to ensure that it does not have unusually high pH. In addition, the water to be treated should be checked to determine whether it contains high concentrations of sulfides and sulfates. The presence of high concentrations of these ions can result in the formation of iron sulfide compounds in the media.[41] This can reduce the binding of phosphorus to iron and consequently reduce the performance of the IESF.

Several different configurations have been suggested for applying IESF technology in BMPs to treat stormwater.[42] These included stand-alone IESFs, IESF trenches installed along the perimeter of wet retention ponds, and IESFs installed in ditch check dams in roadside ditches and swales. Design considerations for IESFs are given in Appendix Fe [Worldox 254103].

IESFs can be constructed as stand-alone filters. A diagram of the basic design is shown in Figure 6.1. In this configuration, runoff enters through the top of the filter and is treated by filtration through the filter media and adsorption of dissolved phosphorus to iron oxides and hydroxides in the filter media. The treated water leaves through an underdrain in the bottom of the filter. An example of this was used to treat water from about 18 acres of farmland that drains toward a shallow wetland and into an agricultural tile drainage system in Wright County, Minnesota.[43] The extent and quality of the drain tile system was unknown. The

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[39] *S.E. Rosenquist, W.C. Hession, M.J. Eick, and D.H. Vaughn, "Variability in Adsorptive Phosphorus Removal by Structural Stormwater Best Management Practices,"* Ecological Engineering, *volume 36, pages 664-671, 2010.*

[40] *Z.D. Wallin,* Orthophosphate Removal from Simulated Agricultural Runoff Using Zerovalent Iron Enhance Soil Media, *Master's Thesis, University of New Hampshire, Durham, New Hampshire, May 2018.*

[41] *N.F. Caraco, J.J. Cole, and G.E. Likens, "Sulfate Control of Phosphorus Availability in Lakes: A Test and Re-Evaluation of Hasler and Einsele's Model,"* Hydrobiologia, *volume 253, pages 275-280, 1993.*

[42] *A.J. Erickson, J.S. Gulliver, and P.T. Weiss, "Capturing Phosphates with Iron Enhanced Sand Filtration,"* Water Research, *volume 46, page 3,032-3,042, 2012.*

[43] *A.J. Erickson, J.S. Gulliver, and P.T. Weiss,* Monitoring an Iron-Enhanced Sand Filter for Phosphorus Capture from Agricultural Tile Drainage, *Project Report No. 581, University of Minnesota St. Anthony Falls Laboratory, June 2017.*

performance of the IESF was monitored during rainfall-induced drainage events over two years.[44] Over 20 drainage events, the IESF reduced the mass load of total phosphorus by an average of 66 percent. Load reductions for individual events varied between 42 and 95 percent. Over 31 drainage events, the IESF reduced the mass load of dissolved phosphorus by an average of 64 percent. Load reductions for individual events varied between 9 and 87 percent.

Another type of iron-enhanced BMP for treating stormwater consists of an iron-enhanced sand filter trench installed along the perimeter of a wet retention pond, either as part of the pond's initial design or as a retrofit.[45] A diagram of this design is shown in Figure 6.2. The surface of this filter is higher than the normal water level of the pond but below the level of the pond's overflow weir. This creates a filter volume that the trench can treat. As the pond fills during a storm or other runoff event, stormwater flows over the surface of the trench and into the filter media. It flows through a mixture of sand and iron and into an underdrain that leads to the outlet structure of the pond. During small runoff events consisting of less than the filter volume, all of the stormwater passes through the filter. During larger runoff events, some of the water in the basin overflows the weir and bypasses the trench. When the water level in the pond drops below the weir, the remaining stormwater passes through the filter. In order to work properly, the filter media needs to be under aerobic conditions when not filtering stormwater. To ensure this, the filter media is separated from the surrounding soil by an impermeable layer and the underdrain is placed above the downstream water level. This allows the media to be in contact with air and dry between runoff events.

The performance of an IESF trench installed adjacent to a wet pond in the City of Prior Lake, Minnesota was monitored and assessed.[46] Over 28 monitored rainfall and runoff events that occurred during the years 2013 through 2015, this IESF removed 26 percent of the mass load of dissolved phosphorus. After non-routine maintenance was conducted in August 2014 to remove decomposing plant material that had accumulated on the surface of the filter, performance improved to removal of 45 percent of the dissolved phosphorus mass load. Most of the phosphate load reduction occurred during larger runoff events that had relatively

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[44] *A.J. Erickson, J.S. Gulliver, and P.T. Weiss, "Phosphate Removal from Agricultural Tile Drainage with Iron Enhanced Sand,"* Water, *volume 9, article 672, doi: 10.3390/w9090672, 2017.*

[45] *Erickson and Gulliver 2010,* op. cit.

[46] *A.J. Erickson, P.T. Weiss, and J.S. Gulliver,* Monitoring and Iron-Enhanced Sand Filter Trench of the Capture of Phosphate from Stormwater Runoff, *Project Report No, 575, University of Minnesota St. Anthony Falls Laboratory, September 2015.*

high influent dissolved phosphorus concentrations and mass loads. Another IESF installation installed at a different location was monitored and found to capture and retain 71 percent of the phosphorus mass load.[47]

IESFs have also been installed as components of ditch check dams in roadside ditches and swales.[48] A diagram of this design is shown in Figure 6.3. These check dams intercept and detain stormwater runoff as it flows through roadside ditches. This allows particles to settle behind the check dam. The runoff then filters through the dam which contains an insert consisting of a geotextile filter sock filled with a media consisting of sand containing about 5 percent iron filings by weight. Corrosion of the iron filings produces iron oxides and hydroxides which strongly adsorb dissolved phosphorus.

Performance of a ditch check dam containing an IESF insert in Stillwater, Minnesota was monitored during 17 rainfall events in 2015[49] and 40 rainfall events in 2016 through 2018.[50] The reductions in the mass of dissolved phosphorus in stormwater treated by this BMP varied between 15 and 54 percent. By comparison, a similar ditch check dam without an IESF insert removed little to no dissolved phosphorus. Cumulative dissolved phosphorus mass retention in the filter insert decreased from 42 percent in 2015 to 23 percent in 2018. Upon examination and testing, it was found that the bottom four inches of the filter insert had provided most of the treatment of stormwater. Treatment of most of the dissolved phosphorus load by this section of the filter diminished its sorption capacity and was likely the reason for the reduction in performance.[51] This suggests that periodically remixing the filter media as a part of maintenance could maintain performance and extend the useful life of the media in the filter insert.

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[47] *Erickson and Gulliver 2010,* op. cit.

[48] *P. Natarajan and J.S. Gulliver,* Assessing Iron-Enhanced Swales for Pollution Prevention, *Project Report No. 576, University of Minnesota St. Anthony Falls Laboratory, September 2015.*

[49] Ibid.

[50] *P. Natarajan, J.S. Gulliver, and P.T. Weiss,* Iron-Enhanced Swale Ditch Checks for Phosphorus Retention: Final Report, *Minnesota Department of Transportation, July 2019.*

[51] Ibid.

Other potential configurations for IESFs and iron enhancements to treat dissolved phosphorus have been suggested, including permeable weir walls,[52] iron-enhanced bioretention facilities,[53] and introduction of metallic iron into lake sediments;[54] however, no field performance data are available for these potential applications.

The costs of installing an IESF will depend on the design and size of the IESF and whether it is installed as a retrofit. The cost in 2010 for installing pond perimeter IESF trenches adjacent to existing stormwater ponds ranged between $3,500 and $5,000.[55] These costs did not include the costs of modifications to the ponds such as additional pipes, modifications to outlet structures, or connection to outlet structures.

IESFs require regular maintenance in order to maintain performance. Routine maintenance includes removing trash and debris from the filter, removing vegetation from the surface of the filter, raking the filter to break up the surface, and removing obstructions to underdrains and outlet structures. Non-routine maintenance may include removing accumulated solids, organics, and/or iron ocher[56] that have accumulated on or near the top of the filter; breaking up clumps of iron shaving conglomerates that have formed in the filter; mixing filter media; or replacing filter media when its phosphorus sorption capacity is exhausted. Maintenance considerations for IESFs are given in Appendix Fe [Worldox 254103].

The operational life of a properly sized, constructed, operated, and maintained IESF has been estimated to be about 30 to 35 years.[57] This has not been verified in the field. Media in IESF inserts for ditch check dams will probably need to be replaced more often. Once the iron in the filter media has been consumed, the media will need to be removed, disposed of, and replaced. It should be noted that the magnetic susceptibility of the iron in an IESF decreases with each inundation of the filter media. This occurs as metallic

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[52] *A.J. Erickson, J.S. Gulliver, and P.T. Weiss, "Capturing Phosphates with Iron Enhanced Sand Filters,"* Water Research, *volume 46, pages 3,032-3042, 2012.*

[53] Ibid.

[54] *P. Natarajan, J.S. Gulliver, and W.A. Arnold,* Internal Phosphorus Load Reductions with Iron Filings, *Project Report No. 582, University of Minnesota St. Anthony Falls Laboratory, September 2017.*

[55] *Erickson and Gulliver 2010,* op. cit.

[56] *Iron ochre is a red or tan gelatinous substance formed by bacteria oxidizing ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}). When iron ochre is formed on a sand filter, it can cause clogging, reducing infiltration.*

[57] *Erickson, Gulliver, and Weiss 2012* op. cit.; *Minnesota Pollution Control Agency 2019,* op. cit.

iron in the media is converted to iron oxides and hydroxides. Magnetic susceptibility is easily measured in the field. Thus, if an initial measurement of magnetic susceptibility is taken upon installation of an IESF, subsequent measurements could be used to indicate the remaining capacity of the media and determine when the media may need to be replaced.[58]

There is evidence that IESFs may also reduce concentrations of some emerging contaminants as well. One study examined concentrations of 384 emerging contaminants at paired IESF inlets and outlets during four seasonal runoff events.[59] This study found that the IESFs examined reduced the concentrations of 17 emerging contaminants with removal efficiencies ranging between 26 percent and 100 percent. These contaminants included some lifestyle and nonprescription pharmaceuticals, some polycyclic aromatic hydrocarbons (PAHs), and some compounds associated with commercial and consumer products. The IESFs showed removal efficiencies greater than 89 percent for acetaminophen, cholesterol, nicotine, triphenyl phosphate and some PAH-related compounds, around 72 percent for menthol and caffeine, and between 26 percent and 36 percent for DEET and tributyl phosphate. The data suggested that another 18 compounds might have been removed; however, the number of samples taken was not sufficient for the statistical methods used in the study to confirm.

It is recommended that pilot projects be conducted to evaluate the performance of using iron-enhanced sand filters under field conditions in the Oak Creek watershed in order to determine whether this approach would be useful in reducing contributions of phosphorus from stormwater runoff and other sources in the watershed. Such pilot projects could involve stand-alone filters or pond-perimeter IESF trenches. It should be investigated whether there are suitable sites within the watershed where stand-alone IESFs could be used to treat discharge from stormwater outfalls.

It is also recommended that these pilot projects incorporate monitoring and studies to evaluate the filters' performance. It is important that studies evaluating the field performance of this approach be conducted as part of pilot projects. Most of the field studies on the use of this technology were conducted in Minnesota which has similar climatic conditions to Wisconsin; however, because of differences in geology and development it is not clear how applicable the results of the Minnesota research may be to conditions

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[58] *Fisher and Feinberg 2019,* op. cit.

[59] *D.J. Fairbairn, S.M. Elliott, R.L. Kiesling, H.L. Schoenfuss, M.L. Ferry, and B.M. Westerhoff, "Contaminants of Emerging Concern in Urban Stormwater: Spatiotemporal Patterns and Removal by Iron-Enhanced Sand Filters (IESPs),"* Water Research, *volume 145, pages 332-345, 2018.*

in the Oak Creek watershed. These studies should incorporate appropriate controls to ensure that the phosphorus removal results can be attributed to the iron enhancements and not the effects of the BMP without the enhancements.

There are several questions that evaluation of the performance iron enhanced BMPs should address. These include:

- How much does the addition of iron enhancement to a BMP reduce concentrations and loads of dissolved phosphorus and total phosphorus over BMPs without iron enhancement?

- Over what range of concentrations of dissolved phosphorus and total phosphorus in influent water is this effective? Are there lower and upper thresholds beyond which performance falls off?

- Are iron-enhanced BMPs capable of removing dissolved phosphorus and total phosphorus during high flow events? How much contact time between stormwater and the iron-sand media is needed for this enhancement to be effective?

- Will iron-enhanced BMPs discharge treated water with low concentrations of dissolved phosphorus and total phosphorus?

- How long will the iron-sand media remain active?

- What maintenance regimen is required to preserve performance?

- Does the use of iron-enhancements to remove dissolved phosphorus cause other changes in water chemistry in the effluent?

Recommended Rural Nonpoint Source Pollution Control Measures

The recommendations of the 2007 SEWRPC RWQMPU as they relate to rural nonpoint source pollution in the Oak Creek watershed were reviewed (see Chapter 2 of this report) and reevaluated under this watershed restoration planning effort. Based on that review and reevaluation—which included consideration of the additional water quality monitoring data collected since the RWQMPU was issued and of recommendations that have already been implemented—the current applicability of the recommendations of the RWQMPU was confirmed. Thus, the following RWQMPU recommendations are reiterated under this plan:

1. **Expand the application of practices to reduce soil loss from cropland to attain erosion rates less than "T", the tolerable soil loss rate.**[60] This could be accomplished through a combination of practices, including, but not limited to, expanded conservation tillage, grassed waterways, use of cover crops, and riparian buffers. The applicable measures should be determined by the development of farm management plans which are consistent with the county land and water resource management plans. It should be noted that the benefits of expansion of these practices in reducing sediments and nutrients delivered to the streams of the watershed were explicitly represented in the water quality modeling analyses conducted for the RWQMPU and are reflected in the water quality modeling results presented in Chapter 5 and Appendix L of this report.

2. **It is recommended that nutrient management plans be prepared for all agricultural operations in the watershed that do not currently have them and that application of manure and other nutrients to fields occur only in accordance with nutrient management plans.**

3. **It is recommended that marginal cropland and pastureland be converted into wetlands and prairies.** The RWQMPU recommended that a total of 10 percent of existing farmland and pasture be converted to either wetland or prairie conditions and that the focus of this effort should be on marginally productive lands, which are defined as agricultural lands other than those highly productive lands designated as Class I and Class II lands by the U.S. Natural Resources Conservation Service. The RWQMPU identified candidate areas to be given first consideration when identifying marginally productive lands to be converted to wetlands and prairies. Approximately 189 acres of candidate areas were identified in the Oak Creek watershed. These candidate areas are shown on Map 2.1 in Chapter 2 of this report. It should be noted that the benefits of expanding the conversion to wetlands and prairies in reducing fecal coliform bacteria, total suspended solids, total phosphorus, and total nitrogen loads delivered to the streams of the watershed were explicitly represented in the water quality modeling analyses conducted for the RWQMPU and are reflected in the water quality modeling results presented in Chapter 5 and Appendix L of this report. These conversions can be used to create new, and augment existing, riparian buffers.

[60] *"T-value" is the tolerable soil loss rate—the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely, as determined by the U.S. Natural Resources Conservation Service. "Excessive" cropland erosion refers to erosion in excess of the tolerable rate, or T-value.*

The RWQMPU made two additional recommendations related to rural nonpoint source pollution control measures that are refined herein for the Oak Creek watershed under this watershed restoration plan. First, the RWQMPU recommended that, at a minimum, county-enforced inspection and maintenance programs be implemented for all new or replacement private onsite wastewater treatment systems (POWTS) constructed after the date on which the counties adopted private sewage system programs, that voluntary county programs be instituted to inventory and inspect POWTS that were constructed prior to the dates on which the counties adopted private sewage system programs, and that the WDNR and the counties work together to strengthen oversight and enforcement of regulations for disposal of septage and to increase funding to adequately staff and implement such programs. As described in Chapter 2 of this report, regulations regarding POWTS set forth by the Wisconsin Department of Safety and Professional Services in Section SPS 383.255 of the *Wisconsin Administrative Code* mandate an expansion of county and municipal POWTS programs. Under the current rules, units of government are required to complete inventories of POWTS in their jurisdictions by October 1, 2017 and have the other elements of the program in place by October 1, 2019. **It is recommended that municipalities in the watershed where onsite wastewater treatment systems are still present implement expanded POWTS programs in accordance with the deadlines given in SPS 383.255**.

Second, the RWQMPU makes several recommendations relative to riparian buffers, including:

- Where existing riparian buffers adjacent to crop and pasture lands are less than 75 feet in width, expanding the buffer to a minimum width of 75 feet

- Pursuing opportunities to expand riparian buffers beyond the recommended minimum 75-foot width along high-quality stream systems, including those that can support and sustain the life cycles of economically important species such as salmon

- Limiting the number of stream crossings and configuring them to minimize the fragmentation of streambank habitat

Recent research has revealed much about the beneficial role of riparian buffers in protecting water quality, groundwater quality and recharge, fisheries, wildlife, and ecological resilience to invasive species.[61] In view

[61] *For example, see the review in SEWRPC, Riparian Buffer Management Guide No. 1,* Managing the Water's Edge: Making Natural Connections, *2010, which is included in Appendix R of this report.*

of the results of this research, the general recommendations of the Oak Creek watershed restoration plan include the following refinements of the general buffer recommendations in the RWQMPU:

1. **It is recommended to protect and expand riparian buffer regions to the greatest extent possible with a minimum 75-foot width and an optimum 1,000-footwidth goal.** The literature has revealed that a 75-foot setback width can provide highly productive instream habitat and significant pollution reduction. It also shows that the protection of a 400-foot minimum and 900-foot optimum riparian buffer width has significant benefits to wildlife populations. Given this information it has been decided that the protection and expansion of riparian buffers to 1,000 feet from the ordinary high-water mark, or within the boundaries defined by floodplains or wetlands, whichever is greater, should be a priority for this watershed.

2. **It is recommended that the continuity and connectivity of riparian buffers be protected and increased.** Fragmentation of riparian buffers by roads, railways, and utilities, combined with encroachment by development, impacts the structure and function of riparian corridors and reduces their ability to adequately protect waterways and wildlife habitat. Stream crossings also tend to have a cumulative impact on the stream and associated lands, as well as an impact on the water quality and the fishery. Therefore, it is important to reduce the linear fragmentation of the existing riparian buffers by either removing crossings where possible or by not increasing the number of crossings where practical. It is recognized that police, fire protection, and emergency medical service access is an overriding consideration for determining whether the objective of removing a crossing is feasible. This recommendation is only meant to apply to situations where more road crossings are present than are necessary to ensure adequate access for emergency services.

More detailed recommendations related to riparian buffers are given in the section on recommendations for habitat later in this chapter. Specific projects recommended to address rural nonpoint source pollution are included in Table 6.1.

Recommended Actions to Reduce Instream Concentrations of Fecal Indicator Bacteria and Pathogens

Concentrations of bacteria indicative of fecal contamination, such as the bacterium *Escherichia coli* (*E. coli*) and fecal coliform bacteria, are generally used to assess the suitability of waters for human contact. The description of surface water quality given in Chapter 4 indicates that high concentrations of these indicator bacteria are often present in surface waters of the Oak Creek watershed. This indicates that these waters may not be safe for human contact because of the possible presence of waterborne disease agents. This reduces the recreational potential of the surface waters of the watershed. Targets for reductions of fecal coliform bacteria, as developed in the RWQMPU, are presented in Chapter 5 of this report.[62]

This subsection presents several recommended measures for the reduction of inputs of fecal indicator bacteria—and the pathogenic organisms for which they serve as surrogates—to surface waters of the Oak Creek watershed. These recommendations are intended to produce the reductions needed to meet the targets set in Chapter 5. It should be kept in mind that these targets were established for the watershed restoration plan based upon the water quality model used in the RWQMPU. As discussed in Chapter 5, meeting these targets will result in improvements in the bacterial water quality of surface waters in the Oak Creek watershed; however, even with full implementation, surface waters of the watershed will not achieve full compliance with the applicable water quality criteria for recreational use.

Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems

It is recommended that those municipalities in the watershed with MS4s regulated under the WPDES system modify their illicit discharge detection and elimination (IDDE) programs to transfer some of the effort currently expended to monitor major outfalls that show no evidence of illicit discharges to outfalls of any size that are considered likely to be conveying water contaminated with sanitary wastewater.

The MS4 discharge permits under which most of the permitted municipalities in the Oak Creek watershed operate their MS4s require that annual dry-weather field screening be conducted at major outfalls, including field analysis of any dry-weather flows from those outfalls.[63] Under this recommendation, **the permitted communities would develop an analysis procedure to identify those stormwater outfalls of all sizes that are most likely to be conveying water contaminated with sanitary wastewater**. This analysis

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[62] *Targets for reduction of fecal indicator bacteria are expressed in terms of fecal coliform bacteria both because the modeling for the RWQMPU simulated fecal coliform bacteria concentrations and because until recently, the State of Wisconsin's recreational use water quality criteria were based upon concentrations of fecal coliform bacteria. It should be noted that* E. coli *is one of several species of fecal coliform bacteria.*

[63] *Major outfalls are defined as those outfalls having the equivalent of an inside diameter equal to or larger than 36 inches which are associated with a drainage area of more than 50 acres, those outfalls that receive stormwater runoff from lands zoned for industrial activity with a drainage area of more than two acres, or from other lands with more than two acres of industrial activity.*

procedure should consider what is known about the age and condition of the associated stormwater and sanitary wastewater conveyance systems, water quality conditions within receiving waters, and other available relevant information. The Menomonee River Watershed MS4 Permittees, which include the Cities of Greenfield and Milwaukee in the Oak Creek watershed, have developed an analysis procedure of this type. This procedure is described in Appendix 6.IDDE [Worldox 255199] of this report. It should also be noted that the WDNR has issued guidance recommending that municipalities adopt a more targeted approach to illicit discharge detection and elimination in which outfalls are prioritized based upon their potential for conveying illicit discharges rather than solely on the size of the pipe or contributing drainage area.[64]

The analysis procedure developed by the communities would be used to target outfalls for field screening. Outfalls would be screened on the following schedule:

- Those major outfalls that had shown no evidence of illicit discharges during the term of the community's previous MS4 permit would be required to be screened at least once during the five-year permit term, with at least one-fifth of all major outfalls being screened each year on a rolling basis

- Those major outfalls for which the last two samplings conducted showed evidence of illicit discharge would be required to be screened a minimum of once per year

- All other outfalls identified for screening under the analysis procedure developed by the communities would be required to be screened annually

- Outfalls identified for annual screening would be screened each year until no evidence of illicit discharge is found for two consecutive years

- Outfalls with indeterminate sources and nonstormwater discharge would be screened annually

Upon detection of an illicit discharge, the municipality would continue to be required to immediately begin an investigation of the sewershed in order to find and eliminate the source(s) of the illicit discharge.

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[64] *Wisconsin Department of Natural Resources, "Illicit Discharge Detection and Elimination," Program Guidance Memorandum No. 3800-2012-01, March 15, 2012.*

This change in procedure is intended to target sources that are likely to be contaminated with human-sourced wastewater. Given this, it would be useful for field screening to explicitly test for fecal contamination. Therefore, **it is recommended that when dry-weather flow is detected in storm sewers during field screening, the field work include sampling for fecal indicator bacteria such as *Escherichia coli*.** Adding this indicator to the suite of indicators used in field screening will give additional data for determining whether dry-weather flows represent discharges contaminated with human wastes. Should additional data be required, the municipalities should consider utilizing microbial source tracking techniques, such as screening for human sourced *Bacteroides* and *Lachnospiraceae*.

For most of the municipalities in the Oak Creek watershed, implementation of this recommendation will require that the WDNR authorize a change in their MS4 discharge permits. This would be best accomplished during the regular reissuance of their permit at the end of a five-year permit cycle. The City of Cudahy is covered under its own permit. This permit expired on June 11, 2018. As of June 2021, the City was operating under an extension of the permit while the WDNR was processing an application for reissuing the permit. The City of Franklin is covered under the Root River Group permit. This permit expired on September 9, 2018. As of June 2021, the City was operating under an extension of the permit while the WDNR was processing an application for reissuing the permit. The Cities of Greenfield and Milwaukee and Milwaukee County are currently covered under the Menomonee River Watershed-Based Permit and have implemented this IDDE program modification recommendation. This permit was reissued on April 1, 2020 and will expire on March 31, 2025. The City of Oak Creek is covered under its own permit, which expired on June 11, 2018. As of June 2021, the City was operating under an extension of the permit while the WDNR was processing an application for reissuing the permit. The City of South Milwaukee is covered under its own permit. This permit expired on June 11, 2018. As of June 2021, the City was operating under an extension of the permit while the WDNR was processing an application for reissuing the permit.

Design Considerations Related to Fecal Indicator Bacteria and Pathogens for Urban Stormwater BMPs

It would be expected that some urban stormwater management practices previously recommended would also act to reduce contributions of fecal indicator bacteria and the pathogens for which they are a surrogate to surface waterbodies. Tables 6.11 and 6.12 summarize data on the performance of several urban stormwater management practices with respect to two commonly used types of fecal indictor bacteria: *E.*

coli, and fecal coliform bacteria.[65] There are considerable differences among BMPs in the reductions of fecal indicator bacteria concentration resulting from treatment by the BMP. The data also show differences in how particular types of BMPs perform when assessed using different types of fecal indicator bacteria. These differences may give some indication of how the performance of particular types of BMPs may differ among different bacterial pathogens.

Several things should be kept in mind when interpreting the performance values given in Tables 6.11 and 6.12. First, for any given BMP the assessment given in the table is based upon a small number of studies. Second, review of the literature shows that the performance of BMPs with respect to fecal indicator bacteria is highly variable. This variability shows up in at least three different ways. The tables suggest that the performance may differ depending upon which type of fecal indicator bacteria is used. In addition, there can be large differences in performance among individual examples of the same practice. For example, the values for the percentage of fecal indicator bacteria removed by retention ponds reported in the literature ranges between 5 percent and 99 percent[66]. At different times or under different conditions, an individual example of a practice can exhibit very different levels of performance. For example, a detention basin in Houston, Texas showed performance levels that ranged between 72 percent reductions and 1,858 percent increases in *E. coli* concentrations during different storm events.[67] Third, it is important to keep in mind that

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[65] *These two indicators are monitored in the Oak Creek watershed. While a third indicator, enterococcus, is not currently monitored in the watershed, it is also recommended for use as an indicator in freshwater by the U.S. Environmental Protection Agency.*

[66] *Thomas R. Schueler and Heather K. Holland, " Microbes and Urban Watersheds: Ways to Kill 'Em," Article 67,* The Practice of Watershed Protection, *Center for Watershed Protection, Volume 3, Pages 566-574, 2000; Stephen R. Pennington, Michael D. Kaplowitz, and Scott G. Witter, "Reexamining Best Management Practices for Improving Water Quality in Urban Watersheds,"* Journal of the American Water Resources Association, *Volume 39, Pages 1,027-1,041, 2003; Lisa Tilman, Andrea Plevan, and Pat Conrad,* Effectiveness of Best Management Practices for Bacterial Removal: Developed for the Upper Mississippi River Bacteria TMDL, *Report to the Minnesota Pollution Control Agency, June 2011; Wright Water Engineers and Geosyntec Consultants,* International Stormwater Best Management Practice (BMP) Database Pollutant Category Summary: Bacteria, *Report to the Water Environment Research Foundation, Federal Highway Administration, and American Society of Civil Engineers, 2010; Geosyntec Consultants, and Wright Water Engineers,* Int-ernational Stormwater Best Management Practices (BMP) Database Pollutant Category Statistical Summary Report: Solids, Bacteria, Nutrients, and Metals, *Report to the Water Environment Research Foundation, Federal Highway Administration, and American Society of Civil Engineers, December 2014.*

[67] *Hanadi Rifai,* Study on the Effectiveness of BMPs to Control Bacteria Loads, *Final Report to the Texas Commission on Environmental Quality, August 2006.*

fecal indicator bacteria are not themselves pollutants of concern. Instead, they act as surrogate measures indicating the likelihood that surface waters are contaminated with fecal wastes and may contain disease-causing agents. The performance of stormwater BMPs with respect to fecal indicator bacteria may not be representative of their performance with respect to disease-causing agents. In general, it is reasonable to expect that the performance data in Tables 6.11 and 6.12 likely give a better representation of BMP performance with respect to pathogenic bacteria than they give of performance with respect to pathogenic viruses, protozoa and protozoan cysts, or helminth eggs. Unfortunately, relatively few data are available regarding the performance of stormwater BMPs with respect to disease agents.

Several factors appear to be important to the fate and transport of fecal indicator bacteria and the pathogens for which they serve as surrogates in aquatic environments.[68] These factors include natural die-off, exposure to sunlight and its ultraviolet component, temperature, the presence of predatory microorganisms, availability of nutrients, sorption to particles, turbidity, and flow rates. Sorption to particles and sedimentation may have complex effects. Sorption to particles tends to increase the rates at which indicator bacteria and pathogens settle out of the water column. While indicator bacteria and pathogens can be removed from the water through sorption and sedimentation, there is evidence that at least some of these species are able to survive in sediment. Because of this, resuspension of sediment may act as a source of indicator bacteria and pathogens to the water. Therefore, removal of indicator bacteria and pathogens through sedimentation may not constitute permanent removal.

The factors above suggest several elements that should be considered in the design of stormwater BMPs in order to reduce concentrations of indicator bacteria and pathogens in water:

- BMPs should be designed in such a way as to maximize exposure to sunlight to promote inactivation of indicator bacteria and pathogens by sunlight and ultraviolet light

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[68] *Reviewed in J.D. Brookes, J. Antenucci, M. Hipsey, M.D. Burch, N.J. Ashbolt, and C. Ferguson, "Fate and Transport of Pathogens in Lakes and Reservoirs,"* Environment International, *Volume 30, Pages 741-759, 2004; C. Ferguson, A.M. de Roda Husman, N. Altavilla, D. Deere, and N. Ashbolt, "Fate and Transport of Surface Water Pathogens in Watersheds,* Critical Reviews in Environmental Science and Technology, *Volume 33, Pages 299-361, 2003; W.A.M. Hijnen, E.F. Beerendonk, and G.J. Medema, "Inactivation Credit of UV Radiation for Viruses, Bacteria and Protozoan (Oo)cysts in Water: A Review,"* Water Research, *Volume 40, Pages 3-22, 2006.*

- BMPs should be designed in such a way as to provide habitat for microorganisms and very small animals that prey upon bacteria, protozoa, protozoan cysts, and helminth eggs

- BMPs should be designed in such a way as to promote sorption of indicator bacteria and pathogens to particles and sedimentation of these particles

- When sorption of bacteria and pathogens is a treatment process, the BMP should be designed to reduce resuspension of settled material

- BMPs with open water should be designed in such a way as to discourage their use by nuisance waterfowl that will be discussed more in the following subsections

It should be noted that practices that infiltrate stormwater will reduce bacteria loading by reducing the volume component of the load. Practices that infiltrate stormwater also typically provide treatment processes enabling sorption and filtration. Where infiltration is used, it is important to recognize that groundwater pollution can also occur, if adequate sorption and filtration do not occur prior to the infiltrated water reaching groundwater.

Reducing Impacts of Nuisance Waterfowl

Nuisance animals, such as waterfowl, can be a significant source of fecal indicator bacteria to surface waters. Studies have found high concentrations of indicator bacteria in the feces of waterfowl. For example, estimates of the concentration of fecal coliform bacteria in the feces of ring-billed gulls range from about 58 million to 1,500 million cells per gram feces, with much of the variation occurring on a seasonal basis.[69] Concentrations of *E. coli* in feces from ring-billed gulls at two Lake Michigan beaches in Chicago and Traverse City, Michigan were 14 million and 490 million cells per gram feces, respectively.[70] Concentrations of fecal coliform bacteria in the feces of Canada geese were found to be about 15,000 cells per gram feces.[71]

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[69] *K.A. Alderisio, and N. DeLuca, "Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (*Larus delawarensis*) and Canada Geese (*Branta canadensis*),"* Applied and Environmental Microbiology, *volume 65, pages 5,628-5,630, 1999.*

[70] *L.R. Fogarty, S.K. Haack, M.J. Wolcott, and R.L. Whitman, "Abundance and Characteristics of the Recreational Water Quality Indicator Bacteria* Escherichia coli *and Enterococci in Gull Faeces,"* Journal of Applied Microbiology, *volume 94, pages 865-878, 2003.*

[71] *Alderisio, and DeLuca, 1999,* op. cit.

In addition to fecal indicator bacteria, feces from nuisance animals can contain pathogenic organisms. For instance, ring-billed gull feces has been found to contain species and strains of bacteria known to be pathogenic to humans, including bacteria in the genera *Aeromonas, Campylobacter, Listeria,* and *Salmonella*.

Programs could be implemented to discourage unacceptably high numbers of waterfowl from congregating near waterbodies. Measures that could be used in these programs include expanded use of informational signs regarding the negative aspects of feeding waterfowl, ordinances prohibiting the feeding of waterfowl, covering trash receptacles near water features, landscaping that reduces the attractiveness of areas to waterfowl use, and other innovative measures such as trained dogs. It is important to note that many of these species are legally protected, so any measures that would depredate these organisms would require a permit from the U.S. Fish and Wildlife Service.

It is recommended that programs to control nuisance animals be conducted on an "as needed" basis in response to identified water quality problems resulting from nuisance animals. Measures to discourage the use of stormwater BMPs by nuisance animals should be incorporated into the design of urban stormwater BMPs.

Several techniques can be used to discourage nuisance waterfowl from congregating in areas adjacent to waterbodies or stormwater BMPs. They tend to work best in combination with one another.

Availability of food is a major reason why geese and gulls are attracted to certain areas and remain there for long periods of time. Methods of reducing food availability, such as enclosing trash containers and enacting and enforcing "no feeding" policies, can make these areas less attractive to geese, gulls, and other unwanted birds and animals.

Geese, in particular, prefer nicely groomed lawns adjacent to water and normally like to walk out of the water on bare, flat, or gently sloping banks. Measures that reduce the amount of these habitat features in riparian areas and adjacent to stormwater BMPs that include permanent pools will make these areas less attractive to geese. These measures include installing vegetative buffer strips, placing rock barriers consisting of boulders at least two feet in diameter along the shoreline,[72] or installing fence barriers that physically prevent geese from walking out of the water into feeding areas.

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[72] *It should be noted that riprap and smaller rock around a pond will not deter geese.*

Reducing the availability of breeding and resting areas will also discourage nuisance waterfowl. Islands and peninsulas are ideal nesting sites for waterfowl. These areas are surrounded by water and offer protection and security from predators. When creating new ponds or retention basins, any islands or peninsulas should be constructed in such a way as to discourage use by waterfowl.

While there are more aggressive measures that can be taken regarding nuisance waterfowl, it is important to note that they are Federally protected under the Migratory Bird Treaty Act of 1918. This act places restrictions on some of the methods that can be used and, in particular, requires a permit from the U.S. Fish and Wildlife Service in order to use methods that would depredate these animals. Prior to using more aggressive measures, it is important to consult with the U.S. Department of Agriculture Wildlife Services.

Reducing Impacts of Pet Waste

The transport of bacteria and other contaminants found in pet waste into surface waterbodies is accelerated in an urban environment with significant areas of impervious surface and engineered stormwater drainage systems. Management of pet wastes may reduce the amounts of these wastes that enter surface waterbodies. The regional water quality management plan update recommends that all municipalities have pet litter control ordinance requirements and that those requirements be enforced.

As described in Chapter 2 of this report, Milwaukee County and four of the six municipalities that are wholly or partially located within the Oak Creek watershed have enacted ordinances regarding control of pet litter. The applicability and requirements of these ordinances vary among the jurisdictions. The County ordinance applies only to County parks and trails. While some municipal ordinances apply only to public property or parks and trails, others apply to any public property or private property other than that belonging to the owner, caretaker, or person in control of the animal. There are also differences among jurisdictions in which animals are regulated under the ordinances. While the County and two municipalities have ordinances that apply to animals, three municipalities have ordinances that specifically apply to dogs and one municipality has an ordinance that specifically applies to dogs and cats.

It is recommended that all municipalities in the watershed have pet litter control ordinance requirements and that those requirements be enforced. Further measures to address pet litter should be considered on a site-specific basis in response to identified water quality problems resulting from pets.

Measures that could be taken to address pet waste in response to an identified water quality problem include:

- Revising existing pet litter control ordinances to apply to any public property or private property other than that belonging to the owner, caretaker, or person in control of the animal

- Stricter enforcement of existing ordinances

- Installing pet waste stations in parks and along trails that are either near waterbodies or near inputs to stormwater management systems that discharge to waterbodies

- Locating any new dog parks away from waterbodies or inputs to stormwater management systems that discharge to waterbodies

- Public outreach and educational programs regarding pet waste management

Best Management Practice (BMP) Pilot Projects to Reduce Fecal Indicator Bacteria and Pathogens

It is recommended that pilot projects be conducted to evaluate the performance of several best management practices (BMPs) under field conditions in the Oak Creek watershed in order to determine whether these practices would be useful in reducing contributions of fecal indicator bacteria and pathogens from stormwater runoff and other sources in the watershed.

At least two approaches to modifying stormwater BMPs could be used to address the contributions of fecal indicator bacteria to surface waters; however, the performance of practices using these approaches in the field and under the types of conditions present within the Oak Creek watershed are not well understood. Because of this, it would be desirable to conduct pilot projects in the watershed in which these practices could be installed, tested, and their performance evaluated. The results of such pilot projects could be evaluated to determine their usefulness. If found to be useful in the field, such results could also be applied to devising strategies for modifying existing types of BMPs to improve their efficacy at reducing contamination of surface waters by fecal indicator bacteria and pathogens. Two approaches that could be evaluated— mycoremediation, and woodchip bioreactors—are discussed below.

Mycoremediation

Mycoremediation is a form of bioremediation in which fungal species are used to either inactivate environmental contaminants or remove them from the environment. Fungi produce non-specific enzymes that are capable of degrading many substances. In addition, fungi take up other substances and accumulate them in their fruiting bodies. As a result of these two characteristics, mycoremediation has been used or proposed for use to address several types of environmental contamination by several types of chemicals including pesticides, heavy metals, pharmaceuticals, and persistent organic compounds. Evidence from several studies suggests that adding fungal enhancements to some common stormwater treatment practices such as bioretention facilities might improve the practices' performance in removing or inactivating fecal indicator bacteria and some pathogens. Adding such enhancements may be a relatively inexpensive way to address fecal contamination in stormwater.

Laboratory studies showed that mycelia of several fungal species grew toward, killed, degraded, and ingested microcolonies of bacteria.[73] These fungi used organic material from the digested bacteria as a source of nutrients for their own growth. It has been hypothesized that the bacterial cells act as a source of nitrogen for the fungi. One study tested 100 species from several fungal groups and found that all of the species that did this were members of the Basidiomycetes (mushrooms) group. Species that were found to be especially active in degrading bacteria include the common mushroom (*Agaricus bisporus*), the scaly inky cap mushroom (*Coprinus quadrifidus*), the wood blewit mushroom (*Lepista nuda*), *and* the pearl oyster mushroom (*Pleurotus ostreatus*) (Figure 6.4). Other studies showed that extracts from several fungal species inhibited the growth of some bacteria species.[74] Bacteria that were sensitive to inhibition by fungal extracts included *E.coli* and three non-waterborne pathogenic species. The results were dependent on the particular combination of bacterium and fungus tested, with some bacteria species being highly sensitive to extracts from certain fungal species and less sensitive to extracts from others. The levels of inhibition varied. In some

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[73] *G. Barron, "Microcolonies of Bacteria as a Nutrient Source for Lignicolous and Other Fungi,"* Canadian Journal of Botany, *volume 66, pages 2,505-2,510, 1988; T.R. Femor and D. Wood, "Degradation of Bacteria by* Agaricus bisporus *and Other Fungi,"* Journal of General Microbiology, *volume 126, pages 377-387, 1981.*

[74] *B.A. Iwalokun, U.A. Usen, A.A. Otunba, D.K. Olykoya, "Comparative Phytochemical Evaluation, Antimicrobial and Antioxidant Properties of* Pleurotus ostreatus*,"* African Journal of Biotechnology, *volume 6, pages 1,732-1,739, 2007; M. Akyuz, A.N. Onganer, P. Erecevit, and S. Kirbag, "Antimicrobial Activity of Some Edible Mushrooms in the Eastern and Southeast Anatolia Region of Turkey,"* Gazi University Journal of Science, *Volume 26, pages 125-130, 2010; F. Kalyoncu, M. Oskay, H. Saglam, T.F. Ergodan, and A.U. Tamer, "Antimicrobial and Antioxidant Activities of Mycelia of 10 Wild Mushroom Species,"* Journal of Medicinal Food, *volume 13, pages 415-429, 2010.*

cases, the degree of inhibition was greater than that produced by four conventional antibiotics. In other cases, it was less. A review of the literature on activity of extracts found that *E. coli* and *Klebsiella pneumoniae* were the most sensitive bacteria species examined to inhibition by fungal extracts.[75] These are both gram negative bacteria and members of the fecal coliform group. Despite this, the review found that gram positive bacteria were generally more sensitive to inhibition than gram negative bacteria.

The differences in the effectiveness of extracts from different fungi against different bacteria species and the sensitivity of *E. coli* and *Klebsiella pneumoniae* have important implications for evaluating the effectiveness of mycoremediation as an approach to addressing fecal contamination of stormwater. In particular, these factors suggest that approaches to evaluating performance that rely on monitoring only *E. coli* or fecal coliform bacteria could overestimate the benefits of mycoremediation with respect to bacterial pathogens.

Laboratory bench-scale and mesocosm-scale studies have shown that treatment of simulated stormwater by exposure to mycelia of fungi such as *P. ostreatus* or *Stropharia* sp. can reduce concentrations and loads of fecal indicator bacteria such as *E. coli* and fecal coliform bacteria (see Figure 6.5).[76] These studies also show that the medium used to grow and support the fungal mycelium may have major effects on performance or cause unintended adverse impacts of fungal treatment. One study found that using straw as a medium to support fungal growth increased concentrations of *E. coli* in simulated stormwater passing through a mesocosm-scale mycofiltration system.[77] While the effects of medium on the growth of pathogenic bacteria has not been studied, the results for indicator bacteria like *E. coli* suggest that the medium used to grow and support the fungal mycelium might have similar effects on pathogenic bacteria.

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[75] *M.J. Alves, I.C.F.R. Ferreira, H.J. Froufe, R. Abreu, A. Martins, and M. Pintado, "Antimicrobial Activity of Phenolic Compounds Identified in Wild Mushrooms, SAR Analysis, and Docking Studies,"* Journal of Applied Microbiology, *volume 115, 346-357, 2013.*

[76] *See, for example, J.P. Harris,* Degradation of Harmful Bacterial in Simulated Wastewater and Stormwater Runoff by the White Rot Fungus *Pleurotus ostreatus, Undergraduate Thesis, University of Delaware, Newark Delaware, Spring 2012; T. Rogers,* Experimental Evaluation of Mycoremediation of *Escherichia coli* Bacteria in Solution Using *Pleurotus ostreatus, Master's Thesis, Evergreen State College, Olympia, Washington, June 2012; L. Stamets,* Best Mycoremediation Practices for Habitat Restoration of Small Parcels, *Master's Thesis, Evergreen State College, Olympia, Washington, June 2012; A.A. Flatt,* Removal of *Escherichia coli from Stormwater Using Mycofiltration,* Master's Thesis, Washington State University, Pullman, Washington, May 2013.

[77] *Flatt, 2013* op. cit.

Another study found that passage of simulated stormwater through biocell reactors using spent mushroom compost to support fungal growth increased the pH of water being treated.[78] In addition, numerous substances, including nutrients such as phosphorus and nitrate, and metals such as aluminum, chromium, copper, iron, manganese, and zinc leached out of the compost.

Review of the available literature found only one strong field test of a BMP incorporating mycoremdiation that included performance data.[79] In this study, two bioretention cells were constructed adjacent to one another. These cells had similar designs and layouts and were planted with similar vegetation. The design of both cells included a surface layer mulch composed of alder chips. The mulch in one cell had been inoculated with the fungi *Pleurotus ostreatus, Pleurotus ulmarius, and Stropharia rugoso-annulata* and incubated to develop fungal mycelia prior to placement in the cell (see Figure 6.4). The mulch in the other cell was not inoculated or incubated. Both cells received runoff from the same horse pasture. In one analysis, concentrations of fecal coliform bacteria were monitored in runoff flowing into each cell and water flowing out of the cells through under drains. Under normal inflow conditions, the fungal-enhanced cell reduced concentrations of fecal coliform bacteria by 90 percent while the control cell reduced concentrations by 67 percent; however, during this test inflow concentrations of fecal coliform bacteria were very low, generally about 30 colony forming units per 100 milliliters (cfu per 100 ml). In a second experiment, water flowing into the cells was spiked with fecal coliform bacteria. A spike of about 13,000 cfu per 100 ml was added to the inflow every 15 minutes over a four-hour period. Concentrations of fecal coliform bacteria in outflow from the fungal-enhanced cell averaged about 5 cfu per 100 ml and never exceeded 10 cfu per 100 ml. Concentrations of fecal coliform bacteria in outflow from the control cell increased from 0 cfu to 376 cfu per 100 ml. Following this, concentrations in outflow from the control cell decreased but remained higher than those in outflow from the fungal-enhanced cell for about 28 hours. Overall, the fungal-enhanced cell removed about 97 percent of the added bacteria while the control cell removed about 92 percent. While this test shows that adding fungal enhancements to bioretention facilities can improve performance in reducing fecal indicator bacteria at low influent concentrations, it does not address how it would perform at higher concentrations and whether there is an upper threshold concentration at which performance drops off.

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[78] *Harris, 2012* op. cit.

[79] *S.A. Thomas, L.M. Aston, D.L. Woodruff, and V.I. Cullinan,* Field Demonstration of Mycoremediation for Removal of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington, *Report to the Jamestown S'Klallam Tribe, March 2009.*

A second field study examined the use of a mycofiltration garden consisting of burlap sacks filled with wood chips inoculated with fungal mycelium placed in the pathway of surface runoff from a cattle feedlot.[80] Runoff entering and leaving the mycofiltration garden were sampled for concentrations of fecal coliform bacteria. In about half of the paired samples, concentrations of fecal coliform bacteria in water leaving the mycofiltration garden were lower than those entering; however, this study lacked controls examining whether burlap sacks filled with uninoculated wood chips would have an effect on bacteria concentrations, so it is not clear whether the presence of the fungal mycelium was responsible for the reduction or whether the reduction resulted from other processes occurring within the bioswale.

Using mycoremediation to enhance stormwater BMPs may be relatively inexpensive. It was estimated that enhancement of eight large bioswales at South Shore Beach in Milwaukee added about $3,000 to project costs of almost $3,000,000.[81]

It is recommended that pilot projects be conducted to evaluate the performance of using fungal enhancements to BMPs under field conditions in the Oak Creek watershed in order to determine whether this approach would be useful in reducing contributions of fecal indicator bacteria and pathogens from stormwater runoff and other sources in the watershed. Such pilot projects could involve the addition of woodchip mulch inoculated and incubated with fungi to bioretention facilities and bioswales.

It is also recommended that these pilot projects incorporate monitoring and studies to evaluate their performance. It is important that studies evaluating the field performance of this approach be conducted as part of the pilot projects. As previously discussed, almost all of the studies examining the potential of mycoremdiation to address fecal indicator bacteria and pathogens in stormwater have been conducted in laboratory settings. The few field data available were collected in the Pacific Northwest and examined bacteria concentrations that are much lower than those often found in stormwater.[82] Given the differences

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[80] *F. Perez,* Noncompetitive Tribal Projects for the Restoration and Protection of Puget Sound: Installation of Mycofiltration Gardens to Treat Polluted Land-Based Runoff, *Report by the Stillaguamish Tribe Department of Natural Resources to the Puget Sound Partnership, December 2015.*

[81] *C. Bristoll-Groll, Stormwater Solutions Engineering, LLC., quoted in: S. Bence, "Can Green Infrastructure Alone Transform Bay View's South Shore into a Swimmable Beach?" WUWM radio, September 4, 2017 www.wuwm.com/post/can-green-infrastructure-alone-transform-bay-views-south-shore-swimmable-beach#stream/0.*

[82] *S.A. Thomas and others, 2009* op. cit.

in climate between the Pacific Northwest and southeastern Wisconsin, it is not clear how applicable the results of this study may be to conditions in the Oak Creek watershed. These studies should incorporate appropriate controls to ensure that the results can be attributed to mycoremediation and not the effects of the BMP without the fungal enhancements.

There are several questions that evaluation of the performance fungal-enhanced BMPs should address. These include:

- How much does the addition of fungal enhancement to a BMP reduce fecal indicator bacteria and pathogen concentrations and loads over controls?

- Over what range of concentrations of fecal indicator bacteria and pathogens in influent water is this effective? Are there lower and upper thresholds beyond which performance falls off?

- Are fungal enhanced BMPs capable of removing fecal indicator bacteria and pathogens during high flow events? How much contact time between stormwater and the fungal mycelium is needed for this enhancement to be effective?

- Will fungal enhanced BMPs discharge treated water with low concentrations of fecal indicator bacteria and pathogens?

- Does the performance of fungal enhanced BMPs against pathogenic bacteria and other pathogens differ from the performance against fecal indicator bacteria? (This is important to address because if fecal indicator bacteria are more sensitive to treatment than waterborne pathogenic bacteria, treatment through mycoremediation might result in receiving waters achieving technical compliance with the recreational use criteria without improving the safety of the waters for human contact).

- Will fungal enhanced BMPs kill bacteria through the entire seasonal cycle? How will desiccation during droughts and freezing during winter affect performance?

- How long will the fungal mycelium remain active?

- What maintenance regimen is required to sustain performance? For example, will periodically adding untreated wood chip mulch be sufficient to maintain existing mycelia or will adding mulch that has been inoculated with fungi and incubated prior to addition be necessary to maintain performance? How often will maintenance need to be performed?

- Do the mushroom species used accumulate heavy metals in their fruiting bodies at concentrations that pose a risk to people who might gather and consume them? This is of concern because the fruiting bodies of several of the species examined in laboratory and field studies are edible. Some fungi have been shown to absorb and retain high concentrations of heavy metals.[83] *Pleurotus* species in particular have been reported to accumulate high levels of heavy metals.[84]

A bibliography of references related to mycoremediation is given in Appendix G [DOCS 254064].

Woodchip Bioreactors

Woodchip bioreactors are constructed by routing water from drainage tiles through an underground trench filled with wood chips. The design includes inflow and outflow control structures which regulate the amount of water entering the bioreactor and ensure that water remains in the bioreactor long enough for treatment to occur. They have generally been used to reduce nutrient concentrations in drainage water, mostly for nitrogen but in some instances for phosphorus. Fewer data are available regarding the performance of woodchip bioreactors with respect to fecal indicator bacteria. One study found that woodchip bioreactors produced reductions in loads of fecal indicator bacteria ranging between 60 and 69 percent.[85] A second study showed reductions of both fecal indicator bacterial and a bacterial virus in municipal wastewater.[86] Because of this, **it is recommended that a small number of woodchip bioreactors pilot projects be conducted in areas of the Oak Creek watershed that are drained by drain tiles in order to evaluate the practicality and utility of this practice for reducing bacterial and pathogen contributions to surface waters.**

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[83] *D. Michelot, E. Siobud, J. Dore, C. Viel, and F. Poirier, "Update on Metal Content Profiles in Mushrooms: Toxicological Implications and Tentative Approach to the Mechanisms of Bioaccumulation,"* Toxicon, *volume 36, pages 1,997-2,012, 1998.*

[84] *M. Kahahi and S. Sachdeva, "Mycoremediation Potential of* Pleurotus *Species for Heavy Metals: A Review,"* Bioresources and Bioengineering, *volume 4, article 32, doi: 10.1186/s40643-017-01628, 2017.*

[85] *A. Ranaivoson, J. Moncrief, R. Venteraea, M. Dittrich, Y. Chandler, and P. Rice, "Bioreactor Performance in Minnesota," Presentation at the 11th Annual Drainage Research Forum, Owatonna, Minnesota, November 23, 2010.*

[86] *F. Rambags, C.C. Tanner, R. Stott, and L.A. Schipper, "Bacteria and Virus Removal in Denitrifying Bioreactors: Effects of Media Type and Age,"* Ecological Engineering, *volume 138, pages 46-53, 2019.*

Recommended Actions to Reduce Concentrations of Chloride

The recommendations of the RWQMPU as they relate to nonpoint source pollution from chlorides in the Oak Creek watershed were reviewed (see Chapter 2 of this report) and reevaluated under this watershed restoration planning effort. Based on that review and reevaluation, which included consideration of the additional water quality monitoring data collected since the RWQMPU was issued and recommendations that have already been implemented, the current applicability of the recommendations of the RWQMPU was confirmed. Thus, the following RWQMPU recommendations are reiterated with some refinements under this plan:

- **Municipalities in the watershed and Milwaukee County should continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose**

- **Municipalities and the County should consider alternatives to current ice and snow control programs**

- **Education programs should be implemented to provide information about alternative ice and snow control measures on public and private properties and optimal application rates for such areas**

- **Education programs should be implemented to provide information about alternative water softening media and the use of more efficient water softeners which are regenerated based upon the amount of water used and the quality of the water**

The RWQMPU recommended that communities also consider implementing measures such as calibration of deicer application equipment, prewetting of solid deicers, and the use of alternative snow and ice control materials.

The MS4 permits that Milwaukee County and the municipalities in the Oak Creek watershed operate under for discharging stormwater include requirements pertaining to the application of deicing chemicals. These permits require that no more road salt or other deicers be applied than the amount necessary to maintain public safety. For most of the communities in the watershed, the permits also require the development and implementation of either a winter road management plan, salt application strategy, or salt reduction strategy to minimize the over-application of deicers. While there are differences among the permits regarding the specific information that should be included in such a plan or strategy, typical elements include:

- Identification of staff responsible for implementing winter road maintenance
- Identification of truck routes with attention to waterway crossings and road areas within 100 feet of a waterbody
- Description of deicing equipment
- Annual calibration of deicing equipment and a description of calibration methods
- Descriptions of deicing and anti-icing products and their effective temperature ranges
- Application rates for deicing and anti-icing products
- Identification of disposal locations for mass snow removal
- Periodic training of winter road maintenance staff

It is recommended that Milwaukee County and the municipalities of the watershed develop and periodically update winter road management plans, salt application strategies, or salt reduction strategies. Such plans could also incorporate a variety of best management practices related to storage and application of deicers. These practices are described in Appendix CI [Docs 254944]. Communities should consider incorporating these practices into their winter road management plans, salt application strategies, or salt reduction strategies.

Discharge of brine used to recharge water softeners also releases chloride to the environment. While sanitary sewerage systems receive most of the brine from water softener recharge in the Oak Creek watershed, some is discharged into the remaining onsite sewage treatment systems that are present in the watershed. Appendix CI describes best management practices for reducing chloride contributions from water softening.

Recommended Actions to Reduce Point Source Pollution

The recommendations of the RWQMPU as they relate to point source pollution in the Oak Creek watershed were reviewed (see Chapter 2 of this report) and reevaluated under this watershed restoration planning effort. Based on that review and reevaluation, which included consideration of the additional water quality monitoring data collected since the RWQMPU was issued and recommendations that have already been implemented, the current applicability of the recommendations of the RWQMPU was confirmed. Thus, the following RWQMPU recommendations are reiterated under this plan:

1. **That the MMSD and the City of South Milwaukee maintain and operate wastewater treatment plants.**

2. **That municipalities in the watershed construct and maintain local sanitary sewer systems.** This recommendation applies to all of the municipalities that are wholly or partially located in the watershed.

3. **That municipalities operating local sewerage systems evaluate the need to reduce clearwater infiltration and inflow into sewers and implement Capacity, Management, Operations, and Maintenance (CMOM) programs.**[87]

4. **That discharges from all points of sewerage flow relief be eliminated.**

5. **That wastewater treatment plant and industrial discharges to surface waters continue to be regulated through the WPDES program, with effluent concentrations of pollutants being controlled to acceptable levels on a case-by-case basis through the operation of the WPDES.**

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[87] *CMOM is a program initiated by USEPA that provides a framework for municipalities to identify and incorporate widely accepted wastewater industry practices in order to better manage, operate, and maintain collection systems; investigate capacity constrained areas of the collection system; and respond to sanitary sewer overflow events. MMSD rules require that communities within its service area implement CMOM programs. Section NR 210.23, "Capacity, Management, Operation and Maintenance Programs," of the* Wisconsin Administrative Code *requires that units of government that have WPDES permits for operation of sewerage systems and/or wastewater treatment plants have implemented CMOM programs as of August 1, 2016.*

The RWQMPU also recommended that the City of South Milwaukee make several improvement and upgrades to its wastewater treatment plant. These improvements and upgrades were completed in 2015.

Recommended Actions to Address Toxic Substances and Emerging Pollutants

Household Hazardous Waste Collection

Improper disposal of household hazardous wastes can introduce pollutants into the environment, leading to contamination of surface waters and groundwater. Within Milwaukee County, MMSD conducts a household hazardous waste collection program. MMSD collects household hazardous waste at the three permanent sites located in the Cities of Franklin and Milwaukee and the Village of Menomonee Falls. In addition, MMSD periodically provides waste collection at temporary collection sites**. It is recommended that MMSD's collection programs for household hazardous wastes be continued and supported.**

Pharmaceuticals and Personal Care Products

Contaminants of emerging concern include pharmaceuticals and personal care products. Recent research shows that these contaminants are entering lakes, rivers, and streams and may be producing adverse effects on fish and other aquatic organisms. These compounds can enter surface waters in a number of ways. These include disposal of medicines or products through flushing down the toilet; disposal of medicines or products by pouring down the drain; and excretion of medications by humans, pets, or farm animals. The extent of the threat posed to human health and to the integrity of surface waters by the presence of these compounds is not currently known.

It is recommended that assessments and evaluations be made of the significance for human health and for aquatic and terrestrial wildlife of the presence of pharmaceuticals and personal care products in surface waters. Ongoing research regarding the presence, effects, and fates of these compounds in the environment should continue to be monitored. As a part of the MMSD Corridor Study conducted by MMSD and USGS, sampling has been conducted for the presence of pharmaceuticals and personal care products in the water column, bed sediment, sediment pore water, and biota. It is recommended that this project be supported.

Given the uncertainty regarding the threat posed by these substances, it would be protective of human health and the integrity of surface waters to reduce inputs of these materials into the environment. Because of this, **it is recommended that collections of expired and unused medications continue to be conducted.** The WDNR has issued guidance on regulatory aspects of collecting unwanted household pharmaceuticals.[88] Several programs are currently active. Drop boxes are available at police departments in all of the municipalities that are wholly or partially located within the Oak Creek watershed.[89] Drop boxes are also available at several pharmacies in or near the Oak Creek watershed.[90] There is also an active mail-back program for disposal of pharmaceuticals. Through this program, free postage-paid drug-disposal envelopes are available at some CVS Pharmacies in the Cities of Cudahy and Milwaukee for the disposal of unwanted or expired prescriptions. With the participation of local law enforcement agencies and others, the Wisconsin Department of Justice sponsors an annual drug take back day.[91] Wisconsin also allows some unused cancer and chronic disease drugs and supplies to be donated to participating pharmacies or medical facilities for use by other patients. Rules governing this are set forth in Chapter HFS 148 of the *Wisconsin Administrative Code*.[92]

It is important to note that household pharmaceutical waste is excluded from regulation as a hazardous waste as set forth in Chapter NR 661, "Hazardous Waste Identification and Listing," of the *Wisconsin Administrative Code*. In general, if a household waste is managed separately by a non-household member, the exemption no longer applies. One exception to this is people collecting strictly household pharmaceuticals. The DNR has issued an enforcement discretion memorandum to allow for the hazardous waste exclusion to apply in this situation. As of October 1, 2020, the WDNR was updating its guidance to reflect the changes rules from the Federal Drug Enforcement Agency, Wisconsin's drug disposal law, and other recent developments.

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[88] *Wisconsin Department of Natural Resources,* Collecting Unwanted Household Pharmaceuticals: Regulatory Guidance for Organizers of Household Pharmaceutical Collection Events, *Pub. WA-1025-2006, August 9, 2006; note that as of June 11, 2021 this guidance document was being revised.*

[89] *As of October 1, 2020, the drop box at the City of Greenfield Police Department was unavailable due to the Covid-19 pandemic.*

[90] *A mapping utility showing the locations of sites in Milwaukee County with drop boxes can be accessed at: www.takebackmymeds.com/.*

[91] *More information on this can be found at doseofrealitywi.gov/drug-takeback.*

[92] *More information on this can be found at www.dhs.wisconsin.gov/guide/cancer-drugrepo.htm.*

Coal-Tar-Based Sealants

As noted in Chapter 4 of this report, the use of coal-tar-based pavement sealants to seal asphalt is a major source of PAHs to surface waters and sediment.[93] As of October 1, 2020, four municipalities in the Oak Creek watershed, the Cities of Franklin, Greenfield, Milwaukee, and Oak Creek, have enacted ordinances prohibiting the use of coal-tar-based sealants within their jurisdictions. **It is recommended that the Cities of Cudahy and South Milwaukee enact and enforce ordinances banning the use of coal-tar-based sealants.**

Molybdenum Contamination of Groundwater

As discussed in Chapter 4 of this report, contamination of private wells with molybdenum has been reported within and in the vicinity of the Oak Creek watershed. **It is recommended that municipal water utilities in the affected municipalities consider extending municipal service to locations affected by such contamination.** It should be noted that this recommendation is consistent with the 2035 water supply service areas recommended in the regional water supply plan.[94]

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

As discussed in Chapter 4 of this report, PFAS contamination has been detected in soil and groundwater at locations at Milwaukee Mitchell International Airport (MMIA) in the Oak Creek watershed. As of October 2020, MMIA and Milwaukee County continue to investigate the amount and extent of contamination on the airport grounds. **It is recommended that MMIA and Milwaukee County continue to document the amount and extent of PFAS contamination at the airport. In addition, consideration should be given to investigating whether surface water and sediment within the Mitchell Field Drainage Ditch have been affected by this contamination.**

Polychlorinated Biphenyls (PCBs)

As discussed in Chapter 4 of this report, high concentrations of PCBs were recently detected in surface sediment samples collected near the mouth of Oak Creek. Subsequent sampling of surficial sediments found

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[93] *B.J. Mahler, P.C. Van Metre, T.J. Bashara, J.T. Wilson, and D.A. Johns, "Parking Lot Sealcoat: An Unrecognized Source of Urban Polycyclic Aromatic Hydrocarbons,"* Environmental Science and Technology, *Volume 39, pages 5,560-5,566, 2005; A.K. Baldwin, S.R. Corsi, M.A Lutz, C.G. Ingersoll, R. Dorman, C. Magruder, and M. Magruder, "Primary Sources and Toxicity of PAHs in Milwaukee-area Streambed Sediment,"* Environmental Toxicology and Chemistry, *Volume 36, pages 1,622-1,635, 2017.*

[94] *SEWRPC Planning Report,* A Regional Water Supply Plan for Southeastern Wisconsin, *December 2010.*

elevated concentrations of PCBs at sites in the mainstem of Oak Creek downstream from the Mill Pond dam. The findings from sediment sampling indicate that further evaluation of sediment quality is warranted in the lower reaches of Oak Creek, especially downstream of the Mill Pond. **Such evaluation is recommended and should include collection and examination of sediment cores to characterize the extent, types, and amounts of contaminants within the sediment through its entire depth.**

The WDNR has issued consumption advisories for Lake Michigan fish due to PCB contamination of fish tissue (see Table 4.27 in Chapter 4). **It is recommended that general notice signs, based upon these fish consumption advisories, be placed at fishing access points for the reaches of Oak Creek that are downstream of the Mill Pond dam.**

6.3 RECOMMENDED ACTIONS TO IMPROVE HABITAT

Recommended Actions to Maintain and Re-establish Natural Surface Water Hydrology

Both urbanization and agricultural development have brought significant changes to the landscape and have produced profound effects on the hydrology within the Oak Creek watershed. These landscape changes historically have included modification of drainage patterns, hardening of surfaces, alteration of groundwater infiltration within urban areas, straightening and ditching of streams, disconnection of streams from their functional floodplain,[95] and installation of drainage tile systems in previous and current agricultural areas. These changes to the landscape generally act to increase the volume and rate of runoff from precipitation events leading to increased flashiness in stream flow, reducing the recharge of groundwater which supplies baseflow for streams and wetlands, and increasing the export of water out of the Oak Creek watershed and into Lake Michigan. The increased flashiness in stream flow reduces streambank and streambed stability, increases pollutant loading, and changes the sediment dynamics within the stream system. These changes ultimately reduce the availability of habitat and degrade its quality.

The recommendations set forth below are intended to promote restoration of the hydrologic functions of streams, wetlands, and other waterbodies in the watershed so that stream discharges more closely resemble those that are thought to have occurred prior to agricultural or urban development, to the extent possible.

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[95] *It should be noted that "functional floodplain," as referred to in the recommendations to improve habitat in this section, is defined as a relatively flat valley floor or bench that can carry and/or retain some volume of flood water that has overtopped the banks of a stream. The use of the term in this section is not necessarily referencing the regulatory 1-percent-annual-probability (100-year recurrence interval) floodplain.*

Specifically, decreases in high-flow magnitude, frequency, and/or duration are sought to provide potential improvements in the biological communities within the Oak Creek watershed. Some of the recommendations necessary to meet the goal of restoring the hydrology of the watershed are described in detail in other sections of this chapter that focus on other management objectives. For implementation purposes, it is important to note that those recommendations will serve multiple objectives.

Recommended Actions to Reduce Runoff Volume and Velocity and Increase Infiltration

Urban Surface Water Hydrology

Urban development often involves manipulation of the landscape in ways that increase volume and speed of runoff and decrease groundwater infiltration. When the amount of urban development in a watershed increases, the amount of impervious surface area also increases. This has been true in the Oak Creek watershed, where the amount of impervious surface has been increasing since the first Commission land use inventory was conducted in 1963. Historically, the approach to managing increases in rates and volumes of runoff caused by impervious surfaces has involved the construction of stormwater infrastructure designed to convey stormwater as quickly as possible to streams and ultimately to Lake Michigan. This has led to increases in the volume of water reaching streams during wet weather and decreases in baseflow to waterbodies and wetlands during dry weather. Such changes are generally detrimental to waterbody health.

Natural features such as wetlands, floodplains, and closed depressions are vital in detaining water, facilitating the occurrence of physical and biological processes that reduce pollutant and sediment loads. Therefore, management actions should be taken to preserve and enhance the ability of the watershed to detain and more slowly release runoff, reduce peak flows, and better approximate natural runoff patterns.

1. **It is recommended to protect, restore, and enhance natural landscape elements that "slow down water" and reduce the magnitude of flashiness in stream flow and its negative effects on aquatic habitat quality.** Specific measures that can be taken to accomplish this recommendation include:

   - Protecting and restoring existing wetlands and expanding them where feasible.

   - Implementing the recommendations described in the next section to protect, expand, and establish new riparian buffers to allow rainfall to be captured and infiltrated and floodwaters to be dissipated when necessary (riparian buffer recommendations are described in detail in the

"Recommended Actions to Protect, Restore, Expand, and Connect Riparian Buffers" section below).

- Implementing recommendations detailed below that emphasize the siting of urban development away from high groundwater recharge areas and installing infiltration practices in those areas where development is necessary or already exists.

In such a highly urbanized watershed like Oak Creek, the capacity of the remaining natural features may be insufficient to achieve the desired goals of detaining and slowing down stormwater runoff. Periodic flooding, water quality impairment, environmental degradation, and the impacts of climate change have demonstrated the need for an alternative and/or supplemental approach to urban stormwater management. Purpose-built artificial structures that seek to manage runoff using a variety of measures to better mimic the precipitation runoff pattern on an undisturbed landscape are recommended to supplement the natural features in the watershed.

2. **It is recommended that measures be implemented to promote stormwater storage and infiltration in existing and planned urban areas[96].** Artificial detention features should be installed to serve new developments or retrofitted to infrastructure in developed areas. With sound planning, it can sometimes be feasible to build features as part of new development that also serve existing development. Implementing this recommendation could involve:

- **Enhancing the ability of rainfall and snowmelt to be detained in, filtered through, and/or infiltrated into soils.** This could be achieved by installing modern stormwater best management practices (BMPs) and green infrastructure associated with low-impact development. Such BMPs include rain gardens, bioswales, porous pavement, stormwater detention basins, and other stormwater infrastructure specifically designed and carefully located to slow runoff, improve water quality, and promote infiltration. Examples of simple infiltration measures include voluntarily directing stormwater to areas of permeable soil and favorable topography or minimizing impervious surfaces. An example of redirecting stormwater would be homeowners disconnecting roof downspouts from storm sewers or away from impervious surfaces. Such initiatives can be promoted

[96] *Measures should meet or exceed minimum requirements set forth in community stormwater ordinances and requirements in place for development or redevelopment within the Milwaukee Metropolitan Sewerage District's planning area under Chapter 13.11 of the Surface Water and Stormwater Rules.*

by active educational outreach, providing instructions and supplies to property owners, and/or through subsidies. Some practices and projects, especially on public property, may qualify for partial funding through the WDNR Healthy Lakes & Rivers program.

Schoolyard spaces within the watershed may provide opportunities for improved stormwater management while also providing environmental education, health, and social benefits. The MMSD green infrastructure for schools guidebook provides information on commonly installed types of green infrastructure that can be implemented on school grounds.[97] Green infrastructure projects and/or programs at schools may provide the additional opportunity to fulfill public information and education requirements that MS4 communities have as part of their municipal stormwater discharge permits. Given the relatively low cost, ease of implementation, and potential educational benefits, **it is recommended that all schools within the Oak Creek watershed consider establishment of at least one rain garden and at least one rain barrel.**

MMSD has recently undertaken more extensive projects at schoolyards in the City of Milwaukee. These projects remove asphalt and concrete pavements located in school playgrounds and replace them with native landscaping, trees, bioswales, cisterns, permeable synthetic turf, and porous pavement. MMSD has funded a large portion of the projects at six schools, with the remaining funds coming from the City of Milwaukee, various State and Federal agencies, and the Fund for Lake Michigan. Along with improved stormwater infiltration, the new schoolyards provide upgraded play spaces and outdoor environmental education classroom opportunities for the students. **It is recommended that funding for similar schoolyard green infrastructure projects be pursued by school districts within the Oak Creek watershed.**

- **Municipalities should ensure that their ordinances are compatible with green infrastructure practices** (see *Green Infrastructure* section above for details).

- **Retrofitting existing stormwater management systems with features that enhance water quality and/or moderate runoff rates.** Elements such as stormwater retention/infiltration basins, bioswales in parking lots and roadway medians, green alleys and other permeable conveyance, increasing the distance between stormwater outfalls and streambanks to allow for filtration through riparian buffers rather than direct discharge, and other infrastructure elements

[97] *Milwaukee Metropolitan Sewerage District,* Green Infrastructure for Schools Guidebook, *2017.*

can help reduce the impact of urban development on the quantity of runoff and its effect on surface water quality.[98] In certain instances, stormwater infrastructure built for new development can be located and sized to also manage stormwater runoff from existing development. Such projects that can be easily integrated into stormwater system upgrades should be considered whenever practical.

- **Integrating advanced stormwater management practices into local permitting processes.** An ordinance requiring onsite stormwater management practices such as permeable conveyance, porous pavement, and limits to impervious surface as a condition of issuance of a building permit for single building developments and the additional requirement of stormwater detention for larger developments may be a step toward a more comprehensive approach that benefits urban developments, surface and groundwater quality, and a more natural watershed hydrology. Such ordinances should be actively enforced when they exist or should be considered for inclusion into existing ordinances.

Specific Area of Concern to Re-Establish Natural Surface Water Hydrology:

Confluence of Oak Creek and North Branch Oak Creek

A location of particular concern in the watershed is the area surrounding the confluence of Oak Creek and North Branch Oak Creek. The stream channels in this area were highly modified in the early 1970s as part of roadway expansion projects involving W. Ryan Road (STH 100) and S. Howell Avenue (STH 38). This work included relocating about a mile of the Oak Creek channel downstream of the W. Ryan Road crossing. This relocation of Oak Creek shortened the length of North Branch Oak Creek and moved the confluence of the two streams about 1,000 feet to the north of its original location (see Figure 4.6). Channel modifications related to the roadway work extend from upstream of W. Ryan Road to nearly 1,000 feet downstream of S. Howell Avenue.

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[98] *For descriptions, applications, and photographs of common green infrastructure practices see, Milwaukee Metropolitan Sewerage District,* Fresh Coast Green Solutions: Weaving Milwaukee's Green & Grey Infrastructure into a Sustainable Future, *no date; Milwaukee Metropolitan Sewerage District,* Regional Green Infrastructure Plan, *June 2013; Milwaukee Metropolitan Sewerage District,* Green Infrastructure Standard Specifications and Plan Template Report, *October 2016; and Stormwater Solutions Engineering, LLC,* Green Infrastructure Operations & Maintenance Standards Guide, *Report to the Milwaukee Metropolitan Sewerage District, February 2020.*

Commission staff obtained plans from the 1972 reconstruction project of W. Ryan Road specifically related to the roadway and culvert work. The plans indicate the elevations of W. Ryan Road, as well as channel bed elevations of Oak Creek, were lowered significantly to allow for re-routing of W. Ryan Road under the Canadian Pacific Railway crossing to the west. Originally the railroad passed under W. Ryan Road at this location. The project included installation of a new three-barrel culvert at W. Ryan Road to convey Oak Creek under the newly expanded and lowered roadway. The 1972 plans further indicate that the new box culvert was installed several feet below the pre-project Oak Creek channel bed elevation, creating a nearly flat stream bed profile in the reach downstream of W. Ryan Road. While review of aerial photos and field observations make it clear that channel relocations occurred in the area downstream of Ryan Road, Commission staff was unable to locate any project design plans or specifications for the new channel construction between W. Ryan Road and S. Howell Avenue.

These channel modifications have caused several water resource management challenges in and potentially beyond the immediate area. These challenges include conditions that compromise the integrity and/or performance of stream crossings, have the potential to affect public safety, reduce the ability of floodplains to manage floodwater and mitigate Oak Creek's sediment and pollutant loads, hinder or prevent aquatic organism passage, and significantly compromise the overall ecological integrity of the stream and stream corridor in this area. Examples of these problems include:

- Re-routed, lowered, ditched, and over-widened stream segments have disconnected Oak Creek from its functional floodplain and have produced channel slopes that are not sufficient to transport the amount of sediment entering the stream. This has led to large accumulations of unconsolidated sediments in the reconstructed reach downstream of W. Ryan Road, has contributed to sedimentation within the road culvert and immediately upstream of the structure, and has greatly reduced instream habitat quality.

- Current sediment accumulations within the Ryan Road culvert have restricted the flow capacity to such an extent that Oak Creek may overtop the road during extreme high flow events, including during a 1-percent-annual-probability (100-year recurrence interval) flood.

- Stream bed erosion on North Branch Oak Creek has exposed the downstream foundation of the Canadian Pacific Railway crossing located about 0.1 miles upstream of the current confluence with the mainstem of Oak Creek. The structure foundation has cracked and crumbled in multiple locations and some of the underlying material has been washed out from beneath the structure. Water has been observed actively flowing under the concrete box culvert structure, a situation that suggests that its structural integrity may be compromised. In addition, the downstream invert of the culvert is perched about 4 feet above the downstream water surface, creating a passage barrier for aquatic organisms.

In order to consider how to best address some of the challenges described above, more detailed information is necessary. Therefore, **it is recommended that a detailed survey be conducted on the mainstem of Oak Creek from S. 13th Street to 1,000 feet downstream of S. Howell Avenue; and on North Branch Oak Creek downstream of W. Puetz Road to its confluence with the mainstem of Oak Creek.** The survey should include the following (see Map 6.26):

- Survey of channel invert elevations to characterize the stream bed profiles of the existing streams
- Detailed cross-section surveys, including sediment depth measurements, to characterize the geometry of the existing stream channels
- Detailed surveys of all stream crossings in the area to include upstream and downstream structure elevations as well as elevations (and/or depths) of current sediment accumulations within the structures
- Survey of elevations of Milwaukee County-owned farmland to the northeast of the Ryan Road culvert, occupying a potential re-connection route to the historical Oak Creek channel location

After a detailed survey of the area has been completed, **it is recommended that a feasibility study be conducted to explore options to address the impairments resulting from the channel modifications described above**. The feasibility study should document the detailed survey information, include detailed hydrologic and hydraulic modeling in order to characterize the existing hydraulics through this area, and evaluate various alternative projects to improve conditions. Potential projects could range from targeted structure maintenance at stream crossings[99] to a comprehensive infrastructure protection and stream naturalization and restoration project that addresses a wide range of issues along the entire reach, including

[99] *A targeted individual project intended to protect the Canadian Pacific Railway culvert foundation from further undermining and to halt flow of water under the culvert is described in Table 6.1. A related project to retrofit the channel downstream of this culvert with a rock ramp in order to provide aquatic organism passage is also provided in Table 6.1.*

potentially re-routing Oak Creek to reconnect to the remnant historical channel. Depending on resource availability, high-priority issues in this area may be addressed individually as funding and importance dictate. The study should address the feasibility of alternative projects that would have the following objectives, in no particular order:

- Improve the stability, safety, and lifespan of road and railway culverts in the area
- Improve the ability of Oak Creek to sufficiently transport sediment through this reach
- Improve connections of Oak Creek and North Branch Oak Creek to their functional floodplains and increase the amount of flow that can be detained in floodplain areas
- Improve water quality, instream fish and aquatic organism passage, and overall instream habitat
- Reduce the potential for roadway overtopping
- Repair current and reduce future streambank erosion
- Incorporate the objectives from Milwaukee County Park's ecological restoration and management plan[100] that has been completed for the County-owned parcels in this area which include rapid response invasive species removal, grassland management, and reforestation of the leased farmland

A successful project would restore the area to a more natural surface water hydrology, while also providing the co-benefits of addressing public safety concerns, reducing maintenance needs, reducing downstream flooding, improving instream and terrestrial habitat, improving water quality, and providing valuable ecological functions.

Rural Surface Water Hydrology

Extensive networks of drainage tile are thought to have been installed within current and former agricultural lands of the watershed to drain wetlands and clear fields of rainwater as rapidly as possible and keep them productive. Some stream channels in the watershed were originally deepened and straightened to facilitate the flow of water from agricultural subsurface drainage tile outlets, to maximize conveyance of agricultural

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[100] *Milwaukee County Parks,* Oak Creek Parkway Ecological Restoration & Management Plan, *2019*.

drain water, to maximize the amount of land available for cultivation, and to make the land easier to cultivate. The following recommendations are intended to mitigate the impacts of channelization and installation of drain tile on the surface water hydrology:

1. **It is recommended to restore natural surface hydrology by reducing, to the extent practicable, unnecessary drainage tile systems and retrofitting needed systems.** Specific measures that can be taken to accomplish this recommendation include:

    - Investigate drainage patterns and drainage tile system maps (when available) to determine whether there are operational drainage systems that are no longer necessary and remove or disconnect any unneeded tile systems. This could include areas that were formerly in agricultural uses but have since been developed in urban uses.[101] This recommendation is especially appropriate for lands owned by Milwaukee County that are currently leased for agricultural uses but are planned to be restored to wetland or forest and could be implemented as part of restoration efforts. Disconnection or breaking up of unneeded tile drainage systems could aid in the restoration of former wetlands.

    - Work with landowners that intend to continue farming to integrate water control structures within drainage tile systems to reduce tile flow during periods when a higher water table would not present a problem for crop production. It is recommended that pilot projects be considered to evaluate the effectiveness of this practice in reducing flashiness in these streams. The effectiveness of this practice in reducing contributions of pollutants, especially nutrients from agricultural fields could also be evaluated as part of the pilot projects.

2. **It is recommended to restore natural landscape elements that "slow down water" and reduce the magnitude of flashiness and its negative effects on aquatic habitat quality.** Specific measures that can be taken to accomplish this recommendation include:

    - Pursue opportunities and funding to restore leased agricultural fields owned by Milwaukee County to wetland, forest, and prairie habitats as described in the ecological restoration and

[101] *This recommendation is subject to determinations that altering such tile drainage systems would not cause flooding or unintended drainage problems for current urban development.*

management plan prepared by Milwaukee County Parks for the Oak Creek parkway.[102] Parcels for potential conversion are shown on Map 6.27. Additional stream restoration objectives such as reconnecting streams to their functional floodplain, streambank stabilization, establishment of riparian buffer areas, and removal of fish passage barriers should be considered as part of restorations of County-owned agricultural land.

- Implement the recommendations described in detail below in Riparian Buffer Recommendations 2 and 3, related to the protection, purchase, and acquisition of vulnerable existing riparian buffer lands and potential buffer areas as well as establishment of new riparian buffer areas with a minimum goal of 75-foot widths and an optimum goal of 1,000-foot widths.

- Work with property owners to consider discontinuing the cultivation of existing farmed wetlands[103] and areas considered by WDNR to be potentially restorable wetlands and restore these areas to their natural wetland conditions (see Map 6.28). Incentives may be available to property owners who pursue this recommendation. This recommendation may be particularly vital if or when these lands are converted from agriculture to urban uses.

- In areas that are planned to remain in agricultural uses and that are drained by drainage tile systems, consider installation of saturated buffers. Saturated buffers redirect flows from main drainage tile lines through a lateral distribution line into a riparian buffer allowing the water to percolate into the soil and get taken up by vegetation.

3. **It is recommended to re-connect the trapezoidal ditches and channelized streams found in the agricultural or previously agricultural portions of the watershed with a functional floodplain.** It is acknowledged that potential restoration of functional floodplains among stream reaches will likely vary in its extent and characteristics based on available land area for restoration and landscape features. However, a functional floodplain should be designed to allow stream flow to overtop the banks of a main channel and spread out over a bench or a natural floodplain to reduce peak flow velocities. This recommendation will be further described in the "Recommended Actions to Maintain and Restore the Quality and Diversity of Instream Habitat" section below.

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[102] *Milwaukee County Parks,* Oak Creek Parkway Ecological Restoration & Management Plan, *2019.*

[103] *Farmed wetlands designations are included as part of the Southeastern Wisconsin Regional Planning Commission's 2015 land use inventory.*

4. **It is recommended that marginal cropland and pastureland be converted to wetlands and prairies.** This is a recommendation from the RWQMPU and is described in further detail in the "Recommended Rural Nonpoint Source Pollution Control Measures" section earlier in this chapter.

Specific Area of Concern to Re-Establish Natural Surface Water Hydrology: Oak Creek Drainage Ditches Wetland Restoration and Drainage Tile Disconnection

A location with particular potential to be restored and expanded to an extensive wetland complex is located mainly in the Oak Creek Drainage Ditches assessment area, with some potential project area also within the Middle Oak Creek assessment area (see Map 6.29). The potential project area is bounded roughly by E. Puetz Road on the north, E. Oakwood Road (also the southern watershed boundary) on the south, S. 15th Avenue on the east, and S. Shepard Avenue on the west. The soils of almost the entire proposed project area consist of hydric soils (see Map 3.16). Review of historical aerial photographs indicates that much of the area had been in agricultural uses as recently as the early 1980's. The prevalence of hydric soils, the historical agricultural land use, and the extensive drainage ditch system that still parallels many of the roads, implies that this area was, and likely still remains, extensively tiled in order to drain the high water table occurring in this portion of the watershed.

As indicated on Map 3.7 large portions of the potential project area are no longer used for agriculture and much of the land has reverted back to wetland conditions. These areas consist of predominantly low-diversity wetlands, mostly large monocultures of reed canary grass and various species of cattails. Despite this, Milwaukee County Natural Areas staff surveys revealed that one southern mesic forest remnant still persists with a complex series of ephemeral wetlands that contain rare semi-aquatic species.[104] The area also contains a fair amount of shrub-carr habitat type. Furthermore, there is a fair amount of land in the potential project area that is considered by WDNR to be potentially restorable wetland. It is likely that remnant drainage tile systems in the area are preventing these wetlands (and the potentially restorable wetland areas) from providing optimal hydrologic and ecological services. Therefore, **it is recommended that a survey be conducted to investigate the extent and location of relict drainage tile systems in this area. If drainage tile systems are found, it is recommended that disconnection and/or removal of drainage tile systems be pursued to assist in restoring this large wetland complex.**[105]

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[104] Ibid.

[105] *This recommendation is subject to determinations that altering such tile drainage systems would not cause flooding or unintended drainage problems for roads or other infrastructure in the area.*

A large amount of the potential project area is currently under public interest ownership, with Milwaukee County, the City of Oak Creek, and the Milwaukee Metropolitan Sewerage District (MMSD) each holding ownership to multiple parcels in the potential project area (see Map 6.29). An ecological restoration and management plan has been completed for the parcels in this area that are owned by Milwaukee County. Recommendations from that plan include specific areas for rapid response invasive species removal, forest stand improvement, reforestation, grassland restoration and management, shallow water wildlife area restoration, formal property line surveys, potential land acquisitions, and flora and fauna surveys to fully assess the potential impacts of ecological restoration activities. **This watershed restoration plan recommends that Milwaukee County and other watershed partners pursue funding to continue the implementation of the ecological management and restoration plans completed for portions of this project area.**

The potential project area also includes privately owned parcels that contain agricultural, industrial, and single-family residential land uses. To be able to pursue restoration actions that would result in a connected wetland complex that would provide optimal hydrological functions, wildlife habitat, and ecological services, private landowner participation would be ideal. Therefore, **it is recommended that engagement with private landowners begins to assess interest in pursuing wetland restoration activities on these parcels. Further, it is recommended that watershed partners evaluate interest in potential voluntary acquisitions of privately owned parcels in the project area** (see Map 6.29). Any restoration activities on private land or property acquisitions would be voluntary and done at the complete discretion of the property owner.

Recommended Actions to Protect Areas of High Groundwater Recharge Potential

Groundwater recharge within the Oak Creek watershed supplies water to the deep and shallow aquifers which, in turn, provide baseflow to the Creek, its tributaries, and wetlands and may also provide baseflow to waterbodies outside of the watershed. Baseflow is vital to maintaining the natural hydrology, habitat quality, and the overall health of the stream system, particularly during droughts and low-flow conditions which may occur more frequently due to climate change.

Directly connected impervious surface areas discharge straight to a stormwater drainage system and ultimately to a stream with no potential for stormwater infiltration. Traditional urban development increases the area of connected impervious surfaces which, in the absence of sound land use planning, preservation of green space, installations of green infrastructure, or other land development measures to promote infiltration of runoff, will reduce infiltration volumes into the shallow aquifer. This reduction in infiltration reduces the baseflows provided by the shallow groundwater system. The loss of baseflow can lead to substantial loss in stream water depth and volume, increased water temperatures, loss of critical fish and other aquatic organism habitat, increased potential for summer fish kills caused by low dissolved oxygen concentrations, and loss or degradation of the coolwater and warmwater fishery.

The estimated percent of connected impervious surface within the Oak Creek watershed is expected to increase from a mean of about 18 percent in 2015 to almost 25 percent of the watershed under planned land use conditions. However, the proportions of impervious surfaces differs within the watershed and some assessment areas are already at or exceed 25 percent connected imperviousness (see Table 6.13). These differences will affect the available options and level of interventions needed for groundwater recharge protection. For instance, for areas that already have large amounts of impervious surface, a sound approach would be to focus on green infrastructure retrofits to treat runoff from these areas and allow for infiltration. For those areas that currently have lower amounts of impervious surface, a sound approach would be to preserve those areas, with special urgency focused on preserving areas that are also considered to have high and very high groundwater recharge potential. The planned land use conditions presented in Chapter 3 show that some current open space land uses that are planned for urban development are located within areas that are currently identified as having high and very high groundwater recharge potential. These areas of planned urban development are shown together with areas of high groundwater recharge potential on Map 6.30.

The preservation and improvement of groundwater recharge is a crucial part of any plan to maintain or improve water quality and habitat conditions by protecting sustainable ecological flows within the Oak Creek watershed.[106] Table 6.13 is intended to help communities assess the level of opportunities that currently remain for groundwater recharge protection and highlight those assessment areas (and the communities that make up the assessment areas) that are projected to potentially lose large proportions of the best remaining areas for groundwater recharge in the absence of mitigation and sound land use planning. For instance, Table 6.13 indicates that the Lower Mitchell Field Drainage Ditch, Upper North Branch Oak Creek, and Drexel Avenue Tributary assessment areas have moderate amounts of land considered to have high or very high groundwater recharge potential. However, large proportions of those areas of high and very high groundwater recharge potential are projected to be developed in urban uses under planned land use conditions. Through innovative land use planning prior to urban development,

[106] *Leroy N. Poff, and others, "The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards"*, Freshwater Biology, *Volume 55, pages 147–170, 2010.*

communities should make these areas a high priority to preserve in natural land cover, restrict the installation of impervious surface, and thus retain the land's ability to infiltrate groundwater. It may be prudent for communities to highlight these areas on planned land use maps to indicate the urgency to preserve their groundwater recharge functions as a part of any future development plans. This would likely be the last chance to protect such critical areas before urban structures and roadway networks are constructed. For those assessment areas currently with high amounts of impervious surfaces and very little remaining areas of high and very high groundwater recharge potential, such as the Mitchell Field Drainage Ditch—Airport and College Avenue Tributary assessment areas, the focus should be on retrofitting areas of impervious surface with green infrastructure and other stormwater infiltration practices to supplement the lost natural groundwater recharge.

Specifically, land managers and policy makers should focus on the following recommended management measures related to groundwater recharge:

1. **It is recommended that communities carefully control new development in the watershed's best remaining groundwater recharge potential areas.** This will help assure local and regional groundwater aquifers are protected. Control can include excluding certain types of development, maintaining recharge potential through thoughtful design, and minimizing impervious surface area, particularly connected impervious surfaces. Specific measures that can be taken to accomplish this recommendation include:

   - Local governments should examine the latest maps and models that identify areas of high groundwater recharge potential prior to the approval of new development proposals and/or plans. These areas should be avoided when locating new buildings or impervious surface.

   - Protect and preserve areas classified as high and very high groundwater recharge potential through conservation easements, land purchases, or voluntary incentive-based measures. Such protection should also incorporate preservation of environmental corridors, isolated natural resource areas, prime agricultural areas, riparian buffers, and open lands that are associated with conservation developments that facilitate groundwater recharge (see Map 6.30 for locations of high and very high groundwater recharge areas as well as the areas planned to be developed from open space uses to urban under community planned land use conditions).

- Installation of sewers, water lines, and other buried utilities which could intercept groundwater flow should be avoided in areas of high and very high groundwater recharge potential.

In instances where it will not be possible to avoid siting urban development on or near areas of high or very high groundwater recharge, it is even more crucial to take measures to maintain both groundwater levels and groundwater quality.

2. **It is recommended that mitigation measures be implemented to reduce the impacts of any future urban development on groundwater recharge quantity and quality.** Specific measures that can be taken to accomplish this recommendation include:

   - Encourage local governments to consider groundwater recharge as an integral part of new development and infrastructure replacement proposals. Some Southeastern Wisconsin communities have promulgated ordinances that require integrated analysis of groundwater and surface water impacts in the process through which developers obtain permission to build new buildings and subdivisions.[107]

   - Review and update as necessary, local land use regulations to promote, where appropriate, conservation development practices that provide for the clustering of new development within the watershed to minimize potential reductions in groundwater recharge.

   - Require developers to actively incorporate infiltration in new stormwater infrastructure. Such infrastructure is best located on areas of high and very high recharge potential (see Map 3.22). Infiltration and recharge rates should be maintained as close to pre-development rates as possible by incorporating runoff management recommendations for enhancing infiltration using low-impact design standards in accordance with the regional water supply plan.[108, 109] Some examples of infiltration techniques and low-impact design include: bioretention cells, curb and gutter

[107] *The Village of Richfield in Washington County is such an example. More information may be found at the Village's website: www.richfieldwi.gov/index.aspx?NID=300*

[108] *SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin, *December 2010.*

[109] *SEWRPC Technical Report No. 48,* Shallow Groundwater Quantity Sustainability Analysis Demonstration for Southeastern Wisconsin Region, *November 2009.*

elimination (when practicable), bioswale road medians, grassed swales, green alleys, green parking design, permeable pavement, infiltration trenches, sand and organic filters, soil amendments, vegetated filter strips, and rain gardens. Infiltrating water must be of good quality. Therefore, existing and proposed site conditions should be taken into account when designing infiltration facilities.

Under 2015 land use conditions, the extent of urban development within the Oak Creek watershed is already enough to negatively affect groundwater quantity and quality in the shallow aquifers, and in turn water quantity and water quality within Oak Creek and its tributaries. Implementing projects that seek to restore the natural flow patterns have the potential to mitigate these effects.

3. **It is recommended that measures be taken to reduce the impact of existing urban development on groundwater recharge quantity and quality.** Specific measures that can be taken to accomplish this recommendation include:

    - Increase the infiltration of urban runoff at those sites where it can be achieved without degrading groundwater quality.

    - Retrofit current urban development to improve infiltration of rainfall and snowmelt using innovative BMPs that are associated with low-impact development. These practices could include rain gardens, installation of porous pavement in parking lots, installation of green alleys at scheduled replacement timetables, converting roadway medians to bioswales, rain garden projects, disconnection of downspouts from sewer systems, and other green infrastructure practices as discussed above.

    - Apply the stormwater management technical standards developed by the WDNR in the design of stormwater management facilities.[110] In particular, the potential for pollutants to enter the groundwater through infiltration should be considered in the design of infiltration facilities. This consideration is especially important in areas with shallow depths to groundwater.

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[110] *WDNR approved stormwater construction technical standards are documents that specify the minimum requirements needed to plan, design, and maintain a wide array of conservation practices aimed at preserving the land and water resources of Wisconsin. Technical standards for various stormwater management practices can be found at dnr.wisconsin.gov/topic/Stormwater/standards/postconst_standards.html*

Although infiltration into soils provides some level of pollution reduction, shallow aquifers can be vulnerable to pollution. Within the Oak Creek watershed there are specific areas associated with land uses that could potentially contribute pollutants to groundwater. These areas include golf courses and agricultural fields in high groundwater recharge areas which could also act as sources of pollution due to over-fertilization and pesticide use. These areas also include urban and residential areas, which could act as sources of a variety of urban runoff pollutants, including chloride from deicing salts, gasoline, heavy metals, fertilizers, and pesticides. Pollutants contributed by these areas can infiltrate into groundwater during rain and snow melt events. This pollution needs to be prevented to the greatest extent possible to avoid contaminating the groundwater and the baseflow of Oak Creek, its tributaries, and wetlands throughout the watershed.

4. **It is recommended that pollution reduction measures be implemented on agricultural lands and other areas, such as golf courses, with high groundwater recharge potential.** Specific measures that can be taken to accomplish this recommendation include:

    - Evaluate agricultural operations located in areas of high groundwater recharge for compliance with State standards for application of integrated nutrient and pest management practices and undertake corrective measures on those operations that are not in compliance.

    - Reduce or eliminate the application of fertilizers and pesticides to the extent practicable on other land uses prone to nutrient and chemical pollution which are located in areas of high groundwater recharge. It is particularly important that nutrient and chemical applications not occur during periods when groundwater levels are known to be high.

    - Municipal and private snow removal operations should be diligent in maintaining best management practices when applying chlorides for de-icing in areas of high groundwater recharge. Alternatives to chloride-based deicers should be considered in those areas. Recommendations to reduce chloride pollution are described in detail in the "Recommended Actions to Improve Water Quality" section earlier in this Chapter.

Recommended Actions to Protect, Restore, Expand, and Connect Riparian Buffers

The protection, restoration, expansion, and connection of riparian buffer areas represent opportunities to achieve the objective proposed by a Federal initiative to conserve and restore the lands, waters, and wildlife habitat with a national goal of conserving 30 percent of U.S. lands and waters by the year 2030. The initiative was launched as a result of a report that was submitted to the National Climate Task Force by the U.S.

Department of the Interior, the U.S. Department of Agriculture, the U.S. Department of Commerce, and the Council of Environmental Quality.[111] The preliminary report recommends a ten-year, locally led campaign to conserve and restore vital land and water and aligns well with measures recommended within this watershed restoration plan. As discussed in Chapter 4, riparian buffers provide a wide array of benefits and are vital to a healthy aquatic and terrestrial ecosystem in the Oak Creek watershed. All riparian buffers provide some level of protection that is greater than if there was no buffer at all. However, wider buffers provide a greater number of functions than do narrower buffers. Therefore, **it is recommended that all efforts are made to protect and restore existing riparian buffers and establish new riparian buffer areas to the maximum extent practicable—up to, and beyond the 1,000-foot optimum buffer width**.

The riparian buffer network within the Oak Creek watershed, as assessed under 2015 conditions, is shown on Maps R.1 through R.22 in Appendix R. These maps highlight existing riparian buffers as well as areas where buffers could potentially be established to 75-foot, 400-foot, and 1,000-foot widths. These potential riparian buffer expansions would be targeted for lands that were not developed in urban uses (as of the most recent SEWRPC land use inventory in 2015), and which could be preserved in open space uses in the future, or at the very least be developed in a way to maximize preservation of riparian buffer areas. In addition, these maps identify the existing riparian buffer network of lands protecting waterbodies in this watershed and potential buffer areas, up to the 1,000-foot optimum core habitat width, which are designated as "vulnerable" to future urban development. Areas are designated as "vulnerable" when they are 1) located outside the one-percent-annual-probability regulatory floodway[112], 2) not designated as ADID wetlands, and 3) not under protected ownership such as public ownership, nonprofit ownership, or conservation organization ownership. To guide the implementation of the riparian buffer recommendations set forth below, Figure R.1 in Appendix R identifies examples of areas that should be targeted on each of the Appendix R maps.

These maps are intended to provide individuals, organizations, and municipalities implementing this plan with guidance on areas which should be prioritized for protection. They also provide guidance as to where new riparian buffer areas could potentially be established throughout the Oak Creek watershed.

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[111] *U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of Commerce, and the Council of Environmental Quality,* Conserving and Restoring America the Beautiful, *2021.*

[112] *As summarized in the floodplain zoning section in Chapter 3, all municipalities within the watershed have adopted floodplain ordinances, however this does not preclude development within the regulatory floodplains of the Oak Creek watershed.*

Additionally, the maps indicate the areas within the watershed where large buffers may not be feasible due to existing urban development, thereby indicating where smaller buffers and other green infrastructure measures should potentially be implemented.

The maps in Appendix R provide the information necessary to begin planning riparian buffer protection and expansion projects. Specifically, land managers and policy makers should focus on the following recommendations regarding riparian buffers:

1. **It is recommended that existing riparian buffers be managed and preserved** (see Examples A and B in Figure R.1, which illustrates areas that should be identified on Maps R.1 through R.22 in Appendix R in order to implement this recommendation). Specific measures that can be taken to accomplish this recommendation include:

    - Actively manage invasive species and promote establishment of native plant species. Partnerships between Milwaukee County Parks, municipal governments, schools, volunteer groups, service organizations, and concerned citizens through participation in programs offered by WDNR are critical in managing an ecologically healthy riparian buffer system in the watershed.

    - Pursue funding and partnerships to implement Milwaukee County Parks Department ecological restoration and management plans that have been developed for the County-owned parks and open space lands within the Oak Creek watershed. These County-owned lands include large expanses of riparian buffers. The management plans aim to maintain and increase native plant and wildlife diversity and reduce the impact of invasive species and represent a blueprint for creating healthier riparian buffer areas throughout the watershed. Milwaukee County Parks Department's ecological restoration plans will be discussed throughout the recommended actions to improve habitat in the watershed.

    - Riparian areas that have been heavily impacted by emerald ash borer should be a priority target for forest stand improvements (see Map 4.13). The rapid decline of floodplain and riparian forest canopy due to ash tree mortality has significantly altered the forest floor habitat, allowing invasive species, particularly common buckthorn and reed canary grass, to rapidly spread into areas where the forest canopy has been newly opened due to ash tree loss. Forest stand improvement should be a priority in these areas. Forest stand improvement could include selectively thinning aggressive native tree species such as ash, basswood, boxelder, removing all woody invasive plant species around desired vegetation, and planting native trees and shrubs in areas of existing canopy gaps. The Milwaukee County Parks Department provides detailed forest stand improvement recommendations for their Oak Creek Parkway properties including proper species to use for reforestation, number of trees to plant per acre, and restoration timelines.[113] For areas that have not had detailed restoration plans developed, the following general guidelines represent a sound approach to smaller scale reforestation efforts of riparian areas that have been heavily impacted by ash tree die-offs:

- Avoid planting ash trees.
- Appropriate maple tree species for floodplains and hardwood swamps include silver, freeman, and red maple.
- No more than 20 percent of planted tree species should be members of the same genus.
- No more than six individuals of any given genus should be planted adjacent to one another.
- No more than 10 percent of planted tree species should be the same species.
- No more than three individuals of any given species should be planted adjacent to one another.
- In addition to hardwood tree species, native shrubs and small trees including willow, buttonbush, cherry, dogwood, hazelnut, winterberry, and viburnum should be included in reforestation projects. These shrubs and small tree species will compete with invasive non-native species while the comparatively slow growing tree species establish.
- An appropriate herbaceous floodplain seed mix should be applied to the project area following site preparation, especially in areas disturbed during planting of trees and shrubs.
- Invasive and non-native species should be controlled as early as possible, particularly buckthorn. Removal becomes more difficult and costly once invasive species are established.

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[113] *Milwaukee County Parks Natural Areas Staff,* Oak Creek Parkway Ecological Restoration & Management Plan, *2019*.

  - Consider enhancing the plantings described above by including aggressive native herbaceous species characteristic of floodplain forests and hardwood swamps. Appropriate matrix species may include many native grasses, sedges, and bulrushes. These species spread aggressively by rhizomes, making them a good choice for areas prone to disturbance and flooding.

- Promote low-impact public use and recreational access to publicly owned riparian buffer areas where possible.

- Promote awareness and education regarding management of these areas to prevent damage from introduction of new invasive species or re-introduction of eradicated invasive infestations.

2. **It is recommended that existing riparian buffers be protected** (see Examples A and B in Figure R.1, which illustrate areas that should be identified on Maps R.1 through R.22 in Appendix R in order to implement this recommendation). All existing riparian buffers that are not under public interest ownership should be considered under this recommendation, however, areas considered vulnerable to urban development should be a higher priority. Vulnerable lands are indicated in black hatching in Figure R.1 and Maps R.1 through R.22. Specific measures that can be pursued to accomplish this recommendation include:

- Acquisition of land by public interest ownership via donation or purchase and establishment of public or private conservation easements on critical lands.

- Consistent implementation and enforcement of local zoning regulations to prohibit any filling or development within the regulatory floodway and ADID wetlands.

- Communities should implement local zoning regulations to prohibit any filling and development within the flood fringe areas of the regulatory floodplain.

- Encourage establishment and management of riparian buffers within the 1-percent-annual-probability floodplain, particularly when zoning of land changes from agricultural to urban uses.

- Consistent and effective application and updating of the regulatory framework including local zoning ordinances, shoreland zoning requirements, State wetland regulations, and U.S. Army Corps of Engineers permit program for wetlands.

- Continued application of limits on development within SEWRPC-delineated primary environmental corridor (PEC) and connection of "vulnerable" existing riparian buffer lands to PEC, secondary environmental corridor (SEC), and isolated natural resource areas (INRA). Additional riparian buffer lands may be added to delineated PEC if they meet the criteria for inclusion in the corridor, thus extending the restrictions on development that are inherent to PEC designated lands.

3. **It is recommended that new riparian buffers be established to the greatest extent possible throughout the watershed with a minimum target of a 75-foot width from water's edge (150-foot total buffer width) and an optimal goal of a 1,000-foot width (or greater) from water's edge** (see Examples C, D, and E in Figure R.1, which illustrate areas that should be identified on Maps R.1 through R.22 in Appendix R to implement this recommendation). Specific measures that can be taken to accomplish this recommendation include:

- Establish undisturbed vegetation along perennial, intermittent, and ephemeral waterways in both urban and rural areas to the extent practicable, but to a minimum of 75-feet from water's edge. The use of native species should be prioritized.

- Areas that are projected to be converted from open space land use categories to urban uses under planned conditions and are also considered to be potential riparian buffer, as indicated on Map 4.7, are high priority areas for establishment of riparian buffers.

- Implement reforestation and grassland restoration projects recommended as part of Milwaukee County Parks Ecological Restoration and Management plans. These projects are described in more detail in the recommendations to protect, preserve, and restore environmentally sensitive areas below.

- Areas that are both identified by WDNR as potentially restorable wetlands and considered to be potential riparian buffer areas, as indicated on Map 4.11, are high priority areas for establishment of riparian buffers.

- Potential riparian buffer areas that are within the 0.2-percent-annual-probability (500-year recurrence interval) floodplain but that are beyond the 1-percent-annual-probability (100-year recurrence interval) regulatory floodplain are high priority areas for the establishment of buffers to provide resiliency against flooding caused by more frequent intense rainfall events that are projected to occur in the Region.

- In agricultural areas, consider installation of harvestable riparian buffers where practicable and where no buffer currently exists.

- Provide informational materials to shoreland property owners on the environmental, social, and economic benefits of establishing riparian buffers and best management practices, including instructions on how to proceed with implementation.

- Promote available incentive programs and provide technical assistance to private landowners to establish riparian buffers on their lands.

4. **It is recommended that connections and corridors between riparian buffer areas be established to ensure connectivity and continuity of a variety of habitat types.** Specific measures that can be taken to accomplish this recommendation include:

- Remove abandoned or nonessential roads and stream crossings where appropriate.

- Develop and implement incentive-based programs to encourage existing landowners and businesses within the 1,000-foot zone to consider landscaping that would enhance wildlife habitat by providing connections or lanes through the lots to larger riparian buffer areas. It would also be helpful to provide educational materials and technical assistance to interested landowners. These programs should encourage the use of native plants which provide cover and food for wildlife.

- When feasible, limit creation of new road crossings of the streams within the Oak Creek watershed.

- Preserve, restore, and/or expand small wetlands, woodlands, and prairies that are not identified as part of an environmental corridor or an isolated natural resource area and link such features by providing corridors connected to larger riparian buffer areas.

Riparian Buffer Protection and Expansion Prioritization Strategies

The framework described above can be achieved through a combination of strategies that include land acquisition, regulation and other opportunities, and implementing best management practices. These three strategies are described in further detail below.

Land Acquisition

Not all of the environmental corridors and associated natural areas in the Oak Creek watershed, which make up large portions of the existing and potential riparian buffer areas, are protected from being cleared and developed for urban uses. It is therefore important that a prioritization for acquisition of these lands be based on the following order of importance (from highest to lowest priority):

1. Protect what currently exists on the landscape. Vulnerable existing riparian buffer areas as indicated in black hatch on Maps R.1 through R.22 in Appendix R should have highest priority for acquisition.

2. Provide a minimum width of buffer for water quality protection. Vulnerable potential riparian buffer lands up to 75-feet wide as indicated in red with black hatch on Maps R.1 through R.22 in Appendix R should have the next highest priority for acquisition.

3. Provide a minimum width of buffer for wildlife protection. Vulnerable potential riparian buffer lands up to 400-feet wide as indicated in orange with black hatch on Maps R.1 through R.22 in Appendix R should have the next highest priority for acquisition.

4. Provide an optimum width of buffer for wildlife protection. Vulnerable potential riparian buffer lands up to 1,000-feet wide as indicated in yellow with black hatch on Maps R.1 through R.22 in Appendix R should have the next highest priority for acquisition.

In addition, special consideration should be given to the acquisition of vulnerable existing and potential riparian buffers in locations designated as having high to very high groundwater recharge potential as shown on Map 3.22 in Chapter 3 of this report. Establishing connections and expanding critical linkages among habitat complexes to protect wildlife abundance and diversity should also be a priority. Connecting the many SECs and INRAs throughout the watershed to larger PEC areas (see Map 3.18), as well as building and expanding upon the existing protected lands, including lands in public interest ownership, the regulatory floodway, and ADID wetlands, represents a sound approach to enhancing the corridor system and wildlife areas within the watershed.

Regulatory and Other Opportunities

Opportunities Related to Existing Regulatory Protections

Existing regulations and other mechanisms restrict some activities adjacent to streams, rivers, and lakes. Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code* establishes a minimum 75-foot development setback running parallel to the ordinary high-water mark of navigable lakes, streams, and rivers.[114] Section NR 151.03 of the *Wisconsin Administrative Code* requires a minimum tillage setback standard of five feet from the top of the channel of surface waters in agricultural lands. In addition, Milwaukee County, which owns and leases a significant amount of the remaining agricultural land in the watershed, requires in its lease agreements that no annual crops be planted within 75 feet of any river or stream or within 30 feet of any field ditch. Instream field observations in the watershed and orthophotograph interpretation indicate that the small amount of remaining agricultural lands adjacent to Oak Creek and its main tributaries meet the five-foot tillage setback. It should be noted that while the five-foot tillage setback and the 75-foot development setback are important requirements to reduce disturbance along the water's edge, neither regulation requires natural vegetative buffers be maintained in these areas adjacent to the waterways and therefore they are not adequate to achieve the water quality and wildlife habitat goals for this watershed. As summarized in Chapter 4 and Appendix R, not having adequate buffer vegetation between a waterway and an agricultural field and/or urban development can contribute to significant sediment and phosphorus loading to the waterway and can significantly limit wildlife habitat.

Priority areas for establishment or expansion of riparian buffer include cropland where the minimum recommended buffer width of 75 feet is not being met, cropland located within the one-percent-annual-probability (100-year recurrence interval) floodplain, and cropland containing potentially restorable wetlands within 1,000 feet of a waterway. If an agricultural area in the watershed that is not owned by Milwaukee County is being considered for conversion to urban development, it may be possible to design portions of the development to accommodate expansion of the riparian buffers to the 400- and 1,000-foot widths. This would likely be the last chance to establish such critical protective boundaries around waterways before urban structures and roadway networks are constructed.

[114] *Where an existing development pattern exists, the shoreland setback for a proposed principal structure may be reduced to the average shoreland setback of the principal structure on each adjacent lot, but the shoreland setback may not be reduced to less than 35 feet from the ordinary high-water mark of any navigable water.*

Protection and Expansion Opportunities Related to Environmental Corridor Status

Protecting existing riparian buffers within or adjacent to environmental corridors and/or establishing new riparian buffers within environmental corridor areas that do not currently have natural land cover characteristics (i.e., Oak Creek Parkway land currently being mowed) would help preserve and increase the ecological services provided by these crucial areas. Furthermore, because the 100-year recurrence interval floodplain boundaries are a significant element of defining PEC lands, restoring these areas to riparian buffer land cover would preserve and/or improve the ability of floodplains to protect communities from future flooding events. Increased community resiliency to flooding events is even more critical as climate change impacts are likely to increase the frequency of intense rainfall events.

PEC's receive a greater level of land use protections than SEC's, INRA's, or SEWRPC designated natural areas outside of PEC.[115]. Increasing the extent of land designated as PEC within the Oak Creek watershed represents a potential strategy for extending current regulatory protections provided by PEC designation to vulnerable existing and potential riparian buffers as areas within the watershed are restored. Opportunities are present in the Oak Creek watershed to expand PEC lands and to connect SEC lands to adjacent SEC and INRA land to form a contiguous corridor large enough to potentially qualify as a PEC. However, this can only be accomplished if there are sufficient natural resource features to meet the criterion for designation as a corridor and if the minimum area (400 acres), minimum length (two miles), and minimum width (200 feet) requirements for designation as PEC are met.[116]

As discussed earlier in this report, Milwaukee County Parks intends to restore all County-owned and leased agricultural land to either forest, wetland, or native grassland conditions as funding opportunities become

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[115] *Implementation of environmental corridor protection recommendations is envisioned to come about primarily through enactment of appropriate zoning regulations at the county and local levels of government. In addition, the WDNR and the Wisconsin Department of Safety and Professional Services seek to bring about the specific recommendations related to protection of the PECs through their public and private sanitary sewer extension approvals. Essentially, the operational rules of those departments require that the PEC protection and development density recommendations, as set forth in the SEWRPC regional land use plan, be met before State approval of sewer extensions. This State policy can have the effect of imposing more stringent development limitations than set forth in local zoning regulations.*

[116] *Procedures utilized by SEWRPC to delineate environmental corridors are documented in "Refining the Delineation of Environmental Corridors,"* SEWRPC Technical Record *Vol. 4, No. 2, March 1981.*

available. In addition, MMSD's conservation plan[117] and SEWRPC's greenway connection plan[118] have identified lands within MMSD's service area that should be targeted for voluntary acquisitions and preserved in order to retain floodwater retention benefits as well as to improve water quality and wildlife habitat conditions. MMSD's Greenseams program aims to make voluntary purchases of the undeveloped, privately owned properties which were identified in the plans described above. Properties that have been acquired as part of the Greenseams program are shown on Map 4.45. It is recommended that MMSD continues to pursue voluntary acquisitions of the remaining properties identified in their conservation plan and the greenway connection plan that remain undeveloped. Both the Milwaukee County Parks and MMSD programs represent opportunities to expand riparian buffers and potentially expand planned PEC lands within the watershed, and thus the protections that a PEC designation provides. Therefore, it is recommended that any future reforestation or grassland restoration of County-owned agricultural fields and land purchased and preserved by MMSD Greenseams program be considered for designation of planned PEC, SEC, or INRA, where appropriate.

Opportunities Related to ADID Wetlands

Wetlands located within PEC lands that have been designated as Advanced Delineation and Identification (ADID) wetlands under Section 404(b)(1) of the Federal Clean Water Act are deemed generally unsuitable for discharge of dredge and fill material.[119] In addition, nonagricultural performance standards set forth in Section NR 151.125 of the *Wisconsin Administrative Code* require establishment of a 75-foot protective area restricting impervious surfaces adjacent to these higher-quality ADID wetlands. This designated protective area boundary is measured horizontally from the delineated wetland boundary to the closest impervious surface.[120] Accordingly, these wetlands would have additional protections from being filled, from being encroached upon by future development, and would retain their riparian buffer functions.

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[117] *The Conservation Fund, et al.,* Conservation Plan for the Milwaukee Metropolitan Sewerage District, *October 2001.*

[118] *SEWRPC Memorandum Report No. 152,* A Greenway Connection Plan for the Milwaukee Metropolitan Sewerage District, *December 2002.*

[119] *Under Federal Law, Federal and State regulatory agencies are empowered to identify, in advance, those wetland areas which they collectively determine to be inappropriate for the disposal of fill and dredged materials. These determinations are made jointly in Southeastern Wisconsin by the U.S. Department of the Army, Corps of Engineers (USACE), the U.S. Environmental Protection Agency (USEPA), and the WDNR. SEWRPC provides technical assistance to these agencies in preparing maps of these areas.*

[120] *Runoff from impervious surfaces located within the protective area must be adequately treated with stormwater best management practices.*

Best Management Practices

A large portion of the vulnerable existing and potential riparian buffers in the Oak Creek watershed are located within privately owned urban and agricultural areas. It is the choice of the private landowners as to whether a riparian buffer is established on their land. Although riparian buffers can be effective in mitigating the negative effects attributed to urbanization and agricultural management practices, they cannot on their own address all the problems associated with pollutants generated by these land uses. Because of this, riparian buffers should be combined with other management practices, such as infiltration facilities, wet detention basins, porous pavements, green roofs, bioswales, and rain gardens to mitigate the effects of urban stormwater runoff. Similarly, riparian buffers should be combined with other management practices, such as reduced tillage, grassed waterways, and filter strips to mitigate the effects of agricultural runoff.

Recommended Actions to Preserve, Restore, Expand, and Connect Wildlife Habitat

The presence of healthy wildlife communities, including healthy populations of animals such as deer, fish, amphibians, reptiles, birds, and small mammals is a significant indication of a healthy watershed. This is largely because wildlife populations require large, well-connected natural areas, which are associated with good water quality and good aquatic and terrestrial habitat. The presence of healthy wildlife populations also provides recreational opportunities, such as bird watching, fishing, and nature hiking.

The development patterns and infrastructure that humans create on the landscape lead to a number of obstructions that can limit both the availability of wildlife habitat and the ability for organisms to travel between multiple habitat types. These obstructions are primarily a result of roadways, railways, and buildings that fragment the natural landscape. Therefore, an effective management strategy to protect wildlife abundance and diversity in the Oak Creek watershed would be to maximize critical linkages between habitat areas in the watershed, ensuring the ability of species to access these areas. **It is recommended that the following critical linkages between habitat areas be maximized**:

- Water's edge (lake, pond, stream, wetland) to terrestrial landscapes

- Water's edge to water's edge (e.g., river to ephemeral pond, lake to ephemeral pond, permanent pond to ephemeral pond)

- Habitat complexes or embedded habitat (e.g., wetland to upland or grassland to woodland)

Recommended Actions to Protect, Preserve, and Restore Environmentally Sensitive Areas

The environmental corridors and isolated natural resource areas (see Map 3.18), as well as SEWRPC designated natural areas (NAs) and critical species habitat sites (see Map 3.19) contain some of the highest quality remaining habitat in the watershed.[121] These areas are crucial to wildlife maintenance and enhancement due to their continuity, size, and in many cases, proximity to Oak Creek and its tributaries. As discussed in the riparian buffer recommendations above, connecting the multiple INRAs and NAs throughout the Oak Creek watershed to the larger PEC and SEC areas and building and expanding upon the existing protected lands, represents a sound approach to enhance the wildlife corridor system and wildlife areas in the watershed.

The Milwaukee County Department of Parks, Recreation, & Culture's (DPRC) Natural Areas staff has been conducting invasive species surveys and developing and implementing site-specific ecological restoration and management plans for many of the County parks and County-owned open space lands located within the Oak Creek watershed. These plans are a blueprint to creating healthier and more ecologically stable open space lands throughout the watershed. Within the Oak Creek watershed, plans have been completed for Barloga Woods, Cudahy Nature Preserve, Falk Park, Oak Creek Parkway, and Rawson Woods.[122] Each plan contains invasive species survey results, identification of potential ecological threats, and restoration objectives specific to each area. These plans share common goals that include a combination of the following:

- Protecting existing high-quality natural areas within the site
- Maintaining and increasing native plant and wildlife diversity
- Reducing negative impacts of invasive species
- Providing passive recreational opportunities for the public

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[121] *Many of these areas are also encompassed by Milwaukee County-owned park and open space lands.*

[122] *Milwaukee County Parks,* Barloga Woods Ecological Restoration & Management Plan 2016-2025, *2018; Milwaukee County Parks,* Cudahy Nature Preserve Ecological Restoration & Management Plan 2018-2027, *2018; Milwaukee County Parks,* Falk Park Ecological Restoration & Management Plan 2016-2025, *2017; Milwaukee County Parks,* Oak Creek Parkway Ecological Restoration & Management Plan, *2019; Milwaukee County Parks,* Rawson Woods Ecological Restoration & Management Plan 2017-2026, *2017.*

- Enhancing and maintaining the environmental corridor

- Engaging the public as part of the restoration management process

- Addressing encroachment activities

To maintain and improve wildlife habitat in the Oak Creek watershed, the following recommendations have been developed:

1. **It is recommended that Milwaukee County and watershed partners pursue funding to continue the implementation of the Milwaukee County DPRC's ecological restoration and management plans.** Specific management or restoration actions include rapid response invasive plant species removal, reforestation, forest stand improvement, grassland management, grassland restoration, shrub management, and creation of shallow-water wildlife areas (see Map 6.31 for recommended project locations). The conversion of all Milwaukee County-leased agricultural land to reforestation, wetland restoration, or native grassland restoration projects is included in these plans. For detailed recommendations see the individual Milwaukee County ecological restoration and management plans.[123]

2. **It is recommended that wildlife habitat be preserved and expanded through protection of riparian buffer areas considered to be "vulnerable" to development throughout the watershed (see Maps R.1 through R.22 in Appendix R) and through establishment of additional riparian buffer areas.** Establishment of riparian buffers should occur particularly at those sites where such establishment can be located contiguous with an environmental corridor and may result in a potential expansion of such corridor areas (see Map 4.8 and Map 4.9). Specific measures that can be taken to accomplish this recommendation include:

    - Implement measures described under Riparian Buffer Recommendations 1 through 4, specifically focusing on expansion of buffer widths to the 400-foot minimum width for wildlife protection and the 1,000-foot optimum width for wildlife protection.

    - Implement measures described under Groundwater Recharge Recommendations 1 and 2.

[123] Ibid.

- Implement measures described under Urban Surface Water Hydrology Recommendation 1 and Rural Surface Water Hydrology Recommendations 1 through 4.

- Implement recommendations for the acquisition and protection of wetland and woodland areas that have been identified in the adopted regional natural areas and critical species habitat protection and management plan.[124] Implementation of these recommendations, in addition to those set forth in the draft park and open space plan for Milwaukee County,[125] and the County's ecological restoration and management plans would complement the protection and preservation of environmentally sensitive lands.

3. **It is recommended that habitat fragmentation be reduced by preserving and further enhancing connections between riparian buffer areas, open space, critical species habitat sites, and natural areas.** Specific measures that can be taken to accomplish this recommendation include:

    - Implement measures described under Riparian Buffer Recommendations 2, 3 and 4.

    - Establish corridors and buffers of natural habitat connecting isolated wetlands and ephemeral ponds to nearby upland wooded areas to allow reptiles and amphibians safe access to uplands necessary for certain life stages.

    - Maintain and/or re-establish connections between streams and overbank floodplains to protect, preserve, and enhance fish and wildlife habitat and water quality benefits. This action should make use of open space lands, riparian corridors, and park lands in flood prone areas, as appropriate. This management measure will be discussed in detail in the "Recommended Actions to Restore Degraded Stream Channels and Re-Establish Connections Between Stream Channels, Floodplains, and Adjacent Wetlands" section below.

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[124] *SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997; SEWRPC,* Amendment to the Natural Areas and Critical Species Habitat Protection and Management Plan for the Southeastern Wisconsin Region, *December 2010.*

[125] *Preliminary Draft of SEWRPC Community Assistance Planning Report No. 132 (2nd Edition),* A Park and Open Space Plan for Milwaukee County, *which was being updated as this plan was under preparation.*

- Municipalities, homeowner associations, and other managers of stormwater detention basins should consider managing stormwater facilities as critical habitat for aquatic and terrestrial wildlife. This can be accomplished by reduced and selective mowing, planting native plant species in and around existing and new basins, reducing or eliminating fertilizers and pesticides near basin slopes, and limiting herbicide application and cutting to invasive species only. The use of native plants in these situations will improve filtration of detention waters, reduce pollutant loading, and provide additional wildlife habitat.

- Maintain connections between streams and wetlands, wetland and upland complexes, and wetlands and ephemeral and/or perennial ponds, all of which provide redundancy in available habitat quantity and quality necessary to help ensure wildlife biodiversity.

- Implement technical assistance programs and/or incentive-based programs meant to encourage landowners, farmers, and businesses within the 1,000-foot optimal wildlife habitat zone to consider native landscaping that would enhance wildlife habitat by providing connections or lanes through their properties. These programs should encourage the use of native plants that provide cover and food for wildlife.

4. **It is recommended that best management practices aimed at maintaining and enhancing wildlife habitat be implemented. These practices should consist of voluntary, educational and technical assistance, and/or incentive-based programs.** Specific measures that can be taken to accomplish this recommendation include:

- Encourage landowners to enroll in programs that provide financial incentives to restore wildlife habitats such as the Conservation Reserve Program, the Wetland Reserve Program, the Wildlife Habitat Incentives Program, and/or the Landowner Incentive Program.

- Encourage homeowners, businesses, and other landowners to implement BMPs on their property. Examples of BMPs could include:

    - Reforesting areas where forest canopy gaps have been created by ash tree mortality. Dead ash trees should be felled prior to reforestation in order to protect any newly planted native trees and shrubs. A select number of dead snags (5-10 per acre) could be left for cavity roosting and/or nesting wildlife.[126]

- Restoring natural fire frequency, intensity, and seasonality. Where feasible, the use of fire should be favored over the use of herbicides as a vegetation management tool, especially in drier upland ecosystems. It will be necessary to consult with appropriate municipal officials for guidelines and/or restrictions before planning and implementing any fire management activities.

- Identifying and protecting embedded, adjacent, and sensitive habitat features such as seasonal wetlands, springs, and rock outcroppings.

- Formulating forest and/or vegetation regeneration plans before removal of large stands of invasive species.[127]

- Using native plant species from local sources if possible when landscaping. Landscaping that increases native flowering plants can attract vital pollinators, encourage a healthy insect food base for birds and amphibians, and help prevent the introduction and spread of exotic species.

- Avoid mowing wetlands, shorelines, and ditches, especially from mid-spring through mid-fall. If mowing of large fields is necessary, raise the blade deck to a height of at least eight inches.

- Avoiding storage of silage, manure, fertilizers, pesticides, deicing salts, and other contaminants near wetlands, waterbodies, or other sensitive habitat areas.

- Using effective nutrient management for agricultural fields (timing, amounts, mechanisms of spreading) including consideration of crop rotation and burning to add nutrients rather than use of chemicals. Nutrient management plans should be developed for agricultural operations in the watershed that do not currently have them.

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[126] *This is a management action recommended by Natural Areas staff for Milwaukee County-owned open spaces but may be also applicable to some privately owned forested land.*

[127] *Ecological restoration and management plans completed by Milwaukee County Parks Natural Areas staff for County-owned open spaces may be a good starting point for restoration and management strategies.*

- Following label directions and using the minimum amounts necessary when using fertilizers, herbicides, and insecticides on agricultural lands, lawns, or golf courses.

- Installing rain gardens that are vegetated with appropriate native plant species.

Recommended Actions to Control and Manage Invasive and Nonnative Species

As described in Chapter 4 of this Report, at least 97 known invasive plant species have been found in waterbodies, wetlands, riparian areas, and uplands of the Oak Creek watershed. In addition, invasive animal species found in the watershed include fish species, such as common carp and round goby; invasive crustacean species, such as rusty crayfish; invasive mollusks, such as the Chinese mystery snail; and invasive insects, such as the emerald ash borer. The presence of exotic invasive species in a habitat can produce alterations in physical and biological characteristics of that habitat. For example, the emerald ash borer has devastated the ash tree population in the Oak Creek watershed, dramatically altering the tree canopy in the riparian areas. This has reduced the quality of these areas as habitat for many other organisms and led to favorable conditions for the spread of other invasive plant species on the forest floors. Invasive species are often strong competitors for nutrients, space, and other resources, allowing them to out-compete and displace native species from habitats. As a result, invasive species have the potential to degrade the remaining high-quality natural areas within the watershed. The following recommendations are intended to control and manage the spread of nonnative and invasive species in the Oak Creek watershed.

1. **It is recommended that Milwaukee County and watershed partners pursue funding to continue implementing the Milwaukee County DPRC's ecological restoration and management plans which include continued inventory, monitoring, and control of invasive species populations.** As part of the management plans, County Natural Areas staff have prioritized targeted control and removal of "rapid response" species. These are invasive plant species that are not yet common within the park system or plant populations but have an inordinate negative impact on existing important wildlife areas. Rapid response invasive species removal areas are shown on Map 6.31. For detailed recommendations specific to each park or open space area see the individual Milwaukee County ecological restoration and management plans.[128] Reforestation and forest stand improvement efforts that are conducted as part of managing invasive species should follow the guidelines for reforestation previously described in the section on protecting and restoring riparian buffers.

[128] *Milwaukee County Parks, op. cit.*

2. **It is recommended that Milwaukee County DPRC continue to update the ecological restoration and management plans for County-owned park and open space sites within the watershed as the plans are implemented or as conditions change.**

3. It is recognized that some methods of invasive species control can be very labor intensive. Because of this, **it is recommended that State agencies, Milwaukee County, municipalities, and non-profit groups conduct invasive species workdays in parks and natural areas, utilizing community volunteers, partner organizations, and contractors in addition to governmental staff.** One example is the annual "Garlic Mustard Pull-A-Thon" sponsored by the Southeastern Wisconsin Invasive Species Consortium, Inc. (SEWISC). This event is a friendly competition, a fundraiser, and a way for the public to join together and have a positive impact on the natural areas in their community by removing the invasive plant species from parks, open spaces, and their own property.

4. **It is recommended that invasive species be removed and/or managed using accepted management methods.** Examples of accepted methods can be found in the Milwaukee County DPRC's invasive species management guide.[129] A copy of this guide is included as Appendix I. New information is constantly becoming available regarding the biology and management of invasive species. Because the most current information is valuable in more effectively managing these pests, **it is recommended that the Milwaukee County DPRC continue to periodically update its management guide as new techniques and knowledge becomes available.**

5. **It is recommended that current monitoring for invasive species in the Oak Creek watershed be continued and expanded.** This should include routine updating of inventories of parks and natural areas as well as new surveys of other publicly owned open space and park lands. Given that it is important that observations of invasive species be compiled and collated, all new observations of invasive species in waterbodies or terrestrial habitats should be reported to the WDNR.[130]

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[129] *Milwaukee County Department of Parks, Recreation & Culture,* Quick Reference Guide: Phenology and Control of Common Invasive Plant Species Found in Southeastern Wisconsin, *2021*.

[130] *This can be done through the WDNR website at dnr.wisconsin.gov/topic/Invasives/report.html. This website also describes the specific information that should accompany such reports.*

6. **It is recommended that Milwaukee County, the University of Wisconsin-Extension, the WDNR, municipalities, and nongovernmental watershed partners continue educational activities related to nonnative and invasive species and the control thereof.** Such educational activities should include, but not be limited to, the distribution of informational materials, presentation of workshops, installation of signage, and answering of direct inquiries from landowners and residents. SEWISC is a good source for information for residents related to invasive species identification and removal. The organization also offers "Fighting Invasive Plants" aluminum signs for a small fee that residents can place on their properties to promote the stewardship practice to others.[131]

7. **It is recommended that roadway managers for communities within the Oak Creek watershed consider implementing guidelines outlined in the SEWISC Roadside Invasive Species Management Plan.[132]** New invasive species populations are often established along roadways and are easily spread to neighboring properties. The basic elements of a program to contain and control invasive plants on rights-of-way (ROW) should be sustained on a continuous basis and include:

   - Adjust and customize ROW mowing to prevent spreading seed and prevent seed set in established patches. In general, this means a full-mowing of the ROW should be implemented prior to seed set.

   - Monitor and identify newly occurring individual plants and very small new patches of invasive species in ROW and eradicate.

   - Aggressive and more costly control of well-established populations should only be conducted if it can be justified for specific locations (i.e., a roadside population poses a definite threat to an adjacent high-quality natural area). The goal is to not spread established populations.

Recommended Actions to Maintain and Restore the Quality and Diversity of Instream Habitat

Since at least the early 1900's, the Oak Creek system has been substantially altered through channelization, agricultural and urban development, road construction, placement of fill, construction of stormwater

[131] *More information can be found on the SEWISC website at www.sewisc.org.*

[132] *Southeastern Wisconsin Invasive Species Consortium, Inc.,* Roadside Invasive Plant Management Plan, *2015.*

conveyance systems, and other actions related to agricultural and urban development. These changes have physically, chemically, and hydrologically degraded aquatic habitat.

Aquatic organisms, including fish, mussels, and insects, are essential to maintaining aquatic health by assuring an ecological balance and are also the sources of extensive recreation, especially related to fisheries. To improve upon the health of the aquatic organism communities in the Oak Creek watershed, it will be important to maintain and improve the physical, chemical, and hydrologic aspects of aquatic habitat. As these three aspects of the stream system are improved over time, there will be improved aquatic organism populations and overall health. The recommendations provided in this section are designed to restore the natural functions in the Oak Creek watershed to the extent possible, mitigate the negative impacts of hydrologic modifications, and provide essential habitat for fish and other aquatic organisms.

Implementation of the recommendations set forth in this Chapter such as re-establishing natural surface water hydrology, protecting groundwater recharge areas, protecting and expanding riparian buffer areas, and managing invasive species will have far-reaching functions that improve many dimensions of aquatic habitat including:

- Filtering total suspended solids; nutrients, such as phosphorus and nitrogen; and chemicals, such as fertilizers and pesticides from water entering streams, resulting in reductions in pollutant loading

- Helping to maintain stream baseflows and stream depths and volumes

- Regulating maximum summer water temperatures

- Reducing destructive peak stream flows during heavy rainfall events

- Restoring natural flow patterns such as stream meandering and floodplain inundation, which will provide a variety of crucial instream habitats including pool and riffle structures and new fish spawning habitat

- Promoting conditions favorable to native aquatic and riparian plant species

- Increasing dissolved oxygen concentrations

- Promoting variable substrate composition necessary for various life stages of aquatic organisms

- Providing cover for organisms in the form of overhanging vegetation and coarse woody habitat

- Increasing streambank stability, thus reducing erosion and the resulting downstream sedimentation

In addition to the benefits that can be obtained from the implementation of recommendations from previous sections, the approaches to conserve and protect instream fish and aquatic organism habitat within the Oak Creek watershed includes four main elements which are described in detail in the following sections:

- Restore degraded stream channels and re-establish connections between streams, floodplains, and adjacent wetlands

- Improve instream connectivity by removing or modifying impediments to aquatic organism passage

- Manage coarse woody habitat

- Address excessive streambank erosion

Recommended Actions to Restore Degraded Stream Channels and Re-Establish Connections Between Streams, Floodplains, and Adjacent Wetlands

As described in Chapter 4 of this Report, large stretches of the mainstem of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch have been straightened, deepened, and channelized. The quantity and distribution of pool, riffle, and run habitat units are fundamental metrics upon which overall instream habitat quality can be assessed. Generally, an equal number of pools and riffles is considered optimal for most aquatic organisms. As indicated in Table 4.7, the lack of riffle habitat units in the Lower Oak Creek, Middle Oak Creek, Lower Mitchell Field Drainage Ditch, Lower North Branch Oak Creek, and Upper North Branch Oak Creek assessment areas has led to inadequate pool/riffle ratios (i.e., lack of adequate number and quality of habitats).

1. **It is recommended that the installation of natural channel design elements such as naturalized meanders to restore pool and riffle habitats, grade control, and/or a series of constructed riffle habitats be considered for installation in the stream reaches listed above to provide valuable fish, mussel, and invertebrate habitat.** The ideal number of constructed riffle installations to be

considered should create pool/riffle ratios for an assessment area closer to a 1:1 ratio. Example design elements of these potential natural channel restoration design installations are provided in Figure 6.6 and Figure 6.7. Installation of such natural channel design features could accompany potential floodplain reconnection projects described below.

Over-excavated channels, excavated spoils deposited on streambanks, and channel incision have led to the disconnection of streams from their functional floodplains throughout the Oak Creek watershed. This disconnection has reduced the natural floodplain storage capabilities to disperse flood waters and decrease their destructive energy during high rainfall events, leading to streambank and streambed erosion and further channel incision. This has also disabled the stream system's ability to capture, store, and process sediment and nutrient loads. Furthermore, disconnection of streams from their functional floodplains has contributed to instream conditions that reduce the availability of quality habitat for aquatic organisms. As a result, many stream reaches in the watershed have poor quality aquatic organism communities.

It is estimated that 55, 38, and 41 percent of the total length of Oak Creek, North Branch Oak Creek, and the lower portions of the Mitchell Field Drainage Ditch, respectively, are at least partially disconnected from a functional floodplain (see Map 4.2). In many of these areas, the best way to restore the stream's hydrologic and hydraulic function and associated sediment transport capacity, streambank and stream bed stability, and overall instream habitat quality, is to physically re-establish a stream-floodplain connection, or a functional floodplain to the extent practicable.[133]

There are four attributes that create and sustain fully functioning floodplains, including:[134]

- Connectivity—floodwaters can overtop streambanks and dissipate across land

- Variable flow—occurrence of flows at different magnitudes and at ecologically beneficial times, durations, and frequencies

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[133] *It should be noted that "floodplain," as referred to in this section, is defined as a relatively flat valley floor that can carry and hold flood waters that have overtopped the banks of a stream. The use of the term in this section is not necessarily referencing the regulatory 1-percent-annual-probability (100-year recurrence interval) floodplain boundary.*

[134] *Johnathan Loos and Eileen Shader,* Reconnecting Rivers to Floodplains: Returning Natural Functions to Restore Rivers and Benefit Communities, *American Rivers River Restoration Program, 2016.*

- Spatial Scale—a minimum area of land accessible to inundation to allow occurrence of a full range of biotic and geomorphic processes

- Habitat and structural diversity—uniquely distributed patches of different habitats created over time by flood disturbance, sediment erosion and deposition, turn-over of vegetation, and debris recruitment

The attributes described above build upon one another, each supporting additional functions that together form a fully functional floodplain system (see Figure 6.8). Restoring functioning floodplains to affected stream reaches within the Oak Creek watershed will help regulate peak flows, provide floodwater storage during heavy rain events, reduce pollutant loads entering streams, prevent erosion, provide recreational benefits, and may contribute to groundwater recharge, all of which lead to an improvement in aquatic and terrestrial wildlife habitat. Implementation of actions to improve floodplain functionality, along with vigilant protection of the regulatory floodplain, are anticipated to help decrease the vulnerability to flooding and increase resiliency of the stream network to better withstand heavy rainfall events and protect human residents and wildlife living in the watershed.

2. **Where land use, land ownership, topography and channel conditions, and soil types are conducive to periodic inundation, it is recommended that actions be taken to restore connections between streams and their functional floodplains to include re-establishing the periodic hydrologic connection of streams to adjacent existing wetlands during high flow periods, where applicable.** Restoration of and connection to adjacent areas considered by WDNR to be "potentially restorable wetlands" should also be considered where applicable. High-priority areas for such restorations are shown on Map 6.32. While the areas shown on Map 6.32 include only parcels under public interest ownership, restoration of adjacent private land could be incorporated into potential projects where the landowner is interested and willing to participate in restoration activities.

In areas where excavation spoils from channelization have been piled on banks or where incision has led to further disconnections from the floodplain, excavation and streambank re-grading will likely be necessary to restore hydrologic connectivity to the floodplain and adjacent wetlands. In reaches where the disconnection from the floodplain is not excessive, less invasive actions that do not require excavation should be explored. An example of such an action may include installing a series of channel grade control structures as described above and shown in Figure 6.7. A more natural option would be installing a series of log jams or rootwads to help initiate the process of debris recruitment that backs-up water and makes the floodplain accessible during higher flow volumes.[135] Woody debris accumulation can also increase sediment storage in a stream reach and help to aggrade streambeds making floodplains more accessible to streamflow over time.[136]

Other restoration actions that should be considered as part of restoring a functional floodplain connection include:

- Ensuring restored floodplain areas are managed to support natural ecosystem functions
- Restoring, maintaining, or planting native wetland and/or riparian vegetation
- Managing and removing invasive species[137]
- Disconnecting or dismantling drain tile systems
- Reintroducing beaver or relocating them from areas of the watershed not conducive to their activities to these areas of restored floodplain and wetland

Some stream channels in the watershed that are disconnected from their floodplains are confined by urban development or other land features that make reconnecting to a larger fully functioning floodplain area impractical. Despite this, many of these reaches still contain opportunities to restore some degree of connection to a smaller floodplain terrace or bench to improve floodplain functionality and ecosystem services. Several methods may be used to accomplish this restoration depending on the severity of

[135] *Lanes for aquatic organism passage should be maintained when installing log jams.*

[136] *Any action intended to increase connectivity to the adjacent floodplain must not raise the regulatory floodplain elevation.*

[137] *Strategies for invasive species management from Milwaukee County Parks ecological restoration and management plans should be implemented for those areas of floodplain restoration where plans have been developed.*

floodplain disconnection and other specific characteristics of each individual stream reach.[138, 139] These methods may be used in conjunction with each other and with other stream restoration methods. Examples of these methods include:

- **Bank shaping**—regrading of streambanks to an angle that can sustain vegetation growth and maintain lateral stability and connection to the floodplain or a floodplain bench.

- **Channelization spoil berm removal or breaks**—excavation and removal of soils that were piled on banks during channel straightening or deepening. Often these spoil piles have disconnected the stream from a floodplain that still exists just beyond the berm. Complete removal of the berms is ideal; however, where flooding concerns may prevent complete removal, strategic breaks in the spoil berms may provide connections to floodplain areas where it is appropriate to allow for some floodplain functions.

- **Multi-stage channel design**—excavating one or more flat benches adjacent to the stream at bankfull elevation and installing associated meanders and/or other habitat features designed to accommodate a range of flows while maintaining sediment transport capacity. Multi-stage channel design includes a channel to accommodate and sustain the low flow habitat features, bankfull floodplain benches, and sometimes an inner berm below a bankfull bench. The most common form of multi-stage channel is the two-stage channel, though three- and four-stage channels are options for larger streams and areas where the necessary space is available.

3. **It is recommended that stream channels that are disconnected from their floodplains and that are confined by urban development or other land features be retrofitted with a two-stage channel design where possible. Bank shaping and breaking or removal of spoil berm piles may also be implemented where appropriate to restore and/or improve floodplain functionality.** Priority areas for this retrofitting are shown on Map 6.32. Some of the stream reaches to be considered for two-stage channel design already resemble a two-stage configuration; however,

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[138] *Iowa Department of Natural Resources, "Floodplain Restoration,"* River Restoration Toolbox Practice Guide 4*, April 2018.*

[139] *The recommendations in this section are general and are not meant to be a comprehensive design. Site-specific engineering and landscape design will be necessary for each stream reach chosen for restoration to determine the most appropriate and practical restoration application.*

down-cutting and channel incision have severed hydrologic connections from the stream to a floodplain bench during most conditions except for extreme high flow events. In these reaches, regrading of the streambanks may be sufficient to encourage connection to the floodplain terrace at flows greater than the 1-year to 2-year recurrence interval flood event (roughly equivalent to bankfull discharge).

Two-stage channels are designed based on geomorphic principals. This design incorporates benches that function as floodplains and attempts to restore or create some natural alluvial channel processes. Figure 6.9 shows that the main channel is designed to carry flows ranging from baseflow to bankfull discharge. By limiting the width of this channel, enough flow can be maintained in the channel during low-flow periods to keep nutrient rich sediments moving and prevent sediment deposition and accumulation. The floodplain benches allow space for the stream to flow out of its banks and spread out during heavy runoff events, dissipating the energy and erosive potential of large flows. During heavy runoff events, finer sediments can settle out over the newly created floodplain bench instead of clogging the main channel. The stability of the channel banks are improved because the toe of the cut meets the floodplain bench rather than the channel bottom (see Figure 6.9).

In addition to providing improved drainage functions, two-stage channel design has the potential to create and maintain improved aquatic habitat. The main channel provides greater water depth during low-flow periods. Grasses and other native plantings on the benches can provide cover and shade for the low-flow channel resulting in moderated water temperatures. Substrates within the main channel are improved because the fine sediments can be deposited on the benches during higher flows. This results in a channel bed consisting of coarser materials such as gravel and cobble which provide more favorable spawning areas for fish and necessary habitat for macroinvertebrates. With the right conditions, two-stage channels have also been known to restore the natural meander patterns of streams over time, creating pool habitats that fish use for refuge.

Several factors should be considered when designing and constructing a two-stage channel.[140] These factors include, but are not limited to:

- Priority project areas should be selected based on need. Stream reaches with severe erosion, sedimentation issues, or drainage concerns should be addressed first.

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[140] *National Institute of Food and Agriculture, U.S. Department of Agriculture, National Integrated Water Quality Program, "Selecting and Sizing a Two-Stage Channel System in an Agricultural Landscape," 2011.*

- All utility lines including sewer and water should be identified as part of the project scope, so that such infrastructure will not be impacted or can be moved as appropriate.

- Existing streambed slopes within project areas should be less than 0.5 percent.

- Pre-project surveying and engineering should be conducted for each site to determine the optimal width and elevation of floodplain benches.

- The low-flow channel should remain undisturbed during construction. As much of the existing vegetation as possible should be left adjacent to the stream to provide stability and facilitate the process of narrowing of the stream.

- All existing drain tile outlets and stormwater outfalls within the project site must be located prior to excavation and preserved to the extent possible. Both drain tiles and stormwater outfalls should be retrofitted to empty at the base of the benches, allowing drainage to be filtered through the vegetated benches. Installing a saturated buffer system in combination with a two-stage channel design may increase the effectiveness of nutrient uptake by vegetation.[141] Outfalls should be reinforced with appropriate rock protection to prevent erosion.

- The stability of the two-stage system is highly dependent on the amount and quality of vegetation on the benches. Benches and side slopes should be seeded with long-rooted native grasses as soon as possible after construction. The use of woody vegetation as the dominant vegetation type is discouraged because trees and shrubs tend to shade sunlight needed for grasses to grow and could impede the flow capacity on the second bench.

The headwaters of both Oak Creek and North Branch Oak Creek are experiencing severe channel incision and areas of excessive erosion. Because these reaches have relatively steep channel slopes and flows that are highly dependent on stormwater contributions, typical restoration options to re-establish floodplain connectivity and address severe bed and bank erosion are not optimal solutions to manage their degraded channels. Regenerative stormwater conveyance (RSC) is a relatively new restoration approach that may be

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[141] *Saturated buffers redirect flow from main drainage tile lines through a lateral distribution line into a riparian buffer allowing the water to percolate into the soil and get taken up by vegetation.*

more suitable for restoring the function and habitat quality of these headwater streams that are dominated by stormwater inputs. This approach provides stormwater treatment, infiltration, and conveyance within one system and can be used as an ecosystem restoration practice for eroded and degraded headwater channels in highly urbanized environments and locations where channel slopes make it difficult to implement more traditional practices.[142] A typical RSC approach utilizes a series of shallow pools, riffle grade controls, native vegetation, and underlying sand and woodchip or gravel beds to treat, detain, and convey stormwater flow. The design of an RSC system should be based upon providing safe and stable conveyance of the peak flows generated by the 1-percent-annual probability (100-year recurrence interval) storm. Figure 6.10 provides a profile view and details of two RSC configurations, including alternating pools and riffles, and three pools following a cascade. The top configuration in Figure 6.10 shows a typical profile using alternating pools and riffles. This configuration is generally used when the change in elevation along the path of the proposed RSC system does not exceed 5 percent. If the existing stream slope does exceed 5 percent, then one or more cascades can be designed into the system to provide added stability (see bottom configuration in Figure 6.10). Generally, the required number of grade control structures (riffles or cascades) and pools is equal to the change in elevation that occurs along the path of the RSC system.[143] While fish passage will likely not be possible during lower flows due to the intermittent, or near-intermittent nature of these headwater stream reaches, properly designed and constructed riffle-weirs should control the grade in a manner that allows for fish passage during higher flow volumes.

4. **It is recommended that regenerative stormwater conveyance restoration methods be considered for the Oak Creek headwater stream reach between Glenwood Drive and about 500 feet downstream of Ryan Road;[144] and for North Branch Oak Creek through Copernicus Park from S. 20th street to where the Creek daylights just south of W. Grange Avenue** (see Map 6.33). The RSC design for the Oak Creek headwater reach should investigate the potential to incorporate the four existing concrete drop structures identified in Appendix X as fish passage impediments (see

[142] *West Virginia Department of Environmental Protection, "Chapter 4.2.7 Regenerative Stormwater Conveyance System (RSC)"* West Virginia Stormwater Management & Design Guidance Manual, *November 2012.*

[143] *Hala Flores, P.E., Dennis McMonigle, and Keith Underwood,* Regenerative Step Pool Storm Conveyance (SPSC) Design Guidelines, *Anne Arundel County, Maryland, December 2012.*

[144] *Regenerative stormwater conveyance design features may not be necessary for the full stream length described in this recommendation. The downstream extent required for an RSC project for this reach is unknown and will need to be determined during a more detailed engineering and design phase.*

Table X.1, Figure X.1 and Map 4.14) to provide the additional benefit of improved aquatic organism passage.

Recommended Actions to Remove or Modify Impediments to Aquatic Organism Passage

Fishing, both recreational angling and commercial harvesting, is an important economic activity in Lake Michigan and the Southeastern Wisconsin Region. The maintenance and continuity of species of economic importance and the species on which they depend is largely associated with the protection, restoration, and access to appropriate habitat. To this end, efforts to remove impediments to aquatic organism migration along the mainstem and tributaries of Oak Creek and between Oak Creek and Lake Michigan are critical elements that would be necessary for the improvement of overall instream habitat and the long-term restoration of the fishery and other aquatic communities.

Commission staff conducted fish passage assessments at all accessible stream crossings along the three principal streams in the watershed, including the mainstem of Oak Creek, North Branch Oak Creek, and the Mitchell Field Drainage Ditch downstream of the MMIA property. Findings from these assessments are provided in Appendix X. Assessments along Oak Creek indicated that eight steam crossings were found to be impediments to fish passage and eight other crossings were found to be potential or partial fish passage impediments. Along North Branch Oak Creek, four stream crossings were determined to be fish passage impediments and two other crossings were determined to be potential or partial fish passage impediments. Finally, all the stream crossings assessed along the Mitchell Field Drainage Ditch downstream of the MMIA property were determined to be passable by fish.[145] The location of fish passage impediments observed by Commission staff are shown on Maps 4.14 and 4.14a, and descriptions of these impediments are provided in Table X.1 in Appendix X. The majority of fish passage obstructions were caused by significant elevation drops from the water surface upstream of a structure to the water elevation downstream of a structure, excessive culvert length, limiting water depths typically caused by oversized culverts, undersized culverts, debris or sediment accumulations, and abandoned structures in disrepair (see Figures 4.27 through 4.30 for example photographs of some impairment types).

Several issues should be kept in mind when contemplating or implementing projects to address fish passage impediments. These barriers can vary greatly in their ease of repair. Removal and/or retrofitting of these obstructions should be accompanied by the restoration or re-creation of habitat within the stream and

[145] *Due to accessibility and security issues within the Milwaukee Mitchell International Airport property, no stream crossings were assessed upstream of College Avenue.*

riparian corridor that is essential for resting, rearing, feeding, and spawning of fish and other organisms. Improving access to high-quality habitats will help to restore the biotic integrity of the streams within the Oak Creek watershed. Even ephemeral streams, which only flow seasonally, can provide fish passage and two-way access to spawning and nursery habitat. Designs to improve fish passage through replacement or modification of hydraulic structures are provided in Appendix Y. Ozaukee County's Fish Passage Program is highly developed and is also a good information resource.[146]

To maintain and restore fish and aquatic organism passage throughout the Oak Creek watershed, the following recommendations have been developed:

1. **It is recommended that plans be developed to replace, retrofit, or modify those fish passage impediments identified in Maps 4.14 and 4.14a, accompanied by the restoration or re-creation of habitat within the stream and riparian corridor.** Improvements to aquatic organism passage should be implemented as opportunities such as structure failure, major blockage, or scheduled road, bridge or culvert reconstruction or replacement under municipal capital improvement programs present themselves. A brief synopsis of potential actions to improve fish passage at each assessed crossing is provided in Table X.1 of Appendix X.

2. **It is recommended that fish passage assessments be conducted at all roadway bridges, culverts, and other stream crossings throughout the watershed that were not assessed by Commission staff.** As described above, Commission staff has conducted fish passage assessments on all accessible stream crossings on the three principal streams in the watershed. For those stream crossings that have not been surveyed, it is advised that fish passage assessments be completed on an assessment area basis, with all stream crossings being evaluated within an assessment area before moving onto another assessment area. In doing so, limitations to aquatic organism passage can be evaluated on an assessment area basis indicating where work needs to be done to allow connections to high-quality habitat areas and to the mainstem of Oak Creek. It is recommended that fish passage assessments be completed first for the unassessed (and in some cases unnamed) streams immediately tributary to the mainstem of Oak Creek, followed by the unassessed streams tributary to the North Branch Oak Creek and Mitchell Field Drainage Ditch (see Map 4.14 to determine locations of crossings that were not assessed by Commission staff). Periodic reassessments of the stream crossings of the Oak Creek system should be conducted to review capabilities to maintain

[146] *See website at www.co.ozaukee.wi.us/619/Fish-Passage.*

fish passage, particularly identifying obstructions due to debris accumulation and to identify where actions need to be taken to improve passage.

Larger scale fish passage impediment removals and retrofits require hydrologic and hydraulic modeling, engineering, detailed design, and permitting. It is recommended that each stream crossing culvert considered to be a fish passage impediment be inspected by a qualified engineer to first determine if the structure is safe and remains serviceable. If inspection determines that a structure is at the end of its serviceable life, it is recommended that it be replaced with a structure that is appropriately designed to allow fish passage (see Appendix Y for replacement structure design considerations). If a stream crossing is no longer needed at a particular location, removal of the fish passage barrier is recommended, along with appropriate restoration and reinforcement of the stream banks and bed in the area to prevent erosion and/or head-cutting. If inspection reveals that a structure remains serviceable, modifications or retrofits aimed at allowing aquatic organism passage should be pursued. There are many ways to retrofit passage impediments depending on the cause of the impediment and the unique characteristics of the structure and surrounding environment. Examples of specific methods and/or retrofits to remedy common types of fish passage impediments found in the Oak Creek watershed include:[147]

- For significant elevation drops:
  - Installing grade control structures such as a series of rock cross-vanes or step-pools at appropriate spacing downstream of the elevation drop to produce a backwater effect sufficient to provide a hydraulic connection from the stream to the structure.
  - Installing a rock ramp leading upstream to elevation drop. Generally, rock ramps should create an incline flatter than 1:20 (vertical : horizontal units).
- For culverts with excessive length:
  - Strategically placing appropriately sized boulders or large cobble throughout the inside of the culvert. These substrates should be placed intermittently along each culvert wall throughout

[147] *The methods and considerations provided here do not represent a complete list of options for remedy of the specific fish passage impediments. Each impediment is unique and may require a greater level of survey and professional engineering design than is provided in the scope of this watershed restoration plan.*

the length of the culvert. Added substrates must be appropriately sized so they can withstand peak flow velocities. Note that any added substrates within the culvert must not impact the regulatory flood elevation.

  - Installing downstream grade control structures to produce a backwater effect and reduce flow velocity within the structure. Note that any installation of grade control structures must not impact the regulatory flood elevation.

- For crossings with limiting water depths (typically caused by oversized culverts):

  - Retrofitting a low-flow channel to direct flows during average flow conditions to one cell of a multi-cell culvert and promote sufficient water depths through the culvert, while allowing overflow into additional culvert cells during higher-flow events.

  - Installing downstream grade control structures to produce a backwater effect and providing sufficient depths through the culvert.

- For debris or sediment accumulations adjacent to or within culvert:

  - Regularly monitoring the structure and removing sediment or debris accumulations as they occur (e.g., beaver sometimes use these to create dams).

3. **It is recommended that the estuary area where Oak Creek flows into Lake Michigan be monitored to ensure that sediments do not accumulate to the point of potentially impeding fish migration between the Lake to Oak Creek. Additional opportunities to improve the estuary area with native plant installations and other habitat improvements should be explored.** The decision regarding management of the Mill Pond and dam may also influence the estuary area downstream of the dam. If the decision is made to remove the Mill Pond dam, it is likely that sediment that is typically trapped within the current configuration of the Mill Pond would be transported downstream. This sediment could be deposited and accumulate in the estuary area. This scenario may provide further opportunities to restore the area near Lake Michigan by converting the current backwater characteristics to wetland estuary habitat. Removal of the dam would also increase the need to monitor sediment accumulations and maintain the connection with Lake Michigan.

Efforts to reduce fragmentation within the stream system should follow a three-tiered approach. As shown graphically in Figure 6.11, the components of this strategy, in order of their importance, are:

- Tier 1—Restoring connectivity and habitat quality along the entire mainstem of Oak Creek as well as between the mainstem of Oak Creek and Lake Michigan
- Tier 2—Restoring connectivity and habitat quality between the tributary streams and the mainstem of Oak Creek
- Tier 3—Restoring the connectivity of the mainstem and tributary streams to the highest-quality fish, mussel, and other aquatic organism habitat throughout the Oak Creek watershed[148]

A decision regarding the future of the Mill Pond and Mill Pond dam has not been made at the time of publication of this Report.[149] Should Milwaukee County, as the owner of the dam, decide to maintain the dam in its current form, then the focus of connectivity efforts should be increasing connectivity of the mainstem upstream of the dam as well as restoring connectivity to areas described in Tier 2 and Tier 3. Alternatively, should it be decided to remove or modify the Mill Pond dam, the planning for and implementation of the removal or modification of the dam could take considerable time. During the interim, programs to improve the free movement of aquatic organisms in the watershed should similarly focus on improving connectivity of the mainstem upstream of the dam as well as implementing Tier 2 and Tier 3 projects.

Within this three-tier framework, opportunities will arise that should be acted upon. For example, even though this strategy implies a principle that activities should generally progress from downstream to upstream, the completion of an action in a headwater area or on a tributary stream should not be passed up or ignored simply because it does not conform to this principle. Rather, all opportunities should be acted upon as they become available. Where multiple opportunities exist and limited funds are available, this strategic framework for in-stream reconnection is intended to assist decision-makers in allocating resources where they would be most appropriate and effective in achieving the goals of this restoration plan.

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[148] *Tier-3 is a "catch all" intended to encourage flexibility for communities and stakeholders to take advantage of opportunities throughout the watershed that may arise independently of the primary strategy of restoring linkages along the mainstem and tributary streams and ultimately with Lake Michigan.*

[149] *Alternatives for the management of the Mill Pond and dam will be discussed in detail later in this Chapter.*

The Tier 1 prioritization is based upon the understanding that Lake Michigan is the most diverse resource and greatest asset available to the watershed for the maintenance of high-quality recreation as well as a sustainable fishery. Lake Michigan acts as a source of aquatic organisms to tributary streams such as Oak Creek. As described in Chapter 4, the most diverse fishery in the Oak Creek watershed is the roughly one-mile reach downstream of the Mill Pond dam. This is the only reach of the stream system in the watershed that is connected to Lake Michigan. Thus, the Mill Pond dam separates most of Oak Creek from achieving its full fisheries potential by severing its connection to Lake Michigan. This prioritization is also based upon the understanding that within stream systems the widest and deepest downstream areas are generally associated with a greater abundance and diversity of fishes than the narrower and shallower upstream areas.[150] Therefore, the highest priority, or Tier 1 approach focuses on restoring continuity of passage and habitat restoration for native fishes on the mainstem of Oak Creek from its mouth at Lake Michigan to its headwaters as shown in Figure 6.11.

The Tier 2 prioritization is based upon the understanding that, through their connection with the mainstem of Oak Creek, the tributaries are the next most diverse resources and greatest assets that have the potential to restore and maintain a sustainable fishery. Many fish species need access to a variety of habitats during their life cycles. For a fish to successfully progress from egg to adult, it must be able to get to each of these habitats at the appropriate life cycle stage. The connection of tributary streams to the associated mainstem provides access to feeding, spawning, and rearing sites as well as to refuges for organisms during periods of thermal stress and low-water and thus has greater potential to increase fish abundance and diversity in the stream system. Therefore, the second-tier approach focuses on addressing fish passage continuity and habitat quality from the tributary streams to the mainstem of Oak Creek. An example of a high-priority fish passage barrier that would be considered under Tier 2 prioritization is the Canadian Pacific Railway culvert on North Branch Oak Creek that is about 0.1 mile upstream of the confluence with the mainstem of Oak Creek (see structure number 65 on Map 4.14 and Figure 4.27). This obstruction completely disconnects the North Branch from the mainstem, preventing free movement of fish from between the majority of the North Branch Oak Creek and the mainstem, thus reducing fish access to a variety of habitats. The Tier 2 prioritization component is illustrated graphically in Figure 6.11.

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[150] *I.J. Schlosser, "A Conceptual Framework for Fish Communities in Small Warmwater Streams," pages 17-24 in W.J. Matthews and D.C. Heins (editors),* Community and Evolutionary Ecology of North America Stream Fishes, *University of Oklahoma Press, 1987.*

The Tier 3 approach focuses on improving fish passage to the best habitat quality throughout the entire watershed whenever opportunities are presented. Prioritization of projects to improve the fishery quality should be based upon areas where fish passage impediments have been identified to be a problem and where improvement in ecosystem structure and function can be attained by removing these barriers. Factors to be considered in prioritizing Tier 3 projects include improving connections to one or more tributaries, increasing the length of stream between passage impediments, and improving connections to high-quality habitat areas. It is anticipated that new development or redevelopment may provide opportunities for interventions that do not conform to the first and second tier approaches. These opportunities should not be ignored; rather, where there are opportunities to enhance passage of fish and aquatic organism and/or to improve instream habitat, and where funds can be obtained, it is recommended that actions be taken to implement those opportunities.

Recommended Actions to Manage Coarse Woody Habitat

Branches, tree limbs, root wads, and entire trees that fall into, and collect along streams are commonly referred to as coarse woody habitat (CWH). CWH plays a vital role in the hydraulic, geomorphic, and biological functions of the streams and floodplains within the Oak Creek watershed. CWH helps control the shape of the channel and provides cover, shelter, resting areas, and feeding opportunities for aquatic organisms. In addition, the interaction between CWH, water, and sediment has a significant effect on channel form and process, increasing geomorphic complexity and the quality of aquatic habitat.[151] In most cases, removal of CWH can be detrimental to fish and other aquatic habitats downstream. For these reasons, **it is recommended that removal of CWH from the streams within the Oak Creek watershed should be discouraged. It is recognized that this will need to be balanced with reasonable removal efforts that are required to maintain safety, reduce the risk of property damage from flooding, and maintain aquatic organism passage.**

In some cases, excessive amounts of coarse wood can accumulate and form massive jams that span the entire width of the stream and extend completely to the bed of the channel. These debris jams can persist for decades. In these extreme instances, large woody debris jams can act as impediments to fish passage. There were 37 such large woody debris jams observed by Commission staff that had the potential to impede fish movement to some degree, as detailed in Chapter 4 (see Map 4.14a). The following recommendations have been developed for the management of large woody debris jams in the Oak Creek watershed:

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[151] *C.J. Brummer, T.B. Abbe, J.R. Sampson, and D.R. Montgomery, "Influence of Vertical Channel Change Associated with Wood Accumulations on Delineating Channel Migration Zones,"* Geomorphology, *Volume 80, pages 298-309, 2006.*

1. **It is recommended that assessments be conducted of all major woody debris jams within the Oak Creek watershed shown on Map 4.14a to determine if they act as barriers to fish passage.** While assessments are most likely to occur during low-flow periods, it is necessary to evaluate whether the coarse woody debris would be submerged during high-flow periods, allowing for fish passage. It is also important to examine whether the jam extends completely to the channel bed. Some accumulations of coarse wood will raft upwards when sufficient stream flows are present allowing for passage of aquatic organisms under or through the jam even though the jam appears to completely block the channel when observed from above the water surface. Woody debris accumulations fitting this description should not be altered unless it is apparent that they are creating other hazards.

2. **It is recommended that selective removal of small sections of woody debris be conducted on those large debris jams that are found to be complete fish passage barriers.** Removing only small sections of the debris jams will provide adequate fish passage without sacrificing the benefits associated with having CWH in the stream.

3. In addition to the large woody debris jams that were observed to potentially impede fish migration, Commission staff observed numerous minor accumulations of CWH. The locations of these accumulations are shown on Maps S.13 through S.35 in Appendix S. **It is recommended that periodic surveys be conducted to reassess the accumulation of CWH. While CWH accumulations can often move downstream, the locations of CWH shown on Maps S.13 through S.35 would be a good starting point for these surveys.**

Most of the bridges on the lower reaches of the mainstem of Oak Creek appear to be capable of passing wood transported downstream by the Creek. However, roadway culverts are more vulnerable to accumulations of large woody debris. Commission staff have observed several roadway culverts on the mainstem of Oak Creek and tributary streams that were occasionally blocked by large woody debris accumulations. These accumulations act to impede flow and have the potential to promote bank erosion, bed scour, and localized roadway flooding. It should be noted that the public works departments of the municipalities in the watershed appear to be responsive in clearing these blockages.

4. **It is recommended that roadway bridges and culverts continue to be periodically examined and that any large woody debris accumulations or blockages that are found at these sites be removed.**

Emerald Ash Borer infestations have caused and continue to cause substantial mortality of ash trees within the riparian corridors adjacent to Oak Creek and other streams in the watershed. As these trees continue to die, the amount of woody debris entering the streams of the Oak Creek watershed will increase. To reduce the likelihood of excessive large woody debris jams in the streams, this plan recommends the following:

5. **It is recommended that periodic thinning of deceased ash trees be carried out within riparian lands located adjacent to Oak Creek and other tributary streams in the watershed. For the purpose of this recommendation, priority should be given to those areas nearest to stream channels or floodplains that may carry fallen trees in flood waters. A selective number of dead snags should be left for cavity roosting and/or nesting wildlife; however, these should be chosen in areas that are not likely to carry flood flows. Recommended guidelines for reforestation of areas impacted by emerald ash borer can be found in the section related to restoring riparian buffers.**

Beaver activity and beaver dams were observed within the channels and corridors of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch. Beaver dams have the potential to limit fish passage and cause flooding of infrastructure. Therefore, it is important to continue to monitor beaver activity and act where appropriate. Those efforts should be focused on areas where there are nearby culverts and bridges where roadways and other structures may become threatened with flooding due to the presence of a beaver dam. Because the removal of beaver dams is a complicated and controversial issue, decisions to remove beaver dams should be addressed on a case-by-case basis.

Recommended Actions to Address Streambank and Streambed Erosion

The energy of flowing water in a stream is dissipated along the stream length by slope (meandering channels decrease slope by increasing channel length), turbulence, streambank and bed erosion, and sediment resuspension. A significant amount of the Oak Creek mainstem and tributaries have been straightened or ditched, removing the meandering channel lengths and directly increasing slope and scouring energy of the flowing water, thus leading to increased bed and bank erosion and loss of instream habitat. In addition, increases in the amount of urban development and land alterations associated with earlier agricultural land uses in the watershed may be expected to result in increases in stream flow rates and discharge volumes that result in an increased potential for streambank and streambed erosion. Excessive streambank and streambed erosion destroys aquatic habitat, spawning areas, and feeding areas; contributes to downstream water quality degradation by releasing large amounts of sediment to the water; and provides material for subsequent sedimentation downstream. This sedimentation buries valuable benthic habitats and contributes to the sediment accumulations in the Mill Pond. In addition, streambank erosion at some locations may threaten vital infrastructure.

The instream survey conducted by Commission staff identified and assessed streambank erosion sites along the Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch. The findings of this survey are described in detail in Chapter 4. In order to evaluate their impact on water quality, erosion sites were modeled using the USEPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) to estimate pollutant loads entering the streams based on measurements of length, height, and estimated lateral recession rates of each erosion site. Estimated load reductions that would result from remedying each inventoried erosion site are provided in Appendix Z. It is important to note that minor streambank erosion is a normal occurrence in any stream system and should be expected.

Capital costs for individual recommended streambank stabilization projects within the Oak Creek watershed are estimated in Table 6.1 and were developed based on year 2019 unit construction costs. These estimates were based on an assumed typical stabilization approach, and include engineering, permitting, mobilization, regrading and revegetating banks, rock toe stabilization, inspection, and other contingency costs. The costs of projects may vary because there are many state-of-the-art methods that can be used to address issues related to streambank stability as alternatives to the standard approach that was assumed for cost-estimating purposes. Some of these methods are listed in Table 6.14. In addition, it is envisioned that many streambank erosion sites could be stabilized as part of recommended floodplain reconnection and/or remeandering projects. This would allow these projects to address multiple objectives. Each streambank erosion site should be evaluated on an individual basis to determine the most effective method based on specific site characteristics as well as environmental and economic factors.

Based on the results of the surveys conducted in the Oak Creek watershed, this plan makes the following recommendations regarding streambank erosion:

1. **It is recommended that the actively eroding streambanks identified in Table 6.1 and on Maps S.13 through S.35 be stabilized as opportunities arise. Priority should be given to those erosion sites listed in Table 6.15.**

- For each streambank erosion site there are many unique factors that determine the most appropriate method to use for stabilization including the extent of erosion; stream dynamics; adjacent land use; soils; topography; and proximity to private property, structures, trees, utilities, and other infrastructure. Individual site assessments and proper pre-project engineering should be performed to determine the most appropriate approach. These assessments should take both environmental considerations and the cost effectiveness of the remediation methods into account (see Table 6.14 for examples of streambank stabilization methods). In all cases it is recommended that revegetation of the banks using bioengineering techniques be employed as part of the stabilization method, to the extent possible. State and/or municipal permits may be required prior to beginning construction activities. It may be prudent to meet with regulatory agencies prior to applying for permits to identify and avoid any potential problems in the permitting process.

2. **It is recommended that the design and implementation of the streambank stabilization projects ensure that the stream is reconnected to its floodplain whenever practicable.**

3. **It is recommended that assessments be conducted periodically following completion of streambank stabilization projects to evaluate the condition and functioning of the stabilization project. Routine maintenance at stabilization projects to sustain the functionality will also be necessary and may include:**

- Removing dead or damaged trees

- Repair and/or replace damaged stabilization material as needed

- Remove invasive plants and prune and selectively cut other vegetation as appropriate to reduce shade canopy to allow for plant establishment

- Treat plants if infested by insects or disease

4. **It is recommended that streambank stability surveys be conducted on streams in the watershed that have not been assessed for this plan.**

Damaged or Failed Outfalls

Commission staff inventoried the location and attributes of outfalls that were observed as part of instream surveys conducted in 2016 and 2017.[152] Data collected included the pipe size, material composition of the outfall, and an assessment of the general condition of each outfall. During the survey, Commission staff observed 136 outfalls discharging into or near surveyed portions of Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch. There were 43 outfalls that were determined to be in poor or failed condition. Many of these outfalls were damaged as the result of streambank or streambed erosion. A summary of the inventory is provided in Table 4.6 and the complete inventory, including mapped locations, outfall attributes, and photos are provided in Appendix O.

It is recommended that outfalls assessed to be in poor or failing condition as identified in Table O.1 in Appendix O be confirmed as active and if so, replaced, repaired, or retrofitted as opportunities arise. Specific outfalls that are recommended to be remedied are also listed in Table 6.1. Methods to remedy damaged outfalls may vary significantly based on the status of the stormwater system connection to the outfall, extent of adjacent bed and bank erosion, length of damaged pipe, elevation and location of the remaining pipe sections, and site-specific conditions. Some repairs may be as simple as removing disconnected pipe and/or end sections from the site and reinforcing the remaining outfall pipe with riprap protection. Other repairs may require extensive excavation, streambank regrading, and installation of new pipe and end sections. All repaired outfalls should be reinforced with appropriate rock protection to prevent erosion. When site conditions allow, retrofit designs should be considered that allow the stormwater to filter through a vegetated buffer before entering the streams, thus providing the opportunity for pollutant removal.

In addition to the outfalls that were observed by Commission staff, all other known inventories of stormwater outfalls were analyzed and integrated into a master inventory (see Chapter 4 for more details of the inventories that were analyzed). Appendix O provides the location and attributes for 163 outfalls in addition to those that were observed by Commission staff as part of their instream surveys. These outfalls were not assessed for condition. **It is recommended that surveys of these outfalls be conducted to confirm their locations and whether they are still active. Surveys should also assess the condition of the outfalls and record the outfall dimensions and construction materials. It is further recommended that outfalls found to be in poor or failing condition be replaced, repaired, or retrofitted as opportunities arise.** Coordinates for each outfall are provided in Appendix O.

[152] *Not all outfalls encountered during the instream survey could be confirmed as stormwater outfalls.*

Recommended Actions to Reduce or Mitigate the Negative Physical, Chemical, and Biological Impacts on Aquatic and Terrestrial Ecosystems that are Associated with Climate Change

The changes in climate in southeast Wisconsin and the Oak Creek watershed that have occurred over the last half century and the changes that are projected to occur through the 21st century are discussed in Chapter 3 of this Report. Climate directly affects water resources and changing climatic conditions can be drivers of changes in water quantity. water quality, and aquatic and terrestrial habitat. Climate change will not be solved at the watershed scale; however, there are actions that can be implemented to mitigate the negative physical, chemical, and biological impacts that climate change can have on the Oak Creek system while at the same time improve the resiliency of the communities within the watershed to the impacts of climate change. Climate change stressors are often difficult to differentiate from, and can often intensify the impacts of, other anthropogenic stressors such as land use changes, hydrologic modifications, invasive species impacts, and loss of riparian buffers.[153] Fortunately, many actions taken to lessen other anthropogenic stressors are also likely to reduce climate change impacts and protect and sustain aquatic organisms. The following paragraphs describe adaptation strategies and restoration actions that, if implemented, would promote resistance to and build ecological resilience to the impacts of climate change in the Oak Creek watershed.

Climate models predict that there will be an increase in annual precipitation as well as an increase in the frequency of intense rainfall events. These changes are likely to have impacts on both the built and natural environments within the Oak Creek watershed. More intense storms may overwhelm under-designed stormwater infrastructure and lead to increased flooding. This indicates that there will be a need for greater investments in both gray and green stormwater infrastructure and continued assessments of the effectiveness of best management practices based on the evolving projections of climate change impacts. In addition, higher peak flows in the streams of the watershed are likely to result in more severe channel incision and streambank erosion, increased amounts of nutrients and other pollutants entering the streams, and diminished instream habitat. To mitigate these effects, **it is recommended that actions be implemented to restore or simulate natural processes that increase the capacity of the watershed to slow down, detain, and treat runoff; reduce the destructive power of peak stream flows; maintain shallow groundwater levels; and protect vital infrastructure from flooding**.

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[153] *Abigail J. Lynch, and others, "Climate Change Effects of North American Inland Fish Populations and Assemblages,"* Fisheries*, Volume 41(7), July 2016.*

Efforts related to providing natural flood water storage through the preservation and restoration of floodplains and wetland areas in the watershed will be vital. Considering projections for an increased frequency of intense rainstorms in the watershed, it may be reasonable to plan for flooding impacts beyond the 1-percent-annual-probability (100-year recurrence interval) floodplain boundary that has typically been used in the past to plan for extreme flooding events. For example, protecting areas beyond the 1-percent-annual-probability (100-year recurrence interval) floodplain to the 0.2-percent-annual-probability (500-year recurrence interval) boundary or greater, where still practicable, would help to provide a greater level of protection from extreme rainfall events that are projected to increase in frequency. Communities within the watershed should consider changes to how they regulate the floodplain boundaries within their jurisdictions. This may include strengthening of floodplain ordinances and their enforcement. This could also include a reassessment and potential expansion of planned Primary Environmental Corridor areas which would provide additional leverage for communities to limit future development and provide protection in areas that may be more prone to flooding in the future. The following levels of stream flooding protections may provide a guide for communities to plan for increased resiliency considering projected climate change impacts[154]:

- *Highest level of protection for climate resiliency*: Regulate the 0.2-percent-annual-probability (500-year recurrence interval) floodplain boundaries with the same restrictions on development and redevelopment that are currently established for the regulatory floodway boundaries (i.e., no new development or compensatory filling allowed)

- *High level of protection for climate resiliency*: Regulate the 1-percent-annual-probability (100-year recurrence interval) floodfringe areas with the same restrictions on development and redevelopment as are currently established for the regulatory floodway boundaries

- *Moderate level of protection for climate resiliency*: Prohibit new structures or compensatory filling in the 1-percent-annual-probability (100-year recurrence interval) floodplain boundaries

- *Low level of protection for climate resiliency*: Continue current floodplain regulations

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[154] *In addition to the added resiliency of communities and the built environment, these additional protections of critical habitat areas would also alleviate the impact of projected increased drought conditions and offset the potential warming of surface waters that would likely result from projected climate change impacts.*

The Governor's Task Force on Climate Change emphasized the need to prioritize wetland and floodplain restoration to ultimately improve the capacity of watersheds across the State to handle the increased intensity and frequency of precipitation and to maintain baseflow and shallow groundwater supply during periods of drought.[155] By preventing the loss of remaining wetlands and by restoring wetlands that were previously converted to agricultural uses, the capacity for adapting to more intense rainfall events will increase. Other specific measures that can be taken to mitigate the impacts of climate change on aquatic and terrestrial systems in the watershed can be achieved by implementing recommendations related to other problems and issues facing the watershed. These can be found in the following sections:

- Recommendations to reduce stormwater runoff pollution
- Recommendations to reduce runoff velocity and increase infiltration
- Recommendations to protect areas of groundwater recharge
- Recommendations to protect, restore, expand, and connect riparian buffer areas
- Recommendations to protect, preserve, and restore environmentally sensitive areas
- Recommendations to re-establish connections between stream channels, floodplains, and adjacent wetlands
- Recommendations to address streambank and streambed erosion

While the annual number of intense rainfall events are expected to increase, models project that there will be little change in total summertime precipitation. This implies that there will be longer stretches of dry weather that could potentially lead to drought conditions. These periods of dry weather could lead to decreased summertime baseflows in the streams of the watershed, and when combined with warmer projected air temperatures, are likely to produce increased water temperatures. As discussed in detail in Chapter 4 of this Report, the USGS "FishVis" decision support tool can display modeled projections of changes in stream temperature, streamflow, and fish species occurrence throughout the 21st century. The model predicted that stream temperatures within the Oak Creek watershed will increase by up to 3.6°F,

[155] *Governor's Task Force on Climate Change Report, State of Wisconsin, December 2020.*

significantly reducing the extent of streams that will be suitable for cool water fish species that currently occur in the watershed. While streams in the Oak Creek watershed becoming unsuitable for cool water fish species is not an inevitable result, it is a likely scenario. This indicates that streams in the watershed are sensitive to changing air and water temperatures, precipitation patterns, and groundwater discharge and will likely require measures to reduce long-term warming in order to preserve the species currently residing in them. Therefore, **it is recommended that actions be implemented to promote stream shading, increase stormwater infiltration volumes, maintain or increase the processes that allow for direct groundwater discharge to streams, and increase and improve access to cool water habitat and refuge areas.** This can be achieved by implementing recommendations related to other problems and issues facing the watershed. These can be found in the following sections:

- Recommendations to reduce stormwater runoff pollution
- Recommendations to reduce runoff velocity and increase infiltration
- Recommendations to protect areas of groundwater recharge
- Recommendations to protect, restore, expand, and connect riparian buffer areas
- Recommendations to protect, preserve, and restore environmentally sensitive areas
- Recommendations to control and manage invasive and nonnative species
- Recommendations to restore degraded stream channels and re-establish connections between stream channels, floodplains, and adjacent wetlands
- Recommendations to remove or modify impediments to aquatic organism passage
- Recommendations to manage coarse woody habitat

Climate change impacts are likely to alter the physical conditions of both streams and riparian areas, potentially affecting the suitability of these habitats for plant and animal species and potentially making them better suited for the establishment of invasive species. Therefore, **it is recommended that existing programs to monitor and manage invasive species and to restrict their spread be continued. In**

addition, response plans should be developed for addressing new areas of infestations as they occur and for addressing newly occurring invasive species when they are found in the watershed (see the section above on recommendations to control and manage invasive and nonnative species).

Recommended Actions to Reduce Trash and Debris Within the Stream Channels and Riparian Areas
Accumulations of trash and debris in the streams and riparian corridors of the Oak Creek watershed degrade the aesthetics of the stream system. Unsightly accumulations of trash can give the public a negative impression of this natural resource and of its potential for restoration or its value as a recreational asset. Trash can also cause physical and/or chemical (toxic) damage to aquatic and terrestrial wildlife and can accumulate to such an extent that it may limit the passage of aquatic organisms. Commission staff recorded and mapped the large trash and debris items that were observed during instream surveys on Oak Creek, North Branch Oak Creek, and Mitchell Field Drainage Ditch. The findings are summarized in Table 4.1 and locations are shown on Maps S.13 through S.35 in Appendix S.

Many of the watershed communities and watershed groups such as Friends of the Mill Pond and Oak Creek Watercourse, Inc. organize and/or participate in annual community cleanup events usually focused around Earth Day celebrations. **It is recommended that these community-oriented cleanup days be continued and expanded.** River cleanup days are one way of organizing and building energy for the common goal of improving the quality of the natural resources that add so much value to the community**. It is recommended that Milwaukee County, municipalities, and non-profit groups plan and organize annual or semi-annual stream cleanup days to remove trash items from streams and riparian areas of the Oak Creek watershed, utilizing community volunteers and partner organizations.** All the trash items identified on Maps S.13 through S.35 in Appendix S should be removed to improve the aesthetics, water quality, wildlife habitat, and recreational experience of the Oak Creek watershed. Coordinates and/or GIS shapefiles of locations of trash items inventoried by Commission staff are available to volunteer groups by request. In planning the Oak Creek watershed cleanup days, it may be prudent to focus cleanup efforts on areas with a particularly high concentration of trash items. Another strategy could be to focus efforts on an assessment area basis with the volunteers concentrating on a particular assessment area for each planned event. By doing so, the inventory of trash items can be updated, and progress can be more easily documented. **It is further recommended that surveys of streams for large trash and debris within the watershed that were not surveyed by Commission staff be conducted. Periodic reassessment and geolocation of large trash items along the streams of the watershed should be conducted to measure progress and to provide targeted areas for future cleanup efforts.**

In addition to removing trash items that have already been deposited in the streams and riparian areas, efforts to reduce the amount of new trash entering these areas should be increased. Considering the large amount of Milwaukee County and municipal parklands adjacent to Oak Creek and its main tributaries **this plan recommends that Milwaukee County and the watershed municipalities place and maintain additional trash receptacles along trails and parkways and in parks.** Placement of receptacles should be concentrated on the Oak Leaf Trail system near crossings of major roads, at the entrances of soft trails and paths, throughout municipal parks, and in areas where people tend to congregate such as popular fishing locations.

Unfortunately, the cost to dispose of large items such as automobile tires, furniture, mattresses, electronics, and appliances may contribute to these items being illegally dumped into steams and riparian areas of the watershed. To help discourage such illegal dumping, **it is recommended that municipalities within the watershed hold free large trash pick-up days multiple times each year**. These days should be scheduled in advance and should be well advertised on municipal websites and newsletters and distributed on trash pickup schedules. On these days, residents should be permitted to place large items on the curb or near their typical trash pickup area that are prohibited from routine trash collections. Scheduling neighborhood fall and spring cleanup days may be good times to initiate neighborhood cleanups and helpful in increasing word of mouth around the community of the large trash collection opportunities. Several watershed municipalities already hold similar large item pickup days. It is recommended that these efforts be continued, advertised, and expanded as necessary.

Electronics often contain hazardous materials such as lead and mercury that can harm human health and pollute the environment if not properly managed. For this reason, many electronic items are required by Wisconsin's electronic recycling laws to be specially recycled for disposal. **It is recommended that watershed municipalities focus efforts on publicizing electronic recycling options for their residents.** Beyond municipal electronic recycling options, "E-Cycle Wisconsin" is a State-wide manufacturer-funded program that recycles common electronics found in homes and schools. The E-Cycle Wisconsin program has a website that provides information on which electronics should be recycled; locations where electronics can be dropped off for a small fee; information for collectors; and outreach resources that local governments, retailers, recyclers, and others can use to educate their residents and customers about recycling electronics.[156]

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[156] *More information related to the E-Cycle Wisconsin program can be found at www.dnr.wisconsin.gov/topic/Ecycle.*

Similarly, improper disposal of household hazardous wastes can introduce pollutants into the environment, leading to contamination of surface waters and groundwater. MMSD has collection programs for such hazardous household items. **It is recommended that MMSD's collection programs for household hazardous wastes be continued and supported.[157] It is further recommended that watershed municipalities continue or expand efforts to publicize hazardous waste disposal programs available to their residents.**

Improving the aesthetics along the stream corridors of the watershed, including removing and preventing trash and litter within these areas, can potentially strengthen the personal investment and connection that each person that lives or visits the Oak Creek watershed has in maintaining and restoring these valuable natural resources.

6.4 RECOMMENDED ACTIONS TO IMPROVE RECREATIONAL OPPORTUNITIES

This section presents recommendations to maintain and enhance the recreational use of and access to the surface water system and riparian areas within and surrounding the Oak Creek watershed. These include recommendations related to parks and parkways, recreational trails, fishing access to surface water, Americans with Disabilities Act (ADA) guidelines for recreational accessibility, and land acquisition for recreational use.[158]

Recommended Actions Related to Parks and Parkways

Parks and parkways encompass and protect many of the natural resources associated with the rivers and streams throughout the Region. These pockets of natural resources contain woodlands and wetlands, wildlife habitat, scenic landscapes, and provide outdoor recreation opportunities for residents within the Region. Actions to preserve, maintain, and expand parks and parkways will both preserve these natural resources and assure that residents are provided with opportunities to participate in a wide variety of outdoor recreational activities.[159] These actions also preserve the Region's cultural heritage and protect and

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[157] *More information related to MMSD's hazardous waste collection programs can be found at www.mmsd.com/what-you-can-do/home-haz-mat-collection.*

[158] *Due to insufficient water depths, most of Oak Creek and its tributaries are not suitable for recreational canoeing, kayaking, or swimming; therefore, activities related to surface waters are primarily focused on the improvement and enhancement of recreational fishing and fishing access.*

[159] *SEWRPC Community Assistance Planning Report No. 132,* A Park and Open Space Plan for Milwaukee County, *1991.*

enhance the quality of the environment. As such, the following recommendations should be considered for the Oak Creek Watershed Restoration Plan.

It is recommended that Milwaukee County and municipalities within the watershed continue to maintain and improve their parks and parkway systems within the Oak Creek watershed, including their trail facilities for biking and hiking, stream access, picnic areas, and areas for passive recreation such as wildlife viewing.

Map 6.34 shows the parks and parkway sites in the watershed that are located adjacent to Oak Creek and its tributaries. Because these sites are directly associated with the major surface waters within the watershed, the protection of these areas can benefit the water quality, instream and terrestrial habitat, as well as enhance the experience of outdoor recreation along Oak Creek mainstem and its tributaries for park users. Examples of park and parkway activities that will enhance the stream and recreational use include maintaining or installing streambank stabilization measures, the installation and maintenance of riparian buffer along the Creek and its tributaries and installing educational and informational signage to enhance the public's understanding of the natural resources within the park or parkway. Cost for installing an informational plaque can vary depending on size, material, and manufacturer.

It is recommended Milwaukee County and watershed municipalities continue its efforts to manage Emerald Ash Borer infestation in its parks and natural areas. As discussed in Chapter 4, emerald ash borer has caused considerable mortality of ash trees in floodplain forests and riparian areas of the Oak Creek watershed, including many areas in the Oak Creek Parkway. Emerald ash borer prevention and management should be considered to improve and enhance trail and stream access, wildlife habitat, and maintain public safety. Such actions will prevent dead and dying trees from damaging parks and trails and injuring people. Other recommendations for addressing the impacts of emerald ash borer are discussed in the sections on recommendations to improve habitat in this chapter.

Land Acquisition Considerations for Recreational Facilities

It is the intent of this plan that all land acquisitions occur on a willing-seller, willing-buyer basis and that landowners receive fair market value for their property. Transactions funded with WDNR grants should follow the WDNR acquisition procedures, which include an appraisal by the WDNR. The recommended acquisition may also occur through land subdivision dedication as well as through donation of fee simple title or of conservation easements. Donations may yield income-tax advantages to those who donate.

Although each conservation easement is unique, some examples of land rights purchased by state or local agencies include the right to improve streams, fence livestock out of the stream corridor, permit public access and prohibit development. In addition, a conservation easement will also help protect water quality, habitat, and natural resources.[160] Where a conservation easement is utilized, the landowner retains title to the property; the easement typically prevents mowing or other disturbance of the area by the owner; provides access for site management purposes, such as the removal of woody vegetation which may shade out desired plant species; and removal of other nuisance vegetation. **It is recommended that the County or municipalities continue to pursue opportunities for acquisition of lands that would enhance the natural resources and recreational opportunities within the Oak Creek watershed.** Lands that should be considered for acquisition are identified in Milwaukee County Parks ecological restoration and management plans for areas adjacent to County parks within the watershed.[161] In addition, MMSD's conservation plan[162] and SEWRPC's greenway connection plan[163] have identified lands within MMSD's service area that should be targeted for voluntary acquisitions and preserved in order to retain floodwater retention benefits as well as to improve water quality and wildlife habitat conditions. Some properties identified by these plans within the Oak Creek watershed have already been purchased through MMSD's Greenseams program (see Map 4.46). Where applicable, these properties may provide recreational opportunities for people living in the Region including hiking, bird watching, and other passive recreation.

Recommended Actions Related to Trails

As described in Chapter 5 of this report, a primary objective and goal for recreational use and access is the continued development and improvement of trails and recreational corridors within and adjacent to the Oak Creek watershed, including an expansion of an interconnected trail system that provides connections to local, county, and regional trail systems. The Oak Leaf Trail is over 125 miles of mostly paved asphalt trail that loops around Milwaukee County with connectors along the parkway drives and municipal streets. Map

[160] *dnr.wisconsin.gov/topic/fl/RealEstate/easements.*

[161] *Milwaukee County Parks,* Barloga Woods Ecological Restoration & Management Plan 2016-2025, *2018; Milwaukee County Parks,* Cudahy Nature Preserve Ecological Restoration & Management Plan 2018-2027, *2018; Milwaukee County Parks,* Falk Park Ecological Restoration & Management Plan 2016-2025, *2017; Milwaukee County Parks,* Oak Creek Parkway Ecological Restoration & Management Plan, *2019; Milwaukee County Parks,* Rawson Woods Ecological Restoration & Management Plan 2017-2026, *2017.*

[162] *The Conservation Fund, et al.,* Conservation Plan for the Milwaukee Metropolitan Sewerage District, *October 2001.*

[163] *SEWRPC Memorandum Report No. 152,* A Greenway Connection Plan for the Milwaukee Metropolitan Sewerage District, *December 2002.*

6.35 shows the extent of the existing Oak Leaf and Forked Aster trail systems in and around the watershed. All sections of the Oak Leaf Trail within the watershed are connected to one another. Furthermore, the Oak Leaf Trail within the Oak Creek watershed is connected to the Oak Leaf Trail's Root River Line to the west through the Drexel Connector and to the south through the Oak Leaf Line. It is also connected to the Oak Leaf Trial along Lake Michigan at two points through the South Shore Line. The following recommendations are intended to promote the development of a more highly interconnected trail system within the watershed and one that is better connected to trails outside of the watershed. The recommended additions to the trail system are shown on Map 6.35. Note, the locations of proposed recreational corridor trails shown on the map are general in nature and are subject to refinement based on detailed facility planning and negotiations with landowners to purchase land for the trails.

It is recommended that Milwaukee County and municipalities within the watershed continue to maintain and improve their recreational trail systems. With the increased use of recreational trails, it is important that these systems be maintained and improved for the safety and continued use by the public. Furthermore, this recommendation can help increase the public's opportunities for exercise and outdoor recreation, leading to improvement in human health and community attention to the surface waters and natural resources within the watershed.

It is recommended that Milwaukee County expand its Oak Leaf Trail system within the Oak Creek watershed by adding 5.7 miles of additional trails. The expansions are numbered and shown on Map 6.35. **The recommended expansions include:**[164]

1. **Extending the Oak Leaf Trail along the mainstem of Oak Creek from its current terminus at E. Puetz Road to where another section begins west of S. Nicholson Road (0.65 miles)**

2. **Extending the Oak Leaf Trail to the southeast from the beginning of the section west of S. Nicholson Road to the existing Oak Leaf Trail at E. Ryan Road (0.80 miles)**

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[164] *Milwaukee County Department of Parks, Recreation, and Culture,* Milwaukee County Trails Network Plan, *2007; and SEWRPC Planning Report No. 55,* VISION 2050, Recommended Regional Land Use and Transportation Plan for Southeastern Wisconsin*, 2nd Edition, June 2020.*

3. **Extending the Oak Leaf Trail along the mainstem of Oak Creek from its current terminus near Oak Creek Parkway Park to W. Ryan Road near the confluence with the North Branch of Oak Creek and then to the south to the watershed boundary and into the Root River watershed (1.4 miles)**

4. **Extending the Oak Leaf Trail to the northwest of the watershed toward Milwaukee Area Technical College campus north along the Canadian-Pacific railroad located directly west of Milwaukee Mitchell International Airport (2.9 miles)**

For a general cost estimate reference of a trail expansion project, Milwaukee County completed the Oak Leaf Trail South Shore Line expansion that runs along the old railroad right-of-way owned by We Energies from Drexel Avenue southeast to Bender Park. The trail extent is approximately three miles long with a soft (stone surface) trail 11 feet wide, except for a few isolated areas of a 10-foot-wide asphalt surface. The total estimated cost for this project was approximately $1.8 million (2020 dollars).[165] Based on the costs of the extension of the trail to Bender Park, the estimated cost for the above Oak Leaf Trail proposals would be approximately $3.2 million.

It is recommended that Milwaukee County and municipalities within the watershed consider developing other connections among trails within the watershed to connect local trail systems and smaller trails to the regional trail system, such as the Oak Leaf Trail. Municipal and locally-owned recreational trails within the Oak Creek watershed should continue to expand and connect to larger trail systems including the Oak Leaf Trail within Milwaukee County and surrounding counties, such as Racine County. The County and municipalities in the northwest portion of the watershed should consider expanding trails to allow for an increased trail and commuter connection throughout the watershed. In addition, the County and municipalities should consider connecting smaller isolated trails to municipal or regional trail systems. Information on municipal and smaller recreational trails, such as biking, hiking, or multi-use trail systems that are not included on Map 6.35 can be found on municipal websites.

Improvements for passive recreational opportunities should be considered with trail expansion or maintenance projects among county, municipal, and local trail networks. **It is recommended that the governing body responsible for recreational trails consider passive recreational opportunities for the**

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[165] *Southeastern Wisconsin Regional Planning Commission,* A Transportation Improvement Program for Southeastern Wisconsin: 2021-2024, *December 2020*.

public. Examples of passive recreation within the Oak Creek watershed include biking, bird watching, fishing, hiking, observing and photographing nature, picnicking, running, walking, and wildlife viewing. Potential projects that could increase passive recreational opportunities include the installation of park and trail benches; informational signage related to surrounding natural features or wildlife; bird nesting boxes to provide additional breeding habitat to help sustain or increase bird populations and improve bird viewing opportunities; and an increase of public educational and informational material available through county and local websites, social media, pamphlets, and public outreach booths on the locations and benefits of local outdoor recreational opportunities.

It is recommended Milwaukee County continue to maintain and expand its Forked Aster trail system within the Oak Creek watershed. County-owned parks with Fork Aster trails are listed in Table 4.42 and shown on Map 4.46. Trails such as these offer recreational users the benefit and experience of walking and hiking within the natural areas of the watershed.

Volunteer trails are unofficial or unsanctioned trails made over time by the public hiking or exploring natural areas or accessing waterways through woodlands or grasslands. Volunteer trails are often undesirable because they may lead to erosion and unsafe conditions, could promote encroachment on public and private property, and may lead to disturbance of sensitive areas. An example of a volunteer trail can be found on the north and south banks of Oak Creek within the Oak Creek Parkway land just downstream of the Mill Pond dam and continuing almost to the Grant Park beach parking lot. Because these volunteer trails are not sanctioned or maintained by the County, they are not monitored for stability or sustainable use. Due to the popularity of the area for hikers and anglers, especially during the annual salmon and trout runs, an officially sanctioned and maintained trail in this area should be considered. **It is recommended that as an addition to its Forked Aster trail system, the County formalizes a sustainable hiking trail along the south shore of Oak Creek from about 800 feet downstream of the Mill Pond dam and continuing on the north shore of Oak Creek to the Grant Park beach parking lot area. The formalized trail should direct hikers away from unstable streambanks and sensitive areas while providing established access points to the Creek for anglers to fish from the shore or access to wading into the Creek to fish. It is further recommended that Milwaukee County continue to address volunteer trails considered unstable or unsustainable for recreational use located within its parks and parkway system**.

It is recommended that Milwaukee County and municipalities in the watershed consider developing and maintaining informational signage throughout the trail system especially at trail head locations to provide trail users with information such as the location and name of the trail, the distance it covers, connections to other trails, and types of activities permitted on the trails. Signage could also provide information pertaining to the natural resources surrounding the trail including identifying native, endangered, threatened, or invasive flora and fauna species that may be present near the trail; describing geographic and ecological features such as the types of soils and biological communities present; and identifying adjacent waterbodies.

Recommended Actions Related to Fishing Access

The recreational use surveys discussed in Chapter 4 found that fishing is a popular water-based activity in the watershed. The following recommendations are intended to help increase recreational fishing and fishing access to the streams of Oak Creek.

It is recommended to maintain, improve, and expand fishing access from the stream banks of Oak Creek and its tributaries. Fishing access to the surface waters of Oak Creek is available from shorelines within public lands adjacent to the Creek and its tributary streams. For the most part, the Creek and its tributaries can be accessed from any public lands that the angler can legally use and where local ordinances do not prohibit fishing. Many of these lands are located within the Milwaukee County Parks and Parkway system. **It is recommended that Milwaukee County and municipalities in the watershed consider installing accessible, marked, and stable fishing locations adjacent to Oak Creek and its major tributaries along the Parkway and in parks.** As a part of this recommendation, it is suggested that signage indicating fishing access points be installed to allow for increased public fishing opportunities.

Depending on the alternative chosen by Milwaukee County to address the Mill Pond and dam (see "Alternatives and Recommended Actions for the Mill Pond and Dam" section), additional fishing access could be provided in the Mill Pond area. Specifically, elements of Alternatives 2, 3, 4, and 5 would provide additional fishing access to the Mill Pond area. **It is recommended that these elements be considered and implemented as appropriate.** In Particular, an additional fishing access project associated to the Mill Pond and dam alternatives is the installation of fishing platforms. Porous pavement platforms can provide safe and accessible recreational fishing for all anglers. The two porous pavement fishing platforms presented in the Mill Pond and Dam alternatives are about 800 square feet combined (based off GIS measurements). The general cost for porous pavement is $15.35 per square-foot, therefore the cost of one platform is about $6,140.[166]

It is recommended to improve aquatic connectivity within the Oak Creek watershed to enhance the health of the Oak Creek fishery. Fish passage barriers strongly influence the distribution of species within a watershed. Removing or reducing fish passage barriers will expand aquatic connectivity and thus provide anglers with an enhanced fishing experience with improved fish populations and species richness throughout the Oak Creek mainstem and its tributaries. Specific projects that would remove or modify barriers to permit passage are included in Table 6.1.

As described in Chapter 4, the Mill Pond is managed as an urban fishing water under the State's urban fishing program. Management of the pond includes annual stocking by WDNR of about 500 catchable-size rainbow trout into the Pond. The depths and water temperatures in the pond are currently insufficient to support these fish. Because of this, **it is recommended that the WDNR reevaluate the Mill Pond's status as an urban fishing water.** In addition, the future viability of continued stocking and management of the pond as an urban fishing water depends upon the alternative chosen by Milwaukee County to address the Mill Pond and dam. Under some alternatives, the pond would be absent and under others the restored area and depth of the pond may not be sufficient to support coldwater fish such as trout. **It is recommended that the WDNR further reevaluate the Mill Pond's status as an urban fishing water following selection and implementation of an alternative for the Mill Pond and dam.**

It is recommended to improve instream fish habitat in Oak Creek and its tributaries. Described previously in this report, every reach within the watershed upstream of the Mill Pond Dam has undergone significant channelization, removal of instream shelter and shading from overhanging vegetation, and

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[166] *CH2MHill, CDM Smith, and Milwaukee Metropolitan Sewerage District,* Regional Green Infrastructure Plan*, June 2013; Metropolitan Sewerage District,* Green Infrastructure Costs and Incentives in Metropolitan Milwaukee, Final Report*, October 2019; Mary Jo Lange, Director of Public Works- City of Cudahy,* "Cost for Permeable Pavement Installation," *electronic mail message to Laura K. Herrick, Chief Environmental Engineer, Southeastern Wisconsin Regional Planning Commission, November 3, 2020; Stevan Keith, Environmental Services Unit Leader- Milwaukee County,* "Green Infrastructure Cost Composite," *electronic mail message to Laura K. Herrick, Chief Environmental Engineer, Southeastern Wisconsin Regional Planning Commission, November 3, 2020; Phillip J. Beiermeister, Environmental Design Engineer- City of Oak Creek,* "Green Infrastructure Costs for Oak Creek- City of Oak Creek," *electronic mail message to Laura K. Herrick, Chief Environmental Engineer, Southeastern Wisconsin Regional Planning Commission, November 6, 2020.*

alteration of the natural riffle, run, and pool structure that sustain diverse habitats for fish and their macroinvertebrate prey (see Tables 4.10 and 4.11). Implementing the recommendations discussed in the section on actions to improve habitat will increase the quality and diversity of fish species throughout Oak Creek and its tributaries. This is likely to enhance opportunities for recreational fishing. Several projects that would improve fish habitat in the watershed are included in Table 6.1.

Recommended Actions Related to Recreational Facilities

It is recommended that the County consider making the Mill Pond Warming House available to the public for the use of group gatherings for recreational or special event purposes. Depending on the County's chosen dam alternative (see "Alternatives and Recommended Actions for the Mill Pond and Dam" Section), recreational ice skating and fishing on the Mill Pond may be enhanced. As such, the County could consider using the Warming House as a facility for those interested in recreational skating or fishing.

Additionally, the Warming House could be used as a place to host special events, community meetings, or group gatherings. This recommendation should be done in a way that is consistent with existing Milwaukee County Parks policies and practices. Estimated costs associated with this recommendation are contingent on the dam alternative chosen and if the County decides to make the Warming House available to the public.

Because there are no nature centers located within the Oak Creek watershed, Milwaukee County should also consider using **the Mill Pond Warming House as an educational and informational multi-use center.** This project would likely require facility renovation and additional County staff and/or volunteers. Potential renovation upgrades might include the enhancement of Warming House amenities (i.e., heating and cooling system, restrooms, or plumbing), up-to-date ADA requirements, available parking to the public, and the provision of staff or volunteers, development of programs, and educational tools (books, maps, displays, signs, charts, and a computer). A potential public-private partnership could be explored to assist the County with the development and/or operation of an educational center. As noted in the "Alternatives and Recommended Actions for the Mill Pond and Dam" section of this report, there is a potential location for a small parking lot just south of the Mill Pond dam on a parcel owned by the City of South Milwaukee. This parcel of land is situated about 165 feet from the Mill Warming House located on top of a steep incline of land. Additionally, a stable walking path and/or stairs would have to be constructed to allow access from the potential parking site to the Warming House. Estimated total cost of this recommendation varies depending on facility upgrades, parking accommodations, and the amount of staff and staff hours needed.

Accessibility of Recreational Facilities to People with Disabilities

The Federal Americans with Disabilities Act, adopted by the U.S. Congress in 1990, requires that "reasonable accommodation" be made to provide persons with disabilities equal opportunities for access to jobs, transportation, public facilities, and services—including access to recreational facilities. All new or renovated park and recreation facilities must be designed and constructed to comply with the requirements of the Act. **It is recommended that existing public park and recreation facilities be evaluated by the unit of government concerned to determine if improvements are feasible to meet Federal accessibility requirements.** If ADA guidelines are not feasible or cannot be achieved, **it is recommended that the unit of government concerned strive to provide an equivalent experience** for those with restricted abilities in order to assist a similar outdoor experience for all those participating in outdoor recreation. Accessibility standards and guidelines are available from several agencies regarding specific types of recreational facilities.[167]

6.5 RECOMMENDED ACTIONS TO ADDRESS TARGETED FLOODING PROBLEMS

The flooding issues in the Oak Creek watershed are scattered throughout the basin as documented in Chapter 4 of this plan. Therefore, recommended actions for flooding problems address the need for very targeted actions on a case-by-case basis. The recommended actions are divided into efforts that focus on reducing stream flooding impacts and efforts that focus on reducing stormwater flooding impacts. It should be noted that work that reduces stormwater flooding impacts may also serve to reduce stream flooding impacts. Many of the flooding recommendations overlap with recommendations in the water quality and habitat sections discussed earlier in this chapter. In addition, specific projects recommended to address targeted flooding problems are included in Table 6.1. Because of this, the discussions included in this section are brief.

It is recommended that actions to address flooding problems should also consider the potential impact of climate change. Climate change model projections predict an increased frequency of intense

[167] *Guidelines for boating facilities are available from the National Park Service at www.nps.gov and the U.S. Access Board at www.access-board.gov/ada. Guidelines for recreational trails can are available from the U.S. Access Board at www.access-board.gov/ada, the U.S. Forest Service at www.fs.usda.gov/managing-land/national-forests-grasslands/accessibility, and the U.S. Department of Transportation Federal Highway Administration at www.fhwa.dot.gov/accessibility. Guidelines for fishing piers and platforms are available from the U.S. Access Board at www.access-board.gov/ada/#ada-1005.*

rainstorms in Southeastern Wisconsin which will cause larger stream and stormwater flooding as compared to past experience. Consideration of a higher standard for flood mitigation actions would increase community resiliency to potential climate change impacts (see "Recommended Actions to Reduce or Mitigate the Negative Physical, Chemical, and Biological Impacts on Aquatic and Terrestrial Ecosystems that are Associated with Climate Change" section above).

Recommended Actions to Address Targeted Stream Flooding

Stream flooding in the Oak Creek watershed was documented based on the FEMA regulatory flood elevations and input from stakeholders. Based on that input, the following recommendations are offered to mitigate stream flooding impacts:

1. **It is recommended to acquire (voluntarily) and remove the remaining insurable structures that are within the regulatory floodplains of the Oak Creek watershed, as opportunities arise.**

2. **It is recommended as part of road improvement projects to evaluate opportunities to elevate or modify road crossings impacted by the regulatory flood elevations.**

3. **It is recommended to evaluate areas of stream flooding in the Oak Creek watershed on a case-by-case basis and evaluate opportunities to reduce flood impacts to public infrastructure and private property**. This may include projects that impact flood flows and flood elevations such as reconnecting the stream to its floodplain, expanding riparian buffers, channel restoration, and removing debris and excessive sediment from the stream channel. This may also include efforts to protect the impacted structure(s) by modifying, elevating, or moving the structure(s) out of the flooded area.

Recommended Actions to Address Targeted Stormwater Flooding

Stormwater flooding in the Oak Creek watershed was documented based input from stakeholders. Based on that input, the following recommendations are offered to mitigate stormwater flooding impacts:

1. **It is recommended that communities and property owners pursue stormwater management projects that retain runoff onsite as close as possible to where the rainwater falls.** This may include green infrastructure projects such as rain gardens, pervious pavement, green roofs, soil amendments, stormwater trees, and rain barrels. This may also include more traditional stormwater control features such as wetland restoration, dry detention basins, and wet retention basins.

2. **It is recommended to evaluate areas of stormwater flooding on a case-by-case basis and evaluate opportunities to reduce flood impacts to public infrastructure and private property.** This may include projects that improve stormwater conveyance or storage. This may also include efforts to protect the impacted structure(s) by modifying, elevating, or moving the structure(s) out of the flooded area.

3. **It is recommended that sufficient undeveloped land be maintained in the Oak Creek watershed for stormwater infiltration and flood storage.** The MMSD Greenseams program is a good example and is discussed in more detail in the recommended actions to protect, restore, expand, and connect riparian buffers earlier in this chapter.

6.6 ALTERNATIVES AND RECOMMENDED ACTIONS FOR THE MILL POND AND MILL POND DAM

Introduction

Issues of Concern

Baseline Condition

Conceptual Alternatives

Bases of Evaluation of Alternatives and Development of Recommendations

Comparison and Evaluations of Alternative Plans

Recommendations

Considerations During the County Decision-Making Process

6.7 RECOMMENDED ACTIONS FOR PUBLIC AWARENESS AND PARTICIPATION IN WATERSHED RESTORATION ACTIVITIES

Civic Engagement

Driving Forces

Goal and Objectives

Other Watershed Initiatives

Engagement Strategies

Integration of Potential Future Efforts in the Information and Education Element

Renaming of the Mitchell Field Drainage Ditch

6.8 PRIORITY PROJECTS FOR IMPLEMENTATION

6.9 MEASURING PLAN PROGRESS AND SUCCESS

Monitoring Recommendations

Evaluation of Existing Water Quality Monitoring and Data Collection Programs

Identification of Additional Monitoring Needs

Recommended Water Quality Monitoring Plan

Tracking Implementation of Plan Recommendations

Interim Measurable Milestones

Evaluating the State of Plan Implementation and the Success of the Plan

6.10 PLAN IMPLEMENTATION

Plan Adoption

Responsible Parties and Other Plan Implementation Organizations

Local-Level Agencies

Area-Wide Agencies

State-Level Agencies

Federal-Level Agencies

Private Organizations

Schedule

Maintaining and Revising this Plan

6.11 REQUIRED TECHNICAL AND FINANCIAL ASSISTANCE

Cost Analysis

Grant and Loan Programs

Community Assistance Planning Report No. 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

PLAN RECOMMENDATIONS

TABLES

Table 6.1
Site-Specific Management Measures for the Oak Creek Watershed

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	**Focus Areas Addressed[b]**	Location	Latitude	Longitude	Municipality	Owner	**Management Action**	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	**Responsible Party**	Capital	Annual O&M	**Potential Funding Sources[d]**	**Priority[e]**
Oak Creek Watershed-Wide Projects (OCW)																	
OCW-01	WQ	Watershed-wide	n/a	n/a	City of South Milwaukee	n/a	Review and audit municipal code and ordinances to assess barriers to implementing green infrastructure	--	--	--	--	--	City of South Milwaukee	10,500	--	2, 10, , 27, 47, 52, 57, 65, 67	Medium
OCW-02	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop and implement written dry-weather screening procedures for MS4 outfalls	--	--	--	--	--	Municipalities, Milwaukee County	--	--	57, 65, 66, 67	High
OCW-03	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop and implement written procedures for investigating and responding to suspected or known illicit discharges into MS4s	--	--	--	--	--	Municipalities, Milwaukee County	--	--	57, 65, 66, 67	High
OCW-04	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop and implement a system for tracking and completing long-term inspections, maintenance, and enforcement of all public and private post-construction stormwater BMPs	--	--	--	--	--	Municipalities, Milwaukee County	--	--	50, 57, 67	High
OCW-05	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop and implement a written salt application or salt reduction strategy	--	--	--	--	--	Municipalities, Milwaukee County	--	--	27, 52, 57, 65, 67	High
OCW-06	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County, MMIA	Municipalities, Milwaukee County, MMIA	Annually calibrate deicing and anti-icing equipment	--	--	--	--	--	Municipalities, Milwaukee County, MMIA	--	--	--	High
OCW-07	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop action benchmarks for bacteria for IDDE screening	--	--	--	--	--	Municipalities, Milwaukee County	--	--	10, 22, 52, 57, 65, 67	High
OCW-08	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop an inventory and map of potential sources of fecal indicator bacteria for MS4	--	--	--	--	--	Municipalities, Milwaukee County	--	--	10, 22, 52, 57, 65, 67	High
OCW-09	WQ	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Municipalities, Milwaukee County	Develop a fecal indicator bacteria elimination plan for MS4	--	--	--	--	--	Municipalities, Milwaukee County	--	--	10, 22, 52, 57, 65, 67	High
OCW-10	WQ, SWF	Watershed-wide	n/a	n/a	Municipalities, Milwaukee County	Milwaukee County	Develop and execute a pilot project that evaluates an innovate BMP design or contracting mechanism for stormwater-related services	--	--	--	--	--	Milwaukee County	--	--	13, 14, 25, 31, 44, 45, 57, 67	Medium
Grant Park Ravine Assessment Area (GPR)																	
GPR-01	H, WQ	Oak Creek estuary area adjacent to Grant Park Beach parking lot	42.90657	-87.84223	City of South Milwaukee	Milwaukee County and City of South Milwaukee	Consider restoration of estuary area to improve habitat and aesthetics with native plan installations and potentially converting backwater areas to wetland estuary habitat	--	--	--	--	--	Milwaukee County and City of South Milwaukee	--	--	3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 20, 21, 22, 23, 24, 25, 26, 45, 49, 52, 60, 61, 67, 69	Medium
GPR-02	WQ, H	Oak Creek mainstem, left bank WPA wall downstream of first Oak Creek Parkway crossing	42.90788	-87.84675	City of South Milwaukee	City of South Milwaukee	Repair or replace falling portion of 18-inch RCP outfall (sequence number 10 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,900	--	7, 57, 67	Medium
GPR-03	WQ, R	Mainstem of Oak Creek by Oak Creek Parkway north of Marquette Avenue (extended)	42.90792	-87.84675	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of human fecal contamination to outfall (sequence number 10 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
GPR-04	SWF	Sanitary lift station near downstream-most crossing of the Oak Creek Parkway	42.90819	-87.84734	City of South Milwaukee	City of South Milwaukee	Complete construction of designed lift station	--	--	--	--	--	City of South Milwaukee	4,800,000	--	12, 30, 46, 50, 67	High
GPR-05	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of the Mill Pond dam[f]	42.90935	-87.84714	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 75 feet of Oak Creek with slight lateral recession rate	600	0.2	--	0.4	0.9	Milwaukee County	26,300	1,580	8, 9, 21, 22, 25, 49, 52, 58, 67	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c] Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
GPR-06	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of the Mill Pond dam[f]	42.91005	-87.84749	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 284 feet of Oak Creek with severe lateral recession rate	46,400	12.1	--	31.5	63.0	Milwaukee County	81,900	4,910	8, 9, 21, 22, 25, 49, 52, 58, 67	High
GPR-07	WQ, H	Right bank of Oak Creek upstream from the first Oak Creek Parkway Crossing[f]	42.91027	-87.84763	City of South Milwaukee	Unknown	Repair or replace filing portion of 24-Inch RCP outfall (sequence number 14 in Appendix O)	--	--	--	--	--	Unknown	4,000	--	7, 57, 67	Medium
GPR-08	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91041	-87.84835	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 154 feet of Oak Creek with a moderate recession rate	8,200	2.1	--	5.5	11.0	Milwaukee County	53,900	3,230	8, 9, 21, 22, 25, 49, 52, 58, 67	Medium
GPR-09	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91034	-87.84876	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 170 feet of Oak Creek with a very severe recession rate	172,000	45.1	--	117.0	234.1	Milwaukee County	59,500	3,570	8, 9, 21, 22, 25, 29, 49, 52, 58, 67	High
GPR-10	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91065	-87.84891	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 34 feet of Oak Creek with a severe recession rate	13,800	3.6	--	9.4	18.7	Milwaukee County	11,900	710	8, 9, 21, 22, 25, 49, 52, 58, 67	Medium
GPR-11	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91104	-87.84831	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 275 feet of Oak Creek with a moderate recession rate	22,600	5.9	--	15.3	30.6	Milwaukee County	96,300	5,780	8, 9, 21, 22, 25, 49, 52, 58, 67	Medium
GPR-12	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91140	-87.84895	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 51 feet of Oak Creek with a severe recession rate	14,400	3.8	--	9.8	19.7	Milwaukee County	17,900	1,070	8, 9, 21, 22, 25, 49, 58 52, 67	Medium
GPR-13	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91153	-87.84968	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 317 feet of Oak Creek with a moderate recession rate	14,800	4.6	--	11.9	2.37	Milwaukee County	111,000	6,660	8, 9, 21, 22, 25, 49, 52, 58, 67	Medium
GPR-14	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 1	42.911213	-87.84982	City of South Milwaukee	Milwaukee County	Forest stand improvement including supplemental canopy gap and understory planting; rapid response invasive species management, wildlife inventory applied to 29.9 acres	--	--	--	--	--	Milwaukee County	175,500	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Medium
GPR-15	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of Mill Pond Dam[f]	42.91223	-87.85262	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 93 feet of Oak Creek with a moderate recession rate	3,600	1.1	--	2.9	5.8	Milwaukee County	32,600	1,950	8, 9, 21, 22, 25, 49, 52, 58, 67	Medium
GPR-16	WQ, R	Mainstem of Oak Creek downstream of 6th Avenue	42.91223	-87.85280	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of canine fecal contamination to outfall (sequence number 21 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
GRP-17	WQ, R	Mainstem of Oak Creek downstream of Mill Road	42.91229	-87.85313	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of human fecal contamination to outfall (sequence number 22 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
Lower Oak Creek-Mill Pond Assessment Area (LMP)																	
LMP-01	SWF, WQ	Oak Creek Mill Pond	42.91227	-87.85361	City of South Milwaukee	Milwaukee County	Repair Oak Creek Mill Pond sluice gate if it is determined not to pursue dam removal[g]	--	--	--	--	--	Milwaukee County	411,000	--	31, 62, 63	High
LMP-02	WQ	Oak Creek Mill Pond and vicinity	42.912780	-87.85397	City of South Milwaukee	Milwaukee County	Complete sediment transport analysis for Mill Pond area.[h]	--	--	--	--	--	Milwaukee County	10,000 to 75,000	--	59, 62, 65	High
LMP-03	WQ, R	Oak Creek Mill Pond off Oak Creek Parkway	42.91350	-87.85366	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of human fecal contamination to outfall (sequence number 27 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
LMP-04	WQ	Oak Creek Mill Pond and vicinity	42.91338	-87.85416	City of South Milwaukee	Milwaukee County	Conduct sediment core sampling and chemical analysis in the Mill Pond Project area[i]	--	--	--	--	--	Milwaukee County	49,000	--	59, 62	High

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LMP-05	H	Oak Creek in Oak Creek Parkway upstream of Mill Pond	42.91491	-87.85600	City of South Milwaukee	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMP-06	H	Oak Creek in Oak Creek Parkway upstream of Mill Pond	42.91498	-87.85621	City of South Milwaukee	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMP-07	H	Oak Creek in Oak Creek Parkway upstream of Mill Pond	42.91503	-87.85649	City of South Milwaukee	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMP-08	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of the Mill Pond[f]	42.91477	-87.85663	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 66 feet of Oak Creek with a moderate lateral recession rate	3,000	1.0	--	2.5	4.9	Milwaukee County	23,100	1,390	8, 9, 22, 25, 29, 49, 52, 58, 67	Medium
LMP-09	SWF, H	Oak Creek upstream of the Mill Pond between the third and fourth Parkway crossing	42.91512	-87.85693	City of South Milwaukee	Milwaukee County	Remove debris jams and sediment accumulations from main channel of Oak Creek and elevate channel invert of newly formed channel that is in close proximity to the Parkway road[j]	--	--	--	--	--	Milwaukee County	--	--	28, 30, 39	High
LMP-10	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 2	42.91491	-87.85756	City of South Milwaukee	Milwaukee County	Reforestation of 0.75 acres; rapid response invasive species management of 22.9 acres; forest stand improvement including supplemental canopy gap and understory planting of 20 acres; floristic survey of 22.9 acres; and survey and posting of property lines	16	0.3	--	--	--	Milwaukee County	148,700	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low
LMP-11	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of the Mill Pond[f]	42.91526	-87.85766	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 26 feet of Oak Creek with a slight lateral recession rate	600	0.2	--	0.5	1.0	Milwaukee County	9,100	550	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-12	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of N. Chicago Avenue[f]	42.91832	-87.86035	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 107 feet of Oak Creek with a severe lateral recession rate	10,200	3.8	--	8.2	16.4	Milwaukee County	37,500	2,250	8, 9, 22, 25, 29, 49, 52, 58, 67	High
LMP-13	WQ, H	Right bank of Oak Creek upstream of N. Chicago Avenue[f]	42.91837	-87.86036	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 18-inch RCP outfall (sequence number 37 in Appendix O)	--	--	--	--	--	Milwaukee County	2,900	--	7, 57, 67	High
LMP-14	WQ, H	Left bank of Oak Creek upstream of N. Chicago Avenue[f]	42.91836	-87.86068	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 74 feet of Oak Creek with a severe lateral recession rate	12,400	3.8	--	9.9	19.9	Milwaukee County	25,900	1,550	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMP-15	WQ, H	Left bank of Oak Creek upstream of N. Chicago Avenue[f]	42.91937	-87.86086	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 105 feet of Oak Creek with a moderate lateral recession rate	5,800	1.8	--	4.6	9.2	Milwaukee County	36,800	2,210	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMP-16	H	Oak Creek in Oak Creek Parkway north of Cherry Street (extended)	42.91972	-87.86088	City of South Milwaukee	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County and City of South Milwaukee	--	--	9, 21, 22, 25, 32, 48, 49	High
LMP-17	WQ, H	Right bank of Oak Creek between Cherry Street (extended) and Walnut Street (extended)	42.91991	-87.86072	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 18-inch RCP outfall (sequence number 38 in Appendix O)	--	--	--	--	--	Milwaukee County	2,900	--	7, 57, 67	Medium
LMP-18	H	Oak Creek channel in Oak Creek Parkway upstream of Chicago Avenue and south of Walnut Street (extended)	42.92025	-87.86084	City of South Milwaukee	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County and City of South Milwaukee	--	--	9, 21, 22, 25, 32, 48, 49	High
LMP-19	WQ, H	Left bank of Oak Creek upstream of N. Chicago Avenue[f]	42.92039	-87.86085	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 53 feet of Oak Creek with a slight lateral recession rate	600	0.2	--	0.4	0.9	Milwaukee County	18,600	1,110	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-20	WQ, H	Right bank of Oak Creek upstream of N. Chicago Avenue[f]	42.92066	-87.86074	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 221 feet of Oak Creek with a moderate lateral recession rate	10,400	3.2	--	8.3	16.5	Milwaukee County	77,400	4,640	8, 9, 22, 25, 49, 52, 58, 67	High

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LMP-21	WQ, H	Right bank of Oak Creek between Walnut Street (extended) and Aspen Street (extended)[f]	42.92083	-87.86079	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 18-inch RCP outfall (sequence number 39 in Appendix O)	--	--	--	--	--	Milwaukee County	2.900	--	7, 57, 67	Medium
LMP-22	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of N. Chicago Avenue[f]	42.92087	-87.86105	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 70 feet of Oak Creek with a moderate lateral recession rate	3,000	0.9	--	2.4	4.8	Milwaukee County	24,500	4,470	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMP-23	WQ, H	Right bank of Oak Creek at Aspen Street (extended)[f]	42.92133	-87.86116	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 27-inch RCP outfall (sequence number 40 in Appendix O)	--	--	--	--	--	City of South Milwaukee	4,200	--	7, 57, 67	Medium
LMP-24	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of N. Chicago Avenue[f]	42.92146	-87.86115	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 80 feet of Oak Creek with a slight lateral recession rate	600	0.2	--	0.4	0.9	Milwaukee County	28,000	4,680	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-25	WQ, H	Right bank of Oak Creek upstream of Oak Creek Parkway and Oak Street (extended)[f]	42.92237	-87.86075	City of South Milwaukee	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 43 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
LMP-26	WQ, H	Right bank of Oak Creek upstream of Oak Creek Parkway and Oak Street (extended)[f]	42.92240	-87.86077	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 27-inch RCP outfall (sequence number 44 in Appendix O)	--	--	--	--	--	City of South Milwaukee	4,200	--	7, 57, 67	Medium
LMP-27	WQ, H	Right bank of Oak Creek upstream of Oak Creek Parkway and Oak Street (extended)[f]	42.92249	-87.86070	City of South Milwaukee	Unknown	Repair or replace failing portion of 18-inch RCP outfall (sequence number 45 in Appendix O)	--	--	--	--	--	Unknown	2,900	--	7, 57, 67	Medium
LMP-28	WQ, H	Right bank of Oak Creek upstream of Oak Creek Parkway and Oak Street (extended)[f]	42.92251	-87.86070	City of South Milwaukee	Unknown	Repair or replace failing portion of 12-inch clay outfall (sequence number 46 in Appendix O)	--	--	--	--	--	Unknown	2,500	--	7, 57, 67	Low
LMP-29	WQ, H	Right bank of Oak Creek upstream of Oak Creek Parkway and Oak Street (extended)[f]	42.92353	-87.86308	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 90 feet of Oak Creek with a slight lateral recession rate	800	0.2	--	0.6	1.3	Milwaukee County	31,500	1,890	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-30	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.92381	-87.86485	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 177 feet of Oak Creek with a slight lateral recession rate	1,200	0.3	--	0.9	1.8	Milwaukee County	62,000	3,720	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-31	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.92389	-87.86532	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 59 feet of Oak Creek with a slight lateral recession rate	400	0.1	--	0.4	0.8	Milwaukee County	20,700	1,240	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-32	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing across from South Milwaukee High School parking lot[f]	42.92388	-87.86603	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 12-inch CMP outfall (sequence number 58 in Appendix O)	--	--	--	--	--	Milwaukee County	2,100	--	7, 57, 67	Low
LMP-33	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Sections 3 and 4	42.92381	-87.86736	City of South Milwaukee	Milwaukee County	Forest stand improvement including canopy gap and understory planting of 55.7 acres; reforestation of 5.7 acres; rapid response invasive species management of 55.7 acres; floristic survey and wildlife inventory of 61.4 acres; and survey and posting of property lines	124	2.2	--	--	--	Milwaukee County	318,200	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LMP-34	WQ, H	Left bank of Oak Creek downstream of 15th Avenue and across from South Milwaukee High School[f]	42.92336	-87.86843	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 12-inch CMP outfall (sequence number 59 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,100	--	7, 57, 67	Low
LMP-35	WQ, H	Left bank of Oak Creek downstream of 15th Avenue and across from South Milwaukee High School[f]	42.92337	-87.86847	City of South Milwaukee	Unknown	Repair or replace failing portion of 27-inch CMP outfall (sequence number 60 in Appendix O)	--	--	--	--	--	Unknown	4,000	--	7, 57, 67	High
LMP-36	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.92337	-87.86849	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 22 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.1	0.3	Milwaukee County	7,700	460	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-37	WQ, Habitat	Left bank of Oak Creek downstream of 15th Avenue and across from South Milwaukee High School[f]	42.92369	-87.86884	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 12-inch CMP outfall (sequence number 61 in Appendix O)	--	--	--	--	--	Milwaukee County	1,200	--	7, 57, 67	Low
LMP-38	WQ, H	Right bank of Oak Creek downstream of 15th Avenue and across from South Milwaukee High School[f]	42.92384	-87.86881	City of South Milwaukee	Unknown	Repair or replace failing portion of 24-inch CMP outfall (sequence number 62 in Appendix O)	--	--	--	--	--	Unknown	3,700	--	7, 57, 67	High
LMP-39	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.92481	-87.86905	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 130 feet of Oak Creek with a slight lateral recession rate	1,000	0.6	--	0.7	1.5	Milwaukee County	45,500	2,730	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMP-40	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.92475	-87.86937	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 61 feet of Oak Creek with a moderate lateral recession rate	2,000	0.6	--	1.6	3.3	Milwaukee County	21,400	1,280	8, 9, 22, 25, 49, 52, 58, 67	Low
LMP-41	SWF	College Avenue – Union Pacific Railroad underpass	42.93009	-87.86352	Cities of Cudahy and South Milwaukee	Milwaukee County	Addition of 10 large capacity stormwater inlets to improve stormwater drainage	--	--	--	--	--	City of Cudahy	115,000	--	31, 42, 46, 57, 63, 67	High
LMP-42	SWF	South Milwaukee High School and sports complex	42.92161	-87.86791	City of South Milwaukee	South Milwaukee School District	Flood mitigation study for South Milwaukee High School and sports fields to review current conditions and refine options to reduce flooding impacts to the property from both Oak Creek and stormwater runoff	--	--	--	--	--	South Milwaukee School District and City of South Milwaukee	50,000	--	48, 57 63, ,65 ,67	Medium
LMP-43	H	Milwaukee County Parks Rawson Woods Management Unit 3	42.92088	-87.86684	City of South Milwaukee	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 2.8 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County Parks	11,100	--	11, 16, 19, 26, 45, 51, 53	Medium
LMP-44	H	Milwaukee County Parks Rawson Woods Management Unit 2	42.9144	-87.86791	City of South Milwaukee	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control; reforestation and inter-seeding of native plants on 20.2 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County Parks	67,600	--	11, 16, 19, 26, 35, 45, 51, 53	High
LMP-45	R	Rawson Woods Natural Area	42.91848	-87.86785	City of South Milwaukee	Milwaukee County	Develop a dedicated off-street nature trail loop with educational signage	--	--	--	--	--	Milwaukee County Parks	--	--	3, 11, 17, 64,	Low
LMP-47	SWF	Marquette Avenue underpass of Union Pacific Railroad crossing	42.9078	-87.86309	City of South Milwaukee	City of South Milwaukee	Flood mitigation study to review previous hydrologic and hydraulic work and develop a preferred alternative to eliminate surface flooding at this location	--	--	--	--	--	City of South Milwaukee	20,000		46, 57, 63, 65, 67	Medium
Lower Oak Creek Assessment Area (LOC)																	
LOC-01	WQ, R	Oak Creek upstream of 15th Avenue	42.92487	-87.87110	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of human fecal contamination to outfall (sequence number 72 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
LOC-02	WQ, H	Left bank of Oak Creek between Elm Avenue (extended) and Oak Street (extended)	42.92302	-87.87411	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 12-inch CMP outfall (sequence number 76 in Appendix O)	--	--	--	--	--	Milwaukee County	2,100	--	7, 57, 67	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LOC-03	H, WQ, SWF	Oak Creek from 1,200 feet downstream of 15th Avenue to Rawson Avenue	42.92269	-87.87474	City of South Milwaukee	Milwaukee County	Stream channel and riparian restoration of about 5,400 feet of channel [k]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 28, 30, 39, 49, 52, 58, 60	Medium
LOC-04	WQ, SWF	Oak Creek Parkway from the entrance to Grant Park Beach to E. Rawson Avenue in the City of South Milwaukee	42.92158	-87.87408	City of South Milwaukee	City of South Milwaukee	Pilot Project – Install 2-foot pervious pavement strips in the parking lanes adjacent to curbs on both sides of the road along the parkway to treat runoff originating on the road	8,113	23.9	--	--	--	City of South Milwaukee	860,000	6,500	8, 25, 52, 57, 63, 66, 67	High
LOC-05	WQ, R	Oak Creek at Cherry Street (extended)	42.91975	-87.87446	City of South Milwaukee	Milwaukee County	Investigate and remedy source of canine fecal contamination to outfall (sequence number 81 in Appendix O)	--	--	--	--	--	Milwaukee County	--	--	10, 22, 52, 57, 65, 67	High
LOC-06	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of E. Rawson Avenue[f]	42.91906	-87.87406	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 78 feet of Oak Creek with a severe lateral recession rate	8,600	2.7	--	6.9	13.8	Milwaukee County	27,300	1,640	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-07	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of E. Rawson Avenue[f]	42.91836	-87.87416	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 46 feet of Oak Creek with a moderate lateral recession rate	1,400	0.4	--	1.1	2.3	Milwaukee County	16,100	970	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-08	WQ, H	Left bank of Oak Creek at Chestnut Street (extended)[f]	42.91809	-87.87410	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 12-inch CMP outfall (sequence number 85 in Appendix O)	--	--	--	--	--	Milwaukee County	2,100	--	7, 57, 67	Low
LOC-09	WQ, R	Oak Creek at Chestnut Street (extended)	42.91796	-87.87415	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of canine fecal contamination to outfall (sequence number 86 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 52, 57, 65, 67	High
LOC-10	WQ, H	Right bank of Oak Creek at Cedar Street (extended)[f]	42.91721	-87.87409	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 18-inch RCP outfall (sequence number 89 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,900	--	7, 57, 67	Medium
LOC-11	WQ, H	Right bank of Oak Creek at Cedar Street (extended)[f]	42.91714	-87.87403	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 12-inch CMP outfall (sequence number 90 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,100	--	7, 57, 67	Low
LOC-12	WQ, H	Right bank of Oak Creek at Maple Street (extended)[f]	42.91630	-87.87375	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 18-inch CMP outfall (sequence number 91 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,100	--	7, 57, 67	Low
LOC-13	WQ, H	Left bank of Oak Creek at Maple Street (extended)[f]	42.91623	-87.87365	City of South Milwaukee	Milwaukee County	Repair or replace failing portion of 15-inch CMP outfall (sequence number 92 in Appendix O)	--	--	--	--	--	Milwaukee County	2,200	--	7, 57, 67	High
LOC-14	H	Milwaukee County Parks Rawson Woods Management Unit 1	42.91558	-87.86876	City of South Milwaukee	Milwaukee County	Invasive species monitoring and select control and reforestation with native tree and shrub species on 1.9 acres	--	--	--	--	--	Milwaukee County Parks	1,700	--	11, 16, 19, 26, 35, 45, 49, 51, 53	High
LOC-15	H	Oak Creek at E. Rawson Avenue and 16th Avenue crossing culvert	42.91490	-87.87279	City of South Milwaukee	City of South Milwaukee	Improve fish passage opportunities through triple cell culvert[m]	--	--	--	--	--	City of South Milwaukee	--	--	9, 11, 21, 25, 45, 48, 49	High
LOC-16	SWF	Sanitary lift station near 16th Avenue and Missouri Avenue (extended)	42.91451	-87.87264	City of South Milwaukee	City of South Milwaukee	Sanitary lift station study to review current configuration and evaluate component elevations relative to Oak Creek floodplain	--	--	--	--	--	City of South Milwaukee	10,000	--	31, 42, 46	Medium
LOC-17	WQ, H	Left bank of Oak Creek between Manitoba Avenue (extended) and Minnesota Avenue (extended)[f]	42.91323	-87.87036	City of South Milwaukee	Unknown	Repair or replace failing portion of 6-inch metal outfall (sequence number 99 in Appendix O)	--	--	--	--	--	Unknown	2,000	--	7, 57, 67	Low
LOC-18	WQ,H	Right bank of Oak Creek at Madison Avenue (extended)[f]	42.90996	-87.87223	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 18-inch CMP outfall (sequence number 107 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,300	--	7, 57, 67	Medium

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LOC-19	WQ, SWF	Alleyway between 15th Avenue on the west, 13th Avenue on the east, Madison Avenue on the north, and Michigan Avenue on the south	42.90950	-87.86847	City of South Milwaukee	City of South Milwaukee	Pilot project – Installation of a 2-foot strip of pervious pavement along the center of the alley to treat runoff originating in the alley	186	0.5	--	--	--	City of South Milwaukee	34,000	200	25, 52, 57, 63, 66, 67	High
LOC-20	WQ, H	Right bank of Oak Creek between Madison Avenue (extended) and Michigan Avenue (extended)[f]	42.90955	-87.87289	City of South Milwaukee	City of South Milwaukee	Repair or replace failing portion of 18-inch CMP outfall (sequence number 108 in Appendix O)	--	--	--	--	--	City of South Milwaukee	2,300	--	7, 57, 67	Medium
LOC-21	H, WQ, SWF	Mainstem of Oak Creek and Parkway from about the south crossing of 15th Avenue to 1,000 feet downstream of Pennsylvania Avenue	42.90897	-87.87332	City of South Milwaukee	Milwaukee County	Stream channel and riparian restoration of about 3,900 feet of channel[k,n]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 28, 28, 30, 39, 49, 52, 58	Medium
LOC-22	SWF	Emergency Sanitary Relief Station near Oak Creek between Michigan Avenue (extended) and Marquette Avenue (extended)	42.90865	-87.87333	City of South Milwaukee	City of South Milwaukee	Emergency sanitary relief station study to review current configuration and evaluate component elevations relative to Oak Creek floodplain	--	--	--	--	--	City of South Milwaukee	10,000	--	31, 42, 46	Medium
LOC-23	WQ, H	Left bank of Oak Creek behind South Milwaukee City Hall	42.90714	-87.87487	City of South Milwaukee	Unknown	Repair or replace failing portion of 11-inch CMP outfall (sequence number 114 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Medium
LOC-24	H	Oak Creek behind/northwest of South Milwaukee City Hall	42.90716	-87.87506	City of South Milwaukee	Milwaukee County	Concrete removal and channel renaturalization of about 150 feet of stream channel	--	--	--	--	--	Milwaukee County	--	--	7, 9, 10, 21, 22, 25, 30, 28, 39, 49, 52, 58	Low
LOC-25	WQ, R	Oak Creek between 16th Avenue (extended) and 17th Avenue (extended)	42.90698	-87.87503	City of South Milwaukee	City of South Milwaukee	Investigate and remedy source of canine fecal contamination to outfall (sequence number 115 in Appendix O)	--	--	--	--	--	City of South Milwaukee	--	--	10, 22, 25, 52, 57, 65, 67	High
LOC-26	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 5	42.90749	-87.87658	City of South Milwaukee	Milwaukee County	Forest stand improvement including canopy gap and understory planting of 21.3 acres; reforestation of 7.3 acres, rapid response invasive species management of 14 acres; floristic survey and wildlife inventory of 21.3 acres; survey and posting of property line	198	3.4	--	--	--	Milwaukee County	134,200	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low
LOC-28	H, WQ, SWF	Oak Creek from Pennsylvania Avenue to about 1,000 feet downstream of S. Pennsylvania Avenue	42.90545	-87.87876	City of South Milwaukee	Milwaukee County	Stream channel and riparian restoration of about 1,000 feet of channel and 20 acres of adjacent County parkland[o]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 28, 30, 39, 49, 52, 58	Medium
LOC-29	H	Oak Creek about 630 feet downstream of S. Pennsylvania Avenue	42.90571	-87.87907	City of South Milwaukee	South Milwaukee School District	Remove or modify large woody debris jam to allow for better aquatic organism passage.	--	--	--	--	--	Milwaukee County and City of South Milwaukee	--	--	9, 21, 22, 25, 32, 48, 49	High
LOC-30	R	South bank of Oak Creek west of S. Pennsylvania Avenue	42.90464	-87.87931	City of South Milwaukee	Milwaukee County	Develop off-street nature trail through wooded area along Oak Creek	--	--	--	--	--	Milwaukee County	--	--	3, 11, 17, 60, 64	Low
LOC-31	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of S. Pennsylvania Avenue[f]	42.90522	-87.88088	City of South Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 54 feet of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.6	Milwaukee County	18,900	1,130	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-32	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90527	-87.88230	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 75 feet of Oak Creek with a moderate lateral recession rate	3,000	0.9	--	2.3	4.7	Milwaukee County	26,300	1,580	8, 9, 22, 25, 49, 52, 58, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Site Information: Latitude	Site Information: Longitude	Site Information: Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Annual Pollutant Reductions: Total Phosphorus (pounds)	Annual Pollutant Reductions: Fecal Coliform Bacteria (trillion cells)	Annual Pollutant Reductions: Total Nitrogen (pounds)	Annual Pollutant Reductions: BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Costs (dollars)[c]: Annual O&M	Potential Funding Sources[d]	Priority[e]
LOC-33	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90527	-87.88230	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 75 feet of Oak Creek with a moderate lateral recession rate	3,000	0.9	--	2.3	4.7	Milwaukee County	26,300	1,580	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-34	WQ, SWF	Subdivision developments north of Oak Creek and east of S. Pennsylvania Avenue	42.90613	-87.88287	City of Oak Creek	City of Oak Creek and Milwaukee County	Pilot Project – Installation of wet retention pond with a pool size of 2.7 acres treating a 57.3-acre drainage area	5,038	15.0	6.32	--	--	City of Oak Creek and Milwaukee County	1,190,000	27,100	8, 12, 25, 31, 52, 57, 63, 67	Medium
LOC-35	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90515	-87.88292	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 242 feet of Oak Creek with a moderate lateral recession rate	6,600	2.0	--	5.3	10.6	Milwaukee County	84,700	5,080	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-36	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90504	-87.88340	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 32 feet of Oak Creek with a moderate lateral recession rate	400	0.2	--	0.4	0.8	Milwaukee County	11,200	670	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-37	H	Oak Creek about 520 feet upstream from S. Pennsylvania Avenue	42.90503	-87.88365	City of Oak Creek	Milwaukee County and Private Landowner	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County, City of Oak Creek, MMSD	--	--	9, 21, 22, 25, 32, 48, 49	High
LOC-38	SWF, H	Oak Creek about 800 feet upstream from S. Pennsylvania Avenue	42.90507	-87.88447	City of Oak Creek	Milwaukee County	Assessment of stability of embankment and/or pond control structure between the small former quarry pond and adjacent creek, including any potential threat of failure and impacts related to downstream flooding and habitat degradation.	--	--	--	--	--	Milwaukee County	--	--	46, 50, 63, 67	Low
LOC-39	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90499	-87.89090	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 67 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.3	0.6	Milwaukee County	23,500	1,410	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-40	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90499	-87.88496	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 67 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.2	0.3	Milwaukee County	31,500	1,890	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-41	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90500	-87.88541	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 34 feet of Oak Creek with a moderate lateral recession rate	2,200	0.7	--	1.7	3.4	Milwaukee County	11,900	710	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-42	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90502	-87.88596	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 32 feet of Oak Creek with a severe lateral recession rate	4,600	1.4	--	3.7	7.4	Milwaukee County	11,200	670	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-43	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90507	-87.88607	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 14 feet of Oak Creek with a moderate lateral recession rate	1,600	0.5	--	1.3	2.6	Milwaukee County	4,900	290	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-44	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90506	-87.88630	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 68 feet of Oak Creek with a moderate lateral recession rate	2,600	0.8	--	2.1	4.2	Milwaukee County	23,800	1,430	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-45	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90503	-87.88650	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 42 feet of Oak Creek with a moderate lateral recession rate	400	0.2	--	0.4	0.9	Milwaukee County	14,700	880	8, 9, 22, 25, 49, 52, 58, 67	Low
LOC-46	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90505	-87.88736	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 327 feet of Oak Creek with a moderate lateral recession rate	3,800	1.8	--	4.6	9.3	Milwaukee County	114,500	6,870	8, 9, 22, 25, 49, 52, 58, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LOC-47	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90517	-87.88879	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 156 feet of Oak Creek with a severe lateral recession rate	7,200	3.3	--	8.6	17.3	Milwaukee County	54,600	3,280	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-48	H	Oak Creek about 650 feet downstream of the confluence with the Mitchell Field Drainage Ditch	42.90532	-87.88897	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	Milwaukee County, City of Oak Creek, MMSD	--	--	9, 21, 22, 25, 27, 32, 48, 49	High
LOC-49	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 6	42.90542	-87.89006	City of Oak Creek	Milwaukee County	Grassland management of 4.6 acres; reforestation of 10.2 acres; rapid response invasive species management of 71.6 acres; forest stand improvement including supplemental gap canopy and understory planting of 64.3 acres; floristic survey and wildlife inventory of 75.8 acres	0	2.7	--	--	--	Milwaukee County	399,400	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low
LOC-50	H, WQ, SWF	About 3,800 feet of Oak Creek from S. Pennsylvania Avenue to 500 feet downstream of E. Drexel Avenue	42.90503	-87.89041	Cities of South Milwaukee and Oak Creek	Milwaukee County	Stream channel and riparian restoration of about 3,800 feet of channel[p]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 28, 30, 39, 49, 52, 58	Medium
LOC-51	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S Pennsylvania Avenue[f]	42.90499	-87.89090	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 214 feet of Oak Creek with a severe lateral recession rate	12,800	5.9	--	15.3	30.5	Milwaukee County	74,900	4,490	8, 9, 22, 25, 49, 52, 58, 67	Medium
LOC-52	WQ, SWF	Southwest of the intersection of STH 32 and E. Forest Hill Avenue	42.89136	-87.86505	City of South Milwaukee	City of Oak Creek	Pilot Project – Installation of wet retention pond with a pool size of 0.74 acres, treating a drainage area of 8.1 acres	460	1.7	0.90	--	--	City of Oak Creek	320,000	6,900	8, 12, 25, 31, 52, 57, 63, 67	Medium
LOC-53	WQ	Pond near S. Ashbury Lane and E. Oakshire Drive	42.88824	-87.86582	City of Oak Creek	City of Oak Creek	Retrofit 1.85-acre wet retention pond WQ-19 into existing pond	53,062	--	--	--	--	City of Oak Creek	345,900	13,820	31, 46, 57, 63, 67	Medium
Middle Oak Creek Assessment Area (MOC)																	
MOC-01	WQ, H	Oak Creek north of E. Drexel Avenue	42.90128	-87.89317	City of Oak Creek	Milwaukee County	Establish riparian buffer along about 500 feet of Oak Creek on about 2.0 acres and manage invasive species	--	0.7	--	--	--	Milwaukee County	8,400	--	4, 7,10, 11, 15, 20, 22, 24, 25, 26, 45, 49, 52, 57, 58, 67	Low
MOC-02	H, SWF	Culvert at E. Drexel Avenue crossing of Oak Creek	42.90087	-87.89298	City of Oak Creek	City of Oak Creek	Monitor and remove accumulations of debris	--	--	--	--	--	City of Oak Creek	--	--	21, 22, 39, 49, 51	Low
MOC-03	WQ, H	Right bank of Oak Creek in Abendschein Park[f]	42.89832	-87.89514	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 49 feet of Oak Creek with a severe lateral recession rate	3,200	1.5	--	3.9	7.8	City of Oak Creek	17,200	1,030	8, 22, 25, 49, 52, 58, 67	Medium
MOC-04	H, WQ, SWF	Oak Creek through Abendschein Park from E. Drexel Avenue to the Union Pacific Railroad crossing downstream of E. Forest Hill Avenue	42.89780	-87.89503	City of Oak Creek	City of Oak Creek, MMSD	Stream channel and riparian restoration of about 3,800 feet of channel[q]	--	--	--	--	--	City of Oak Creek, MMSD	--[l]	--	7, 9, 10, 21, 22, 25, 28, 28, 30, 39, 49, 52, 58	High
MOC-05	WQ, H	Right bank of Oak Creek in Abendschein Park[f]	42.89725	-87.89508	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 75 feet of Oak Creek with a moderate lateral recession rate	1,000	0.5	--	1.3	2.5	City of Oak Creek	26,300	1,580	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-06	WQ, H	Left bank of Oak Creek in Abendschein Park[f]	42.89688	-87.89422	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 83 feet of Oak Creek with a slight lateral recession rate	400	0.2	--	0.4	0.8	City of Oak Creek	29,100	1,740	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-07	H	Oak Creek about 580 feet downstream of Union Pacific Railroad crossing	42.89618	-87.89348	City of Oak Creek	MMSD	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-08	WQ, H	Right bank of Oak Creek downstream of Union Pacific Railroad crossing[f]	42.89557	-87.89333	City of Oak Creek	MMSD	Bank stabilization to address bank erosion along 17 feet of Oak Creek with a moderate lateral recession rate	600	0.2	--	0.5	1.1	MMSD	6.000	360	8, 9, 22, 25, 49, 52, 58, 67	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MOC-09	WQ, H	Right bank of Oak Creek downstream of Union Pacific Railroad crossing[f]	42.89516	-87.89243	City of Oak Creek	MMSD	Bank stabilization to address bank erosion along 51 feet of Oak Creek with a slight lateral recession rate	600	0.2	--	0.4	0.9	MMSD	17,900	1,070	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-10	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Union Pacific Railroad crossing[f]	42.89520	-87.89111	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 44 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.2	0.4	Milwaukee County	15,400	920	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-11	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of E. Forest Hill Avenue[f]	42.89297	-87.88920	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 54 feet of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.5	Milwaukee County	18,900	1,130	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-12	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 7	42.89221	-87.88800	City of Oak Creek	Milwaukee County	Grassland management of 24.2 acres; reforestation of 4.6 acres; grassland restoration of 12 acres; rapid response invasive species of 75.7 acres, forest stand improvement including supplemental canopy gap and understory planting of 26.1 acres; floristic survey and wildlife inventory of 75.7 acres; surveying and posting of property lines	8,139	0	--	--	--	Milwaukee County	349,300	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low
MOC-13	H	Oak Creek about 980 feet upstream of E. Forest Hill Avenue	42.89128	-87.88791	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-14	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of E. Forest Hill Avenue[f]	42.89090	-87.88740	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 109 feet of Oak Creek with a slight lateral recession rate	800	0.2	--	0.6	1.2	Milwaukee County	38,200	2,290	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-15	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of E. Forest Hill Avenue[f]	42.89074	-87.88713	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 7 feet of Oak Creek with a slight lateral recession rate	0	1.0	--	0.0	0.1	Milwaukee County	2,500	150	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-16	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of E. Forest Hill Avenue[f]	42.88956	-87.88713	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 151 feet of Oak Creek with a slight lateral recession rate	1,200	0.4	--	1.0	2.0	Milwaukee County	52,900	, 3,170	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-17	H	Oak Creek about 1,300 feet downstream of E. Puetz Road	42.88949	-87.88726	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-18	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of E. Forest Hill Avenue[f]	42.88851	-87.88726	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 192 feet of Oak Creek with a moderate lateral recession rate	8,600	2.7	--	6.9	13.9	Milwaukee County	67,200	4,030	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-19	H, WQ, SWF	Oak Creek from the Union Pacific Railroad crossing downstream of E. Forest Hill Avenue to about 2,800 feet downstream of S. Shepard Avenue	42.88953	-87.88728	City of Oak Creek	Milwaukee County and MMSD	Stream channel and riparian restoration of about 9,500 feet of channel and about 320 acres of adjacent publicly owned land[r]	--	--	--	--	--	Milwaukee County and MMSD	--[l]	--	7, 9, 10, 21, 22, 25, 28, 28, 30, 39, 49, 52, 58	High
MOC-20	WQ, SWF	City of Oak Creek storm sewer running parallel to E. Puetz Road from the west side of S. Pennsylvania Avenue to its outlet near the Oak Creek	42.88648	-87.88384	City of Oak Creek	City of Oak Creek	Pilot project – Daylighting about 720 feet of storm sewer treating a drainage area of 35.3 acres	929	3.9	0.38	--	--	City of Oak Creek	220,000	7,400	8, 10, 12, 14, 31, 46, 50, 52, 57, 63, 67	Medium
MOC-21	H, SWF	E. Puetz Road crossing of Oak Creek0	42.88633	-87.88560	City of Oak Creek	City of Oak Creek	Monitor beaver activity and remove debris as needed	--	--	--	--	--	City of Oak Creek	--	--	--	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MOC-22	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of E. Puetz Road[f]	42.88453	-87.88564	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 48 feet of Oak Creek with a moderate lateral recession rate	2,000	0.6	--	1.6	3.3	Milwaukee County	16,800	1,010	8, 22, 25, 49, 52, 58, 67	Low
MOC-23	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 8	42.88325	-87.88667	City of Oak Creek	Milwaukee County	Shallow wetland design and installation of 5 acres; reforestation of 65.9 acres; rapid response invasive species management of 42.5 acres; floristic survey and wildlife inventory of 70.9 acres; survey and posting of property line	107,400	40.1	--	--	--	Milwaukee County	478,500	--	4, 5, 7, 11, 25, 26, 35, 37, 38, 49, 52, 69	High
MOC-24	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of E. Puetz Road[f]	42.88300	-87.88562	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 67 feet of Oak Creek with a slight lateral recession rate	600	0.2	--	0.4	0.9	Milwaukee County	23,500	1,410	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-25	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of E. Puetz Road[f]	42.88214	-88.88702	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 186 feet of Oak Creek with a moderate lateral recession rate	8,800	2.7	--	7.0	13.9	Milwaukee County	65,100	3,910	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-26	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of E. Puetz Road[f]	42.88178	-87.88933	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 59 feet of Oak Creek with a moderate lateral recession rate	2,800	0.9	--	2.2	4.4	Milwaukee County	20,700	1,240	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-27	WQ, H	Left bank of Oak Creek within Oak Creek Parkway between S. Nicholson Road and the Union Pacific Railroad crossing	42.88151	-87.89146	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 47 feet of Oak Creek with a slight lateral recession rate	400	0.2	--	0.4	0.8	Milwaukee County	16,500	990	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-28	WQ, H	Left bank of Oak Creek within Oak Creek Parkway between S. Nicholson Road and the Union Pacific Railroad crossing	42.88143	-87.89209	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 40 feet of Oak Creek with a moderate lateral recession rate	400	0.2	--	0.4	0.8	Milwaukee County	14,000	840	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-29	H	Oak Creek immediately downstream of S. Nicholson Road bridge	42.88147	-87.89223	City of Oak Creek	Milwaukee County	Existing placement of rock across channel may obstruct passage for some fish species. Rearrange excess rubble to allow for better passage	--	--	--	--	--	Milwaukee County	--	--	3, 6, 11, 15, 16, 18, 21, 22, 49	High
MOC-30	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S. Nicholson Road[f]	42.88139	-87.89287	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 5 feet of Oak Creek with a moderate lateral recession rate	200	0.1	--	0.2	0.3	Milwaukee County	1,800	110	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-31	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 10	42.88099	-87.89555	City of Oak Creek	Milwaukee County	Rapid response invasive species management of 68.2 acres; forest stand improvement including supplemental canopy and understory planting of 7.3 acres; grassland management of 14 acres; grassland restoration of 19.7 acres; floristic survey and wildlife inventory of 65.3 acres	40,180	7.3				Milwaukee County	331,700	--	4, 5, 7, 11, 16, 25, 26, 35, 49, 52	High
MOC-32	H	Oak Creek about 1,100 feet downstream of S. Nicholson Road	42.87975	-87.89577	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-33	WQ, H	Left bank of Oak Creek partially within Oak Creek Parkway and on private parcel 873-1034-0000[f]	42.87909	-87.89671	City of Oak Creek	Milwaukee County and private landowner	Bank stabilization to address bank erosion along 79 feet of Oak Creek with a slight lateral recession rate	400	0.2	--	0.4	0.8	Milwaukee County	27,700	1,660	8, 21, 22, 25, 49, 52, 67	Low
MOC-34	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S. Nicholson Road[f]	42.87833	-87.89770	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 108 feet of Oak Creek with a moderate lateral recession rate	5,000	1.6	--	4.0	8.1	Milwaukee County	37,800	2,270	8, 9,22, 25, 49, 52, 58, 67	Medium
MOC-35	WQ, H	Right bank of Oak Creek at Oak Creek East Middle School	42.87663	-87.89777	City of Oak Creek	Oak Creek School District	Bank stabilization to address bank erosion along 132 feet of Oak Creek with a moderate lateral recession rate	6,200	1.9	--	4.9	9.9	Oak Creek School District	46,200	2,770	8, 21, 22, 25, 49, 52, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MOC-36	H	Oak Creek about 2,380 feet downstream of S. Shepard Avenue	42.87611	-87.89740	City of Oak Creek	Unknown	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-37	H, WQ, SWF	Oak Creek from Oak Creek East Middle School to about 1,800 feet downstream	42.87580	-87.87695	City of Oak Creek	Oak Creek School District and Others	Stream channel and riparian restoration of about 1,800 feet of channel[s]	--	--	--	--	--	Oak Creek School District and Others	--[l]	--	7, 9, 10, 21, 22, 25, 28, 30, 39, 49, 52, 58	High
MOC-38	H	Oak Creek about 2,200 feet downstream from S. Shepard Avenue	42.87557	-87.89707	City of Oak Creek	Unknown	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-39	WQ, H	Left bank of Oak Creek east of Oak Creek East Middle School on parcel 873-1034-000[f]	42.87460	-87.89705	City of Oak Creek	Unknown	Bank stabilization to address bank erosion along 59 feet of Oak Creek with a moderate lateral recession rate	3,000	0.9	--	2.4	4.8	Unknown	20,700	1,240	8, 22, 25, 27, 49, 52, 58, 67	Medium
MOC-40	WQ, H	Left bank of Oak Creek southeast of Oak Creek East Middle School on parcel 873-1034-000[f]	42.87380	-87.89759	City of Oak Creek	Unknown	Bank stabilization to address bank erosion along 93 feet of Oak Creek with a moderate lateral recession rate	4,200	1.3	--	3.4	6.7	Unknown	32,600	1,950	8, 22, 25, 27, 49, 52, 58, 67	Medium
MOC-41	SWF, WQ, H	Culvert carrying drainage ditch at confluence with Oak Creek southeast of Oak Creek East Middle School	42.87385	-87.89782	City of Oak Creek	Unknown	Remove and replace failing culvert which causes backup of drainage ditches. If the culvert is no longer necessary, remove it and stabilize the drainage ditch channel and banks with riprap at the location where it flows into Oak Creek	--	--	--	--	--	Unknown	--	--	8,11, 12, 27, 31, 39, 49, 52, 57, 67	Medium
MOC-42	H	Oak Creek about 1,050 feet downstream of S Shepard Avenue	42.87434	-87.89904	City of Oak Creek	Milwaukee County Oak Creek School District	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-43	H, WQ, SWF	Oak Creek south of Oak Creek East Middle School	42.87428	-87.90000	City of Oak Creek	Milwaukee County and Oak Creek School District	Stream channel and riparian restoration of about 1,000 feet of channel and 20 acres of adjacent Milwaukee County parkland and leased agricultural fields[t]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 28, 28, 30, 39, 49, 52, 58, 60	Medium
MOC-44	WQ, H	Left bank of Oak Creek downstream of S. Shepard Avenue and south of Oak Creek East Middle School[f]	42.87389	-87.90096	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 39 feet of Oak Creek with a severe lateral recession rate	8,400	2.6	--	6.7	13.5	Milwaukee County	13,700	820	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-45	WQ, H	Oak Creek about 400 feet downstream of S. Shepard Avenue	42.87394	-87.90113	City of Oak Creek	Milwaukee County and Oak Creek School District	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-46	WQ	S. Shepard Avenue and E. Ryan Road (subbasin O10-5)	42.87253	-87.90189	City of Oak Creek	City of Oak Creek	Install 0.83-acre wet retention pond (WQ-39)	27,279	--	--	--	--	City of Oak Creek	167,400	6,690	31, 57, 67	Medium
MOC-47	H, SWF	Culvert at S. Shepard Avenue crossing of Oak Creek	42.87433	-87.90286	City of Oak Creek	City of Oak Creek or Milwaukee County	Monitor beaver activity and remove debris as needed	--	--	--	--	--	City of Oak Creek or Milwaukee County	--	--	--	Low
MOC-48	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87475	-87.90356	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 33 feet of Oak Creek with a severe lateral recession rate	4,600	1.4	--	3.7	7.3	Milwaukee County	11,600	690	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-49	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87522	-87.90365	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 86 feet of Oak Creek with a severe lateral recession rate	20,600	6.4	--	16.5	33.0	Milwaukee County	30,100	1,810	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-50	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87549	-87.90411	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 34 feet of Oak Creek with a moderate lateral recession rate	1,800	0.5	--	1.4	2.8	Milwaukee County	11,900	710	8, 9, 22, 25, 49, 52, 58, 67	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MOC-51	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87535	-87.90463	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 67 feet of Oak Creek with a moderate lateral recession rate	4,200	1.3	--	3.3	6.7	Milwaukee County	23,500	1,410	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-52	WQ, H	Left bank of Oak Creek within Oak Creek Parkway and American Legion Park upstream of S. Shepard Avenue[f]	42.87556	-87.90489	City of Oak Creek	Milwaukee County and American Legion	Bank stabilization to address bank erosion along 91 feet of Oak Creek with a moderate lateral recession rate	5,000	1.5	--	4.0	7.9	Milwaukee County and American Legion	31,900	1,910	7, 8, 11, 22, 25, 27, 49, 52, 58, 67	Medium
MOC-53	WQ, SWF	Subdivision development to the northeast of S. Howell Avenue and E. Ryan Road	42.87587	-87.90667	City of Oak Creek	City of Oak Creek and Milwaukee County	Pilot Project – Installation of wet retention pond with a pool size of 3.3 acres treating a drainage area of 26.4 acres	3,200	9.5	1.63	--	--	City of Oak Creek and Milwaukee County	1,020,000	20,200	8, 12 ,25, 31, 52, 57, 63, 67	Medium
MOC-54	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87613	-87.90516	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 107 feet of Oak Creek with a severe lateral recession rate	20,600	6.3	--	16.4	32.9	Milwaukee County	37,500	2,250	8, 9, 22, 25, 49, 52, 58, 67	High
MOC-55	WQ, H	Left bank of Oak Creek within Oak Creek Parkway and American Legion Park upstream of S. Shepard Avenue[f]	42.87707	-87.90508	City of Oak Creek	Milwaukee County and American Legion	Bank stabilization to address bank erosion along 166 feet of Oak Creek with a severe lateral recession rate	24,000	7.4	--	19.1	38.2	Milwaukee County and American Legion	58,100	3,490	7, 8, 11, 22, 25, 27, 49, 52, 58, 67	High
MOC-56	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87812	-87.90566	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 139 feet of Oak Creek with a moderate lateral recession rate	6,200	1.9	--	4.9	9.9	Milwaukee County	48,700	2,920	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-57	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 11	42.87755	-87.90714	City of Oak Creek	Milwaukee County	Rapid response invasive species management of 53.8 acres; forest stand improvement including supplemental canopy and understory planting of 19.3 acres; reforestation of 2.6 acres; shrubland management of 25.4 acres; floristic surveys and wildlife inventory of 53.8 acres	58	1.0				Milwaukee County	271,700	--	4, 5, 7, 11, 16, 25, 26, 35, 49, 52	Low
MOC-58	H, WQ	Privately-owned natural areas to the north of Milwaukee County Parks Oak Creek Parkway Management Section 11	42.88103	-87.90974	City of Oak Creek	Private landowners	Voluntary acquisition of wooded/natural portions of private parcels adjacent to the north of Management Section 11 to protect wildlife dispersal corridor, buffers to Parks natural areas, and wetlands that are hydrologically connected to parkland	--	--	--	--	--	Milwaukee County and/or partners	--	--	19, 20, 35, 38, 46, 49, 58, 60, 61, 65, 69	Low
MOC-59	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue[f]	42.87768	-87.90974	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 100 feet of Oak Creek with a moderate lateral recession rate	5,000	1.7	--	4.5	9.0	Milwaukee County	35,000	2,1000	8, 9, 22, 25, 49, 52, 58, 67	Medium
MOC-60	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of S. Howell Avenue[f]	42.87692	-87.91219	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 15 feet of Oak Creek with a slight lateral recession rate	0	0.0	--	0.1	0.1	Milwaukee County	5,300	320	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-61	H	S. Howell Avenue bridge crossing of Oak Creek	42.87681	-87.91248	City of Oak Creek	Milwaukee County	Explore opportunities to improve fish passage under the bridge by improving water depths[u]	--	--	--	--	--	Milwaukee County	--	--	9, 11, 21, 22, 25, 42, 45, 48, 49	High
MOC-62	WQ, SWF	City of Oak Creek storm sewer running north of E. Parkway Estates Drive from subbasin OC-471 to its outlet near Oak Creek	42.87598	-87.91221	City of Oak Creek	City of Oak Creek	Pilot Project –Abandon section of storm sewer and construct about 500 feet of swale to Oak Creek. Project serves about 19.2 acres	811	2.9	0.21	--	--	City of Oak Creek	260,000	8,000	12, 23, 25, 46, 52, 57, 67,	Medium
MOC-63	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of S. Howell Avenue[f]	42.87619	-87.91400	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 15 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.2	0.3	Milwaukee County	14,000	840	8, 9, 22, 25, 49, 52, 58, 67	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MOC-64	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of S. Howell Avenue[f]	42.87577	-87.91515	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 62 feet of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.6	Milwaukee County	21,700	1,300	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-65	WQ, H	Right bank of Oak Creek within Oak Creek Parkway downstream of S. Howell Avenue[f]	42.87530	-87.91650	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 114 feet of Oak Creek with a severe lateral recession rate	26,000	8.0	--	20.8	41.6	Milwaukee County	39,900	2,390	8, 9, 22, 25, 49, 52, 58, 67	High
MOC-66	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream of S. Howell Avenue[f]	42.87510	-87.91674	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 21 feet of Oak Creek with a moderate lateral recession rate	600	0.2	--	0.5	1.0	Milwaukee County	7,400	440	8, 9, 22, 25, 49, 52, 58, 67	Low
MOC-67	H	Oak Creek about 860 feet downstream of the confluence with the North Branch of Oak Creek	42.87465	-87.91999	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
MOC-68	WQ, H	Left bank of Oak Creek within Oak Creek Parkway downstream at confluence with the North Branch of Oak Creek[f]	42.87524	-87.92264	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 145 feet of Oak Creek with a moderate lateral recession rate	10,800	3.3	--	8.6	17.2	Milwaukee County	50,800	3,050	8, 9, 22, 25, 49, 52, 58, 67	High
MOC-69	WQ	Subbasin O15-4 east of S. Nicholson Road near S. Chelsea Lee Court	42.86143	-87.88842	City of Oak Creek	City of Oak Creek	Install 8.29 wetland treatment system WQ-40	27,371	--	--	--	--	City of Oak Creek	83,400	3,290	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	Medium
Middle Oak Creek Drainage Ditches Assessment Area (MDD)																	
MDD-01	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 9	42.877701	-87.87662	City of Oak Creek	Milwaukee County	Reforestation of 35.2 acres; rapid response invasive species management of 92.4 acres; forest stand improvement including supplemental canopy and understory planting of 27.8 acres; floristic surveys and wildlife inventory of 120.6 acres; survey and posting of property lines	98,810	36.9	--	--	--	Milwaukee County	492,700	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	High
MDD-02	H, WQ	Privately owned wooded parcels to the north of Oak Creek Parkway Management Section 9	42.88391	-87.87597	City of Oak Creek	Private landowners	Voluntary acquisition of wooded private parcels adjacent to the north of Management Section 9 to protect wildlife dispersal corridor, buffers to Parks natural areas, and wetlands that are hydrologically connected to parkland	--	--	--	--	--	Milwaukee County and partners	554,400	--	19, 20, 35, 38, 46, 49, 58, 60, 61, 65, 69	Low
MDD-03	WQ, H, SWD	Wetland complex occupying portions of land bounded by E. Puetz Road on the north, S. 15th Avenue on the east, E. Oakwood Road on the south, and S. Shepard Avenue on the west	42.86573	-87.88475	City of Oak Creek	Milwaukee County, MMSD, and Private landowners	Investigate the extent and locations of relict drainage tile systems. Disconnect and/or remove any systems found to assist in restoring the wetland complexes	--	--	--	--	--	Milwaukee County, MMSD, and Private landowners	--	--	4, 6, 8, 11,12, 20, 23, 25, 27, 37, 38, 39, 46, 49, 52, 58, 66,	Medium
MDD-04	H WQ	Privately-owned natural areas to the west, north, and east of Milwaukee County Parks Oak Creek Parkway Management Section 13	42.86357	-87.87623	City of Oak Creek	Private landowners	Voluntary acquisition of wooded and natural private parcels adjacent to the Management Section 3 to protect wildlife dispersal corridor, buffers to Parks natural areas, and wetlands that are hydrologically connected to parkland	--	--	--	--	--	Private landowners, Milwaukee County, and partners	--	--	19, 20, 35, 38, 46, 49, 58, 60, 61, 65, 69	Low
MDD-05	WQ, H, SWF	Wetland complex occupying portions of land bounded by E. Puetz Road on the north, S. 15th Avenue on the east, E. Oakwood Road on the south, and S. Shepard Avenue on the west	42.87543	-87.88489	City of Oak Creek	Private landowners	Assess interest of private landowners in pursuing wetland restoration activities. Evaluate landowner interest in voluntary acquisition of parcels	--	--	--	--	--	Milwaukee County and partners	--	--	8, 20, 22, 25, 33, 37, 40, 46, 49, 58, 60, 61, 63, 65	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
MDD-06	WQ	Northeast of 15th Avenue and E. Carollton Drive	42.88030	-87.86802	City of Oak Creek	City of Oak Creek	Retrofit 0.26-acre wet retention pond WQ-41 into existing pond to sere subbasin O17-2	4,746	--	--	--	--	City of Oak Creek	67,800	2,470	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	Medium
MDD-08	SWF	E. Ryan Road between S. Pennsylvania Avenue and S. Shepard Avenue	42.87175	-87.88736	City of Oak Creek	City of Oak Creek	Raise the elevation of E. Ryan Road to prevent overtopping by stormwater	--	--	--	--	--	City of Oak Creek	1,364,400	--	31, 42, 46, 47	Medium
MDD-09	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 13	42.86077	-87.88563	City of Oak Creek	Milwaukee County	Shallow wetland design and installation of 5 acres; rapid response invasive species management of 128.6 acres; forest stand improvement including supplemental canopy gap and understory planting of 41.6 acres; reforestation of 7.3 acres; floristic surveys and wildlife inventory of 169.3 acres; property line survey and posting	13,250	4.9	--	--	--	Milwaukee County	653,200	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	Low
Upper Oak Creek Headwaters Assessment Area (UOC)																	
UOC-01	H, WQ, SWF	Area surrounding the confluence of the North Branch of Oak Creek and the mainstem of Oak Creek	42.87521	-87.92278	City of Oak Creek	WisDOT, Milwaukee County, City of Oak Creek, Canadian Pacific Railway	Conduct a detailed survey of the mainstem of Oak Creek from S. 13th Street to 1,000 feet downstream of S. Howell Avenue and the North Branch of Oak Creek downstream from W. Puetz Road to its confluence with the mainstem.[v]	--	--	--	--	--	WisDOT, Milwaukee County, City of Oak Creek, Canadian Pacific Railway	20,000	--	45, 47, 65	High
UOC-02	H, WQ, SWF	Area surrounding the confluence of the North Branch of Oak Creek and the mainstem of Oak Creek	42.87522	-87.92278	City of Oak Creek	WisDOT, Milwaukee County, City of Oak Creek, Canadian Pacific Railway	Conduct a feasibility study to explore options to address the impairments resulting from the channel modifications related to the W. Ryan Road and S. Howell Avenue expansion projects in the early 1970s.[w]	--	--	--	--	--	WisDOT, Milwaukee County, City of Oak Creek, Canadian Pacific Railway	70,000	--	28, 32, 65	High
UOC-03	H, SWF	Oak Creek W. Ryan Road culvert upstream of the confluence with the North Branch of Oak Creek	42.87225	-87.92207	City of Oak Creek	WisDOT	Monitor sediment accumulations and depths within culvert, ensure that obstructions are expeditiously removed and excavate accumulated sediment whenever threshold conditions that may lead to overtopping of W. Ryan Road are met or exceeded; remove sediment blockage on upstream side of culvert to a height just above normal flows (maintain and reinforce substrate blockage to a height just above normal flows to direct low flow to eastern cell, but allow higher flows to access the other two cells)	--	--	--	--	--	WisDOT	--	--	28, 32, 57, 63, 65, 67	Medium
UOC-04	H, WQ	Milwaukee County Parks Oak Creek Parkway Management Section 12	42.86656	-87.92134	City of Oak Creek	Milwaukee County	Rapid response invasive species management on 179.7 acres; forest stand improvement including supplemental canopy and understory planting of 65.4 acres; grassland management of 4 acres; grassland restoration of 3 acres; reforestation of 53.8 acres; floristic surveys and wildlife inventories of 200.6 acres; survey and posting of property lines	50,970	27.4	--	--	--	Milwaukee County	899,700	--	4, 5, 7, 11, 16, 20, 25, 26, 35, 49, 52	High
UOC-05	H	Canadian Pacific Railway culvert crossing on secondary channel of Oak Creek south of W. Ryan Road	42.87097	-87.92411	City of Oak Creek	Canadian Pacific Railway	Work with Canadian Pacific Railway to consider options for removal or replacement of old, failing culvert on secondary channel	--	--	--	--	--	Canadian Pacific Railway	--	--	28, 31, 46	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
UOC-06	H	Canadian Pacific Railway main culvert crossing of Oak Creek south of W. Ryan Road	42.87083	-87.92412	City of Oak Creek	Canadian Pacific Railway	Install strategically placed cobble and boulder substrates along both walls of south cell to provide resting areas for passing fish	--	--	--	--	--	Canadian Pacific Railway	--	--	7, 9, 11, 21, 25, 45, 48, 49, 52	Medium
UOC-07	H	Private farm road upstream of Canadian Pacific Railway crossing	42.87087	-87.92461	City of Oak Creek	Private landowner	Outlet of culvert is completely inundated by downstream ponding and concrete surrounding culvert is failing. Assess interest of landowner to remove culverts and stabilize adjacent streambank. If the access road is still needed, replace culverts with an appropriately sized culvert of span bridge	--	--	--	--	--	Private landowner	--	--	12, 27, 28, 30, 46, 48, 49, 52, 61, 63	High
UOC-08	WQ, H	Right bank of Oak Creek within Oak Creek Parkway upstream of Canadian Pacific Railway crossing[f]	42.87091	-87.92486	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 39 feet of Oak Creek with a moderate lateral recession rate	1,600	0.6	--	1.2	2.4	Milwaukee County	13,700	820	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-09	H	Oak Creek about 125 feet downstream of Canadian Pacific Railway crossing	42.87092	-87.92496	City of Oak Creek	Unknown	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City or Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
UOC-10	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Canadian Pacific Railway crossing[f]	42.87063	-87.92519	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 56 feet of Oak Creek with a moderate lateral recession rate	2,600	0.8	--	2.1	4.2	Milwaukee County	19,600	1,180	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-11	WQ, H	Left bank of Oak Creek within Oak Creek Parkway upstream of Canadian Pacific Railway crossing[f]	42.87021	-87.92551	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 78 feet of Oak Creek with a moderate lateral recession rate	3,600	1.1	--	2.9	5.8	Milwaukee County	27,300	1,640	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-12	H	Oak Creek about 450 feet downstream of Canadian Pacific Railway crossing	42.87018	-87.92569	City of Oak Creek	Unknown	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City or Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
UOC-13	H	Oak Creek about 575 feet downstream of Canadian Pacific Railway crossing	42.87011	-87.92616	City of Oak Creek	Unknown	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City or Oak Creek, Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
UOC-14	WQ, H	Right bank of Oak Creek at parcel 905-9998-001[f]	42.87023	-87.92655	City of Oak Creek	Private landowner	Bank stabilization to address bank erosion along 33 feet of Oak Creek with a moderate lateral recession rate	1,400	0.4	--	1.1	2.3	Private landowner	11,600	690	8, 21, 22, 25, 27, 32, 48, 49	Low
UOC-15	H	Abandoned farm road crossing Oak Creek downstream of S. 13th Street	42.87005	-87.93052	City of Oak Creek	Milwaukee County or Amazon	Remove abandoned and failing wooden and steel crossing structure and rearrange rock rubble to improve fish passage	--	--	--	--	--	Milwaukee County or Amazon	--	--	6, 11, 21, 22, 25, 45, 50, 52	High
UOC-16	H	S. 13th Street culvert crossing of Oak Creek	42.87048	-87.93219	City of Oak Creek	WisDOT or City of Oak Creek	Conduct a fish passage assessment on road crossing that was replaced as part of Amazon Distribution Center development	--	--	--	--	--	WisDOT or Milwaukee County	--	--	6, 11, 21, 22, 25, 45, 50, 52	Low
UOC-17	H	Crossings of Oak Creek at IH 94 northbound, southbound, and on-ramp bridges	42.86917	-87.93717	City of Oak Creek	WisDOT	Add strategically placed large cobble or boulder substrates throughout stream channel under bridges to create channel roughness and resting areas for passing fish	--	--	--	--	--	WisDOT	--	--	6, 11, 21, 22, 25, 45, 50, 52	Medium
UOC-18	WQ, H	Left bank of Oak Creek under the southbound lanes of IH 94[f]	42.86910	-87.93727	City of Oak Creek	Unknown	Repair or replace failing portion of 24-inch RCP outfall (sequence number 271 in Appendix O)	--	--	--	--	--	Unknown	4,000	--	7, 57, 67	High
UOC-19	H, WQ	Oak Creek upstream of S. 20th Street and about 4.5 acres of adjacent riparian land	42.86895	-87.94053	City of Oak Creek	City of Oak Creek	Establish new or expand existing riparian buffer to a minimum of 75 feet from each streambank or to the extent allowable based on existing development constraints and manage invasive species	--	--	--	--	--	City of Oak Creek	18,800	--	4, 7,10, 11, 15, 20, 22, 24, 25, 26, 45, 49, 52, 57, 58, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
UOC-20	WQ, H	Right bank of Oak Creek downstream of S. 20th Street[f]	42.86926	-87.94082	City of Oak Creek	Unknown	Repair or replace failing portion of 18-inch corrugated plastic outfall (sequence number 275 in Appendix O) draining truck stop to the north	--	--	--	--	--	Unknown	2,300	--	7, 57, 67	Medium
UOC-21	WQ	Love's Travel Stops & Country Stores parking lot west of S. 20th Street and north of Oak Creek	42.86949	-87.94129	City of Oak Creek	Love's Travel Stops & Country Stores, Inc.	Install bioretention, bioswale, or other appropriate green infrastructure to treat runoff from truck stop parking lot that currently flows directly to Oak Creek through the outfalls cited in projects UOC-20 and UOC-22[x]	--	--	--	--	--	Love's Travel Stops & Country Stores, Inc	--	--	6, 8, 11, 12, 13, 14, 25, 27, 30, 31, 45, 52, 57, 63, 67	High
UOC-22	WQ, H	Right bank of Oak Creek downstream of S. 20th Street[f]	42.86928	-87.94173	City of Oak Creek	Unknown	Repair or replace failing portions on one 18-inch corrugated plastic outfall and one 18-inch CMP outfall draining truck stop parking lot (sequence number 277 in Appendix O)	--	--	--	--	--	Unknown	4,600	--	7, 57, 67	Medium
UOC-23	WQ, SWF	Boulevard median of S. 20th Street from W. Ryan Road to south of Ridgeview Drive	42.87192	-87.94217	City of Oak Creek	City of Oak Creek	Pilot Project – Installation of bioswales in about 1,140 feet of boulevard median to treat runoff from 50 percent of the boulevard (1.6 acres)[y]	1,523	2.5	0.02	--	--	City of Oak Creek	69,000	4,100	8, 12, 13, 14, 25, 31, 52, 57, 63, 66, 67	Medium
UOC-24	H	S. 20th Street culvert crossing of Oak Creek	42.86902	-87.94234	City of Oak Creek	City of Oak Creek	Approximately 8-foot-wide CMP arch culvert is likely undersized based on upstream and downstream ponding. Replace with a new appropriately sized culvert	--	--	--	--	--	City of Oak Creek	--	--	7, 57, 67	Low
UOC-25	WQ, H	Right bank of Oak Creek upstream of S. 20th Street[f]	42.86906	-87.94448	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 47 feet of Oak Creek with a slight lateral recession rate	200	0.1	--	0.2	0.4	City of Oak Creek	16,500	990	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-26	WQ, H	Right bank of Oak Creek downstream of S. 27th Street[f]	42.86959	-87.95002	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 62 feet of Oak Creek with a moderate lateral recession rate	2,400	0.7	--	1.9	3.9	City of Oak Creek	21,700	1,300	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-27	WQ, H	Right bank of Oak Creek downstream of S. 27th Street[f]	42.86964	-87.95052	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 66 feet of Oak Creek with a moderate lateral recession rate	2,400	0.7	--	1.9	3.7	City of Oak Creek	23,100	1,390	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-28	H	S. 27th Street culvert crossing of Oak Creek	42.86970	-87.95109	City of Oak Creek	City of Oak Creek and WisDOT	Reinforce existing sediment bar at inlet of north cell to continue to direct fair-weather flow to the south cell and maintain sufficient water depths for fish passage but allow flow into north cell during high flow events	--	--	--	--	--	City of Oak Creek and WisDOT	--	--	7, 9, 11, 21, 25, 45, 48, 49, 52	Medium
UOC-29	H	Oak Creek about 740 feet upstream of S. 27th Street	42.87077	-87.95401	City of Franklin	Straddling Franklin Hotel Company LLC and Halquist Brothers R/E Partnership	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City of Franklin, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
UOC-30	H	31st Street culvert crossing of Oak Creek	42.87043	-87.95607	City of Franklin	City of Franklin	One cell of the two-cell structure appears to be sufficient for the majority of flow conditions and sediment accumulation and shallow water depths may make fish passage difficult during low-flow conditions. Retrofit channel at culvert inlet to direct flow during fair-weather conditions to one cell and allow flow into the second cell when needed during high flows	--	--	--	--	--	City of Franklin	--	--	28, 32, 57, 63, 65, 67	High
UOC-31	H	Oak Creek about 250 feet downstream of S. 31st Street	42.87023	-87.95716	City of Franklin	Private landowner	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City of Franklin, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
UOC-32	WQ, H	Right bank of Oak Creek upstream of S. 31st Street[f]	42.87001	-87.95788	City of Franklin	Private landowner	Bank stabilization to address bank erosion along 90 feet of Oak Creek with a moderate lateral recession rate	3,800	1.2	--	3.1	6.2	Private landowner	31,500	1,890	7, 8, 11, 27, 49	Medium
UOC-33	WQ, H	Left bank of Oak Creek upstream of S. 31st Street[f]	42.86996	-87.95843	City of Franklin	Private landowner	Bank stabilization to address bank erosion along 40 feet of Oak Creek with a moderate lateral recession rate	1,600	0.5	--	1.2	3.5	Private landowner	14,000	840	7, 8, 11, 27, 49	Low
UOC-34	H	Oak Creek about 650 feet downstream of S. 31st Street	42.87001	-87.95856	City of Franklin	Private landowner	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City of Franklin, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49,	Medium
UOC-35	WQ, H	Left bank of Oak Creek downstream of S. 35th Street[f]	42.86998	-87.95915	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 86 feet of Oak Creek with a moderate lateral recession rate	3,600	1.1	--	3.0	5.9	Milwaukee County	30,100	1,810	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-36	H, WQ, SWF	Oak Creek mainstem downstream of S. 35th Street	42.86999	-87.95949	City of Franklin	Milwaukee County	Stream channel and riparian restoration of about 500 feet of channel and 5 acres of adjacent open space land[z]	--	--	--	--	--	Milwaukee County	--[l]	--	7, 9, 10, 21, 22, 25, 30, 39, 49, 52, 58	Medium
UOC-37	WQ, H	Right bank of Oak Creek downstream of S. 35th Street[f]	42.87000	-87.95956	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 42 feet of Oak Creek with a moderate lateral recession rate	1,400	0.4	--	1.2	2.3	Milwaukee County	14,700	880	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-38	WQ, H	Both banks of Oak Creek downstream of S. 35th Street	42.86995	-87.95996	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 24 feet of Oak Creek with a moderate lateral recession rate	800	0.2	--	0.6	1.3	Milwaukee County	8,100	480	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-39	WQ, H	Left bank of Oak Creek downstream of S. 35th Street[f]	42.86985	-87.96005	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 154 feet of Oak Creek with a severe lateral recession rate	18,800	5.8	--	15.1	30.2	Milwaukee County	53,900	3,230	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-40	H	35th Street culvert crossing of Oak Creek	42.86990	-87.96044	City of Franklin	City of Franklin	Culvert is a likely impediment to fish passage due to sediment accumulation, rock placement and water flowing through the seams of the culvert wall. Seal culvert wall joints; add grade control downstream to provide sufficient water depths through the culvert and stability for the culvert and streambank; add strategically placed cobble and boulder substates within culvert cells along both walls to provide resting areas for passing fish; rearrange rock placement downstream of culvert	--	--	--	--	--	City of Franklin	--	--	28, 32, 57, 63, 65, 67	High
UOC-41	H	Oak Creek 120 feet downstream of S. 35th Street	42.87002	-87.96105	City of Franklin	Milwaukee County	Remove or modify large woody debris jam for better aquatic organism passage	--	--	--	--	--	MMSD, City of Franklin, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
UOC-42	WQ, H	Right bank of Oak Creek upstream of S.35th Street within Oakwood Park[f]	42.87010	-87.96163	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 42 feet of Oak Creek with a moderate lateral recession rate	400	0.2	--	0.5	1.1	Milwaukee County	14,700	880	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-43	WQ, H	Left bank of Oak Creek upstream of S.35th Street within Oakwood Park[f]	42.87020	-87.96202	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 38 feet of Oak Creek with a moderate lateral recession rate	1,600	0.5	--	1.3	2.6	Milwaukee County	13,300	800	8, 9, 22, 25, 49, 52, 58, 67	Low
UOC-44	WQ, H	Right bank of Oak Creek upstream of S.35th Street within Oakwood Park[f]	42.87025	-87.96216	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 10 feet of Oak Creek with a severe lateral recession rate	2,400	0.7	--	1.9	3.8	Milwaukee County	3,500	210	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-45	WQ, H	Left bank of Oak Creek upstream of S.35th Street within Oakwood Park[f]	42.87029	-87.96239	City of Franklin	Milwaukee County	Bank stabilization to address bank erosion along 11 feet of Oak Creek with a severe lateral recession rate	1,200	0.4	--	1.0	1.9	Milwaukee County	3,900	230	8, 9, 22, 25, 49, 52, 58, 67	Medium
UOC-46	WQ, H	Left bank of Oak Creek upstream of S.35th Street[f]	42.87036	-87.96254	City of Franklin	Unknown	Repair or replace failing portion of 24-inch CMP outfall (sequence number 285 in Appendix O)	--	--	--	--	--	Unknown	3,700	--	7, 57, 67	Medium
UOC-47	WQ, H	Left bank of Oak Creek downstream of W. Ryan Road upstream crossing[f]	42.87097	-87.96347	City of Franklin	Jubilee Faith Center, Inc.	Bank stabilization to address bank erosion along 16 feet of Oak Creek with a moderate lateral recession rate	600	0.2	--	0.5	1.0	Jubilee Faith Center, Inc.	5,600	340	7, 8, 11, 27, 49	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	**Management Action**	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	**Responsible Party**	Capital	Annual O&M	**Potential Funding Sources[d]**	**Priority[e]**
UOC-48	WQ, H	Left bank of Oak Creek downstream of W. Ryan Road upstream crossing[f]	42.87125	-87.96420	City of Franklin	Jubilee Faith Center, Inc. and Ryan Green Apartments, LLC	Bank stabilization to address bank erosion along 66 feet of Oak Creek with a moderate lateral recession rate	1,600	0.5	--	1.2	2.5	Jubilee Faith Center, Inc. and Ryan Green Apartments, LLC	23,100	1,390	7, 8, 11, 27, 49	Low
UOC-49	H	W. Ryan Road upstream culvert crossing of Oak Creek	42.87260	-87.96461	City of Franklin	City of Franklin	Investigate potential for improved fish passage with addition of downstream grade control to improve water depths through the culvert during low-flow periods; add strategically placed cobble and boulder substrates along both culvert walls to provide resting areas for passing fish	--	--	--	--	--	WisDOT and City of Franklin	--	--	28, 32, 57, 63, 65, 67	Medium
Oak Creek Headwaters Assessment Area (OCH)																	
OCH-01	H	Concrete drop structure No. 1 upstream from W. Ryan Road upstream crossing	42.87484	-87.96482	City of Franklin	National Venture Corporation	Drop structure completely blocks flow during fair weather except for flow through cracks in the structure. Remove drop structure to improve fish passage[aa]	--	--	--	--	--	MMSD and National Venture Corporation	--	--	7, 9, 11, 21, 25, 27, 28 30, 45, 48, 49, 52, 57, 63, 65, 67	Medium
OCH-02	H	Southwood Drive culvert crossing of Oak Creek	42.87650	-87.96574	City of Franklin	City of Franklin	Sediment accumulation at one point in the culvert constricts flow and water depths such that depth in the culvert may be insufficient for fish passage during low flow periods. Consider downstream grade control to provide sufficient water depth and adding strategically placed cobble and boulder substrates along both culvert walls of each culvert cell to provide resting areas for passing fish	--	--	--	--	--	City of Franklin	--	--	7, 9, 11, 21, 25,45, 48, 49, 52, 60	Medium
OCH-03	H	Concrete drop structure No. 2 upstream from W. Southwood Drive	42.87699	-87.96620	City of Franklin	National Venture Corporation	Drop structure completely blocks flow during fair-weather flow conditions. Remove drop structure to improve fish passage[aa]	--	--	--	--	--	MMSD and National Venture Corporation	--	--	7, 9, 11, 21, 25, 27,28, 30, 45, 48, 49, 52, 63, 65, 67	Medium
OCH-04	H	Concrete drop structure No. 3 upstream from W. Southwood Drive	42.87794	-87.96662	City of Franklin	National Venture Corporation	Drop structure is perched about 18 inches above downstream water surface. Remove drop structure to improve fish passage[aa]	--	--	--	--	--	MMSD and National Venture Corporation	--	--	7, 9, 11, 21, 25, 27, 28, 30, 45, 48, 49, 52, 63, 65, 67	Medium
OCH-05	WQ, R	Oak Creek at Martinson Drive (extended)	42.87828	-87.96669	City of Franklin	City of Franklin	Investigate and remedy source of canine fecal contamination to outfall (sequence number 295 in Appendix O)	--	--	--	--	--	City of Franklin	--	--	10, 22, 52, 57, 65, 67	High
OCH-06	H	Oak Creek about 915 feet upstream of W. Southwood Drive	42.87893	-87.96650	City of Franklin	Natural Venture Corporation	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Franklin, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
OCH-07	H, WQ, SWF	Oak Creek from Glenwood Drive to downstream of STH 100	42.87917	-87.96618	City of Franklin	Natural Venture Corporation and private landowners	Consider regenerative stormwater conveyance restoration using a series of shallow pools, riffle grade controls, native vegetation, and underlying woodchip or gravel beds to address streambed and bank erosion and incised channels.[bb]	--	--	--	--	--	Natural Venture Corporation and private landowners	--[cc]	--	6, 7, 9, 11, 21, 25, 27, 28, 30, 45, 48, 49, 52, 67	Medium
OCH-08	H	Concrete drop structure No. 4 upstream from W. Southwood Drive	42.87961	-87.96595	City of Franklin	Natural Venture Corporation	Drop structure blocks most stream flow during fair-weather flow conditions. Remove drop structure to improve fish passage[aa]	--	--	--	--	--	MMSD and National Venture Corporation	--	--	7, 9, 11, 21, 25, 27, 28, 30, 45, 48, 49, 52, 63, 65, 67	Medium
OCH-09	WQ, H	Left bank of Oak Creek downstream from W. Woodward Drive[f]	42.88035	-87.96608	City of Franklin	Private landowner	Bank stabilization to address bank erosion along 22 feet of Oak Creek with a moderate lateral recession rate	800	0.3	--	0.7	1.4	Private landowner	7,700	460	7, 8, 11, 27, 49	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
OCH-10	WQ, H	Both banks of Oak Creek at W. Woodward Drive	42.80866	-87.96600	City of Franklin	Private landowner	Bank stabilization to address bank erosion along 298 feet of Oak Creek with a severe lateral recession rate	57,2000	17.6	--	45.8	91.5	Private landowner	104,300	6,260	7, 8, 11, 27, 49	High
OCH-11	H	Oak Creek downstream of W. Southland Drive culvert crossing	42.88101	-87.96615	City of Franklin	City of Franklin	Culvert is passable for fish, but a large accumulation of rock downstream is a likely obstruction for some species, Re-arrange the rock downstream from the culvert to improve fish passage	--	--	--	--	--	City of Franklin	--	--	7, 9, 11, 21, 25, 45, 48, 49, 52	Medium
OCH-12	WQ, H	Both banks of Oak Creek upstream of W. Southland Drive	42.881491	-87.96619	City of Franklin	Private landowner	Bank stabilization to address bank erosion along 428 feet of Oak Creek with a severe lateral erosion rate.	87,400	26.9	--	69.8	139.7	Private landowner	149,800	8,990	7, 8, 11, 27, 49	High
Lower Mitchell Field Drainage Ditch Assessment Area (LMF)																	
LMF-01	WQ, H	Left bank of Mitchell Field Drainage Ditch just upstream of confluence with Oak Creek[f]	42.90535	-87.89140	City of Oak Creek	Wisconsin Electric Power Company	Bank stabilization to address bank erosion along 43 feet of the Mitchell Field Drainage Ditch with a severe lateral recession rate	12,400	3.8	--	9.9	19.8	Wisconsin Electric Power Company	15,100	900	7, 8, 11, 27, 49	Medium
LMF-02	WQ, H	Left bank of Mitchell Field Drainage Ditch upstream of confluence with Oak Creek[f]	42.90570	-87.89135	City of Oak Creek	Wisconsin Electric Power Company	Bank stabilization to address bank erosion along 41 feet of the Mitchell Field Drainage Ditch with a severe lateral recession rate	14,800	4.5	--	11.8	23.6	Wisconsin Electric Power Company	14,400	860	7, 8, 11, 27, 49	Medium
LMF-03	H	Michell Field Drainage Ditch about 300 feet upstream of confluence with Oak Creek	42.90579	-87.89144	City of Oak Creek	Wisconsin Electric Power Company	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMF-04	WQ, H	Left bank of Mitchell Field Drainage Ditch upstream of confluence with Oak Creek[f]	42.90611	-87.89130	City of Oak Creek	Wisconsin Electric Power Company	Bank stabilization to address bank erosion along 68 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	3,800	1.1	--	3.0	5.9	Wisconsin Electric Power Company	23,800	1,430	7, 8, 11, 27, 49	Medium
LMF-05	WQ, H	Right bank of Mitchell Field Drainage Ditch just downstream of Union Pacific Railroad crossing[f]	42.90664	-87.87114	City of Oak Creek	Wisconsin Electric Power Company	Bank stabilization to address bank erosion along 38 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	1,200	0.4	--	0.9	1.9	Wisconsin Electric Power Company	13,300	800	7, 8, 11, 27, 49	Low
LMF-06	WQ	Subbasin M5-7 east of the intersection of S. Clement Avenue and E. Montana Avenue	42.90735	-87.89424	City of Oak Creek	City of Oak Creek	Install 1.02-acre wet retention pond WQ-25	32,981	--	--	--	--	City of Oak Creek	200,700	8,030	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	High
LMF-07	H	Mitchell Field Drainage Ditch about 700 feet upstream of Union Pacific Railroad Crossing	42.90883	-87.89283	City of Oak Creek	Milwaukee County and Private landowner	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMF-08	H	Mitchell Field Drainage Ditch about 1,030 feet upstream of Union Pacific Railroad Crossing	42.90974	-87.89277	City of Oak Creek	Milwaukee County and Private landowner	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMF-09	WQ, H	Right bank of Mitchell Field Drainage Ditch upstream of Union Pacific Railroad crossing[f]	42.90987	-87.89267	City of Oak Creek	Private landowner	Bank stabilization to address bank erosion along 37 feet of the Mitchell Field Drainage Ditch with a slight lateral recession rate	400	0.1	--	0.3	0.5	Private landowner	13,000	780	7, 8, 11, 27, 49	Low
LMF-10	H	Mitchell Field Drainage Ditch about 1,750 feet upstream of Union Pacific Railroad Crossing	42.91091	-87.89271	City of Oak Creek	Milwaukee County and Private landowner	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LMF-11	H	Mitchell Field Drainage Ditch about 340 feet downstream of E. Rawson Avenue	42.91430	-87.89264	City of Oak Creek	Milwaukee County and Private landowner	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Medium
LMF-12	WQ, H	Right bank of Mitchell Field Drainage Ditch just downstream of E. Rawson Avenue	42.91486	-87.89250	City of Oak Creek	Private landowner	Bank stabilization to address bank erosion along 28 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	1,000	0.3	--	0.9	1.7	Private landowner	9,800	590	7, 8, 11, 27, 49	Low
LMF-13	H, SWF	E. Rawson Avenue culvert crossing of Mitchell Field Drainage Ditch	42.91570	-87.89252	City of Oak Creek	Milwaukee County	Monitor beaver activity upstream and downstream of the culvert and remove any dams that may cause flooding of the road or nearby infrastructure as needed	--	--	--	--	--	Milwaukee County	--	--	--	Low
LMF-14	WQ, H	Left bank of Mitchell Field Drainage Ditch upstream of E. Rawson Avenue[f]	42.91715	-87.89189	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 29 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	1,000	0.3	--	0.7	1.4	Milwaukee County	10,500	610	8, 22, 25, 49, 52, 58, 67	Low
LMF-15	WQ	Subbasin MF-20 north of E Rawson Avenue, adjacent to the Mitchell Field Drainage Ditch	42.91874	-87.89235	City of Oak Creek	City of Oak Creek	Install 0.4-acre wet retention pond WQ-27	16,788	--	--	--	--	City of Oak Creek	89,900	3,600	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	Medium
LMF-16	WQ, H	Left bank of Mitchell Field Drainage Ditch upstream of E. Rawson Avenue[f]	42.92159	-87.89138	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 278 feet of the Mitchell Field Drainage Ditch with a slight lateral recession rate	600	0.3	--	0.7	1.3	Milwaukee County	97,300	5,840	8, 22, 25, 49, 52, 58, 67	Low
LMF-17	WQ, H	Left bank of Mitchell Field Drainage Ditch upstream of E. Rawson Avenue[f]	42.92221	-87.89132	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 97 feet of the Mitchell Field Drainage Ditch with a slight lateral recession rate	800	0.2	--	0.6	1.3	Milwaukee County	34,000	2,040	8, 22, 25, 49, 52, 58, 67	Low
LMF-18	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	4.92421	-87.89056	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 143 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	6,600	2.1	--	5.4	10.7	Milwaukee County	50,100	3,000	8, 22, 25, 49, 52, 58, 67	Medium
LMF-19	WQ	Subbasin M3-2 south of E. College Avenue, adjacent to Mitchell Field Drainage Ditch	42.92455	-87.89091	City of Oak Creek	City of Oak Creek	Install 0.52-acre wet retention pond WQ-24	16,301	--	--	--	--	City of Oak Creek	113,200	4,500	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	Medium
LMF-20	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	42.92465	-87.89051	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 50 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	2,000	0.6	--	1.6	3.1	Milwaukee County	1,800	110	8, 22, 25, 49, 52, 58, 67	Medium
LMF-21	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	42.92506	-87.89052	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 52 feet of the Mitchell Field Drainage Ditch with a severe lateral recession rate	7,400	2.3	--	6.0	12.0	Milwaukee County	18,200	1,090	8, 22, 25, 49, 52, 58, 67	Medium
LMF-22	H	Mitchell Field Drainage Ditch about 1,770 feet downstream of E. College Avenue	42.92509	-87.89055	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
LMF-23	H, WQ, SWF	Mitchell Field Drainage Ditch from about 1,000 feet upstream from the confluence with Oak Creek to E. College Avenue	42.92510	-87.89047	Cities of Oak Creek and Milwaukee	Milwaukee County, City of Milwaukee, and Private landowners	Stream channel and riparian restoration of about 8,500 feet of channel[dd]	--	--	--	--	--	Milwaukee County, City of Oak Creek MMSD,, Private landowners	--[l]	--	7, 8, 9, 10, 21, 22, 25, 27, 28, 30, 39, 49, 52, 58	High
LMF-24	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	42.92546	-87.89047	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 140 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	5,400	1.7	--	4.4	8.7	Milwaukee County	49,000	2,940	8, 9, 22, 25, 49, 52, 58, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information				Owner	Management Action	Annual Pollutant Reductions					Responsible Party	Costs (dollars)[c]		Potential Funding Sources[d]	Priority[e]
		Location	Latitude	Longitude	Municipality			TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)		Capital	Annual O&M		
LMF-25	WQ	Subbasin M2-2 south of E. College Avenue adjacent to Mitchell Field Drainage Ditch	42.92589	-87.89099	City of Oak Creek	City of Oak Creek	Install 0.47-acre wet retention pond WQ-23	20,404	--	--	--	--	City of Oak Creek	104,400	4,170	4, 6, 8, 12, 22, 25, 30, 45, 57, 58, 67	High
LMF-26	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	42.92667	-87.89041	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 94 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	5,200	1.6	--	4.1	8.2	Milwaukee County	32,900	1,970	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMF-27	WQ, H	Left bank of Mitchell Field Drainage Ditch downstream of E. College Avenue[f]	42.92859	-87.89032	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 45 feet of the Mitchell Field Drainage Ditch with a moderate lateral recession rate	2,200	0.6	--	3.4	1.7	Milwaukee County	15,800	950	8, 9, 22, 25, 49, 52, 58, 67	Medium
LMF-28	H	Mitchell Field Drainage Ditch about 130 feet downstream of E. College Avenue	42.92953	-87.89037	City of Oak Creek	Milwaukee County	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
LMF-29	H	Milwaukee County Parks Cudahy Nature Preserve Management Unit 1	42.92940	-87.90363	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive monitoring and select control on 15.5 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	9.500	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
LMF-30	H	Milwaukee County Parks Cudahy Nature Preserve Management Units 2 and 3	42.92769	-87.90418	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive monitoring and select control on 9.7 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	6,300	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
LMF-31	H	Milwaukee County Parks Cudahy Nature Preserve Management Unit 4	42.92406	-87.90617	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive monitoring and select control on 17.0 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	10,300	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
LMF-32	H, WQ	Privately-owned woodlands adjacent to the southwest corner of Cudahy Nature Preserve	42.92432	-87.90616	City of Oak Creek	Private landowner	Voluntary acquisition of 5.2-acre woodland adjacent to Management Unit 4 of the preserve[ee]	--	--	--	--	--	Milwaukee County and Watershed partners	--	--	11, 20, 35, 38, 45, 49, 60, 61	Low
LMF-33	H, WQ	Privately-owned wetland/woodland complex adjacent to the northwest corner of Cudahy Nature Preserve	42.92921	-87.90639	City of Oak Creek	Private landowner	Voluntary acquisition of 11.7-acre woodland/wetland complex adjacent to Management Unit 1 of the preserve[ff]	--	--	--	--	--	Milwaukee County and Watershed partners	--	--	11, 20, 35, 38, 45, 49, 60, 61	Low
LMF-34	H	Cluster of woodlands adjacent to the Runway Dog Park and directly southeast of Cudahy Nature Preserve	42.92155	-87.89629	City of Oak Creek	Milwaukee County	Extend the intergovernmental agreement between MMIA and DPRC for Runway Dog Park to include this 30.1-acre cluster of woodlands, allowing DPRC staff to control invasive species in the woodlands	--	--	--	--	--	Milwaukee County	--	--	26, 61	Medium
Mitchell Field Drainage Ditch-Airport Assessment Area (MFA)																	
MFA-01	H, SWF	E. College Avenue Crossing of Mitchell Field Drainage Ditch	42.93017	-87.88993	City of Milwaukee	Milwaukee County	Remove accumulated sediment and debris from the upstream end of the culvert and monitor sediment accumulation	--	--	--	--	--	Milwaukee County	--	--	11, 22, 24, 25, 48, 51, 52, 57	Medium
MFA-02	WQ, SWF	Milwaukee Mitchell International Airport	42.93827	-87.90299	City of Milwaukee	Milwaukee County-MMIA	Install rain gardens, green roofs, infiltration features, and other stormwater management features to reduce stormwater runoff throughout the airport	--	--	--	--	--	Milwaukee County-MMIA	--	--	6, 8, 11, 12, 13, 14, 25, 45, 52, 57, 63, 67	Medium
MFA-03	WQ, SWF	Milwaukee Mitchell International Airport	42.93827	-87.90299	City of Milwaukee	Milwaukee County-MMIA	Develop green infrastructure policy and/or design and construction guidelines for green infrastructure	--	--	--	--	--	Milwaukee County-MMIA	--	--	13, 14, 57, 67	Medium
MFA-04	WQ	Milwaukee Mitchell International Airport	42.93418	-87.90300	City of Milwaukee	Milwaukee County-MMIA	Train onsite airport personnel in pollution prevention procedures and make the stormwater management plan available at construction sites for review	--	--	--	--	--	Milwaukee County-MMIA	--	--	22,43, 57, 65, 67	Medium
MFA-05	WQ	Milwaukee Mitchell International Airport	42.93418	-87.90300	City of Milwaukee	Milwaukee County-MMIA	Ensure that construction sites are inspected frequently to ensure compliance with the stormwater management plan	--	--	--	--	--	Milwaukee County-MMIA	--	--	57, 66, 65, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information				Owner	Management Action	Annual Pollutant Reductions					Responsible Party	Costs (dollars)[c]		Potential Funding Sources[d]	Priority[e]
		Location	Latitude	Longitude	Municipality			TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)		Capital	Annual O&M		
MFA-06	WQ	Milwaukee Mitchell International Airport	42.93418	-87.90300	City of Milwaukee	Milwaukee County-MMIA	Coordinate stormwater management plan elements with airport tenant plans	--	--	--	--	--	Milwaukee County-MMIA	--	--	--	Medium
MFA-07	WQ	Milwaukee Mitchell International Airport	42.93418	-87.90300	City of Milwaukee	Milwaukee County-MMIA	Continue evaluation BMPs and use of technologies to reduce unnecessary deicing	--	--	--	--	--	Milwaukee County-MMIA	--	--	57, 65, 67	Medium
Lower North Branch of Oak Creek Assessment Area (LNB)																	
LNB-01	WQ, H	Left bank of North Branch of Oak Creek upstream of confluence with Oak Creek[f]	42.87537	-87.92304	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 68 feet of North Branch of Oak Creek with a severe lateral recession rate	12,200	3.8	--	9.8	19.6	Milwaukee County	23,800	1,430	8, 9, 22, 25, 49, 52, 58, 67	Medium
LNB-02	WQ, H	Right bank of North Branch of Oak Creek upstream of confluence with Oak Creek[f]	42.87595	-87.92309	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 279 feet of North Branch of Oak Creek with a moderate lateral recession rate	15,200	4.7	--	12.2	24.4	Milwaukee County	97,700	5,860	8, 9, 22, 25, 49, 52, 58, 67	Medium
LNB-03	H	North Branch of Oak Creek channel downstream of Canadian Pacific Railway crossing for about 400 feet	42.87622	-87.92330	City of Oak Creek	Canadian Pacific Railway, Milwaukee County[gg]	Channel bed erosion downstream of the culvert has caused about a 4-foot drop from the culvert to the downstream water surface. Retrofit the channel bed downstream from the culvert with a rock ramp with a slope of 1.5 percent to provide adequate slope for aquatic organism passage	--	--	--	--	--	Canadian Pacific Railway, Milwaukee County, Watershed partners	387,500	--	7, 9, 11, 21, 25, 27, 45, 48, 49, 52	High
LNB-04	WQ, H	Right bank of North Branch of Oak Creek downstream of Canadian Pacific Railway crossing[f]	42.87628	-87.92354	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 113 feet of North Branch of Oak Creek with a severe lateral recession rate	17,600	5.4	--	14.1	28.2	Milwaukee County	39,600	2,370	8, 9, 22, 25, 49, 52, 58, 67	High
LNB-05	WQ, H	Left bank of North Branch of Oak Creek downstream of Canadian Pacific Railway crossing[f]	42.87628	-87.92354	City of Oak Creek	Milwaukee County	Bank stabilization to address bank erosion along 113 feet of North Branch of Oak Creek with a severe lateral recession rate	16,200	5.0	--	13.0	26.0	Milwaukee County	39,600	2,370	8, 9, 22, 25, 49, 52, 58, 67	High
LNB-06	H, SWF	North Branch of Oak Creek railroad culvert crossing 0.1 mile upstream from the confluence with Oak Creek	42.87638	-87.92368	City of Oak Creek	Canadian Pacific Railway	Conduct a detailed inspection and structural integrity analysis of the Canadian Pacific Railway culvert crossing of the North Branch of Oak Creek[hh]	--	--	--	--	--	Canadian Pacific Railway	25,000	--	28, 63	High
LNB-07	H, SWF	North Branch of Oak Creek railroad culvert crossing 0.1 mile upstream from the confluence with Oak Creek	42.87645	-87.82390	City of Oak Creek	Canadian Pacific Railway	If the inspection called for in LNB-06 shows that the structure is still serviceable, action should be taken to protect the culvert bedding and foundation from further undermining and to halt flow of water under the culvert.[ii]	--	--	--	--	--	Canadian Pacific Railway	470,400	--	28, 46, 63	High
LNB-08	WQ, H	Right bank of North Branch of Oak Creek upstream of Canadian Pacific Railway crossing[f]	42.87886	-87.92448	City of Oak Creek	Aldi, Inc.	Bank stabilization to address bank erosion along 132 feet of North Branch of Oak Creek with a severe lateral recession rate	22,200	6.8	--	17.7	35.5	Aldi, Inc.	46,200	2,770	7, 8, 11, 27, 49	High
LNB-09	WQ, H	Right bank of North Branch of Oak Creek upstream of Canadian Pacific Railway crossing[f]	47.87985	-87.92467	City of Oak Creek	Riverview Estates Homeowner's Association	Bank stabilization to address bank erosion along 116 feet of North Branch of Oak Creek with a moderate lateral recession rate	2,800	0.9	--	2.3	4.6	Riverview Estates Homeowner's Association	40,600	2,440	7, 8, 11, 27, 49	Medium
LNB-10	WQ, H	Left bank of North Branch of Oak Creek upstream of Canadian Pacific Railway crossing[f]	42.88002	-87.92508	City of Oak Creek	Riverview Estates Homeowner's Association	Bank stabilization to address bank erosion along 266 feet of North Branch of Oak Creek with a slight lateral recession rate	200	0.0	--	0.1	0.2	Riverview Estates Homeowner's Association	9,100	550	7, 8, 11, 27, 49	Low
LNB-11	WQ, H	Left bank of North Branch of Oak Creek upstream of Canadian Pacific Railway crossing[f]	42.88033	-87.92538	City of Oak Creek	Riverview Estates Homeowner's Association	Bank stabilization to address bank erosion along 29 feet of North Branch of Oak Creek with a moderate lateral recession rate	1,000	0.3	--	0.7	1.4	Riverview Estates Homeowner's Association	10,200	610	7, 8, 11, 27, 49	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LNB-12	H	North Branch of Oak Creek upstream of W. York Street (extended)	42.88054	-87.92539	City of Oak Creek	Riverview Estates Homeowner's Association	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
LNB-13	H, WQ	Privately-owned natural areas northwest of Milwaukee County Parks Oak Creek Parkway Management Section 12	42.88074	-87.92431	City of Oak Creek	Private Landowners	Evaluate the interest of private landowners in voluntary acquisitions of wooded and natural portions of private property adjacent to Parkway Management Unit 12[jj]	--	--	--	--	--	Milwaukee County and Watershed partners	--	--	11, 20, 35, 38, 45, 49, 60, 61	Low
LNB-14	H	North Branch of Oak Creek downstream of W. Potomac Drive (extended)	42.88123	-87.92470	City of Oak Creek	Riverview Estates Homeowner's Association	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
LNB-15	WQ, H	Right bank of North Branch of Oak Creek downstream of W. Puetz Road within Hunter's Run Condominiums	42.88616	-87.92391	City of Oak Creek	Condominium Owners	Bank stabilization to address bank erosion along 43 feet of North Branch of Oak Creek with a slight lateral recession rate	200	0.1	--	0.2	0.3	Condominium Owners	15,100	900	7, 8, 11, 27, 49	Low
LNB-16	H	W. Puetz Road culvert crossing of North Branch of Oak Creek	42.88683	-87.92434	City of Oak Creek	City of Oak Creek	Culvert has been replaced since SEWRPC survey was completed. A new fish passage assessment should be conducted of the culvert	--	--	--	--	--	City of Oak Creek	--	--	48	Low
LNB-17	H, WQ	North Branch of Oak Creek upstream of W. Puetz Road	42.88742	-87.92415	City of Oak Creek	City of Oak Creek	Discontinue mowing to bank of North Branch of Oak Creek; establish a vegetated riparian buffer with a minimum 75-foot width from each stream bank or to the extent allowable based on existing development (about 2.0 acres); manage for invasive species	--	--	--	--	--	City of Oak Creek	8,400	--	11, 16, 19, 26	Medium
LNB-18	WQ, H	Left bank of Oak Creek upstream of W. Puetz Road at City of Oak Creek DPW[f]	42.90773	-87.92409	City of Oak Creek	Unknown	Repair or replace failing portion of 15-inch RCP (sequence number 185 in Appendix O)	--	--	--	--	--	Unknown	2,700	--	7, 57, 67	Medium
LNB-19	WQ, H	Right bank of Oak Creek upstream of W. Puetz Road at City of Oak Creek DPW[f]	42.88827	-87.92360	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 50 feet of North Branch of Oak Creek with a moderate lateral recession rate	2,000	0.6	--	1.6	3.1	City of Oak Creek	17,500	1,100	8, 9, 22, 25, 49, 52, 58, 67	Medium
LNB-20	WQ, H	Right bank of Oak Creek upstream of W. Puetz Road at City of Oak Creek DPW[f]	42.88982	-87.92361	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 58 feet of North Branch of Oak Creek with a moderate lateral recession rate	1,800	0.6	--	1.4	2.9	City of Oak Creek	20,300	1,220	8, 9, 22, 25, 49, 52, 58, 67	Low
LNB-21	WQ, H	Left bank of Oak Creek upstream of W. Puetz Road at City of Oak Creek DPW[f]	42.89001	-87.92449	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 130 feet of North Branch of Oak Creek with a moderate lateral recession rate	6,000	1.9	--	4.9	9.7	City of Oak Creek	45,500	2,730	8, 9, 22, 25, 49, 52, 58, 67	Medium
LNB-22	WQ, H	Right bank of North Branch of Oak Creek at Willow Heights Park[f]	42.89468	-87.82549	City of Oak Creek	Unknown	Repair or replace failing portion of 24-inch corrugated plastic pipe outfall (sequence number 188 in Appendix O)	--	--	--	--	--	Unknown	3,700	--	7, 57, 67	Medium
LNB-23	H,WQ, SWF	North Branch of Oak Creek through Willow Heights Park and to 700 feet downstream of the park	42.89531	-87.92655	City of Oak Creek	City of Oak Creek	Stream channel and riparian restoration of about 1,950 feet of channel[kk]	--	--	--	--	--	City of Oak Creek	--[l]	--	7, 9, 10, 21, 22, 25, 30, 39, 49, 52, 58	Low
LNB-24	WQ, H	Left bank of North Branch of Oak Creek downstream of Weatherly Drive in Willow Heights Park	42.89543	-87.92684	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 43 feet of North Branch of Oak Creek with a moderate lateral recession rate	1,600	0.5	--	1.3	2.6	City of Oak Creek	15,100	900	8, 22, 25, 49, 52, 58, 67	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
LNB-25	H	Weatherly Drive bridge over North Branch of Oak Creek	42.89675	-87.92767	City of Oak Creek	City of Oak Creek	Newly constructed bridge is a good model for a "fish friendly" crossing design; however, excessive rock placed across the channel under the crossing likely creates a fish passage impediment. Rock should be re-arranged to allow for better passage lanes.	--	--	--	--	--	City of Oak Creek	--	--	--	Medium
LNB-26	H, WQ	North Branch of Oak Creek from confluence with Drexel Avenue Tributary to W. Drexel Avenue crossing	42.89922	-87.92608	City of Oak Creek	City of Oak Creek	Establish new or expand existing riparian buffer to a minimum of 75 feet from each streambank or to the extent allowable based on existing development constraints (about 5.3 acres). Manage invasive species	--	--	--	--	--	City of Oak Creek	22,100	--	4, 7,10, 11, 15, 20, 22, 24, 25, 26, 45, 49, 52, 57, 58, 67	Medium
LNB-27	WQ, H	Right bank of North Branch of Oak Creek downstream of W. Drexel Avenue[f]	42.90035	-87.92417	City of Oak Creek	City of Oak Creek	Repair or replace failing portion of 36-inch RCP outfall (sequence number 192 in Appendix O)	--	--	--	--	--	City of Oak Creek	5,000	--	7, 57, 67	High
LNB-28	H	W. Drexel Avenue culvert crossing of North Branch of Oak Creek	42.90133	-87.92365	City of Oak Creek	City of Oak Creek	Monitor beaver activity and remove dams if the begin to affect structure	--	--	--	--	--	City of Oak Creek	--	--	--	Low
LNB-29	WQ, SWF	Boulevard median of W. Drexel Avenue from S. 10th Street east to the crossing of North Branch of Oak Creek	42.90152	-87.92646	City of Oak Creek	City of Oak Creek	Pilot Project – Installation of bioswales in about 630 feet of W. Drexel Avenue to treat 50 percent of the boulevard (1.0 acre)[y]	432	0.8	0.02	--	--	City of Oak Creek	38,000	2,200	8, 12, 13, 14,25, 27, 31, 52, 57, 63, 67	High
LNB-30	WQ, H	Left bank of North Branch of Oak Creek upstream of S. 6th Street[f]	42.90271	-87.92936	City of Oak Creek	City of Oak Creek	Repair or replace failing portion of 21-inch CMP outfall (sequence number 193 in Appendix O)	--	--	--	--	--	City of Oak Creek	3,400	--	7, 57, 67	Medium
LNB-31	WQ, H	Right bank of North Branch of Oak Creek upstream of S. 6th Street and adjacent to Oak Creek Little League Complex[f]	42.90286	-87.91690	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 67 feet of North Branch of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.6	City of Oak Creek	23,500	1,410	8, 9, 22, 25, 49, 52, 58, 67	Low
LNB-32	WQ, H	Right bank of North Branch of Oak Creek upstream of S. 6th Street and adjacent to Oak Creek Little League Complex[f]	42.90299	-87.91626	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 131 feet of North Branch of Oak Creek with a moderate lateral recession rate	3,600	1.1	--	2.9	5.7	City of Oak Creek	45,900	2,750	8, 9, 22, 25, 49, 52, 58, 67	Medium
LNB-33	H, WQ, SWF	North Branch of Oak Creek from S. 6th Street upstream to confluence with Rawson Avenue Tributary	42.90355	-87.91539	City of Oak Creek	City of Oak Creek	Stream channel and riparian restoration of about 2,100 feet of channel[ll]	--	--	--	--	--	City of Oak Creek	--[l]	--	7, 9, 10, 21, 22, 25, 30, 39, 49, 52, 58, 60	Medium
LNB-34	WQ, H	Left bank of North Branch of Oak Creek upstream of S. 6th Street and adjacent to Oak Creek Little League Complex[f]	42.90475	-87.91514	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 89 feet of North Branch of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.6	City of Oak Creek	31,200	1,870	8, 9, 22, 25, 49, 52, 58, 67	Low
LNB-35	WQ, H	Left bank of North Branch of Oak Creek upstream of S. 6th Street and adjacent to Oak Creek Little League Complex[f]	42.90554	-87.91561	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 71 feet of North Branch of Oak Creek with a slight lateral recession rate	400	0.1	--	0.3	0.7	City of Oak Creek	24,900	1,490	8, 9, 22, 25, 49, 52, 58, 67	Low
Upper North Branch of Oak Creek Assessment Area (UNB)																	
UNB-01	WQ, H	Left bank of North Branch of Oak Creek downstream of W. Marquette Avenue[f]	42.90746	-87.91526	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 62 feet of North Branch of Oak Creek with a moderate lateral recession rate	1,800	0.6	--	1.5	2.9	City of Oak Creek	21,700	1,300	8, 9, 22, 25, 49, 52, 58, 67	Low
UNB-02	WQ, H	Left bank of North Branch of Oak Creek downstream of W. Marquette Avenue[f]	42.90761	-87.91537	City of Oak Creek	Unknown	Repair or replace failing portion of 18-inch CMP outfall (sequence number 228 in Appendix O)	--	--	--	--	--	Unknown	2,300	--	7, 57, 67	Medium

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information				Owner	Management Action	Annual Pollutant Reductions					Responsible Party	Costs (dollars)[c]		Potential Funding Sources[d]	Priority[e]
		Location	Latitude	Longitude	Municipality			TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)		Capital	Annual O&M		
UNB-03	H	W. Marquette Avenue bridge crossing of North Branch of Oak Creek	42.90901	-87.91522	City of Oak Creek	City of Oak Creek	Water levels may be insufficient for fish passage during low-flow conditions. Retrofitting a "low-flow channel" with a narrower channel width would promote sufficient water depths during average flow conditions while allowing overflow into a second "tiers" when higher flows occur	--	--	--	--	--	City of Oak Creek	--	--	21, 25, 28, 45, 52, 58	Low
UNB-04	H	Right bank of North Branch of Oak Creek upstream of W. Marquette Avenue[f]	42.91057	-87.91507	City of Oak Creek	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 232 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-05	H	Left bank of North Branch of Oak Creek upstream of W. Marquette Avenue[f]	42.91078	-87.91511	City of Oak Creek	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 233 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-06	H	Left bank of North Branch of Oak Creek upstream of W. Marquette Avenue[f]	42.91109	-87.91514	City of Oak Creek	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 234 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-07	H	Right bank of North Branch of Oak Creek upstream of W. Marquette Avenue[f]	42.91141	-87.91501	City of Oak Creek	Unknown	Repair or replace failing portion of corrugated plastic outfall (sequence number 235 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-08	H, WQ	North Branch of Oak Creek from confluence with Rawson Avenue Tributary upstream to S. 6th Street	42.91279	-87.91497	City of Oak Creek	City of Oak Creek	Establish a "no-mow" zone and establish new or expand existing riparian buffer along about 5,390 feet of stream to a minimum width of 75 feet from each stream bank or to the extent allowable based on existing development constraints (about 15.0 acres). Manage invasive species	--	--	--	--	--	City of Oak Creek	62,600	--	4, 7,10, 11, 15, 20, 22, 24, 25, 26, 45, 49, 52, 57, 58, 67	Medium
UNB-09	WQ, H	Right bank of North Branch of Oak Creek downstream of W. Rawson Avenue[f]	42.91367	-87.91490	City of Oak Creek	Unknown	Repair or replace failing portion of corrugated plastic outfall (sequence number 238 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-10	WQ, H	Right bank of North Branch of Oak Creek downstream of W. Rawson Avenue[f]	42.91388	-87.91489	City of Oak Creek	Unknown	Repair or replace failing portion of corrugated plastic outfall (sequence number 239 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-11	WQ, H	Right bank of North Branch of Oak Creek downstream of W. Rawson Avenue[f]	42.91422	-87.91488	City of Oak Creek	Unknown	Repair or replace failing portion of corrugated plastic outfall (sequence number 241 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-12	WQ, H	Left bank of North Branch of Oak Creek downstream of S. 6th Street	42.91465	-87.91511	City of Oak Creek	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 243 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-13	H, SWF	W. Rawson Avenue culvert crossing of North Branch of Oak Creek	42.91560	-87.91488	City of Oak Creek	City of Oak Creek	Monitor sediment accumulation and excavate excessive sediment when accumulation may become a fish passage impediment or lead to flooding of the road or nearby infrastructure	--	--	--	--		City of Oak Creek	--	--	11, 22, 24, 25, 48, 51, 52, 57	Low
UNB-14	WQ, H	Left bank of North Branch of Oak Creek downstream of W. Rawson Avenue[f]	42.91764	-87.91765	City of Oak Creek	Unknown	Repair or replace failing portion of corrugated plastic outfall (sequence number 242 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-15	H	North Branch of Oak Creek upstream from the S. 6th Street crossing	42.91869	-87.92036	City of Oak Creek	City of Oak Creek	Stream channel and riparian restoration of about 2,000 feet of channel[mm]	--	--	--	--		City of Oak Creek	--[l]	--	7, 9, 10, 21, 22, 25, 30, 39, 49, 52, 58	Low
UNB-16	WQ, H	Left bank of North Branch of Oak Creek across from United Parcel Service	42.92230	-87.92055	City of Oak Creek	Unknown	Repair or replace failing portion of 12-inch CMP outfall (sequence number 248 in Appendix O)	--	--	--	--	--	Unknown	2,100	--	7, 57, 67	Low
UNB-17	H	North Branch of Oak Creek 250 feet downstream of MATC driveway crossing	42.92351	-87.92050	City of Oak Creek	MATC	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
UNB-18	H	North Branch of Oak Creek 210 feet downstream of MATC driveway crossing	42.92364	-87.92049	City of Oak Creek	MATC	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
UNB-19	WQ	Right bank of North Branch of Oak Creek on MATC grounds behind baseball complex[f]	42.92374	-87.92013	City of Oak Creek	MATC	MATC winter deicing salt storage building is located only 50 east of North Branch of Oak Creek. Relocated the salt storage away from a waterway to reduce unintended chloride pollution	--	--	--	--	--	MATC	--	--	45, 57, 65, 67	Medium
UNB-20	H	MATC driveway culvert crossing of North Branch of Oak Creek	42.92437	-87.92037	City of Oak Creek	MATC	Remove large debris blockage at upstream side of the culvert that is causing a fish passage impediment	--	--	--	--	--	MATC	--	--	9, 21, 22, 25, 27, 32, 48, 49	Low
UNB-21	H	North Branch of Oak Creek at upstream end of MATC driveway crossing	42.92441	-87.92050	City of Oak Creek	MATC	Remove or modify large woody debris jam to allow for better aquatic organism passage	--	--	--	--	--	MMSD, City of Oak Creek, and Milwaukee County	--	--	9, 21, 22, 25, 32, 48, 49	Low
UNB-22	WQ, H	Right bank of North Branch of Oak Creek upstream of MATC campus[f]	42.92702	-87.92177	City of Oak Creek	City of Oak Creek	Bank stabilization to address bank erosion along 88 feet of Oak Creek with a moderate lateral recession rate	2.800	0.8	--	2.2	4.4	City of Oak Creek	30,800	1,850	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-23	H	Abandoned private crossing on North Branch of Oak Creek downstream of W. College Avenue	42.92714	-87.92185	City of Oak Creek	Private landowner	Steel structure is collapsing and collecting debris, causing a fish passage impediment. Structure is also a safety hazard. Remove the structure and stabilize streambanks to prevent erosion	--	--	--	--	--	Private landowner	--	--	12, 21, 25, 29 39, 46, 47	High
UNB-24	H	Abandoned private crossing on North Branch of Oak Creek downstream of W. College Avenue	42.92737	-87.92215	City of Oak Creek	Private landowner	Remove deteriorating steel bridge and stabilize streambanks to prevent erosion	--	--	--	--	--	Private landowner	--	--	12, 21, 25, 29 39, 46, 47	Medium
UNB-25	H	Abandoned private crossing on North Branch of Oak Creek downstream of W. College Avenue	42.92791	-87.92286	City of Oak Creek	Private landowner	Remove deteriorating steel bridge and stabilize streambanks to prevent erosion	--	--	--	--	--	Private landowner	--	--	12, 21, 25, 29 39, 46, 47	Medium
UNB-26	H	Abandoned private crossing on North Branch of Oak Creek downstream of W. College Avenue	42.92855	-87.92385	City of Oak Creek	Private landowner	Remove deteriorating steel bridge and stabilize streambanks to prevent erosion	--	--	--	--	--	Private landowner	--	--	12, 21, 25, 29 39, 46, 47	Medium
UNB-27	H, SWF	W. College Avenue culvert crossing of North Branch of Oak Creek	42.93073	-87.92636	City of Milwaukee	City of Milwaukee or WisDOT	There is heavy sediment accumulation just upstream of the culvert with water surface only 1.5 feet below the top of the culvert cell. Condition of the interior of the culvert is unknown. Culvert should be monitored for sediment accumulation and capacity to pass stream flow	--	--	--	--	--	City of Milwaukee or WisDOT	--	--	--	Low
UNB-28	H, SWF	S. 13th Street culvert crossing of North Branch of Oak Creek	42.93246	-87.92938	City of Milwaukee	City of Milwaukee	Condition of interior of three-cell corrugated metal culvert is unknown. Consider replacing with span bridge when time for replacement	--	--	--	--	--	City of Milwaukee	--	--	31, 39, 46, 47	Low
UNB-29	H, WQ	North Branch of Oak Creek through Maitland Park	42.93484	-87.93208	City of Milwaukee	Milwaukee County	At a minimum, establish new or expand existing riparian buffers to or beyond 75 feet from each streambank and manage invasive species[nn]	--	--	--	--	--	Milwaukee County	20,900	--	15, 20, 22, 24, 25, 26, 45, 49, 52, 57, 58, 67	Medium
UNB-30	H	S. 20th Street culvert crossing of North Branch of Oak Creek	42.94217	-87.93921	City of Milwaukee	City of Milwaukee or Milwaukee County	Debris accumulation within the pipe culverts at the upstream end are causing a fish passage impediment. Clear debris from culvert pipes	--	--	--	--	--	City of Milwaukee or Milwaukee County	--	--	11, 48, 49, 57	High

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
UNB-31	WQ, H	Left bank of North Branch of Oak Creek upstream of S. 20th Street in Copernicus Park[f]	42.94224	-87.93951	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 10 feet of North Branch of Oak Creek with a moderate lateral recession rate	400	0.1	--	0.3	0.6	Milwaukee County	3,500	210	8, 9, 22, 25, 49, 52, 58, 67	Low
UNB-32	WQ, H	Left bank of North Branch of Oak Creek upstream of S. 20th Street in Copernicus Park[f]	42.94230	-87.93970	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 25 feet of North Branch of Oak Creek with a severe lateral recession rate	4,800	1.5	--	3.8	7.7	Milwaukee County	8,800	530	8, 22, 25, 27, 49, 52, 58, 60, 67	Medium
UNB-33	WQ, H	Left bank of North Branch of Oak Creek downstream of footbridge in Copernicus Park[f]	42.94287	-87.94017	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 51 feet of North Branch of Oak Creek with a moderate lateral recession rate	2,400	0.7	--	1.9	3.8	Milwaukee County	17,900	7,070	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-34	WQ, H	Right bank of North Branch of Oak Creek downstream of footbridge in Copernicus Park[f]	42.94301	-87.94003	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 41 feet of North Branch of Oak Creek with a moderate lateral recession rate	2,000	0.6	--	1.5	3.1	Milwaukee County	14,400	860	8, 9, 22, 25, 49, 52, 58, 67	Low
UNB-35	WQ, H	Right bank of North Branch of Oak Creek downstream of footbridge in Copernicus Park[f]	42.94311	-87.93998	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 41 feet of North Branch of Oak Creek with a moderate lateral recession rate	2,600	0.8	--	2.0	4.1	Milwaukee County	14,400	860	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-36	WQ, H	North Branch of Oak creek throughout Copernicus Park from S. 20th Street upstream to the point the Creek daylights just south of W. Grange Avenue	42.94348	-87.94019	City of Milwaukee	Milwaukee County and City of Milwaukee	Consider regenerative stormwater conveyance restoration using a series of shallow pools, riffle grade controls, native vegetation, and underlying woodchip or gravel beds to address streambed and bank erosion and incised channels.	--	--	--	--	--	Milwaukee County and City of Milwaukee	--[cc]	--	6, 7, 9, 11, 21, 25, 28, 30, 45, 48, 49, 52, 67	Medium
UNB-37	WQ, H	Right bank of North Branch of Oak Creek upstream of footbridge in Copernicus Park[f]	42.94365	-87.94034	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 36 feet of North Branch of Oak Creek with a moderate lateral recession rate	1,800	0.6	--	2.9	1.5	Milwaukee County	12,600	760	8, 9, 22, 25, 49, 52, 58, 67	Low
UNB-38	WQ, H	Right bank of North Branch of Oak Creek upstream of footbridge in Copernicus Park[f]	42.94378	-87.94071	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 138 feet of North Branch of Oak Creek with a moderate lateral recession rate	6,400	2.0	--	10.3	5.2	Milwaukee County	48,300	2,900	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-39	WQ, H	Left bank of North Branch of Oak Creek upstream of footbridge in Copernicus Park[f]	42.94374	-87.94074	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 141 feet of North Branch of Oak Creek with a moderate lateral recession rate	6,400	2.0	--	10.6	5.3	Milwaukee County	49,400	2,960	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-40	WQ, H	Left bank of North Branch of Oak Creek downstream of North Branch of Oak Creek Outfall in Copernicus Park[f]	42.94388	-87.94155	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 196 feet of North Branch of Oak Creek with a moderate lateral recession rate	13,800	4.2	--	22.0	11.0	Milwaukee County	68,600	4,110	8, 9, 22, 25, 49, 52, 58, 67	Medium
UNB-41	WQ, H	Left bank of North Branch of Oak Creek downstream of North Branch of Oak Creek Outfall in Copernicus Park[f]	42.94409	-87.94212	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 145 feet of North Branch of Oak Creek with a severe lateral recession rate	31,400	9.6	--	50.1	25.1	Milwaukee County	50,800	3,050	8, 9, 22, 25, 49, 52, 58, 67	High
UNB-42	WQ, H	Right bank of North Branch of Oak Creek downstream of North Branch of Oak Creek Outfall in Copernicus Park[f]	42.94425	-87.94223	City of Milwaukee	Milwaukee County	Bank stabilization to address bank erosion along 45 feet of North Branch of Oak Creek with a severe lateral recession rate	8,600	2.7	--	13.8	6.9	Milwaukee County	15,800	950	8, 9, 22, 25, 49, 52, 58, 67	High
UNB-43	WQ, H	Downstream of W. Grange Avenue where North Branch of Oak Creek daylights in Copernicus Park	42.94426	-87.94238	City of Milwaukee	City of Milwaukee	Repair or replace failing portion of outfall where North Branch of Oak Creek daylights	--	--	--	--	--	City of Milwaukee	--	--	7, 57, 67	High
Drexel Avenue Tributary Assessment Area (DAT)																	
DAT-01	H, WQ	Milwaukee County Parks Falk Park Management Unit Number 8	42.90586	-87.94077	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 9.5 acres; reforestation of 1.3 acres; maintain wildlife exclusion barrier	--	--	--	--	--	Milwaukee County	9,300	--	11, 16, 19, 26, 35, 45, 51, 53	Low

Table 6.1 (Continued)

		Site Information						Annual Pollutant Reductions						Costs (dollars)[c]			
ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Location	Latitude	Longitude	Municipality	Owner	Management Action	TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
DAT-02	H, WQ	Woodland component of private residential property directly south of Milwaukee County Parks Falk Park Management Unit Number 4	42.90567	-87.94193	City of Oak Creek	Private landowner	Voluntary acquisition of 4.2-acre wooded component of residential partial directly south of Unit 4[oo]	--	--	--	--	--	Milwaukee County and Watershed partners	163,400	--	11, 20, 35, 38, 45, 49, 60, 61, 68	Low
DAT-03	H	Milwaukee County Parks Falk Park Management Unit Number 6	42.90490	-87.94411	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 3.7 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	4,300	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
DAT-04	H, WQ	Milwaukee County Parks Falk Park Management Unit Number 7	42.90278	-87.74535	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 16.8 acres; reforestation of 8.4 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	19,900	--	11, 16, 19, 26, 35, 45, 51, 53	High
DAT-05	H	Milwaukee County Parks Barloga Woods Management Unit Number 1	42.90077	-87.94186	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 8.8 acres;	--	--	--	--	--	Milwaukee County	17,300	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
DAT-06	H	Milwaukee County Parks Barloga Woods Management Unit Number 2	42.89877	-87.94615	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control; forest stand improvement on 5.1 acres	--	--	--	--	--	Milwaukee County	21,600	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
DAT-07	H	Milwaukee County Parks Barloga Woods Management Unit Number 3	42.89862	-87.94413	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 33.8 acres; inter-seeding native plants on 10 acres; reforestation on 1 acre; wildlife monitoring	--	--	--	--	--	Milwaukee County	120,000	--	11, 16, 19, 26, 35, 45, 51, 53	High
DAT-08	H, WQ	Milwaukee County Parks Barloga Woods Management Unit Number 4	42.89393	-87.94522	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 2.3 acres; shrub planting on 2.6 acres; wildlife monitoring	100	1.7	--	--	--	Milwaukee County	12.600	--	11, 16, 19, 26, 35, 45, 51, 53	Low
DAT-09	H	Milwaukee County Parks Barloga Woods Management Unit Number 5	42.89545	-87.93887	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control; forest stand improvement on 23.4 acres; inter-seeding native plants on 10 acres; reforestation on 1 acre; wild live monitoring	--	--	--	--	--	Milwaukee County	88,500	--	11, 16, 19, 26, 35, 45, 51, 53	High
DAT-10	H, WQ	Milwaukee County Parks Barloga Woods Management Unit Number 6	42.89904	-87.93808	City of Oak Creek	Milwaukee County	Invasive species control; invasive species monitoring and select control; reforestation of 18.0 acres; wildlife monitoring	32,040	12.0				Milwaukee County	61,700	--	11, 16, 19, 26, 35, 45, 51, 53	High
DAT-11	H	Milwaukee County Parks Barloga Woods Management Unit Number 6	42.89376	-87.93805	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control; forest stand improvement on 6.9 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	27,100	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
DAT-12	H, WQ	WisDOT property adjacent to the east of Barloga Woods Management Unit Number 5	42.89710	-87.93713	City of Oak Creek	WisDOT	Voluntary acquisition of 11.3-acre parcel containing the eastern section of ephemeral pond #4783[pp]	--	--	--	--	--	Milwaukee County, Watershed partners	--	--	8, 12, 25, 27, 49, 50, 52, 60, 57, 63, 65, 67	Low
Rawson Avenue Tributary Assessment Area (RAT)																	
RAT-01	H, SWF	Bridge crossing of Rawson Avenue Tributary at 7600 S. 6th Street	42.90722	-87.92000	City of Oak Creek	City of Oak Creek	As part of bridge replacement, consider removing concrete from adjacent stream channel	--	--	--	--	--	City of Oak Creek	400,000	--	21, 25, 28, 46, 57	High
RAT-02	WQ, R	Outfall discharging into tributary to Rawson Avenue Tributary south of W. Rawson Avenue	42.91274	-87.92693	City of Oak Creek	City of Oak Creek	Investigate and remedy source of human fecal contamination to outfall (sequence number 218 in Appendix O)	--	--	--	--	--	City of Oak Creek	--	--	7, 57, 67	High

Table 6.1 (Continued)

ID Number (see Maps 6.1 –6.13)[a]	Focus Areas Addressed[b]	Site Information: Location	Latitude	Longitude	Municipality	Owner	Management Action	Annual Pollutant Reductions: TSS (pounds)	Total Phosphorus (pounds)	Fecal Coliform Bacteria (trillion cells)	Total Nitrogen (pounds)	BOD (pounds)	Responsible Party	Costs (dollars)[c]: Capital	Annual O&M	Potential Funding Sources[d]	Priority[e]
RAT-03	WQ, R	Outfall discharging into tributary to Rawson Avenue Tributary south of W. Rawson Avenue	42.91403	-87.92677	City of Oak Creek	Unknown	Investigate and remedy source of human fecal contamination to outfall (sequence number 223 in Appendix O)	--	--	--	--	--	Unknown	--	--	7, 57, 67	High
RAT-04	WQ, R	Outfall discharging into tributary to Rawson Avenue Tributary south of W. Rawson Avenue	42.91407	-87.92689	City of Oak Creek	Unknown	Investigate and remedy source of human fecal contamination to outfall (sequence number 224 in Appendix O)	--	--	--	--	--	Unknown	--	--	7, 57, 67	High
RAT-05	H	Milwaukee County Parks Falk Park Management Unit Number 1	42.91543	-87.93799	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 8.0 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	7,300	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
RAT-06	H, WQ	Milwaukee County Parks Falk Park Management Unit Number 2	42.91331	-87.93741	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control; allowing succession to hardwood forest on 6.4 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	6,200	--	11, 16, 19, 26, 35, 45, 51, 53	High
RAT-07	H	Milwaukee County Parks Falk Park Management Unit Number 3	42.90928	-87.93858	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 14.2 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	11,700	--	11, 16, 19, 26, 35, 45, 51, 53	Medium
RAT-08	H	Milwaukee County Parks Falk Park Management Unit Number 4	42.91268	-87.94070	City of Oak Creek	Milwaukee County	Vegetation survey; invasive species control; invasive species monitoring and select control on 83 acres; reforestation of understory of 5 acres; forest stand improvement of 8.3 acres; wildlife monitoring	--	--	--	--	--	Milwaukee County	92.900	--	11, 16, 19, 26, 35, 45, 51, 53	High
RAT-09	H, WQ	Milwaukee County Parks Falk Park Management Unit Number 5	42.91005	-87.94280	City of Oak Creek	Milwaukee County	Convert leased agricultural land to hardwood forest and upland shrub habitat; vegetation survey; invasive species control; invasive species monitoring and select control; reforestation of 9.2 acres; wildlife monitoring, future wildlife exclusion barrier when development to the west occurs	16,830	6.3	--	--	--	Milwaukee County	26,100	--	61	Low
RAT-10	H, WQ	Private woodland adjacent to northwest lobe of Milwaukee County Parks Falk Park Management Unit Number 4	42.91423	-87.94510	City of Oak Creek	Private landowner	Voluntary acquisition of 13.7-acre private woodlands adjacent to the northwest lobe of Unit 4[qq]	--	--	--	--	--	Milwaukee County and Watershed partners	158,300	--	11, 20, 35, 38, 45, 49, 60, 61, 68	Low

[a] *Prefixes indicate the assessment area that the project is mapped in. The project areas of some projects extend into more than one assessment area.:*

[b] *Abbreviations for focus areas:*
WQ = Water quality
H = Habitat
SWF = Stormwater drainage/flooding
R = Recreational access and use

[c] *Costs reflect 2019 conditions, based on an* Engineering News-Record *Construction Cost Index of 14,744.*

[d] *Potential funding source numbers correspond to the reference numbers given in Table 6.41.*

[e] *It is anticipated that at least 25 percent of medium-priority projects will be implemented during the first 10 years of plan implementation with at least 50 percent being implemented during the first 15 years of plan implementation, and the majority being implemented during the 20-year implementation period. It is envisioned that at least 10 percent of low-priority projects will be implemented during the first 15 years of implementation, with least 25 percent being implemented during the 20-year implementation period, and the balance being implemented after 20 years. It is recognized that some priority rankings may change during refinement and preliminary engineering of projects.*

[f] *Left bank and right bank are based on orientation when looking upstream..*

[g] *If the dam is not removed, repairs to the sluice gate could be completed prior to selecting a preferred alternative for the dam and pond as they would be necessary for any modification that does not fully remove the dam.*

Table 6.1 (Continued)

[h] This should be completed as part of refining alternatives for the Mill Pond area. Such an analysis would provide a better estimate of the amount of sediment being delivered to the area by Oak Creek, which would clarify the frequency of maintenance dredging that would be required for Alternatives 1 through 4. The complexity of the recommended analysis could range from a simple land use-based model to detailed sediment measurements. A basic modeling effort would include a literature review of the amount of bedload and sediment delivered by similar current land uses and streams, and subsequent completion of a model such as a unit area load model for the Oak Creek watershed. Field measurement efforts could include mapping the sediment accumulation in the Mill Pond over several years or sampling of sediment in the Creek upstream of the pond for at least a year. See the section on alternatives and recommended actions for the Mill Pond and Mill Pond dam in this chapter.

[i] This work will determine the level of sediment contamination and potential dredged material disposal options, both of which would impact the cost and feasibility of the alternatives for the Mill Pond and dam that are presented in this plan.

[j] The goal of this project would be to re-direct the main flow volume to the original channel and prevent streambank erosion form undermining infrastructure along the Oak Creek Parkway.

[k] Restoration could include two-stage channel design retrofit; bank regrading/shaping; breaking or removal of spoil berms to provide hydrologic connection to a floodplain terrace; improvement of habitat quality by installing natural channel design elements such as naturalized meanders, grade control, and constructed riffles; invasive species management; and riparian buffer restoration. This could be done as a single project or multiple projects.

[l] Depending on features incorporated, estimated capital costs range between $500 and $1,360 per linear foot.

[m] Potential improvements include retrofitting upstream channel to direct flow into two of the cells during lower flows, installing strategically placed cobble and bolder substrates within the culvert to provide channel roughness and resting areas for fish, and installation of grade control downstream of culvert to increase water depths inside culvert cells.

[n] Restoration could also include reforestation, rapid response invasive species removal, and forest stand improvements. These are not included in the estimates of cost per linear foot.

[o] Restoration could include restoration of existing adjacent wetlands and lands considered to be potentially restorable wetlands by the WDNR; stabilizing eroding streambanks; reestablishing hydrologic connections between the stream channel and adjacent wetlands; installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffles; invasive species management; and forest stand improvement. This could be done as a single project or multiple projects. Depending on the restoration options selected, this project could incorporate projects LOC-26 and LOC-31 a

[p] Restoration could include two-stage channel design retrofit, bank regarding/shaping, and/or breaking or removal of spoil berms to provide hydrological connection to a floodplain terrace; improvement of instream habitat by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffles; invasive species management and riparian buffer restoration. This project could be done as a single project or multiple projects. Depending on the restoration options selected, this project could incorporate project LOC-49 and address bank erosion addressed by projects LOC-32, LOC-35, LOC-36, LOC-39 through LOC-47, LCO-51 and LOC-53.

[q] Restoration could include two-stage channel design retrofit, bank regarding/shaping, and/or breaking or removal of spoil berms to provide hydrological connection to a floodplain terrace; improvement of instream habitat by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffles; invasive species management and riparian buffer restoration. This project could be done as a single project or multiple projects. Depending on the restoration options selected, this project could incorporate projects MOC-03, MOC-05, MOC-06, MOC-08, and MOC-09.

[r] Restoration could include restoration of existing adjacent wetlands and those lands to be potentially restorable wetlands by WDNR; stabilization of eroding streambanks; reestablishing of hydrological connections between stream channel and adjacent wetlands; instream habitat improvement by installing natural channel design features such as naturalized meanders, grade control, and/or constructed riffles; riparian buffer restoration including invasive species management; reforestation, grassland restoration, grassland management, and forest stand improvements. This project could be done as a single project or multiple projects. Depending on the restoration options selected, this project could incorporate projects MOC-12, MOC-23, and MOC-31 and address bank erosion addressed by projects MOC-10, MOC-11, MOC-14 through MOC-16, MOC-18, MOC-22, MOC-24 through MOC-28, MOC-30, MOC-33, and MOC-34..

[s] Restoration could include two-stage channel design retrofit, bank regrading/shaping, and/or breaking or removal of spoil berms to provide hydrologic connection to a floodplain terrace; installation of natural channel design elements such as naturalized meanders, grade control, and/or constructed riffles; invasive species management; and riparian buffer restoration. This project could be done as a single project or multiple projects. Depending on the restoration options selected, this project could address bank erosion addressed by projects MOC-35, MOC-39, and MOC-40.

[t] Restoration could include restoring adjacent wetlands and lands considered to be potentially restorable wetlands by the WDNR; stabilizing eroding streambanks; reestablishing hydrologic connection between the stream channel and adjacent wetlands; improving stream habitat quality by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffle habitats; invasive species management; and riparian buffer restoration to included Milwaukee County Parks' recommended grassland restoration of a currently-leased agricultural field in management Section 10 f the Oak Creek Parkway. Depending on the restoration options selected, this project could address bank erosion addressed by project MOC-44.

[u] Potential improvements could include retrofitting channel under the bridge to direct flow to a "low-flow channel" to promote sufficient water during low flow conditions while allowing overflow onto second "tier" when higher flows occur. The main "low-flow channel" should have widths similar to the channel upstream of the crossing.

[v] The survey should include channel invert elevations, detailed cross section surveys including sediment depths, detailed survey of all stream crossings including upstream and downstream structure elevations, and surveyed elevations of Milwaukee County-owned farmland that occupies a potential reconnection route to the historical channel location of Oak Creek.

[w] Further description of the proposed feasibility study is provided in the section "Recommended Actions to Maintain and Re-establish Natural Surface Water Hydrology" in this chapter.

[x] Project could be combined with repair of stormwater outfalls called for in projects UOC-20 and UOC-22.

[y] An alternative pilot project for this location would be to install bioretention facilities at this site. See the section on stormwater management pilot projects in this chapter.

[z] Restoration could include restoring adjacent wetlands and lands considered to by potentially restorable wetlands by WDNR; reestablishing hydrologic connections between the stream channel and adjacent wetlands; stabilizing eroding streambanks; improving stream habitat quality by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffle habitats; invasive species management; and riparian buffer restoration. Depending on the restoration options selected, this project could address bank erosion addressed by projects UOC-35 and UOC-37 through UOC-39.

[aa] Drop structure was likely installed to control head-cutting of the channel bed. If the structure is removed, replacement grade control would be necessary. One option to consider is to stabilize the structure and utilize it as grade control in a regenerative stormwater conveyance design for this reach as recommended in project OCH-07.

[bb] The design should investigate the potential to incorporate the four existing drop concrete structures addressed by projects OCH-01, OCH-03, OCH-04, and OCH-08.

[cc] Capital costs estimated at $950 per linear foot. It should be noted that there was considerable variation in the costs per linear foot among the regenerative stormwater conveyance projects for which data were available based upon whether the practice was installed in a ditch, gulley, or stream; the width and depth channel created/restored, and specific details of construction. A higher estimate was used to account for the relatively wide channels in the Oak Creek watershed sites and the potential that such projects might require diverting the stream during construction.

[dd] Restoration could include restoring existing adjacent wetlands and those lands considered to be potentially restorable wetlands by the WDNR; stabilizing eroding streambanks; reestablishing hydrologic connections between the stream channel and adjacent wetlands; improving stream habitat quality by installing natural channel design features such as naturalized meanders, grade control, and/or constructed riffle habitats; invasive species management; and riparian buffer restoration. Depending on the restoration options selected, this project could address bank erosion addressed by projects LMF-01, LMF-02, LMF, 04, LMF-05, LMF-09, LMF-12, LMF-14, LMF-16 through LMF-18, LMF-20, LMF-21, LMF-24, LMF-26, and LMF-27.

[ee] Protection and management of this woodland is essential to the long-term ecological stability of the larger Cudahy Nature Preserve. This would also preserve an area considered to be vulnerable riparian buffer land.

[ff] Protection and management of this woodland/wetland complex is essential to the long-term ecological stability of the larger Cudahy Nature Preserve. This would also preserve and restore areas considered to be vulnerable riparian buffer land.

[gg] Canadian Pacific Railway owns the culvert; riparian areas are railway right-of-way; adjacent parcel is owned by Milwaukee County.

[hh] Commission staff observed significant deterioration of culvert structure including foundation cracks and crumbling. Water was observed actively flowing under the concrete box culvert structure, suggesting that the culvert's structural integrity may be compromised.

[ii] Potential actions to protect the culvert bedding and foundation include installing sheet piling, injecting grout, and installing tailwater energy dissipating armor. If the recommended inspection finds that the culvert is no longer serviceable, the structure should be replaced. Any new structure must account for current hydrology and stream morphology to prevent further channel head-cutting from undermining the stability of the new structure and/or continuing upstream—It must not simply replicate the existing structure. Replacement of the culvert with a new railroad crossing is estimated to cost about $519,000.

[jj] Acquisition would protect wildlife dispersal corridors, buffers adjacent to County Parks natural areas, wetlands that are hydrologically connected to parkland, and areas considered to be vulnerable riparian buffers. In addition, acquisition may assist in implementation of projects recommended for the area of the confluence of the North Branch of Oak Creek and the mainstem of Oak Creek.

[kk] Restoration could include two-stage channel design retrofit, bank grading/reshaping, and/or breaking or removal of spoil berms to provide hydrologic connection to a floodplain terrace; improving instream habitat by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffle habitats; invasive species management; and riparian buffer restoration. Depending on the restoration options selected, this project could address bank erosion addressed by project LNB-24.

Table 6.1 (Continued)

[ii] Restoration could include two-stage channel design retrofit, bank grading/reshaping, and/or breaking or removal of spoil berms to provide hydrologic connection to a floodplain terrace; improving instream habitat by installing natural channel design elements such as naturalized meanders, grade control, and/or constructed riffle habitats; invasive species management; and riparian buffer restoration. Depending on the restoration options selected, this project could address bank erosion addressed by projects LNB-31, LNB-32, LNB-35, and LNB-35.

[mm] The initial 75 feet upstream of the S. 6th Street crossing has a steep cascade with excessive amounts of rock creating a fish passage impediment. The entire reach is channelized with a dike on the west bank preventing a connection to a large floodplain wetland area. At a minimum, excessive rock should be removed to promote fish passage. A more extensive project would be to remove the dike on the west bank and restore a sinuous channel with a connection to adjacent wetlands.

[nn] Currently established riparian buffer through the park is about 25 feet on each side of the Creek and consists mostly of cattails. There is parkland available to establish larger buffers beyond the 75-foot minimum. A more extensive project could add sinuosity and vertical complexity to the channel.

[oo] Protection and management of this area is essential to the long-term ecological stability of Falk Park. This would also preserve area considered to be vulnerable riparian buffer.

[pp] Protection and management of this area is essential to the long-term ecological stability of Barloga Woods.

[qq] Protection and management of this area is essential to the long-term ecological stability of Falk Park. This would also preserve area considered to be vulnerable riparian buffer.

Source: 1000 Friends of Wisconsin; City of Cudahy; City of Oak Creek; City of Racine Public Health Department; City of South Milwaukee; Inter-Fluve, Inc.; Milwaukee County; Milwaukee County Department of Parks, Recreations and Culture; Milwaukee Metropolitan Sewerage District; Milwaukee Mitchell International Airport; Minnesota Department of Agriculture; Root-Pike WIN; Wisconsin Department of Natural Resources; Wisconsin Department of Transportation; and SEWRPC

#256464 – CAPR-330 Table 6.2 - Pond Pilot Projects
300-4010
JEB/mid
2/1/21

Table 6.2
Wet Retention Pond Pilot Projects Designed and Analyzed for the Oak Creek Watershed

Subbasin Served[a]	Pool Size (acres)	Area Treated (acres)	Average Annual Pollutant Load Reductions			Capital Costs (dollars)[d]	Annual Operations and Maintenance Cost (dollars)[d]
			Total Suspended Solids (pounds)[b]	Total Phosphorus (pounds)[b]	Fecal Coliform Bacteria (trillion cells)[c]		
L3-4	0.74	8.1	460	1.67	0.895	320,000	6,900
OC-472[c]	3.30	26.4	3,200	9.51	1.630	1,020,000	20,200
O23-2 & O23.5	2.70	57.3	5,038	14.96	6.323	1,190,000	27,100
OC-472 & OC-471[c]	3.30	45.7	11,000	30.90	2.822	1,020,000	20,200

[a] *See Maps 6.15 through 6.18.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Pollutant load reductions were estimated using unit area loads from HSPF and median values of bioretention performance from the International Stormwater BMP Database.*

[d] *Costs given in 2019 dollars.*

[e] *OC-472 and OC-472 & OC-471 represent the same wet detention pond pilot project design serving different drainage areas.*

Source: SEWRPC

#256465 – CAPR-330 Table 6.3 - Daylighting Pilot Projects
300-4010
JEB/mid
2/1/21

Table 6.3
Storm Sewer Daylighting Pilot Projects Designed and Analyzed for the Oak Creek Watershed

			Average Annual Pollutant Load Reductions				
Subbasin Served[a]	**Bioswale Length (acres)**	**Area Treated (acres)**	Total Suspended Solids (pounds)[b]	Total Phosphorus (pounds)[b]	Fecal Coliform Bacteria (trillion cells)[c]	**Capital Costs (dollars)**[d]	**Annual Operations and Maintenance Cost (dollars)**[d]
OC-471	500	19.2	811	2.78	0.206	260,000	8,000
O18-5	720	35.3	929	3.85	0.378	220,000	7,400

[a] *See Maps 6.15, 6.19, and 6.20.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Pollutant load reductions were estimated using unit area loads from HSPF and median values of bioretention performance from the International Stormwater BMP Database.*

[d] *Costs given in 2019 dollars.*

Source: SEWRPC

#256467 – CAPR-330 Table 6.4 - Bioswale Pilot Projects
300-4010
JEB/mid
2/1/21

Table 6.4
Boulevard Bioswale Pilot Projects Designed and Analyzed for the Oak Creek Watershed

Subbasin Served[a]	Area Served	Bioswale Length (feet)	Area Treated (acres)	Average Annual Pollutant Load Reductions			Capital Costs (dollars)[d]	Annual Operations and Maintenance Cost (dollars)[d]
				Total Suspended Solids (pounds)[b]	Total Phosphorus (pounds)[b]	Fecal Coliform Bacteria (trillion cells)[c]		
NB-42B	100 percent of subbasin	630	2.0	1,076	2.18	0.031	38,000	2,200
NB-42B	50 percent of boulevard	630	1.0	432	0.84	0.015	38,000	2,200
OC-451	100 percent of subbasin	1,140	17.4	2,459	4.45	0.261	69,000	4,100
OC-451	50 percent of boulevard	1,140	1.6	1,523	2.46	0.024	69,000	4,100

[a] *See Maps 6.15, 6.21, and 6.22.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Pollutant load reductions were estimated using unit area loads from HSPF and median values of bioswale performance from the International Stormwater BMP Database.*

[d] *Costs given in 2019 dollars.*

Source: SEWRPC

#256468 – CAPR-330 Table 6.5 - Bioretention Pilot Projects
300-4010
JEB/mid
2/1/21

Table 6.5
Boulevard Bioretention Pilot Projects Designed and Analyzed for the Oak Creek Watershed

Subbasin Served[a]	Area Served	Bioretention cell area (square feet)	Area Treated (acres)	Average Annual Pollutant Load Reductions: Total Suspended Solids (pounds)[b]	Average Annual Pollutant Load Reductions: Total Phosphorus (pounds)[b]	Average Annual Pollutant Load Reductions: Fecal Coliform Bacteria (trillion cells)[c]	Capital Costs (dollars)[d]	Annual Operations and Maintenance Cost (dollars)[d]
NB-42B	100 percent of subbasin	10,500	2.0	2,280	50.6	--	240,000	2,600
NB-42B	50 percent of boulevard	10,500	1.0	1,271	3.01	--	240,000	2,600
OC-451	100 percent of subbasin	12,500	17.4	5,146	9.27	--	300,000	3,000
OC-451	50 percent of boulevard	12,500	1.6	2,711	4.43	--	300,000	3,000

[a] *See Map6.15, 6.21, and 6.22.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Pollutant load reductions were estimated using unit area loads from HSPF and median values of bioretention performance from the International Stormwater BMP Database.*

[d] *Costs given in 2019 dollars.*

Source: SEWRPC

#256471 – CAPR-330 Table 6.6 - Parking Lot Pilot Projects
300-4010
JEB/mid
2/1/21

Table 6.6
Parking Lot Pilot Projects Designed and Analyzed for the Oak Creek Watershed

Parking Lot Served[a]	Connection Scenario	Parking Lot Area (acres)	Total Drainage Area (acres)	Pervious Pavement Area (acres)	Average Annual Pollutant Load Reductions			Capital Costs (dollars)[b]	Annual Operations and Maintenance Cost (dollars)[c]
					Total Suspended Solids (pounds)[b]	Total Phosphorus (pounds)[b]	Fecal Coliform Bacteria (trillion cells)		
N2-5C	Indirectly Connected	3.5	12.3	0.10	92	0.14	--	67,000	500
N2-5C	Indirectly Connected	3.5	12.3	0.25	107	0.18	--	167,000	1,300
N2-5C	Indirectly Connected	3.5	12.3	0.50	116	0.20	--	334,000	2,500
N2-5C	Indirectly Connected	3.5	12.3	1.00	123	0.22	--	669,000	5,100
N2-5C	Indirectly Connected	3.5	12.3	2.00	127	0.23	--	1,340,000	10,100
N2-5C	Directly Connected	3.5	12.3	0.10	834	1.21	--	67,000	500
N2-5C	Directly Connected	3.5	12.3	0.25	1,095	1.62	--	167,000	1,300
N2-5C	Directly Connected	3.5	12.3	0.50	1,298	1.98	--	334,000	2,500
N2-5C	Directly Connected	3.5	12.3	1.00	1,512	2.42	--	669,000	5,100
N2-5C	Directly Connected	3.5	12.3	2.00	1,722	2.90	--	1,340,000	10,100
Northeast Parking	Indirectly Connected	6.0	6.0	0.10	160	0.24	--	67,000	500
Northeast Parking	Indirectly Connected	6.0	6.0	0.25	184	0.28	--	167,000	1,300
Northeast Parking	Indirectly Connected	6.0	6.0	0.50	199	0.31	--	334,000	2,500
Northeast Parking	Indirectly Connected	6.0	6.0	1.00	211	0.33	--	669,000	5,100
Northeast Parking	Indirectly Connected	6.0	6.0	2.00	218	0.35	--	1,340,000	10,100
Northeast Parking	Directly Connected	6.0	6.0	0.10	1,447	2.08	--	67,000	500
Northeast Parking	Directly Connected	6.0	6.0	0.25	1,902	2.76	--	167,000	1,300
Northeast Parking	Directly Connected	6.0	6.0	0.50	2,253	3.30	--	334,000	2,500
Northeast Parking	Directly Connected	6.0	6.0	1.00	2,585	3.86	--	669,000	5,100
Northeast Parking	Directly Connected	6.0	6.0	2.00	2,896	4.43	--	1,340,000	10,100

[a] *See Map 6.15.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Costs given in 2019 dollars.*

Source: SEWRPC

#256506 – CAPR-330 Table 6.7 - Alleyway Pilot Projects
300-4010
JEB/mid
2/2/21

Table 6.7
Alleyway Pervious Pavement Pilot Projects Designed and Analyzed for the Oak Creek Watershed

			Average Annual Pollutant Load Reductions				
Subbasin Served[a]	**Width of Pervious Pavement Strip (feet)**	**Area Treated (acres)**	Total Suspended Solids (pounds)[b]	Total Phosphorus (pounds)[b]	Fecal Coliform Bacteria (trillion cells)	**Capital Costs (dollars)**[b]	**Annual Operations and Maintenance Cost (dollars)**[c]
OC-40000	1	0.33	160	0.41	--	17,000	100
OC-40000	2	0.33	186	0.49	--	34,000	200
OC-40000	3	0.33	200	0.54	--	51,000	400
OC-40000	4	0.33	210	0.57	--	67,000	500

[a] *See Map 6.15.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Costs given in 2019 dollars.*

Source :SEWRPC

Table 6.8
Parkway Pervious Pavement Pilot Projects Designed and Analyzed for the Oak Creek Watershed

Area Treated (acres)[a]	Width of Pervious Pavement Strip (feet)	Sides of Parkway Treated	Average Annual Pollutant Load Reductions: Total Suspended Solids (pounds)[b]	Average Annual Pollutant Load Reductions: Total Phosphorus (pounds)[b]	Average Annual Pollutant Load Reductions: Fecal Coliform Bacteria (trillion cells)	Capital Costs (dollars)[c]	Annual Operations and Maintenance Cost (dollars)[c]
9	1	1	3,151	9.14	--	210,000	1,600
9	2	1	4,056	11.99	--	430,000	3,200
9	1	2	6,404	18.28	--	430,000	3,200
9	2	2	8,113	23.99	--	860,000	6,500

[a] *See Map 6.15.*

[b] *Pollutant load reductions were estimated using WinSLAMM.*

[c] *Costs given in 2019 dollars.*

Source :SEWRPC

#252644 – CAPR-330 Table 6.9 - MMSD GI Plan
300-4010
JEB/mid
2/29/20

Table 6.9
Green Infrastructure Strategies Recommended for Implementation by 2035 in the Portion of the Oak Creek Watershed Located in the MMSD Planning Area[a]

Green Infrastructure Strategy	Units	Number of Units	Average Annual Stormwater Volume Captured (million gallons)	Cost (dollars)[b]
Porous Pavement	Average city blocks[c]	730	10,334.6	30,170,000
Bioretention/Rain Gardens	150-square foot rain gardens	12,000	288.0	31,380,000
Stormwater trees	Trees[d]	27,820	6.0	6,030,000
Green Roofs	Buildings with 5,000-square-foot green roofs	100	85.0	21,720,000
Cisterns	Large buildings with 1,000-gallon cisterns[e]	150	8.5	1,210,000
Native Landscaping	Average city blocks[c]	100	283.2	2,410,000
Rain Barrels	House with rain barrel	7,100	21.7	1,210,000
Soil Amendments	Average city blocks[c]	100	239.6	2,410,000
		Total	11,258.1	96,540,000

[a] *The MMSD planning area encompasses all of the Oak Creek watershed except for the City of South Milwaukee.*

[b] *Costs were adjusted from 2013 dollars to 2019 dollars using the Engineering Record Construction Cost Index (CCI), CCI_{2013} = 12,217.705, CCI_{2019} =14,743.85 (multiplier of 1.206).*

[c] *The area of an average city block is estimated as being five acres.*

[d] *The MMSD Green Infrastructure Plan recommends the planting of nine new trees per average city block. The area of the portion of the Oak Creek watershed that is located in the MMSD planning area is about 3,090 average city blocks.*

[e] *The plan defines large buildings as those with roof areas greater than 6,500 square feet.*

Source: Milwaukee Metropolitan Sewerage District and SEWRPC

#252646 – CAPR-330 Table 6.10 - GI Timeline
300-4010
JEB/mid
2/29/20

Table 6.10
Timeline for Achieving an Equivalent 0.5-Inch Rainwater Capture Volume Envisioned in the MMSD Green Infrastructure Plan

Year	Level of Implementation (percent)
2013	0.0
2014	0.2
2015	0.4
2016	0.7
2017	0.9
2018	1.1
2019	7.0
2020	12.0
2021	18.6
2022	25.7
2023	30.7
2024	35.7
2025	41.4
2026	47.8
2027	53.6
2028	59.3
2029	65.0
2030	70.7
2031	77.1
2032	82.9
2033	87.9
2034	95.0
2035	100.0

Source: Milwaukee Metropolitan Sewerage District and SEWRPC

#254817 – Table 6.11 - BMP Performance E. coli
300-4010
JEB/LKH/mid
8/31/20, 6/8/21

Table 6.11
Median Influent and Effluent Concentrations for *E. coli* Reported for Stormwater Best Management Practices

BMP Category	BMPs Analyzed		Storms Analyzed		Median Concentration (cells per 100 ml)	
	In-Flow	Out-Flow	In-Flow	Out-Flow	In-Flow	Out-Flow
Bioretention	7	7	97	96	1,200	240
Grass Swale	5	6	39	46	3,500	4,400
Retention (Wet) Pond	4	4	69	65	2,000	80
Wetland Basin	6	6	77	76	2,800	1,000
Wetland Basin/Retention Pond	10	10	146	141	2,300	450

Source: International Stormwater Best Management Database

Table 6.12
Median Influent and Effluent Concentrations for Fecal Coliform Bacteria Reported for Stormwater Best Management Practices

BMP Category	BMPs Analyzed		Storms Analyzed		Median Concentration (cells per 100 ml)	
	In-Flow	Out-Flow	In-Flow	Out-Flow	In-Flow	Out-Flow
Composite/Treatment Train	4	4	64	56	15,000	12,000
Detention (Dry) Basin	15	15	170	194	1,800	640
Grass Swale	12	11	91	82	4,900	4,400
Media Filter	15	15	184	169	900	400
Retention (Wet) Pond	10	12	121	161	3,400	1,400
Wetland Basin	5	5	42	39	12,000	900
Wetland Basin/Retention Pond	15	17	163	200	5,000	1,200
Wetland Channel	3	3	21	20	6,000	4,000

Source: International Stormwater Best Management Database

Table 6.13
Estimated Percent of Current and Planned Connected Impervious Surface, Percent of Area that has High or Very High Groundwater Recharge Potential, and Percent of High and Very High Groundwater Recharge Potential Within Areas Planned to be Developed in Urban Uses

Assessment Area[a]	Communities	Percent Connected Impervious (2015)	Percent Connected Impervious Planned Conditions	Percent of Assessment Area that has High and Very High Groundwater Recharge Potential[b]	Percent of High and Very High Groundwater Recharge Potential that is Within Areas Planned to be Developed in Urban Uses[c]
Mainstem					
Grant Park Ravine	South Milwaukee	11	11	60	0
Lower Oak Creek – Mill Pond	South Milwaukee, Cudahy	29	31	15	3
Lower Oak Creek	South Milwaukee, Oak Creek, Cudahy	19	21	12	25
Middle Oak Creek Drainage Ditches	Oak Creek	7	12	3	55
Middle Oak Creek	Oak Creek	15	19	14	10
Upper Oak Creek	Oak Creek, Franklin	21	34	18	27
Oak Creek Headwaters	Franklin	12	13	3	10
Mitchell Field Drainage Ditch					
Lower Mitchell Field Drainage Ditch	Oak Creek, Milwaukee, Cudahy	15	31	24	32
Mitchell Field Drainage Ditch – Airport	Oak Creek, Milwaukee	31	34	3	14
North Branch Oak Creek					
Lower North Branch Oak Creek	Oak Creek	20	26	32	15
Upper North Branch Oak Creek	Oak Creek Milwaukee, Greenfield	25	34	32	30
Southland Creek	Oak Creek, Franklin	11	19	26	23
Drexel Avenue Tributary	Oak Creek	11	21	11	39
Rawson Avenue Tributary	Oak Creek, Franklin	24	34	14	18
College Avenue Tributary	Oak Creek, Franklin, Milwaukee	25	31	8	30
	Total Watershed	18	25	16	21

Note: Background colors indicate the level concern or potential need for intervention to mitigate negative impacts based upon the current and planned land use relative to the amounts of imperviousness and groundwater recharge potential within each assessment area:

Very High Level of Concern (red): Priority for mitigation –green infrastructure and protection

High Level of Concern (orange): Priority for mitigation – green infrastructure and protection

Moderate Level of Concern (yellow): Priority for protection

Low Level of Impact (green): Priority for protection

[a] *Assessment areas are shown on Map 3.2 and their total areas in acres are presented in Table 3.1.*

Table 6.13 (Continued)

[b] *This column implies the level of opportunities remaining in each assessment area for protecting vital groundwater recharge areas. It should be noted that one of the inputs used in developing the model to indicate areas with high and very high groundwater recharge potential was SEWRPC's year 2000 land use inventory. Considering the age of that land use inventory, it is reasonable to assume that some of the areas defined by the model as having high or very high groundwater recharge potential may have since been developed into urban uses including the addition of impervious surfaces which may lessen the potential for groundwater recharge. For details on the model used to indicate groundwater recharge potential for areas throughout the Region, see SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Model, *July 2008.*

[c] *This column indicates assessment areas with higher levels of urgency for protection of groundwater recharge areas before they are potentially lost based on future planned urban development.*

Source: SEWRPC

Table 6.14
Alternative Streambank Stabilization Practices

Instream Practices
Vanes or J-Hook Vanes
Cross Vanes
Streambank Treatment
Bank Shaping and Planting
Branch Packing
Brush Mattresses
Coconut Fiber Roll
Dormant Post Plantings
Vegetated Gabions
Joint Plantings
Live Cribwalls
Live Stakes
Live Fascines
Log, Rootwad, and Boulder Revetments
Multi-stage Channel Design/Restoration
Riprap
Stone Toe Protection
Tree Revetments
Vegetated Geogrids

Source: AECOM, City of Racine, and SEWRPC

#257663 – CAPR-330 Table 6.15
300-4010
JEB, LKH/mid
5/13/21, 7/5/21

Table 6.15
High Priority Streambank Erosion Projects for the Oak Creek Watershed Restoration Plan[a,b]

Identification Number (see Maps 6.1 - 6.13)	Location	Management Action	Focus Areas Addressed	Potential Benefits	Capital Cost (dollars)[c]	Responsible Party
GPR-06	Right bank of Oak Creek within the Oak Creek Parkway downstream of the Mill Pond dam	Bank stabilization to address bank erosion along 234 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 46,400 pounds TSS, 12.1 pounds total phosphorus	81,900	Milwaukee County
GPR-09	Left bank of Oak Creek within the Oak Creek Parkway downstream of the Mill Pond dam	Bank stabilization to address bank erosion along 170 feet of Oak Creek with a very severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 172,200 pounds TSS, 45.1 pounds total phosphorus	59,500	Milwaukee County
LMP-12	Right bank of Oak Creek within the Oak Creek Parkway upstream of Chicago Avenue	Bank stabilization to address bank erosion along 107 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 10,200 pounds TSS, 3.2 pounds total phosphorus	37,500	Milwaukee County
LMP-20	Right bank of Oak Creek within the Oak Creek Parkway upstream of Chicago Avenue	Bank stabilization to address bank erosion along 221 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 10,400 pounds TSS, 3.2 pounds total phosphorus	77,400	Milwaukee County
MOC-51	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue	Bank stabilization to address bank erosion along 67 feet of Oak Creek with a moderate lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 4,200 pounds TSS, 1.3 pounds total phosphorus	23,500	Milwaukee County
MOC-54	Left bank of Oak Creek within Oak Creek Parkway upstream of S. Shepard Avenue	Bank stabilization to address bank erosion along 107 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 20,600 pounds TSS, 6.3 pounds total phosphorus	37,500	Milwaukee County
MOC-55	Left bank of Oak Creek within Oak Creek Parkway and American Legion Park upstream of S. Shepard Avenue	Bank stabilization to address bank erosion along 166 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 24,000 pounds TSS, 7.4 pounds total phosphorus	58,100	Milwaukee County and American Legion
MOC-65	Right bank of Oak Creek within Oak Creek Parkway upstream of S. Howell Avenue	Bank stabilization to address bank erosion along 114 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 26,000 pounds TSS, 8.0 pounds total phosphorus	39,900	Milwaukee County

Table 6.15 (Continued)

Identification Number (see Maps 6.1 - 6.13)	Location	Management Action	Focus Areas Addressed	Potential Benefits	Capital Cost (dollars)[c]	Responsible Party
OCH-10	Both banks of Oak Creek at W. Woodward Drive	Bank stabilization to address bank erosion along 298 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 57,200 pounds TSS, 17.6 pounds total phosphorus	104,300	Private landowner
OCH-12	Both banks of Oak Creek upstream of W. Southland Drive	Bank stabilization to address bank erosion along 428 feet of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 87,400 pounds TSS, 26.9 pounds total phosphorus	149,800	Private landowner
LNB-04	Left bank of North Branch of Oak Creek downstream of Canadian Pacific Railway crossing	Bank stabilization to address bank erosion along 113 feet of North Branch of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 17,600 pounds TSS, 5.4 pounds total phosphorus	39,600	Milwaukee County
LNB-05	Right bank of North Branch of Oak Creek downstream of Canadian Pacific Railway crossing	Bank stabilization to address bank erosion along 113 feet of North Branch of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 16,200 pounds TSS, 5.0 pounds total phosphorus	39,600	Milwaukee County
LNB-08	Right bank of North Branch of Oak Creek upstream of Canadian Pacific Railway Crossing	Bank stabilization to address bank erosion along 132 feet of North Branch of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 22,200 pounds TSS, 6.8 pounds total phosphorus	46,200	Aldi, Inc.
UNB-41	Left bank of North Branch of Oak Creek downstream of North Branch of Oak Creek outfall in Copernicus Park	Bank stabilization to address bank erosion along 145 feet of North Branch of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 31,400 pounds TSS, 9.6 pounds total phosphorus	50,800	Milwaukee County
UNB-42	Right bank of North Branch of Oak Creek downstream of North Branch of Oak Creek outfall in Copernicus Park	Bank stabilization to address bank erosion along 45 feet of North Branch of Oak Creek with a severe lateral recession rate	Water Quality, Habitat	Stabilization of creek bank, estimated annual pollutant load reductions of 8,600 pounds TSS, 2.7 pounds total phosphorus	15,800	Milwaukee County

[a] *Table 6.1 provides more details on the priority projects.*

[b] *Prioritization based on total cost, length of erosional area, severity of lateral recession rate, total load reduction of total suspended solids, potential threat to infrastructure, and cost-effectiveness of load reduction of total suspended solids.*

[c] *Costs are given in 2019 dollars.*

Source: SEWRPC

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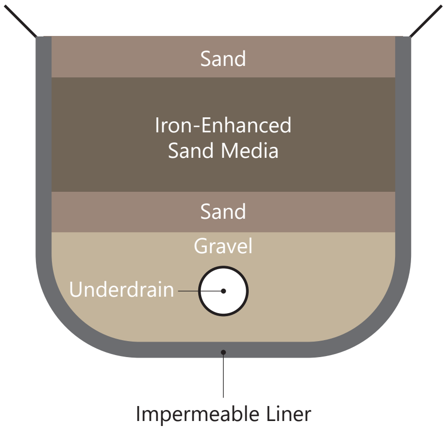
A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

PLAN RECOMMENDATIONS

FIGURES

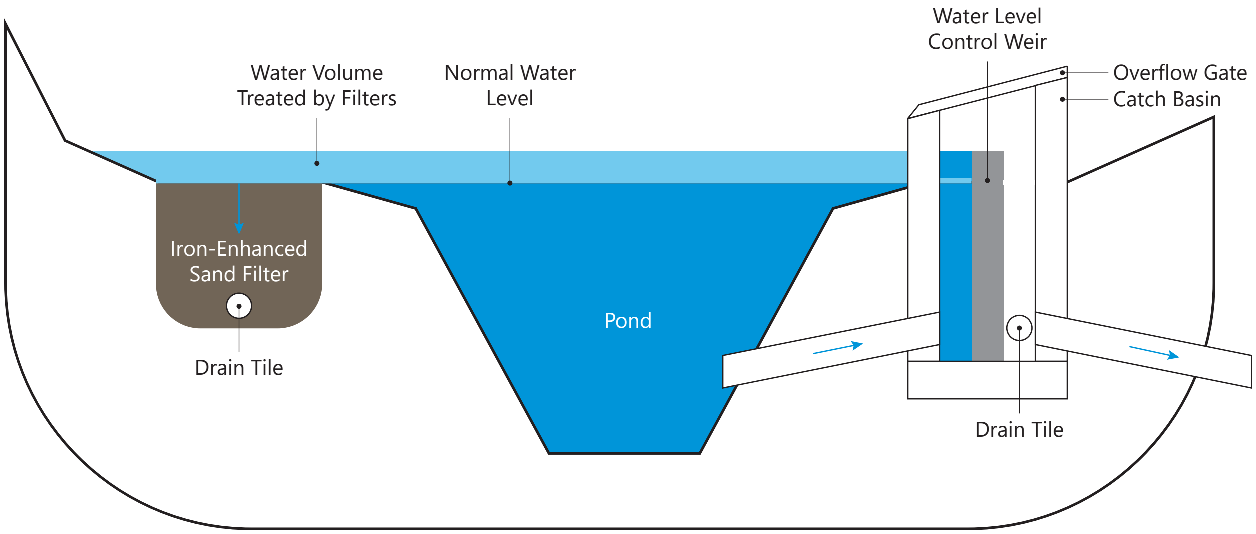
Figure 6.1
General Design of Iron-Enhanced Sand Filters



Note: drawing is not to scale.

Source: University of Minnesota Saint Anthony Falls Laboratory and SEWRPC

Figure 6.2
General Design of Iron-Enhanced Sand Filter Stomwater Trenches

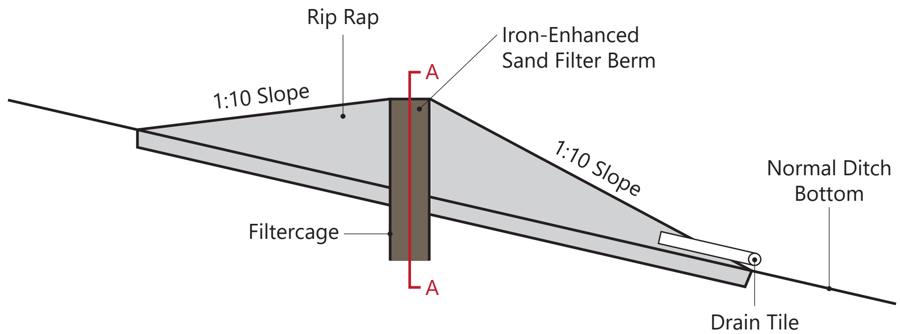


Note: drawing is not to scale.

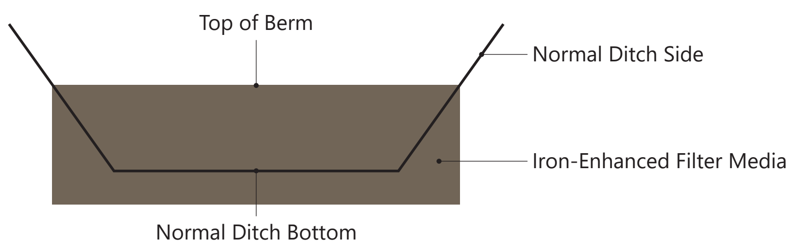
Source: University of Minnesota Saint Anthony Falls Laboratory and SEWRPC

Figure 6.3
General Design of Iron Enhanced Sand Filter Ditch Check Dams

A. Profile



B. Cross-Section (A-A)



Note: drawing is not to scale.

Source: University of Minnesota Saint Anthony Falls Laboratory and SEWRPC

Figure 6.4
Examples of Fungal Species Found to Kill, Digest, or Inhibit Fecal Indicator Bacteria

BURGANDY MUSHROOM
Stropharia rugosos-annulata

BUTTON MUSHROOM
Agaricus bisporus

PEARL OYSTER MUSHROOM
Pleurotus ostreatus

SCALY INK CAP MUSHROOM
Coprinus quadrifidus

WHITE ELM OYSTER MUSHROOM
Pleurotus ulmarius

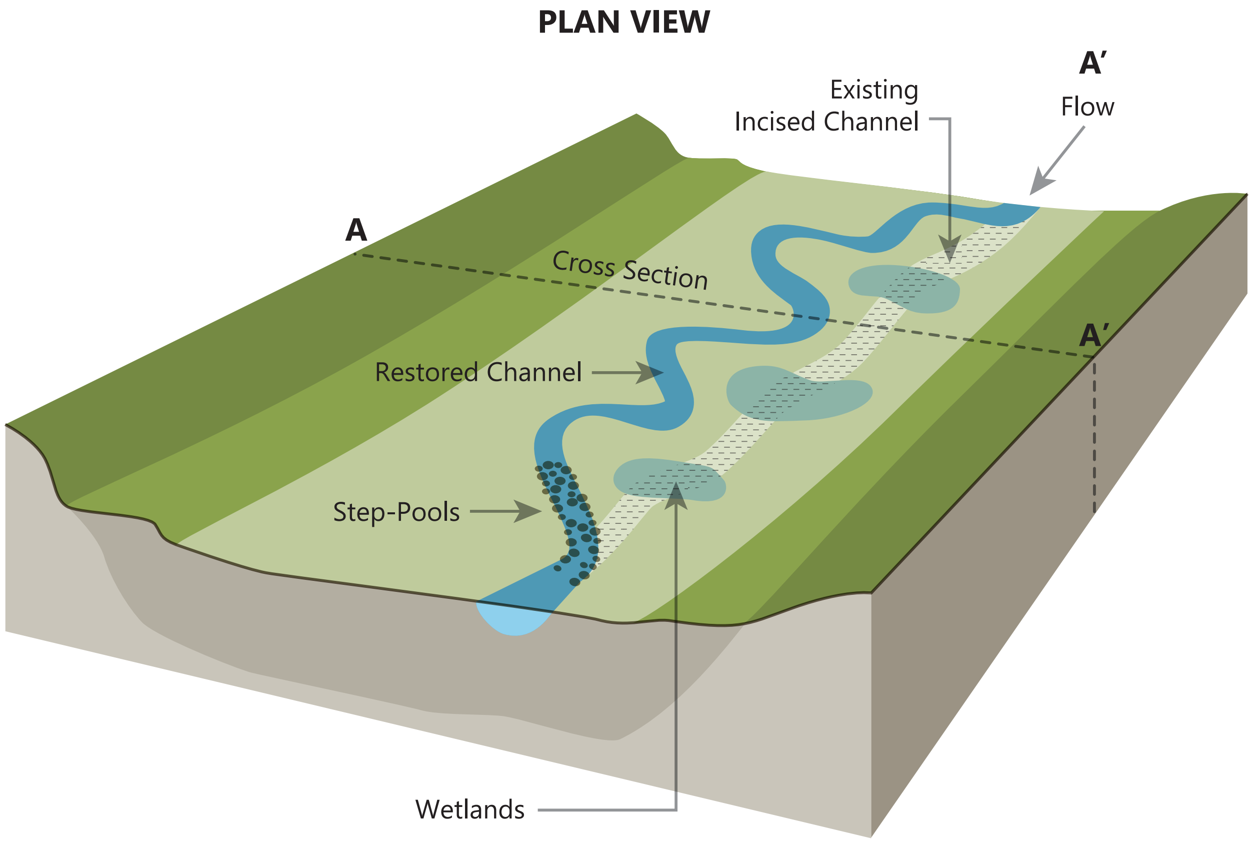
WOOD BLUET MUSHROOM
Lepista nuda

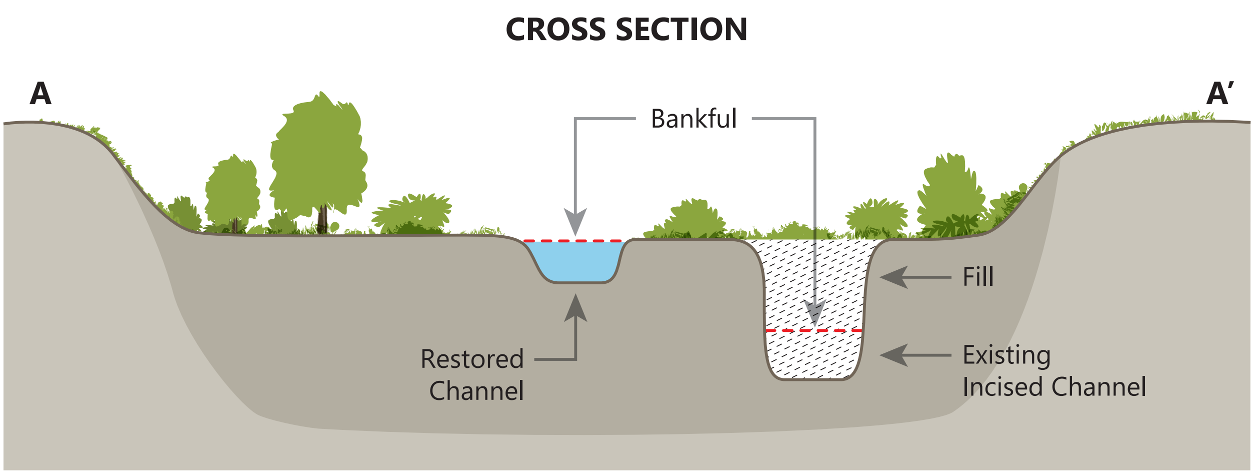
Source: Individual cited photographers and SEWRPC

Figure 6.5
Mycelium of the Pearl Oyster Mushroom (*Pleurotus ostreatus*) Growing in Wood Chip Media

Source: Wikimedia Commons User Rick Proser and SEWRPC

Figure 6.6
Potential Stream Restoration Design Elements to Improve Sinuosity and Stream Function



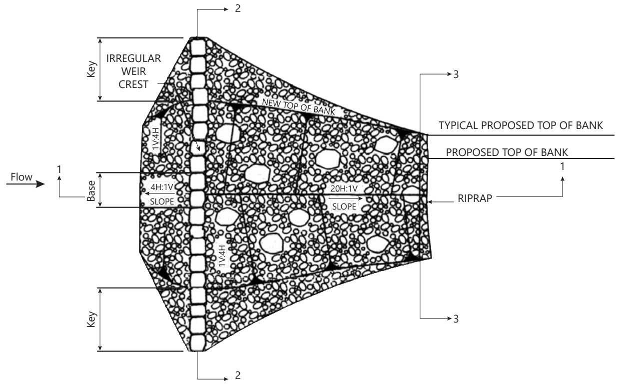


Note: The example shown in this schematic includes a raised elevation for the restored channel bed when compared to the existing channel. Any changes to channel bed elevation would need to consider upstream and downstream channel elevation profiles and elevations of road culverts and other fixed structures.

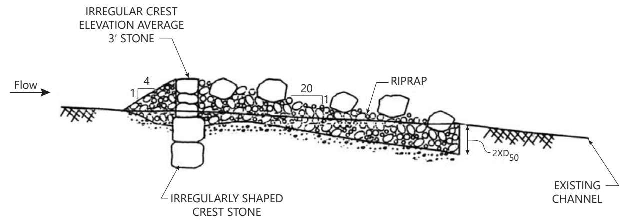
Source: Modified from W. Harman, R. Starr, M. Carter, et al., A Function-Based Framework for Stream Assessments and Restoration Projects, *US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC, EPA 843-K-12-006, p. 36, 2012 and SEWRPC*

Figure 6.7
Example Design Elements – Naturalized Channel Grade Control Concepts

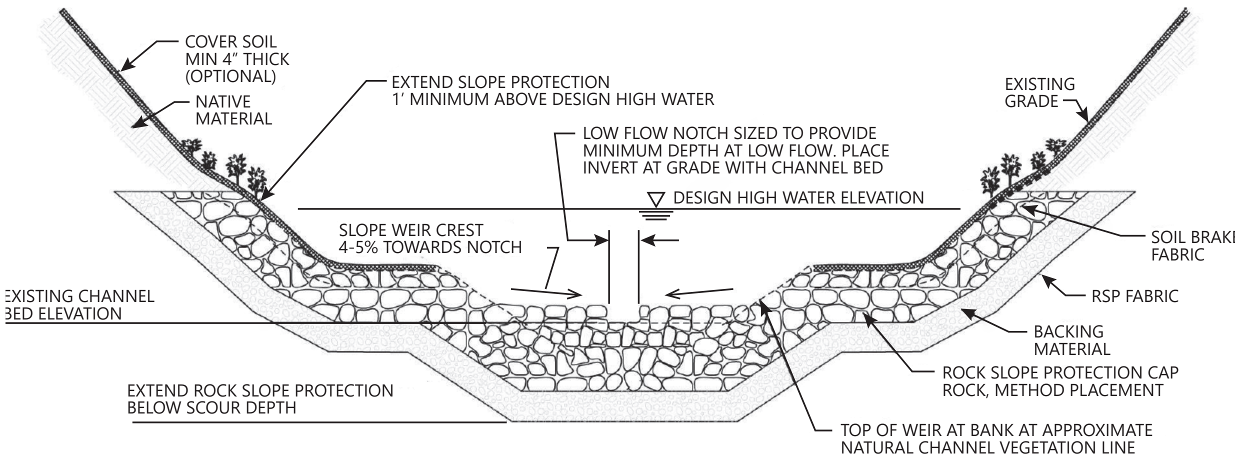
Typical Riffle Structure Plan View



Typical Riffle Structure Profile View



Section at Weir



Note: Avoid excessive use of stone - avoid pavement-like or armored appearance. All installations must include choker material to bind and seal streambed. Coarse wood structure may be used to supplant stone in some applications. Grade control elements must be able to withstand high flow – key pieces must be sized to remain immobile and structures must extend beyond flood-prone width. Distribute vertical fall over several short (e.g., < 6-inch tall) riffles, and avoid channel sections with > 2 feet of vertical fall over 100 feet of channel length.

Source: Modified from D.T. Williams, David T. Williams and Associates; W. White, J. Beardsley, and S. Tomkins, Waukegan River Illinois National Nonpoint Source Monitoring Program Project, *Illinois State Water Survey, January 2011; Caltrans,* Fish Passage Design for Road Crossings: An Engineering Document Providing Fish Passage Design Guidance for Caltrans Project, *May 2007 and SEWRPC*

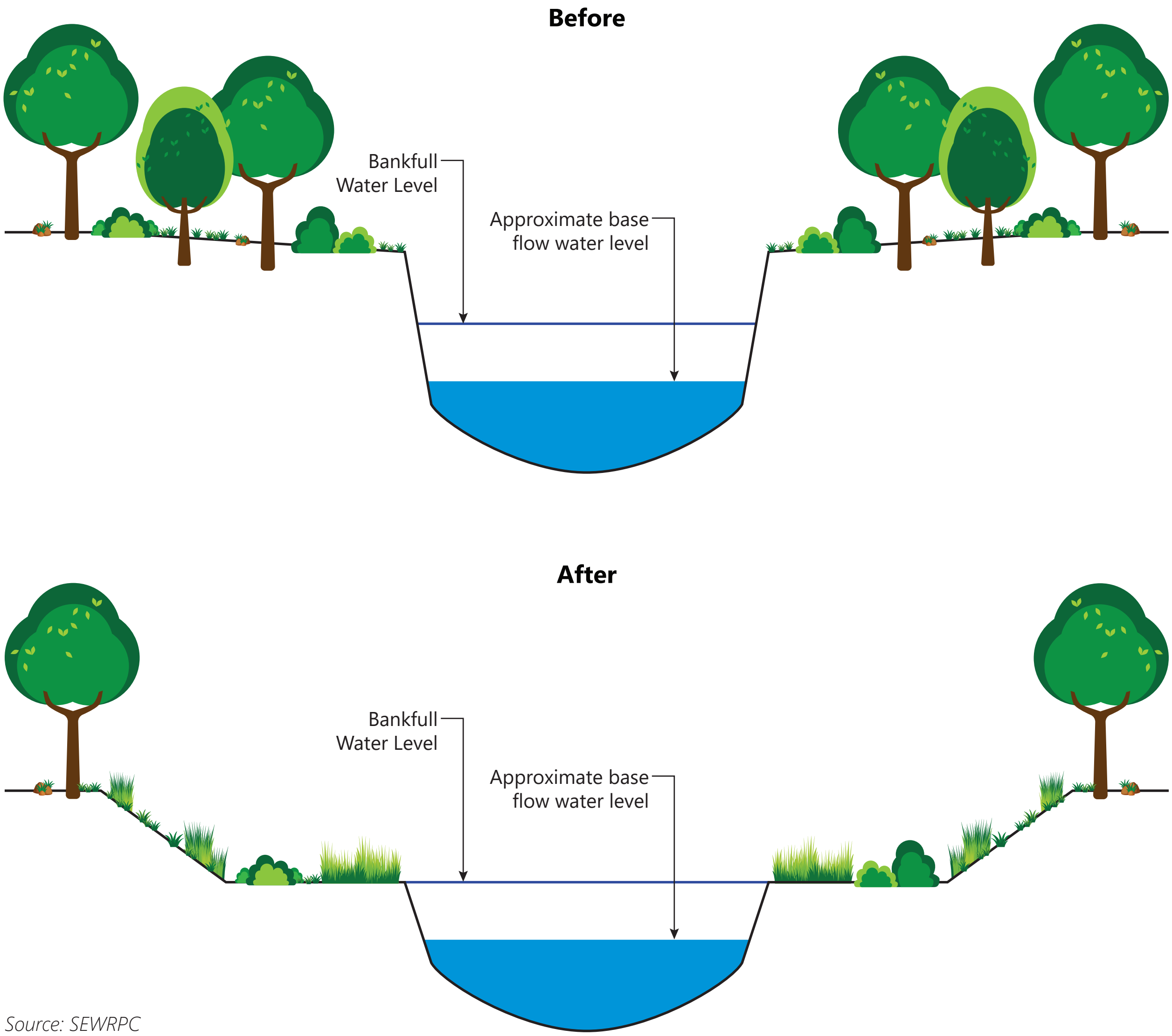
Figure 6.8
Attributes, Functions, and Benefits of Ecologically Functional Floodplains

Non-Functioning → Partially Functioning → Fully Functioning

Attributes	Functions	Benefits
Connectivity	→ Floodplains convey floodwaters → Supports natural shifts in channel and floodplain morphology over time	→ Floods move more slowly → Reduces flood stage downstream → Naturally maintains riverbank form
Variable Flow	→ High and low flows occur → Exchange of nutrients and sediment between land and water → Connects in-stream and riparian habitat	→ Sustains riparian buffers → Maintains water quality → Increased groundwater flows
Spatial Scale	→ Wetland and side-channel habitat are sustained → Wider hyporheic exchange flow paths → Conveys small and large magnitude floods → Gradients in disturbance frequency and hydrologic connection emerge	→ Longer floodplain water residence time; supplements groundwater and stream base-flows → Reduced reliance on expensive flood-control infrastructure
Habitat and Structural Diversity	→ Habitat mosaics develop overtime → Supports diversity of species and life-histories → Habitat temperature gradients emerge → Floodplain surface roughness enhanced	→ Slows high waters → Supports economically important species of fish and wildlife → Enhanced recreation, education, and aesthetic land values → More resilient river and floodplain

Source: Modified from Jonathon Loos and Eileen Shader, Reconnecting Rivers to Floodplains: Returning Natural Functions to Restore Rivers and Benefit Communities, *2016 and SEWRPC*

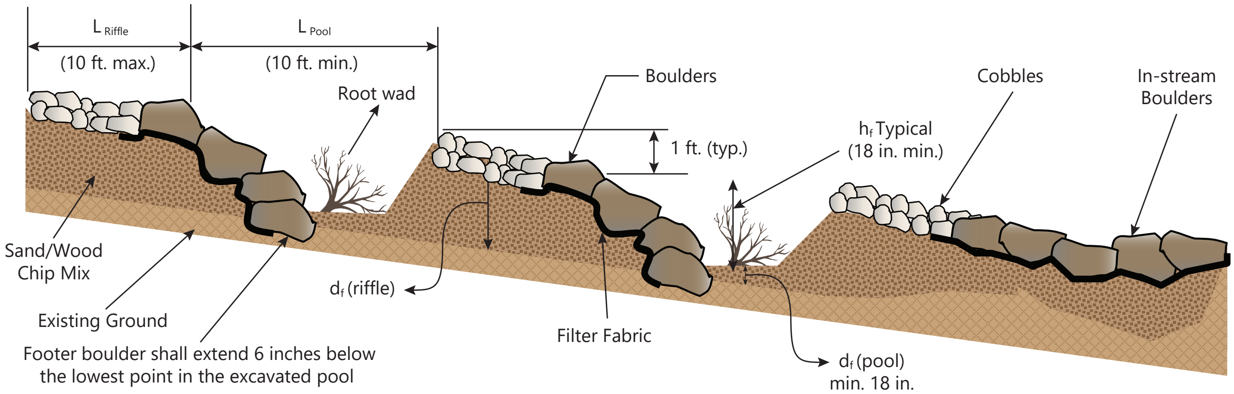
Figure 6.9
Cross-Section Schematic of a Two-Stage Channel Design



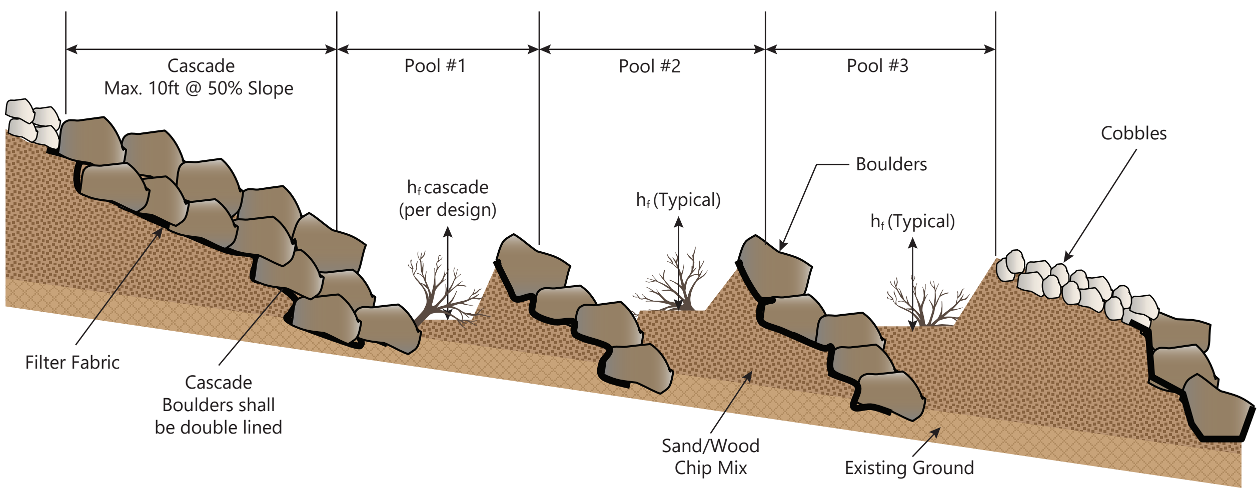
Source: SEWRPC

Figure 6.10
Schematic Profiles of Two Typical Configurations for Regenerative Stormwater Conveyance Systems

Typical Profile – Alternating Pools and Riffles



Cascade Profile – Three Pools Following Cascade

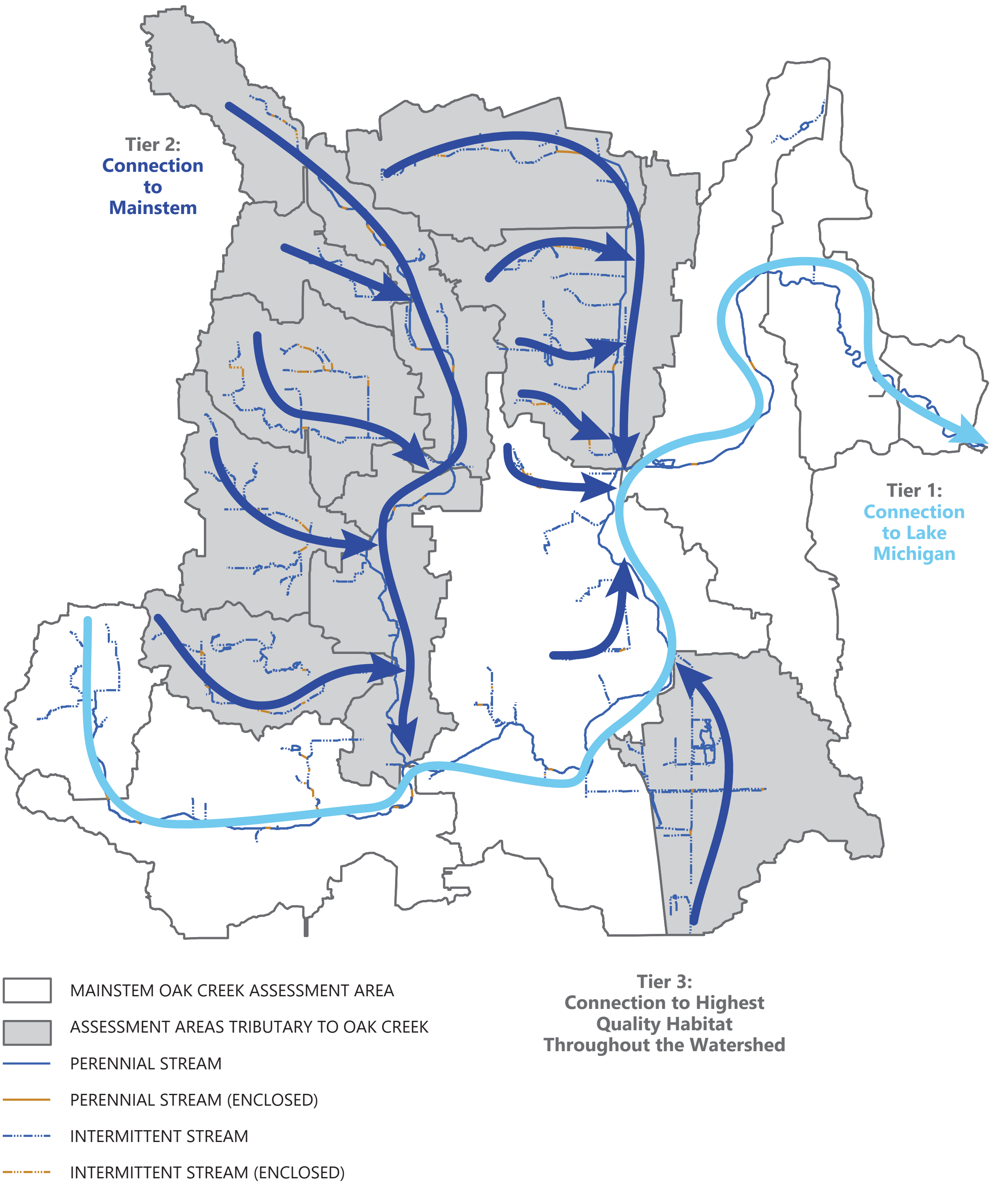


Note: Abbreviatations indicate:

h_f = depth of constructed pool, minimum 18 inches
d_f = depth of sand/woodchip mix filter bed, minimum 24 inches
L_{Riffle} = Length of constructed riffle
L_{Pool} = Length of constructed pool

Source: Modified from Stormwater Management and Design Guidance Manual Chapter 4.2.7 Regenerative Stormwater Conveyance System, *West Virginia Department of Environmental Protection, November 2012 and SEWRPC*

Figure 6.11
Instream Three-Tier Prioritization Strategy Within the Oak Creek Watershed



Source: SEWRPC

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A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

PLAN RECOMMENDATIONS

MAPS

Map 6.1
Recommended Projects Within the Grant Park Ravine Assesment Area

HABITAT AND WATER QUALITY PROJECT

WATER QUALITY AND RECREATIONAL USE AND ACCESS PROJECT

STORMWATER DRAINAGE/FLOODING PROJECT

GPR-17 PROJECT ID IN TABLE 6.1

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details. No specific projects are proposed for areas of this assessment area that are not shown.

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

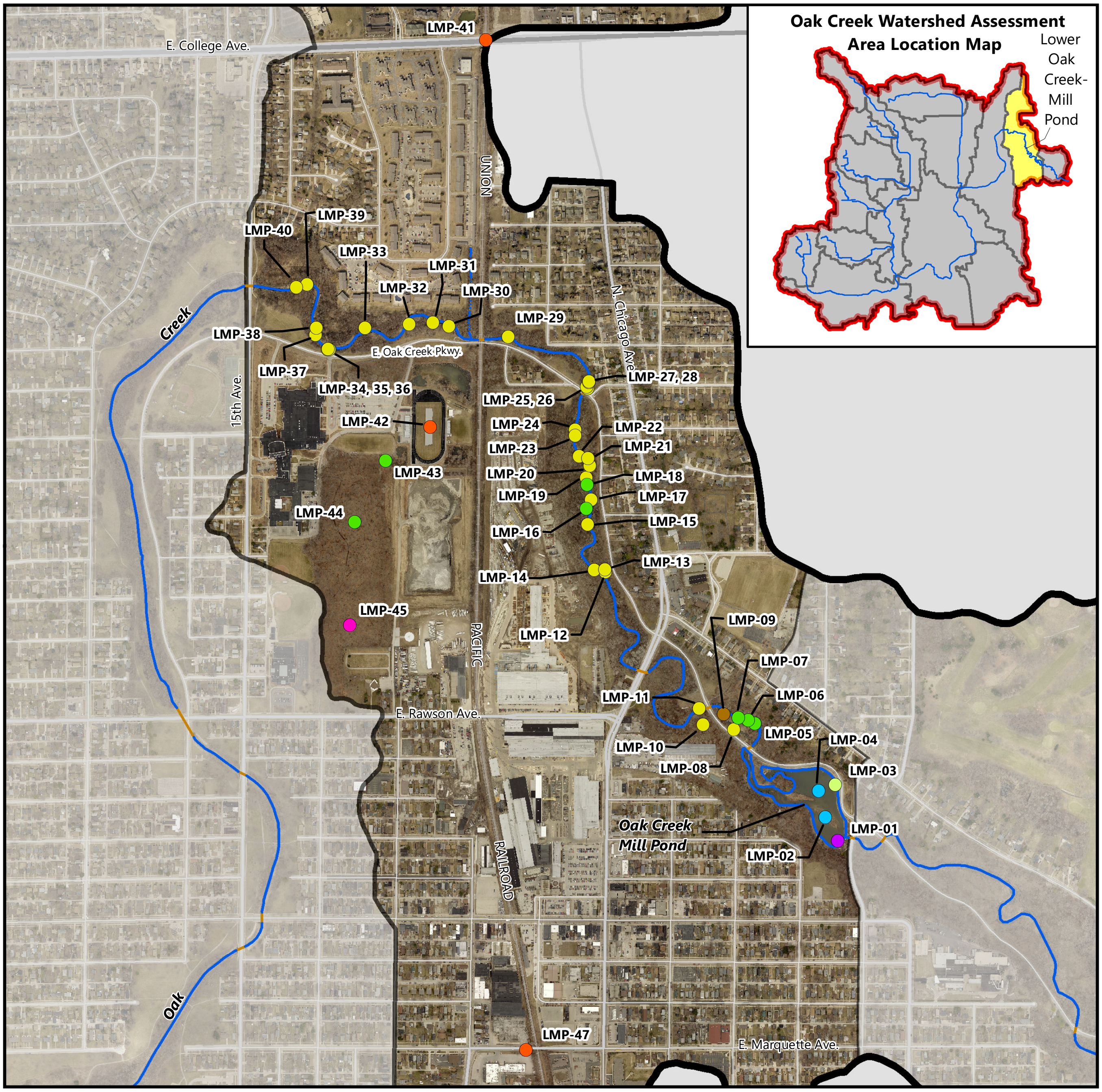
SURFACE WATER

N

0 250 500 Feet

Source: SEWRPC

Map 6.2
Recommended Projects Within the Lower Oak Creek- Mill Pond Assessment Area



- HABITAT AND WATER QUALITY PROJECT
- HABITAT PROJECT
- WATER QUALITY PROJECT
- WATER QUALITY AND STORMWATER DRAINAGE/FLOODING PROJECT
- HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT
- WATER QUALITY AND RECREATIONAL USE AND ACCESS PROJECT
- STORMWATER DRAINAGE/FLOODING PROJECTS
- RECREATIONAL USE AND ACCESS PROJECT

LMP-47 PROJECT ID IN TABLE 6.1

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

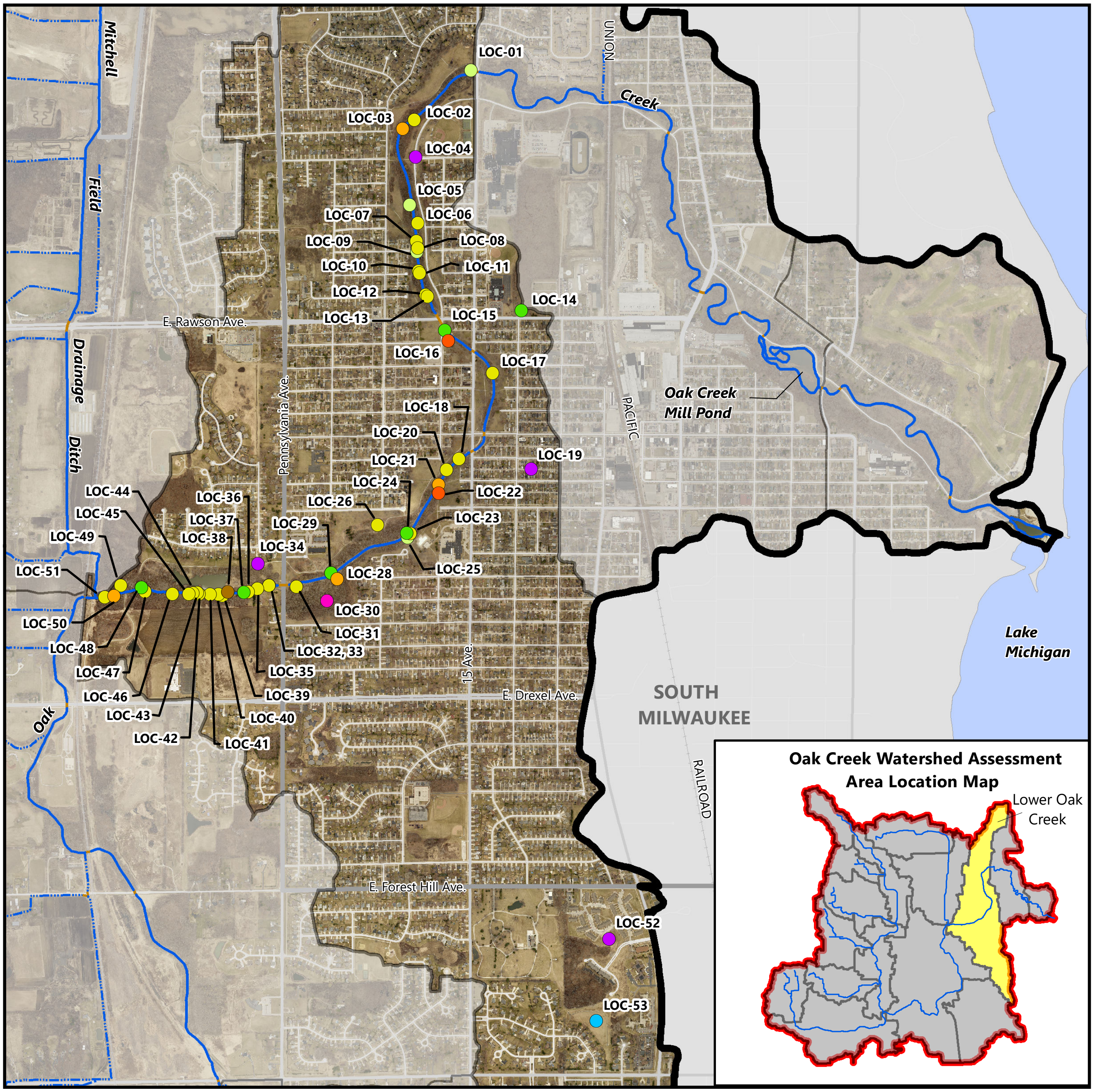
N

0 500 1,000 Feet

Source: SEWRPC

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details. No specific projects are proposed for areas of this assessment area that are not shown.

Map 6.3
Recommended Projects Within the Lower Oak Creek Assessment Area



HABITAT AND WATER QUALITY PROJECT
HABITAT PROJECT
WATER QUALITY PROJECT
HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT
WATER QUALITY AND STORMWATER DRAINAGE/FLOODING PROJECT
HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT
WATER QUALITY AND RECREATIONAL USE AND ACCESS PROJECT
STORMWATER DRAINAGE/FLOODING PROJECTS
RECREATIONAL USE AND ACCESS PROJECT
LOC-53 PROJECT ID IN TABLE 6.1

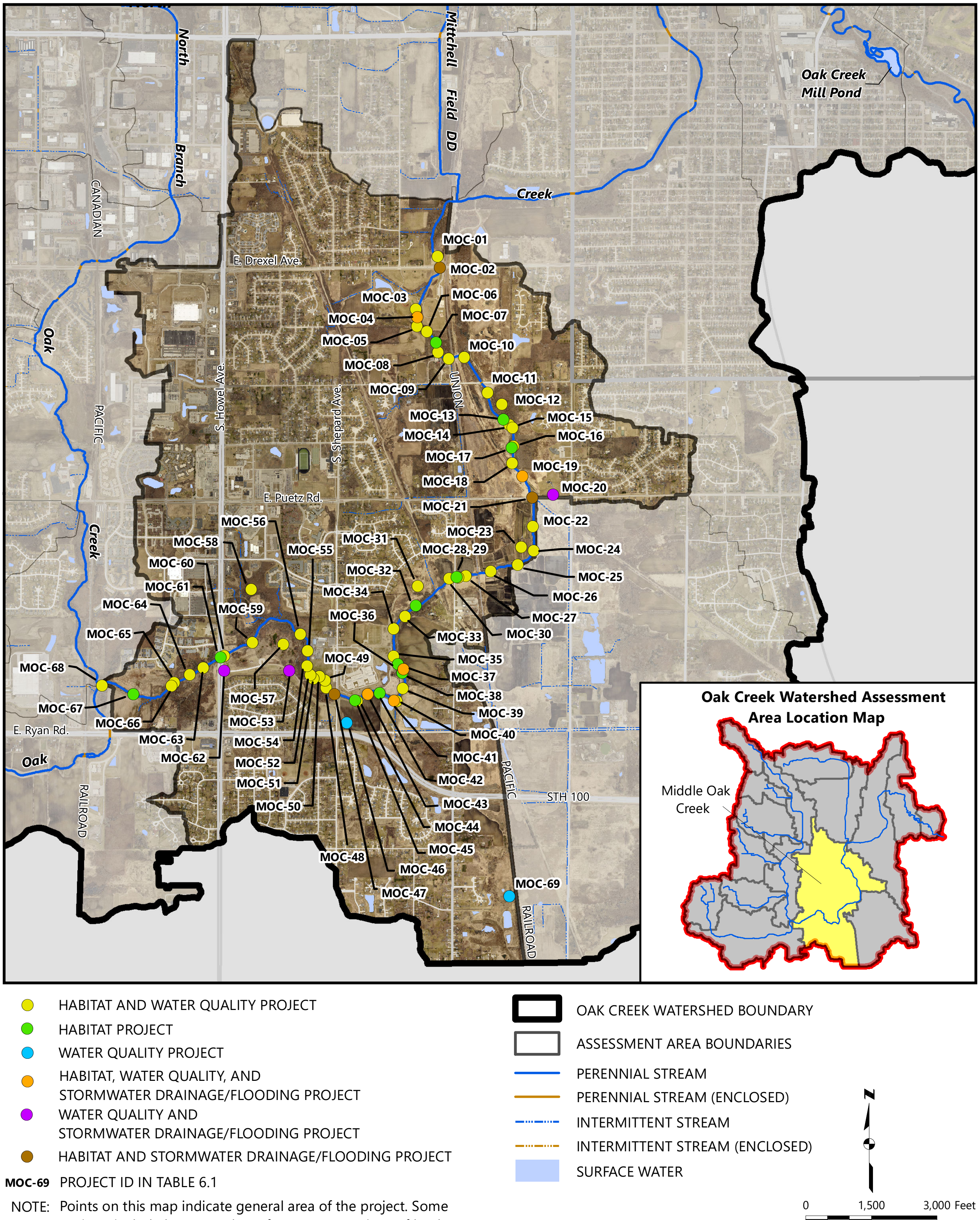
OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)
SURFACE WATER

0 1,000 2,000 Feet

Source: SEWRPC

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details. No specific projects are proposed for areas of this assessment area that are not shown.

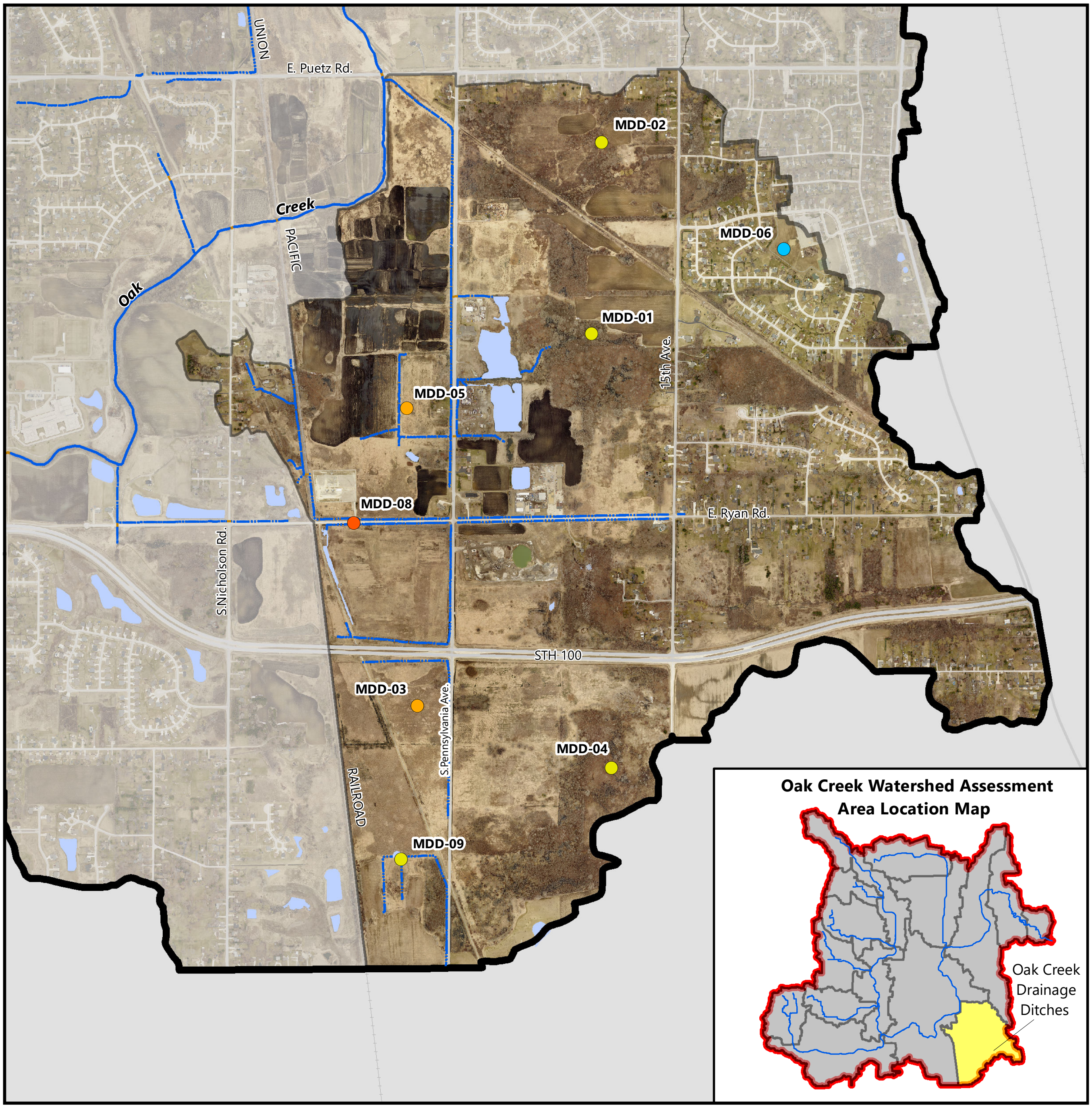
Map 6.4
Recommended Projects Within the Middle Oak Creek Assessment Area



NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

Source: SEWRPC

Map 6.5
Recommended Projects Within the Middle Oak Creek - Drainage Ditches Assessment Area



HABITAT AND WATER QUALITY PROJECT

WATER QUALITY PROJECT

HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT

STORMWATER DRAINAGE/FLOODING PROJECT

RECREATIONAL USE AND ACCESS PROJECT

GPR-01 PROJECT ID IN TABLE 6.1

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

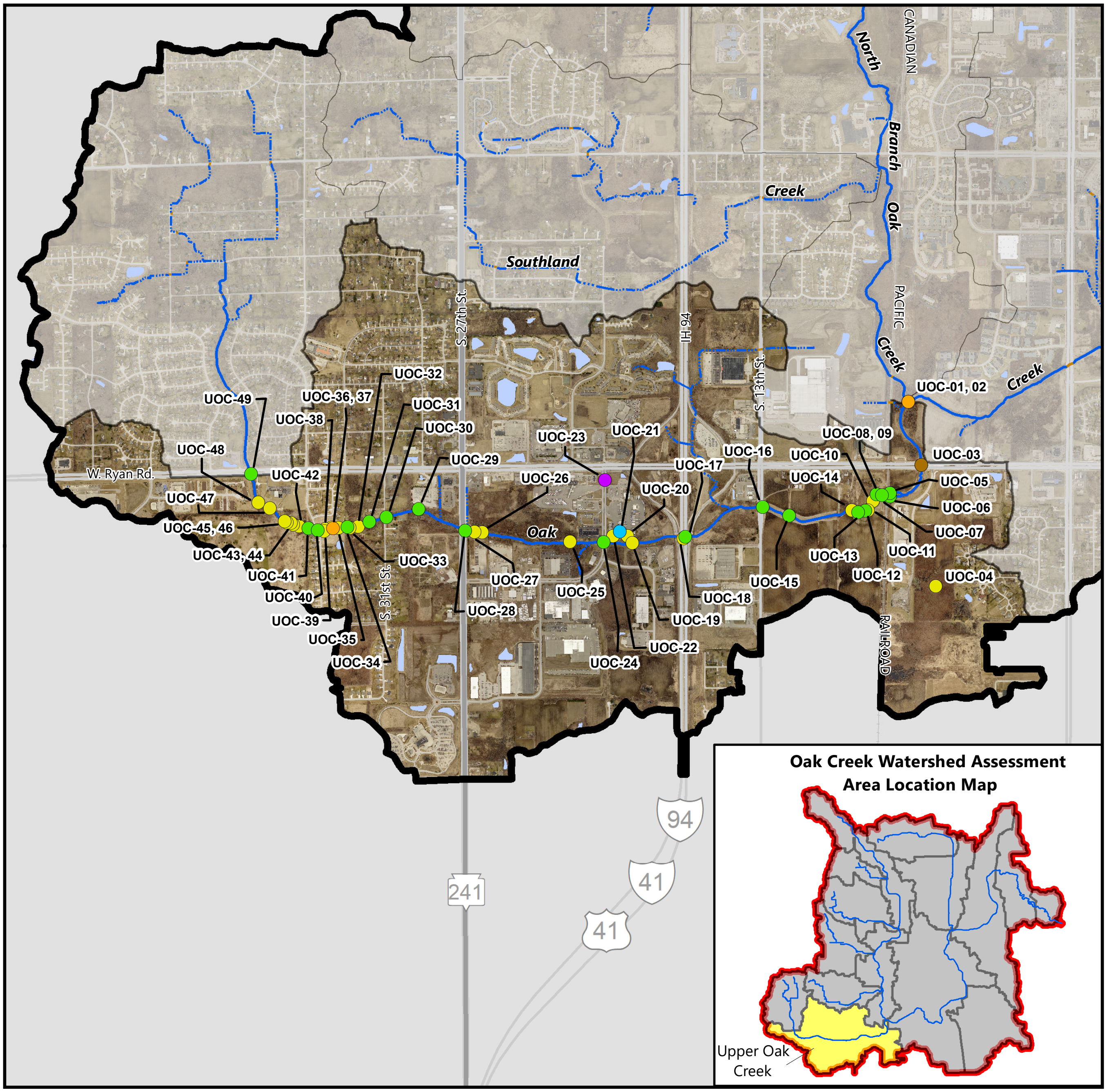
SURFACE WATER

0 750 1,500 Feet

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

Source: SEWRPC

Map 6.6
Recommended Projects Within the Upper Oak Creek Assessment Area



- HABITAT AND WATER QUALITY PROJECT
- HABITAT PROJECT
- WATER QUALITY PROJECT
- HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT
- WATER QUALITY AND STORMWATER DRAINAGE/FLOODING PROJECT
- HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT

UOC-49 PROJECT ID IN TABLE 6.1

- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

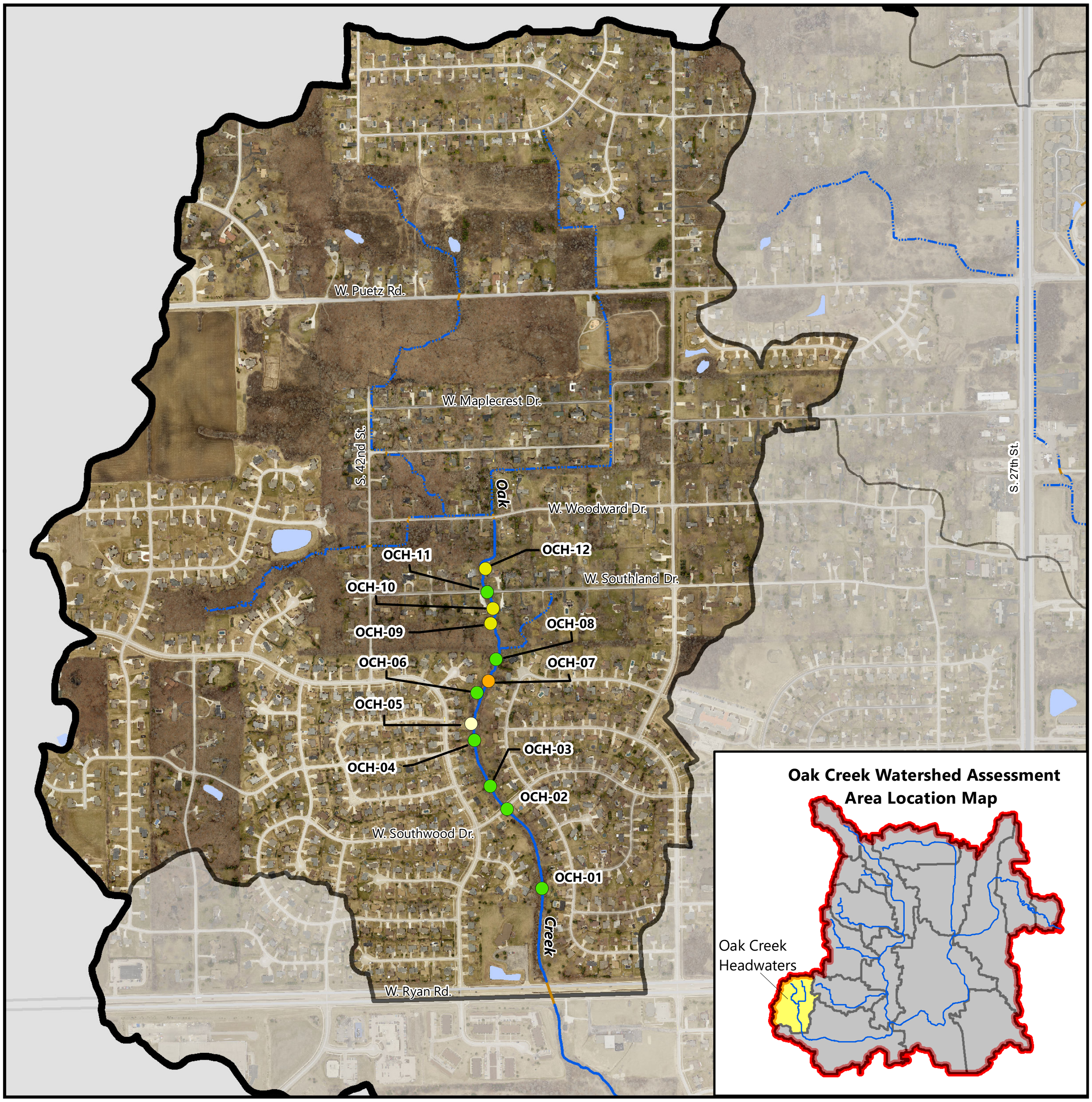
N

0 1,000 2,000 Feet

Source: SEWRPC

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

Map 6.7
Recommended Projects Within the Oak Creek Headwaters Assessment Area



- HABITAT AND WATER QUALITY PROJECT
- HABITAT PROJECT
- HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT
- WATER QUALITY AND RECREATIONAL USE AND ACCESS PROJECT

OCH-12 PROJECT ID IN TABLE 6.1

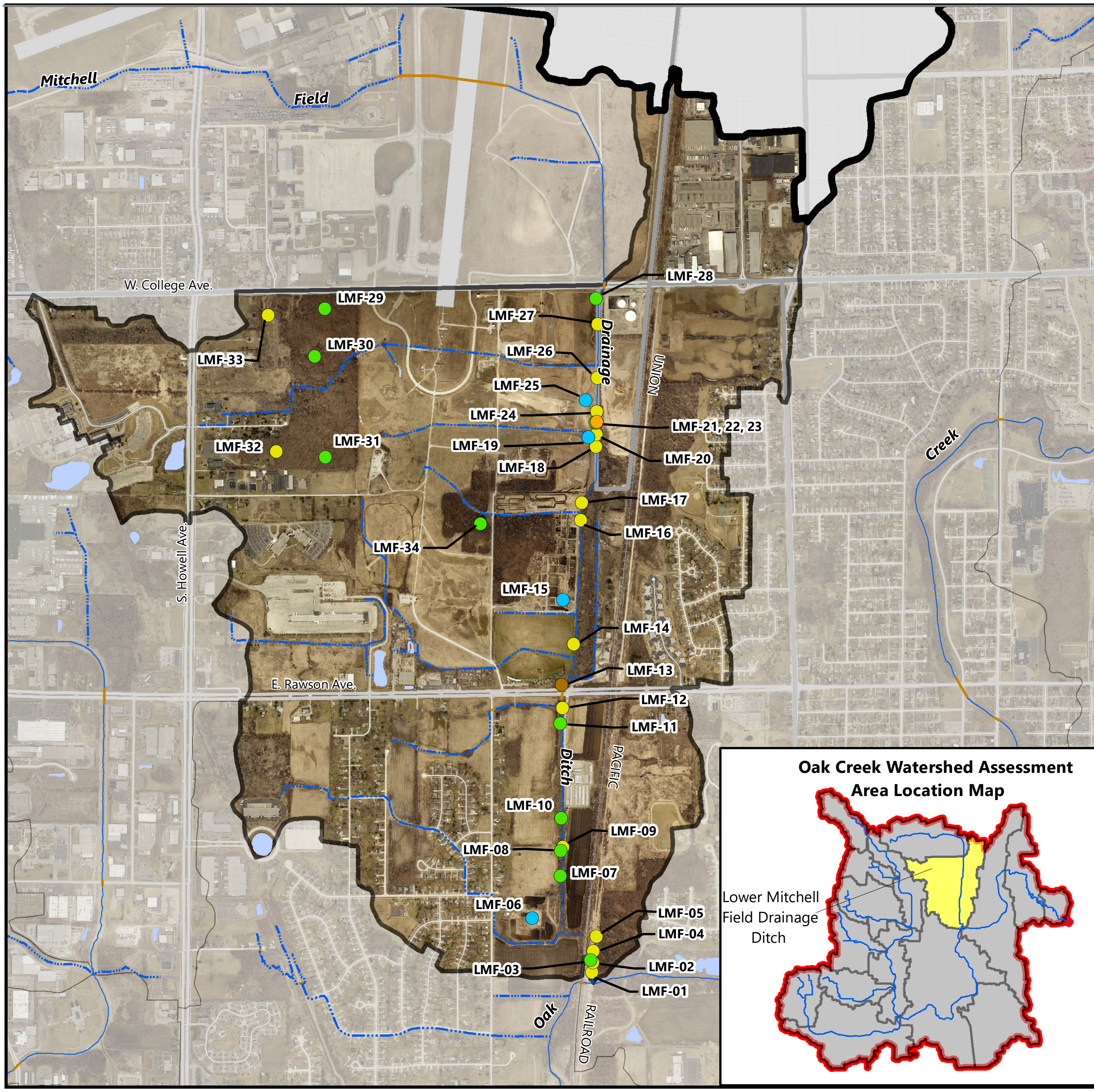
- OAK CREEK WATERSHED BOUNDARY
- ASSESSMENT AREA BOUNDARIES
- PERENNIAL STREAM
- PERENNIAL STREAM (ENCLOSED)
- INTERMITTENT STREAM
- INTERMITTENT STREAM (ENCLOSED)
- SURFACE WATER

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

0 500 1,000 Feet

Source: SEWRPC

Map 6.8
Recommended Projects Within the Lower Mitchell Field Drainage Ditch Assessment Area



HABITAT AND WATER QUALITY PROJECT

HABITAT PROJECT

WATER QUALITY PROJECT

HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT

HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT

LMF-34 PROJECT ID IN TABLE 6.1

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

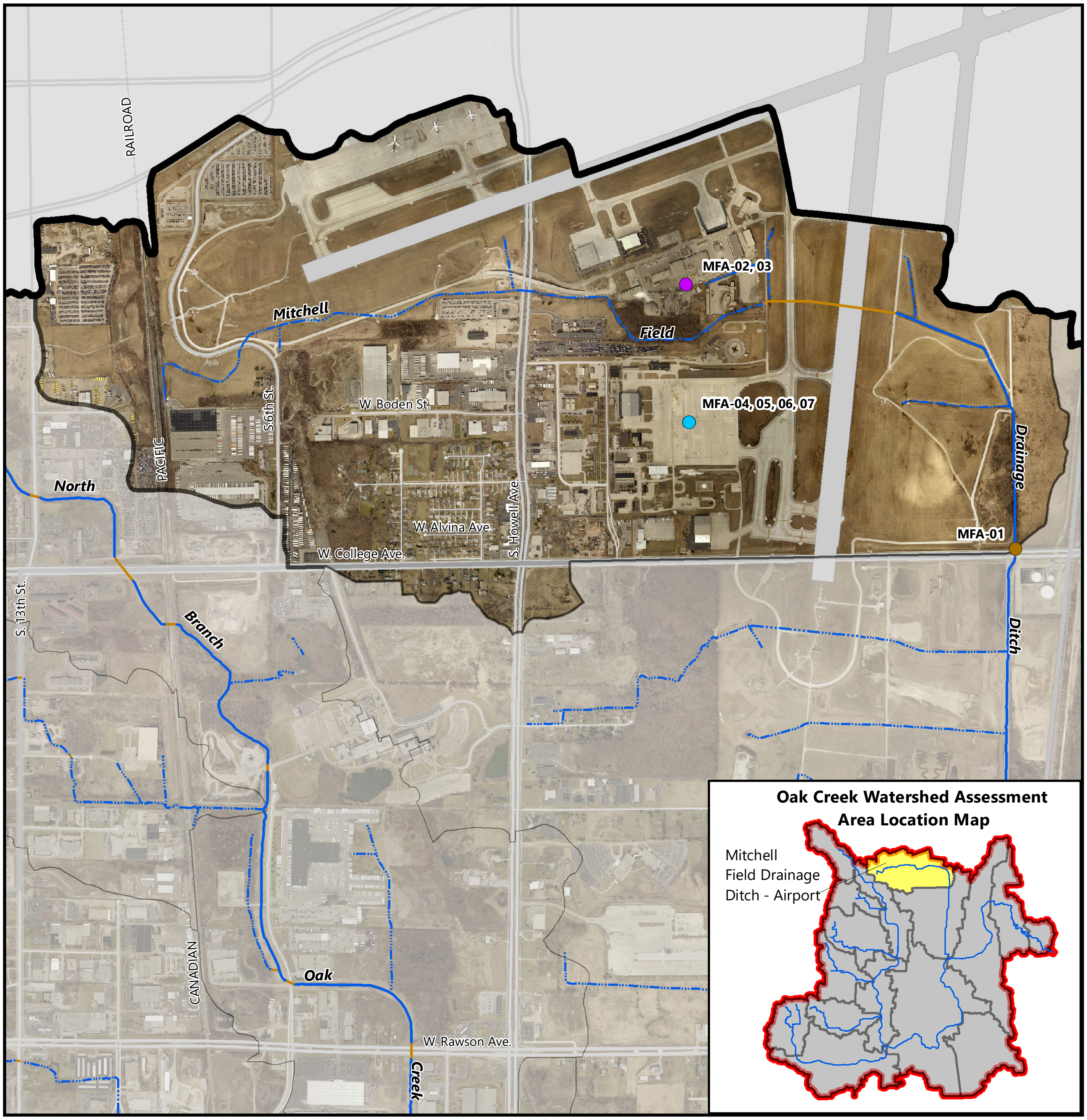
NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

N

0 1,000 2,000 Feet

Source: SEWRPC

Map 6.9
Recommended Projects Within the Mitchell Field Drainage Ditch - Airport Assessment Area



WATER QUALITY PROJECT

WATER QUALITY AND STORMWATER DRAINAGE/FLOODING PROJECT

HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT

MFA-07 PROJECT ID IN TABLE 6.1

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

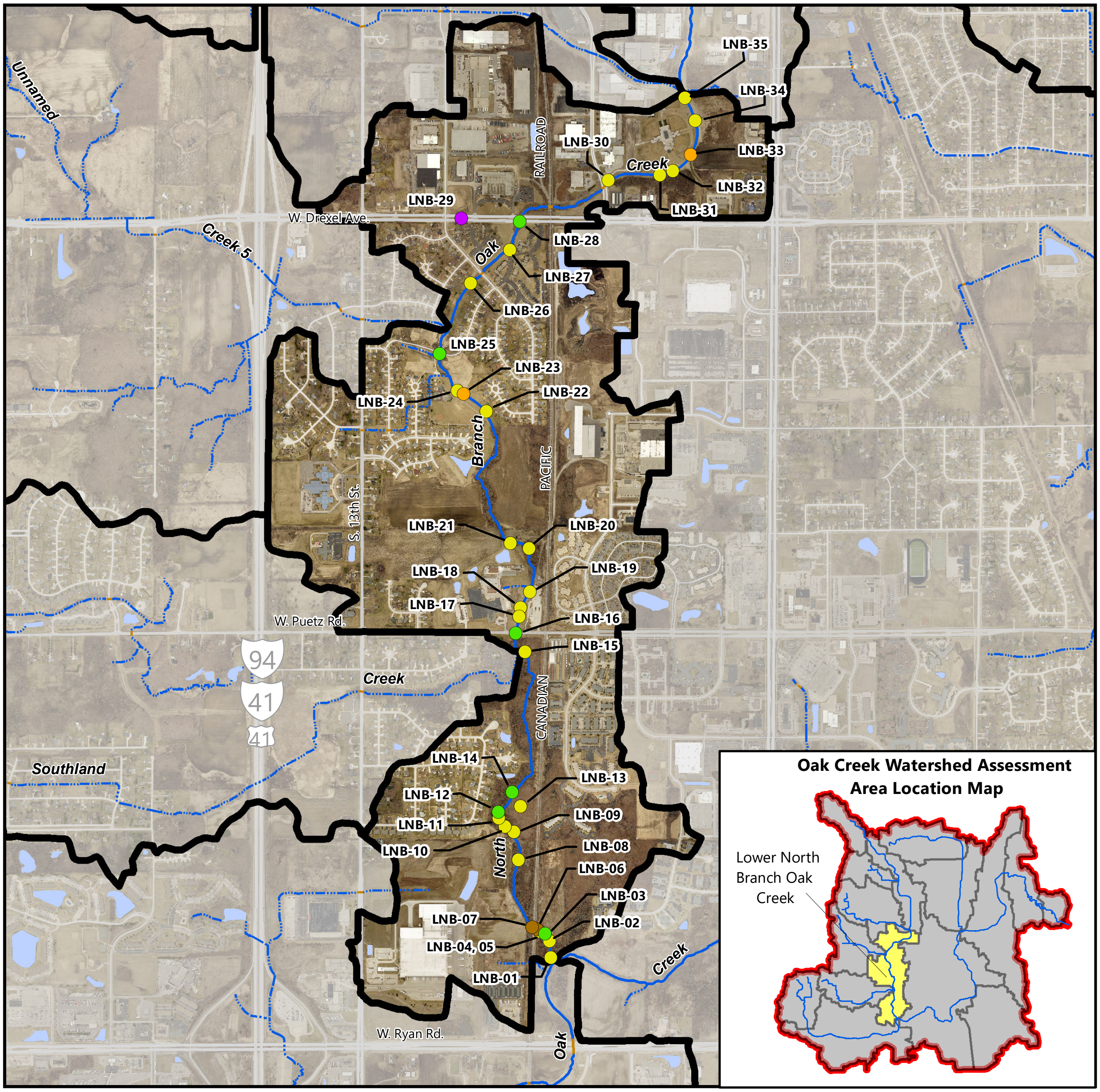
N

0 500 1,000 Feet

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

Source: SEWRPC

Map 6.10
Recommended Projects Within the Lower North Branch Oak Creek Assessment Area



HABITAT AND WATER QUALITY PROJECT
HABITAT PROJECT
HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT
HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT
WATER QUALIITY AND STORMWATER DRAINAGE/FLOODING PROJECT
LNB-35 PROJECT ID IN TABLE 6.1

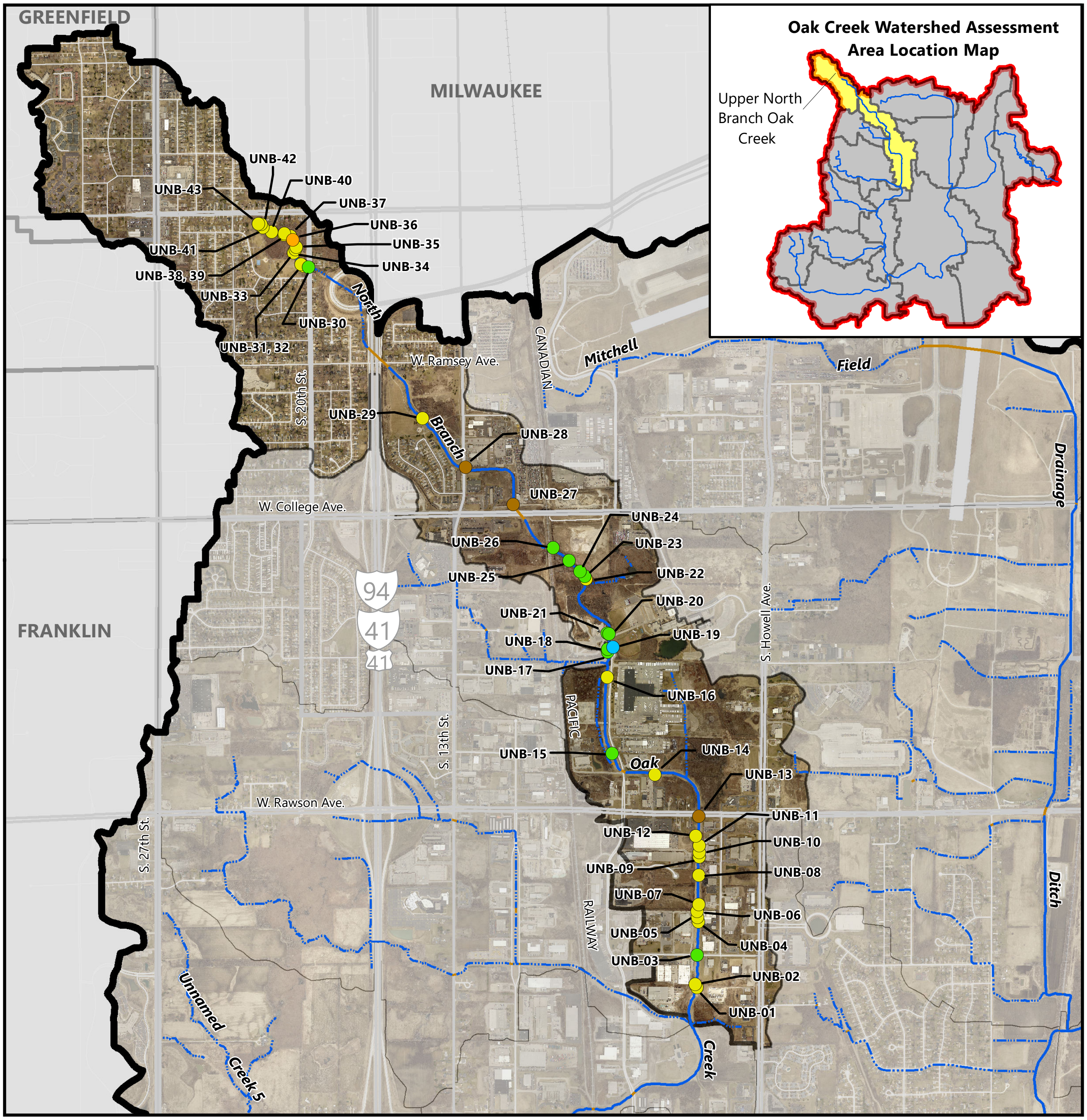
OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)
SURFACE WATER

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

0 1,000 2,000 Feet

Source: SEWRPC

Map 6.11
Recommended Projects Within the Upper North Branch Oak Creek Assessment Area



HABITAT AND WATER QUALITY PROJECT

HABITAT PROJECT

WATER QUALITY PROJECT

HABITAT, WATER QUALITY, AND STORMWATER DRAINAGE/FLOODING PROJECT

HABITAT AND STORMWATER DRAINAGE/FLOODING PROJECT

UNB-43 PROJECT ID IN TABLE 6.1

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

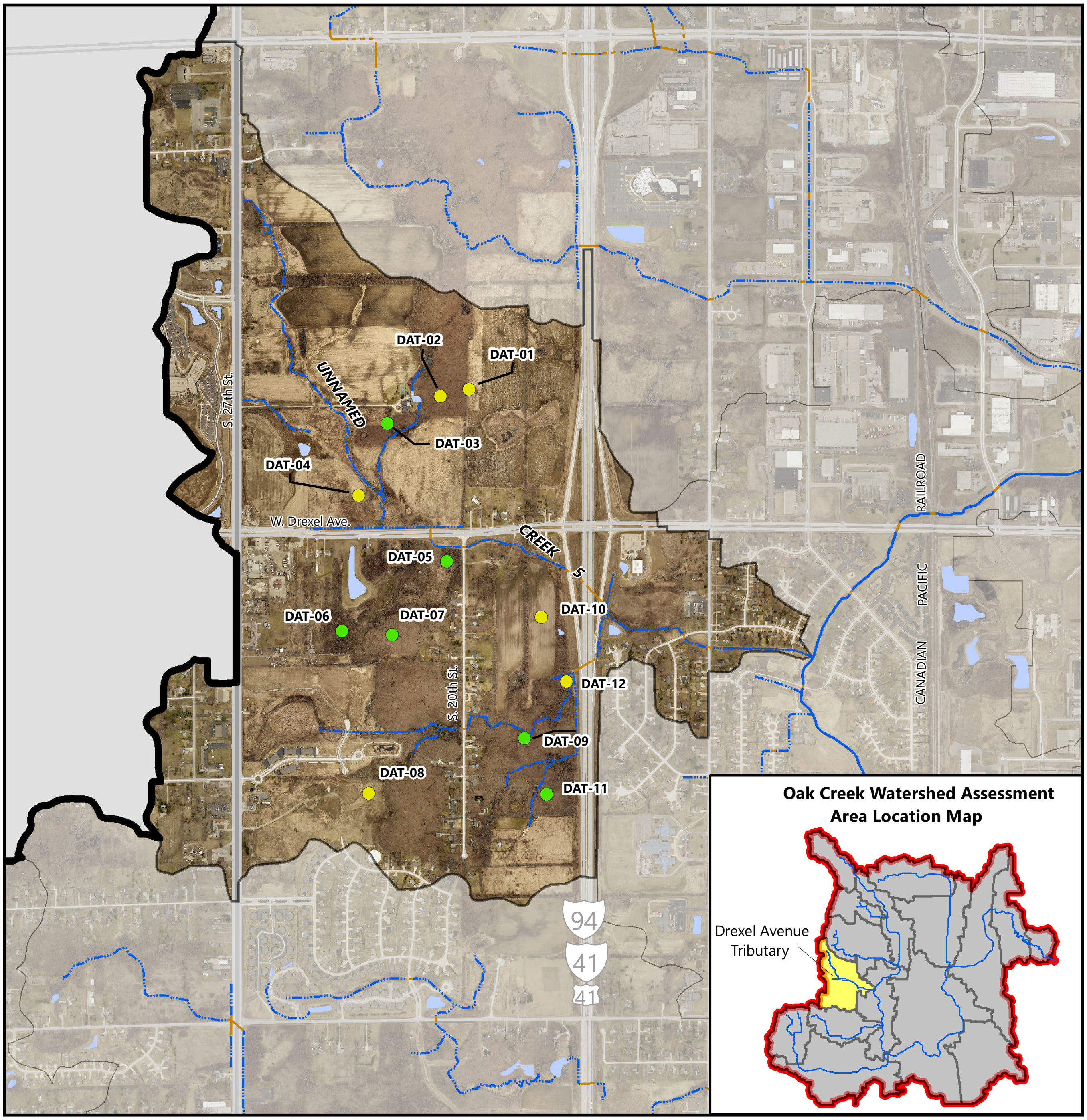
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 1,000 2,000 Feet

Source: SEWRPC

Map 6.12
Recommended Projects Within the Drexel Avenue Tributary Assessment Area



HABITAT AND WATER QUALITY PROJECT

HABITAT PROJECT

DAT-12 PROJECT ID IN TABLE 6.1

NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

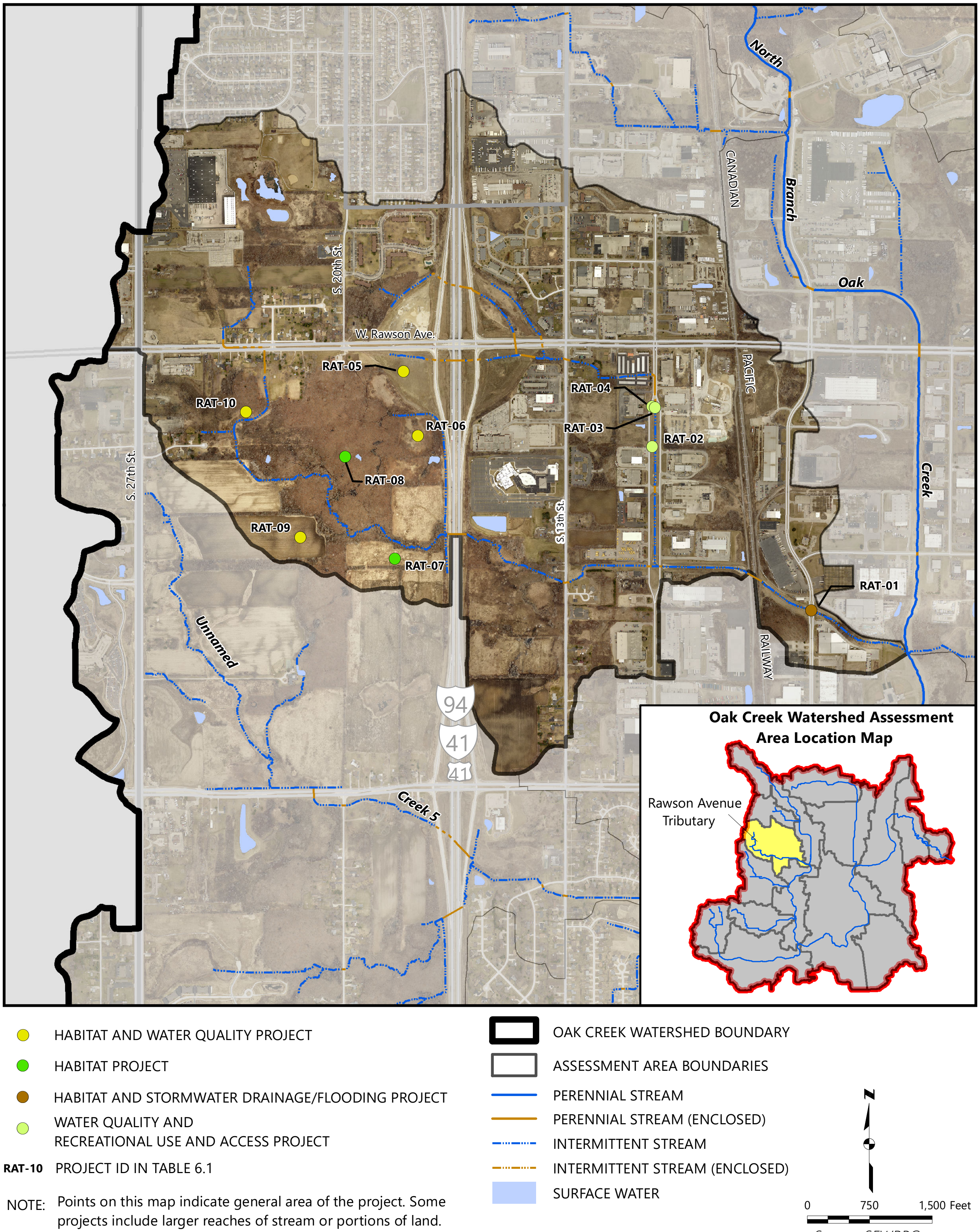
SURFACE WATER

N

0 500 1,000 Feet

Source: SEWRPC

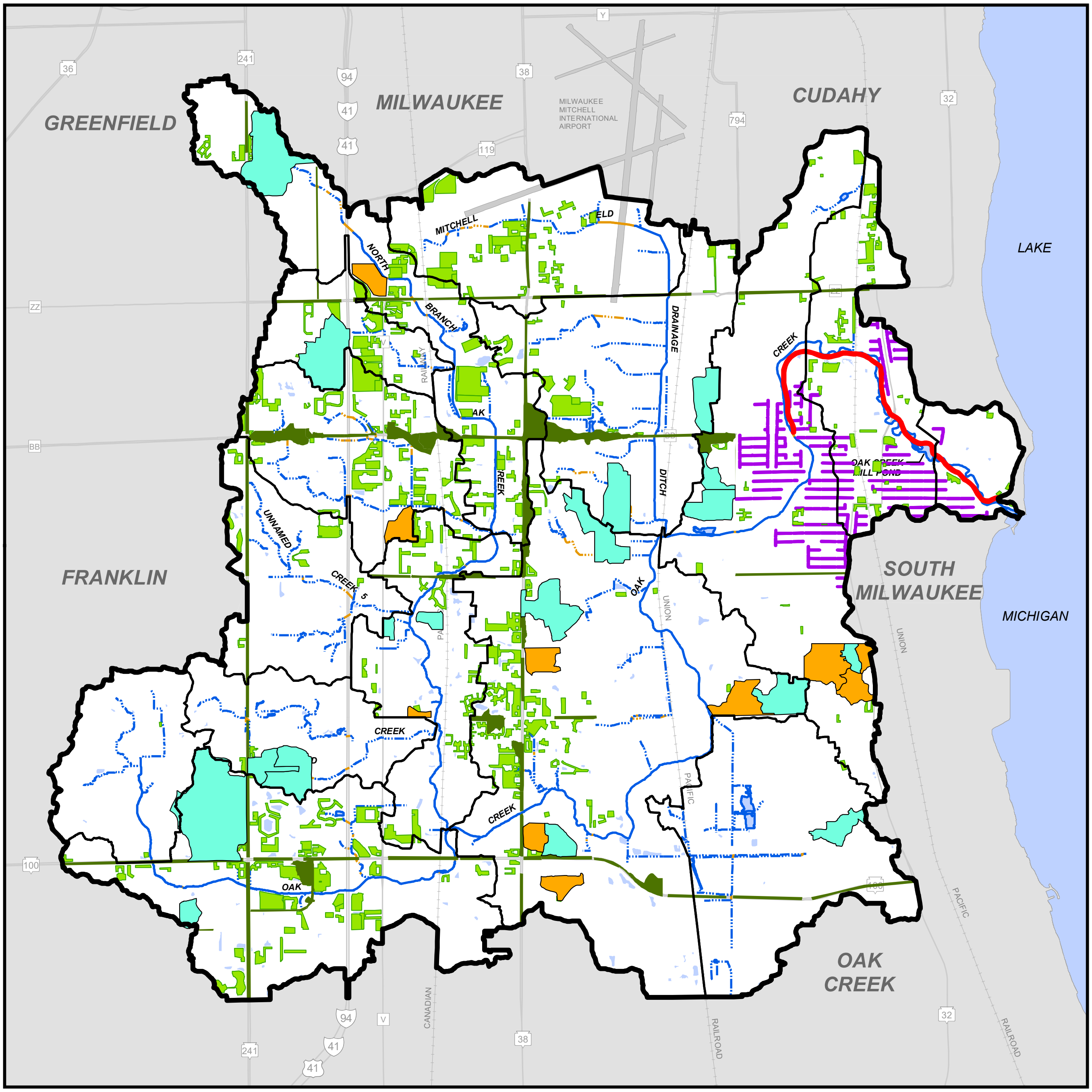
Map 6.13
Recommended Projects Within the Rawson Avenue Tributary Assessment Area



NOTE: Points on this map indicate general area of the project. Some projects include larger reaches of stream or portions of land. See Table 6.1 for project details.

Source: SEWRPC

Map 6.14
Preliminary Candidate Locations for Installation of Selected Stormwater Management Practices in the Oak Creek Watershed



ALLEYS IN WHICH TO INSTALL PERVIOUS PAVEMENT

AREAS TO BE SERVED BY BOULEVARD MEDIAN BIORETENTION OR BIOSWALE

OAK CREEK PARKWAY LOCATIONS IN WHICH TO INSTALL PERVIOUS PAVEMENT

PARKING LOTS IN WHICH TO INSTALL PERVIOUS PAVEMENT

SUBBASIN TO BE SERVED BY STORM SEWER DAYLIGHTING AND DRAINAGE SWALE

SUBBASIN TO BE SERVED BY WET RETENTION POND

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

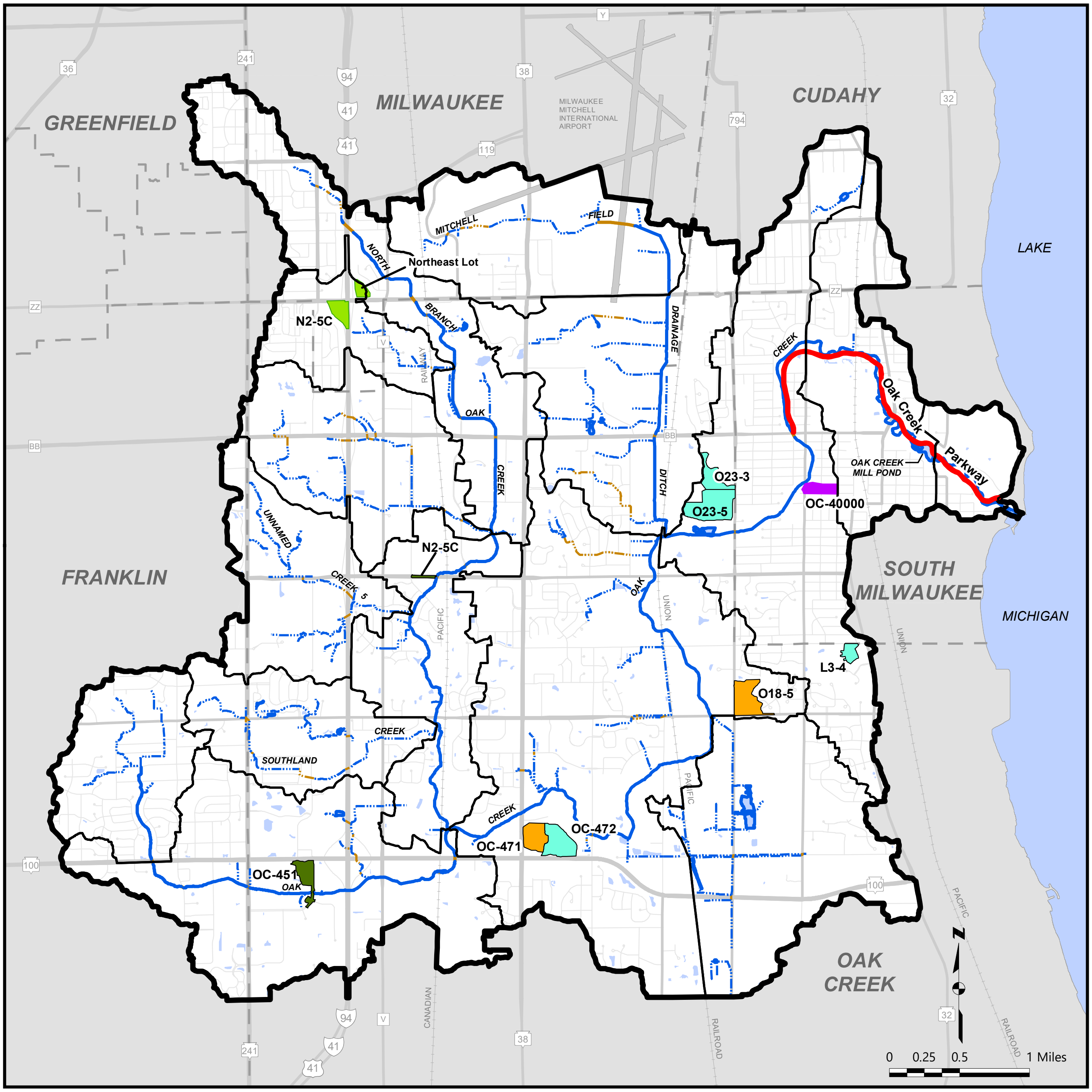
INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

0 0.25 0.5 1 Miles

Source: SEWRPC

Map 6.15
Locations Stormwater Managment Practice Pilot Projects Evaluated in the Oak Creek Watershed



ALLEY PERVIOUS PAVEMENT PILOT PROJECTS

PARKWAY PERVIOUS PAVEMENT PILOT PROJECTS

PARKING LOT PERVIOUS PAVEMENT PILOT PROJECTS

BIORETENTION OR BIOSWALE PILOT PROJECTS

STORM SEWER DAYLIGHTING AND DRAINAGE SWALE PILOT PROJECTS

WET RETENTION POND PILOT PROJECTS

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

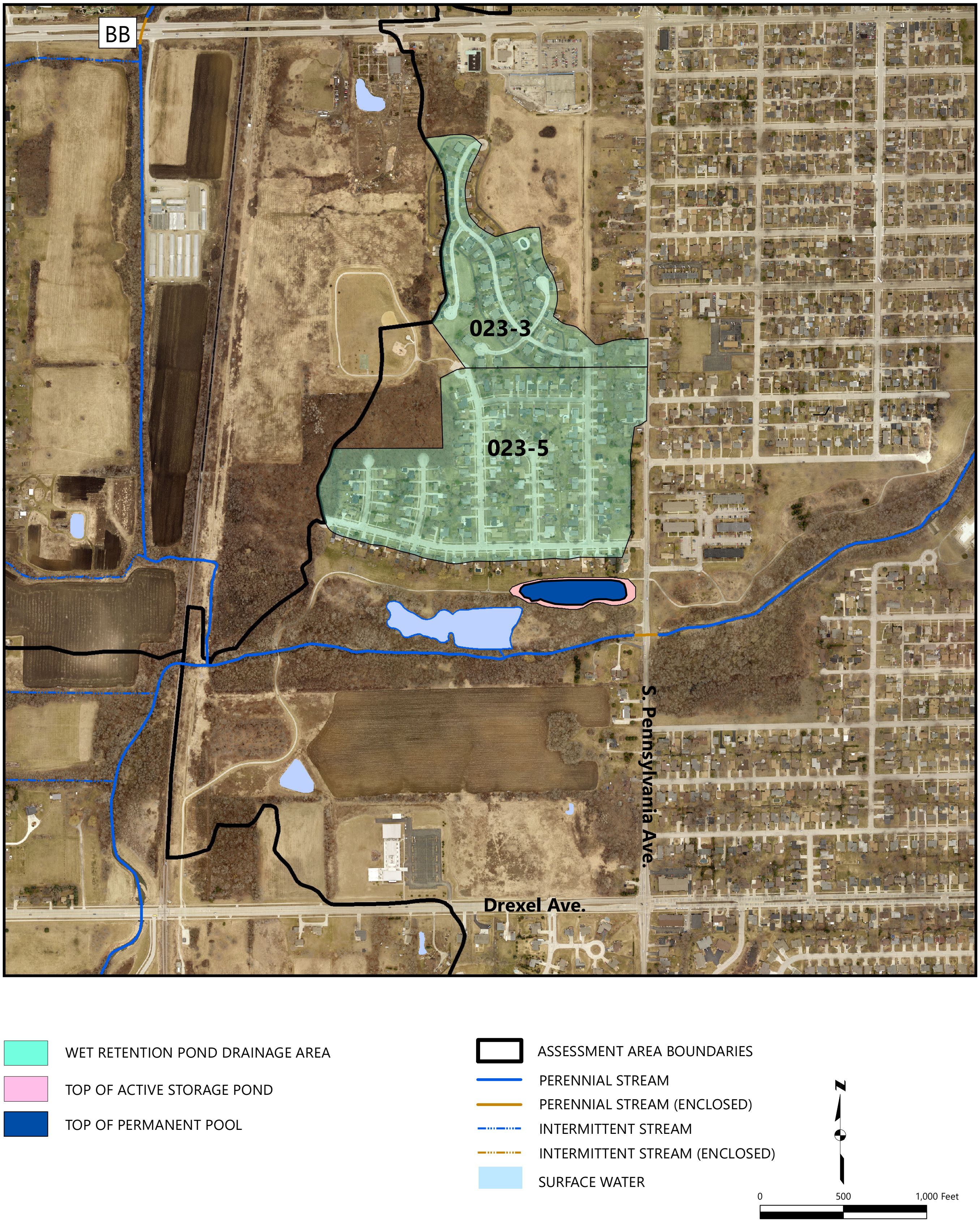
INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

Source: SEWRPC

Map 6.16
Wet Retention Pond Pilot Project near E. Montana Avenue and S. Pennsylvania Avenue

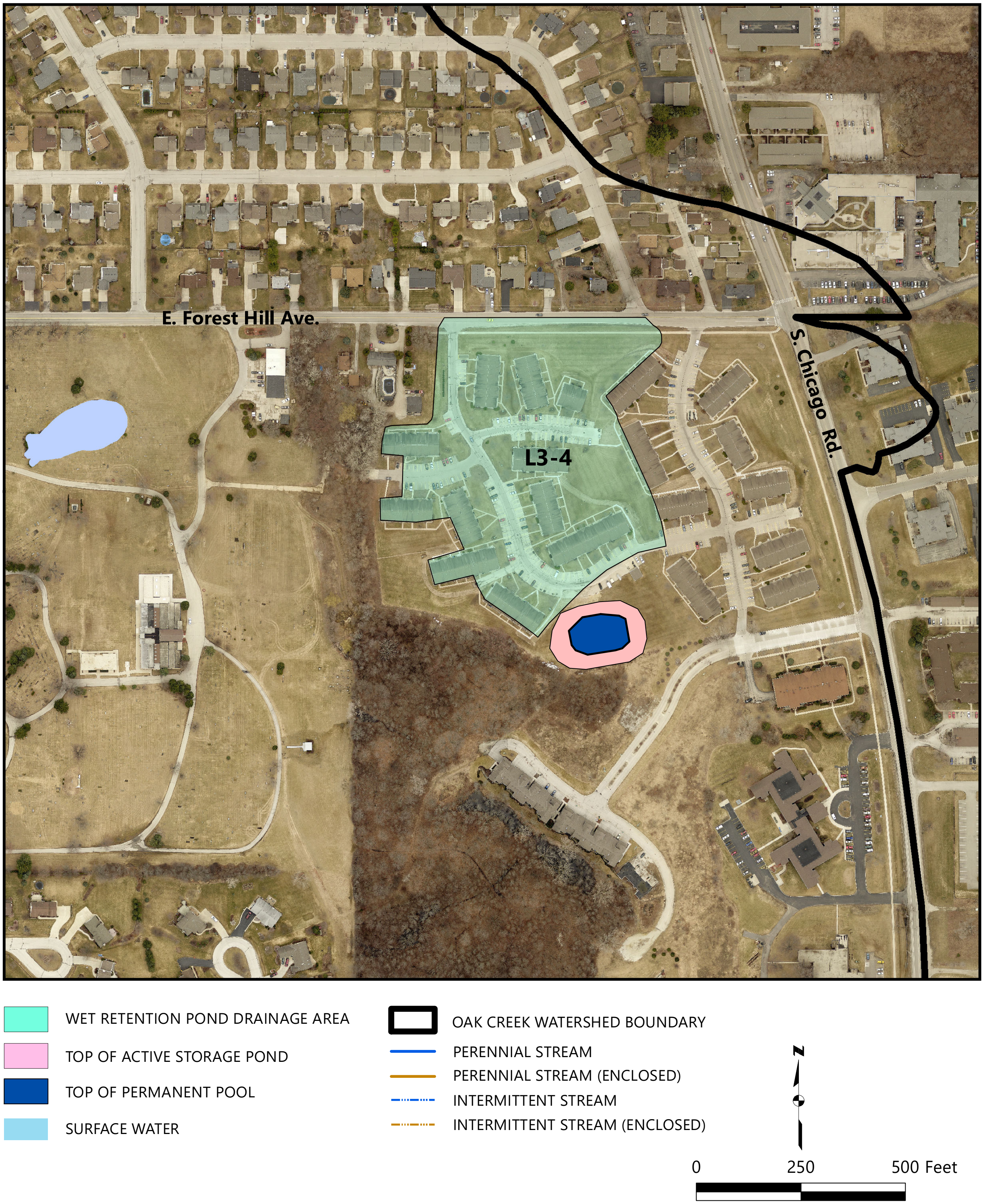


Source: SEWRPC

Map 6.17
Wet Retention Pond Pilot Project North of E. Parkway Estates Drive

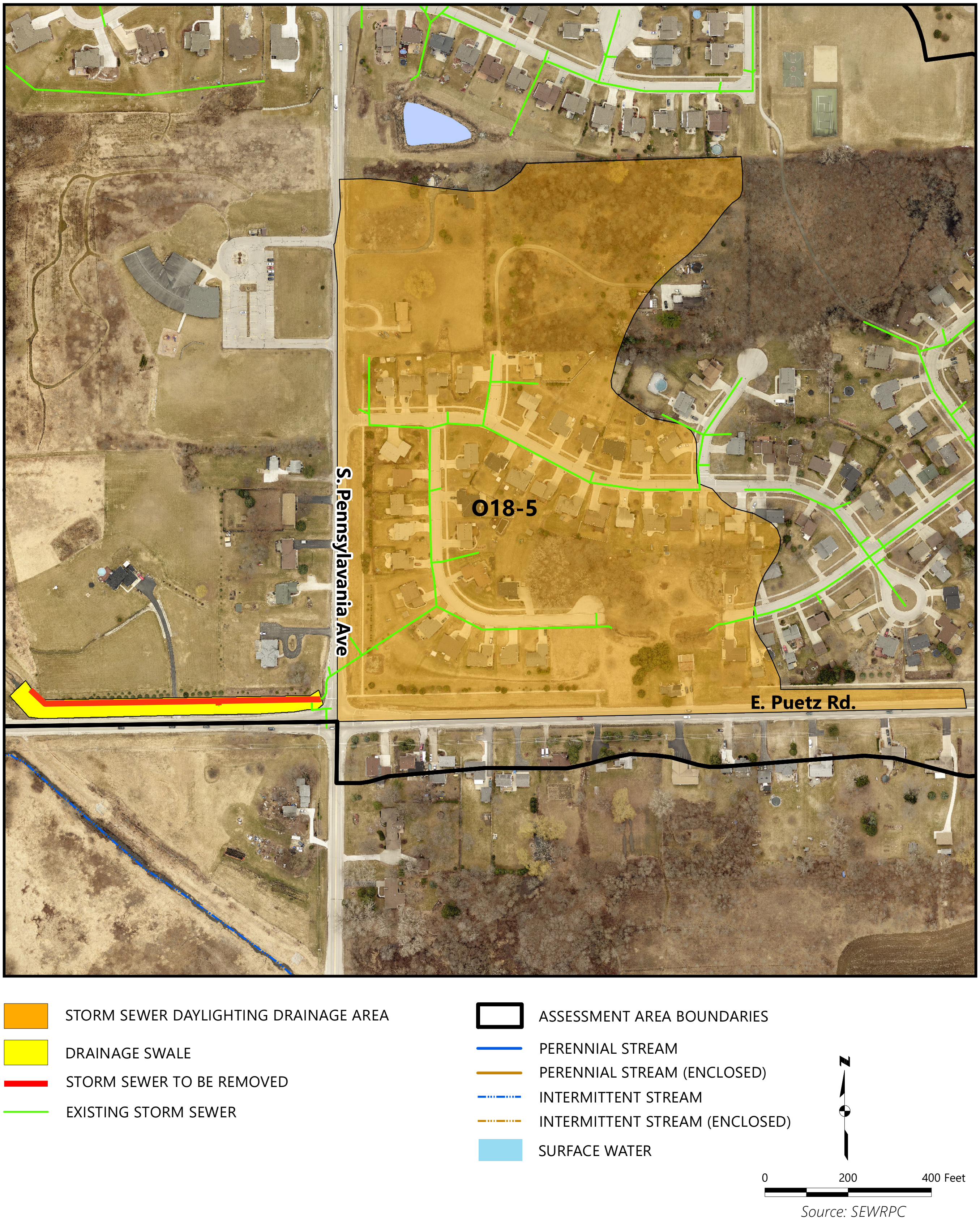
Source: SEWRPC

Map 6.18
Wet Retention Pond Pilot Project near E. Forest Hill Avenue and Newbury Drive



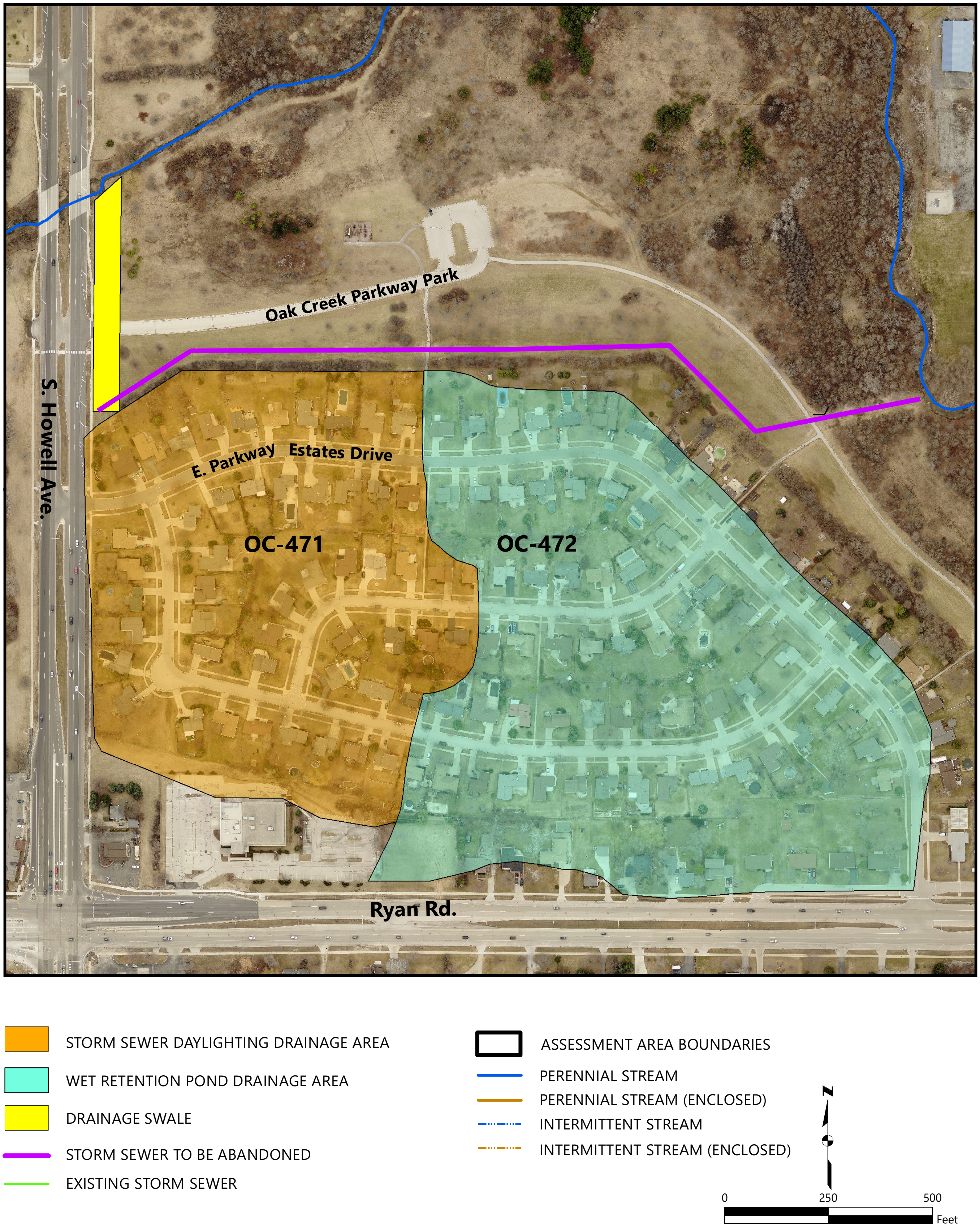
Source: SEWRPC

Map 6.19
Storm Sewer Daylighting Pilot Project near E. Puetz Road and S. Pennsylvania Avenue



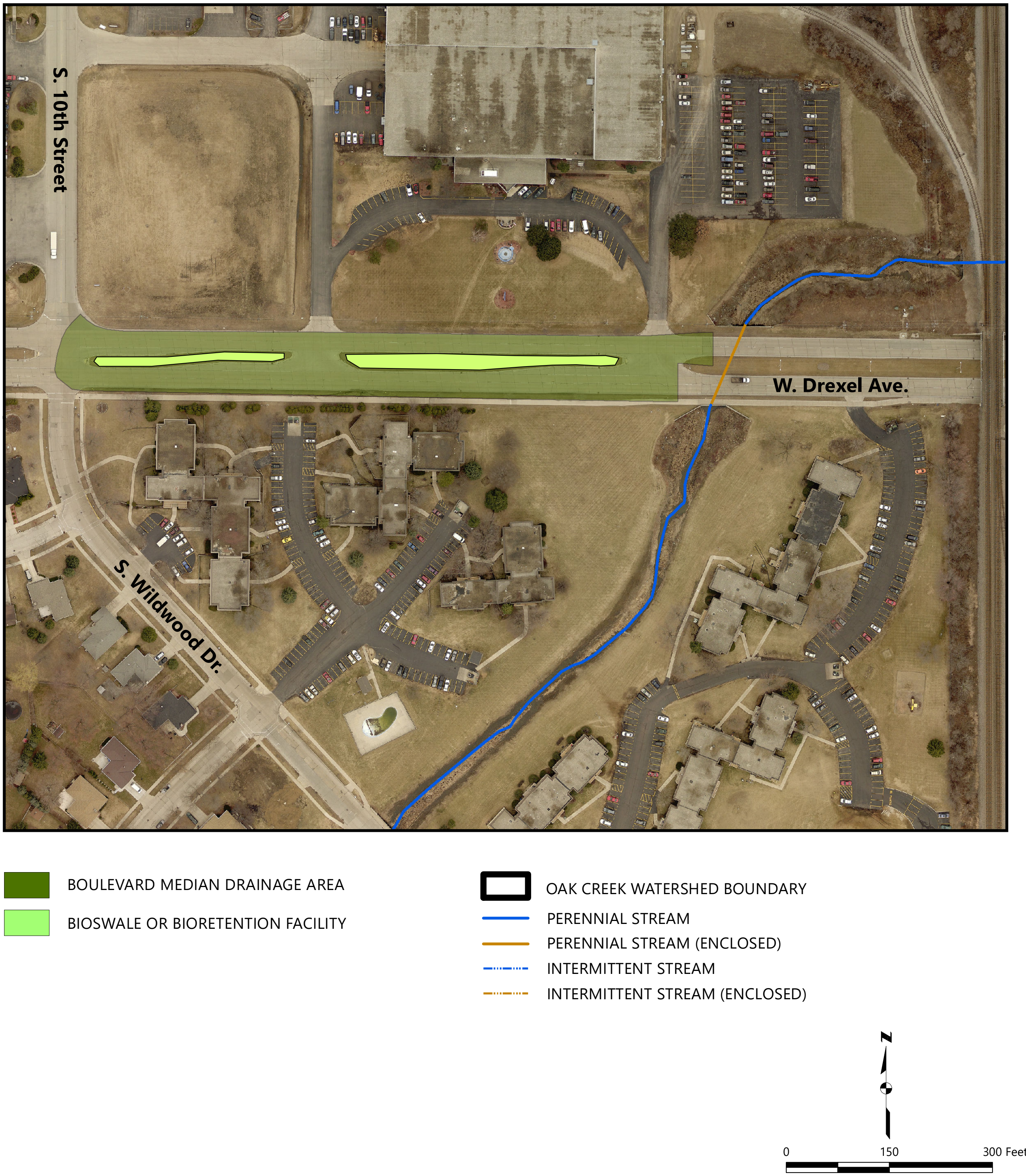
Source: SEWRPC

Map 6.20
Storm Sewer Daylighting Pilot Project near E. Parkway Estates and S. Howell Avenue



Source: SEWRPC

Map 6.21
Boulevard Median Bioswale or Bioretention Pilot Project Along W. Drexel Avenue near S.10th Street



Source: SEWRPC

Map 6.22
Boulevard Median Bioswale or Bioretention Pilot Project Along S. 20th Street near W. Ryan Road

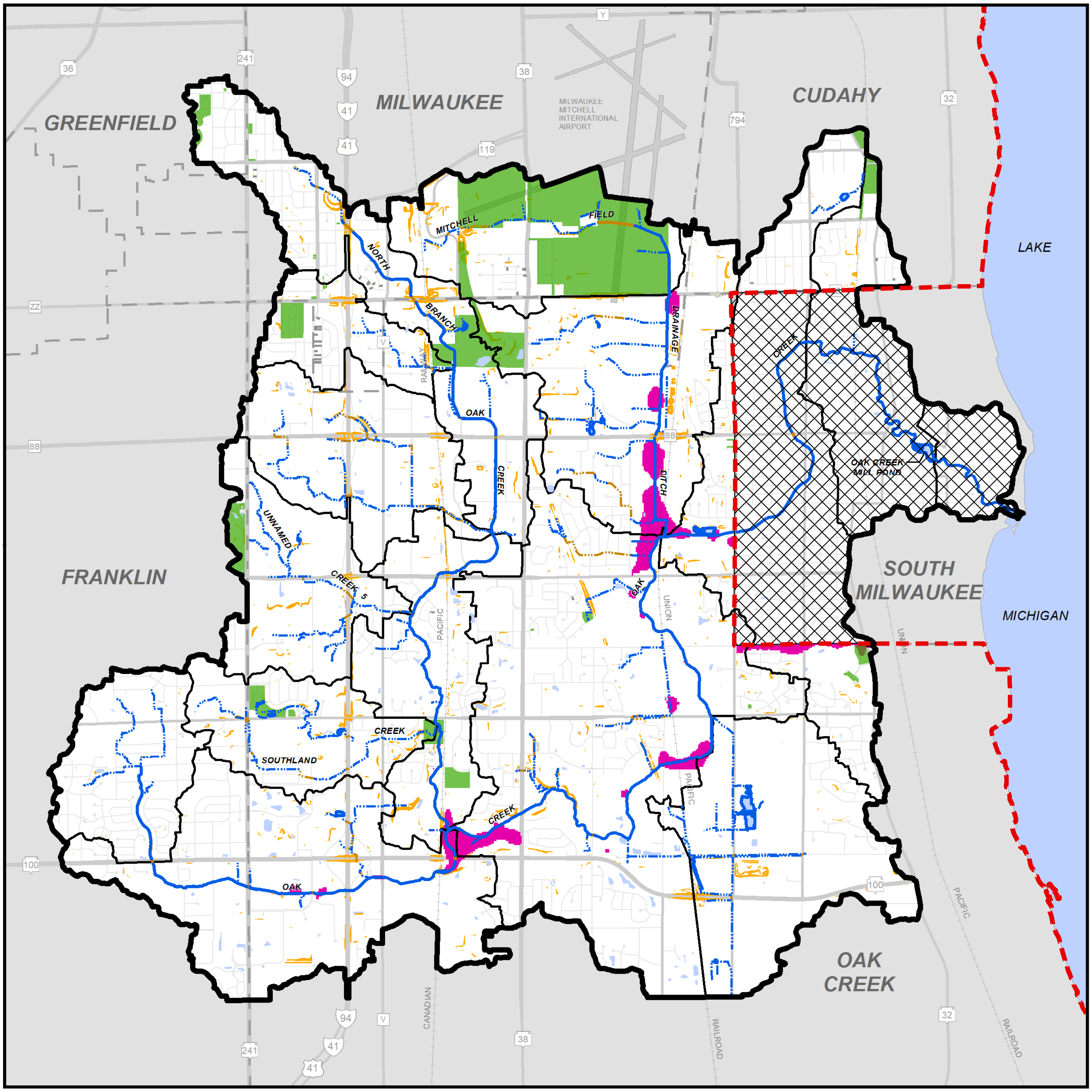
BOULEVARD MEDIAN DRAINAGE AREA
BIOSWALE OR BIORETENTION FACILITY
SURFACE WATER
OAK CREEK WATERSHED BOUNDARY
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)

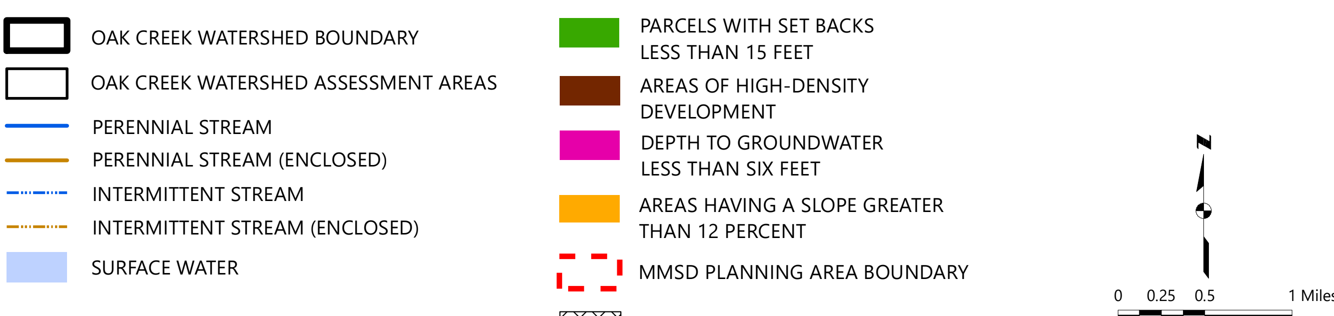
N

0 0.055 0.11 Miles

Source: SEWRPC

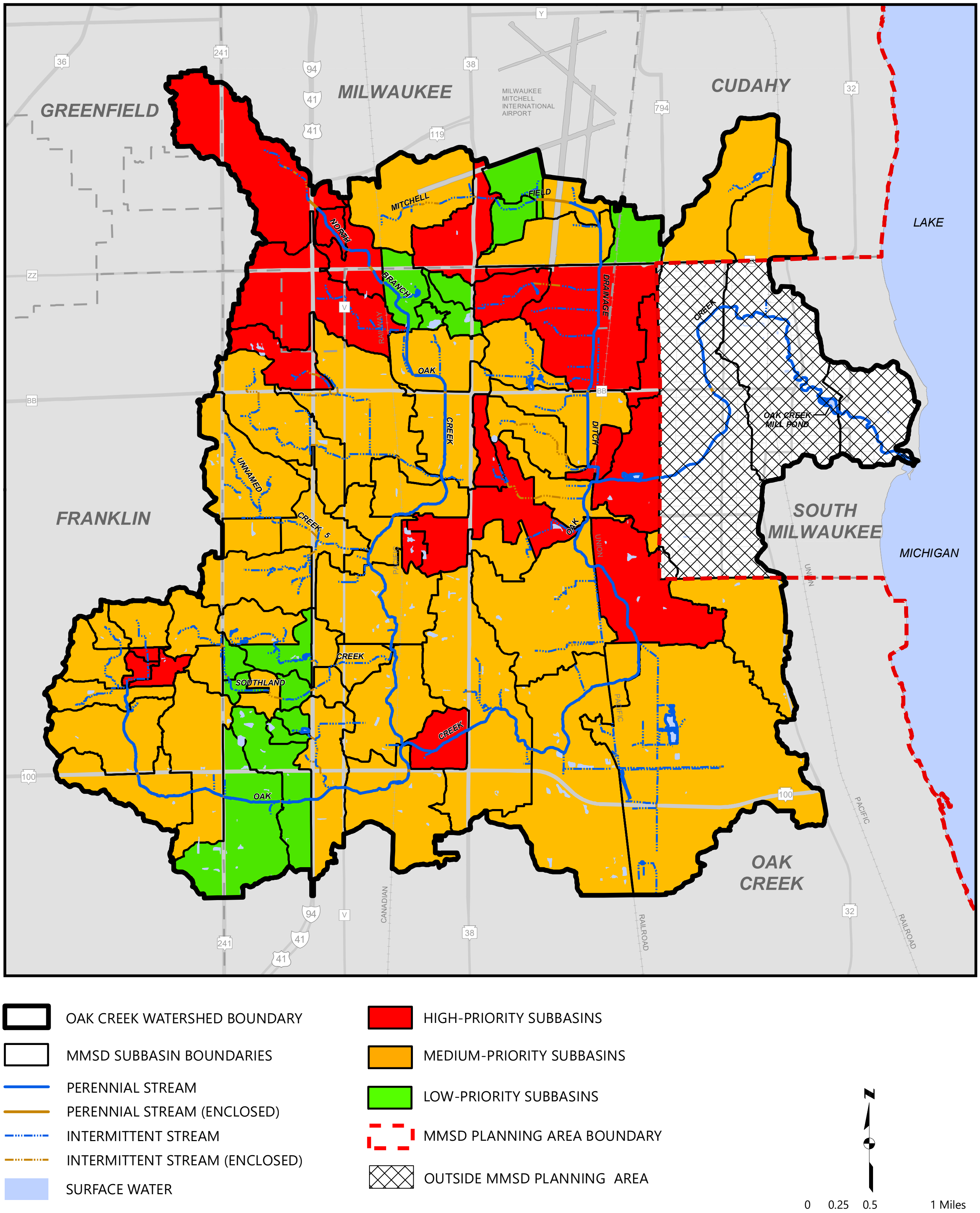
Map 6.23
Potential Constraints to the Use of Green Infrastructure Strategies Within the Portion of the Oak Creek Watershed Located in the Milwaukee Metropolitan Sewerage District Planning Area





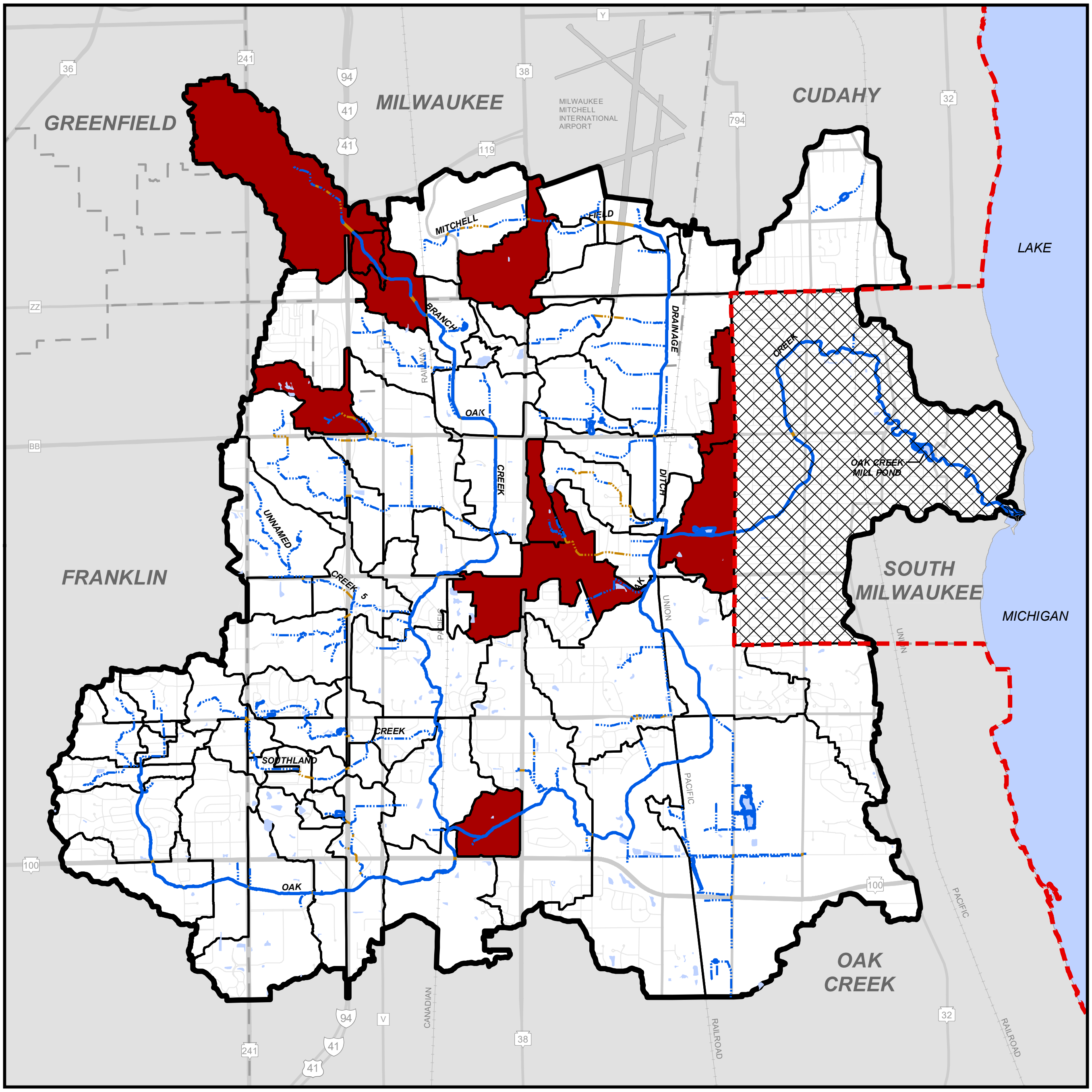
Source: SEWRPC

Map 6.24
Combined Benefit and Opportunity Ranks for the Use of Green Infrastructure Strategies Within the Portion of the Oak Creek Watershed Located in the Milwaukee Metropolitan Sewerage District Planning Area



Source: SEWRPC

Map 6.25
High Priority Subbasins for the Implementation of Green Infrastructure Strategies Within the Portion of the Oak Creek Watershed Located in the Milwaukee Metropolitan Sewerage District Planning Area



OAK CREEK WATERSHED BOUNDARY
MMSD SUBBASIN BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)
SURFACE WATER
HIGH-PRIORITY SUBBASINS FOR GREEN INFRASTRUCTURE STRATEGIES
MMSD PLANNING AREA BOUNDARY
OUTSIDE MMSD PLANNING AREA

NOTE: Some high-priority areas identified on Map 6.24 were not characterized as high priority for implementation.

0 0.25 0.5 1 Miles

Source: SEWRPC

Map 6.26
Recommended Areas for Detailed Survey near the Oak Creek and North Branch Oak Creek Confluence

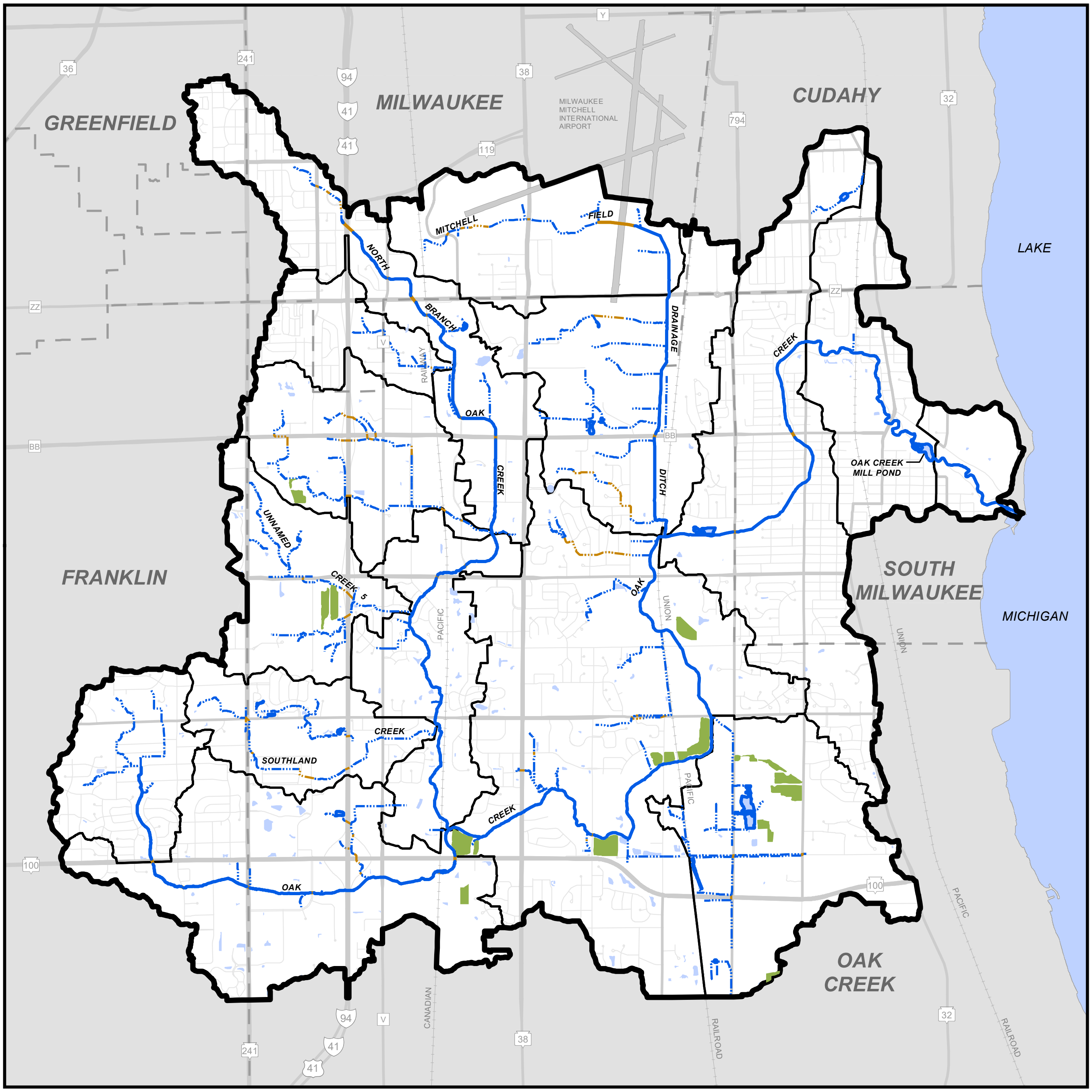
ESTIMATED AREAS FOR DETAILED CHANNEL SURVEYS

POTENTIAL RE-CONNECTION ROUTE TO HISTORICAL CHANNEL

STREAM CROSSING FOR DETAILED SURVEY (CROSSING OF PARTICULAR CONCERN)

STREAM CROSSING FOR DETAILED SURVEY

Map 6.27
Milwaukee County Owned Agricultural Fields to be Restored to Forest, Wetland, or Grassland



OAK CREEK WATERSHED BOUNDARY

OAK CREEK WATERSHED ASSESSMENT AREAS

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

SURFACE WATER

MILWAUKEE COUNTY OWNED AND LEASED AGRICULTURAL FIELDS PLANNED TO BE REFORESTED OR RESTORED TO WETLAND OR GRASSLAND HABITATS

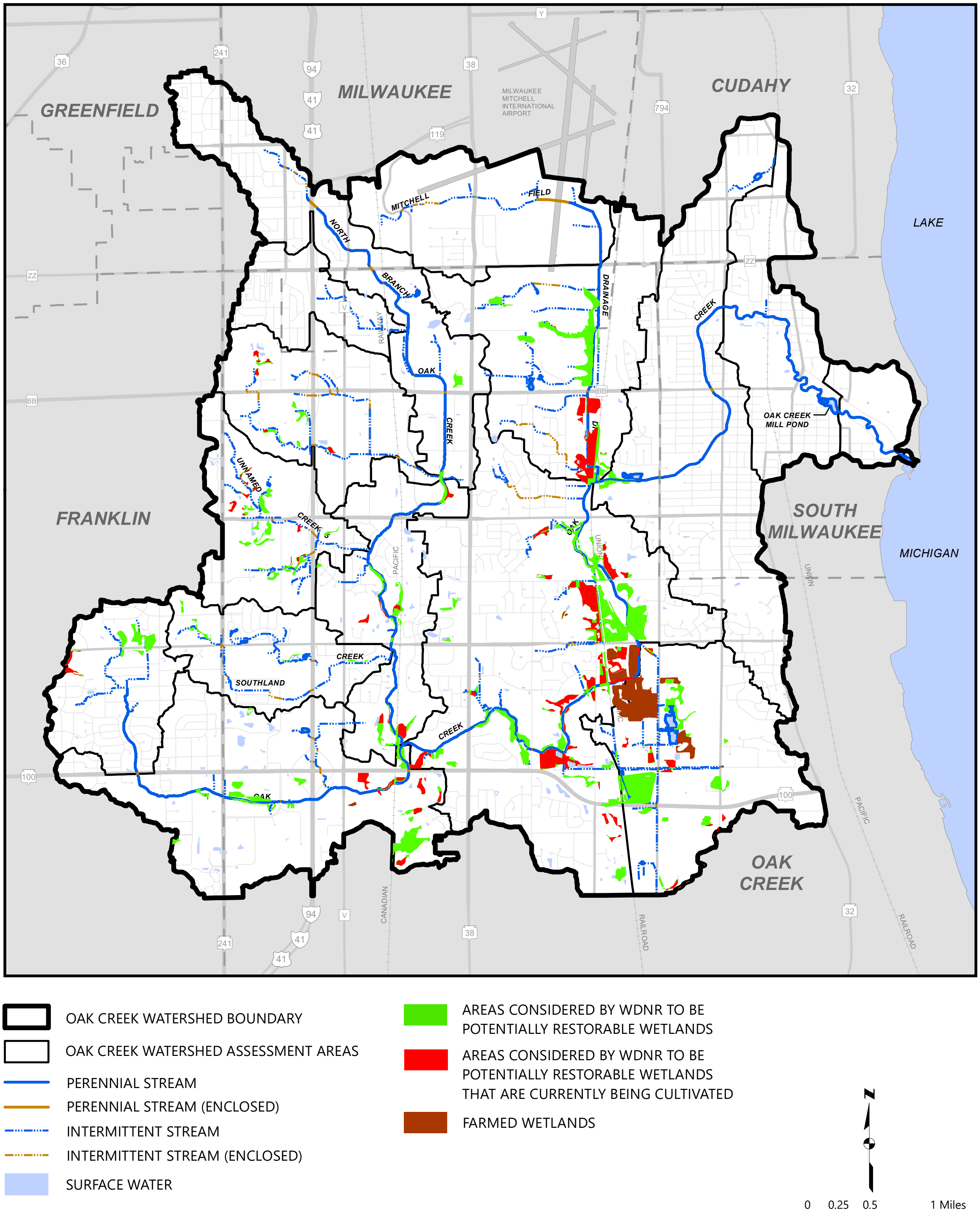
Note: See Map 6.31 for specific restoration details.

N

0 0.25 0.5 1 Miles

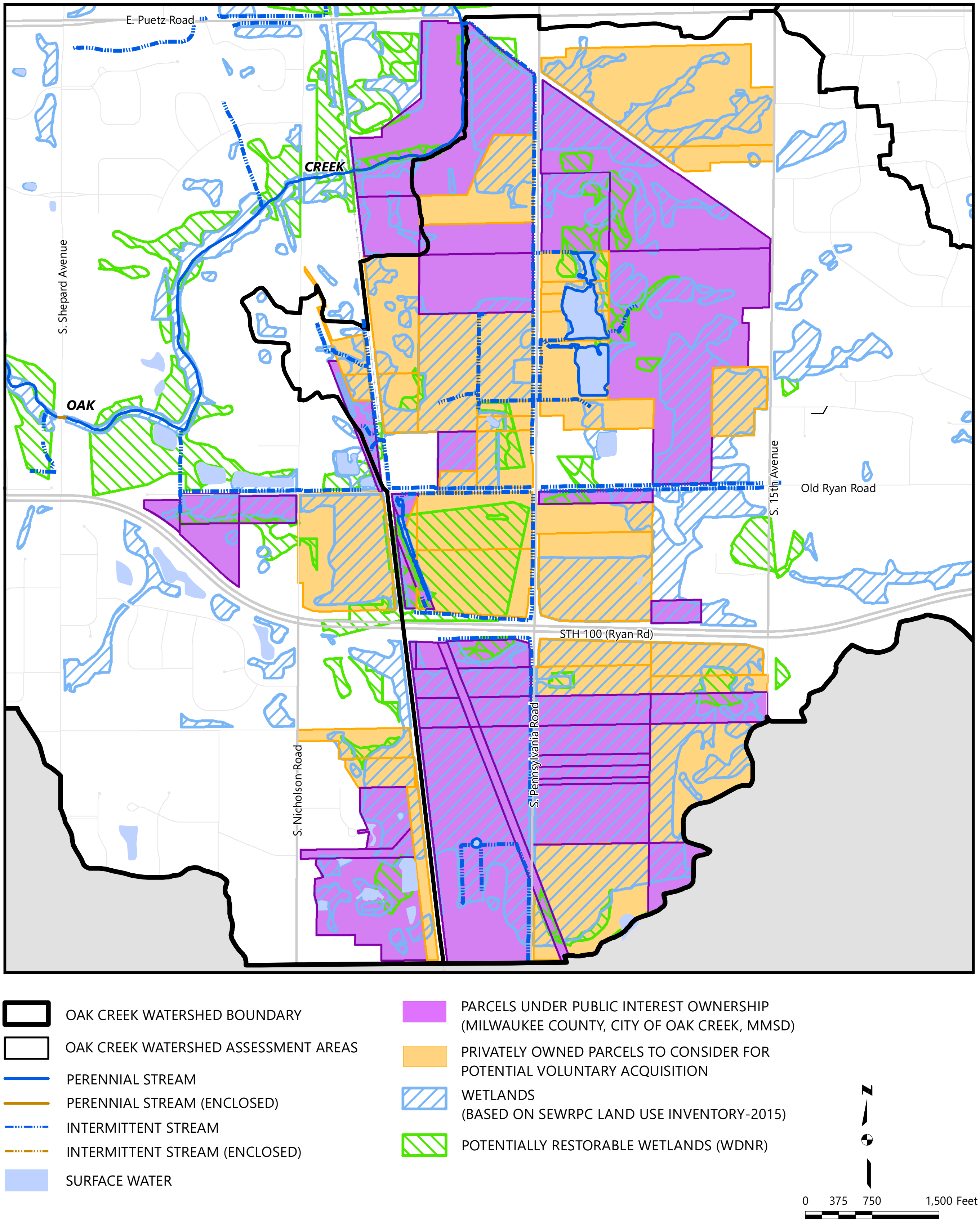
Source: SEWRPC

Map 6.28
Areas to be Considered for Wetland Restoration in the Oak Creek Watershed



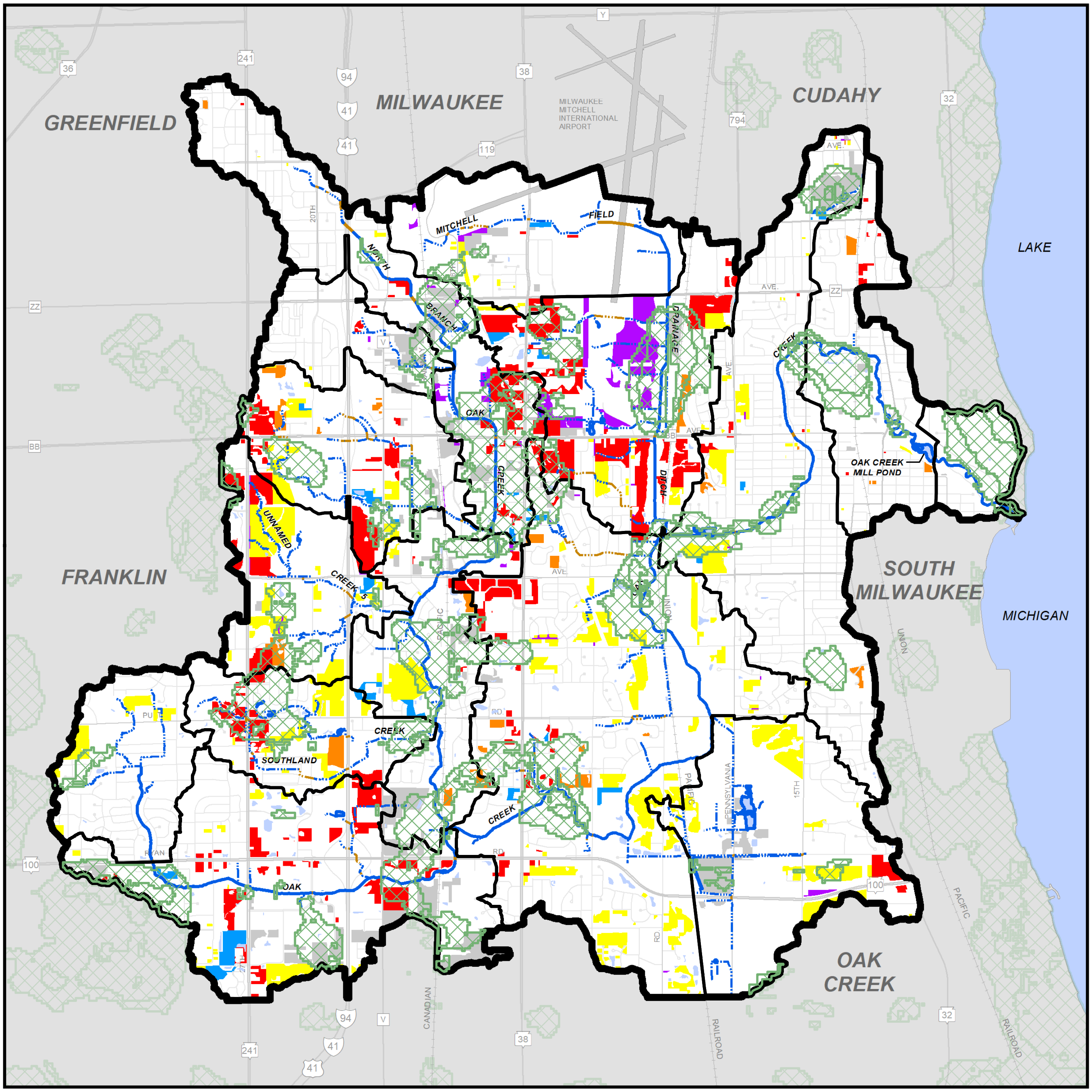
Source: SEWRPC

Map 6.29
Potential Area to be Considered for Drainage Tile System Disconnection and Wetland Restoration



Source: SEWRPC

Map 6.30
Areas of High Groundwater Recharge Potential and Areas Where Existing Year 2015 Agricultural Lands, Open Lands, and Woodlands are Projected to be Converted to Urban Uses Under Planned Conditions



AREAS OF HIGH AND VERY HIGH GROUNDWATER RECHARGE POTENTIAL

PLANNED LAND USE CATEGORY
(2015 LAND USE WAS AGRICULTURE, OPEN LAND, OR WOODLAND)

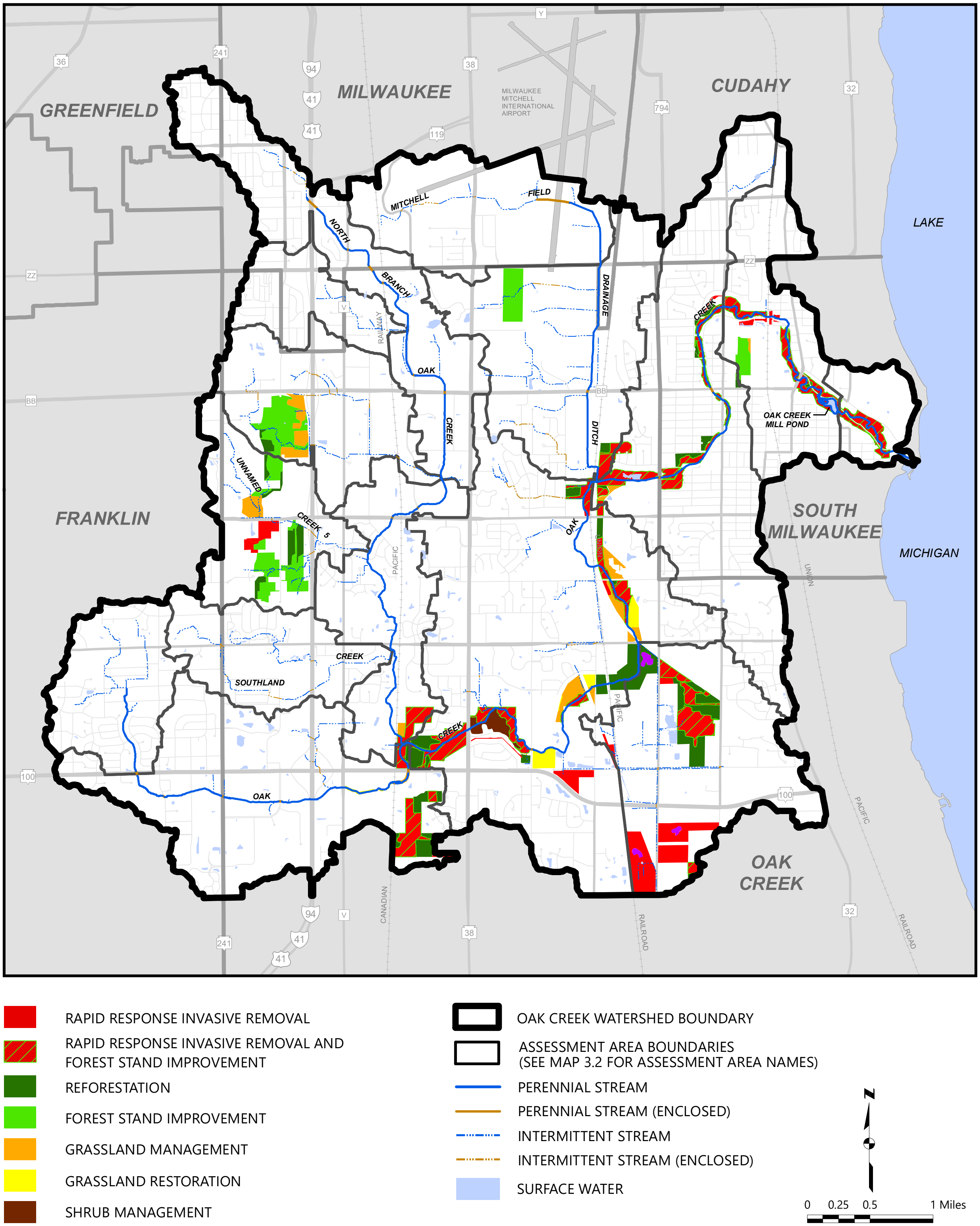
SINGLE-FAMILY RESIDENTIAL
MULTI-FAMILY RESIDENTIAL
COMMERCIAL
INDUSTRIAL
TRANSPORTATION, COMMUNICATIONS, AND UTILITIES
GOVERNMENT AND INSTITUTIONAL

OAK CREEK WATERSHED BOUNDARY
ASSESSMENT AREA BOUNDARIES
PERENNIAL STREAM
PERENNIAL STREAM (ENCLOSED)
INTERMITTENT STREAM
INTERMITTENT STREAM (ENCLOSED)
SURFACE WATER

0 0.25 0.5 1 Miles

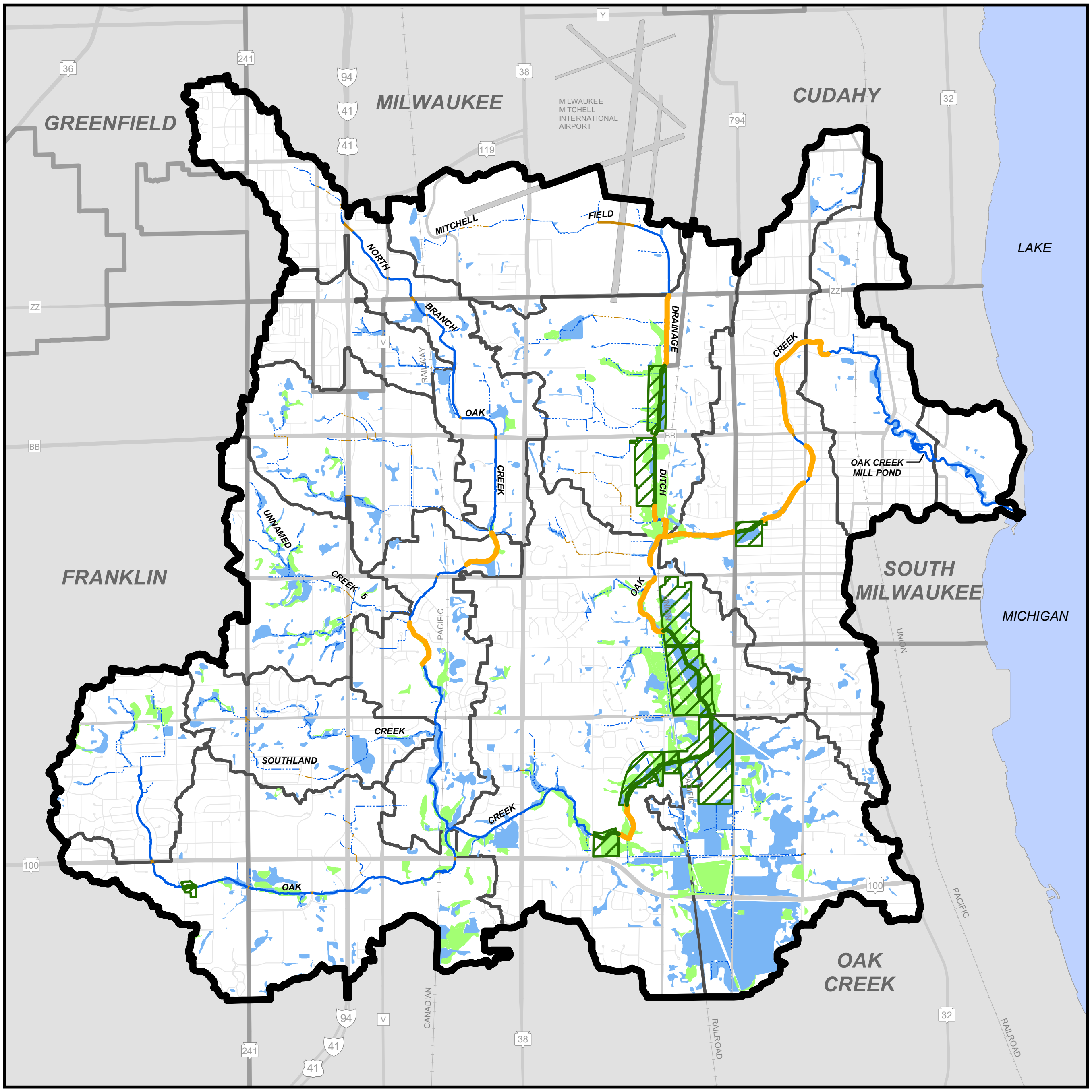
Source: SEWRPC

Map 6.31
Recommended Projects from Milwaukee County Parks Ecological Restoration and Management Plans Within the Oak Creek Watershed



Source: Milwaukee County Parks and SEWRPC

Map 6.32
Potential Locations for Projects to Re-Establish a Connection Between Streams and Floodplains



AREAS TO CONSIDER PROJECTS THAT RE-ESTABLISH A FUNCTIONAL FLOODPLAIN, RESTORE WETLANDS, AND RE-ESTABLISH HYDROLOGIC CONNECTION BETWEEN STREAMS AND WETLAND COMPLEXES

STREAM REACHES TO CONSIDER PROJECTS TO IMPROVE FLOODPLAIN CONNECTION SUCH AS TWO-STAGE CHANNEL DESIGN, REMOVING OR BREAKING SPOIL PILES OR BERMS, OR REGRADING CHANNEL BANKS

EXISTING WETLANDS (2015)

POTENTIALLY RESTORABLE WETLANDS (WDNR)

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES
(SEE MAP 3.2 FOR ASSESSMENT AREA NAMES)

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

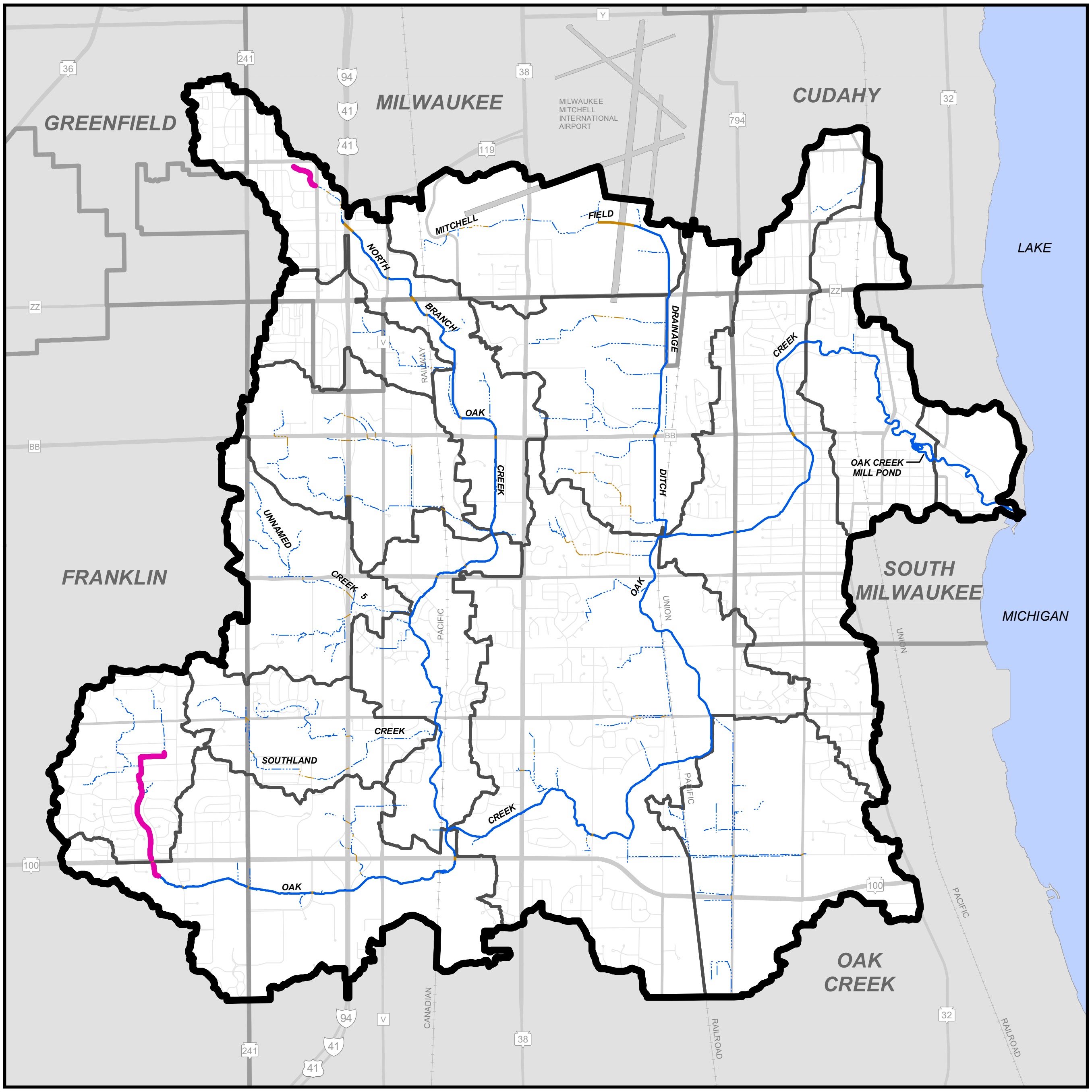
INTERMITTENT STREAM

INTERMITTENT STREAM (ENCLOSED)

0 0.25 0.5 1 Miles

Source: WDNR and SEWRPC

Map 6.33
Stream Reaches to be Considered for Regenerative Stormwater Conveyance Restoration Projects



STREAM REACHES TO BE CONSIDERED FOR REGENERATIVE STORMWATER CONVEYANCE RESTORATION PROJECTS

OAK CREEK WATERSHED BOUNDARY

ASSESSMENT AREA BOUNDARIES (SEE MAP 3.2 FOR ASSESSMENT AREA NAMES)

PERENNIAL STREAM

PERENNIAL STREAM (ENCLOSED)

INTERMITTENT STREAM

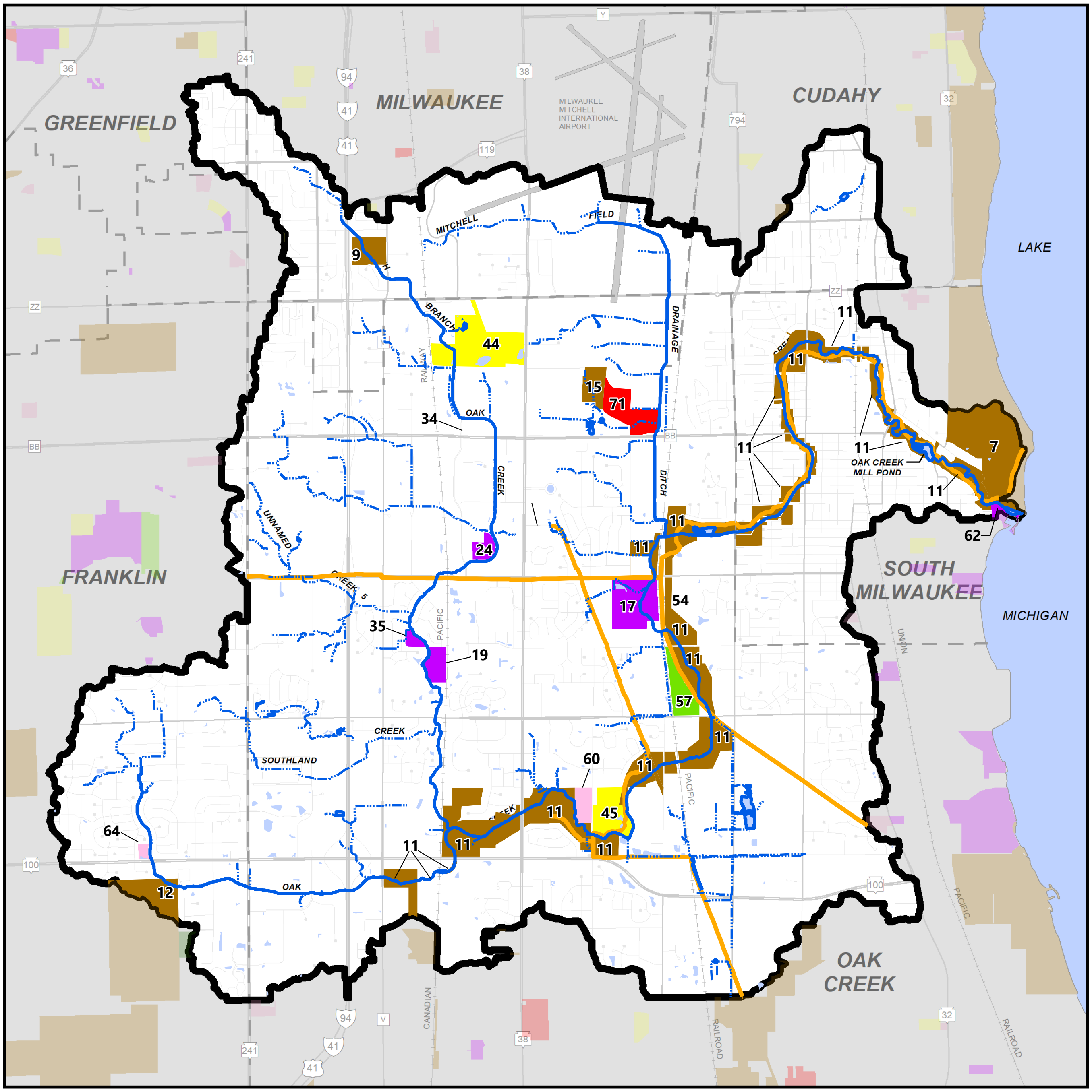
INTERMITTENT STREAM (ENCLOSED)

N

0 0.25 0.5 1 Miles

Source: SEWRPC

Map 6.34
County, Municipal, and Private Organization Owned Park and Open Space Land Within the Oak Creek Watershed: 2020



COUNTY-OWNED SITE
MUNICIPAL-OWNED SITE
SCHOOL DISTRICT-OWNED SITE
PRIVATE ORGANIZATION-OWNED SITE
COMMERCIAL SITE (LEASED FROM COUNTY)
MMSD-OWNED SITE
EXISTING RECREATIONAL TRAIL

OAK CREEK WATERSHED BOUNDARY
PERENNIAL STREAM
INTERMITTENT STREAM
SURFACE WATER

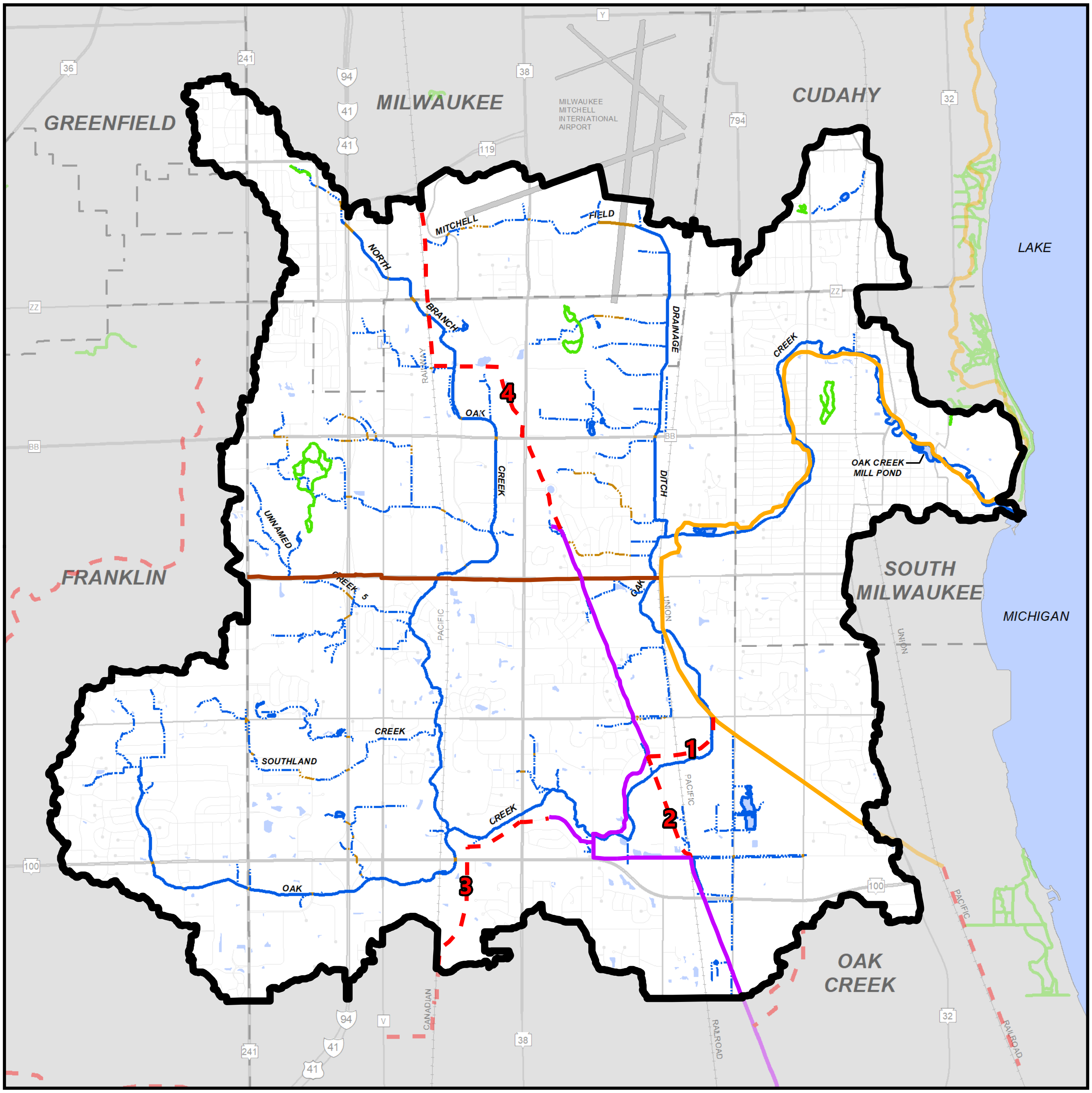
Note: See Table 4.42 for site names and details. Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

N

0 0.25 0.5 1 Miles

Source: SEWRPC

Map 6.35
Existing and Proposed Multi-Use Trails Within the Oak Creek Watershed: 2021



FORKED ASTER HIKING TRAIL

OAK LEAF TRAIL BY NAME
(TRAIL NUMBERS 1 THROUGH 4 DISCUSSED IN TEXT):

SOUTH SHORE LINE

OAK LEAF LINE

DREXEL CONNECTOR

PROPOSED OAK LEAF TRAIL

OAK CREEK WATERSHED BOUNDARY

PERENNIAL STREAM

INTERMITTENT STREAM

SURFACE WATER

Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

0 0.25 0.5 1 Miles

Source: SEWRPC