Technical memorandum

To: Tina Carstens—Ramsey-Washington Metro Watershed District
From: Tyler Olsen and Erin Anderson Wenz—Barr Engineering Co.
Subject: Fish Creek subwatershed feasibility study
Date: October 22, 2020
Project: 23/62-1200.20
c: Paige Ahlborg, Ramsey-Washington Metro Watershed District

1.0 Introduction

This memorandum summarizes the conceptual designs for several proposed best management practices (BMPs) identified in the Fish Creek subwatershed of the Ramsey-Washington Metro Watershed District (RWMWD). The identified BMPs aim to improve and maintain Fish Creek's water quality by retaining or filtering runoff to remove sediment, nutrients, debris, and other pollutants. Barr identified BMP retrofit opportunities based on guidance from the accelerated implementation project category description of the Clean Water Fund, the RWMWD watershed restoration and protection strategies (WRAPS) report, and the RWMWD watershed management plan (Plan). Barr considered more than a dozen potential BMP retrofits in the watershed. This memo summarizes conceptual designs for BMPs and other water quality improvement recommendations for seven areas in the Fish Creek subwatershed.

2.0 Background information

The Fish Creek subwatershed covers 783 acres, in the cities of Maplewood, St. Paul, Woodbury, and Newport. The majority of the Fish Creek subwatershed is located in Ramsey County, with the southeastern portion in Washington County. The subwatershed receives flow from Carver Lake, which is the headwaters of Fish Creek. The total area tributary to Fish Creek, including Carver Lake, is 3,055 acres. Fish Creek is a perennial, urban stream that originates at Carver Lake and ultimately discharges to Eagle Lake and the Mississippi River. Fish Creek is the only District-managed waterbody within the Fish Creek subwatershed. Significant areas of the Fish Creek subwatershed are park and open space owned by Ramsey County or the City of Maplewood, as well as some areas classified as agricultural (Bailey Nursery). The remainder of the subwatershed is single-family residential land use, with some highway (Interstate-494 [I-494]) and commercial areas in the southeastern portion of the subwatershed. In a feasibility study that evaluated sediment source loading to Fish Creek (Barr, 2007), it was noted that Bailey Nursery may sell their property for residential redevelopment, which would significantly change the land use and could change the nutrient loading patterns.

Historically, Fish Creek experienced significant streambed erosion caused by increased stormwater flows. In the late 1980s, the RWMWD undertook a significant restoration project that included the construction of drop structures along the length of the creek as well as the construction of an underground pipe to handle the flood flows in the steeper section of the creek. The RWMWD continues to conduct maintenance on the creek to sustain that project.

Fish Creek was added to the 2014 MPCA Impaired Waters 303(d) List with an aquatic recreation impairment due to Escherichia coli (E. coli). E. coli bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a human health risk.

The RWMWD conducts regular nutrient monitoring on Fish Creek. Based on an average phosphorus concentration exceeding MPCA stream eutrophication standards at the time of the Watershed Management Plan (RWMWD, 2017), the District has assigned a RWMWD nutrient water quality classification of "At Risk" to Fish Creek. As part of the RWMWD WRAPS Report (Barr, 2016), trend analyses were performed on Fish Creek water quality data. The results showed improving trends for TSS, TP, and Nitrate. Water quality monitoring data through 2019 is shown on Figure 1 below.

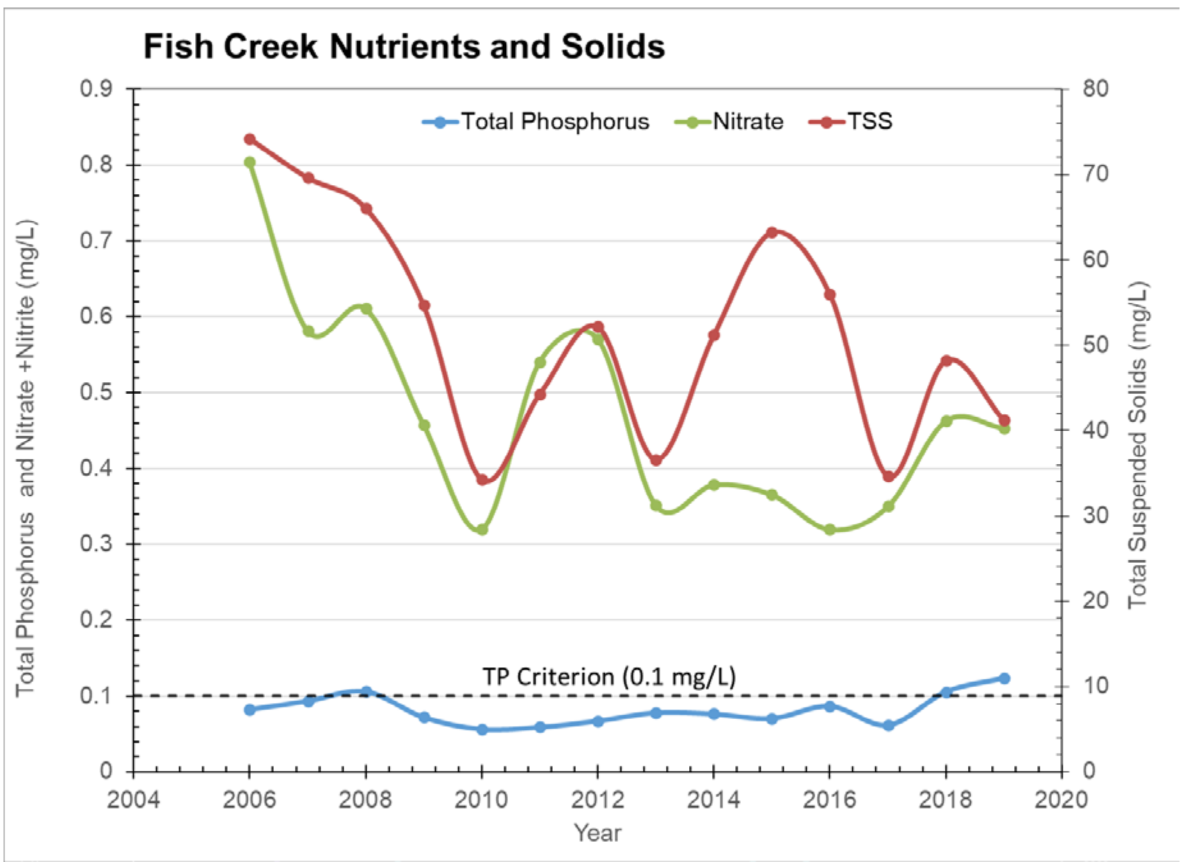


Figure 1 Fish Creek nutrient and solids monitoring data through 2019

The Twin Cities Management Area (TCMA) Chloride TMDL identified Fish Creek as a "high risk" stream for chloride impairment. Chloride monitoring data through 2019 is shown on Figure 2 below. While there are no cost-effective BMP recommendations for reducing chloride already in waterbodies or stormwater, the MPCA recommends several practices to reduce the sources of chloride loading within watersheds. These practices are outlined in Section 3.2.7 of this memo.

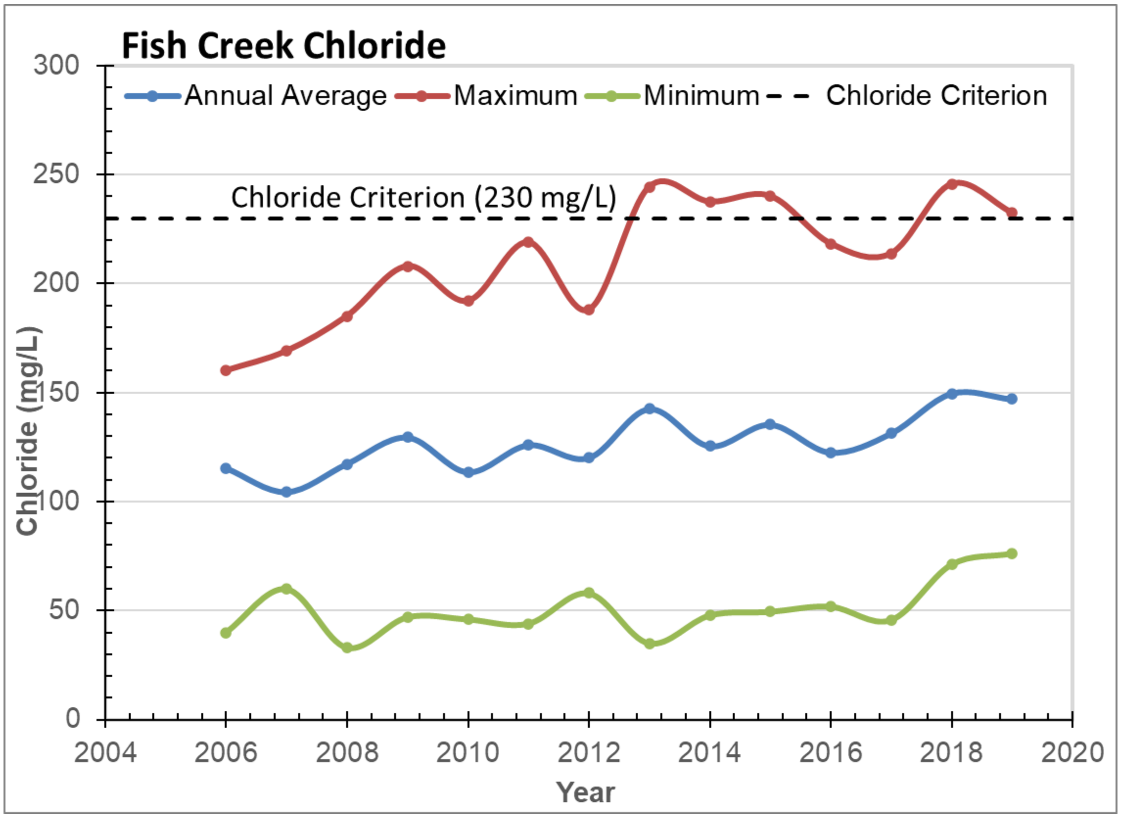


Figure 2 Fish Creek chloride monitoring data through 2019

3.0 Proposed improvements

The goal of this study is to identify possible improvements that the RWMWD could implement throughout the Fish Creek subwatershed to treat stormwater runoff and improve water quality. Where feasible, Barr prioritized infiltration BMPs because they are generally the most cost-effective solution to treating stormwater runoff. Where infiltration was not feasible, we recommended filtration or detention BMPs. This study also qualitatively considers the potential for educational features or partnership to promote continued awareness and mindfulness for improving water quality in RWMWD.

3.1 Site selection for BMP retrofits

Barr investigated the Fish Creek subwatershed to identify potential locations for BMP retrofit projects and other water quality improvement opportunities. The preliminary method for site evaluation was a desktop analysis. Barr used elevation data, storm-sewer data, imperviousness data, national wetland inventory data, aerial imagery, and Google Street View™ imagery to identify potential sites. Additionally, Barr reviewed the RWMWD's cost-share, permitted, and capital improvements plan projects to identify locations where activity has already taken place in the Fish Creek subwatershed.

Because the Fish Creek subwatershed is relatively undeveloped, the desktop analysis did not identify many sites with significant impervious areas. Barr considered sites that did have larger impervious areas more desirable, as the BMP would have a larger treatment impact. We also gave higher priority to sites with high public traffic (i.e., parks), since they have more opportunity for public engagement and education. In addition, we considered sites owned by the City or County more promising, as a partnership with public entities is generally simpler to establish than a partnership with a private landowner. From this initial list, Barr prioritized sites by eliminating locations with no immediate access for storm-sewer connections, limited direct drainage area, unfavorable (steep) grade change, complex grading within the BMP footprint, or significant trees within the BMP footprint. This prioritization exercise narrowed down the list of sites to seven preferred sites. Barr staff visited these sites for further analysis and developed conceptual designs for them.

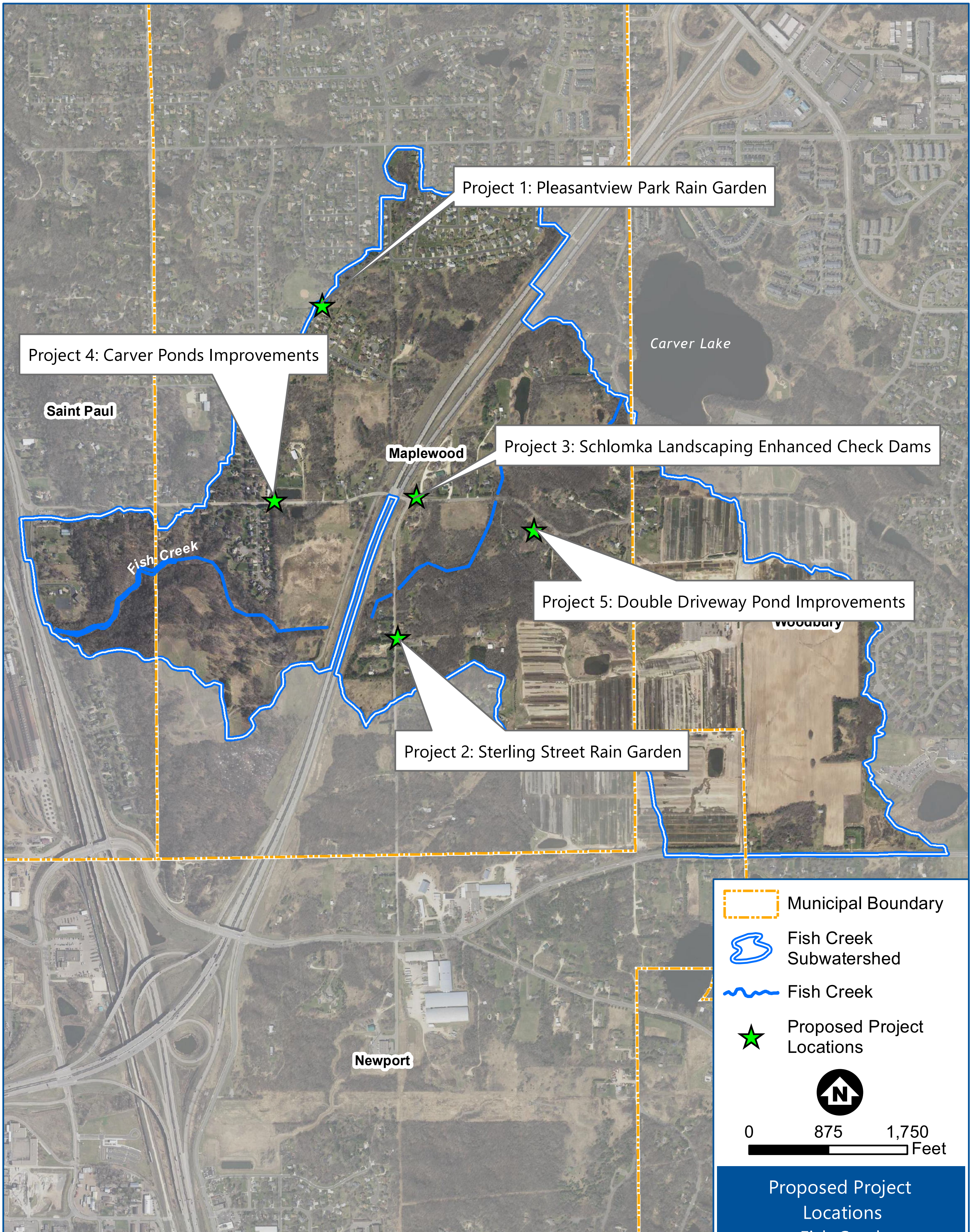
3.2 Proposed Water Quality Improvement Projects

The following section discusses the concept designs Barr developed for the seven prioritized locations in the Fish Creek subwatershed. Table 1 includes the estimated average annual phosphorus removal for each alternative using the MPCA's minimal impact design standards (MIDS) calculator and the Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds (P8). Figure 3 shows the locations of the identified project locations in the Fish Creek subwatershed.

Table 1 Summary water-quality benefits for alternatives in the Fish Creek subwatershed

Proposed WQ Improvement Project	Estimated annual TP reduction (lbs/yr)	Estimated annual TSS reduction (lbs/yr)
Pleasantview Park Rain Garden	2.4	429
Sterling Street Rain Garden	1.3	229
Schlomka Landscaping Enhanced Ditch Check Dams	1.8	433
Carver Pond Improvements[1]	2.8 – 24.6	194
Double Driveway Pond Improvements	19.8	1218
Fish Creek Erosion Survey and Improvements	0.4	840

[1]Estimates based on a range of implementation activities including enhanced filtration, dredging, or alum treatment



Proposed Project Locations
Fish Creek
Feasibility Study
FIGURE 3

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3.2.1 Project 1: Pleasantview Park Rain Garden

The first proposed project is a biofiltration basin (rain garden) at Pleasantview Park in Maplewood, located at the end of Crestview Court. For this project, runoff is collected from the intersection of Crestview Court and Schadt Drive and the residential homes on Crestview Court, and it is routed north to the end of the road. There are parking spaces and a catch basin located at the end of Crestview Court.

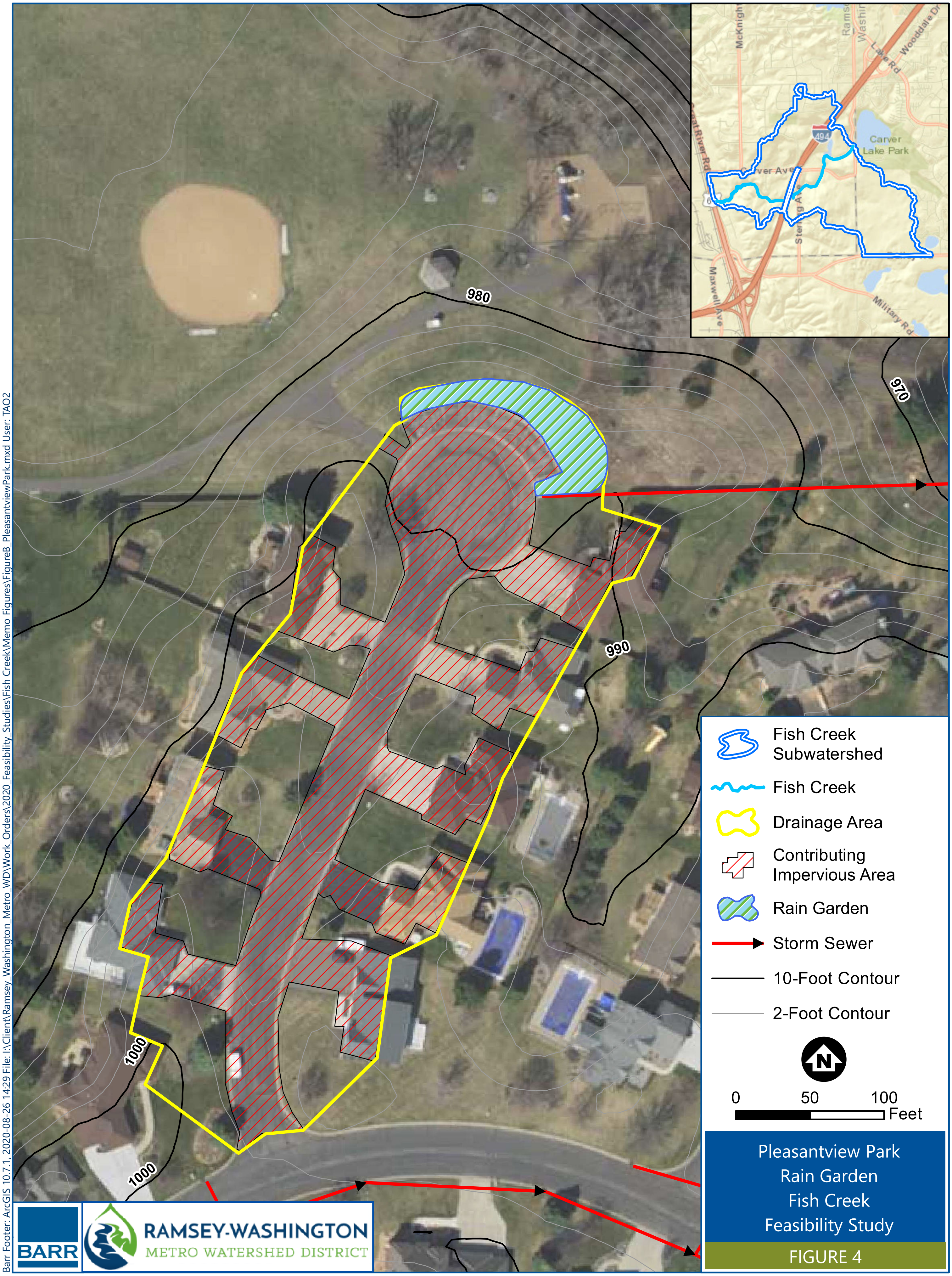
The RWMWD could construct a rain garden in the green space at the end of the road to capture runoff from Crestview Court, as shown on Figure 4. The location receives runoff from 2.09 acres, including 1.20 acres of impervious area. Barr sized the rain garden to capture 1.1 inches of runoff from the contributing impervious areas, resulting in a footprint of approximately 3,900 square feet. Depending on the infiltration capacity of the soils, the rain garden could be designed to either infiltrate the volume within 48 hours or filter runoff through an underdrain connected to the existing storm sewer on Crestview Court. In order to effectively retain water in the rain garden, this project would require modification of the existing storm sewer inlet to route runoff into the rain garden.

The benefits of this rain garden include a reduction in downstream TP loading by 2.4 pounds per year and significant BMP visibility that would provide an opportunity for an educational component located at the adjacent Pleasantview Park. The challenges to constructing a BMP at this location include coordination with the City of Maplewood (park property owner) and moderate grading as there is a slight slope where the proposed rain garden footprint is located, requiring excavation of 0 to 2 feet of soil.

3.2.2 Project 2: Sterling Street Rain Garden

Project 2 is a rain garden located in a resident's yard at the low point of Sterling Street in Maplewood. This low point receives runoff from the street, houses, and driveways. There is an existing catch basin located in the low point that discharges west across Sterling Street into a small channel that connects to Fish Creek. The total watershed area to this location is 12.13 acres, including 0.35 acres of directly connected impervious area. Barr sized the rain garden to capture 1.1 inches of runoff from the contributing impervious area (not including disconnected impervious area from homes, as runoff in these areas is most likely intercepted before it would reach the rain garden), resulting in a footprint of approximately 1500 square feet, as shown on Figure 5. The existing catch basin will be modified to retain the appropriate runoff volume in the rain garden. Depending on the infiltration capacity of the soils, the rain garden could either infiltrate the volume within 48 hours or filter runoff through an underdrain connected to the existing catch basin.

The benefits of constructing this rain garden include a reduction in downstream TP loading by 1.3 pounds per year and some BMP visibility for the local residents, however the educational impact may be limited by the rain garden's location on a road with limited foot traffic. The challenges to constructing a BMP at this location include coordination with and buy-in from the property owner and, if the project extends into the right-of-way of Sterling Street, coordination with the city of Maplewood.



McKnight
Rams
Washin
Lake Rd
Wooddale Dr
494
Carver Lake Park
Carver Ave
Sterling Ave
Maxwell Ave
Military Rd
980
970
990
1000
1000
Fish Creek Subwatershed
Fish Creek
Drainage Area
Contributing Impervious Area
Rain Garden
Storm Sewer
10-Foot Contour
2-Foot Contour
N
0
50
100
Feet
Pleasantview Park
Rain Garden
Fish Creek
Feasibility Study
FIGURE 4
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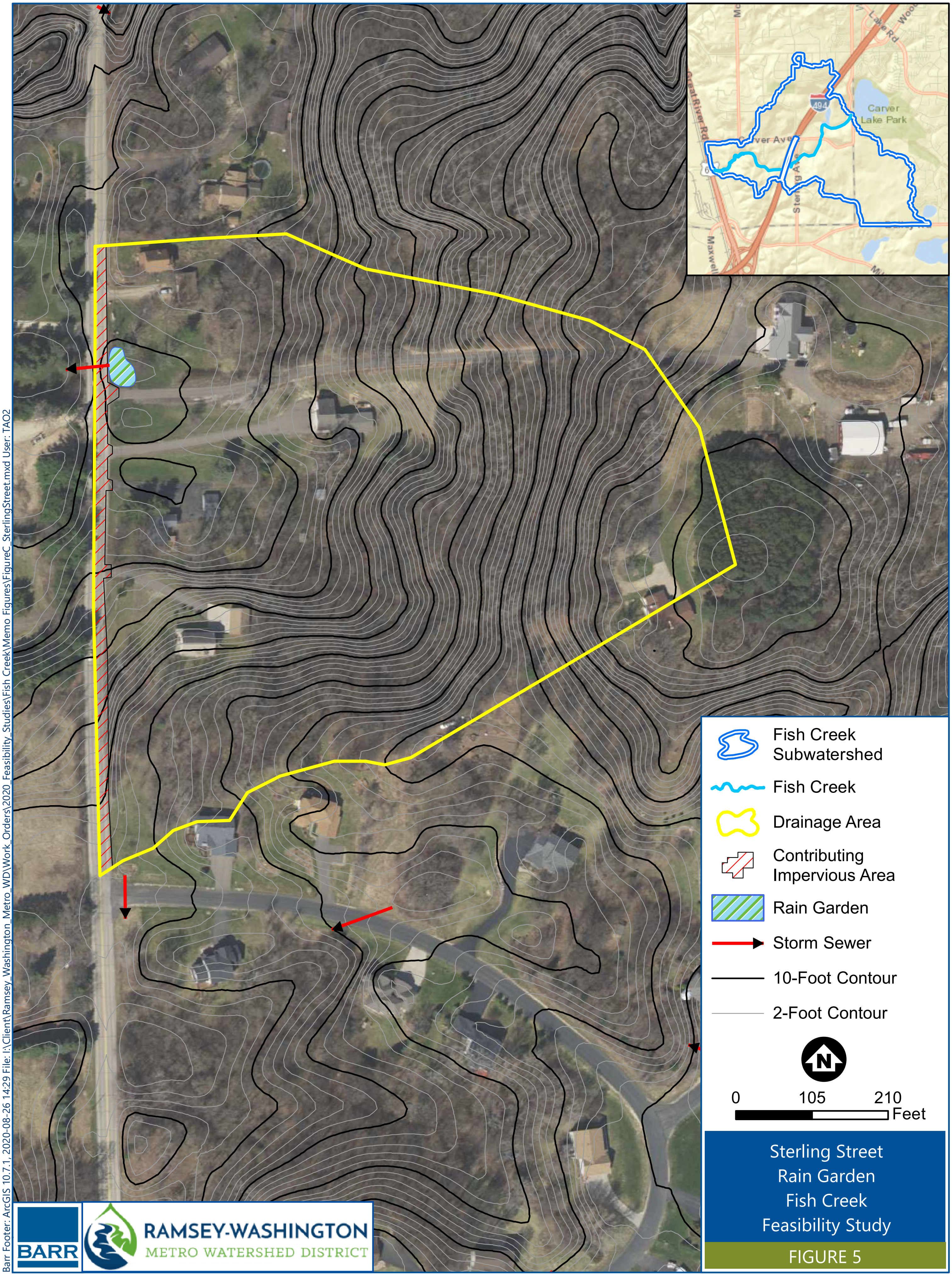


Sterling Street
Rain Garden
Fish Creek
Feasibility Study

FIGURE 5

3.2.3 Project 3: Schlomka Landscaping Enhanced Ditch Check Dams

Project 3 is a series of two enhanced filtration check dams along the swale running along the southern property boundary of Schlomka Landscaping in Maplewood. This technology was researched at the St. Anthony Falls Laboratory (SAFL) in collaboration with the Minnesota Department of Transportation (Mn/DOT) to evaluate treatment of street and highway runoff using iron-enhanced sand. A schematic of the check dam design in shown on Figure 6 where runoff is pooled behind the dam up to 2 feet and filtered through the core of iron-enhanced sand. A photo of the filter core is shown in Figure 7. Results from research at SAFL show dissolved phosphorus removals from enhanced check dams that are comparable to a typical iron-enhanced sand filter (typically 30% to 50% dissolved phosphorus removal).

Barr is proposing the construction of two ditch check dams: one upstream (east) of the Schlomka Landscaping driveway along Carver Road, and one upstream of the crossing under Carver Road (see Figure 8). Check dams in these two locations will allow for runoff to be treated in two locations and reduce the pooled volume of runoff during larger events. The total watershed area to these BMPs is 2.74 acres, including 1.27 acres of impervious area. The width of the filter core is 2 feet and the side slopes are at 10H:1V (horizontal:vertical) on the upstream and downstream sides. The benefits of constructing this BMP include a reduction in TP loading by 1.8 pounds per year. A drawback of this technology is that it is relatively new, and therefore the removals may not accurately reflect field performance for the Fish Creek site as no specific design criteria exist to date. Additionally, the long-term effectiveness of this technology is unknown, but assumed to be similar to a typical iron-enhanced sand filter.

This project may present an opportunity to partner with SAFL, as the research on iron-enhanced check dams is ongoing. This project would provide unique data, as other monitoring sites have been located off major highways in Minnesota; this project would represent a different application of this new technology.

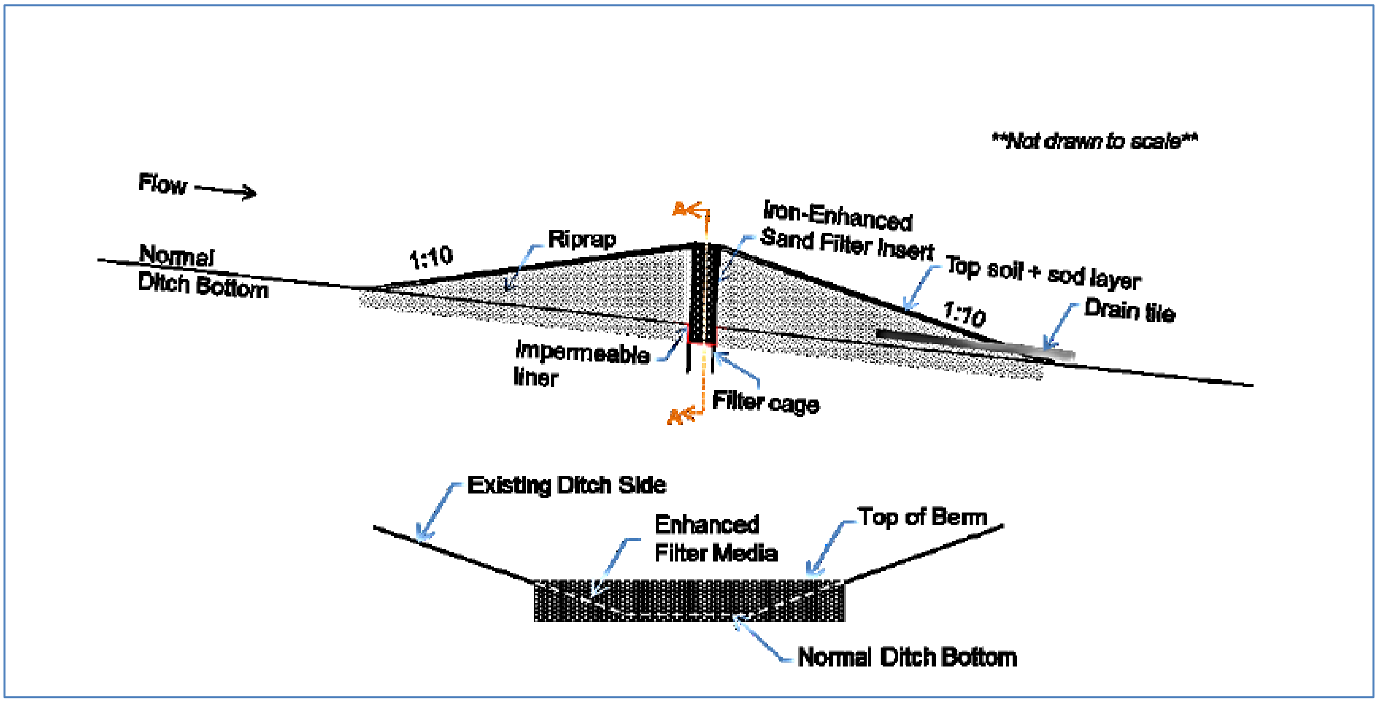
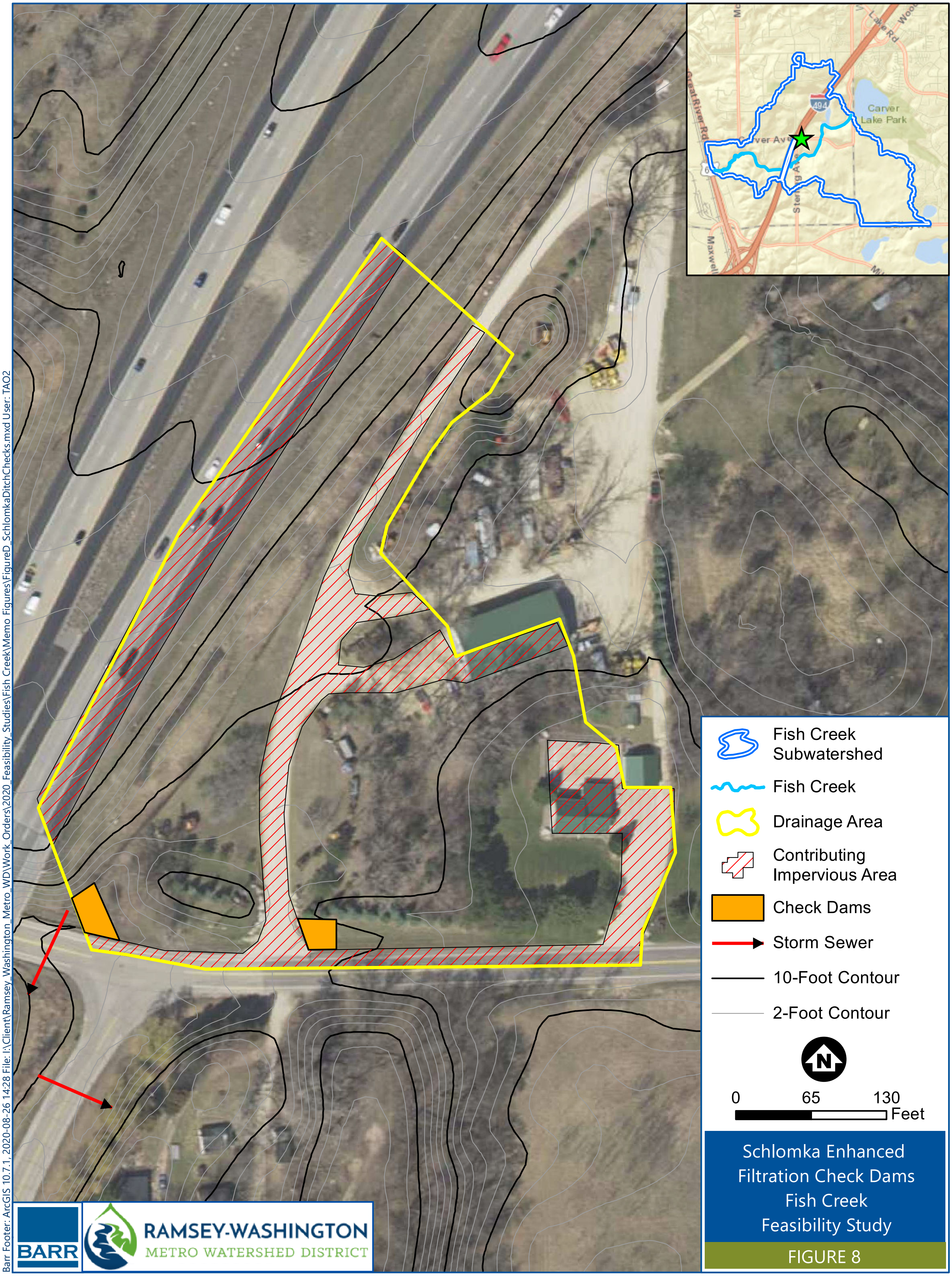


Figure 6 Schematic of the iron-enhanced check dam (from Natarajan and Gulliver, 2015)

Figure 7 Photo of filter core in check dam (from Natarajan and Gulliver, 2019)



Schlomka Enhanced Filtration Check Dams
Fish Creek
Feasibility Study

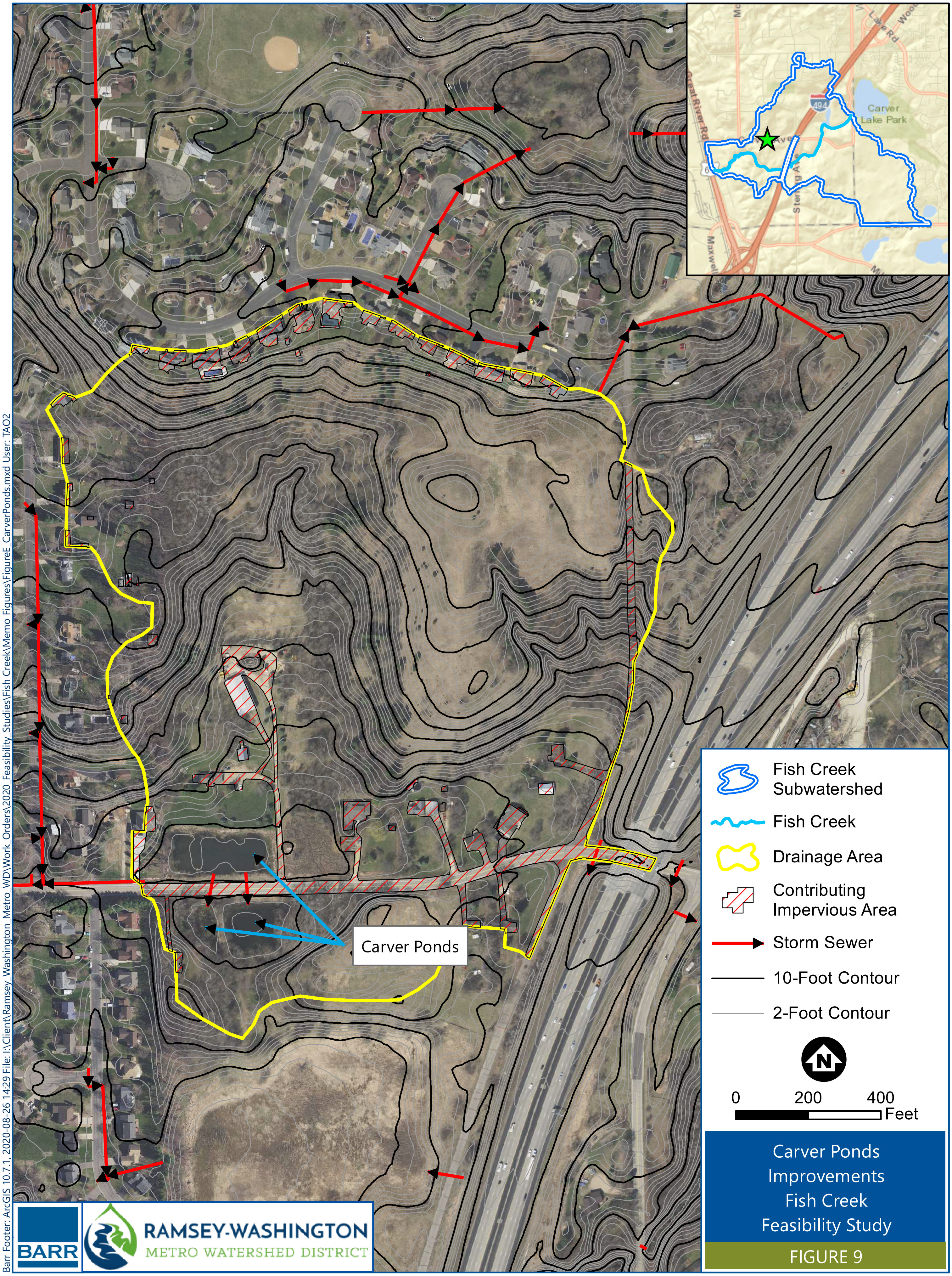
FIGURE 8

3.2.4 Project 4: Carver Ponds Improvements

Three existing stormwater ponds (hereafter referred to as Carver Ponds) are located near the property of 2405 Carver Ave in Maplewood. The ponds and their contributing watershed are shown on Figure 9. The ponds are connected under Carver Ave by two large culverts and discharge westward via storm sewer. The receiving storm sewer is directly connected to the high flow bypass along Fish Creek. The Carver Ponds receive runoff from the surrounding residential areas within the Fish Creek watershed. During the field visit, we noted that the ponds are currently hypereutrophic, and the outflow form the northern most pond contained metallic and oily sheen, as well as significant algal growth. Most likely, these ponds are exporting large quantities of phosphorus downstream to Fish Creek. The total drainage area to the Carver Ponds is 56 acres, including 5.38 acres of impervious area.

Barr recommends further inspection of these stormwater ponds, including collection of sediment cores, to determine their condition and export of phosphorus to Fish Creek. Based on the results of this characterization, additional recommendations may include dredging, chemical treatment (i.e. alum), or enhanced filtration BMP construction to treat discharge from the Carver Ponds and/or prevent further internal loading (we suspect this is high due to water quality observed during the field visit). Around the ponds there are several areas where an enhanced filtration BMP could be constructed, including near the outlet or between the two southern Carver Ponds.

The benefit of this project is that these ponds receive runoff from a large area. If the ponds are acting as sources of phosphorus due to sediment phosphorus release (rather than removing phosphorus via settling of sediments, as designed), this portion of the watershed is effectively untreated before reaching the creek. Based on staff experience and the field observations, it is highly likely that this pond is exporting phosphorus and management activity would greatly reduce loading. Using estimates from projects of similar scale, the benefit of this project could reduce TP loading by 2.8 to 24.6 pounds per year based on the management activities implemented.



Carver Ponds Improvements
Fish Creek Feasibility Study

FIGURE 9

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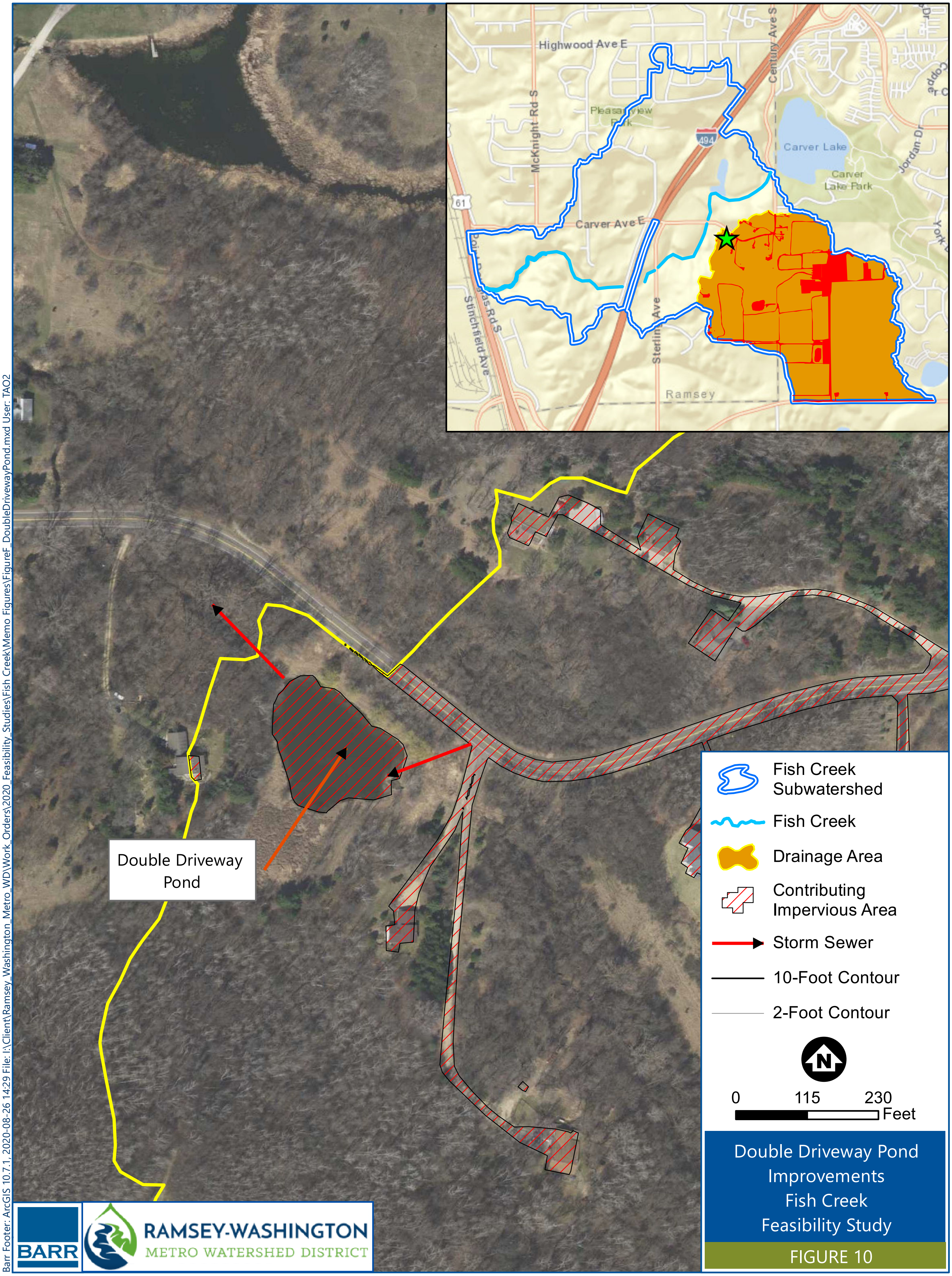
3.2.5 Project 5: Double Driveway Pond Improvements

There is an existing stormwater pond located at the discharge point of the Bailey Nursery property along Carver Ave in Maplewood, nicknamed "Double Driveway Pond" and shown on Figure 10. Because this pond receives runoff from 308.3 acres, including 156.3 acres of impervious area, it requires frequent management to remove accumulated sediment. Double Driveway Pond has been dredged several times over the last two decades to manage accumulated sediment in the pond. However, based on Barr's observations in the field the pond has refilled with sediment and is therefore not providing much water quality benefit.

Barr recommends that the following improvements be considered for Double Driveway Pond to maximize its water quality benefit:

- Dredging of accumulated sediment and pond bottom to an additional 3 feet of depth
- Installation of hydrodynamic separators in upstream catch basins/manholes
- Treatment of pond with alum to prevent internal loading of phosphorus

The benefit of this project is that the additional volume in the Double Driveway Pond would increase its water quality treatment of runoff and reduce maintenance frequency. Assuming each improvement is implemented, the project would reduce TP loading by approximately 19.8 pounds per year. A challenge of this project is that it does not address upstream sediment and nutrient loading from the Bailey Nursery. Therefore, sediment will continue to accumulate in Double Driveway Pond unless preventative practices are implemented by the private property owners. However, this project will slow the rate of accumulation and decrease the frequency of maintenance.


Highwood Ave E
Pleasantview Park
McKnight Rd S
494
Century Ave S
Carver Lake
Carver Lake Park
Jordan Dr
61
Carver Ave E
Stinchfield Ave
Sterling Ave
Ramsey
York
Double Driveway
Pond
Fish Creek
Subwatershed
Fish Creek
Drainage Area
Contributing
Impervious Area
Storm Sewer
10-Foot Contour
2-Foot Contour
N
0
115
230
Feet
Double Driveway Pond
Improvements
Fish Creek
Feasibility Study
FIGURE 10
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3.2.6 Project 6: Fish Creek Erosion Survey and Improvements

Several projects have been conducted on Fish Creek to improve erosion observed during routine inspections by the RWMWD. However, during the RWMWD's 2018 inspection, several areas were marked as eroding and "to watch" for continued erosion. All of these areas were located upstream of Fish Creek's crossing under I-494. These areas are denoted with yellow pentagons on Figure 11. Areas marked "No" on Figure 11 are areas with no observed erosion. The area marked "Yes" was observed to have active erosion. Photos from eroding areas showing bank erosion and undercutting of banks are shown on Figure 12 and Figure 13, respectively.

While erosion primarily causes increased sediment loading, erosion can also cause increased nutrient loading (including TP) because of the nutrients adsorbed to sediment particles. Using the Minnesota Board of Soil and Water Resources Pollution Reduction Estimator (BWSR, 2019), Barr estimated that the TP load to Fish Creek due to erosion is approximately 0.4 pounds per year if 10% of the creek length is eroding. If erosion continues to worsen, the TP loading would also increase.

To reduce erosion and associated sediment and nutrient loading, Barr recommends continued inspection of Fish Creek and targeted restoration of eroding areas. These restoration activities may include hard armoring, regrading, and/or installation of rock riffles and pools.

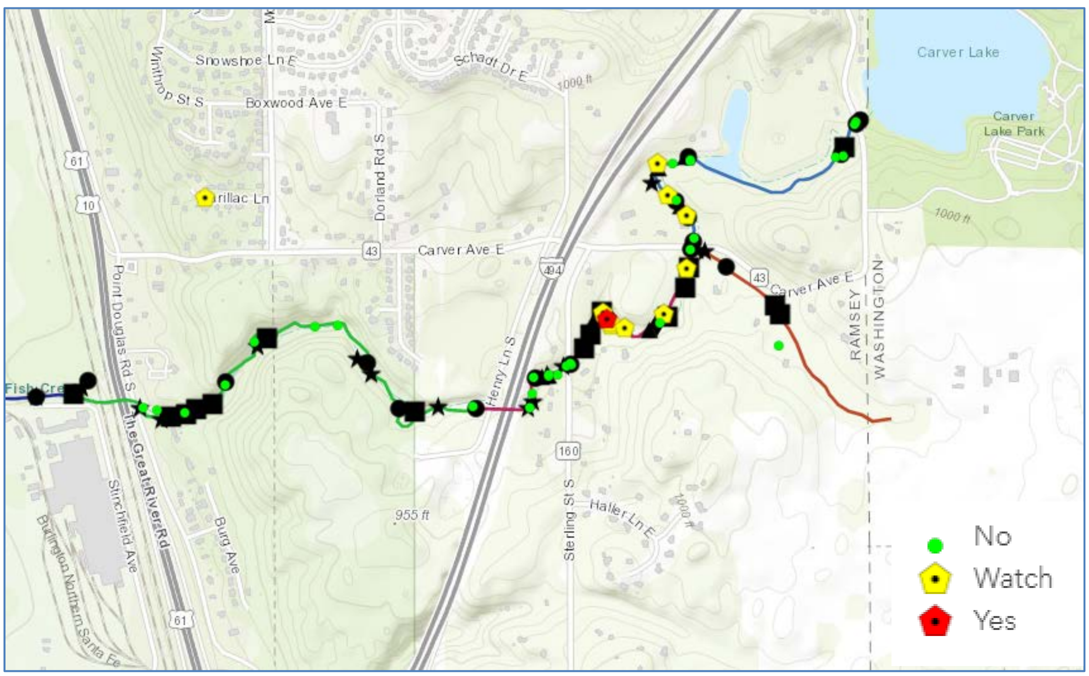

Figure 11 RWMWD 2018 Fish Creek inspection results

Figure 12 Stream bank erosion in Fish Creek (source: RWMWD)

Figure 13 Undercutting of stream bank along Fish Creek

3.2.7 Chloride Reduction Strategies for Fish Creek Subwatershed

Because Fish Creek is considered at "high risk" for chloride impairment, some of the MPCA's guidance and recommendations for chloride management based on strategies outlined in the Twin Cities Chloride Management Plan (MPCA, 2016) are included in this technical memorandum. These strategies are focused on prevention rather than treatment, as there are currently no cost-effective or scalable treatment practices to remove chloride from surface water. Below are a sample of chloride reduction strategies targeted at both road salt application and water softener usage within the subwatershed.

Road Salt Reduction Strategies:

- Support local and state winter maintenance crews in their efforts to reduce their salt use
- Work with local government, businesses, schools, churches and non-profits to find ways to reduce salt use
- Encourage slow driving
- Shovel, rather than apply salt to melt snow and ice
- Use appropriate salt ratio: 4 pounds of salt per 1000 square feet

Water Softener Salt Reduction Strategies:

- Consider if a water softener is needed – test water for hardness
- Change from a timer-based to a demand-based softener that recharges only when needed, based on how much water is used
- Install a bypass so landscape irrigation water is not softened

The MPCA has also created guidance for monitoring surface waters that are categorized as high-risk for chloride impairment. The MPCA suggests the following guidance for additional monitoring of high-risk waters:

1. Identify dates or periods of past chloride concentrations that were either:
    a. Exceedances (exceeded the chronic chloride standard), and
    b. "high" occurrences, defining "high" as less than but within 10% of the chronic standard (thus >207 mg/L)

2. Select a 4-week period centered on each such date or period, and for each:
    a. Sample for chloride weekly, always on the same day of the week
    b. Sample at the same depth or depths as in past sampling

3. If an electrical conductivity meter is available, take and record a "matching" conductivity reading with each lab sample taken:
    a. "matching" = from the same primary sample that provides the lab subsample, if the primary sample is a sufficiently larger volume than the laboratory bottle used; or otherwise
    b. "matching" = same location and depth as the lab sample

4. Possible expanded effort:
    a. Monitor twice weekly rather than once, always on the same days of the week (e.g., Monday and Thursday) including, as resources permit:
        i. Chloride sample and conductivity measurement if possible
        ii. Chloride sample only if lacking conductivity meter
        iii. Conductivity measurement only on the increased frequency if laboratory costs limit sampling but a meter is available

Sampling for chloride at least weekly during the selected 4-week period(s) is a necessary minimum effort for ensuring the value of this additional monitoring; conductivity measurements alone will not suffice at present. This could change in the future if a reliable and accurate relationship between chloride and conductivity is developed for an individual waterbody.

There are dozens of other resources to reference for reducing salt use through application and policy at the following website: https://www.pca.state.mn.us/water/statewide-chloride-resources.

3.3 Planning-level opinions of probable cost of projects

Barr developed planning-level cost estimates for each conceptual design and performed cost-benefit analyses, as shown in Table 2. As feasibility-level concepts, there is significant cost uncertainty associated with the proposed projects. The planning-level opinion of costs include a 25-percent contingency and estimated cost ranges of -30 percent to +50 percent. Additionally, we estimated the engineering cost for the design of each proposed project as 40 percent of the total cost. This 40-percent fee includes 30-percent engineering and design and 10-percent construction observation and administration. These costs assume that no wetland mitigation will be required as part of these projects, no contaminated soils will be encountered, and no purchase of easements or properties will be required.

Table 2 Summary of planning-level opinions of probable costs for BMPs in the Fish Creek subwatershed

Proposed Project	planning-level opinion of cost[1,2]	estimated engineering cost[3]	total project cost
Pleasantview Park Rain Garden	$60,200 ($50,700 - $108,600)	$24,100	$84,300 ($74,800 - $132,700)
Sterling Street Rain Garden	$47,200 ($33,000 - $70,800)	$18,900	$66,100 ($51,900 - $89,700)
Schlomka Landscaping Enhanced Ditch Check Dams	$25,200 ($17,700 - $37,800)	$10,100	$35,300 ($27,800 - $47,900)
Carver Pond Improvements	$206,600 ($144,600 - $309,900)	$82,600	$289,200 ($227,200 - $392,500)
Double Driveway Pond Improvements[4]	$355,400 ($248,800 - $533,100)	$142,200	$497,600 ($391,000 - $675,300)
Fish Creek Erosion Survey and Improvements	$121,900 ($85,400 - $182,900)	$48,800	$170,700 ($134,200 - $231,700)

[1] Costs include 25-percent contingency. These do not include costs related to education and outreach, legal, long-term maintenance, or monitoring. Costs are represented as a feasibility-level class 4 cost estimate as defined by the Association for the Advancement of Cost Estimating with a +50% /-30% uncertainty.

[2] These costs assume that no wetland mitigation will be required as part of these projects, and that contaminated soils will not be encountered.

[3] Engineering cost is estimated to be 40 percent of the construction cost, excluding the purchase of properties and/or easements. This cost includes engineering and design and construction observation and administration.

[4] Includes cost of two (2) hydrodynamic separators

To estimate the cost benefit for each proposed BMP retrofit project, Barr calculated annualized costs for each proposed BMP per pound of phosphorus removed. Table 3 presents the annualized costs as a range for BMP lifespans of 20 to 35 years. The capital cost used for each BMP includes the opinion of probable cost and the engineering design cost. Annual costs include an estimated annual maintenance cost for the BMPs and an assumed interest rate of 4 percent.

Table 3 Summary of annualized costs for projects in the Fish Creek subwatershed

Proposed BMP	Annual cost per pound of TP removed ($/lb.)[1]	Annual cost per pound of TSS removed ($/lb.)[1]
Pleasantview Park Rain Garden	$5,000 - $6,500	$15 - $20
Sterling Street Rain Garden	$3,200 - $4,200	$18 - $24
Schlomka Landscaping Enhanced Ditch Check Dams	$1,200 - $1,600	$5 - $7
Carver Pond Improvements	$700 - $1,000	$95 - $125
Double Driveway Pond Improvements[2]	$1,600 - $2,100	$26 - $34
Fish Creek Erosion Survey and Improvements	$27,100 - $35,700	$13 - $17

[1] Range represents the annualized cost based on a 35-year and 20-year lifespan at an interest rate of 4 percent.

[2] Includes cost of two (2) hydrodynamic separators

3.4 Permits

The following permits may be required for one or more of the proposed BMP retrofit projects:

- **Excavating and grading permit (City of Maplewood):** An excavating and grading permit application, along with an erosion control plan, must be submitted with the final grading plans to the City of Maplewood any time a significant amount of soil is being displaced or a drainage pattern is being altered. If disturbed area is greater than 1 acre, watershed and National Pollutant Discharge Elimination System (NPDES) permits will be required.

- **Right-of-way permit (City of Maplewood):** Any work in the public rights of way requires a city right-of-way permit.

- **Erosion and sediment control (RWMWD):** An erosion and sediment control permit is required if the proposed land disturbance is greater than 1 acre or if the proposed land disturbance is within the 100-year floodplain and greater than 10,000 square feet. If required, an erosion and sediment control plan must be submitted with the permit application.

4.0 Meetings

Barr staff presented the alternatives from this memo to the RWMWD Board of Managers on October 7, 2020. The Managers reacted favorably to the projects and indicated that they should be included in the project prioritization tool to be considered for future implementation. Additionally, the Managers were interested in continuing to implement chloride reduction strategies in the subwatershed.

Future discussion related to meetings with the RWMWD, City of Maplewood, or other property owners can be included in this section, if they occur.

5.0 Summary and recommendations

This memo includes conceptual design of six water quality improvement project opportunities and chloride management strategies to improve water quality entering Fish Creek from the Fish Creek subwatershed. Of the rain garden concepts, the Sterling Street rain garden is the most cost-effective option for removing TP. However, the enhanced check dams and pond improvements projects are more cost effective and remove more TP overall. The Pleasantview Park rain garden option is the most visible project and offers a good opportunity for outreach and education for the District. Barr recommends including these projects in the District's project prioritization tool for comparison against other potential projects that have been identified through other feasibility studies. Barr also recommends continuing the Fish Creek erosion survey every 2 to 3 years to monitor erosion along the creek and identify areas for restoration.

While these projects can help reduce TP and chloride loading to Fish Creek, we also recommend considering other subwatershed activities that could improve the water quality, including:

- Providing education materials to chloride applicators within the subwatershed to reduce chloride loading to Fish Creek.
- Regular maintenance of existing BMPs including rain garden vegetation trimming, inlet maintenance, cleanout of hydrodynamic structures, etc.
- Continued public education and outreach in the subwatershed about stormwater runoff and at-home practices that can be adopted to improve runoff water quality.

6.0 References

Association for the Advancement of Cost Estimating. Rev. 2016. AACE International Recommended Practice NO. 18R-97, March 1, 2016.

ASTM E2516-11, Standard Classification for Cost Estimate Classification System, ASTM International, West Conshohocken, PA, 2011, www.astm.org.

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