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For the City of Apple Valley

Long and Farquar Lakes TMDL Implementation Plan Update

10.17.2017

wq-iw9-06c

Cover Image

Swans on Farquar Lake

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1. EXECUTIVE SUMMARY

The 2009 Long and Farquar Lakes Nutrient Total Maximum Daily Load (TMDL determined that significant reductions in nutrients impacting the lakes were needed. The TMDL identified a 76% reduction in total phosphorus loading to Long Lake and a 67% reduction in total phosphorus loading to Farquar Lake were needed in order to meet the State shallow lake phosphorus concentration standard of less than 90 µg/L. Local stakeholders have also shown interest in improving the lakes' quality so the lakes can better serve as community assets. To date, the City has been active in pursuing goals and a number of in-lake and watershed best management practices (BMP) have been implemented in an effort to reach this target. From those previous efforts progress has been made but is still short of meeting the goals. It is estimated that an additional 112 lbs of external phosphorus load reduction and 140 lbs of internal phosphorus load reduction are needed for Long Lake, and an additional 30 lbs of external phosphorus loading and 218 lbs of internal phosphorus load reduction are needed for Farquar Lake to fully meet the TMDL targets.

To address the required reductions in external (i.e. watershed) phosphorus loading, a suite of practices have been identified for further consideration by the City. For lake management, upstream watershed sources must be addressed first to cut off the source, before addressing in-lake nutrient releases. Focus was placed on watershed practices that infiltrate or "retain" runoff, since these practices have the potential to have a synergetic impact on any existing practices that are located downstream, thereby increasing the efficiency of the entire system of treatment practices. These strategies include, first and foremost, suggestions for incorporating retention practices into planned road corridor reconstruction projects, which can be coordinated with street reconstruction to be more cost effective. Many retrofit opportunities are identified, including enhancing infiltration of existing basins, a regional infiltration facility, and retrofitting commercial/institutional and residential areas.

This study proposes a suite of in-lake management strategies tailored to each lake, including lake drawdown, sediment alum treatment, curlyleaf pondweed herbicide treatments, winter aeration, and fisheries management. In-lake management should be considered an extensive and long-term approach to rectifying the decades of human disturbances that have occurred within these watersheds, with the ultimate goal of transforming the lakes from their present-day algae dominated state back to a clear water, aquatic plant dominated state. Full implementation of all the recommended in-lake strategies is needed to achieve a clear water state in Long and Farquar Lakes and achieve the internal load reduction goals from the original TMDL.

It is estimated that the projects identified here, both upstream in the watershed and in-lake, could result in substantial progress toward, if not complete achievement of, the TMDL reduction goals.

2. BACKGROUND

2.1. Project Overview

In 2002, the Minnesota Pollution Control Agency (MPCA) determined that Long and Farquar Lakes did not meet the water quality standard for aquatic recreation and, as a result, listed both lakes as “impaired” under Section 303(d) of the Clean Water Act. The main cause for the impairment is excessive nutrients in the lakes. Algal blooms caused by the excess nutrients occur throughout much of the summer season on both lakes and negatively impact recreational use and aesthetic enjoyment. The U.S. Environmental Protection Agency (EPA) requires states to develop Total Maximum Daily Load (TMDL) studies for impaired waters. A TMDL was developed for Long and Farquar Lakes in 2009 that determined the level of reduction needed in each lake to meet State standards for in-lake total phosphorus concentration. In 2010, the City developed an implementation plan that identified specific watershed and in-lake practices to reduced total phosphorus loading to the lakes. Since adoption of the 2010 implementation plan, the City has constructed several water quality projects in the Long Lake watershed. The City has also engaged in several in-lake activities aimed at reducing internal loading in both lakes. The previous TMDL implementation plan was envisioned to be a five year work plan after which the City would reevaluate its approach. At this time, the City is reviewing the progress that has been made to date in reaching the goals of the TMDL and investigating additional activities to be taken to fully meet the goal.

The following report summarizes the past studies that have been conducted and evaluates the effectiveness of recent water quality practices. The report then lays out a recommended approach for additional water quality improvements, BMPs aimed at reducing phosphorus from watershed runoff, and in-lake management activities designed to control internal phosphorus loading within the lakes.

2.2. Long and Farquar Lakes 2009 Nutrient TMDL

In 2009, the City of Apple Valley led the development of the Long and Farquar Lakes Nutrient TMDL for the MPCA in partnership with the Vermillion River Joint Powers Organization. The Long and Farquar Lakes Nutrient TMDL (Bonestroo, 2009) assessed the phosphorus load reductions needed for Long and Farquar Lakes to comply with Minnesota water quality standards. The specific sources of nutrients, target reductions from each source, strategies to achieve the reductions, and the approach to meet the applicable water quality standards for each lake are discussed in the TMDL report.

At the time of the TMDL development, both lakes had very high summer average in-lake total phosphorus (TP) concentrations (2005 Summer Average for Long Lake was 252 μg/L and for Farquar Lake was 186 μg/L). The TMDL determined the allowable TP loading to each lake, which was divided among watershed, internal and atmosphere sources as shown in Table 1. In the case of Farquar Lake, the watershed load is further divided among areas draining directly to Farquar Lake and the outflow from Long Lake. The primary purpose of the TMDL report was to determine the reductions in TP load needed for each lake to meet the State shallow in-lake TP concentration

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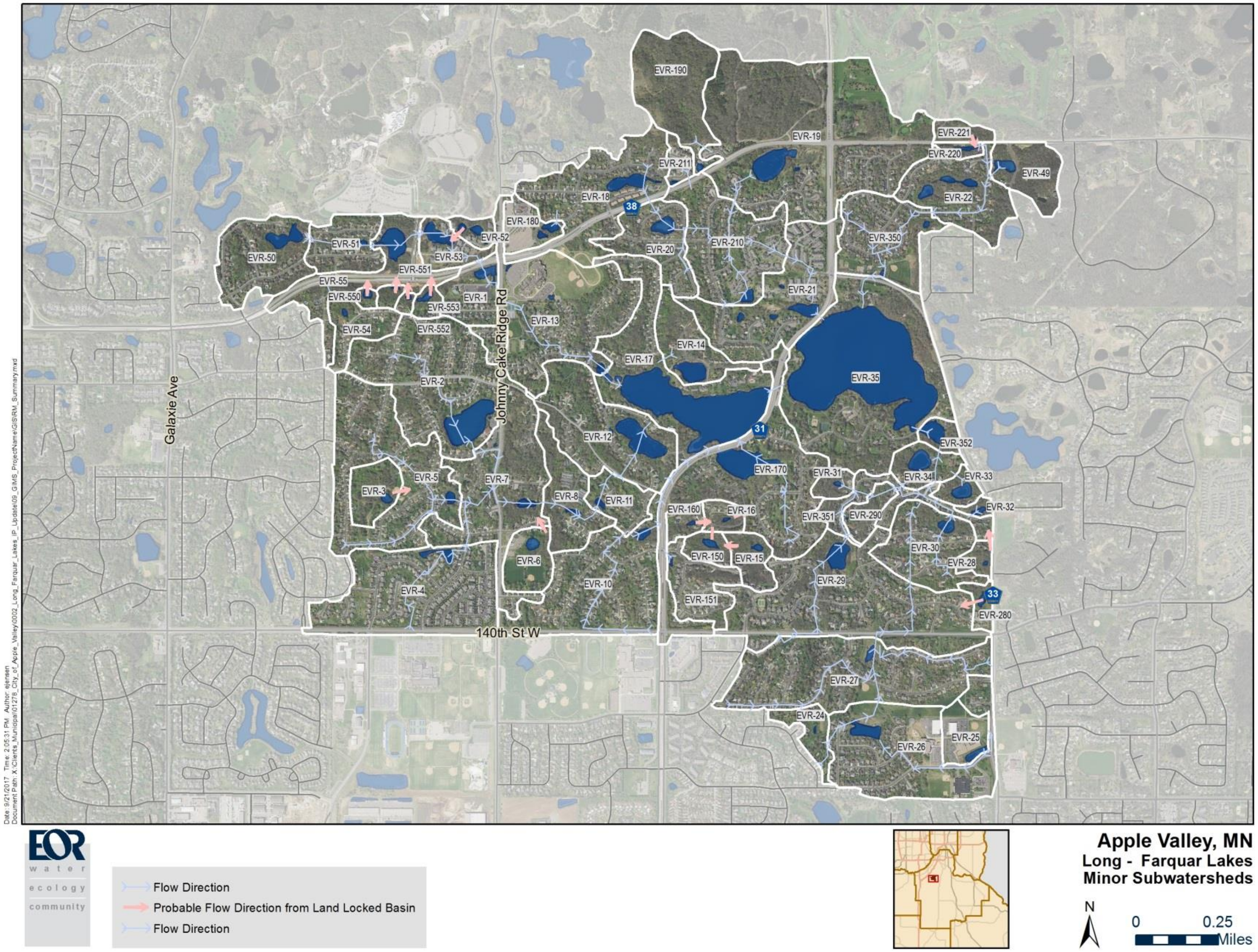


Figure 1. Long & Farquar Lakes Minor Subwatersheds

standard of less than 90 µg/L. The TMDL determined that a 76% reduction in phosphorus loading to Long Lake and a 67% reduction in phosphorus loading to Farquar Lake were needed in order to meet the State standard. Table 1 shows the load reductions needed from the watershed and internal components. Additionally, for Farquar Lake the watershed load reductions are further divided between areas draining directly to Farquar Lake and the outflow from Long Lake. This emphasizes the important role Long Lake plays in TP loading to Farquar Lake.

Table 1. 2009 TMDL Existing TP Loads and Load Reductions Needed to Meet State In-lake TP Standard

Long Lake TP TMDL	Total Load (lbs/yr)	Watershed Load (lbs/yr)	Internal Load (lbs/yr)	Atmosphere Load (lbs/yr)
2005 Existing Conditions (In-lake TP = 252 µg/L)	508	311	188	9
Reductions needed to achieve the State Standard (In-lake TP = 90 µg/L)	**(385)** 76% ↓	**(236)** 76% ↓	**(149)** 79% ↓	**0** 0%

Farquar Lake TP TMDL	Total Load (lbs/yr)	Watershed Load (lbs/yr)		Internal Load (lbs/yr)	Atmosphere Load (lbs/yr)
		Direct	Long Lake Outflow		
2005 Existing Conditions (In-lake TP = 186 µg/L)	792	80	185	510	17
Reductions needed to achieve the State Standard (In-lake TP = 90 µg/L)	**(529)** 67% ↓	**(30)** 38% ↓	**(139)** 75% ↓	**(360)** 71% ↓	**0** 0%

2.3. Long and Farquar Lakes Nutrient TMDL Implementation Plan 2010

In 2010, the City of Apple Valley – in cooperation with the lake associations on each lake, the VRWJPO, and Dakota County – developed an implementation plan that sets forth activities to be undertaken to reduce phosphorus loading to the two lakes. The objective for the implementation plan was to outline specific actions to be taken to reduce lake phosphorus loadings to the level specified in the TMDL. The implementation plan included specific projects, estimated costs, and scheduling for a 5-year period. The implementation plan was structured around the main subwatersheds to each lake and included TP load reduction goals for each subwatershed as shown in Table 2.

The highest priority subwatershed area for Long Lake was determined to be the area draining through EVR-P12. The highest priority for Farquar Lake was to reduce the phosphorus load from Long Lake.

Table 2. 2010 TMDL Implementation Plan Proposed Phosphorus Reduction by Source

Phosphorus Source	Proposed Phosphorus Reduction (lbs/yr)
Long Lake	
Sub-watershed through EVR-P13	22
Sub-watershed through EVR-P12	178.5
Sub-watershed through EVR-P170	38
Direct drainage to Long Lake (EVR-17)	12.5
Internal Load	134
Total Long Lake Reduction	**385**
Farquar Lake	
Drainage from Long Lake	139
Direct drainage to Farquar Lake (EVR-35)	17.5
Sub-watershed through EVR-P21	22
Other watershed projects, if needed	8
Internal Load	360
Total Farquar Lake Reduction	**546.5**

2.4. Past Management Activities

Since adoption of the 2010 Implementation Plan, the City has undertaken significant efforts to improve water quality in Long and Farquar Lakes. Several watershed BMPs have been installed in the Long Lake watershed including the use of cutting edge technologies, such as iron-enhanced sand filters to reduce phosphorus loading. The focus for Farquar Lake has been internal lake management efforts, most significantly the removal of rough fish but including fish stocking and curlyleaf pondweed removal.

Table 3. Recent Long Lake Watershed Projects

Project	Subwatershed	Estimated TP Removal (lbs/year)
EVR-Pond 8 Iron Enhanced Sand Filter	EVR-12	45
Long Lake Park 2-cell Iron Enhanced Sand Filter	EVR-13	33
EVR-Pond 12 Alum Treatment	EVR-12	23
Expansion of EVR-Pond 13 in Long Lake Park	EVR-13	21
FRMS Raingarden Retrofit	EVR-12	2
Everest Ave Tree Filter north of 133rd Street Ct	EVR-12	0.3
Everest Ave Raingarden south of 133rd Street Ct	EVR-12	0.15

Note: Estimated TP removals were supplied by the City/other reports and were not modeled.

In addition to the watershed improvement projects, the City also conducted several projects aimed at reducing the internal loading component to Long Lake. These projects included the following:

- Partial drawdown of Long Lake
- Long Lake inlet sediment delta removal
- EVR-Pond 170 inlet sediment delta removal
- Alum treatment of EVR-Pond 170 (considered part of Long Lake)

Quantification of the phosphorus removal from these internal projects is difficult, but at least 9 lbs/year of TP removal can be attributed to the alum treatment project in EVR-Pond 170. Based on the TP reduction goal from the 2009 TMDL and the work completed to date, it was determined that an additional 112 lbs/year of watershed TP reduction and an additional 140 lbs/year of internal load reduction is needed for Long Lake.

Table 4. Long and Farquar Lakes TMDL Reductions Needed, Achieved, and Remaining

Phosphorus Source	TMDL Phosphorus Reductions (lbs/year)		
	Total Needed	Achieved to Date	Remaining
Long Lake			
Watershed Load **	236	124	**112**
Internal Load	149	9	**140**
Farquar Lake			
Watershed Load	30	0	**30**
Long Lake Outflow	139	76	**63**
Internal Load	360	142	**218**

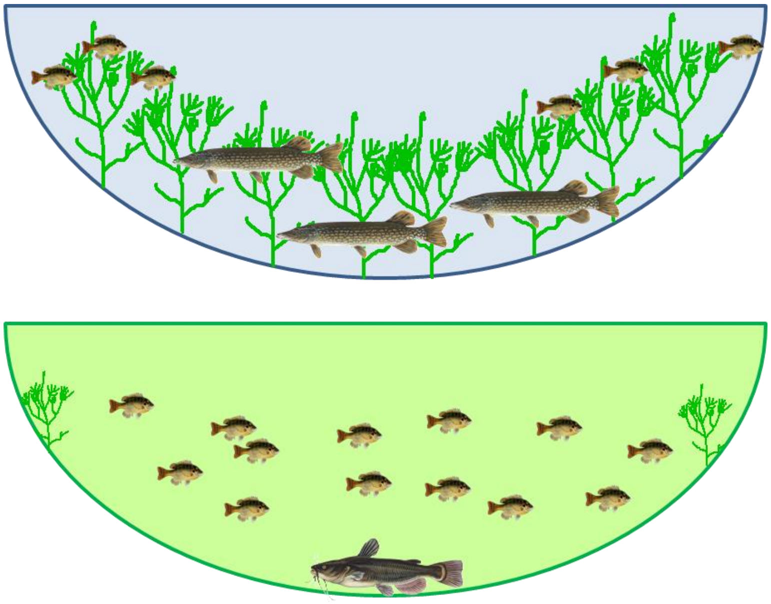
***Proposed adjusted reductions after EVR-P170 Load Allocation component removed*

Note: Estimated TP removals were supplied by the City/other reports and were not modeled.

3. COMPREHENSIVE IN-LAKE MANAGEMENT ALTERNATIVES

Lakes are considered shallow when most (>80%) of the lake area is less than 15 feet. Depths less than 15 feet are important biologically because these depths have the potential to support aquatic plant growth because sunlight can generally penetrate to the lake bottom. In addition, all the living organisms in shallow lakes are concentrated in a smaller volume than in deeper lakes. Consequently, the relationship between phosphorus concentration and the amount of algae growth (measured by chlorophyll-*a* pigments and water transparency) is often different in shallow lakes as compared to deeper lakes. In deeper lakes, algae abundance is often controlled by physical and chemical factors such as light availability, temperature, and nutrient concentrations. The biological components of the lake (such as microbes, algae, aquatic plants, zooplankton and other invertebrates, and fish) are distributed throughout the lake, along the shoreline, and on the bottom sediments. In shallow lakes, the biological components are more concentrated into less volume and exert a stronger influence on the ecological interactions within the lake. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes because oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between phosphorus and the response factors.

The result of this impact of biological components on the ecological interactions is that **shallow lakes normally exhibit one of two ecologically alternative stable states (Figure 2): the turbid water, algae-dominated state, and the clear water, aquatic plant-dominated state.** The clear state is the most preferred, since algae communities are held in check by diverse and healthy zooplankton and fish communities. In addition, rooted plants stabilize the sediments, lessening the amount of sediment stirred up by the wind. Long and Farquar Lakes are currently in the turbid water, algae-dominated state, therefore, the management alternatives proposed are geared towards flipping the lake into the clear water state.



CLEAR

Large fish (or the absence of all fish) and abundant rooted plants keep water clear.

TURBID

Too many panfish or too few rooted plants keep water turbid.

Figure 2. Alternative Stable States in Shallow Lakes

3.1. Overall Approach

To achieve a clear water state in Long and Farquar Lakes, several key functions will need to be achieved through watershed and in-lake management activities (see Figure 3). First, phosphorus load reductions are needed to reduce algae blooms and increase water clarity. Phosphorus load reductions are needed from watershed sources (see Section 3.1) and from sediment or internal sources. Under increased water clarity, sunlight penetration to the lake bottom will fuel aquatic plant growth. Therefore, management of aquatic invasive plant species is needed next to promote the growth of native species over invasive species. Additional management of aquatic plants and fish are also needed because aquatic plants and fish can have a strong influence on water clarity in shallow lakes without any changes in phosphorus loads.

The following discussion of management alternatives is organized by the basic function(s) performed by each practice as illustrated in Figure 3. Whole lake drawdown is the only management alternative that achieves all key functions. Alum treatment can simultaneously reduce sediment phosphorus, reduce algae blooms, and increase water clarity; while dredging can reduce sediment phosphorus. Algaecide or aeration can reduce algae booms and increase water clarity. While combinations of several smaller scale management alternatives can be used to manage aquatic plants and fish.

It is important to note that Long and Farquar Lakes have undergone extensive changes from human disturbances over a long period of time. Therefore, management of these lakes should also be expected to be extensive and long-term. That is to say, continual management of shallow lakes is needed to maintain clear water. Management efforts at the beginning will be more intensive to effectively switch the lake from a turbid water to a clear water condition, followed by ongoing, less intensive management to maintain healthy aquatic plants, fish, and clear water. Refer to section 5 for the recommended approach for in-lake management

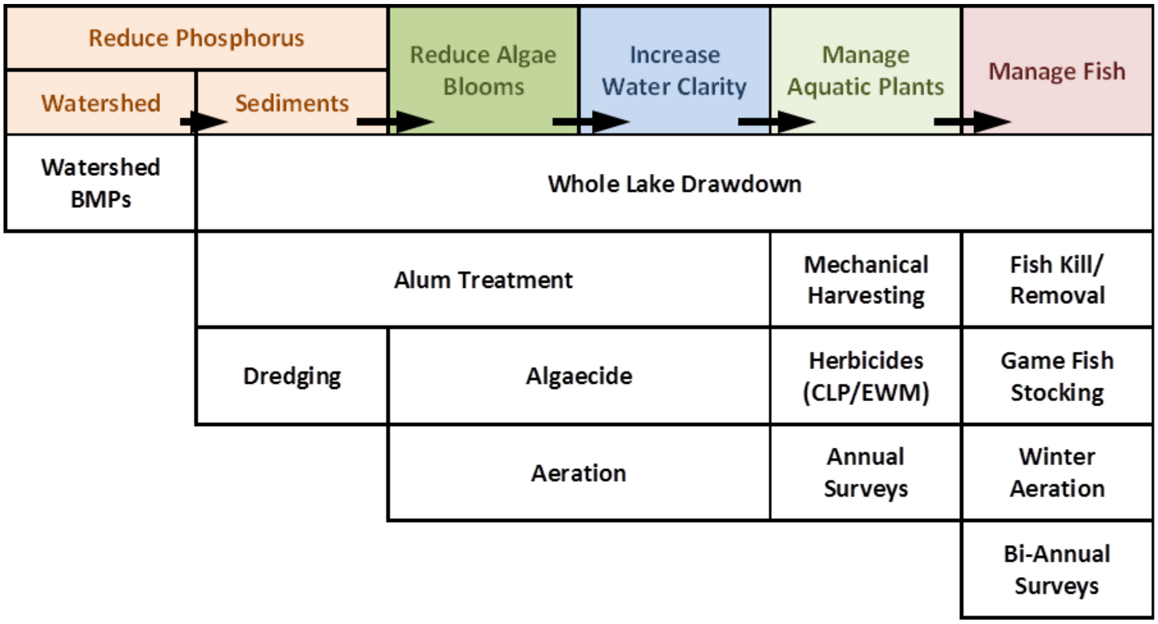


Figure 3. In-Lake Management Alternatives

3.2. Alternatives Comparison

In-lake Management Alternative	Description	Benefits	Considerations	Recommended for Long?	Recommended for Farquar?
Whole-lake Drawdown	A whole-lake drawdown is the process of passively or actively removing all water in a lake and expose the entire lake bottom to the air to: a) oxidize and consolidate sediment, b) freeze curlyleaf pondweed turions, c) kill all fish, and d) promote re-germination of native plant species. This activity simultaneously achieves all shallow lake key functions.	• **Reduce sediment phosphorus** • **Reduce algae blooms** • **Increase water clarity** • **Manage aquatic plants** • **Manage fish**	Lake aesthetics may be moderately impacted, and consideration must be given to downstream discharge of the high phosphorus lake water. An outlet structure system and a downstream resource capable of receiving the drawdown water are needed. Best in fall/winter when runoff low	**Yes.** An existing outlet structure exists. Consider in a drier year to achieve a complete drawdown.	**No.** No outlet structure nor downstream resource capable of receiving the drawdown water.
Sediment Alum Treatment	The application of aluminum sulfate as a floc layer at the lake sediment/water interface that can bind with phosphorus released from the sediments for an extended period of time. The aluminum sulfate used in alum treatments strongly binds with phosphorus through a chemical reaction under most lake conditions, prohibiting phosphorus release from the sediments into the lake water. Alum will also strip phosphorus from the water column as it is applied, resulting in immediate improvements in water clarity and algae. When applied as an appropriate dose, alum will prevent internal recycling of phosphorus over 5-10 years.	• **Reduce sediment phosphorus** • **Reduce algae blooms** • **Increase water clarity**	Usually applied with a buffer, to maintain appropriate lake pH levels. Requires lake access for application pontoons or barges. There are a finite number of alum binding sites in each alum treatment that are used over time as phosphorus is slowly released by the lake sediments. Therefore, additional alum treatments are needed every 5-10 years, depending on the initial dose, to replenish the amount of available alum binding sites for sediment phosphorus. Best in late fall or early spring, when aquatic plant growth is minimal	**No.** Whole-lake drawdown more appropriate.	**Yes.** Internal load 64% of total phosphorus load to lake.

In-lake Management Alternative	Description	Benefits	Considerations	Recommended for Long?	Recommended for Farquar?
Sediment Dredging	Dredging permanently removes phosphorus laden sediments and increases lake depths.	• **Reduce sediment phosphorus**	Disposal of dredge sediment is a difficult/expensive effort due to the water content and weight of the material. Large, nearby drying areas are needed to reduce the water content of the sediment prior to disposal. Dredging will also remove the seedbank within the lake, destroy in-lake habitat and temporarily increase lake turbidity.	**No.** Cost prohibitive and destructive.	**No.** Cost prohibitive and destructive.
Algaecides	Temporary chemical treatment of algae to reduce an algae bloom.	• **Reduce algae blooms** • **Increase water clarity**	Requires regular monitoring throughout the season, and multiple treatments on an as-needed basis. Reactive approach and does not solve root of water quality problem, just a temporary treatment of the symptom.	**No.** Temporary aesthetic treatment.	**No.** Temporary aesthetic treatment.
Growing Season Aeration	Add air to bottom waters (hypolimnion). Goal is to ensure that bottom waters are oxygenated so that phosphorus is not released from sediment. Appropriate for lakes with high sediment internal load that would benefit from oxic bottom waters.	• **Reduce algae blooms** • **Increase water clarity**	Requires electricity and ongoing maintenance. For lakes with undesired winter fish kill, can also be used in winter to prevent fish kill. Most applicable to deep lake bottom waters, or to very small treatment ponds.	**No.** Lake too large and shallow.	**No.** Lake too large and shallow.

In-lake Management Alternative	Description	Benefits	Considerations	Recommended for Long?	Recommended for Farquar?
Mechanical Harvesting	Cutting and removal of aquatic vegetation. Goal is to remove vegetation from the water to eliminate it as a source of nutrients as the vegetation degrades, and encourage growth of native plants.	• Manage aquatic plants	Mechanical harvesting of CLP in early spring, before turions are produced, can be effective at reducing dense populations of CLP. Once CLP density decreases, CLP management should transition to less disruptive herbicide treatments, to limit turion dispersal to lake sediments.	**Yes.** Can reduce dense mats, enhance recreational value, and remove source of nutrients to the lake.	**Yes.** Can reduce dense mats, enhance recreational value, and remove source of nutrients to the lake.
Herbicides	Application of chemical herbicides to the littoral area of the lake. Goal is to kill aquatic vegetation to eliminate it as a source of nutrients. Endothall is often used for curly-leaf pondweed control	• Manage aquatic plants	Properly applied herbicides generally have little effect on overall native macrophytes, though can change species abundance. Multiple years of treatment are needed to manage plant growth. Will not eradicate plants. Best in late spring when CLP growing	**Yes.** To manage CLP community for lower densities, if drawdown does not freeze all turions.	**Yes.** To manage CLP community for lower densities.
Fish Kill	Kill fish population using pesticide. Goal is to eliminate an unbalanced fish population in order to re-establish a healthy fish population. Allows lake to be "restarted" with fully defined new fish population. Treatment has been able to shift shallow systems to clear water state for a period of time (many years)	• Manage fish	Kills all fish, but not usually black bullheads or carp. May also kill zooplankton. May limit use of lake as habitat for wildlife because of lack of available food (fish). Need to rotenone entire watershed to be most effective, or conduct regular treatments. Best in winter when oxygen concentrations are lowest	**Yes.** Doesn't usually support large fish. Manage lake for no fish.	**No.** Can support large fish. Manage lake for large fish.

In-lake Management Alternative	Description	Benefits	Considerations	Recommended for Long?	Recommended for Farquar?
Fish Stocking	Alteration of fish population structure. Goal is to alter fish population structure so that fewer planktivorous fish are present, leaving the zooplankton present to reduce the algae population.	• Manage fish	May not be effective if high internal load from sediment still present. May take a long time to see full effect of biomanipulation efforts. Rotenone, fish harvest, and fish stocking can be used to support biomanipulation. Best in early spring to allow juvenile fish to grow during warmer summer months.	**No.** Doesn't usually support large fish. Manage lake for no fish.	**Yes.** Can support large fish. Manage lake for large fish.
Winter Aeration	Maintain a small plume of high oxygen water in lake. Goal is to eliminate winter fish kills. Increases oxygen to maintain game fish species with minimal energy consumption. Takes away competitive advantage of bullheads and carp under low oxygen conditions	• Manage fish	Requires electricity and ongoing maintenance. Must obtain a permit to install and fence off aerated lake area. Best to begin aeration soon after ice over	**No.** Doesn't usually support large fish. Manage lake for no fish.	**Yes.** Can support large fish. Manage lake for large fish.

4. WATERSHED LOAD REDUCTION ALTERNATIVES

EOR analyzed existing information on stormwater infrastructure treatment efficiencies, soils data, surface and groundwater hydrology, existing BMP locations, and planned capital improvement projects to develop a watershed-scale assessment methodology for identifying and prioritizing locations for future implementation projects. The assessment focused on practices that perform phosphorus load reduction primarily through retention (i.e. infiltration), in keeping with the secondary goal of more closely mimicking the natural, semi-landlocked state of many portions of these watersheds.

Figure 4 Watershed BMP Strategies and Priority

This methodology prioritized projects in the following order:

1. **Road Corridor BMP Projects**: Integration of low-impact design (LID) practices into planned road reconstruction projects with an emphasis on Johnny Cake Ridge Road, which will undergo redevelopment in 2018. Other roads identified may not be slated for near-term reconstruction, but should be considered either for BMP integration or retrofit potential.
2. **Priority Infiltration Basins**: Identification of portions of the watershed with soils conducive to supporting infiltration practices on public parcels.
3. **Stormwater Pond Infiltration Benches**: Identification of portions of the watershed with soils conducive to supporting infiltration practices in areas surrounding existing stormwater ponds.
4. **Large Site Retrofits**: Identification of large, impervious areas within the watershed where retrofit opportunities exist.
5. **Riparian Buffer Quality Assessment**: Identification of nearshore areas with high quality buffers that should be protected and areas with low quality buffers that would benefit from planned enhancements based on a qualitative assessment of the buffer area within 50 feet of Long and Farquar Lakes.

6. **Residential BMPs**: Prioritizing locations of residential BMPs – including rain gardens, tree trenches, and opportunities for installation of porous pavements – based on a review of current aerial imagery, the existing storm utility network, and soils data.
7. **Street Sweeping**: Recommendations for improved street sweeping procedures.

Since it is important to report estimated removals at the inlet to the lakes themselves – as opposed to reporting the watershed load reduction, or the reduction at the stormwater pond nearest a practice, for example – a consistent methodology was used to estimate TP load reductions for each type of project, such that the predicted reductions could be viewed in the context implementation staging. This method of accounting accomplishes two things: first, it ensures that the benefits of an individual project are not overestimated, since there are often diminishing returns when practices are constructed in series; second, however, it also ensures that any increase in system efficiency resulting from overall discharge reduction (i.e. runoff retention) is simulated. This latter point is important to consider in the context of the detention ponds in series within these watersheds – many of which are not currently operating at optimal efficiency. In other words, by concentrating efforts on the types of practices discussed in this section of the report, it should be fully expected that the efficiency of existing practices will increase in kind, since the proportion of upstream discharge that they can efficiently treat is increased as a consequence of upstream volume retention.

4.1. Road Corridor BMP Projects

Recognizing that integrating BMP projects with planned or potential road reconstruction projects presents a low-cost alternative to BMP retrofits, a high-level review of the Johnny Cake Ridge Road (JCRR) corridor was conducted to identify potential BMP locations and estimate their benefits to water quality improvement and water quantity reduction (see Figure 5 through Figure 10). The results of this review were then used to estimate the potential for additional BMP integration opportunities in either reconstruction or retrofit projects along other major roads within the watershed, including: Pilot Knob Road, 140th Street, and McAndrews Road, as shown in Figure 5. The City's existing P8 model was used to estimate the potential impacts of implementing BMPs within the corridors by reducing the tributary areas of those subcatchments that contained segments of these roadways, as described below.

In the Johnny Cake Ridge Road corridor, individual catchments for roadway catch basins were delineated in order to determine the amount of impervious area concentrating runoff to each catch basin in the roadway corridor. Reviewing this, in conjunction with existing storm sewers, directed placement of structural BMPs, such as catch basin retrofits with sumps and sediment collection enhancements or underground stormwater quality tanks. These types of devices should be viewed as enhancement to a suite of BMPs – providing treatment where room may not allow for more expansive BMPs or for pretreatment to other BMPs. In many cases, the pedestrian trail intersected the drainage areas, which presents the opportunity of treatment extending below the walking surface. Adjacent city park areas were also identified as opportunities to augment road corridor BMPs.

Potential constraints to BMP construction were also taken into consideration during the review, including mature tree coverage, proximity of private property, adjacent steep slopes, turn lanes, or trail convergences with the roadway. Illustrations of typical road corridor LID sections, along with figures showing examples of typical BMPs, can be found in Appendix C: Johnny Cake Ridge Road Interim Memo and BMP Examples.

Initially, calculation of impervious runoff volume generated for a 1-inch rainfall was conducted to determine the treatment depth given the drainage and footprint areas of roadway corridor BMPs. Soils in the area are identified as moderately to well-drained. Maps of the Johnny Cake Ridge Road corridor – including potential BMPs and corresponding drainage areas – are shown in Figure 6 through Figure 10.

The main outcome from the Johnny Cake Ridge Road review that was used in estimating BMP impacts on all of the major roads in the watershed (as listed above) was the determination of an approximate treatment area per linear foot of reconstructed roadway that could be fully treated (i.e. no discharge for the average year's rainfall). Therefore, for each linear foot of major roadway within each minor subwatershed, the tributary area in the P8 model was reduced by 0.0065 acres.

The P8 model simulation indicated that implementing BMPs in all four of these road corridors could reduce existing TP loading to Long Lake by 21.2%, or approximately 29.7 lbs/yr, as shown in Table 5. The results show that high watershed load reductions are diminished as the load reductions are tracked downstream through the treatment train; however, the results also show an increase in system efficiency as indicated by the reduction in Long Lake TP inflow exceeding the combined reductions at the EVR-12 and EVR-13 outlets. This is most likely the result of the overall reduction in runoff volumes, thereby showcasing the benefits of a Low Impact Development (LID) approach over a detention-only approach to stormwater management.

Although they are shown in Figure 5, the analysis did not include potential road reconstruction projects within the drainage areas to Farquar Lake at this time. It should be noted, however, that with all of these BMPs, any external or internal load reductions to Long Lake will in turn have benefit to Farquar Lake since the majority of its load comes from Long Lake outflow.

Given the high level of this analysis, and the generally tight limitations of working in a corridor setting, a 50% contingency factor was applied for the BMP treatment area to account for unknowns, such as final BMP type selection, BMP side slopes, void space (if underground), utility conflicts. That is to say, only half of the BMP footprint is considered for the depth calculation.

Potential project costs were estimated by applying established per-unit-volume costs to each BMP sited in the JCRR corridor. These varied by BMP type and ranged between $7 and $12 per cubic foot of retention capacity. Then, the overall costs were divided by the total length of the corridor (6,654 feet), resulting in a range of unit costs from $75 to $130 per linear foot of roadway. For reference, these numbers are provided in Table 6 for the entire watershed (including areas tributary to Farquar Lake). It should be emphasized that these costs will appear large since they represent the ambitious goal of retaining 1” of runoff along the entire corridor. It is important to note that these costs will increase if BMPs are constructed as retrofits rather than as part of a larger reconstruction effort.

Table 5: Predicted potential watershed and net load reductions resulting from road reconstruction projects in major subwatersheds EVR-12 and EVR-13 only.

Minor Subwatershed	Major Subwatershed	Road Projects Included	Length of Major Road Corridors (ft)	Watershed TP Load Reduction (lbs/yr)
EVR-4	EVR-12	140th, JCRR	3635	11.9
EVR-7	EVR-12	JCRR	4565	10.3
EVR-10	EVR-12	140th, Pilot Knob	2658	6.3
EVR-170	EVR-12	140th, Pilot Knob	6511	10.1
EVR-1	EVR-13	McAndrews	870	3.3
EVR-13	EVR-13	JCRR, McAndrews	2194	6.1
EVR-55	EVR-13	McAndrews	3772	18.3
Net Reductions:	*EVR-12 outflow*			*9.4*
	EVR-13 outflow			*13.0*
	Long Lake inflow			*29.7*

Table 6: Approximate LID implementation costs for major roads in the entire Long & Farquar Lake watershed.

Road	Approx. Length (ft)	LID Cost
McAndrews Rd	12,200	$915,000 - $1,586,000
Johnny Cake Ridge Rd	6,600	$495,000 - $858,000
140th St. NW	11,000	$825,000 - $1,430,000
Pilot Knob Rd	10,500	$787,500 - $1,365,000

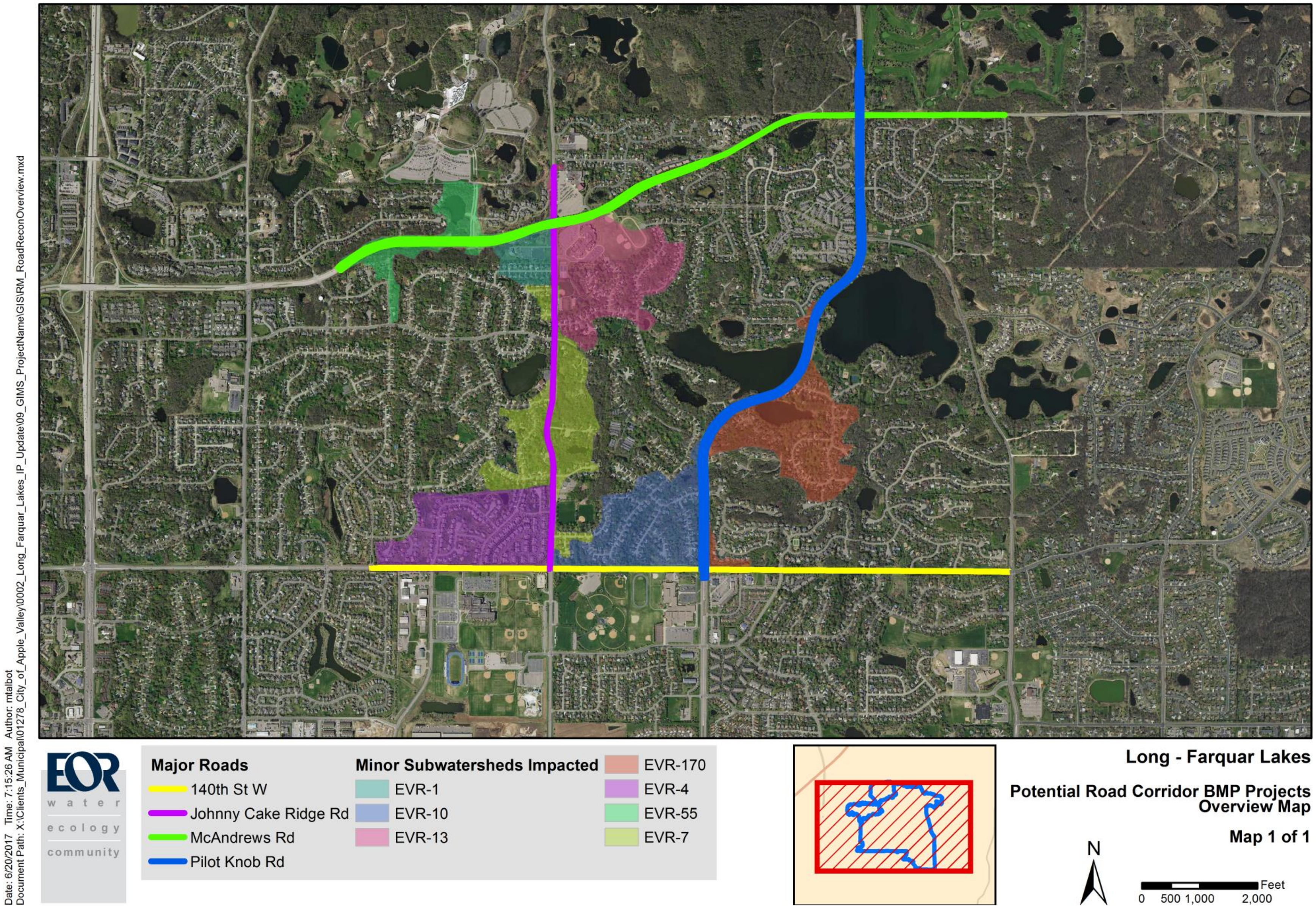
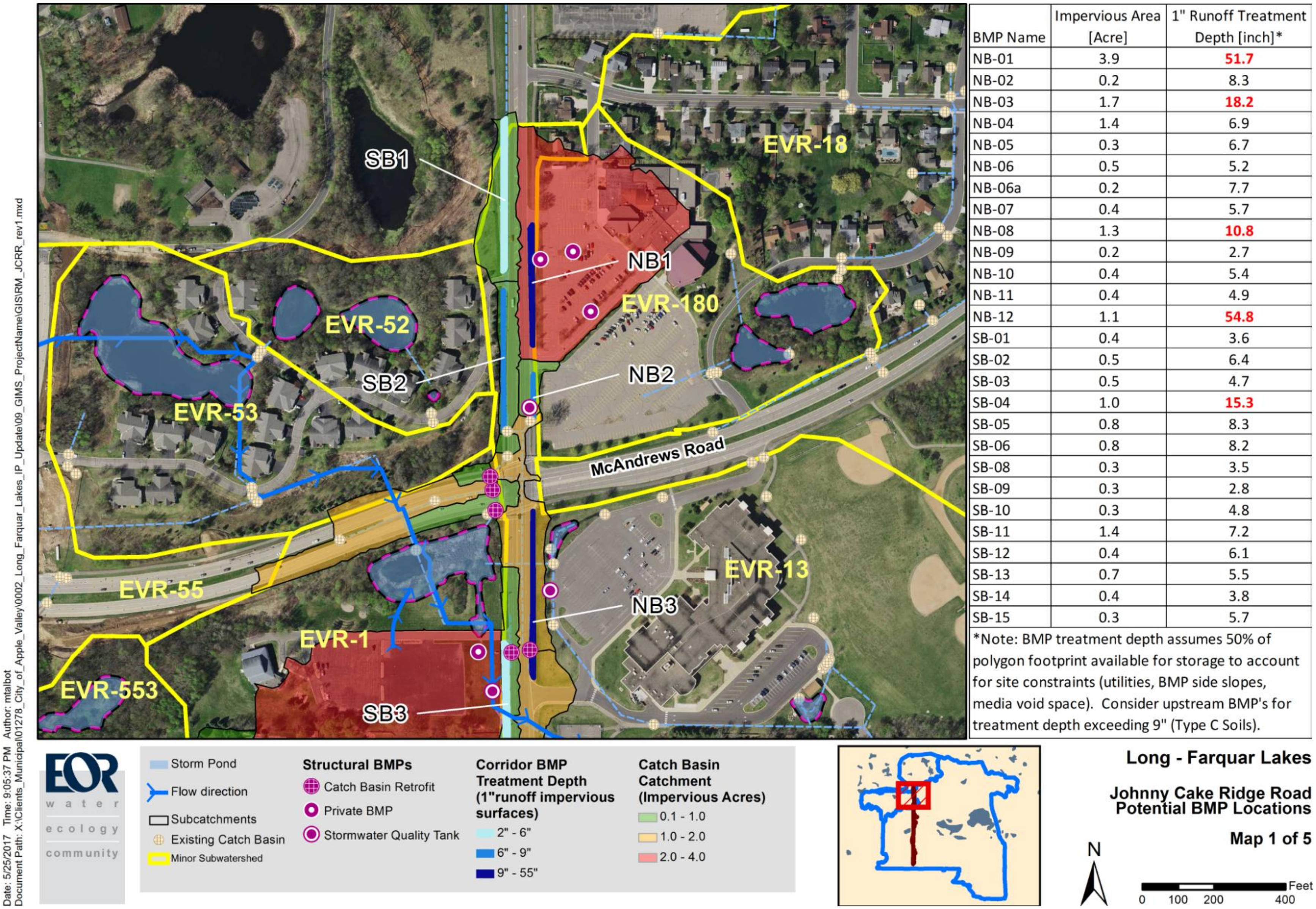


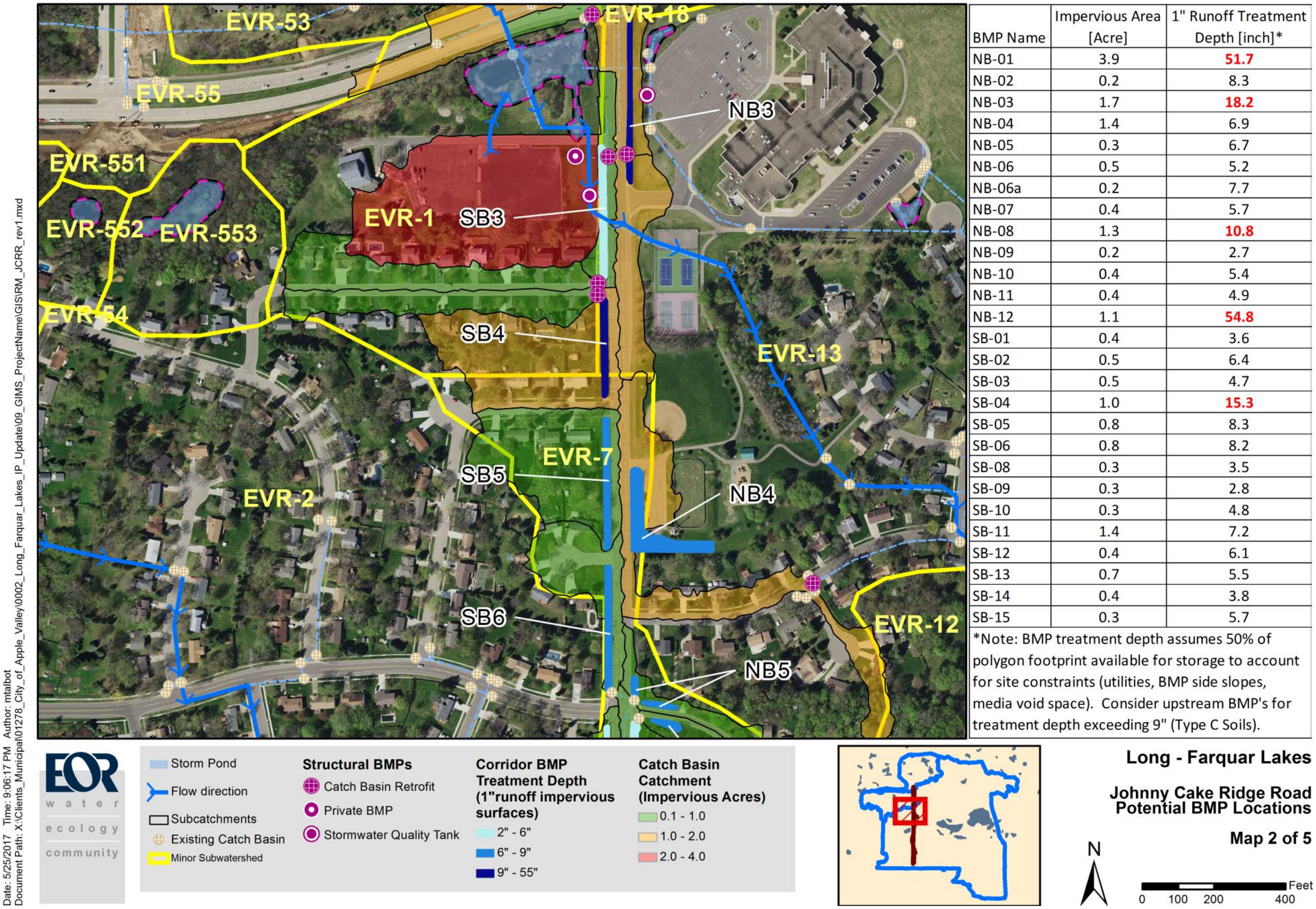
Figure 5: Overview map of potential road reconstruction and corridor BMP retrofit projects.



BMP Name	Impervious Area [Acre]	1" Runoff Treatment Depth [inch]*
NB-01	3.9	51.7
NB-02	0.2	8.3
NB-03	1.7	18.2
NB-04	1.4	6.9
NB-05	0.3	6.7
NB-06	0.5	5.2
NB-06a	0.2	7.7
NB-07	0.4	5.7
NB-08	1.3	10.8
NB-09	0.2	2.7
NB-10	0.4	5.4
NB-11	0.4	4.9
NB-12	1.1	54.8
SB-01	0.4	3.6
SB-02	0.5	6.4
SB-03	0.5	4.7
SB-04	1.0	15.3
SB-05	0.8	8.3
SB-06	0.8	8.2
SB-08	0.3	3.5
SB-09	0.3	2.8
SB-10	0.3	4.8
SB-11	1.4	7.2
SB-12	0.4	6.1
SB-13	0.7	5.5
SB-14	0.4	3.8
SB-15	0.3	5.7

*Note: BMP treatment depth assumes 50% of polygon footprint available for storage to account for site constraints (utilities, BMP side slopes, media void space). Consider upstream BMP's for treatment depth exceeding 9" (Type C Soils).

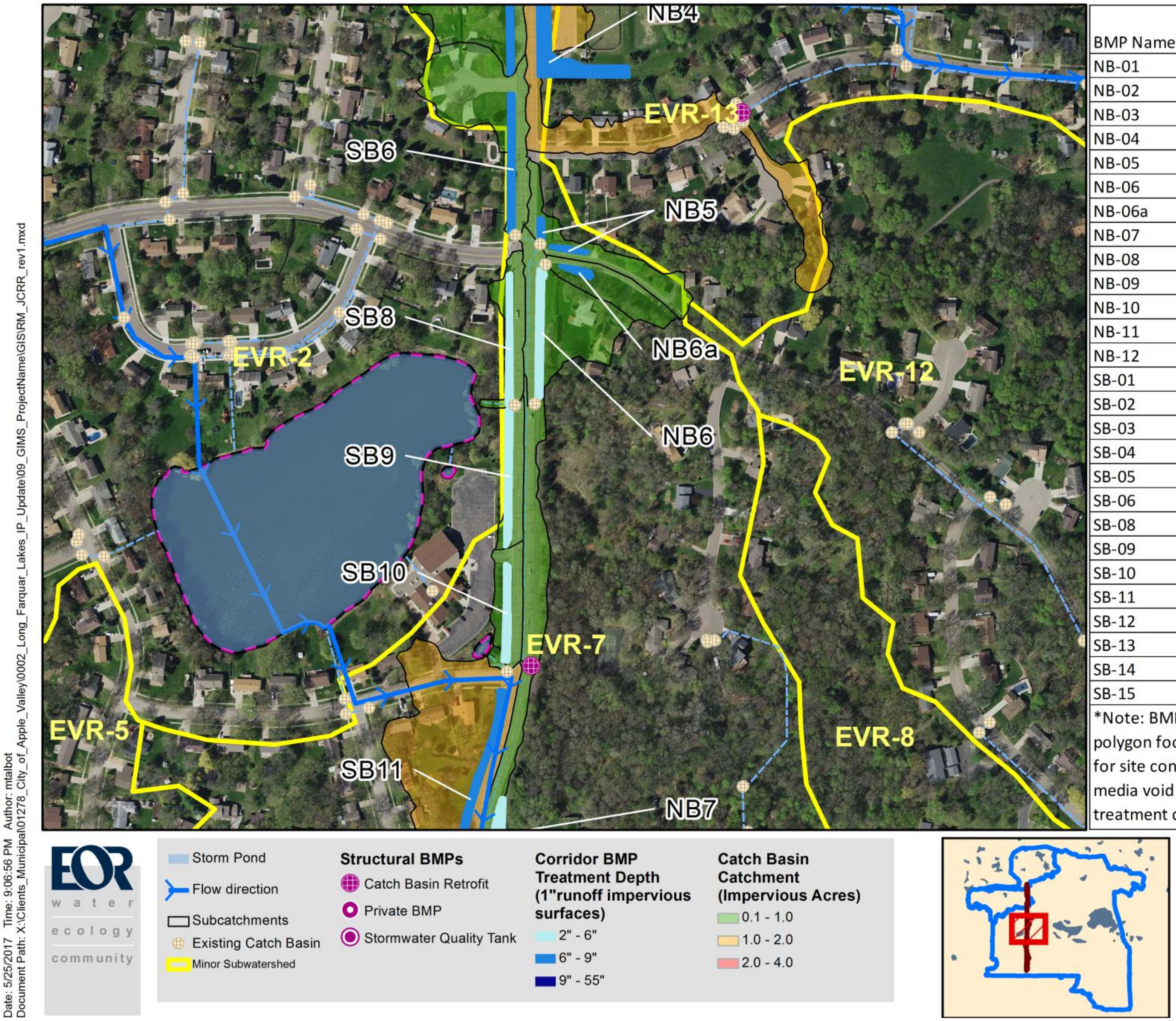
Figure 6: Johnny Cake Ridge Road potential BMP locations (1 of 5).



BMP Name	Impervious Area [Acre]	1" Runoff Treatment Depth [inch]*
NB-01	3.9	51.7
NB-02	0.2	8.3
NB-03	1.7	18.2
NB-04	1.4	6.9
NB-05	0.3	6.7
NB-06	0.5	5.2
NB-06a	0.2	7.7
NB-07	0.4	5.7
NB-08	1.3	10.8
NB-09	0.2	2.7
NB-10	0.4	5.4
NB-11	0.4	4.9
NB-12	1.1	54.8
SB-01	0.4	3.6
SB-02	0.5	6.4
SB-03	0.5	4.7
SB-04	1.0	15.3
SB-05	0.8	8.3
SB-06	0.8	8.2
SB-08	0.3	3.5
SB-09	0.3	2.8
SB-10	0.3	4.8
SB-11	1.4	7.2
SB-12	0.4	6.1
SB-13	0.7	5.5
SB-14	0.4	3.8
SB-15	0.3	5.7

*Note: BMP treatment depth assumes 50% of polygon footprint available for storage to account for site constraints (utilities, BMP side slopes, media void space). Consider upstream BMP's for treatment depth exceeding 9" (Type C Soils).

Figure 7: Johnny Cake Ridge Road potential BMP locations (2 of 5).



BMP Name	Impervious Area [Acre]	1" Runoff Treatment Depth [inch]*
NB-01	3.9	51.7
NB-02	0.2	8.3
NB-03	1.7	18.2
NB-04	1.4	6.9
NB-05	0.3	6.7
NB-06	0.5	5.2
NB-06a	0.2	7.7
NB-07	0.4	5.7
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NB-09	0.2	2.7
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NB-11	0.4	4.9
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SB-04	1.0	15.3
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SB-06	0.8	8.2
SB-08	0.3	3.5
SB-09	0.3	2.8
SB-10	0.3	4.8
SB-11	1.4	7.2
SB-12	0.4	6.1
SB-13	0.7	5.5
SB-14	0.4	3.8
SB-15	0.3	5.7

*Note: BMP treatment depth assumes 50% of polygon footprint available for storage to account for site constraints (utilities, BMP side slopes, media void space). Consider upstream BMP's for treatment depth exceeding 9" (Type C Soils).

Long - Farquar Lakes

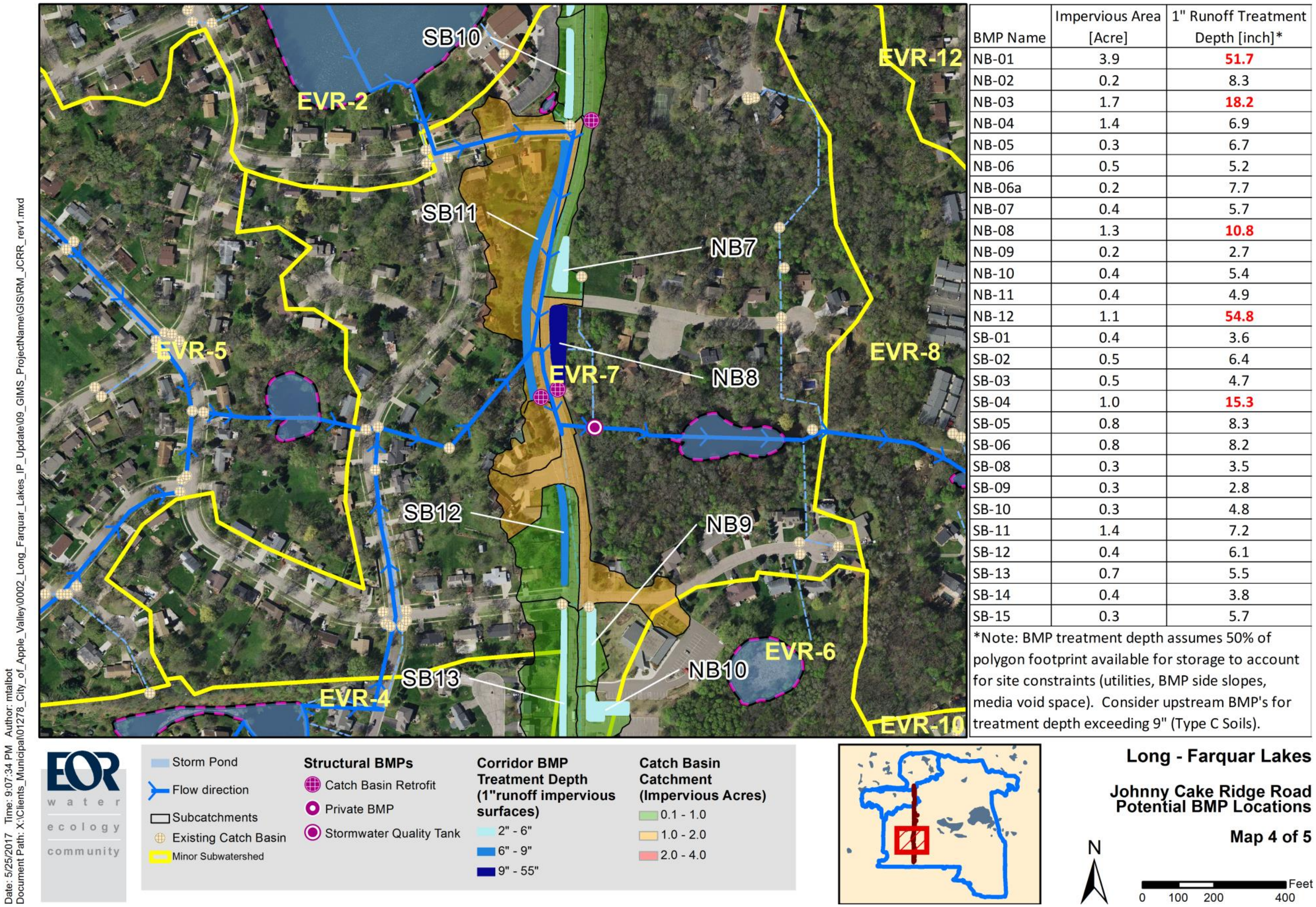
Johnny Cake Ridge Road Potential BMP Locations

Map 3 of 5

N

Feet
0 100 200 400

Figure 8: Johnny Cake Ridge Road potential BMP locations (3 of 5).



BMP Name	Impervious Area [Acre]	1" Runoff Treatment Depth [inch]*
NB-01	3.9	51.7
NB-02	0.2	8.3
NB-03	1.7	18.2
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NB-05	0.3	6.7
NB-06	0.5	5.2
NB-06a	0.2	7.7
NB-07	0.4	5.7
NB-08	1.3	10.8
NB-09	0.2	2.7
NB-10	0.4	5.4
NB-11	0.4	4.9
NB-12	1.1	54.8
SB-01	0.4	3.6
SB-02	0.5	6.4
SB-03	0.5	4.7
SB-04	1.0	15.3
SB-05	0.8	8.3
SB-06	0.8	8.2
SB-08	0.3	3.5
SB-09	0.3	2.8
SB-10	0.3	4.8
SB-11	1.4	7.2
SB-12	0.4	6.1
SB-13	0.7	5.5
SB-14	0.4	3.8
SB-15	0.3	5.7

*Note: BMP treatment depth assumes 50% of polygon footprint available for storage to account for site constraints (utilities, BMP side slopes, media void space). Consider upstream BMP's for treatment depth exceeding 9" (Type C Soils).

Figure 9: Johnny Cake Ridge Road potential BMP locations (4 of 5).

BMP Name	Impervious Area [Acre]	1" Runoff Treatment Depth [inch]*
NB-01	3.9	**51.7**
NB-02	0.2	8.3
NB-03	1.7	**18.2**
NB-04	1.4	6.9
NB-05	0.3	6.7
NB-06	0.5	5.2
NB-06a	0.2	7.7
NB-07	0.4	5.7
NB-08	1.3	**10.8**
NB-09	0.2	2.7
NB-10	0.4	5.4
NB-11	0.4	4.9
NB-12	1.1	**54.8**
SB-01	0.4	3.6
SB-02	0.5	6.4
SB-03	0.5	4.7
SB-04	1.0	**15.3**
SB-05	0.8	8.3
SB-06	0.8	8.2
SB-08	0.3	3.5
SB-09	0.3	2.8
SB-10	0.3	4.8
SB-11	1.4	7.2
SB-12	0.4	6.1
SB-13	0.7	5.5
SB-14	0.4	3.8
SB-15	0.3	5.7

*Note: BMP treatment depth assumes 50% of polygon footprint available for storage to account for site constraints (utilities, BMP side slopes, media void space). Consider upstream BMP's for treatment depth exceeding 9" (Type C Soils).

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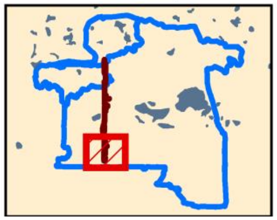
EOR water ecology community

- ▭ Storm Pond
- Flow direction
- ▭ Subcatchments
- ⊕ Existing Catch Basin
- ▭ Minor Subwatershed

Structural BMPs
- ⊕ Catch Basin Retrofit
- ◉ Private BMP
- ◉ Stormwater Quality Tank

Corridor BMP Treatment Depth (1"runoff impervious surfaces)
- ▬ 2" - 6"
- ▬ 6" - 9"
- ▬ 9" - 55"

Catch Basin Catchment (Impervious Acres)
- 🟩 0.1 - 1.0
- 🟨 1.0 - 2.0
- 🟥 2.0 - 4.0



Long - Farquar Lakes

Johnny Cake Ridge Road Potential BMP Locations

Map 5 of 5

N

0 100 200 400 Feet

Figure 10: Johnny Cake Ridge Road potential BMP locations (5 of 5).

4.2. Priority Infiltration Basin

A desktop GIS review of topography, soils, and storm sewer data was conducted to locate areas in the watershed that have potential for implementing large-scale infiltration practices – particularly on public property, where barriers to implementation are significantly lowered. The review highlighted one particular basin that is reported to be operating as an infiltration practice under existing conditions, but is potentially being underutilized. The basin is located within subwatershed EVR-27 just south of 140 St. W. and east of 142nd Path W. Subsoils in this part of the watershed appear to be extremely conducive to infiltration, and existing topography suggested that an expansion of this basin is feasible. While the City's stormwater infrastructure database indicated that storm sewers may already be daylighting into this basin, preliminary modeling showed that a basin expansion and outlet modification could likely result in the retention of 100% of runoff from EVR-27 for an average year – possibly up to a 5-year event or beyond. The review also indicated that a portion of the drainage from EVR-24, EVR-25, and/or EVR-26 could potentially be diverted to this location.

A graphic of the EVR-27 basin showing potential proposed contours assuming a moderate amount of regrading and excavation is shown in Figure 11 – amounting to approximately 4,000 cubic yards of cut across an area of approximately one acre. It should be noted that the amount of area available within the publicly owned parcel in which this basin is located allows for even more expansive improvement (i.e. steeper slopes and/or a deeper basin) than is shown, and the potential cost of the project is entirely dependent on the scale of the improvement. Conversely, given high infiltration rates or the inability to redirect all of the upstream subwatersheds, for example, it may be determined during a feasibility analysis that the degree of excavation could be significantly lower than what is shown in Figure 11. For this example grading schematic, the project is estimated at between $158,000 and $257,000 including a feasibility study, design, and engineering, among other itemized costs as shown in Appendix A: Stormwater Pond IMPROVEMENTS Cost Estimate.

Due to the variability in the potential extent and configuration of such a design, and to the number of unknowns currently involved, only a basic modeling analysis was performed using the City's HydroCAD model. Following this evaluation, as this improved BMP was not included in any of the P8 model runs, the contributing area (EVR-27) was simply taken offline in the P8 model to simulate complete retention of the average year rainfall – an assumption that appears feasible but requires further study. Based on the modeling, this analysis suggests an expected reduction of at least 6.1 lbs/yr. A feasibility study would be required to develop a better understanding of the existing conditions of this basin and the potential for infiltration.

It should be noted that this project has the potential to provide benefits beyond TP reduction alone, as it could also reduce the overall stormwater discharge volume reaching Farquar Lake from a relatively large portion of the watershed during large storm events. These additional benefits should also be considered when evaluating the sizing of the basin and the potential project costs.

10/16/17

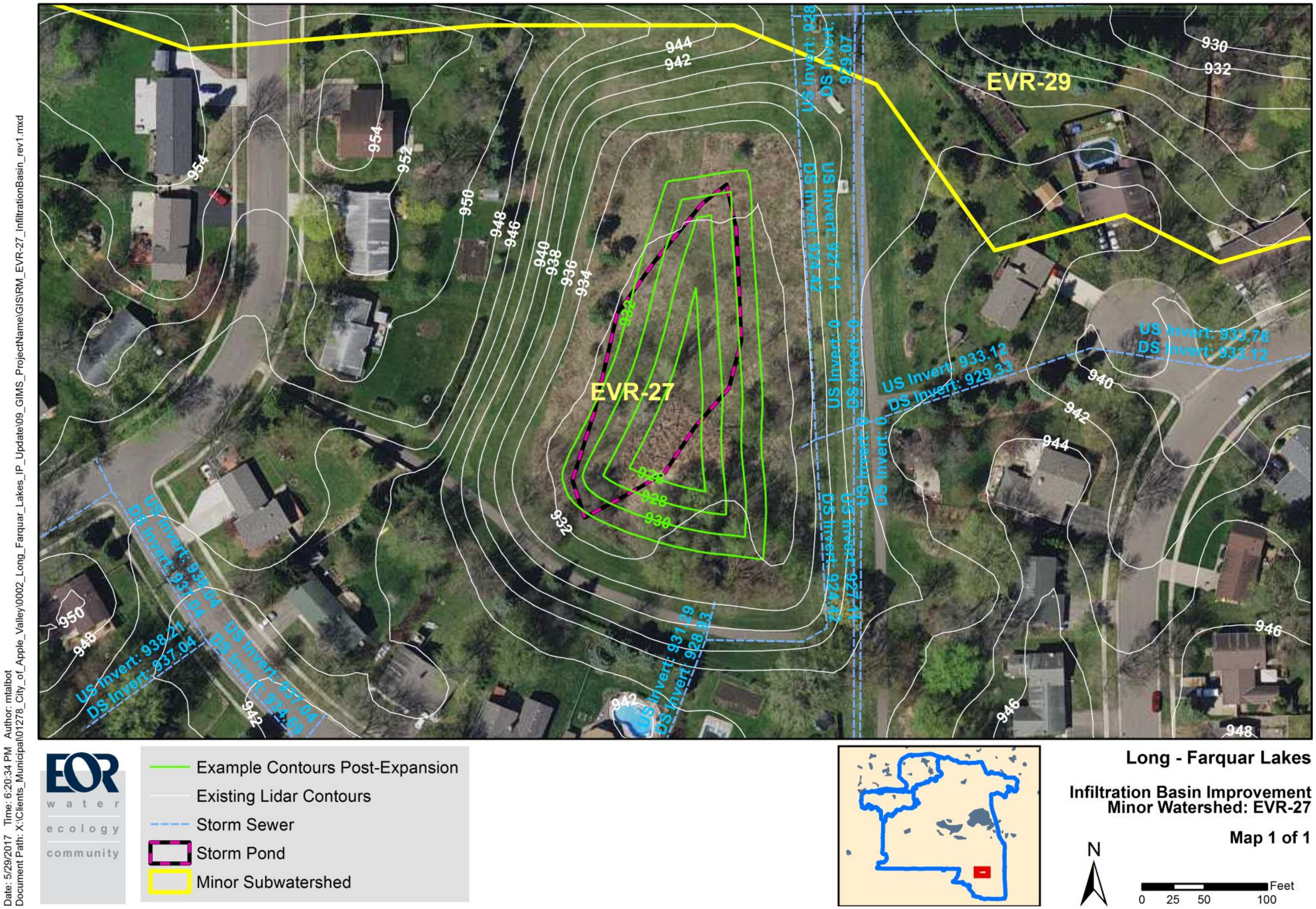


Figure 11: Potential infiltration basin improvement at the outlet to minor subwatershed EVR-27.

4.3. Stormwater Pond Infiltration Benches

Many of the City's stormwater ponds are located within natural depressions/basins within the landscape that were likely to be historically landlocked – even for very large storm events – as evidenced in part by the depth of these basins and by the apparent lack of defined overland flow pathways on historic USGS topographic maps. It is also evident from the prevalence of well- and excessively-drained soils throughout both watersheds that the standing water present in these ponds is typically due to the accumulation of sediments over time – which has effectively made the bottoms of these features impermeable – rather than being an indicator of the emergence of a regional water table. Therefore, a significant amount of natural infiltration capacity likely still exists in the immediate vicinity of these ponds.

One way to take advantage of this naturally occurring infiltration capacity is to allow the water in the ponds to periodically inundate the proximate shoreline during smaller storm events – without any modification to the existing soils or vegetation. This can be accomplished by installing an outlet structure that has been designed to do three things:

a. Raise the water levels significantly during small storm events,
b. Allow the water levels to drawdown more slowly than it currently does for these small events, but still within a defined time window, and
c. Minimize the net increase in water levels that will occur during large storm events.

The cost of these outlet modifications is estimated at between $95,000 and $156,000 for all 13 ponds considered, or around $9,100± each on average, assuming a simple adjustable weir structure that does not require heavy machinery or poured-in-place concrete to construct. A summary of these cost estimates can be found in Appendix A: Stormwater Pond IMPROVEMENTS Cost Estimate,. These estimates include costs associated with a feasibility analysis (e.g. geotechnical review), which will be necessary to verify that site soils, wetland status, water table depth, etc., are consistent with the conditions indicated in the soil survey and other GIS datasets used in this desktop analysis.

In areas that are naturally conducive to regrading, these outlet modifications can be accompanied by improvements to the natural soils through the construction of an engineered infiltration bench around a portion of a pond. This would allow the surface soils to be removed, thus exposing the sandy subsoils and allowing for, potentially, significantly higher infiltration rates. It should be noted that sand benches have been oversized by 20% to account for media clogging that will occur over time, but that a feasibility analysis should include an assessment of methods for minimizing the rate of clogging such as the incorporation of pretreatment devices, street sweeping[1], and/or practices that help prevent the resuspension of settled particulates. The cost of these engineered infiltration benches is estimated at between $239,000 and $388,000 for all five ponds considered, or around $46,000± each on average for the three benches without iron enhancement and around $78,000± each on average for the two benches with iron enhancement. A summary of these cost estimates can also be found in the Appendix A: Stormwater Pond IMPROVEMENTS Cost Estimate.

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[1] Continuation of the City's current street sweeping practices will minimize sediment transport into the ponds relative to historic conditions, as discussed at the end of section 4.7.

In order to roughly estimate the impacts on total phosphorus reduction resulting from implementing these pond modifications, the City's existing P8 model was used. However, since P8's ability to simulate complex outlet structures is limited, HydroCAD was first used to define the hydraulic impacts on the system, and the simulation results were interpreted to determine appropriate modifications to the hydrology in the P8 model that would represent those impacts during an average rainfall year. A description of this process follows – refer to Figure 1 throughout for pond locations.

The City's existing HydroCAD model was used to simulate the impacts on system hydraulics of implementing outlet modifications and engineered benches for a subset of stormwater ponds. Outlets modifications were simulated for 13 candidate ponds shown in Table 7 by adding a high-capacity weir structure at an elevation one foot higher than the existing outlet elevation. Infiltration was added for the area inundated around the edges of the ponds, with an assumed infiltration rate that varied based on the drainage class indicated on the soil survey. For five of these ponds, a portion of the infiltration was increased to a higher rate to represent an engineered infiltration bench. Additionally, two of these ponds (EVR-P7 and EVR-P53) appear to have storm sewer inlet locations that are potentially conducive to implementing iron-enhanced sand filters (IESF) in a similar manner to the existing IESF at EVR-P8. Since the estimated TP removal performance of an improved EVR-P7 is on the lower end, the IESF option is recommended for further consideration either in addition to or in lieu of an engineered infiltration bench.

The HydroCAD model was run using the 1", 1.5", 2-year (2.8"), and 5-year (3.6") storm events. The simulation results were then interpolated to determine the event depth that could be completely infiltrated by each modified pond. By comparing these depths with the average year (2006) daily rainfall record, an exceedance probability was computed.

These values were then used to reduce tributary areas within the P8 model in order to predict impacts on phosphorus load reductions for the average year simulation. For example, the HydroCAD simulation indicated that outlet modifications to pond EVR-P50 could facilitate the infiltration of a 2" rainfall event. Since a 2" rainfall event was greater than 94% of rainfall events that caused runoff during 2006, the direct tributary area to EVR-P50 (watershed EVR-50) was reduced by 94% in the P8 model.

Along with the pond modifications discussed, this analysis also incorporated the road reconstruction projects and EVR-27 infiltration basin discussed in the previous section. This simulation indicated an additional 33.2% or about 46.5 lbs of TP load reduction to Long Lake; no outlet modifications were proposed in the Farquar Lake watershed at this time.

As with any such analysis, there are a variety of ways to estimate the potential impacts of these projects. This methodology has benefits over some of the potential alternatives in that it accounts for the reduction in both runoff volumes and phosphorus loads that can be expected during an average year, allowing for the evaluation of progress towards TMDL phosphorus reduction goals as well as impacts on flood reduction. However, it is a simplified approach, and the results shown in Table 7 should be viewed as preliminary and rough given the inherent assumptions, and that site investigations will be required to further assess project feasibility at each proposed location.

These site assessments will need to include an evaluation of the City's existing stormwater easements, which were assumed here to encompass at least the 100-year high water contour around each pond. Easements for access will also need to be verified – assumed here to be located overlying the inlet and outlet pipes to the ponds. Since these features have all been long since transitioned from their historic states to stormwater ponds, and since the proposed modifications represent high frequency but low duration inundation of the riparian zone, we do not anticipate issues with permitting related to impacts on emergent vegetation in most cases.

It is worth noting that the 2007 Surface Water Management Plan identifies EVR-P11 as potentially requiring an increase in outlet capacity if the capacity of the outlet from EVR-P8 is increased. Therefore, if the EVR-P8 outlet is slated for upsizing, the City should consider completing the outlet reconstruction and modification efforts for EVR-P11 simultaneously.

Table 7: Summary of infiltration bench assumptions for each candidate pond.

Pond	Flows To	Major subwshd.	Watershed Area	Natural Infiltration Rate (in/hr)	Potential IESF?	Engineered bench?	% of Perimeter Engineered	Engineered Infiltration Rate (in/hr)	Storm Event Retained	TP Load Reduction (lbs/yr)		Approx. % of Runoff Treated
										For BMP Only[1]	For Tributary Area[2]	
EVR-P10	EVR-P170	EVR-170	74.1	1.00		X	40%	1.20	< 1-inch	9.1	9.1	53%
EVR-P2	EVR-P7	EVR-12	84.2	0.45					> 1.5-inch	5.8	5.8	94%
EVR-P4	EVR-P7	EVR-12	84.2	1.00		X	40%	1.20	< 1-inch	14.4	14.4	56%
EVR-P5	EVR-P7	EVR-12	79.3	0.45					< 1-inch	6.6	6.6	47%
EVR-P6	EVR-P7	EVR-12	16.6	1.00					> 5-year (3.6-inch)	1.7	1.7	100%
EVR-P7	EVR-P8	EVR-12	79.9	0.45	X	X	40%	1.20	< 1-inch	12.2	35.1	53%
EVR-P11	EVR-P12	EVR-12	15.8	1.00					< 1-inch	0.8	33.8	18%
EVR-P1	EVR-P13	EVR-13	19.1	0.45					> 1.5-inch	3.1	3.1	94%
EVR-P50	EVR-P51	EVR-13	39.9	0.45					> 1.5-inch	3.4	3.4	94%
EVR-P52	EVR-P53	EVR-13	6.6	0.45					> 5-year (3.6-inch)	0.4	0.4	100%
EVR-P53	EVR-P55	EVR-13	14.5	0.45	X	X	10%	1.20	> 5-year (3.6-inch)	0.0	0.1	100%
EVR-P54	EVR-P55	EVR-13	17.0	0.45					> 1.5-inch	2.1	2.1	94%
EVR-P55	EVR-P13	EVR-13	39.7	0.45		X	10%	1.20	> 1.5-inch	7.2	10.2	94%
Net Reductions:			*EVR-P12 outflow*								*27.0*	
			EVR-P13 outflow								*13.8*	
			EVR-P170 outflow								*9.0*	
			EVR-P17 (Long Lake) inflow								*46.5*	

[1] Reflects the estimated removal of TP from implementing each pond retrofit independently. Excludes increases in efficiency due to upstream retrofits.

[2] Reflects the estimated increase in TP reduction at each location from Scenario 2 to Scenario 3 due to implementing all pond retrofits. Includes increases in efficiency due to upstream retrofits.

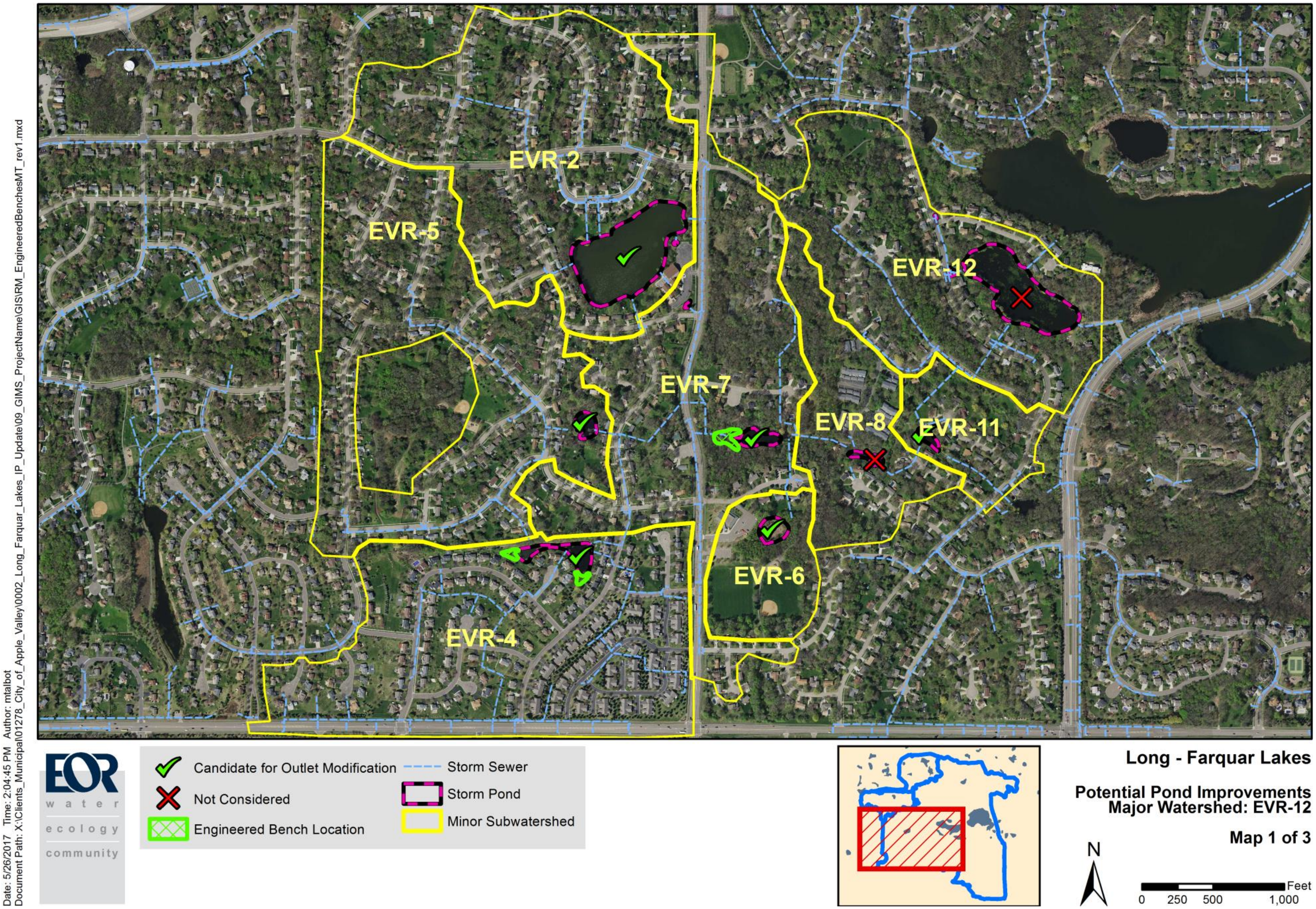

Figure 12: Potential pond improvements (1 of 3).

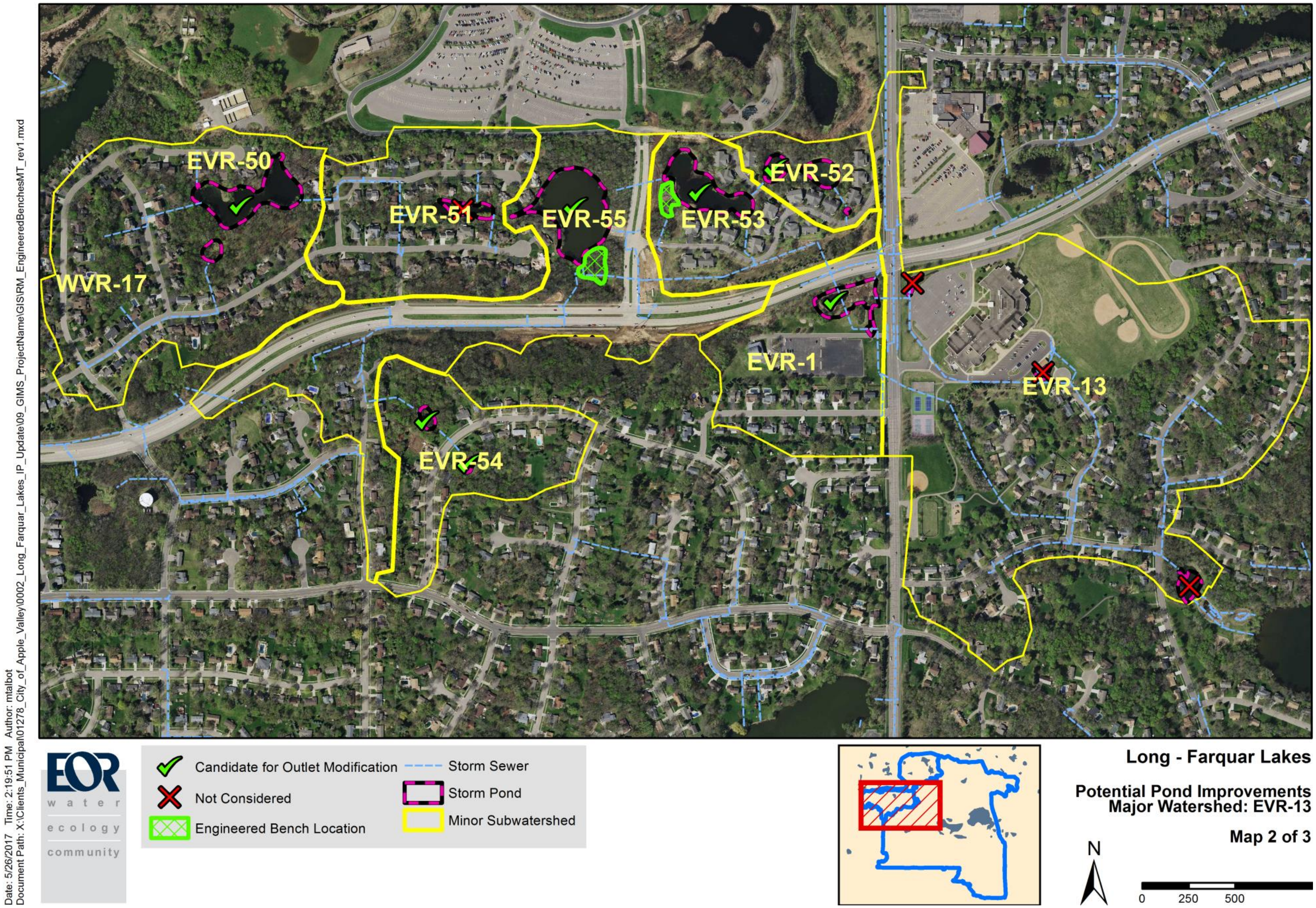

Figure 13: Potential pond improvements (2 of 3).

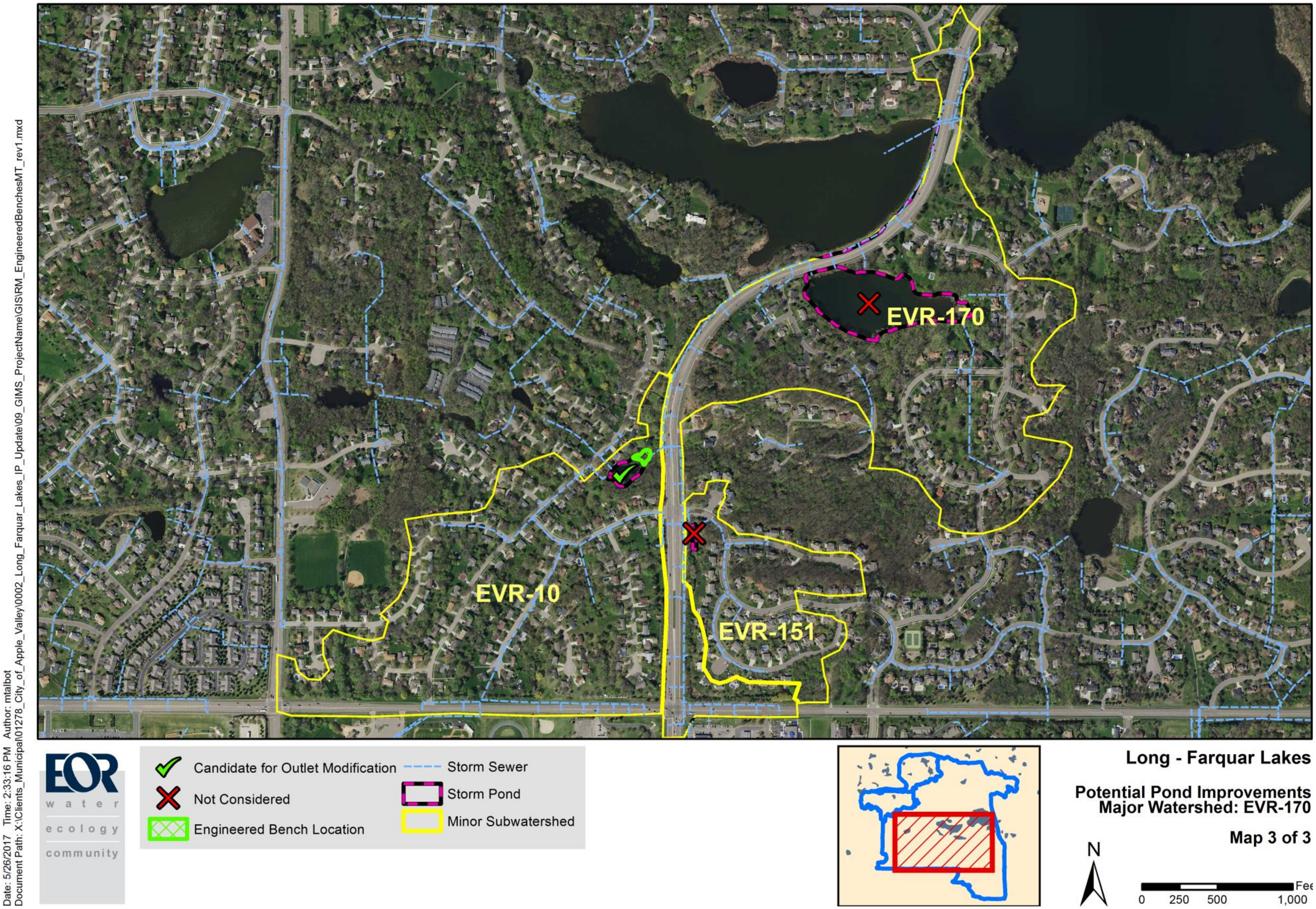

Figure 14: Potential pond improvements (3 of 3).

4.4. Private Large Site Retrofits

The siting of Large Site Retrofits (large impervious areas) was based on a desktop review using aerial photography to identify and site potential parking lot improvements. Each minor watershed was reviewed to identify large impervious areas where implementation of LID practice retrofits could be implemented. Heads-up digitization of large impervious areas within each minor boundary resulted in the identification of six large parking lots ranging in size from 0.38 acres to 5.62 acres. Implementation of LID practices (e.g. porous asphalt parking, infiltration basins, and water harvesting) practices were simulated by modeling a 50% reduction in contributing area from these six sites. Recommended practices are in addition to several, previously publicly funded projects which were installed in these large impervious areas.

Incorporation of LID practices take advantage of the watershed's existing features (i.e., soils with a high infiltration capacity) and mimic natural hydrology and maximize infiltration. Furthermore, these types of practices can also be designed to be aesthetically pleasing, thereby maximizing property value. There is great variability in the type and cost of watershed BMPs that could potentially be implemented in the Long and Farquar Lake watersheds. While it is possible to reduce watershed TP loading, incorporation of LID practices on these six large sites alone will not achieve the required reductions needed for Long and Farquar Lake.

A project cost for each site was estimated using typical BMP costs per unit volume of runoff treated, assuming that half of the treatment will be provided by rain gardens and the other half by infiltration trenches. The required treatment volume was estimated as the 1.1" runoff volume across the drainage area. These values were then used in conjunction with, in part, the unit costs found in the MPCA's report (Minnesota Pollution Control Agency 2011) on BMP construction costs[2], along with input from City staff. Estimated costs are shown in Table 8.

Table 8. Large Parking Lot Retrofit Opportunities

Location Name	Minor Subwatershed	Parking Lot Area (ac)	Treatment Volume (ft^3)	Approx. Cost
Heritage Lutheran	EVR-2	0.38	1,504	$10,100
Community of Christ	EVR-6	0.63	2,505	$20,000
Heritage Lutheran	EVR-7	0.46	1,837	$12,400
Christ Church	EVR-1	1.99	7,945	$53,500
Falcon Ridge Middle School	EVR-13	2.18	8,716	$58,700
Shepherd of the Valley	EVR-180	5.62	22,429	$151,200

To further assess the benefits of a staged approach to implementation, a P8 simulation was performed to incorporate the large lot retrofits with the previous simulation that included road corridor improvements, the EVR-27 infiltration basin, and stormwater pond improvements. The

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[2] In addition, Weiss et al. (2005) found that the unit cost of "bioinfiltration filters" did not vary considerably with the scale of the BMP.

simulation showed an additional 1% or about 1.4 lbs of TP load reduction to Long Lake, and an additional 1.7% or 1.7 lbs of reduction to Farquar Lake.

4.5. Riparian Buffer Quality Assessment

The siting of nearshore BMPs (shoreline buffers) was based on review of aerial photography to evaluate the health of the shoreline area within 50 feet of the Ordinary High Water Line (OHWL) for Long and Farquar Lake. The 50 foot distance equates to the minimum buffer width requirement under the state of Minnesota's Buffer Law, although it should be noted that this law is only required for agricultural lands. The City of Apple Valley requires a minimum of a 16.5 foot buffer zone on all new construction projects on Long and Farquar Lakes that require a plat. EOR staff began the visual assessment by intersecting a parcel shapefile with a 50 foot buffer of the OHWL for each lake using GIS. The portion of each parcel that intersected this 50 foot buffer was subsequently ranked qualitatively as follows:

1. High Quality – Consider protection BMPs such as Zoning Ordinances that limit development on high quality, forested buffers.
2. Medium Quality – Moderate priority for restoration BMPs, including shoreline buffers.
3. Low Quality – High priority for restoration BMPs, including shoreline buffers.

Once each parcel had been assigned an appropriate ranking (Appendix B: Riparian Buffer Quality Assessment) the total area within each minor watershed with a low or medium quality buffer was determined. Next, the total area within the low/medium quality buffer area was divided by the total area within the minor watershed to determine the percentage of each minor watershed with low/medium quality buffers where shoreline buffers could be enhanced. This percentage was then multiplied by the total phosphorus (TP) load from the entire minor watershed from the P8 model to determine the TP load that could potentially be generated from this portion of each minor watershed boundary. The TP load generated from these low/medium quality buffer areas was then multiplied by the following equation developed by Nieber et al. (2011) in a study for the Minnesota Department of Transportation which can be used to estimate TP removal as a function of buffer width:

$$\text{TP removal efficiency (\%)} = 15.84 \ln(\text{buffer width in feet}) + 5.9$$

The TP reduction achieved through incorporation of a 50 foot buffer upgrade on all existing low/medium quality buffers is shown in Table 9. Refer to Appendix B for a map of the Riparian Buffer Quality Assessment.

Incorporation of shoreline buffers containing native perennial grasses, flowers, shrubs, and forbs helps to filter out phosphorus, nitrogen, and sediment. Shoreline buffers can also be designed to be aesthetically pleasing and often serve as valuable pollinator habitat when native wildflowers are incorporated. Restoration of shoreline buffers prevents shoreline erosion by absorbing wave action and reduces landowner maintenance, thereby allowing for more leisure time to relax and enjoy the fish and wildlife that also call the lakeshore home.

There is great variability in the type and cost of shoreline improvements that could potentially be implemented in the nearshore areas around Long and Farquar Lake with low or medium quality buffers. While it is possible to reduce watershed TP loading through implementing 50 foot or greater buffers on all nearshore areas, incorporation of these nearshore BMPs alone will not achieve the required reductions needed for Long and Farquar Lake.

Table 9. Near-shore BMP Opportunities

Minor Watershed	Buffer Size Area (Ac)	Length (ft)	TP Reduction Efficiency
EVR- 14+17 (Long Lake Direct)	3.01	2622	68%
EVR-170	1.79	1559	68%
EVR-21	0.17	148	68%
EVR-35 (Farquar Lake Direct)	3.97	3459	68%

To further assess the benefits of a staged approach to implementation, a P8 simulation was performed to incorporate the riparian buffers with the previous simulation that included road corridor improvements, the EVR-27 infiltration basin, stormwater pond improvements, and large lot retrofits. The simulation showed an additional 0.1% or about 0.2 lbs of TP load reduction to Long Lake, and an additional 0.3% or 0.3 lbs of reduction to Farquar Lake.

4.6. Residential BMPs

The siting of residential BMPs was based on a desktop analysis of recent, high resolution aerial photography to identify and site potential residential BMPs based on a review of the existing stormwater utility network. EOR staff did a virtual walkthrough of each roadway within the Long and Farquar watershed to review the approximate right-of-way and the street throughout the watershed. A total of 686 potential practices were identified, including roadside bioinfiltration (labeled simply “bioinfiltration device” in the figures that follow), tree trenches, backyard bioinfiltration, and opportunities for improvements (i.e. reducing imperviousness) in cul-de-sacs. Roadside bioinfiltration practices included potential street-scape focused practices (i.e., rain garden placed between the curb and sidewalk) located in areas with naturally permeable soils. Backyard bioinfiltration devices represented larger, bioinfiltration/detention basins which were located in communal areas. These areas captured runoff from a larger direct drainage area relative to the roadside bioinfiltration practices. Targeted locations for both roadside and backyard infiltration practices included sites where a potentially simplistic, site-integrated design could provide an opportunity for runoff infiltration, filtration, storage, and water uptake by vegetation which may include a raingarden, an infiltration area, a bio-filtration practice, or other appropriate BMP as determined during the site-specific design phase.

These practices are shown within each major watershed in Figure 15 through Figure 22. The approximate drainage area to each type of residential BMP practice was delineated using LiDAR. Knowledge of the average drainage area to each BMP was used to derive sizing and associated cost estimates based on literature values for drainage ratios and per-unit-area construction costs for each BMP type.

Unit costs for each BMP ranged between $1 and $14 per cubic foot of retention, with bioretention-type practices on the low end and porous pavement on the high end of that range. Individual project costs varied with size, but the average per project cost was around $28,800 for backyard bioinfiltration, $6,500 for a tree trench, $50,000 for a cul-de-sac improvement, and $3,300 for a roadside bioinfiltration basin.

There is great variability in the type and cost of watershed BMPs that could potentially be implemented in the Long and Farquar Lake watersheds. For comparison purposes, the residential BMPs were broken down into four BMP types. The total number of BMPs within each BMP type and the cumulative reduction resulting from implementing these residential BMPs are separated by major watershed in Table 10 and further by minor subwatershed in Appendix D: Residential BMPs by Minor Subwatershed. While it is possible to reduce watershed TP loading, the return on investment for residential BMPs is often lower than other watershed BMPs; hence the lower prioritization placed on residential BMPs.

To further assess the benefits of a staged approach to implementation, a P8 simulation was performed to incorporate the residential BMPs with the previous simulation that included road corridor improvements, the EVR-27 infiltration basin, stormwater pond improvements, additional large lot retrofits, and riparian buffers. The simulation showed an additional benefit of 13.1% or about 18.3 lbs of TP load reduction at the inlet to Long Lake, and an additional 35% or 35 lbs of TP load reduction to Farquar Lake.

Table 10. Residential BMPs by Major Watershed

	BMP Type (# of Practices)				BMP Cost (Thousands of Dollars)				Comparison Metrics			
Major Watershed	Roadside Bioinfiltration	Tree Trench/ Infiltration Trench	Backyard Bio-infiltration	Potential Cul-de-sac BMP	Roadside Bioinfiltration Total Cost	Tree Trench/ Infiltration Trench Total Cost	Backyard Bio-infiltration Total Cost	Potential Cul-de-sac BMP Total Cost	Watershed TP Load Export (lbs/year)	Total Cost All BMPs	TP Reduced to Downstream Pond (lbs)	Cost ($)/lb of TP
EVR12	42	197	6	24	$ 85	$ 1,170	$ 146	$ 910	286	$2,311,000	204	$11,300
EVR13	9	21	2	4	$ 18	$ 125	$ 49	$ 151	81	$343,000	17	$20,000
EVR17	5	1	0	0	$ 10	$ 6	$ -	$ -	92	$16,000	3	$5,400
EVR170	31	52	0	9	$ 63	$ 31	$ -	$ 340	41	$434,000	21	$20,500
EVR21	55	24	3	18	$ 111	$ 142	$ 73	$ 680	138	$1,006,000	38	$27,000
EVR35	6	6	0	0	$ 12	$ 36	$ -	$ -	148	$48,000	9	$5,000
EVR350	17	0	0	2	$ 34	$ -	$ -	$ 75	3	$109,000	1	$109,000
EVR351	12	1	0	1	$ 24	$ 6	$ -	$ 38	6	$68,000	3	$23,000
EVR352	53	67	0	18	$ 107	$ 400	$ -	$ 680	58	$1,187,000	27	$43,000

Figure 15: Potential residential BMP locations (1 of 8).

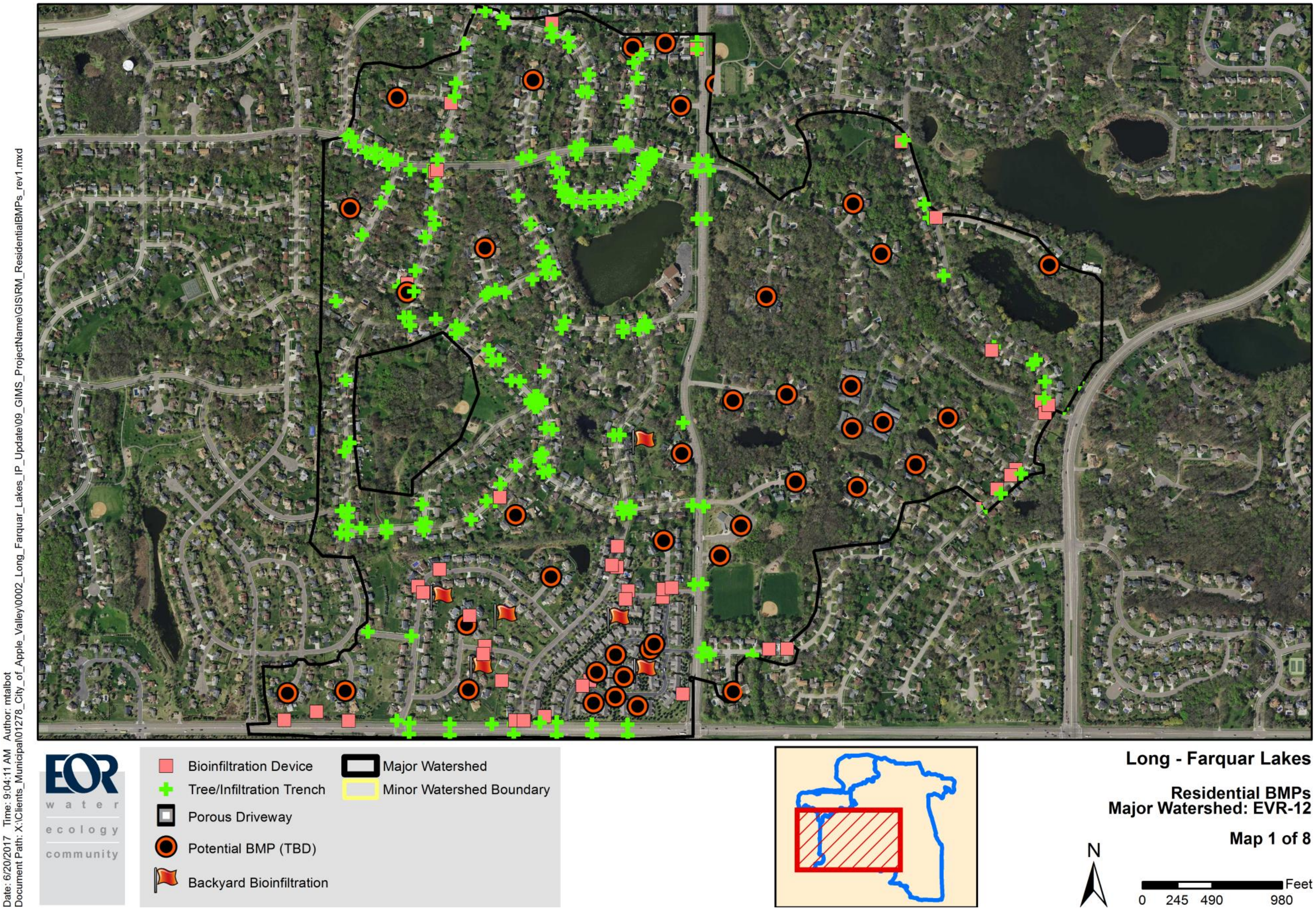


Figure 16: Potential residential BMP locations (2 of 8).

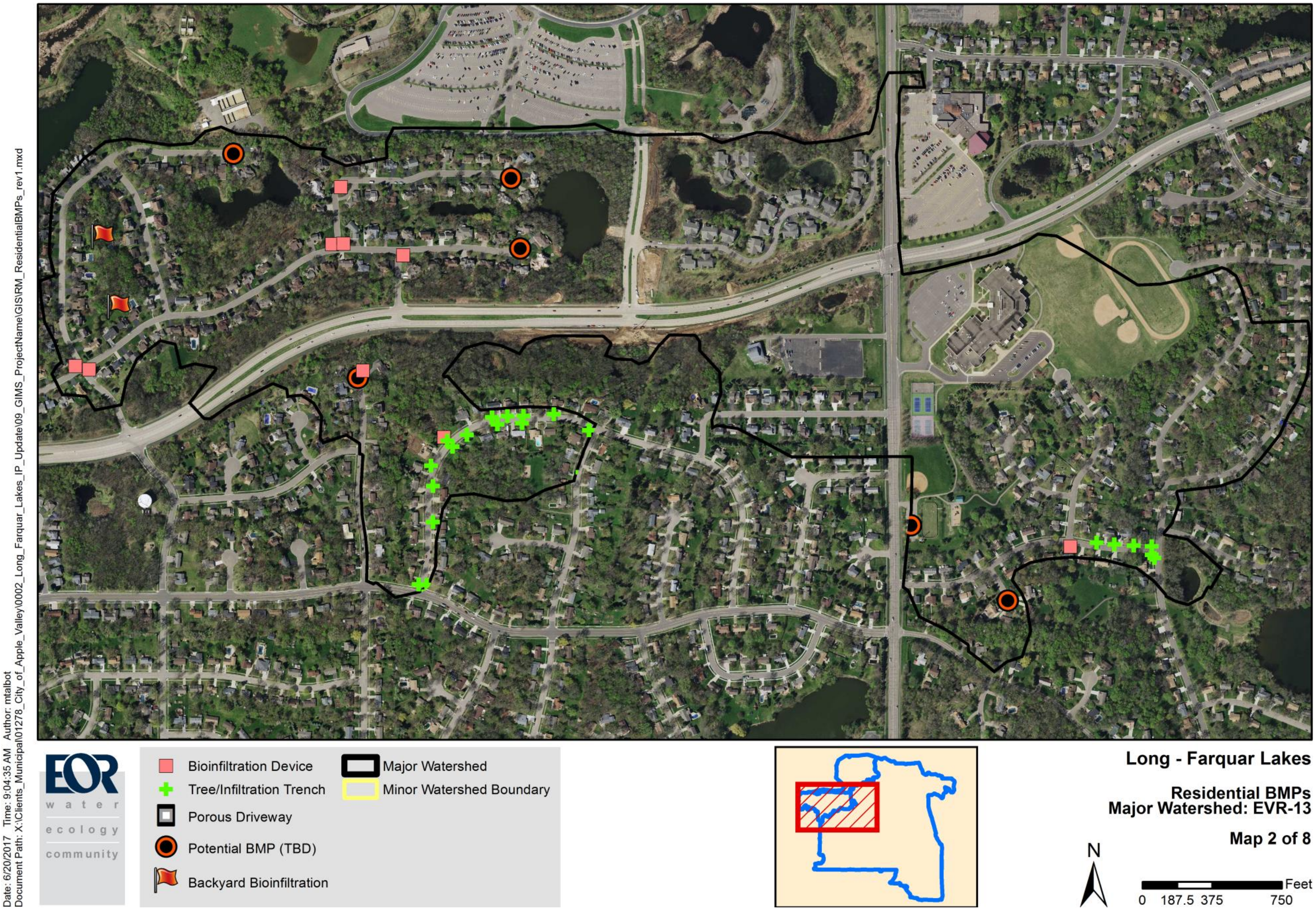


Figure 17: Potential residential BMP locations (3 of 8).

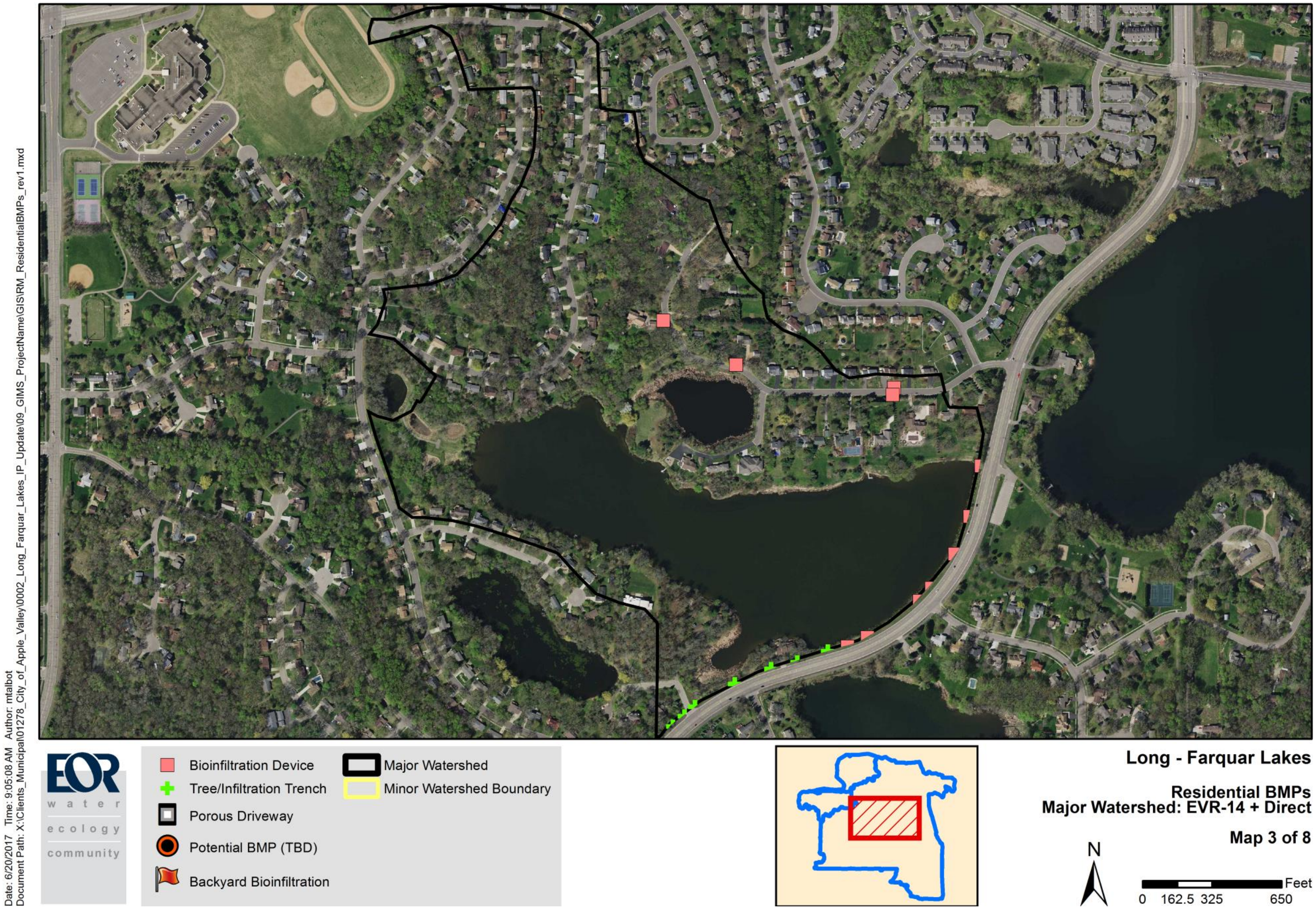


Figure 18: Potential residential BMP locations (4 of 8).

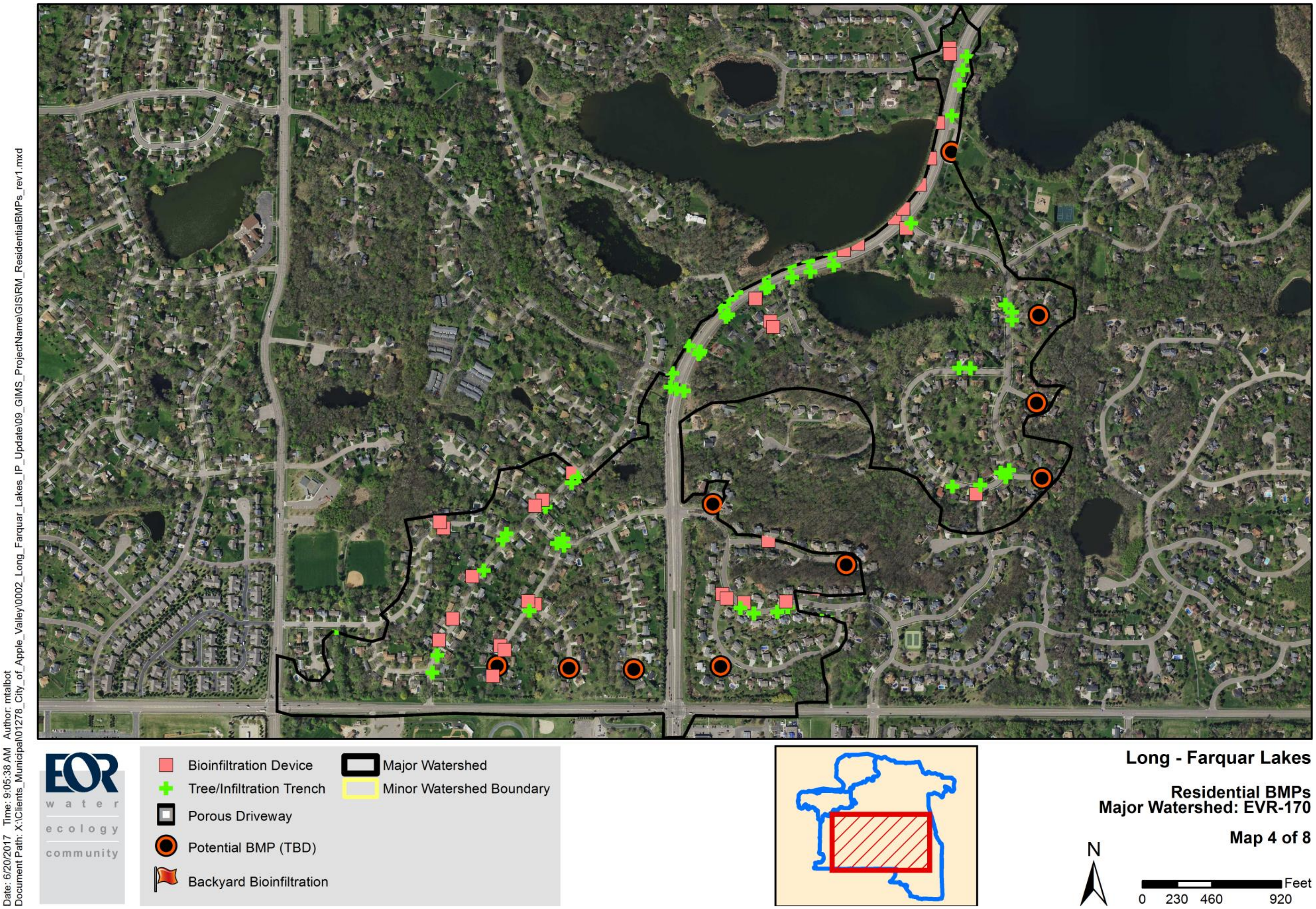


Figure 19: Potential residential BMP locations (5 of 8).

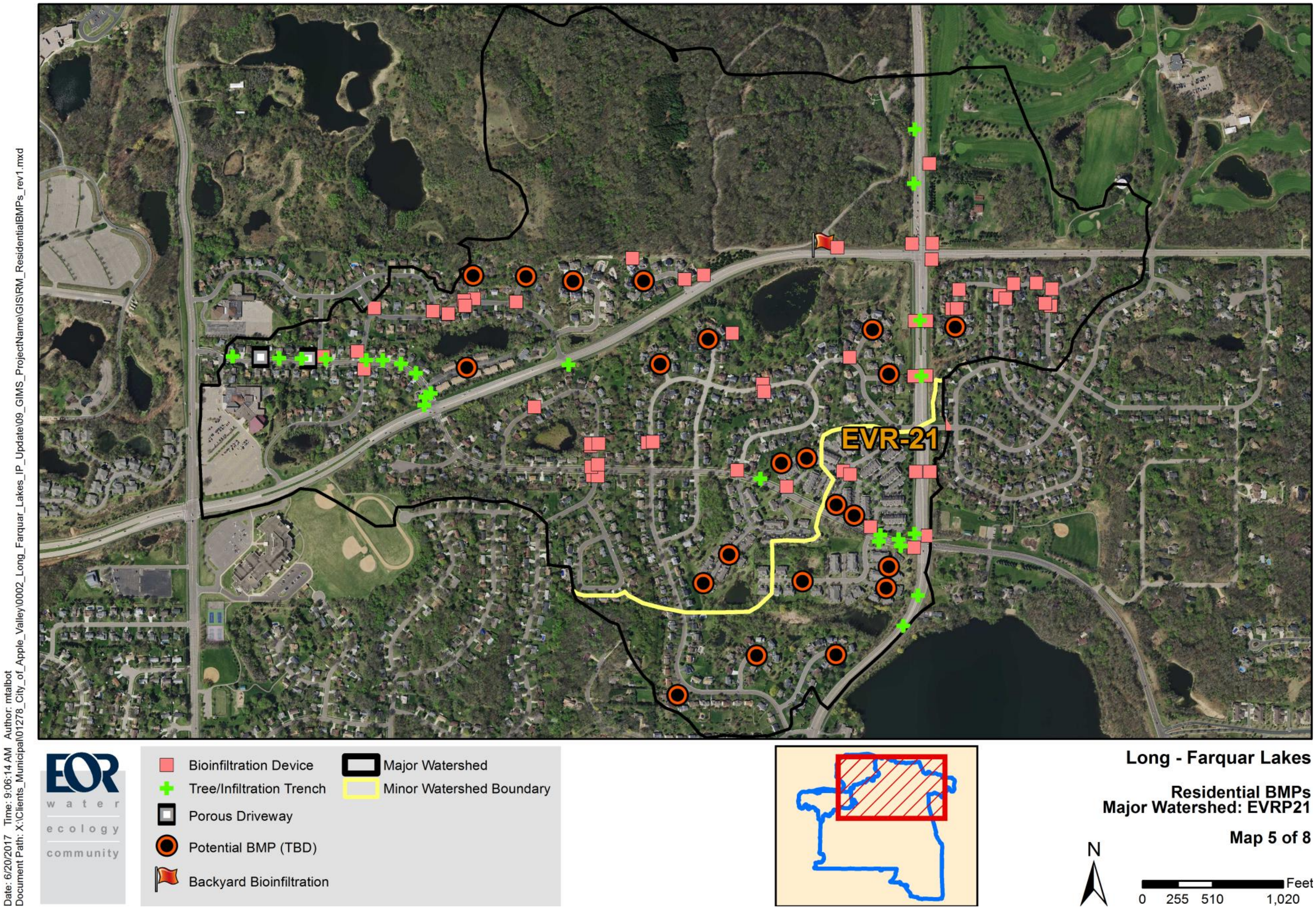


Figure 20: Potential residential BMP locations (6 of 8).

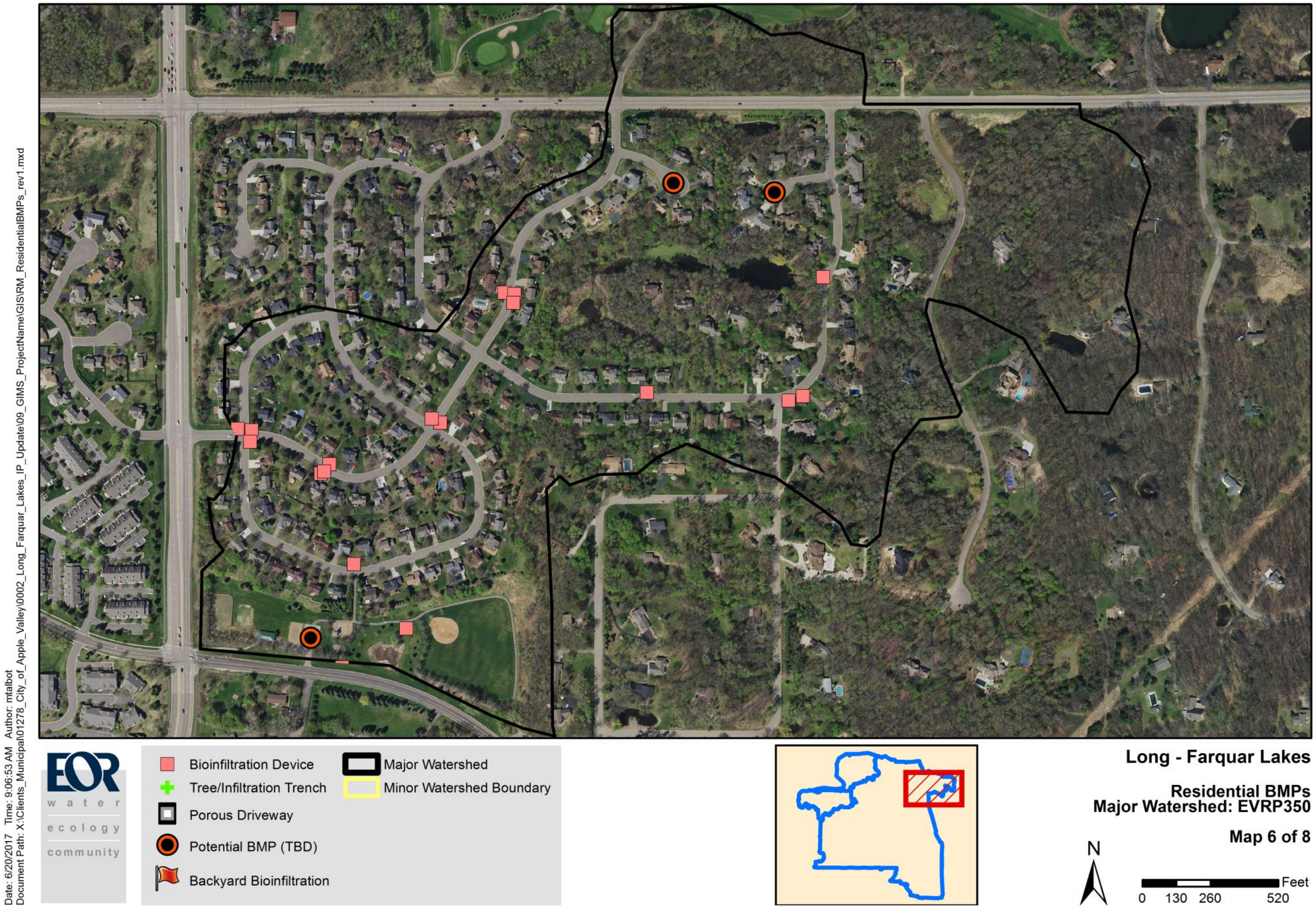


Figure 21: Potential residential BMP locations (7 of 8).

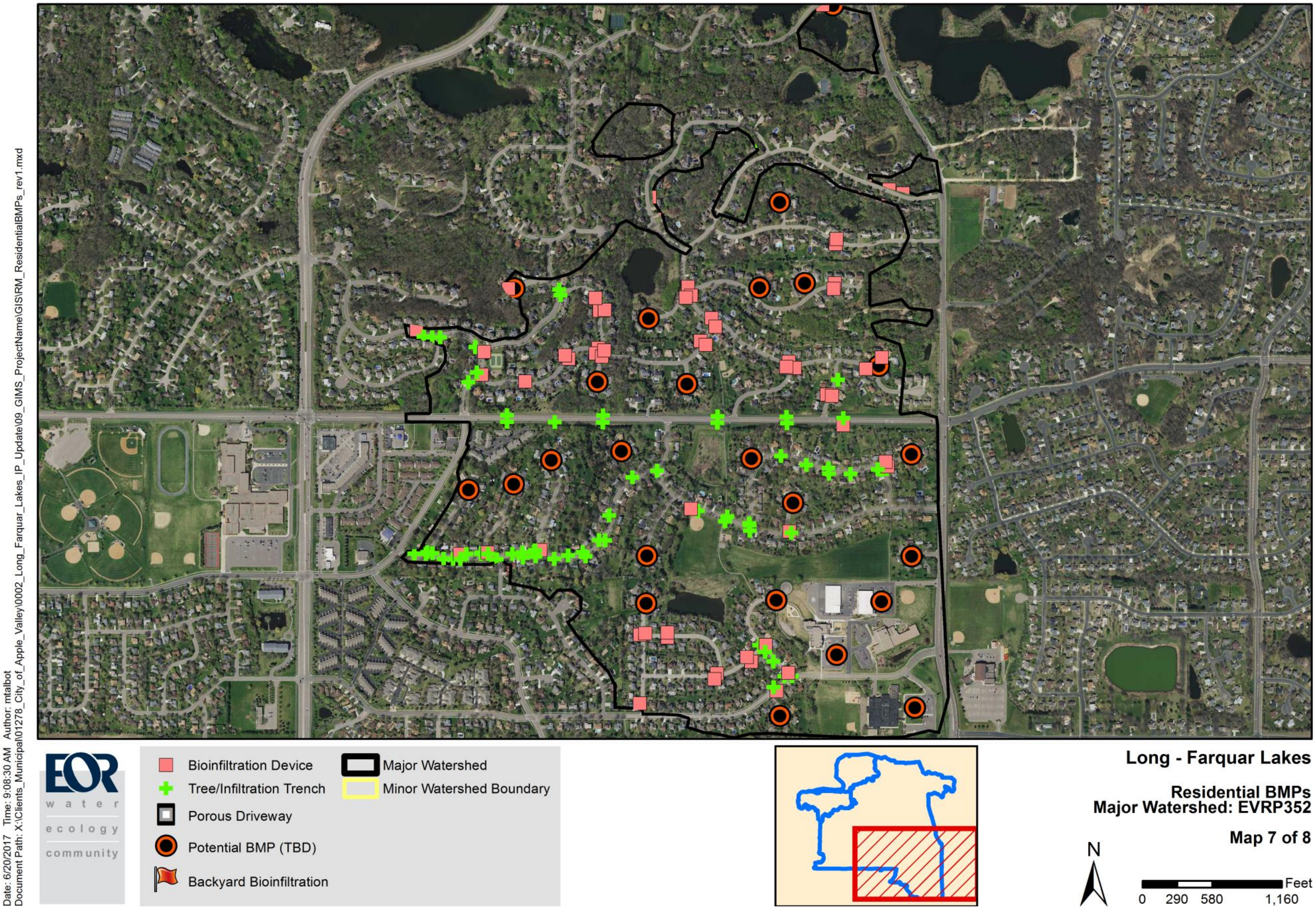
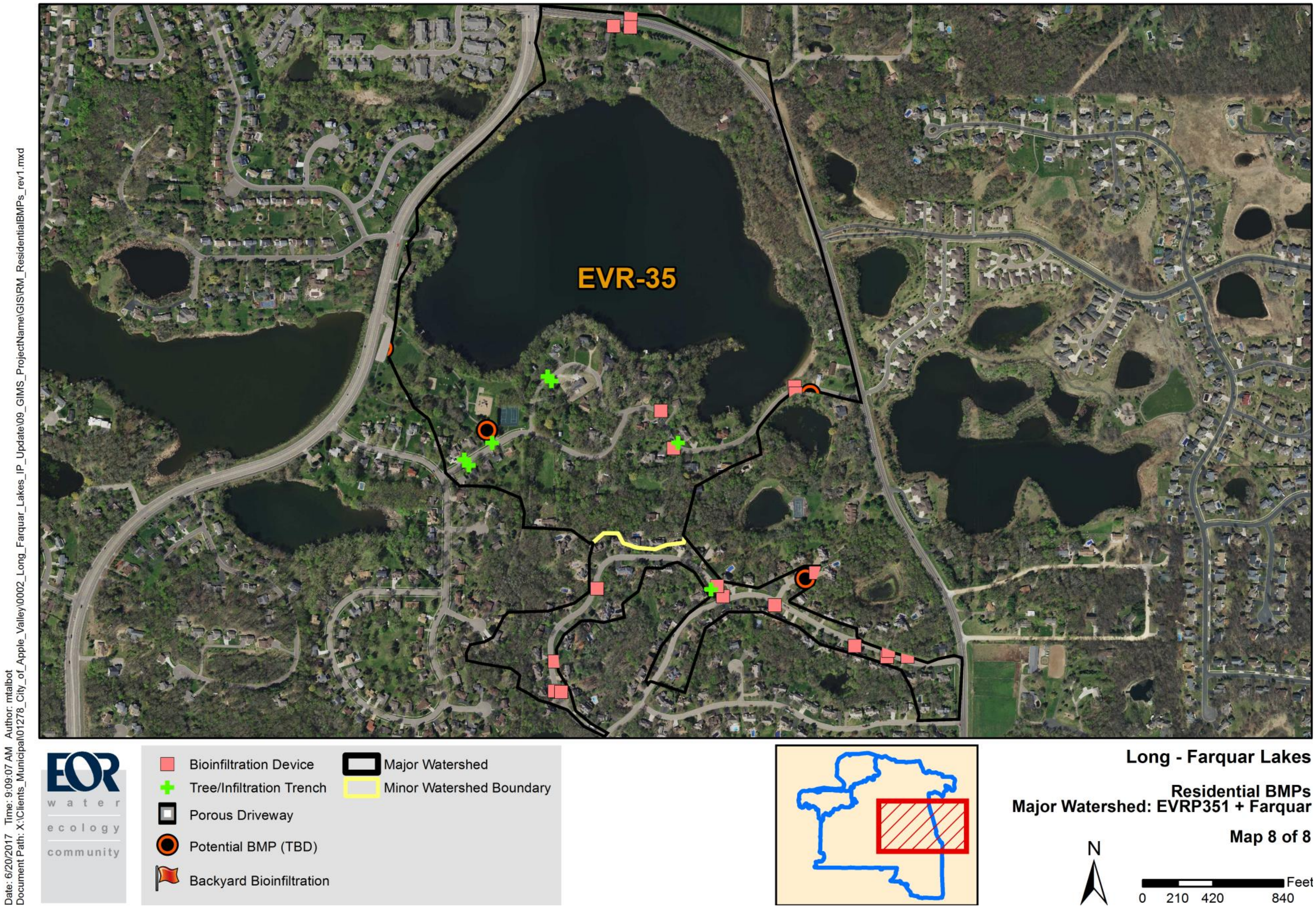


Figure 22: Potential residential BMP locations (8 of 8).



4.7. Street Sweeping

Street sweeping practices were evaluated within the direct drainage area to Long and Farquar Lakes. Previous research on street sweeping practices has shown that monthly sweeping with a high-efficiency regenerative air (or comparable) sweeper was found to be the most cost-effective option with an average cost of $152/lb for phosphorus recovery compared to the baseline cost-efficiency of $205/lb associated with traditional mechanical broom sweepers (Kalinosky, et. al, 2015). It is also recommended that sweeping frequency be increased during the snow-free season.

In order to calculate estimated solids and nutrient recovery, it was necessary to first determine the length of street surfaces located within each drainage area to Long and Farquar Lake. Tree canopy covers were visually inspected using 2016 color FSA aerial photographs of the drainage area. Areas of street with similar canopy cover were assigned a score of 1-5 corresponding to the range of canopy cover densities described in Table 11. Examples of tree canopy cover are provided below.

Table 11. Tree Canopy Rating Scheme

Assigned Score	Canopy Description		Over-Street Canopy Cover*
0	None	None over street, very few or no immature tree in yards/lots.	0%
1	Very Low	Immature trees near street, very little/no over street canopy, very low tree density in yards/lots.	2%
2	Low	Some visible cover over the street, mostly immature trees, general low density of trees.	5%
3	Medium	Visible cover over portions of the street, mix of immature and mature trees in yards/lots.	10%
4	Medium-High	Visible canopy over portions of the street, fairly dense, uniform canopy across yards, or stands of mature tree in backyards/common areas.	14%
4.5	High	Visible canopy along the majority of the street, uniform canopy of mature tree across yards/stands of mature trees in backyards/common areas.	18%
5	Very High	Very dense canopy, canopy cover fairly continuous across lot and street boundaries on aerial photos.	25%

*Based on comparison to quantified tree canopies in Prior Lake, MN (Kalinosky, et. al, 2013).

Total solids and nutrient recovery were estimated for streets located within the direct drainage areas of Long and Farquar Lake using a street sweeping planning calculator tool developed by the University of Minnesota 'Estimating Nutrient and Solids Load Recovery through Street Sweeping' (Kalinosky, et. al, 2014) under three, unique levels of effort. This methodology is superior to available method for estimating sediment and nutrient recovery in P8 because it takes into account the length of street miles swept, existing tree canopy, type of street sweeping equipment used, and is calibrated to data collected in Minnesota.

1. Seasonal sweeping – all streets are swept once in the spring and once in the fall.
2. Monthly sweeping – all streets are swept once per month during the snow-free season (taken as April – October).
3. Bi-weekly sweeping – all streets are swept twice per month during the snow-free season (April – October).

In the monthly and bi-weekly sweeping scenarios, a sweeping season of April through October was assumed. For the initial sweeping event in each scenario (the first sweeping in April), load recovery was estimated as the average of predicted recovery for single sweepings in March and April. In the calculator tool, initial sweepings in these two months represent the high and low end of loading intensities encountered during spring cleaning operations. Pollutant load recovery estimated using the calculator tool depends on the density of over-street tree canopy cover. Total solids and phosphorus loading rates for each of the three defined levels of effort are outlined for a range of over-street tree canopy covers in Table 12.

Street sweeping in the City of Apple Valley is done using both regenerative air and mechanical broom sweepers; currently, the cities' fleet of sweepers includes one regenerative air sweeper – unit #324. As mentioned, mechanical broom sweepers have lower overall pick-up efficiency compared to higher efficiency technologies, such as regenerative air and vacuum assist street sweepers. The calculator tool used to estimate pollutant load recovery, however, is based on results for regenerative air technology. Previous research conducted in Edina and Prior Lake demonstrated that monthly sweeping with a high-efficiency regenerative air (or comparable) sweeper is the most cost-effective option. The analysis shown in Table 13 demonstrates that while the cost for sweeping would double, the TP removed increases by approximately 60% when going from monthly to bi-weekly sweeping. Monthly sweeping within the direct drainage area of Long and Farquar Lake from April through October using unit #324 could help to recover an estimated 39,367 pounds of total suspended loads (wet weight) and 23 pounds of total phosphorus. Actual pollutant reductions to Long/Farquar Lake (as opposed to pollutant recovery from streets) would be less as it is necessary to take into account pollutant removal through BMPs located along flow paths to priority waters. It should also be noted that regular street sweeping is expected to extend the useful life of structural BMPs by reducing solids loads.

Table 12. Summary of sweeping zone characteristics including average over-street tree canopy cover and total curb-miles of street (length of street x 2).

Major Drainage	Minor Watershed	Estimated Over-street % Canopy (weighted average)	Curb-miles of Street in Direct Drainage Area
Long Lake	EVR-14	10%	0.78
	EVR-17	14%	1.54
	EVR-170	10%	7.48
Farquar Lake	EVR -21	2%	3.32
	EVR- 35	14%	2.92

Table 13. Estimated load recovery rates (lb/curb-mile/yr) for total wet solids and total phosphorus for three levels of effort, sweeping with a regenerative air (or comparable) sweeper.

			Seasonal Sweeping		Monthly Sweeping		Bi-weekly Sweeping	
Minor Watershed	Curb-miles of Street Swept in Direct Drainage Area	Over-street % Canopy Cover	TS	TP	TS	TP	TS	TP
EVR-14	0.78	10%	793	0.5	1,930	1.1	3,169	1.8
EVR-17	1.54	14%	1,844	1.1	4,490	2.7	7,369	4.3
EVR-170	7.48	10%	7,605	4.6	18K	11.0	30K	17.6
EVR-21	3.32	2%	2,433	1.4	5,922	3.4	10K	5.5
EVR-35	2.92	14%	3,497	2.1	8,513	5.1	14K	8.2
Total	**16**		**16K**	**9.7**	**39K**	**23**	**64K**	**37**

5. RECOMMENDATIONS FOR IMPLEMENTATION STAGING

Overall, combined implementation of the watershed BMPs identified could result in a reduction in TP loading to Long Lake of approximately 75.3 lbs (53.8%), as shown in Table 14, and a reduction in TP loading to Farquar Lake of approximately 43.1 lbs (43.1%), as shown in Table 15.[3] It is important to note that the P8 model that is currently in use is not identical to the model used during the TMDL study, so the magnitude of the reductions presented here cannot necessarily be compared directly to the TMDL study numbers. To illustrate this point, consider that the overall watershed TP load to Long Lake from the TMDL study was 311 lbs/yr, while the overall watershed TP load from the current P8 model is just 140 lbs/yr.[4] Therefore, to put these numbers in perspective it is helpful to compare instead the percent reductions from the TMDL report, which called for a 76% reduction in external TP loads to Long Lake and a 38% reduction in external TP loads to Farquar Lake. It is estimated that a 40% reduction in external loads to Long Lake has already been achieved through previous implementation, leaving just 36% to be achieved.

If considered in this context, consulting Table 14 suggests that implementation of scenarios 1 and 3 alone may be enough to meet the external reduction goals for the Long Lake watershed. Since it is estimated that little progress has been made toward the (albeit relatively small) external load reductions needed to Farquar Lake, consulting Table 15 suggests that all scenarios identified here should be considered for implementation. One takeaway here is that, since the implementation of the residential BMPs appears to be generally the least cost-effective option, any program for incentivizing implementation of these practices should be focused on the direct tributary areas to Farquar Lake. As indicated in Table 14 and Table 15, several of the scenarios that are likely to be less cost-effective should be considered for implementation on an “as feasible” basis, i.e. when favorable circumstances arise (such as BMP integration as part of another project, when costs are likely to be lower).

All in all, although it is difficult to accurately quantify the expected impacts numerically given all of the different methods used in estimating both the goals and the potential reductions, these results do suggest that implementing the practices identified in this report could result in substantial progress towards the TMDL goals.

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[3] The potential external load reduction to Farquar Lake resulting from load reductions to Long Lake was not estimated, since it depends on the extent of reductions to both external and internal loading to Long Lake. However, the existing load was estimated at 109 lbs/yr based on 2013-2016 monitoring data, so any significant reductions to Long Lake’s loading will in turn be of significant benefit to Farquar Lake. When compared with the 185 lbs/yr load from the TMDL study, the monitoring suggests that substantial progress due to implementation of past projects is potentially already being realized.

[4] Several attempts were made to run the model during different periods to match the original TMDL results, but from the models we received it was not possible to trace the changes that produced these differences.

Table 14: Estimated TP reduction for combined BMP implementation at Long Lake

Scenario	Description	TP Reduction Estimate (lbs/yr)		TP Reduction Estimate (%)		Target % to Implement
		Scenario[1]	Overall[2]	Scenario[1]	Overall[2]	
1	Johnny Cake Ridge Road Reconstruction	8.9	8.9	6.4%	6.4%	100%
3	Stormwater Pond Infiltration Benches	46.5	55.4	33.2%	39.6%	100%
4	Large Site Retrofits	1.4	56.8	1.0%	40.6%	As feasible
5	Riparian Buffers	0.2	57	0.1%	40.7%	As feasible
6	Residential BMPs	18.3	75.3	13.1%	53.8%	As feasible

**Practices above the dotted line are estimated to be sufficient to meet the TMDL external load reduction goal, 36% of which is estimated to remain at the time of this report.*

[1] *Represents the BMP reduction.*

[2] *Represents the cumulative reduction of the BMP and the preceding scenarios.*

Table 15: Estimated TP reduction for combined BMP implementation at Farquar Lake

Scenario	Description	TP Reduction Estimate (lbs/yr)		TP Reduction Estimate (%)		Target % to Implement
		Scenario[1]	Overall[2]	Scenario[1]	Overall[2]	
2	Priority Infiltration Basin	6.1	6.1	6%	6.1%	100%
4	Large Site Retrofits	1.7	7.8	1.7%	7.8%	100%
5	Riparian Buffers	0.3	8.1	0.3%	8.1%	100%
6	Residential BMPs	35	43.1	35.0%	43.1%	As feasible

**Practices above the dotted line are estimated to be sufficient to meet the TMDL external load reduction goal for Farquar Lake, assuming the Long Lake outflow reduction goals are met.*

[1] *Represents the BMP reduction.*

[2] *Represents the cumulative reduction of the BMP and the preceding scenarios.*

It is also worth noting that the P8 model is not capable of adequately simulating the impacts from many of the projects that are currently in place, such as the iron-enhanced sand filter near EVR-P8. For these types of practices, the model can be (and has been) used to explicitly assign reductions based on expected performance, but since simulating the complex physical functions of the practices is beyond the capability of the model, things like treatment train impacts are not predicted. As discussed earlier in the report, it is expected that while the overall annual loads to these existing practices may decrease as a result of the implementation of upstream practices, the percentage of discharge from upstream that an existing practice will be able to treat will increase. Therefore, while it is difficult to say broadly that a practice will retain its present-day performance, it is possible (if not likely) that the efficiency of treatment of an individual practice will actually increase as a consequence of implementing volume retention practices elsewhere in the watershed. For this reason, the presence of an existing practice should not discourage the City from implementing practices higher up in the watershed, especially infiltration practices.

Implementation is always subject to access to the sites and the reduced costs of combining and coordinating efforts, so timing will also be dictated by other factors such as the timing of road reconstruction work. So, while the practices identified in this report have been prioritized, given potential unforeseen constraints these projects may also be viewed as an a la carte menu of projects that can be implemented wherever circumstances are amenable. Also, since this is a high-level review, maintaining flexibility throughout feasibility and construction of these practices (along with being watchful for additional opportunities) is prudent, and will likely result in even better returns on investment than what has been estimated in the report.

As alluded to elsewhere in this report, viewing the entire watershed in the context of the treatment train concept – where implementing BMPs higher up in the watershed can increase the efficiencies of both new and existing BMPs downstream – is crucial, particularly in a mostly developed watershed with limited opportunities for the construction of centralized, regional-scale stormwater management facilities. By using a watershed-wide approach, incremental, small-scale improvements such as residential rain gardens and roadside BMPs can have a significant and measureable impact on both pollutant reduction and overall runoff volume reduction that is reflected at the site of raindrop impact, at Long and Farquar Lakes, and at every point in between. Only through imagining this watershed as it once was – the infrequency with which flooding and discharge likely occurred, and the stable habitat it provided for innumerable species – can we begin to close the gap between the behavior of stormwater in an urban environment and a natural one.

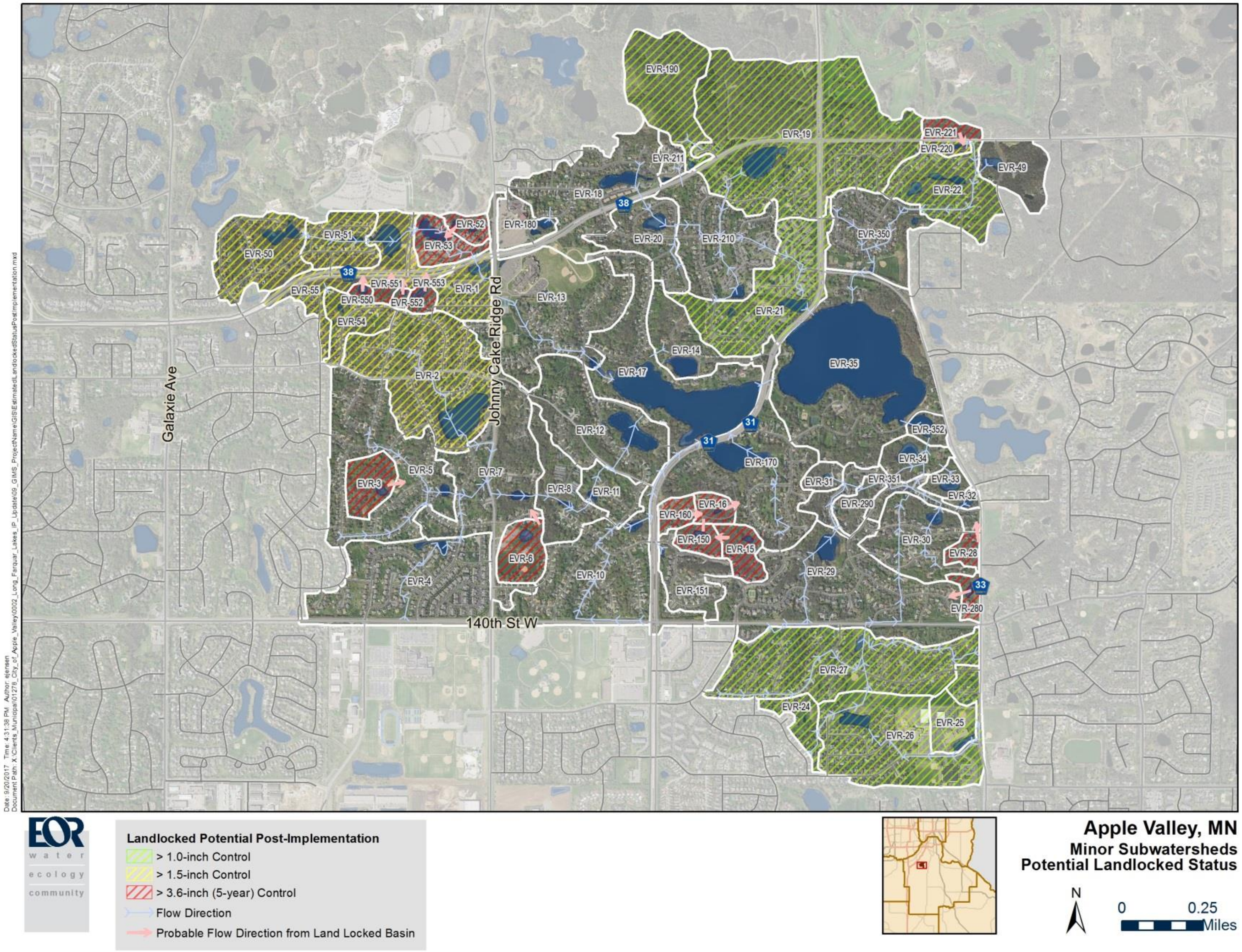

Figure 23. Landlocked Potential- Post Implementation

Recommendations for prioritization and staging include both short-term (5-year) and medium-term (10-year) timelines and incorporate both in-lake strategies and watershed BMP implementation. These strategies are outlined generally below, as well as detailed in Table 16.

0-5-years

- Watershed BMPs
    1. Johnny Cake Ridge Road corridor BMPs
    2. Outlet modifications and infiltration benches on EVR-P7 and EVR-P55
    3. Infiltration basin improvement/expansion on EVR-P27
    4. Pursue implementation of residential BMPs in cooperation with individual landowners through cost-sharing or other incentive program(s)
- In-Lake Treatment
    1. Continue curlyleaf pondweed treatments
    2. Continue fisheries management
    3. Long Lake drawdown in 2018

5 - 10-years

- Watershed BMPs
    1. Continue incorporation of BMPs into road corridor reconstruction projects
    2. Pursue implementation of additional outlet modifications and infiltration benches
    3. Large lot retrofit projects in EVR-13 and EVR-180
    4. Pursue implementation of residential BMPs in cooperation with individual landowners through cost-sharing or other incentive program(s)
- In-Lake Treatment
    1. Farquar Lake alum treatment
    2. Continue fisheries management
    3. Long Lake drawdown (year 10 of the first 10-years of implementation of this plan)
    4. Continue curlyleaf pondweed treatments

Table 16: Implementation staging table.

Implementation Activity	Timeline	Cost	Comments
Long Lake drawdown	2018 and at 5 year intervals	Nominal Cost	Outlet structure already installed. City ould consider using pump to further lower the lake level and thus improve the effectiveness of the drawdown
Johnny Cake Ridge Road corridor BMPs	With road re-construction project	$500,000 - $850,000	TP reduction was evaluated for EVR-12 and EVR-13 to be 29.7 lbs overall
EVR-P7 Outlet modifications and infiltration benches	0-5 Years	$63,000 - $102,000	Includes outlet modification and engineered infiltration bench; estimated reduction 15.1 lbs/yr (pond export)
EVR-P55 Outlet modifications and infiltration benches	0-5 Years	$38,000 - $61,500	Includes outlet modification and engineered infiltration bench; estimated reduction 13.6 lbs/yr (pond export)
EVR-P27 Infiltration basin improvement/expansion	0-5 Years	$158,000 - $257,000	Efficacy depends on the scale of the improvement; estimated reduction at least 6.1 lbs/yr at Farquar Lake
Long Lake Fish Kill	0-5 Years	$10,500/treatment	$229/acre for 35.3 acres of Long Lake and 10 acres of upstream ponds
EVR-P1 Outlet Modifications	5-10 Years	$7,300 - $12,000	Estimated reduction 7.7 lbs/yr (pond export)
EVR-P2 Outlet Modifications	5-10 Years	$7,300 - $12,000	Estimated reduction 21.4 lbs/yr (pond export)
EVR-P11 Outlet Modifications	5-10 Years	$7,300 - $12,000	Estimated reduction 0.8 lbs/yr (pond export)
EVR-P50 Outlet Modifications	5-10 Years	$7,300 - $12,000	Estimated reduction 9.3 lbs/yr (pond export)
Shepard of the Valley Stormwater Retrofit	5-10 Years	$151,200	Estimated reduction 1.4 lbs/yr to Long Lake and 1.7 lbs/yr to Farquar Lake for large lot retrofits combined
Farquar Lake alum treatment	5-10 Years	$65,000 - $100,000/treatment	Based on the 2010 estimate in 2017 dollars
EVR-P4 Outlet Modifications and Infiltration Benches	10-20 Years	$38,000 - $61,500	Includes outlet modification and engineered infiltration bench; estimated reduction 27.8 lbs/yr (pond export)
EVR-P5 Outlet Modifications	10-20 Years	$7,300 - $12,000	Estimated reduction 14.8 lbs/yr (pond export)
EVR-P10 Outlet Modifications and Infiltration Benches	10-20 Years	$38,000 - $61,500	Includes outlet modification and engineered infiltration bench; estimated reduction 17.9 lbs/yr (pond export)
Falcon Ridge Middle School Stormwater Retrofit	10-20 Years	$58,700	Estimated reduction 1.4 lbs/yr to Long Lake and 1.7 lbs/yr to Farquar Lake for large lot retrofits combined
Heritage Lutheran Stormwater Retrofits	10-20 Years	$22,500	Estimated reduction 1.4 lbs/yr to Long Lake and 1.7 lbs/yr to Farquar Lake for large lot retrofits combined
Community of Christ Stormwater Retrofits	10-20 Years	$20,000	Estimated reduction 1.4 lbs/yr to Long Lake and 1.7 lbs/yr to Farquar Lake for large lot retrofits combined
Christ Church Stormwater Retrofits	10-20 Years	$53,500	Estimated reduction 1.4 lbs/yr to Long Lake and 1.7 lbs/yr to Farquar Lake for large lot retrofits combined
Long Lake Curlyleaf Pondweed Treatment	On-going Program	$4000.00 per year	$550 per acre, by contractor. Maximum treatment area = 15% of littoral zone, or 5.1 acres. Includes $1K for annual CLP survey
Long Lake Fisheries Management	On-going Program		
Farquar Lake Curlyleaf Pondweed Treatment	On-going Program	$7,000 per year	$550 per acre, by contractor. Maximum treatment area = 15% of littoral zone, or 9.5 acres. Includes $2K for annual CLP survey
Farquar Lake Fisheries Management	On-going Program		
Farquar Lake Winter Aeration	On-going Program	Electrical fees (variable)	System installed in 2006
Fish Surveys	Bi-Annual	$3,000-$4,000/year	Based on previous City costs. Includes reporting.
Game fish stocking based on results of fish surveys	Bi-Annual	$2,000/year	2 Pound per Littoral Acre = 70 lbs. 10 fish per pound = 700 lbs. Cost per pound for 6-9" Walleye $2.85
Rough Fish Removal (based on results of fish survey)	Bi-Annual	$10,000/harvest	Based on previous City costs
Fish Surveys	Bi-Annual	$3,000-$4,000/year	Based on previous City costs. Includes reporting.
Rough Fish Removal (based on results of fish survey)	As needed	$10,000/harvest	Based on previous City costs
Watershed-wide Residential BMPs	On-going Program	$10,000 per year	In cooperation with individual landowners through cost-sharing or other incentive program(s)
Riparian Buffer Improvements			
Improved Street Sweeping	On-going Program	No additional cost	Continuation of existing City street sweeping with targetted focus
140th Street Corridor BMPs	Reserve for if reconstruction occurs	$800,000 - $1,400,000	TP reduction was evaluated for EVR-12 and EVR-13 to be 29.7 lbs overall
Pilot Knob Road Corridor BMPs	Reserve for if reconstruction occurs	$800,000 - $1,400,000	TP reduction was evaluated for EVR-12 and EVR-13 to be 29.7 lbs overall
McAndrews Road Corridor BMPs	Reserve for if reconstruction occurs	$900,000 - $1,600,000	TP reduction was evaluated for EVR-12 and EVR-13 to be 29.7 lbs overall

🟧	Road Corridor BMPs	🟨	In-Lake Management
🟦	Stormwater Pond Infiltration Benches	🟪	Private Large Lot Redevelopment
🟩	Priority Infiltration Basin	🟫	Residential BMPs/Buffers/Sweeping

6. CITATIONS

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7. APPENDIX A: STORMWATER POND IMPROVEMENTS COST ESTIMATE

SCHEDULE OF QUANTITIES AND ENGINEER'S OPINION OF PROBABLE PROJECT COST

CITY OF APPLE VALLEY

APPLE VALLEY, MINNESOTA

LONG FARQUAR LAKES IP UPDATE

OPTION: MODIFIED POND OUTLET FOR 13 LOCATIONS

PREPARED BY EMMONS & OLIVIER RESOURCES, INC.

JOB NO. 01278-0002

REVISED: Sunday, October 15, 2017

LINE ITEM	MN/DOT SPEC. NO.	BASE BID ITEM	UNIT	ESTIMATED QUANTITY	VERIFIED QUANTITY	UNIT PRICE	TOTAL AMOUNT
MODIFIED POND OUTLET							
1	2021.501	MOBILIZATION	LS	1		$13,000.00	$ 13,000.00
2	2506.502	EXISTING POND OUTLET RETROFIT W/CONTROL STRUCTURE & ADJUSTMENT	EA	13		$3,000.00	$ 39,000.00
3	2573.550	MISCELLANEOUS	EA	1		$11,200.00	$ 11,200.00
						CONSTRUCTION SUBTOTAL:	$ 63,200.00
			30%	CONSTRUCTION CONTINGENCY			$ 18,960.00
						CONSTRUCTION TOTAL	**$ 82,160.00**
			10%	PLANNING (GEOTECHNICAL ANALYSIS, EASEMENT REVIEW, WETLAND DETERMINATION, CONSTRUCTION ACCESS, ETC.)			$ 8,216.00
			20%	ENGINEERING AND DESIGN			$ 16,432.00
			5%	PERMITTING AND APPROVALS			$ 4,108.00
			10%	BIDDING & CONSTRUCTION ADMINISTRATION			$ 8,216.00
						PROFESSIONAL FEES TOTAL	**$ 36,972.00**
						TOTAL PROJECT COST	**$ 119,132.00**
		ESTIMATED ACCURACY RANGE* **	**-20%**	**$ (23,826.40)**			**$ 95,305.60**
			30%	**$ 35,739.60**			**$ 154,871.60**

***This **feasibility-level (Class 5, 0 to 2% design completion per ASTM E 2516-06)** cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of completion of design, but are not included at this level of project definition. **The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +30%.** The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. **The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.** Operation and Maintenance costs are not included.

SCHEDULE OF QUANTITIES AND ENGINEER'S OPINION OF PROBABLE PROJECT COST

CITY OF APPLE VALLEY

APPLE VALLEY, MINNESOTA

LONG FARQUAR LAKES IP UPDATE

OPTION: INFILTRATION BENCH MODIFICATION FOR 5 LOCATIONS WITH IRON ENHANCEMENT AT 2 LOCATIONS

PREPARED BY EMMONS & OLIVIER RESOURCES, INC.

JOB NO. 01278-0002

REVISED: Sunday, October 15, 2017

LINE ITEM	MN/DOT SPEC. NO.	BASE BID ITEM	UNIT	ESTIMATED QUANTITY	VERIFIED QUANTITY	UNIT PRICE	TOTAL AMOUNT

INFILTRATION BENCH MODIFICATION W/IRON ENHANCEMENT FOR TWO BENCHES**

LINE ITEM	MN/DOT SPEC. NO.	BASE BID ITEM	UNIT	ESTIMATED QUANTITY	VERIFIED QUANTITY	UNIT PRICE	TOTAL AMOUNT
1	2021.501	MOBILIZATION	LS	1		$37,000.00	$ 37,000.00
2	2101.501	CLEARING	AC	0.20		$25,000.00	$ 5,000.00
3	2101.506	GRUBBING	AC	0.20		$25,000.00	$ 5,000.00
4	2105.501	COMMON EXCAVATION W/ HAUL	CY	533		$25.00	$ 13,333.33
5	2451.503	WASHED SAND FOR SAND FILTER (CV)	CY	373		$45.00	$ 16,794.00
6	SPECIAL	45-MIL EPDM LINER	SY	320		$22.00	$ 7,045.87
7	2451.503	WASHED SAND OVER FILTER (CV)	CY	53		$45.00	$ 2,402.00
8	2451.509	WASHED AGGREGATE FOR DRAINAGE UNDER FILTER	CY	89		$62.00	$ 5,515.70
9	2451.503	WASHED SAND FOR IES FILTER (CV)	CY	160		$48.00	$ 7,686.40
10	SPECIAL	IRON FILINGS (5%)	LB	32027		$0.80	$ 25,621.33
11	2502.541	8" PERFORATE HDPE DRAINTILE W/NO SOCK	LS	288		$25.00	$ 7,206.00
12	2502.573	8" CLEAN OUT W/DUCTILE IRON FOME LOCKING GRATE	EA	4		$750.00	$ 3,000.00
13	2502.573	8" VALTERRA KNIFE GATE VALVE AND 16" PVC HOUSING	EA	2		$2,000.00	$ 4,000.00
14	2573.550	EROSION AND SEDIMENT CONTROL ALLOWANCE	ALL	1		$15,000.00	$ 15,000.00
15	2575.555	VEGETATION ESTABLISHMENT	AC	0.20		$20,000.00	$ 4,000.00
						CONSTRUCTION SUBTOTAL:	$ 158,604.64
			30%	CONSTRUCTION CONTINGENCY			$ 47,581.39
						CONSTRUCTION TOTAL	**$ 206,186.03**
			10%	PLANNING (GEOTECHNICAL ANALYSIS, EASEMENT REVIEW, WETLAND DETERMINATION, CONSTRUCTION ACCESS, ETC.)			$ 20,618.60
			20%	ENGINEERING AND DESIGN			$ 41,237.21
			5%	PERMITTING AND APPROVALS			$ 10,309.30
			10%	BIDDING & CONSTRUCTION ADMINISTRATION			$ 20,618.60
						PROFESSIONAL FEES TOTAL	**$ 92,783.71**
						TOTAL PROJECT COST	**$ 298,969.74**
ESTIMATED ACCURACY RANGE* **			**-20%**	**$ (59,793.95)**			**$ 239,175.79**
			30%	**$ 89,690.92**			**$ 388,660.66**

***This **feasibility-level (Class 5, 0 to 2% design completion per ASTM E 2516-06)** cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of completion of design, but are not included at this level of project definition. **The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +30%.** The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. **The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.** Operation and Maintenance costs are not included.

**Area of sand filter and iron sand filter increased 20% to provide additional BMP area to increase capacity and accommodate potential clogging.

SCHEDULE OF QUANTITIES AND ENGINEER'S OPINION OF PROBABLE PROJECT COST

CITY OF APPLE VALLEY

APPLE VALLEY, MINNESOTA

LONG FARQUAR LAKES IP UPDATE

OPTION: INFILTRATION BASIN IMPROVEMENT

PREPARED BY EMMONS & OLIVIER RESOURCES, INC.

JOB NO. 01278-0002

REVISED: Sunday, October 15, 2017

LINE ITEM	MN/DOT SPEC. NO.	BASE BID ITEM	UNIT	ESTIMATED QUANTITY	VERIFIED QUANTITY	UNIT PRICE	TOTAL AMOUNT
INFILTRATION BASIN IMPROVEMENT							
1	2021.501	MOBILIZATION	LS	1		$18,000.00	$ 18,000.00
2	2101.501	COMMON EXCAVATION W/HAUL	CY	4000		$18.00	$ 72,000.00
3	2573.550	EROSION AND SEDIMENT CONTROL ALLOWANCE	ALL	1		$10,000.00	$ 10,000.00
4	2575.555	VEGETATION ESTABLISHMENT	AC	0.50		$10,000.00	$ 5,000.00
						CONSTRUCTION SUBTOTAL:	$ 105,000.00
			30%			CONSTRUCTION CONTINGENCY	$ 31,500.00
						CONSTRUCTION TOTAL	**$ 136,500.00**
			10%			PLANNING (GEOTECHNICAL ANALYSIS, EASEMENT REVIEW, WETLAND DETERMINATION, CONSTRUCTION ACCESS, ETC.)	$ 13,650.00
			20%			ENGINEERING AND DESIGN	$ 27,300.00
			5%			PERMITTING AND APPROVALS	$ 6,825.00
			10%			BIDDING & CONSTRUCTION ADMINISTRATION	$ 13,650.00
						PROFESSIONAL FEES TOTAL	**$ 61,425.00**
						TOTAL PROJECT COST	**$ 197,925.00**
		ESTIMATED ACCURACY RANGE***	**-20%**			**$ (39,585.00)**	**$ 158,340.00**
			30%			**$ 59,377.50**	**$ 257,302.50**

***This **feasibility-level (Class 5, 0 to 2% design completion per ASTM E 2516-06)** cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of completion of design, but are not included at this level of project definition. **The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +30%.** The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. **The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.** Operation and Maintenance costs are not included.

SCHEDULE OF QUANTITIES AND ENGINEER'S OPINION OF PROBABLE PROJECT COST

PARAMETERS FOR ACCURACY

ESTIMATE CLASS	LEVEL OF PROJECT DEFINITION (EXPRESEES AS % OF COMPLETE DEFINITION)	ACCURACY RANGE
5	0% TO 2%	-20% TO -30%
		+30% TO +50%
4	1% TO 15%	-10% TO -20%
		+20% TO +30%
3	10% TO 40%	-5% TO -15%
		+10% TO +20%
2	30% TO 70%	-5% TO -10%
		+5% TO +15%
1	50% TO 100%	-3% TO -5%
		+3% TO +10%
***THIS PROJECT PHASE		

PARAMETERS FOR CONSTRUCTION CONTINGENCY

PHASE OF PROJECT	PERCENTAGE ENGINEERING COMPLETED	APPLICABLE CONSTRUCTION CONTINGENCY PERCENTAGE (%)
FUNDING, SCOPE AND BUDGET	0% TO 5%	30.00%
SCHEMATIC DESIGN	5% TO 15%	25.00%
PRELIMINARY	15% TO 60%	20.00%
FINAL	60% TO 100%	10.00%
CONSTRUCTION	100%	5.00%
***THIS PROJECT PHASE		

Note: The contigency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.

8. APPENDIX B: RIPARIAN BUFFER QUALITY ASSESSMENT

Figure 24. Buffer Quality Assessment – Farquar Lake Watersheds EVR-21, EVR-35

Figure 25. Buffer Quality Assessment – Long Lake Watershed EVR-170

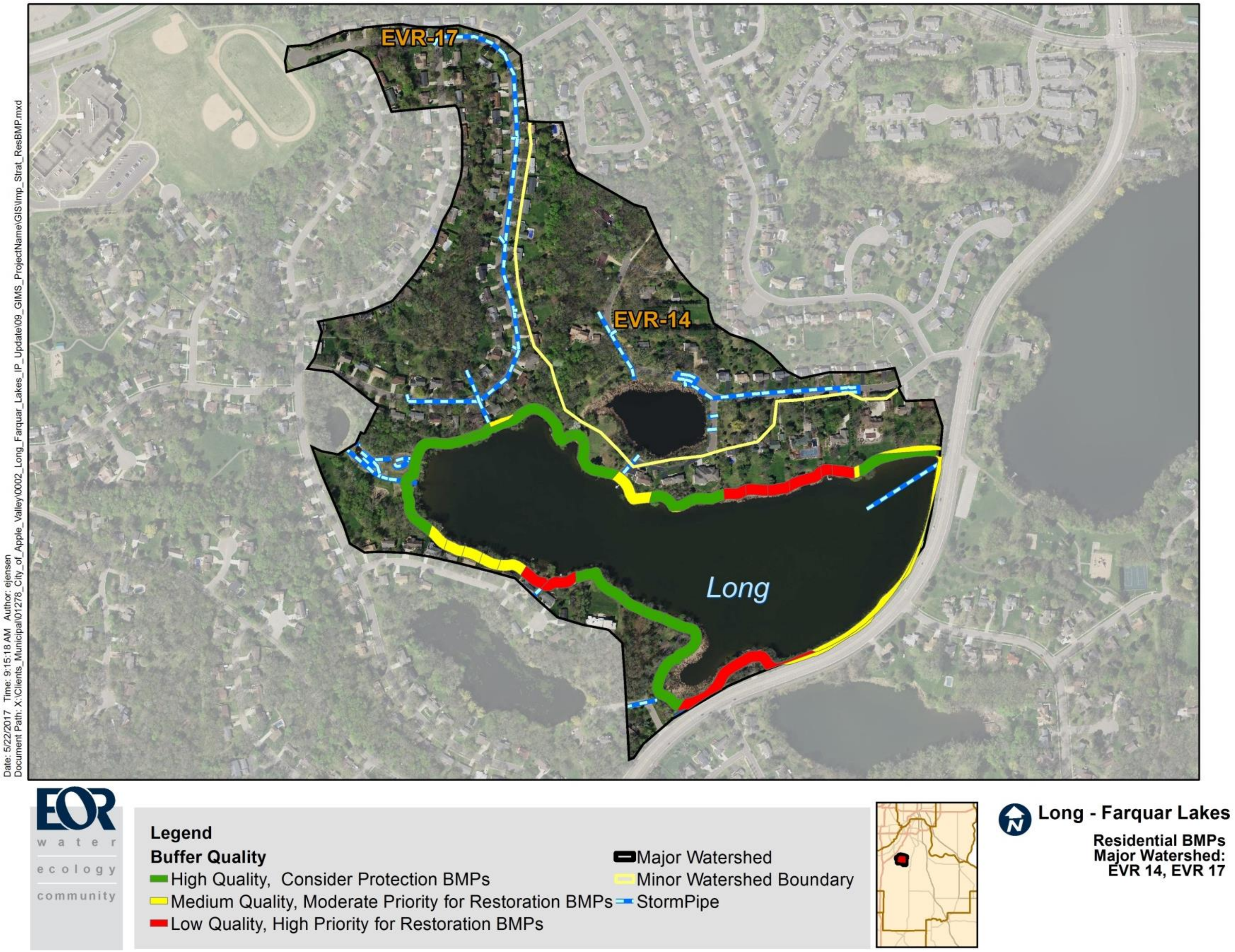
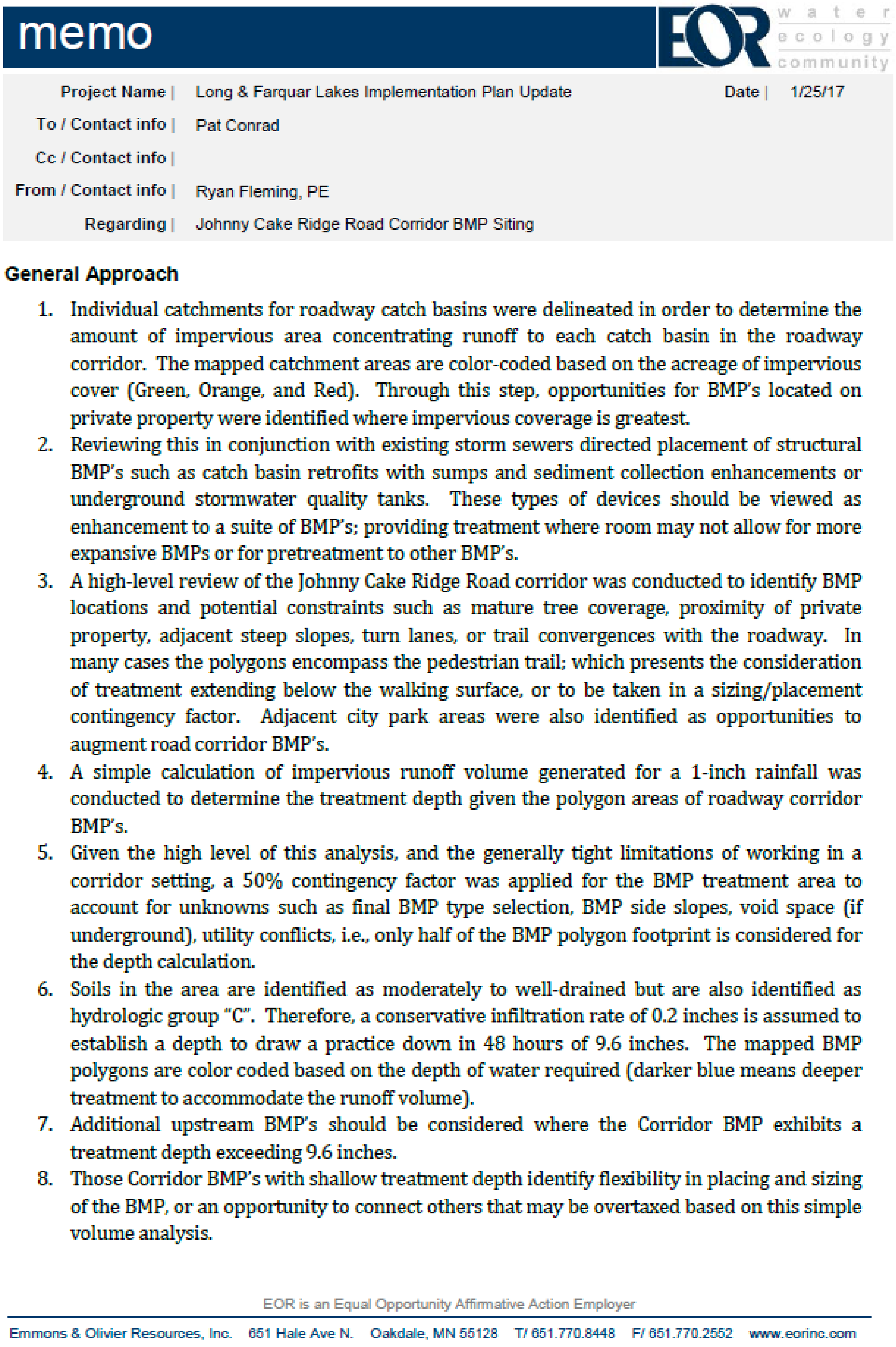


Figure 26. Buffer Quality Assessment – Long Lake Watersheds EVR-14, EVR-17

9. APPENDIX C: JOHNNY CAKE RIDGE ROAD INTERIM MEMO AND BMP EXAMPLES



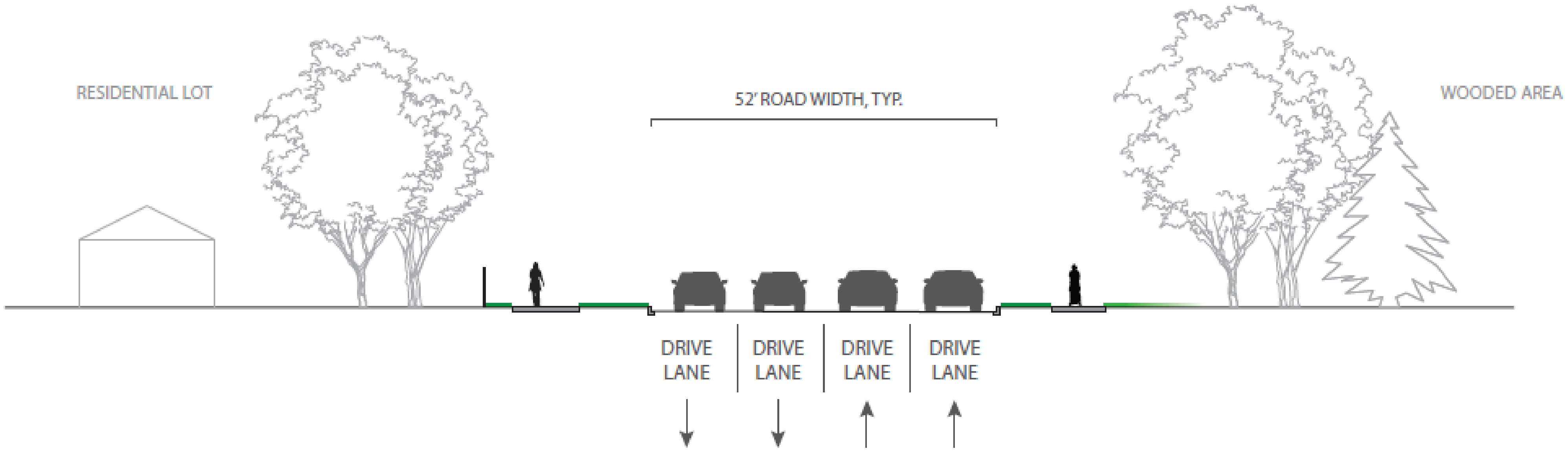
memo

Project Name |	Long & Farquar Lakes Implementation Plan Update	**Date** |	1/25/17
To / Contact info |	Pat Conrad		
Cc / Contact info |			
From / Contact info |	Ryan Fleming, PE		
Regarding |	Johnny Cake Ridge Road Corridor BMP Siting		

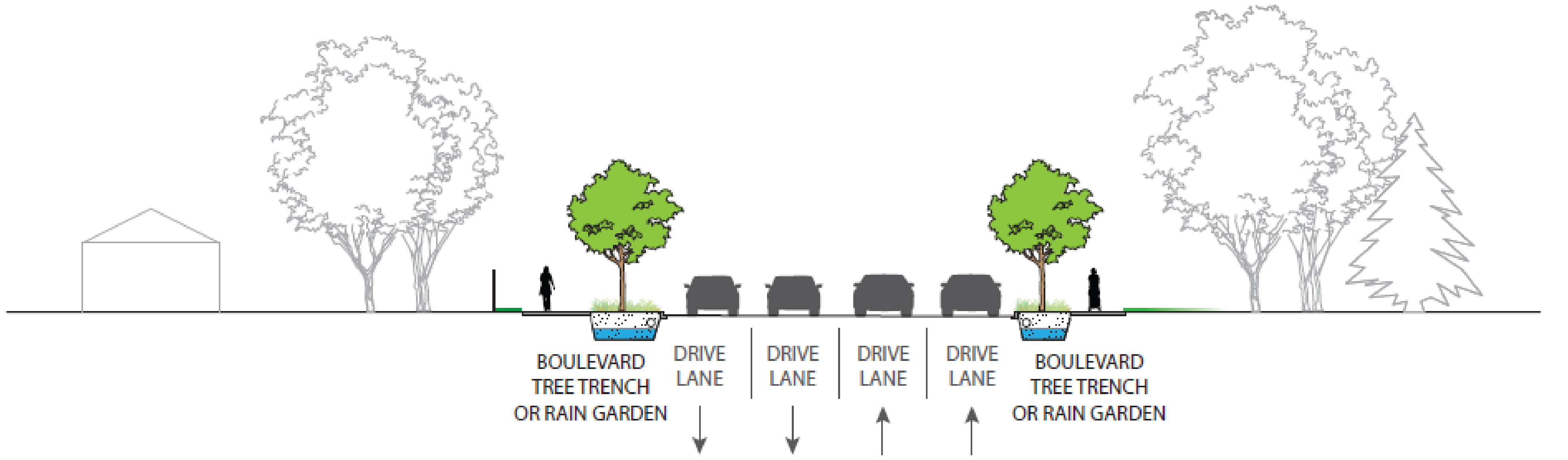
General Approach

1. Individual catchments for roadway catch basins were delineated in order to determine the amount of impervious area concentrating runoff to each catch basin in the roadway corridor. The mapped catchment areas are color-coded based on the acreage of impervious cover (Green, Orange, and Red). Through this step, opportunities for BMP's located on private property were identified where impervious coverage is greatest.
2. Reviewing this in conjunction with existing storm sewers directed placement of structural BMP's such as catch basin retrofits with sumps and sediment collection enhancements or underground stormwater quality tanks. These types of devices should be viewed as enhancement to a suite of BMP's; providing treatment where room may not allow for more expansive BMPs or for pretreatment to other BMP's.
3. A high-level review of the Johnny Cake Ridge Road corridor was conducted to identify BMP locations and potential constraints such as mature tree coverage, proximity of private property, adjacent steep slopes, turn lanes, or trail convergences with the roadway. In many cases the polygons encompass the pedestrian trail; which presents the consideration of treatment extending below the walking surface, or to be taken in a sizing/placement contingency factor. Adjacent city park areas were also identified as opportunities to augment road corridor BMP's.
4. A simple calculation of impervious runoff volume generated for a 1-inch rainfall was conducted to determine the treatment depth given the polygon areas of roadway corridor BMP's.
5. Given the high level of this analysis, and the generally tight limitations of working in a corridor setting, a 50% contingency factor was applied for the BMP treatment area to account for unknowns such as final BMP type selection, BMP side slopes, void space (if underground), utility conflicts, i.e., only half of the BMP polygon footprint is considered for the depth calculation.
6. Soils in the area are identified as moderately to well-drained but are also identified as hydrologic group "C". Therefore, a conservative infiltration rate of 0.2 inches is assumed to establish a depth to draw a practice down in 48 hours of 9.6 inches. The mapped BMP polygons are color coded based on the depth of water required (darker blue means deeper treatment to accommodate the runoff volume).
7. Additional upstream BMP's should be considered where the Corridor BMP exhibits a treatment depth exceeding 9.6 inches.
8. Those Corridor BMP's with shallow treatment depth identify flexibility in placing and sizing of the BMP, or an opportunity to connect others that may be overtaxed based on this simple volume analysis.

EXISTING CONDITION



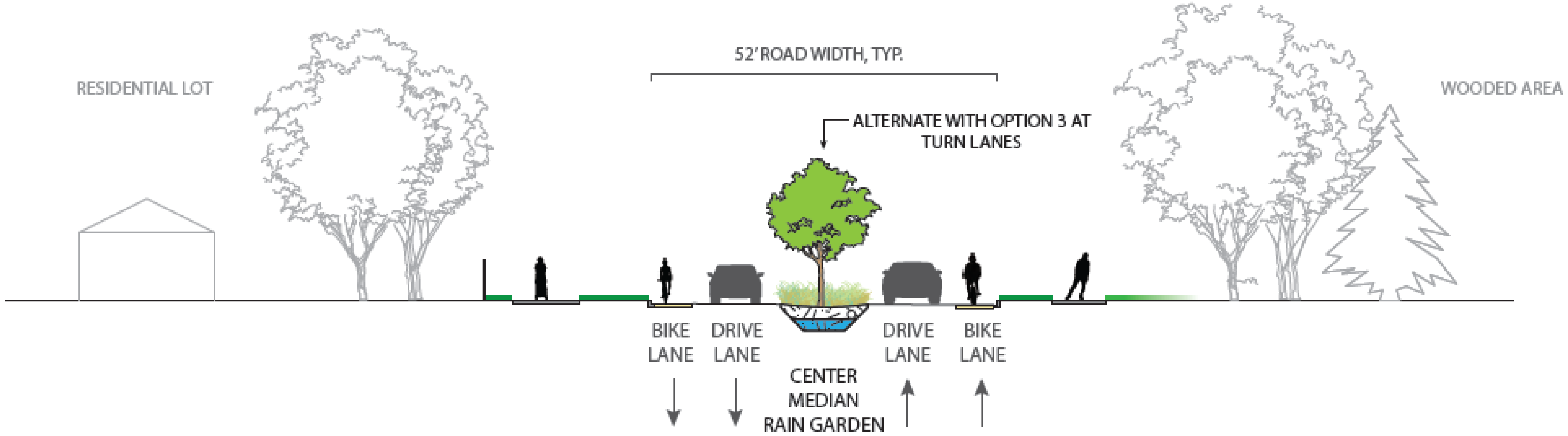
OPTION 1



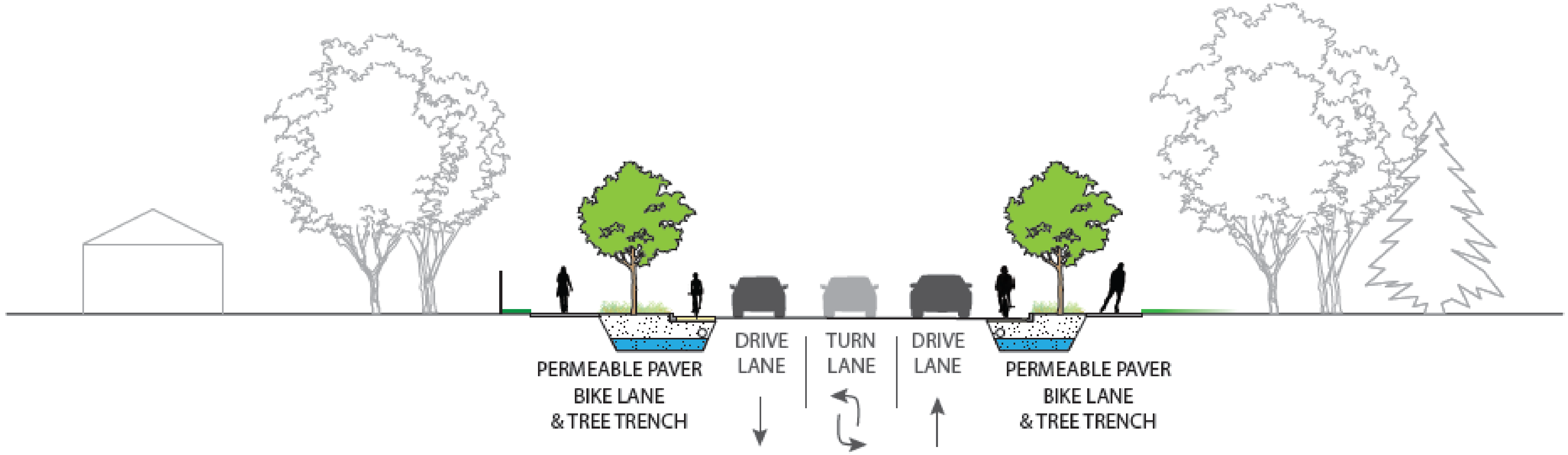
JOHNNY CAKE RIDGE ROAD
BMP INTEGRATION, TYPICAL SECTIONS

SCALE: 1" = 20' (@ 11x17)

OPTION 2



OPTION 3



JOHNNY CAKE RIDGE ROAD
BMP INTEGRATION, TYPICAL SECTIONS

SCALE: 1" = 20' (@ 11x17)

bioretention


Concept Rendering of Roadside Bioretention (EOR)


Cul-de-Sac Rain Garden in Inver Grove Heights (EOR)


Median Rain Garden in Inver Grove Heights (EOR)

BMP ROADWAY INTEGRATION PRECEDENTS

EOR water ecology community

permeable pavers


Permeable Pavers, installed (EOR)


Concept Rendering of Permeable Paver Boulevard (EOR)


Permeable Paver Intersection in Inver Grove Heights (EOR)


Permeable Paver Bike Lane (EPIC Systems)

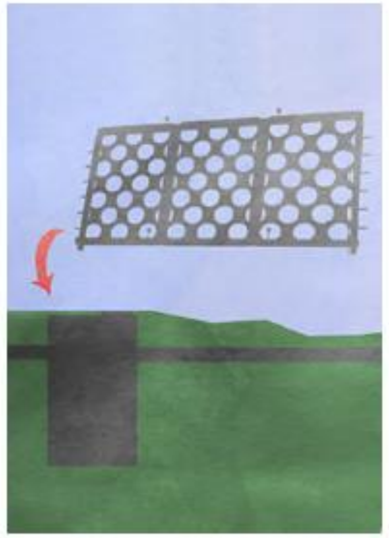

Permeable Paver Boulevard (David Baker Architects)

BMP ROADWAY INTEGRATION PRECEDENTS

Manhole Sturctural Pollution Control Retrofits

Deep Sump Manhole (EOR)

The Preserver Dissipator & Skimmer
(Momentum Environmental)



SAFL Baffle
(Upstream Technologies)

Hydrodynamic Separator
(CDS Stormwater Treatment)

BMP ROADWAY INTEGRATION PRECEDENTS

Underground Stormwater Quality Units

Stormwater Quality Tank Pre-Installation (EOR)

Off-Line Stormwater Quality Tank Concept (Prinsco)

Embedded Stormwater Quality Tank (Prinsco)

BMP ROADWAY INTEGRATION PRECEDENTS

10. APPENDIX D: RESIDENTIAL BMPS BY MINOR SUBWATERSHED

Minor Watershed	Roadside Rain Garden	Cul-de-sac Improvement	Tree Trench	Backyard Bio-infiltration	Minor Watershed Reduction Efficiency (%)	Minor Watershed TP Load Export (lbs/year)	Bio-infiltration Device /Rain Garden Total Cost	Porous Pavement/ Roundabout LID Total Cost	Cost Tree Trench/ Infiltration Trench Total Cost	Cost Wet Detention Basin Total Cost	Cost All BMPs	Total Area (Acres) Treated All BMPs	Minor Watershed Area	Percent of Watershed Treated
EVR-10	13	3	12	0	39%	16.4	$26,305	$113,312	71,225	$0	$210,841	29	74	39%
EVR-11	4	1	2	0	7%	63.4	$8,094	$37,771	$11,871	$0	$57,735	8	16	48%
EVR-12	5	3	9	0	26%	54.9	$10,117	$113,312	$53,419	$0	$176,848	22	61	36%
EVR-13	1	1	6	0	14%	50.6	$2,023	$37,771	$35,612	$0	$75,406	10	84	12%
EVR-14	4	0	0	0	65%	1.3	$8,094	$0	$0	$0	$8,094	2	26	8%
EVR-151	5	3	4	0	43%	3.5	$10,117	$113,312	$23,742	$0	$147,171	17	23	72%
EVR-17	1	0	1	0	32%	90.7	$2,023	$0	$5,935	$0	$7,959	2	83	2%
EVR-170	13	3	36	0	49%	21.4	$26,305	$113,312	$213,674	$0	$353,291	53	96	55%
EVR-18	10	3	11	0	52%	15.9	$20,234	$113,312	$65,289	$0	$198,836	27	66	40%
EVR-19	25	5	4	3	59%	18.7	$50,586	$188,853	$23,742	$72,843	$336,024	40	170	24%
EVR-190	1	0	0	0	32%	3.9	$2,023	$0	$0	$0	$2,023	1	46	1%
EVR-2	2	4	74	0	64%	6.9	$4,047	$151,083	$439,219	$0	$594,348	84	84	100%
EVR-20	8	0	0	0	61%	2.9	$16,187	$0	$0	$0	$16,187	4	29	14%
EVR-21	7	6	7	0	22%	62.4	$14,164	$226,624	$41,548	$0	$282,336	32	64	49%
EVR-210	4	3	2	0	21%	32	$8,094	$113,312	$11,871	$0	$133,276	15	58	25%
EVR-211	0	1	0	0	57%	1.7	$0	$37,771	$0	$0	$37,771	4	6	58%
EVR-22	7	2	0	0	94%	0.3	$14,164	$75,541	$0	$0	$89,705	11	41	26%
EVR-26	12	2	6	0	86%	6.4	$24,281	$75,541	$35,612	$0	$135,435	19	80	24%
EVR-27	7	8	42	0	53%	27.3	$14,164	$302,165	$249,286	$0	$565,616	74	91	81%
EVR-29	29	5	19	0	77%	13.6	$58,679	$188,853	$112,772	$0	$360,305	51	113	45%
EVR-30	4	3	0	0	77%	1.7	$8,094	$113,312	$0	$0	$121,406	13	38	33%
EVR-35	6	0	6	0	20%	147.9	$12,141	$0	$35,612	$0	$47,753	9	142	6%
EVR-350	10	0	0	0	75%	2.5	$20,234	$0	$0	$0	$20,234	5	42	12%
EVR-351	12	1	1	0	0%	6	$24,281	$37,771	$5,935	$0	$67,987	11	22	49%
EVR-352	1	0	0	0	46%	8.5	$2,023	$0	$0	$0	$2,023	1	7	7%
EVR-4	24	6	17	5	40%	25.6	$48,562	$226,624	$100,902	$121,406	$497,494	60	84	71%
EVR-5	4	2	68	0	39%	12.5	$8,094	$75,541	$403,606	$0	$487,242	77	79	97%
EVR-50	2	1	0	2	61%	3.5	$4,047	$37,771	$0	$48,562	$90,380	9	40	21%
EVR-51	4	2	0	0	30%	6.7	$8,094	$75,541	$0	$0	$83,635	9	23	40%
EVR-54	1	0	15	0	54%	2.1	$2,023	$0	$89,031	$0	$91,054	16	17	91%
EVR-55	1	0	0	0	51%	18.2	$2,023	$0	$0	$0	$2,023	1	40	1%
EVR-7	3	6	27	1	21%	59.3	$6,070	$226,624	$160,256	$24,281	$417,231	52	80	64%
EVR-8	0	2	0	0	8%	63.6	$0	$75,541	$0	$0	$75,541	7	29	24%