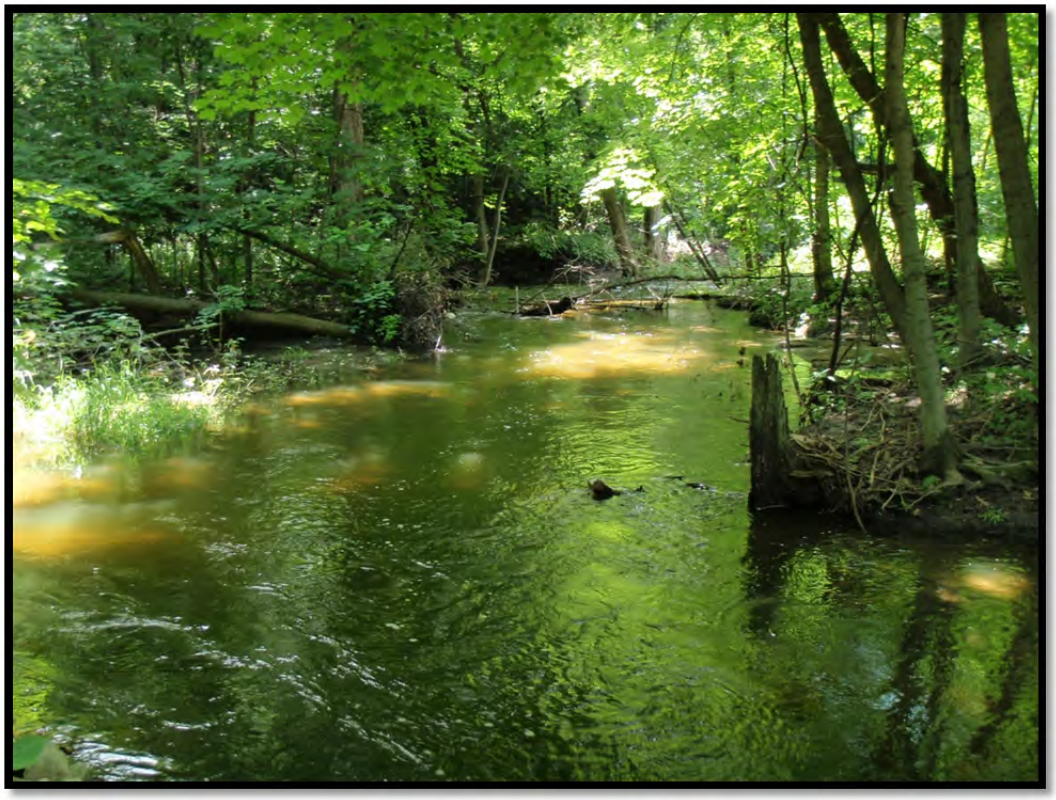
2014 Prior Lake Outlet System Annual Operations Report



February 2015

PRIOR LAKE - SPRING LAKE
WATERSHED DISTRICT

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INTRODUCTION

The Prior Lake Outlet Structure and Outlet Channel were constructed in 1983 under DNR permit 79-6016 to address high lake level issues on Prior Lake, which does not have a natural outlet. The Prior Lake Outlet Channel (PLOC) is utilized by the Prior Lake- Spring Lake Watershed District (District or PLSLWD) in managing lake levels on Prior Lake, as well as a trunk stormwater system for the Cities of Prior Lake and Shakopee, and the Shakopee Mdewakanton Sioux Community. The 7 mile long PLOC has been divided into 8 management Segments. Segment 1 is on the southern end beginning at the Prior Lake Outlet Structure, while Segment 8 is on the northern end and flows into the Minnesota River in Shakopee.

To address current needs and plan for future development in the watershed, in 2007 the District finalized a Joint Powers Agreement/Memorandum of Agreement (JPA/MOA) with the Cities of Prior Lake and Shakopee, and the Shakopee Mdewakanton Sioux Community for the operation, maintenance and use of the Prior Lake Outlet Channel. This group of cooperators oversees the operation of the PLOC, while the District administers the day to day operations. In the early 2000's, it was determined by these JPA/MOA Cooperators that while the channel and outlet had worked well since their inception, if modified in several places, they could operate more efficiently, reduce long term maintenance and enhance the environment. With this in mind, the cooperators formed the JPA/MOA and undertook a 5-7 year project to restore and enhance the PLOC. Acknowledging that the PLOC is used as a stormwater conveyance system and is not just a natural conveyance, the JPA/MOA cooperators focus is to manage the easements of the channel and the channel itself to maintain hydrologic capacity, reduce maintenance needs, provide long-term stability and improve water quality. Secondary benefits include increased aesthetics, providing improved habitat and providing consistency with city and county plans for parks and greenways.

Operation of the Prior Lake Outlet Structure is governed by the DNR-approved Prior Lake Outlet Control Structure Management Policy and Operating Procedures dated October 2004, approved February 2005. This plan specifies a review procedure that is to be repeated every 3 years. A review and revision of this document is anticipated to occur in 2015 now that a calibrated rating curve has been established for the new design of the Prior Lake Outlet Structure. Additionally, an Operation, Inspection and Maintenance Manual was drafted and adopted in September 2011 for the Prior Lake Outlet Structure. The purpose of this secondary manual is to establish guidelines and practices to provide existing and future District Staff with the knowledge of how to properly operate, inspect and maintain the structural and operational components of the outlet to maximize the life and effectiveness of the structure. The manual includes a table of recommended inspection items along with the recommend frequency of inspection. These recommendations will be reviewed periodically by District Staff to determine if the frequency is appropriate based on findings in the field and the manual will be updated accordingly.

According to the National Oceanic and Atmospheric Administration records, the 30-year county wide average annual precipitation for Scott County is 30.95 inches. The rainfall in 2014 at the PLSLWD office totaled 36.44 inches. (Note the PLSLWD office moved to Prior Lake City Hall in July and precipitation was recorded at the City Hall after September 17th) Record rainfalls in June totaled 13.01 inches, creating massive floods on Prior Lake. Figure 1 and Attachment G summarize the precipitation recorded within the District in more detail.

In 2014, the extreme rainfalls (see Figure 1) created record flood conditions and caused the outlet structure and outlet channel to be engulfed with water for long periods of time. Prior Lake reached a record 906.16', which was the highest recorded lake level since 1915, when 907 feet was recorded.

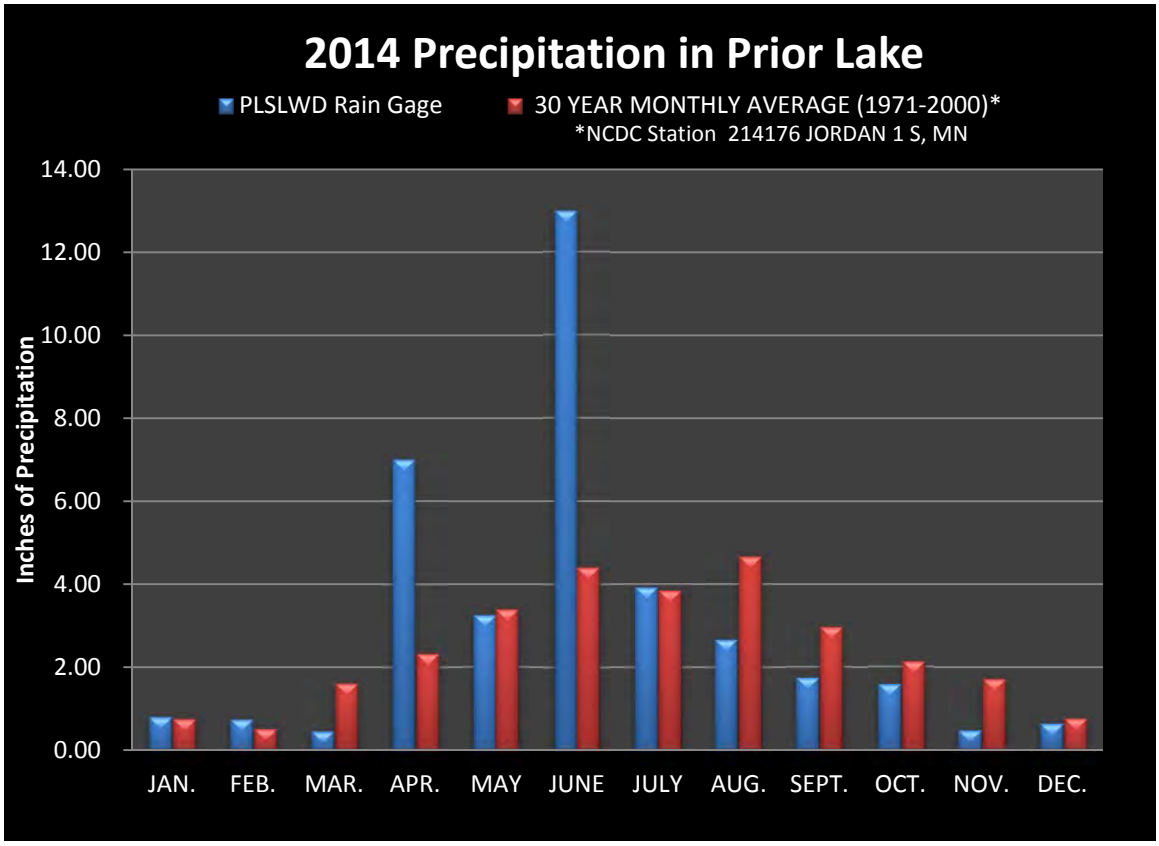


FIGURE 1 PRECIPITATION GRAPH

OUTLET STRUCTURE

HISTORY

The Prior Lake Outlet Structure (Figure 2) was originally constructed in, and has been operated since1983. The original design of the structure required manual operation to open and close gates to regulate the flow. This design posed safety concerns to staff while operating the structure during high water levels. Additionally, there were inefficiencies in the structure's design because the 36 inch pipe connected to the structure did not reach its maximum flow of 65 cfs until lake levels well surpassed the outlet elevation. Over the years the structure had also developed wear and required minor maintenance.

Given these conditions, a replacement structure was pursued by the District and installed in 2010. The new design has increased the efficiency of discharging water by allowing the outlet pipe to reach capacity sooner. It has also proven to provide safer conditions for staff during inspections and maintenance, and is self-operating, which will reduce overall operations and maintenance costs. A schematic of the outlet structure is provided in Attachment A.

FIGURE 2 – OUTLET STRUCTURE

MAINTENANCE AND OPERATION

The new structure needs minimal maintenance in order to operate. Once Prior Lake reaches 902.5', water starts spilling over the accordion shaped weir located inside the trash rack seen in Figure 2. Maintenance includes visual inspections, greasing gates, and removing debris from the trash rack. Removing vegetation and other debris from the trash rack is the most time-consuming and labor-intensive task. When the structure is operating (Prior Lake is greater than 902.5'), the structure will be inspected no less than once a week, and as much as twice per day (depending on the lake level and amount of vegetation getting stuck on the trash rack). Inspections and debris removal is typically conducted by PLSLWD staff. During the 2014 flood, however, the City of Prior Lake staff helped remove vegetation once per day and on the weekends in addition to District staff also removing the vegetation daily in order to ensure Outlet Structure was not blocked.

Excluding 2009, the Prior Lake Outlet Structure had flow, at least partially, every year since 1999. The year 2011 held the greatest volume of water flowing through the system since the structure's establishment in 1983. This was partially due to the more efficient design of the new Outlet Structure; however, the primary factor was the duration of continuous discharge being significantly greater than in previous years.

During 2014 operations, the Prior Lake Outlet Structure performed well throughout the duration that water discharged from the lake. The Prior Lake elevation receded below the outlet elevation on September 11 and remained so for the rest of the year. In its 136 days of discharge during 2014, an estimated 6.10 feet of vertical volume was eliminated from the lake through the Prior Lake Outlet Structure. This is the second largest volume of water discharged through the outlet structure since 1983 (See Attachment D). It is estimated that the lake level of Prior Lake could have reached approximately 912.26 feet without the outlet structure (See Figure 3 and Figure 4). Attachment D is provided for comparison between years on the overall usage of the Prior Lake Outlet Structure. The numbers shown are calculated based on the most accurate information available. They are not exact and are intended for yearly comparisons only. Attachments E and F show daily Prior Lake elevations throughout 2014.

FIGURE 3 – OUTLET STRUCTURE DURING FLOOD IN 2014

FIGURE 4 – OUTLET STRUCTURE DURING NORMAL CONDITIONS

OUTLET CHANNEL

CULVERT INSPECTIONS AND MAINTENANCE

As stated above, the Prior Lake Outlet Structure was in full operation and discharging water from April 29th to September 11th. Before and during operations, the District is required to perform regular inspections of the Outlet Structure and the PLOC in accordance with the Outlet Operations Manual. However, the inspection guideline in the Outlet Operations Manual was found to be too vague, so a more detailed Inspection Frequency Guideline was created and adopted by the JPA/MOA group in 2014 (see Attachment I and Figure 5). On the basis of these inspections, the District was able to determine that the Outlet Structure and PLOC were structurally sound and able to handle the lake discharges and surface flows downstream of the Outlet Structure. However, due to the severity and intensity of the flood in June, unavoidable damage occurred in several locations along the channel.

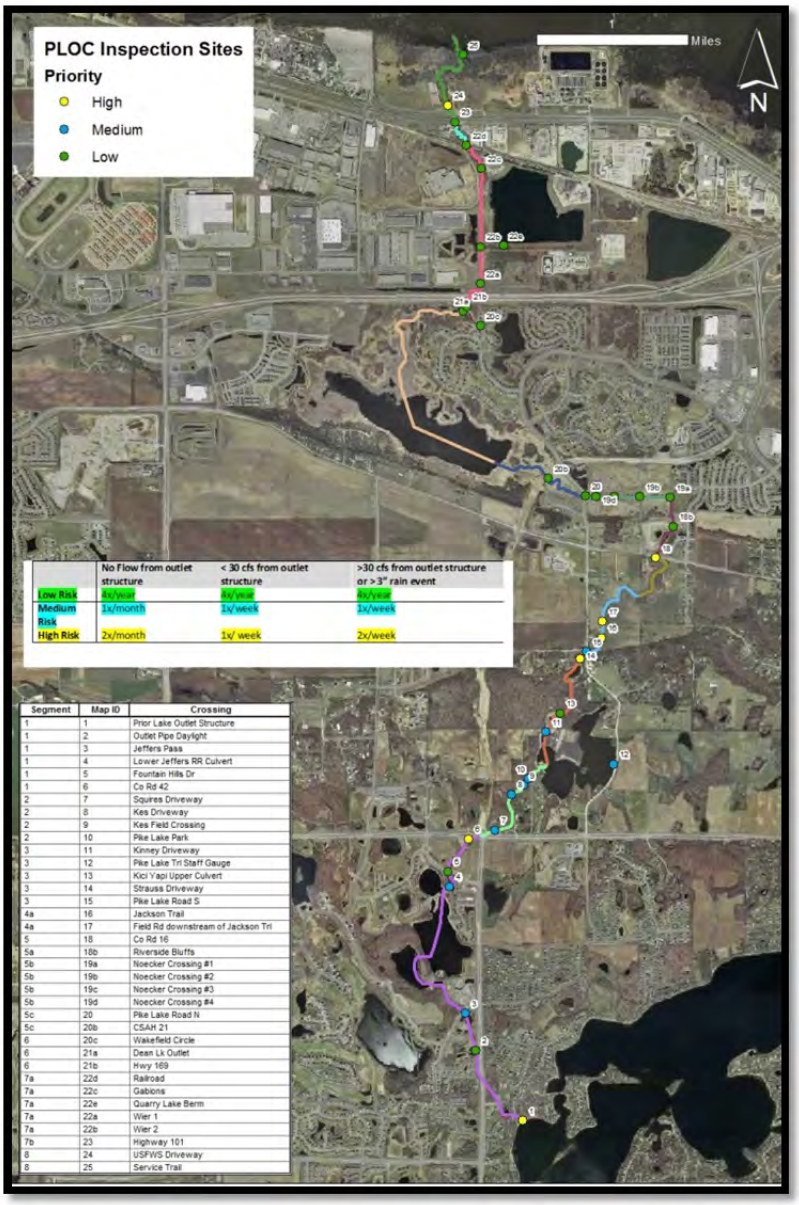


FIGURE 5 MAP OF CULVERT INSPECTIONS

Extreme velocity and duration of flow during the flood caused bank erosion to worsen along the entire length of the channel (see Figure 6). According to a Bank Erosion Survey conducted by EOR in fall of 2014, over 20,000 feet of bank erosion was observed. Many trees fell into the channel due to the erosion as well. Details of this survey can be found in Attachment J.

FIGURE 6 BANK EROSION AND FALLEN TREES

In early January, segment 2 experienced what appeared to be groundwater seepage during some below-zero temperatures. The water continued to rise and then freeze, causing a concern that the culvert under Kes Driveway would become completely frozen which could cause the culvert to become plugged. Fortunately, the water stopped rising and flowing after about a week and never plugged completely (see Figure 7).

FIGURE 7 GROUNDWATER SEEPS IN JANUARY

Due to the 2014 flood, the Kes field road crossing has eroded on the downstream side of the crossing and also experienced some piping (water flowing along the outside of culvert). The PLSLWD is working with FEMA to repair this crossing (See Figure 8).

FIGURE 8 KES FIELD ROAD CROSSING EROSION

Also in segment 2, the Pike Lake Park crossing experienced erosion along the bank due to the water overtopping the road and creating a gouge in the bank where the water eroded the bank as it flowed back into the channel (Figure 9). PLSLWD is working with FEMA to repair this erosion.

FIGURE 9 PIKE LAKE PARK BANK EROSION

Segment 3 had two areas of damage – the KiciYapi culvert and the Strauss Driveway crossing. The KiciYapi culvert was damaged during the flood because the culvert was rusted and the increased velocities eroded the soil around the culvert (See Figure 10). In addition, when the road overtopped, more erosion occurred and was impassible. A permit was issued and the SMSC repaired the culvert over the 2014-2015 winter.

FIGURE 10 KICIYAPI CULVERT CROSSING DURING EMERGENCY REPAIR

In Segment 3, the Strauss driveway overtopped with water, dropping debris and eroding the driveway (See Figure 11). The City of Prior Lake removed the debris from the driveway.

FIGURE 11 STRAUSS DRIVEWAY DURING FLOOD

Bank erosion in segment 4a was temporarily repaired to prevent a homeowner's pole building from falling into the channel. A more permanent fix will move the entire channel away from the driveway and realign the channel in its original location. The realignment will be completed in 2015 (see Figure 12 for progress as of January 2015).

FIGURE 12 SEGMENT 4A REALIGNMENT

In segment 4a, two crossings were damaged during the flood. The Jackson culvert was overtopped by water (Figure 13), but no significant damage resulted. More gravel was added to the crossing to replace the gravel that was washed away in the flood.

FIGURE 13 JACKSON TRAIL DURING FLOOD

Another culvert in Segment 4a (Gonyea, aka Field Road downstream of Jackson Trail) was washed out and in need of replacement (See Figure 14). This culvert was installed by Minnesota Dirt Works in October 2013. The PLSLWD is working with FEMA to get funding for repair of this culvert.

FIGURE 14 GONYEA CULVERT AFTER FLOOD

At the end of Segment 4, the culvert under County Road 16 was clogged and caused the water to overtop the road and erode the walking path and road (See Figure 15). Scott County repaired this crossing.

FIGURE 15 COUNTY ROAD 16 AFTER FLOOD DAMAGE

Segment 5 collected more sediment deposition during the flood due to upstream erosion (See Figure 16). PLSLWD is seeking funds from the State for removal of this sediment delta.

FIGURE 16 SEDIMENT DELTA IN SEGMENT 5

Segment 8 had two culverts with damage. The USFWS driveway got completely washed out (See Figure 17). The USFWS may be replacing this crossing, or possibly removing it for good.

FIGURE 17 USFWS DRIVEWAY DURING FLOOD

The Service Trail crossing experienced some erosion on the downstream side as well (See Figure 18). At the time this report was written, it is unclear who will be repairing this erosion.

FIGURE 18 EROSION AT SERVICE TRAIL CROSSING AFTER FLOOD

Removal of vegetation and debris from several culverts or grates throughout the year to ensure free flows was the primary extent of the additional maintenance that occurred (See Figure 19).

FIGURE 19 REMOVING VEGETATION FROM CULVERT GRATE AT CR42

MONITORING

Monitoring along the outlet channel in 2014 consisted of water quantity and quality, and vegetation and erosion monitoring. Some of this monitoring is funded by the JPA/MOA, and some is done for other programs or entities. A map is provided below, and in Attachment H, that displays the monitoring sites.

WATER QUANTITY AND QUALITY

Water quantity monitoring consisted of obtaining continuous stage and flow measurements at the Outlet Structure (Map ID #1), Pike Lake Road South (Map ID #10), and the Service Trail (Map ID #25), and Deans Lake Inlet (Map ID #20b). At each site, a level logger recorded stage in 15 minute increments. Flow measurements were taken at various stages in order to create a stage-discharge relationship (rating curve). The primary goal for monitoring flow at the outlet structure was to provide an accurate field verified rating curve for the new Outlet Structure. Additionally, the flow data was used to help estimate pollutant loads at the outlet structure site. The Pike Lake Road and Service Trail water quantity monitoring was used to update and calibrate the XP-SWMM model. The Deans Lake Inlet site was monitored by Scott Soil and Water Conservation District for purposes of quantifying water volume going into Deans Lake.

By recording water levels and taking flow measurements, a stage-discharge relationship (rating curve) can be developed. Stage (level) is recorded every 15 minutes by an automated level logger. Flow measurements (discharge) are taken at various lake levels and a stage-discharge relationship is developed. This data allows us to calculate the total annual volume of water discharged through the structure.

A new field-verified rating curve for the outlet structure was developed in 2014. A graph showing the Prior Lake rating curve can be seen in Attachment C. Flow measurements were taken by EOR, Scott SWCD, and PLSLWD at the outlet of the pipe coming from the outlet structure (outlet daylight). All meters used for measuring flow were calibrated no earlier than June of 2012. When comparing flow meters at high velocities at the outlet daylight, they proved to be very precise with a relative percent difference of no greater than 5%. More detail on these comparisons can be found in the 2013 PLSLWD Stream Flow Monitoring Equipment Analysis Memo. The maximum measured flow in 2014 was 63.85 cfs when the lake was 906.13' on July 7th (see Attachment C for all flow measurements). For stage or discharge data for Pike Lake Road South, the Service Trail, or Deans Lake Inlet, please contact the PLSLWD office.

Water quality (and quantity) was monitored at multiple sites along the outlet channel (see Figure 20). Refer to map in Appendix H or Figure 20 for locations. Sonde monitoring is conducted by using a multi-parameter Hydrolab MS5 to measure pH, temperature, conductivity, turbidity, and dissolved oxygen. Samples were taken on three separate occasions.

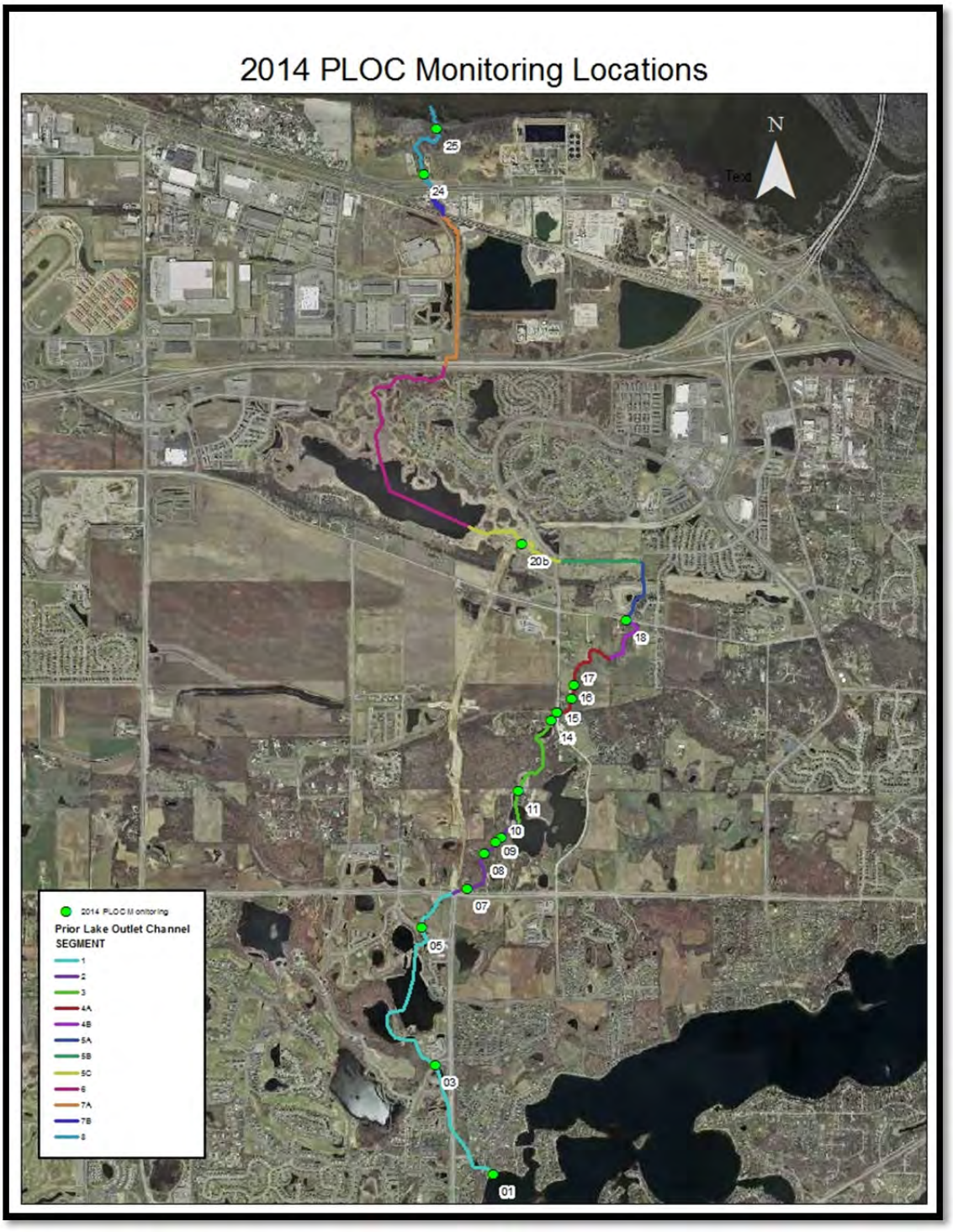


FIGURE 20 MONITORING SITES ALONG THE OUTLET CHANNEL

TABLE 1 MONITORING TYPES AND LOCATIONS

Map ID	Monitoring Type	Location	Monitoring Organization
01	Level and Flow	Prior lake Outlet Structure	PLSLWD
03	Sonde	Jeffers Pass	PLSLWD
05	Sonde	Fountain Hills	PLSLWD
07	Sonde	Squires/Campbell Driveway	PLSLWD
08	Sonde	Kes Driveway	PLSLWD
09	Sonde	Kes Field Crossing	PLSLWD
10	Sonde	Pike Lake Park	PLSLWD
11	Sonde	Kinney Driveway	PLSLWD
14	Sonde	Strauss Driveway	PLSLWD
15	Level and Flow	Pike Lake Road S	PLSLWD
16	Sonde	Jackson Trail	PLSLWD
17	Sonde	Gonyea	PLSLWD
18	Sonde	County Road 16	PLSLWD
20b	Chemistry and Flow	Deans Lake Inlet	Scott SWCD
24	Chemistry	USFWS Driveway	Scott SWCD
25	Level and Flow	Service Trail	PLSLWD

TABLE 2 SONDE MONITORING RESULTS

Map ID and Date	DO (mg/L)	Turbidity (FNU)	Conductivity (µm/cm)	pH	Water Temp °C
5/13/2014					
1	11.02	2.2	432.5	8.62	11.89
3	11.36	1.3	436.9	8.59	12.73
5	11.3	0.8	436.9	8.55	13.16
7	11.14	0.4	438.2	8.61	13.52
10	10.69	2.7	427.3	8.54	13.49
11	11.46	1.7	440.9	8.59	13.55
15	10.4	0	443.7	8.55	14.07
18	10.39	16.7	443.6	8.4	14.24
24	10.18	3	464.6	8.24	14.79
25	10.32	2.8	465.8	8.26	14.82
8/5/2014					
1	10.37	0.4	393.6	8.92	25.72
3	7.02	0	399.1	8.68	25.33
5	4.93	0	404.1	8.27	25.5
6	5.34	0	406.5	8.12	25.71
7	6.51	15.3		8.24	25.65
8	7.45	2	405.1	8.21	25.51
9	7.72	53.4	380.3	8.17	25.54
10	7.76	56.7	271.6	8.21	25.56
11	7.28	0	396.2	8.25	26.03
14	5.69	0	398	8.13	25.86
15	5.84	0.6	396.8	7.99	25.78
16	6.57	0	398	8.02	25.77
17	7.07	0	397.9	8.02	25.78
24	7.65	0.2	931.4	7.9	25.41
8/18/2014					
1	5.97	1.3	403.4	8.12	25.08
3	6.81	0	401.2	8.11	25.71
5	6.42	0.4	397.5	8.1	26.08
6	6.58	0	398.2	8.16	26.22
7	7.87	25.2		8.21	26.5
8	7.67	6.3	400	8.16	26.18
9	7.74	5.4	398.9	8.17	26.21
10	7.8	27.8		8.17	26.17
11	7.39	4.1	389	8.11	26.25
14	6.76	3.4	390.2	8.18	27.12
15	6.56	7.4	390.5	7.93	26.57
16	7.01	9.1	246.3	7.91	26.57
17	7.31	2.5	390.3	7.96	26.58
24	7.37	0.9	463.7	7.82	25.5

Water quality samples were also collected in the outlet channel at the Deans Lake Inlet (Map ID# 20b) and USFWS Driveway (Map ID #24) by the Scott SWCD. The results of this monitoring can be found by contacting the Scott SWCD or LMRWD.

LAKE MONITORING

The Three Rivers Park District conducted monitoring on Pike Lake. The PLOC flows through Pike Lake. Samples are collected bimonthly in the east and west bay.

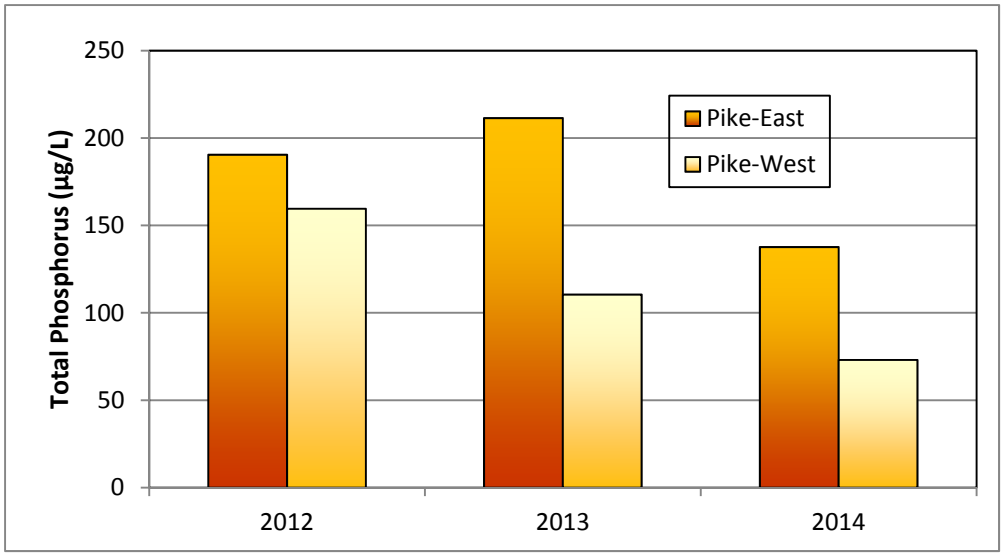


FIGURE 21 TOTAL PHOSPHOROUS SEASON AVERAGE

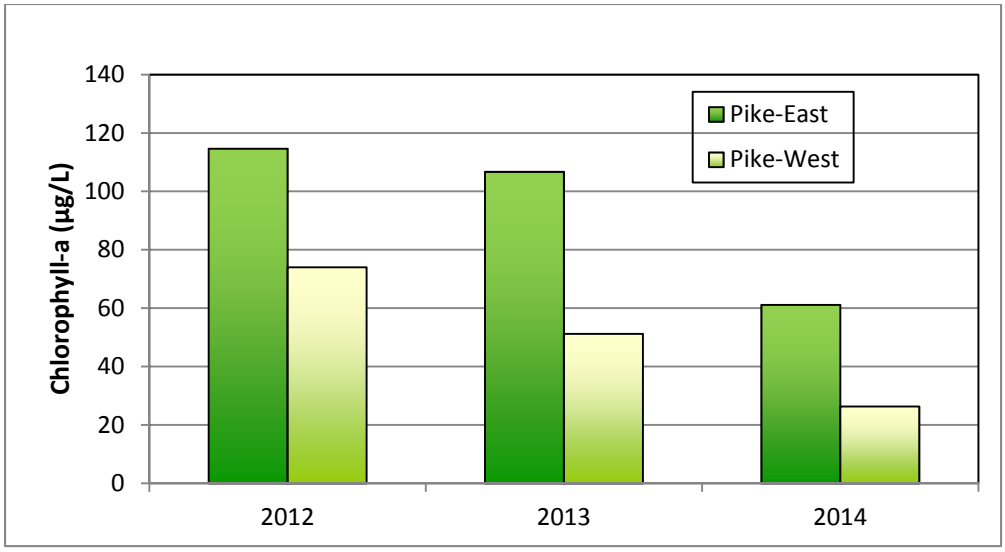


FIGURE 22 CHLOROPHYLL-A SEASON AVERAGE

FIGURE 23 SECCHI DEPTH SUMMER AVERAGE

The Lower Minnesota River Watershed District (LMRWD) conducted a Paleolimnology study on Dean's Lake in 2014. This study provides information on historic water quality conditions based off of sediment core samples. This information can be obtained by calling the LMRWD for a copy of the report.

VEGETATION AND EROSION MONITORING

Vegetation and erosion surveys were completed along the easements of the PLOC in the spring and fall by EOR. These assessments collected data on species composition and distribution of noxious plants, noted erosion sites along the PLOC, and identified land cover and plant community types.

The JPA/MOA has extended the contract with EOR to continue the surveys through June of 2016. After each survey is completed, a memo is provided detailing the results of the surveys, as well as management recommendations. These reports are included in Attachment J and K. There is also a summary regarding the vegetation management found in the Outlet Channel Restoration and Enhancement Project section of this report. The bank erosion survey conducted in fall was much more detailed than previous erosion surveys in order to get a good understanding of the additional bank erosion caused by the flood.

PERMITS

The District maintained seven active permits in 2014. Jeffers Waterfront (permit 2010.02), Jeffers Pointe (permit 2011.03), Pike Lake Road Culvert Replacement (permit 2012.05), Jeffers Pass Outlet (2013.01), Valley Park Business Center (2013.04), East Village 3rd Addition (permit 2013.05), and KiciYapi Culvert (2014.01) remain active and will likely be closed out in 2015.

- Jeffers Waterfront, Pike Lake Road Culvert Replacement, and Jeffers Pass Outlet permits require a signed Certificate of Completion before the permit can be closed out.
- Valley Park Business Center and East Village 3rd Addition need a final site visit before a Certificate of Completion is approved.

- The Jeffers Pointe permit needs staff to work with developer to address the degraded raingarden onsite before assigning a Certificate of Completion.
- KiciYapi was opened in 2014 and the work will be completed in early 2015. An as-built survey will be required before the permit is closed.

The District also received a permit from the DNR to realign the channel in Segment 4a. This DNR permit (2015-0758) was issued on December 29, 2014. This work will be completed early in 2015.

Outlet Channel Restoration and Enhancement Project

Over the last few years, the JPA/MOA cooperators have undertaken a project to restore and enhance the PLOC. The purpose of the project has been to maintain hydrologic capacity, reduce maintenance needs, provide long-term stability, improve water quality, increase aesthetics, provide improved habitat and provide consistency with city and county plans for parks and greenways. Several portions of this project have been completed.

- Work completed on Segment 1 in 2006 consisted of bank stabilizations, increased native plantings and a creation of a spillway between Upper and Lower Jeffers Ponds.
- A basin was excavated and sinuosity was added to the channel in Segment 5c prior to entering Dean Lake during the early portion of 2007.
- Work in 2009 included the replacement of an undersized culvert on the northern end of Segment 8.
- The year 2010 held the finalization of work in several Segments including: banks being reshaped, in addition to toe stabilization and weir reinforcements put in place on Segment 7a; toe stabilization, bank protections and flow realignment in Segment 3; and work to build up the channel bed and reconnect it to the floodplain in Segment 2.
- Additional site checks were made throughout 2012 to ensure stability against erosion and vegetation survival within the areas of previous work in Segments 2, 3, and 7a.
- In 2013, three failing culverts were replaced between Segments 3 and 4B (Pike Lake Road, Jackson Trail, and the Field Road downstream of Jackson Trail). In addition, vegetation along the channel was managed for herbaceous invasives by EOR and woody invasives by Applied Ecological Services. Garlic mustard was hand cut in Segments 3-8. Small populations of Common burdock were cut in Segments 4A, 4B, and 8. Block locust, common buckthorn, and Tatarian honeysuckle suckers and seedlings were treated in segments 1, 3, 4A, 5C, 6, and 7A.

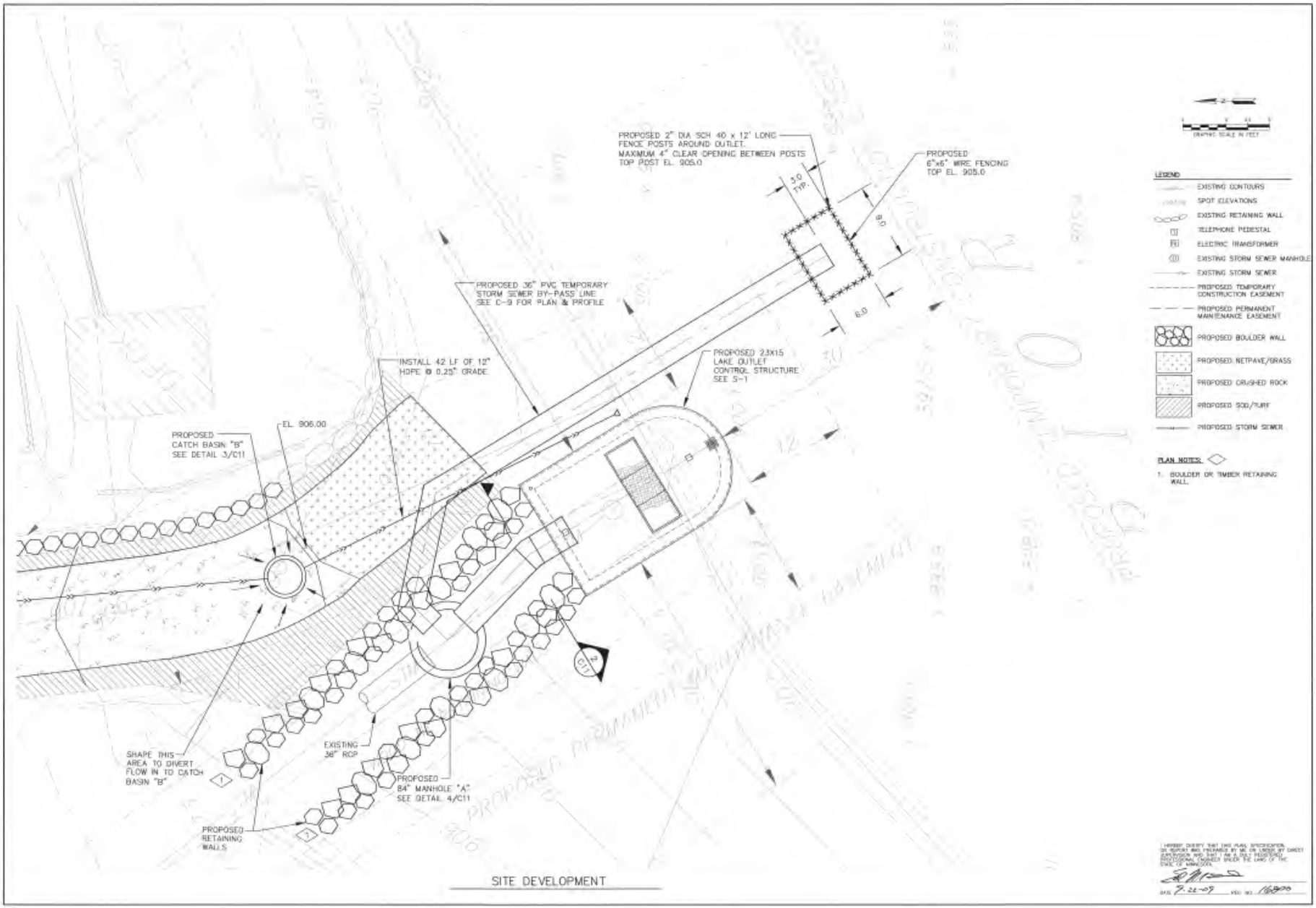
In 2014, activities include:

- Garlic mustard was hand cut with a weed cutter in segments 3-7 by EOR.
- Wild Parsnip was hand cut with a weed cutter in segment 1 by EOR (only location wild parsnip was found).
- A foliar spray was applied for woody invasives (black locust, common buckthorn, and honeysuckle) in segments 1, 3, 4a, 5c, 6, and 7a (by AES).

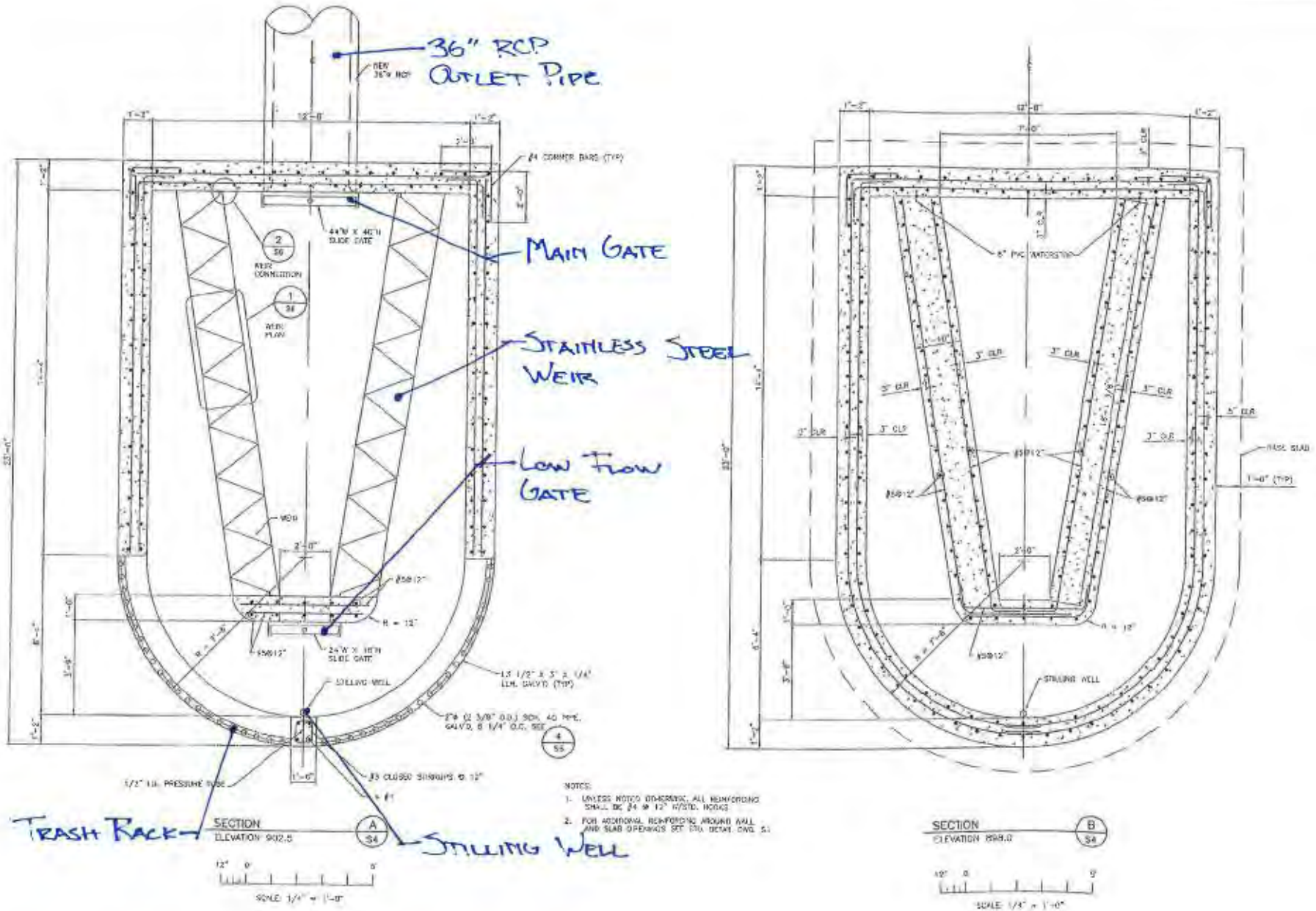
Additional areas with planned future reconstruction include Segments 4b and 7b. Segment 4b will include bank stabilizations, grade controls, cattle exclusion fencing and vegetation plantings within the bank and riparian area. Segment 7b is planned to have toe stabilizations and bank protection installed. These additional reconstruction items will be addressed with the JPA/MOA cooperators as they progress. Additional channel repair work will be completed as pending FEMA and state funding is granted.

ATTACHMENT A

PRIOR LAKE OUTLET STRUCTURE DIAGRAM



SITE DEVELOPMENT


36" RCP
OUTLET PIPE
MAIN GATE
STAINLESS STEEL
WEIR
LOW FLOW
GATE
TRASH RACK
STILLING WELL
SECTION
ELEVATION 902.5
SECTION
ELEVATION 898.0
SCALE: 1/4" = 1'-0"
SCALE: 1/4" = 1'-0"

ATTACHMENT B

OUTLET OPERATIONS SUMMARY

Date	Elevation	Outlet Activity	Inspections/Channel Activity
4/14/2014	901.50	Walk Channel	Walked segment 4 and 5. See document for details. Took pictures of the channel condition.
4/21/2014	901.71	Walk Channel	Walked segment 1. See document for details. Took pictures of the channel condition.
4/22/2014	901.73	Walk Channel	Walked segment 1, 2, 3, and 6. See document for details. Took pictures of the channel condition.
4/29/2014	902.52	Maintenance	Prior Lake started outletting today. Installed Ott Logger.
4/30/2014	902.68	Walk Channel	Walked segment 7 and 8. See document for details. Took pictures of the channel condition.
4/30/2014	902.68	Culvert Inspection	Weeds and sticks at Jeffers Pass. Branch with cattails at Strauss. Debris at Gonyea.
5/2/2014		Walk Channel	Walked segment 7. See document for details. Took pictures of the channel condition.
5/7/2014	903.10	Culvert Inspection	Removed veg from outlet structure. Cleaned debris from Jeffers pass. Veg on CR42 grate. Removed debris at Kes field crossing and CR16.
5/13/2014	903.44	Culvert Inspection	Took sonde readings at multiple culvert crossings. Water over CR42, Strauss, USFWS culvert. Water over Pike Lake Trail staff gage. Log at Gonyea.
5/20/2014	903.50	Culvert Inspection	Cleared veg from outlet structure, Jeffers Pass. Water over culvert at CR42, Kinney Driveway, Stauss, USFWS. Pike staff gage under water. Lots of reeds at Strauss driveway. Log at Gonyea.
5/28/2014	903.36	Culvert Inspection	Cleared veg from outlet structure, Jeffers Pass, Lower Jeffers RR Culvert & Fish Barrier. Culvert under water at CR42, Strauss, CR16. Branch at Gonyea. Reeds at Strauss. Calibrated Ott Logger at outlet structure.
6/2/2014	903.63	Culvert Inspection	Calibrated outter Ott Logger at outlet structure, not inner. Path near CR42 crossing has water bubbling out of it. Cleared tree trunks from Kes Driveway and water overtopping culvert. 8 inches overtopping culvert at Pike Lake park. Water overtopping road at Kes. Pike staff gage underwater and ~ 9in showing. Debris on top of water at Strauss. Water almost over culvert. Branch perpendicular to culvert about 10 feet upstream of culvert. CR16 under water.
6/5/2014	903.85	Culvert Inspection	CR42, Strauss culvert under water. Road damage at USFWS driveway.
6/10/2014	904.05	Culvert Inspection	Cleared veg from outlet structure. Small tree in front of Lower Jeffers culvert. Carp and vortex at CR42 crossing - downstream plugged - removed some but too much - alerted county. Veg at Kinney - alerted Prior Lake. Boards still functioning at driveway at KiciYapi. Strauss, CR16 submerged. Lots of erosion at USFWS driveway.
6/13/2014	903.99	Culvert Inspection	Cleared veg at outlet structure - Pile of weeds was picked up by City of Prior Lake. Some veg on CR42 grate - cleared what we could - underwater. Strauss, CR16, USFWS culvert underwater.
6/16/2014	904.25	Culvert Inspection	Veg cleared from structure. Veg at Jeffers Pass. Water bubbling on path near CR42 culvert again - culvert submerged - veg in downstream grate. 1" water over driveway. Pike staff gage under water. Some veg and underwater at Strauss. Tree down about 50 feet upstream of Gonyea. CR16 culvert under water.
6/19/2014	904.85	Culvert Inspection	Outlet Structure grates under water. Jeffers pass, Lower Jeffers RR, CR42, Squires, Kes Driveway culvert underwater. Pike Lake Park road, Strauss driveway, Jackson, Gonyea, CR16, USFWS driveway, flowing over road. Unnaccessable to Kinney Driveway.
6/23/2014		Culvert Inspection	Removed veg from outlet structure for about 4 hours. Few sticks at Jeffers Pass. Downstream CR42 grate still needs clearing. Erosion across Kes Field Crossing. Water over road at Kinney Driveway. Pike staff gage under water. City of Prior lake crew cleared logs from Stauss Driveway. Vortex at Pike Lake Park. Culvert submerged at Jackson Trl. Gonyea washed away. Flowing over road at CR16. Water very dirty at Pike lake Road N, but crystal clear leaving Deans Lake. RR crossing has new culvert approximately 30' upstream of RR culvert. Quarry berm overtopping and eroding quarry lake bank. USFWS driveway completely washed out. Trail flooded and can't get to Service Trail culvert.
6/26/2014	905.95	Culvert Inspection	Some veg on outlet structure. CR42 culvert underwater - downstream grate still plugged with veg. Fresh gravel at Pike Lake Park. Stauss not visable. CR16 closed. Culvert displaced at USFWS. Service Trail still flooded.
7/1/2014	906.16	Culvert Inspection	Removed veg from outlet structure. Vortex at CR42 upstream - downstream still veg (have alerted county numerous times). Water overtopping Kinney Driveway. Pike staff gage under water. Lots of erosion at KiciYapi. Water overtopping CR16 road still - lots of erosion. Service Trail still flooded.
7/3/2014	906.10	Culvert Inspection	Cleared veg from outlet structure. CR42 culvert underwater. Stauss culvert underwater and debris on top.
7/8/2014	905.87	Culvert Inspection	Bars clear on outlet structure. Mat of green algae on top of water and 2 4x2 boards cleared. Small amount of veg at Jeffers Pass. CR42 culvert under water. Kes field crossing has erosion on culvert. Kinney under water - looks clear. Strauss culvert underwater w/debris on top of water - driveway eroded. Trees down downstream at Pike Lake Rd S. Road still closed at CR16 and road is destroyed.
7/11/2014	905.69	Culvert Inspection	Raining. Cleared veg from outlet structure - water running down road and into lake. Small amount veg at Jeffers Pass.CR42 culvert underwater. Squires culvert underwater - dirt washing off road and into stream. Kes driveway, Kes field crossing, Pike Lake Park, Kinney, Strauss culvert underwater. 5 holes showing at Pike Lake staff gage, but gage still underwater. Pike Lake Rd S and Jackson Trl almost underwter.
7/14/2014	905.70	Culvert Inspection	2" rain over weekend. Veg cleared from outlet structure and Jeffers pass. Almost overtopping Jeffers Pass culvert. One branch on Lower Jeffers apron - not impeding flow. CR42 culvert underwater. Water over road at Kinney Driveway - vortexes in culverts. Pike staff gage underwater - 4 holes. Regraded Strauss driveway - lots of algae and debris on upstream side - tree down on downstream side. Almost over culvert at Pike Lake Rd S and Jackson Trail.
7/17/2014	905.47	Culvert Inspection	Cleared part of downstream grate at CR42. Culvert not visible at Strauss. Water still on path to Service trail - could not get to.
7/21/2014	905.17	Culvert Inspection	Cleared veg from outlet structure - water still over bars. CR42 culvert underwater but grate looks clear. Strauss culvert still underwater - debris on top of water. CR16 culvert underwater - road eroded.
7/24/2014	904.90	Culvert Inspection	Cleared veg from outlet structure. Cleared some debris from Upper Jeffers. Lower part of grate full at CR42. Kinney culvert underwater - new gravel on road. Pike staff gage under water - 7 holes. Stauss culvert underwater.
7/28/2014	904.60	Culvert Inspection	Veg cleared from structure - checked ott logger. CR42 culvert underwater. Strauss culvert underwater - debris on surface of water.
7/31/2014	904.29	Culvert Inspection	8 holes showing at Pike Staff gage. Strauss culvert underwater.
8/5/2014	903.82	Culvert Inspection	Some veg cleared from outlet structure. Sonde reading taken at some culvert crossings. Jeffer Pass culvert underwater - veg on grate - tried to clear. Small amount of veg at CR42 - partially underwater. Pike staff gage underwater - 9 holes. Strauss driveway culvert underwater - lots of debris on top.
8/7/2014	903.60	Culvert Inspection	Clear
8/14/2014	903.00	Culvert Inspection	Cleared veg from outlet structure. Unable to remove all veg from Jeffers Pass. Veg in downstream grate at CR42. Strauss culvert underwater.
8/18/2014	903.20	Culvert Inspection	Cleared veg from outlet structure. Tried to clear more veg from Jeffers Pass. Took sonde readings. CR42 NOT underwater. Pike Staff gage 3.09. Cleared veg from Strauss.
8/27/2014	902.60	Culvert Inspection	Cleared veg from outlet structure. Cleared lots of veg from jeffers pass. Small amount of veg on upstream and downstream grates of CR42. Pike staff gage 2.00
9/3/2014	902.03	Culvert Inspection	Cleared and installed inner stilling well ott logger at outlet structure. Veg on end of grate at CR42 - cleared downstream side. More erosion on downstream side of Kes field crossing. Pike staff gage 1.86 - hard to read. Tree down at Strauss upstream ~ 50'.
9/8/2014	902.52	Culvert Inspection	Pike staff gage 1.58.
9/15/2014	902.4	Culvert Inspection	Outlet structure not outletting. Cleared upstream grate at CR42. Pike staff gage 1.25' - hard to read. Level logger well out of water at Pike Lake Rd S - moved it back into water.
10/6/2014	902.2	Culvert Inspection	Pike Staff gage 1.10 - need to clean. Trees down upstream and downstream at Strauss Driveway. Culvert eroded at CR16, but being worked on. Cleared veg from rocks in front of culvert at USFWS.
10/21/2014	901.95	Culvert Inspection	Doesn't appear to be flowing at Strauss, Jackson Trail. Dry at Gonyea. Road construction in progress at CR16.
11/4/2014	901.76	Culvert Inspection	Not flowing at outlet structure, but small flow at outlet daylight. Pike staff gage too hard to read. Water dries up about 30' downstream of Strauss. CR16 still under construction.
11/18/2014	901.64	Culvert Inspection	Outlet structure, CR42, Strauss frozen. Jackson, Gonyea dry. Finished putting in new culvert at CR16, graded, but no bank stabilization. USFWS still blown out - FWS says they are going to take out crossing.

ATTACHMENT C

STAGE-DISCHARGE RELATIONSHIP

Flow Measurements:

Date	Time	Lake Stage NGVD29	Stage above weir (ft)*	Q [cfs]
5/21/2013	14:15	902.91	0.41	26.48
5/22/2013	9:25	902.94	0.44	32.15
6/13/2013	13:45	903.13	0.63	41.49
6/17/2013	14:58	903.31	0.81	43.40
6/18/2013	15:00	903.34	0.84	46.96
7/2/2013	14:00	903.36	0.86	45.56
7/15/2013	14:30	903.70	1.20	54.90
7/22/2013	11:20	903.94	1.44	58.10
8/16/2013	11:50	902.72	0.22	21.01
8/22/2013	9:10	902.54	0.04	4.56
6/12/2014	9:53	904.01	1.51	54.73
7/2/2014	13:43	906.13	3.63	63.85
8/5/2014	14:14	903.90	1.40	52.34
8/5/2014	13:30	903.90	1.40	52.33

*Top of Weir = 902.5'

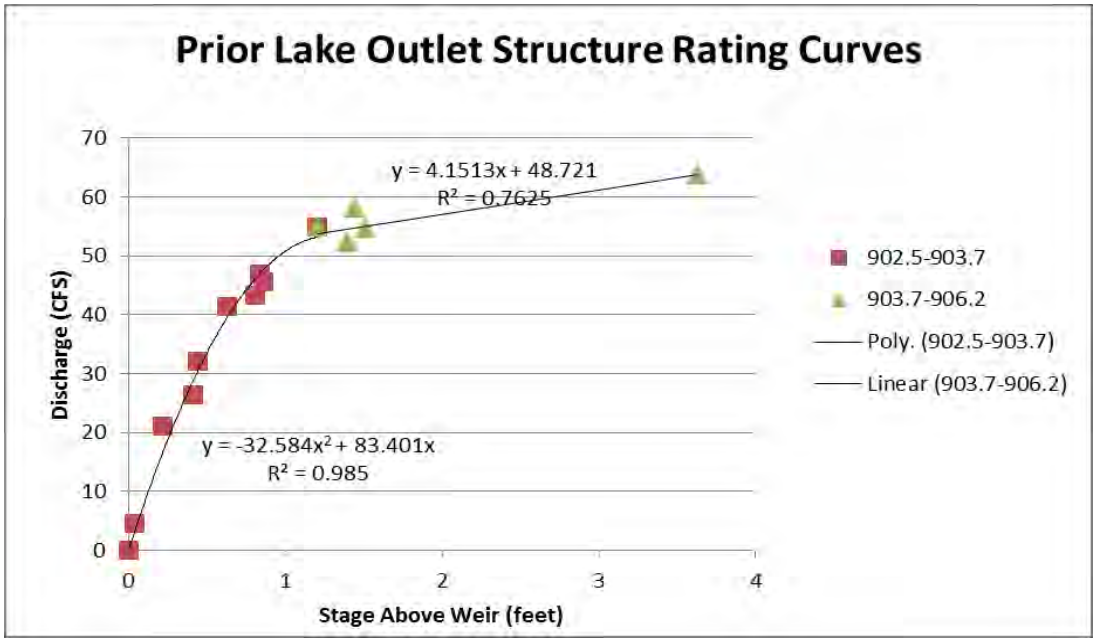
Stage Above Weir (ft)	Lake Level (mean sea elevation in feet)
0	902.5
1	903.5
2	904.5
3	905.5
4	906.5

2014 Rating Curve:

For Lake Levels less than 902.5', flow = 0.0 cfs.

For Lake Levels between 902.5' (stage above weir = 0) and 903.7' (stage above weir = 1.2'), use rating curve $y = -32.584x^2 + 83.401x$

For Lake Levels greater than 903.7' (stage above weir = 1.2'), use rating curve $y = 4.1513x + 48.721$



ATTACHMENT D

VOLUMES DISCHARGED FROM LAKE

Volumes Discharged from the Prior Lake Outlet and Associated Elevations								
Year	**Volume Discharged (ac*ft)**	**Depth Eliminated from Lake (ft)**	**Min Elevation for the Year**	**Date of Min Elevation**	**Max Elevation for the Year**	**Date of Max Elevation**	**Max Elevation *without* the Outlet**	**Annual Rainfall**
2014	12028	6.10	900.1	3/28/2014	906.16	6/30/2014	912.26	36.44
2013	7609	3.93	900.25	3/28/2013	903.95	7/22/2013	907.88	33.25
2012	5751	3.00	900.48	12/6/2012	903.59	6/25/2012	906.59	30.57
2011	20314	9.93	900.87	12/28/2011	903.95	4/5/2011	913.88	26.07
2010	1110	0.59	899.38	1/14/2010	902.78	12/23/2010	903.37	37.23
2009	0	0.00	898.98	9/30/2009	900.44	4/29/2009	900.44	27.41
2008	4993	2.61	900.28	12/29/2008	902.90	5/8/2008	905.51	23.88
2007	1395	0.74	900.55	8/10/2007	902.78	4/23/2007	903.52	28.59
2006	4331	2.27	900.50	12/14/2006	903.27	4/7/2006	905.54	27.77
2005	2299	1.21	900.71	1/18/2005	903.10	10/18/2005	904.31	38.02
2004	13	0.01	900.50	4/15/2004	902.79	7/12/2004	902.80	32.96
2003	5921	3.08	900.62	12/30/2003	903.17	5/23/2003	906.25	23.00
2002	9520	4.88	900.70	3/4/2002	903.60	9/10/2002	908.48	41.96
2001	8692	4.47	901.04	12/28/2001	904.28	5/7/2001	908.75	28.52
2000	80	0.04	901.52	2/20/2000	903.00	7/11/2000	903.04	26.09
1999	6240	3.24	902.00	11/25/1999	904.78	5/27/1999	908.02	33.29
1998			*902.05*	*1/1/1998*	*903.90*	*4/13/1998*		35.00*
1997	4150	2.18	901.20	2/28/1997	902.90	4/21/1997	905.08	32.36*
1996		0.00	*900.77*	*11/4/1996*	*902.98*	*4/10/1996*		26.52*
1995			*902.26*	*9/26/1995*	*903.25*	*3/30/1995*		30.62*
1994	1760+	0.93	901.90	9/7/1994	903.05	10/24/1994	903.98	35.28*
1993	10000+	5.12	902.00	3/9/1993	904.49	7/14/1993	909.61	36.40*
1992	8331	4.29	899.95	2/19/1992	903.16	10/12/1992	907.45	35.86
1991			*898.11*	*4/1/1991*	*900.92*	*6/13/1991*		
1990			*895.46*	*4/24/1990*	*899.38*	*8/10/1990*		
1989			*895.49*	*11/27/1989*	*897.15*	*4/3/1989*		
1988			*896.90*	*11/11/1988*	*899.63*	*1/1/1988*		
1987			*899.63*	*12/31/1987*	*901.54*	*3/6/1987*		
1986			*901.22*	*2/14/1986*	*903.96*	*5/15/1986*		
1985			*902.23*	*9/12/1985*	*903.93*	*4/25/1985*		
1984			*901.75*	*10/9/1984*	*903.60*	*6/24/1984*		
1983	Outlet Installed		*901.76*	*1/17/1983*	*905.68*	*7/20/1983*		
1982			*900.06*	*3/24/1982*	*902.56*	*5/21/1982*		
1981			*898.91*	7/31/1981	*899.88*	*9/17/1981*		
1980			*899.92*	*12/29/1980*	*902.60*	*4/18/1980*		
Averages	**5695 (when operated)**	**2.92 (when operated)**	**900.29**		**902.73**		**906.03**	**30.90**
Unless otherwise noted, data is taken from annual Prior Lake Outlet operations reports								
* Rainfall data is from MN Climatology office for 115N, 22W, 15 Prior Lake; all other rainfall as recorded at PLSLWD Office								
Italicized data from PLSLWD Historic Volunteer Collected Lake Level Data								

ATTACHMENT E

PRIOR LAKE ELEVATIONS AND PRECIPITATION

Elevation		Precipitation	
Average	903.41	**Yearly Total**	36.44
Minimum	900.10	**Max 1 Day**	3.83
Maximum	906.16		

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
01/14/14			0.17
01/16/14			0.03
01/23/14			0.20
01/26/14			0.21
01/31/14			0.20
02/13/14			0.03
02/19/14			0.30
02/21/14			0.42
03/03/14			0.02
03/05/14			0.01
03/28/14		900.10	0.44
04/01/14		900.98	
04/04/14			0.90
04/14/14		901.50	
04/16/14		901.53	
04/17/14			0.80
04/21/14		901.71	0.27
04/23/14		901.75	
04/24/14			0.75
04/25/14		901.91	0.48
04/28/14		902.27	2.20
04/29/14	902.56	902.52	1.13
04/30/14	902.66	902.68	0.49
05/01/14	902.76	902.78	0.15
05/02/14	902.84	902.84	0.01
05/03/14	902.91		
05/04/14	902.97		
05/05/14	903.01	903.01	
05/06/14	903.06	903.07	
05/07/14	903.09	903.10	
05/08/14	903.16	903.12	0.32
05/09/14	903.22	903.20	0.50
05/10/14	903.24		
05/11/14	903.26		
05/12/14	903.40	903.39	1.02
05/13/14	903.44	903.42	0.20
05/14/14	903.46	903.44	

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
05/15/14	903.47		0.01
05/16/14	903.47	903.46	
05/17/14	903.47		
05/18/14	903.45		
05/19/14	903.48	903.43	
05/20/14	903.52	903.50	0.95
05/21/14	903.51	903.50	
05/22/14	903.50	903.49	
05/23/14	903.48	903.47	
05/24/14	903.46		
05/25/14	903.42		
05/26/14	903.39		
05/27/14	903.38	903.38	0.01
05/28/14	903.36	903.36	0.09
05/29/14	903.32	903.28	
05/30/14	903.27		
05/31/14	903.24		
06/01/14	903.53		3.83
06/02/14	903.65	903.63	
06/03/14	903.70		
06/04/14	903.77	903.80	
06/05/14	903.81	903.85	
06/06/14	903.86		
06/07/14	903.95		
06/08/14	904.01		
06/09/14	904.03		1.20
06/10/14	904.03	904.05	
06/11/14	904.03	904.05	0.18
06/12/14	904.01	904.01	
06/13/14	903.99	903.99	
06/14/14	904.00		
06/15/14	904.21		
06/16/14	904.27	904.25	2.61
06/17/14	904.34		0.47
06/18/14	904.39		0.13
06/19/14	904.81	904.85	2.49
06/20/14	905.19		1.51
06/21/14	905.39	905.41	
06/22/14	905.56		
06/23/14	905.70		0.05
06/24/14	905.81		
06/25/14	905.89		
06/26/14	905.95	905.95	
06/27/14	906.00		
06/28/14	906.06		

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
06/29/14	906.15		
06/30/14	906.16		0.54
07/01/14	906.16	906.16	0.07
07/02/14	906.13		0.02
07/03/14	906.10	906.10	
07/04/14	906.05		
07/05/14	906.00		
07/06/14	905.96		
07/07/14	905.91		0.11
07/08/14	905.87	905.87	0.47
07/09/14	905.80		
07/10/14	905.72		
07/11/14	905.76	905.73	0.19
07/12/14	905.80		
07/13/14	905.77		
07/14/14	905.70	905.70	1.90
07/15/14	905.63		0.17
07/16/14	905.56		
07/17/14	905.49	905.47	
07/18/14	905.41		
07/19/14	905.32		
07/20/14	905.24		
07/21/14	905.17	905.17	
07/22/14	905.09		
07/23/14	905.00	905.00	
07/24/14	904.92	904.90	
07/25/14	904.89		0.97
07/26/14	904.82		
07/27/14	904.71		
07/28/14	904.60	904.60	0.04
07/29/14	904.50		
07/30/14	904.39		
07/31/14	904.29	904.29	
08/01/14	904.20		
08/02/14	904.10		
08/03/14	904.01		
08/04/14	903.91		
08/05/14	903.81	903.82	
08/06/14	903.71		
08/07/14	903.62	903.60	
08/08/14	903.52		
08/09/14	903.43		
08/10/14	903.34		
08/11/14	903.25		0.25
08/12/14	903.16		

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
08/13/14	903.07		
08/14/14	902.99	903.00	
08/15/14	902.91		
08/16/14	902.84		
08/17/14	902.85		
08/18/14	902.95	903.20	1.92
08/19/14	902.90		0.02
08/20/14	902.86		0.01
08/21/14	902.83		0.15
08/22/14	902.79		
08/23/14	902.76		
08/24/14	902.73		
08/25/14	902.70		0.15
08/26/14	902.66		
08/27/14	902.63	902.60	
08/28/14	902.61		
08/29/14	902.60		0.18
08/30/14	902.63		
08/31/14	902.62		
09/01/14	902.66		
09/02/14	902.64		1.15
09/03/14	902.62	902.63	0.15
09/04/14	902.62		
09/05/14	902.59		0.02
09/06/14	902.57		
09/07/14	902.54		
09/08/14	902.52	902.52	
09/09/14	902.51		
09/10/14	902.51		0.13
09/11/14	902.48		0.03
09/12/14	902.45		
09/13/14	902.43		
09/14/14	902.41		
09/15/14	902.39	902.40	0.07
09/16/14	902.38		
09/17/14	902.36		
09/18/14	902.35		
09/19/14	902.33		
09/20/14	902.33		
09/21/14	902.33		
09/22/14	902.31		0.19
09/23/14	902.30		
09/24/14	902.28		0.02
09/25/14	902.27		
09/26/14	902.26		

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
09/27/14	902.24		
09/28/14	902.23		
09/29/14	902.21		
09/30/14	902.19		
10/01/14	902.19		0.10
10/02/14	902.24		0.46
10/03/14	902.27		0.89
10/04/14	902.24		
10/05/14	902.21		
10/06/14	902.19	902.20	0.03
10/07/14	902.18		
10/08/14	902.16		
10/09/14	902.14		
10/10/14	902.12		
10/11/14	902.11		
10/12/14	902.09		
10/13/14	902.08		0.02
10/14/14	902.07		0.02
10/15/14	902.05		
10/16/14	902.04		
10/17/14	902.02		
10/18/14	902.00		
10/19/14	901.99		
10/20/14	901.98		
10/21/14	901.97	901.95	
10/22/14	901.95		
10/23/14	901.94		0.08
10/24/14	901.93		
10/25/14	901.92		
10/26/14	901.91		
10/27/14	901.89		
10/28/14	901.87		
10/29/14	901.85		
10/30/14	901.84		
10/31/14	901.82		
11/01/14	901.80		
11/02/14	901.78		
11/03/14	901.77		
11/04/14	901.76	901.76	0.02
11/05/14	901.75		
11/06/14	901.73		
11/07/14	901.72		
11/08/14	901.71		
11/09/14	901.69		
11/10/14	901.69		0.06

Date	Automated Logger (daily average)*	Staff Gage**	Precipitation***
11/11/14	901.68		
11/12/14	901.66		0.03
11/13/14	901.65		
11/14/14	901.63		
11/17/14			0.16
11/19/14			0.01
11/25/14			0.02
11/26/14			0.19
12/01/14			0.14
12/08/14			0.03
12/22/14			0.17
12/23/14			0.12
12/30/14			0.19

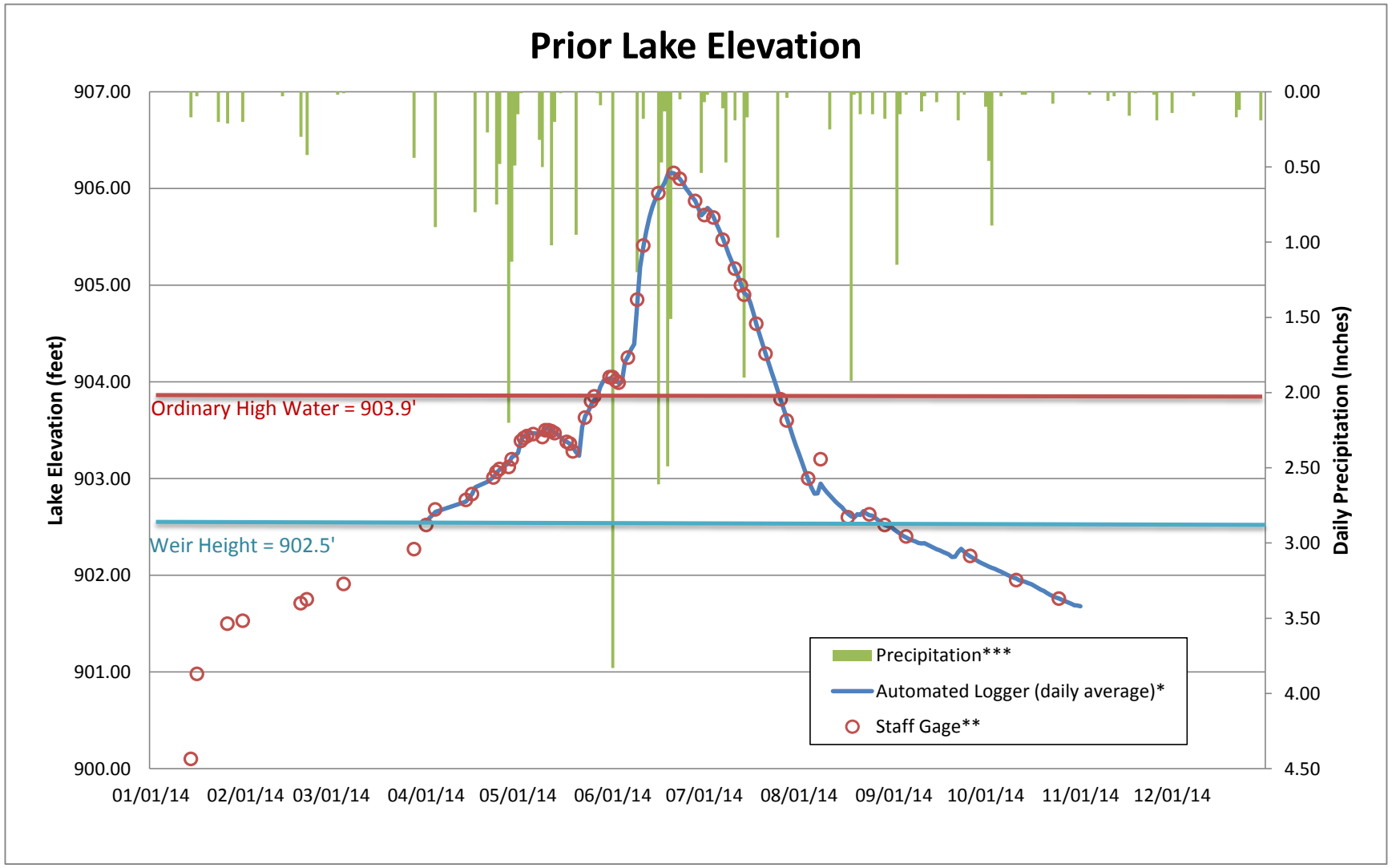
*Automated Logger is an Ott Ecolog 500 located on the outside of the trash barrier on the Outlet Structure. Values are averaged daily.

**Staff Gage is located under Highway 21 Wagon Bridge on pillar

***Precipitation Gage waas located at 14070 Commerce Ave NE (PLSLWD Office) until September 17th, then moved to 4646 Dakota Street SE at Prior Lake City Hall.

ATTACHMENT F

PRIOR LAKE ELEVATIONS GRAPH



*Automated Logger is an Ott Ecolog 500 located on the outside of the trash barrier on the Outlet Structure
**Staff Gage is located under Highway 21 Wagon Bridge on pillar
***Precipitation Gage is located at PLSLWD Office

ATTACHMENT G

SUMMARY OF PRECIPITATION WITHIN PLSLWD

Month	PLSLWD 2014 Office Readings (in.)	PLSLWD 2014 YTD (in.)
Jan	0.81	0.81
Feb	0.75	1.56
Mar	0.47	2.03
Apr	7.02	9.05
May	3.26	12.31
Jun	13.01	25.32
Jul	3.94	29.26
Aug	2.68	31.94
Sep	1.76	33.70
Oct	1.60	35.30
Nov	0.49	35.79
Dec	0.65	36.44
Year Total	36.44	inches

NOAA Scott Co 30yr mo ave*	NOAA Scott Co 30yr YTD ave
0.73	0.73
0.62	1.35
1.73	3.08
2.53	5.61
3.69	9.30
4.64	13.94
3.49	17.43
5.05	22.48
3.41	25.89
2.47	28.36
1.64	30.00
0.95	30.95
30.95	inches

* NOAA 30 year average is per the NWS site in Jordan for the years 1981-2010

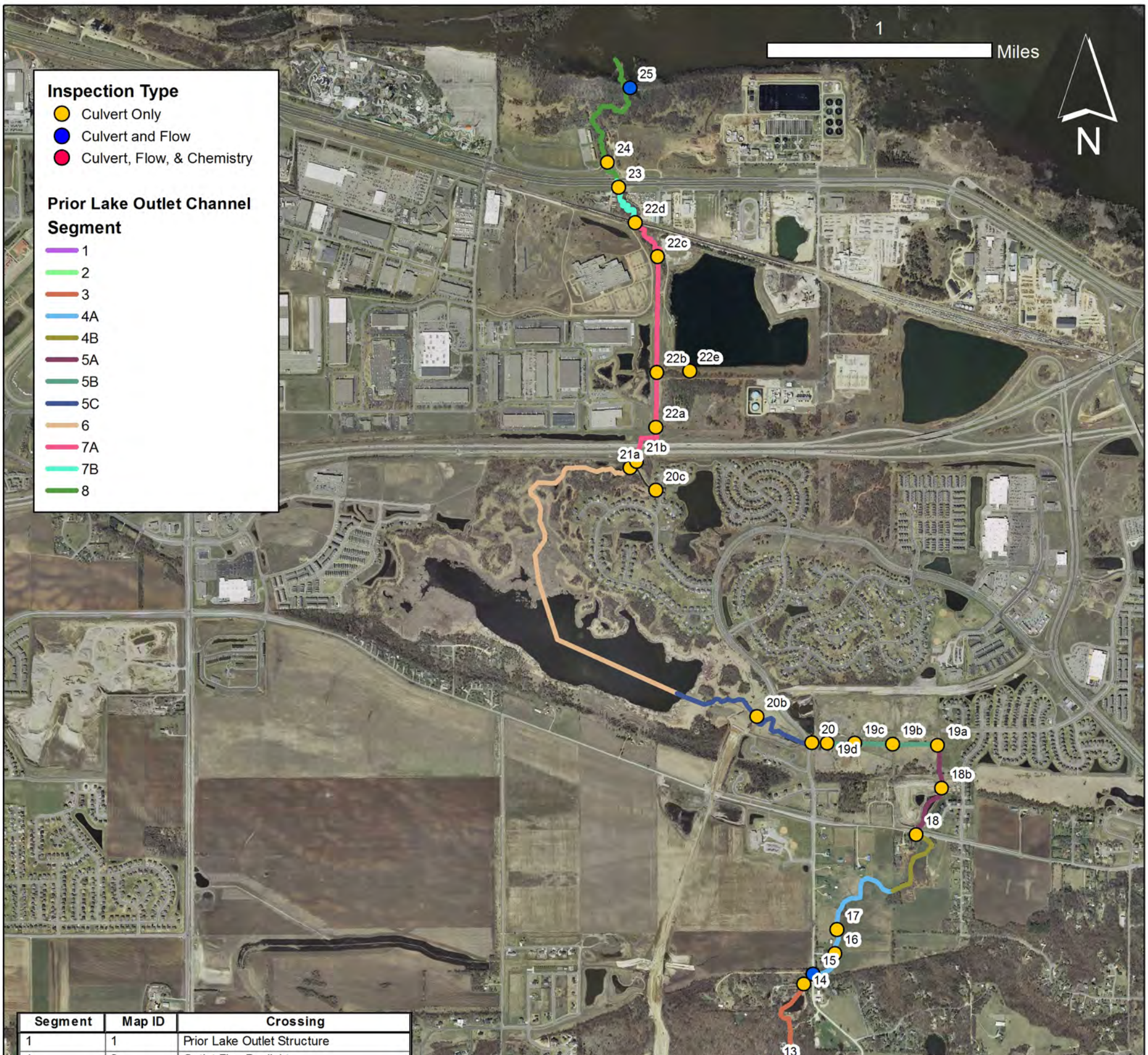
Monthly % Deviation**	Monthly Numeric Deviation	YTD % Deviation	YTD Numeric Deviation
11.0%	0.08	11.0%	0.08
21.0%	0.13	15.6%	0.21
-72.8%	-1.26	-34.1%	-1.05
177.5%	4.49	61.3%	3.44
-11.7%	-0.43	32.4%	3.01
180.4%	8.37	81.6%	11.38
12.9%	0.45	67.9%	11.83
-46.9%	-2.37	42.1%	9.46
-48.4%	-1.65	30.2%	7.81
-35.2%	-0.87	24.5%	6.94
-70.1%	-1.15	19.3%	5.79
-31.6%	-0.30	17.7%	5.49
		17.7%	5.49

**Deviation is calculated by the difference between the current year PLSLWD average and the 30 year Scott County average

ATTACHMENT H

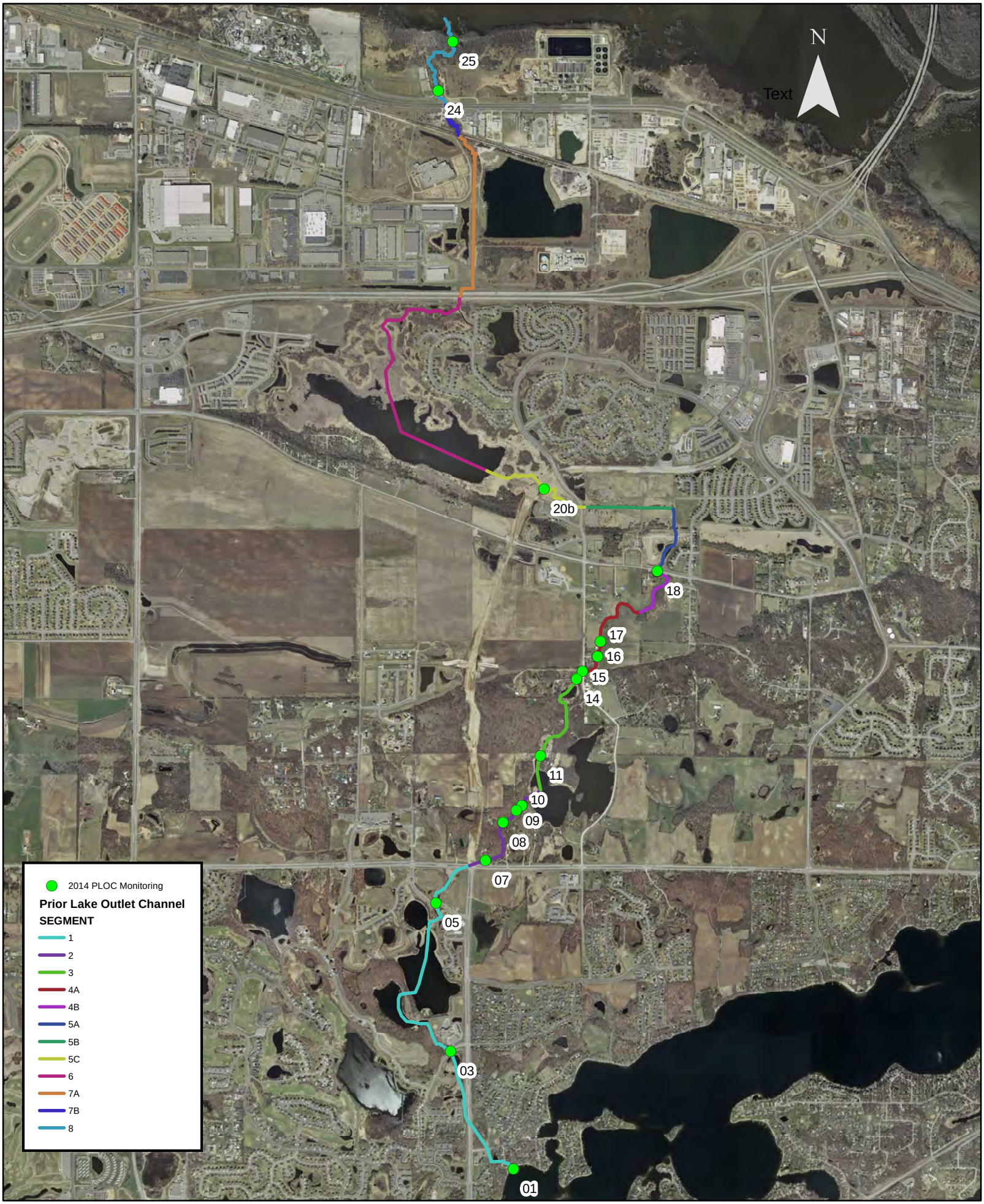
CULVERT INSPECTIONS AND MONITORING SITES

Outlet Channel Inspection Sites



Segment	Map ID	Crossing
1	1	Prior Lake Outlet Structure
1	2	Outlet Pipe Daylight
1	3	Jeffers Pass
1	4	Low er Jeffers RR Culvert
1	5	Fountain Hills Dr
1	6	Co Rd 42
2	7	Squires Drivew ay
2	8	Kes Drivew ay
2	9	Kes Field Crossing
2	10	Pike Lake Park
3	11	Kinney Drivew ay
3	12	Pike Lake Trl Staff Gauge
3	13	Kici Yapi Upper Culvert
3	14	Strauss Drivew ay
3	15	Pike Lake Road S
4a	16	Jackson Trail
4a	17	Field Rd dow nstream of Jackson Trl
5	18	Co Rd 16
5a	18b	Riverside Bluffs
5b	19a	Noecker Crossing #1
5b	19b	Noecker Crossing #2
5b	19c	Noecker Crossing #3
5b	19d	Noecker Crossing #4
5c	20	Pike Lake Road N
5c	20b	CSAH 21
6	20c	Wakefield Circle
6	21a	Dean Lk Outlet
6	21b	Hw y 169
7a	22d	Railroad
7a	22c	Gabions
7a	22e	Quarry Lake Berm
7a	22a	Wier 1
7a	22b	Wier 2
7b	23	Highw ay 101
8	24	USFWS Drivew ay
8	25	Service Trail

2014 PLOC Monitoring Locations



ATTACHMENT I

INSPECTION FREQUENCY GUIDELINES

Prior Lake Outlet Channel Inspection Frequency Guidelines

Semi-annual channel inspections – walk entire length of channel

- Spring erosion inspections – PLSLWD staff to ensure channel is open - look for erosion (leaf off) or blockage before opening outlet structure
- Fall erosion inspections – PLSLWD staff to keep eye out for erosion or blockage issues
- Spring Vegetation Inspections – EOR walk full channel until 2016
- Fall Vegetation Inspections – EOR walk full channel until 2016

All crossings of the outlet channel will be inspected based on risk factor. These are general guidelines and may be modified if needed.

1. **LOW RISK CROSSINGS**.
    - Bridges (Fountain Hills Drive)
    - Box culverts (Riverside Bluffs, Pike Lake Rd N, CR21, Hwy 169, Segment 7 RR, Hwy 101, 2013 Quarry Lake Crossing)
    - Oversized culverts (USFWS Service Trail)
    - Weirs (Dean Lake Outlet, Segment 7 weir, Jeffers weir)
    - Other (Outlet Pipe Daylight, Gabions, Quarry Lake Berm)

2. **MEDIUM RISK CROSSINGS:**
    - All crossings that are not considered high or low risk
    - KiciYapi being inspected by Maintenance crew at YMCA camp

3. **HIGH RISK CROSSINGS.**
    - Grates (CR 42, Outlet Structure)
    - Undersized (Strauss, CR 16, USFWS Driveway)
    - Crossings with items of concern from previous inspections (Jackson Trail and Gonyea in 2014 because of recent construction)

	No Flow from outlet structure	**< 30 cfs from outlet structure**	**>30 cfs from outlet structure or > 3" rain event**
Low Risk	4x/year	4x/year	4x/year
Medium Risk	1x/month	1x/week	1x/week
High Risk	2x/month	1x/ week	2x/week

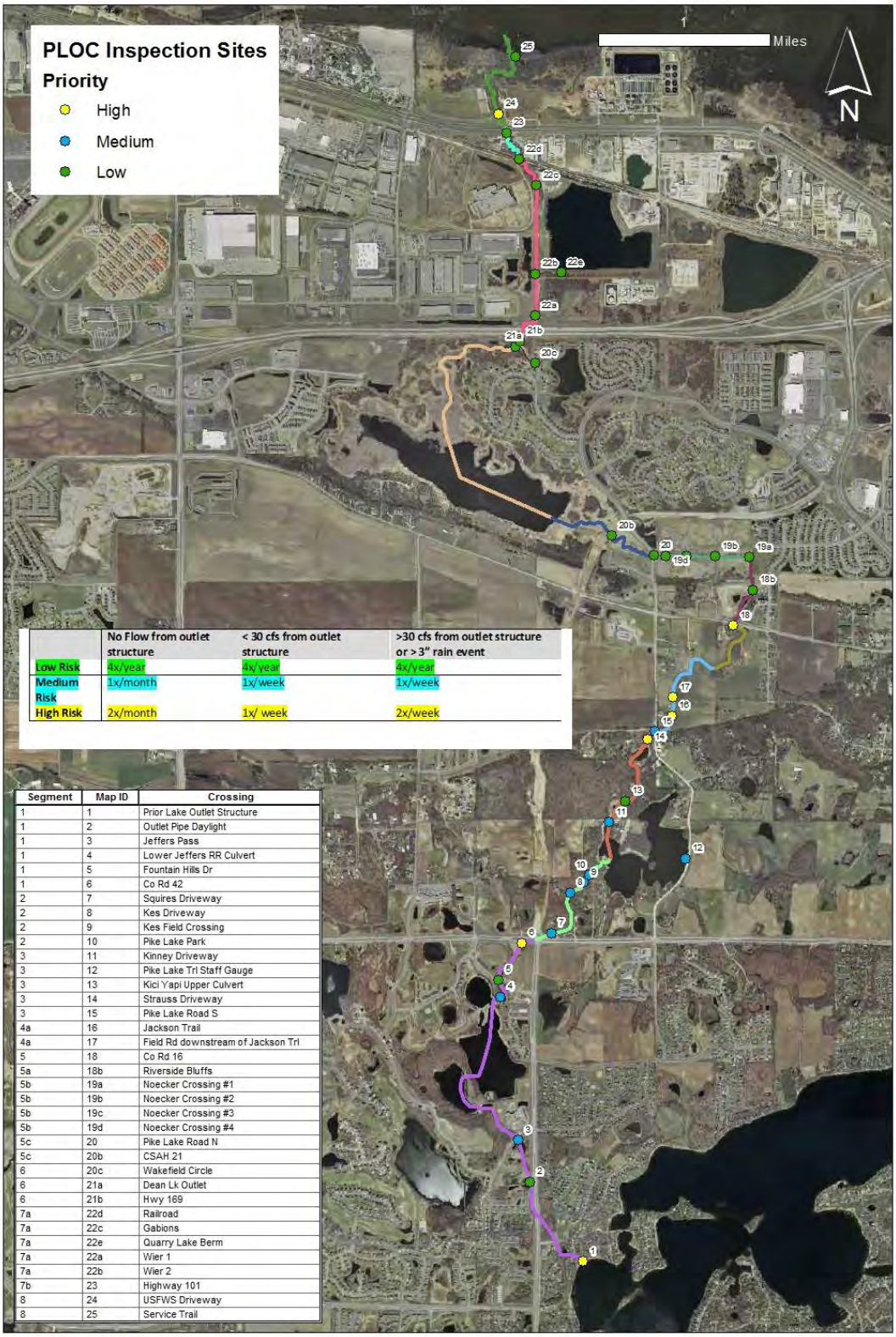
Report Frequency – Reports will only be sent out after spring and fall full-channel inspections and when issues arise and need attention. An annual report also be produced and emailed to all partners by February 20th of each year.

Date:	Current Weather Conditions:
Inspector:	Ground Conditions:
Recent Precip:	Inspection Start Time:
Level of Prior Lake:	Inspection End Time:

Note: Only discrete crossings are listed, record any additional channel conditions in "Notes" section

TIME	*SEGMENT*	*CROSSING NAME/MAP ID #*	*NOTES*
	1	1-Prior Lake Outlet Structure	
	1	2-Outlet Pipe Daylight	
	1	3-Jeffers Pass	
	1	4-Lower Jeffers RR Culvert & Fish Barrier	
	1	5-Fountain Hills Dr	
	1	6-Co Rd 42	
	2	7-Squires Driveway (4070)	
	2	8-Kes Driveway	
	2	9-Kes Field Crossing	
	2	10-Pike Lake Park	
	3	11-Kinney Driveway (4270)	
	3	12-Pike Lake Trl Staff Gauge	
	3	13-Kici Yapi Upper Culvert (camp manager inspects this all year)	
	3	14-Strauss Driveway (2318)	
	3	15-Pike Lake Rd	
	4a	16-Jackson Trail	
	4a	17-Field Rd downstream of Jackson Trl	
	5	18-Co Rd 16	
	5a	18b-Riverside Bluffs (Check West pond outlet)	
	5b	19-Noecker property- 4 crossings total	
	5c	20-Pike Lake Road	
	5c	20b-CSAH 21	
	6	21-Dean Lk Outlet & Hwy 169	
	7a	22-Gabions, Quarry Lake Berm, Railroad, New Quarry Lake Park Crossing	
	7b	23-Highway 101	
	8	24-US FWS Driveway	
	8	25-Service Trail	

Outlet Channel Inspection Sites



	No Flow from outlet structure	< 30 cfs from outlet structure	>30 cfs from outlet structure or > 3" rain event
Low Risk	4x/year	4x/year	4x/year
Medium Risk	1x/month	1x/week	1x/week
High Risk	2x/month	1x/ week	2x/week

Segment	Map ID	Crossing
1	1	Prior Lake Outlet Structure
1	2	Outlet Pipe Daylight
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1	6	Co Rd 42
2	7	Squires Driveway
2	8	Kes Driveway
2	9	Kes Field Crossing
2	10	Pike Lake Park
3	11	Kinney Driveway
3	12	Pike Lake Trl Staff Gauge
3	13	Kici Yapi Upper Culvert
3	14	Strauss Driveway
3	15	Pike Lake Road S
4a	16	Jackson Trail
4a	17	Field Rd downstream of Jackson Trl
5	18	Co Rd 16
5a	18b	Riverside Bluffs
5b	19a	Noecker Crossing #1
5b	19b	Noecker Crossing #2
5b	19c	Noecker Crossing #3
5b	19d	Noecker Crossing #4
5c	20	Pike Lake Road N
5c	20b	CSAH 21
6	20c	Wakefield Circle
6	21a	Dean Lk Outlet
6	21b	Hwy 169
7a	22d	Railroad
7a	22c	Gabions
7a	22e	Quarry Lake Berm
7a	22a	Wier 1
7a	22b	Wier 2
7b	23	Highway 101
8	24	USFWS Driveway
8	25	Service Trail

ATTACHMENT J

BANK EROSION INVENTORY

Emmons & Olivier Resources, Inc.
for the Prior Lake - Spring Lake Watershed District

Prior Lake Outlet Channel Bank Erosion Inventory

Fall 2014

EOR water ecology community

Cover Images

Left Image: Photo of bank erosion. Emmons & Olivier Staff - September 2014.

Right Image: Photo of bank erosion. Emmons & Olivier Staff - September 2014.

Document Component Specs

Text: Staples • multipurpose paper, 24 lb. text – 50% post-consumer fibers, FSC Certified.
Back Cover: Neenah Paper • Esse • Texture, Sapphire • 100 lb. cover • 30% post-consumer fibers, Green Seal® Certified
Wire Binding: Manufactured using recycled high carbon steel

Background

From June 1 to June 30, 2014, the Prior Lake-Spring Lake Watershed district received 11.70 inches of rain in Township 114 N, Range 22W, Section 3 (Lower Prior Lake) and 13.79 inches of rain in Township 114N, Range 22W, Section 16 (Spring Lake) according to precipitation data downloaded from the Minnesota Climatology Network. The Lower Prior Lake outlet operated at full capacity from the first week of June through the first week in August, resulting in sustained high flows in the Prior Lake Outlet Channel (PLOC). During this time, several culverts along the PLOC were washed out including the new Gonyea culvert in Segment 4, the County Road 16 culvert at the downstream end of Segment 4, and the two culverts under the USFWS gravel maintenance road at the upstream end of Segment 8. The water level in Lower Prior Lake dropped below the outlet elevation on September 11. After water levels receded in the channel, an inventory of bank erosion was requested by the Prior Lake Outlet Channel Joint Powers Agreement members to document the channel condition along the entire PLOC and develop a cost estimate and ranking system to guide bank restoration activities in each segment.

Methodology

Bank erosion along the PLOC was assessed from Segment 1 to Segment 8 in mid-September of 2014. For each segment, the channel was walked from upstream to downstream and the length and height of each raw or eroded bank was surveyed. Bank lengths were surveyed using a Trimble sub-meter handheld GPS unit. For each eroded bank, a start point was logged at the upstream end of the bank and a stop point was logged at the downstream end of the bank. Survey points were also collected in between start and stop points and along bank meanders. In addition, bank height was measured from toe of slope to top of bank at each survey point using a telescopic stadia rod with $1/100^{th}$ foot graduations. Following the completion of the erosion assessment, all survey data was imported into ArcGIS to measure bank lengths and calculate average bank heights. The length of each bank was measured by digitizing between the survey points. To determine priority sites for bank restoration, each bank was ranked with a low, moderate, or high priority identifier depending on the bank condition. Bank condition was ranked based on the average eroded bank height and maximum eroded bank height of each bank. The maximum bank height was measured at the highest eroded point along each bank. In general, average bank heights 2.0 feet or less with maximum eroded bank heights 3.0 feet or less were rated low priority, average bank heights between 2.0 feet and 3.0 feet with maximum eroded bank heights between 3.1 and 4.5 feet were rated moderate priority, and average bank heights greater than 3.0 feet with maximum eroded bank heights greater than 4.5 feet were rated high priority.

Results

The following is a summary of bank erosion for each segment. An overview map displays the locations of the eroded banks followed by a table that includes the bank ID, location, bank length, average bank height, maximum bank height, priority ranking, and estimated cost for each bank identified on the map. Due to the orientation and scale of the PLOC, the segments were divided into reaches to accommodate map labels and features. The upper, middle, and lower reach labels denote the upstream, middle, and downstream sections of the segments respectively.

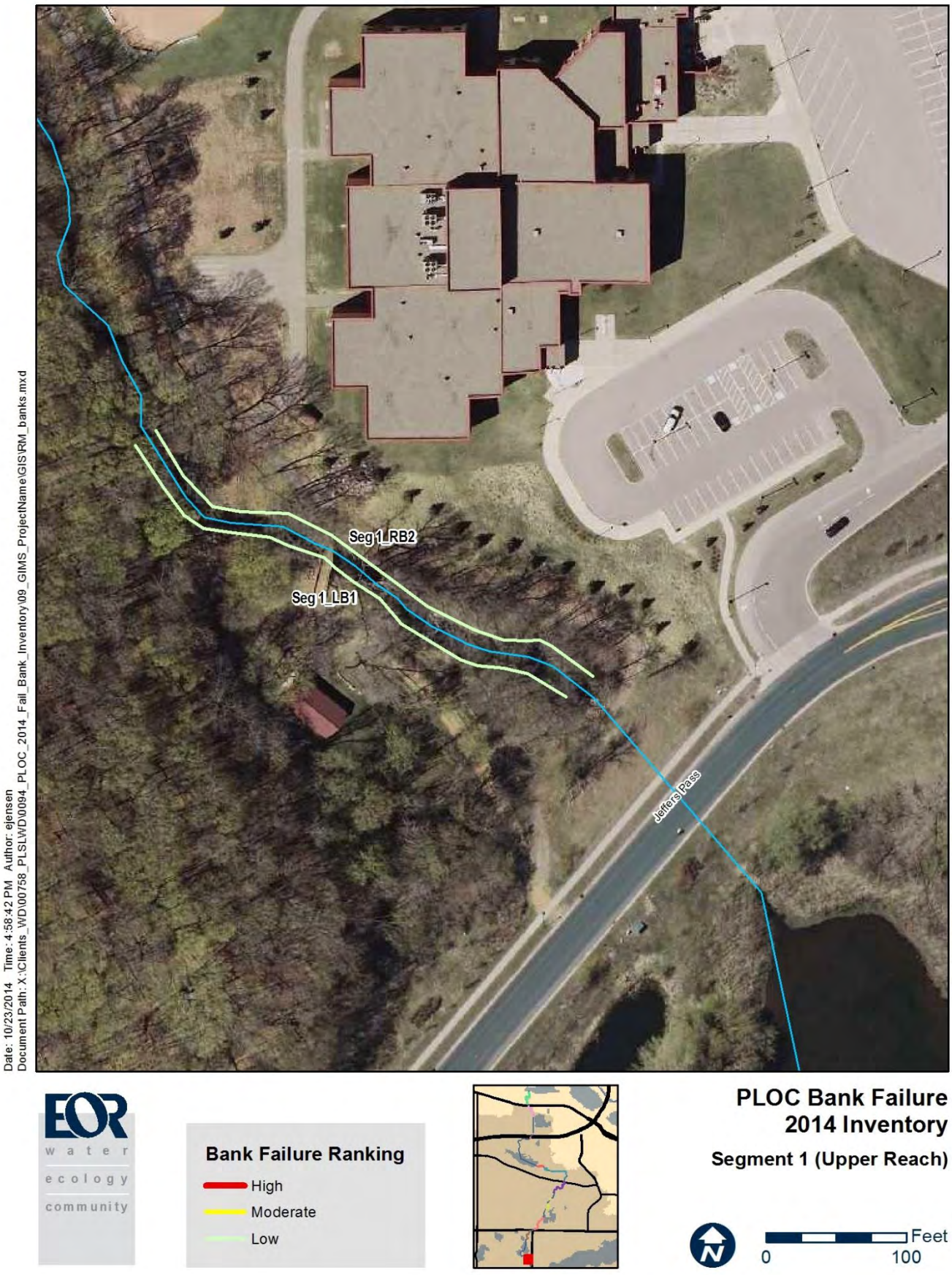


Figure 1. Segment 1 (Upper Reach) Bank Erosion Location.

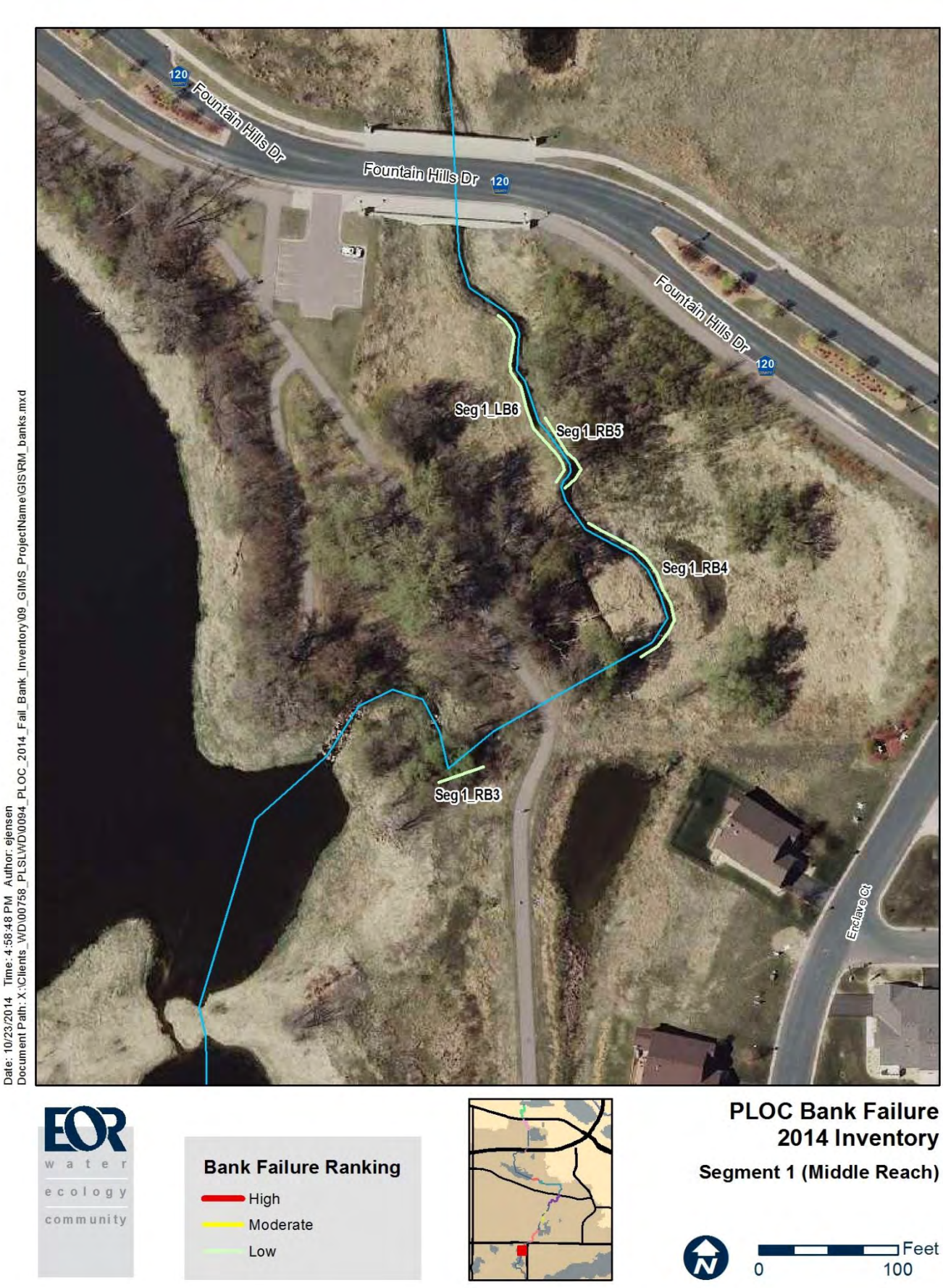


Figure 2. Segment 1 (Middle Reach) Bank Erosion Locations

Figure 3. Segment 1 (Lower Reach) Bank Erosion Locations

Table 1. Segment 1 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 1_LB1	Left Bank	370	2.0	2.5	Low	$20,774
Seg 1_RB2	Right Bank	373	2.0	2.6	Low	$20,942
Seg 1_RB3	Right Bank	34	2.4	2.8	Low	$1,909
Seg 1_RB4	Right Bank	135	1.2	1.2	Low	$7,580
Seg 1_RB5	Right Bank	63	1.3	1.8	Low	$3,537
Seg 1_LB6	Left Bank	138	1.7	2.4	Low	$7,748
Seg 1_RB7	Right Bank	381	2.1	3.0	Low	$21,391
Seg 1_LB8	Left Bank	207	1.8	2.1	Low	$11,622
Seg 1_LB9	Left Bank	33	2.8	2.8	Low	$1,853
Seg 1_RB10	Right Bank	68	2.6	3.0	Low	$3,818
Seg 1_RB11	Right Bank	68	2.1	2.5	Low	$3,818
Seg 1_RB12	Right Bank	126	2.0	2.2	Low	$7,074
Seg 1_LB13	Left Bank	121	2.2	3.0	Low	$6,794
Seg 1_LB14	Left Bank	61	1.4	1.9	Low	$3,425
	Total Length	**2178**			**Segment Total**	**$122,284**

Figure 4. Segment 2 (Upper Reach) Bank Erosion Locations

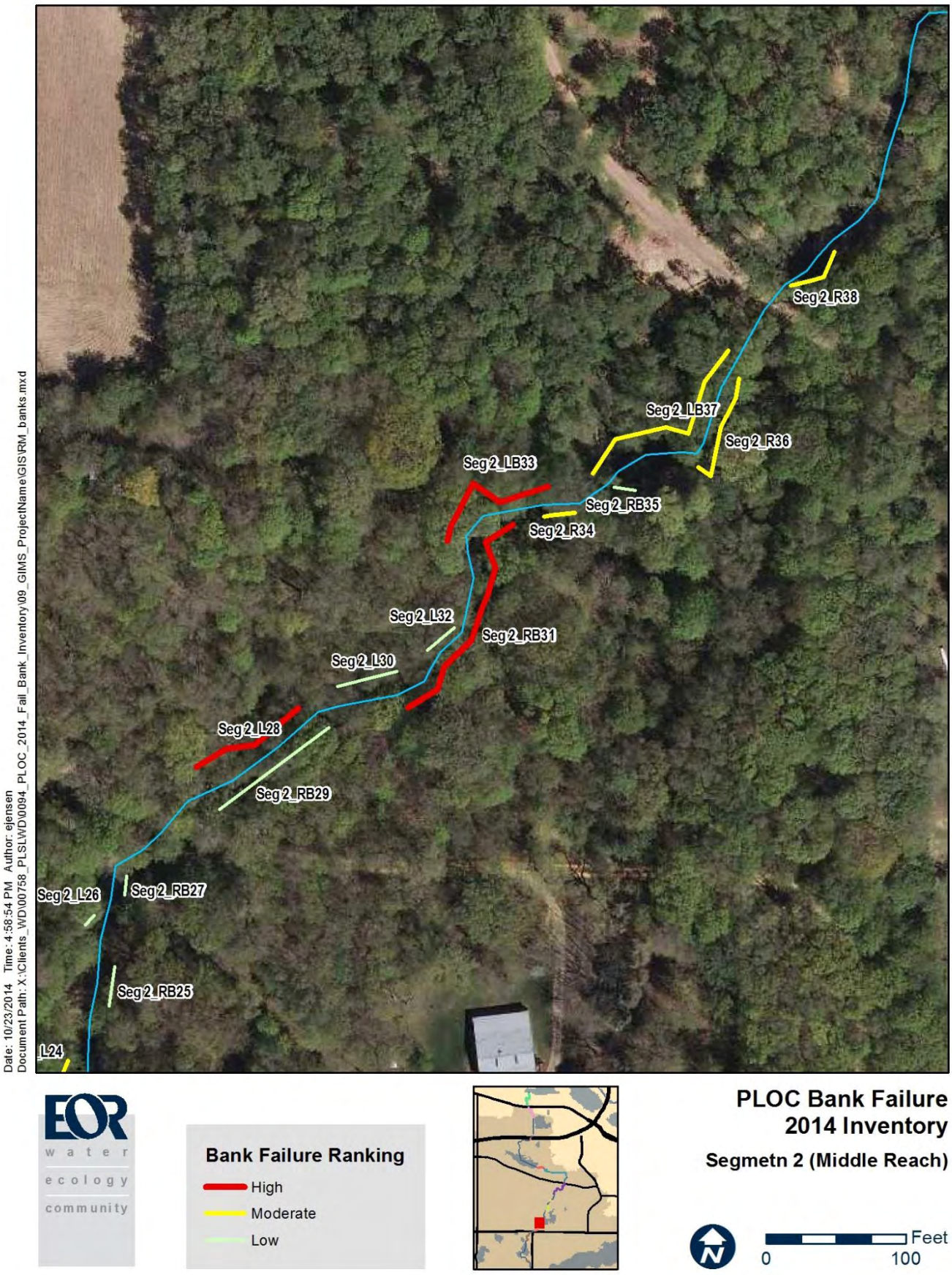


Figure 5. Segment 2 (Middle Reach) Bank Erosion Locations

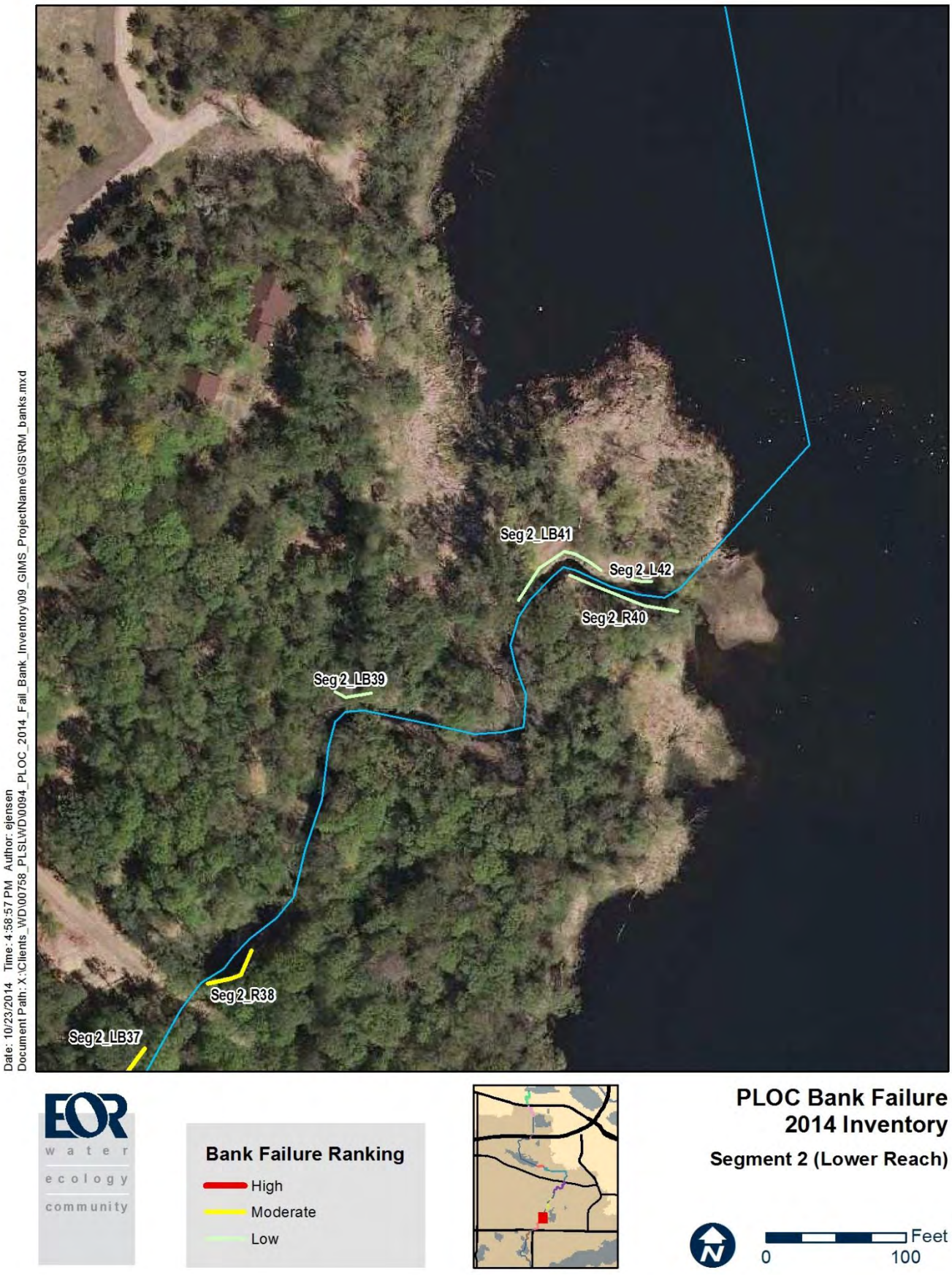


Figure 6. Segment 2 (Lower Reach) Bank Erosion Locations

Table 2. Segment 2 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 2_RB15	Right Bank	25	3.0	3.0	Moderate	$1,558
Seg 2_LB16	Left Bank	161	4.2	8.8	High	$10,029
Seg 2_R17	Right Bank	71	2.7	6.0	High	$4,414
Seg 2_L18	Left Bank	35	1.9	2.5	Low	$2,180
Seg 2_LB19	Left Bank	80	3.7	7.0	High	$4,997
Seg 2_R20	Right Bank	200	2.2	3.0	Low	$12,414
Seg 2_LB21	Left Bank	142	2.3	6.0	High	$8,827
Seg 2_R22	Right Bank	58	3.0	8.0	High	$3,613
Seg 2_LB23	Left Bank	19	6.5	7.0	High	$1,173
Seg 2_L24	Left Bank	160	2.2	3.1	Moderate	$9,922
Seg 2_RB25	Right Bank	28	1.7	2.2	Low	$1,765
Seg 2_L26	Left Bank	9	1.8	2.0	Low	$558
Seg 2_RB27	Right Bank	14	2.1	2.2	Low	$842
Seg 2_L28	Left Bank	86	4.4	7.5	High	$5,357
Seg 2_RB29	Right Bank	97	0.8	1.0	Low	$6,046
Seg 2_L30	Left Bank	44	2.0	2.4	Low	$2,713
Seg 2_RB31	Right Bank	166	2.8	6.5	High	$10,307
Seg 2_L32	Left Bank	25	1.0	1.0	Low	$1,544
Seg 2_LB33	Left Bank	104	4.7	9.5	High	$6,468
Seg 2_R34	Right Bank	22	2.1	3.3	Moderate	$1,382
Seg 2_RB35	Right Bank	15	1.5	2.5	Low	$949
Seg 2_R36	Right Bank	84	2.3	3.3	Moderate	$5,208
Seg 2_LB37	Left Bank	149	1.6	4.5	Moderate	$9,265
Seg 2_R38	Right Bank	43	2.1	4.0	Moderate	$2,696
Seg 2_LB39	Left Bank	27	1.0	1.8	Low	$1,677
Seg 2_R40	Right Bank	82	1.8	2.8	Low	$5,075
Seg 2_LB41	Left Bank	78	1.4	3.0	Low	$4,854
Seg 2_L42	Left Bank	14	1.2	2.2	Low	$882
	Total Length	**2037**			**Segment Total**	**$126,714**

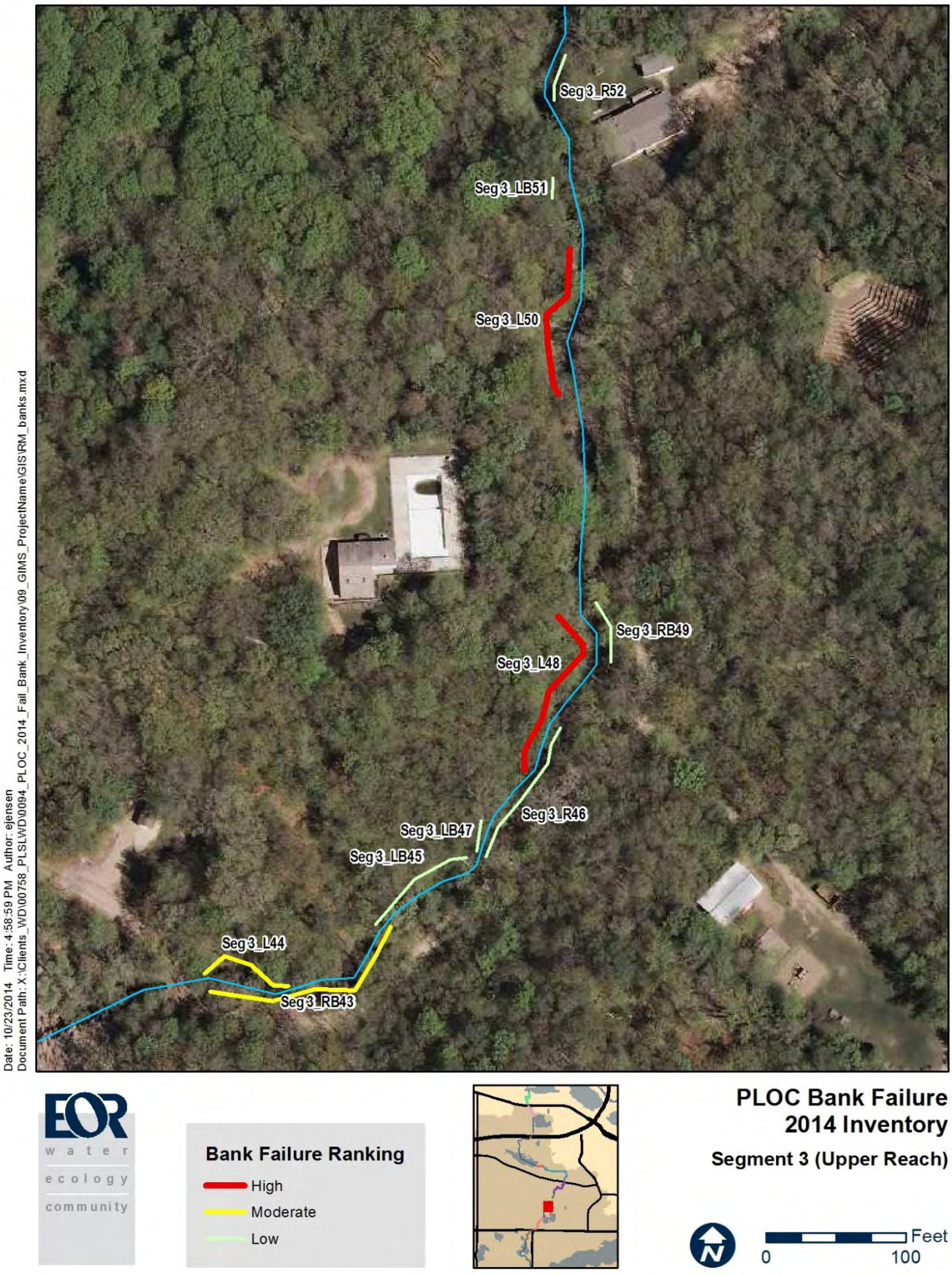


Figure 7. Segment 3 (Upper Reach) Bank Erosion Locations

Figure 8. Segment 3 (Lower Reach) Bank Erosion Locations

Table 3. Segment 3 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 3_RB43	Right Bank	157	2.0	3.9	Moderate	$9,646
Seg 3_L44	Left Bank	71	2.4	4.2	Moderate	$4,396
Seg 3_LB45	Left Bank	83	1.6	2.7	Low	$5,104
Seg 3_R46	Right Bank	108	1.5	2.9	Low	$6,621
Seg 3_LB47	Left Bank	22	1.8	2.5	Low	$1,339
Seg 3_L48	Left Bank	130	3.6	8.0	High	$8,025
Seg 3_RB49	Right Bank	46	1.6	3.1	Low	$2,802
Seg 3_L50	Left Bank	112	4.2	6.8	High	$6,897
Seg 3_LB51	Left Bank	14	2.5	3.0	Low	$889
Seg 3_R52	Right Bank	34	1.9	2.5	Low	$2,082
Seg 3_RB53	Right Bank	24	1.4	2.3	Low	$1,483
Seg 3_L54	Left Bank	132	1.8	2.8	Low	$8,107
	Total Length	**932**			**Segment Total**	**$57,390**

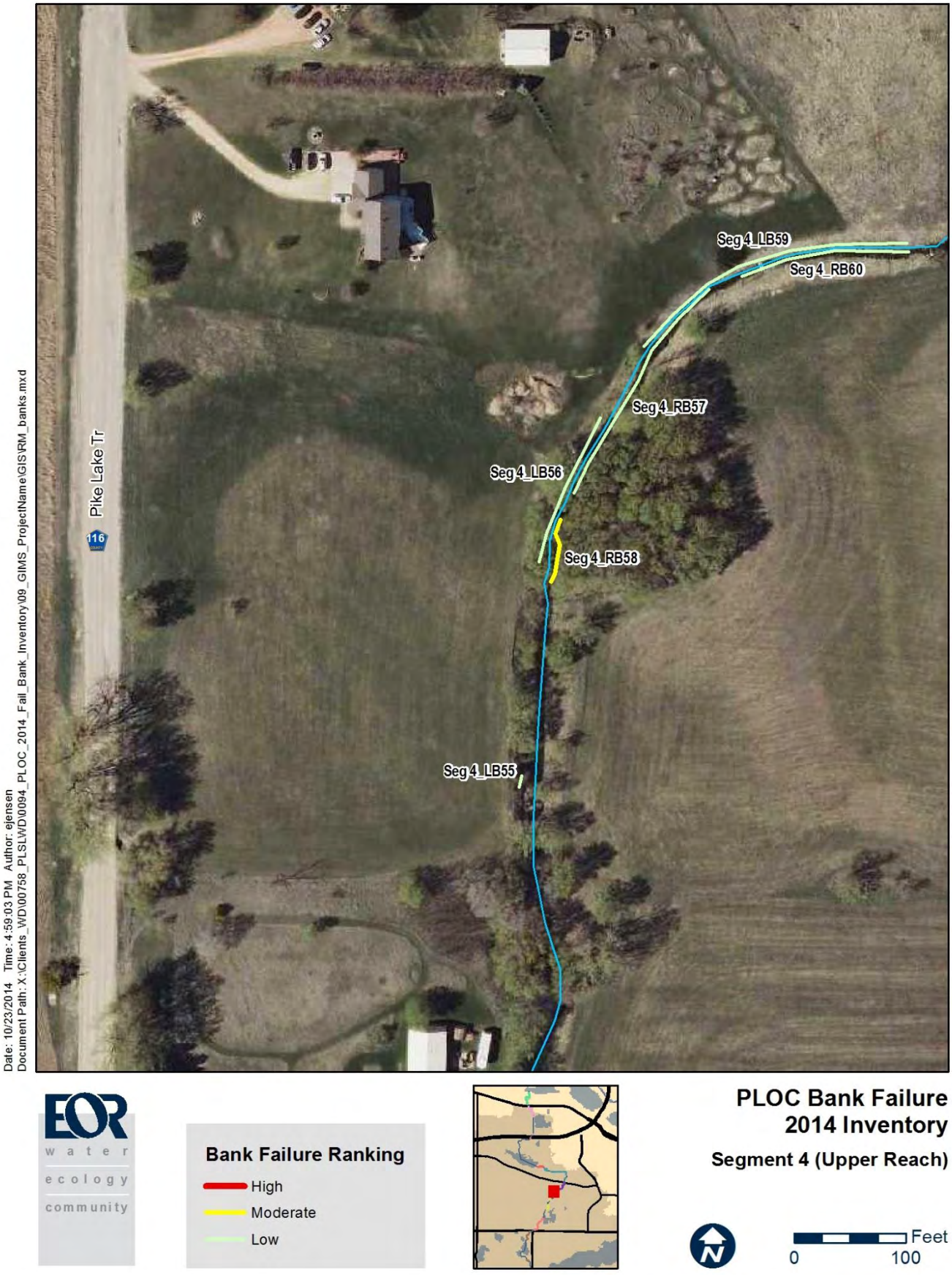


Figure 9. Segment 4 (Upper Reach) Bank Erosion Locations

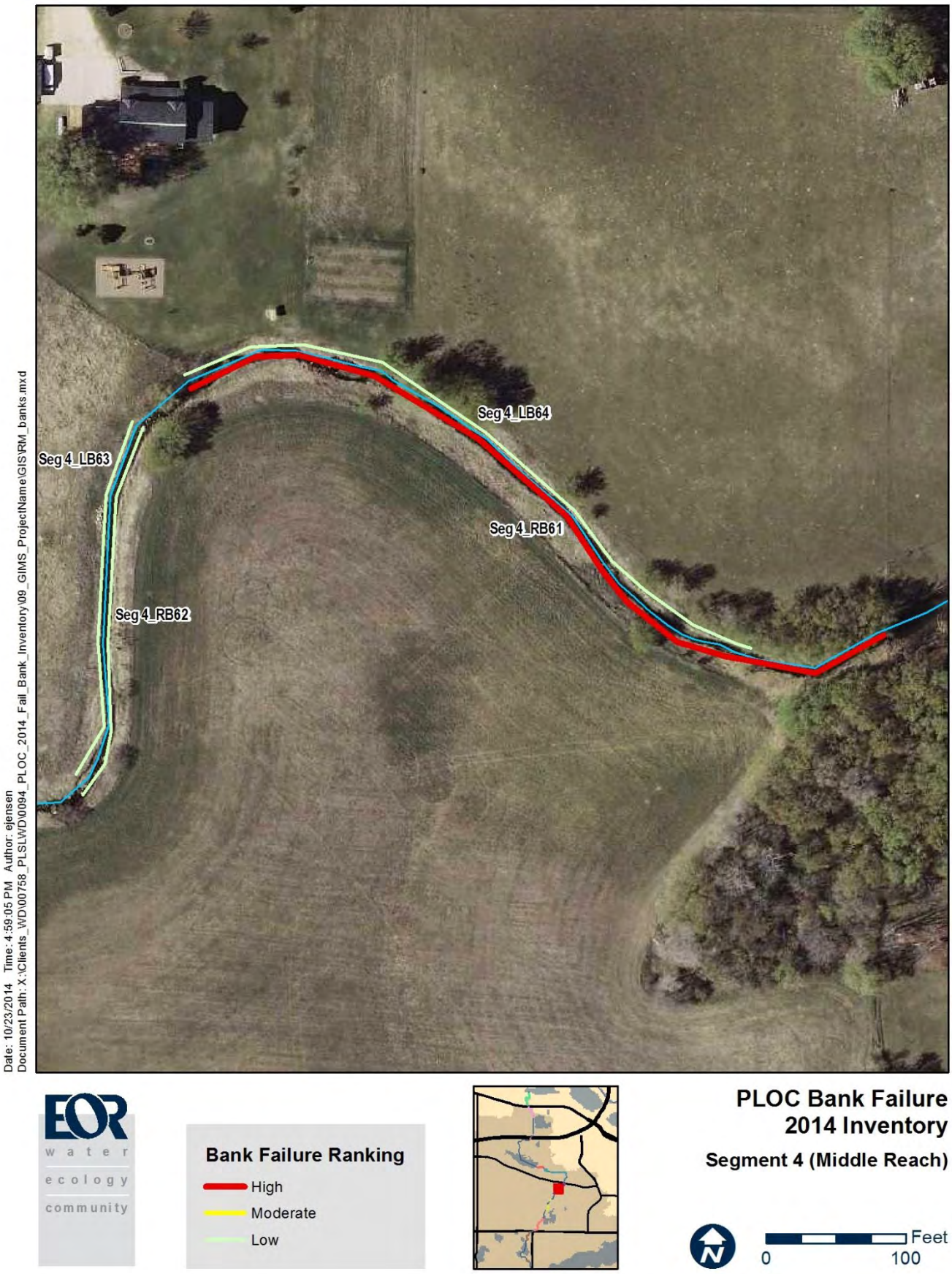


Figure 10. Segment 4 (Middle Reach) Bank Erosion Locations

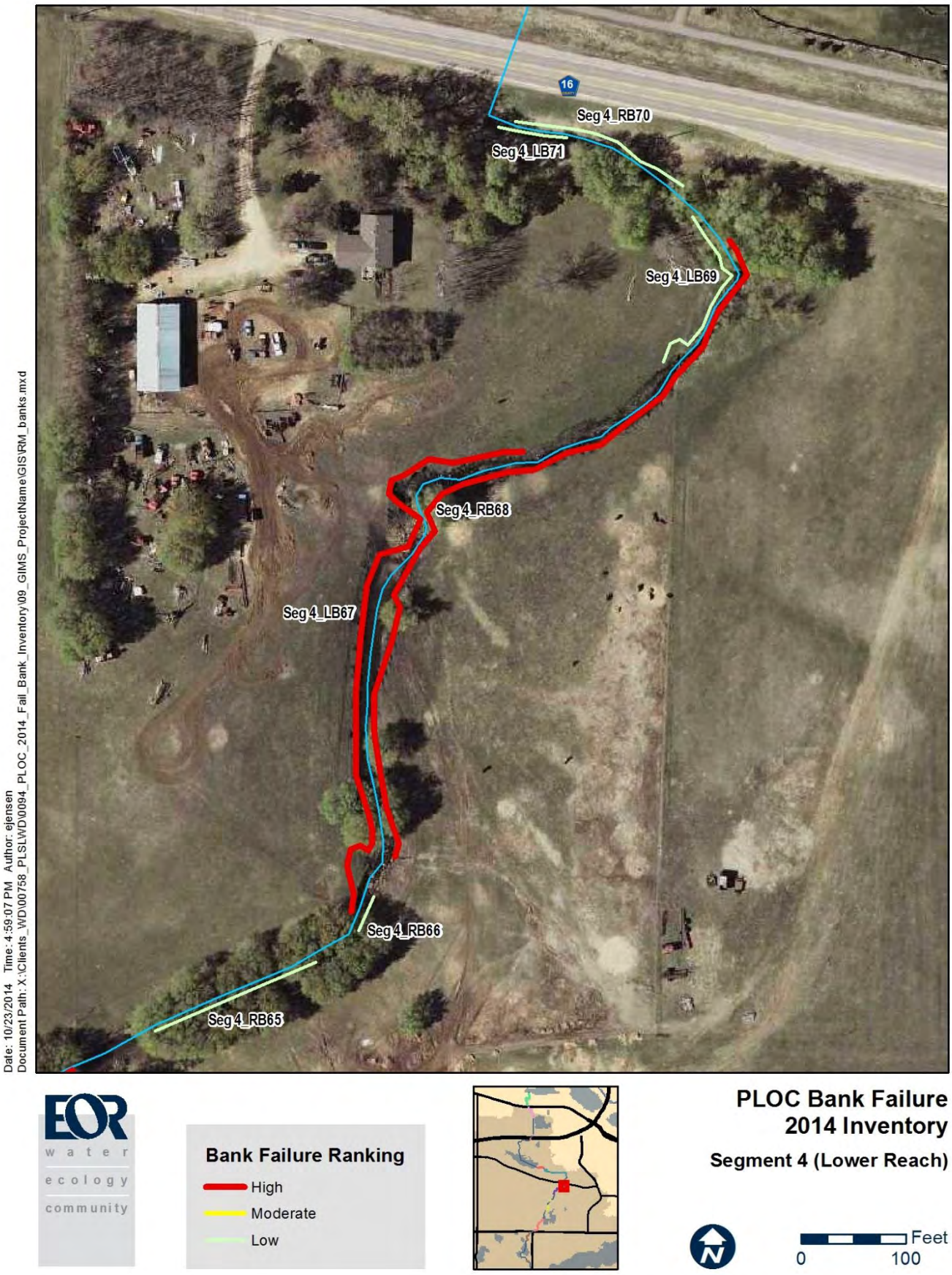


Figure 11. Segment 4 (Lower) Bank Erosion Locations

Table 4. Segment 4 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 4_LB55	Left Bank	10	1.4	2.0	Low	$572
Seg 4_LB56	Left Bank	139	1.7	2.5	Low	$7,844
Seg 4_RB57	Right Bank	220	1.3	1.7	Low	$12,360
Seg 4_RB58	Right Bank	58	2.7	4.0	Moderate	$3,242
Seg 4_LB59	Left Bank	263	1.4	2.0	Low	$14,819
Seg 4_RB60	Right Bank	152	0.9	1.0	Low	$8,560
Seg 4_RB61	Right Bank	585	2.4	4.5	High	$32,949
Seg 4_RB62	Right Bank	271	1.5	2.5	Low	$15,245
Seg 4_LB63	Left Bank	260	1.3	1.5	Low	$14,652
Seg 4_LB64	Left Bank	482	1.4	2.5	Low	$27,150
Seg 4_RB65	Right Bank	166	2.2	2.3	Low	$9,330
Seg 4_RB66	Right Bank	35	1.2	1.3	Low	$1,970
Seg 4_LB67	Left Bank	606	3.1	7.5	High	$34,128
Seg 4_RB68	Right Bank	783	2.4	5.3	High	$44,094
Seg 4_LB69	Left Bank	185	1.6	3.1	Low	$10,420
Seg 4_RB70	Right Bank	174	1.7	2.6	Low	$9,814
Seg 4_LB71	Left Bank	65	1.7	2.5	Low	$3,667
	Total Length	**4456**			**Segment Total**	**$250,817**

Note that the outlet channel through the Miller property located between Pike Lake Trail and the Jackson field road crossing was not assessed. The channel will be reconstructed in 2015 under a separate contract.

Figure 12. Segment 5 (Upper Reach) Bank Erosion Locations

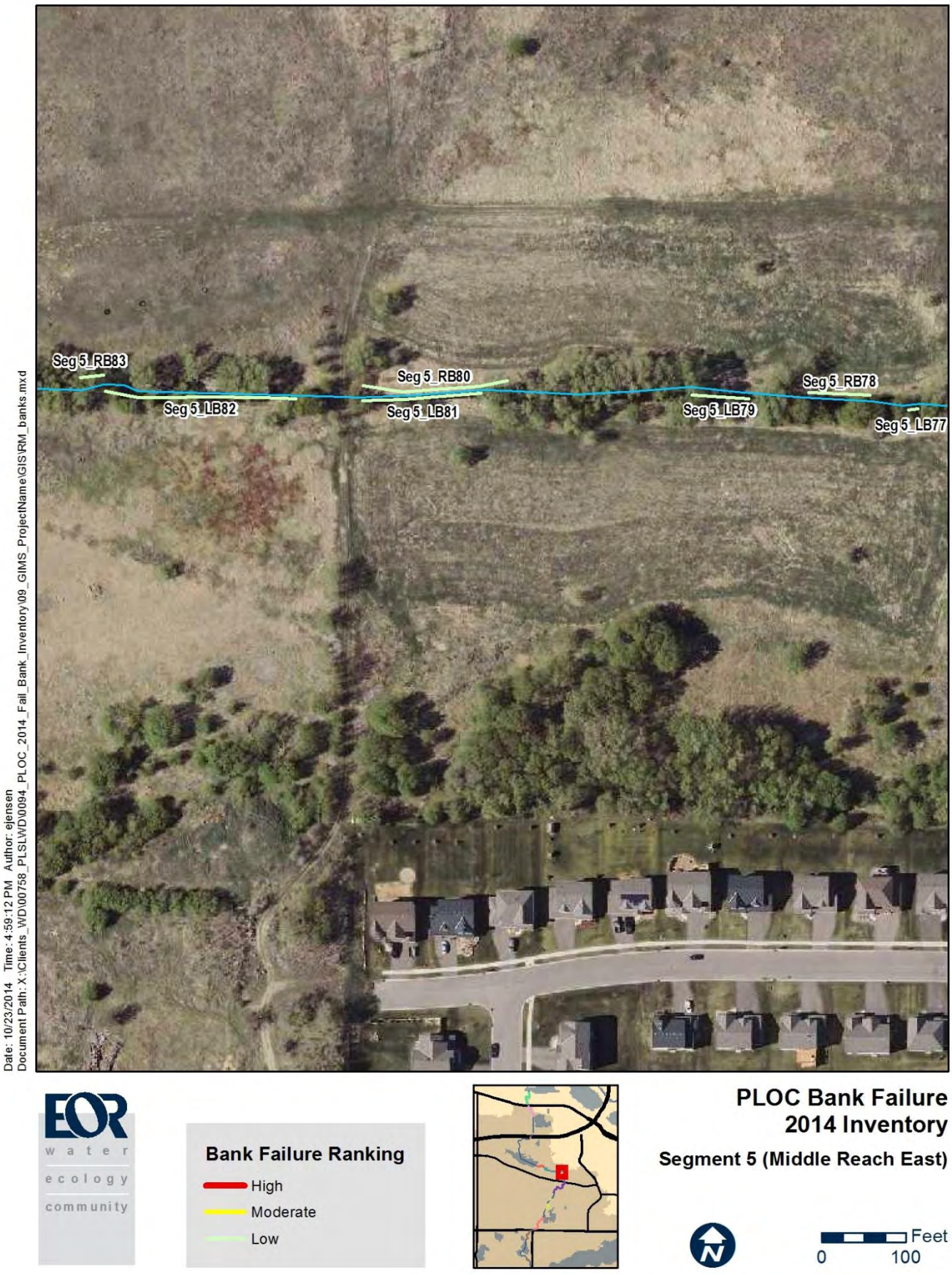


Figure 13. Segment 5 (Middle Reach East) Bank Erosion Locations

Figure 14. Segment 5 (Middle Reach West) Bank Erosion Locations

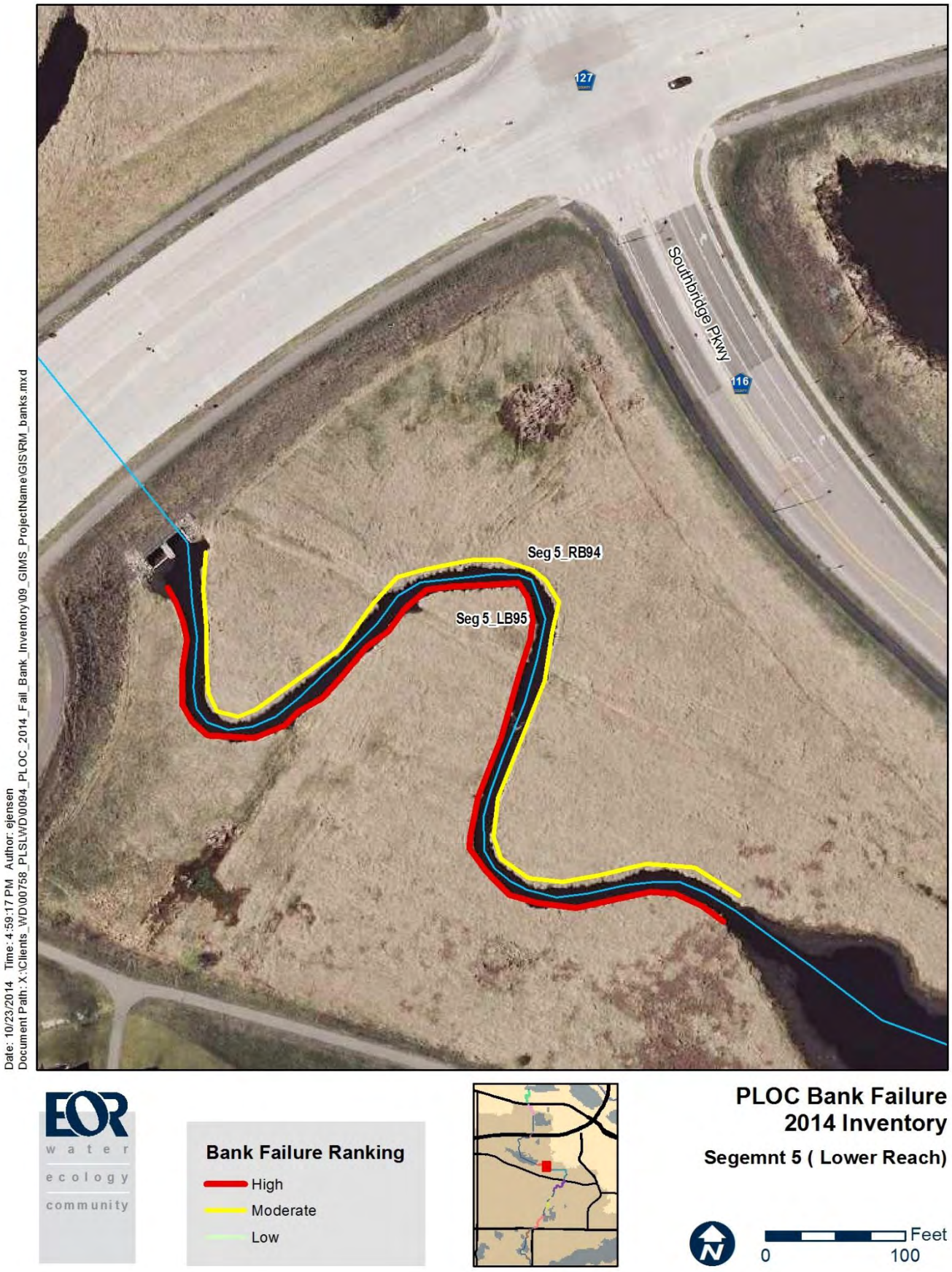


Figure 15. Segment 5 (Lower Reach) Bank Erosion Locations

Table 5. Segment 5 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 5_RB72	Right Bank	90	1.3	2.0	Low	$5,155
Seg 5_LB73	Left Bank	48	1.5	2.5	Low	$2,719
Seg 5_LB74	Left Bank	326	1.6	2.3	Low	$18,599
Seg 5_RB75	Right Bank	15	1.2	1.3	Low	$830
Seg 5_RB76	Right Bank	276	1.8	2.5	Low	$15,740
Seg 5_LB77	Left Bank	11	1.2	1.4	Low	$648
Seg 5_RB78	Right Bank	73	0.6	0.6	Low	$4,142
Seg 5_LB79	Left Bank	67	1.2	1.3	Low	$3,840
Seg 5_RB80	Right Bank	173	1.3	2.0	Low	$9,850
Seg 5_LB81	Left Bank	141	1.2	1.5	Low	$8,063
Seg 5_LB82	Left Bank	227	1.6	2.5	Low	$12,936
Seg 5_RB83	Right Bank	28	1.0	1.0	Low	$1,591
Seg 5_RB84	Right Bank	22	1.6	2.5	Low	$1,279
Seg 5_RB85	Right Bank	50	1.4	1.8	Low	$2,854
Seg 5_RB86	Right Bank	83	2.0	2.5	Low	$4,710
Seg 5_RB87	Right Bank	128	2.7	6.0	High	$7,287
Seg 5_LB88	Left Bank	24	1.2	1.2	Low	$1,380
Seg 5_LB89	Left Bank	145	2.1	3.0	Low	$8,243
Seg 5_LB90	Left Bank	96	1.8	2.6	Low	$5,464
Seg 5_RB91	Right Bank	49	1.8	2.2	Low	$2,819
Seg 5_LB92	Left Bank	155	2.1	3.0	Low	$8,811
Seg 5_RB93	Right Bank	133	1.8	2.0	Low	$7,607
Seg 5_RB94	Right Bank	786	2.5	3.3	Moderate	$44,823
Seg 5_LB95	Left Bank	783	2.9	5.0	High	$44,631
	Total Length	**3930**			**Segment Total**	**$224,022**

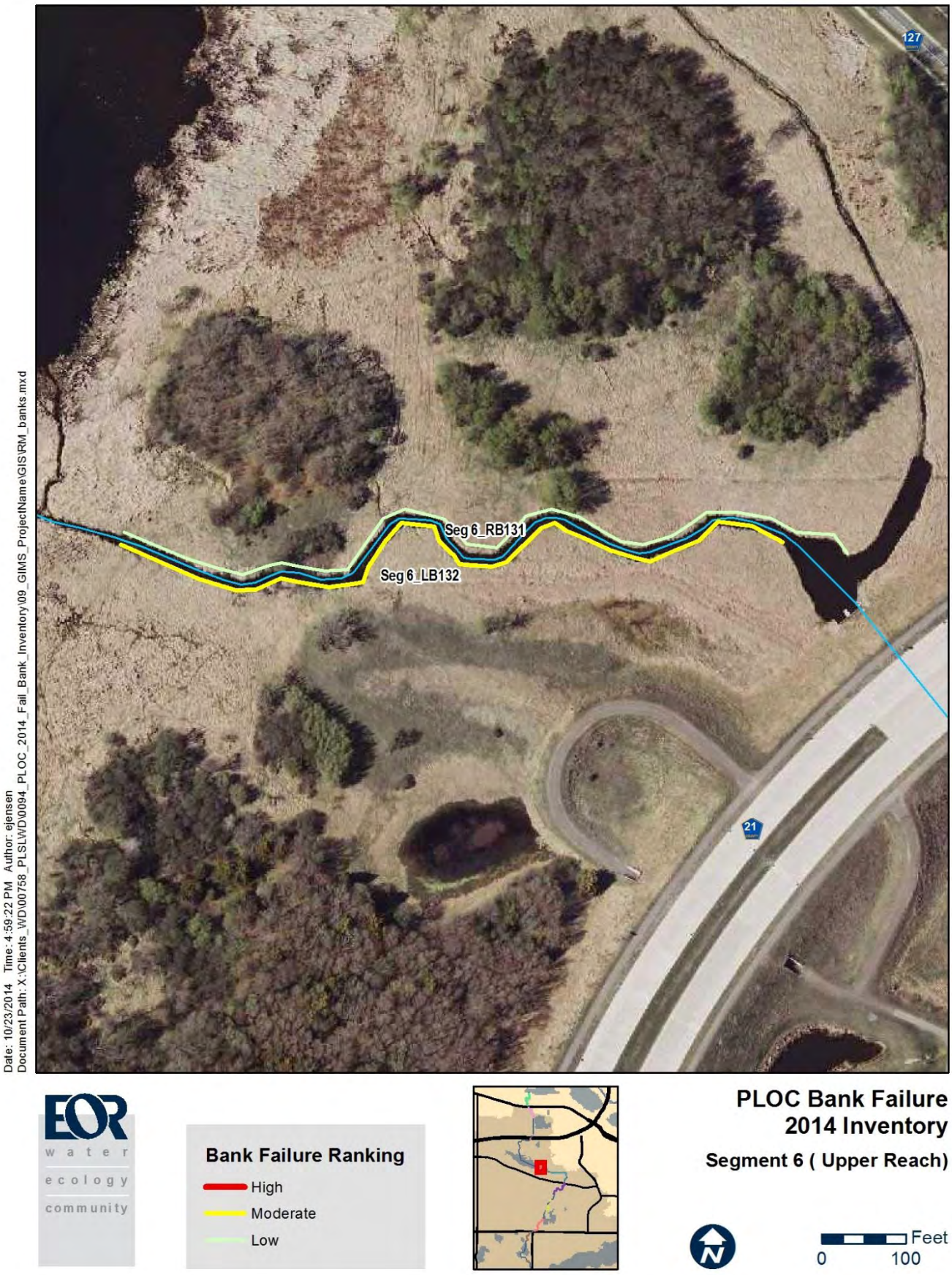


Figure 16. Segment 6 (Upper Reach) Bank Erosion Locations

Figure 17. Segment 6 (Lower Reach) and Segment 7 (Upper Reach) Bank Erosion Locations

Table 6. Segment 6 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 6_RB131	Right Bank	974	2.2	3.0	Low	$57,090
Seg 6_LB132	Left Bank	913	2.5	3.2	Moderate	$53,489
Seg 6_LB133	Left Bank	120	2.0	3.0	Low	$7,011
	Total Length	**2007**			**Segment Total**	**$117,591**

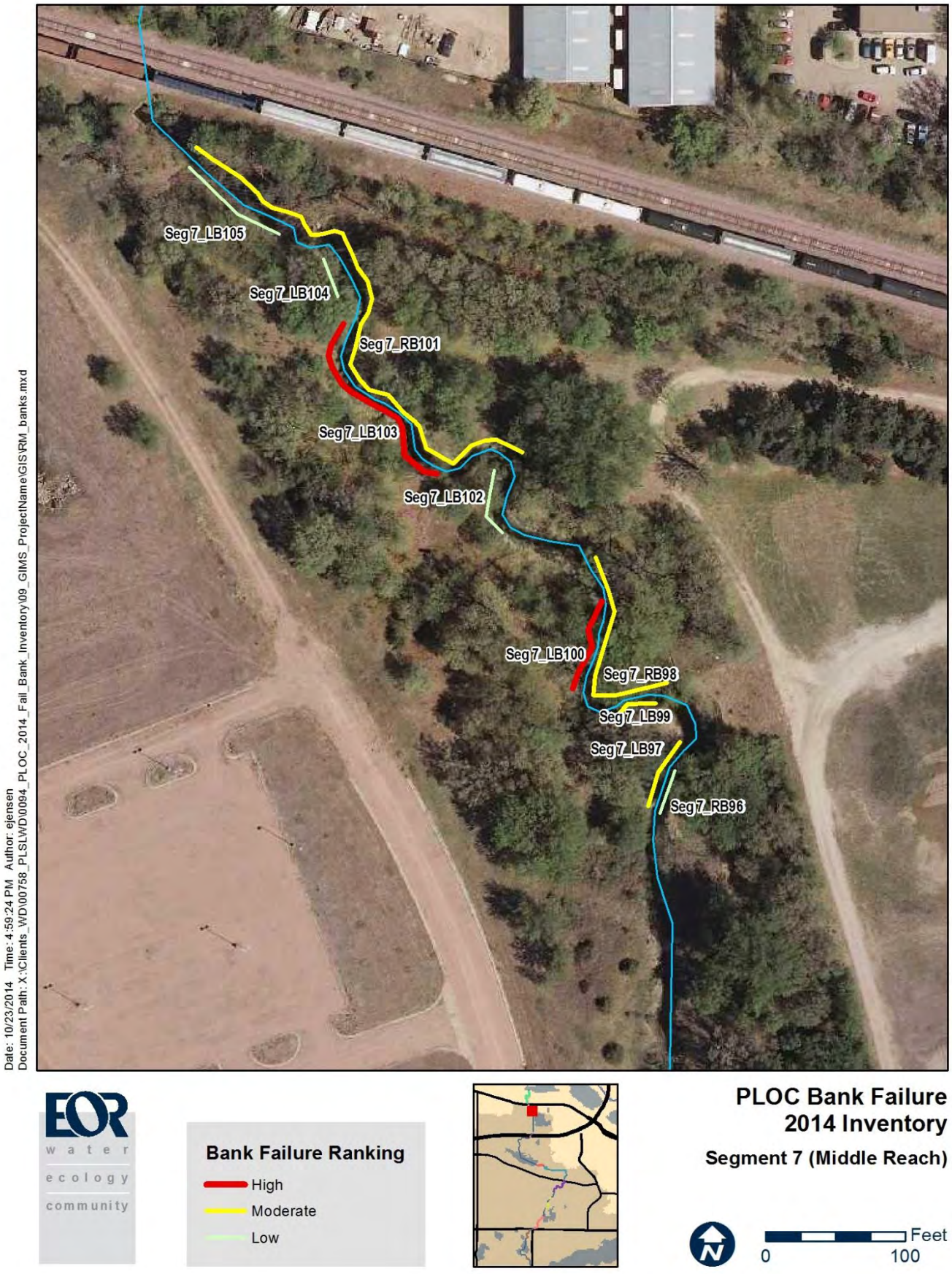


Figure 18. Segment 7 (Middle Reach) Bank Erosion Locations

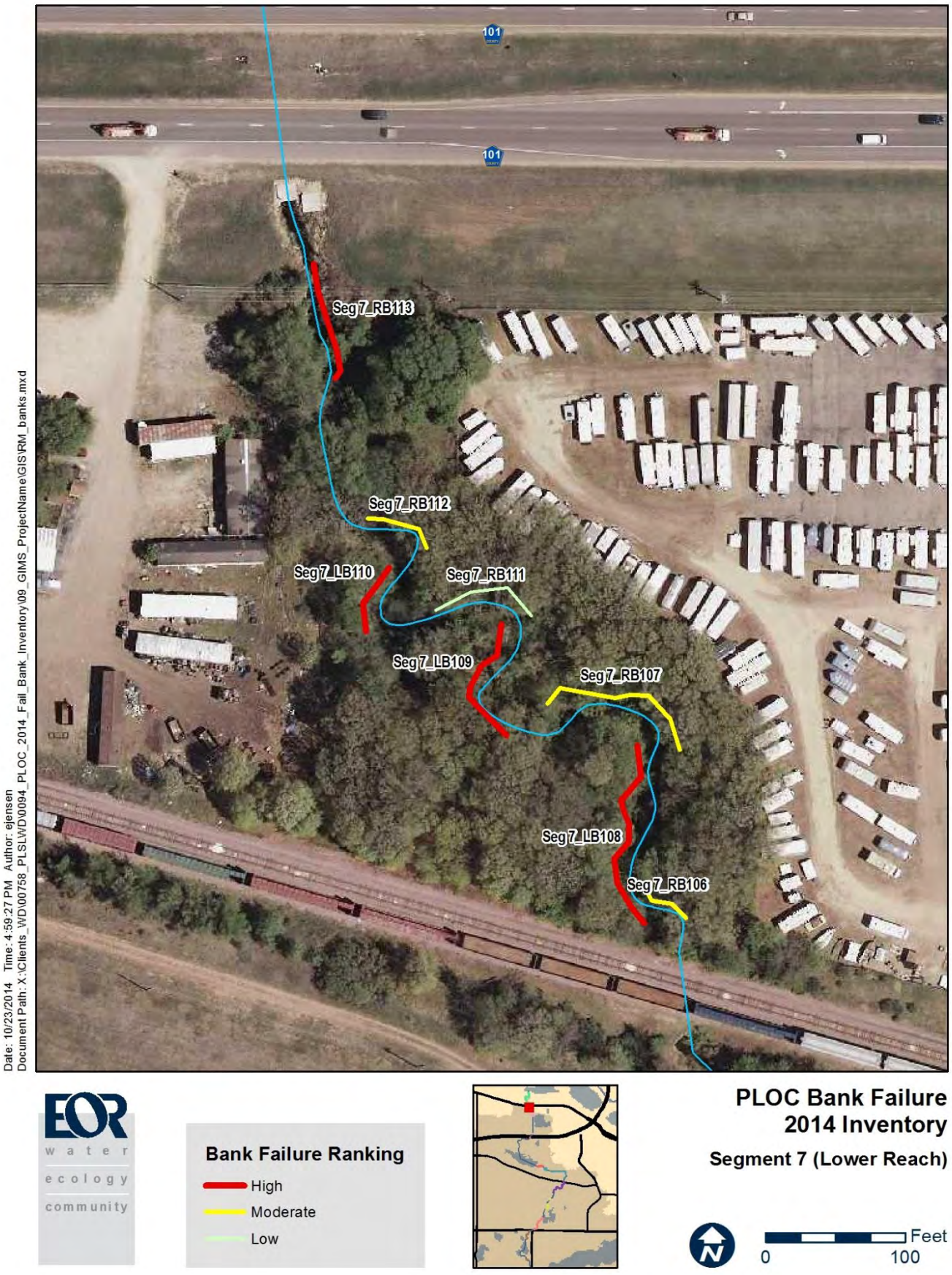


Figure 19. Segment 7 (Lower Reach) Bank Erosion Locations

Table 7. Segment 7 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 7_RB96	Right Bank	32	1.1	1.1	Low	$1,977
Seg 7_LB97	Left Bank	52	2.8	4.0	Moderate	$3,189
Seg 7_RB98	Right Bank	156	2.1	3.2	Moderate	$9,570
Seg 7_LB99	Left Bank	29	2.1	3.2	Moderate	$1,763
Seg 7_LB100	Left Bank	68	4.8	10.0	High	$4,168
Seg 7_RB101	Right Bank	395	2.0	4.2	Moderate	$24,204
Seg 7_LB102	Left Bank	49	1.6	2.4	Low	$3,023
Seg 7_LB103	Left Bank	149	3.4	8.0	High	$9,157
Seg 7_LB104	Left Bank	29	1.0	1.0	Low	$1,764
Seg 7_LB105	Left Bank	81	1.9	2.0	Low	$4,955
Seg 7_RB106	Right Bank	39	3.1	4.0	Moderate	$2,378
Seg 7_RB107	Right Bank	124	2.5	3.5	Moderate	$7,576
Seg 7_LB108	Left Bank	143	2.6	6.0	High	$8,750
Seg 7_LB109	Left Bank	98	3.9	7.0	High	$6,016
Seg 7_LB110	Left Bank	52	3.3	6.5	High	$3,167
Seg 7_RB111	Right Bank	81	2.3	3.0	Low	$4,947
Seg 7_RB112	Right Bank	52	2.4	4.0	Moderate	$3,182
Seg 7_RB113	Right Bank	85	3.5	7.5	High	$5,186
Seg 7_RB134	Right Bank	52	1.7	2.5	Low	$3,212
Seg 7_RB135	Right Bank	122	1.8	2.5	Low	$7,458
	Total Length	**1888**			**Segment Total**	**$115,640**

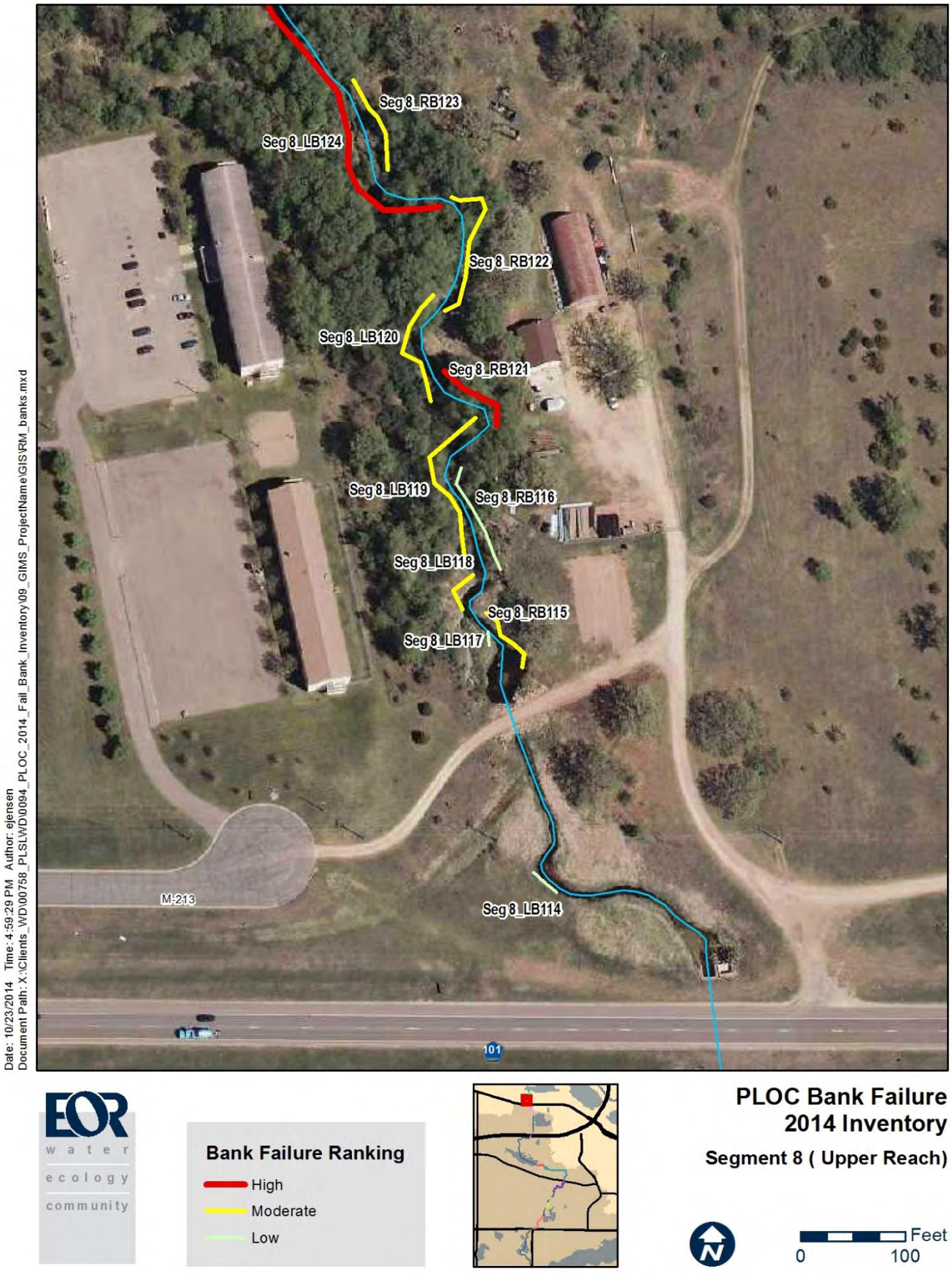


Figure 20. Segment 8 (Upper Reach) Bank Erosion Locations

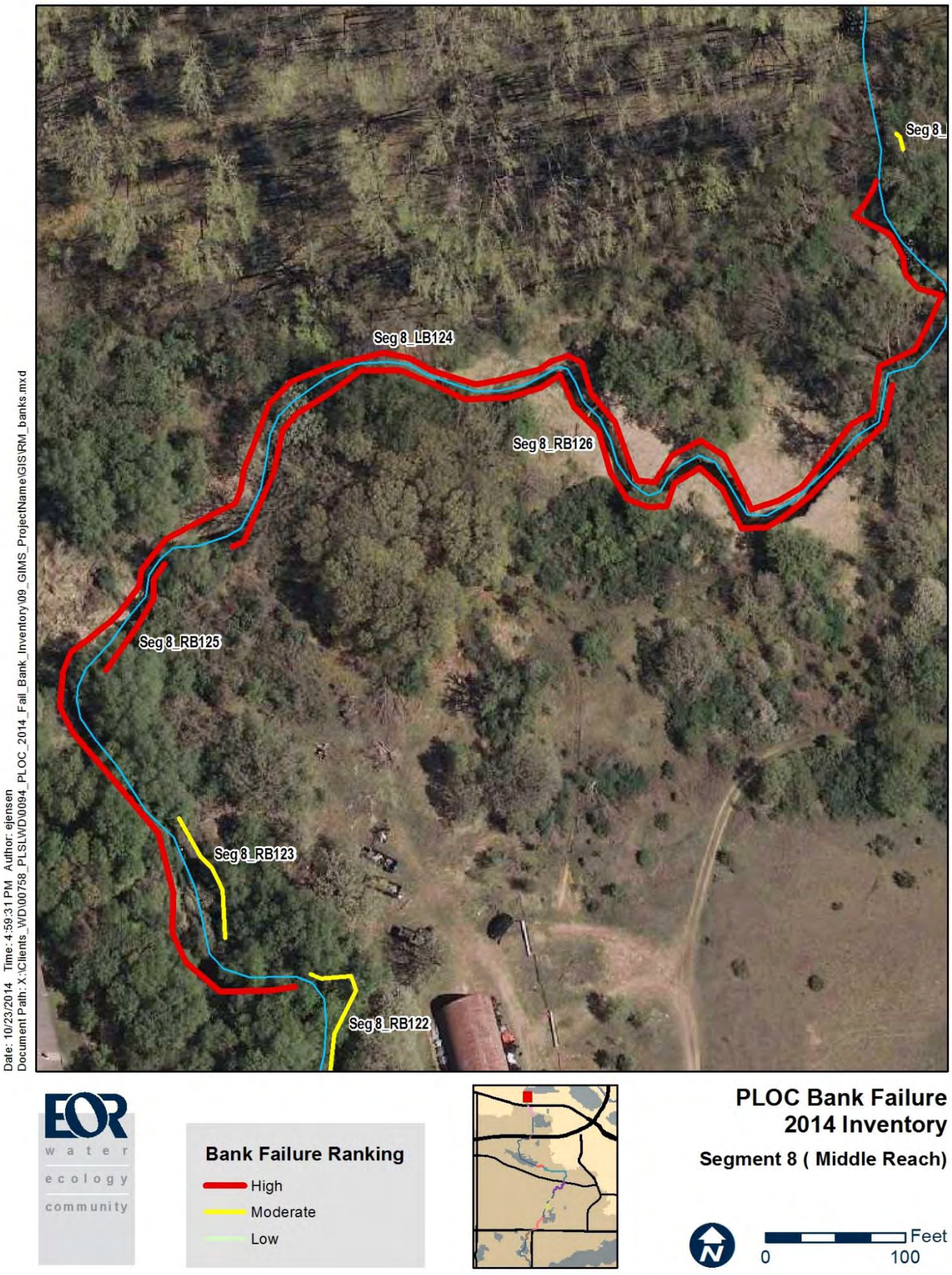


Figure 21. Segment 8 (Middle Reach) Bank Erosion Locations

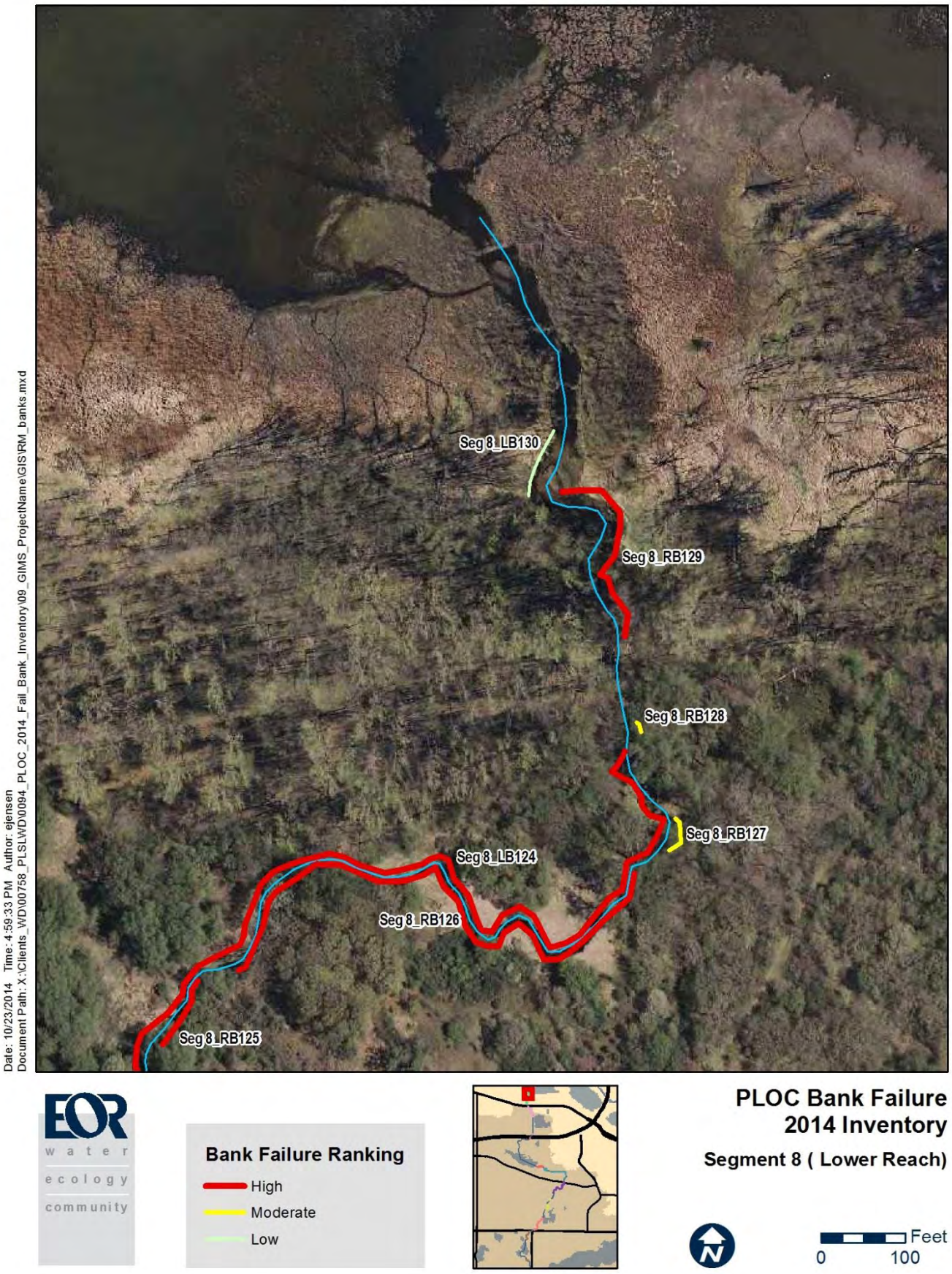


Figure 22. Segment 8 (Lower Reach) Bank Erosion Locations

Table 8. Segment 8 Bank Erosion Summary Table

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 8_LB114	Left Bank	29	1.3	2.5	Low	$1,771
Seg 8_RB115	Right Bank	69	2.2	3.8	Moderate	$4,167
Seg 8_RB116	Right Bank	108	1.6	3.1	Low	$6,521
Seg 8_LB117	Left Bank	13	1.0	1.0	Low	$789
Seg 8_LB118	Left Bank	44	1.8	3.5	Moderate	$2,646
Seg 8_LB119	Left Bank	162	2.0	3.2	Moderate	$9,803
Seg 8_LB120	Left Bank	122	2.3	4.0	Moderate	$7,384
Seg 8_RB121	Right Bank	80	2.4	4.5	High	$4,835
Seg 8_RB122	Right Bank	150	1.8	4.2	Moderate	$9,079
Seg 8_RB123	Right Bank	95	2.6	4.2	Moderate	$5,740
Seg 8_LB124	Left Bank	1371	2.7	6.5	High	$83,111
Seg 8_RB125	Right Bank	89	3.5	8.0	High	$5,371
Seg 8_RB126	Right Bank	696	2.4	5.0	High	$42,176
Seg 8_RB127	Right Bank	48	2.0	3.2	Moderate	$2,883
Seg 8_RB128	Right Bank	12	2.0	3.5	Moderate	$743
Seg 8_RB129	Right Bank	249	4.4	8.0	High	$15,073
Seg 8_LB130	Left Bank	83	1.4	2.3	Low	$5,046
	Total Length	**3416**			**Segment Total**	**$207,140**

Stream Bank Stabilization and Estimated Costs

A standard bank stabilization practice was used to develop preliminary estimated costs to address the channel instabilities identified along the PLOC segments. This practice includes re-shaping the stream banks to a 3:1 slope and installing native seed (MNDOT mix 34-261), mulch material (type 3 clean grain straw), erosion control blanket (DeKoWe ® 700 or equal product made of biodegradable woven coir fiber), and boulders along the toe of the slope (boulder toe). The general sequence of construction includes mobilization of heavy machinery, construction access clearing and installation of a rock entrance, site clearing of brush and trees along the banks that are to be re-shaped, bank shaping with an excavator and/or dozer, installation of boulder toe, installation of native seed and type 3 mulch, installation of erosion control blanket, staking of blanket with wooden stakes (dead stout stakes), and general site cleanup and seeding of access routes.

The estimated costs are based on typical application rates and quantities of material used for standard bank stabilization. This includes installing boulder toe at a rate of 0.6 tons of rock per linear foot, overlapping erosion control blanket by a minimum of 6 inches, applying mulch material at a rate of one ton per acre, and applying native seed at a rate of 31.5 pounds per acre. The estimated costs assume the district has easements along the entire PLOC and that there are no additional costs associated with obtaining temporary or permanent easements.

The following table summarizes the cost for bank stabilization broken down per segment.

Table 9. Summary of Bank Erosion and Estimated Costs

Segment	Total Bank Erosion [ft.]	Preliminary Estimate of Probable Cost
1	2178	$122,284
2	2037	$126,714
3	932	$57,390
4	4456	$250,817
5	3930	$224,022
6	2007	$117,591
7	1888	$115,640
8	3416	$207,140
Grand Total	**20844**	**$1,221,598**

ATTACHMENT K

VEGETATION SURVEY RESULTS

memo

Project	PLOC Vegetation Monitoring & Maintenance	**Date**	January 16, 2015
To	Diane Lynch – PLSLWD Administrator	**Contact Info**	
Cc	Jaime Rockney – PLSLWD Water Resources Specialist	**Contact Info**	
From	Mike Majeski	**Contact Info**	
Regarding	PLOC Vegetation Survey – Fall 2014		

The purpose of this memorandum is to present findings from the fall 2014 vegetation survey of the Prior Lake Outlet Channel (PLOC) and provide a summary on invasive species management conducted in 2014.

Background

Emmons & Olivier Resources, Inc. (EOR) has been contracted to conduct vegetation surveys along the easements of the outlet channel twice annually (spring and fall) to determine invasive species composition and distribution. The vegetation surveys are based only on the species included in the Minnesota Department of Natural Resources *Invasive Terrestrial Plants* list[1]. The primary objective of these surveys is to document the occurrence and density of invasive species growing within the easements of the PLOC from the Prior Lake outlet daylight pipe in segment 1 to the channel outlet at the Minnesota River in segment 8. Recommendations based on the surveys guide vegetation management activities including annual cutting of specific woody and herbaceous invasive species to reduce or eliminate specific populations.

Following the baseline vegetation assessment of 2011, a list of invasive species was amassed for each segment and the relative densities of each species were plotted on maps. For detailed information about the baseline vegetation assessment including survey methodology, results, maps, and images, refer to the document "Prior Lake Outlet Channel (PLOC) Vegetation Report Fall 2011." Subsequent surveys conducted in 2012-2014 were used to update the densities and extents of invasive species in each segment (Appendix A). Bank erosion was also measured and quantified. Following the flood event in June 2014, a comprehensive bank erosion assessment was completed to document the extent of bank erosion along the PLOC. Refer to the document "Prior Lake Outlet Channel Bank Erosion Inventory" for information on the extent of bank erosion and preliminary repair cost estimates.

Vegetation Management Activities

Vegetation management activities conducted in 2014 include herbaceous invasive species management by EOR and the treatment of woody invasive species by Applied Ecological Services (AES):

- Garlic mustard (*Alliaria petiolata*) was hand cut with a weed cutter in segments 3-7 on May 20 and May 27. This species has not been documented in segments 1 and 2.

- Wild parsnip (*Pastinaca sativa*) was hand cut with a weed cutter in segment 1 on June 11. This is the only segment where wild parsnip was found within the PLOC easement.

- A site walk through with AES was conducted on May 20 in segments 1, 3, 4A, 6, and 7A to assess woody invasive sucker growth and foliar spray treatment options in areas managed in the fall of 2012 and spring of 2013. Seedling and sucker growth of black locust (*Robinia pseudoacacia*), common buckthorn (*Rhamnus cathartica*), and Tatarian honeysuckle (*Lonicera tatarica*) were observed in segments where these species were treated in 2012.

- A foliar spray was completed by AES in October 2014. The effectiveness of this treatment will be assessed by EOR in the spring of 2015.

2014 Vegetation Summary

Partial reaches within all eight segments of the PLOC that *have not* been managed for invasive species, in part due to planned restoration/stabilization work, forthcoming development and/or lack of landowner cooperation or approval, include:

- Segment 1: Jeffers Fish Pond to County Road 42
- Segment 2: County Road 42 to Pike Lake
- Segment 3: The easement around the large open water wetland upstream of Pike Lake Trail
- Segment 4: Pike Lake Trail to Jackson Trail, the western easement between Jackson Trail and the Gonyea culvert, and the pasture in Segment 4B
- Segment 5: County Road 16 to County Road 21 (except garlic mustard)
- Segment 6: County Road 21 to Dean Lake (except small pocket of buckthorn and honeysuckle)
- Segment 7: Railroad crossing to State Highway 101 (except garlic mustard)
- Segment 8: State Highway 101 to the Minnesota river (except garlic mustard)

Invasive species documented within these segments include common buckthorn, Tatarian honeysuckle, black locust, silver poplar (*Populus alba*), Siberian elm (*Ulmus pumila*) reed canary grass (*Phalaris arundinacea*), leafy spurge (*Euphorbia esula*) smooth brome (*Bromus inermis*), thistle (*Cirsium spp*.), creeping charlie (*Glechoma hederacea*), spotted knapweed (*Centaurea maculosa*), garlic mustard, and cow vetch (*Vicia cracca*). The following is a summary of invasive species specifically managed from 2011-2014:

Herbaceous Invasive Species

Significant populations of garlic mustard have been managed in segments 4B, 5B and 7B since 2011. Although a notable reduction in the population size was observed 2012, the garlic mustard re-bounded in 2013 with dense growth at historic patches in segments 4B, 5B, and 7B. This re-growth was likely the result of germination from seed banks that exist in the soil and from seeds blowing in from adjacent populations outside the easements. In the spring of 2014, a reduction of approximately 40% of the population was observed in several large historic patches in segments 4B and 5B. The most notable decline in population was observed in segment 4 upstream of the cattle pasture and also upstream of County Road 16. It is possible the seed bank in these patches is becoming reduced by the annual cutting of mature plants. Conversely, garlic mustard densities increased in areas managed for woody invasives including the area adjacent to the new Gonyea culvert in segment 4A and the downstream end of segment 7A. Germination of garlic mustard is common in areas where woody invasive species have been removed. In the absence of a dense canopy, sunlight can reach the ground surface and promote the germination of dormant seeds. Managing garlic mustard by mechanical means can be effective in reducing the density of mature plants by exhausting the existing seed bank; however, if seeds continue to migrate into the easements from adjacent populations it will be difficult to eradicate the species from the PLOC. The populations of garlic mustard in segments 3, 6, and 8 remain at low densities.

Leafy spurge was observed in all segments except segment 2. The majority of segment 2 occurs within a maple-basswood forest with no grassland habitat. The heavy shade likely inhibits the growth of any seeds that migrate into this segment. The greatest densities of leafy spurge occur in segments 4 and 7 where grassland habitat is common. A notable population also exists near the downstream end of segment 5B east of Pike Lake Trail.

The treatment of leafy spurge using biological methods was instituted in 2011 with the release of flea beetles (*Aphthona spp*.) by PLSLWD staff in segments 4 and 7. Since the beetle release, the density of leafy spurge has remained relatively unchanged in segment 7, but a reduction in plant density in segment 4 was observed in 2014. It is possible a small population of flea beetles has become established in this segment. The success of this treatment method largely depends of the density of leafy spurge. Typical release sites require at least ½ acre of leafy spurge to establish and maintain a population of flea beetles. The leafy spurge densities in segments 1, 3, 4, 5, and 8 were too low to support the release of the beetles. The following excerpt from the University of North Dakota extension service discusses the use of flea beetles to control leafy spurge:

"If a flea beetle population becomes established but does not control leafy spurge, perhaps a second release of the same and/or different species will improve control. However, if the insect population does not increase after multiple releases, the site may not be suitable for Aphthona spp. to control leafy spurge. Each Aphthona spp. requires a slightly different type of habitat for survival. Also, Aphthona spp. generally will not establish at sites with excess moisture, long periods of shade, very sandy soil, high leafy spurge density, or poor snow cover in the winter. Of these problems only the density of the leafy spurge stand can be altered. Herbicide application in the fall and sheep or goat grazing from mid-May until mid-August will reduce the leafy spurge density and both methods are compatible with flea beetles.
Unlike herbicides, biological control agents do not provide predictable, consistent levels of leafy spurge control. Often Aphthona spp. take several years to become established and then require several more years to reduce a leafy spurge stand. Wide-scale rapid reduction of leafy spurge infestations are so far the exception, not the rule. Biological control of leafy spurge with flea beetles is not a "quick fix" and a land manager must practice patience when using this control method."[2]

Based on this information, it was decided that subsequent biological treatments of leafy spurge should be implemented in 2015 at segments 4 and 7. In October 2014, EOR submitted a request for beetles with the Minnesota Department of Agriculture. If the beetles can be obtained in 2015, the species of beetle and location of release will be documented, along with the soil type associated with the infestation. This information will help guide future biological management of leafy spurge within these segments.

Woody Invasive Species

Applied Ecological Services was contracted to manage the treatment of woody invasive species in designated reaches in segments 1, 3, 4A, 5C, 6, and 7A. Black locust, common buckthorn, and honeysuckle suckers and seedlings were documented in the treatment areas where these species were removed in the fall of 2012 and spring of 2013. A site walk through with AES occurred on May 20 at segments 1, 3, 4A, 6, and 7A to assess woody invasive sucker growth and foliar spray treatment options in areas previously managed. During the walk through, it was decided that foliar treatment activities should be postponed until the fall of 2014 to avoid impacts to the existing native herbaceous ground layer, particularly spring ephemeral species. Foliar treatment was conducted by AES starting the week of October 20. The effectiveness of the foliar spray will be documented by EOR in the spring of 2015.

Recommendations

Monitoring populations of garlic mustard in managed areas will help determine the effectiveness of mechanic removal of this species. Cutting dense populations of garlic mustard within easement areas will reduce the seeding potential to downstream segments, but complete eradication of this species within the PLOC is not possible since larger populations exist outside of the easements. It is not recommended to treat garlic mustard with herbicides since herbicides in general are non-selective and application during the growing season could negatively impact any native plants and seedlings growing in or near the treatment area.

Leafy spurge should be managed using biological and/or mechanical methods. Several species of flea beetles should be released in segments 4 and 7 following guidance from Minnesota Department of Agriculture and the University of North Dakota extension service. Beetle releases should be conducted for a minimum of two consecutive years in areas where the beetles have not become established. Any mowing activities should be performed when the plants begin flowering, typically during late May.

The satellite population of silver poplar in segment 1 should be cut and the stumps treated with a glyphosate solution as soon as possible. This area occurs within the headwaters of the PLOC and removing the trees will help prevent the migration of this species to downstream resources.

Woody invasive species that occur within unmanaged areas in segments 1-8 should be cut and the stumps treated with a glyphosate solution. Removal of these species will promote the growth of an herbaceous ground layer by enabling light to reach the ground surface. The increase in light may also encourage the growth of other invasive species; therefore, close monitoring and maintenance should be conducted if this option is implemented. If management is implemented in these segments, routine maintenance and spot treating will be necessary to limit re-infestation of invasive species since significant populations occur adjacent to the PLOC corridor.

Conclusion

Managing invasive species will benefit the local flora and fauna of the PLOC and encourage the re-establishment of native species along the banks of the channel. Restoring riparian vegetation will reduce bank erosion and improve the water quality along the outlet channel. Complete eradication of common invasive species will not be possible along the PLOC as long as larger populations exist outside of the easement; however, efforts should be made to target these species in unmanaged areas.

Sources

1. © Minnesota Department of Natural Resources. 2015. The Minnesota Department of Natural Resources Website (online). Accessed Jan. 13, 2015 at mndnr.gov/copyright. Minnesota Department of Natural Resources 500 Lafayette Road St. Paul, MN 55155-4046 http://www.dnr.state.mn.us/invasives/terrestrialplants/index.html

2. Biological Control of Weeds: How to Successfully Release Leafy Spurge Flea Beetles. North Dakota State University. J.J. Knodel. http://www.ag.ndsu.edu/griggscountyextension/biological-control-of-weeds-1/biological-control-of-weeds-how-to-successfully-release-leafy-spurge-flea-beetles

Appendix A

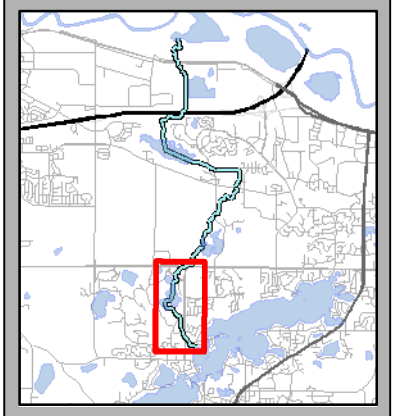
PLOC Vegetation Invasive Species Maps

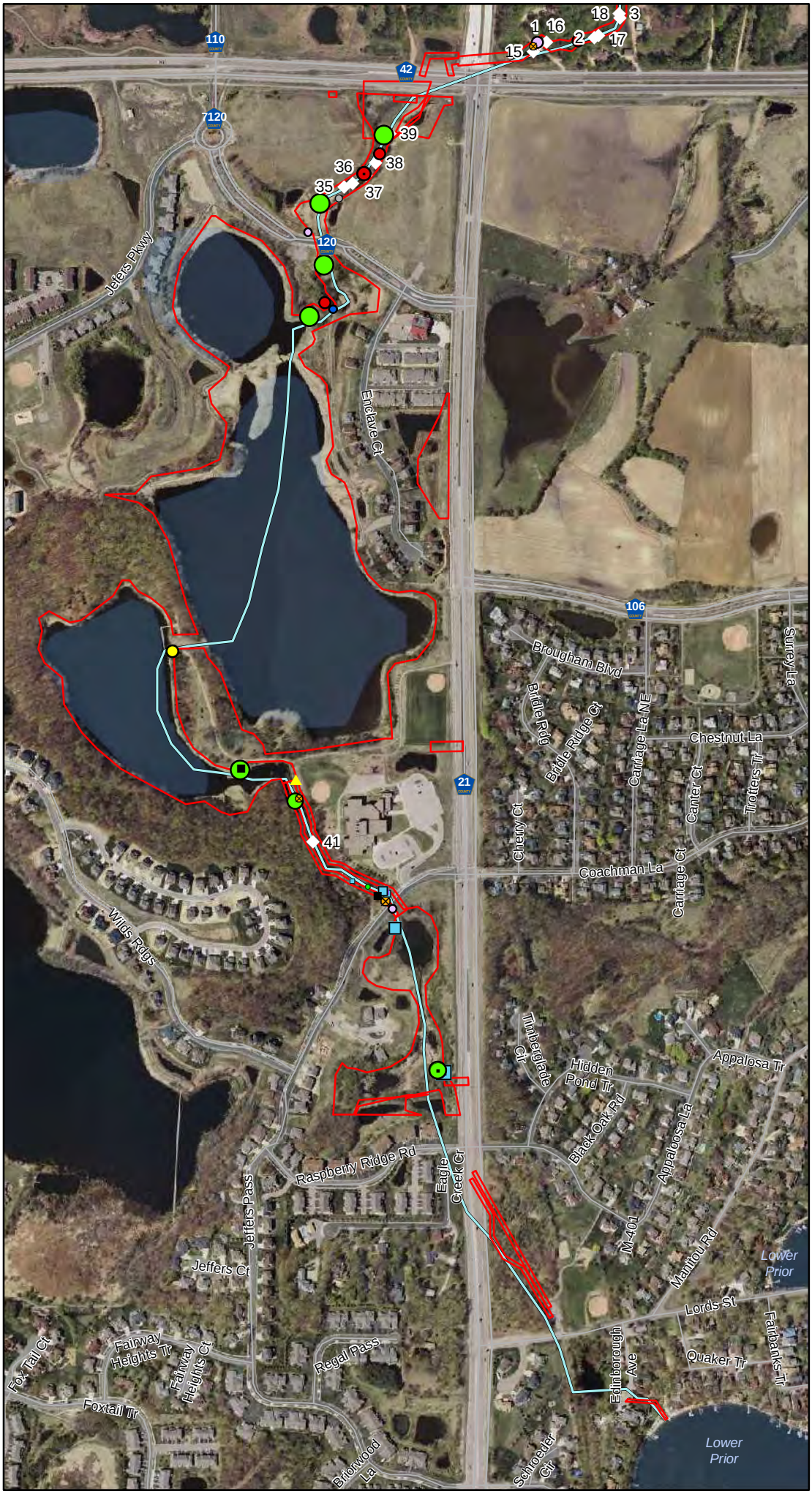
Segment 1

Invasive Species 2014

Plant Species, Cover Class

- Black locust, 1 (0-3%)
- Black locust, 2 (3-10%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Cow vetch, 1 (0-3%)
- Creeping charlie, 1 (0-3%)
- Creeping charlie, 2 (3-10%)
- Creeping charlie, 4 (25-50%)
- Creeping charlie, 5 (50-75%)
- Creeping charlie, 6 (75-100%)
- Honeysuckle, 2 (3-10%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 1 (0-3%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Siberian elm, 1 (0-3%)
- Silver Poplar, 1 (0-3%)
- Wild Parsnip, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries





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Segment 2

Invasive Species 2014

Plant Species, Cover Class

- Black locust, 1 (0-3%)
- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Canada thistle, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Erosion Site
- Outlet Channel Easement Boundaries

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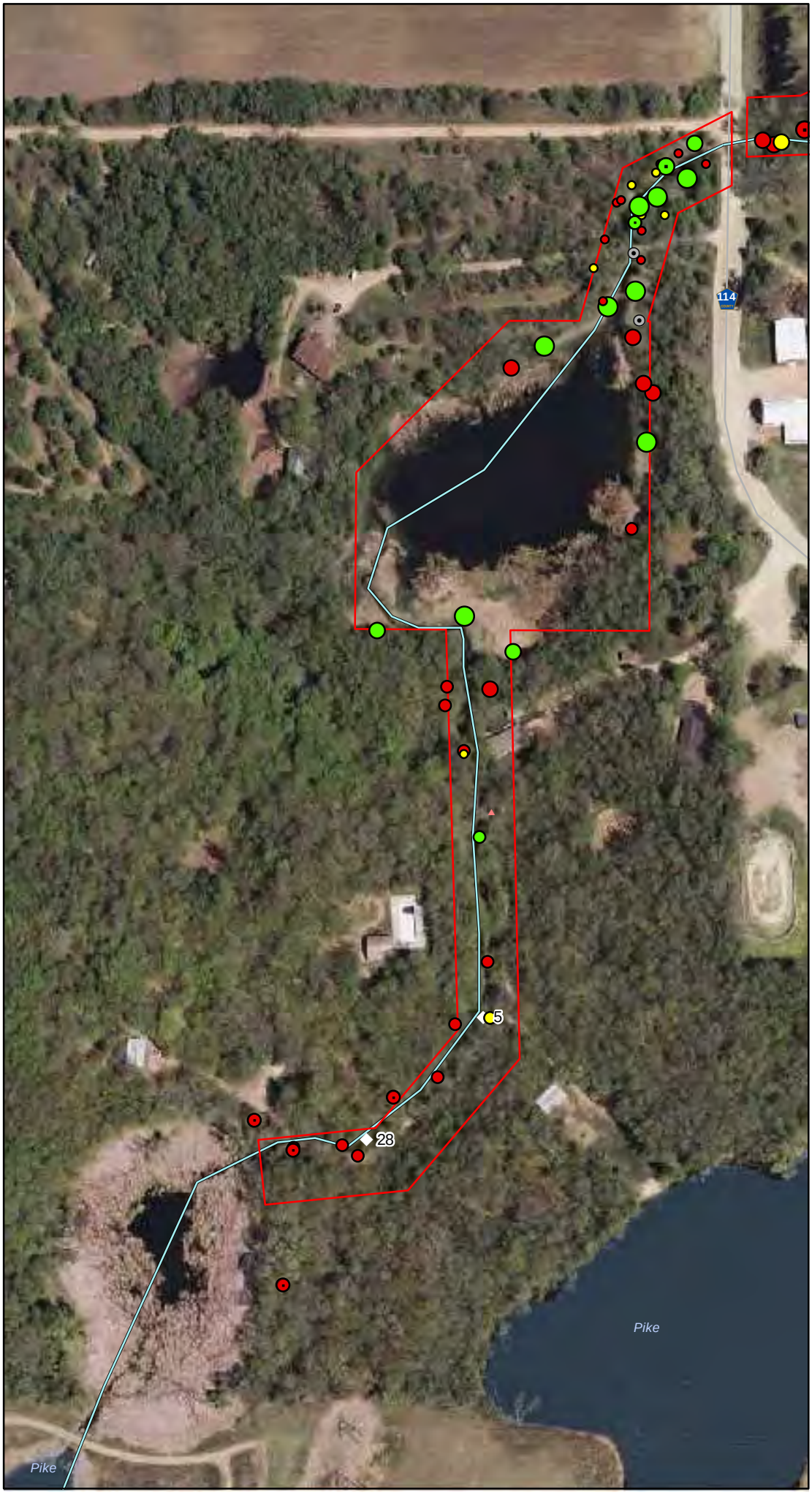
Segment 3

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Garlic mustard, 1 (0-3%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 4 (25-50%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



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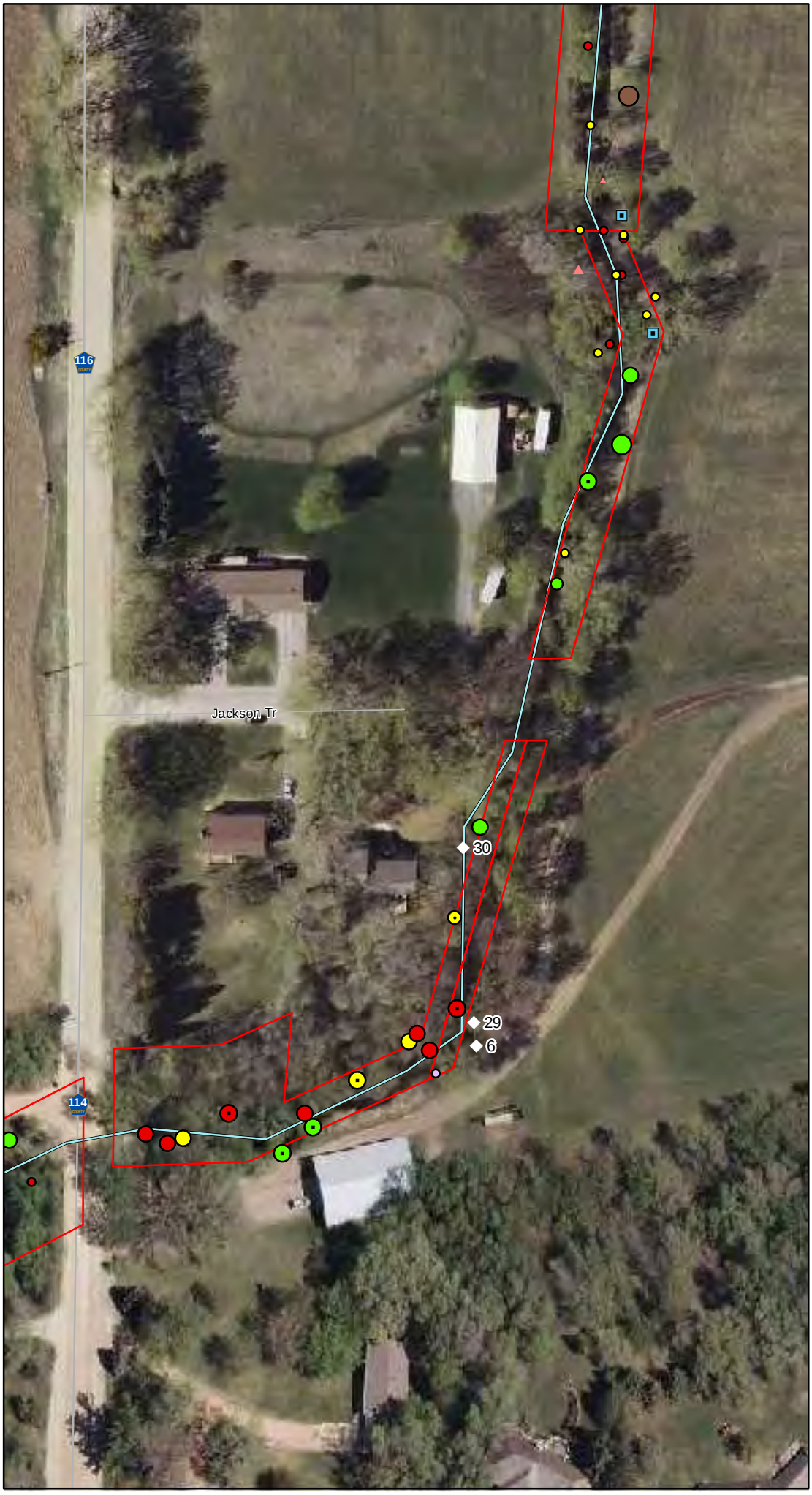
Segment 4a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



water ecology community

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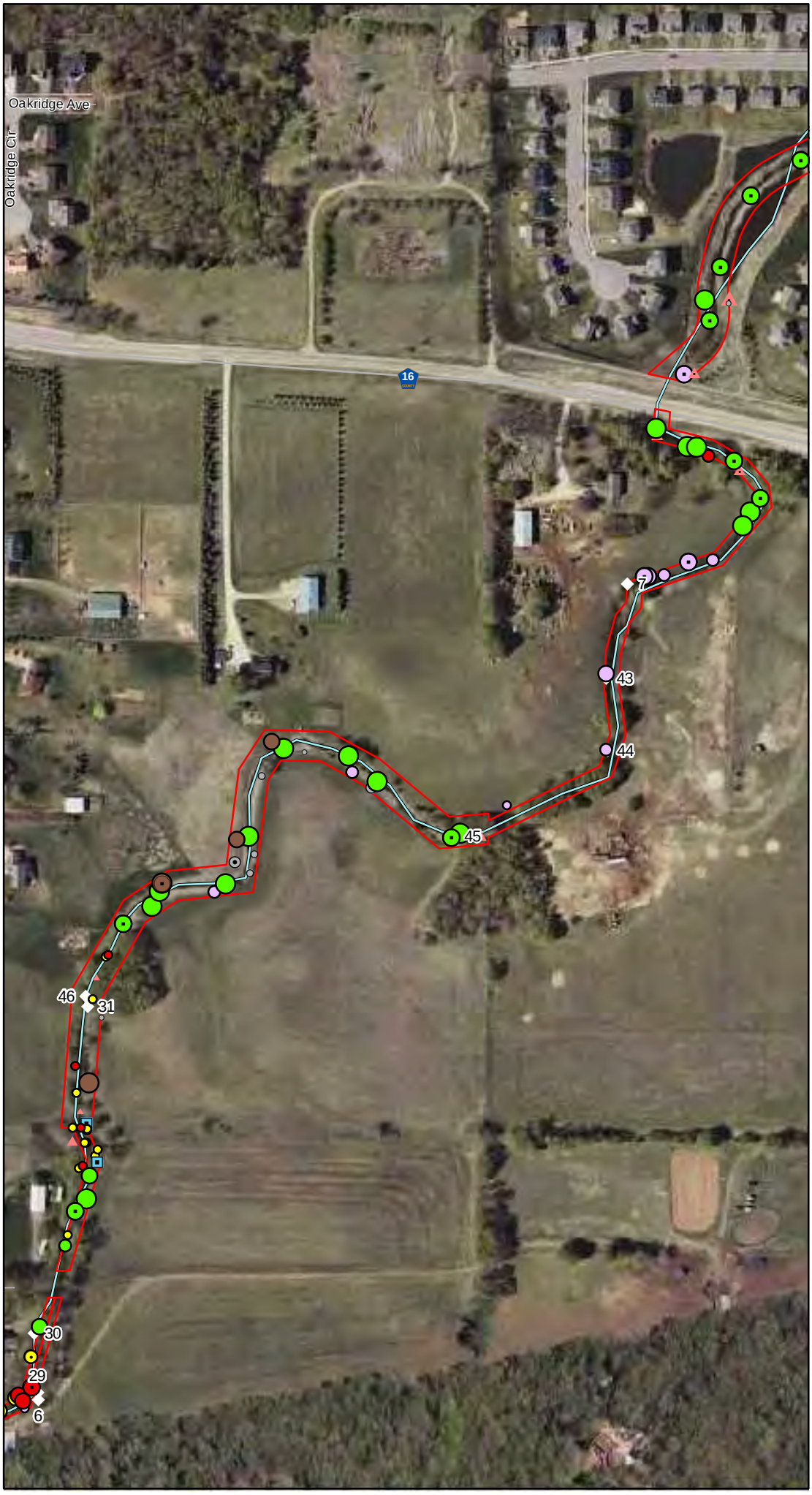
Segment 4b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



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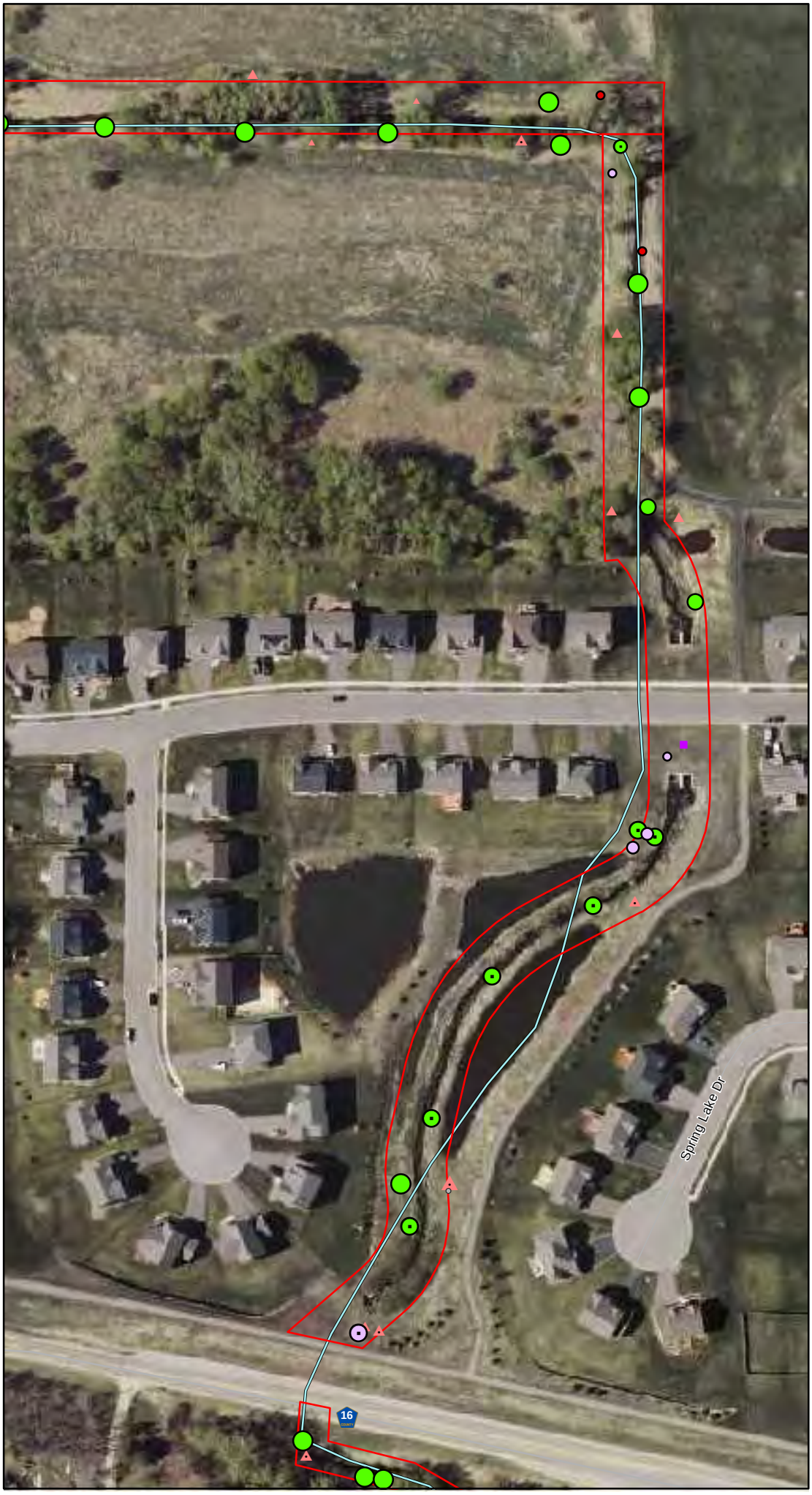
Segment 5a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 5 (50-75%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Outlet Channel Easement Boundaries



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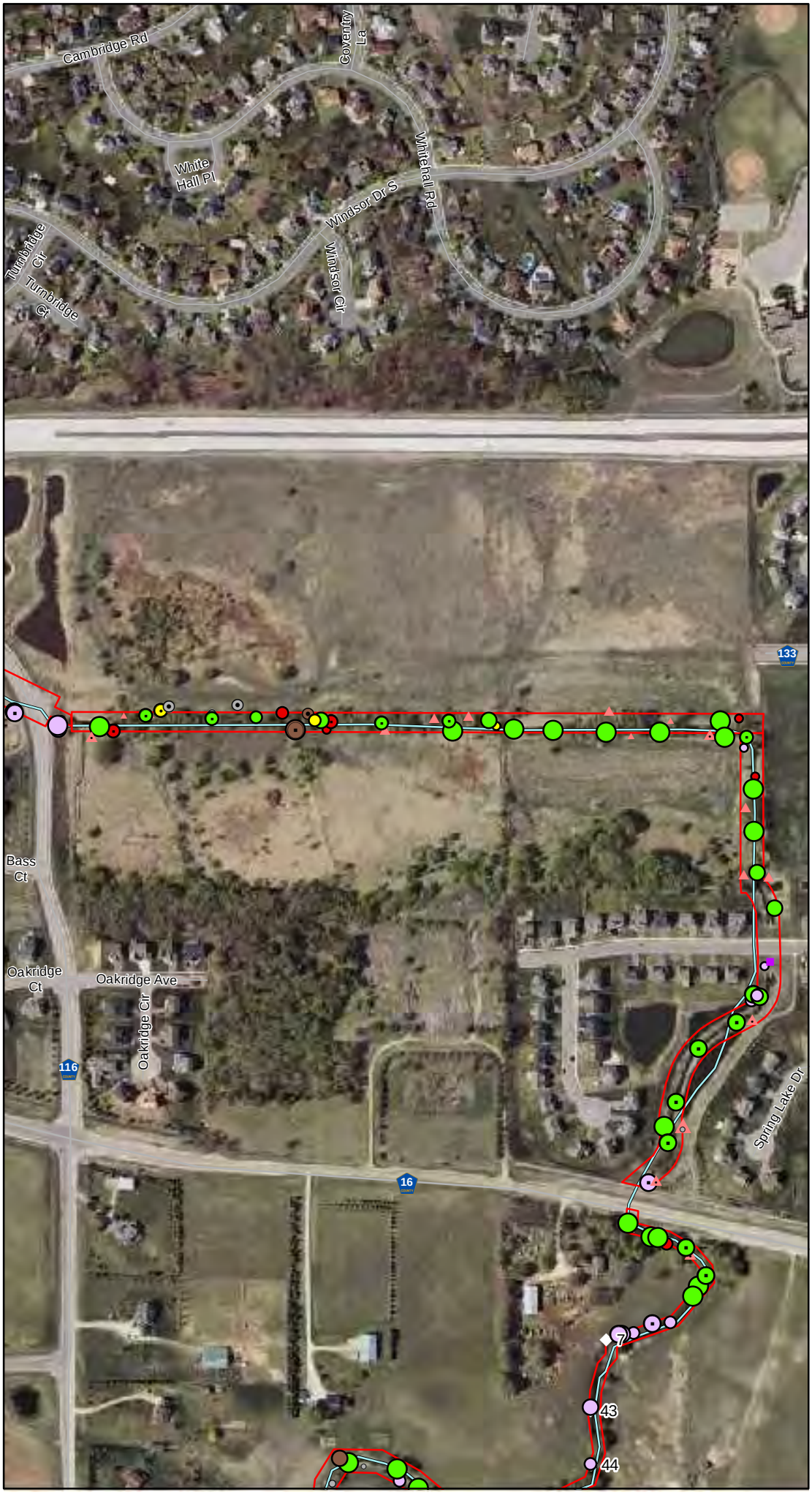
Segment 5b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Canada thistle, 6 (75-100%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 3 (10-25%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Spotted knapweed, 2 (3-10%)
- Erosion Site
- Outlet Channel Easement Boundaries



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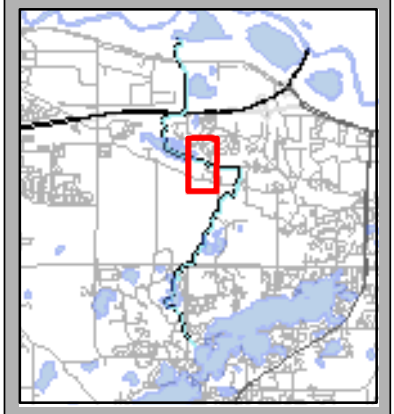
Segment 5c

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 3 (10-25%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Canada thistle, 6 (75-100%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 1 (0-3%)
- Leafy spurge, 1 (0-3%)
- Reed Canary, 6 (75-100%)
- Spotted knapweed, 2 (3-10%)

Outlet Channel Easement Boundaries



water ecology community

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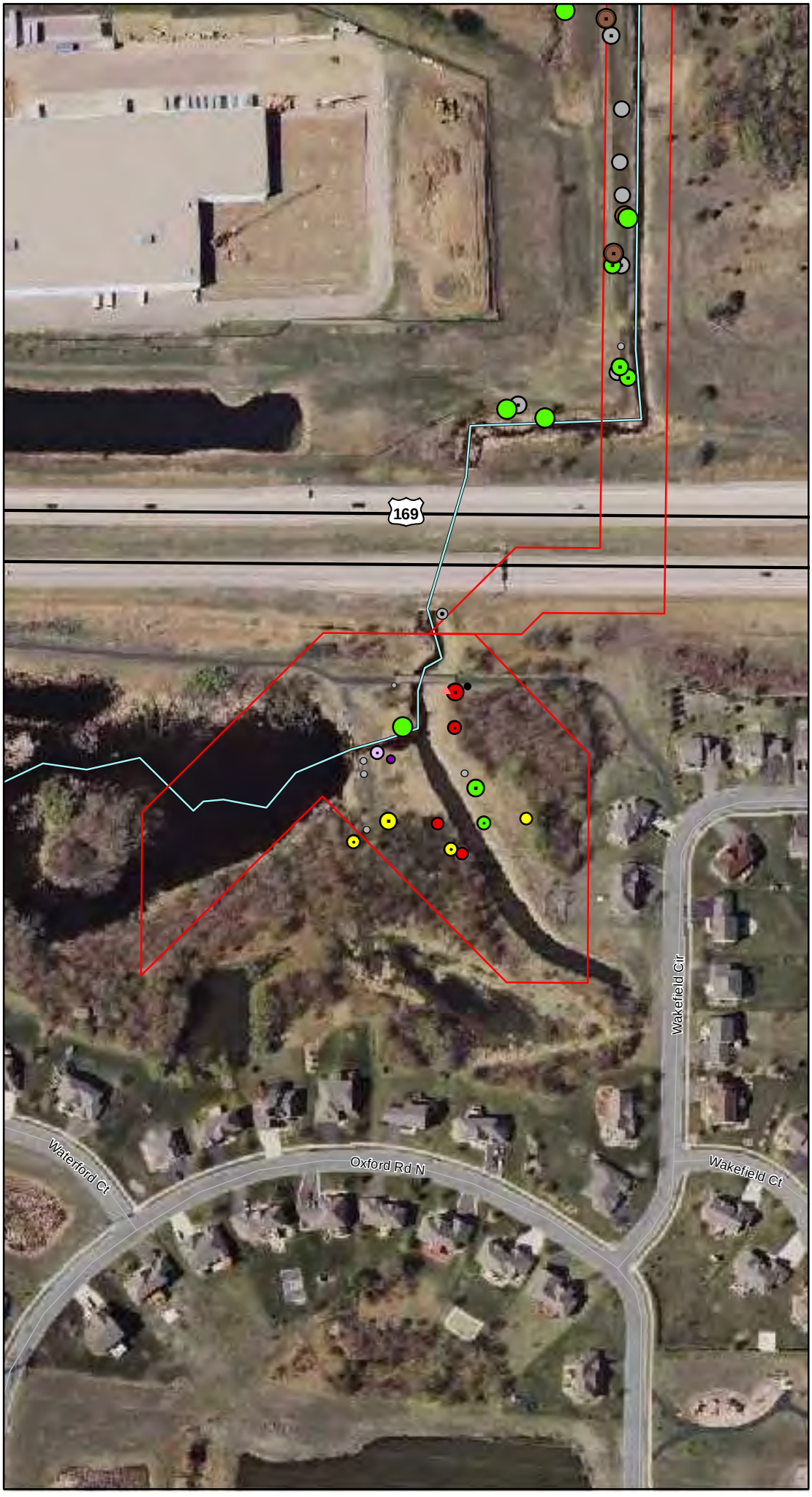
Segment 6

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 3 (10-25%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Leafy spurge, 4 (25-50%)
- Leafy spurge, 5 (50-75%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Purple Loosestrife, 1 (0-3%)
- Outlet Channel Easement Boundaries



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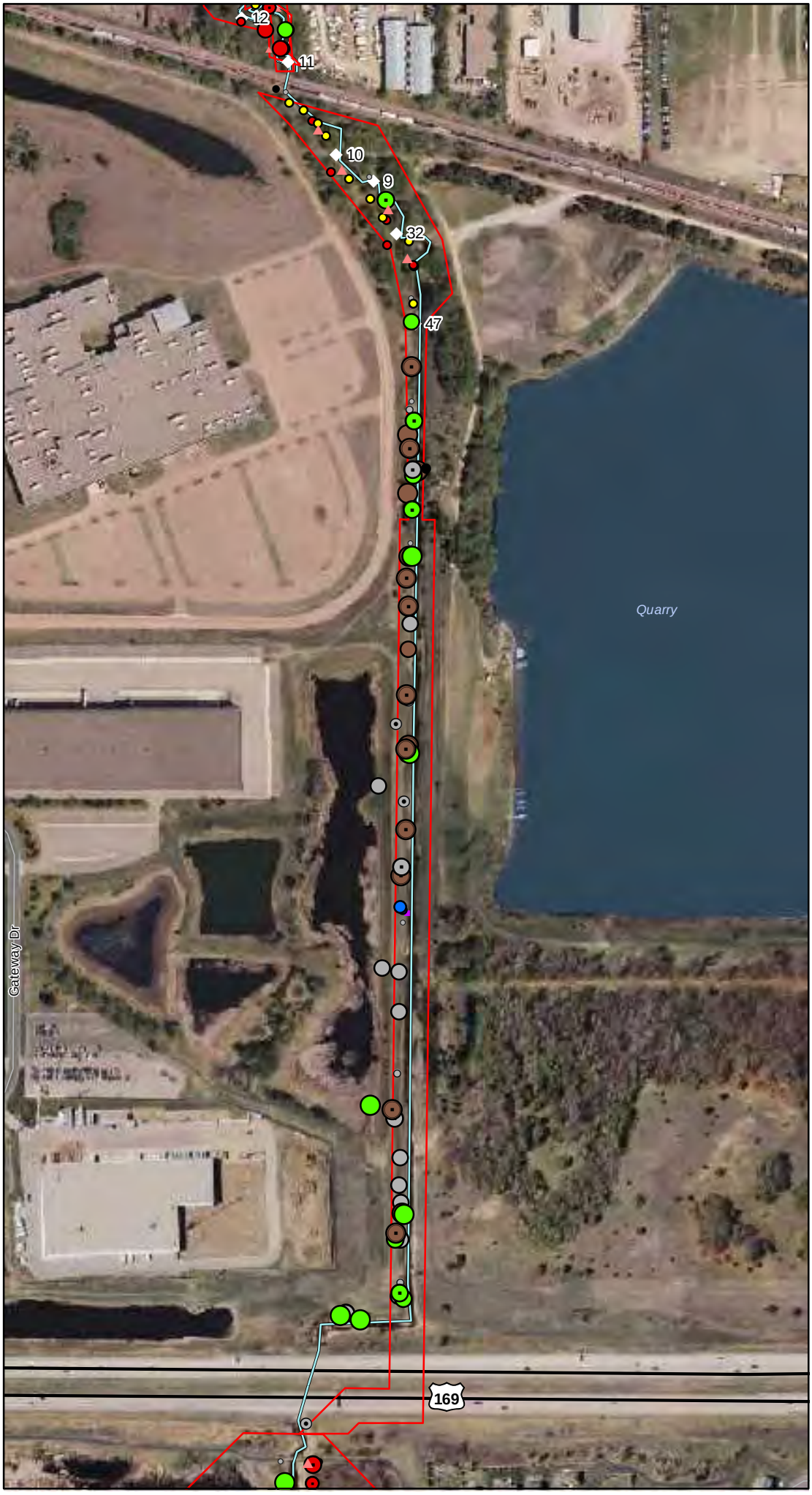
Segment 7a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Cow vetch, 1 (0-3%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Leafy spurge, 4 (25-50%)
- Leafy spurge, 5 (50-75%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Siberian elm, 1 (0-3%)
- Siberian elm, 2 (3-10%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Spotted knapweed, 2 (3-10%)
- Erosion Site
- Outlet Channel Easement Boundaries



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Segment 7b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries

water ecology community

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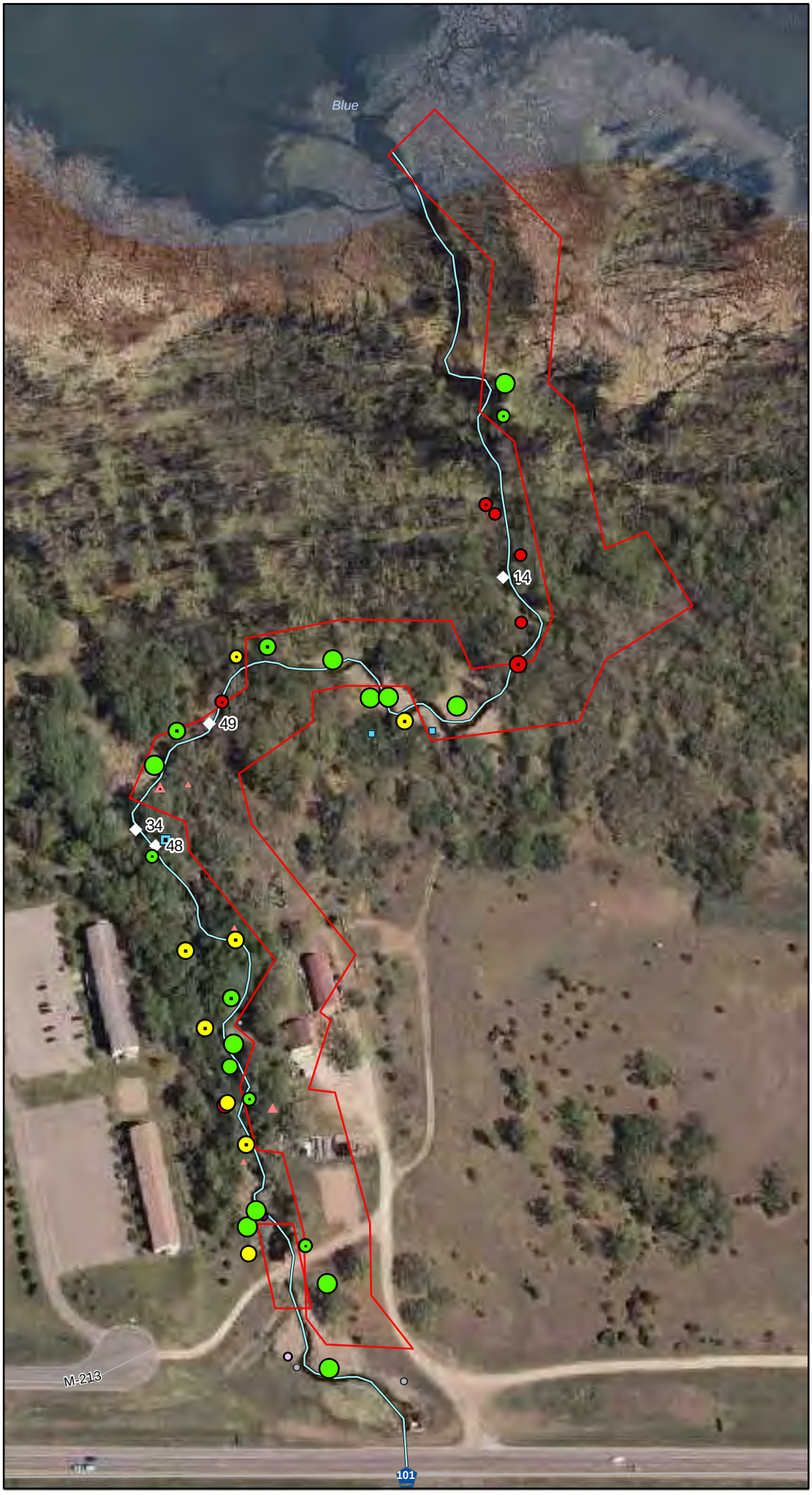
Segment 8

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Creeping charlie, 2 (3-10%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Purple Loosestrife, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries



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memo

Project	PLOC Vegetation Monitoring	**Date**	June 24, 2014
To	Diane Lynch – PLSLWD Administrator	**Contact Info**	
Cc	Jaime Rockney – PLSLWD Water Resources Specialist	**Contact Info**	
From	Mike Majeski	**Contact Info**	
Regarding	PLOC Vegetation Survey – Spring 2014		

The purpose of this memorandum is to present findings from the spring 2014 vegetation survey of the Prior Lake Outlet Channel (PLOC) and provide an update on invasive species management conducted in 2014.

Background

EOR has been contracted to conduct vegetation surveys along the easements of the outlet channel twice annually (spring and fall) to determine species composition and distribution of invasive species. EOR's initial vegetation surveys occurred in the spring and fall of 2011. The final inspection occurred in the spring of 2014 under the initial contract. A contract extension was awarded to EOR to continue providing monitoring services through June 2016. The primary focus of these surveys is to document the type and extent of invasive species growing within the easements of the PLOC from the Prior Lake outlet daylight pipe in segment 1 to the outlet at the Minnesota River in segment 8. For detailed information about the baseline vegetation assessment including survey methodology, results, baseline maps, and images, refer to the document "Prior Lake Outlet Channel (PLOC) Vegetation Maintenance Plan Fall 2011".

Following the initial vegetation surveys of 2011, a list of invasive species was compiled for each segment and the relative densities of each species were plotted on maps. Bank erosion along the PLOC was also measured and mapped. Subsequent surveys conducted in 2012-2014 were used to update the densities and extents of invasive species in each segment and document changes in bank erosion (Appendix A, Appendix B).

Vegetation Management Activities

Vegetation management activities conducted in the spring of 2014 include herbaceous invasive species management by EOR and an inspection of woody invasives by EOR and Applied Ecological Services (AES):

- Garlic mustard (*Alliaria petiolata*) was hand cut with a weed cutter in segments 3-7 on May 20 and May 27.

- Wild parsnip (*Pastinaca sativa*) was hand cut with a weed cutter in segment 1 on June 11. This is the only segment where wild parsnip was found within the PLOC easement.

- A site walk through with AES was conducted on May 20 at segments 1, 3, 4A, 6, and 7A to assess woody invasive sucker growth and foliar spray treatment options in areas managed in the fall of 2012 and spring of 2013. Seedling and sucker growth of black locust (*Robinia pseudoacacia*), common buckthorn (*Rhamnus cathartica*), and Tatarian honeysuckle (*Lonicera tatarica*) were observed in segments where these species were treated in 2012.

2014 Vegetation Summary

The densities of common invasive species *not managed* along the PLOC have remained relatively unchanged compared to previous assessments. These species include common buckthorn, Tatarian honeysuckle, Siberian elm (*Ulmus pumila*) reed canary grass (*Phalaris arundinacea*), leafy spurge (*Euphorbia esula*), smooth brome (*Bromus inermis*), common burdock (*Arctium minus*), thistle (*Cirsium spp*.), creeping charlie (*Glechoma hederacea*), spotted knapweed (*Centaurea maculosa*), and cow vetch (*Vicia cracca*). The following is a summary of invasive species specifically managed from 2011-2014:

Herbaceous Invasive Species

Significant populations of garlic mustard have been managed in segments 4B, 5B and 7B since 2011. Although a notable reduction in the population size was observed 2012, the garlic mustard re-bounded in 2013 with dense growth at historic patches in segments 4B, 5B, and 7B. This re-growth was likely the result of germination from seed banks that exist in the soil and from seeds blowing in from adjacent populations outside the easements. In 2014, a reduction of approximately 40% of the population was observed in several large historic patches in segments 4B and 5B. The most notable decline in population was observed in segment 4 upstream of the cattle pasture and also upstream of CR 16. It is possible the seed bank in these patches is becoming reduced by the annual cutting of mature plants. Conversely, garlic mustard densities increased in areas managed for woody invasives including the area adjacent to the new Gonyea culvert in segment 4A and the downstream end of segment 7A. Germination of garlic mustard is common in areas where woody invasive species have been removed. In the absence of a dense canopy, sunlight can reach the ground surface and promote the germination of dormant seeds. Managing garlic mustard by mechanical means can be effective in reducing the density of mature plants by exhausting the existing seed bank; however, if seeds continue to migrate into the easements from adjacent populations it will be difficult to eradicate the species from the PLOC. The populations of garlic mustard in segments 3, 6, and 8 remain at low densities.

Leafy spurge was observed in all segments except segment 2. The majority of segment 2 occurs within a maple-basswood forest with no grassland habitat. The heavy shade likely inhibits the growth of any seeds that migrate into this segment. The greatest densities of leafy spurge occur in segments 4 and 7 where grassland habitat is common. A notable population also exists near the downstream end of segment 5B east of Pike Lake Trail.

In 2011, flea beetles (*Aphthona spp*.) were released by PLSLWD staff as a biological control method to control leafy spurge in segments 4 and 7. These segments were chosen based on the density of leafy spurge. Typical release sites require at least ½ acre of leafy spurge to establish and maintain a population of flea beetles. The leafy spurge densities in segments 1, 3, 4, 5, and 8 were too low to support the release of the beetles. Following the beetle release in 2011, the density of leafy spurge has remained relatively unchanged in segment 7, but a reduction in plant density at segment 4 was observed for the first time since the beetle release. It is possible a small population of flea beetles has become established in this segment. The following excerpt was taken from the University of North Dakota extension service which discusses the use of flea beetles to control leafy spurge:

"If a flea beetle population becomes established but does not control leafy spurge, perhaps a second release of the same and/or different species will improve control. However, if the insect population does not increase after multiple releases, the site may not be suitable for Aphthona spp. to control leafy spurge. Each Aphthona spp. requires a slightly different type of habitat for survival. Also, Aphthona spp. generally will not establish at sites with excess moisture, long periods of shade, very sandy soil, high leafy spurge density, or poor snow cover in the winter. Of these problems only the density of the leafy spurge stand can be altered. Herbicide application in the fall and sheep or goat grazing from mid-May until mid-August will reduce the leafy spurge density and both methods are compatible with flea beetles.

Unlike herbicides, biological control agents do not provide predictable, consistent levels of leafy spurge control. Often Aphthona spp. take several years to become established and then require several more years to reduce a leafy spurge stand. Wide-scale rapid reduction of leafy spurge infestations are so far the exception, not the rule. Biological control of leafy spurge with flea beetles is not a "quick fix" and a land manager must practice patience when using this control method."
http://www.ag.ndsu.edu/griggscountyextension/biological-control-of-weeds-1/biological-control-of-weeds-how-to-successfully-release-leafy-spurge-flea-beetles

Woody Invasive Species
Applied Ecological Services was contracted to manage the treatment of woody invasives in segments 1, 3, 4A, 5C, 6, and 7A. Black locust, common buckthorn, and honeysuckle suckers and seedlings were documented in the target areas where these species were removed in the fall of 2012 and spring of 2013. A site walk through with AES occurred on May 20 at segments 1, 3, 4A, 6, and 7A to assess woody invasive sucker growth and foliar spray treatment options in areas previously managed. During the walk through, it was decided that foliar treatment activities should occur in the fall of 2014 to avoid impacts to the existing native herbaceous ground layer, particularly spring ephemeral species. Spraying in the fall will minimize incidental contact with native species since the majority of native species will be dormant. The contract with AES is still open and follow-up treatments in areas where buckthorn and honeysuckle seedlings/suckers were observed in the spring of 2014 will be treated in the fall of 2014. Observations from each segment are listed below:

Segment 1: Black locust seedlings have sprouted following cut stump treatment in the fall of 2012. Some seedlings exceed 4 feet in height. No re-growth of Siberian elm was observed. Several silver poplar (*Populus alba*) trees were noted along the paved trail northwest of Jeffers Pond Elementary School.

Segment 3: Occasional sucker growth from cut stumps of buckthorn and honeysuckle was observed. Re-growth of native herbaceous species has occurred so foliar spraying will be conducted during the fall. No re-growth of Siberian elm was observed.

Segment 4A: Occasional sucker growth from cut stumps of buckthorn and honeysuckle was observed. Re-growth of native herbaceous species has occurred so foliar spraying will be conducted during the fall. No re-growth of Siberian elm was observed. Dense stands of honeysuckle and buckthorn occur between Pike Lake Trail and Jackson Trail, as well as on the western easement between Jackson Trail and the Jackson field road crossing. These areas were not managed in 2012 due to conflicting easement information and property access.

Segment 5C: Slight sucker growth from cut stumps of buckthorn and honeysuckle was noted in the small treatment area immediately upstream of Dean's Lake.

Segment 6: Buckthorn seedlings were observed in the treatment area on the east side of the Dean's Lake weir.

Segment 7A: Occasional sucker growth from cut stumps of buckthorn and honeysuckle was observed. Re-growth of native herbaceous species has occurred so foliar spraying will be conducted during the fall. No re-growth of Siberian elm was observed.

Recommendations
Monitoring populations of garlic mustard in areas where hand cutting occurred in 2011-2014 will increase our knowledge of the effectiveness of this control method. Cutting dense populations of garlic mustard within easement areas will reduce the seeding potential to downstream segments, but

complete eradication of this species within the PLOC will not be possible as long as larger populations exist outside of the easements. It is not recommended to treat garlic mustard with herbicides since herbicides in general are non-selective and spraying during the growing season could possibly eradicate any native plants and seedlings growing in or near the treatment area.

Leafy spurge should be managed with biological or mechanical methods. Flea beetles should be released in segments 4, 5C, and 7 following guidance from Minnesota Department of Agriculture or the University of North Dakota extension service. Beetle releases should be conducted at a minimum of two consecutive years in areas where the beetles have not become established. Any mowing activities should be performed when the plants begin flowering, typically during late May. Mowing is recommended along road embankments and other accessible areas to control the populations of leafy spurge as well as thistle, common burdock, cow vetch, and spotted knapweed.

The satellite population of silver poplar in segment 1 and the black locust seedlings near Jeffers Pass should be cut and the stumps treated with a glyphosate solution in the fall of 2014. This area occurs within the headwaters of the PLOC and removing the trees will help prevent the migration of these species to downstream resources.

If possible, the remaining stands of common buckthorn and honeysuckle in segments 1, 2, 3, 4A, 4B, 5B, 6, 7B, and 8 should be cut and the stumps treated with a glyphosate solution. Removal of these species will promote the growth of an herbaceous ground layer by enabling light to reach the ground surface. The increase in light may also encourage the growth of invasive species; therefore, close monitoring and maintenance should be conducted if this option is implemented. If management is implemented in these segments, routine maintenance and spot treating will be necessary to limit the re-growth of invasive species since significant populations occur adjacent to the PLOC corridor.

Conclusion

Satellite populations of invasive species should be treated as soon as possible to limit the spread of the species to other areas. Complete eradication of common invasive species will not be possible along the PLOC as long as larger populations exist outside of the easement; however, managing common invasive species along the PLOC will benefit the local flora and fauna of the PLOC and will help stabilize soils along the banks of the channel.

Appendix A

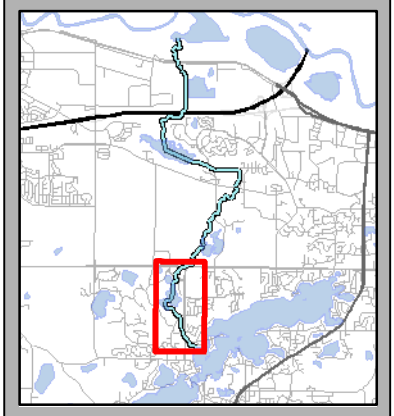
PLOC Vegetation Invasive Species Maps

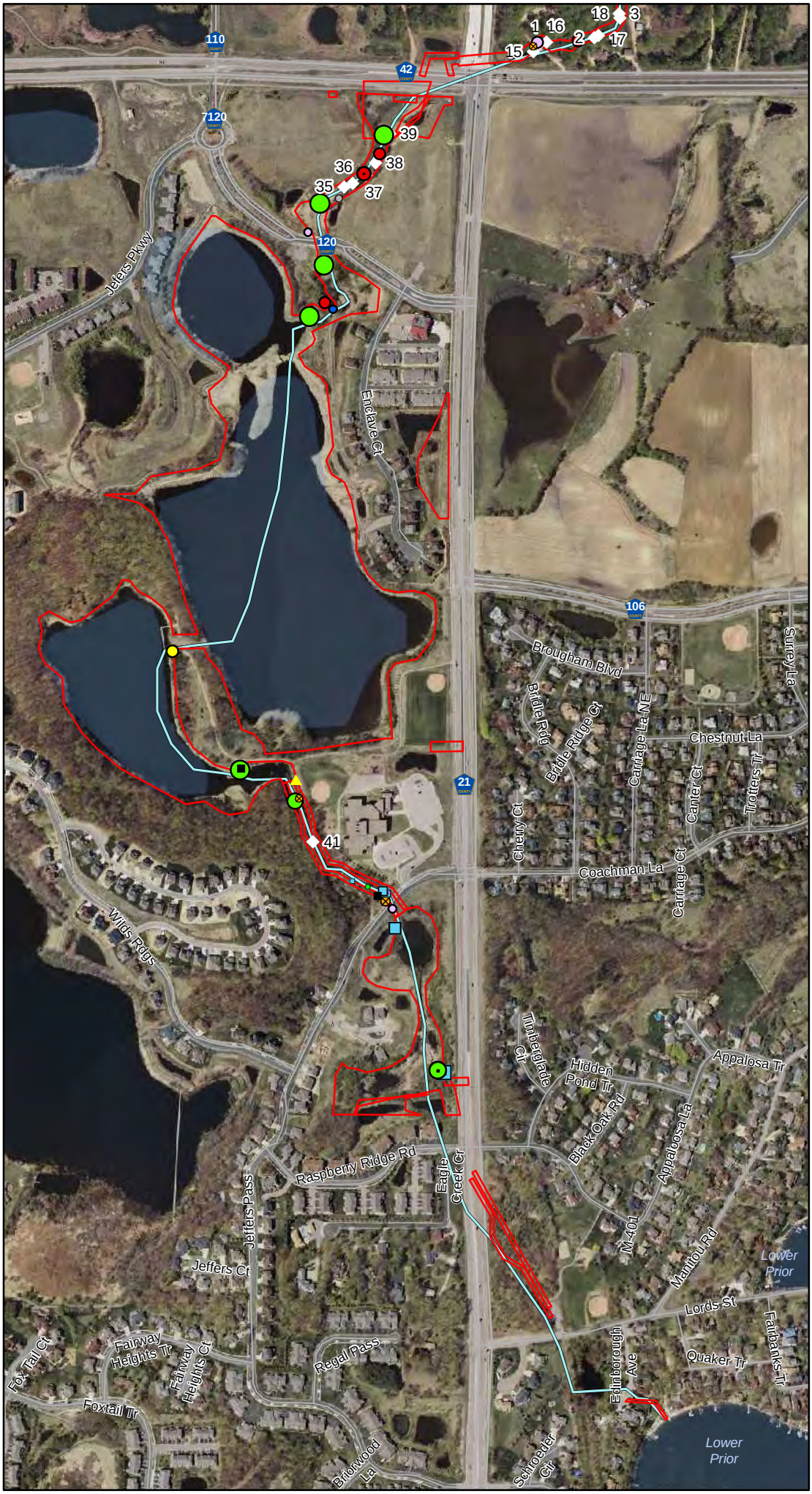
Segment 1

Invasive Species 2014

Plant Species, Cover Class

- Black locust, 1 (0-3%)
- Black locust, 2 (3-10%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Cow vetch, 1 (0-3%)
- Creeping charlie, 1 (0-3%)
- Creeping charlie, 2 (3-10%)
- Creeping charlie, 4 (25-50%)
- Creeping charlie, 5 (50-75%)
- Creeping charlie, 6 (75-100%)
- Honeysuckle, 2 (3-10%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 1 (0-3%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Siberian elm, 1 (0-3%)
- Silver Poplar, 1 (0-3%)
- Wild Parsnip, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries





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Segment 2

Invasive Species 2014

Plant Species, Cover Class

- Black locust, 1 (0-3%)
- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Canada thistle, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Erosion Site
- Outlet Channel Easement Boundaries

Feet

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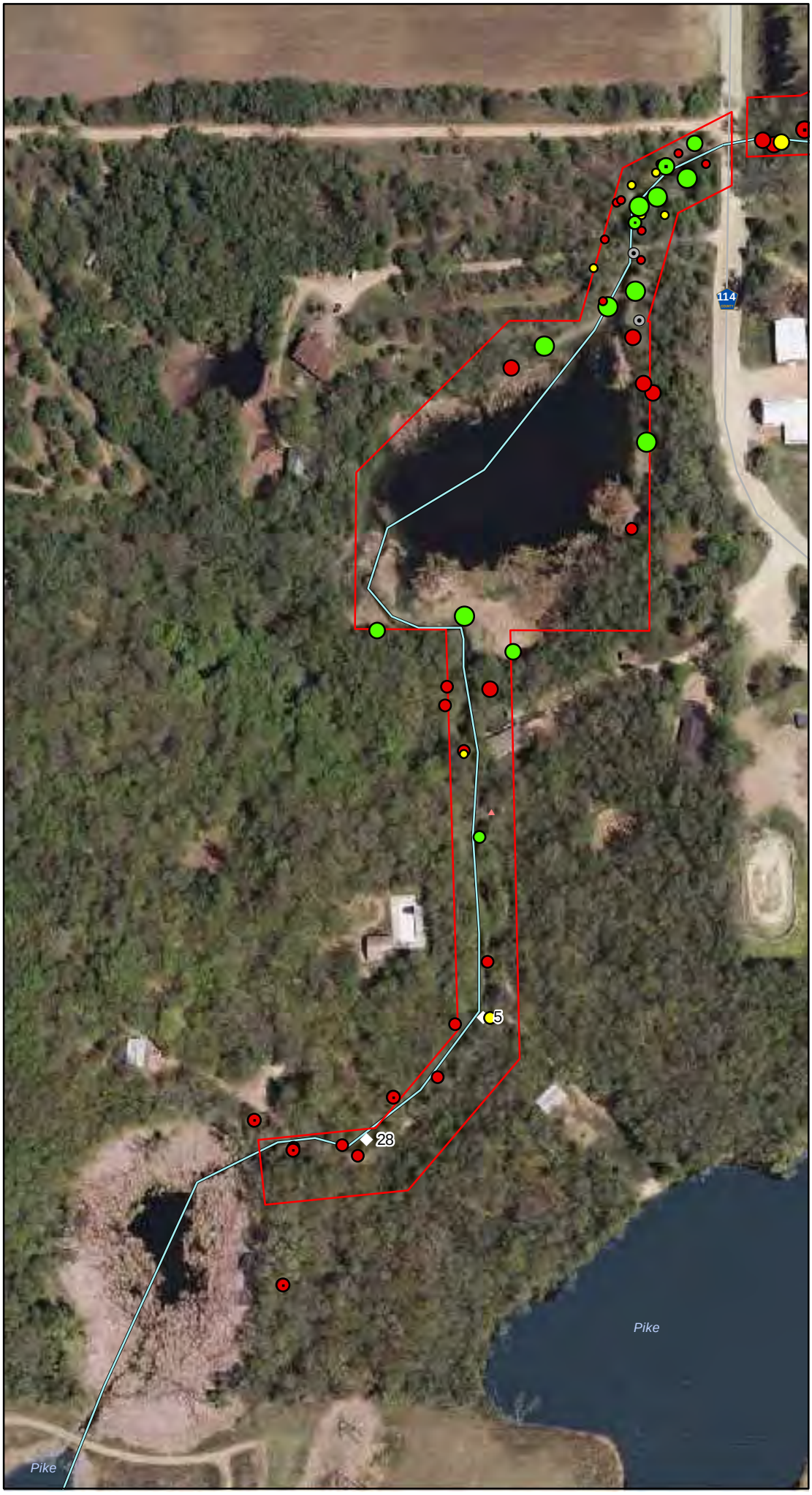
Segment 3

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Garlic mustard, 1 (0-3%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 4 (25-50%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



water ecology community

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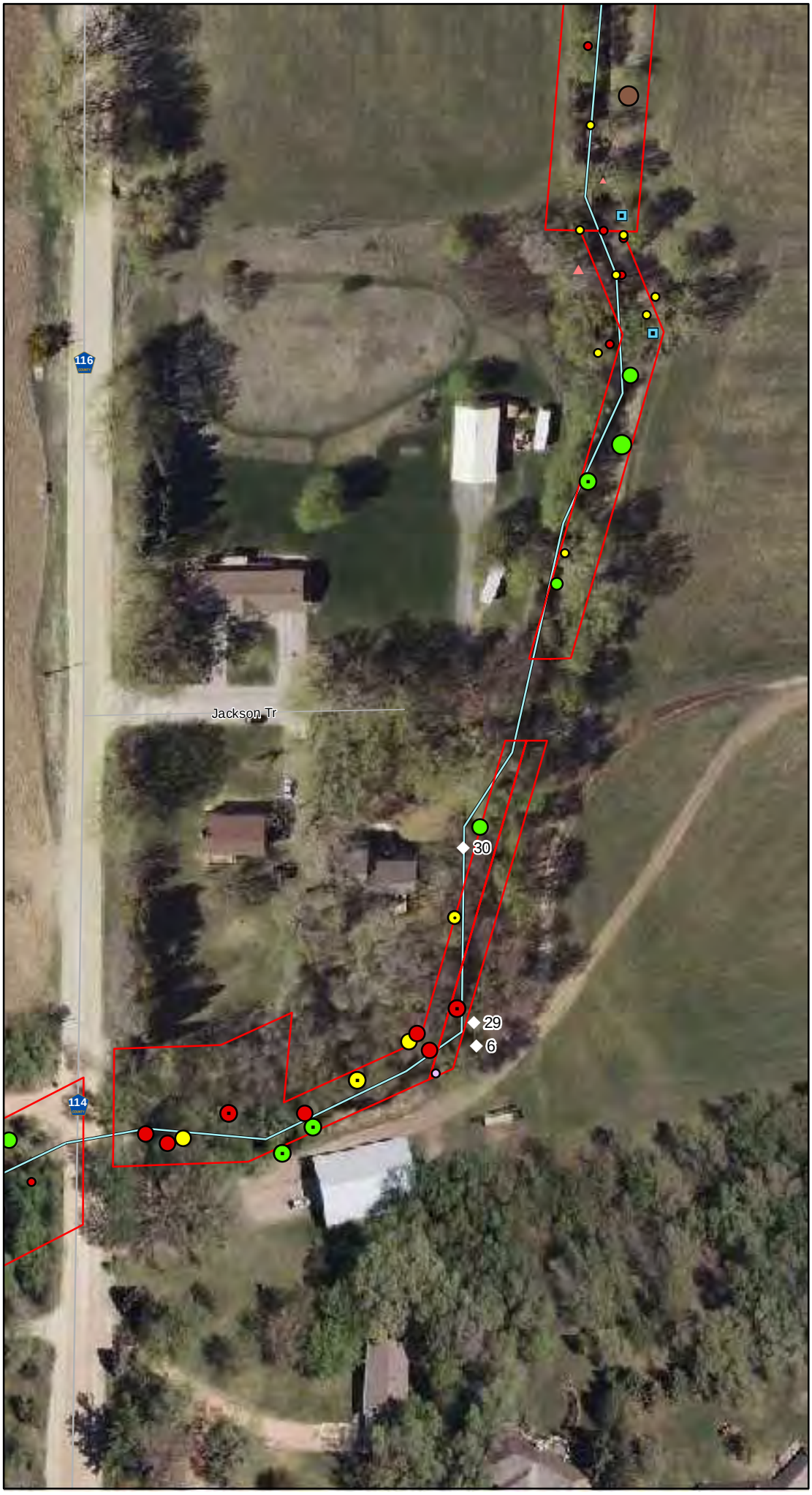
Segment 4a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



water ecology community

Feet

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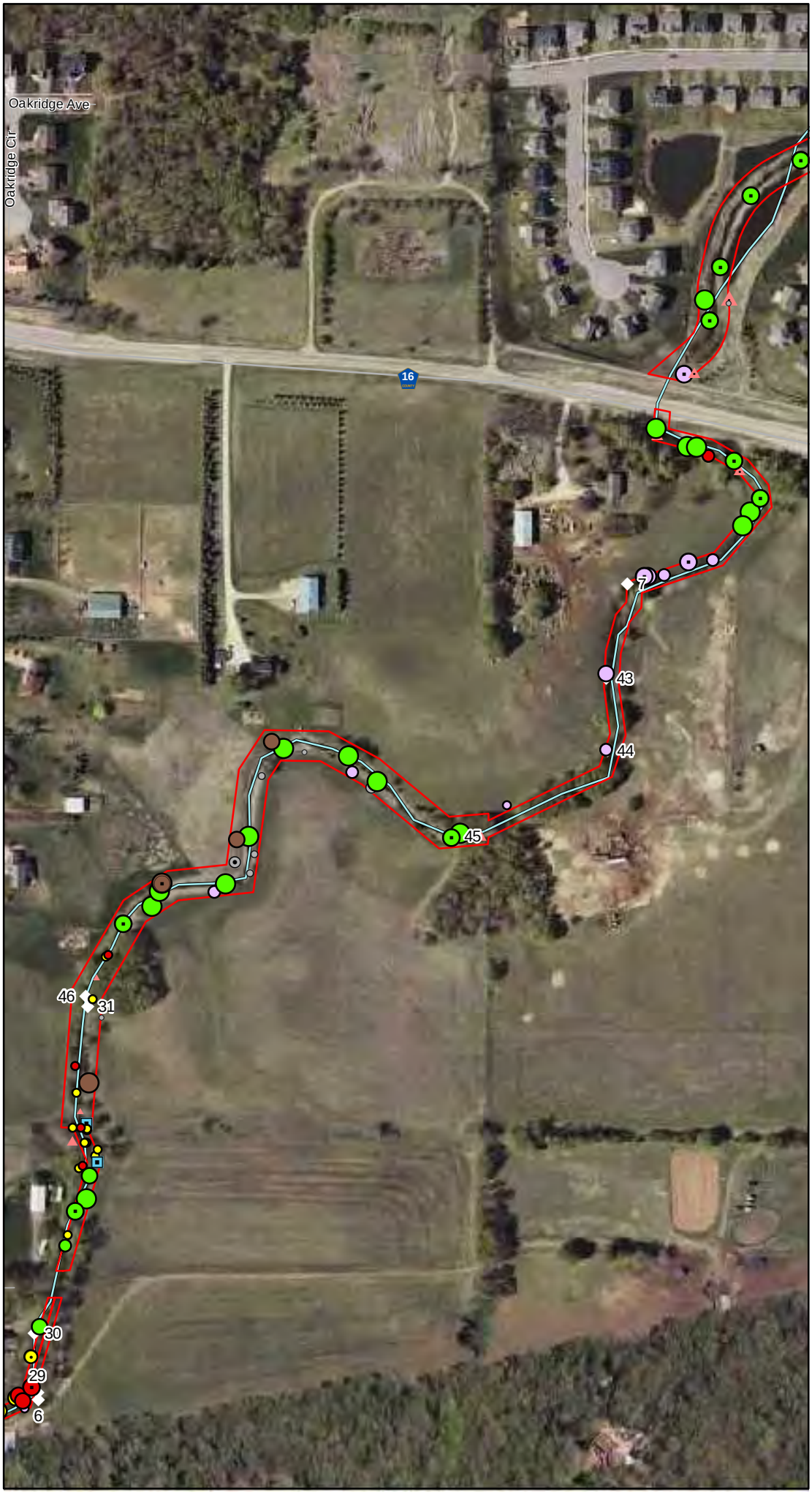
Segment 4b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Erosion Site
- Outlet Channel Easement Boundaries



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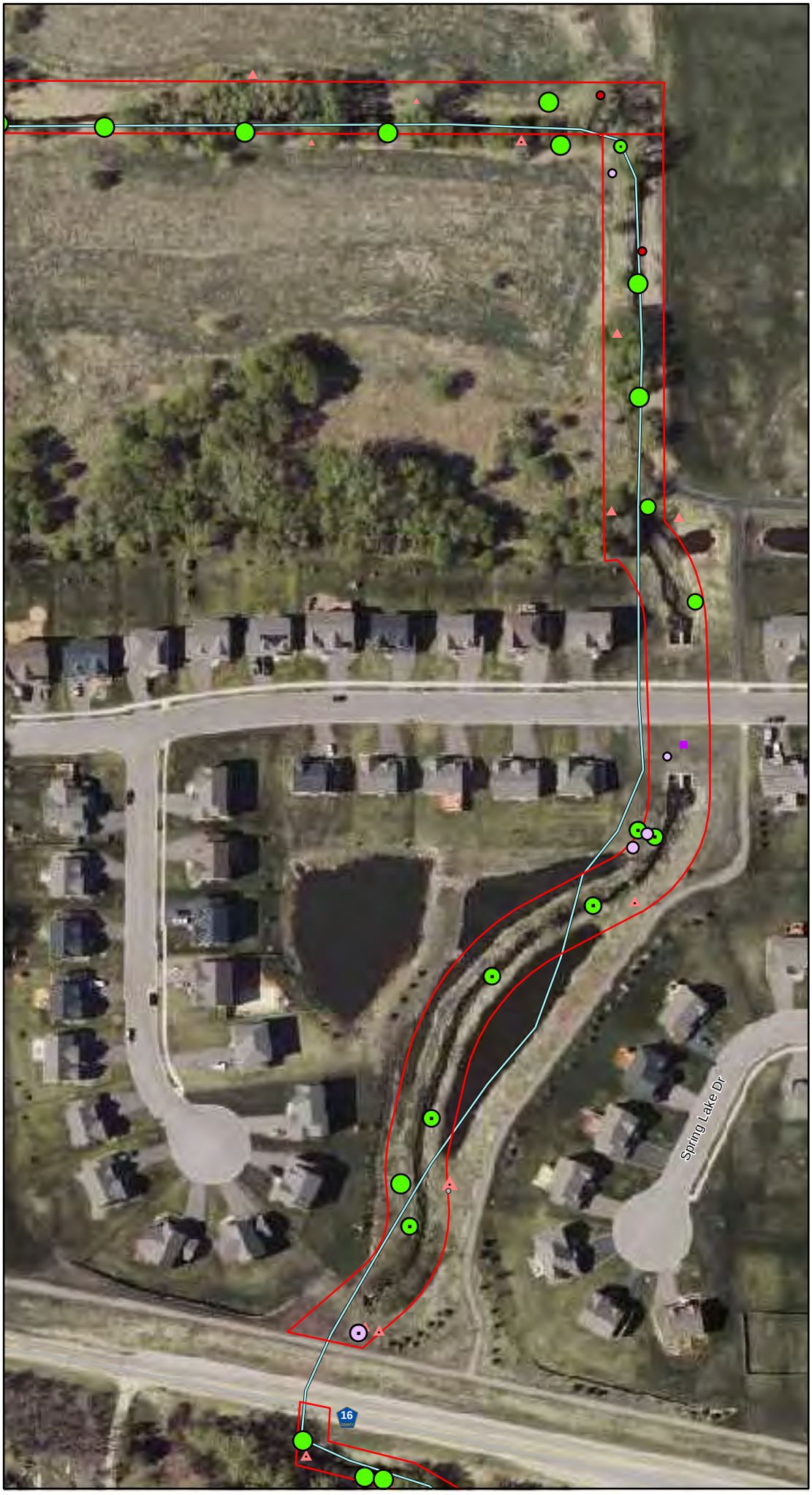
Segment 5a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 5 (50-75%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Outlet Channel Easement Boundaries



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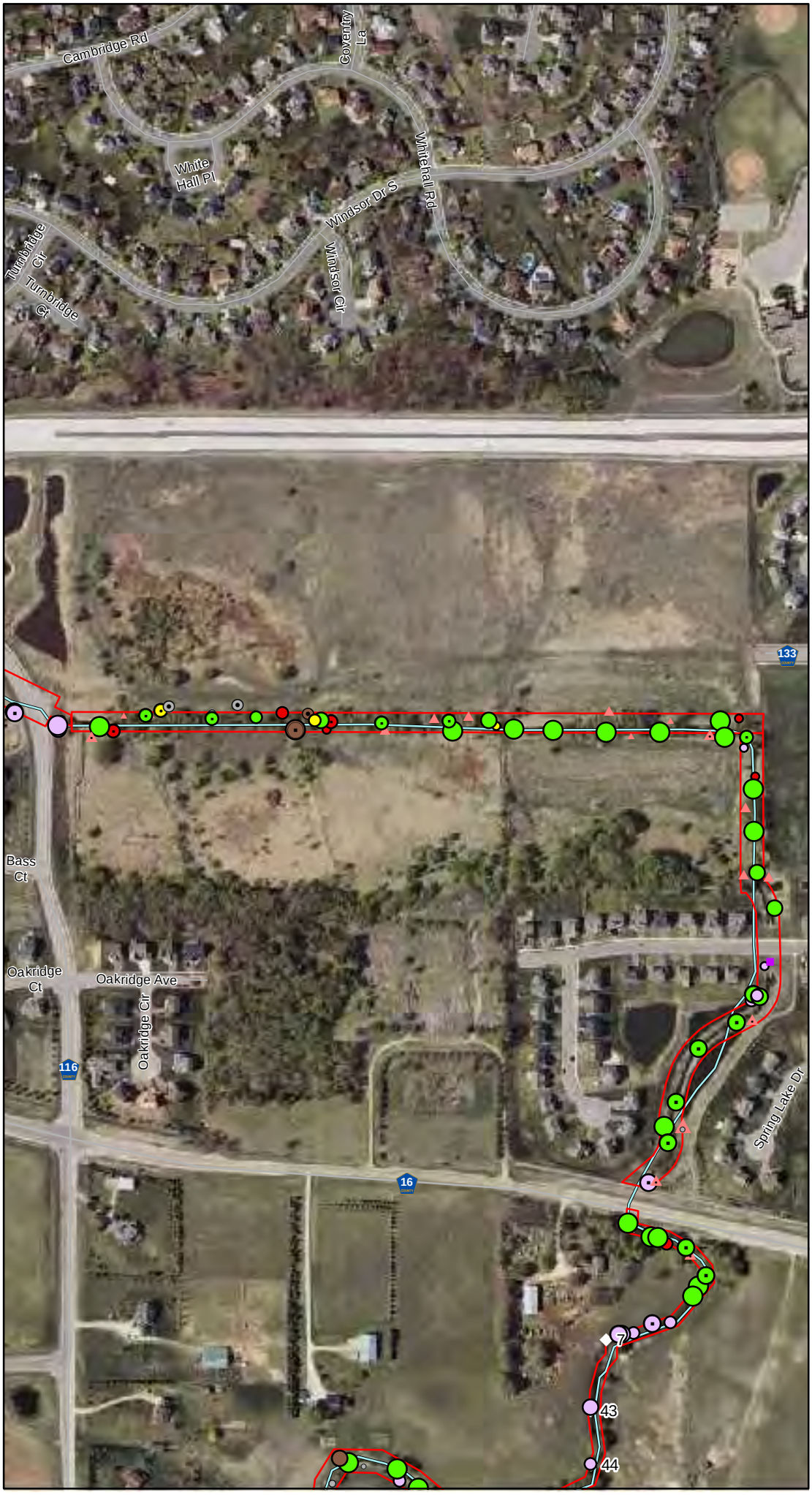
Segment 5b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Canada thistle, 1 (0-3%)
- Canada thistle, 2 (3-10%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Canada thistle, 6 (75-100%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Garlic mustard, 5 (50-75%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Reed Canary, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 3 (10-25%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Spotted knapweed, 2 (3-10%)
- Erosion Site
- Outlet Channel Easement Boundaries



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Feet

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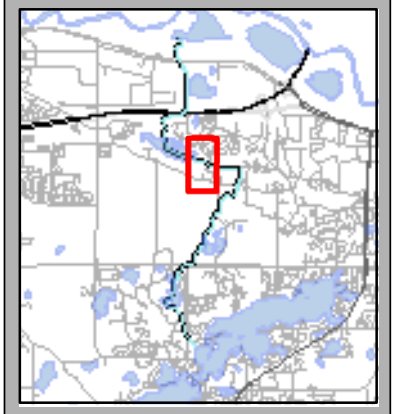
Segment 5c

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 3 (10-25%)
- Canada thistle, 4 (25-50%)
- Canada thistle, 5 (50-75%)
- Canada thistle, 6 (75-100%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 1 (0-3%)
- Leafy spurge, 1 (0-3%)
- Reed Canary, 6 (75-100%)
- Spotted knapweed, 2 (3-10%)

Outlet Channel Easement Boundaries



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Feet

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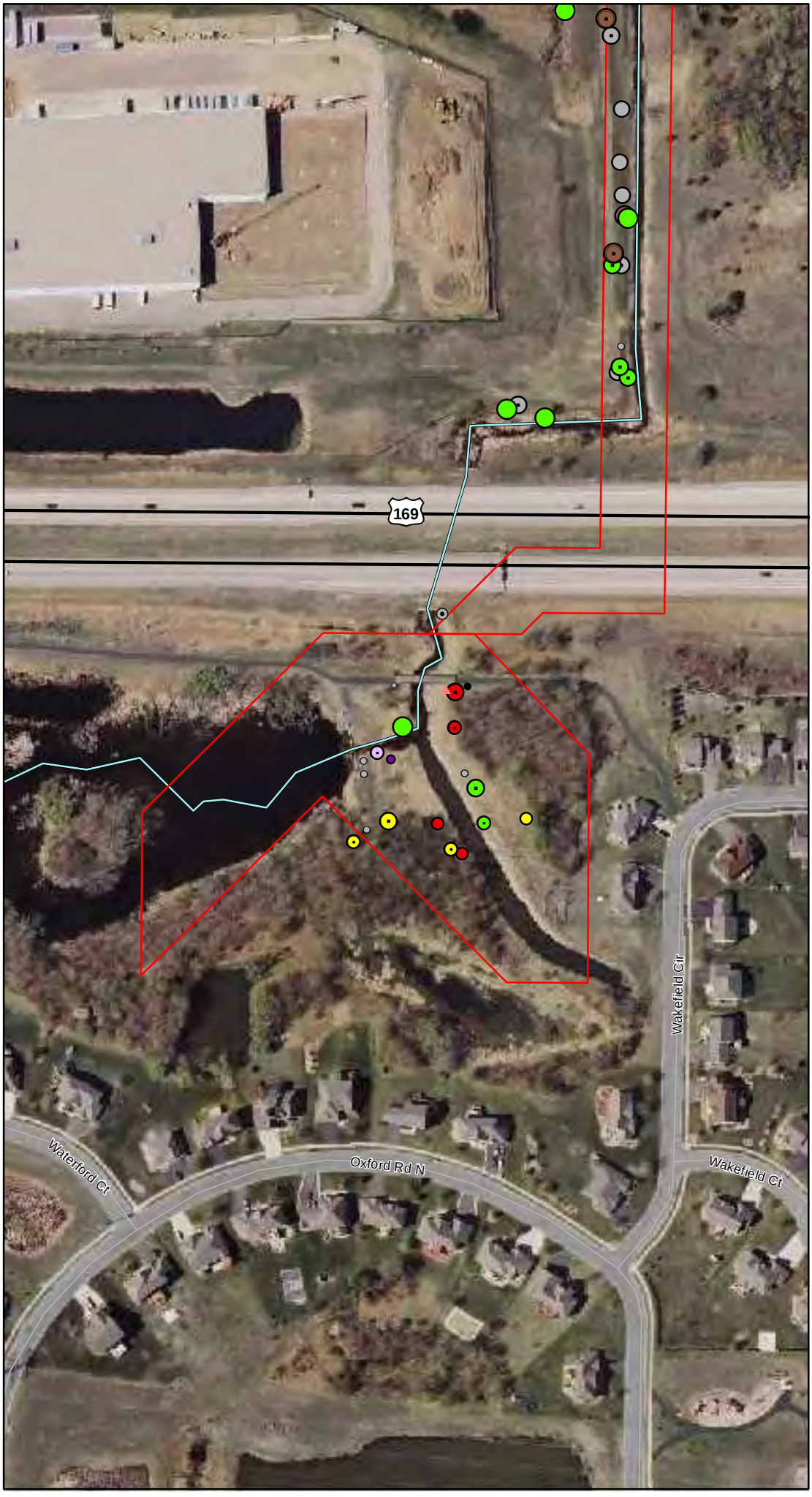
Segment 6

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 3 (10-25%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Leafy spurge, 4 (25-50%)
- Leafy spurge, 5 (50-75%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Purple Loosestrife, 1 (0-3%)
- Outlet Channel Easement Boundaries



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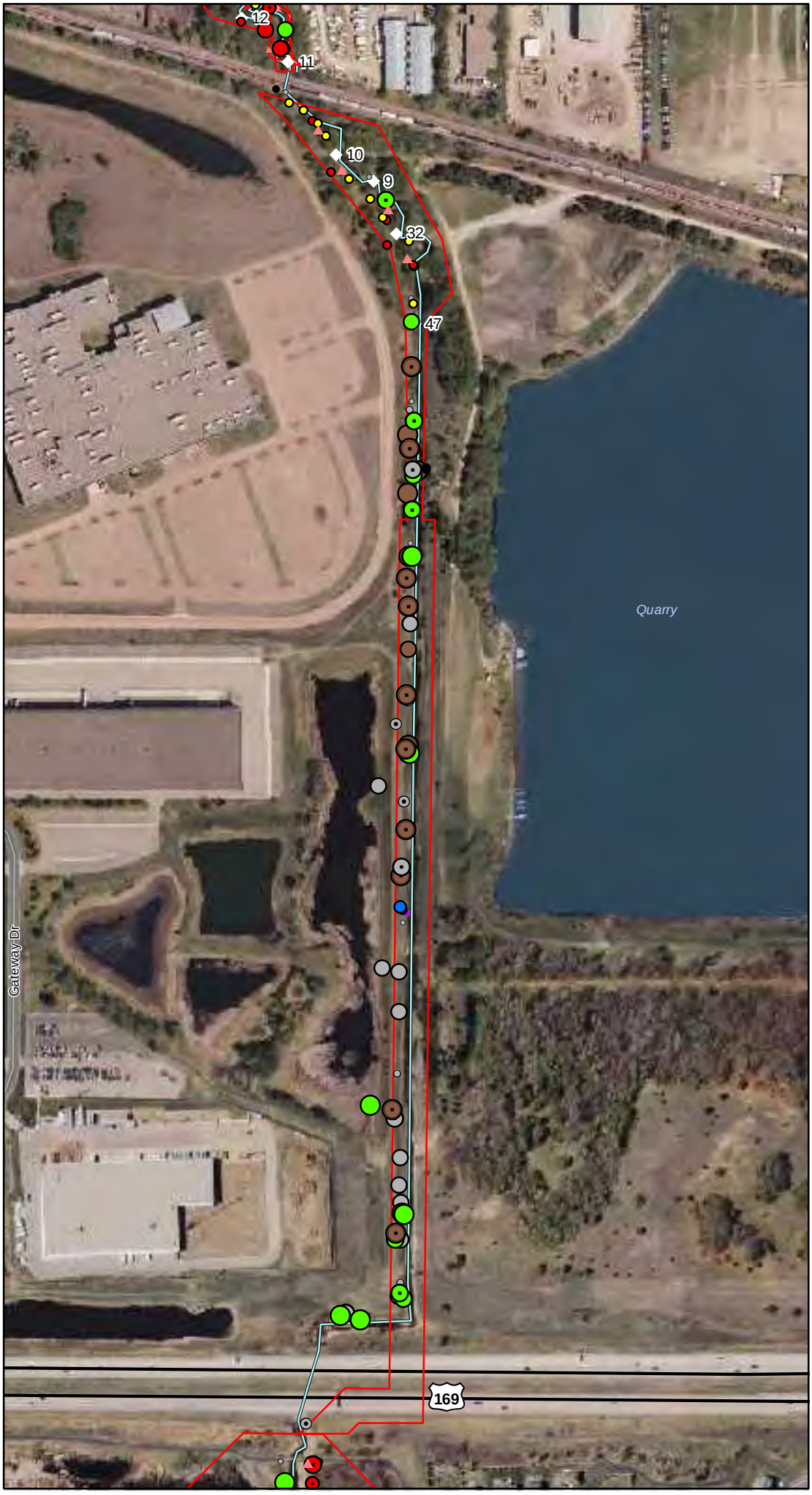
Segment 7a

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Cow vetch, 1 (0-3%)
- Cow vetch, 2 (3-10%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Leafy spurge, 3 (10-25%)
- Leafy spurge, 4 (25-50%)
- Leafy spurge, 5 (50-75%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Siberian elm, 1 (0-3%)
- Siberian elm, 2 (3-10%)
- Smooth brome, 4 (25-50%)
- Smooth brome, 5 (50-75%)
- Smooth brome, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Spotted knapweed, 2 (3-10%)
- Erosion Site
- Outlet Channel Easement Boundaries



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Segment 7b

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 1 (0-3%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 1 (0-3%)
- Honeysuckle, 2 (3-10%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Spotted knapweed, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries

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Feet

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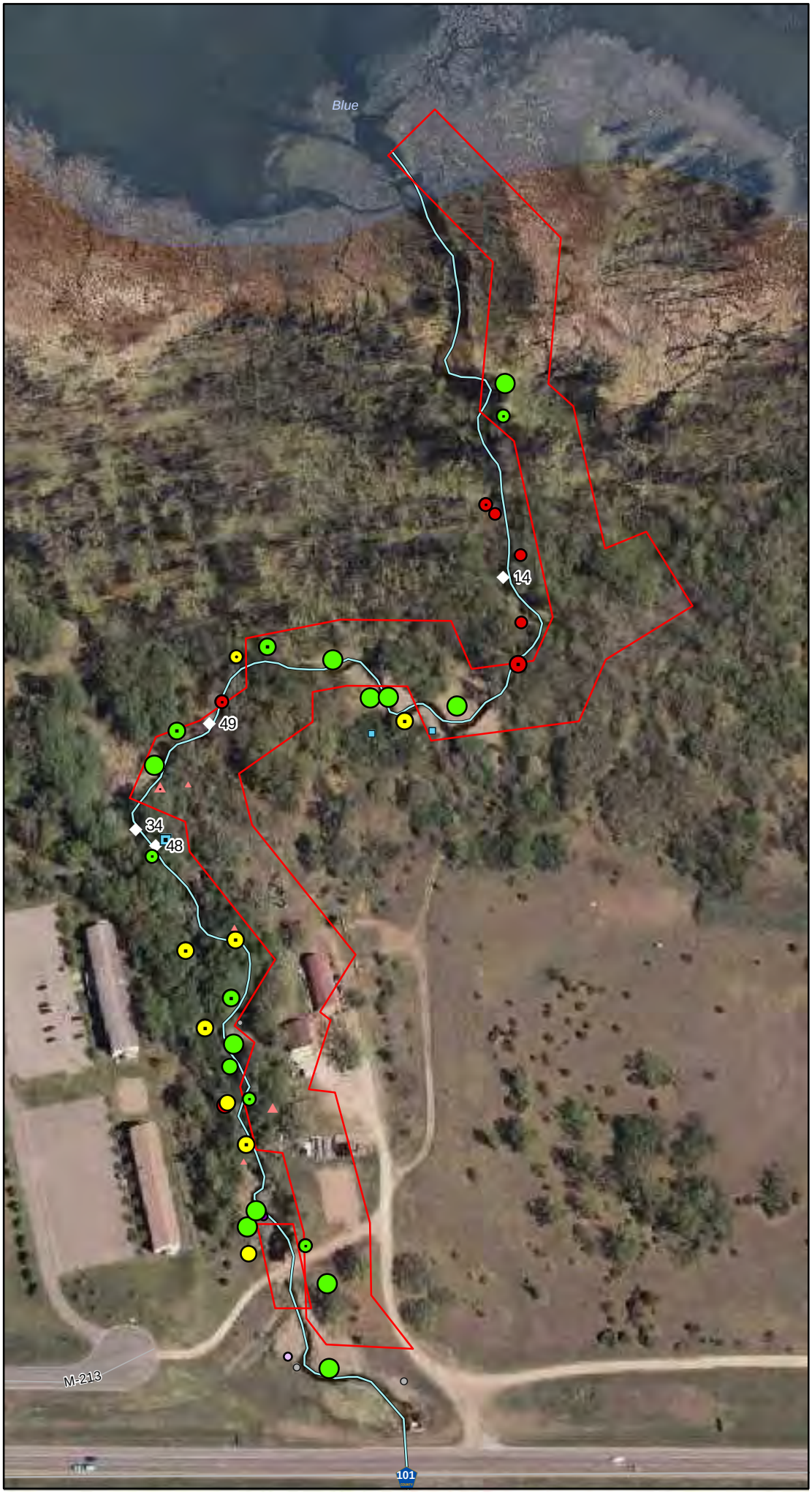
Segment 8

Invasive Species 2014

Plant Species, Cover Class

- Buckthorn, 2 (3-10%)
- Buckthorn, 3 (10-25%)
- Buckthorn, 4 (25-50%)
- Buckthorn, 5 (50-75%)
- Canada thistle, 1 (0-3%)
- Creeping charlie, 2 (3-10%)
- Creeping charlie, 3 (10-25%)
- Garlic mustard, 1 (0-3%)
- Garlic mustard, 2 (3-10%)
- Garlic mustard, 3 (10-25%)
- Honeysuckle, 3 (10-25%)
- Honeysuckle, 4 (25-50%)
- Honeysuckle, 5 (50-75%)
- Leafy spurge, 1 (0-3%)
- Leafy spurge, 2 (3-10%)
- Reed Canary, 3 (10-25%)
- Reed Canary, 4 (25-50%)
- Reed Canary, 5 (50-75%)
- Reed Canary, 6 (75-100%)
- Purple Loosestrife, 1 (0-3%)
- Erosion Site
- Outlet Channel Easement Boundaries



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Feet

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Appendix B

PLOC Bank Erosion Tables

Segment 1

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
34	20 x 3	60	Raw bank
35	25 x 3	75	Raw bank
36	40 x 3	120	Raw bank
37	30 x 4	120	Raw bank
38	100 x 3	300	Raw bank
39	20 x 1	20	Raw bank

Segment 2

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
1	75 x 10	750	Raw bank
2	50 x 7	350	Raw bank
3	15 x 15	225	Raw bank
4	150 x 10	1500	Raw bank
15	10 x 5	50	Raw bank / downstream of driveway
16	60 x 6	360	Raw bank
17	20 x 3	60	Raw bank
18	30 x 8	240	Raw bank/ driveway embankment
19	100 x 2	200	Undercut bank
20	20 x 10	200	Raw bank
21	30 x 7	210	Raw bank
22	30 x 2	60	Undercut bank
23	30 x 6	180	Raw bank
24	80 x 2	160	Undercut bank
25	40 x 8	320	Raw bank / undercut elm
26	20 x 3	60	Raw bank / undercut cottonwood
27	30 x 4	120	Undercut bank
40	15 x 4	60	Raw bank
42	40 x 2	80	Raw bank

Segment 3

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
5	30 x 6	180	Raw bank
28	80 x 2	160	Raw bank

Segment 4

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
6	100 x 2	200	Raw bank
7	60 x 6	360	Raw bank
29	150 x 4	600	Raw bank
30	75 x 2	150	Raw bank
31	40 x 2	80	Raw bank
43	200 x 3	600	Raw bank
44	30 x 4	120	Raw bank
45	200 x 3	600	Raw bank
46	200 x 3	600	Raw bank

Segment 7

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
9	40 x 4	160	Raw bank
10	30 x 6	180	Raw bank
11	25 x 3	75	Raw bank
12	120 x 4	480	Raw bank
13	50 x 2	100	Raw bank
32	25 x 6	150	Raw bank / large oak at top of bank
33	40 x 3	120	Raw bank
47	25 x 6	150	Raw bank

Segment 8

Point Number	Length x Height [ft.]	Exposed Area [sq.ft.]	Notes
14	25 x 5	125	Raw bank
41	50 x 4	200	Raw bank
48	75 x 5	375	Raw bank
49	75 x 3	225	Raw bank