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For the PLOC Cooperators

Prior Lake Outlet Channel Master Plan



Cover Image

Prior Lake Outlet Channel – Segment 1 Upper Jeffers Pond Outlet

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EXECUTIVE SUMMARY

The purpose of this master plan is to assess the current conditions of the Prior Lake Outlet Channel (PLOC) from a channel capacity, bank stability, easement alignment with physical conditions, and invasive species management standpoint. The Cooperators requested this master plan as a means to guide PLOC MOA activities over the next five years as a bridge to consideration of alternate means to manage the channel.

The PLOC, in its current condition, has adequate capacity to convey the 100-year, 24-hour storm event without overtopping roads and driveways at all but three crossings. The overtopped crossings are the Pike Lake Outlet, Camp Kici Yapi driveway, and the Strauss driveway in Segment 3. Upsizing these crossings to prevent overtopping was shown not to adversely affect the capacity of downstream crossings.

The channel operated at full capacity during the flooding of June 2014, resulting in roughly 7,400 linear feet of eroded banks. FEMA funding has been secured to repair these banks, with construction scheduled to start in 2018. Roughly 10,200 linear feet of eroded banks will remain after completion of this project and should be considered for future work.

A summary of existing easements along the channel is presented in section 2.3. Many of these easements have been corrected in recent years to more accurately align with the channel. However, other easements will need to be adjusted, in coordination with development of those areas.

Management of invasive species has been ongoing since 2011, with vegetation surveys occurring twice a year, once in the spring and once in the fall. Annual vegetation activities have managed both herbaceous and woody invasive species through hand pulling and cutting, herbicides, and biological controls. Managed species include garlic mustard, purple loosestrife, leafy spurge, and common buckthorn, among others. Monitoring and management of these species is recommended to continue into the future to promote the success of deeper rooted vegetation that aids in stability of the channel banks.

The following table summarizes the estimated additional costs, above and beyond annual operations and maintenance, for bank repair and invasive species management of the PLOC over the next five years.

ACTIVITY	2019	2020	2021	2022	2023
Bank Repair	\$150,000	\$206,000	\$88,000	\$111,500	\$132,500
Bank Inspection	\$7,500	\$7,500	\$7,500	\$7,500	\$7,500
Invasives Mgmt.	\$7,500	\$7,500	\$5,000	\$5,000	\$5,000
TOTAL	\$165,000	\$221,000	\$100,500	\$124,000	\$145,000

1. BACKGROUND AND HISTORY

1.1. Construction of the Outlet Channel

Construction of the Prior Lake Outlet Structure and Outlet Channel began in 1982, almost ten years after a feasibility study identified an outlet structure as the best option to stabilize lake levels on Prior Lake. From 1983 to 1984 the region experienced extremely high rainfalls, forcing the Prior Lake – Spring Lake Watershed District (District) to open the outlet structure prior to final stabilization of the channel. This resulted in extensive erosion of channel banks downstream of the outlet structure which became the subject of numerous repair projects in the following years.

Figure 1-1 identifies the alignment of the Prior Lake Outlet Channel from the Prior Lake Outlet Structure to Blue Lake with respect to channel segments, municipal boundaries and model stations. Figure 1-2 identifies road and trail crossings along the length of the channel.

1.2. Early Maintenance & Repairs: 1983-1990

After initial flooding in 1983, the District launched Flood Emergency Project 83-2. This project focused on erosion control along unstable banks and culvert repairs at stream crossings. Repairs continued through 1990 under Outlet Repair Projects 76-4R84, 76-R85, 76-4M88, and 83-2R85. The majority of repairs occurred within Channel Segments 4 and 5, including culvert replacement and repairs, sediment and debris removal, and placement of riprap and rock baffles. In 1987, the District approved the construction of a stream crossing on the Squires property along Segment 2.

1.3. Maintenance & Repairs: 1991-2003

Maintenance and repairs continued for the remainder of the 1990s. From 1993 to 1995 several improvements were made on the Jeffers property in Segment 1. This work involved riprap placement, sediment removal from Jeffers Upper Pond, outlet repairs, and repairs to the damaged trail crossing downstream of Jeffers Lower pond. Around the same time, the culvert at the Kes driveway was dredged to remove sediment and riprap was placed within the channel on the YMCA Camp Kici Yapi property. In 1995, the outlet channel was temporarily realigned to accommodate installation of a sanitary sewer line passing under the Shakopee Bypass. 1995 also saw the removal of deposited sediment from Dean Lake in Segment 6. In Segment 4, just north of County Road 16, the channel was regraded and rock baffles were placed in collaboration with the Meadowbrook Run development. In the late 1990s, repairs were made to the outlet of Pike Lake, including restoration of the road crossing and placement of riprap and gabions. Temporary repairs were made on the outlet structure in 1998 to combat cracking that had occurred over the last 15 years. Repairs from 2000 to 2001 included bank stabilization at Camp Kici Yapi, riprap placement and reshaping of slopes on Segments 2 and 4A, and planting of willow stakes north of Highway 101 in Segment 8. Debris was removed from the outlet structure of Jeffers Upper Pond in 2001. From 2001 to 2003 a gabion drop structure was constructed on Segment 7A, just south of the railroad tracks. Additional stabilization work occurred in this area in 2004. A second culvert was constructed at the outlet of Pike Lake in 2003.

1.4. PLOC Improvement Project & Subsequent Repairs: 2003-2007

In 2003 the District began a long term project entitled PLOC Improvement Project (this project has also been referred to as the Outlet Channel Restoration and Enhancement Project). The project was to be constructed in several phases over 5 to 7 years. Work on Phase 1 was completed in 2006. This phase included work on Segment 1 (erosion control measures and debris removal from the outlet pipe to the inlet of Jeffers Pond) and Segment 4B (erosion control, debris removal, and cattle fencing). A sediment delta on Pike Lake was removed in 2006 as part of Phase 2. Phase 3 was completed in 2007 on Segment 5C. Phase 3 also included channel realignment (adding sinuosity) of Segment 5C in cooperation with the Riverside Bluffs development. Phase 4 of the project never came to fruition. This phase would have included re-sloping of banks, plunge pools, removal of deposited sediment, and willow and dogwood plantings at various locations along segments 6-8. In 2007, the Multi-year Outlet and Channel Improvement Project was initiated and a Memorandum of Agreement signed between the District, City of Prior Lake, City of Shakopee, and the Shakopee Mdewakanton Sioux Community (via a Joint Powers Agreement).

1.5. Summary of Projects: 2008-Present Day

In 2008, an undersized culvert was replaced at the U.S. Fish and Wildlife Service (USFWS) trail crossing on Segment 8. Channel stabilization on several segments was completed between 2008 and 2010. The Prior Lake outlet structure was replaced in 2010 with a more efficient and aesthetically pleasing design. A flood in 2011 resulted in overtopping of the channel on Segment 7 near Quarry Lake, resulting in a gully washout and sediment depositing into the lake. In response, a berm was constructed to contain water within the channel during subsequent flood events. That same year the culvert at the Squires driveway in Segment 2 was replaced (by the landowner). In 2013, several more culverts (Pike Lake Road, Jackson Trail crossing, and Gonyea crossing) were replaced in Segments 3 and 4. A set of box culverts was installed just south of the railroad tracks on Segment 7 to facilitate access to the newly-built Quarry Lake Park. A large flood in 2014 caused widespread erosion along the channel and resulted in several failed culverts. Channel realignment and stabilization of Segment 4A was completed in 2015. Debris removal from the 2014 flood was completed in 2015. Damaged culverts were repaired or replaced by 2016. Instead of replacing the USFWS trail crossing, the culvert was removed and the area restored to native conditions. Also in 2016, the outlet pipe was inspected and found to be in good condition. Minimal repairs were completed at that time. Chemical grouting to seal leaking joints was completed during the spring of 2018.

Projects partially funded with FEMA Public Assistance dollars that have been completed include: Tree and Debris removal along all Segments, Culvert Repairs at Kes Field Road, Pike Lake Park Crossing, and Gonyea Field Road, and Segment 5 Sediment Removal. Projects designed and to be constructed include Bank Stabilization in Segments 1, 2, 3, 4, 7, and 8.

1.6. PLOC Project Database

DISCLAIMER: This listing of projects included in the PLOC Project Database is intended to include all known construction, maintenance, repair, and improvement projects on the outlet structure and

outlet channel from its inception to present day. Although it is intended to be exhaustive, it is likely that additional records will be uncovered and could be added to the database.

Projects were found through an extensive search of historic District documents that had been scanned into an internal filing system (Laserfiche). The lack of complete records, along with the quality of scans, from earlier projects made it difficult to accurately describe project scope, budget, and completion. These records have been compiled into an Excel sheet “database” which allows users to sort records and search for individual projects and locate file names for ease of retrieval.

A reduction of the database is attached in Appendix A of this report while the full database will be made available online through the District website. The individual project files that were used to generate this database are available upon request from the District.

The PLOC Project Database provides the following information for each project:

File Name - The name of the file or folder containing the details of the project.

Project Title - The official title for a given project, if applicable.

Project Type - Designator for the type of work that was undertaken. Either Construction, Maintenance/Repairs, or Improvements.

Start Year - The first year that information on the project was found in the file. NOTE: This is not necessarily the year that the project was initiated or the year that construction began.

End Year - The last year that information on the project was found in the file. NOTE: This is not necessarily the year that construction was completed.

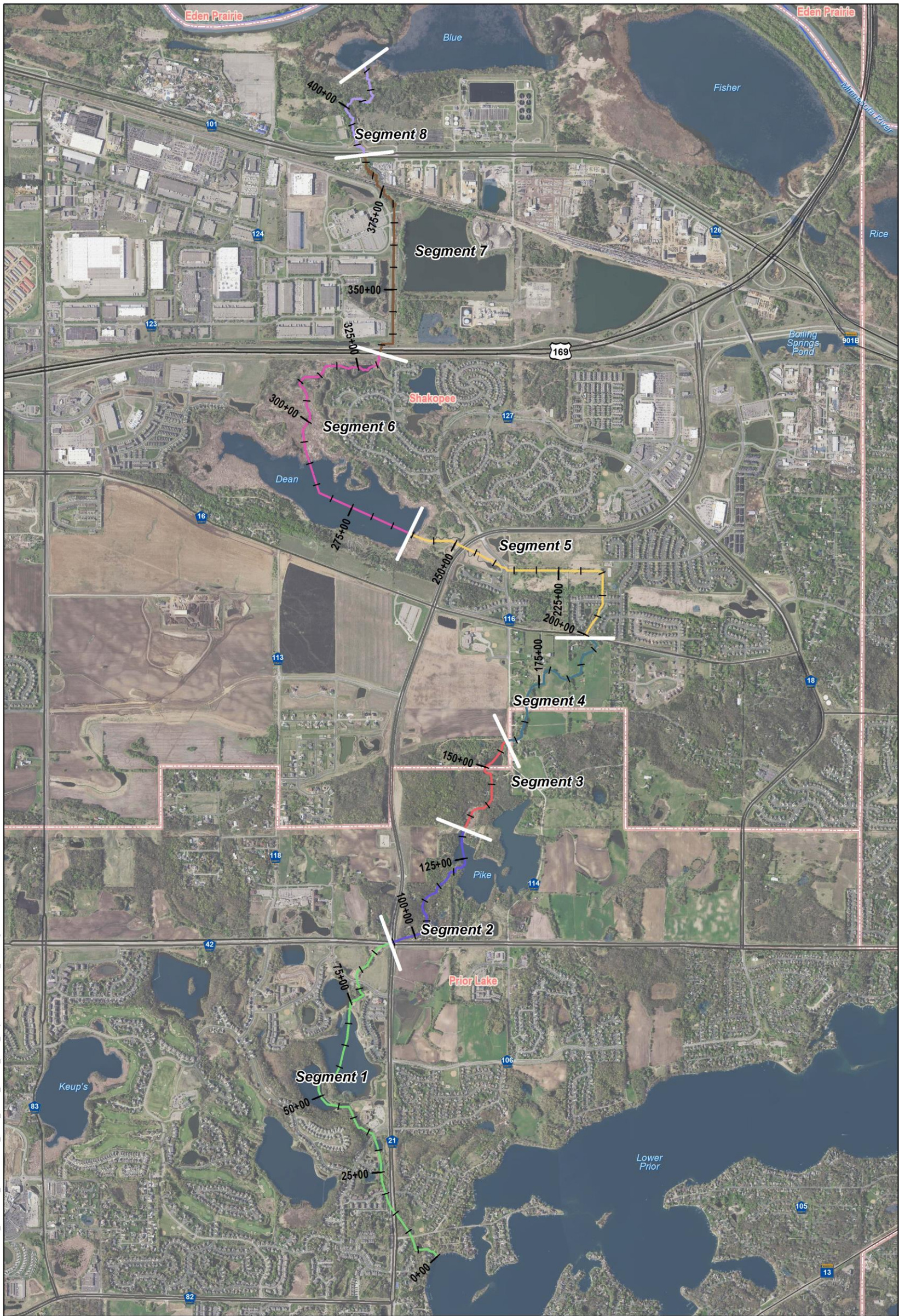
Segment - The segment (1-8) that the project was concerned with. May include multiple segments.

Location - A description of the location within the segment where the project occurred. Often identified by a road crossing or property owner.

Project Description/Scope - A brief description of the work that was done in the project (e.g. erosion control, culvert repairs).

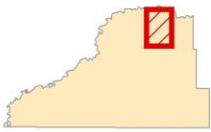
File Description - A brief description of the contents of the file (e.g. correspondence, bid specifications, reports, legal documentation, etc.).

Date: 8/15/2018 Time: 2:45:07 PM Author: ejensen
Document Path: X:\Clients_WD\00759_PLS\WD0122_PLOC_Master_Plan\09_GIMS_ProjectName\GISRM_stationing.mxd



Legend

- Municipal Boundary
- XXX+00 PLOC XPSWMM Stationing



**PLOC Master Plan
Channel Alignment**

0 0.25 Miles

N

Figure 1-1. Prior Lake Outlet Channel Alignment



Figure 1-2. Prior Lake Outlet Channel Crossings

2. ASSESSMENT OF CONDITIONS

2.1. Capacity Assessment

2.1.1. Background

The XPSWMM H&H model for the PLOC was originally constructed in 2007 by Wenck Associates, then underwent substantial revision by EOR in 2012. It has been the subject of annual maintenance and revision since then, including a recalibration in 2014 to monitored flows measured at two locations – Pike Lake Trail and the (then) downstream USFWS Crossing – during the summer of 2013. The 2012 revision revised hydrologic boundaries throughout the watershed, but many of the hydraulic elements were (and remain) carried over from the original amalgamation of models acquired from the MOA partners. The two exceptions to this are where new developments have taken place since 2012, and along the channel itself.

The model currently does not incorporate the upper watershed (upstream of the Prior Lake Outlet Structure), but rather incorporates the peak design flow rate of the Prior Lake Outlet Structure – 65 cfs – as an inflow at the upper end of the PLOC. Design storm model simulations are performed such that the channel is at steady state with 65 cfs of baseflow before a rainfall event begins.

The H&H model has been used since 2012 to ensure that new culverts at crossings along the PLOC are appropriately sized. It should be noted, however, that the release of Atlas 14 (and the subsequent adoption of these rainfall depths by engineers around 2014), as well as the release of NRCS guidance for use of the MSE3 MN rainfall distribution in or around 2015 led to a significant increase in the rainfall depth and intensity used by engineers in the design process. Therefore, some existing PLOC crossings that were designed, assessed, and/or installed during this time period may be undersized by today's standards.

In 2018, the PLOC TAC decided that the “capacity” of the PLOC should be defined as *the ability of the channel to convey the flows from the 100-year storm plus 65 cfs without overtopping crossings*. To that end, the XPSWMM H&H model was used here to assess the channel for compliance with this definition.

2.1.2. XPSWMM H&H Model Updates

The PLOC XPSWMM H&H model was updated prior to performing model runs associated with assessing the capacity of crossings along the channel. These updates included:

- Refining channel segments to introduce higher resolution and eliminate long segments in several locations;
- Refining channel cross sections to include more survey transects, including newly surveyed portions that may have changed since the 2014 flood event;
- Refining hydrology associated with the direct drainage to the channel in order to increase resolution thereby reducing the number of artificially high peak flows in the channel, as well as introducing changes associated with recent development (e.g. Ridge Creek);

- Refining hydraulics along the channel to reflect changes due to recent development (e.g. culvert removals associated with Ridge Creek), to reflect slope breaks associated with check dams in Segment 4 and Segment 7, and to better represent the Deans Lake bypass and the stormwater management area west of Quarry Lake Park;
- Validating model representation of important crossings and structures (e.g. the Pike Lake outlet) as well as crossing overflow elevations.

2.1.3. Capacity Assessment Model Runs

After completion of the model updates, the model was run for the 100-year, 24-hour Atlas 14 storm (7.2 inches) using the MSE3 MN rainfall distribution. The model predicts that three crossings would overtop during this storm event: the Pike Lake outlet, the Camp Kici Yapi driveway, and the Strauss driveway (see APPENDIX B). To evaluate the potential impacts were these crossings to be upsized in the future, the model was run with higher capacity culverts in order to determine any potential cascading impacts on downstream crossings. None of the downstream crossings were overtopped under this hypothetical scenario, indicating that *the remaining crossings in the channel have sufficient capacity to convey runoff from the 100-year, 24-hour runoff event without overtopping*, barring any significant changes to existing crossings (other than the three crossings highlighted here).

2.2. Stability Assessment

2.2.1. Background

In the spring of 2013, channel stability and bank erosion were visually assessed during vegetation surveys completed along the PLOC. These assessments were only cursory visual estimates of actively eroding banks along the PLOC. At the time, the intention of collecting these estimates was for informative purposes only. During the spring 2013 survey, EOR staff estimated 3,765 linear feet of bank erosion along the entire length of the PLOC (Segment 1 through Segment 8).

During June of 2014, significant rainfall events occurred throughout the watershed district. According to precipitation data downloaded from the Minnesota Climatology Network from June 1 to June 30, 2014, Lower Prior Lake received 11.70 inches of rain in Township 114 N, Range 22W, Section 3 and Spring Lake received 13.79 inches of rain in Township 114N, Range 22W, Section 16. The Prior Lake Outlet Structure operated at full capacity from the first week of June through the first week in August, resulting in sustained high flows in the PLOC. During this time, several culverts along the PLOC were washed out including the culvert downstream of Jackson Trail in Segment 4 (Gonyea culvert), 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. By September of 2014, water levels receded in the channel, and an inventory of bank erosion was requested by the PLOC Cooperators to document the channel condition following the June flood event. The data collected during the 2014 bank erosion inventory was used to develop a ranking system and cost estimates to guide future bank stabilization projects in each segment.

2.2.2. Methodology to Assess & Classify Bank Erosion

Bank erosion along the PLOC was assessed from Segment 1 to Segment 8 in 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 delineated using a Trimble sub-meter handheld GPS unit. Bank heights were measured from toe of slope to top of bank at several locations along each bank using a telescopic stadia rod with 1/10th foot graduations. Following the completion of the bank assessment, all survey data was imported into ArcGIS to measure bank lengths and calculate average bank heights. To determine priority sites for bank stabilization, 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.

Based on the approximate bank heights visually assessed in the spring of 2013, the outlet channel banks would have been classified as moderate or high priority sites as defined by the methodology described above. During the September 2014 bank erosion inventory, a total of 11,108 feet of bank erosion was classified as moderate and high priority. After subtracting the 3,765 feet of bank erosion visually assessed during 2013, it was determined that 7,343 feet of bank erosion could be attributed to the June 2014 flood for moderate and high priority banks. Although low priority banks were not quantified in 2013, it was estimated that 50% of the bank erosion measured at low priority sites in September 2014 could be attributed to the June 2014 flood event.

2.2.3. 2018 Bank Stabilization & Future Stabilization Projects

Data collected during the September 2014 bank erosion inventory were used to secure funding through FEMA to stabilize eroding channel banks attributed to the June 2014 flood event. Barr Engineering was retained to develop construction plans for the PLOC stabilization project proposed in 2018. The locations of the proposed FEMA bank stabilization areas identified on the Barr construction plans were overlaid on the 2014 bank erosion inventory maps (Appendix C) to identify eroded channel banks that are not currently scheduled for repair and stabilization via FEMA funding. Based on field observation, these areas should be considered for future stabilization work. The length of remaining bank erosion is summarized in Table 2-1. Additional details are included in the figures of Appendix C and the tables in Appendix E.

Table 2-1. Summary of Remaining Bank Erosion along the PLOC (following bank stabilization activities in 2018)

Segment	Remaining Bank Erosion [feet]
1	101
2	176
3	38
4	1,499
5	3,776
6	2,007
7	285
8	2,274
Total	10,156

2.3. Easement Assessment

The following table presents a brief summary of the existing easements along the channel. Several of these easements have been corrected in recent years to better match the meandering of the channel, while others have yet to be addressed. Areas not accurately covered by existing easements are proposed to be rectified upon development/land use permitting activity.

Table 2-2. Summary of Existing Easements along the PLOC

	# of privately-owned parcels with an easement # of these easements that need an amendment # of privately-owned parcels without an easement # of PLOC partner-owned parcels TOTAL # of parcels # that need GIS shapefiles created/verified					
Segment 1	8	3	0	6	14	7
Segment 2	4	2	0	3	7	4
Segment 3	1	1	0	1	2	1
Segment 4	14	9	0	0	14	9
Segment 5	0	0	1	5	6	0
Segment 6	0	0	2	1	3	0
Segment 7	5	0	3	0	8	0
Segment 8	1	1	2	0	3	1
TOTAL:	33	16	8	16	57	22
% of Total Parcels:	58%	28%	14%	28%	100%	39%

2.4. Invasive Species Assessment

2.4.1. Summary of Terrestrial Invasive Species Management – 2011 to 2017

Vegetation surveys along the easements of the outlet channel from Segment 1 to Segment 8 have been conducted twice annually (spring and fall) to determine species composition and distribution of terrestrial invasive plants. Initial vegetation surveys occurred in the spring and fall of 2011. Subsequent annual vegetation surveys have been completed through 2017. During each annual vegetation assessment, a Trimble GPS unit was used to survey the locations of new satellite populations of invasive plants encountered along the PLOC. The vegetation surveys targeted only problematic and early detection invasive species such as those found in the Minnesota Department of Transportation's list of noxious weeds and those included in the Minnesota Department of Natural Resources list of terrestrial invasive species¹. Common non-native plants such as common dandelion (*Taraxacum officinale*), common burdock (*Arctium minus*), white clover (*Trifolium repens*), common mullein (*Verbascum thapsus*) broadleaf plantain (*Plantago major*), and other naturalized weeds were not assessed. Invasive species management has occurred annually since 2011 following the annual vegetation inspections. Management practices have included manual cutting and hand-pulling, herbicide treatments, and biological control for select invasive species. EOR has conducted hand pulling and manually cutting of select invasive species (primarily garlic mustard and purple loosestrife), and Applied Ecological Services (AES) has conducted herbaceous invasive species management using herbicides and cut stump treatments for woody invasive species.

Partial reaches along the outlet channel have not been routinely managed for invasive species (as of 2017), in part due to planned bank stabilization work, forthcoming development, and/or lack of landowner cooperation or approval. These reaches include:

- Segment 1: Jeffers Upper Pond to County Road 42
- Segment 3: The easement around the shallow marsh immediately downstream of Pike Lake, and the easement around the deep marsh downstream of the Kici Yapi property
- Segment 4: Pike Lake Trail to Jackson Trail (north and west easement area), Jackson Trail to Gonyea culvert (west easement), and the cattle pasture in Segment 4B (Muhlenhardt property)
- Segment 5: County Road 16 to County Road 21 (except for garlic mustard)
- Segment 6: County Road 21 to Deans Lake weir (except small pocket of buckthorn and honeysuckle upstream of Deans Lake)
- Segment 7B: Railroad crossing to State Highway 101 (except for garlic mustard)
- Segment 8: State Highway 101 to Blue Lake (except for garlic mustard)

Invasive species documented within these unmanaged reaches include common buckthorn (*Rhamnus cathartica*), Tatarian honeysuckle (*Lonicera tatarica*), Siberian elm (*Ulmus pumila*) reed canary grass (*Phalaris arundinacea*), leafy spurge (*Euphorbia esula*) smooth brome (*Bromus inermis*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), creeping charlie (*Glechoma*

hederacea), spotted knapweed (*Centaurea maculosa*), garlic mustard (*Alliaria petiolata*), hoary alyssum (*Berteroa incana*), and crown vetch (*Coronilla varia*).

It should be noted that significant populations of terrestrial invasive species occur adjacent to the easements at numerous locations along the PLOC. For example, many woodlots adjacent to the PLOC contain common buckthorn and non-native bush honeysuckles. Complete eradication of common invasive species will not be possible along the PLOC as long as larger populations exist outside of the easements; however, the efforts of managing select invasive species within the easements of the outlet channel will benefit the local flora and fauna and encourage the re-establishment of native species along the banks of the outlet channel. Restoring native riparian vegetation will also reduce bank erosion and improve the water quality of the PLOC and the waterbodies in which it intersects including Jeffers Ponds, Pike Lake, and Deans Lake.

The following is a summary of invasive species specifically managed from 2011-2017.

Herbaceous Invasive Species

- Garlic mustard has been found in Segments 2-8. Significant populations of garlic mustard have been managed in Segments 4B, 5B and 7B, primarily through manually cutting and herbicide treatments. Very small populations exist in Segments 2, 3, and 6; annual hand-pulling has been effective in further reducing these populations. A large population at the downstream end of Segment 4B, just upstream of the cattle pasture, has been nearly eliminated through routine manual cutting efforts. Applied Ecological Services has been contracted to manage the remaining large populations of garlic mustard, primarily through the use of herbicide treatments on an annual basis.
- Purple loosestrife (*Lythrum salicaria*) has been found in segments 4A, 5A, 6, and 7A. Although this species is not considered a terrestrial invasive species, it has been managed along the outlet channel due to its recent population expansion within the easements of the channel. In 2014, one plant was found just downstream of the Deans Lake weir, and the plant was promptly hand-pulled. In 2016, four plants were found in Segment 4A along the re-graded channel banks just downstream of Pike Lake Trail. These plants were hand-pulled by AES. In 2017, about 30 purple loosestrife plants in total were found within Segments 4A, 5A, 6, and 7A. The plants in 4A and 6 were located near the previous known locations, and two new populations were found in Segments 5A and 7A. EOR and AES staff removed all of the plants by hand-pulling, cutting, and uprooting with shovels. A larger population of purple loosestrife plants was also discovered growing within the large wetland complex to the west of Segment 7A. This population has not been managed as of 2017.
- Wild parsnip (*Pastinaca sativa*) has been found in Segments 1 and 4A. Only one small population was known from Segment 1 and it has been treated with herbicide for several consecutive years. The total population was less than 10 plants. In the fall of 2017, an individual plant that had already senesced for the season was found near the downstream end of Segment 4A. In the spring of 2018, a small population of wild parsnip was found

immediately downstream of Fountain Hills Road and a second population was located at the upstream end of Segment 4A.

- Canada thistle has been found in Segments 1, 3-6, and 8. The larger populations have been managed by AES through herbicide treatments, especially in Segment 4B where a large population has flourished within the cattle pasture.
- Leafy spurge has been documented in all Segments except Segment 2. The greatest densities of leafy spurge have occurred 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; however, this area is now under development and subsequently is not being actively managed. In 2011, flea beetles (*Aphthona spp.*) were released by PLSLWD staff in Segments 4 and 7 in an attempt to manage leafy spurge using biological control. These segments were chosen based on the high densities of leafy spurge. At the time, leafy spurge densities in Segments 1, 3, 6, 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 significant reduction in plant density in Segment 4 was observed in 2014 and has remained low through 2017. In an attempt to continue biological control of leafy spurge in Segment 7, a second flea beetle release was conducted on June 26, 2015. EOR obtained 3,000 flea beetles (*Aphthona lacertosa*) from the Minnesota Department of Agriculture (MDA) and released 1,000 beetles at three separate sites along Segment 7.

Woody Invasive Species

Applied Ecological Services was contracted to manage the woody invasive species documented in Segments 1, 2, 3, 4A, 5C, 6, and 7A. As stated above, the woody invasive species that occur in other reaches of the outlet channel were not managed due in part to proposed bank stabilization work, forthcoming development, or lack of landowner cooperation or approval. The initial management of woody invasive species along the PLOC occurred in the fall of 2012 with the cutting of black locust, common buckthorn, Tatarian honeysuckle, and Siberian elm. All cut stumps were treated with a glyphosate solution and follow-up foliar spray treatments were conducted in the summer of 2013. Annual follow-up foliar spray treatments have occurred annually since 2013 in areas that were originally targeted in 2012. The following is a summary of woody invasive species specifically managed from 2012-2017.

- Common buckthorn has been found in Segments 1-8. Significant populations have been managed in Segments 2, 3, 4A, 6, and 7A using cut stump and herbicide treatments. Seedlings and saplings continue to occur in all previously managed areas and require on-going foliar spray treatments.
- Tatarian honeysuckle has been found in Segments 1-8. Significant populations have been managed in Segments 2, 3, 4A, 6, and 7A using cut stump and herbicide treatments. Seedlings and saplings continue to occur in all previously managed areas and require on-going foliar spray treatments.

- Black locust (*Robinia pseudoacacia*) has been only found in Segments 1-3. All mature trees have been cut and removed from the previous dense stand located adjacent to Jeffers Pass NW, but occasional seedlings and saplings continue to develop in the immediate vicinity of the treatment areas.
- White poplar (*Populus alba*) has been only found in Segment 1 adjacent to Jeffers Elementary School. Although this species is not listed as a terrestrial invasive species by MNDNR, it was decided to remove the few trees that occurred within the reach before it could spread to the adjacent woodlands and other segments along the PLOC.

2.4.2. 2018 Management Activities

Three vegetation inspections are to be completed in 2018: one completed during spring (early May), one completed during summer (early July), and one to be completed during fall (September). The purpose of the summer inspection will be to readily identify invasive species that have not developed in spring (such as purple loosestrife and wild parsnip) so AES can promptly manage these target invasive species before they produce seeds. EOR will communicate with PLSLWD and AES staff after each inspection to report and discuss findings which will be used to help guide the timing of treatments proposed during the year.

AES will cut and treat woody and herbaceous vegetation on three separate trips. The spring trip will target garlic mustard (and wild parsnip if possible), the summer trip will target thistles, wild parsnip, purple loosestrife, and possibly crown vetch, and the fall trip will target woody invasive species.

Common buckthorn will be managed in Segments 2, 3, and 7B, and black locust will be managed in Segments 1-3. If budget allows, management of woody invasive species in Segment 4A is proposed if landowner approval can be obtained.

Herbaceous vegetation will be managed in Segments 1, 4A, 4B, 5A, 6, and possibly 7A, specifically:

Segment 1 – wild parsnip, thistle species

Segment 4A – purple loosestrife, garlic mustard, wild parsnip

Segment 4B – thistle species

Segment 5A – garlic mustard, purple loosestrife (immediately downstream of County Road 16)

Segment 6 – purple loosestrife (downstream of Deans Lake Weir)

Segment 7A – purple loosestrife and crown vetch (if budget is available)

In addition, ongoing biological control of leafy spurge will be conducted in 2018 in Segment 7A. The success of this treatment method largely depends of the density of leafy spurge and the species of beetle released. Typical release sites require at least ½ acre of leafy spurge to establish and maintain a population of flea beetles. Segment 7A contains the greatest density of leafy spurge along the PLOC, covering approximately 3 acres within the easement alone. 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, a third beetle release is proposed in 2018 in Segment 7A. Beetles will be collected from a known source zone located near the site and will be released in three separate areas along the segment. All release locations will be surveyed with GPS to aid in monitoring the effectiveness of the beetle release. For reference, the beetle local source zone is located in the grassy area immediately south of Park Drive and east of Valley Park Drive near Valley Fair (Scott County).

2.4.3. Future Priority Areas & Recommendations

Monitoring populations of garlic mustard in managed areas will help determine the effectiveness of mechanical removal and herbicide treatment of this species. As noted above, the large population at the downstream end of Segment 4B, just upstream of the cattle pasture, has been nearly eliminated through routine manual cutting efforts. The cutting efforts were conducted when the garlic mustard was starting to flower (typically early to mid-May). 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 in areas that contain a diverse native understory since the application could negatively impact native vegetation growing within the treatment areas.

Leafy spurge should be managed using biological and/or mechanical methods in Segments 4 and 7A. Herbicides are not recommended to treat leafy spurge in these two segments since the leafy spurge grows in close association with native species that could be negatively affected by herbicide use, particularly in Segment 7 where remnant populations of prairie blue-eyed grass, puccoon, large beardtongue, spotted horsemint, leadplant, silky prairie clover, prairie coreopsis, spiderwort, white sage, and other native grasses and forbs have been documented. The leafy spurge in the remaining segments of the PLOC could be targeted with herbicides or other methods, if warranted. It is recommended several species of flea beetles should be released in Segment 7A 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 proposed should be performed before the plants begin flowering (mid-May to early June).

Woody invasive species that occur within the unmanaged areas in Segments 1-8 should be cut and the stumps treated with a glyphosate solution if funding and/or landowner approval can be secured. 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 (i.e. garlic mustard); 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 of several species (i.e. common buckthorn and garlic mustard) occur adjacent to the PLOC corridor.

3. IMPLEMENTATION PLAN

Of the channel conditions (capacity, stability, easements, and invasive species) assessed as part of this master plan, the primary condition in need of attention and annual budgeting for future special projects is the areas of remaining bank instability. In addition, it is recommended that the Cooperators consider increased annual budgets for channel inspection of areas to be repaired by FEMA funding for potential future maintenance as well as increased invasive species management in Segment 7.

3.1. Bank Repair Cost Estimation

A standard bank stabilization practice was used to develop preliminary estimates of probable cost to address the remaining channel instabilities following the FEMA funded repair project (starting in 2018). This standard practice includes re-shaping the stream banks to a 3:1 slope and installing native seed (MNDOT mix 34-261), hydromulch material (Type 8 fiber matrix), erosion control blanket (100% biodegradable woven coir fiber), and boulder toe. The estimated costs shown in Table 3-1 are based on typical application rates and quantities of material used for standard bank stabilization. This includes installing boulder toe at a rate of 0.2 tons of rock per linear foot, installing erosion control blanket on all disturbed slopes, applying hydromulch a rate of 2,500 pounds per acre, and applying native seed at a rate of 32 pounds per acre. Project design, mobilization, and site clearing/ grubbing costs are included in the preliminary estimates of probable cost. The estimated costs assume that there are no additional costs associated with obtaining temporary construction access easements. Appendix E includes a table of individual channel banks that will require bank stabilization practices following the FEMA funded project starting in 2018 as well as the estimated costs by segment. Costs would be funded per the cost-share allocation percentage approved by the PLOC MOA.

Also included in Appendix E is a table of channel banks recommended for monitoring following the proposed project in 2018. It is recommended that stabilization projects implemented in each segment should be inspected over the next 3 years to assess vegetation establishment and to direct site repairs as needed.

Table 3-1. Summary of Remaining Bank Stabilization and Sediment Removal along the PLOC & Estimated Costs per Segment (following bank stabilization activities in 2018)

Segment	Remaining Bank Erosion [feet]	Preliminary Estimate of Probable Cost
1	101	\$6,500
2	176	\$11,000
3	38	\$2,500
4	1,499	\$73,000
5	3,776	\$336,000
6	2,007	\$111,500
7	285	\$15,000
8	2,274	\$132,500
Total	10,156	\$688,000

3.2. Implementation Schedule

The activities listed below are not inclusive of all Prior Lake Outlet Channel MOA operations; they are intended to be considered as special projects during the establishment of annual budgets. Actual costs may vary from those listed here based on future inspection of channel bank stability conditions and potential for additional erosive flows within the channel.

It has been observed that the sediment accumulated in Segments 5a and 5b that were not eligible for FEMA Public assistance dollars is migrating downstream to Segment 5c and will need to be removed in the future. It is recommended that this work be scheduled after completion of the City of Shakopee Segment 5 Re-Meandering Project. The preliminary estimate of probable cost included in Table 3-2 is 1.25 times the cost to complete this work in 2017/18.

Table 3-2. Five-Year Implementation Plan

ACTIVITY	2019	2020	2021	2022	2023
Bank Repair	\$150,000	\$206,000	\$88,000	\$111,500	\$132,500
Segment 1		\$6,500			
Segment 2		\$11,000			
Segment 3		\$2,500			
Segment 4			\$73,000		
Segment 5A-B	\$150,000*				
Segment 5C		\$186,000**			
Segment 6				\$111,500	
Segment 7			\$15,000		
Segment 8					\$132,500
Bank Inspection	\$7,500	\$7,500	\$7,500	\$7,500	\$7,500
Invasives Mgmt.	\$7,500	\$7,500	\$5,000	\$5,000	\$5,000
TOTAL	\$165,000	\$221,000	\$100,500	\$124,000	\$145,000

The cost estimates listed above are 2018 present value.

* Contribution towards City of Shakopee Segment 5 Channel Re-meandering Project

** Cleanout of the Pike Lake Road box culverts and downstream sedimentation pond

3.3. Implementation Roles

As per standard practice, bank repair design and construction, bank inspections, and invasive species management will continue to be managed by the PLSLWD on behalf of the MOA Cooperators. Draft bank repair plans will be reviewed by the TAC and approved by the Cooperators.

It is envisioned that Segment 5C re-meandering will be managed by the City of Shakopee, with plan review by the TAC and approval by the Cooperators.

Maintenance and reconstruction of crossings is the responsibility of the owner (whether public or private entity). If a crossing identified as under-capacity (or any other crossing) is proposed to be reconstructed, the owner must obtain MOA Cooperator approval.

REFERENCES

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 PROJECT DATABASE

This appendix is an abridged summary from the database discussed in section 1.6 and does not include all database fields. A complete, up-to-date database is available through the District's website as discussed above.

Table A-1: PLOC Project Database

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
1	FOLDER: WD 76-4	Original Outlet Project 76-4	Construction	1976	1985	All	All	Construction of outlet pipe, necessary channel connections and improvements
2	FOLDER: WD 83-2	Flood Emergency Project 83-2	Improvements	1983	1984	2, 4-5, 7	Upstream of Jeffers pond, upstream of CR 42, at CR 16, upstream of railroad bridge on Shiely property	Gabion checkdams, erosion control, culvert repairs
3	WD 76-4R84	Outlet Repair Project 76-4R84	Maintenance/Repairs	1984	1985	4, 5, 7	Varies	Replace culverts, widen channel, seeding
4	WD 76-4R85	Outlet Channel Repair 76-4R85	Maintenance/Repairs	1984	1987	5	90° bend	Sediment removal, culvert installation, riprap placement, diversion structure
5	WD 83-2R85	Outlet Repair Project 83-2R85	Maintenance/Repairs	1985	1985	4, 5	Varies	Sediment removal, tree removal, riprap, turf placement
6	History of Improvements	Outlet Repair Project 76-4M85	Maintenance/Repairs	1986	1987	4, 5	Hanson, Muhlenhardt, and Melby properties	Culvert repairs, sediment removal, riprap, rockfill weirs

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
7	Squires 1987 culvert	None	Construction	1987	1987	2	Squires driveway	Construction of crossing at Squires driveway
8	FOLDER: WD 76-4M88	Outlet Channel Maintenance 76-4M88	Maintenance/Repairs	1988	1991	4, 5, 7	varies	Rockfill baffles, culvert replacement, erosion control, fencing on Hanson property
9	1995 Repairs	1995 Outlet Channel Repairs Project	Maintenance/Repairs	1991	1995	1, 4	Jeffers outlet, South of CR 16, Meadowbrook Run development	Channel regrading, rock baffles, riprap placement and stump removal (Jeffers)
10	1993 Repairs	None	Maintenance/Repairs	1993	1994	1-3, 5	Jeffers Upper Pond, Hanson property, Kes property, Camp Kici Yapi	Outlet repair (Jeffers), dredging (Kes culvert), riprap (Camp Kici Yapi)
11	1994 Jeffers Repairs	None	Maintenance/Repairs	1993	1994	1	Field road, pond	Repair field road crossing, remove sediment from pond
12	1994 Repairs	None	Maintenance/Repairs	1993	1994	3	Kes Driveway, Camp Kici Yapi bridge	Remove sediment from culvert, riprap bridge embankment
13	Sanitary Bypass	None	Improvements	1995	1995	6-7	Under Shakopee bypass	Temporary channel realignment to accommodate sanitary sewer installation, new box culverts under highway
14	1995 Sediment Removal	1995 Outlet Channel Sediment	Maintenance/Repairs	1995	1997	5-6	Hanson-Shutrop	Sediment removal, repair field road crossing

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
		Removal Project					properties, Dean Lake	
15	Pike Lake Repairs	None	Maintenance/Repairs	1996	1998	2	Hanson crossing	Repair road crossing, place riprap, gabions, excavation/fill
16	1998 Outlet Box Repair	None	Maintenance/Repairs	1998	1998	OS	Outlet Structure	Repair cracking, pour new concrete, reinforce with steel, install trash grate
17	FOLDER: 1998 Sed. Removal	1998 Outlet Channel Sediment Removal Project	Maintenance/Repairs	1998	1999	5	Straight segment East of Dean Lake (Shutrop and Hanson properties)	Sediment removal, temporary sedimentation basin
18	ADC Repair	2000 Outlet Channel Maintenance Project	Maintenance/Repairs	2000	2001	3	Camp Kici Yapi	Bank stabilization
19	2000 Repairs	2000 Outlet Channel Maintenance Project	Maintenance/Repairs	2000	2001	4A	North of Jackson Tr, East of Pike Lake Rd	Backfill/resloping of banks, riprap placement, riprap check dams, vegetation
20	Jeffers Pond	None	Maintenance/Repairs	2001	2001	1	Jeffers Pond	Debris removal, removal of winter-kill carp plugging outlet structure
21	Pavlish Crossing	None	Maintenance/Repairs	2001	2001	2, 3	Pavlish and Kinney Crossings	Installation of riprap and aggregate
22	Willow Plantings	None	Maintenance/Repairs	2001	2001	8	Immediately north of Hwy 101	Planting willow stakes to prevent erosion

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
23	2001 Maintenance	None	Maintenance/Repairs	2001	2001	2	Various locations along Segment 2	Riprap and gabion placement, backfill
24	Gabion Drop Structure	None	Improvements	2001	2003	7	South of Hwy 101, North of Shakopee Bypass	Construction of gabion drop structure, miscellaneous repairs, protect interceptor pipe sewer line
25	Kinney Crossing	Kinney Driveway Culvert Installation Project	Improvements	2003	2003	3	Kinney driveway	Installation of a second culvert at crossing
26	FOLDER: IP Phase 1 - 1	PLOC Improvement Project - Phase 1	Improvements	2003	2006	1	Lake outlet to Jeffers Pond	Tree removal, erosion control, debris removal, reconstructed outlet for Lower Jeffers Pond
27	Gabion Bank Repairs	None	Maintenance/Repairs	2004	2004	7	North of Gabion structure, on East bank of channel	Tree revetment, bank stabilization
28	CR 16 Culvert Replacement	None	Maintenance/Repairs	2004	2005	4B	Immediately south of CR 16	Culvert lining, bank stabilization
29	FOLDER: IP Phase 1 - 4B	PLOC Improvement Project - Phase 1	Improvements	2004	2007	4B	Entirety of Segment 4B, immediately south of CR 16	Tree removal, erosion control, debris removal, fencing, cattle crossing

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
30	FOLDER: Riverside Bluffs	Outlet Channel Restoration and Enhancement Project: Segment 5A	Improvements	2004	2012	5	Riverside Bluffs development	Channel realignment due to development
31	FOLDER: Dean's Lake Bypass	Dean Lake Outlet Structure	Construction	2005	2005	6	Dean Lake	Construction of an outlet structure and bypass control structure for Dean Lake
32	IP Phase 2	PLOC Improvement Project - Phase 2	Improvements	2005	2006	2, 3	Pike Lake	Sediment removal
33	FOLDER: IP Phase 3 - 5C	Outlet Channel Restoration and Enhancement Project: Segment 5C	Improvements	2006	2007	5C	Between Dean Lake and Pike Lake Rd	Erosion control, excavation/fill
34	FOLDER: Seg 7b	None	Maintenance/Repairs	2008	2008	7B	Whole segment	Channel stabilization
35	FOLDER: Seg 8 culvert replacement	None	Maintenance/Repairs	2008	2008	8	USFWS service trail	Culvert replacement
36	FOLDER: 2009-2010 I-F work	PLOC Stream Restoration Project, Segments 2, 3 and 7	Maintenance/Repairs	2008	2011	2- 4, 7-8	Description file within permit folder	Earthwork, tree management, channel stabilization, Replacement of culvert at northern end of Segment 8

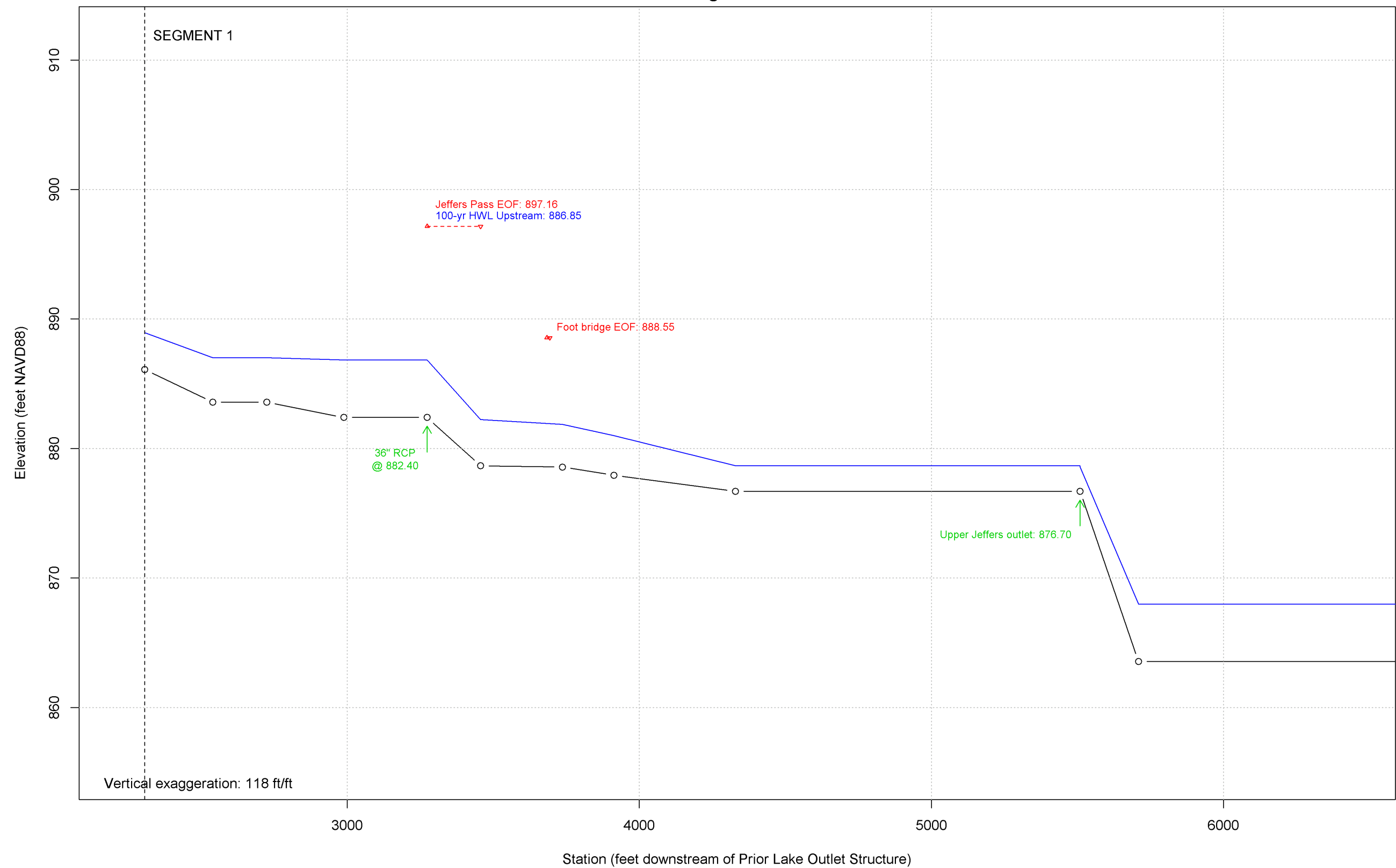
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37	FOLDER: Quiring LLC	PL Outlet Structure Construction	Improvements	2009	2013	OS	Outlet Structure	Erosion control, construction of new outlet structure, temporary coffer dam, muck excavation, vegetation
38	FOLDER: Squires	None	Maintenance/Repairs	2011	2011	2	Squires driveway	Culvert replacement
39	2012 PLOC Operations Report Final	None	Maintenance/Repairs	2011	2012	8	USFWS driveway	Repair of partially washed out culverts
40	FOLDER: Quarry Lake Overflow 2011	None	Maintenance/Repairs	2011	2012	7	Quarry Lake	Repair gully washout, construct berm, sediment removal, tree removal
41	2013 PLOC Operations Report - FINAL	None	Maintenance/Repairs	2013	2013	3	Pike Lake Rd	Installation of new culvert
42	2014 Jan - Segment 4A Design Scope	Segment 4A Channel Stabilization	Maintenance/Repairs	2013	2014	4A	Pike Lake Tr to culvert below Jackson Tr	Stabilize erosion on right bank
43	FOLDER: 2013 Jackson Trail culvert replacement	None	Maintenance/Repairs	2013	2014	4A	Jackson Tr crossing	Culvert replacement
44	FOLDER: Valley Park	None	Construction	2013	2014	7A	Quarry Lake Park crossing	Installation of box culverts to allow access to Quarry Lake Park
45	FOLDER: 2013 Gonyea culvert replacement	None	Maintenance/Repairs	2013	2014	4A	Gonyea crossing	Replacement of original culvert, upsizing to 42"
46	2014 PLOC Operations Report_FINAL	None	Maintenance/Repairs	2014	2014	2	Kes culvert	Repair existing culvert
47	FOLDER: 0088_CR_16_Culvert_Replace_June_2014_Flood	None	Maintenance/Repairs	2014	2014	4B	CR 16 crossing	Culvert Replacement

	File Name	Project Title	Project Type	Start Year	End Year	Segment	Location	Project Description/Scope
48	FOLDER: YMCA Culvert (Kici Yapi) review	None	Maintenance/Repairs	2014	2015	3	Camp Kici Yapi crossing	Removal of old culvert, repairs to road, construction of emergency overflow
49	FOLDER: Jerry Miller 4a	PLOC Segment 4A Realignment	Improvements	2014	2015	4A	Intersection of Pike Lake Rd	Channel realignment and stabilization
50	2015 PLOC Operations Report_FINAL	None	Maintenance/Repairs	2015	2015	8	USFWS service trail	Crossing removed and restored to native conditions
51	2015 PLOC Operations Report_FINAL	None	Maintenance/Repairs	2015	2016	1-5, 7	Varies	Tree and debris removal
52	2016 PLOC Operations Report_FINAL	None	Maintenance/Repairs	2016	2016	2, 4A	Kes field crossing, Pike Lake Park Crossing, Gonyea crossing	Culvert repairs
53	FOLDER: Manhole Smoothing	None	Maintenance/Repairs	2016	2016	1	Outlet pipe	Manhole repairs, smoothing, sealing of leaks
54	FOLDER: MCES Blue Lake Sanitary Sewer Rehab Project	Blue Lake Sanitary Sewer Rehabilitation	Construction	2016	2017	7B	Union Pacific and Hwy 101 culverts	Temporary channel realignment to accommodate sanitary sewer maintenance
55	FOLDER: Grouting	None	Maintenance/Repairs	2017	2018	1	Outlet Pipe	Pipe reaming, grout joints
56	2017 PLOC Operations Report_Final	Silt and Sediment Control Project	Maintenance/Repairs	2017	Ongoing	5	Intermittent locations between CR 16 and CR 21	Sediment removal, partially FEMA public assistance funded
57	2017 PLOC Operations Report_Final	Bank Erosion Project	Maintenance/Repairs	2018	Ongoing	1-4, 7-8	Varies	Bank stabilization, riprap placement, rock vanes, live stakes

APPENDIX B. 100-YR FLOOD PROFILES

The images below provide the peak water elevations along the length of the channel during the 100-year storm event. Also included are the elevations of crossings and corresponding culverts along the channel. Reference Figures 1-1 and 1-2 for channel alignment and crossing locations.

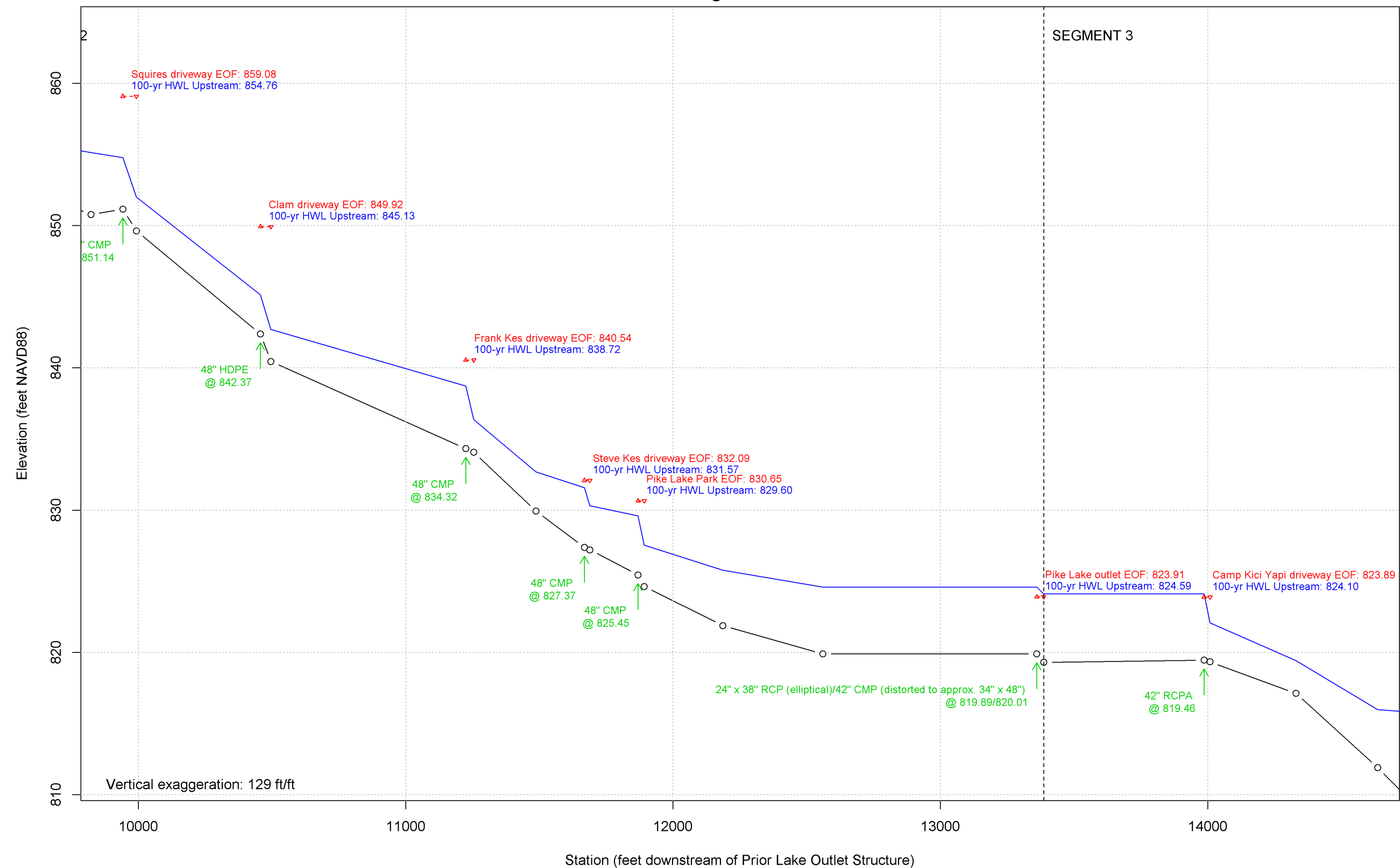
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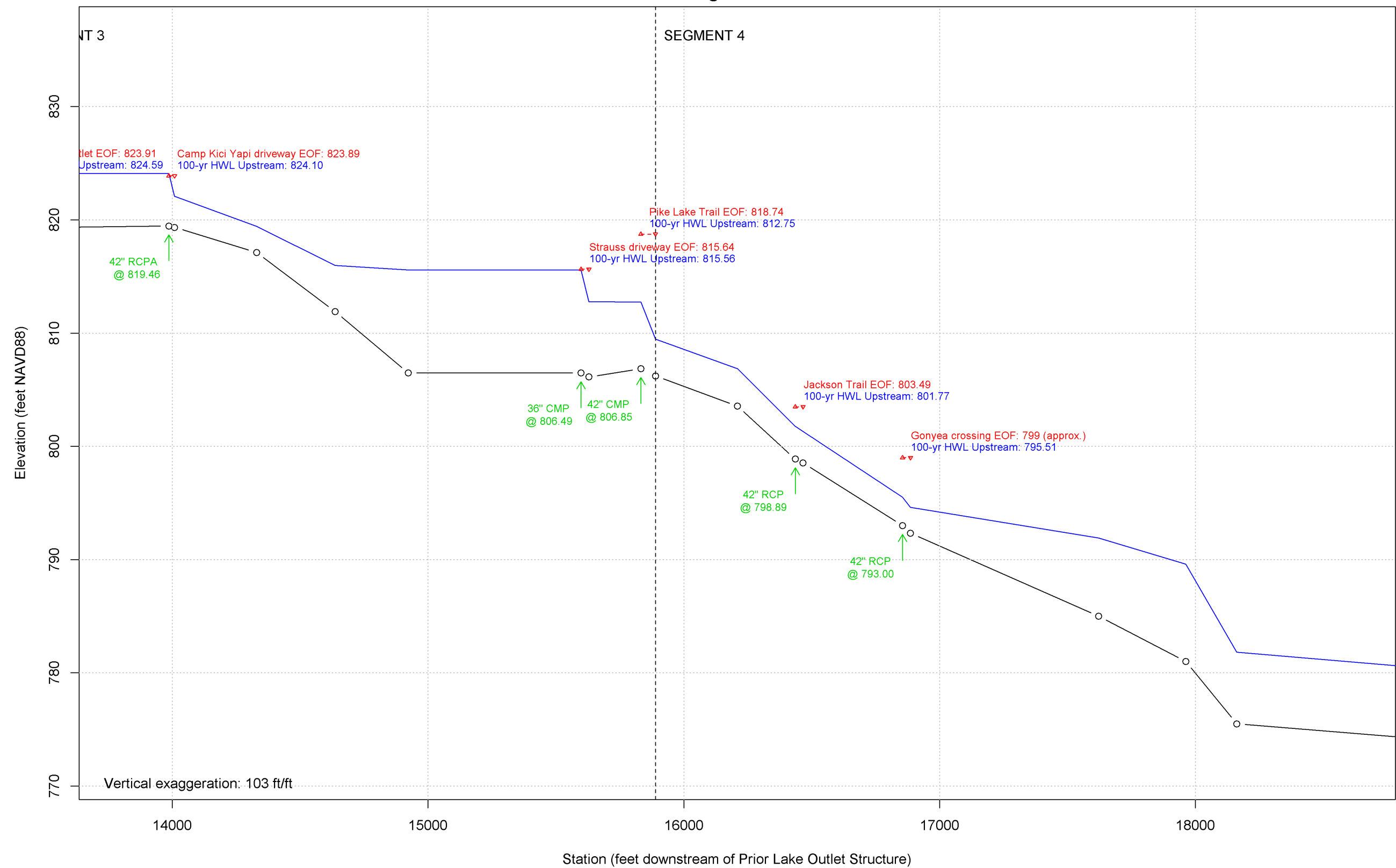
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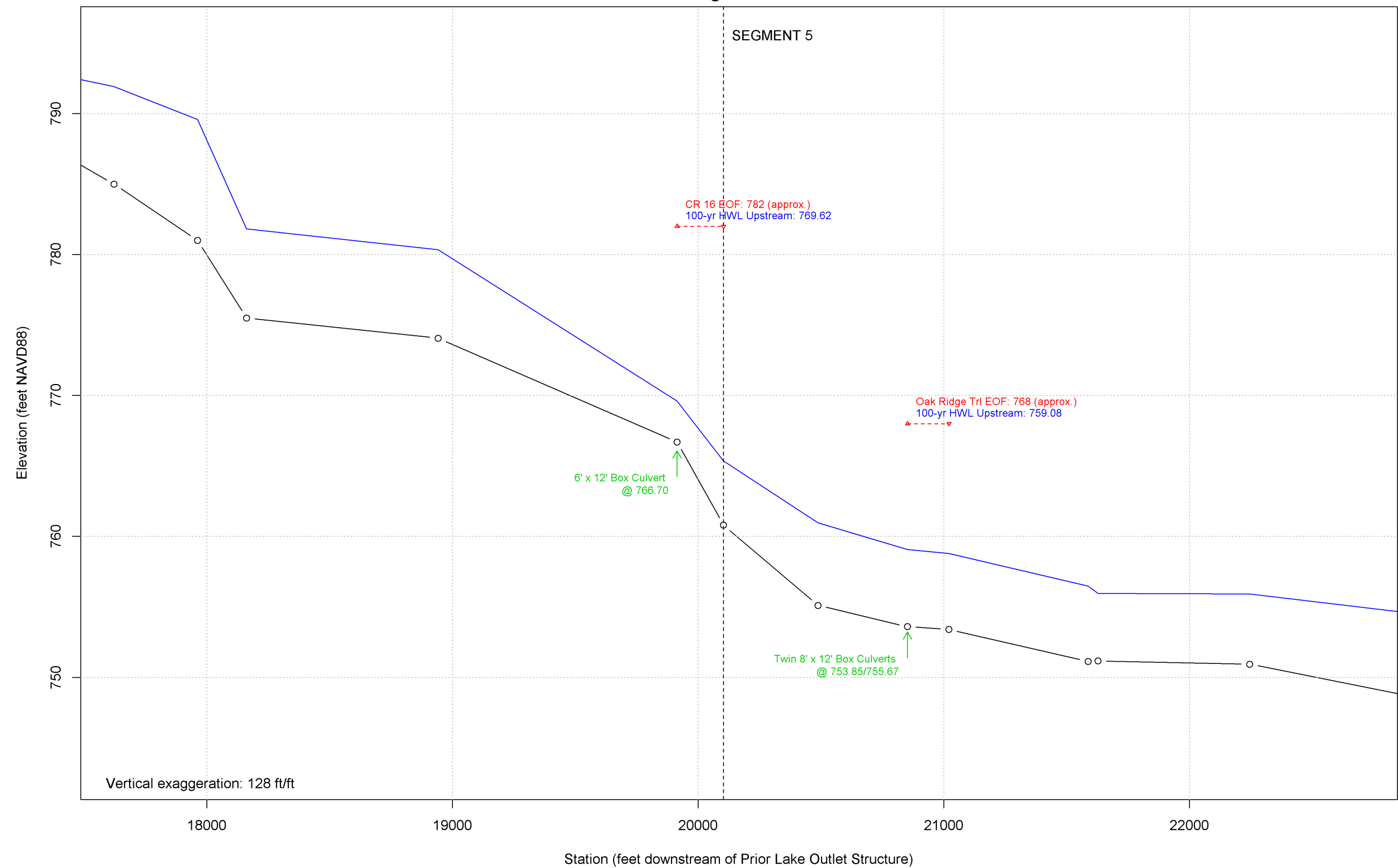
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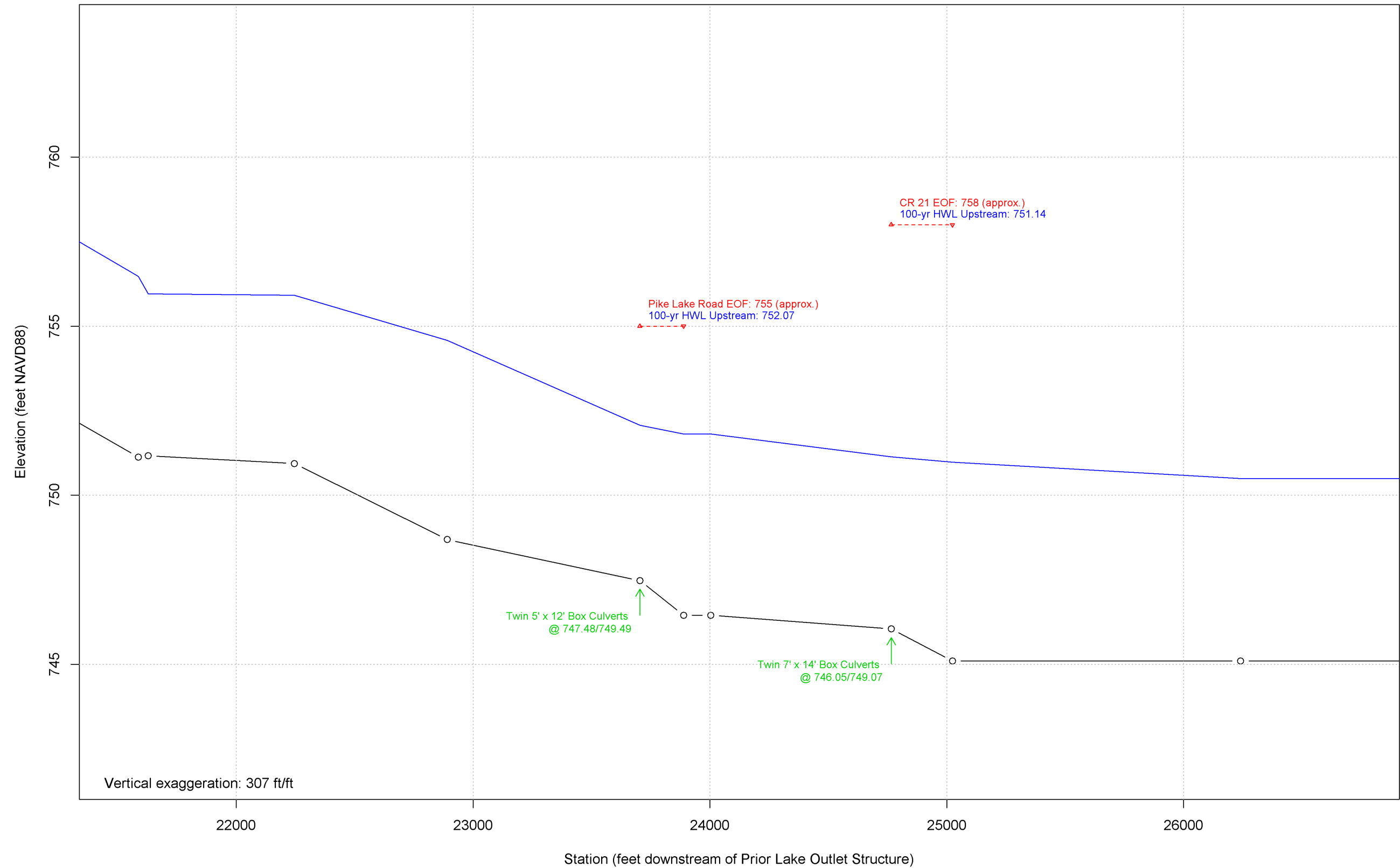
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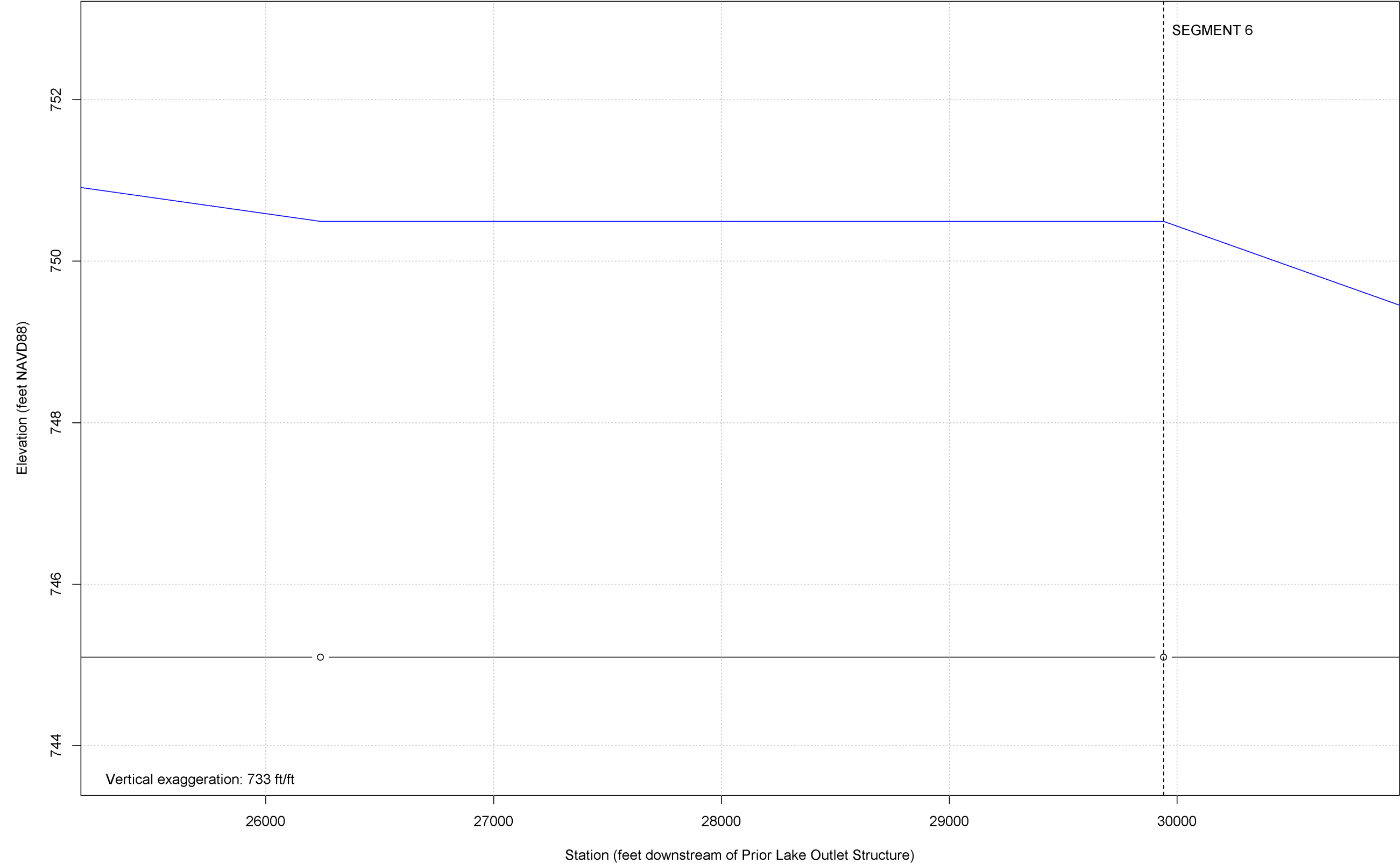
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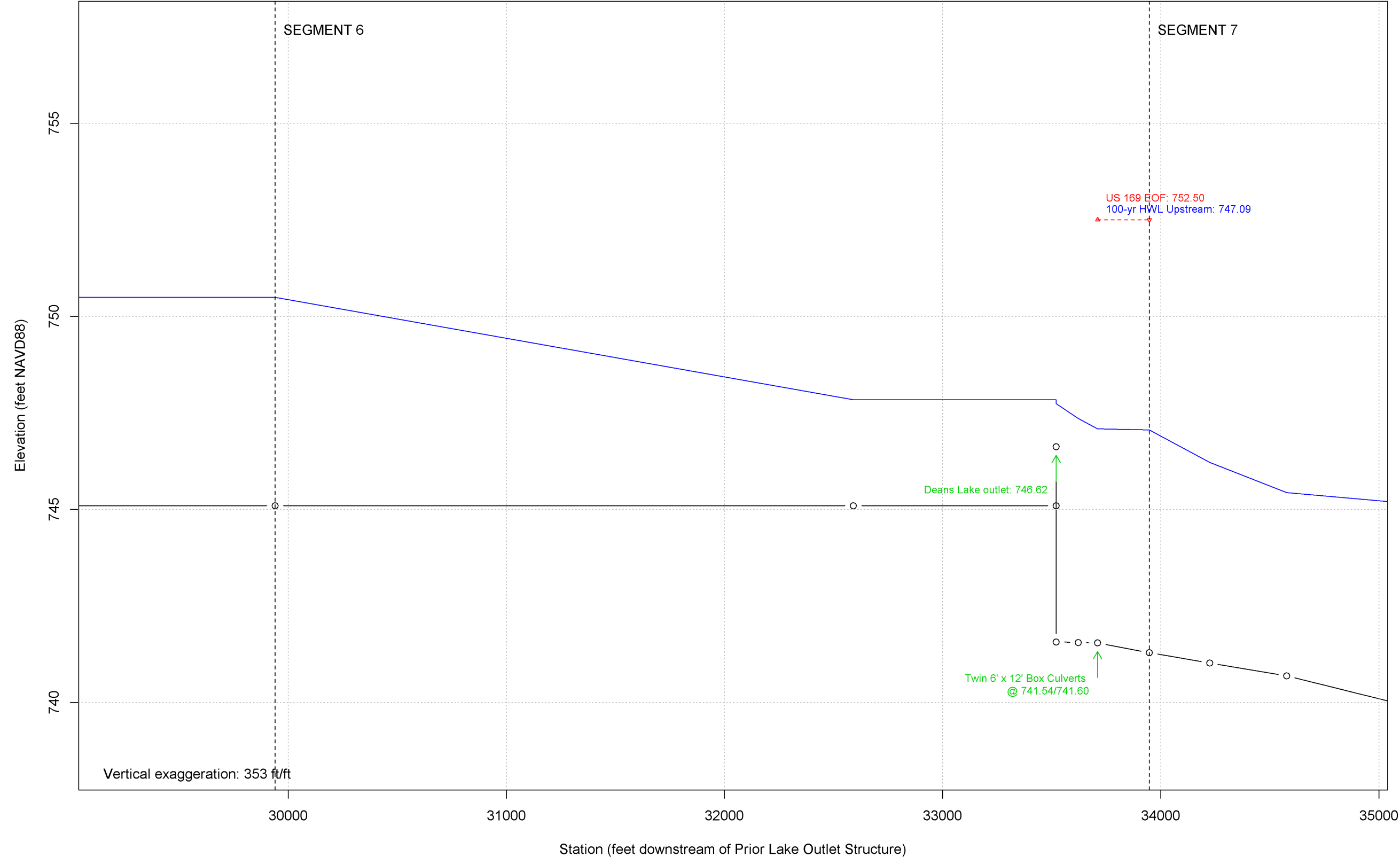
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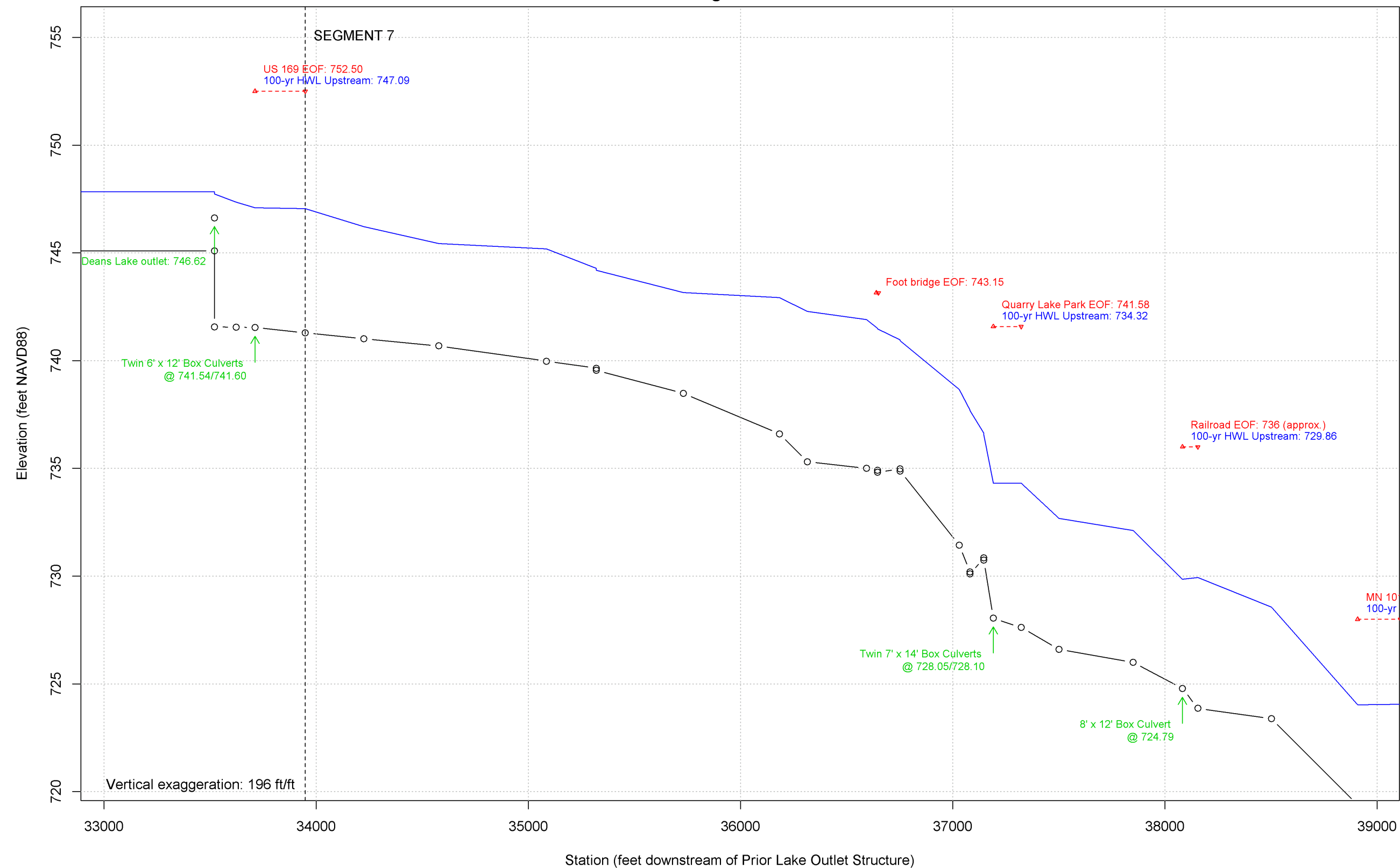
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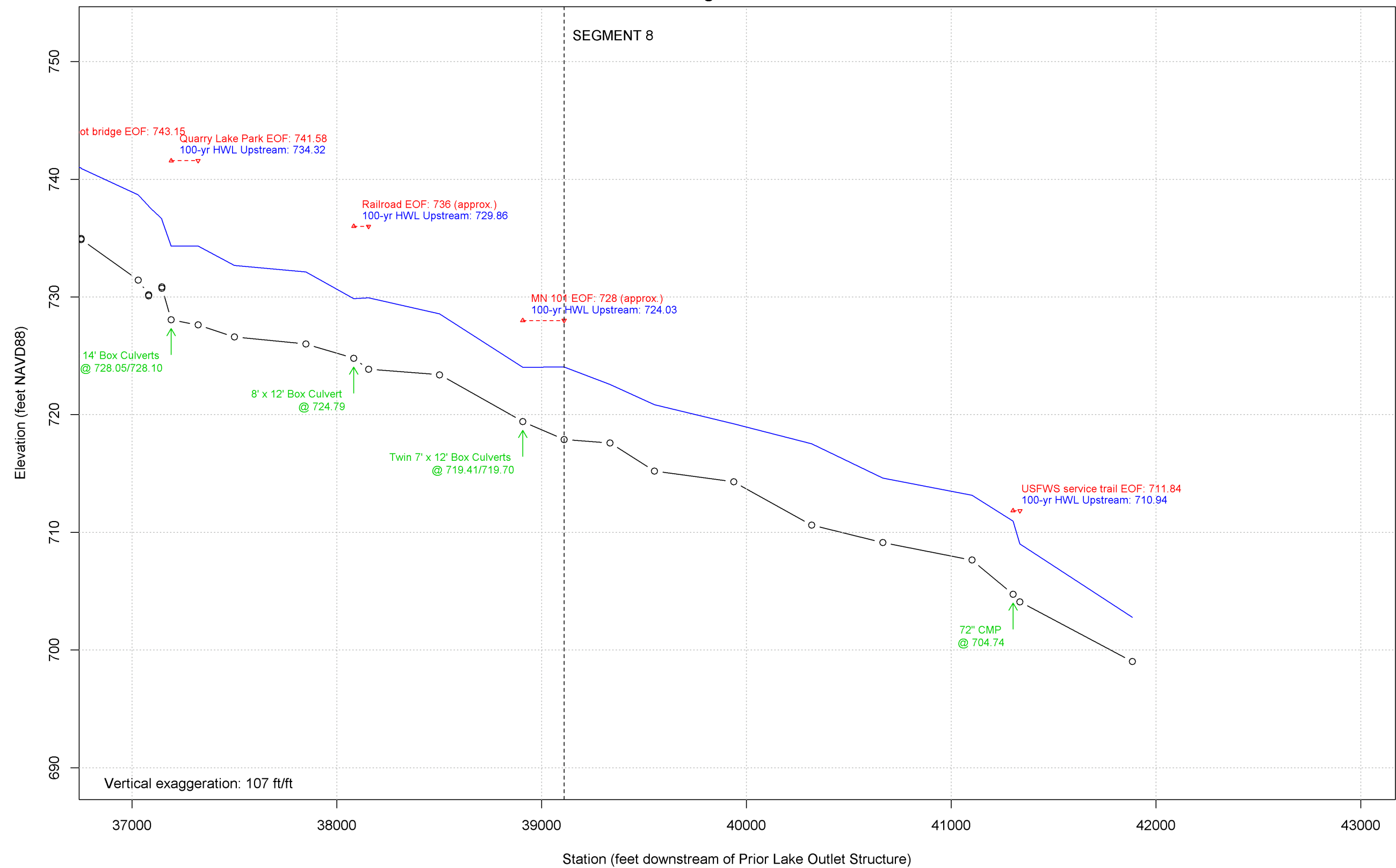
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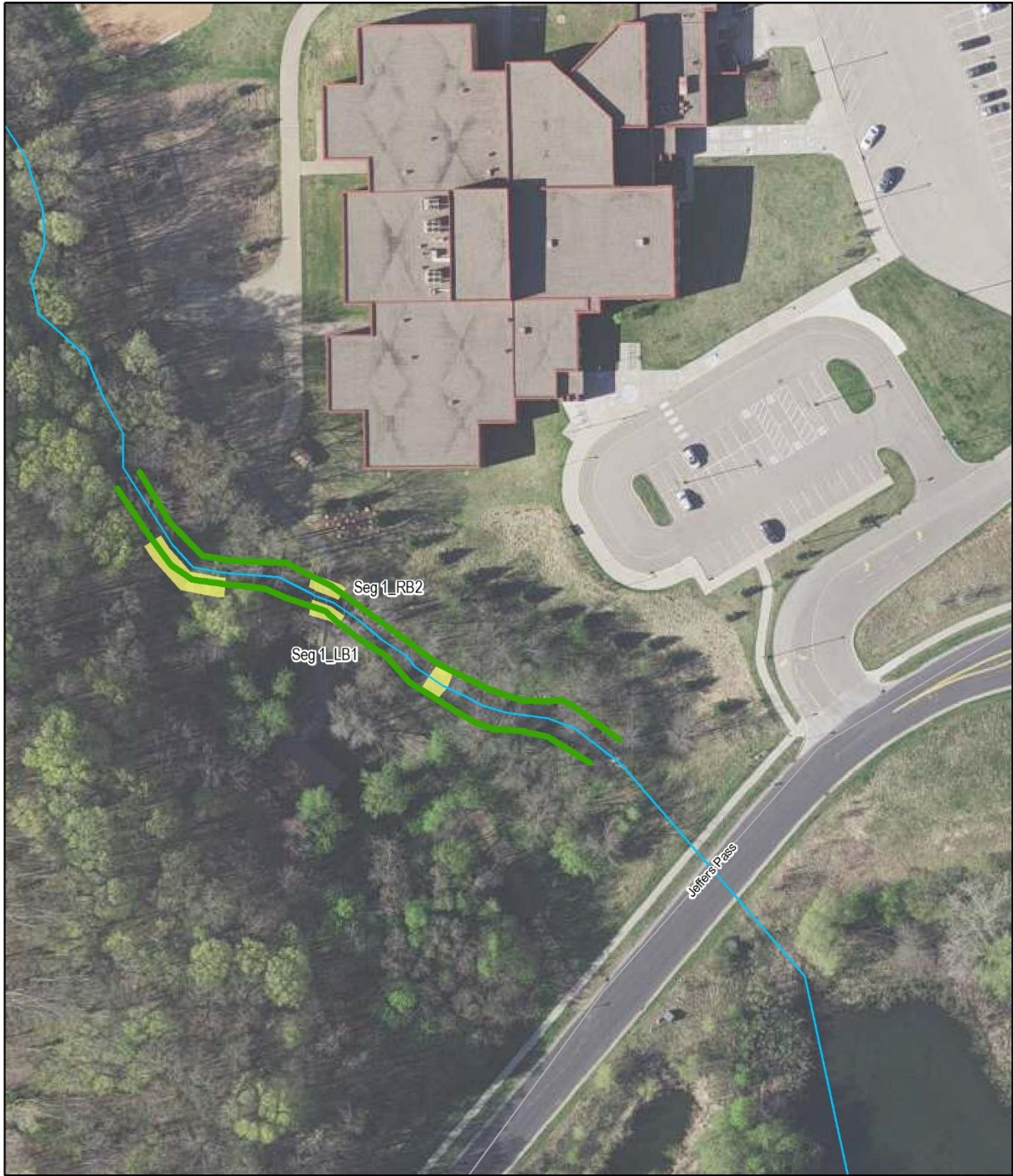
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Page 10 of 10



APPENDIX C. 2014 BANK EROSION INVENTORY AND 2018 PROPOSED BANK STABILIZATION SITES

The figures in this appendix provide all locations of bank erosion from 2014 along with sites proposed for stabilization in 2018. There may be small gaps between figures where the channel alignment is not displayed. The reaches not displayed did not experience bank erosion and were not listed in the inventory.

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Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 1 (Upper Reach)

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Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



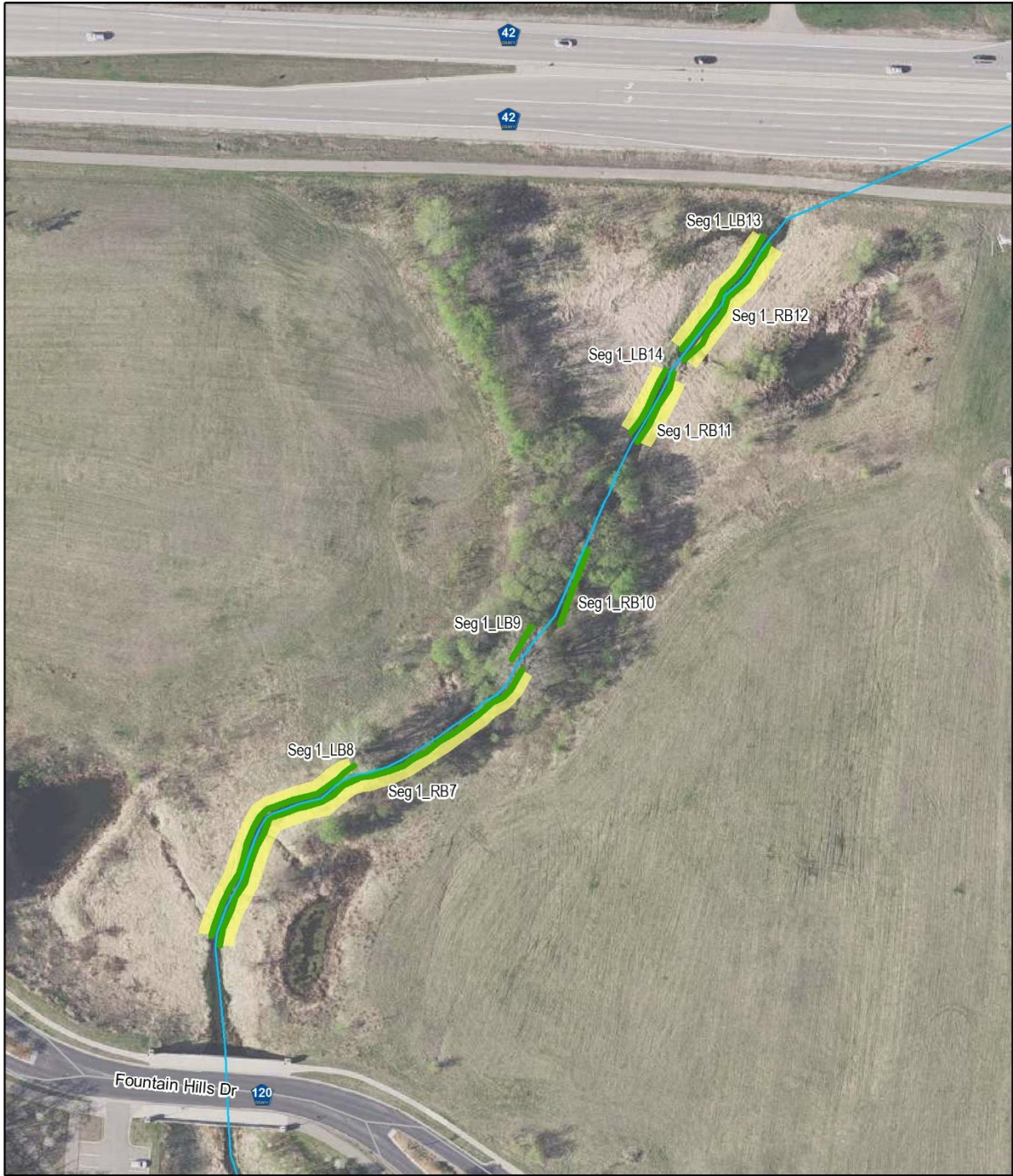
PLSLWD Segment 1 (Middle Reach)



Feet

0 100

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 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

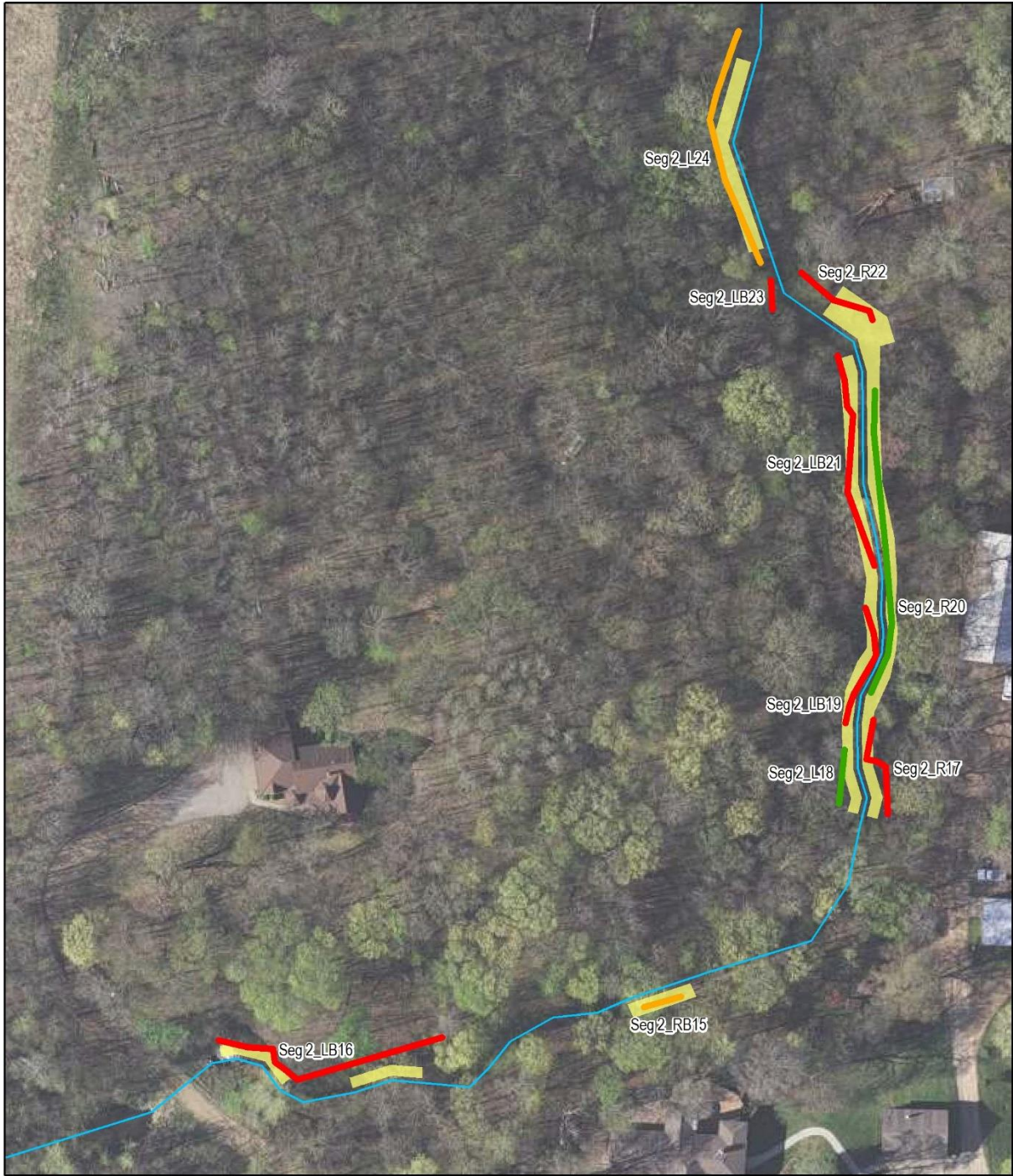
- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 1 (Lower Reach)



Legend

Bank Failures 2014	 FEMA Funded Repair Area
 High	
 Moderate	
 Low	



**PLSLWD
Segment 2
(Upper Reach)**

Date: 8/8/2018 Time: 10:32:20 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



PLSLWD Segment 2 (Middle Reach)

0 Feet 100

A horizontal scale bar with markings at 0 and 100 feet.

Date: 8/8/2018 Time: 10:30:47 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



PLSLWD Segment 2 (Lower Reach)



Feet

0 100

Date: 8/8/2018 Time: 10:36:24 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014	 FEMA Funded Repair Area
— High	
— Moderate	
— Low	



**PLSLWD
Segment 3
(Upper Reach)**



Legend

Bank Failures 2014

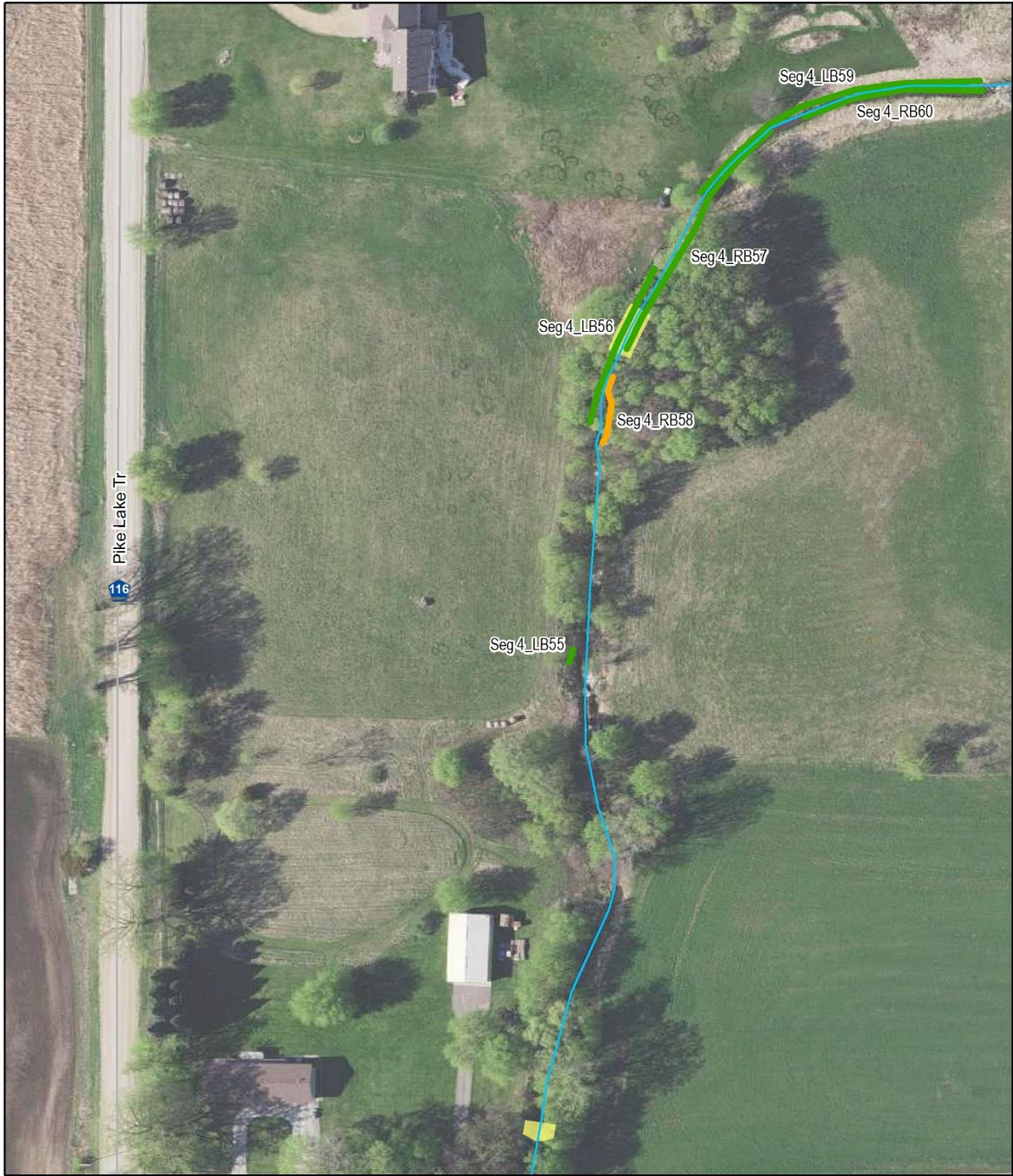
- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 3 (Lower Reach)



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 4 (Upper Reach)

Date: 8/8/2018 Time: 10:23:06 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



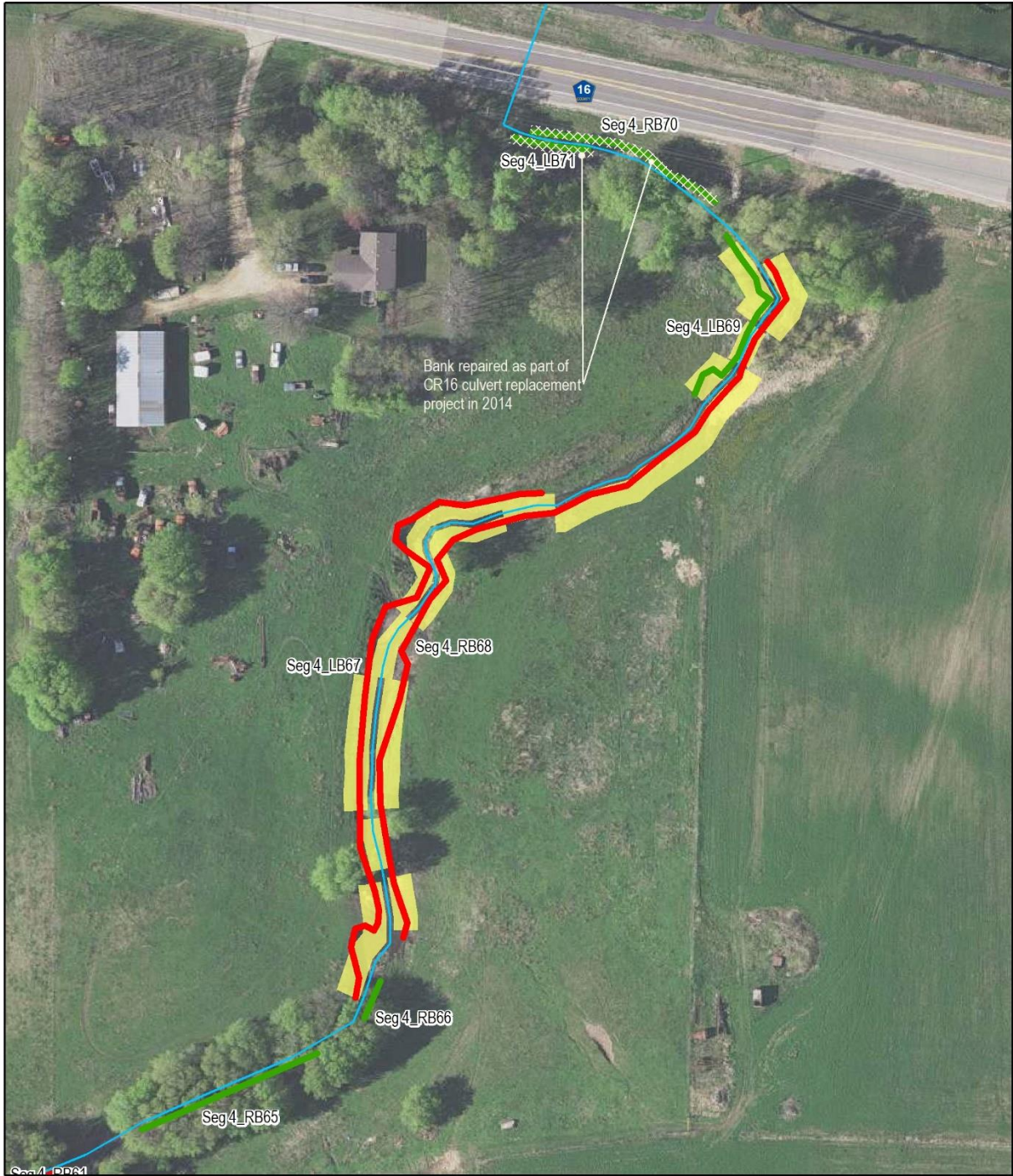
PLSLWD Segment 4 (Middle Reach)



Feet

0 100

Date: 8/8/2018 Time: 10:21:20 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area

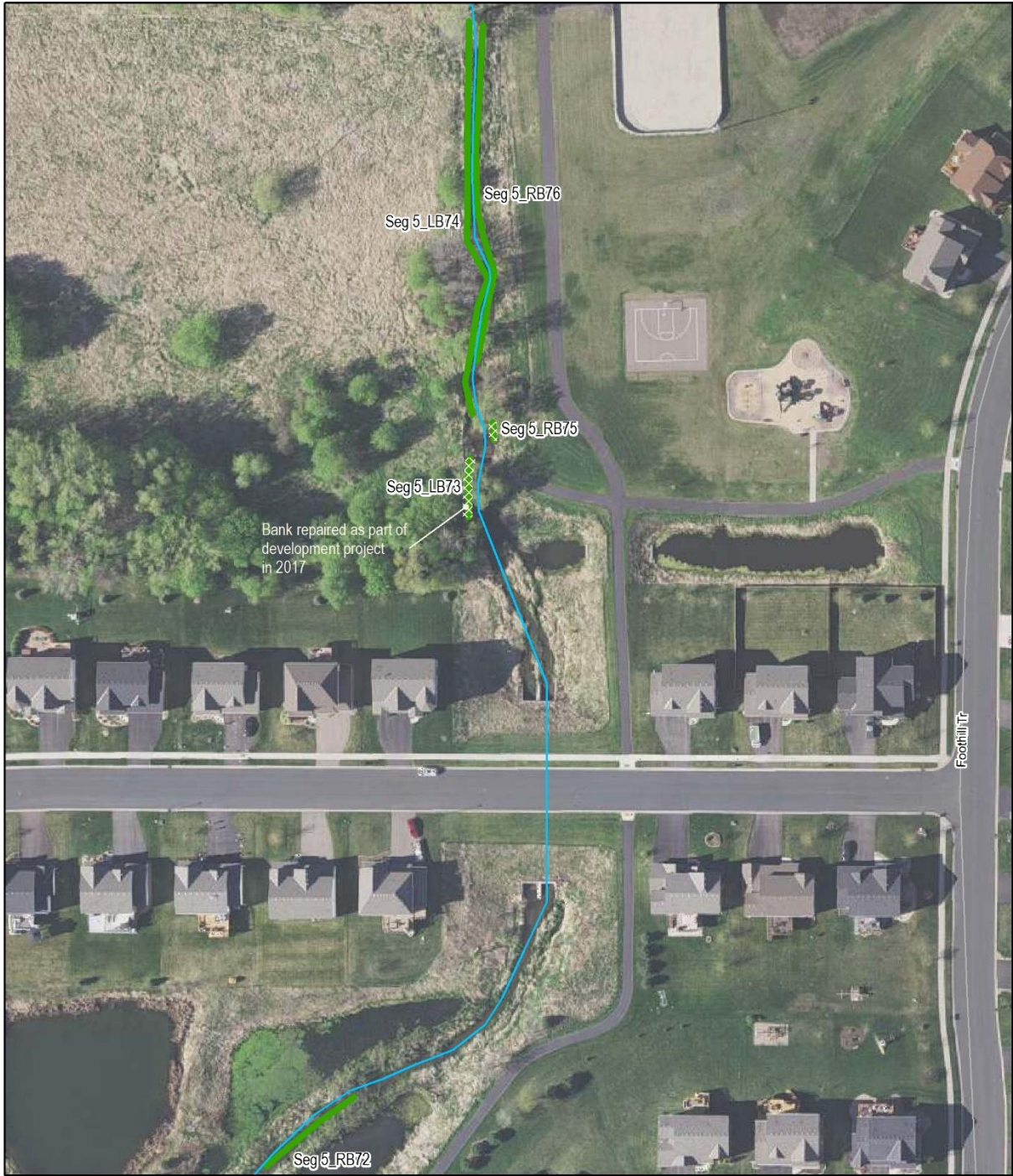
Previously Repaired



0 Feet 100

PLSLWD Segment 4 (Lower Reach)

Date: 8/8/2018 Time: 10:41:26 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

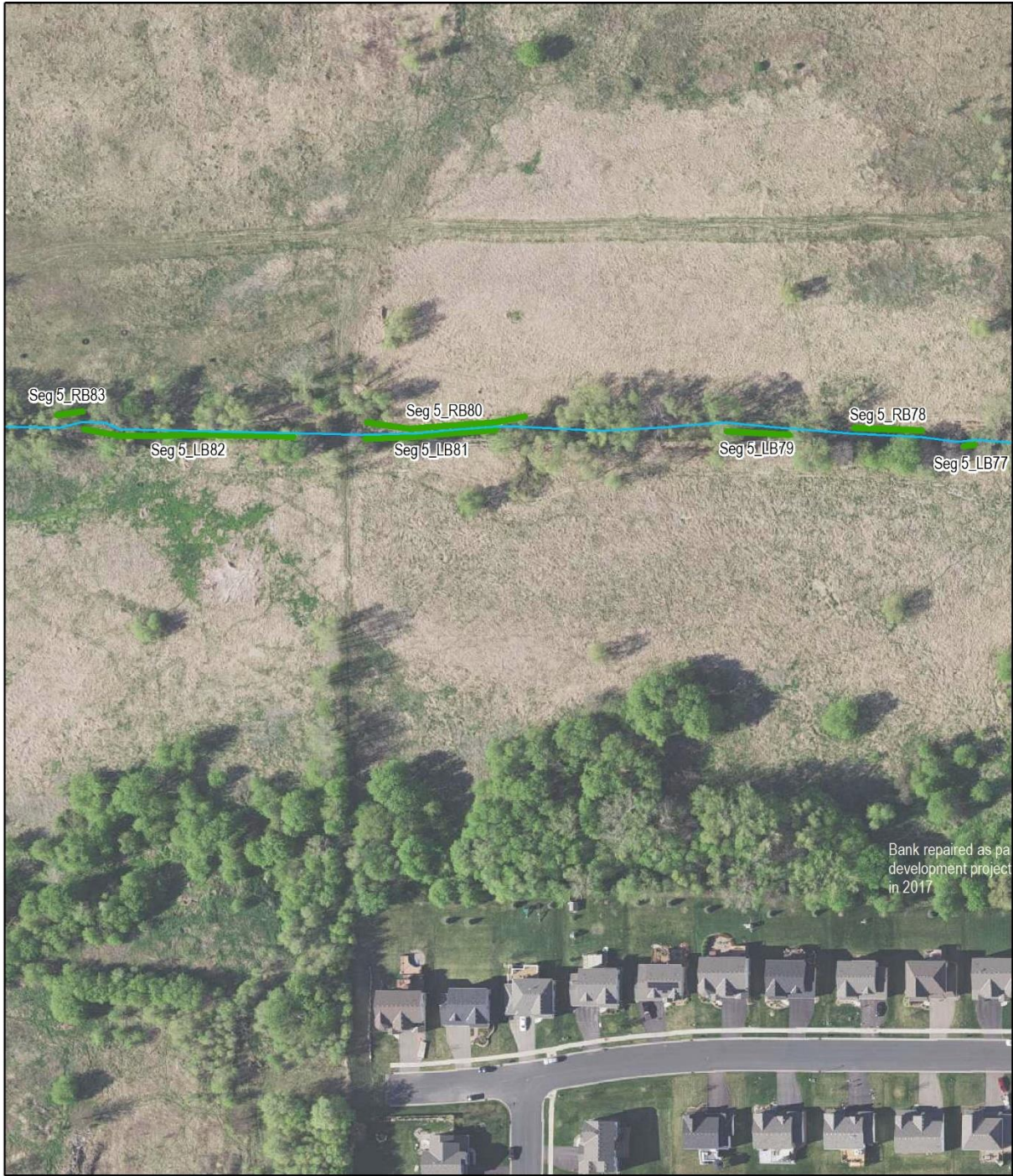
- FEMA Funded Repair Area
- Previously Repaired



0 Feet 100

PLSLWD Segment 5 (Upper Reach)

Date: 8/8/2018 Time: 10:43:49 AM Author: ejensen
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Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 5 (Middle Reach E)

Date: 8/8/2018 Time: 10:45:14 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

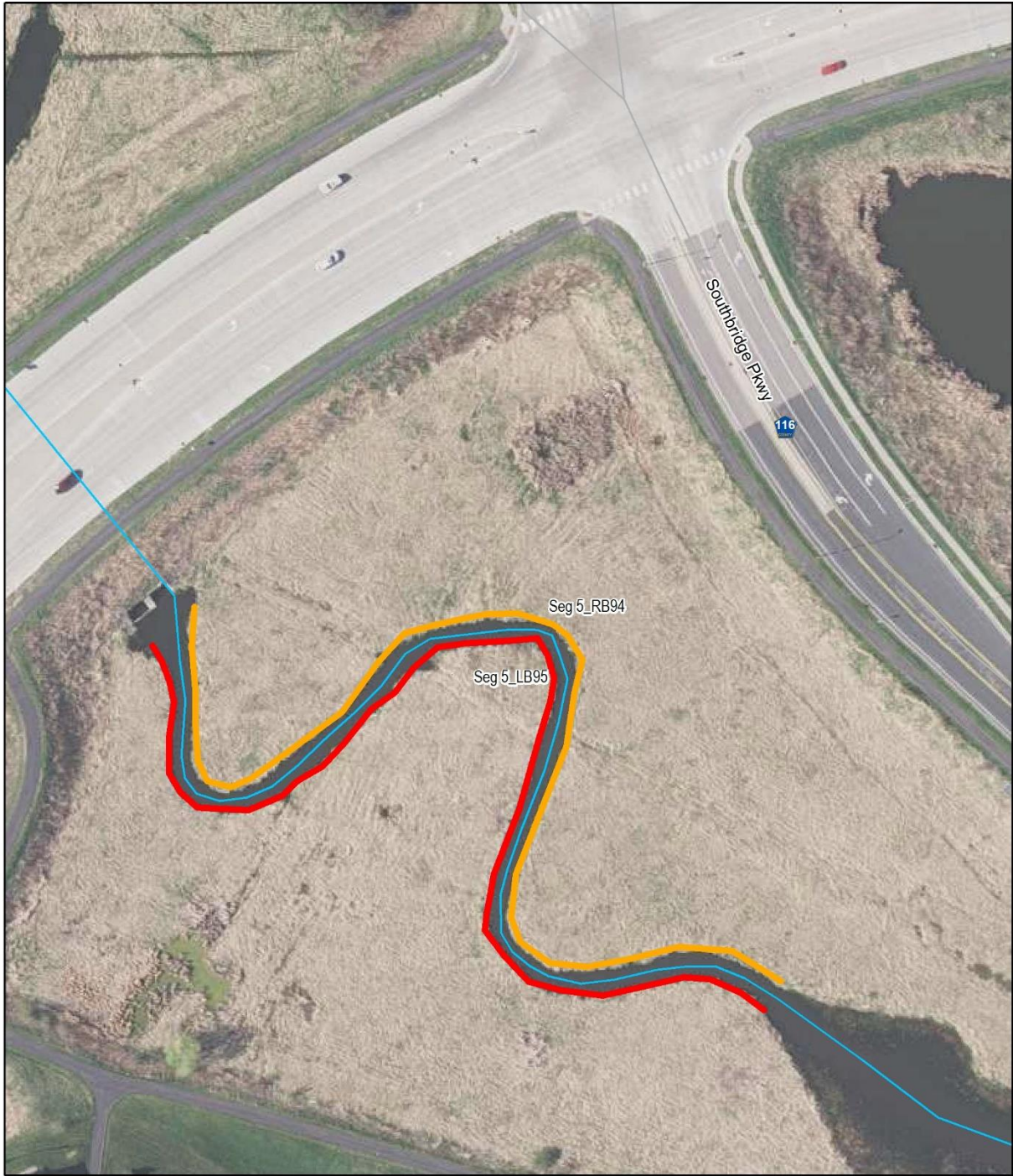
FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 5 (Middle Reach W)

Date: 8/8/2018 Time: 10:39:51 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



PLSLWD Segment 5 (Lower Reach)



0 Feet 100

Date: 8/8/2018 Time: 10:46:49 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

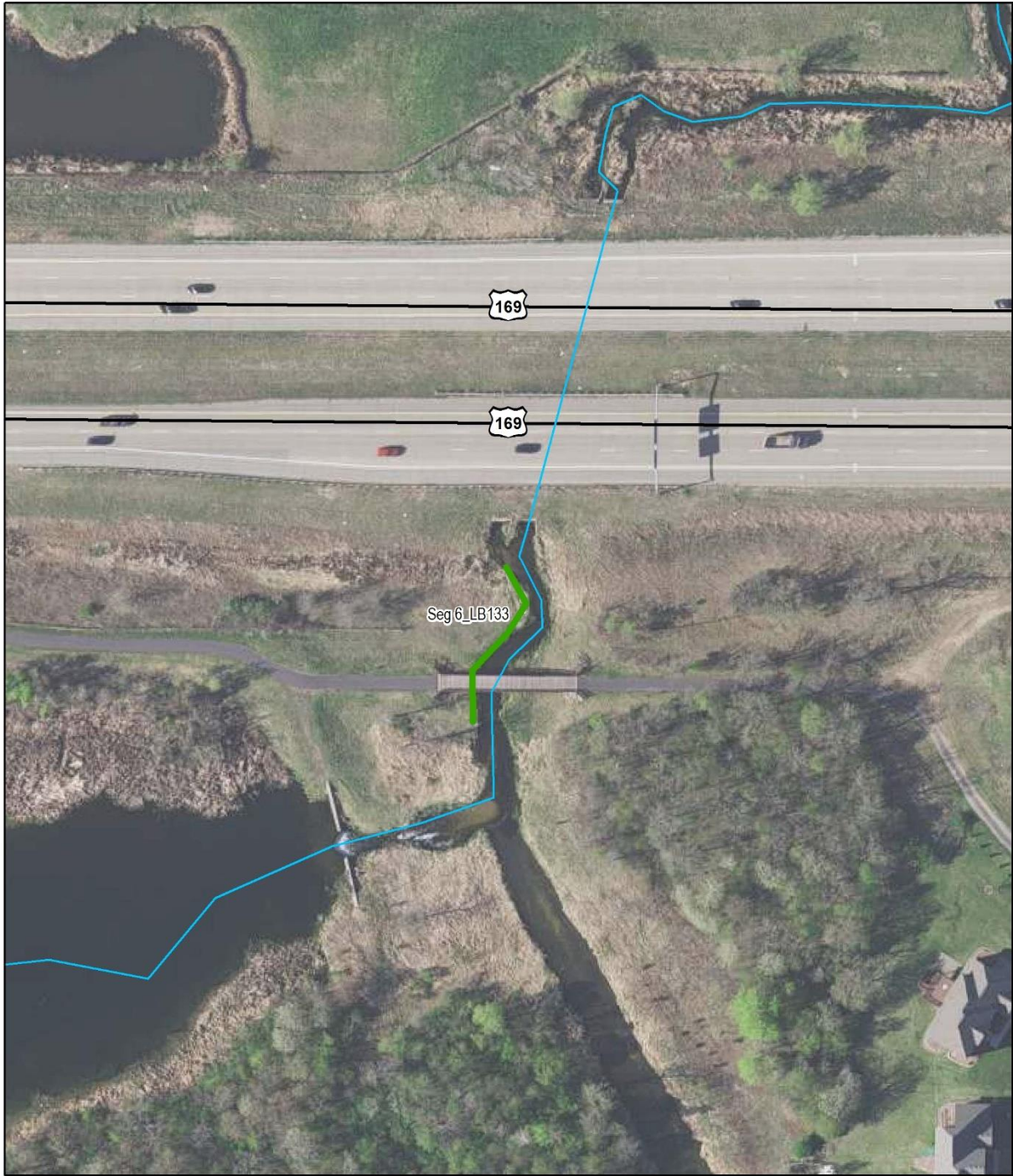
FEMA Funded Repair Area



PLSLWD Segment 6 (Upper Reach)

0 Feet 100

Date: 8/8/2018 Time: 10:48:09 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

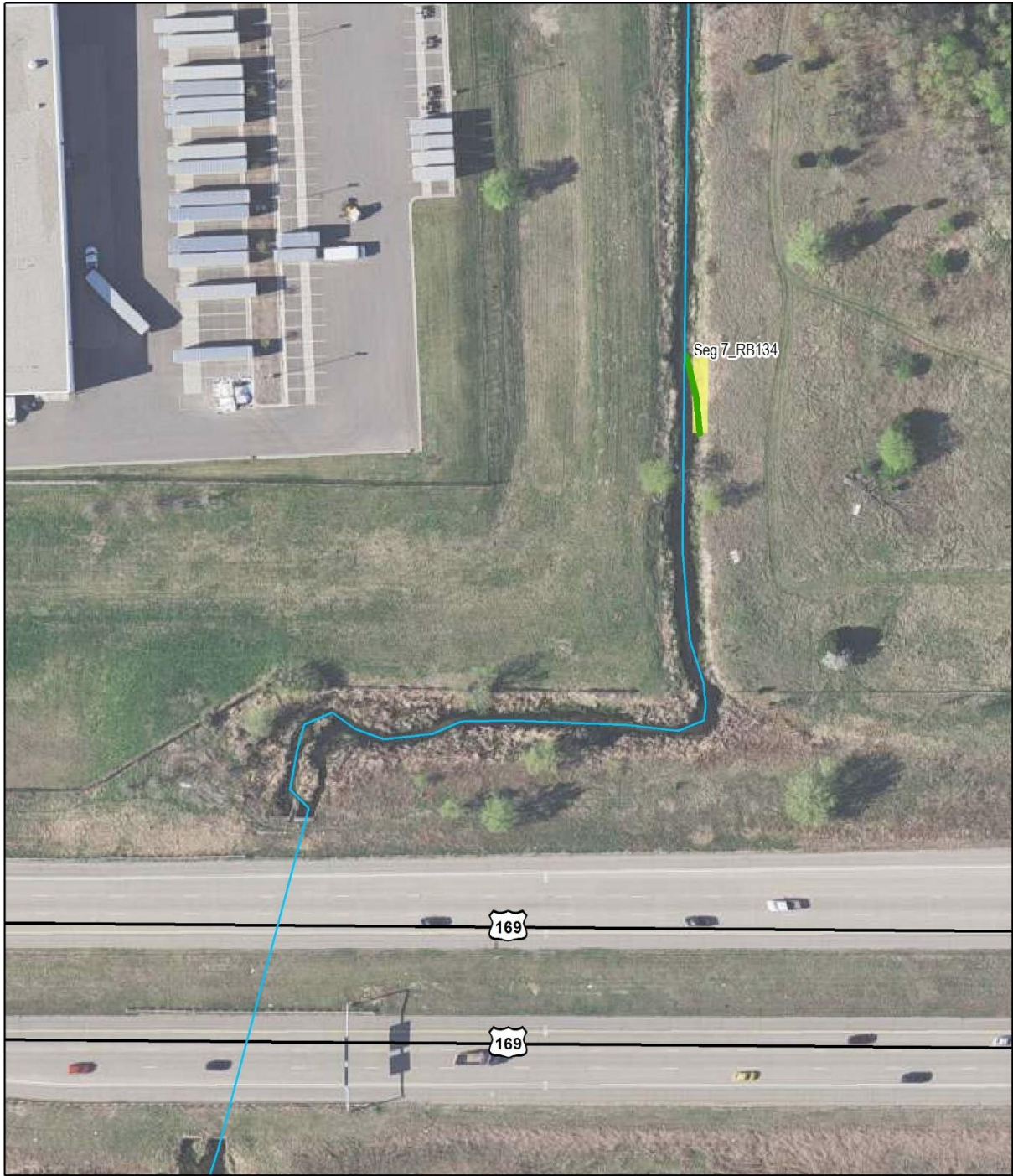
- High
- Moderate
- Low

FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 6 (Lower Reach)



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area

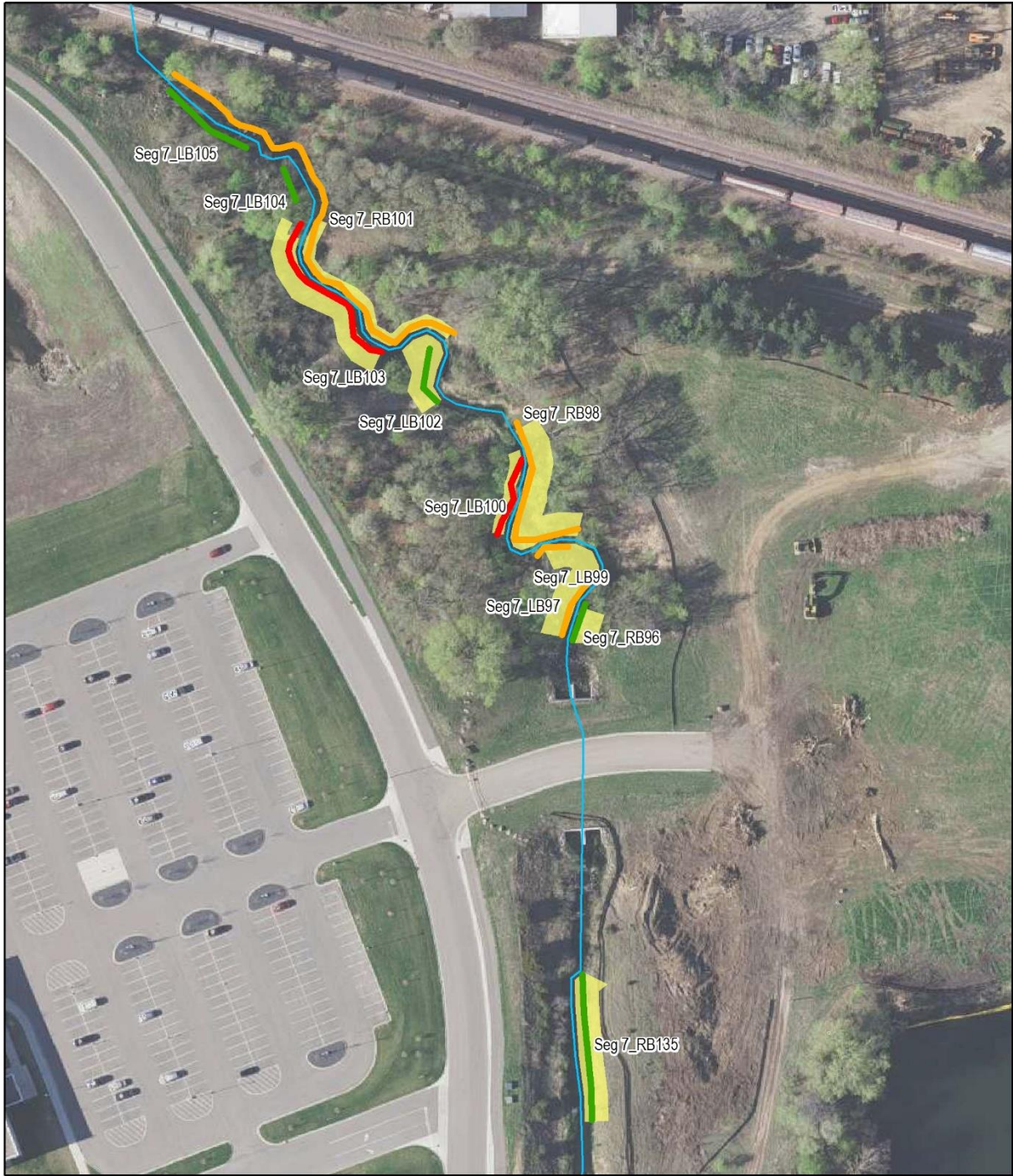


**PLSLWD
 Segment 7
 (Upper Reach)**



0 Feet 100

Date: 8/8/2018 Time: 10:50:55 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area

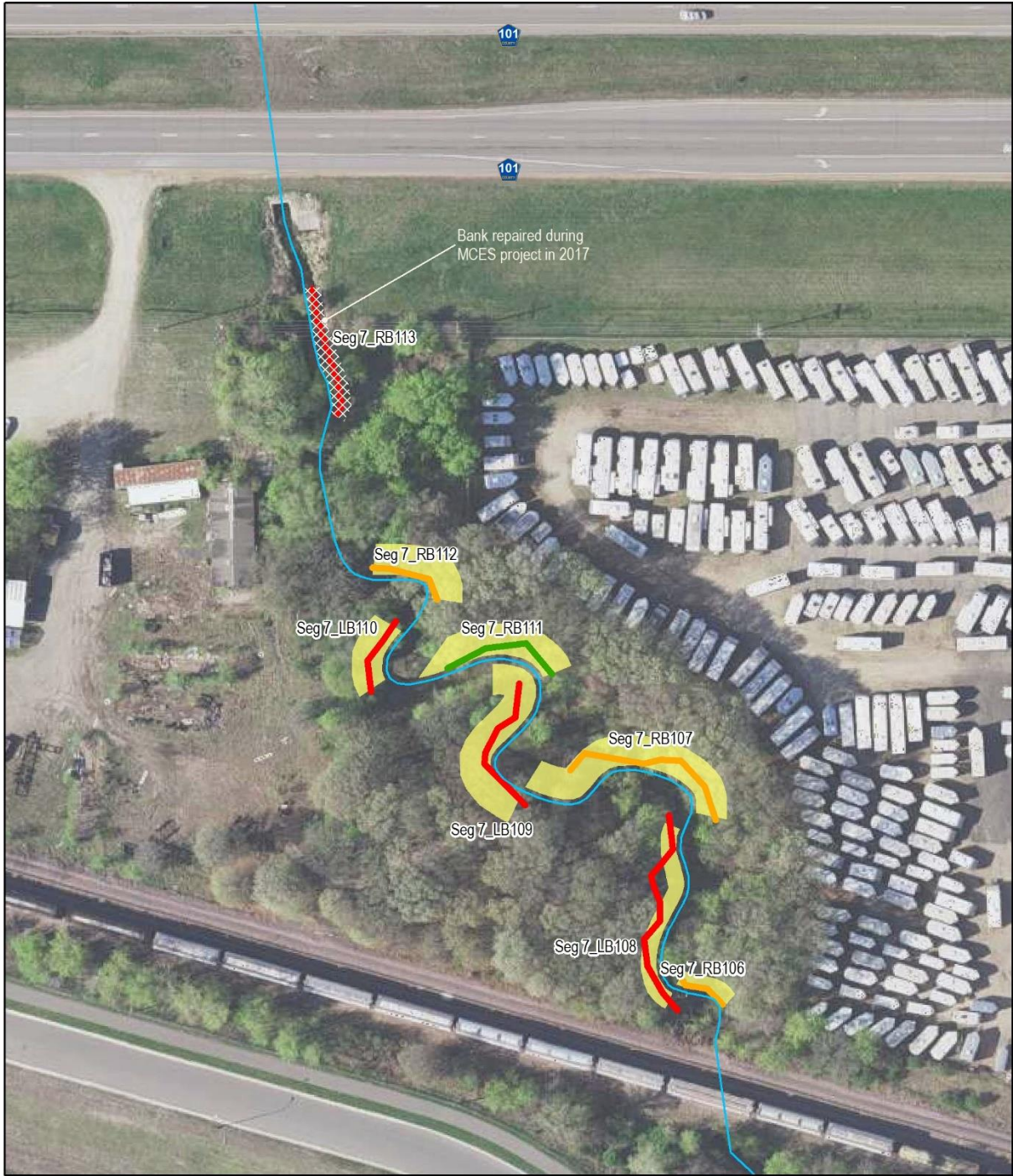


PLSLWD Segment 7 (Middle Reach)



0 Feet 100

Date: 8/8/2018 Time: 10:49:39 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

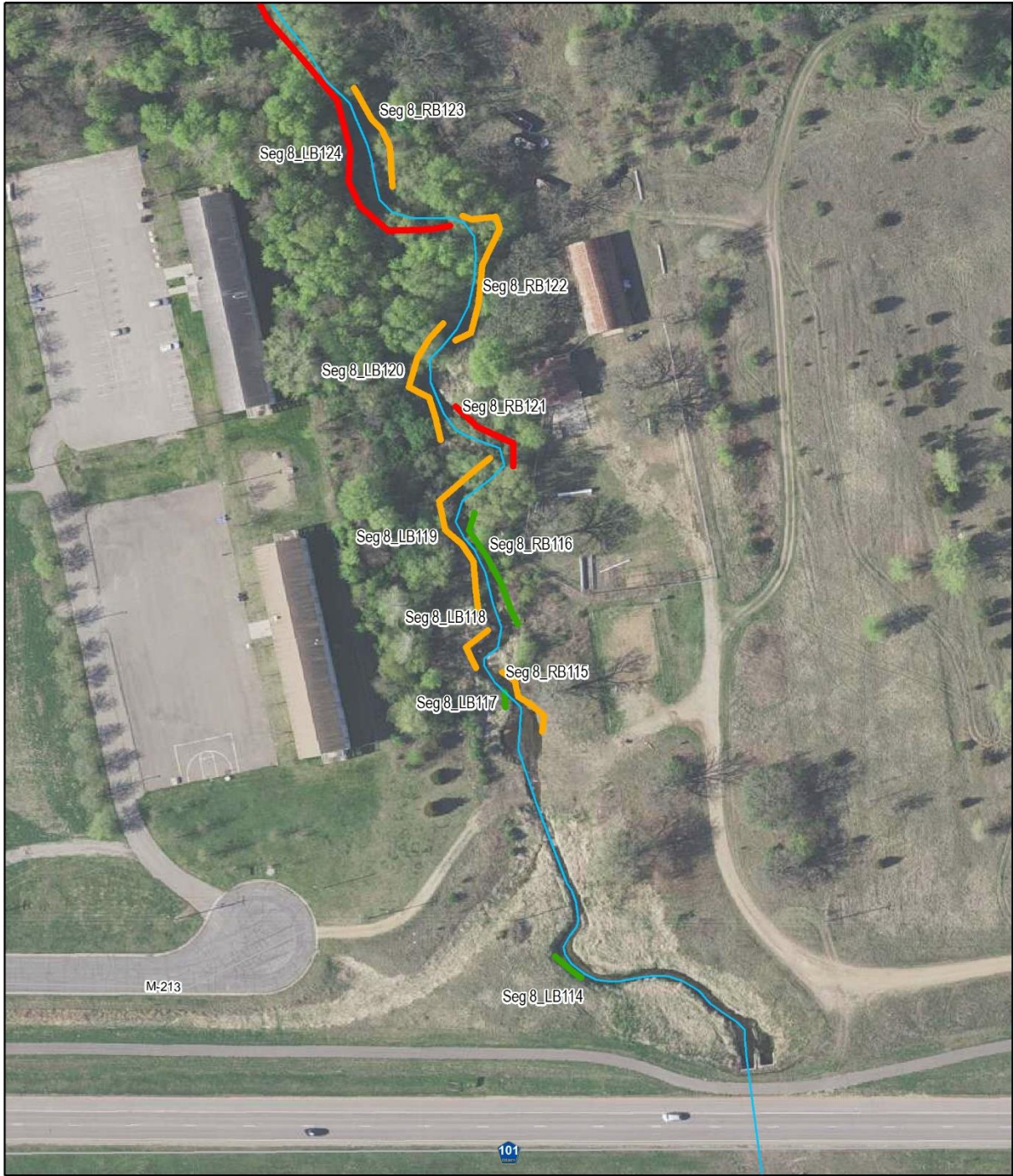
- FEMA Funded Repair Area
- Previously Repaired



0 Feet 100

PLSLWD Segment 7 (Lower Reach)

Date: 8/8/2018 Time: 10:54:20 AM Author: ejensen
 Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

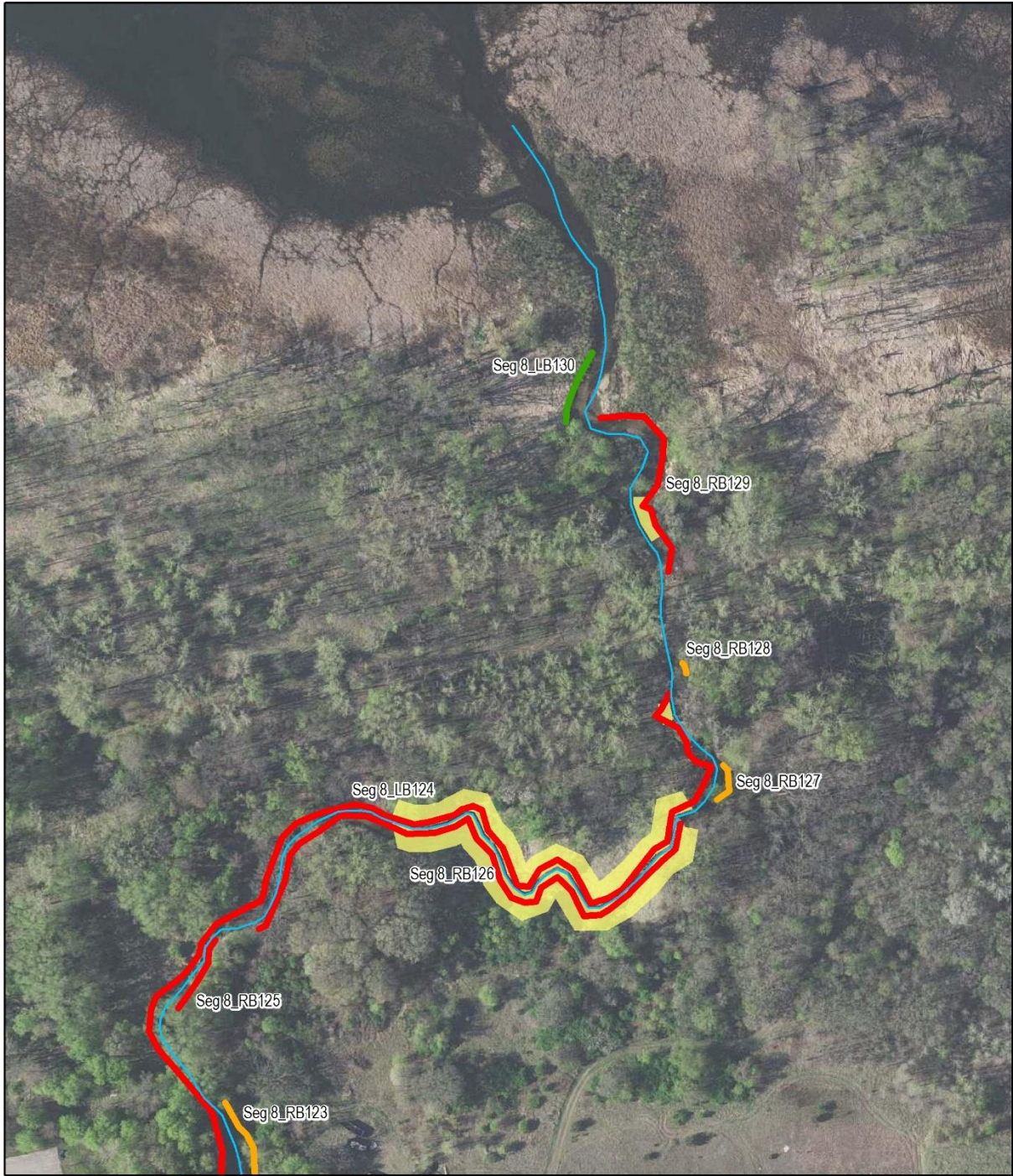
FEMA Funded Repair Area



0 Feet 100

PLSLWD Segment 8 (Upper Reach)

Date: 8/8/2018 Time: 10:56:31 AM Author: ejensen
Document Path: X:\Clients_WD\00758_PLSLWD\0122_PLOC_Master_Plan\09_GIMS_ProjectName\GIS\RM_BARR_const.mxd



Legend

Bank Failures 2014

- High
- Moderate
- Low

FEMA Funded Repair Area



PLSLWD Segment 8 (Lower Reach)

0 Feet 100

APPENDIX D. EASEMENT MAPS

APPENDIX E. 2018 POST-CONSTRUCTION MONITORING SITES & FUTURE BANK STABILIZATION AREAS WITH PRELIMIARY ESTIMATES OF PROBABLE COST

Appendix E includes two sets of tables for each segment. The first outlines the locations in need of future stabilization, while the second identifies locations to monitor after FEMA funded stabilization in 2018.

Table E-1. Segment 1 Future Bank Stabilization Areas

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 1_LB9	Left Bank	33	2.8	2.8	Low	\$1,995
Seg 1_RB10	Right Bank	68	2.6	3.0	Low	\$4,111
	Total Length	101			Segment Cost	\$6,500

Table E-2. Segment 1 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 1_LB1	Left Bank	370
Seg 1_RB2	Right Bank	373
Seg 1_RB3	Right Bank	34
Seg 1_RB4	Right Bank	135
Seg 1_RB5	Right Bank	63
Seg 1_LB6	Left Bank	138
Seg 1_RB7	Right Bank	381
Seg 1_LB8	Left Bank	207
Seg 1_RB11	Right Bank	68
Seg 1_RB12	Right Bank	126
Seg 1_LB13	Left Bank	121
Seg 1_LB14	Left Bank	61
	Total Length	2077

Table E-3. Segment 2 Future Bank Stabilization Areas

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 2_LB23	Left Bank	19	6.5	7.0	High	\$1,175
Seg 2_RB25	Right Bank	28	1.7	2.2	Low	\$1,731
Seg 2_L26	Left Bank	9	1.8	2.0	Low	\$556
Seg 2_RB27	Right Bank	14	2.1	2.2	Low	\$866
Seg 2_L30	Left Bank	44	2.0	2.4	Low	\$2,720
Seg 2_L32	Left Bank	25	1.0	1.0	Low	\$1,546
Seg 2_R34	Right Bank	22	2.1	3.3	Moderate	\$1,360
Seg 2_RB35	Right Bank	15	1.5	2.5	Low	\$927
Total Length		176			Segment Cost	\$11,000

Table E-4. Segment 2 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 2_RB15	Right Bank	25
Seg 2_LB16	Left Bank	161
Seg 2_R17	Right Bank	71
Seg 2_L18	Left Bank	35
Seg 2_LB19	Left Bank	80
Seg 2_R20	Right Bank	200
Seg 2_LB21	Left Bank	142
Seg 2_R22	Right Bank	58
Seg 2_L24	Left Bank	160
Seg 2_L28	Left Bank	86
Seg 2_RB29	Right Bank	97
Seg 2_RB31	Right Bank	166
Seg 2_LB33	Left Bank	104
Seg 2_R36	Right Bank	84
Seg 2_LB37	Left Bank	149
Seg 2_R38	Right Bank	43
Seg 2_LB39	Left Bank	27
Seg 2_R40	Right Bank	82
Seg 2_LB41	Left Bank	78
Seg 2_L42	Left Bank	14
Total Length		1862

Table E-5. Segment 3 Future Bank Stabilization Areas

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 3_LB51	Left Bank	14	2.5	3.0	Low	\$763
Seg 3_RB53	Right Bank	24	1.4	2.3	Low	\$1,307
	Total Length	38			Segment Cost	\$2,500

Table E-6. Segment 3 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 3_RB43	Right Bank	157
Seg 3_L44	Left Bank	71
Seg 3_LB45	Left Bank	83
Seg 3_R46	Right Bank	108
Seg 3_LB47	Left Bank	22
Seg 3_L48	Left Bank	130
Seg 3_RB49	Right Bank	46
Seg 3_L50	Left Bank	112
Seg 3_R52	Right Bank	34
Seg 3_L54	Left Bank	132
Total Length		895

Table E-7. Segment 4 Future Bank Stabilization Areas

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	\$484
Seg 4_LB56	Left Bank	139	1.7	2.5	Low	\$6,724
Seg 4_RB57	Right Bank	220	1.3	1.7	Low	\$10,642
Seg 4_RB58	Right Bank	58	2.7	4.0	Moderate	\$2,806
Seg 4_LB59	Left Bank	263	1.4	2.0	Low	\$12,722
Seg 4_RB60	Right Bank	152	0.9	1.0	Low	\$7,353
Seg 4_RB62	Right Bank	196	1.5	2.5	Low	\$9,481
Seg 4_LB63	Left Bank	260	1.3	1.5	Low	\$12,577
Seg 4_RB65	Right Bank	166	2.2	2.3	Low	\$8,030
Seg 4_RB66	Right Bank	35	1.2	1.3	Low	\$1,693
Total Length		1499			Segment Cost	\$73,000

Table E-8. Segment 4 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 4_RB61	Right Bank	585
Seg 4_RB62	Right Bank	75
Seg 4_LB64	Left Bank	482
Seg 4_LB67	Left Bank	606
Seg 4_RB68	Right Bank	783
Seg 4_LB69	Left Bank	185
Total Length		2716

Table E-9. Segment 5 Future Bank Stabilization Areas

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 5_LB74	Left Bank	326	1.6	2.3	Low	\$17,671
Seg 5_RB76	Right Bank	276	1.8	2.5	Low	\$14,961
Seg 5_LB77	Left Bank	11	1.2	1.4	Low	\$596
Seg 5_RB78	Right Bank	73	0.6	0.6	Low	\$3,957
Seg 5_LB79	Left Bank	67	1.2	1.3	Low	\$3,632
Seg 5_RB80	Right Bank	173	1.3	2.0	Low	\$9,378
Seg 5_LB81	Left Bank	141	1.2	1.5	Low	\$7,643
Seg 5_LB82	Left Bank	227	1.6	2.5	Low	\$12,305
Seg 5_RB83	Right Bank	28	1.0	1.0	Low	\$1,518
Seg 5_RB84	Right Bank	22	1.6	2.5	Low	\$1,193
Seg 5_RB85	Right Bank	50	1.4	1.8	Low	\$2,710
Seg 5_RB86	Right Bank	83	2.0	2.5	Low	\$4,499
Seg 5_RB87	Right Bank	128	2.7	6.0	High	\$6,938
Seg 5_LB88	Left Bank	24	1.2	1.2	Low	\$1,301
Seg 5_LB89	Left Bank	145	2.1	3.0	Low	\$7,860
Seg 5_LB90	Left Bank	96	1.8	2.6	Low	\$5,204
Seg 5_RB91	Right Bank	49	1.8	2.2	Low	\$2,656
Seg 5_LB92	Left Bank	155	2.1	3.0	Low	\$8,402
Seg 5_RB93	Right Bank	133	1.8	2.0	Low	\$7,209
Seg 5_RB94	Right Bank	786	2.5	3.3	Moderate	\$42,606
Seg 5_LB95	Left Bank	783	2.9	5.0	High	\$42,443
Total Length		3776			Segment Cost	\$205,000

Table E-10. Segment 5 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 5_RB72	Right Bank	90
Total Length		90

Table E-11. Segment 6 Future Bank Stabilization Areas

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	\$54,019
Seg 6_LB132	Left Bank	913	2.5	3.2	Moderate	\$50,636
Seg 6_LB133	Left Bank	120	2.0	3.0	Low	\$6,655
	Total Length	2007			Segment Cost	\$111,500

Table E-12. Segment 7 Future Bank Stabilization Areas

Bank ID	Location	Length [ft.]	Average Height [ft.]	Max Height [ft.]	Priority Ranking	Preliminary Estimate of Probable Cost
Seg 7_RB101	Right Bank	175	2.0	4.2	Moderate	\$9,144
Seg 7_LB104	Left Bank	29	1.0	1.0	Low	\$1,515
Seg 7_LB105	Left Bank	81	1.9	2.0	Low	\$4,233
	Total Length	285			Segment Cost	\$15,000

Table E-13. Segment 7 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 7_RB96	Right Bank	32
Seg 7_LB97	Left Bank	52
Seg 7_RB98	Right Bank	156
Seg 7_LB99	Left Bank	29
Seg 7_LB100	Left Bank	68
Seg 7_RB101	Right Bank	220
Seg 7_LB102	Left Bank	49
Seg 7_LB103	Left Bank	149
Seg 7_RB106	Right Bank	39
Seg 7_RB107	Right Bank	124
Seg 7_LB108	Left Bank	143
Seg 7_LB109	Left Bank	98
Seg 7_LB110	Left Bank	52
Seg 7_RB111	Right Bank	81
Seg 7_RB112	Right Bank	52
Seg 7_RB134	Right Bank	52
Seg 7_RB135	Right Bank	122
Total Length		1518

Table E-14. Segment 8 Future Bank Stabilization Areas

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	\$1,690
Seg 8_RB115	Right Bank	69	2.2	3.8	Moderate	\$4,020
Seg 8_RB116	Right Bank	108	1.6	3.1	Low	\$6,292
Seg 8_LB117	Left Bank	13	1.0	1.0	Low	\$757
Seg 8_LB118	Left Bank	44	1.8	3.5	Moderate	\$2,563
Seg 8_LB119	Left Bank	162	2.0	3.2	Moderate	\$9,438
Seg 8_LB120	Left Bank	122	2.3	4.0	Moderate	\$7,108
Seg 8_RB121	Right Bank	80	2.4	4.5	High	\$4,661
Seg 8_RB122	Right Bank	150	1.8	4.2	Moderate	\$8,739
Seg 8_RB123	Right Bank	95	2.6	4.2	Moderate	\$5,535
Seg 8_LB124	Left Bank	820	2.7	6.5	High	\$47,773
Seg 8_RB125	Right Bank	89	3.5	8.0	High	\$5,185
Seg 8_RB126	Right Bank	230	2.4	5.0	High	\$13,400
Seg 8_RB127	Right Bank	48	2.0	3.2	Moderate	\$2,796
Seg 8_RB128	Right Bank	12	2.0	3.5	Moderate	\$699
Seg 8_RB129	Right Bank	120	4.4	8.0	High	\$6,991
Seg 8_LB130	Left Bank	83	1.4	2.3	Low	\$4,836
Total Length		2274			Segment Cost	\$132,500

Table E-15. Segment 8 Banks to Monitor Following the FEMA Funded Bank Repair Project (2018)

Bank ID	Location	Stabilized Length [ft.]
Seg 8_LB124	Left Bank	550
Seg 8_RB126	Right Bank	465
Seg 8_RB129	Right Bank	129
Total Length		1144