

# 2016 PRIOR LAKE OUTLET SYSTEM ANNUAL OPERATIONS REPORT



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February 2017

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 Memorandum of Agreement (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 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. Acknowledging that the PLOC is used as a stormwater conveyance system and is not just a natural conveyance, the cooperator's 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.

## OUTLET STRUCTURE

### *HISTORY*

The Prior Lake Outlet Structure was originally constructed in, and has been operated since 1983. 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 (Figure 1). 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 1**

## *MAINTENANCE AND OPERATION*

Operation of the Prior Lake Outlet Structure is governed by the DNR-approved Prior Lake Outlet Control Structure Management Policy and Operating Procedures (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 2017 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 recommended 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.

The new structure needs minimal maintenance to operate. Once Prior Lake reaches 902.5', water starts spilling over the accordion shaped weir located inside the trash rack. 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 (Figure 2). 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 to ensure the Outlet Structure was not blocked.



**FIGURE 2**

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 2016 operations, the Prior Lake Outlet Structure performed well throughout the duration that water discharged from the lake. Prior Lake overtopped the outlet weir from January 1 to May 18, May 26 to June 26, August 12 to November 8, and November 16 through the end of the year. In other words, the Outlet Structure operated all but 62 days.



At certain lake levels, the Low Flow gate allows more water through the outlet structure, resulting in the lake level lowering more quickly and creating more storage (see Attachment C). To reduce the risk of flooding, the District opened the Low Flow gate on December 21, 2015 due to high lake levels (902.92'), saturated conditions, and minimal storage capacity in the watershed. The gate was closed on January 8, 2016 when the lake reached 902.5'. Again, on August 18, due to high water levels (902.81') and the forecast predicting more rain, the PLSLWD opened the Low Flow gate and closed it on September 12 (lake level 902.5' – See Figure 3).



**FIGURE 3**

In its 303 days of discharge during 2016, an estimated 4.80 feet of vertical volume was eliminated from the lake through the Prior Lake Outlet Structure (see Attachment D). Prior Lake theoretically could have reached approximately 907.66' without operating the outlet structure. 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 2016.

## OUTLET PIPE

The Outlet Pipe leads from the Outlet Structure to the beginning, or “daylight,” of the outlet channel. It is buried underground for approximately 2075 feet, with 5 manholes and 7 access points (Figure 4).

Visu-Sewer last televised the entire length of the pipe on September 15, 2015 to look for potential damage, areas in need of repair, blockages, accumulated debris, and to assess whether the pipe is reaching full hydraulic capacity. They concluded there were no pipe blockages from broken pipe,



**FIGURE 4**

no significant root intrusion, and no substantial debris, such as tree branches. They did find some areas with deposits of fine material in the bottom of the pipe which restrict the flow by no more than ten percent. They suspect these deposits would be washed out of the pipe by the force of flow when the outlet structure is in use. They also found that the outfall pipe access manholes were not constructed with nice, smooth benches which they suspect could cause substantial headloss during peak flow periods.

In general, the lake outfall pipe is in good to fair condition. They identified one defect that is coded red for immediate attention. The reinforcement is visible on the edge of the pipe on the downstream end of manhole number 3. Exposed steel is subject to rusting and allows water into the concrete pipe.

The pipe also has leaking joints with mineral deposits in every pipe segment and some of these joints are likely the source of the fine deposits. While the volume of water leaking through an individual joint may not be substantial, the accumulation of mineral deposits will affect the hydraulic capacity of the pipeline and perhaps more importantly, the movement of fine soils from the area surrounding the pipe can eventually shorten the life of the pipeline as the supporting soils are lost and the pipe can move.

In 2016, the spalling joint and manholes gutter bases were repaired by IBA Manhole (Figure 5 & Figure 6). This work should decrease turbulence at the manhole benches and allow the pipe to reach full capacity faster.

Chemical grouting is scheduled to be completed in 2017 to address the leaking joints. Following the grouting, another televising will be scheduled in 2017 to document the manhole smoothing, spalling joint, and grout work.



**FIGURE 5 MANHOLE BENCH BEFORE SMOOTHING**



**FIGURE 6 MANHOLE BENCH AFTER SMOOTHING**

# OUTLET CHANNEL

The MOA cooperator goals of the outlet channel include: 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 of these goals have been met, but the channel will always require maintenance.

## *Maintenance*

While the Outlet Structure is in full operation and discharging water, the District is required to perform regular inspections (at least once per week) of the Outlet Structure and the Outlet Channel in accordance with the Operating Procedures looking for debris or any other issue along the channel or at the structure. Debris, downed trees, or other material are removed when they pose a risk, such as flooding or erosion. When debris is too difficult for PLSLWD staff to remove, the party in charge of that culvert, or land, will be contacted to inform them of the work needing to be done and they will need to address the issue.

The Prior Lake Outlet Channel incurred substantial damage during the 2014 flood, including downed trees, accumulated woody debris, sediment accumulation, culvert damage and over 2.8 miles of bank erosion. In 2015, most of the tree and woody debris removal work was completed and one of the culverts (KiciYapi) was repaired by the Shakopee Mdewakanton Sioux Community. Removal of the remaining trees and woody debris, culvert repairs (Gonyea and Kes Field Crossing), and Pike Lake Park stream crossing repair work was completed in 2016. The bank erosion repair work and the silt & sediment removal project will begin in 2017. The Federal Emergency Management Administration (FEMA) has approved federal funding to cover 75% of the costs of the 2014 flood damage to the PLOC. The State of Minnesota will pay the remaining 25%.

A summary of maintenance projects that have been completed include:

- 2006
  - 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.
- 2007
  - 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.
- 2009
  - Replacement of an undersized culvert on the northern end of Segment 8.
- 2010
  - 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
  - Work to build up the channel bed and reconnect it to the floodplain in Segment 2.
- 2012
  - 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.
- 2013
  - Three failing culverts were replaced between Segments 3 and 4B (Pike Lake Road, Jackson Trail, and Gonyea field crossing).



- 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. Black locust, common buckthorn, and Tatarian honeysuckle suckers and seedlings were treated in segments 1, 3, 4A, 5C, 6, and 7A.
- 2014
  - 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).
- 2015
  - Garlic Mustard was hand cut by EOR on May 15 in segments 3 through 8.
  - EOR released flea beetles on June 26 in Segment 7 to treat the leafy spurge in that segment.
  - Downed trees were removed from the channel by WHR.
  - Segment 4A was realigned by Sunram to protect field road from eroding (EOR design). Trees replaced by Scott SWCD.
  - The Shakopee Mdewakanton Sioux Community replaced the KiciYapi culvert in Segment 3 (Bolton and Menk design).
  - USFWS removed the field road crossing near the parking lot north of Highway 101. This crossing experienced damage many times and restored the area to a native flood plain instead of replacing the crossing again.
- 2016
  - EOR hand-cut Garlic Mustard in segments 3-7.
  - A site visit with EOR and Minnesota Department of Agriculture determined beetle establishment in Segment 7 was successful, but too low to capture and redistribute beetles to more sites. Another assessment will be completed in 2017.
  - In Segment 1, AES spot-treated wild parsnip, locust and thistle and removed Locust and Silver Poplar.
  - AES treated a large patch of Garlic Mustard on the north and south side of County Road 16 (Segments 4 and 5).
  - A large purple loosestrife plant was removed from Segment 4A by AES.
  - All manhole benches in the outlet pipe were reconstructed (smoothed) by IBA manhole.
  - Kes Field Crossing culvert (Figure 7), Gonyea culvert, and Pike Lake Park stream crossing repaired by Nadeau Companies
  - The remaining downed trees and woody debris were removed by WHR



**FIGURE 7 KES FIELD CROSSING**



# MONITORING

Monitoring along the outlet channel in 2016 consisted of water quantity (flow), water quality (chemistry), vegetation surveys, and erosion monitoring. Some of this monitoring is funded by the MOA cooperators, and some is done for other programs or entities.

## *WATER QUANTITY AND QUALITY*

Water quantity monitoring consisted of obtaining continuous stage and flow measurements. PLSLWD staff measured flow and stage at the beginning of the Outlet Channel (ST\_OTs) and the end of the Outlet Channel (ST\_32A). Scott SWCD and EOR helped collect flow samples on occasion. Each site recorded stage in 15 minute increments on a level logger recorded. Flow measurements were taken at various stages to create a stage-discharge relationship (rating curve). Flow data can be used to help estimate pollutant loads, calibrate the XP-SWMM model, and determine the level and volume of water flowing through the system. Site ST\_OTs is located at the Outlet Structure. The lake level is recorded using an Ott Level Logger and updated hourly on the PLSLWD website.

Three Rivers Park District monitored water quality at two locations on Pike Lake (the east and west bay). Samples are collected bimonthly and analyzed at Three River Park District's laboratory. Parameters that are sampled include temperature, dissolved oxygen, pH, conductivity, secchi, Chlorophyll-a, total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorides. Results for these sites can be found on the PLSLWD website.

## *VEGETATION AND EROSION MONITORING*

In the fall of 2016, a vegetation assessment was conducted concurrently with a channel stability inspection by EOR. The vegetation inspection assessed previously managed areas for invasive plant species and documented any satellite populations of invasive species growing within the channel easements. The channel inspection was assessed on foot from Segment 1 through Segment 8. A series of photos documented stream conditions, new bank erosion, and obstructions to flow. A memo written by Mike Majeski at EOR (titled *PLOC Channel Inspection*) on October 25, 2016 summarized the results.

Blue Water Science conducted a late summer point intercept survey on Jeffers Pond in 2016. As far as we know, this is the first time a vegetation survey has ever been completed on this pond. In 2017, a survey will also be done on Jeffers Fish Pond and Jeffers Wildlife Pond as well. The results of these surveys can be found on the District's website when they are complete.

Vegetation density, bathymetry, and bottom hardness were collected using a software called BioBase. In 2016, the PLSLWD and a company called Platypus used BioBase software to monitor some lakes along the Outlet Channel, including Jeffers Fish Pond and Pike Lake. This program uses a depth finder to map the waterbody. The depth finder can be mounted to a boat, or as with Platypus, a remote-control boat. Results from this study can be found by contacting PLSLWD staff.

## PERMITS

In 2016, the District had four open permits along the PLOC:

- Permit #10.02 *Jeffers Waterfront*: The Certificate of Completion has been signed and received by the landowner. The District is waiting for the snow melt this spring to inspect the site for adequate vegetative cover before officially closing the permit.
- Permit #11.03 *Jeffers Pointe*: The developer is working with the District to address the degraded raingarden onsite before assigning a Certificate of Completion.
- Permit #13.04 *Valley Park Business Center*: A few minor issues onsite need to be resolved before a Certificate of Completion is approved.
- Permit #13.05 *East Village 3<sup>rd</sup> Addition*: This permit was closed in 2016.

The District anticipates closing out the three remaining open permits in 2017.

## EASEMENTS

The District holds drainage easements along most of the Outlet Channel. An easement allows the District to access and maintain the channel and the land within the easement area. Because of damage in the channel by the 2014 flood, bank repair is needed along much of the channel. During the preparatory review process for this work, it had come to light that some of the easements are inaccurate and need to be amended. This could be because the channel has shifted over time, or due to errors in the legal description when it was originally established. Although the existing easements may be erroneous, the District retains prescriptive rights along the channel.

In 2016, the District contacted 3 landowners along the channel to work with them to amend their easement to include more accurate descriptions and/or to obtain additional easement rights along the channel where warranted. The District is currently in negotiations with all three, and anticipates completing two easement amendments in 2017.

## OTHER ACTIVITIES

### *BLUE LAKE SANITARY SEWER REHABILITATION PROJECT*

Metropolitan Council Environmental Services (MCES) was in the process of rehabilitating sanitary sewer lines for the Blue Lake Sanitary Sewer System starting in 2016. A portion of the project involved creating a temporary diversion of the Outlet Channel and potentially dewatering activities at the construction area along the channel. Additionally, a temporary conveyance for the sewer line will be routed through the Union Pacific and Highway 101 culverts in Segment 7B. As the District manages this conveyance system on behalf of the Cooperators, district staff and the MOA technical advisory committee reviewed the plan and provided comments to MCES. District staff inspected the project site to ensure flow was maintained, erosion was controlled, and no contamination could reach the Outlet Channel. Construction work at the site affecting the channel begins in 2017. Note: As the project lies outside of the Watershed District boundaries, a Watershed District permit was not required.

### *MODEL UPDATES*

The cooperators hired EOR to analyze the current XP-SWMM model and propose updates and improvements. Two main issues of concern included areas that are known to be inaccurate under existing conditions and existing culverts that are indicated to be undersized per the PLOC JPA allowable discharge rates for ultimate flow conditions. EOR obtained from

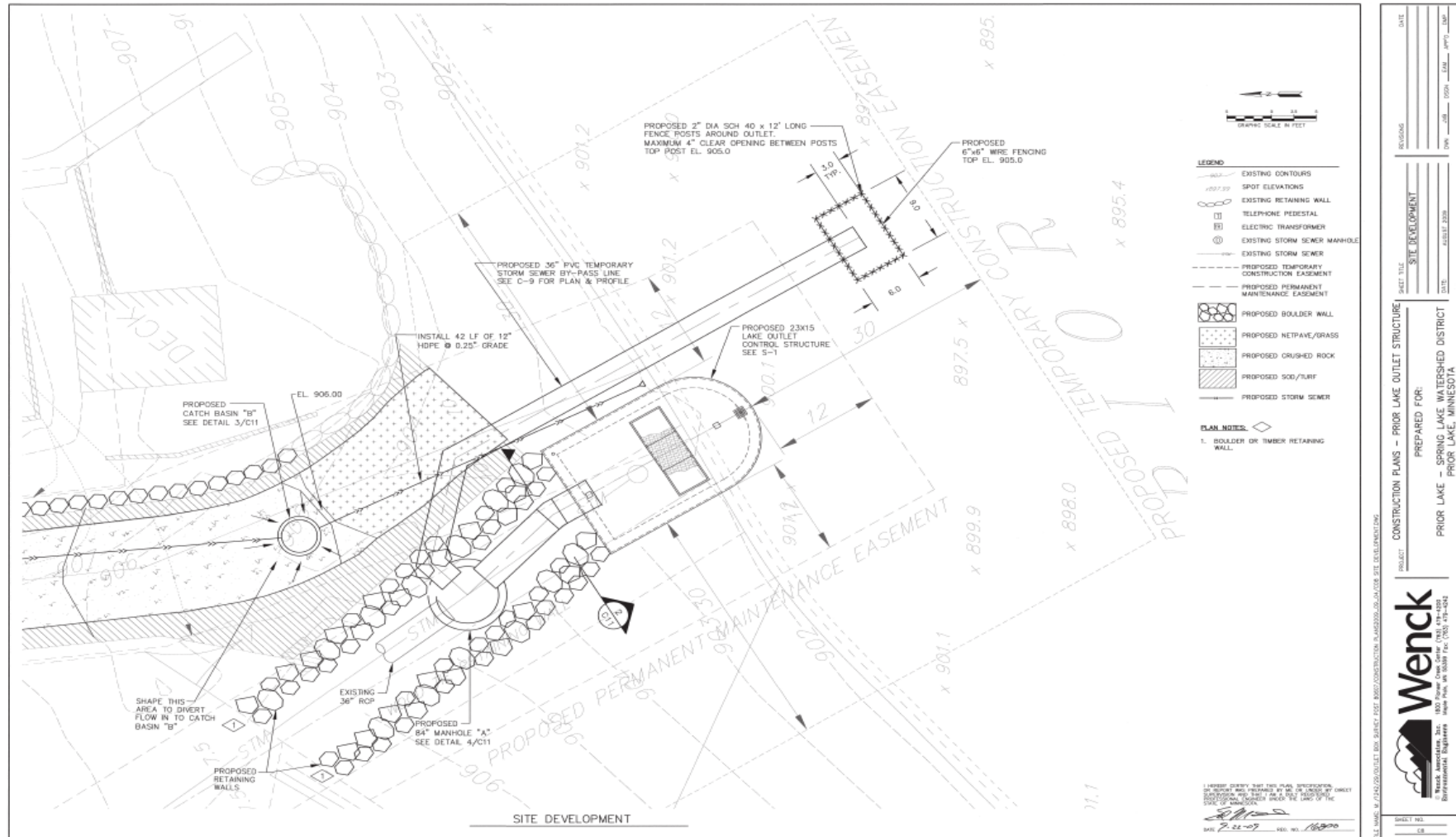
road authorities the construction plans, or as-built plans where available, for multiple crossings on major tributaries to the PLOC and updated the XP-SWMM model per these plans. Based on the updated model, EOR also provided a memo dated 9/2/2016 summarizing the crossings that have the potential need to be increased in capacity with future development. The memo also included discussion points for future modeling revisions to guide bank repair work and discharge governance protocol. Based on TAC direction, EOR will complete additional model edits in January of 2017 to simulate upsizing of PLOC crossing to JPA allowable flow rates and run the model with Atlas 14 precipitation depths and the MSE 3 24-hour rainfall distribution.

## *EDUCATION*

A newsletter was sent to all landowners that had property within or adjacent to the Prior Lake Outlet Channel. This was the first educational newsletter sent to landowners informing them of flood updates, work within the channel (upcoming and completed), history of the Outlet Channel, and easement information. This newsletter was created by Green Corp staff that the PLSLWD housed, at no cost to the District. In addition, landowners along the channel received letters advising them of the scheduled downed tree and culvert work on the channel.



## Attachment A. Prior Lake Outlet Structure Diagram



## Attachment B. Annual Outlet Channel Operations Summary

Date	Elevation	Outlet Activity	Inspections/Channel Activity
1/6/2016		Monitoring	Flow measurements at outlet structure with low-flow open.
1/7/2016	902.45	Inspection	low flow gate open. Was opened on 12-21-15. 8.09' td at railing on structure. Debris on Jeffers grate, tried to remove but stuck. Debris backing up water at CR42. Water overtopping bank at Pike Lake Rd S. Stump/trees in stream at Jackson trail.
1/8/2016	902.45	Low-Flow Gate	CLOSED LOW-FLOW GATE.
1/8/2016		Meeting	Meeting with Muhlenhardt
1/15/2016		Site Visit	Mark trees for removal
1/27/2016		Site Visit	Segment 2 site visit.
2/8/2016		Meeting	Meet with Homeland Security (Wayne) at Segment 5
2/18/16		Site Visit	Mark easement on 7B.
2/19/2016	902.54	Inspection	Some debris at RR crossing. Debris causing backup at CR 42. Water running under ice at Jackson. Flowing at CR16.
2/20/2016		Admin	Complete Annual Report
2/24/2016	902.53	Inspection	8.06' td at railing on structure. Veg building at jeffers pass. Debris at rr crossing not causing issues. Veg removed from CR42 since last time. Took video of trib coming from the east of cattle pasture near CR42/Hwy 21.
2/25/2016		Inspection	Final walk through for tree removal project.
3/2/2016	902.56	Inspection	Removed veg at Jeffers pass.
3/4/2016		Admin	Bid opening - FEMA Sediment Delta (1st bid)
3/4/2016		Monitoring	Install lake level logger on Prior Lake outlet structure.
3/8/2016	902.58	Inspection	Some debris at jeffers pass, upstream and downstream. Some debris on CR42 grate. Pike staff gauge: 2.70. Debris on downstream side of Jackson Trail - not problematic.
3/15/2016	902.66	Inspection	Some veg on outlet structure, removed some. Veg on Jeffers Pass grate - removed. Veg on CR42 grate - removed. One tree branch in culvert from PLOC tree removals. Backing up at Pike Lake Rd but does not appear to be clogged. Debris downstream at Jackson.
3/21/2016	902.68	Inspection	Cleaned veg from outlet structure. Cleaned veg from CR42 grate. Branch from FEMA tree removals at Strauss still in culvert.
3/23/2016		Admin	Send mailing to landowners regarding tree removal.
4/1/2016		Inspection	Little veg at Jeffers Pass. Removed debris from Strauss driveway.
4/7/2016	902.74	Inspection	Removed veg at structure, jeffers pass. Veg at RR crossing gone. Veg at CR42 should be removed. Culvert 19a filled with debris and water is backing up.
4/12/2016		Meeting	Meet Sean Corrigan at house, Segment 5, to discuss high water.
4/14/2016		Whole Channel Walk	Photos taken of channel, walking upstream to downstream. Downed trees counted. Looked for blockages.
4/21/2016		Monitoring	Flow measurements at outlet structure with low-flow open and closed.
4/26/2016		Meeting	MOA Cooperators meeting
4/28/2016		Meeting	Meeting w/visuSewer about manhole project.
5/1/2016		Site Visit	Tree Removals complete.
5/5/2016	902.54	Inspection	Removed veg at structure, jeffers pass, Pike Lake Rd S, Jackson. Culvert 19a veg has been cleared.
5/9/2016		Maintenance	EOR cut garlic mustard in segments 3-7.
5/13/2016	902.53	Inspection	Veg at structure should be removed soon. Removed veg from Jeffers Pass. Water appears to be eroding soil next to culvert at RR crossing. Pike Lake Staff Gauge: 3.02' (wavy conditions 2.98-3.08). Debris building downstream of jackson trail.
5/16/2016		Site Visit	Talk to Dean and Judy Morlock about manhole bench smoothing.
5/17/2016		Monitoring	Flow measurement with low-flow gate open.
5/20/2016	902.43	Inspection	Debris on downstream side of culvert at Kes, Pike Lake Rd S, Jackson. Pike Lake staff gauge: 2.53'.
5/23/2016		Site Visit	Meet VisuSewer in field to discuss manhole project.
5/25/2016		Site Visit	Segment 4 site visit - restoration areas.
5/27/2016	902.48	Inspection	Removed debris from downstream side of culvert at Pike Lake Rd and Jackson Trail.
5/31/2016		Meeting	TAC Meeting
6/2/2016	902.50	Inspection	Still needs pile of veg and dead fish removed. Pike Lake Staff Gauge: 2.22'. Leaf pile on property by Jackson trail.
6/2/2016		Site Visit	EOR met MN Department of Ag to determine beetle establishment.
6/8/2016	902.48	Inspection	Cleared veg from outlet structure. Took pics of garlic mustard at CR 16. Pond outlet sedimented in at Riverside Bluffs. Lots of spurge at Dean Lake outlet. Water very clear like always. Met VisuSewer and IBA manhole - Dan and Eric Mraz and Gary w/IBA, Todd Stelmacher w/VisuSewer. Pike Lake staff gauge: 2.23'.

Date	Elevation	Outlet Activity	Inspections/Channel Activity
6/17/2016	902.70	Inspection	Cleared veg from outlet structure. Pike Lake staff gauge 2.83'.
6/23/2016	902.50	Inspection	Cleared veg from structure, CR42. 2.46' at Pike Lake staff gauge.
6/27/2016	902.43	Inspection	Removed veg from CR42. Pike Staff gauge 2.24' - cleaned staff gauge. Erosion starting on upstream side of culvert at Kes.
6/29/2016		Meeting	FEMA reporting/project coordination meeting
7/1/2016		Monitoring	Flow measurements with low-flow gate open.
7/6/2016		Meeting	Meeting with DNR, Jennie Skanckie, to discuss potential channel restoration above and beyond FEMA work.
7/8/2016		Meeting	Meeting with Muhlenhardt regarding easement.
7/15/2016		Meeting	Meet with Homeland Security (Wayne) at EOR
7/21/2016		Monitoring	Flow measurements with low-flow gate open.
7/27/2016		Meeting	TAC Meeting
7/28/2016		Meeting	Meeting at Blue Lake
8/2/2016		Monitoring	Flow measurements with low-flow gate open.
8/9/2016		Monitoring	Flow measurements with low-flow gate open.
8/11/2016	902.35	Inspection	Lots of bullheads and at least one large fish on downstream side of jeffers pass. Need path cleared to upstream culvert at jeffers - lots of veg on grate upstream. 1-2 cfs at RR crossing. ~ 4cfs at Jackson. ~ 6cfs at CR16. Pond filled to top of culvert near Riverside Bluffs.
8/18/2016	902.80	Inspection/	Cleared off structure. Moved a little debris from kinney driveway. Pike Staff gauge under water. Large tree down near culvert
8/18/2016		Low Flow Gate	OPENED LOW FLOW GATE TODAY.
8/18/2016		Meeting	Blue Lake sanitary sewer line meeting.
8/19/2016		Meeting	Sediment Delta meeting with City Shakopee
8/22/2016	902.75	Inspection	Cleared veg from structure. Still veg on grate at jeffers upstream. Cleared a little debris from kinney driveway, tried to move log on downstream side but floated away. Pike Lake staff gauge under water. Big log stuck in downstream side of culvert at jackson.
8/31/2016	902.64	Inspection	cleared veg from structure. Pike staff gauge under water. Tree removed from Jackson. Road construction at CR16.
9/1/2016		Meeting	Meeting with Reed Beckler to discuss appraisal
9/8/2016		Inspection	cleared veg from structure. Quarry park - lots of silt fence/construction - new storm pond? New trail bridge across Outlet channel by Rosemount/Quarry Park. Water super clear. 4.19' tapedown at USFWS culvert at 16:00.
9/9/2016		Meeting	Meeting with Army Corp
9/12/2016		Low-Flow Gate	CLOSED LOW-FLOW GATE.
9/13/2016	902.48	Inspection	cleared veg from structure - not much. Closed low-flow gate yesterday. Nice path cleared by city to upstream side of jeffers pass - lots of veg on grate. Some sticks should be removed from CR42 upstream and downstream, not many. Pike staff gauge 3.30'. Undercutting the bank downstream of KiciYapi culvert.
9/15/2016		Meeting	Blue Lake Interceptor meeting
9/21/2016	902.55	Inspection	cleared veg from structure, jeffers pass, kes driveway. Pike staff gauge 2.73'.
9/27/2016		Meeting	MOA Cooperators meeting
9/27/2016		Site Visit	Blue Lake project inspection. Visit with Reed Beckler.
9/28/2016		Site Visit	Meet IBA Manhole on-site to view manholes.
9/29/2016	902.71	Inspection	Cleared veg from structure. Pike staff gauge 3.31'.
10/4/2016	902.71	Inspection	Cleared veg from structure. Veg on downstream side of CR42. Pike lake 3.09' staff gauge. Downstream erosion getting worse at Jackson.
10/6/2016		Meeting	Blue Lake Intercept Project Meeting
10/7/2016		Admin	Bid opening - FEMA Sediment Delta (2nd bid)
10/11/2016	902.82	Inspection	cleared veg from structure. Removed branches from culvert at RR crossing. Veg at downstream grate of CR42, upstream a little bit. Small branch near kes driveway. Pike staff gauge 3.22'. Leaves piled along channel on upstream side of jackson trail.
10/12/2016		Meeting	Pre-construction meeting - DRC Eagle Creek subdivision
10/13/2016		Monitoring	Flow measurements with low-flow gate open and closed.
10/14/2016		Whole Channel Walk	Full channel walk - inspect erosion and vegetation. Photos taken along entire channel. Memo summarizes inspection - written by EOR Mike Majeski on 10-25-16, "PLOC Channel Inspection".
10/19/2016		Site Visit	Gonyea, Kes, and Pike Lake Park inspection.
10/21/2016		Site Visit	Gonyea, Kes, and Pike Lake Park inspection.
10/26/2016		Meeting	Eagle Creek Subdivision Meeting
10/26/2016		Site Visit	Gonyea culvert inspection



Date	Elevation	Outlet Activity	Inspections/Channel Activity
10/28/2016		Inspection	cleared veg from structure. Some veg at jeffers pass. Some veg up and downstream at CR42.
10/28/2016		Meeting	Eagle Creek Subdivision Meeting
10/31/2016		Inspection	cleared veg from structure. Some veg at jeffers pass. Some veg up and downstream at CR42.
10/31/2016		Site Visit	Meet contractor at Jackson Trail for bid on erosion.
11/1/2016		Site Visit	Culvert work (Kes, Pike Lake Park, Gonyea) considered substantially complete.
11/7/2016		Outlet Pipe Maintenance	CLOSED MAIN GATE ON OUTLET PIPE TO DO MAINTENANCE ON OUTLET PIPE - Manhole bench smoothing begins. No flow leaving the lake.
11/16/2016		Outlet Pipe Maintenance	Opened main gate back open because manhole smoothing work is done.
11/23/2016	902.76	Inspection	Veg on structure. Cleared lots of veg from Jeffers upstream. Some veg stuck at CR42. Removed some sticks from Kes. Stick stuck at Pike lake Park but water too fast to remove. Pike staff gauge: 3.27'.
11/28/2016	902.85	Inspection	Cleared veg from structure, jeffers pass. Removed wooden fence post and veg stuck on grate at CR42. Pike Staff guage under water. Pulled stick out of Jackson trail. Sticks at CR16 but water moving too fast.
11/29/2016		Meeting	TAC Meeting
12/5/2016	902.85	Inspection	Cleaned one rake-full from the structure Cleared veg and sticks off upstream grate at jeffers - water very high. Some veg/sticks at CR42 upstream and downstream. Removed stick from kes. Smaller culvert almost under water at kinney. Pike staff gauge completely under water. Strauss culvert completely under water.
12/8/2016		Meeting	MOA Cooperators meeting
12/16/2016	902.73	Inspection	Some ice around bars of structure. Most all culverts had some ice near, on or around them. CR42 downstream has a lot of ice frozen on grate where veg was (potentially still is). Pike Lake frozen.
12/21/2016	902.69	Inspection	Veg stuck on grate but is frozen underneath at jeffers. CR42 ice frozen on top of grate (downstream). Water flowing pretty good at Squires. Pike Lake frozen, mostly snow covered. Stauss culvert still completely under water and pond upstream is frozen. Water flowing good at CR16 under ice.
12/29/2016		Inspection	Outlet structure still flowing. ~15 cfs at Pike Lake park. Talked to Steve Kes. Smells like manure at Jackson trail.

## Attachment C. Stage-Discharge Relationship

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### MEMORANDUM

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**TO:** FILE  
**FROM:** JAIME ROCKNEY  
**SUBJECT:** FLOW MEASUREMENTS AT OUTLET STRUCTURE WITH LOW FLOW GATE OPEN  
**DATE:** UPDATED 11-29-16 (THIS MEMO WILL BE UPDATED AS MORE DATA IS GATHERED)

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The data presented in this memo may be useful for:

- Decision-making regarding the flood study
- Calculating discharge and annual pollutant loads from Prior Lake
- Deciding when it is beneficial to open the low-flow gate
- Determining how much additional flow would discharge from Prior Lake, if the low-flow gate were opened (in addition to just overtopping the weir with gate closed)
- Updating the *Management Policy and Operating Procedures* for the Outlet Structure

#### Background

The outlet structure was rebuilt in 2010 for increased safety and efficiency. An otherwise land-locked basin, the outlet structure allows water to leave Prior Lake by overtopping a weir, located inside the outlet structure, at an elevation of 902.45' (NGVD 29 Datum). The structure includes an optional low-flow gate (gate) that allows for the lake to be lowered to 902.0' when opened. However, the gate is always closed unless the DNR has approved for it to be opened temporarily.

One of the main reasons to open the gate is when risk of flooding is high in spring due to potential high volumes of snowmelt runoff. Opening the gate prior to spring rains provides more storage capacity in the lake; however, the gate has been opened at other times of the year as well with special permission from the DNR. See the "Outlet Control Structure for Prior Lake; Management Policy and Operating Procedures" for more detail about the purpose and timing of opening the gate.

The low flow gate was designed to add up to approximately 33 cubic feet per second (cfs) more water through the outlet pipe to the daylight of the outlet channel. PLSLWD staff wanted to check how closely the modeled flow estimates compare to the actual measurements after the structure has been built. Staff had been taking flow measurements at the outlet pipe daylight since it was installed, but until late 2015, no flow measurements had been taken while the gate was open. This was mostly because the gate was rarely open. PLSLWD staff decided to open the gate temporarily at different lake elevations to start developing a rating curve with the gate open.

Figure 1 is the “theoretical rating curve developed by Wenck for the new outlet structure. Based on these curves, opening the gate would add as much as 33 cfs to total discharge until the pipe (inlet control) becomes the limiting factor, and reaching full capacity would be reached 0.2 feet sooner [902.7 vs 902.9 where the rating curves intersect the pipe-control curve (the vertical line between 55 and 60 cfs)]” per PLSLWD District Engineer, Carl Almer.

This memo will compare field-verified results to the designed rating curve, summarize results of field measurements, provide rating curves for the Outlet Structure, and offer a more accurate representation of flow through the outlet pipe.

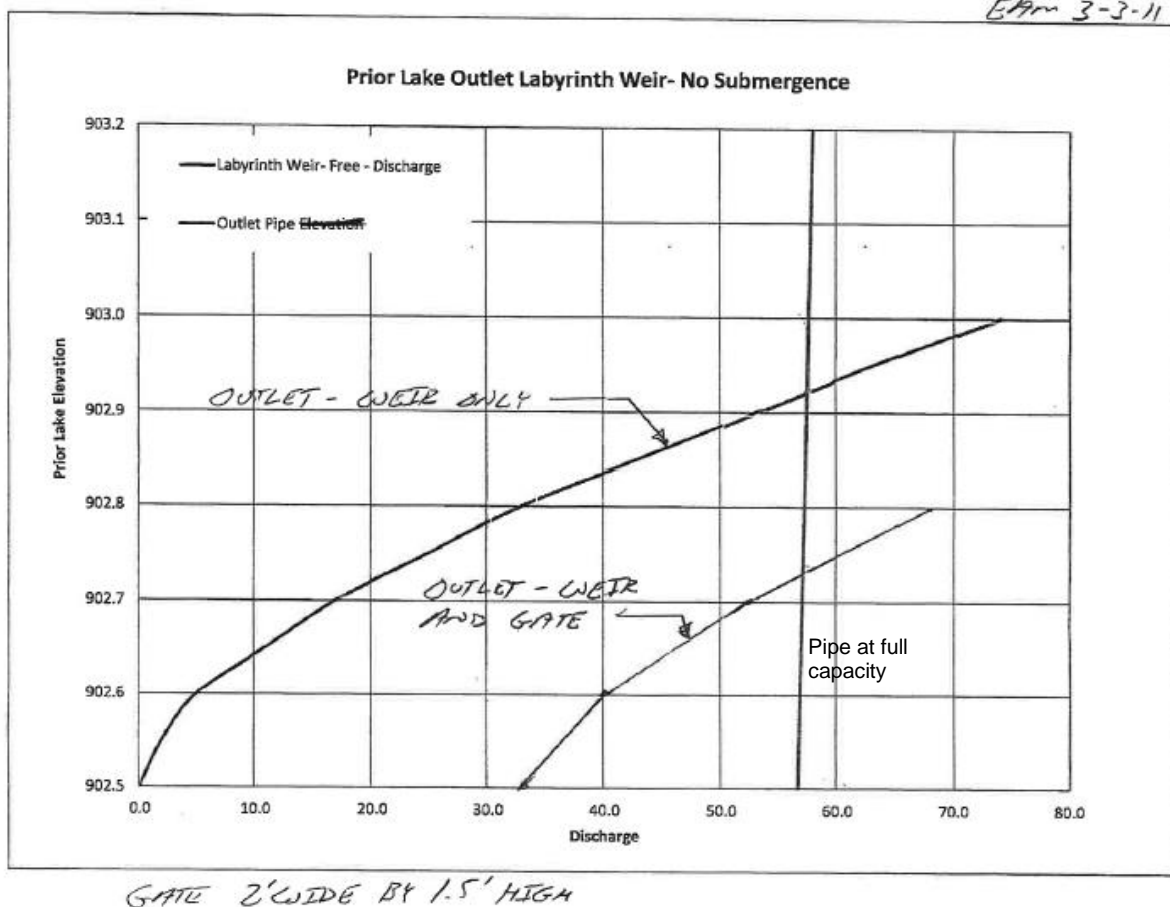
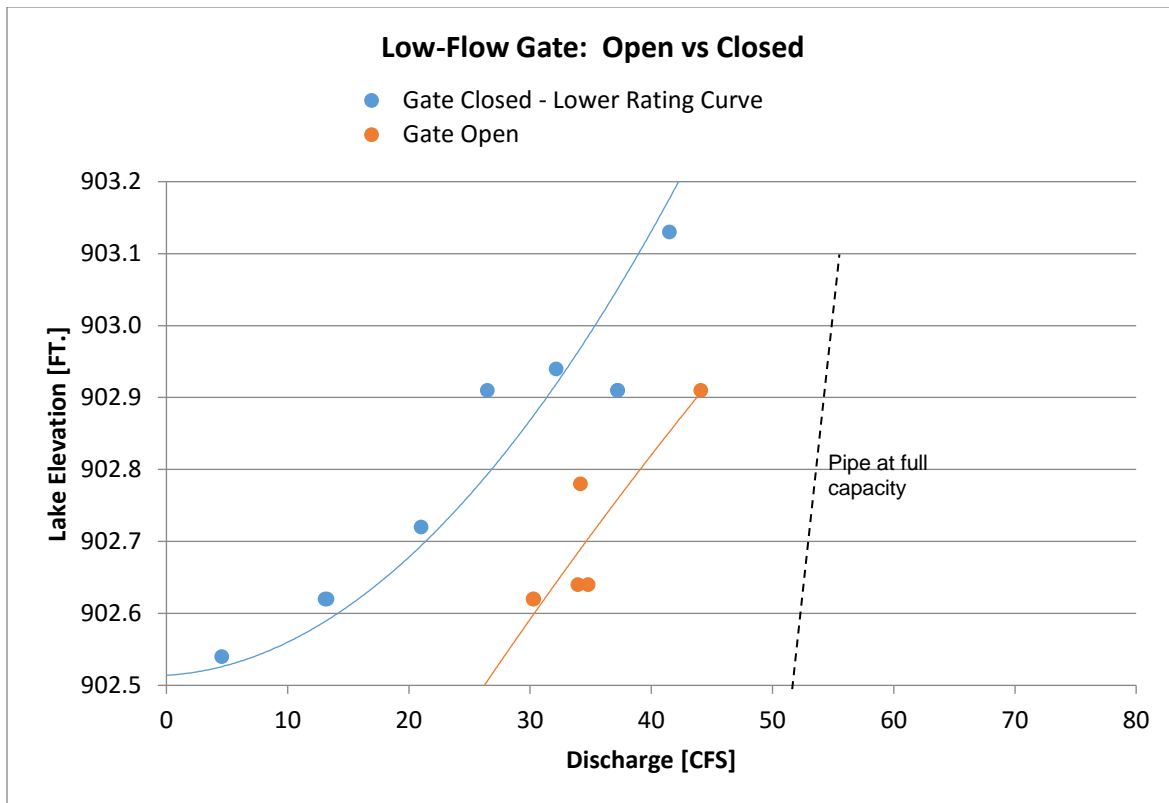


Figure 1 – Original design discharge (CFS) estimates with gate opened (“Outlet-Weir and Gate”) and closed (“Outlet-Weir Only”). Vertical line is estimated full capacity of the pipe.

## Results

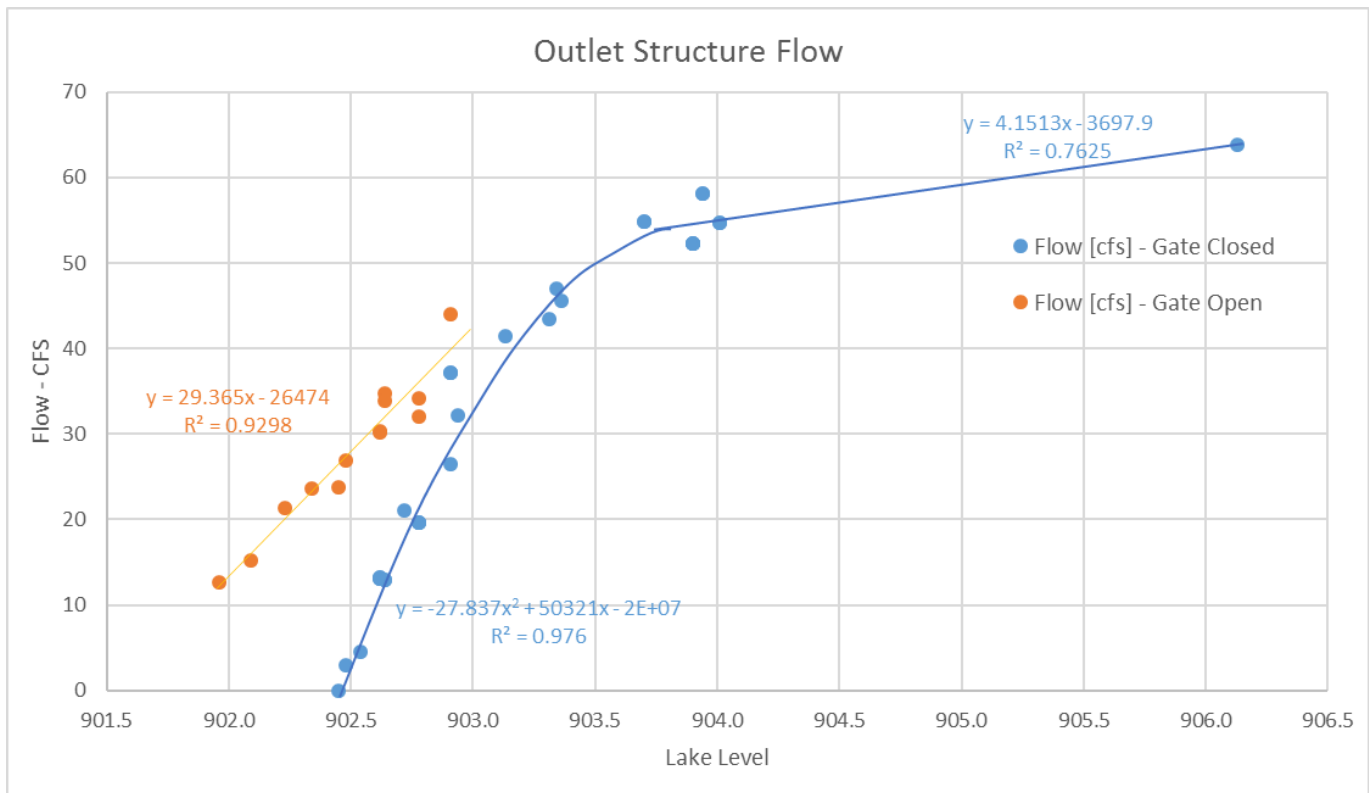
Figure 2 displays actual measurements taken by the District and/or consultants with the gate open and closed. The graph is displayed with the same scale as Figure 1 for easy comparison. It appears the pipe does not meet full capacity at the lake level indicated in Figure 1. Prior to taking flow measurements with the gate open, and according to this design, the PLSLWD was under the belief that any elevation above 902.9' with the gate shut, or 902.7' with the gate open, the pipe was at “full capacity.”



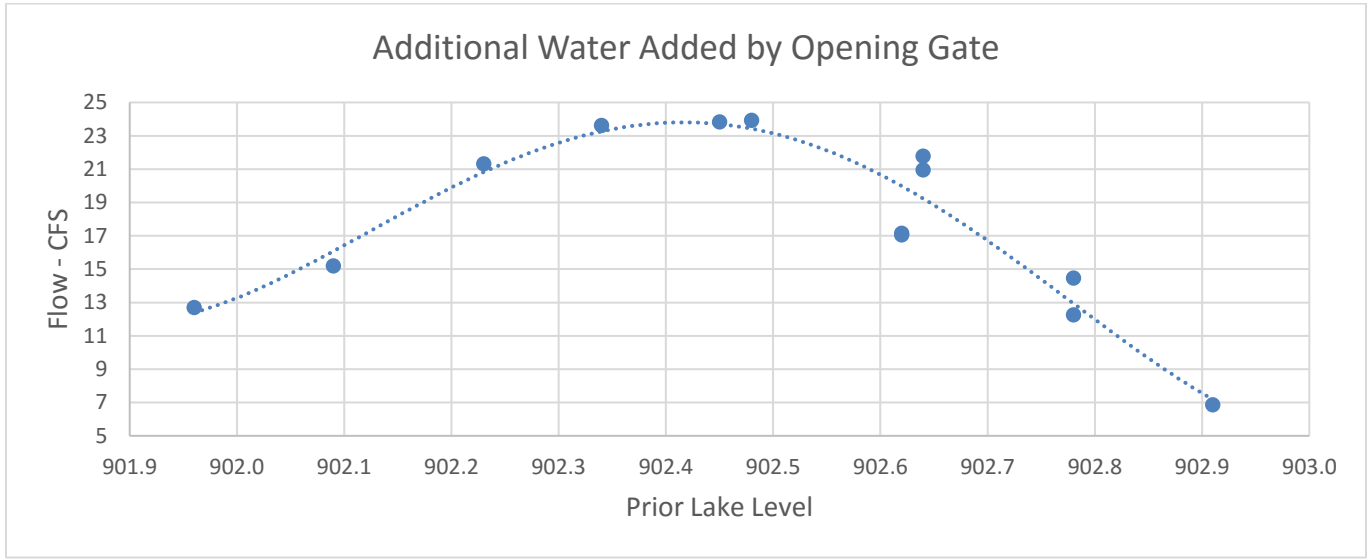


**Figure 2 Field verified flow measurements compared to same scale as Figure 1. Dots are actual measurements, the blue and orange lines are the lines that represent the rating curve, and the dashed, black vertical line is estimated full capacity of the pipe.**

Figure 3 displays almost all the flow measurements taken by District staff and/or consultants since the new structure was built. The rating curves associated with those flow measurements are displayed on the graph. Per this figure, full capacity is reached somewhere between 903.5' and 904'. When lake level is high, hydraulic pressure pushes a little more discharge through the pipe. During the 2014 flood, flow measured 64 cfs (gate was closed) when the lake level was nearly peaked at 906.13' (max lake level during flood was 906.17').



**Figure 3 Flow Measurements (dots) and Rating Curve Equations (lines) for the Outlet Structure (Updated 11/22/16)**



**Figure 4 Amount of additional flow discharge when the Low-Flow Gate is open. Blue dots represent “Flow with gate open minus Flow with gate closed”. The line is the average.**

### Summary

By using data gathered by flow measurements, Table 1 gives an estimate of flow based on lake level, whether the gate is open or closed. This table will continue to be updated as

more flow measurements are taken. The lake level has not been above 903.0' since this study has begun, therefore, there are no flow estimates over 903' with the gate open.

**Table 1 – Flow estimates using a calculated rating curve.**

Lake Level	Flow with Gate Closed (CFS)	Flow with Gate Open (CFS)	Additional Flow from Opening Gate (CFS)
902	0	13	13
902.1	0	16	16
902.2	0	19	19
902.3	0	22	22
902.4	0	25	25
902.5	4	28	24
902.6	11	31	20
902.7	18	34	16
902.8	24	37	13
902.9	29	40	10
903	34	N/A	N/A
903.1	39	N/A	N/A
903.2	43	N/A	N/A
903.3	46	N/A	N/A
903.4	49	N/A	N/A
903.5	51	N/A	N/A
903.6	53	N/A	N/A
903.7	54	N/A	N/A
903.8	54	N/A	N/A
903.9	55	N/A	N/A
904	55	N/A	N/A
904.5	57	N/A	N/A
905	59	N/A	N/A
905.5	61	N/A	N/A
906	63	N/A	N/A
906.1	64	N/A	N/A
906.5	65	N/A	N/A

Information revealed based on the study:

- The 36" underground pipe becomes the limiting factor for flow around 903.5' (rather than 902.9' in original design). See Figure 3.
- The point at which the pipe reaches full capacity with the gate open is undetermined now. Staff will continue to collect flow measurements above 903' until that level is determined.
- Maximum discharge the gate adds when open is about 25 cfs (rather than 33 cfs as indicated in the original design). This is when the lake has just stopped flowing over the weir at approximately 902.45'. As the lake rises or falls from 902.45', flow contribution from the gate decreases. See Figure 4.

Rating Curves (as of 11/23/16):

Lake Level (ft)	Gate Open or Closed	Rating Curve*	R <sup>2</sup> Value
902-903	Open	$y = 29.365x - 45.568$	0.93
>903	Open	Undetermined	Undetermined
902.0-902.45	Closed	N/A – no flow possible	N/A – no flow possible
902.45-903.6	Closed	$y = -27.837x^2 + 214.34x - 357.99$	0.98
903.6-906.5	Closed	$y = 4.1513x + 38.343$	0.76
>906.5	Closed	Undetermined	Undetermined

\*Microsoft Excel has issues creating rating curves when using big numbers, like the elevation values. For these rating curves to work, you must subtract 900' from the elevation, which is the same value as the staff gauge. For example, when the staff gauge is 3.27', the lake level 903.27' Mean Sea Level.



## Disclaimers

Flow measurements used for calculating the rating curves are subject to error for a few reasons. However, even with the potential room for error, many flow measurements have been taken providing reasonably reliable data.

- 1) No known vendors are capable of calibrating flow meters above 2 feet per second, so it is impossible to know exactly how accurate the velocity data is. However, numerous comparisons between different model flow meters have been compared and they are very precise. For example, on 4/21/16, the Scott SWCD and EOR took two flow measurements, one immediately after another. The Scott SWCD flow meter measured 13.10 cfs and EOR's flow meter measured 13.26. The "2013 PLSLWD Stream Flow Monitoring Equipment Analysis" memo, dated 10/10/2013, also compares many scenarios between many flow meters. That memo is located here: Class 509\637 - Monitoring and Research\Streams\Stream Data\2013 Data.
- 2) Another area subject to error is measuring the depth of the water during the flow measurements. Because the velocity is very high and often exceeds 10 feet per second, the water splashes onto the flow meter rod, making it difficult to determine the correct depth (See Figure 6). Staff does the best they can to estimate depth. When available, a machete is used to measure depth as it is slender and does not splash water as high.



**Figure 5 Water splashing on wading rod making it difficult to get accurate depth.**

- 3) Since the water is flowing very fast, it is impossible to stand in the stream. Staff must kneel on the side of the culvert and reach across the culvert to take the velocity readings (Figure 6). Reaching the middle of the stream is difficult and extremely dangerous since the water is moving very swiftly. If safety was a concern, the staff person did not collect the velocity measurements in the middle of the culvert. This

leaves a percentage of the flow to be estimated. PLSLWD has discussed alternative flow options, but all are very costly.



**Figure 6 Safety issues make it difficult to take measurements in the middle of the cross section.**

## Attachment D. Volumes Discharged from Prior 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 <i>without</i> the Outlet	Annual Rainfall
2016	9351	4.80	901.96	8/9/2016	902.86	12/1/2016	907.66	36.74
2015	3043	1.60	901.09	3/20/2015	902.91	12/21/2015	904.51	35.74
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			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	6044 (when operated)	3.10 (when operated)	900.35		902.83		906.32	31.98
Unless otherwise noted, data is taken from annual Prior Lake Outlet operations reports								
Italicized rainfall data is from MN Climatology office for 115N, 22W, 15 Prior Lake; all other rainfall as recorded at PLSLWD Office								
Italicized lake level data is from PLSLWD Historic Volunteer Collected Lake Level Data								

## Attachment E. Prior Lake Elevations and Precipitation

Elevation	
Average	902.60
Minimum	901.96
Maximum	902.86

Precipitation	
Yearly Total	36.74
Max 1 Day	3.65

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. The automated logger is calibrated to the staff gauge readings.

Precipitation Gage was measured by PLSLWD staff at the city hall rain gauge.

Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
4-Mar	902.57	1/6	902.48	1/1	0.00
5-Mar	902.57	1/7	902.45	1/2	0.00
6-Mar	902.57	1/8	902.45	1/3	0.00
7-Mar	902.57	1/11	902.49	1/4	0.00
10-Mar	902.60	1/14	902.57	1/5	0.00
11-Mar	902.60	1/15	902.58	1/6	0.01
12-Mar	902.61	1/19	902.57	1/7	0.06
13-Mar	902.62	1/21	902.58	1/8	0.11
14-Mar	902.63	1/26	902.57	1/9	0.00
15-Mar	902.66	1/29	902.55	1/10	0.00
16-Mar	902.68	2/2	902.56	1/11	0.02
17-Mar	902.69	2/8	902.57	1/12	0.01
18-Mar	902.69	2/17	902.54	1/13	0.00
19-Mar	902.70	2/24	902.53	1/14	0.00
20-Mar	902.70	3/2	902.56	1/15	0.00
21-Mar	902.70	3/4	902.57	1/16	0.00
22-Mar	902.69	3/7	902.57	1/17	0.00
23-Mar	902.71	3/24	902.70	1/18	0.00
24-Mar	902.73	4/21	902.62	1/19	0.00
25-Mar	902.72	6/8	902.48	1/20	0.03
26-Mar	902.72	8/17	902.80	1/21	0.00
27-Mar	902.74			1/22	0.01
28-Mar	902.73			1/23	0.00
29-Mar	902.73			1/24	0.00
30-Mar	902.77			1/25	0.00
31-Mar	902.78			1/26	0.07
1-Apr	902.79			1/27	0.01
2-Apr	902.77			1/28	0.00
3-Apr	902.77			1/29	0.00
4-Apr	902.76			1/30	0.00
5-Apr	902.75			1/31	0.00
6-Apr	902.75			2/1	0.00
7-Apr	902.74			2/2	0.00
8-Apr	902.73			2/3	0.22
9-Apr	902.71			2/4	0.00
10-Apr	902.70			2/5	0.01
11-Apr	902.69			2/6	0.00
12-Apr	902.67			2/7	0.00
13-Apr	902.66			2/8	0.00
14-Apr	902.65			2/9	0.00
15-Apr	902.64			2/10	0.00
16-Apr	902.63			2/11	0.00
17-Apr	902.62			2/12	0.01
18-Apr	902.62			2/13	0.00
19-Apr	902.62			2/14	0.00
20-Apr	902.63			2/15	0.00
21-Apr	902.65			2/16	0.00
22-Apr	902.64			2/17	0.00
23-Apr	902.62			2/18	0.00
24-Apr	902.61			2/19	0.01
25-Apr	902.65			2/20	0.00
26-Apr	902.65			2/21	0.00
27-Apr	902.63			2/22	0.14
28-Apr	902.64			2/23	0.01
29-Apr	902.65			2/24	0.00

Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
30-Apr	902.64			2/25	0.00
1-May	902.62			2/26	0.00
2-May	902.61			2/27	0.00
3-May	902.60			2/28	0.00
4-May	902.58			2/29	0.01
5-May	902.57			3/1	0.01
6-May	902.55			3/2	0.00
7-May	902.53			3/3	0.00
8-May	902.51			3/4	0.00
9-May	902.51			3/5	0.00
10-May	902.54			3/6	0.00
11-May	902.54			3/7	0.02
12-May	902.53			3/8	0.00
13-May	902.52			3/9	0.01
14-May	902.50			3/10	0.01
15-May	902.48			3/11	0.00
16-May	902.47			3/12	0.00
17-May	902.45			3/13	0.00
18-May	902.44			3/14	0.05
19-May	902.44			3/15	0.04
20-May	902.43			3/16	0.37
21-May	902.43			3/17	0.01
22-May	902.42			3/18	0.00
23-May	902.41			3/19	0.00
24-May	902.41			3/20	0.00
25-May	902.42			3/21	0.05
26-May	902.47			3/22	0.00
27-May	902.49			3/23	0.00
28-May	902.51			3/24	0.16
29-May	902.52			3/25	0.00
30-May	902.52			3/26	0.00
31-May	902.52			3/27	0.00
1-Jun	902.51			3/28	0.28
2-Jun	902.50			3/29	0.00
3-Jun	902.50			3/30	0.50
4-Jun	902.52			3/31	0.04
5-Jun	902.53			4/1	0.07
6-Jun	902.51			4/2	0.00
7-Jun	902.50			4/3	0.00
8-Jun	902.49			4/4	0.00
9-Jun	902.60			4/5	0.00
10-Jun	902.63			4/6	0.07
11-Jun	902.63			4/7	0.01
12-Jun	902.62			4/8	0.02
13-Jun	902.61			4/9	0.00
14-Jun	902.63			4/10	0.00
15-Jun	902.66			4/11	0.00
16-Jun	902.64			4/12	0.00
17-Jun	902.62			4/13	0.01
18-Jun	902.61			4/14	0.00
19-Jun	902.59			4/15	0.00
20-Jun	902.58			4/16	0.00
21-Jun	902.55			4/17	0.00
22-Jun	902.53			4/18	0.00
23-Jun	902.51			4/19	0.04
24-Jun	902.49			4/20	0.22
25-Jun	902.47			4/21	0.33
26-Jun	902.45			4/22	0.27
27-Jun	902.43			4/23	0.00
28-Jun	902.40			4/24	0.00
29-Jun	902.38			4/25	0.82
30-Jun	902.37			4/26	0.03
1-Jul	902.34			4/27	0.00
2-Jul	902.32			4/28	0.36
3-Jul	902.30			4/29	0.38
4-Jul	902.27			4/30	0.00
5-Jul	902.27			5/1	0.00
6-Jul	902.35			5/2	0.00



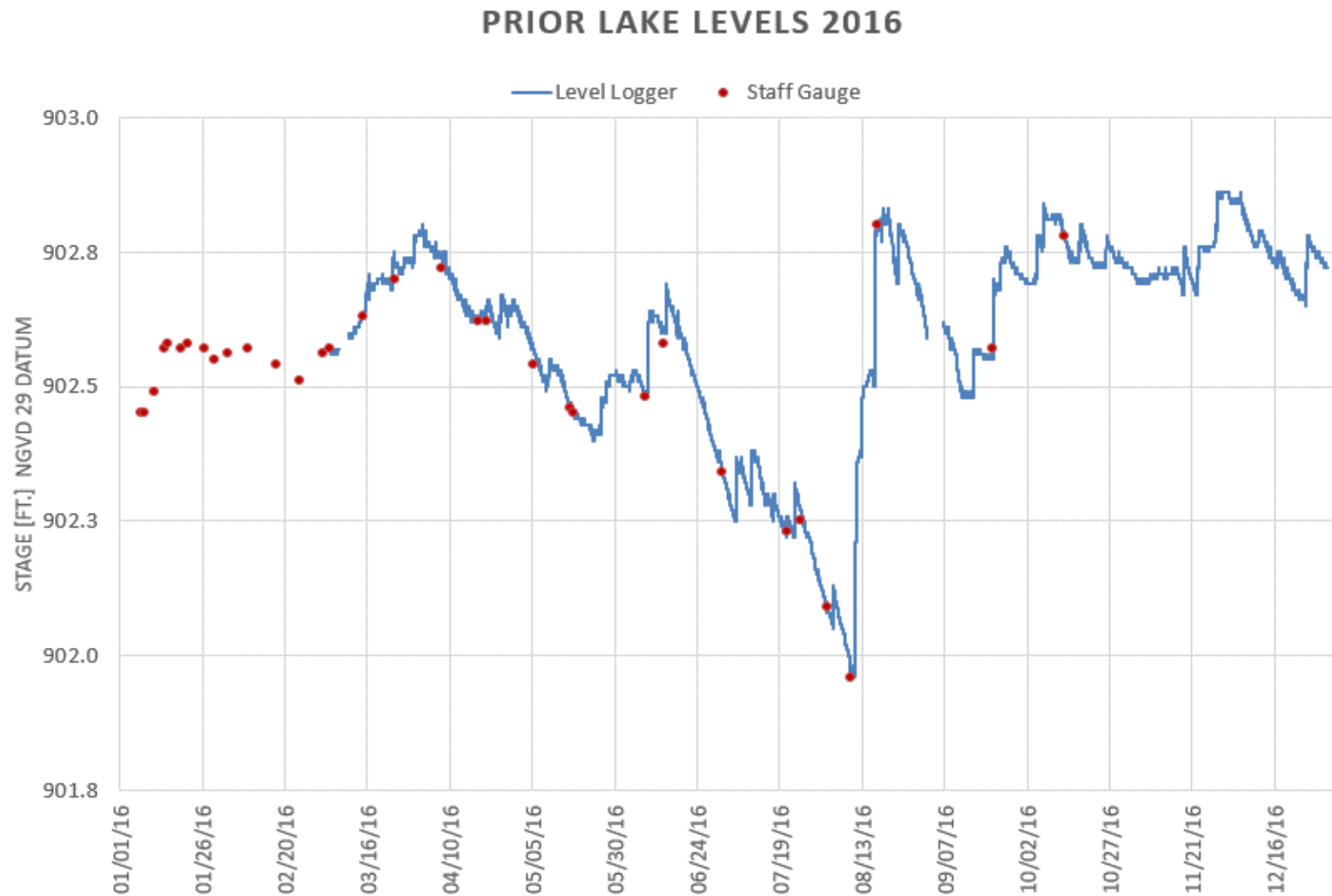
Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
7-Jul	902.35			5/3	0.00
8-Jul	902.32			5/4	0.00
9-Jul	902.30			5/5	0.00
10-Jul	902.36			5/6	0.00
11-Jul	902.37			5/7	0.00
12-Jul	902.36			5/8	0.00
13-Jul	902.33			5/9	0.00
14-Jul	902.29			5/10	0.73
15-Jul	902.29			5/11	0.00
16-Jul	902.27			5/12	0.17
17-Jul	902.28			5/13	0.02
18-Jul	902.27			5/14	0.00
19-Jul	902.25			5/15	0.00
20-Jul	902.23			5/16	0.16
21-Jul	902.25			5/17	0.00
22-Jul	902.24			5/18	0.00
23-Jul	902.27			5/19	0.00
24-Jul	902.29			5/20	0.00
25-Jul	902.27			5/21	0.00
26-Jul	902.24			5/22	0.00
27-Jul	902.23			5/23	0.00
28-Jul	902.21			5/24	0.08
29-Jul	902.18			5/25	0.03
30-Jul	902.15			5/26	0.97
31-Jul	902.13			5/27	0.02
1-Aug	902.11			5/28	0.00
2-Aug	902.09			5/29	0.00
3-Aug	902.07			5/30	0.00
4-Aug	902.09			5/31	0.52
5-Aug	902.09			6/1	0.00
6-Aug	902.06			6/2	0.01
7-Aug	902.04			6/3	0.00
8-Aug	902.01			6/4	0.00
9-Aug	901.99			6/5	0.00
10-Aug	901.99			6/6	0.55
11-Aug	902.33			6/7	0.02
12-Aug	902.40			6/8	0.00
13-Aug	902.49			6/9	1.32
14-Aug	902.51			6/10	0.06
15-Aug	902.52			6/11	0.00
16-Aug	902.59			6/12	0.00
17-Aug	902.79			6/13	0.13
18-Aug	902.80			6/14	0.01
19-Aug	902.81			6/15	0.00
20-Aug	902.81			6/16	0.88
21-Aug	902.79			6/17	0.01
22-Aug	902.75			6/18	0.00
23-Aug	902.71			6/19	0.00
24-Aug	902.80			6/20	0.15
25-Aug	902.78			6/21	0.00
26-Aug	902.76			6/22	0.00
27-Aug	902.74			6/23	0.00
28-Aug	902.71			6/24	0.00
29-Aug	902.68			6/25	0.00
30-Aug	902.68			6/26	0.00
31-Aug	902.65			6/27	0.00
1-Sep	902.61			6/28	0.00
6-Sep	902.61			6/29	0.00
7-Sep	902.61			6/30	0.00
8-Sep	902.59			7/1	0.13
9-Sep	902.58			7/2	0.00
10-Sep	902.55			7/3	0.00
11-Sep	902.51			7/4	0.00
12-Sep	902.49			7/5	0.00
13-Sep	902.49			7/6	0.94
14-Sep	902.48			7/7	0.10
15-Sep	902.50			7/8	0.00
16-Sep	902.56			7/9	0.00

Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
17-Sep	902.57			7/10	0.00
18-Sep	902.56			7/11	1.05
19-Sep	902.55			7/12	0.10
20-Sep	902.55			7/13	0.00
21-Sep	902.56			7/14	0.00
22-Sep	902.68			7/15	0.22
23-Sep	902.70			7/16	0.00
24-Sep	902.73			7/17	0.00
25-Sep	902.75			7/18	0.49
26-Sep	902.75			7/19	0.00
27-Sep	902.73			7/20	0.00
28-Sep	902.72			7/21	0.25
29-Sep	902.71			7/22	0.00
30-Sep	902.70			7/23	0.00
1-Oct	902.70			7/24	0.00
2-Oct	902.69			7/25	0.60
3-Oct	902.69			7/26	0.00
4-Oct	902.70			7/27	0.00
5-Oct	902.77			7/28	0.08
6-Oct	902.77			7/29	0.00
7-Oct	902.82			7/30	0.00
8-Oct	902.81			7/31	0.00
9-Oct	902.81			8/1	0.00
10-Oct	902.81			8/2	0.00
11-Oct	902.82			8/3	0.00
12-Oct	902.80			8/4	0.77
13-Oct	902.78			8/5	0.05
14-Oct	902.75			8/6	0.00
15-Oct	902.74			8/7	0.00
16-Oct	902.73			8/8	0.00
17-Oct	902.74			8/9	0.00
18-Oct	902.79			8/10	0.00
19-Oct	902.77			8/11	3.65
20-Oct	902.75			8/12	0.01
21-Oct	902.74			8/13	0.00
22-Oct	902.73			8/14	0.00
23-Oct	902.73			8/15	0.99
24-Oct	902.72			8/16	0.01
25-Oct	902.73			8/17	1.74
26-Oct	902.77			8/18	0.01
27-Oct	902.76			8/19	0.40
28-Oct	902.74			8/20	0.00
29-Oct	902.74			8/21	0.00
30-Oct	902.73			8/22	0.83
31-Oct	902.73			8/23	0.01
1-Nov	902.72			8/24	1.14
2-Nov	902.72			8/25	0.00
3-Nov	902.71			8/26	0.00
4-Nov	902.70			8/27	0.00
5-Nov	902.69			8/28	0.00
6-Nov	902.69			8/29	0.05
7-Nov	902.69			8/30	0.26
8-Nov	902.70			8/31	0.01
9-Nov	902.70			9/1	0.01
10-Nov	902.71			9/2	0.00
11-Nov	902.71			9/3	0.00
12-Nov	902.71			9/4	0.00
13-Nov	902.71			9/5	0.00
14-Nov	902.71			9/6	1.45
15-Nov	902.71			9/7	0.35
16-Nov	902.71			9/8	0.03
17-Nov	902.69			9/9	0.18
18-Nov	902.72			9/10	0.00
19-Nov	902.72			9/11	0.00
20-Nov	902.70			9/12	0.01
21-Nov	902.69			9/13	0.01
22-Nov	902.69			9/14	0.01
23-Nov	902.76			9/15	0.00

Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
24-Nov	902.76			9/16	0.91
25-Nov	902.76			9/17	0.00
26-Nov	902.76			9/18	0.00
27-Nov	902.76			9/19	0.11
28-Nov	902.83			9/20	0.00
29-Nov	902.85			9/21	0.12
30-Nov	902.86			9/22	1.00
1-Dec	902.86			9/23	0.02
2-Dec	902.85			9/24	0.00
3-Dec	902.84			9/25	0.00
4-Dec	902.85			9/26	0.70
5-Dec	902.85			9/27	0.00
6-Dec	902.83			9/28	0.04
7-Dec	902.81			9/29	0.00
8-Dec	902.79			9/30	0.00
9-Dec	902.77			10/1	0.00
10-Dec	902.76			10/2	0.00
11-Dec	902.78			10/3	0.00
12-Dec	902.78			10/4	0.08
13-Dec	902.76			10/5	0.85
14-Dec	902.75			10/6	0.00
15-Dec	902.74			10/7	0.00
16-Dec	902.73			10/8	0.00
17-Dec	902.74			10/9	0.00
18-Dec	902.73			10/10	0.01
19-Dec	902.71			10/11	0.02
20-Dec	902.70			10/12	0.01
21-Dec	902.69			10/13	0.00
22-Dec	902.68			10/14	0.00
23-Dec	902.67			10/15	0.00
24-Dec	902.67			10/16	0.00
25-Dec	902.69			10/17	0.05
26-Dec	902.77			10/18	0.00
27-Dec	902.76			10/19	0.01
28-Dec	902.75			10/20	0.01
29-Dec	902.74			10/21	0.00
30-Dec	902.73			10/22	0.00
31-Dec	902.72			10/23	0.00
				10/24	0.00
				10/25	0.00
				10/26	0.76
				10/27	0.02
				10/28	0.00
				10/29	0.00
				10/30	0.00
				10/31	0.15
				11/1	0.01
				11/2	0.00
				11/3	0.00
				11/4	0.00
				11/5	0.00
				11/6	0.00
				11/7	0.00
				11/8	0.00
				11/9	0.00
				11/10	0.00
				11/11	0.00
				11/12	0.00
				11/13	0.00
				11/14	0.00
				11/15	0.00
				11/16	0.00
				11/17	0.00
				11/18	0.24
				11/19	0.43
				11/20	0.00
				11/21	0.00
				11/22	0.00

Date Auto Logger	Auto Logger	Date Staff Gage	Staff Gage	Date Precipitation	Precipitation
				11/23	1.20
				11/24	0.00
				11/25	0.00
				11/26	0.00
				11/27	0.00
				11/28	0.35
				11/29	0.46
				11/30	0.07
				12/1	0.09
				12/2	0.00
				12/3	0.00
				12/4	0.00
				12/5	0.20
				12/6	0.00
				12/7	0.00
				12/8	0.01
				12/9	0.00
				12/10	0.00
				12/11	0.00
				12/12	0.49
				12/13	0.00
				12/14	0.00
				12/15	0.00
				12/16	0.05
				12/17	0.00
				12/18	0.00
				12/19	0.32
				12/20	0.00
				12/21	0.00
				12/22	0.00
				12/23	0.00
				12/24	0.00
				12/25	0.00
				12/26	1.25
				12/27	0.00
				12/28	0.00
				12/29	0.00
				12/30	0.00
				12/31	0.00

## 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



## Attachment G. Summary of Precipitation within PLSLWD

Month	*2016 Rain Gauge Readings (inches)	PLSLWD 2016 YTD (in.)
Jan	0.33	0.33
Feb	0.41	0.74
Mar	1.55	2.29
Apr	2.63	4.92
May	2.70	7.62
Jun	3.14	10.76
Jul	3.96	14.72
Aug	9.93	24.65
Sep	4.95	29.60
Oct	1.97	31.57
Nov	2.76	34.33
Dec	2.41	36.74
<b>Year Total</b>	36.74	inches

\*measurements recorded by  
rain gauge at Prior Lake City Hall

NOAA Scott County 30yr mo avg**	NOAA Scott County 30yr YTD avg
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
-54.8%	-0.40	-54.8%	-0.40
-33.9%	-0.21	-45.2%	-0.61
-10.4%	-0.18	-25.6%	-0.79
4.0%	0.10	-12.3%	-0.69
-26.8%	-0.99	-18.1%	-1.68
-32.3%	-1.50	-22.8%	-3.18
13.5%	0.47	-15.5%	-2.71
96.6%	4.88	9.7%	2.17
45.2%	1.54	14.3%	3.71
-20.2%	-0.50	11.3%	3.21
68.3%	1.12	14.4%	4.33
153.7%	1.46	18.7%	5.79
		18.7%	5.79

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