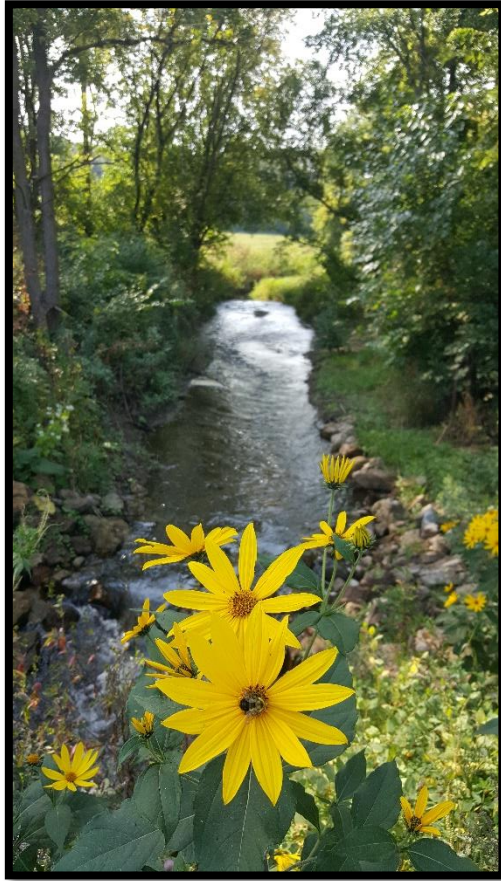


2017 PRIOR LAKE OUTLET SYSTEM ANNUAL OPERATIONS REPORT



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February 2018

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 1982 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, which occurred in 2017. Changes mostly addressed guidance for opening the low-flow gate and removing old language that referred to the old outlet structure.

Additionally, an Operation, Inspection and Maintenance Manual was drafted and adopted in September 2011 for the Prior Lake Outlet Structure. The purpose of this secondary manual is to establish guidelines and practices to provide existing and future District Staff with the knowledge of how to properly operate, inspect and maintain the structural and operational components of the outlet to maximize the life and effectiveness of the structure. The manual includes a table of recommended inspection items along with the recommend frequency of inspection. These recommendations will be reviewed periodically by District Staff to determine if the frequency is appropriate based on findings in the field and the manual will be updated accordingly.

The new structure needs minimal maintenance to operate. Once Prior Lake reaches 902.45', 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 902.45'), 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 times when water is high and lots of vegetation is getting stuck on the track rack, the City of Prior Lake staff helped remove vegetation 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 2017 operations, the Prior Lake Outlet Structure performed well throughout the duration that water discharged from the lake. Prior Lake overtopped the outlet weir the entire year with a few exceptions: July 16-18, August 4-16, September 30-October 1, and December 23-29. In other words, the Outlet Structure operated all but 26 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 from on April 25 due to anticipated high lake levels. The low-flow gate was closed on June 27 when the lake reached 902.58'. (See Figure 3).

In its 339 days of discharge during 2017, an estimated 6.0 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 909.56' 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 2017.



FIGURE 3 – OPENING THE LOW-FLOW GATE

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 6 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,

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



FIGURE 4 – MAP OF OUTLET PIPE

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 decreased turbulence at the manhole benches and allows the pipe to reach full capacity faster.

Chemical grouting was scheduled to be completed in 2017 to address the leaking joints. However, due to staff injuries, the company was unable to complete this task in 2017. Following the grouting, another televising will be scheduled in 2018 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 Silt and Sediment Control Project began in the fall of 2017. It was delayed due to weather and contractual obligations. The project will be completed in the Spring of 2018. Due to permit and engineering design delays, the Bank Erosion project is expected to be started in the Spring of 2018 and completed mid-summer. 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

- 2017
 - Segment 1 – Locust foliar, Parsnip rosette, and thistle spot treatment
 - Segment 2 – Buckthorn foliar treatment, larger than ½” diameter cut/treat
 - Segment 4a – Buckthorn scouting/treating (foliar treat small individuals, cut/treated larger as needed); Pulled loosestrife
 - Segment 4b - Buckthorn scouting/treating (foliar treat small individuals, cut/treat larger as needed); Spot treat thistle northern half – especially pasture
 - CR 16 – Garlic mustard treatment; Pulled loosestrife



FIGURE 8 - CUTTING INVASIVES IN SEGMENT 1

MONITORING

Monitoring along the outlet channel in 2017 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, flow measurements, and water quality samples.



FIGURE 9 - PIKE LAKE PARK MONITORING SITE

PLSLWD and Scott SWCD staff measured flow and stage at the beginning of the Outlet Channel (ST_OTs), in the middle at Pike Lake Park (ST_26A), and the end of the Outlet Channel (ST_32A). 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. Prior Lake's 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 2017, 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 December 6, 2017 summarized the results.

Blue Water Science conducted a late summer point intercept survey on Jeffers Pond in 2016. As far as we know, this was the first time a vegetation survey has ever been completed on this pond. In 2017, a survey was 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. Early and late summer point intercept surveys were done on Pike Lake to check for Curlyleaf Pondweed and Eurasian Water Milfoil. Results of these surveys can be found on the PLSLWD website.

PERMITS

In 2017, the District had three open permits along the PLOC:

- Permit #10.02 *Jeffers Waterfront*: The District will complete the final inspection and close the permit in 2018.
- Permit #11.03 *Jeffers Pointe*: The District and the City of Prior Lake are coordinating to ensure proper establishment of the raingarden, at which time this permit will be closed.
- Permit #13.04 *Valley Park Business Center*: This permit was closed in 2017.

The District anticipates closing out the two remaining open permits in 2018.

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 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 negotiated successfully with two landowners in 2017 and plans to complete purchase of revised easements in 2018.

OTHER ACTIVITIES

BLUE LAKE SANITARY SEWER REHABILITATION PROJECT

In 2017, Metropolitan Council Environmental Services (MCES) completed rehabilitation of the sanitary sewer lines for the Blue Lake Sanitary Sewer System. A portion of the project involved creating a temporary diversion of the Outlet Channel and dewatering activities at the construction area along the channel. Additionally, a temporary conveyance for the sewer line was routed through the Union Pacific and Highway 101 culverts in Segment 7B. District staff inspected the project site to ensure flow was maintained, erosion was controlled, and no contamination could reach the Outlet Channel. The District requested that the contractor to clean out the culvert under Highway 101 following sedimentation observed after construction activities were completed. The District will be checking the culvert again in the spring of 2018 to ensure no additional sedimentation occurs as a result of the project activities. 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 MOA 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 completed XP-SWMM model edits in January of 2017 to simulate upsizing of PLOC crossing to MOA allowable flow rates and ran the model with Atlas 14 precipitation depths and the MSE 3 24-hour rainfall distribution to provide guidance for the design of the FEMA Bank Repair Project.

EDUCATION

All property owners along the PLOC were contacted by letter and asked to provide temporary construction easements for the bank erosion project. The majority of the landowners agreed.

Prior to work beginning on the Sediment Delta in Segment 5, homeowners along the five locations received a flier advising them of pending work.

LEGEND

- EXISTING CONTOURS
- SPOT ELEVATIONS
- EXISTING RETAINING WALL
- TELEPHONE PEDESTAL
- ELECTRIC TRANSFORMER
- EXISTING STORM SEWER MANHOLE
- EXISTING STORM SEWER
- PROPOSED TEMPORARY CONSTRUCTION EASEMENT
- PROPOSED PERMANENT MAINTENANCE EASEMENT
- PROPOSED BOULDER WALL
- PROPOSED NETPAVE/GRASS
- PROPOSED CRUSHED ROCK
- PROPOSED SOG/SLURF
- PROPOSED STORM SEWER

PLAN NOTES

- BOULDER OR TIMBER RETAINING WALL

CONSTRUCTION PLANS - PRIOR LAKE OUTLET STRUCTURE

PREPARED FOR:

PRIOR LAKE - SPRING LAKE WATERSHED DISTRICT

PRIOR LAKE, MINNESOTA

Wenck

1825 Pioneer Creek, Cedar Creek, MN 55005

Environmental Engineers

Phone: 763.455.1100, Fax: 763.455.1101

DATE: 2-21-07

BY: [Signature]

SCALE: 1" = 10'-0"

SHEET NO. 18

Attachment B. Annual Outlet Channel Operations Summary

Date	Elevation	Outlet Activity	Inspections/Channel Activity
1/9/2017	902.65	inspection	Cleaned Jeffers pass of debris, Pike staff gauge frozen,
1/20/2017	902.61	inspection	Few pieces of veg on outlet structure, lots of veg at jeffers pass frozen and needs removal downstream since thick branch stuck in grate. Stuff caught in CR42 grate and frozen.
1/23/2017	902.61	staff gauge	checked staff gauge
2/3/2017	902.60	inspection	thin sheet of ice around outlet structure. Lot of dead veg caught on upstream grate at jeffers. Veg on grate at CR42.
2/10/2017	902.56	inspection	some veg on grate at jeffers. Smelled bad downstream. 5 swans in pond by jefferes rr culvert (neighbor said about 15 hang out in the ponds in the winter and have been there about 1.5 months). Veg frozen on upstream grate and stuck downstream.
2/15/2017	902.54	inspection	lots of veg at jeffers, mostly dead cattails. Some veg on cr42 grates. Pulled branches from kes driveway. Pike Lake staff gauge still frozen in ice however you can now see the top part of the woodboard the gauge is on even w/the ice so the lake level is definately lower than it was early winter. Snow has melted off of half of the hillside, leaving the erosion blanket exposed again, gullies seem larger than in the fall at Gonyea.
2/23/2017	902.66	inspection	pulled a couple branches off the bars of outlet structure. Lots of veg needs to be cleaned from Jeffers Pass. Some veg at CR42. Several tires dumped on side of road near Pike Lake staff gauge. Gauge and woodboard under water - water higher than last week.
3/2/2017	902.70	inspection	outlet grate clear of veg. LOTS of veg caught on upstream grate at jeffers - removed most. Veg needs to be removed at CR42. Pulled some dead cattails that had piled up at Kinney Driveway. Water almost completely fills culvert at Strauss.
3/10/2017	902.68	inspection	dead leaves and sticks stuck on outlet structure. Removed veg from jeffers. Veg on grate at CR42, up and downstream. Pulled branch out at Kes Driveway. Ice out happened earlier this week at Pike Lake - gauge and board underwater. Green algae under ice last week is gone at Pike staff gauge.
3/17/2017	902.65	inspection	cleared thin branches and 2x4's and plywood from outlet structure. Cleared veg from jeffers. Removed bunch of vg from CR42. Pike Lake refrozen, including whole eastern lobe. Culvert ~ 2/3 full at Strauss.
3/22/2017	902.60	inspection	bay near outlet structure open water again but no debris on outlet structure. Removed veg from Jeffers Pass. Removed sticks from CR42. Lake 100% ice out again at Pike Lake (2nd time this year), but gauge still under water.
3/29/2017	902.57	inspection	removed some veg from outlet structure and large dead carp washed up on beach. Removed veg from jeffers. Some veg at CR42. 4.84' on NEW staff gauge which extends high enough to read level, however, levels of new and old gauge are different. Lazy flow thru Strauss.
4/11/2017	902.54	inspection	removed bit of veg at outlet structure and jeffers and CR42. Repaired and seeded ruts from when truck got stuck at Kes Driveway. Pike Lake 4.68' on NEW gauge. Level Logger installed on old gauge post last week.
4/20/2017	902.83	inspection	removed veg at outlet structure and jeffers, but no veg at CR42 upstream... still some downstream. Pulled sapling from stream at Squires driveway. Pike Lake 5.58' new gauge. Grass starting to grow at gonyea.
4/25/2017	902.87	open low-flow	Opened Low-flow gate
4/26/2017	902.93	staff gauge	Staff gauge hard to read because of waves.
4/28/2017	902.90	inspection	cleaned debris from outlet including veg, wood board, basketball and sand play bucket. Removed veg from jeffers - all culverts very full. CR42 culvert almost completely under water upstream and downstream veg has water dammed up and needs to be removed. Removed sapling from Squires driveway. Strauss culvert under water.
5/3/2017	902.90	inspection	Removed veg and debris from structure... and dead wood duck. Removed veg from upstream side at jeffers. Stuff caught in grate downstream side of CR42 causing mini dam. Removed stick from Kes Driveway - grass starting to com in. Water over new pike lake staff gauge and also overflowing into kiciyapi horse pasture. Saw muskrat cross Strauss driveway and go for a swim. Grass coming in at gonyea... large erosion rills on downsream side not fixed.
5/10/2017	902.79	inspection	removed veg debris from structure - mostly clp and filamentous algae, some sticks. Removed veg from jeffers and 42 - lots still downstream. Strauss culvert still under water.
5/16/2017	902.86	inspection	bunch of dead veg at structure. Removed little veg from jeffers. County removed veg from downstream side of CR42! Water down at Strauss - no vortex. Water at Servce trail very muddy - think it's due to consrutcion upstream, level logger gone and lots of ticks!

Date	Elevation	Outlet Activity	Inspections/Channel Activity
5/24/2017	903.40	inspection	cleared veg from structure yesterday. Jeffers clear. Vortex at CR42, culvert full. 0.88' td from Pike Lake Park culvert. Vortex at Kinney driveway. Pike staff gauge under water. Strauss submerged and vortex. Water diverted into bank at Jackson - tpost in center of channel. Water flowing from SMSC land.
6/2/2017	903.46	inspection	carp stuck in grate at outlet structure. Veg caught at jeffers - removed it. CR42 downstream grate has "stuff stuck in there." Pike staff gauge 6.38'. Culvert under water at strauss.
6/9/2017	903.20	inspection	veg cleared twice daily this week from outlet structure - veg holding water back significantly. Removed veg from jeffers. Culvert still under water at strauss. Pike Lake 6.19'.
6/15/2017	903.20		checked staff gauge
6/16/2017	903.12	inspection	removed veg from jeffers. Pike Lake 6.54'. Strauss still under water.
6/26/2017	902.62	inspection	not too much veg on structure or jeffers. Pulled veg off at 42. Pike Lake 5.72(?)
6/27/2017	902.56	close low-flow	Closed low-flow gate
7/6/2017		inspection	barely any veg. New rock bed at 42. Downstream grate removed from CR42 crossing. Pike Lake 4.57.
7/12/2017	902.51	inspection	some veg cleared from structure. Pike 4.30'. Water very low.
7/21/2017	902.60	inspection	removed some veg from structure and jeffers and 42. Pike 4.67'.
7/26/2017		inspection	barely any veg at structure. Lots removed from jeffers. Pike 4.58'.
8/17/2017	902.68	inspection	removed veg from structure and jeffers. Lots of erosion from construction site up the easement road... sand washed away near the structure... took pics.
8/23/2017	902.73	inspection	some veg on structure... holding back a bit of water, removed veg. Several sticks on Jeffers should be removed. Downstream grate at 42 removed - some steam coming out of culvert.... Weird. Gullies on hill above culvert have been filled and riprap placed on top. Grass at Kes Field crossing that was run over this winter now looks like it did before! Tree 10-12" in diameter fell across channel upstream of culvert 30' at Pike Lake Park and several gullies forming on right side of downstream bank where repair work happened with FEMA. Pike Lake 4.95'. Bank erosion just above culvert at Jackson and a little bit below culvert on east bank of channel seems to be worsening.
8/31/2017	902.82	inspection	veg on structure holding back a couple inches of water. Jeffers upstream grate completely covered in debris - lots of sticks and branches - looks like beaver dam... water in wetland higher than normal. Lots of veg at 42. Pike Lake 4.87'.
9/8/2017		Jeffers Pass Beaver Dam	First official inspection of site (for Ryan Bonney, which was hired to remove beaver dam material). No significant animal activity. Removed small amount of vegetation from the grate. Sediment appears to be altering drainage height of the culvert due to build up against culvert guard. I will remove sediment during the next inspection to try to restore normal drainage to the culvert. Down stream side is clear of debris and flowing smoothly.
9/9/2017		Jeffers Pass Beaver Dam	Flow severely impeded by vegetation due to beaver activity. The amount of material jammed into this dam was impressive. At least 30 willow (i think?) saplings. This is actually the perfect ammo for an ambitious beaver. The saplings are about 1-2 in thick and flexible. The beaver is likely chewing them off by the dozens a night and just allowing the flow to jam them into the culvert. Removing this mess took 50 mins and required significant effort.
9/10/2017		Jeffers Pass Beaver Dam	Signs of beaver activity. Some vegetation on culvert guard but flow does not appear to be impeded significantly. I removed some of the trees but had to halt due to rain and lightning from a small storm. I will remove any remaining vegetation tomorrow morning.
9/11/2017		Jeffers Pass Beaver Dam	Significant flow impedement due to beaver activity. Dozens of willows wedged into the culvert guard. Removing debris took 1.5 hours. I was able to get most all of the debris and sediment out down to the bottom of the guard which had previously been buried in debris when i took over monitoring. Flow is once again fully restored.
9/12/2017		Jeffers Pass Beaver Dam	Heavy debris and trees. Many willows. Removal took ~45mins.
9/13/2017		Jeffers Pass Beaver Dam	Flow impeded. Not as elaborate as 9/12 but close. Removal took ~35 mins on outlet structure.
9/14/2017	902.60	inspection	Cleared veg from structure - not holding water back. Beaver activity at Jeffers. Tree down upstream of Pike Lake Park road. Pike Lake 4.72'.
9/14/2017		Jeffers Pass Beaver Dam	This appears to be the new norm. Heavy blockage consistent with previous days.

Date	Elevation	Outlet Activity	Inspections/Channel Activity
9/15/2017		Jeffers Pass Beaver Dam	Water level considerably lower then usual. No apparent beaver activity. Bottom of the guard is now visable above the water line.
9/16/2017		Jeffers Pass Beaver Dam	Water level even lower than yesterday. I suspect that the lake level at Prior Lake is approaching the weir height. No apparent beaver activity. Perhaps the water level is enough of a deterrant?
9/17/2017		Jeffers Pass Beaver Dam	No activity to note. Water level is consistent with yesterday.
9/18/2017		Jeffers Pass Beaver Dam	Back with a vengeance. A shift in dam building material is now seen. This new blockage is mostly aquatic plants heavily laden with mud and only a handful of willows and sticks to form a skeleton. This dam took ~30 mins to remove. The pitch fork earned its purchase price today as I had to fork out huge piles of aquatic plants. The blockage also extended back from the mouth of the culvert by about 5-6 feet which has not been present until today. Water level has risen about 1-2 feet since yesterday. Likely due to this blockage.
9/19/2017		Jeffers Pass Beaver Dam	No activity. Some build up of sediment against bottom of culvert. Nothing concerning yet.
9/21/2017	902.54	staff gauge & inspection	checked staff gauge. Fair amount of veg at structure, but not really blocking flow - removed. Beaver taking break at Jeffers. Pike 4.41' (old gauge finally showing).
9/24/2017		Jeffers Pass Beaver Dam	No activity yet again. Water level is way down. Likely that beavers house is getting very dry by now. I suspect if this continues he might move on to greener pastures such as Jeffers Pond if it is unoccupied.
10/1/2017		Maintenance	Collins tree care removed debris from Jeffers Pass beaver dam and the tree upstream of pike lake road.
10/4/2017	902.58	inspection	some buildup on structure. Construction up from structure has mud on road and claims they will clean it up before the end of the day. No beaver activity at jeffers. New grate installed by county on upstream side of CR42 - Huge!! Some veg already on the new grate. Pike Lake 4.56'.
10/13/2017	902.58	inspection	LOTS of veg at structure - took 40 minutes to clear. Silt fence up the hill still non-functional. No beaver activity at Jeffers, but some veg on grate. Veg stuck on new CR42 grate - needs to be removed - excavated dirt dumped in wetland. Pike Lake 4.49. Jackson erosion getting worse and carving into bank.
10/19/2017	902.64	inspection	No beaver activity at jeffers, but some veg on grate.
10/23/2017		inspection	took 45 minutes to clear structure, lots of coontail, water celery gone, was holding water back
11/8/2017	902.54	inspection	not too much veg at structure. Fair amount of debris at jeffers - cleared. Bunch of debris at 42. Thin layer of ice at Pike Lake staff gauge (no measurement).
11/17/2017	902.51	inspection	No veg on structure! Little debris at jeffers and 42. Pike Lake 4.24'... Old gauge showing.
12/1/2017	902.47	inspection	No veg on structure! RR crossing - hannel flow is offset from culvert - might have found where the beaver from jeffers Pass moved. The stormwater pond across the path from the culvert has a number of trees w/beaver marks on them and some cut down. Wetland delineation flags at kes driveway. Trees upstream of Kes Field crossing have fallen into channel - not sure if new. Two new trees removed just upstream from culvert at Pike Lake Park. Very thin film of ice at Pike Lake Park - 4.08. TV dumped on side of Pike Lake Rd just north of strauss driveway - come on people!! Biolog at Gonyea needs to be removed.
12/11/2017	902.50	staff gauge	

Attachment C. Stage-Discharge Relationship

MEMORANDUM

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)

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.

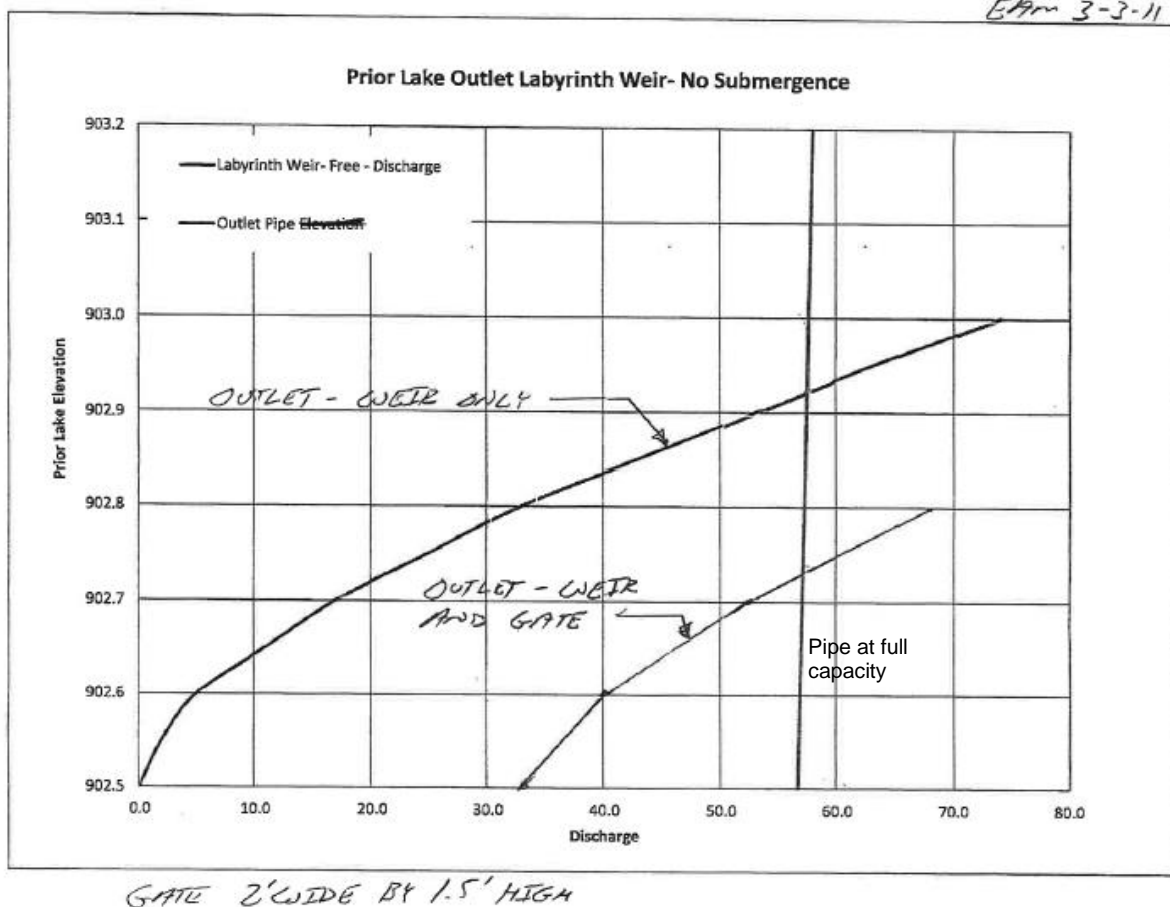


Figure 1 – Original design discharge (CFS) estimates with gate opened (“Outlet-Weir and Gate”) and closed (“Outlet-Weir Only”). Vertical line is estimated full capacity of the pipe.

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.”

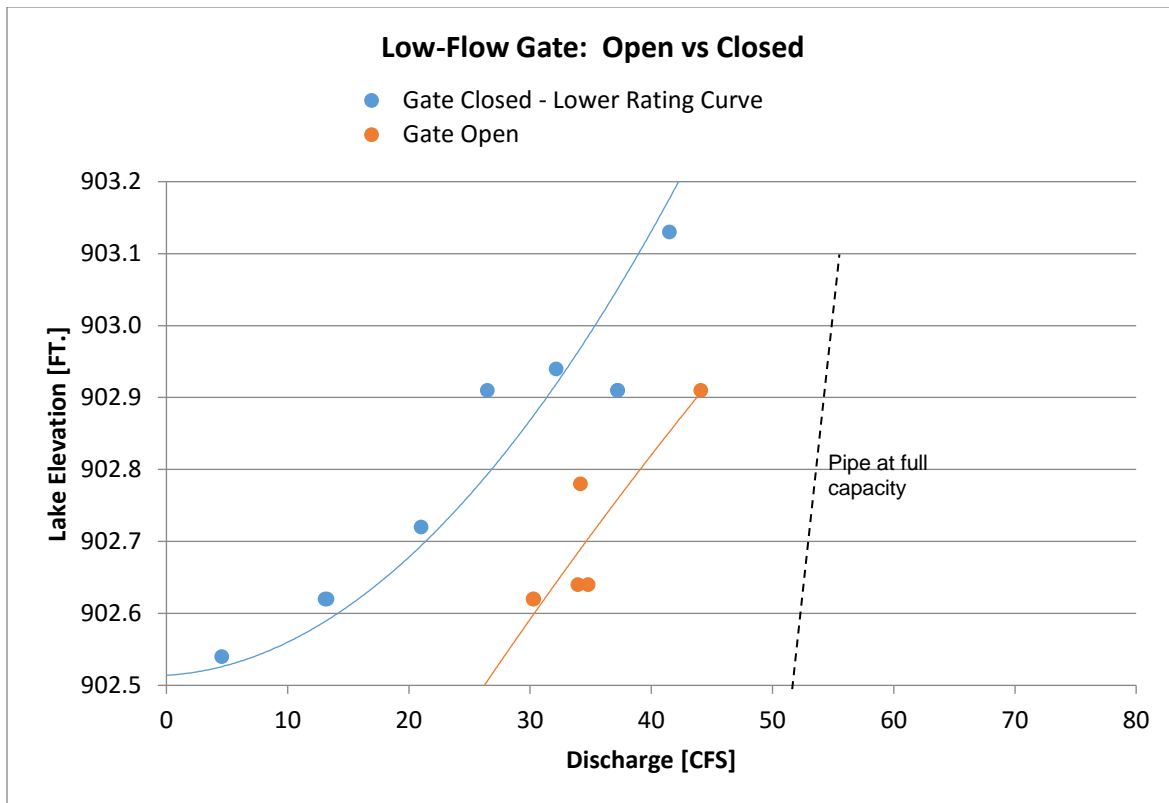


Figure 2 Field verified flow measurements compared to same scale as Figure 1. Dots are actual measurements, the blue and orange lines are the lines that represent the rating curve, and the dashed, black vertical line is estimated full capacity of the pipe.

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').

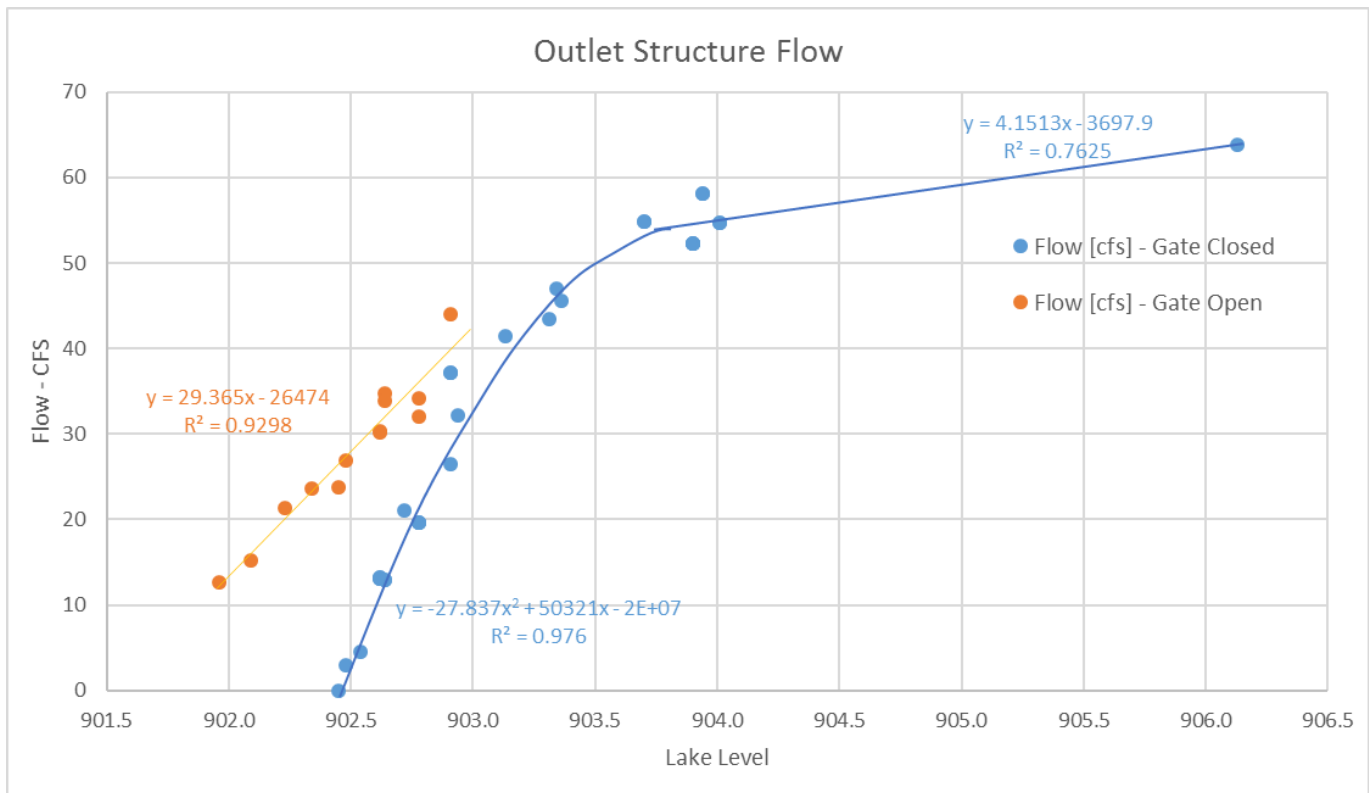


Figure 3 Flow Measurements (dots) and Rating Curve Equations (lines) for the Outlet Structure (Updated 11/22/16)

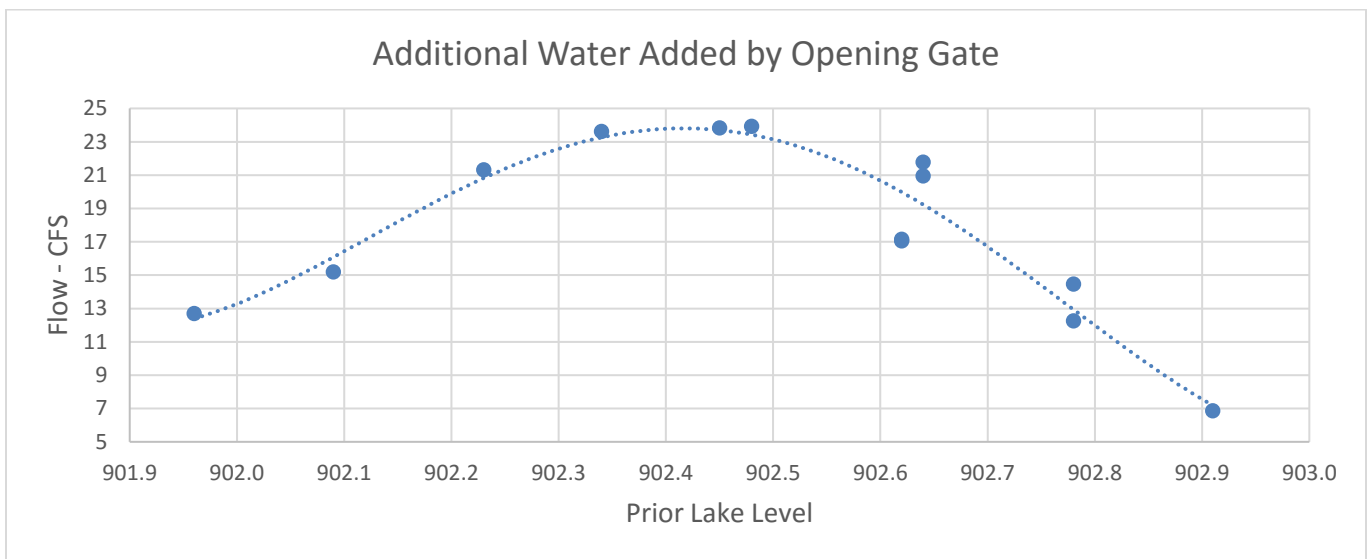


Figure 4 Amount of additional flow discharge when the Low-Flow Gate is open. Blue dots represent “Flow with gate open minus Flow with gate closed”. The line is the average.

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 ² 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> Outlet	Annual Rainfall
2017	11942	6.00	902.35	8/13/2017	903.56	5/29/2017	909.56	32.4
2016	9351	4.80	902.36	8/9/2016	903.55	12/1/2016	908.35	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		
Average	6312 (when operated)	3.23 (when operated)	900.42		902.87		906.49	32.00
Unless otherwise noted, data is taken from annual Prior Lake Outlet operations reports								
<i>Italicized rainfall data is from MN Climatology office for 115N, 22W, 15 Prior Lake; all other rainfall as recorded at PLSLWD Office</i>								
<i>Italicized lake level data is from PLSLWD Historic Volunteer Collected Lake Level Data</i>								

Attachment E. Prior Lake Elevations and Precipitation

Elevation		Precipitation	
Average	902.67	Yearly Total	34.28
Minimum	902.36	Max 1 Day	2.48
Maximum	903.55		

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 from the MN Climatology Working Group- BYRG at T114N, 22W, 4

Date	Auto Logger	Staff Gage	Precipitation
1/1	902.71		0.00
1/2	902.71		0.00
1/3	902.70		0.01
1/4	902.69		0.00
1/5	902.68		0.00
1/6	902.68		0.00
1/7	902.67		0.00
1/8	902.65		0.00
1/9	902.65		0.00
1/10	902.66		0.14
1/11	902.66		0.18
1/12	902.65		0.03
1/13	902.64		0.00
1/14	902.63		0.00
1/15	902.62		0.00
1/16	902.61		0.00
1/17	902.63		0.29
1/18	902.62		0.00
1/19	902.61		0.00
1/20	902.61		0.02
1/21	902.61		0.06
1/22	902.61		0.01
1/23	902.61	902.61	0.00
1/24	902.61		0.00
1/25	902.62		0.10
1/26	902.62		0.10
1/27	902.62		0.00
1/28	902.62		0.00
1/29	902.61		0.00
1/30	902.61		0.00
1/31	902.61		0.00
2/1	902.61		0.00
2/2	902.60		0.00
2/3	902.60		0.00
2/4	902.59		0.00
2/5	902.59		0.00
2/6	902.58		0.00
2/7	902.58		0.00
2/8	902.57		0.00

Date	Auto Logger	Staff Gage	Precipitation
2/9	902.56		0.00
2/10	902.56		0.00
2/11	902.55		0.00
2/12	902.55		0.03
2/13	902.55		0.00
2/14	902.55		0.00
2/15	902.54		0.00
2/16	902.54		0.00
2/17	902.54		0.00
2/18	902.54		0.00
2/19	902.54		0.00
2/20	902.58		0.00
2/21	902.63		0.64
2/22	902.65		0.00
2/23	902.66		0.00
2/24	902.68		0.00
2/25	902.68		0.00
2/26	902.69		0.00
2/27	902.69		0.00
2/28	902.70		0.00
3/1	902.70		0.10
3/2	902.70		0.00
3/3	902.69		0.00
3/4	902.69		0.00
3/5	902.69		0.00
3/6	902.70		0.00
3/7	902.71		0.20
3/8	902.70		0.00
3/9	902.69		0.00
3/10	902.68		0.00
3/11	902.67		0.00
3/12	902.67		0.00
3/13	902.68		0.32
3/14	902.67		0.00
3/15	902.66		0.00
3/16	902.65		0.00
3/17	902.65		0.00
3/18	902.64		0.00
3/19	902.62		0.00
3/20	902.62		0.00
3/21	902.61		0.00
3/22	902.59		0.00
3/23	902.58		0.00
3/24	902.59		0.10
3/25	902.58		0.00
3/26	902.58		0.03
3/27	902.58		0.00
3/28	902.57		0.00
3/29	902.57		0.00
3/30	902.57		0.05
3/31	902.56		0.00

Date	Auto Logger	Staff Gage	Precipitation
4/1	902.56		0.00
4/2	902.56		0.00
4/3	902.56		0.00
4/4	902.56		0.15
4/5	902.56		0.00
4/6	902.55		0.00
4/7	902.54		0.00
4/8	902.54		0.00
4/9	902.54		0.00
4/10	902.54		0.06
4/11	902.54		0.14
4/12	902.54		0.00
4/13	902.55		0.22
4/14	902.55		0.00
4/15	902.67		1.40
4/16	902.71		0.56
4/17	902.72		0.00
4/18	902.73		0.00
4/19	902.76		0.15
4/20	902.84		1.02
4/21	902.85		0.01
4/22	902.86		0.00
4/23	902.86		0.00
4/24	902.87		0.00
4/25	902.88		0.01
4/26	902.93		0.76
4/27	902.92		0.20
4/28	902.90		0.02
4/29	902.88		0.00
4/30	902.86		0.00
5/1	902.92		0.93
5/2	902.92		0.16
5/3	902.90		0.00
5/4	902.90		0.00
5/5	902.88		0.00
5/6	902.86		0.00
5/7	902.84		0.00
5/8	902.82		0.00
5/9	902.80		0.01
5/10	902.78		0.00
5/11	902.76		0.01
5/12	902.73		0.00
5/13	902.71		0.00
5/14	902.69		0.00
5/15	902.72		0.00
5/16	902.85		1.97
5/17	902.92		0.41
5/18	903.07		1.73
5/19	903.08		0.04
5/20	903.15		0.02
5/21	903.26		1.42

Date	Auto Logger	Staff Gage	Precipitation
5/22	903.31		0.05
5/23	903.36		0.04
5/24	903.41		0.09
5/25	903.44		0.00
5/26	903.47		0.02
5/27	903.50		0.00
5/28	903.54		0.01
5/29	903.55		0.00
5/30	903.54		0.00
5/31	903.52		0.00
6/1	903.50		0.00
6/2	903.47		0.00
6/3	903.47		0.00
6/4	903.49		0.00
6/5	903.50		0.00
6/6	903.47		0.00
6/7	903.41		0.00
6/8	903.36		0.00
6/9	903.30		0.00
6/10	903.23		0.00
6/11	903.25		0.00
6/12	903.26		1.17
6/13	903.24		0.49
6/14	903.24		0.29
6/15	903.19	903.20	0.00
6/16	903.12		0.00
6/17	903.07		0.00
6/18	903.04		0.63
6/19	902.97		0.00
6/20	902.91		0.06
6/21	902.85		0.00
6/22	902.82		0.01
6/23	902.78		0.29
6/24	902.72		0.00
6/25	902.67		0.03
6/26	902.61		0.01
6/27	902.56		0.00
6/28	902.61		0.94
6/29	902.62		0.05
6/30	902.61		0.00
7/1	902.60		0.12
7/2	902.58		0.00
7/3	902.57		0.00
7/4	902.55		0.00
7/5	902.54		0.00
7/6	902.53		0.00
7/7	902.51		0.00
7/8	902.49		0.00
7/9	902.48		0.00
7/10	902.53		0.00
7/11	902.52		0.00

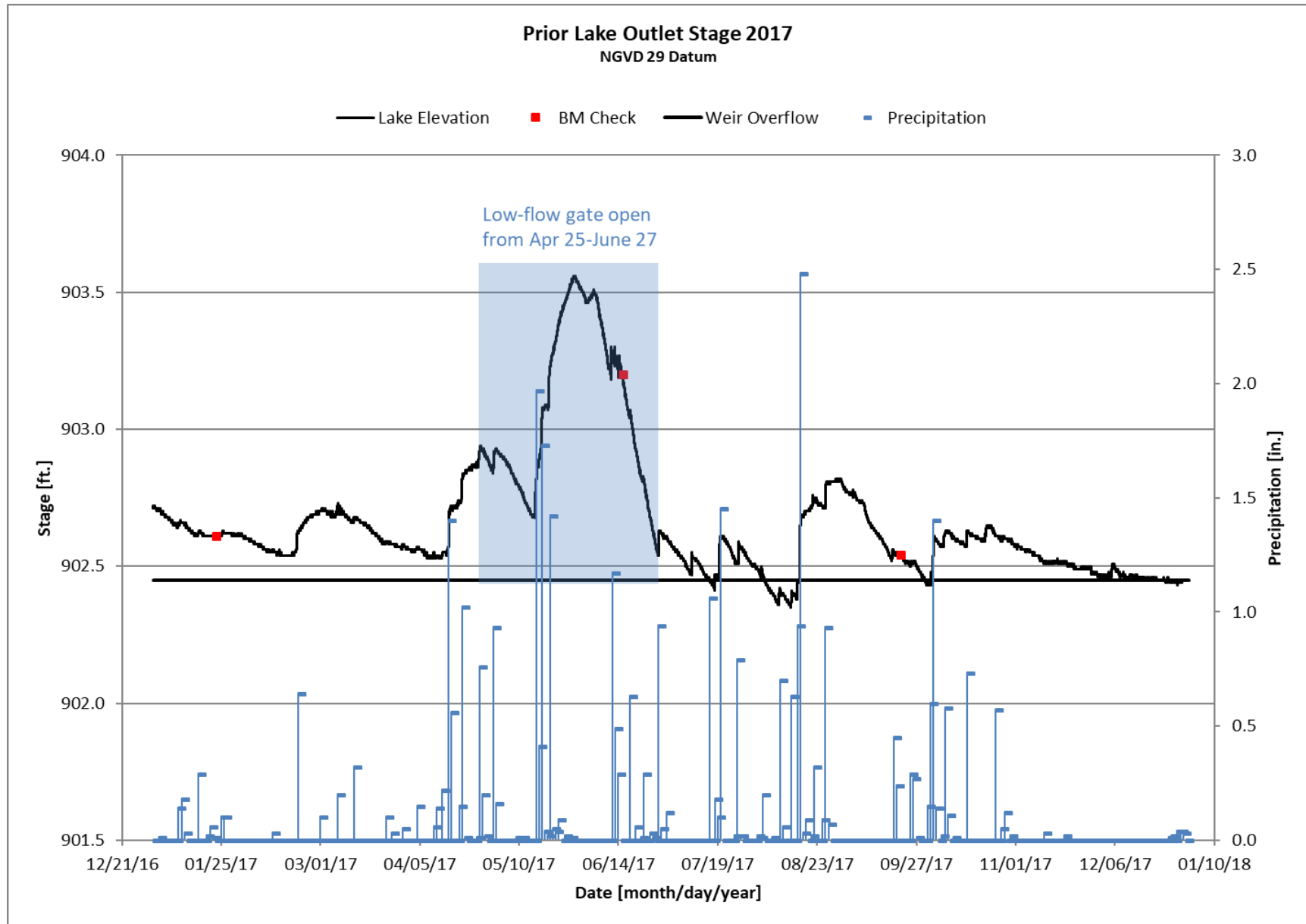
Date	Auto Logger	Staff Gage	Precipitation
7/12	902.51		0.00
7/13	902.49		0.00
7/14	902.47		0.00
7/15	902.46		0.00
7/16	902.44		1.06
7/17	902.43		0.00
7/18	902.46		0.18
7/19	902.50		0.10
7/20	902.61		1.45
7/21	902.60		0.00
7/22	902.58		0.00
7/23	902.56		0.00
7/24	902.54		0.00
7/25	902.52		0.02
7/26	902.56		0.79
7/27	902.56		0.02
7/28	902.55		0.00
7/29	902.53		0.00
7/30	902.52		0.00
7/31	902.50		0.00
8/1	902.50		0.00
8/2	902.48		0.02
8/3	902.47		0.01
8/4	902.45		0.20
8/5	902.43		0.00
8/6	902.41		0.00
8/7	902.40		0.01
8/8	902.38		0.00
8/9	902.38		0.00
8/10	902.40		0.70
8/11	902.39		0.06
8/12	902.38		0.00
8/13	902.36		0.00
8/14	902.40		0.63
8/15	902.39		0.00
8/16	902.46		0.94
8/17	902.67		2.48
8/18	902.69		0.03
8/19	902.70		0.09
8/20	902.71		0.00
8/21	902.73		0.02
8/22	902.74		0.32
8/23	902.73		0.00
8/24	902.72		0.00
8/25	902.72		0.09
8/26	902.80		0.93
8/27	902.81		0.07
8/28	902.81		0.00
8/29	902.81		0.00
8/30	902.82		0.00
8/31	902.81		0.00

Date	Auto Logger	Staff Gage	Precipitation
9/1	902.79		0.00
9/2	902.77		0.00
9/3	902.77		0.00
9/4	902.76		0.00
9/5	902.76		0.00
9/6	902.74		0.00
9/7	902.73		0.00
9/8	902.72		0.00
9/9	902.69		0.00
9/10	902.66		0.00
9/11	902.64		0.00
9/12	902.63		0.00
9/13	902.62		0.00
9/14	902.60		0.00
9/15	902.58		0.00
9/16	902.57		0.00
9/17	902.54		0.00
9/18	902.54		0.00
9/19	902.55		0.45
9/20	902.55		0.24
9/21	902.54	902.54	0.00
9/22	902.53		0.00
9/23	902.52		0.00
9/24	902.51		0.00
9/25	902.51		0.29
9/26	902.52		0.27
9/27	902.50		0.01
9/28	902.48		0.00
9/29	902.46		0.00
9/30	902.44		0.00
10/1	902.44		0.15
10/2	902.48		0.60
10/3	902.60		1.40
10/4	902.59		0.14
10/5	902.58		0.00
10/6	902.58		0.02
10/7	902.63		0.58
10/8	902.63		0.11
10/9	902.61		0.00
10/10	902.60		0.01
10/11	902.59		0.00
10/12	902.59		0.00
10/13	902.58		0.00
10/14	902.59		0.00
10/15	902.62		0.73
10/16	902.61		0.00
10/17	902.61		0.00
10/18	902.60		0.00
10/19	902.60		0.00
10/20	902.60		0.00
10/21	902.62		0.00

Date	Auto Logger	Staff Gage	Precipitation
10/22	902.65		0.00
10/23	902.64		0.00
10/24	902.62		0.00
10/25	902.61		0.57
10/26	902.60		0.00
10/27	902.60		0.05
10/28	902.60		0.12
10/29	902.59		0.00
10/30	902.59		0.02
10/31	902.58		0.00
11/1	902.57		0.00
11/2	902.57		0.00
11/3	902.56		0.00
11/4	902.56		0.00
11/5	902.56		0.00
11/6	902.55		0.00
11/7	902.54		0.00
11/8	902.54		0.00
11/9	902.53		0.00
11/10	902.52		0.00
11/11	902.52		0.03
11/12	902.51		0.00
11/13	902.51		0.00
11/14	902.52		0.00
11/15	902.52		0.00
11/16	902.51		0.00
11/17	902.51		0.00
11/18	902.51		0.02
11/19	902.51		0.00
11/20	902.51		0.00
11/21	902.50		0.00
11/22	902.49		0.00
11/23	902.49		0.00
11/24	902.49		0.00
11/25	902.49		0.00
11/26	902.49		0.00
11/27	902.49		0.00
11/28	902.48		0.00
11/29	902.47		0.00
11/30	902.47		0.00
12/1	902.47		0.00
12/2	902.46		0.00
12/3	902.46		0.00
12/4	902.47		0.00
12/5	902.50		0.00
12/6	902.49		0.00
12/7	902.47		0.00
12/8	902.47		0.00
12/9	902.47		0.00
12/10	902.46		0.00
12/11	902.47		0.00

Date	Auto Logger	Staff Gage	Precipitation
12/12	902.46		0.00
12/13	902.46		0.00
12/14	902.46		0.00
12/15	902.46		0.00
12/16	902.46		0.00
12/17	902.45		0.00
12/18	902.45		0.00
12/19	902.45		0.00
12/20	902.45		0.00
12/21	902.45		0.00
12/22	902.45		0.00
12/23	902.45		0.00
12/24	902.45		0.00
12/25	902.45		0.01
12/26	902.44		0.02
12/27	902.44		0.00
12/28	902.44		0.04
12/29	902.45		0.04
12/30	902.45		0.03
12/31	902.45		0.00

Attachment F. Prior Lake Elevations Graph



Attachment G. Summary of Precipitation within PLSLWD

Month	*2017 Rain Gauge Readings (inches)	PLSLWD 2016 YTD (in.)
Jan	0.82	0.82
Feb	0.57	1.39
Mar	0.57	1.96
Apr	4.26	6.22
May	6.85	13.07
Jun	3.57	16.64
Jul	3.56	20.20
Aug	6.28	26.48
Sep	1.37	27.85
Oct	3.89	31.74
Nov	0.12	31.86
Dec	0.53	32.39
Year Total	32.39	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
12.3%	0.09	12.3%	0.09
-8.1%	-0.05	3.0%	0.04
-67.1%	-1.16	-36.4%	-1.12
68.4%	1.73	10.9%	0.61
85.6%	3.16	40.5%	3.77
-23.1%	-1.07	19.4%	2.70
2.0%	0.07	15.9%	2.77
24.4%	1.23	17.8%	4.00
-59.8%	-2.04	7.6%	1.96
57.5%	1.42	11.9%	3.38
-92.7%	-1.52	6.2%	1.86
-44.2%	-0.42	4.7%	1.44
		4.7%	1.44

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