LITTLE TRAVERSE LAKE WATER LEVEL INVESTIGATION

7/15/2014

Little Traverse Lake Property Owners Association

Prepared by: Gosling Czubak Engineering Sciences, Inc

1280 Business Park Dr.

Traverse City, MI 49686

231-946-9191

TABLE OF CONTENTS

APPENDIX

List of Items

- Overall Study Area Map
- System Profile Along Creek
- W. Traverse Lake Road Culvert Plan View
- Co. Road 669 Culvert Plan View
- Beaver Dam Plan View
- Lake Michigan Road Culvert Plan View
- W. Traverse Lake Road Culvert Water Surface Elevations – Spring 2013
- W. Traverse Lake Road Culvert Water Surface Elevations – Spring 2014
- Computer Outputs (8 pages)
- June 11, 2012 National Park Service Memo

Little Traverse Lake Water Level Investigation

LITTLETRAVERSE LAKE PROPERTY OWNERS ASSOCIATION

INTRODUCTION AND GOALS OF THE INVESTIGATION

Some LTLPOA members have experienced high lake levels and desire to learn more about what influences water levels on the lake and what actions might be taken to alleviate high water level conditions. Specific concern revolves around a culvert at Traverse Lake Road and a culvert at county road 669 on Shalda Creek, but other contributing factors will also be investigated.

The goal of the investigation will be to obtain factual data about the creek system all the way to Lake Michigan; to determine if these culverts have an impact on current lake levels; and if any other factors may be involved, including a reported beaver dam about ¾ of a mile downstream of CR 669. The investigation will also analyze possible methods to lowering lake levels, including up-sizing existing road culverts or replacing the culverts with clear span bridges.

METHODS

A field survey using GPS equipment on a common datum was performed at the three culverts in Shalda Creek between Little Traverse Lake and Lake Michigan. Survey information was also obtained at a beaver dam located downstream of CR 669. Stream level gauges that were installed by the county road commission were also surveyed and the gauge elevations were converted to the common datum (NAVD88).

The survey work was performed after a heavy snowpack melt and measured water elevations representative of levels that have been reported to cause crawl space flooding and other damage to lake front homes.

A stream velocity gauge was also used to measure actual stream velocity at each culvert. These readings were used to calculate flow rates and calibrate a hydraulic model of each culvert's performance capabilities.

Past reports from LTLPOA member Len Allgaier, the National Park Service, the Leelanau Conservancy, and other information was reviewed and incorporated into our findings.

FINDINGS OF FACT

The work scope for the investigation proposed to answer specific questions about the creek system so that analysis and planning decisions could be based on the best available information.

1. What are the culvert sizes and the true water surface elevation at key locations from the lake outlet to just downstream of the culvert at W. Lake Michigan Road?

		T/CULVERT		W.S.E (4/23/14)		STREAM GAGE
CULVERT LOCATION	SIZE	U/S	D/S	U/S	D/S	T/GAGE
W. Traverse Lake Road	64x43 Arch	596.49	595.68	595.75	595.46	597.8
CR 669	71x47 Arch	594.56	592.88	594.78	594.55	596.7
Lake Michigan Road	64x43 Arch	585.68	585.36	583.80	583.27	
	42" Dia	585.32	585.12	583.80	583.27	
Lake Michigan				578.0		
	All elevations are in feet; NAVD88 Datum					

2. Are all the water surface gauges on the same datum (do they correspond to each other)?

No, they are not. The gauges at W. Traverse Lake Road are slightly different (relative elevation) than the gauges at CR 669. Corrected for NAVD88 datum, the gauge adjustments are:

- Add 0.8' to the gauge reading at WTL gauges
- Add 0.7' to the gauge readings at CR 669

3. What is the location, size, and water level of the beaver dam downstream of CR 669?

The location and size of the beaver dam is shown on the attached site plan and survey detail map. The water level difference across the dam was measured at 0.57' (6-7/8") in April, 2014. Beaver dam configurations are continuously changing and could impact water levels in different ways in the future.

After the initial field survey, another beaver dam was located further downstream. The location and size of the beaver dam is shown on the attached site plan. The water level difference across the dam was estimated at 4' in June, 2014. This beaver dam is located approximately 9,150 feet downstream of CR 669.

4. What is the "normal" flow rate range through Shalda Creek?

There are a wide range of flows reported for the outlet of Little Traverse Lake. A 1994 report "*A Study of Development and Water Quality Within the Little Traverse Lake and Lime Lake Watersheds*" prepared for Leelanau County by the University of Michigan summarized "base flow" conditions as:

Little Traverse Lake Water Balance	Rate of Flow	Percent of Total
Streams In:	15.3 cfs	71 %
Precipitation:	2.8 cfs	13 %
Ground Water In:	3.4 cfs	16 %
Total In:	21.5 cfs	100 %
Streams Out:	18.4 cfs	86 %
Evaporation Out:	2.8 cfs	13 %
Groundwater Out:	0.3 cfs	1 %
Total Out:	21.5 cfs	100 %

The reported outflow of approximately 18.4 cfs is considered a "dry weather-low groundwater" condition that may not be representative of conditions in 2014.

5. What is the range of flow rate during storm events?

The Michigan Department of Environmental Quality (MDEQ) Hydrological Unit has provided estimated peak runoff flow rates for various rainfall events, as estimated for each culvert location:

	Total Drainage Area (Sq. Miles)	Cont. Drainage Area (Sq. Miles)	Flow (cfs) at Frequency			
			50% (2yr)	10% (10yr)	2% (50yr)	1%(100yr)
West Traverse Lake Road	18.7	15.8	20	120	350	500
CR 669	19.2	16.3	20	120	350	500
West Lake Michigan Road	36	30.9	320	550	750	800
Rainfall Depth by Frequency (in)			2.4	3.25	4.2	4.67

In May, 2014 creek flow velocity measurements were taken to estimate creek flow. This was performed soon after a large, but slow and steady snowpack melt. Lake levels were high and this condition appears to represent some of the higher lake levels experienced in the past few years. The results are presented in the following table.

May 7, 2014 Velocity Measurements - Flow Calculations

			T/CULVERT		WSE (5/7/14)		FLOW AREA (SFT)		MEASURED VEL. (FT/S)		FLOW (CFS)	
CULVERT LOCATION	**SIZE**	**AREA (SFT)**	**U/S**	**D/S**	**U/S**	**D/S**	**U/S**	**D/S**	**U/S**	**D/S**	**U/S**	**D/S**
W. Traverse Lake Road	64x43 Arch	15.08	596.49	595.68	595.7	595.45	12.34	14.6	5.9	6.6	72.8	96.4
CR 669	71x47 Arch	18.18	594.56	592.88	594.72	594.48	18.18	18.18	3.3	6.5	60.0	118.2
Lake Michigan Road	64x43 Arch	15.08	585.68	585.36	583.43	583.19	6.07	6.52	10.0	8.5	60.7	55.4
	42" Dia	9.62	585.32	585.12	583.57	583.29	4.81	4.51	6.0	7.0	28.9	31.6

6. Rainfall and Water Level Gauge Readings

Water level gauge readings provided by Len Allgaier were reviewed and compared to rainfall events from a NOAA weather station in Maple City. The data has been converted to NAVD datum and presented in the attached charts. The observed high water level readings reported in 2013 and 2014 closely match the conditions observed in May, 2014.

In 2013 and 2014, the lowest reported upstream water level was about 595.2. In April, 2014, a rainfall event of 1.64" raised the water level from 595.3 to 595.8. Several consecutive days of rain between .25" and .75 inches were noted during the first half of May that did not seem to significantly affect the water level. It seems the lake level is more responsive to early season rain and snow melt and there may be other variables that affect lake levels of this complex system. Len's report also indicates shoreline erosion damage occurs at 595.2 and crawl space flooding at 595.65.

7. General Observations

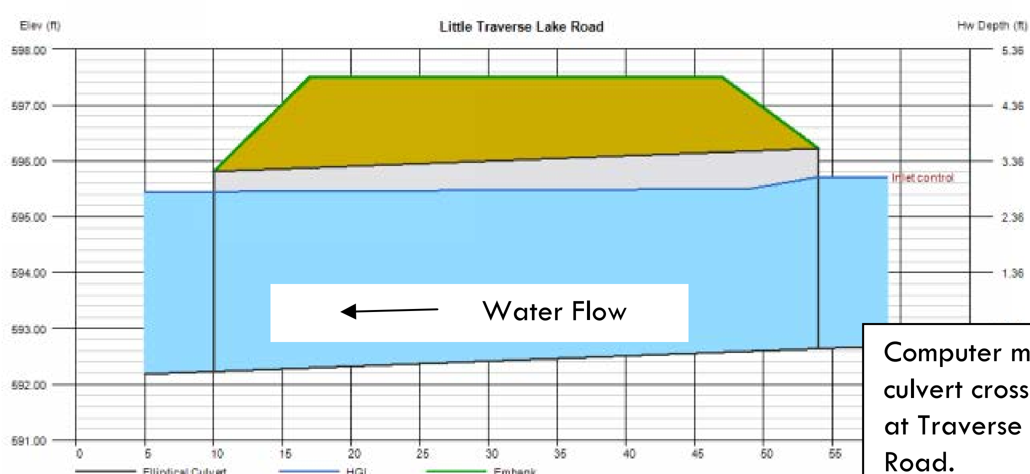
One aspect of the Shalda Creek system that should be noted is the widely varying water surface slope (and therefore flow capacity) at different sections of the creek. From the Lake Michigan Road culvert to the beaver dam that was located and surveyed in April, the water surface slope is at least 0.11%. However, with the subsequent discovery of the large beaver dam retaining about 4 feet of water, the slope in this section could be steeper. From the first beaver dam to CR 669 culvert, the slope is 0.015% - over 7 times less steep. From CR 669 to the LTL Rd. culvert, the slope is 0.028% - almost twice the slope of the section downstream.

ANALYSIS

Based on the field measurements and other information, we have performed two types of analysis on the culverts. One is an individual analysis of each culvert, without any attempt to model connectivity to other creek features. The second analysis is an attempt to evaluate how the system works as a whole and how performance at one culvert affects another. The analysis focused on the section of Shalda Creek between the beaver dam and the lake outlet. The HEC-RAS water surface profile computer model analysis is limited by the assumptions made regarding actual creek cross sections that were beyond the scope of this investigation.

1. Do the calculated water surface levels at the culverts match real world observations?

Yes. Using the measured flow and water gauge readings were able to calibrate a hydraulic model of each culvert that followed real world observations very closely.



Computer modeled culvert cross section at Traverse Lake Road.

2. Does the culvert at Traverse Lake Road impede creek flow or impact Little Traverse Lake levels?

Yes. The culvert at Traverse Lake Road normally experiences a high tailwater condition that limits the capacity of the culvert. At flows lower than about 60 cfs, capacity of the culvert would be improved if the tailwater condition is lowered. However, at flows greater than 60 cfs, the culvert operates under "inlet control" conditions. This means that no matter how low the tailwater condition is, the water can't get into the inlet fast enough, so the headwater level will be about the same, regardless of the tailwater condition. See attached analysis outputs.

3. Does the culvert at County Road 669 impede creek flow or impact Little Traverse Lake levels?

Yes, but to a lesser degree than the W. Traverse Lake Road culvert. This culvert also normally experiences a high tailwater condition that limits its capacity. At flows lower than about 120 cfs, capacity of the culvert would be improved if the tailwater condition is lowered. However, at flows greater than 120 cfs, the culvert operates under "inlet control" conditions. This means that the headwater level will be about the same, regardless of the tailwater condition. See attached analysis outputs.

4. What is the size and capacity of the culvert on West Lake Michigan Road?

The culvert on West Lake Michigan Road is actually two culverts. The dimensions are shown in the summary table in the "findings" section. The capacity of this culvert system is much greater than the upper culverts due to its larger effective opening and its relatively low tailwater condition. The culvert generally operates under inlet control and has a capacity of about 140 cfs before overtopping the top of the culvert.

5. If the culvert(s) were removed or increased in size, how would lake levels change?

To effectively answer this question, additional stream cross section data is needed, along with a detailed HEC-RAS water surface profile analysis. Based on the very preliminary stream data gathered as part of this first phase of investigation, the answer is: Yes, but the change is relatively minor and does not lower lake levels enough to eliminate the problems that have been associated with high water levels.

We estimate that if the culverts at CR 669 and W. Traverse Lake Rd. were removed and replaced with full span bridges (no flow restrictions) the lake level would drop by about 0.6' under the same flow conditions experienced this spring. That would lower lake levels to about 595.3. But, the LTLPOA has indicated erosion damage at 595.2 and crawl space flooding at 595.65.

Water level measurements were taken on June 4, 2014 during a period of "normal" lake water level and reduced outflow. The beaver dam downstream of CR 669 was reported to not be retaining as much water as was observed in April. The Lake level was 595.35. Direct flow measurements were not taken, but based on observed water level changes at each culvert, it is estimated the flow on June 4, 2014 was approximately 15-30 cfs. The total head loss at the Traverse Lake Road culvert was 0.17 feet. The total head loss at the CR 669 culvert was 0.12 feet. So, if the culverts were removed under these lower flow conditions, the lake level drop would be an additional 0.3 feet.

6. Does the beaver dam impact lake levels?

Yes, depending on the flow conditions. As we have learned through this study, there is more than one beaver dam to consider. The way each dam affects creek flow and lake levels can vary at each dam location. A beaver dam does create a higher tailwater condition at the culverts than might naturally occur. So, removing the beaver dam under these flow conditions would lower the lake level.

Under higher flow conditions the culverts are under inlet control, so removing a beaver dam would have less affect on lake levels. However, removing a beaver dam could keep the "base" lake level lower so that when high flows do occur the impact from high lake levels could be of a shorter duration (lake levels could return to the base level more quickly).

It is beyond the scope of this report to calculate how water levels would change if the beaver dams were removed. However, using the rough computer model based on creek cross sections at the culverts, removing the beaver dam at CR 669 and removing both culverts, the predicted change to lake levels is roughly 0.6' at flows of 70 cfs.

We do not have enough data to predict what would happen if the 4' dam were removed. However, if we assume the lower water would transfer all the way to CR 669 (lowering the tailwater by 4') then we predict the lake level would be about the same as current conditions when flows exceed 70 cfs. Again, if the 4' dam where removed, high lake levels would likely return to "normal" much more quickly.

OPTIONS

The overall hydrologic system is quite complex. A report prepared by the NPS in June 11, 2012 provides a very good summary of the system and is appended to this report for reference. Implementation of any option requires more in depth analysis, but the following general conclusions and options are offered for discussion. The attached table provides a summary of several options considered, the advantage/disadvantage each option brings, the expected impact to lake levels, and the relative cost to implement.

In summary, replacing the existing culverts with higher capacity culverts or a clear span bridge may not produce the desired lake level reduction unless it is coupled with some form of beaver dam control. Beaver dam control without culvert modifications will continue to produce high lake levels at flows near or above 70 cfs.

LITTLE TRAVERSE LAKE
SUMMARY OF FLOOD LEVEL CONTROL ALTERNATIVES

Alternative	Advantages	Disadvantages	Impact to Lake Levels	Relative Cost
No Action	- No cost	-Doesn't relieve flooding	0	none
1. Install additional culverts next to existing culverts (multi-tube)	- Lower cost - No change to low water level - mimics full width flow	- Doesn't dramatically reduce high water -Generally not preferred by MDEQ	0.4 feet lower at 70 cfs	lowest
2. Remove existing culverts and replace with higher capacity culverts	- Provides less high flow restriction - mimics full width flow - lower cost than bridge	- May lower "normal" lake level - Doesn't dramatically reduce high water	Lower lake levels by less than 0.6 feet	moderate
3. Remove existing culverts and replace with clear span bridge	- Provides no high flow restriction - Provides full width flow - highest cost	- May lower "normal" lake level - Doesn't dramatically reduce high water -Lake levels may still be impacted by beaver dams	Lower lake levels by approx. 0.6 feet	highest
4. Keep existing culverts but remove all beaver dam restrictions	- Lower cost - Lower lake levels during normal flow	- May lower "normal" lake level - High water level difficult to predict, but culverts will still impede flow during high flow period -Lake levels may still be impacted by beaver dams in future - Requires regulatory approval from NPS	Likely lower, but total change uncertain under low flow. Under high flow, lower lake level by a negligible amount	low
5. Replace all culverts with bridges and remove all beaver dam restrictions	- Provides no high flow restriction - Provides full width flow - highest cost	- May lower "normal" lake level - High water level difficult to predict -Lake levels may still be impacted by beaver dams in future - Requires regulatory approval from NPS	Greater than 0.5' at 70 cfs, maybe considerably more	highest

APPENDIX

- Overall Study Area Map
- System Profile Along Creek
- W. Traverse Lake Road Culvert Plan View
- Co. Road 669 Culvert Plan View
- Beaver Dam Plan View
- Lake Michigan Road Culvert Plan View
- W. Traverse Lake Road Culvert Water Surface Elevations – Spring 2013
- W. Traverse Lake Road Culvert Water Surface Elevations – Spring 2014
- Computer Outputs (8 pages)
- June 11, 2012 National Park Service Memo

OVERALL STUDY AREA

SCALE: 1"=1/4 MILE (1320 FT)

GoslingCzubak
engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603

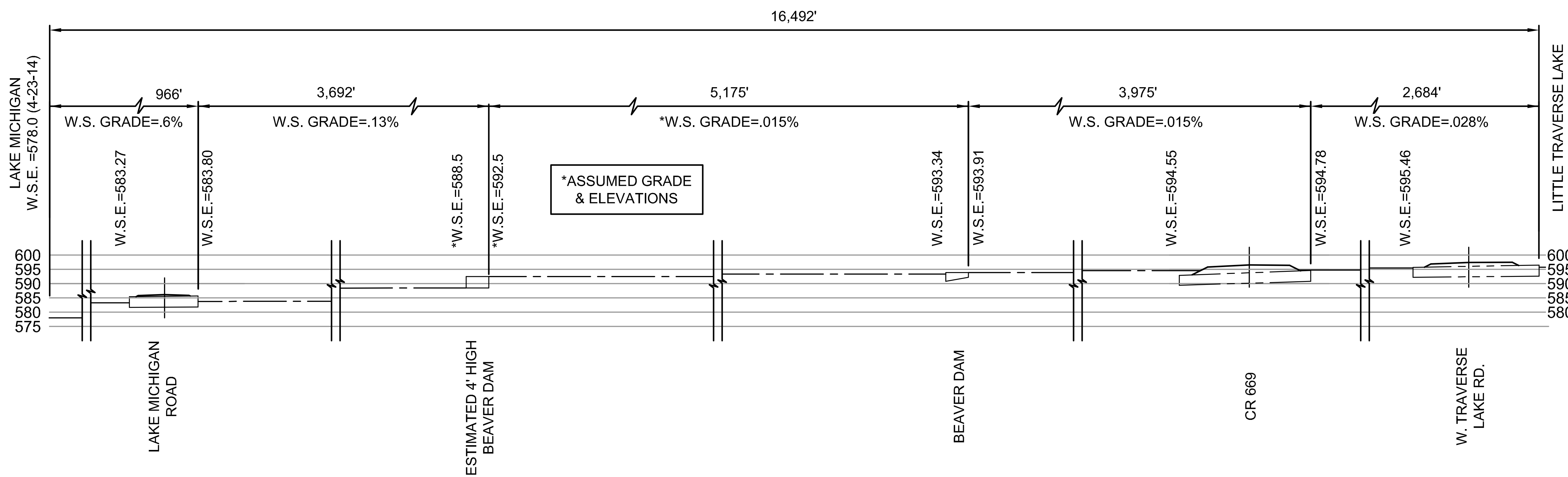
- Engineers
- Surveyors
- Environmental Services
- Landscape Architecture

Job #: 2014462.01
Date: 06-03-2014
Scale: AS NOTED
Drawn: RMV
Chk'd.: DAC
Rev.: 07-02-2014

OVERALL STUDY AREA
LITTLE TRAVERSE LAKE P.O.A.
CULVERT STUDY

Location:
SECTIONS 9 AND 10
T29N, R13W
CLEVELAND TOWNSHIP
LEELANAU COUNTY, MICHIGAN

Sheet 1



SYSTEM PROFILE ALONG CREEK

N.T.S.

P:\2014462.01\CADD-Data\201446201 Water Level Survey.dwg Tab: PROFILE Saved by: rmverschaeve 7/7/2014 3:39 PM Plotted by: Bob Verschaeve 7/7/2014 3:39 PM

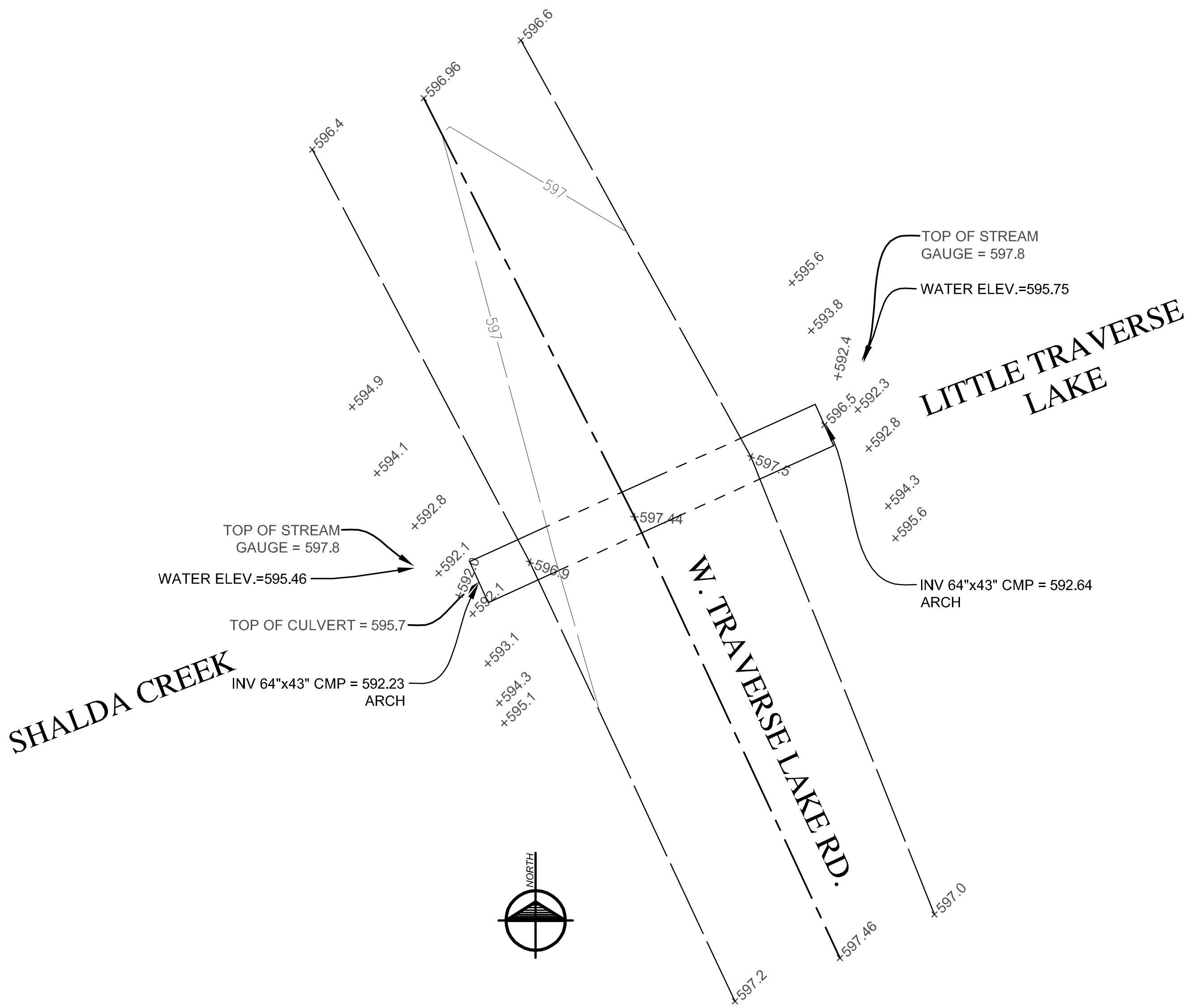
Gosling Czubak engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603
• Engineers
• Surveyors
• Environmental Services
• Landscape Architecture

Job #: 2014462.01
Date: 06-03-2014
Scale: N.T.S.
Drawn: RMV
Chk'd.: DAC
Rev.: 07-02-2014

SYSTEM PROFILE
LITTLE TRAVERSE LAKE P.O.A.
CULVERT STUDY

Location:
SECTIONS 9 AND 10
T29N, R13W
CLEVELAND TOWNSHIP
LEELANAU COUNTY, MICHIGAN

Sheet 2



W. TRAVERSE LAKE RD. CULVERT PLAN VIEW

SCALE: 1" = 20'

Client: Sheet 3

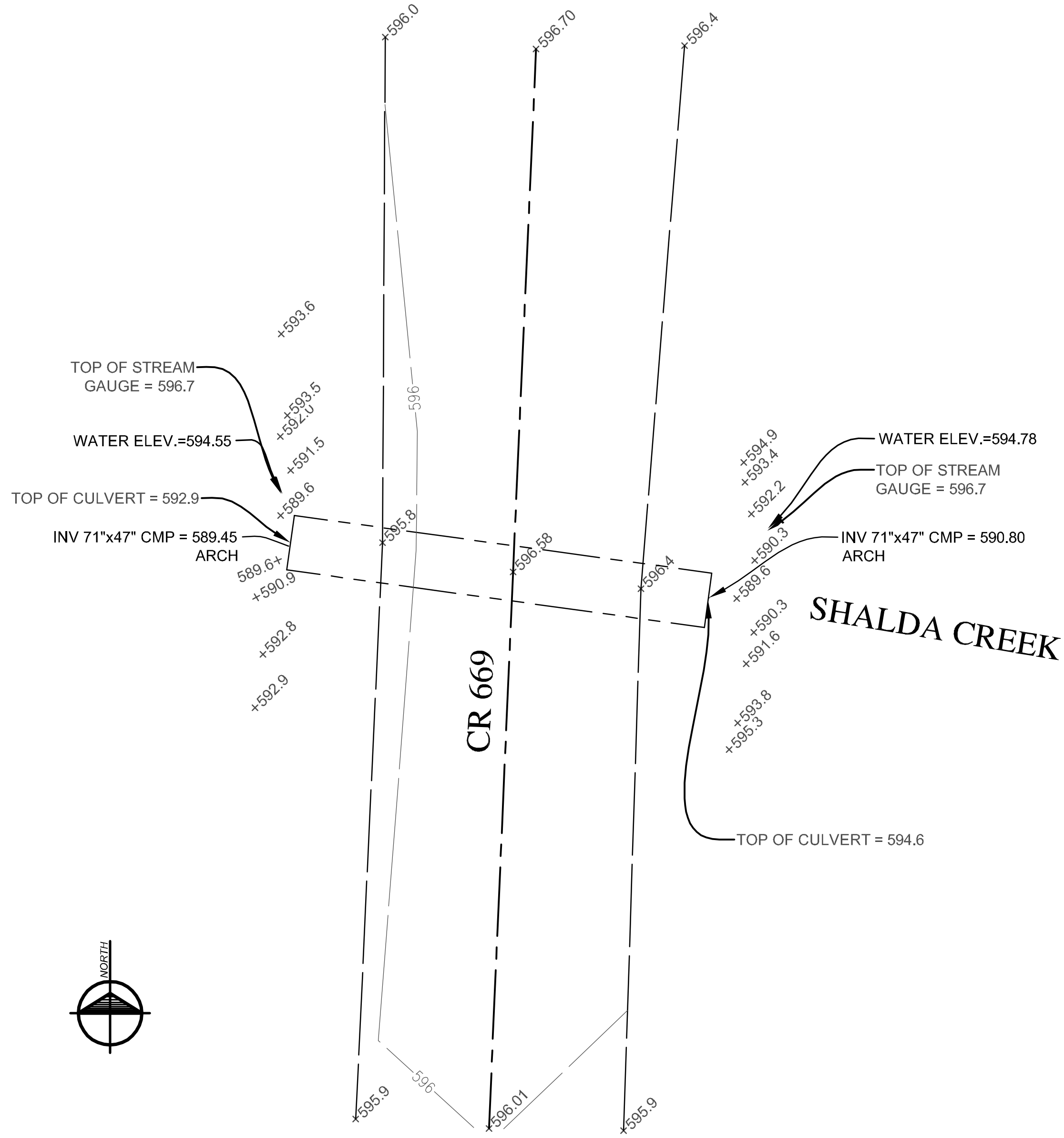
W. TRAVERSE LAKE RD. PLAN
LITTLE TRAVERSE LAKE P.O.A.

CULVERT STUDY

Job No.:	2014462.01
Date:	06-03-2014
Scale:	AS NOTED
Drawn:	RMV
Chk'd.:	DAC
Rev.:	

Gosling Czubak
engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603

- *Engineers*
- *Surveyors*
- *Environmental Services*
- *Landscape Architecture*



CO. RD. 669 CULVERT PLAN VIEW

SCALE: 1" = 20'

Client: Sheet 4

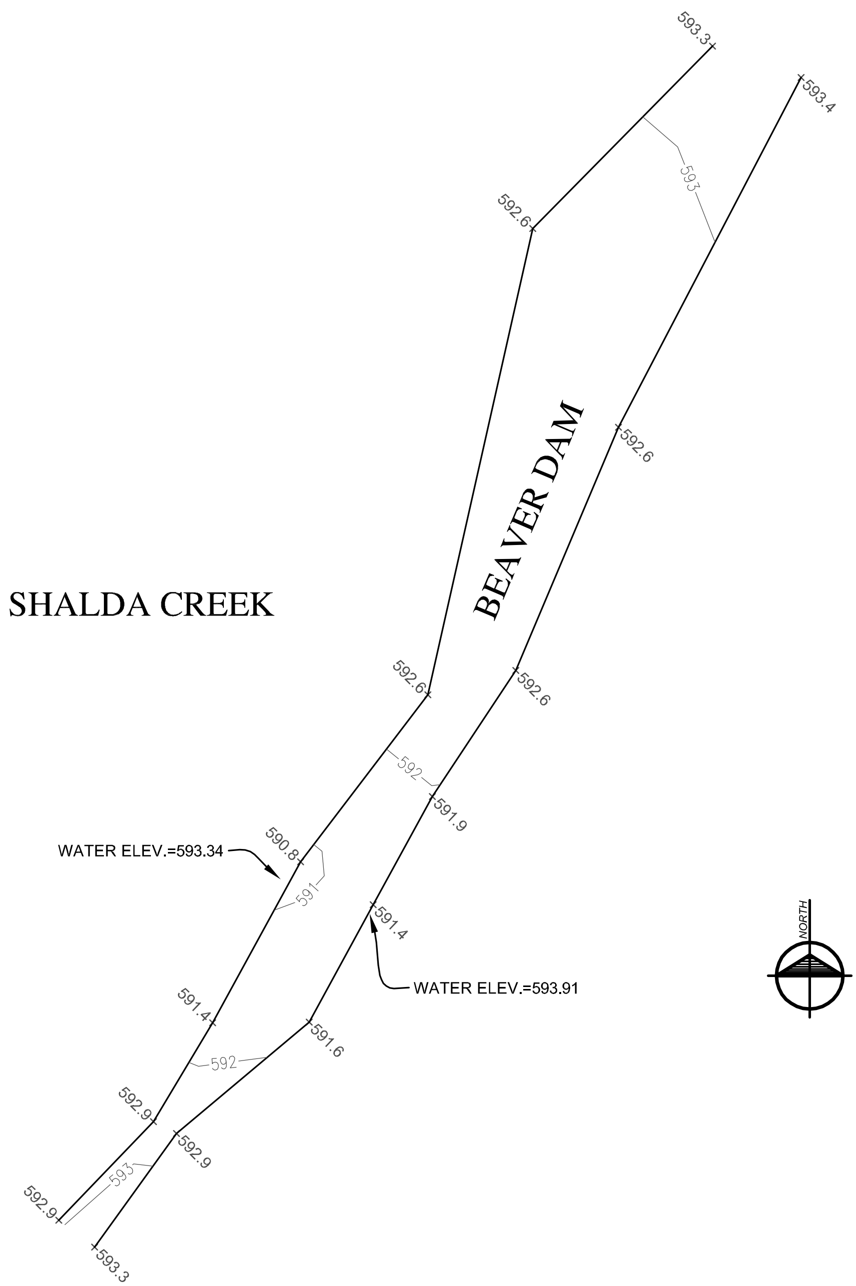
COUNTY ROAD 669 PLAN VIEW
LITTLE TRAVERSE LAKE P.O.A.

CULVERT STUDY

Job No.:	2014462.01
Date:	06-03-2014
Scale:	AS NOTED
Drawn:	RMV
Chk'd.:	DAC
Rev.:	

GoslingCzubak
engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603

- Engineers
- Surveyors
- Environmental Services
- Landscape Architecture



BEAVER DAM PLAN VIEW

SCALE: 1" = 20'

Client: Sheet 5

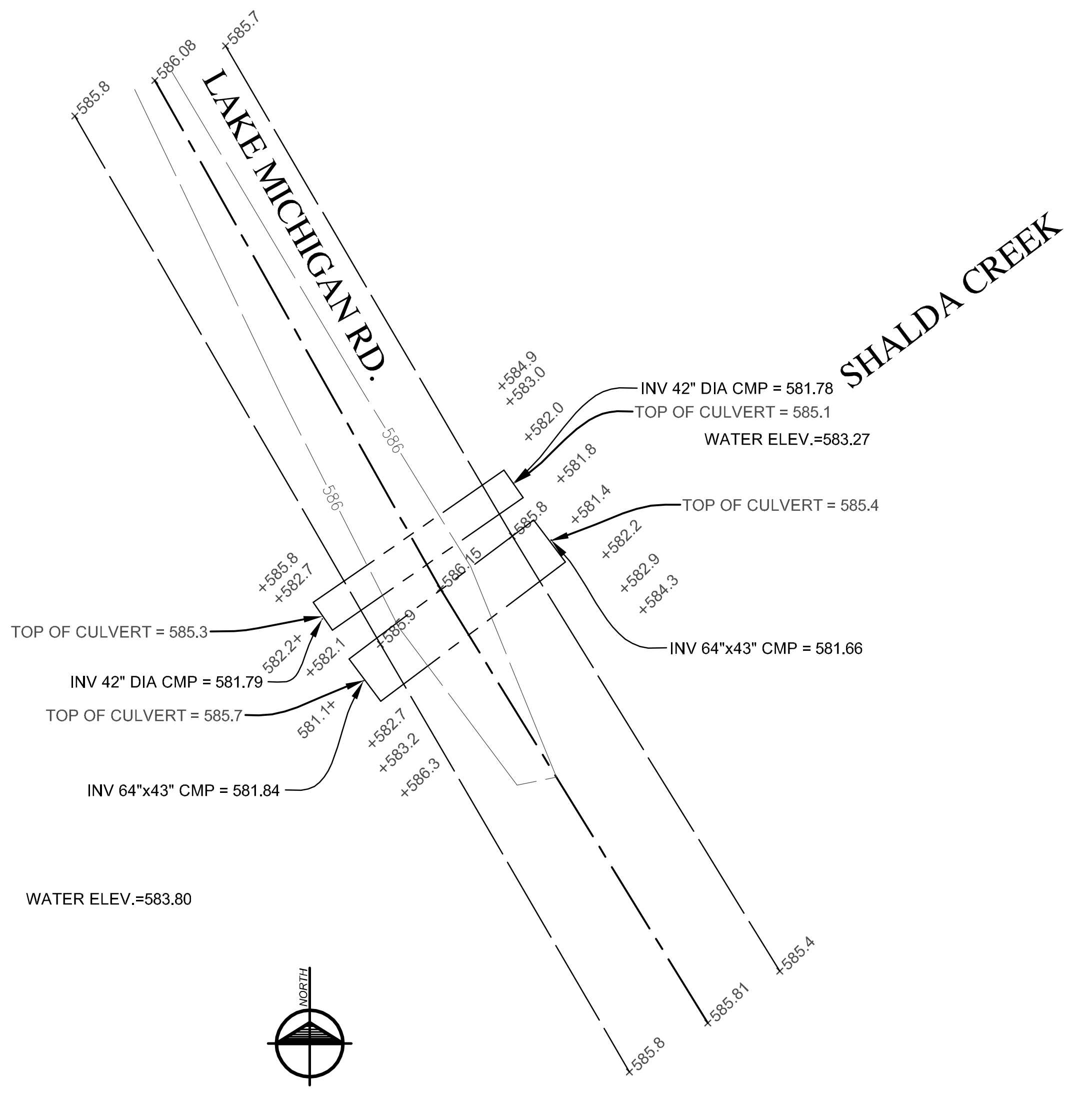
BEAVER DAM PLAN VIEW
LITTLE TRAVERSE LAKE P.O.A.

CULVERT STUDY

Job No.:	2014462.01
Date:	06-03-2014
Scale:	AS NOTED
Drawn:	RMV
Chk'd.:	DAC
Rev.:	

GoslingCzubak
engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603

- *Engineers*
- *Surveyors*
- *Environmental Services*
- *Landscape Architecture*



LAKE MICHIGAN RD. CULVERT PLAN VIEW

SCALE: 1" = 20'

Client: Sheet 6

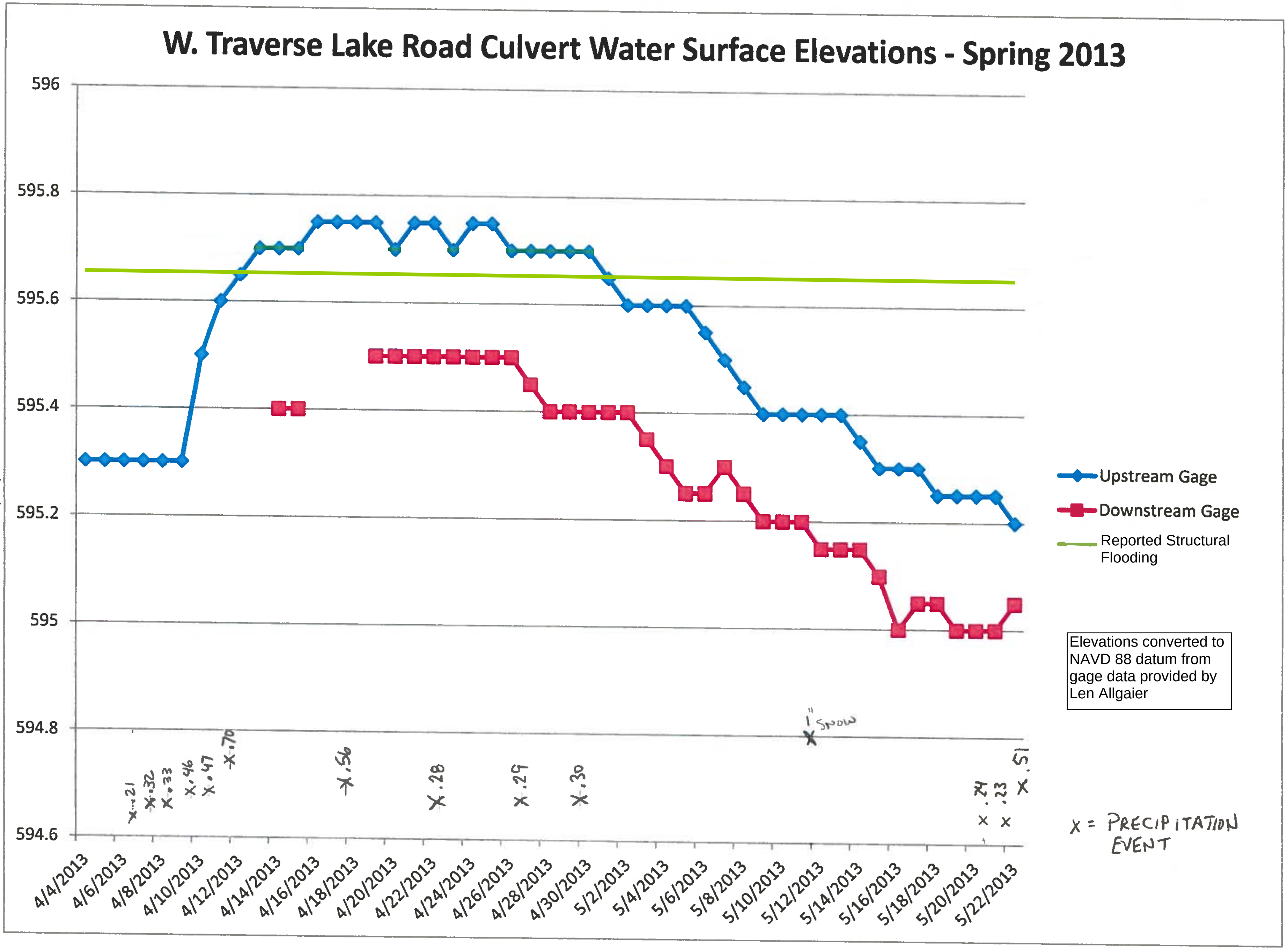
LAKE MICHIGAN RD. PLAN
LITTLE TRAVERSE LAKE P.O.A.

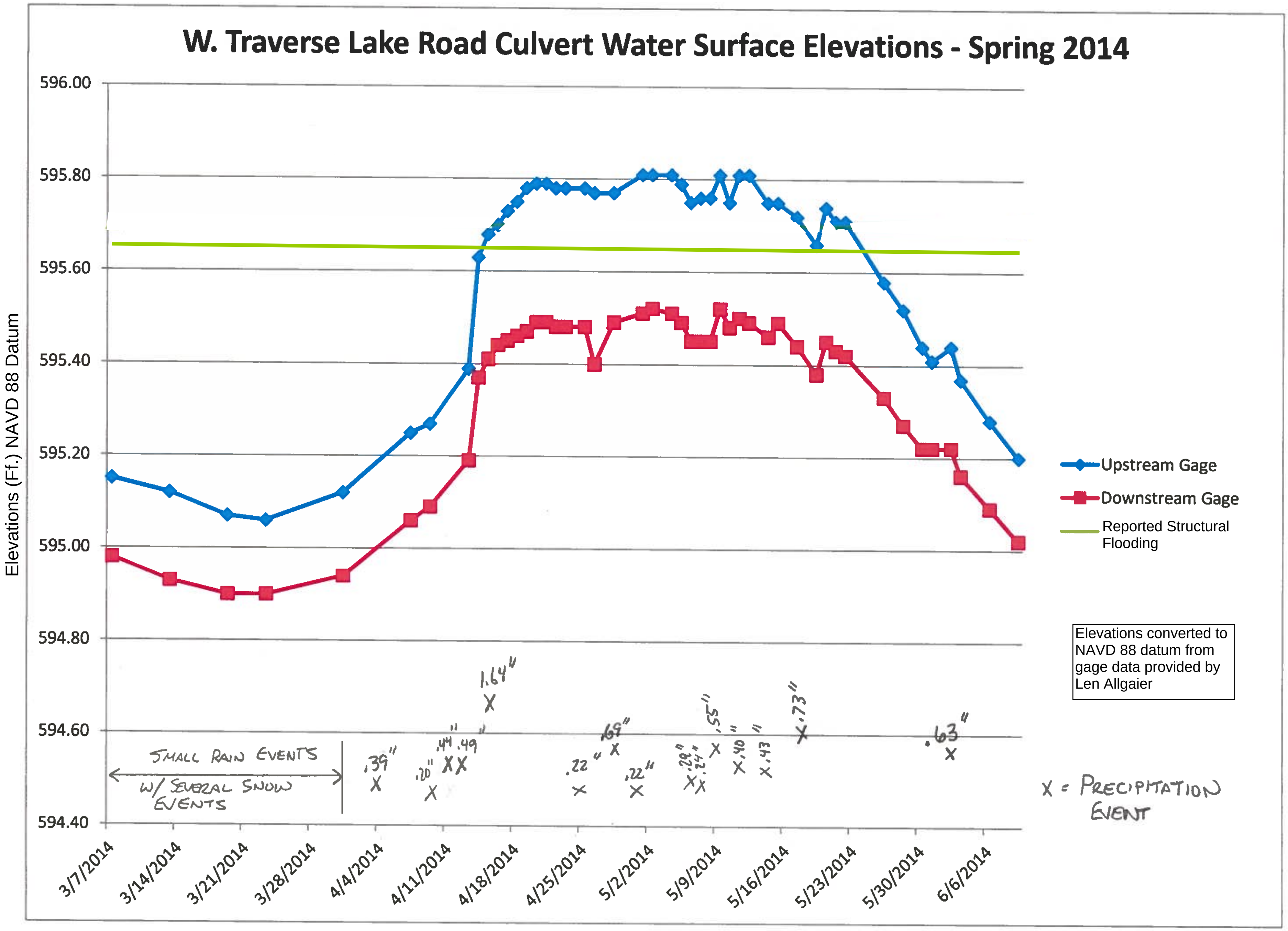
CULVERT STUDY

Job No.:	2014462.01
Date:	06-03-2014
Scale:	AS NOTED
Drawn:	RMV
Chk'd.:	DAC
Rev.:	

GoslingCzubak
engineering sciences, inc.
1280 Business Park Drive
Traverse City, MI 49686-8607
231-946-9191 800-968-1062
Fax: 231-941-4603

- *Engineers*
- *Surveyors*
- *Environmental Services*
- *Landscape Architecture*


W. Traverse Lake Road Culvert Water Surface Elevations - Spring 2013
Elevations (Ft.) NAVD 88 Datum
596
595.8
595.6
595.4
595.2
595
594.8
594.6
4/4/2013
4/6/2013
4/8/2013
4/10/2013
4/12/2013
4/14/2013
4/16/2013
4/18/2013
4/20/2013
4/22/2013
4/24/2013
4/26/2013
4/28/2013
4/30/2013
5/2/2013
5/4/2013
5/6/2013
5/8/2013
5/10/2013
5/12/2013
5/14/2013
5/16/2013
5/18/2013
5/20/2013
5/22/2013
Upstream Gage
Downstream Gage
Reported Structural Flooding
Elevations converted to NAVD 88 datum from gage data provided by Len Allgaier
1" snow
X = PRECIPITATION EVENT


W. Traverse Lake Road Culvert Water Surface Elevations - Spring 2014
Elevations (Ft.) NAVD 88 Datum
596.00
595.80
595.60
595.40
595.20
595.00
594.80
594.60
594.40
3/7/2014
3/14/2014
3/21/2014
3/28/2014
4/4/2014
4/11/2014
4/18/2014
4/25/2014
5/2/2014
5/9/2014
5/16/2014
5/23/2014
5/30/2014
6/6/2014
Upstream Gage
Downstream Gage
Reported Structural Flooding
Elevations converted to NAVD 88 datum from gage data provided by Len Allgaier
SMALL RAIN EVENTS
W/ SEVERAL SNOW EVENTS
X = PRECIPITATION EVENT
1.64"
.39"
.20"
.44"
.49"
.22"
.69"
.22"
.55"
.73"
.63"

Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Tuesday, Jul 15 2014

West Traverse Lake Road Culvert

Invert Elev Dn (ft)	= 592.23
Pipe Length (ft)	= 44.00
Slope (%)	= 0.93
Invert Elev Up (ft)	= 592.64
Rise (in)	= 43.0
Shape	= Elliptical
Span (in)	= 64.0
No. Barrels	= 1
n-Value	= 0.023
Culvert Type	= Horizontal Ellipse Concrete
Culvert Entrance	= Groove end projecting (H)
Coeff. K,M,c,Y,k	= 0.0045, 2, 0.0317, 0.69, 0.2

Embankment

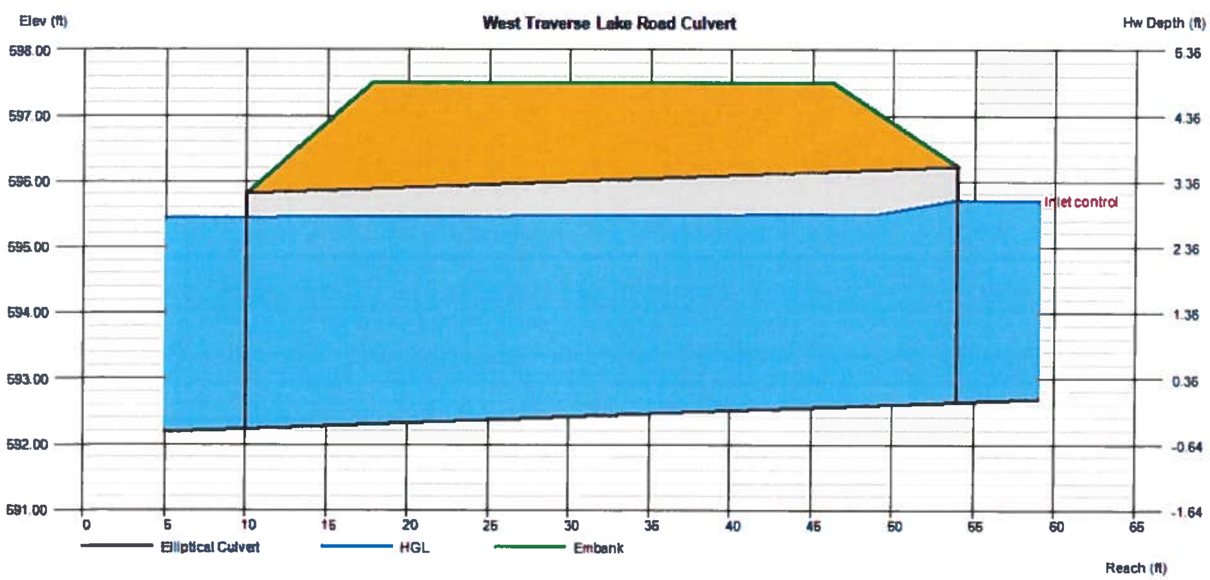
Top Elevation (ft)	= 597.50
Top Width (ft)	= 28.50
Crest Width (ft)	= 30.00

Calculations

Qmin (cfs)	= 10.00
Qmax (cfs)	= 200.00
Tailwater Elev (ft)	= 595.45

Highlighted

Qtotal (cfs)	= 60.00
Qpipe (cfs)	= 60.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.16
Veloc Up (ft/s)	= 4.59
HGL Dn (ft)	= 595.45
HGL Up (ft)	= 595.51
Hw Elev (ft)	= 595.71
Hw/D (ft)	= 0.86
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Tuesday, Jul 15 2014

West Traverse Lake Road Culvert

Invert Elev Dn (ft)	=	592.23
Pipe Length (ft)	=	44.00
Slope (%)	=	0.93
Invert Elev Up (ft)	=	592.64
Rise (in)	=	43.0
Shape	=	Elliptical
Span (in)	=	64.0
No. Barrels	=	1
n-Value	=	0.023
Culvert Type	=	Horizontal Ellipse Concrete
Culvert Entrance	=	Groove end projecting (H)
Coeff. K,M,c,Y,k	=	0.0045, 2, 0.0317, 0.69, 0.2

Embankment

Top Elevation (ft)	=	597.50
Top Width (ft)	=	28.50
Crest Width (ft)	=	30.00

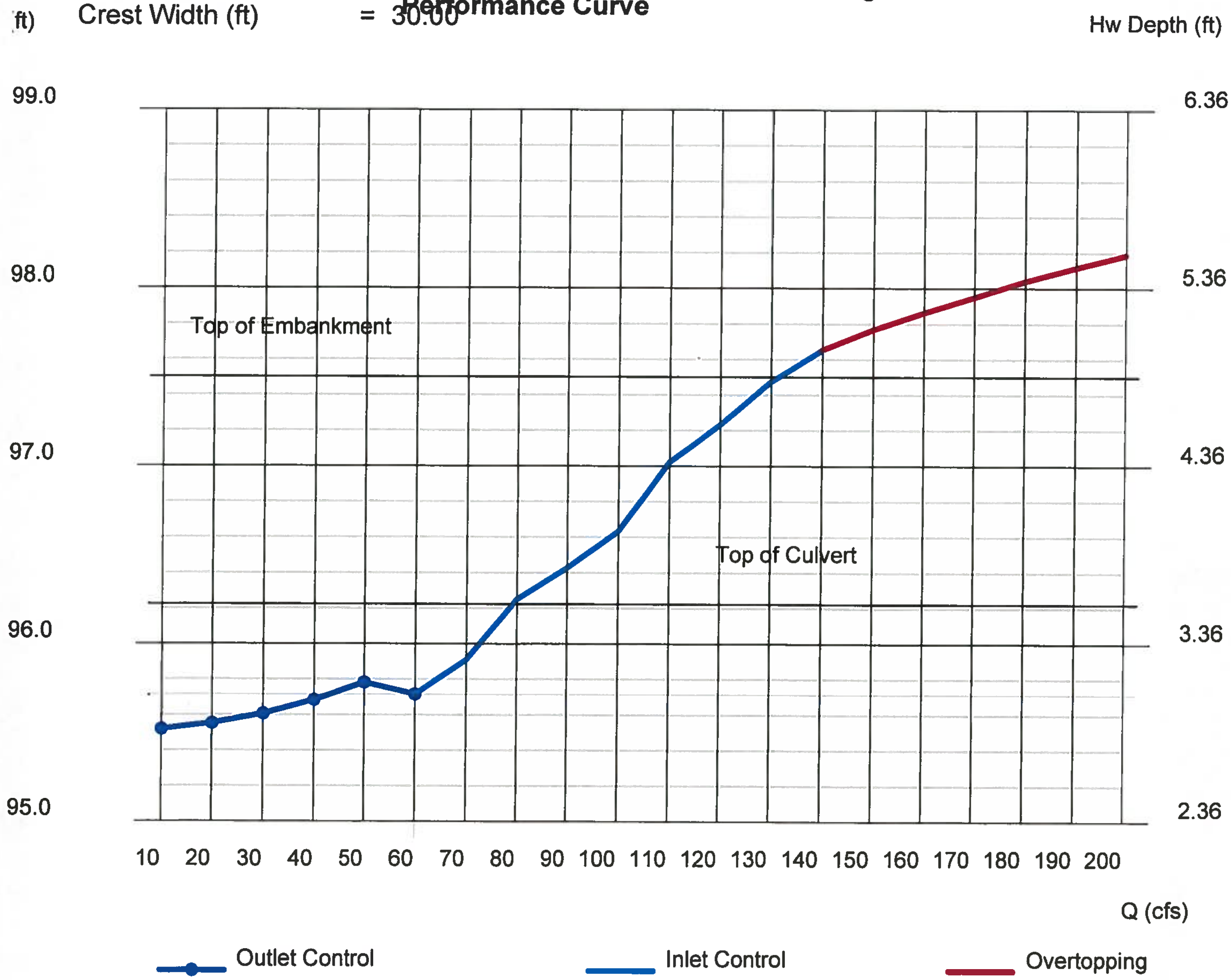
Calculations

Qmin (cfs)	=	10.00
Qmax (cfs)	=	200.00
Tailwater Elev (ft)	=	595.45

Highlighted

Qtotal (cfs)	=	60.00
Qpipe (cfs)	=	60.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	4.16
Veloc Up (ft/s)	=	4.59
HGL Dn (ft)	=	595.45
HGL Up (ft)	=	595.51
Hw Elev (ft)	=	595.71
Hw/D (ft)	=	0.86
Flow Regime	=	Inlet Control

Performance Curve



Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Tuesday, Jul 15 2014

County Road 669

Invert Elev Dn (ft)	= 589.45
Pipe Length (ft)	= 46.00
Slope (%)	= 2.93
Invert Elev Up (ft)	= 590.80
Rise (in)	= 47.0
Shape	= Elliptical
Span (in)	= 71.0
No. Barrels	= 1
n-Value	= 0.023
Culvert Type	= Horizontal Ellipse Concrete
Culvert Entrance	= Groove end projecting (H)
Coeff. K,M,c,Y,k	= 0.0045, 2, 0.0317, 0.69, 0.2

Embankment

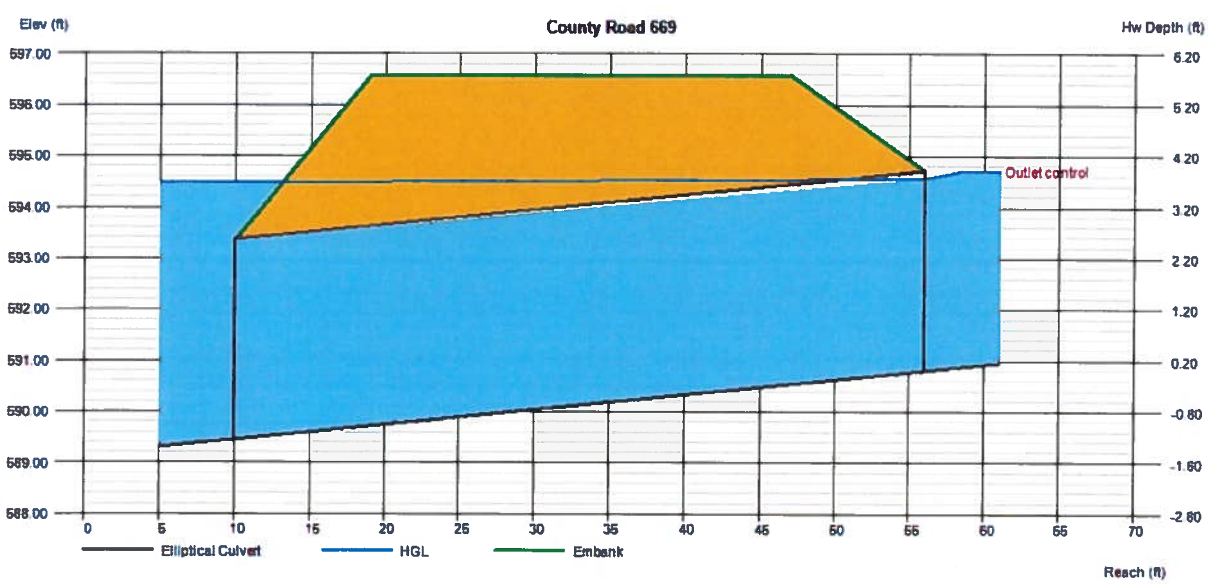
Top Elevation (ft)	= 596.58
Top Width (ft)	= 28.00
Crest Width (ft)	= 32.00

Calculations

Qmin (cfs)	= 10.00
Qmax (cfs)	= 200.00
Tailwater Elev (ft)	= 594.48

Highlighted

Qtotal (cfs)	= 50.00
Qpipe (cfs)	= 50.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 2.75
Veloc Up (ft/s)	= 2.79
HGL Dn (ft)	= 594.48
HGL Up (ft)	= 594.56
Hw Elev (ft)	= 594.71
Hw/D (ft)	= 1.00
Flow Regime	= Outlet Control



Culvert Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2012 by Autodesk, Inc. Tuesday, Jul 15 2014

County Road 669

Invert Elev Dn (ft)	=	589.45
Pipe Length (ft)	=	46.00
Slope (%)	=	2.93
Invert Elev Up (ft)	=	590.80
Rise (in)	=	47.0
Shape	=	Elliptical
Span (in)	=	71.0
No. Barrels	=	1
n-Value	=	0.023
Culvert Type	=	Horizontal Ellipse Concrete
Culvert Entrance	=	Groove end projecting (H)
Coeff. K,M,c,Y,k	=	0.0045, 2, 0.0317, 0.69, 0.2

Embankment

Top Elevation (ft)	=	596.58
Top Width (ft)	=	28.00
Crest Width (ft)	=	32.00

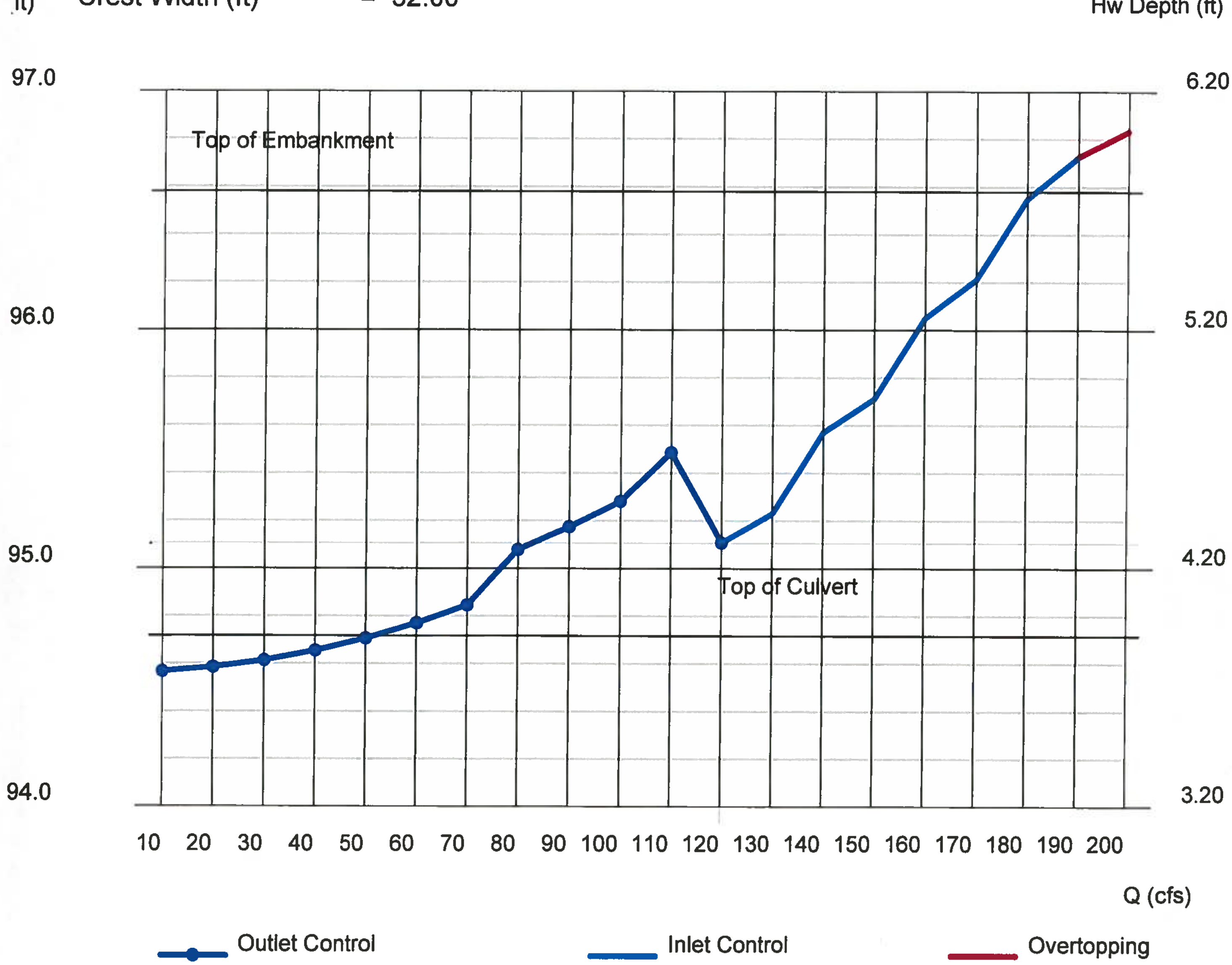
Calculations

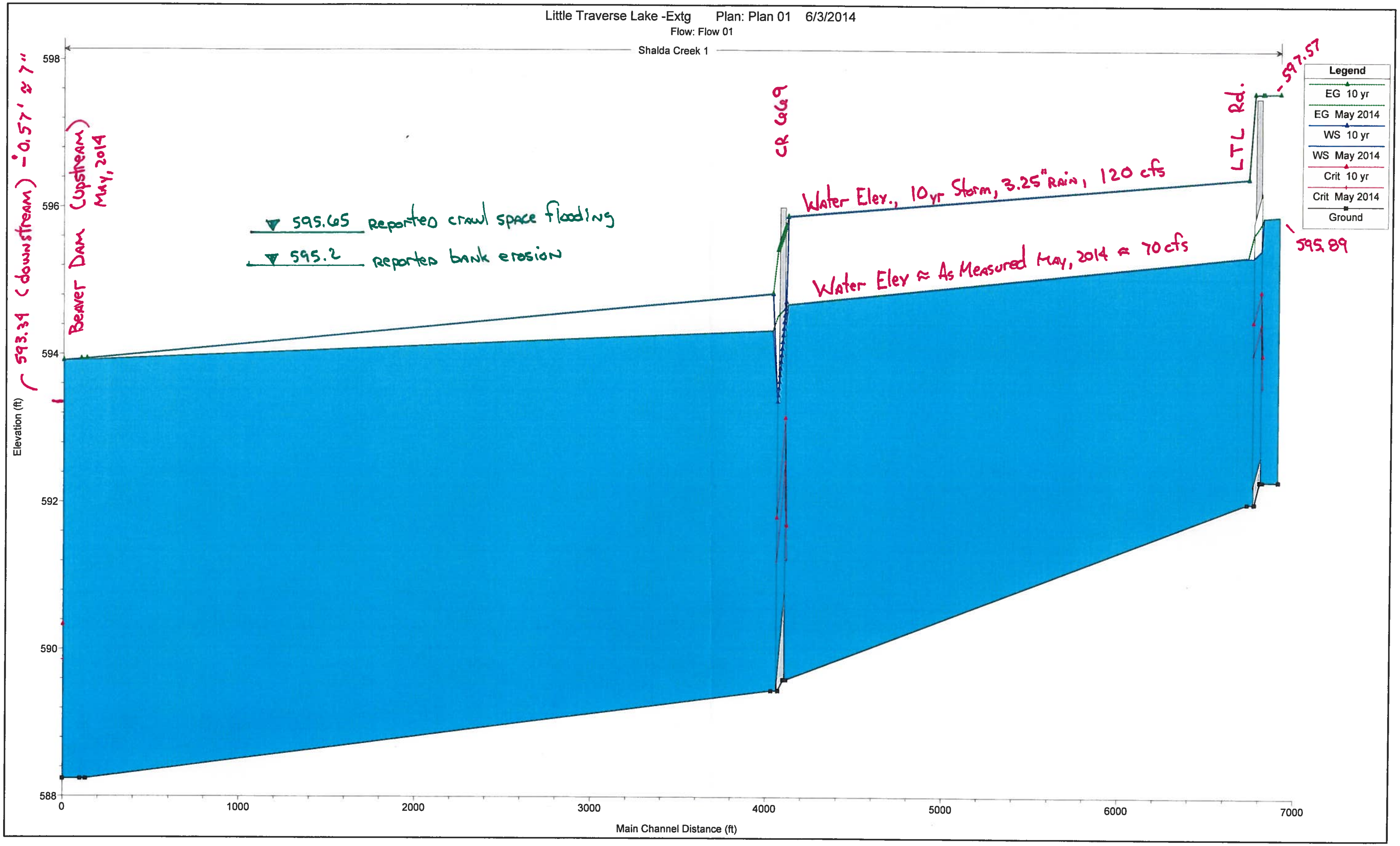
Qmin (cfs)	=	10.00
Qmax (cfs)	=	200.00
Tailwater Elev (ft)	=	594.48

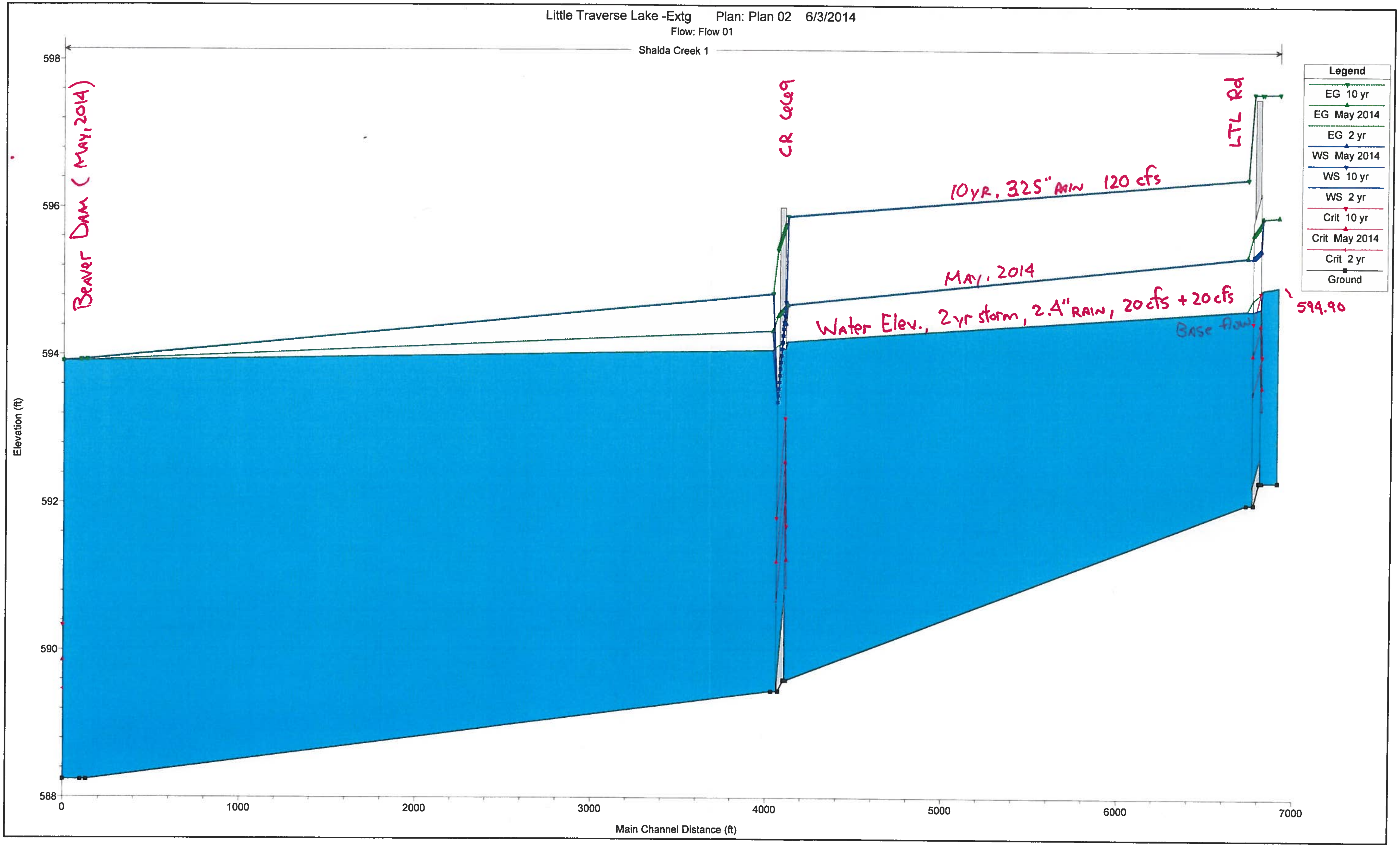
Highlighted

Qtotal (cfs)	=	120.00
Qpipe (cfs)	=	120.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	6.59
Veloc Up (ft/s)	=	6.59
HGL Dn (ft)	=	594.48
HGL Up (ft)	=	594.86
Hw Elev (ft)	=	595.11
Hw/D (ft)	=	1.10
Flow Regime	=	Inlet Control

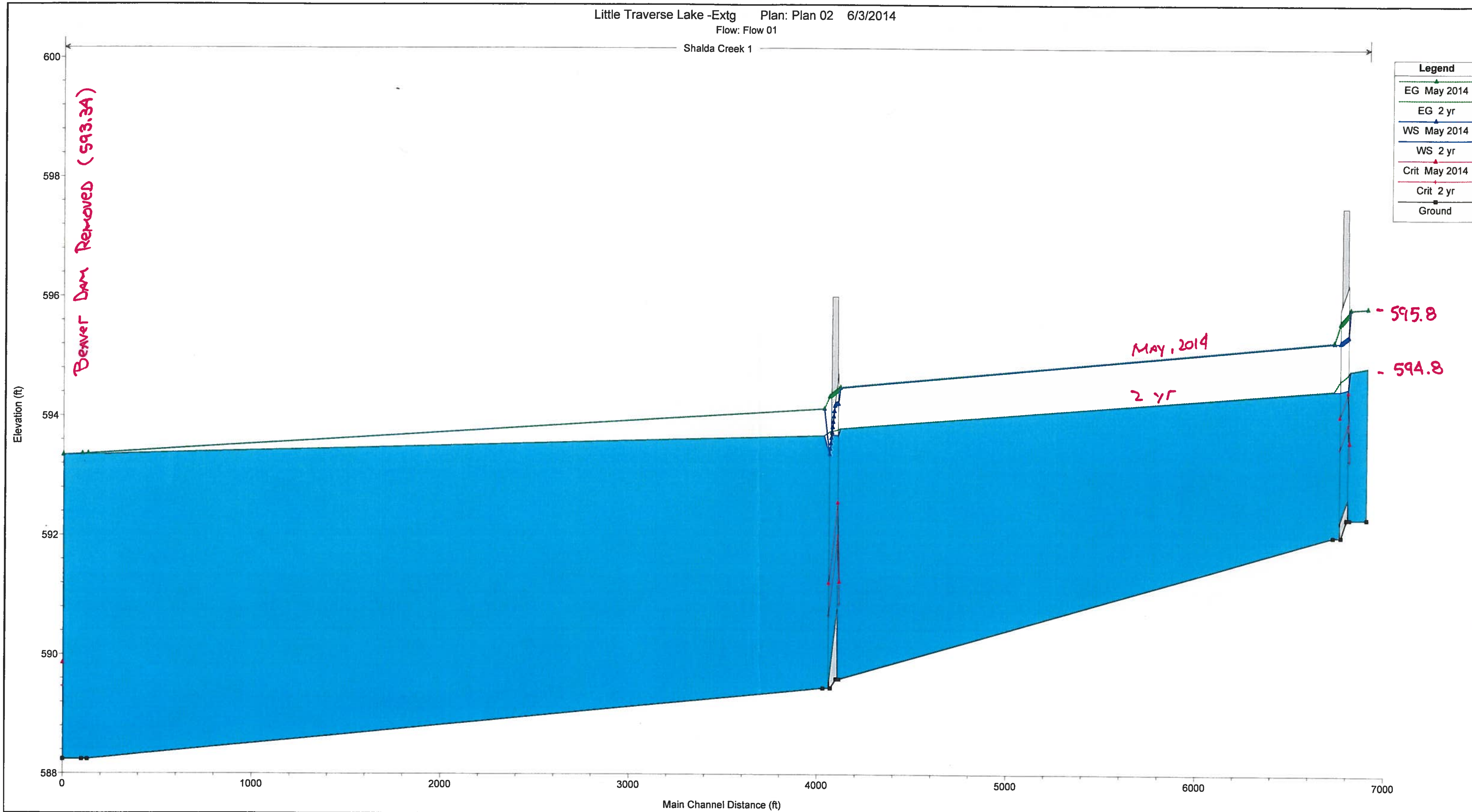
Performance Curve



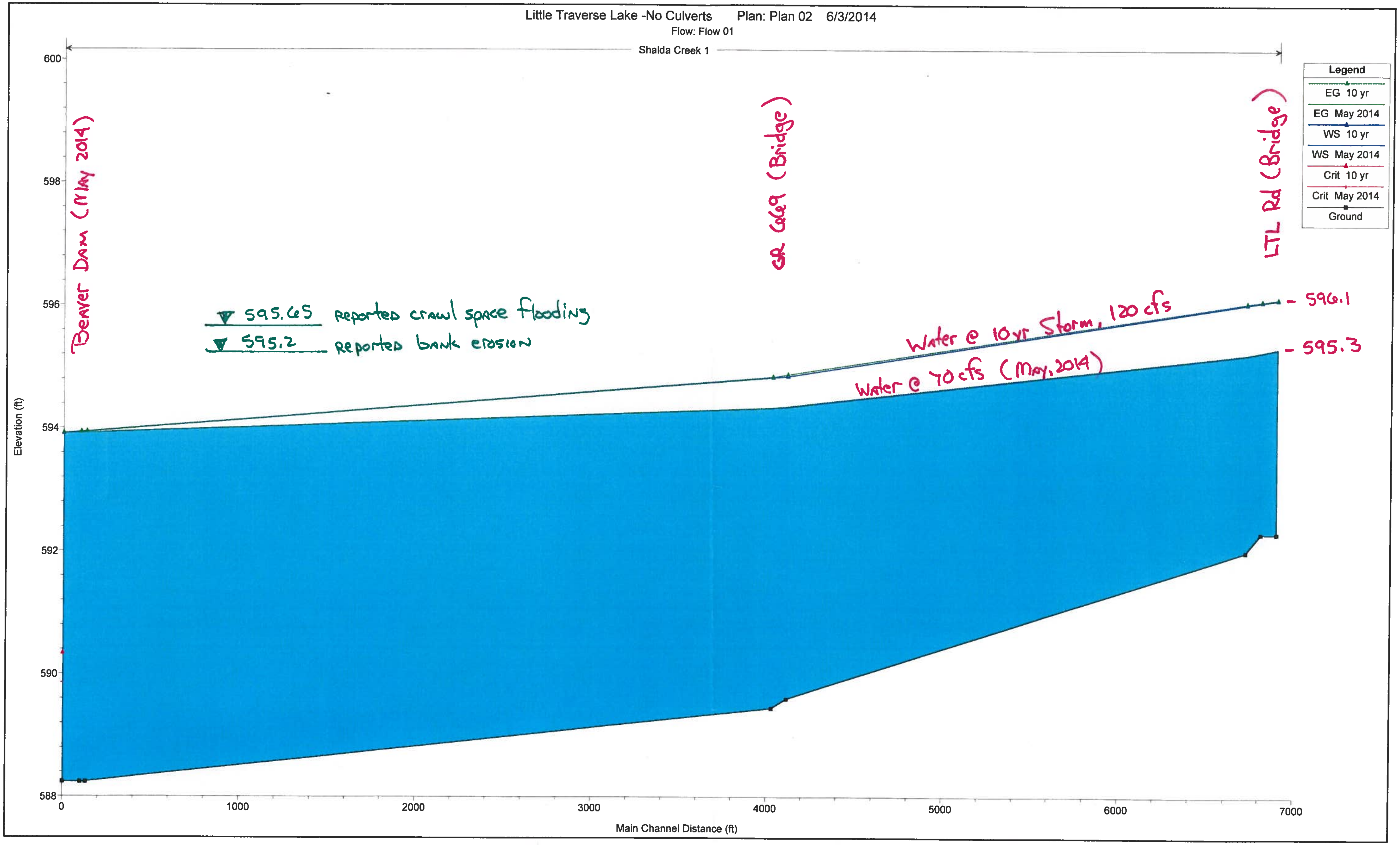

Little Traverse Lake -Extg Plan: Plan 01 6/3/2014
Flow: Flow 01
Shalda Creek 1
Legend
EG 10 yr
EG May 2014
WS 10 yr
WS May 2014
Crit 10 yr
Crit May 2014
Ground
Elevation (ft)
598
596
594
592
590
588
Main Channel Distance (ft)
0
1000
2000
3000
4000
5000
6000
7000
(593.34 (downstream) -0.57' ≈ 7"
Beaver Dam (upstream) May, 2014
595.65 Reported crawl space flooding
595.2 Reported bank erosion
CR 669
LTL Rd.
597.57
595.89
Water Elev., 10yr Storm, 3.25" Rain, 120 cfs
Water Elev ≈ As Measured May, 2014 ≈ 70 cfs



Little Traverse Lake -Extg Plan: Plan 02 6/3/2014
Flow: Flow 01
Shalda Creek 1
Legend
EG 10 yr
EG May 2014
EG 2 yr
WS May 2014
WS 10 yr
WS 2 yr
Crit 10 yr
Crit May 2014
Crit 2 yr
Ground
Elevation (ft)
Main Channel Distance (ft)
598
596
594
592
590
588
0
1000
2000
3000
4000
5000
6000
7000
Beaver Dam (May, 2014)
CR 669
LTL Rd
10YR, 3.25" RAIN 120 cfs
MAY, 2014
Water Elev., 2yr storm, 2.4" RAIN, 20cfs + 20cfs
Base flow
594.90



Little Traverse Lake -Extg Plan: Plan 02 6/3/2014
Flow: Flow 01
Shalda Creek 1
Legend
EG May 2014
EG 2 yr
WS May 2014
WS 2 yr
Crit May 2014
Crit 2 yr
Ground
Elevation (ft)
Main Channel Distance (ft)
600
598
596
594
592
590
588
0
1000
2000
3000
4000
5000
6000
7000
Beaver Dam Removed (593.34)
May, 2014
2 yr
- 595.8
- 594.8



Little Traverse Lake -No Culverts Plan: Plan 02 6/3/2014
Flow: Flow 01
Shalda Creek 1
Legend
EG 10 yr
EG May 2014
WS 10 yr
WS May 2014
Crit 10 yr
Crit May 2014
Ground
Elevation (ft)
600
598
596
594
592
590
588
0
1000
2000
3000
4000
5000
6000
7000
Main Channel Distance (ft)
Beaver Dam (May 2014)
CR 669 (Bridge)
LTL Rd (Bridge)
595.65 reported crawl space flooding
595.2 reported bank erosion
Water @ 10yr Storm, 120 cfs
Water @ 70 cfs (May, 2014)
- 596.1
- 595.3

United States Department of the Interior

NATIONAL PARK SERVICE
Water Resources Division
1201 Oakridge Drive, Suite 250
Fort Collins, Colorado 80525

IN REPLY REFER TO:
L54(2380)
MWR/SLBE

June 11, 2012

Memorandum

To: Dusty Shultz, Superintendent, Sleeping Bear Dunes National Lakeshore (SLBE)

Through: Gary Rosenlieb, Acting Chief, Water Resources Division (WRD)

From: Mike Martin, Hydrologist (WRD)

Subject: Hydraulic Assessment of Little Traverse Lake and Shalda Creek, December 7–9, 2011

Purpose

The primary purpose of this report is to identify and describe possible reasons for elevated lake levels in Little Traverse Lake. Additionally, we provide several approaches for quantifying the causes of these elevated levels.

Problem Statement

Little Traverse Lake (LTL), a privately owned lake located just upstream from the SLBE boundary, has experienced relatively high lake levels over the past year or so. The elevated levels, which are reported to be about 6 to 12 inches over "normal," may negatively affect some of the riparian landowners, and therefore concerns have been raised by these local residents. One perceived cause of the higher-than-normal lake levels is downstream beaver activity, specifically, dam building in the downstream reaches of the creek that drains the lake. However, there are other conditions associated with the lake/stream system that could cause elevated lake levels. The goal of this report is to identify and describe possible causes of the observed lake levels based on site reconnaissance and provide recommendations for future management decisions.

While the entire perimeter of Little Traverse Lake is in private ownership, almost all of the downstream drainage, Shalda Creek, is owned by SLBE. Consequently, any actions along the creek undertaken to affect the lake level must be in accordance with NPS management objectives and dependent on the approval and cooperation of SLBE.

Setting

LTL is a relatively large interdunal lake that is primarily fed by rainfall runoff and maintained by a high water table. As mentioned, LTL drains directly into Shalda Creek, which is almost entirely in park ownership. This perennial creek flows predominantly west and north for about three miles before entering Lake Michigan less than one mile to the north. The overall terrain in this area is referred to as dune–swale topography with the local drainages primarily occupying the interdunal low areas separated by vegetated dunal uplands. This type of topography places strong control on stream channel alignment, forcing it to wind through the swales that separate the topographic highs. As a result, the eight foot drop along Shalda Creek between LTL and Lake Michigan occurs over a three-mile distance resulting in a channel gradient of less than 0.06%. In fact, the actual flowpath gradient is much less due to the meandering nature of the channel.

Additionally, there are two biological elements that further reduce the flowpath gradient, at least locally. One of these elements is the presence of extensive aquatic and wetland vegetation that occupies broad areas of the channel margins (figures 1 and 2). Another element is the previously mentioned beaver activity, which periodically creates small dams that locally raise the water surface elevation and "flatten" the energy grade.

Lastly, there is another set of physical features present along the creek that also affect water surface elevations: culverted road crossings. Two roads cross Shalda Creek within about 2,500 feet downstream of LTL, both crossings providing flow conveyance through corrugated metal pipe culverts, with one of these roads located immediately downstream from LTL (figure 1).

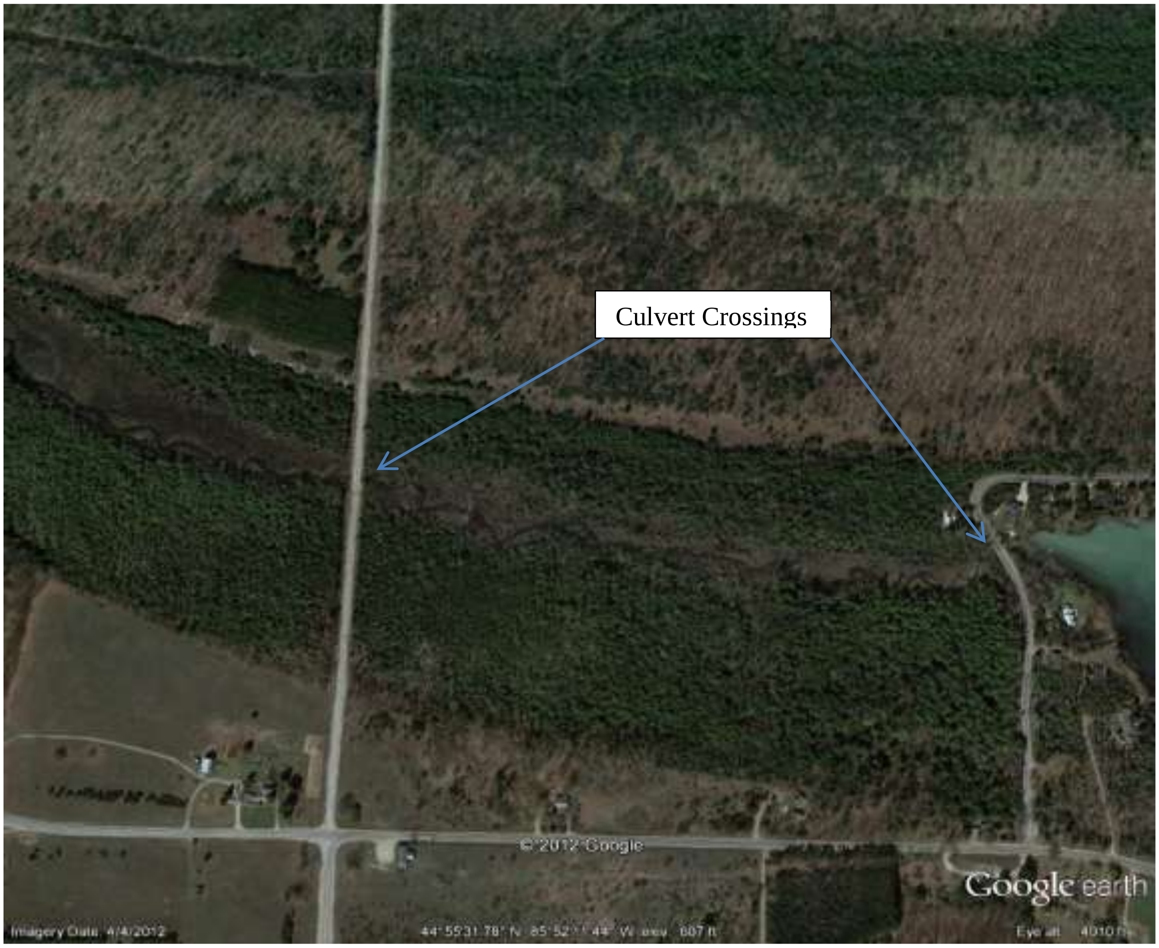


Figure 1. Google earth image of Shalda Creek immediately downstream of Little Traverse Lake, which is visible in the right of the image. Note the sinuosity of the channel and the relatively broad floodplain that supports extensive wetland vegetation visible as a brownish-grey corridor through the dark green upland timber.

Discussion
There are five points that we would like to discuss regarding these lake levels and flow conditions on Shalda Creek:

(1) the channel of Shalda creek is very low gradient due to the surrounding terrain;
(2) extensive wetland environments exist on the margins of the creek creating broad reaches of reduced hydraulic conveyance;
(3) the culvert crossing immediately downstream from LTL represents a substantial constriction in the natural stream channel and certainly adds to elevated lake levels, especially during times of high inflow into the lake;
(4) beaver dams create local areas of lowered channel gradient and backwater conditions for some distance upstream; and
(5) higher than normal precipitation input may be at least part of the reason for the observed lake levels.

During the site visit we carefully examined the two culverts downstream from LTL, the stream channel and overbanks, and the beaver dams that we were able to access from the shore. Additionally, we also measured the water surface drop across the culvert that drains LTL using an optical transit. The results of these measurements follow.

Stream channel conditions
As mentioned, Shalda Creek has a very low gradient due to the tortuous route through the dune and swale topography that is present on the lakeshore. This low channel gradient, along with other physical conditions has allowed the formation of prolific wetlands to flourish on the margins of, and within, the channel (figures 1 and 2). Immediately downstream from the outlet of LTL, the greater floodplain is as much as 120 feet wide in places, while the channel ranges from about 20 to 30 feet wide. During periods of elevated discharge, flow accesses these overbank areas, however, the conveyance is not very efficient due to the prolific aquatic vegetation, which provides a great deal of flow resistance and hydraulic roughness, lowering the energy grade and adding to any backwater effect already present.

Figure 2. View of Shalda Creek immediately downstream from the LTL culvert. Note the extensive stands of aquatic/wetland vegetation present on both sides of the channel (NPS 2011).

From a natural resource standpoint, this type of well-vegetated riverine riparian system is very desirable and provides diverse habitat, flood storage and attenuation, as well as water quality maintenance. Conversely, from an efficiency of flow standpoint, these channel conditions provide minimal flow conveyance and may result in substantial backwater conditions, especially during periods of higher flow. Additionally, given the overall low gradient of the channel, resulting backwater conditions may extend a substantial distance upstream. With that, anything that causes a flow restriction or raises the water surface, such as road crossings or beaver dams, can add to this backwater effect, increasing the elevation of the water surface in an upstream direction, possibly for a considerable distance.

Culvert Crossings

As mentioned, there are two culvert crossings within about 2,500 feet of LTL, one of which is immediately downstream of LTL. Given the constriction that occurs through this crossing, it is very likely that this particular culvert has a substantial effect on the lake level of LTL, especially during periods of greater inflow to the lake. More specifically, if the rainfall-runoff inputs into the lake exceed the potential outflow of the culvert, then the lake level will rise and will remain elevated until the culvert outflow compensates for the extra hydrologic inputs through time. In the case of this condition, there should be a measurable drop through the culvert from the upstream to the downstream end. During the site visit, we measured such a drop of about 0.1 feet indicating that there is some retention of hydraulic head above the culvert and some degree of flow restriction from LTL. However, the very small difference in water surface elevations across the culvert suggests that there may also be a backwater condition affecting this culvert from downstream, or possibly, a function of the very low gradient channel.

Beaver Dams

As mentioned, the construction of beaver dams along Shalda Creek may raise the water surface in the immediate upstream area of the dam. This backwater effect is proportional to the effective height of the dam and may translate for a considerable distance upstream in this low gradient environment.

To identify beaver dams that might affect the outlet of LTL, we reconnoitered several hundred feet downstream but were unable to locate any beaver dams in that distance. However, more recently, satellite imagery collected in April 2012 shows a cross-channel obstruction that is about 800 feet downstream from LTL that could be a beaver dam (figure 3). Careful inspection of the image suggests evidence of an associated backwater for some distance upstream of the supposed beaver dam. Specifically, a greater width of flow in the main channel upstream of the feature and side channels that appear flooded for an upstream distance of about 500 feet. Interestingly, these effects do not appear to extend to the reach just downstream from LTL.

An example of backwater conditions resulting from a beaver dam is evident at the crossing on County Road 669. At this location, a raised water level due to a small, downstream beaver dam has completely flooded the culvert on both the upstream and downstream sides. However, as mentioned, the culvert immediately downstream from LTL is not completely flooded.

Higher than normal hydrologic inputs

Another possible reason that lake levels in LTL are somewhat higher than normal may have nothing to do with the creek channel. As pointed out, the constriction of the culvert outlet will restrict outflow and if rainfall-runoff input exceeds the culvert outflow the lake level will rise. There are anecdotal reports of higher than average precipitation in the year preceding our site visit. A rigorous analysis of local precipitation records was beyond the scope of this assessment, and even if completed, may not provide unequivocal proof of greater than “normal” hydrologic inputs. The extreme spatial variability of precipitation coupled with the relatively sparse distribution of precipitation gauges, may not capture the true amount of input into LTL. However, such an analysis could provide general information regarding regional precipitation trends. A wetter-than-average period for the region could not only provide more input into LTL but could also raise local water tables, which ultimately translate into elevated lake levels.

Figure 3. Google earth image from 4/4/2012 of Shalda Creek for about 750 feet downstream of LTL (just east of the road). Features to note include a presumed beaver dam and evidence of the resulting backwater effect: a relatively wide main channel and flooded side channels. Also note the relatively narrow main channel and the apparent lack of flooded side channels immediately downstream from LTL.

Recommendations

Examination of the stream/lake system during the site visit did not yield a conclusive explanation for the observed lake levels. Rather, it appears that there may be a number of contributing factors. It is not clear which elements of the stream system are having the greatest effect on observed lake levels, but it could very well be a combination of higher than average hydrologic input coupled with the physical features that reduce conveyance in the system (extensive side-channel wetlands, beaver dams, and culverts, specifically the one directly downstream of LTL).

One approach that could determine the overall effect of a particular dam on lake levels would be to conduct a simple removal experiment and monitor associated changes in lake level, if any occur. Specifically, park staff could remove the closest beaver dam in the downstream direction from the outlet of LTL. Both the approximate distance from the culvert to the beaver dam, and more importantly, the approximate drop of the water surface across the dam should be recorded. Immediately after removal, water surface elevations should be measured at the outlet culvert to LTL, both above and below the culvert. This may be easily accomplished using a steel tape and measuring down from the rim of the culvert to the water surface. With this simple assessment, park staff may be able to quantify and document the specific affect that a downstream dam has on lake levels in LTL. However, we recognize that this is an invasive procedure and may conflict with natural resource management goals. Furthermore, this proposed experiment does not represent a viable treatment as it would require constant manipulation of the natural conditions associated with Shalda Creek.

Another approach that could help assess the effect of a particular dam on lake levels would be to complete a very accurate survey of the difference in elevation between the lake surface and the immediate downstream dam. This information would not determine the magnitude of the effect on lake level from the dam, but would determine the amount of elevational drop between the two and allow calculation of the hydraulic gradient. Qualitatively, a large elevational difference would suggest little possibility of effect while a small elevational difference would suggest a greater possibility.

Other more complex approaches such as hydraulic modeling of water surfaces could be attempted, however, such studies would be expensive, difficult, and would not necessarily answer the question beyond any doubt.

Lastly, as mentioned, a rigorous analysis of local/regional precipitation trends would provide background information for assessing possible causes of elevated lake levels.

WRD staff will be available for ongoing consultation regarding any aspect of this issue.

cc: (by e-mail only)
2380–Rosenlieb, Smillie, Enck (file);
SLBE–Ulrich, Flaugh, Otto;
MWR–Cummings