Dam Failure Analysis

(Final)

Olivotti Lake Dam

Lincoln County, Wisconsin

Report prepared for

Houle Enterprises, LLC

Oshkosh, Wisconsin

Report prepared by

Mead & Hunt

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1. Executive Summary

Houle Enterprises, LLC retained Mead & Hunt, Inc. (Mead & Hunt) to perform a Dam Failure Analysis for the Olivotti Lake Dam in accordance with the Wisconsin Administrative Code Chapters NR 116 – Wisconsin's Floodplain Management Program, and NR 333 – Dam Design and Construction, as well as the Wisconsin Department of Natural Resources (WDNR)'s *Waterway and Wetland Handbook*. The analysis was performed at the request of the State of Wisconsin because the dam has never been permitted or authorized by the WDNR, and therefore a dam failure analysis has never been done for the dam to assess the downstream hazard and assign a hazard rating.

This report describes the dam failure analysis performed to develop the inundation maps at the Mukwonago Dam. The analysis included the following tasks.

- Review of the hydrologic calculations performed by the WDNR for the dam.
- Gathering the necessary topographic data from Lincoln County for the land within the vicinity of Olivotti Lake and downstream of the dam.
- Gathering and reviewing the survey data collected by Houle Enterprises for the dam site and roadways downstream of the dam.
- Developing the Hydrologic Engineering Center's River Analysis System (HEC-RAS) model for the hydraulic shadow (dam failure), dam in place (no failure), and dam nonexistent (no dam) conditions for the 100-year flood event.
- Developing breach parameters for a sensitivity analysis of the hydraulic shadow (dam failure) condition.
- Developing inundation maps for the hydraulic shadow (dam failure), dam in place (no failure), and dam nonexistent (no dam) conditions.

This dam failure analysis was performed to define the limits of potential downstream impacts if the dam were to fail during the 100-year flood event. The study does not analyze the potential for migration of sediment, nor does it analyze the environmental impacts of displaced sediment or release of the reservoir. These topics are beyond the scope of this study.

2. Project Description

The Olivotti Lake Dam is owned, operated, and maintained by the Girl Scouts of the Northwestern Great Lakes, Inc. The lake and dam in part make up the Camp Birch Trails facility located 10 miles north of Merrill, Wisconsin. The dam consists of a 200-foot-long, 15-foot-high earth embankment and a primary spillway that consists of an open channel that leads to a fabricated metal weir structure. The spillway is detached from the earth embankment and located approximately 800 feet to the southwest of the right abutment. It discharges into a small stream that routes it through a culvert under an access road and discharges into the wetlands downstream of the embankment dam.

The crest elevation of the embankment dam varies, but its lowest point is at elevation 1481.20.[1] The spillway's sharp-crested weir has a crest elevation of 1478.50, which is 1.0 feet below the normal pool elevation of 1479.50. The top of the spillway wingwalls are at an elevation of 1480.6. Since the top of the spillway wingwalls are below the crest of the embankment dam, the wingwalls could be overtopped and act like a sharp-crested weir prior to the embankment dam being overtopped. Drawings of the dam are located in Appendix B.

[1] Elevations in this report are in feet and referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29)

3. Spillway Hydraulic Capacity

The hydraulic capacity of the spillway at the Olivotti Lake Dam was established assuming both the weir and the wingwalls act as a sharp-crested weir. The elevations of the weir crest and wingwalls were obtained during the site survey conducted by Houle Enterprises in May 2012. The spillway crest is at elevation 1478.5, and the wingwalls are at elevation 1480.6. Hydraulic losses for the small pedestrian bridge that crosses the spillway channel just upstream of the weir were assumed to be minimal and therefore neglected. Also, the low chord of the bridge structure is at an elevation of 1480.2, which is above the 100-year peak reservoir elevation of 1479.78. The spillway has the hydraulic capacity to pass 110 cubic feet per second (cfs) before the embankment dam would be overtopped. The headwater-discharge rating curve for the Olivotti Lake Dam is included in Appendix C. The calculated headwater-discharge rating curve is very similar to the HEC-RAS model computations for the rating curve at the spillway.

4. Hydrologic Data

The hydrologic analysis data for the Olivotti Lake Dam was obtained from the WDNR. Prior to starting the dam failure analysis, Terry Cummings of the WDNR ran an analysis in December 2011 using the WDNR's Hydrology Tool. The tool delineates watersheds and uses the 2003 Regional Regression Equations developed by the U.S. Geologic Survey (USGS) for the state of Wisconsin to calculate flood flows for events with recurrence intervals ranging from 2 to 100 years. The calculations were reviewed and found to be acceptable.

The Hydrology Tool calculated a drainage area for the dam of 0.885 mi^2 and is comprised of approximately 24% storage. The small drainage basin and large amount of storage results in relatively small flood flows, which are listed in Table 1 below.

Table 1. Summary of Flood Flows at the Olivotti Lake Dam

Flood Event	Peak Discharge (cfs)
2-Year	14
5-Year	21
10-Year	25
25-Year	31
50-year	35
100-year	40

The 100-year event of 40 cfs was used for the dam failure analysis to model the hydraulic shadow (dam failure), dam in place (no failure), and dam nonexistent (no dam) conditions. A synthetic hydrograph was established using the Natural Resources Conservation Services (NRCS) Dimensionless Unit Hydrograph methodology. The total length of the hydrograph was assumed to be 24 hours with a time to peak of 9 hours. The 100-year inflow hydrograph used for the dam failure analysis can be found in Appendix D.

5. Model Geometric Data

The geometric data used in the HEC-RAS model was generated using the HEC-GeoRAS (Version 10) extension of ArcGIS. The model cross sections were obtained from a digital elevation model (DEM) supplied by Lincoln County that was generated from LiDAR data gathered in 2008. The model extends from the upstream end of Olivotti Lake to just upstream of Olivotti Lake Road, approximately 0.9 miles downstream of the embankment dam. Therefore, the total length of the model is approximately 1.55 miles. The cross sections through Olivotti Lake were modified to account for the lake bottom that was not captured in the LiDAR data. A detailed bathymetric survey was not performed, but multiple depth measurements were made by Houle Enterprises from just upstream of the embankment dam to the overflow spillway. A trapezoidal section was assumed below the water surface, and the depth measurements were used to establish the lake bottom for the section of lake between the embankment dam and the spillway. The lake bottom upstream of the spillway was assumed to continue at a constant slope to the upstream end of the lake.

Initial model runs extended to a point approximately 1.1 miles downstream of Olivotti Lake Road. The results of the initial model runs showed that the water surface for the no dam scenario and dam failure scenario converge to within 1.0 feet just upstream of Olivotti Lake Road. However, the results indicated that these two hydraulic profiles could de-converge downstream of Olivotti Lake Road. Since the study area is within a rural area, Chapter 140 of the WDNR's *Waterway and Wetland Handbook* states that the study must extend to a point at which the hydraulic profile for the dam failure scenario is within 1.0 feet of the hydraulic profile for the no dam scenario. During a conference call on July 2, 2012, Bill Sturtevant of the WDNR indicated that it would be acceptable to terminate the model just upstream of Olivotti Lake Road and adjust the downstream boundary condition accordingly to account for the presence of the roadway and culvert.

Manning's roughness coefficients (Manning's n) were established for the cross sections from both visual inspection during a site visit, and from aerial photos. The Manning's n values for the area downstream of the dam were set relatively high because the area is comprised mostly of wetlands and heavy brush with no clearly defined channel. Also, ineffective flow limits were designated for a number of cross sections within the model to account for the areas of the floodplain that would not be actively conveying flow downstream, but would still act as storage areas to attenuate the breach and flood flows. Interpolated cross sections were added at certain sections of the model for the no dam and dam failure scenarios to mitigate problems with model instability.

The crest of the embankment dam was modeled for the no failure and failure scenarios using the results of the site survey performed by Houle Enterprises in May 2012. Also, since there is no discharge outlet at the embankment dam itself, a small amount of pilot flow (0.5 cfs) was assigned to the embankment dam within the model to allow the model to run properly. The spillway and spillway channel were modeled as a separate stream with a junction at the point where it joins the main flow path downstream of the embankment dam. This was done to accurately route the spillway flows through the channel and through the culvert beneath the access road that crosses the spillway channel. The spillway itself was modeled as a lateral structure along the reservoir, and was assigned a discharge coefficient of 3.30 for a sharp-crested weir.

Several modifications were made to the model for the no dam scenario. The inline structure representing the dam was removed. Also, the lateral structure for the overflow spillway was removed along with the spillway channel because the spillway and spillway channel would not be needed if the embankment dam were not impounding the lake. The cross sections within the lake were also modified to include a small trapezoidal section cut into the lake bottom. This was done to not only represent the more natural condition that would occur if the dam were removed, but also to mitigate model instabilities encountered when modeling the no dam scenario.

6. Model Unsteady Flow Data

The unsteady-state functions of HEC-RAS Version 4.1.0 were used to perform the dam breach analysis. For all scenarios modeled, a synthetic 100-year flood hydrograph was used as the upstream boundary condition of the model. Since the upstream extent of the model is at the upstream end of Olivotti Lake, the attenuation effect of the reservoir is accounted for in the dam (no failure/failure) scenarios. Also, in order to allow the model to run properly for the dam in place conditions (no failure/failure), an upstream boundary condition was entered for the upstream end of the spillway channel, which simply included a constant hydrograph of very minimal flow (1 cfs). No lateral inflows were added to the model because no tributaries enter the reach within the extents of the study.

The downstream boundary condition was set as a rating curve for cross section 5871, which is located just upstream of Olivotti Lake Road. The rating curve for the cross section was developed using the results of the initial model runs that extended beyond Olivotti Lake Road and included the roadway and culvert.

7. Breach Parameters

The breach of the embankment dam was assumed to occur when the water level upstream of the dam reached the peak of the no failure stage hydrograph. The breach parameters were selected to be in accordance with the current Federal Energy Regulatory Commission (FERC) guidelines for dam failure analyses of an embankment dam. The embankment dam was assumed to fail down to the bottom of the cross section geometry, which represents the base of the dam at elevation 1464.0.

A sensitivity analysis was performed using both a longer breach time and a smaller breach to analyze the sensitivity of the model to both parameters. Table 2 summarizes the dam breach parameters, and Table 3 presents the results of the sensitivity analysis.

Table 2. Assumed Breach Parameters for Olivotti Lake Dam Sensitivity Analysis

	Base Breach	Narrower Breach	Longer Breach Time
Bottom elevation	1464.0	1464.0	1464.0
Breach height	19 feet	19 feet	19 feet
Breach bottom width	76 feet (Average breach width = 5 times breach height)	57 feet (Average breach width = 4 times breach height)	76 feet (Average breach width = 5 times breach height)
Side slopes	1:1	1:1	1:1
Time to develop maximum size	0.5 hours	0.5 hours	1.0 hour
Reservoir elevation to initiate breach	1479.77	1479.77	1479.77

Table 3. Sensitivity Analysis Comparison

Location d/s of dam (miles)	HEC-RAS Cross Section	Maximum Stage (feet)			Maximum Flow (cfs)		
		Base	Narrower	Longer	Base	Narrower	Longer
0.05	10213	1466.44	1466.28	1465.33	4,850	4,544	3,154
0.53	7658	1459.01	1459.01	1459.02	1,099	1,102	1,113
0.90	5871	1455.63	1455.62	1455.63	653	647	653

Since the dam is not overtopped during the 100-year flood event, the breach was modeled as a piping failure for all of the above modeled breaches. For each of the breaches, the breach was initiated when the headwater reached elevation 1479.77, which is 1/100 of a foot below the peak water surface elevation of 1479.78 that was reached during the no failure scenario.

The results of the sensitivity analysis show that the model is sensitive to both breach size and timing. However, the resulting peak flows and stages are only affected at cross sections immediately downstream of the dam. For example, the longer breach time creates a lower stage and peak flow at cross section 10213 (0.05 miles downstream of the dam), but the peak stage and peak flow are virtually

unchanged at cross section 7658 (0.53 miles downstream of the dam) when compared to the base breach scenario. The same can be said when comparing the narrower breach to the base breach scenario. The most conservative breach parameters (listed as the Base Breach in Table 2 above) were chosen for modeling the dam failure scenario. A HEC-RAS plot of the breach section selected for the analysis can be found in Appendix F.

8. Analysis Results

The dam failure analysis results show that a failure of the Olivotti Lake Dam would result in incremental rises ranging from 7.2 feet just downstream of the dam, to 0.7 feet just upstream of Olivotti Lake Road. The incremental rise is defined as the difference in peak water surfaces when comparing the dam failure scenario with the no failure scenario. HEC-RAS model plots of the hydrographs at the cross section immediately downstream of the dam, and the cross section just upstream of Olivotti Lake Road, are presented in Appendix G.

Tables 4, 5, and 6 summarize the results of each of the conditions modeled. The 100-year flood profiles and 100-year flood inundation maps for each of the three conditions are presented in Appendix I and Appendix J, respectively. The floodway was delineated for each of the three conditions based on the locations of ineffective flow areas within the model. Also, areas within the delineated floodplain that would be acting as storage areas were not included in the floodway area.

Table 4. Floodway Data Table for the Hydraulic Shadow (Dam Failure)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
10458	0.00	125	1470.9	4918	8.9
10381	0.01	1259	1468.8	4915	7.2
10318	0.03	155	1467.9	4901	6.0
10262	0.04	156	1467.1	4880	5.6
10213	0.05	180	1466.4	4877	5.3
10097	0.07	286	1465.6	4858	3.2
10007	0.09	403	1465.3	4829	2.2
9901	0.11	382	1465.0	4778	2.4
9762	0.13	493	1464.6	4675	2.1
9571	0.17	995	1464.6	4697	1.0
9424	0.20	1038	1464.6	4354	1.0
9297	0.22	778	1464.4	4124	1.4
9161	0.25	632	1464.2	4065	1.5
8970	0.28	438	1464.0	3984	2.1
8808	0.31	369	1464.0	3888	2.7
8689	0.34	497	1464.0	3708	1.9
8527	0.37	479	1464.0	3237	1.5
8358	0.40	393	1464.0	2812	1.8
8204	0.43	404	1464.0	2401	1.4
8033	0.46	519	1464.0	1646	0.7
7899	0.48	566	1464.0	1033	0.3
7796	0.50	560	1464.0	1092	0.4

Table 4. Floodway Data Table for the Hydraulic Shadow (Dam Failure)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
7658	0.53	181	1459.0	1099	5.2
7575	0.55	472	1456.7	748	0.9
7458	0.57	797	1456.7	730	0.4
7298	0.60	789	1456.7	715	0.5
7075	0.64	653	1456.6	679	0.9
6808	0.69	799	1456.5	660	0.9
6629	0.73	943	1456.4	653	0.8
6409	0.77	1,251	1456.4	648	0.6
6238	0.80	586	1456.3	646	0.6
6090	0.83	369	1456.1	646	1.0
5938	0.86	529	1455.8	646	0.9
5871	0.87	657	1455.6	646	0.8
Spillway Channel					
973	N/A	2	1476.2	29	0.1
930	N/A	11	1476.0	29	2.3
874	N/A	138	1475.9	28	0.5
802	N/A	174	1475.9	28	0.4
712	N/A	191	1475.9	27	0.6
630	N/A	197	1475.9	27	0.7
530	N/A	227	1475.9	27	0.8
483	N/A	283	1475.9	27	0.8
443	N/A	188	1475.9	27	0.7
413	N/A	89	1475.9	27	1.1
392	N/A	41	1475.9	27	1.1
366	N/A	3	1465.7	24	7.9
341	N/A	3	1464.6	23	1.2
306	N/A	5	1464.6	23	0.1

Table 5. Floodway Data Table for the Dam in Place (No Failure)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
10458	0.00	9	1463.8	0	0
10381	0.01	21	1462.0	0	0
10318	0.03	76	1461.3	0	0
10262	0.04	101	1460.9	0	0
10213	0.05	91	1460.5	0	0
10097	0.07	240	1460.1	0	0.0
10007	0.09	352	1460.1	0	0.0
9901	0.11	334	1460.1	0	0.0
9762	0.13	363	1460.1	0	0.0
9571	0.17	935	1460.1	24	0.0
9424	0.20	941	1460.1	24	0.0
9297	0.22	559	1460.1	24	0.1
9161	0.25	532	1460.1	23	0.1
8970	0.28	415	1460.1	24	0.1
8808	0.31	332	1460.1	24	0.1
8689	0.34	469	1460.1	23	0.0
8527	0.37	464	1460.1	23	0.0
8358	0.40	366	1460.1	23	0.0
8204	0.43	378	1460.1	23	0.0
8033	0.46	519	1460.1	23	0.0
7899	0.48	549	1460.1	23	0.0
7796	0.50	379	1460.1	24	0.0
7658	0.53	53	1456.8	35	2.2
7575	0.55	464	1455.0	33	0.1
7458	0.57	793	1455.0	33	0.0
7298	0.60	773	1455.0	33	0.0
7075	0.64	639	1455.0	33	0.1
6808	0.69	736	1454.9	33	0.1
6629	0.73	786	1454.9	33	0.1
6409	0.77	825	1454.9	33	0.1
6238	0.80	542	1454.9	33	0.1
6090	0.83	360	1454.9	33	0.1
5938	0.86	428	1454.9	33	0.1
5871	0.87	634	1454.9	33	0.1

Table 5. Floodway Data Table for the Dam in Place (No Failure)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
Spillway Channel					
973	N/A	2	1476.3	29	0.1
930	N/A	11	1476.2	29	2.0
874	N/A	138	1476.1	29	0.5
802	N/A	174	1476.1	29	0.4
712	N/A	191	1476.1	29	0.5
630	N/A	197	1476.1	29	0.6
530	N/A	227	1476.1	29	0.7
483	N/A	283	1476.1	29	0.7
443	N/A	188	1476.1	29	0.7
413	N/A	89	1476.1	29	1.1
392	N/A	41	1476.1	29	1.1
366	N/A	3	1465.6	29	11.0
341	N/A	3	1461.7	29	9.3
306	N/A	5	1460.1	23	0.4

Table 6. Floodway Data Table for the Dam Nonexistent (No Dam)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
10458	0.00	4	1461.0	39	1.9
10381	0.01	12	1460.9	39	2.1
10318	0.03	76	1460.8	39	2.3
10262	0.04	102	1460.6	39	2.5
10213	0.05	91	1460.4	39	1.2
10097	0.07	240	1460.2	32	0.2
10007	0.09	352	1460.2	31	0.2
9901	0.11	334	1460.2	31	0.1
9762	0.13	363	1460.2	30	0.1
9571	0.17	935	1460.1	29	0.0
9424	0.20	971	1460.1	29	0.0
9297	0.22	558	1460.1	29	0.1
9161	0.25	532	1460.1	29	0.1
8970	0.28	415	1460.1	29	0.1

Table 6. Floodway Data Table for the Dam Nonexistent (No Dam)

Cross Section Number	Distance Downstream of Dam (mi)	Floodway Top Width (ft)	Peak Water Surface Elevation (ft, NGVD 29)	Peak Discharge (cfs)	Channel Velocity (ft/sec)
8808	0.31	332	1460.1	29	0.1
8689	0.34	469	1460.1	29	0.0
8527	0.37	464	1460.1	29	0.0
8358	0.40	366	1460.1	29	0.0
8204	0.43	378	1460.1	29	0.0
8033	0.46	519	1460.1	29	0.0
7899	0.48	550	1460.1	29	0.0
7796	0.50	379	1460.1	29	0.0
7658	0.53	53	1456.8	35	2.2
7575	0.55	464	1454.9	32	0.1
7458	0.57	794	1454.9	32	0.0
7298	0.60	773	1454.9	32	0.0
7075	0.64	639	1454.9	31	0.1
6808	0.69	736	1454.9	31	0.1
6629	0.73	786	1454.9	31	0.1
6409	0.77	825	1454.9	31	0.1
6238	0.80	542	1454.9	31	0.1
6090	0.83	360	1454.9	31	0.1
5938	0.86	429	1454.9	31	0.1
5871	0.87	634	1454.9	31	0.1

9. Downstream Structures

There are no structures downstream of the dam within the hydraulic shadow (dam failure) inundation. The inundated area downstream of the dam is comprised mostly of wetlands and wooded area. It should be noted that several sections of Olivotti Lake Road would be inundated during the 100-year flood both with and without a failure of the dam.

10. Hazard Rating

According to the dam hazard ratings criteria within Chapter NR 333.06 (1) (a):

> A low hazard rating shall be assigned to those dams that have no development unrelated to allowable open space use in the hydraulic shadow where the failure or mis–operation of the dam would result in no probable loss of human life, low economic losses (losses are principally limited to the owners property), low environmental damage, no significant disruption of lifeline facilities, and have land use controls in place to restrict future development in the hydraulic shadow.

Based on the dam hazard rating criteria, it is our recommendation that the Olivotti Lake Dam should be given a low hazard rating since no development was identified within the hydraulic shadow. Also, even though Olivotti Lake Road would be inundated if the dam were to fail during the 100-year flood, the roadway would be inundated during the 100-year flood even if the dam were not to fail. Therefore, a failure of the dam would not significantly disrupt a lifeline facility that would not have otherwise been inundated.

It is likely the WDNR will continue to classify the Olivotti Lake Dam as high hazard until hydraulic shadow (dam failure condition) zoning is adopted downstream of the dam. Once the required hydraulic shadow zoning has been adopted, a written request can be made to the WDNR requesting that the hazard rating be lowered to low hazard.

11. Conclusions

Based on the results of this dam failure analysis, we have concluded that the Olivotti Lake Dam should be considered a low hazard dam because no development was identified within the hydraulic shadow in accordance with Chapter NR 333.06(1)(a). Also, it is our opinion that this dam failure analysis is conservative. The breach parameters used for the analysis were very conservative. In addition, the model assumed a very linear path for the breach flow due to the limited abilities of HEC-RAS being a one-dimensional hydraulic model. In reality, flood waters from a breach of the Olivotti Lake Dam would spread in multiple directions, including overtopping Olivotti Lake Road at more than one location, and spilling some into Tug Lake. However, for reasons related to the stability of the HEC-RAS model, the flood waters were assumed to follow a linear path corresponding to the path at which a majority of the flood waters would flow. Therefore, because of these simplified assumptions, the flood wave within the model is not being attenuated to the extent that it would in real life, thus yielding conservative results.

According to NR 333.07(1), a dam with a low hazard rating must have a total spillway capacity equal to or greater than a 100-year flood flow. For the Olivotti Lake Dam, the 100-year peak inflow is 40 cfs. According to the headwater-discharge rating curve presented in Appendix C, the hydraulic capacity of the spillway is 110 cfs without overtopping the embankment dam. Therefore, the dam has sufficient capacity to meet the requirements set forth in NR 333.07(1).

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Appendix A. Vicinity Map

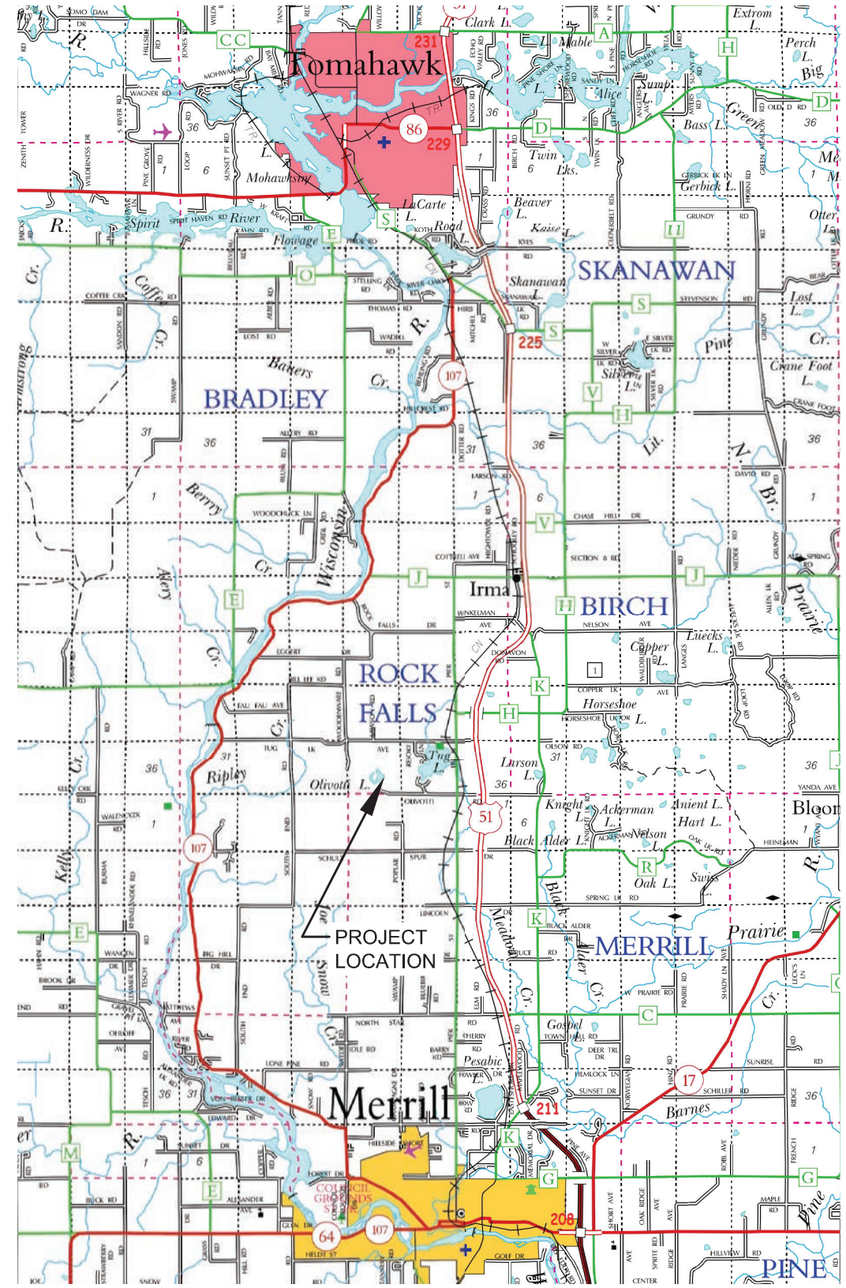
GIRL SCOUTS OF THE NORTHWESTERN GREAT LAKES, INC.

OLIVOTTI LAKE DAM

LINCOLN COUNTY, WISCONSIN

WISCONSIN STATE MAP
NOT TO SCALE

Sheet Number	Sheet Title
GENERAL	
G-101	TITLE SHEET AND DRAWING INDEX
CIVIL	
C-101	SITE IMPROVEMENT PLAN
C-201	SECTIONS AND DETAILS



PROJECT VICINITY MAP
NOT TO SCALE

FOR REVIEW ONLY
JUNE 2012

Mead & Hunt
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6501 Watts Road
Madison, WI 53719
608.273.6380
fax: 608.273.6391
www.meadhunt.com

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GIRL SCOUTS OF THE NORTHWESTERN GREAT LAKES, INC.
OLIVOTTI LAKE DAM
LINCOLN COUNTY, WISCONSIN

REVISION

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

FERC NO.:
M&H NO.: 4084800-120342.01
DATE: JUNE 15, 2012
DESIGNED BY: JJB
DRAWN BY: DMS
CHECKED BY: JAA

DO NOT SCALE DRAWINGS

SHEET CONTENTS
TITLE SHEET AND DRAWING INDEX

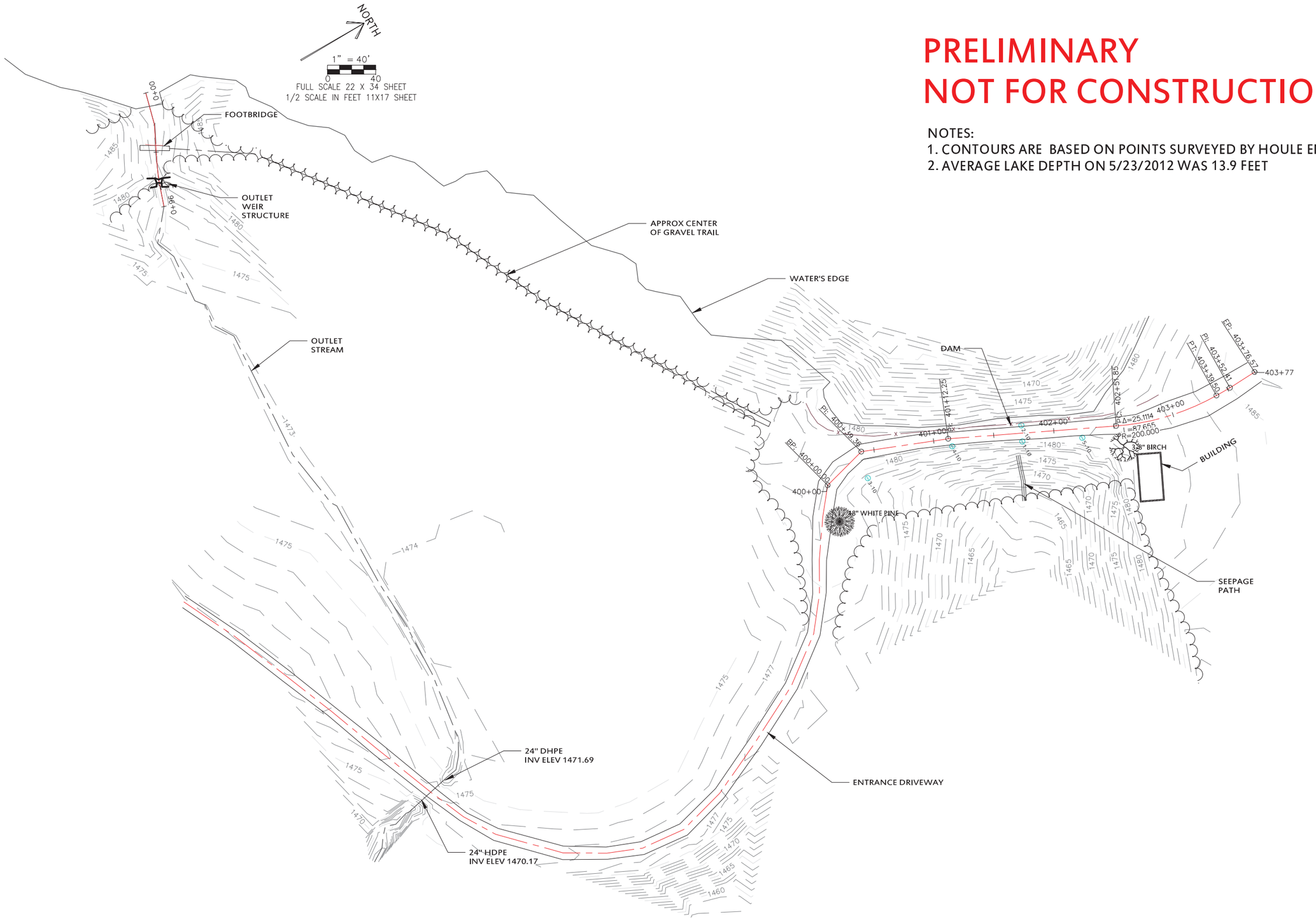
SHEET NO.
G-101

X:\4084800\120342\01\TECH\CAD\G-001.DWG
6/18/2012 10:30:51 AM

Appendix B. Dam Plan and Survey Sketch

PRELIMINARY
NOT FOR CONSTRUCTION

NOTES:
1. CONTOURS ARE BASED ON POINTS SURVEYED BY HOULE ENTERPRISES
2. AVERAGE LAKE DEPTH ON 5/23/2012 WAS 13.9 FEET



Date

Designed

Drawn W. MEYER 05/24/2012

Checked

Approved

OLIVOTTI DAM IMPROVEMENTS
DAM & OUTLET STREAM
PLAN VIEW

Houle Enterprises

File No.
PLAN

Drawing No.
SHEET 2

Sheet 2 of 13

C:\Users\WJM\Documents\Houle Enterprises\2012 Olivotti Dam\CAD\Olivotti Dam.dwg, 2 40-scale PLAN VIEW, 5/24/2012 10:50:32 AM, WJM

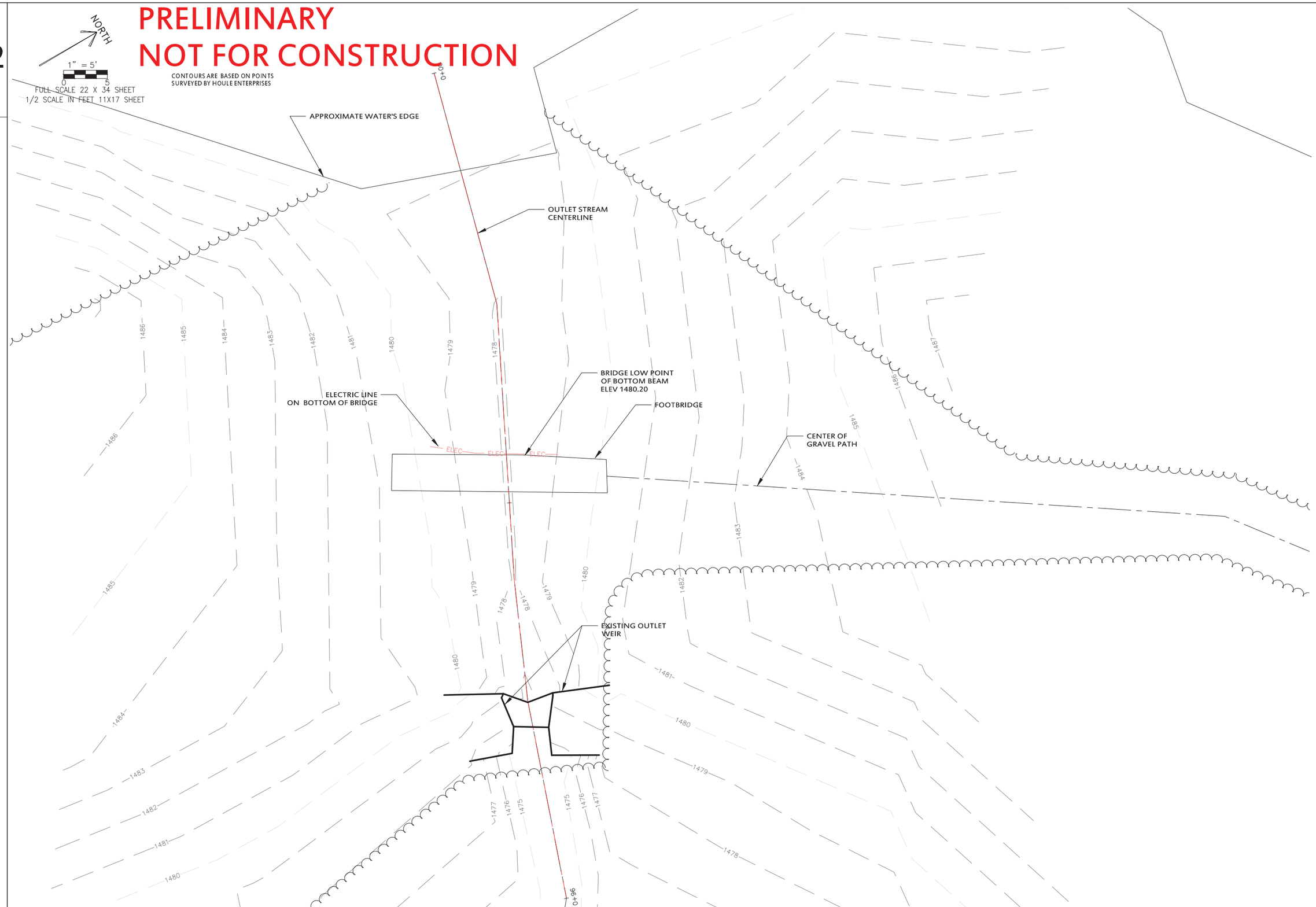
2

PRELIMINARY
NOT FOR CONSTRUCTION

NORTH

1" = 5'
0 5
FULL SCALE 22 X 34 SHEET
1/2 SCALE IN FEET 11X17 SHEET

CONTOURS ARE BASED ON POINTS
SURVEYED BY HOULE ENTERPRISES



Date

Designed

Drawn W. MEYER 05/24/2012

Checked

Approved

2

OLIVOTTI DAM IMPROVEMENTS
LAKE OUTLET
PLAN VIEW

Houle Enterprises

File No.
DETAILS

Drawing No.
SHEET 4

Sheet 4 of 13

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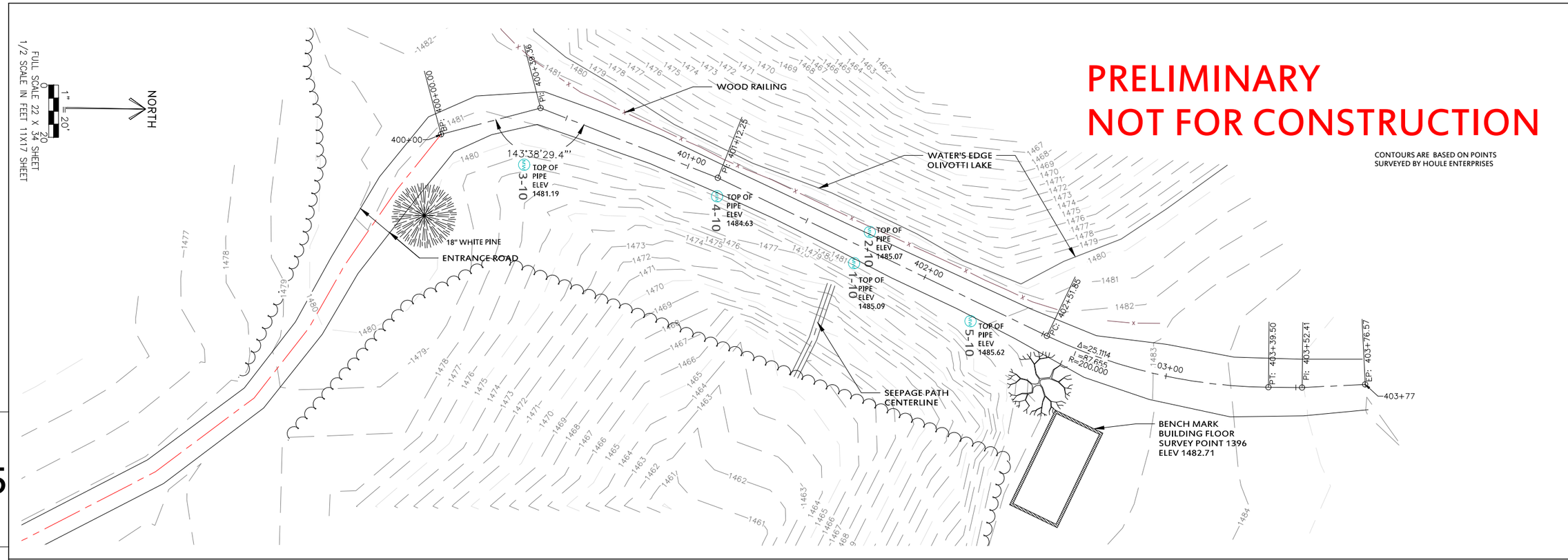
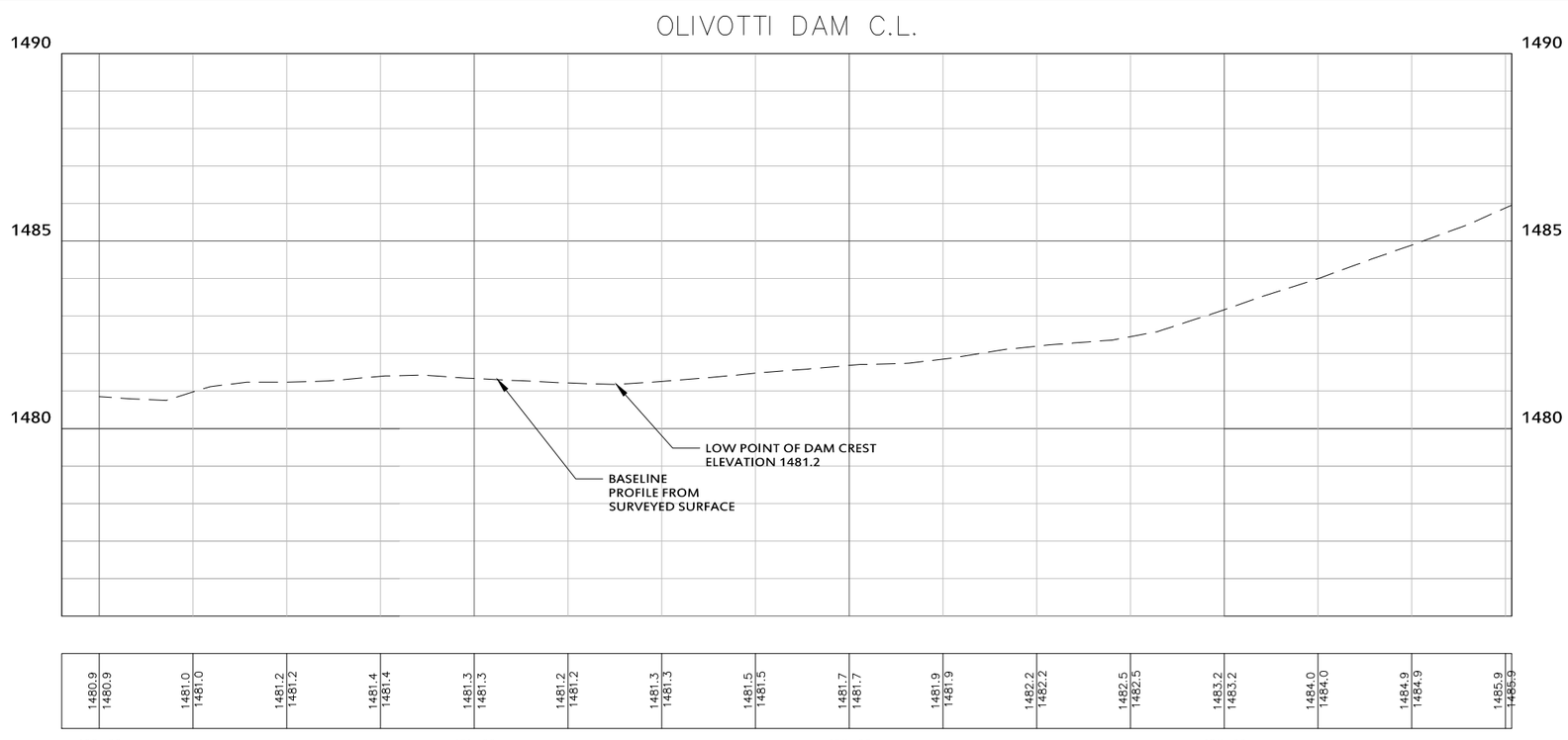




Date

Designed

Drawn W. MEYER 07/23/2012

Checked

Approved

OLIVOTTI DAM IMPROVEMENTS
DAM ROADWAY
PLAN & PROFILE

5

File No. P&P

Drawing No. SHEET 6

Sheet 6 of 13

C:\Users\WJM\Documents\Houle Enterprises\2012 Olivotti Dam\CAD\Olivotti Dam without DEM Surface.dwg, 6 P & P DAM, 7/23/2012 12:32:04 PM, WJM

Appendix C. Headwater-Discharge Rating Curve

Olivotti Dam Spillway Headwater-Discharge Rating Curve

Assumptions:

Weir Discharge Coefficient, C =	3.3	(sharp crested weir)
Weir Crest Length =	6.0	feet
Weir Crest El. =	1478.5	feet, NGVD 29 (from survey performed by Houle Enterprises)
Wingwall Crest El. =	1480.6	feet, NGVD 29 (from survey performed by Houle Enterprises)
Wingwall Crest Length =	13.28	feet

Headwater-Discharge Rating Curve

Headwater El. (ft, NGVD 29)	Description	H_{weir} (ft)	$H_{wingwall}$ (ft)	Q (cfs)
1478.50	Weir crest	0.00	-	0
1478.75		0.25	-	2
1479.00		0.50	-	7
1479.25		0.75	-	13
1479.50	Normal Lake Elevation	1.00	-	20
1479.75		1.25	-	28
1480.00		1.50	-	36
1480.25		1.75	-	46
1480.50	1,000 year event	2.00	-	56
1480.75		2.25	0.19	70
1481.00		2.50	0.44	91
1481.20	Embankment dam crest	2.70	0.64	110

Note: The difference between normal lake elevation and the weir crest is approximately 1 foot

Appendix D. Upstream Boundary Reservoir Inflow Hydrograph

Wisconsin Peak Flow Regression Calculator (2003 equations)

Basin ID	41

	Input Data	Region 1		Region 2		Region 3	
		Min	Max	Min	Max	Min	Max
Area (A)	**0.885**	0.28	2120	0.56	1760	1	2240
Rainfall (INTENS)	**4.660**	5.18	5.29	4.38	5.28	4.24	5.29
Channel Slope (S)	**33.225**	2.27	270	3.65	96	0.84	3.4
Storage (ST)	**23.724**	0	8.2	0	28.8	0	39.7
Soil Permeability (SP)	**1.650**	0.12	4.22	0.2	2.88	0.12	8.46
Snowfall (SN)	**55.197**	29.65	45.47	34.29	66.61	38.19	83.5
Forest Cover (FOR)	**91.202**	0	56.9	3.17	87.9	1.18	95.3

Area contribution (%)	0	0	100
			Design Discharges (cfs)
Return Period (years)	Region 1	Region 2	Region 3
2	0	32	14
5	0	54	21
10	0	68	25
25	0	87	31
50	0	101	35
100	0	115	40

Legend:

Valid number
Not applicable
Out of range

System data:

D:\Data\geodata\wtgislib\hydrology_tool\WI_base\XLSFiles\RC_W_41_201112211

D:\Data\geodata\wtgislib\hydrology_tool\WI_base\wi021511d.MDB
Watershed

Olivotti Dam Q100 Inflow Hydrograph

Using NRCS Dimensionless Unit Hydrograph methodology

Q100 Peak Inflow = 40 cfs

Total length = 24 hrs

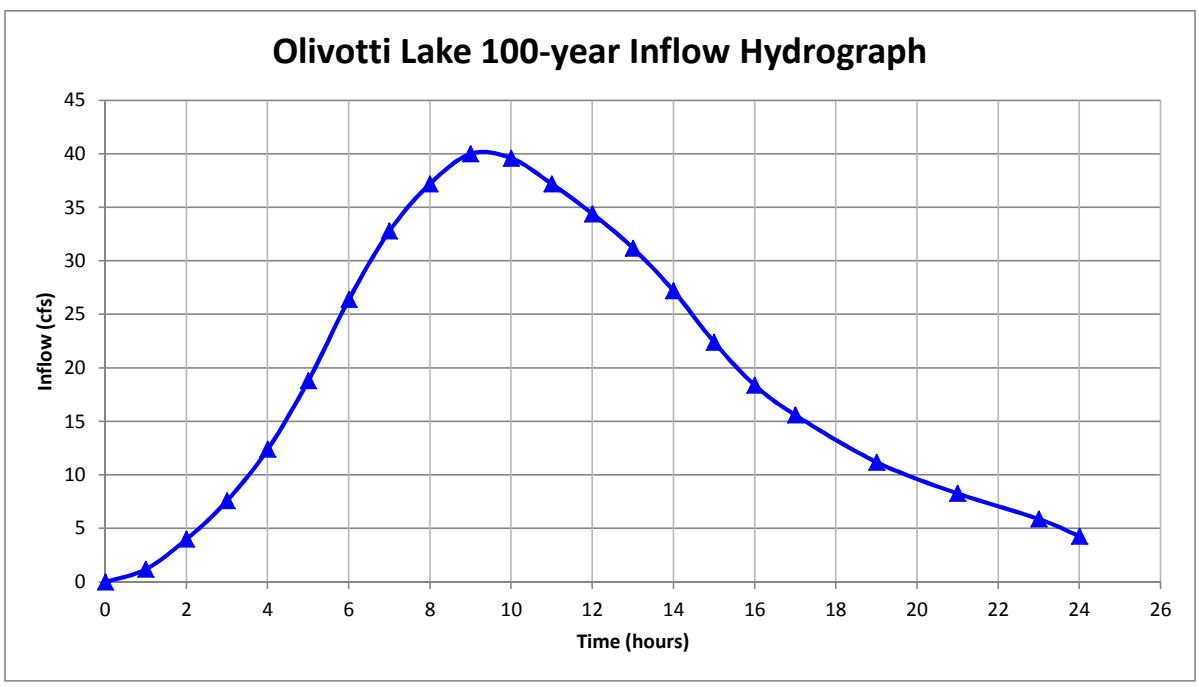
Time to peak, T_P = 9 hrs

$$T_P = \frac{T_{Total}}{2.667}$$

(p. 496 of Water Resources Engineering by Wurbs)

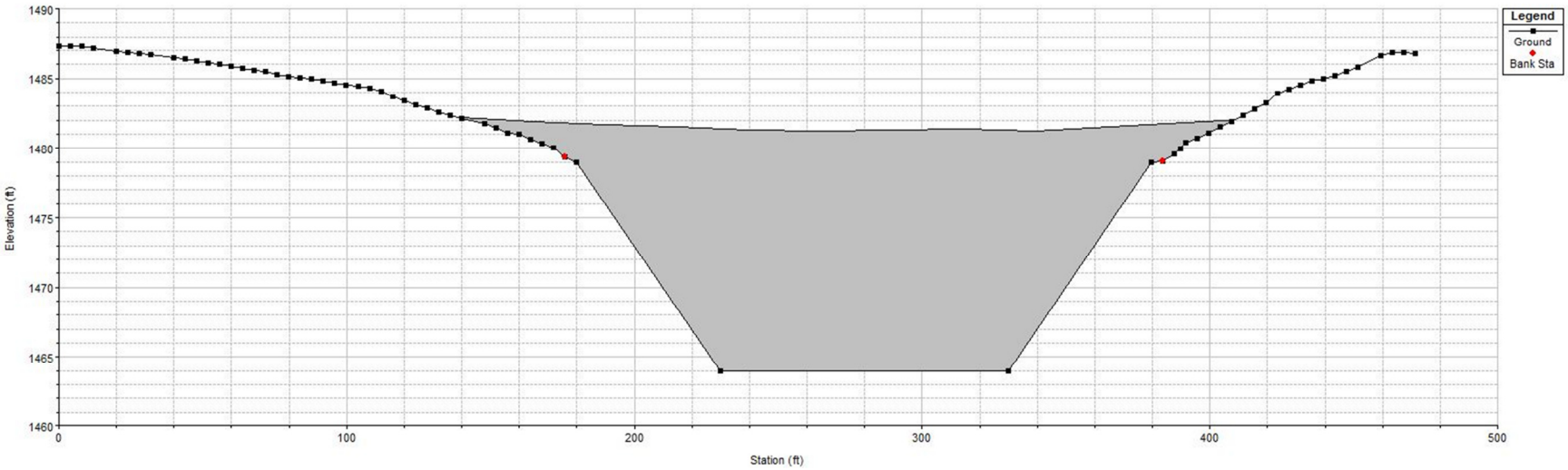
t (hrs)	t/T_P	Q/Q_P	Q (cfs)
0	0	0	0
1	0.11	0.03	1.2
2	0.22	0.1	4
3	0.33	0.19	7.6
4	0.44	0.31	12.4
5	0.56	0.47	18.8
6	0.67	0.66	26.4
7	0.78	0.82	32.8
8	0.89	0.93	37.2
9	1.00	1	40
10	1.11	0.99	39.6
11	1.22	0.93	37.2
12	1.33	0.86	34.4
13	1.44	0.78	31.2
14	1.56	0.68	27.2
15	1.67	0.56	22.4
16	1.78	0.46	18.4
17	1.89	0.39	15.6
19	2.11	0.28	11.2
21	2.33	0.207	8.28
23	2.56	0.147	5.88
24	2.67	0.107	4.28

Curvilinear Unit Hydrograph Ratios (Table 8.6 of Wurbs)	
t/T_P	Q/Q_P
0	0
0.1	0.03
0.2	0.1
0.3	0.19
0.4	0.31
0.5	0.47
0.6	0.66
0.7	0.82
0.8	0.93
0.9	0.99
1	1
1.1	0.99
1.2	0.93
1.3	0.86
1.4	0.78
1.5	0.68
1.6	0.56
1.7	0.46
1.8	0.39
1.9	0.33
2	0.28
2.2	0.207
2.4	0.147
2.6	0.107
2.8	0.077
3	0.055
3.2	0.04
3.4	0.029
3.6	0.021
3.8	0.015
4	0.011
4.5	0.005
5	0

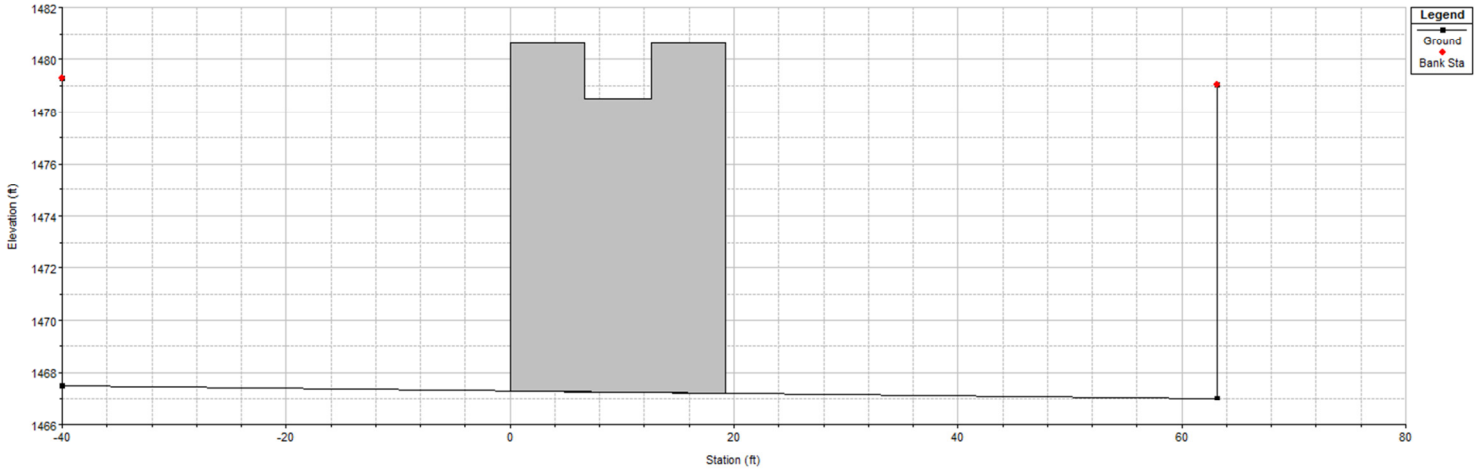


Appendix E. Dam Cross Section

Embankment Dam Cross Section

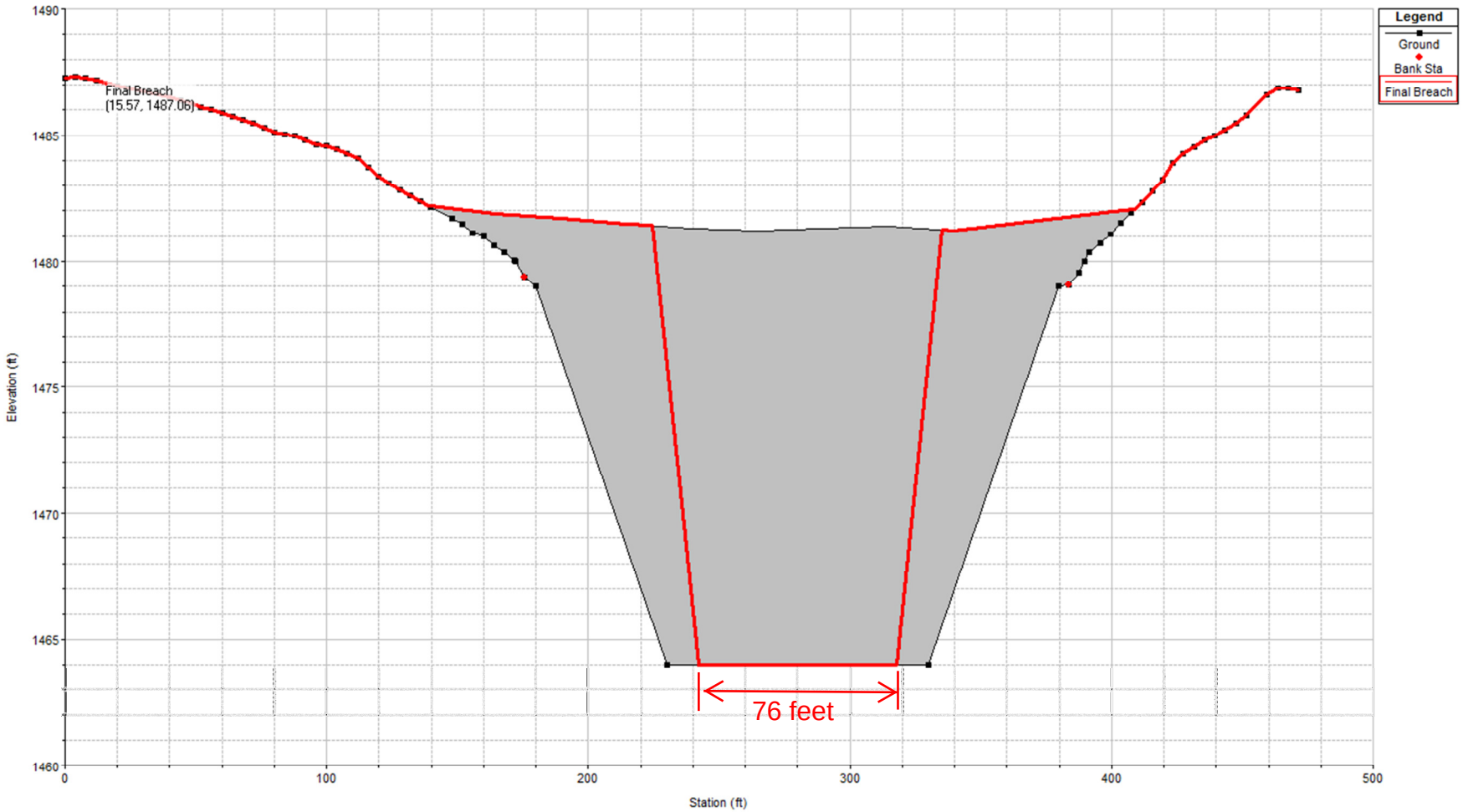


Spillway Cross Section (modeled as a lateral structure)



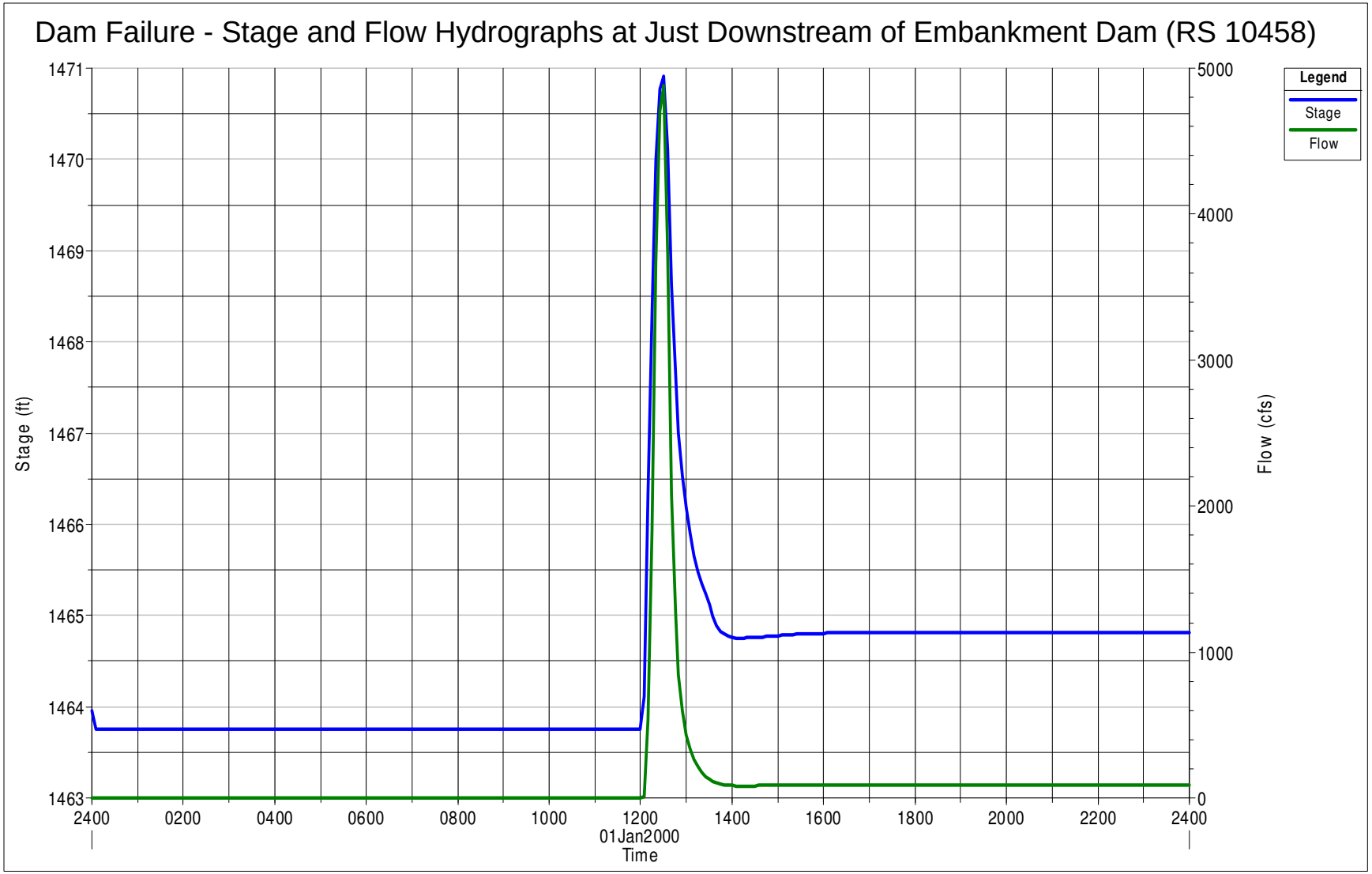
Appendix F. Selected Dam Breach Section

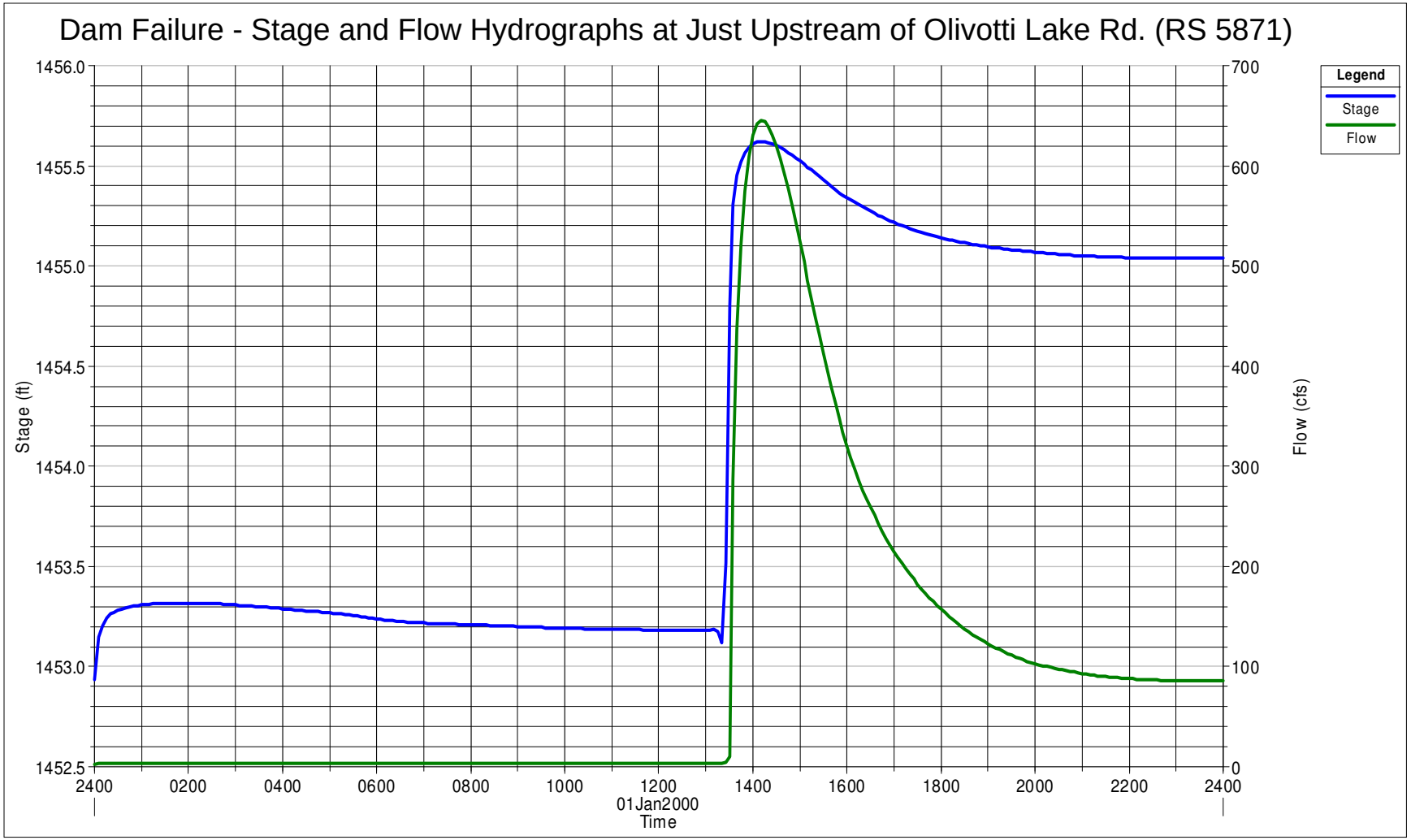
Selected Breach Dimensions for Hydraulic Shadow (Dam Failure) Condition



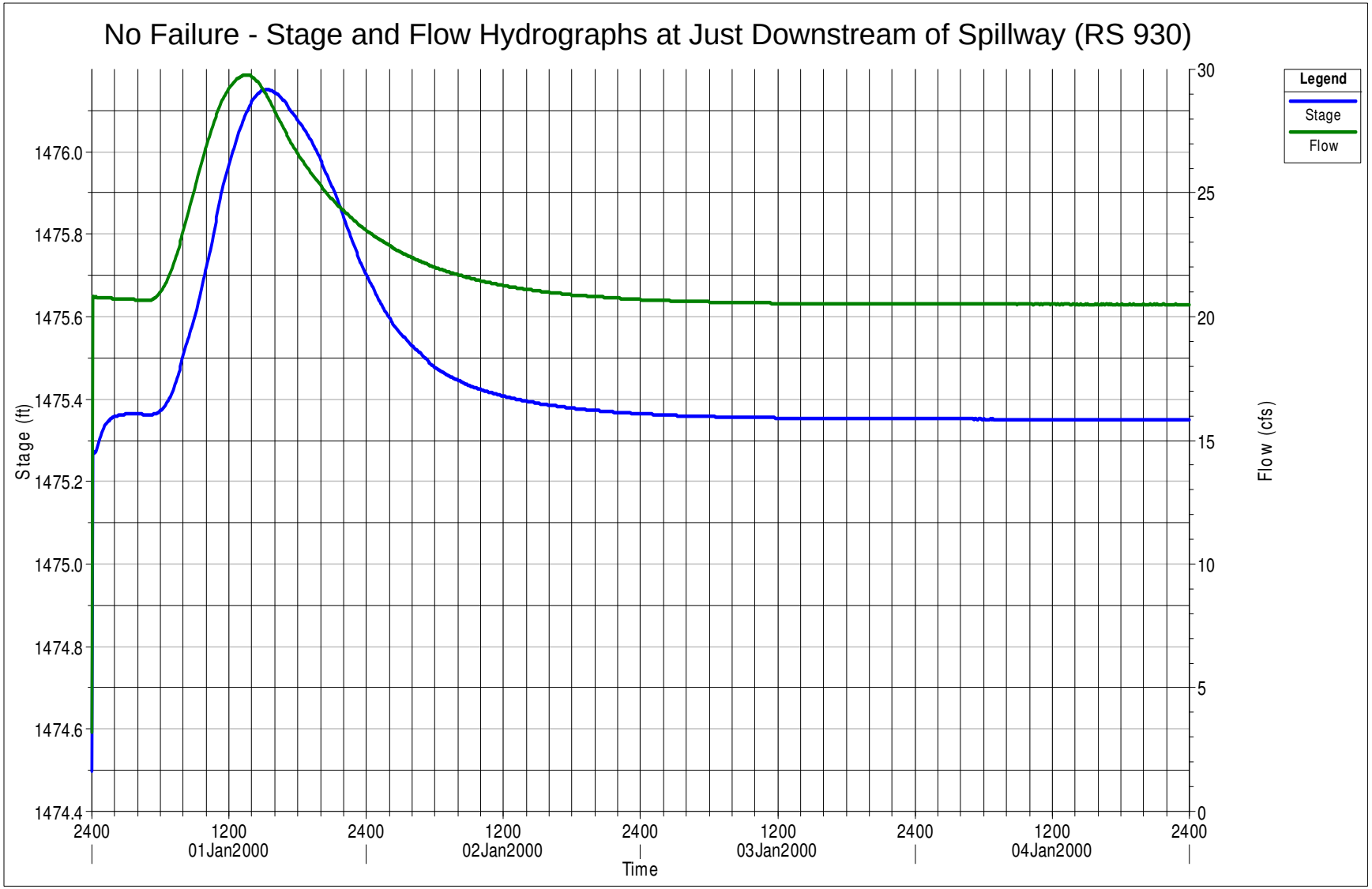
Appendix G. Hydrographs Downstream of Dam

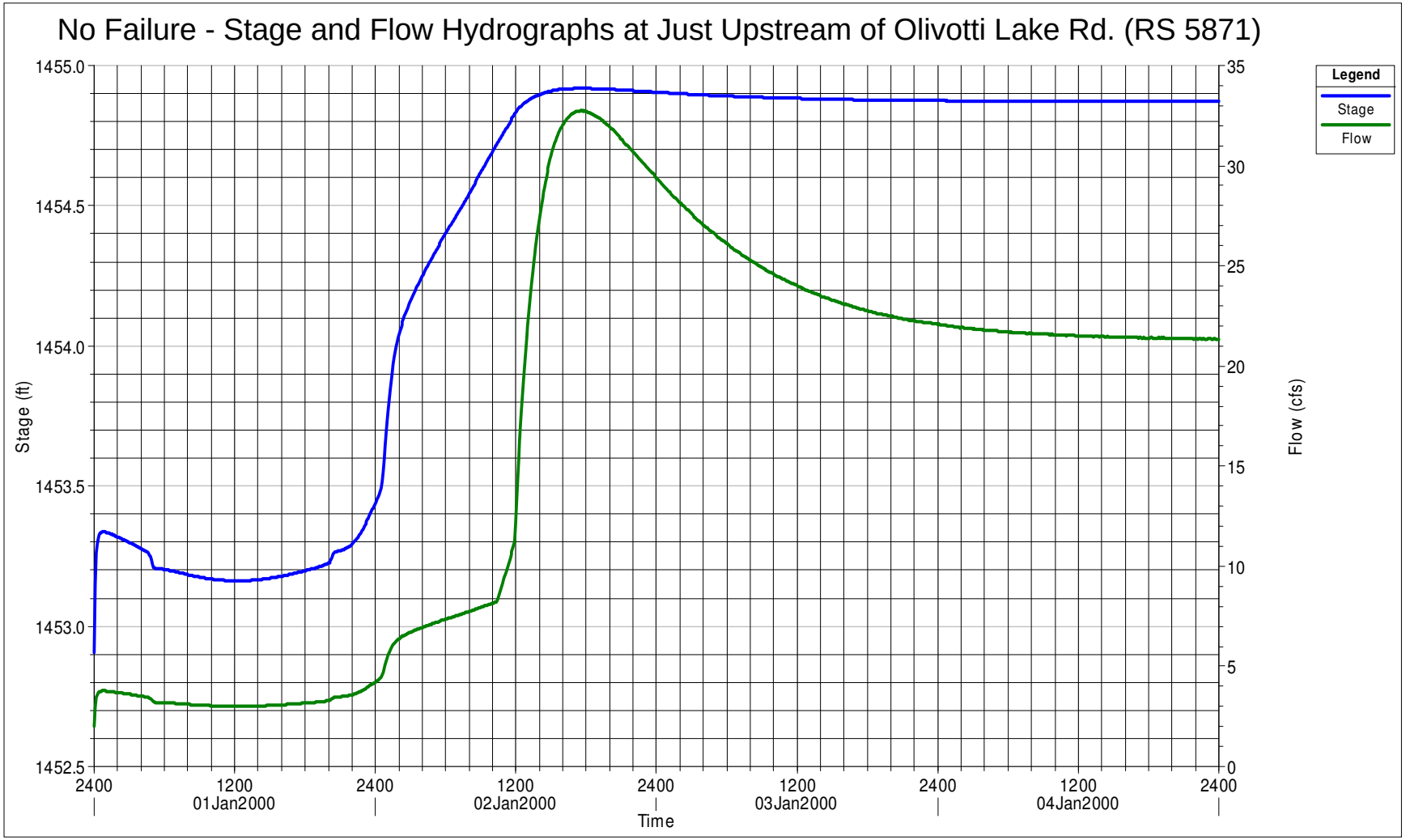
Hydraulic Shadow (Dam Failure)


Dam Failure - Stage and Flow Hydrographs at Just Downstream of Embankment Dam (RS 10458)
Legend
Stage
Flow
Stage (ft)
Flow (cfs)
1471
1470
1469
1468
1467
1466
1465
1464
1463
5000
4000
3000
2000
1000
0
2400
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
2400
01Jan2000
Time


Dam Failure - Stage and Flow Hydrographs at Just Upstream of Olivotti Lake Rd. (RS 5871)
Legend
Stage
Flow
Stage (ft)
Flow (cfs)
1456.0
1455.5
1455.0
1454.5
1454.0
1453.5
1453.0
1452.5
700
600
500
400
300
200
100
0
2400
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
2400
01Jan2000
Time

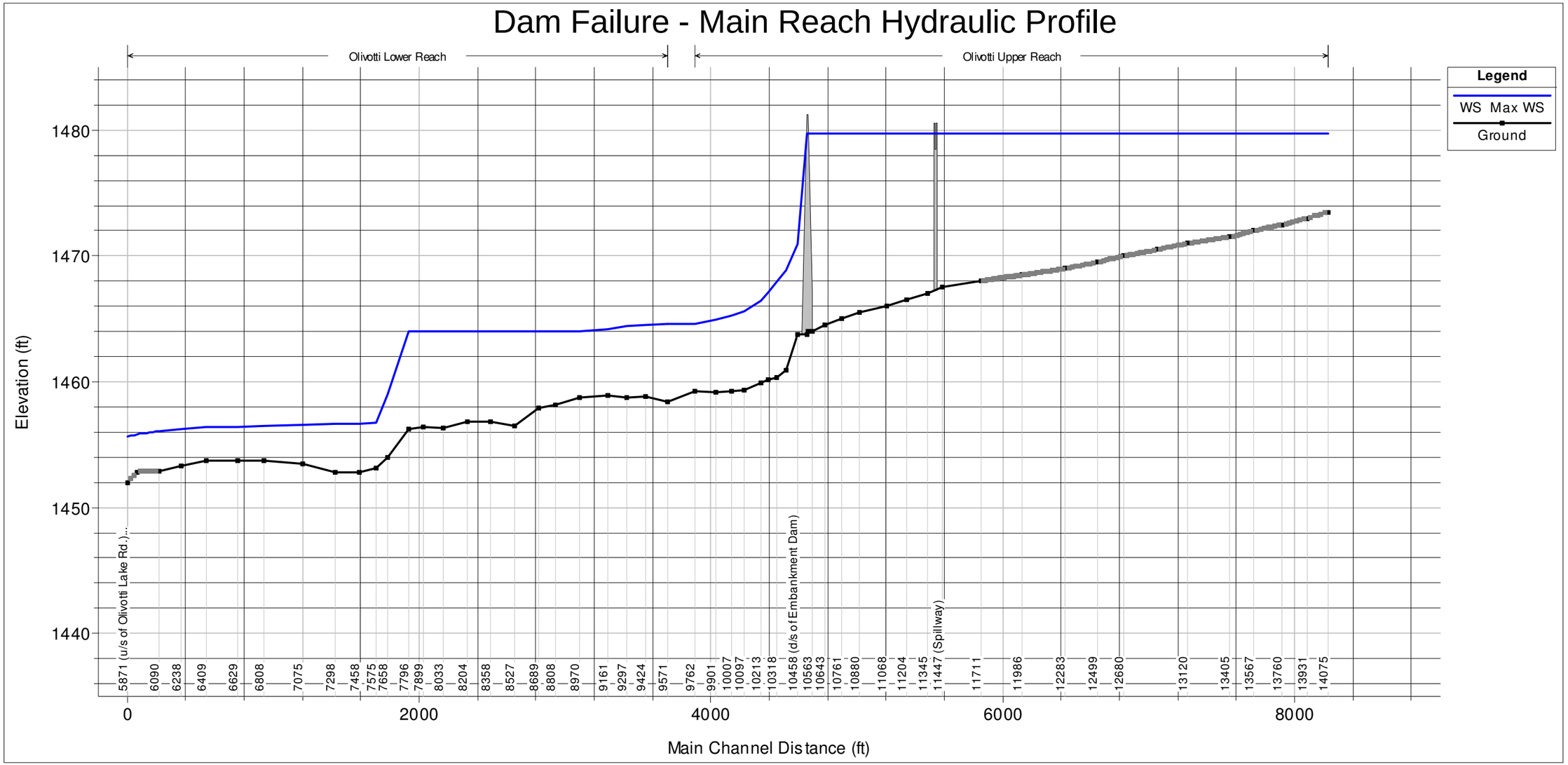
Dam in Place (No Failure)

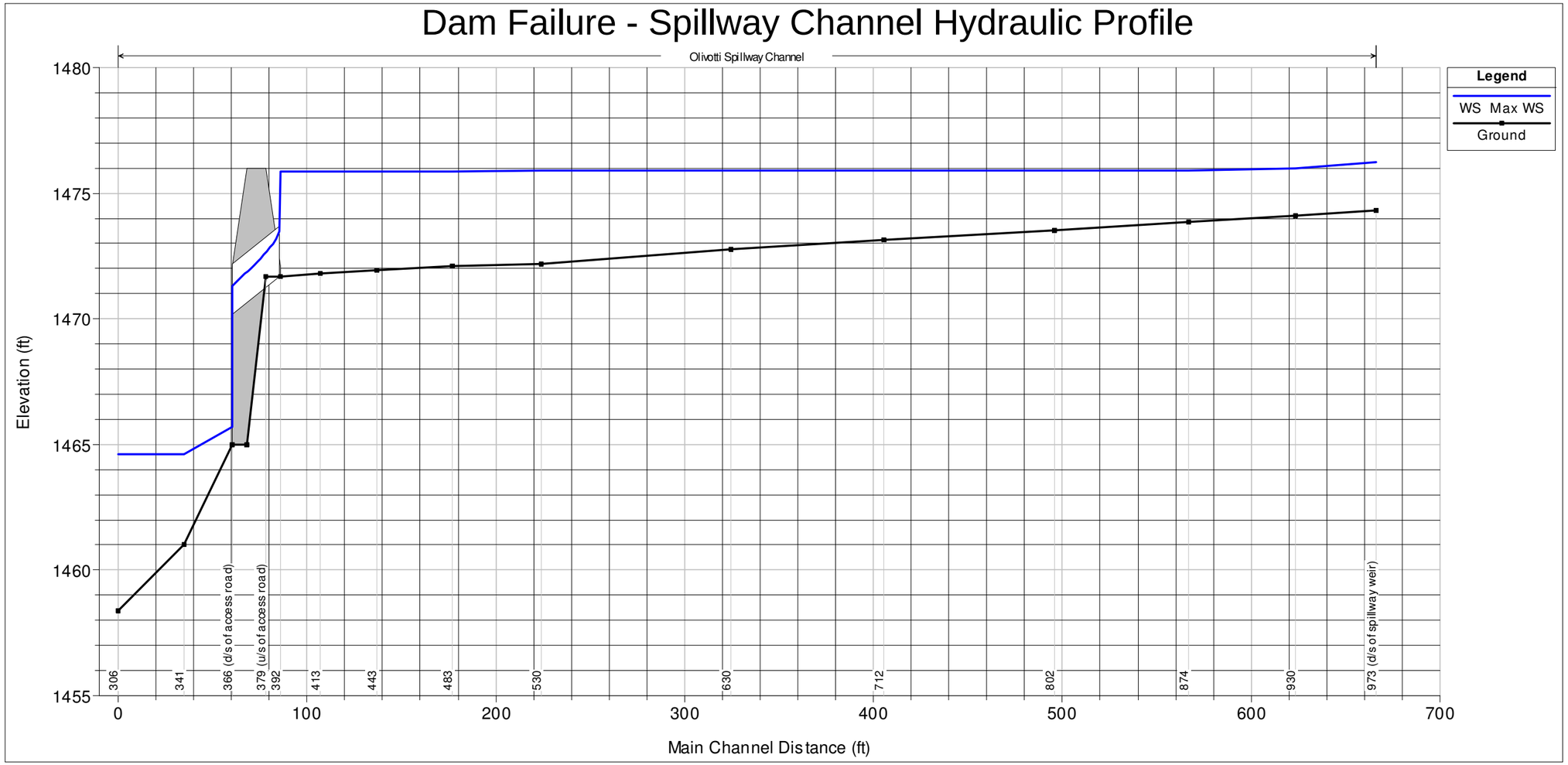

No Failure - Stage and Flow Hydrographs at Just Downstream of Spillway (RS 930)
Legend
Stage
Flow
Stage (ft)
1476.0
1475.8
1475.6
1475.4
1475.2
1475.0
1474.8
1474.6
1474.4
Flow (cfs)
30
25
20
15
10
5
0
2400
1200
01Jan2000
2400
1200
02Jan2000
2400
1200
03Jan2000
2400
1200
04Jan2000
2400
Time


No Failure - Stage and Flow Hydrographs at Just Upstream of Olivotti Lake Rd. (RS 5871)
Legend
Stage
Flow
Stage (ft)
Flow (cfs)
Time
1455.0
1454.5
1454.0
1453.5
1453.0
1452.5
35
30
25
20
15
10
5
0
2400
1200
01Jan2000
2400
1200
02Jan2000
2400
1200
03Jan2000
2400
1200
04Jan2000
2400

Appendix H. 100-Year Flood Profiles

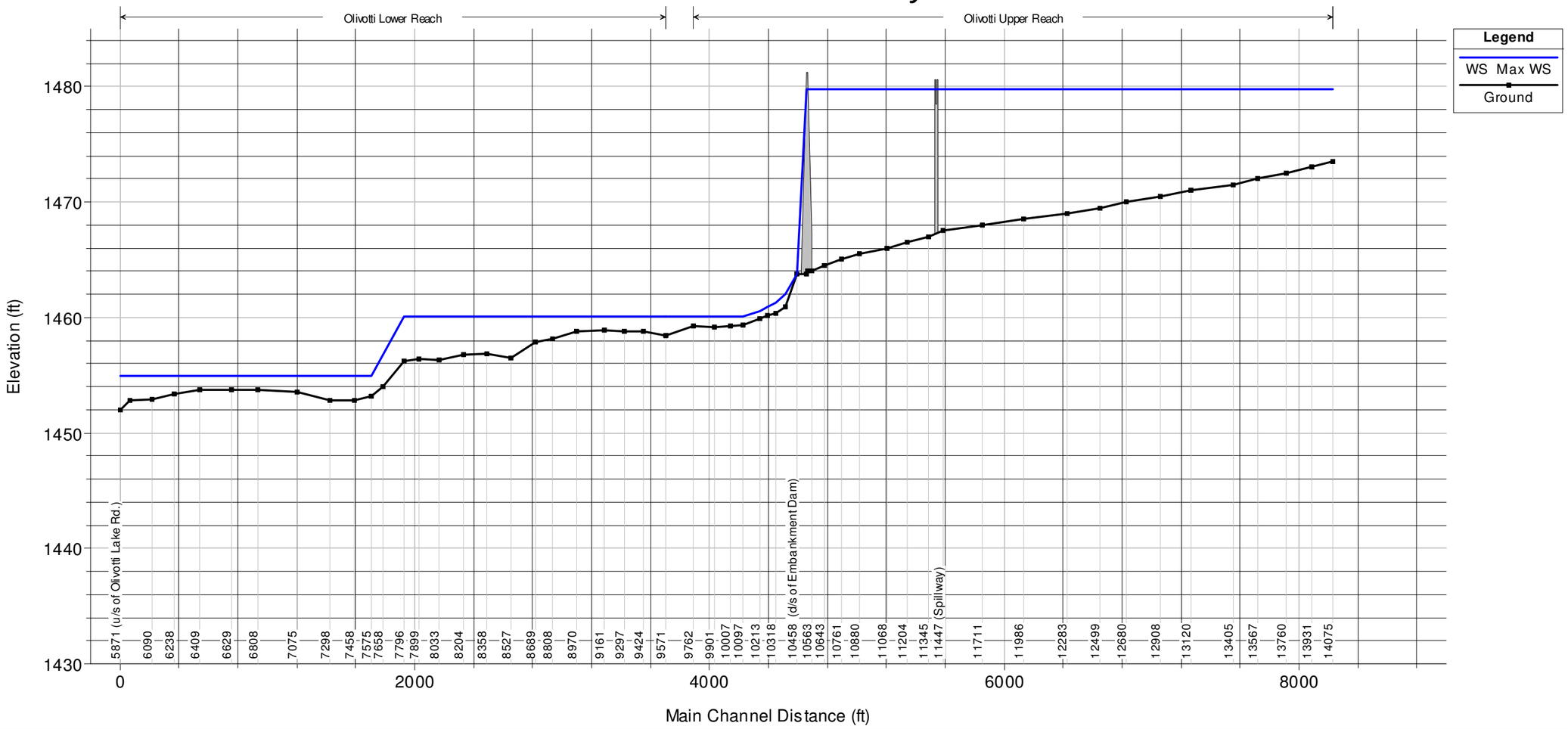
Hydraulic Shadow (Dam Failure)


Dam Failure - Main Reach Hydraulic Profile
Olivotti Lower Reach
Olivotti Upper Reach
Legend
WS Max WS
Ground
Elevation (ft)
1480
1470
1460
1450
1440
5871 (u/s of Olivotti Lake Rd.),...
6090
6238
6409
6629
6808
7075
7298
7458
7575
7658
7796
7899
8033
8204
8358
8527
8689
8808
8970
9161
9297
9424
9571
9762
9901
10007
10097
10213
10318
10458 (d/s of Embankment Dam)
10563
10643
10761
10880
11068
11204
11345
11447 (Spillway)
11711
11986
12283
12499
12680
13120
13405
13567
13760
13931
14075
0
2000
4000
6000
8000
Main Channel Distance (ft)

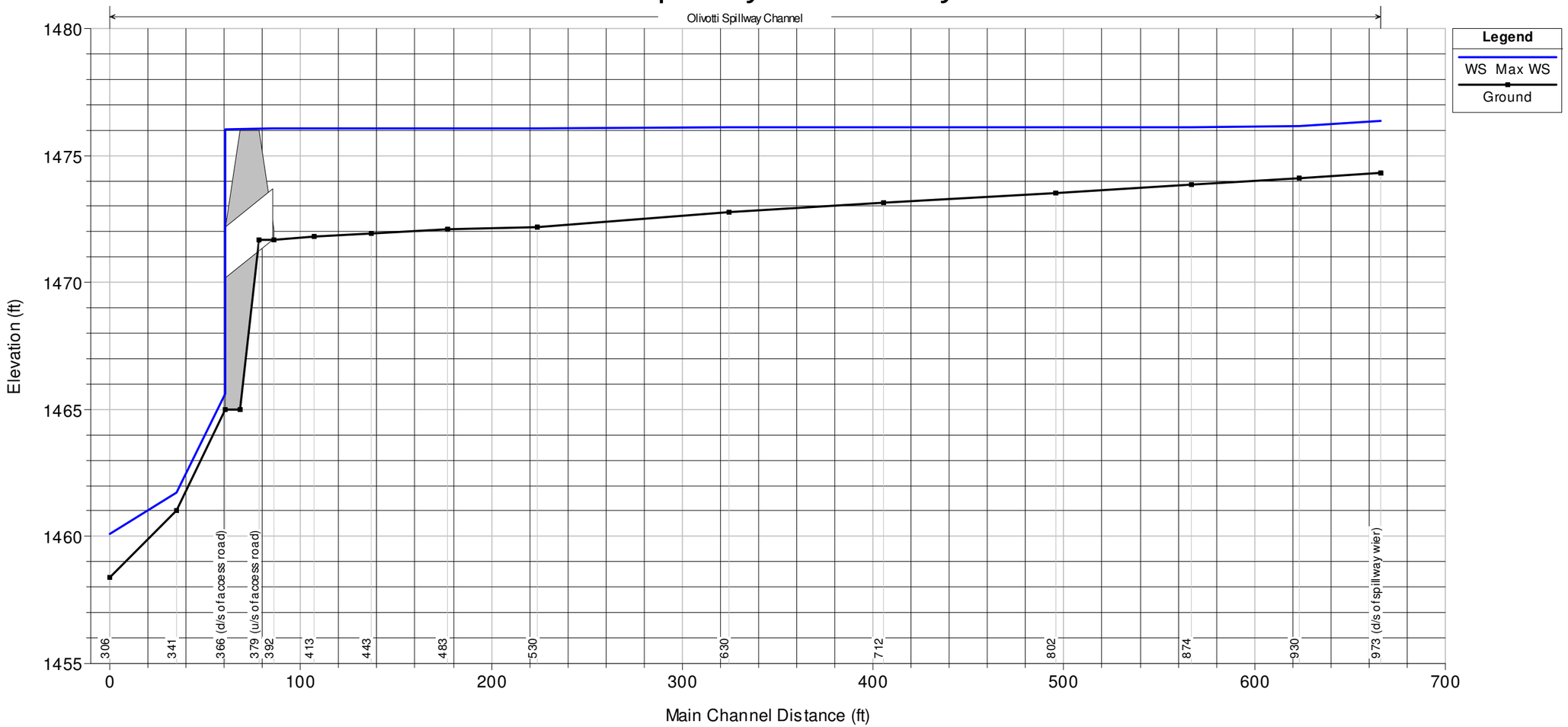

Dam Failure - Spillway Channel Hydraulic Profile
Olivotti Spillway Channel
Legend
WS Max WS
Ground
Elevation (ft)
1480
1475
1470
1465
1460
1455
306
341
366 (d/s of access road)
379 (u/s of access road)
392
413
443
483
530
630
712
802
874
930
973 (d/s of spillway weir)
0
100
200
300
400
500
600
700
Main Channel Distance (ft)

Dam in Place (No Failure)

No Failure - Main Reach Hydraulic Profile

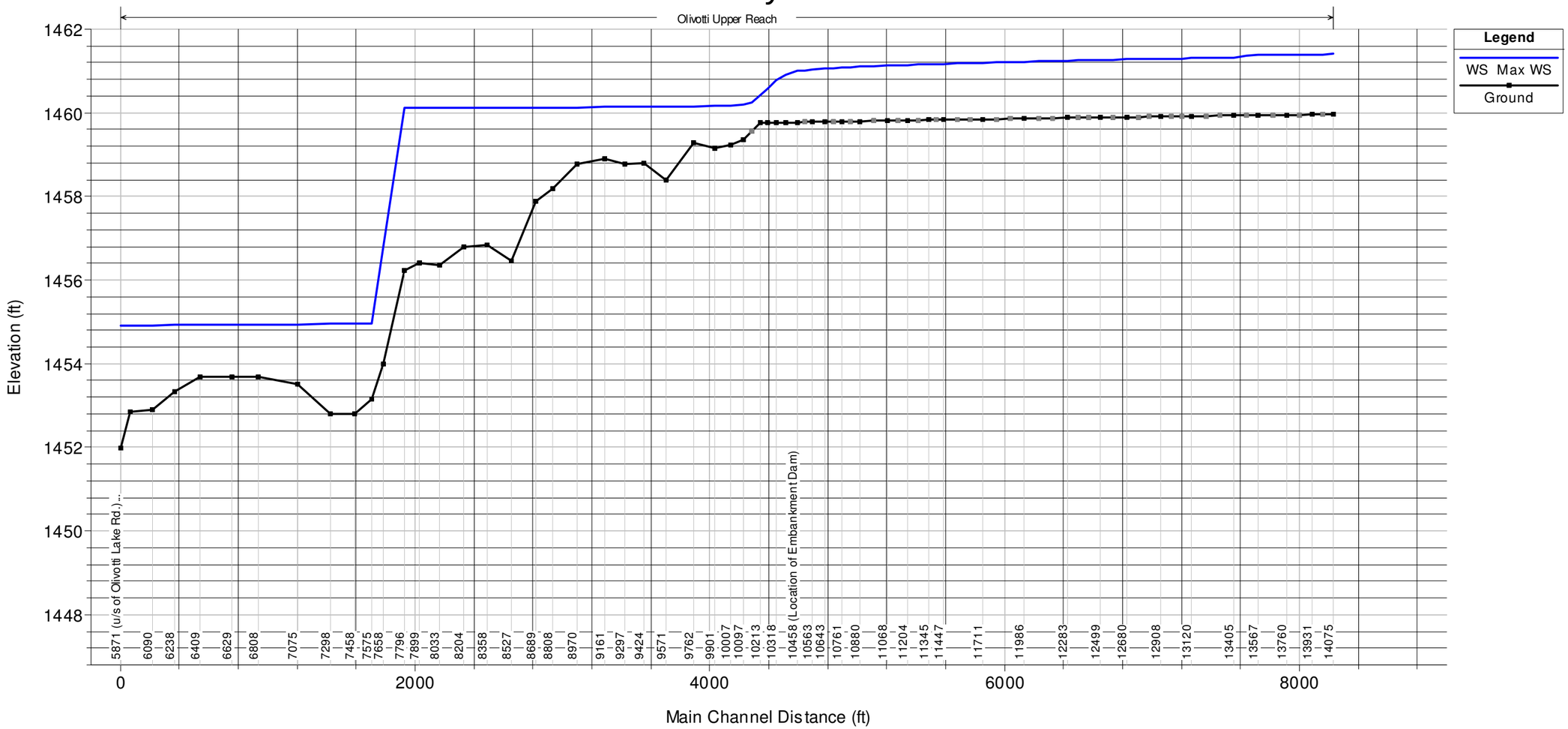


No Failure - Spillway Channel Hydraulic Profile



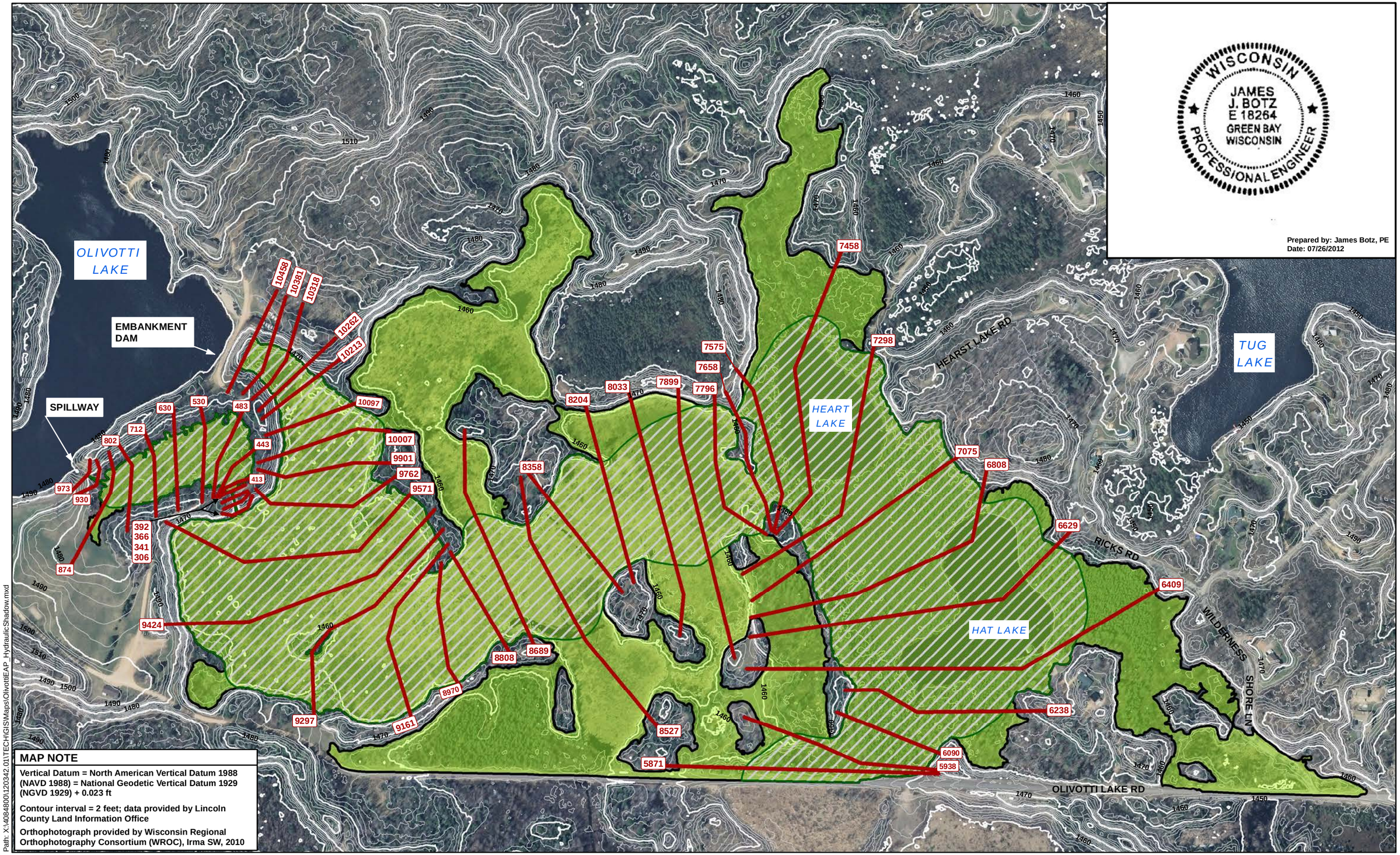
Dam Nonexistent (No Dam)

No Dam - Hydraulic Profile



Appendix I. 100-Year Flood Inundation Maps

Hydraulic Shadow (Dam Failure)



GIRL SCOUTS OF THE NORTHWESTERN GREAT LAKES, INC.
Olivotti Lake Dam
Lincoln County, Wisconsin

0 250 500 Feet

N

Legend

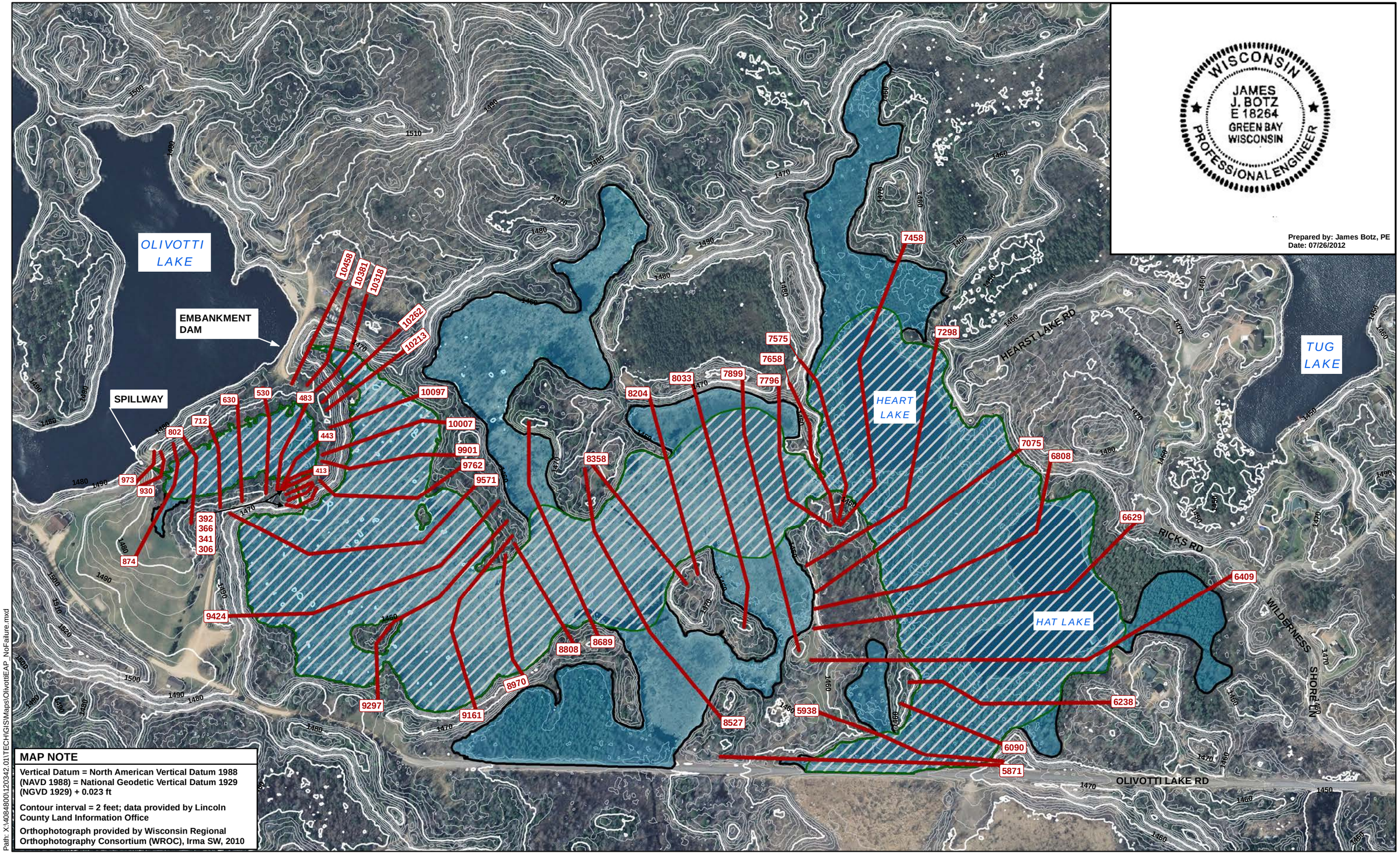
- CROSS SECTION
- XXXXX CROSS SECTION LABEL
- INUNDATION AREA
- FLOODWAY

Mead & Hunt

INUNDATION MAP

HYDRAULIC SHADOW - DAM FAILURE

Dam in Place (No Failure)



MAP NOTE

Vertical Datum = North American Vertical Datum 1988 (NAVD 1988) = National Geodetic Vertical Datum 1929 (NGVD 1929) + 0.023 ft

Contour interval = 2 feet; data provided by Lincoln County Land Information Office

Orthophotograph provided by Wisconsin Regional Orthophotography Consortium (WROC), Irma SW, 2010

GIRL SCOUTS OF THE NORTHWESTERN GREAT LAKES, INC.
Olivotti Lake Dam
Lincoln County, Wisconsin

0 250 500 Feet

N

Legend

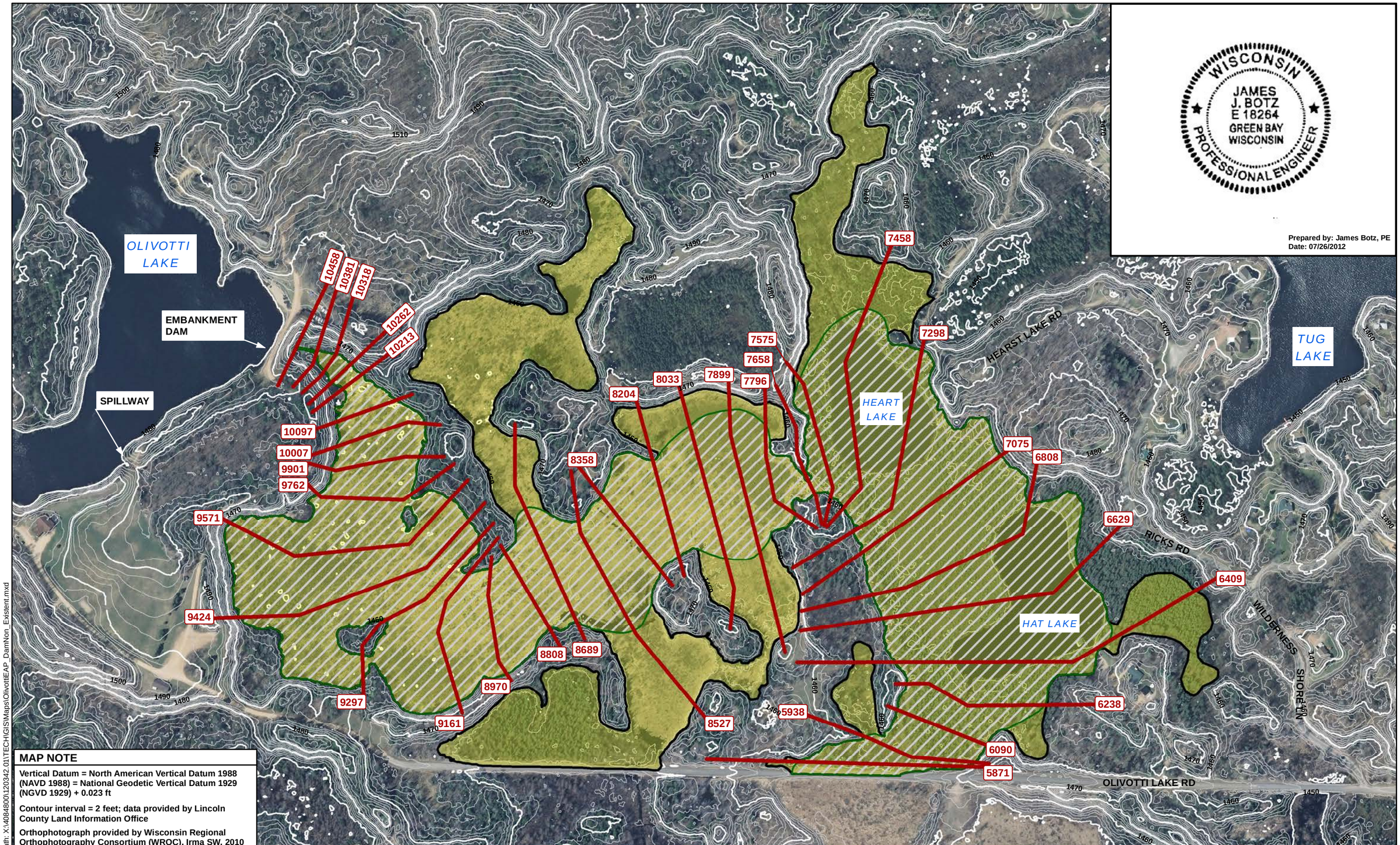
- CROSS SECTION
- XXXXX CROSS SECTION LABEL
- INUNDATION AREA
- FLOODWAY

Mead & Hunt

INUNDATION MAP

DAM-IN-PLACE NO FAILURE

Dam Nonexistent (No Dam)



GIRL SCOUTS OF THE NORTHWESTERN GREAT LAKES, INC.
Olivotti Lake Dam
Lincoln County, Wisconsin

0 250 500 Feet

N

Legend

	CROSS SECTION		INUNDATION AREA
XXXXX	CROSS SECTION LABEL		FLOODWAY

Mead & Hunt

INUNDATION MAP
DAM NONEXISTENT