Appendix B

Hydraulic & Hydrology Appendix

Little Manistee River
Manistee County, Michigan

Hydraulics & Hydrology Appendix

December 07, 2017

US Army Corps
of Engineers
Detroit District

1.0 Introduction

The purpose of this report is to document the hydrologic and hydraulic analysis of the proposed sea lamprey barrier project along the Little Manistee River in Manistee County, Michigan (Figure 1). The project consists of rehabbing the Fish and Wildlife fish trapping station and excavating a side channel to create a spillway. The spillway will consist of a sheetpile barrier that is set at a proper height to block the passage of sea lamprey during spawning season when they are migrating upstream. The trapping station will be designed to operate as it currently does with stop logs used during sea lamprey migration season.

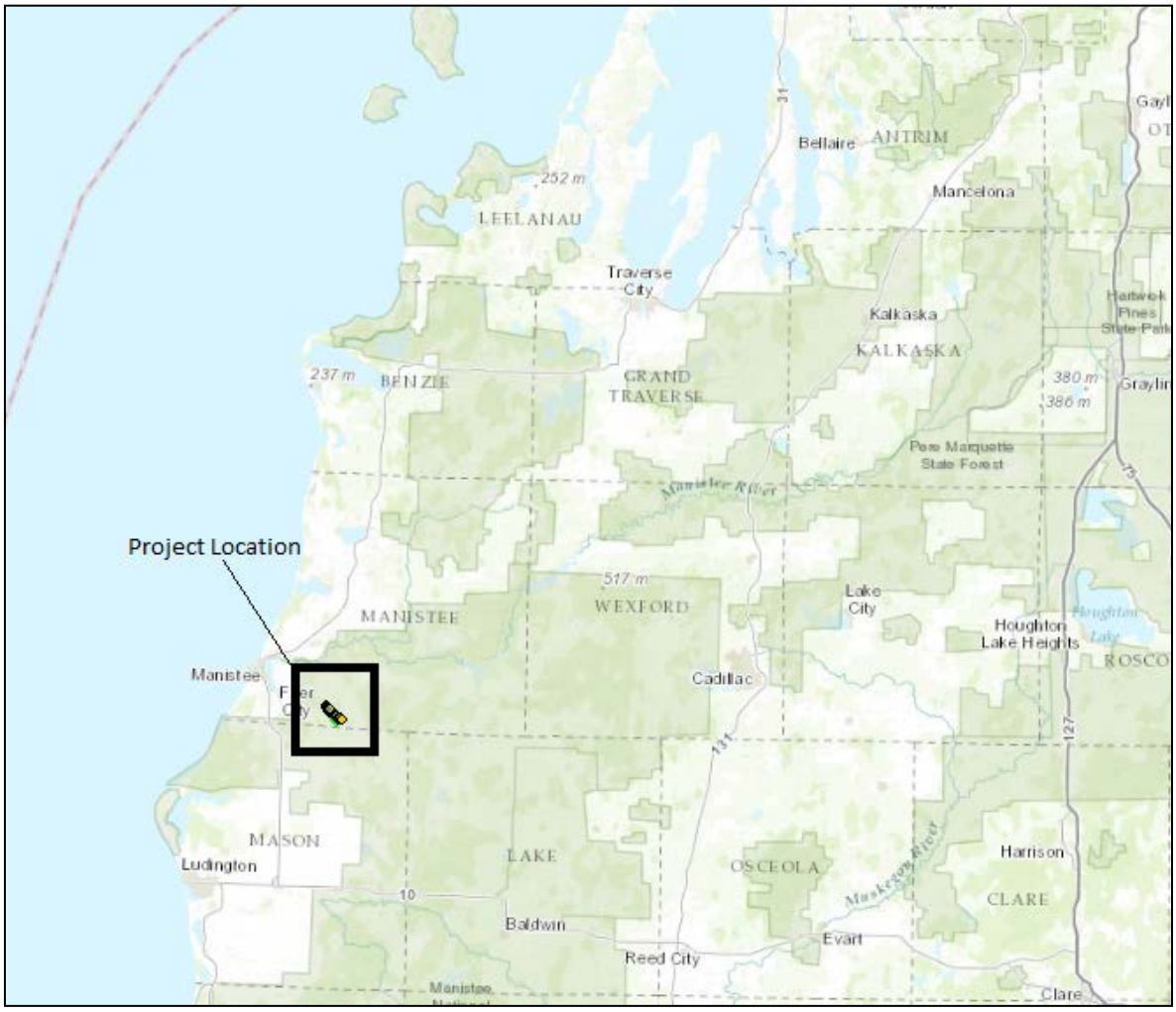


Figure 1: Project Location

The land use in the affected area is heavily forested. The Little Manistee Weir can be seen in relation to the Little Manistee River Watershed (Figure 2). The weir is located approximately 2.7 miles upstream (east) of Old Stronach Rd, and 1.7 miles downstream (west) of Six Mile Bridge Rd.

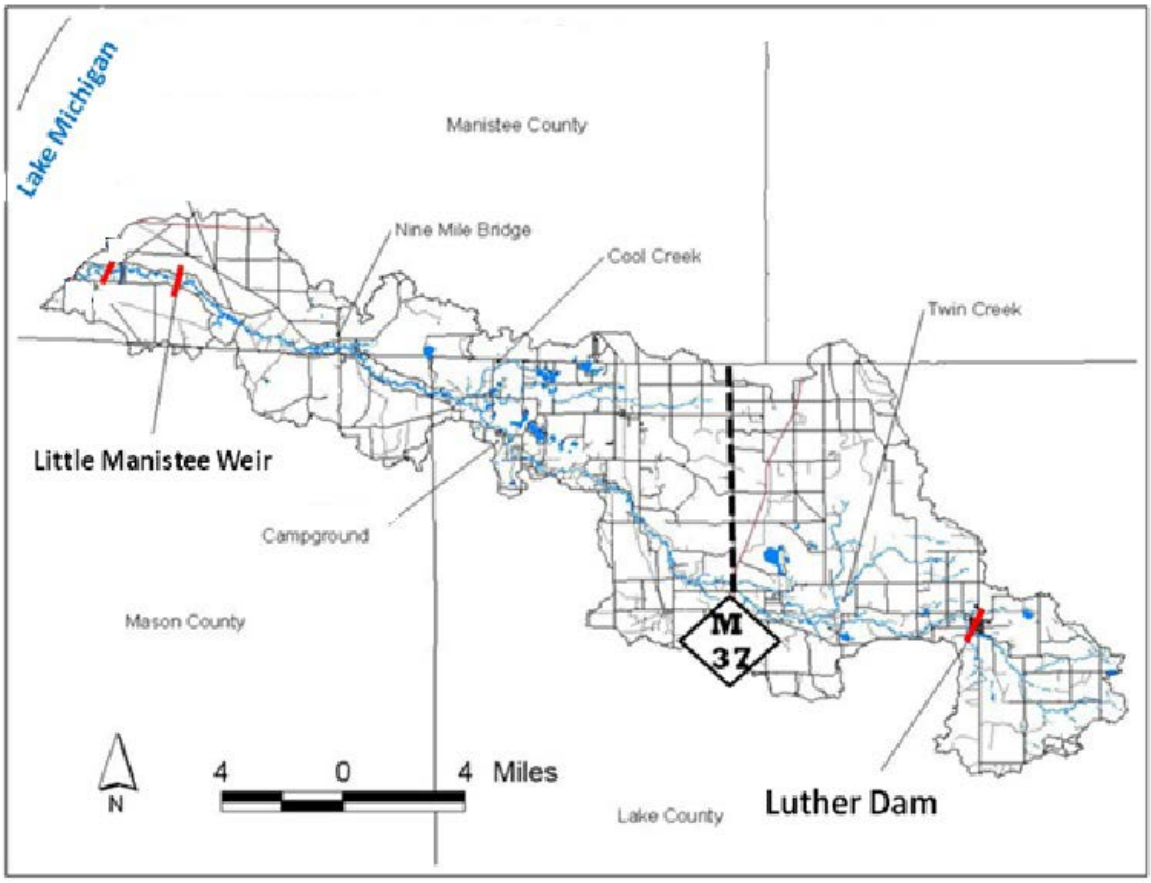


Figure 2: Little Manistee Watershed

This analysis includes gathering and evaluating hydrologic, hydraulic, and survey data, and creating a hydraulic model with existing and proposed project conditions to determine design dimensions and potential flooding impacts. This report details the methodology and results of the proposed project hydraulic analysis.

2.0 Hydrology

The Michigan Department of Environmental Quality (MDEQ) provides flood discharge estimates for all streams and rivers in the State of Michigan. The MDEQ Flood Discharge is calculated using the MDEQ modified SCS method and the National Resource Conservation Service's (NRCS') TR-55 method for small watersheds and the United States Geologic Service (USGS) regression method for larger ones. If stream gage data is available, the MDEQ flood discharge system uses a statistical frequency analysis of the annual maximum floods using the USGS' PEAKFQ program for the statistical analysis.

The MDEQ Flood Discharge request for the Little Manistee River in the project area was received, and those range of discharge frequencies were used in the hydraulic analysis to determine potential flooding impacts. The 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year), and 0.2% (500-year) annual chance exceedance discharges developed by the MDEQ and used in the analysis are

shown in Table 1 and the email from the MDEQ providing the flood discharge request information is included as Attachment 1.

Table 1: MDEQ Flood Event Discharges

Discharge Event	**50% (2-Yr)**	**20% (5-Yr)**	**10% (10-Yr)**	**4% (25-Yr)**	**2% (50-Yr)**	**1% (100-Yr)**	**0.5% (200-Yr)**	**0.2% (500-Yr)**
Flow (cfs)	410	550	650	750	850	900	1000	1100

A quick hydrologic review to ensure that the MDEQ data is reasonable was conducted, including a Flood Frequency Analysis (FFA) using HEC-SSP v2.1 of the available peak streamflow USGS gage data from the USGS 04126200 - Little Manistee River near Freesoil gage. The gage only has 26 years of peak discharge data, from 1957 to 1982, so while a quick SSP analysis was run, the slightly higher discharge values from the MDEQ were utilized for this analysis. The FFA using regional skew statistics from the USGS Water-Resources Investigations Report 83-4194 report, Estimating Generalized Flood Skew Coefficients for Michigan, 1983, due to the short period of record, gave a 1% discharge of 730 cfs. The results of the FFA analysis is included as Attachment 2. The MDEQ calculated the 1% discharge at 900 cfs, and that is what they will regulate to unless a full hydrologic analysis is submitted for their review and concurrence. The quick hydrologic review of the limited gage data available showed that the MDEQ reported values were reasonable.

3.0 Hydraulics

A hydraulic model was developed in HEC-RAS version 5.0.3 for existing and proposed conditions. There is not a detailed FEMA Zone AE floodplain in the project area, and therefore no effective FEMA hydraulic model that could be utilized. There is a FEMA Zone A approximate floodzone for this site, and a copy of the FIRM is included as Attachment 3.

A new georeferenced hydraulic model had to be created from the available USGS 1/9-Arc Second (10 meter) Digital Evaluation Model (DEM) and new survey data provided to USACE from Gourdie-Fraser, Inc. in 2014. The design criterion for the sea lamprey barrier is to provide a 1.5 foot drop from the tailwater elevation to the crest of the weir. After many analyses and discussions with the US Fish and Wildlife Service (USFWS), it was decided that the minimum protection flood event criteria would be the 10% annual chance (10-year) flood event.

The HEC-RAS file for this project is entitled, *"LittleManistee.prj".* The Existing Conditions plan has the Little Manistee Weir Station in its current state without stop logs in place. This is the assumed operation scenario when sea lamprey are not migrating. Multiple proposed plans are included in the model, including the ones described in detail in this hydraulic report. The project area extends from cross-sections 1813.97 to 2079.12.

Design targets for fish passage were not considered in the analysis based on the assumption that current operating procedures for fish passage at the Little Manistee Weir will remain the same.

All surveys and models are geo-referenced to the horizontal datum of NAD 1983 with a horizontal projection of Michigan State Plane Central feet. The vertical datum of the survey data, DEM, and elevations in the hydraulic model and reports is set to NAVD 88 feet.

Once the model was geo-referenced and the cross sections were created in GIS, the cross sections were exported using the Export RAS Data tool in GeoRAS. All cross-sections in the model have their geometries expanded far enough from the survey points using the 10 meter DEM to ensure containment of the 1% annual chance exceedence floodplain in the hydraulic model for all alternatives. Several cross sections were also created using a combination of the DEM and the surveyed channel bottom from an adjacent cross section. A list of cross sections that were approximated from surrounding cross sections can be found in Table 2.

Table 2: Approximated Cross Sections

Cross-Sections in Project Area that were Approximated from DEM and adjacent surveyed channel data	1971, 4441.179, 6322.19, 7534.32, 8921.91, 10052.47, 11138.7, 12124.68

There are no bridges located within our project area. The closest bridges, both upstream and downstream are beyond the area of influence of this project. The project is located in an area of the Manistee National Forest that is undeveloped. The Little Manistee Weir and associated existing earthen and concrete spillway apron are the only structures located in the floodplain in the project area of influence and the model extents.

The downstream boundary condition on the Little Manistee River is set to normal depth with a slope of 0.001. The upstream boundary condition for the Little Manistee River is also set to normal depth with the same slope.

The Manning's roughness coefficients chosen for the Little Manistee River were 0.04 for the channel and 0.1 for the densest part of the overbanks (*HEC-RAS Reference Manual, Version 4.1, Hydraulic Engineering Center, USACE, January 2010)*. This winding channel is pretty clean with some pools and shoals. The areas of the overbank/floodplain that have some light brush and heavy weeds was assigned a Manning's value of 0.05, while a value of 0.08 was assigned to the areas that were a little more dense but not heavily forested. All of the assumptions in deciding what to use for Manning's values were made by using the photographs provided by Gourdie-Fraser, Inc. and aerial photography from GIS.

3.1 Existing Conditions

An Existing Conditions model was created for the Little Manistee River, and it can also be considered Alternative 1 – No Action. The existing conditions were analyzed as run of river with the stop logs out to get a base condition. The existing condition at the Little Manistee Weir is shown in Figure 3. The water surface elevations shown are all headwater elevations. The base of the weir is the existing structure without any stop logs. The sill elevation in this scenario is set at an elevation of 597.94 ft which is the current elevation based on the Gourdie-Fraser survey from 2014. There are 6 bays in the model, each 9 ft wide with 1 ft between them. The total width of the weir if there were no bays is 59 ft. Under these conditions, the model shows some water escaping the channel at the 2% annual chance (50-year) event.

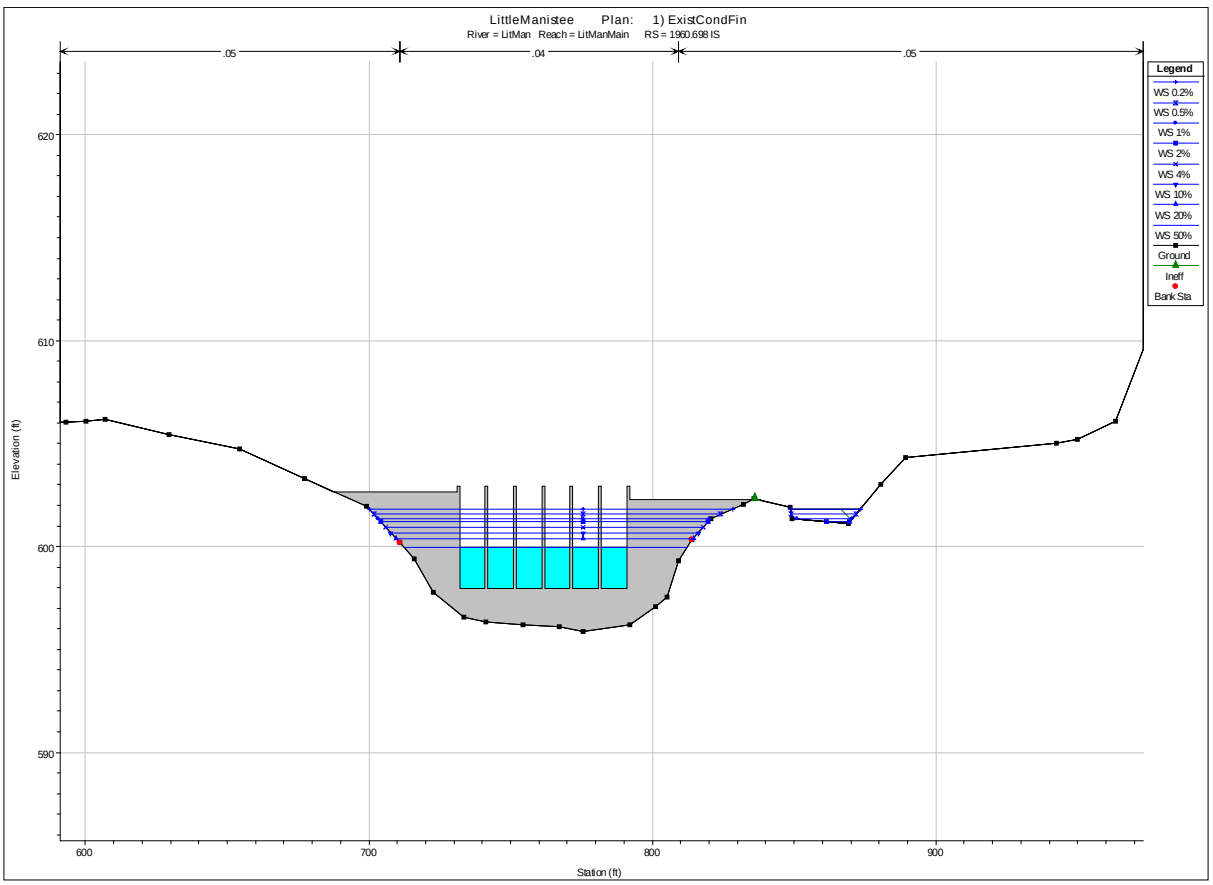


Figure 3: Existing Condition at Little Manistee Weir

The existing conditions were also analyzed with the operational stop logs in place to see if an effective barrier could be configured with the existing structure. The stop log elevation needed to achieve the 1.5 ft drop from crest of weir to tailwater elevation for the 10% annual chance (10-year) flood event is 601.00 ft, and the elevation required for the 4% annual chance (25-year) flood event is 601.32 ft. So, for the 4% event, in order to get the 1.5 ft drop, a minimum of 3.38 ft of stop logs will need to be in place. This scenario is displayed in Figure 4. The water surface elevations shown are all headwater elevations.

Under these conditions, every event above the 99.9 % annual chance (1-year) event overtops the banks at the Little Manistee Weir. Table 3 shows the difference in water levels between the two different scenarios at each cross section contained in the hydraulic model. It was determined that a modification to the structure would be required for it to serve as an effective Sea Lamprey Barrier without causing upstream impacts.

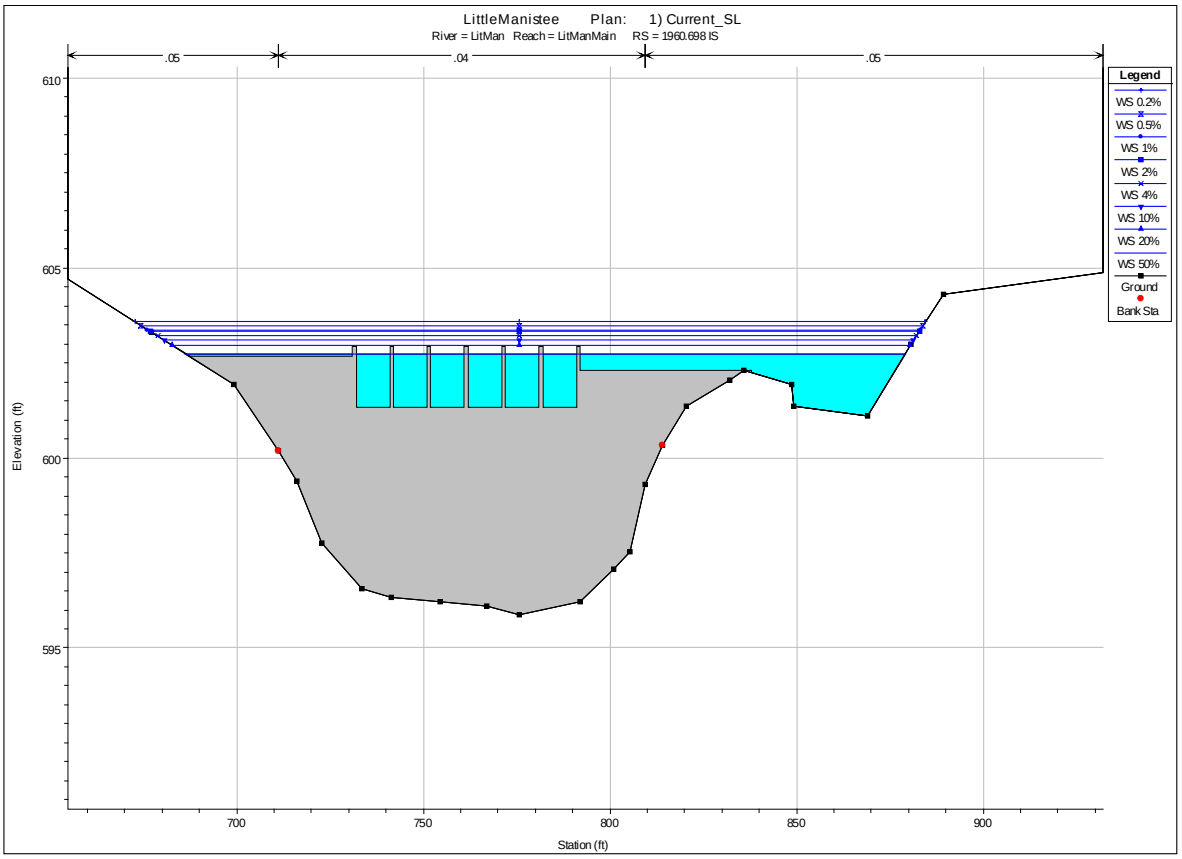


Figure 4: Current Condition at Weir with Stop Logs in Place to elevation of 601.32 ft NAVD88

3.2 Alternative 2 – Construct a Permanent Lamprey Barrier at or downstream of the MDNR Weir

This Demolition of the Existing MDNR Weir Structure and Construction of a Permanent Lamprey Barrier and Trap at the Weir Location: This alternative consists of demolishing and disposing of the existing MDNR weir structure. The portion of the MNDR egg collection facility such as the holding tanks and raceways, the concrete spillway, the MDNR building where the salmon eggs are taken, and facility pump station would be integrated with the new barrier structure. The new barrier will consist of replacing the existing structure in kind and installing a new adjustable steel sheet pile barrier/spillway adjacent to the concrete structure. The new structure would be constructed to block and trap lamprey during the 10% annual chance (10-year) to 4% annual chance (25-year) flood event. Stoplog sections would be incorporated on the barrier to allow FWS and MDNR

personnel to manipulate outflows and to increase the effectiveness of downstream fish passage and lamprey trapping at the barrier. A walkway would be constructed over the barrier and outfitted with davit lifts to allow FWS lamprey control or MDNR egg collection personnel access to traps and to remove and replace stop logs in the adjustable structure. In addition, downstream a fish guidance weir will be installed to ensure fish approach the fish collection facility.

3.3 Alternative 3 – Modify the existing weir structure (Proposed Design)

The recommended alternative is Alternative 3, which consists of modifying the existing MDNR Weir Structure by keeping the main stop log bay crest elevation as 597.94 ft NAVD88 and using adjustable height stop logs to increase the elevation in order to meet the criterion used to stop sea lamprey at the weir, which is to achieve at least a 1.5 ft drop from the crest of the stop logs/weir to the tail water elevation. This alternative also consists of removing the existing earthen and concrete spillway apron and constructing a low head adjustable spillway in order to relieve some flooding issues that would otherwise occur. Multiple design flood events were analyzed to determine impacts, protection, cost, and constructability. After coordination with the USFWS, it was determined that the minimum protection during the lamprey spawning period would be for the 10% annual chance (10-year) flood event protection elevation in the main dam area and for the 4% annual chance (25-year) flood event protection elevation for the spillway, both using stop logs. This corresponds to elevations of 601.00 ft and 601.31 ft, respectively. The stoplogs will be removed for the larger flood events like the 1% annual chance (100-year) flood to ensure there are no upstream flood impacts.

The midchannel earthen high ground that extends from XS 1813.979 to XS 2025.914 will also need to be dredged to allow more flow through this bottleneck along the river. Once the area is dredged out, the spillway can be placed near the right bank of the river. The midchannel high ground can be seen in Figure 5**.** This alternative with no stop logs in place is shown in Figure 6. This alternative with stoplogs in place to the 10% elevation for the main dam and the spillway elevation set to the 25% elevation is shown in Figure 7. It's important to note that the water surface elevations shown in the figures are all headwater elevations. The results can be seen in Table 3.

Figure 5: Sand Bar to be dredged for Proposed Design

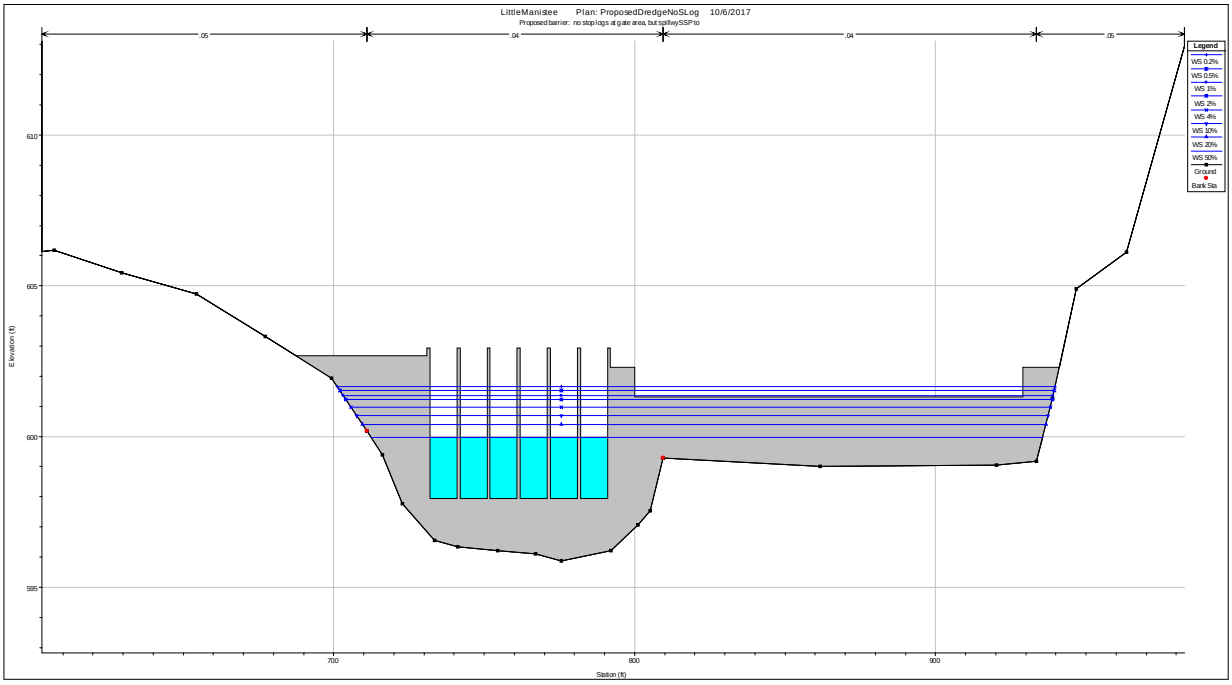


Figure 6: Proposed Conditions (spillway) at Weir with no Stop Logs in Place

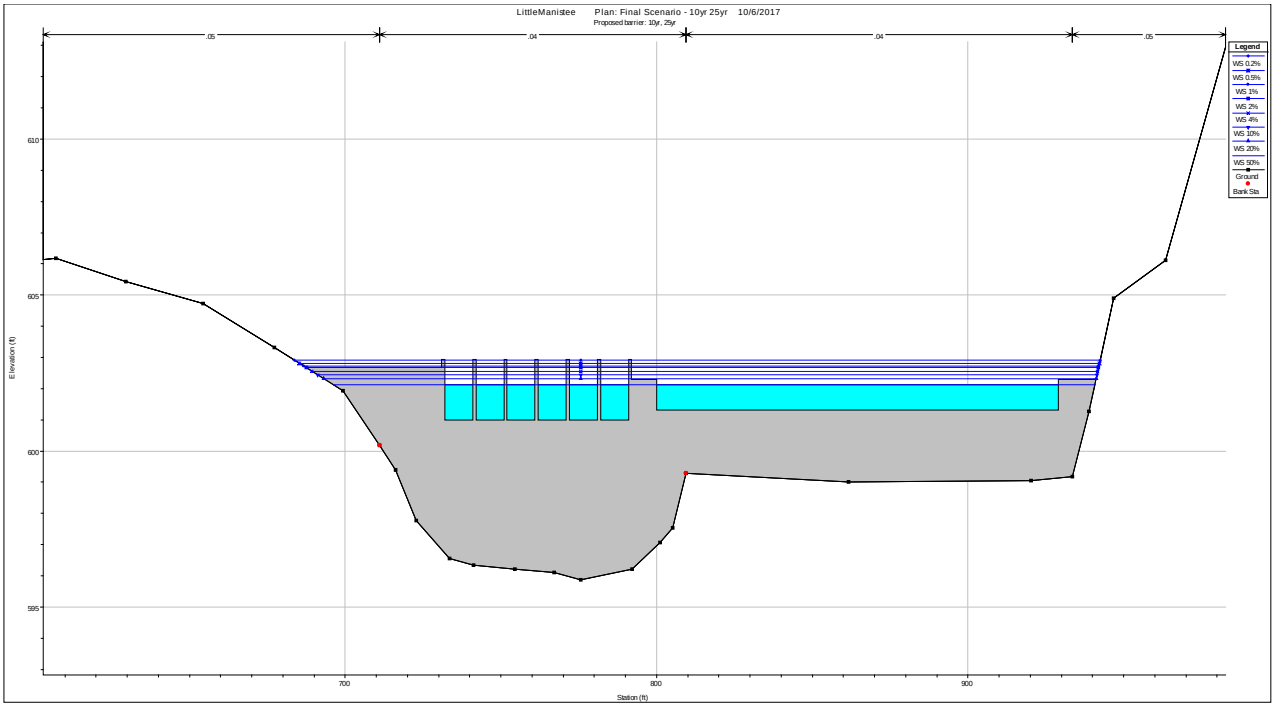


Figure 7: Proposed Conditions (spillway) at Weir with Stop Logs in Place

Table 3: H&H Results of Alternative 3 with Stop Logs in Place for the 10% (10-yr) main dam and 4% (25-yr) spillway elevations

		Upstream					Downstream					
Flow Event	Flow (cfs)	Water-surface Elevation (ft)	Average Channel Bottom Elevation (ft)	Channel Velocity (ft/s)	Existing Condition Water-surface Elevation (ft)	Water-surface Elevation Change (ft)	Water-surface Elevation (ft)	Average Channel Bottom Elevation (ft)	Channel Velocity (ft/s)	Minimum Drop from Sill to Water-surface (ft)	Approximate Depth of Water over Spillway (ft)	Height From Water Surface to Catwalk (ft)
Low Flow	300	601.95	595.87	0.43	601.44	0.51	598.14	592.33	0.46	2.86	0.64	0.98
50%	410	602.11	595.87	0.56	601.76	0.35	598.67	592.33	0.55	2.33	0.8	0.82
20%	550	602.31	595.87	0.71	602.12	0.19	599.17	592.33	0.67	1.83	1	0.62
10%	650	602.44	595.87	0.82	602.34	0.1	599.5	592.33	0.74	1.5	1.13	0.49
4%	750	602.55	595.87	0.92	602.51	0.04	599.81	592.33	0.81	1.19	1.24	0.38
2%	850	602.66	595.87	1.01	602.67	-0.01	600.09	592.33	0.87	0.91	1.35	0.27
1%	900	602.71	595.87	1.06	602.75	-0.04	600.22	592.33	0.9	0.78	1.4	0.22
0.50%	1000	602.8	595.87	1.15	602.88	-0.08	600.47	592.33	0.96	0.53	1.49	0.13
0.20%	1100	602.9	595.87	1.24	602.99	-0.09	600.7	592.33	1.02	0.3	1.59	0.03

Stoplog Crest Elevation =	601	ft
Spillway Crest Elevation =	601.31	ft
Stoplog Height =	**3.06**	**ft**
Crest of Dam (no stoplogs) =	597.94	ft

3.4 Flood Impacts

FEMA designates areas of flooding at the 1% annual exceedence. As an official FEMA Zone A approximate floodplain, there is not an official baseflood elevation. Instead, the requirement is to show no negative impacts to the floodplain for the 1% annual exceedence event.

Operating under the assumption that for a 1% exceedance event the stop logs would not be in place, the most relevant comparison for the project is between the existing condition and proposed condition, each without stop logs. The changes in water surface elevations for the 1% floodplain for the proposed and existing conditions, without the stop logs in place, can be found in the red shaded column of Table 4 below. In this scenario, there are mostly decreases in the water levels, up to a maximum decrease of 0.07 ft at XS 2025.914 and XS 2202.336. One cross section shows a very slight increase of 0.03 ft just upstream of the weir at XS 1971.

The 1% water surface profiles for the existing and proposed conditions with stop logs in place, which would be a worst case scenario, is shown in Figure 8. For this scenario, there would be an increase to the 1% water surface elevation for less than a mile with no upstream structures impacted.

The 1% water surface profiles for the existing and proposed conditions without the stop logs, which would be the expected conditions during a major flood event and matches the values from Table 4, is shown in Figure 9. This scenario shows that there is only a very minor and localized impact to the water surface elevation that does not propagate upstream.

Flood inundation mapping of the 1% floodplains for the existing and proposed conditions without stop logs was completed to determine impacts to the floodplain. The 1% flood inundation map for the section of river modeled is shown in Figure 10 below. Since the maximum change in water-surface elevation between the existing and proposed conditions without stop logs is only -0.07 feet, which is within mapping tolerance of the DEM, the two floodplains are the same except in the area of the proposed weir where the proposed spillway will be located. A close-up of the 1% floodplains for the existing and proposed conditions, without stop logs, in the area of the proposed spillway is shown in Figure 11.

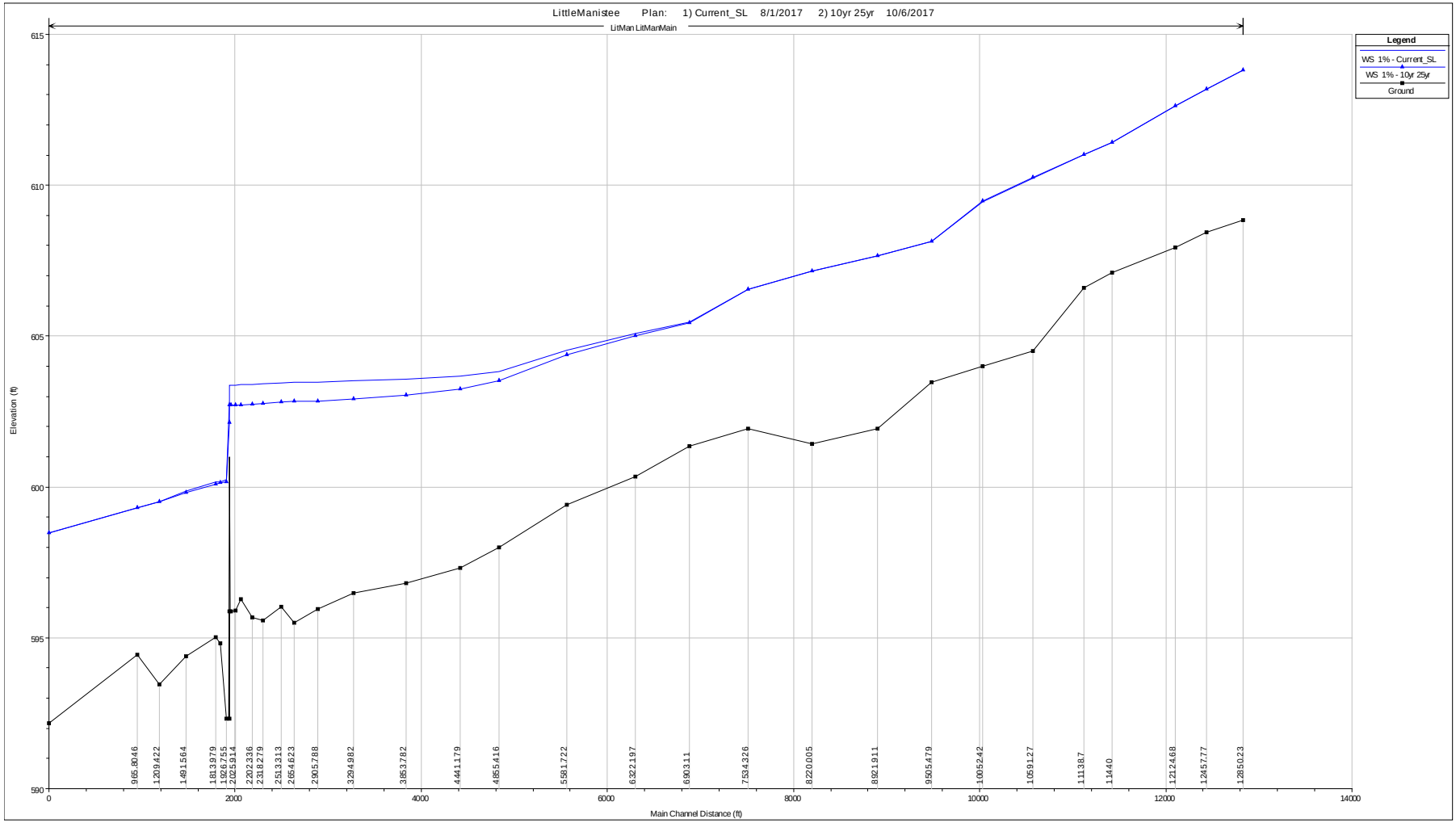


Figure 8: 1% Water Surface Profiles for Existing and Proposed Conditions With Stop Logs in Place

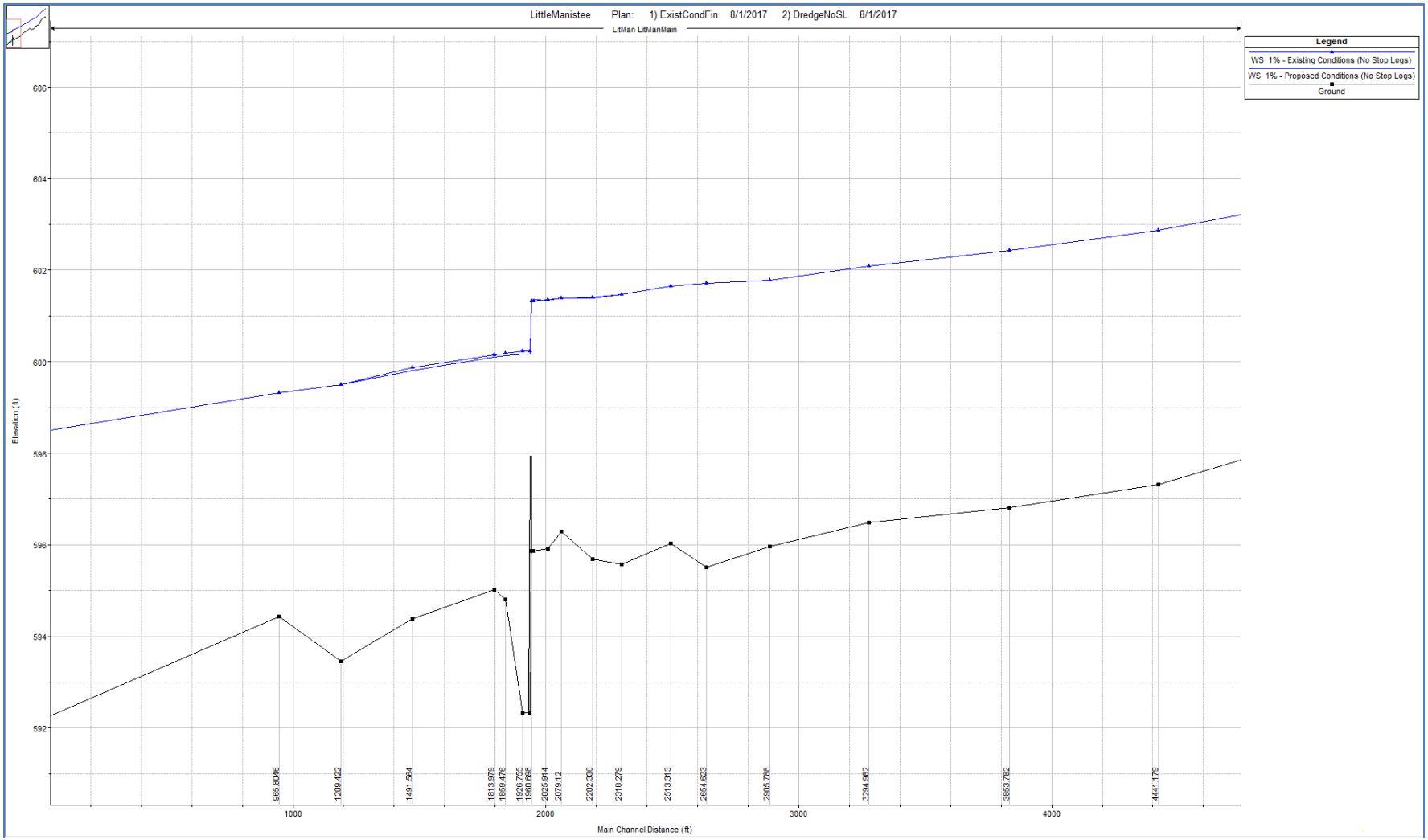


Figure 9: 1% Water Surface Profiles for Existing and Proposed Conditions Without Stop Logs (what would be expected during flood conditions)

Table 4: Water Surface Elevations for the %1 Annual Exceedence (100-year) Event with NO StopLogs

River Station	Existing Condition Water Surface Elevation (ft)	Proposed Condition Water Surface Elevation (ft)	Difference Between Existing Condition w/o SL to Proposed Condition w/o SL
12850.23	613.8	613.8	0
12457.77	613.19	613.19	0
12124.68	612.62	612.62	0
11440	611.41	611.41	0
11138.7	611.01	611.01	0
10591.27	610.25	610.25	0
10052.42	609.47	609.47	0
9505.479	608.13	608.13	0
8921.911	607.66	607.66	0
8220.005	607.15	607.15	0
7534.326	606.55	606.55	0
6903.11	605.43	605.43	0
6322.197	604.99	604.99	0
5581.722	604.32	604.32	0
4855.416	603.3	603.30	0
4441.179	602.87	602.87	0
3853.782	602.43	602.43	0
3294.982	602.09	602.09	0
2905.788	601.78	601.78	0
2654.623	601.72	601.71	-0.01
2513.313	601.65	601.65	0
2318.279	601.48	601.47	-0.01
2202.336	601.4	601.39	-0.01
2079.12	601.39	601.38	-0.01
2025.914	601.35	601.35	-0.0
1971	601.33	601.36	0.03
1960.698 IS			
1926.755	600.24	600.17	-0.07
1859.476	600.18	600.14	-0.04
1813.979	600.16	600.09	-0.07
1491.564	599.87	599.81	-0.06
1209.422	599.5	599.5	0
965.8046	599.32	599.32	0
18.9868	598.46	598.46	0

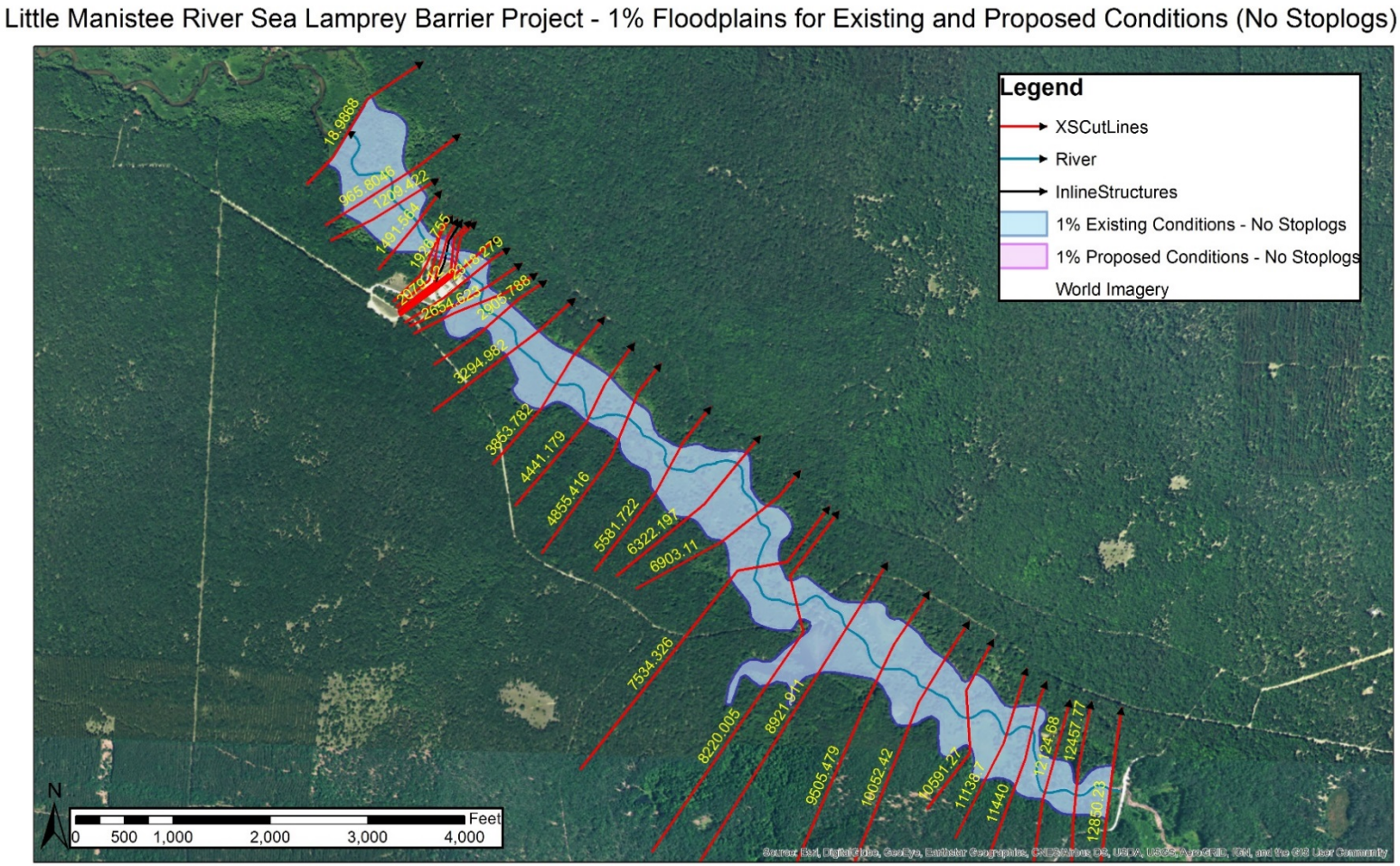


Figure 10: 1% Floodplains for Existing and Proposed Conditions Without Stop Logs

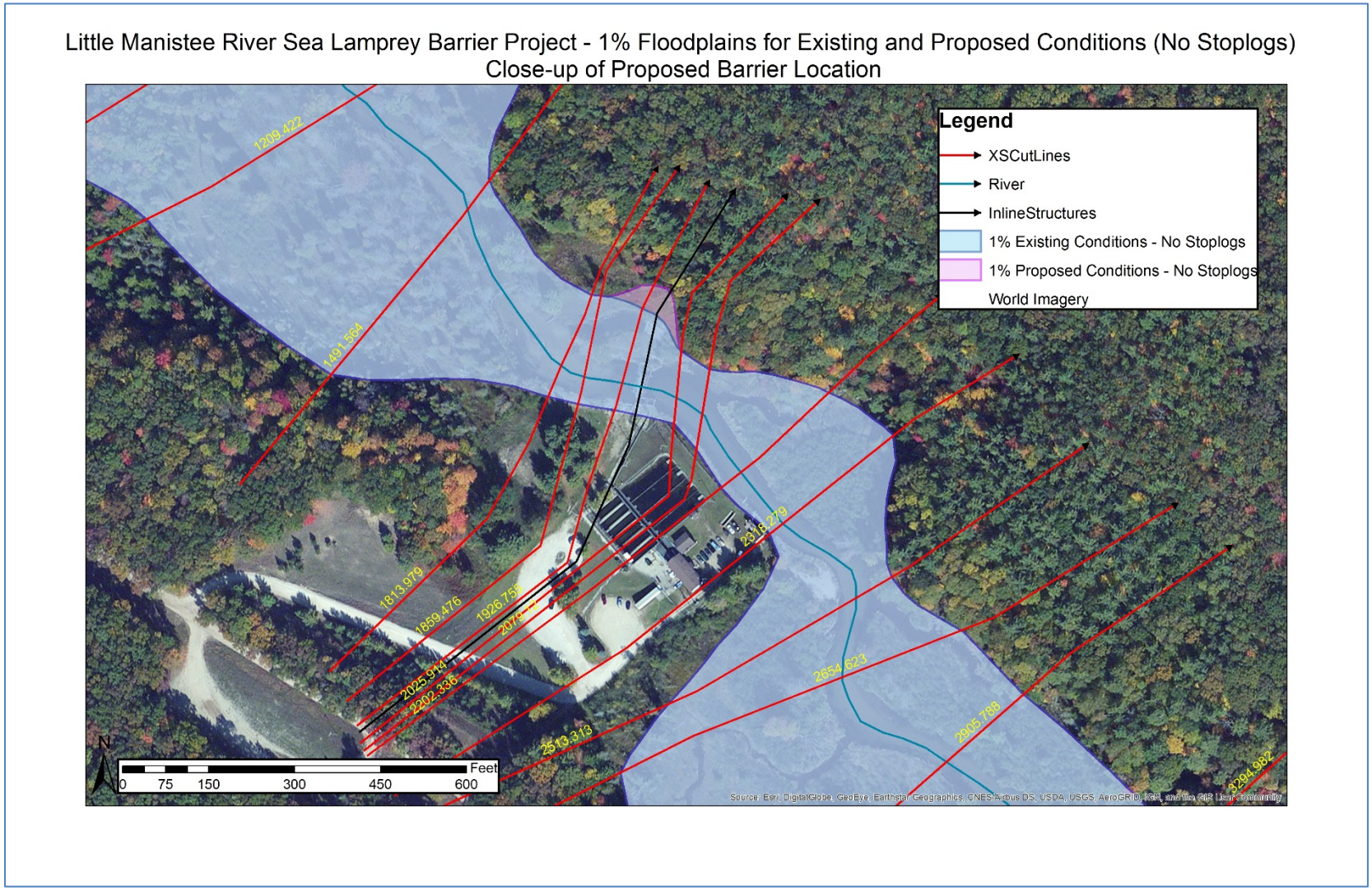


Figure 11: 1% Floodplains for Existing and Proposed Conditions Without Stop Logs (close up of only area impacted)

4.0 Summary

The recommended proposed alternative, Alternative 3 – Modify the existing weir structure, includes utilizing stop logs at the Little Manistee MDNR Weir location to create the required crest height of at least 601.00 ft in the main dam area, dredging the midchannel high ground to assist with flood relief, and installation of a spillway set to an elevation of 601.31 ft to allow for enough flood relief to prevent upstream flood impacts during the 1% flood event. This design will prevent sea lamprey from migrating upstream by providing a 1.5 foot drop from the crest height to the tail water elevation for the 10% annual chance (10-year) flood at the main dam and the 4% (25-year) flood across the spillway. It will allow for the current fish passage procedures currently in use at the Little Manistee Weir location, and also for the stop logs to be removed during large flood events like the 1% annual chance (100-year) flood in order to prevent upstream impacts.

Attachment 1

From: Sidick, Charles L (Chuck) CIV USARMY CELRE (US)
To: Tule, Shelley J CIV USARMY CELRE (US)
Subject: FW: flood or low flow discharge request (ContentID - 168812)
Date: Wednesday, December 06, 2017 1:49:14 PM

-----Original Message-----
From: deq-wrd-qreq [mailto:deq-wrd-qreq@michigan.gov]
Sent: Thursday, September 18, 2014 2:11 PM
To: Sidick, Charles L LRE <Charles.L.Sidick@usace.army.mil>
Subject: [EXTERNAL] RE: flood or low flow discharge request (ContentID - 168812)

This reply is being sent via email only.

We have estimated the flood frequency discharges requested in your email of September 4, 2014 (Process No. 20140370), as follows:

Little Manistee River at DNR Weir Station, Section 25, T21N, R16W, Stronach Township, Manistee County, has a total drainage area of 187 square miles and a contributing drainage area of 164 square miles. The 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% chance peak flows are estimated to be 410 cubic feet per second (cfs), 550 cfs, 650 cfs, 750 cfs, 850 cfs, 900 cfs, 1000 cfs, and 1100 cfs, respectively. (Watershed Basin No. 20 Manistee).

Please include a copy of this letter with your inspection report or any subsequent application for permit. These estimates should be confirmed by our office if an application is not submitted within one year. If you have any questions concerning the discharge estimates, please contact Ms. Susan Greiner, Hydrologic Studies and Dam Safety Unit, at 517-284-5579, or by email at: GreinerS@michigan.gov. If you have any questions concerning the hydraulics or the requirements for the dam safety inspection report, please contact Mr. Jim Pawloski of our Dam Safety Program at 989-370-1528, or by email at: PawloskiJ@michigan.gov.

-----Original Message-----
From: charles.l.sidick@usace.army.mil [mailto:charles.l.sidick@usace.army.mil]
Sent: Thursday, September 04, 2014 2:55 PM
To: deq-wrd-qreq
Subject: flood or low flow discharge request (ContentID - 168812)

Requestor: Charles Sidick
Company: USACE
Address: 477 Michigan Ave
City: Detroit/MI
Zip: 48226
Phone: 3132263395
Date: 9/4/14
F50percent: Yes
F20percent: Yes
F10percent: Yes
F4percent: Yes
F2percent: Yes
F1percent: Yes
F0.5percent: Yes
F0.2percent: Yes
ContactAgency: None Selected
ContactPerson:

Watercourse: Little Manistee
LocalName:
CountyLocation: Manistee
CityorTownship: Stonach, MI
Section: 25
Town: 21N
Range: 16W
Location: DNR Weir Station on the Little Manistee about 3/4 of a mile downstream of 6 mile road.
FFR1: Dam

Attachment 2

Bulletin 17 Editor - FFA - regional skew

Name: FFA - regional skew

Description: FFA computed with regional skew

Flow Data Set: Peak-Little Manistee-Freesoil

DSS File Name: D:\LittleManisteeSLB\SSP\LittleManistee\LittleManistee.dss

Report File: D:\LittleManisteeSLB\SSP\LittleManistee\Bulletin17Results\FFA_-_regional_skew\FFA_-_regional_skew.rpt

General | Options | EMA Data | Tabular Results

Frequency Curve for: Peak-Little Manistee-Freesoil

Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Confidence Limits Flow in cfs	
			0.05	0.95
0.2	832.0	903.3	1068.0	706.3
0.5	774.2	824.6	974.2	664.8
1.0	728.7	766.1	902.2	631.7
2.0	681.4	707.7	828.8	596.6
5.0	614.8	629.9	728.6	546.0
10.0	559.9	568.6	649.0	502.9
20.0	498.5	502.6	564.2	452.7
50.0	396.0	396.0	434.8	360.9
80.0	311.0	308.1	342.3	275.0
90.0	272.8	267.9	304.1	234.8
95.0	244.3	237.2	276.1	204.8
99.0	197.4	184.8	230.2	156.5

Statistics

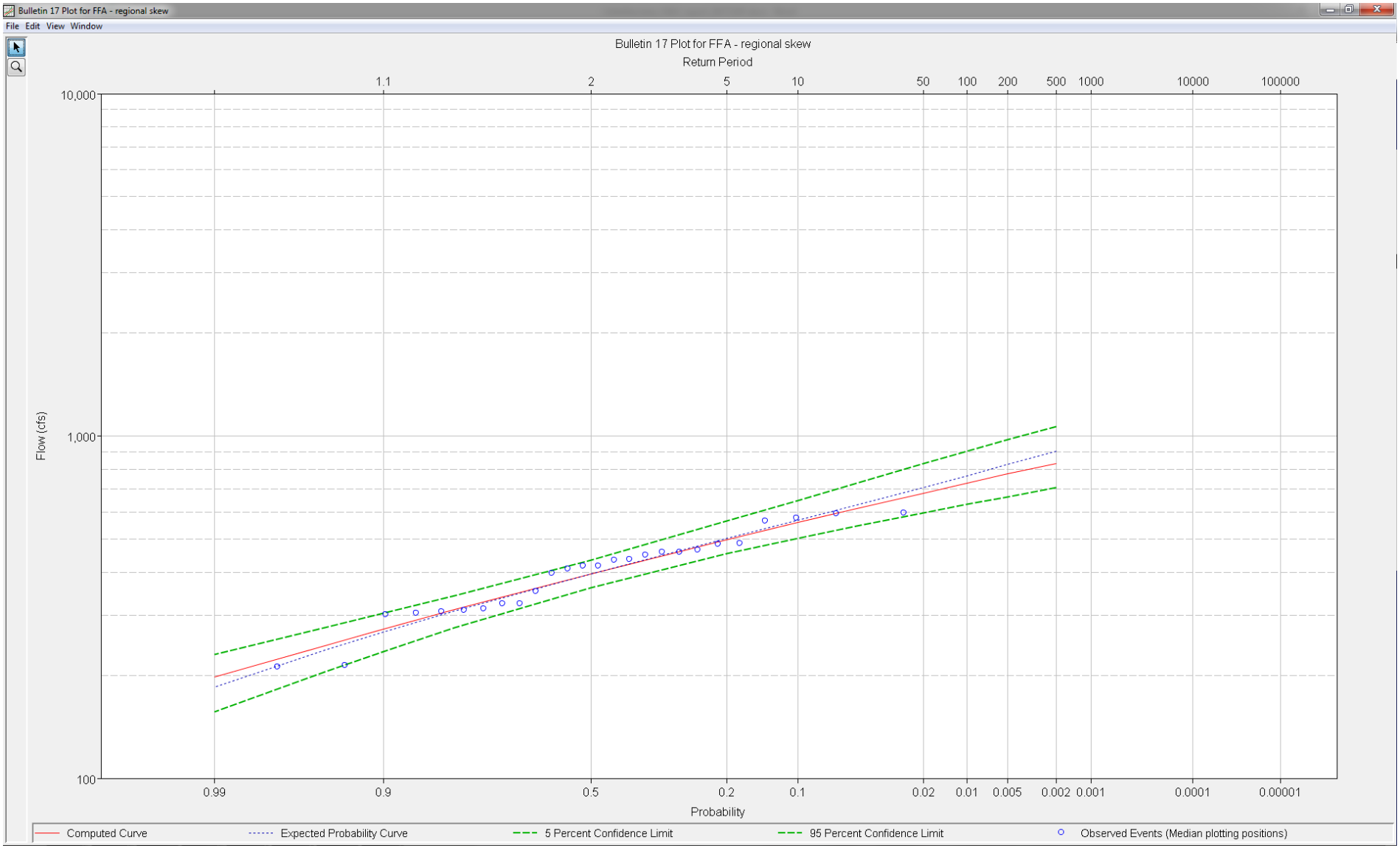
Log Transform: Flow

Statistic	Value
Mean	2.594
Standard Dev	0.122
Station Skew	-0.536
Regional Skew	-0.170
Weighted Skew	-0.336
Adopted Skew	-0.170

Number of Events

Event	Number
Historic Events	0
High Outliers	0
Low Outliers	0
Zero Or Missing	0
Systematic Events	26
Historic Period	

Compute | Plot Curve | View Report | Print | OK | Cancel | Apply


Bulletin 17 Plot for FFA - regional skew
File Edit View Window
Bulletin 17 Plot for FFA - regional skew
Return Period
1.1
2
5
10
50
100
200
500
1000
10000
100000
10,000
1,000
100
Flow (cfs)
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
0.00001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)

Attachment 3

CORPORATE LIMITS
ZONE C
ZONE A
ZONE C
ZONE C
ZONE C
ZONE A
ZONE C
ZONE C
ZONE C
ZONE C
ZONE C
KEY TO MAP
ZONE C
Zone Designations*
ZONE A
ZONE C
Base Flood Elevation Line With Elevation In Feet**
Base Flood Elevation In Feet Where Uniform Within Zone**
Elevation Reference Mark
Zone D Boundary
River Mile
*Referenced to the National Geodetic Vertical Datum of 1929
*EXPLANATION OF ZONE DESIGNATIONS
ZONE
EXPLANATION
A
A0
AH
A1-A30
A99
B
C
D
V
V1-V30
NOTES TO USER
INITIAL IDENTIFICATION:
SEPTEMBER 30, 1988
FLOOD HAZARD BOUNDARY MAP REVISIONS:
FLOOD INSURANCE RATE MAP EFFECTIVE:
SEPTEMBER 30, 1988
FLOOD INSURANCE RATE MAP REVISIONS:
APPROXIMATE SCALE
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
TOWNSHIP OF
STRONACH,
MICHIGAN
MANISTEE COUNTY
(ONLY PANEL PRINTED)
COMMUNITY-PANEL NUMBER
260801 0025 A
EFFECTIVE DATE:
SEPTEMBER 30, 1988
Federal Emergency Management Agency