Executive Summary of Flood Study and Conceptual Design Basis Reports by GEI

Introduction

Following the May 19, 2020, storm event, the Four Lakes Task Force (FLTF) requested GEI Consultants of Michigan, P.C. (GEI) to provide planning-level opinions of probable construction costs to reconstruct and/or rehabilitate the four dams. These high-level cost estimates were provided in our Technical Memorandum to David Kepler of the FLTF dated July 13, 2020.

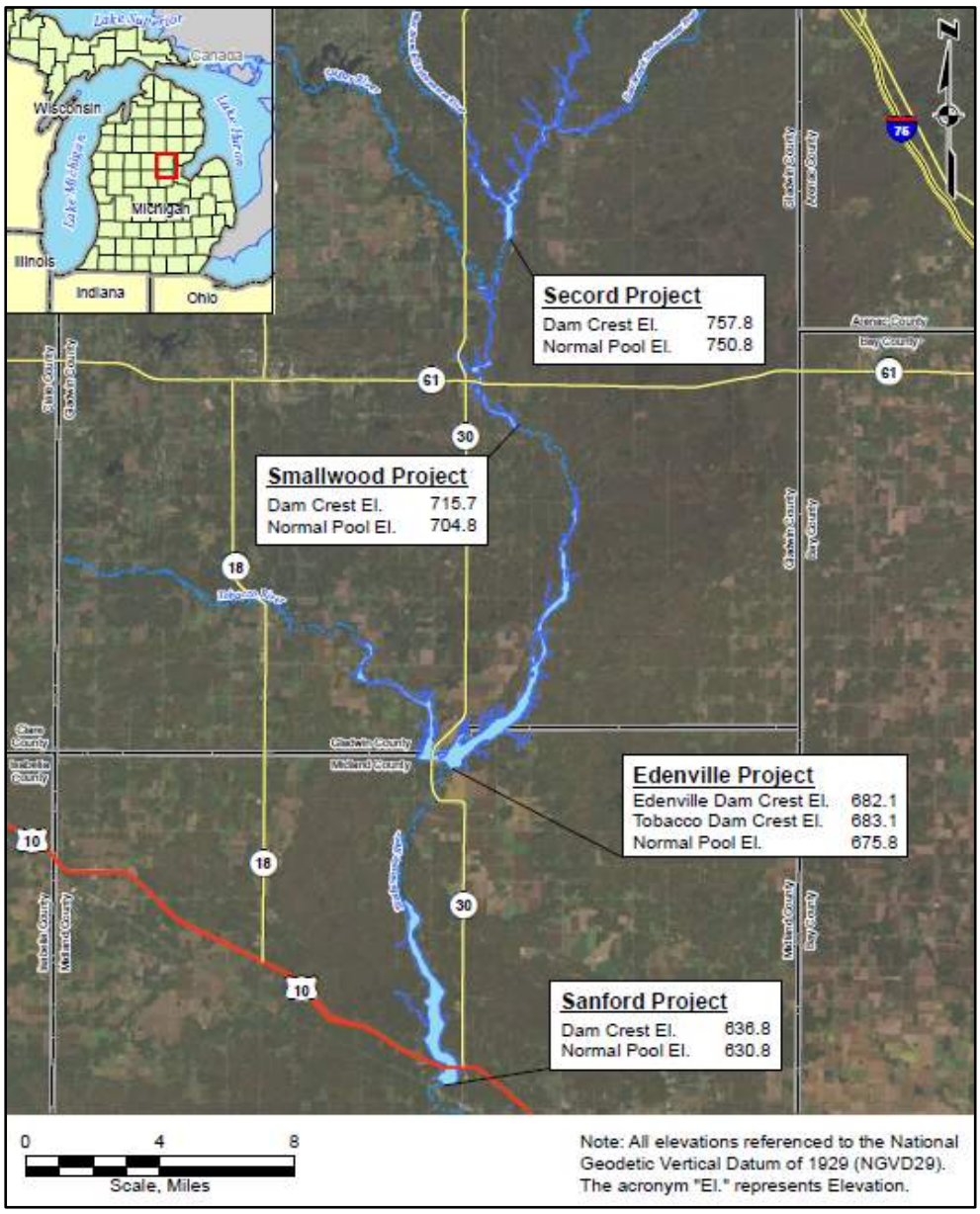
As follow-up to our July 2020 Planning Level Cost Study, the FLTF requested two (2) additional engineering studies be undertaken.

1. A hydrologic and hydraulic flood study of the Tobacco and Tittabawassee River watersheds to update and finalize the design storms at each of the four dams and determine the additional minimum spillway capacity required to safely pass the ½ PMF. That study was a collaborative effort between GEI, Ayres Associates (Ayres) and the Spicer Group, Inc. (SGI). The results of the flood study are provided in GEI's March 2021 study titled "*Flood Study of the Tittabawassee River from Secord to Sanford Dam."*
2. An engineering study to further develop the conceptual designs for dam rehabilitation and reconstruction to the 30% schematic level based on:
    - Updated spillway capacity requirements determined during the 2021 flood study.
    - GEI's external inspections of the four dams completed in October 2020 and internal inspections conducted in January 2021 at Secord and Smallwood Dams.
    - "Value engineering" completed by the design team with the goal of improving the design details and constructability, compressing the construction schedule, and reducing overall project costs.
    - Design and construction of interim stabilization measures currently underway at Tobacco Spillway to stabilize the river bed and restore flow into the Tobacco River channel, and planned interim stabilization measures at Edenville Spillway and Sanford Dam which may also be eligible for NRCS Emergency Watershed Protection Program funding.

The results of these engineering studies and inspections are provided in GEI's Conceptual Design Basis and Inspection Reports dated March 2021 for Secord, Smallwood, Edenville and Sanford Dams. This results of these studies and current conceptual-level opinions of probable construction costs are summarized below.

A location map FLTF dams and their respective lakes are shown on Exhibit 1.

Exhibit 1 – Plan of FLTF Dam Sites



Note that all references to left and right herein are with respect to looking in a downstream direction. All elevations listed herein are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

Flood Study of the Tittabawassee River from Secord Dam to Sanford Dam Summary

As highlighted by the May 2020 flood event, all four dams had insufficient spillway capacity to safely pass the design flood (by either State of Michigan or FERC criteria), in addition to a number of other safety deficiencies with the earthen and concrete water retaining structures. Furthermore, the May 2020 flood brought into question both the existing spillway discharge rating curves (i.e., how much flow each dam can pass prior to overtopping) and the river inflow at each dam associated with storm events (e.g., 100-year, 500-year, 1,000-year, ½ PMF) up to

the PMF. The March 2021 Flood Study was undertaken to achieve the following goals in support of preliminary design of the required flood capacity upgrades:

- Determine the existing spillway capacity of each dam.
- Update the PMF Inflow Hydrographs *(still in progress by Ayres).*
- Evaluate spillway configurations to pass the ½ PMF plus some additional contingency amount as a hedge against a possible future increase in either the PMF or the minimum spillway capacity required by the State of Michigan.
- Develop floodplain inundation mapping to identify roads, highways, habitable structures, and other critical infrastructure impacted from the proposed spillway configurations for a range of design storm events.

Final design and permitting of proposed dam repairs with the State of Michigan will require completion of a risk-based study (Inflow Design Flood Study) to determine the final spillway design capacity criteria. We anticipate this will require the completion of the following:

- Completion of a site specific PMP (probable maximum precipitation study – currently in progress by Applied Weather Associates [AWA] to be completed in June 2021) and a probability assessment of various design storm rainfall depths for the Tittabawassee River basin.
- AWA will provide the updated rainfall depths and distributions to Ayres to develop site specific ½ PMF and full PMF inflow hydrographs. The ongoing PMP and PMF studies by AWA and Ayres are expected to be completed in June 2021.
- Once the site specific PMP and PMF studies are completed, GEI will perform an incremental consequence analysis to determine downstream consequences of dam failure for a range of flood flows up to the PMF. This approach aligns with the FEMA guidelines and recommendations of the Michigan Dams Safety Task Force for dams.

Updated Flood Study Results

The following table summarizes the existing (pre-flood) spillway capacity at each of the four dams, the current ½ PMF and full PMF inflow at each dam and corresponding freeboard (i.e., remaining dam height before the reservoir begins overtopping the dam), and the recommended ½ PMF plus contingency (1/2 PMF + design storm) based on the results of the flood study:

Summary of Existing and Required Spillway Discharge Capacity

Parameter	Secord Project	Smallwood Project	Edenville Project		Sanford Project
			Edenville Dam	Tobacco Dam	
Total Existing Spillway Capacity (cfs)	7,695[(1)]	10,185[(2)]	10,750	9,920	29,690 [(3)]
½ PMF Inflow (cfs)	18,075	19,065	41,260		37,695
½ PMF Freeboard (feet) [(4)]	0.0	2.4	-2.1		-0.4

Parameter	Secord Project	Smallwood Project	Edenville Project		Sanford Project
			Edenville Dam	Tobacco Dam	
PMF Inflow (cfs)	43,020	58,640	116,525		116,065
PMF Freeboard (feet) [4]	-1.9	-2.7	-4.7		-7.5
Recommended Spillway Design Flood (cfs)	**21,150**	**24,550**	**52,275**		**47,300**

1. Does not include the peak outflow to the Tea Creek Ridgeline or Left embankment overtopping.
2. Does not include the overtopping of the left embankment
3. Not including the fuseplug emergency spillway, which was intended to add 6,485 cfs of capacity but did not trigger during the May 2020 flood.
4. Negative number indicates flow overtopping the dam.

Discussion of the Inflow Design Flood

Considering the schedule of the site specific PMP and PMF study by AWA and Ayres, an interim IDF was selected for the purposes of this flood study and developing 30% design plans and budgetary costs for the FLTF projects. The current state of Michigan EGLE spillway requirement for high hazard dams is the ½ PMF. However, the project team (GEI, SGI, Essex and the FLTF) collaboratively selected a more conservative design criteria considering the uncertainty of the State of Michigan EGLE spillway capacity requirements and the upcoming results of the site specific PMP and PMF studies.

The Secord ½ PMF is estimated to be the approximately 2,000-year storm event and the Smallwood Dam ½ PMF is estimated to be the approximately 1,200-year storm event. The design team acknowledges the limitations of these flood frequency curves and elected to increase the design flood at both Secord and Smallwood to the 5,000-year flood event (calculated by Ayres) or 1/5,000 (0.0002 Annual Exceedance Probability). This resulted in a peak inflow increase of approximately 17% at Secord and 29% at Smallwood Dam. The flood frequency curves at downstream Edenville and Sanford Dams were considered to be overly conservative and an unrealistic representation of the flood frequency at those dams. Therefore, for the purposes of this analysis, a 15% increase in the HEC-HMS discharge ratio was applied for the Edenville and Sanford Dams. This 15% discharge ratio increase resulted in a ½ PMF peak inflow increase of 26% at Edenville Dam and Sanford Dam. For the purposes of this study, the selected IDF is the ½ PMF + Design Storm, where the incremental increase in peak inflow ranges from 17% to 26%, depending on the dam site, as summarized in the table below. Once the site specific PMP, PMF, and flood recurrence studies are complete, the IDF will be re-evaluated using the techniques prescribed in FEMA P-94.

Summary of Inflow Design Flood (1/2 PMF + Design Storm)

Dam	½ PMF (cfs)	PMF (cfs)	½ PMF +[1] (cfs)	Notes	Annual Exceedance Probability (AEP)
Secord Dam	18,075	43,020	**21,150**	½ PMF + 17% Peak Inflow	1/5000 or 0.0002
Smallwood Dam	19,065	58,640	**24,550**	½ PMF + 28% Peak Inflow	1/5000 or 0.0002
Edenville Total	41,260	116,525	**52,275**	½ PMF + 26% Peak Inflow	TBD
Sanford Dam	37,695	116,065	**47,300**	½ PMF + 26% Peak Inflow	TBD

1. The current IDF for the FLTF Projects is the ½ PMF + design storm.

Development of the Conceptual Designs to Restore Legal Lake Levels

The proposed conceptual designs to restore the lakes to pre-flood levels were developed to the 30% schematic level in accordance with the following design criteria and goals:

- The reconstruction / rehabilitation of the FLTF dams will provide 75+ year design service life.
- The reconstruction / rehabilitation of the FLTF dams will be designed to meet the current industry standards of engineering practice and design standards for high hazard dams in accordance with State of Michigan EGLE.
- The proposed primary spillways when combined with the auxiliary spillways should have sufficient discharge capacity to pass the ½ PMF + design storm without overtopping the embankments, and provide sufficient freeboard below the dam crest.
- Operation of the crest control gates will be the primary means for regulated releases to the Tittabawassee River under both normal and flood conditions during warm and cold weather conditions. The crest gates offer a means to pass flood flows, flotsam debris and ice during the freshet (i.e., spring-time ice out). Crest gates work by active pressurization and if conditions occur that lack power, the gates with drop by gravity to allow safe full overflow condition.
- The proposed auxiliary spillways will have an un-gated passive overflow crest to assist in safely passing the ½ PMF + design storm and operate without human intervention.
- A means to draw down the impoundment below the level of gated spillways, if necessary, and pass base river flows in the winter is considered essential to dam and operator safety to help manage ice buildup at the spillways. This will be accomplished by modifying the existing water passages in the powerhouses to function as a low-level outlet during low flow and winter flow conditions to reduce ice build-up on and below the crest gates.
- The four impoundments will be drawn down three feet in winter in accordance with the current lake operating level standards to minimize static ice loading on the auxiliary spillways. The winter pool drawdown will also reduce ice loads on crest gates and auxiliary spillways.
- The ability to safely pass base flows plus flood flows (assumed 100-year storm event) without failing during construction.
- Provide robust and state-of-practice boat booms upstream of the four dams to prevent vessels, flotsam and reduce ice jams. The booms just upstream of the gated spillways will direct boaters well away from flows over the crest gates.
- Provide designs that improve flood water passage, offer safer operations, provide auxiliary spillways, and enhance boater safety on the lakes.

Our conceptual design summaries and opinions of probable construction cost for each dam are provided below for each of the dam sites listed from upstream to downstream.

Proposed Repairs to Restore Lake Levels at Secord Dam

There are several fundamental dam safety issues that must be addressed before the water level can be permanently raised:

- Insufficient spillway discharge capacity to meet regulatory criteria, including State of Michigan requirements.
- Inadequate downstream embankment slope and seepage stability.
- Inadequate height and length of the downstream spillway training walls to prevent overtopping and reduce erosion during high flow events.
- Embankments leak excessively and lack internal filters and drains to protect against seepage-induced internal erosion.
- Inadequate embankment slope armoring to prevent damage from erosion and back cutting during floods.
- Areas of structurally unsound concrete at spillway and powerhouse that need repair and stabilization.
- Restore dam to have a permanent low-level outlet to base pass flows during winter and provide a means to draw down the impoundment below the spillway sill elevation.

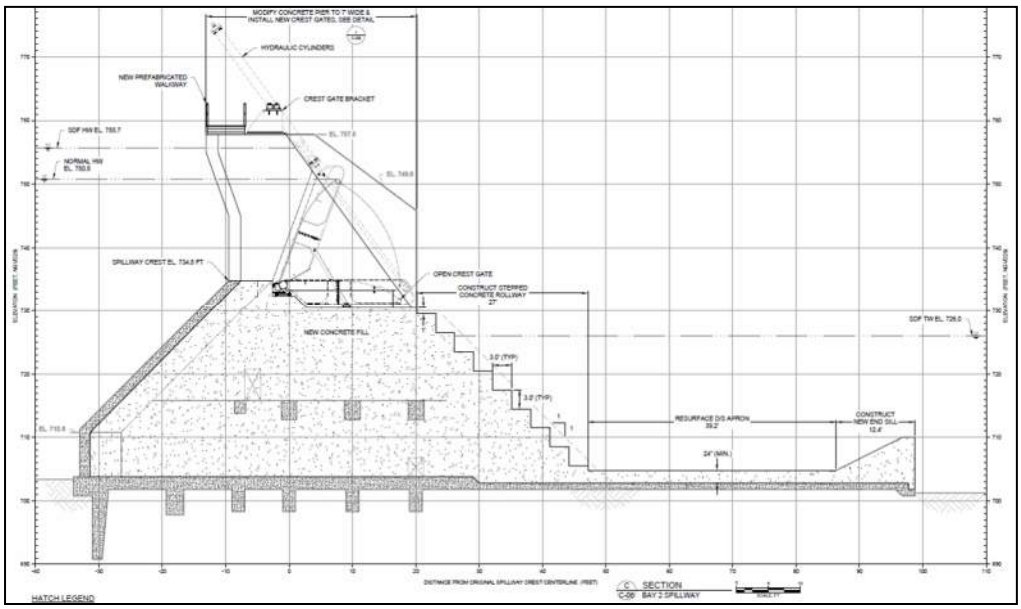
Exhibit 2 – Aerial View of Secord Dam Spillway and Non-Operational Powerhouse

Exhibit 3 – Inspection Photographs of Secord Dam

Primary Spillway Modifications

The existing Tainter gate spillway will be partially demolished and the two (2) Tainter gates will be replaced with two (2) hydraulically operated crest gates at sill El. 734.8 to increase the spillway capacity. The new left crest gate will be 18-feet-wide by 16-feet-high and the new right crest gate will be 21-feet-wide by 16-feet-high.

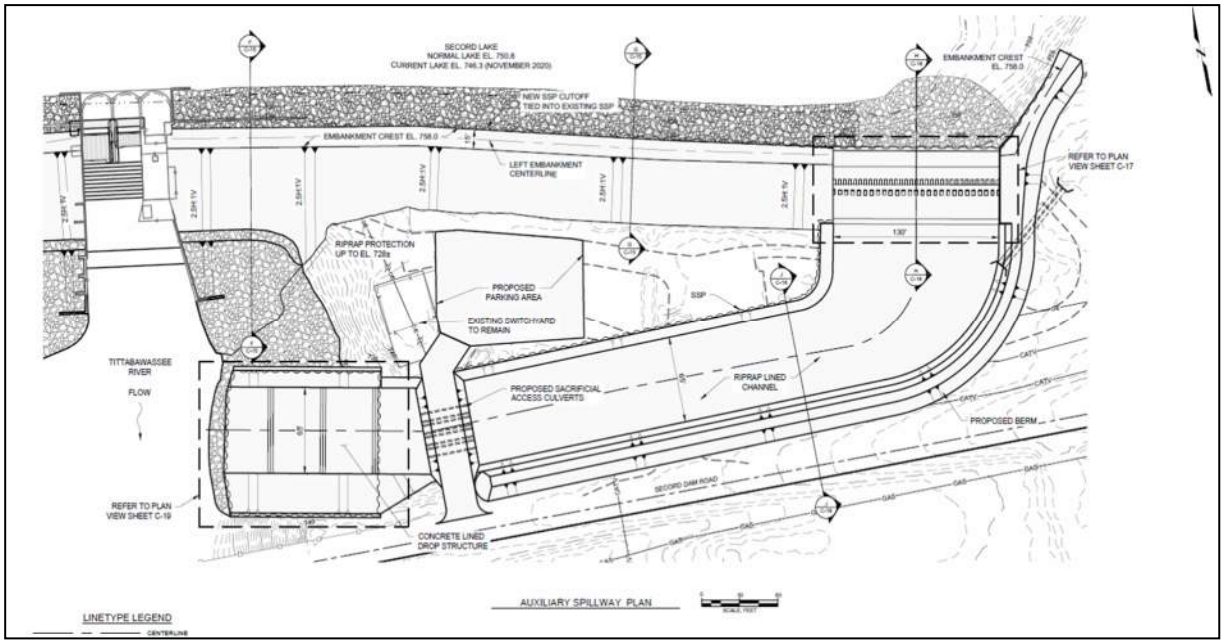
Exhibit 4 – Cross Section View of Proposed Secord Dam Crest Gate Spillway



New Auxiliary Spillway

A new 130-foot-wide pin flashboard overflow spillway will be constructed across the top of the left embankment at El. 748.5. Fusible steel pipe stanchions embedded in the concrete floor slab will support 42-inch tall timber flashboards to maintain the normal summer pool at El. 750.8. The flashboard and pipe stanchions will be designed to fail by bending over downstream when flood flows exceed what the gated spillway can pass and overflow 12-inches to 18-inches over the top of the flashboards. These types of spillways have been used successfully at other dams for over 100 years.

Exhibit 5 – Plan View of Proposed Secord Dam Auxiliary Spillway



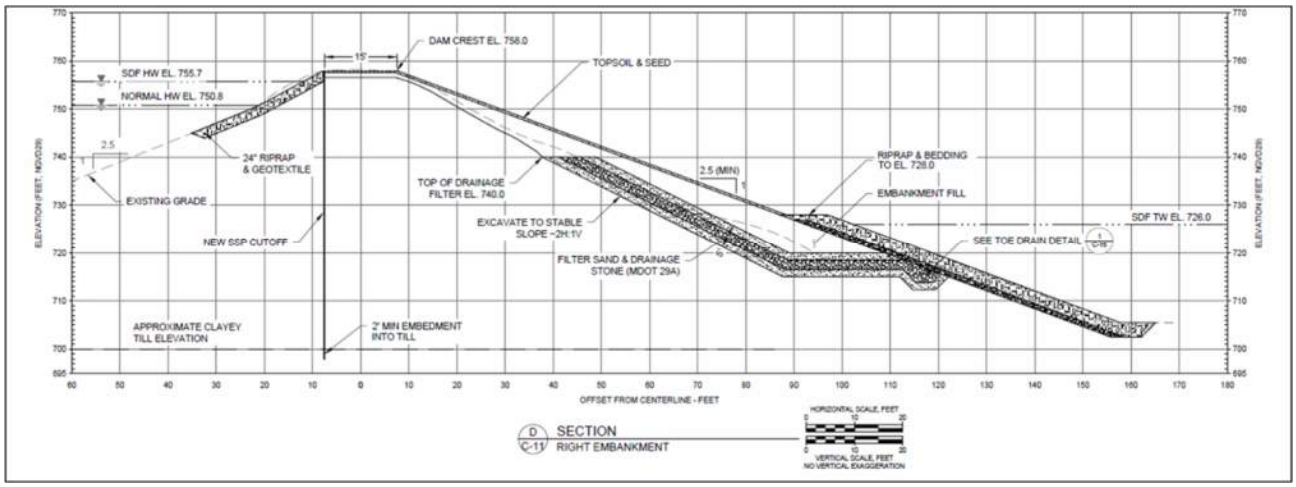
Powerhouse Modifications

To help manage ice on the crest gates, a reliable low-level outlet will be developed by retrofitting the existing powerhouse to pass base flows during the winter (100 to 200 cfs) at reduced winter pool 3 ft below summer pool. This will be accomplished by removing the existing generator, turbine shaft, wicket gates and ancillary mechanical and electrical equipment, installing a bulkhead over the runner pit and fixing the runner into place. A new upstream slide gate will be used to control flows at the intake and provided with protective trash racks.

Embankment Repairs

The downstream slope will be flattened to improve stability and an upstream sheet pile seepage cutoff from dam crest into the clay hardpan foundation will be installed across right and left embankment dams. The downstream overlay fill will include an internal filter and drainage layers will be installed to protect against seepage-induced internal erosion. The drainage systems will discharge to a weir to allow monitor seepage rates.

Exhibit 6 – Cross Section View of Secord Dam Embankment Repairs



Summary of Opinion of Probable Construction Costs – Secord Dam

An engineer's opinion of probable construction cost (OPCC) was developed to pass the ½ PMF + design storm with contingency based on the proposed preliminary design. The OPCC includes 25% contingency for all construction items and includes an allowance for site investigations, engineering design, permitting and construction engineering / management costs. The total OPCC for the Secord Dam to pass the ½ PMF + design storm is approximately **$25 million** and is summarized as follows:

Item	Description	Estimated Cost	
0.00	General Conditions	$	1,236,000
1.00	Site Preparation and Cofferdams	$	1,470,000
2.00	Site Demolition (Spillway and Powerhouse)	$	826,000
3.00	Left Embankment Repair and Stabilization	$	2,723,000
4.00	Right Embankment Repair and Stabilization	$	1,648,000
5.00	New Crest Gate Spillway and Outlet Works	$	4,542,000
6.00	Powerhouse Rehabilitation	$	1,000,000
7.00	Auxiliary Spillway Structure	$	1,415,000
8.00	Discharge Channel	$	3,739,000
9.00	Site Restoration	$	150,000
	Subtotal	$	18,749,000
	Contingency (25%)	$	4,687,000
	Construction Subtotal	$	23,436,000
	Site Investigations, Engineering, Permitting and Construction Management	$	1,700,000
	Total Estimated Cost	**$**	**25,136,000**

Proposed Repairs to Restore Lake Levels at Smallwood Dam

There are several fundamental dam safety issues that must be addressed before the lake levels can be permanently raised:

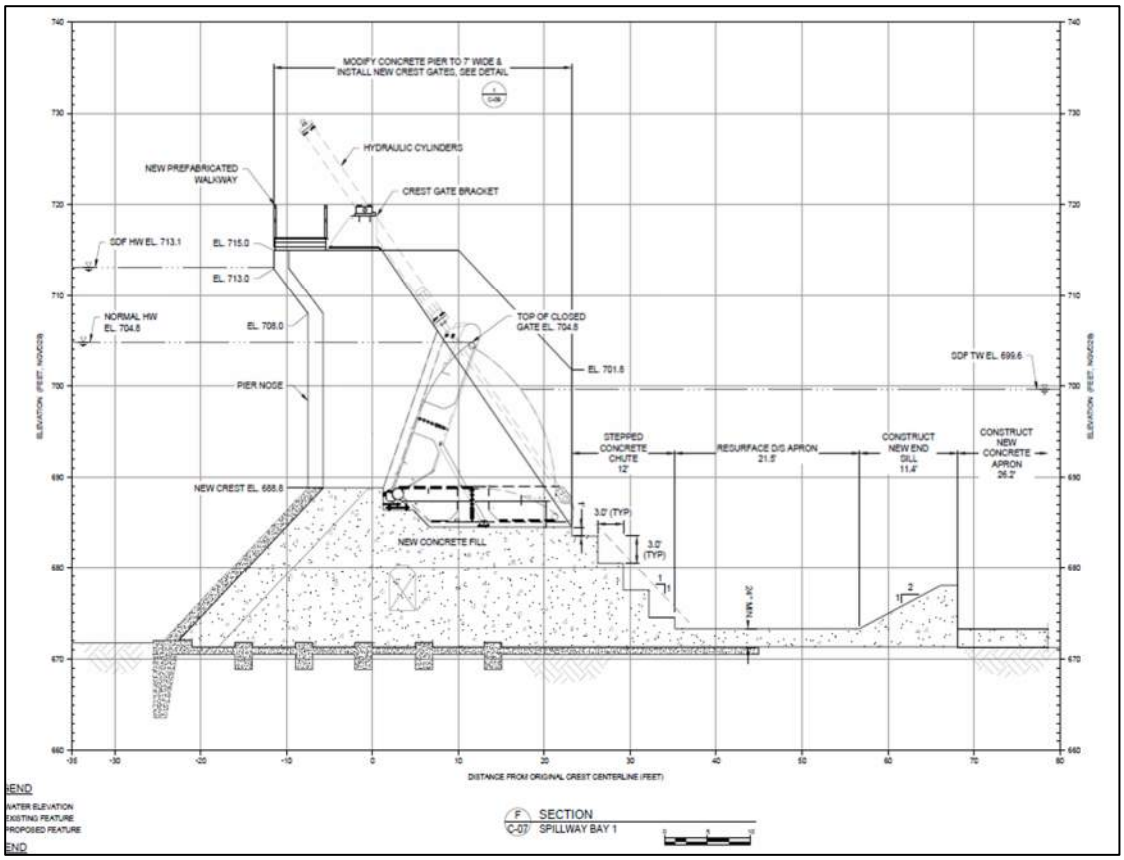
- Insufficient spillway discharge capacity to meet regulatory criteria, including State of Michigan requirements.
- Structurally unsound spillway rollway and deteriorated training wall concrete due to age and freeze-thaw damage.
- Lack of height and length of the downstream spillway training walls to reduce dam toe erosions during high tailwater.
- Embankment lacks filters and drains to protect against seepage-induced internal erosion.
- Inadequate embankment slope armoring to prevent damage from erosion and back cutting during floods.
- Restore dam to have a permanent low-level outlet.

Exhibit 7 – Inspection Photographs of Smallwood Dam Spillway and Powerhouse

Primary Spillway Modifications

The existing Tainter gate spillway will be partially demolished and the two (2) Tainter gates will be replaced with two (2) hydraulically operated crest gates at sill El. 688.8 to increase the spillway capacity. The left crest gate and the right gate will be 22.6-feet-wide by 16-feet-high.

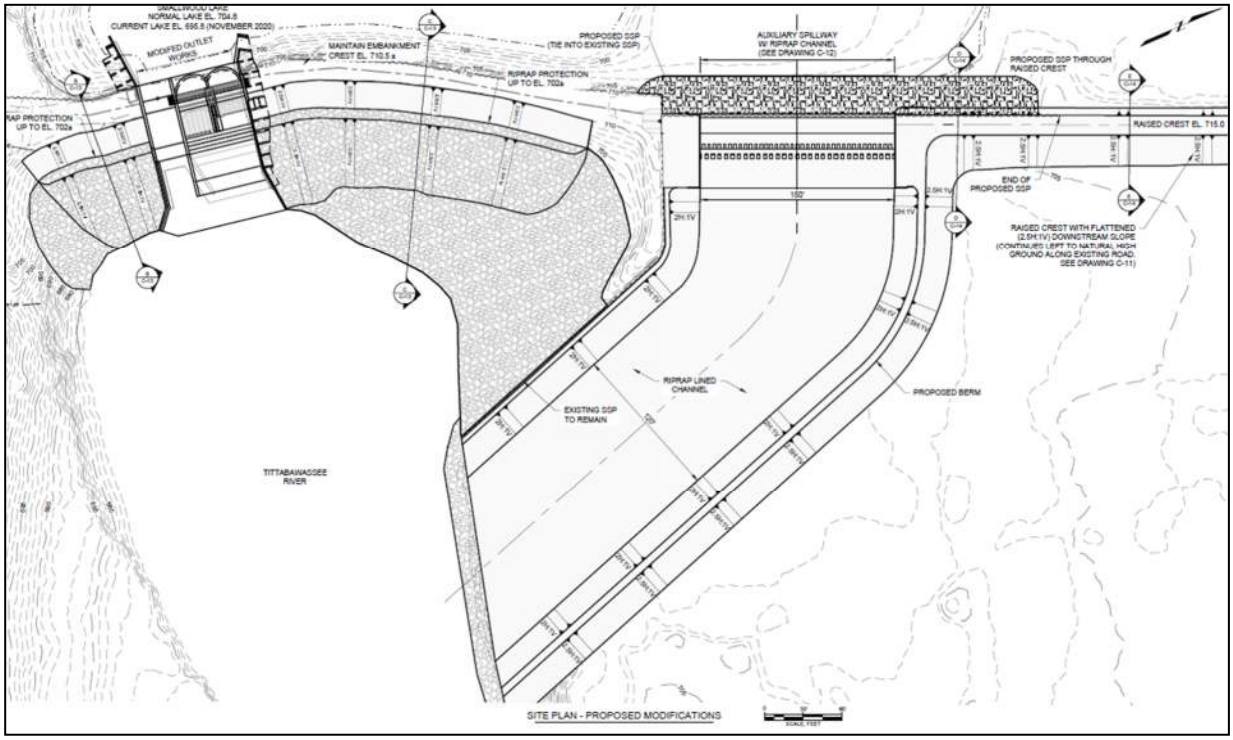
Exhibit 8 – Cross Section View of Smallwood Dam Crest Gate Spillway



New Auxiliary Spillway

A new 150-foot-wide ungated pin flashboard overflow spillway will be constructed across the of the left embankment adjacent (east) to the steel sheet pile section of the left embankment at El. 706.0. Fusible steel pipe stanchions embedded in the concrete floor slab will support 48-inch tall timber flashboards. The flashboards and stanchion piles will be designed to fail by bending over downstream when flood flows beyond what the gated spillway can pass overflow 12 inches to 18 inches over the top of the flashboards.

Exhibit 9 – Plan View of Smallwood Dam Auxiliary Spillway



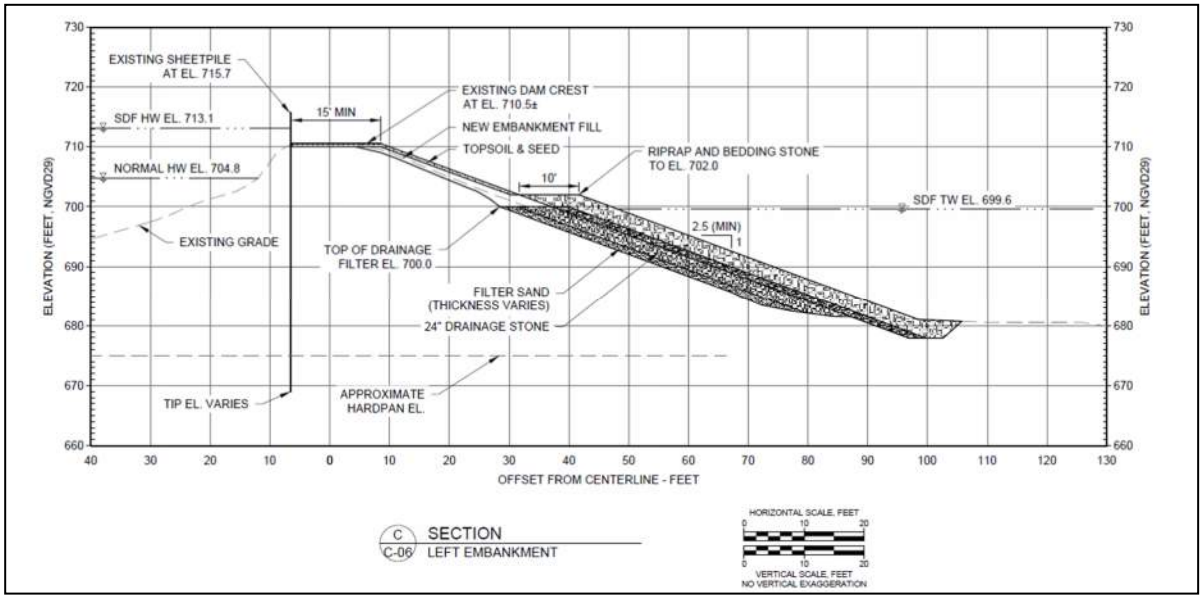
Powerhouse Modifications

To help manage ice on the crest gates, a reliable low-level outlet will be developed by retrofitting the existing powerhouse to pass base flows during the winter (100 to 200 cfs) at reduced winter pool 3 feet below summer pool, similar to Secord Dam. This will be accomplished by removing the existing generator, turbine shaft, wicket gates and ancillary mechanical and electrical equipment, installing a bulkhead over the runner pit and fixing the runner into place. A new upstream slide gate will be used to control flows at the intake with protective trash racks.

Embankment Repairs

The upstream and downstream embankment slopes will be flattened and the crest widened to at least 15 feet the downstream slope to provide adequate stability. There will be filter sand and gravel drain blanket under the downstream slope to protect the dam from potential future internal erosion. The overflow section of the left embankment will be raised to El. 715.0 and extended approximately 700 feet to the east to "tie-in" to high ground at the left abutment. A new steel sheet pile cutoff will be installed starting at the left end of the existing steel sheet pile cutoff from the dam crest into the hardpan foundation clay will extend to the left under the new auxiliary spillway and 100 feet left (east) of the new spillway.

Exhibit 10 – Cross Section View of Smallwood Dam Embankment Repairs



Summary of Opinion of Probable Construction Costs – Smallwood Dam

An engineer's OPCC was developed to pass the ½ PMF + design storm with contingency based on the proposed preliminary design. The OPCC includes 25% contingency for all construction items and includes an allowance for site investigations, engineering design, permitting and construction engineering / management costs. The total OPCC for the Smallwood Dam to pass the ½ PMF + design storm is approximately **$18.0 million** and is summarized as follows:

Item	Description	Estimated Cost
0.00	General Conditions	$ 867,000
1.00	Site Preparation and Cofferdams	$ 1,470,000
2.00	Site Demolition (Spillway and Powerhouse)	$ 560,000
3.00	Left Embankment Repair and Stabilization	$ 1,222,000
4.00	Right Embankment Repair and Stabilization	$ 201,000
5.00	New Crest Gate Spillway and Outlet Works	$ 3,817,000
6.00	Powerhouse Rehabilitation	$ 1,500,000
7.00	Auxiliary Spillway Structure	$ 1,262,000
8.00	Discharge Channel	$ 2,060,000
9.00	Site Restoration	$ 150,000
	Subtotal	$ 13,109,000
	Contingency (25%)	$ 3,280,000
	Construction Subtotal	$ 16,389,000
	Site Investigations, Engineering, Permitting and Construction Management	$ 1,550,000
	Total Estimated Cost	**$ 17,939,000**

Proposed Repairs to Restore Lake Levels at Wixom Lake (Edenville and Tobacco Dams)

The May 2020 Flood caused catastrophic damage to the Edenville Dam, including:

- Left embankment breached.
- Powerhouse and equipment damaged.
- Both the Tobacco and Edenville Tainter gated spillways damaged.
- Inadequate height and length of the downstream spillway training walls to prevent overtopping and reduce erosion at the dam toe during high flow events.
- Upstream slope of embankments have heel area scoured and undermined due M-30 breach channel flows.
- M-30 bridge and causeway between the rivers was washed out.
- No low-level outlets.

Exhibit 11 – Aerial View of Edenville Dam Failure

Interim Stabilization Measures

Interim repairs are being implemented under a FLTF Memorandum of Understanding with the State of Michigan and NRCS at both the Tobacco Spillway and the Edenville Spillway. The objective is to restore flow into the original Tobacco and Tittabawassee River channels and reduce on-going erosion. Construction of the interim measures is currently underway at Tobacco Spillway. Lowering the Edenville Spillway down to the base slab with the two powerhouse units left-in-place, and constructing a dam across the left embankment breach area is planned for 2021. Our goal is to incorporate the major elements of these interim repairs into the permanent, long-term design.

Proposed Permanent Repairs to Restore Lake Levels

The following major repairs / reconstruction activities are planned to permanently restore pre-flood lake levels.

- Construct new primary (gated) spillways at Tobacco and Edenville spillways.
- Construction a new labyrinth-type (ungated) auxiliary spillway at the north embankment breach.
- Reconstruct / repair damaged embankments.
- Stabilize and raise remaining embankments.
- Develop a new low-level outlet at the existing powerhouse location.

Primary Spillway Modifications

At Edenville, the gated spillway and the leftmost powerhouse bay will be demolished and the three (3) Tainter gate spillway bays will be replaced with three (3) hydraulically operated crest gates at sill El. 659.8 to increase the spillway capacity. The leftmost powerhouse bay will also be converted into a fourth crest gate bay. Each gate will be 24-feet-wide by 16-feet-high. The hydraulic gate operators will be supported on new, reinforced concrete piers.

The Tobacco Dam Tainter gate spillway will be partially demolished and the three (3) Tainter gates will be replaced with three (3) automated hydraulically operated crest gates at El. 659.8 to increase spillway capacity. The left and right crest gates will be 18.3-feet wide by 16-feet-high and the center crest gate will be 15.5-feet-wide by 16-feet-high.

Exhibit 12 – Cross Section View of Edenville Dam 3-Bay Crest Gate Spillway

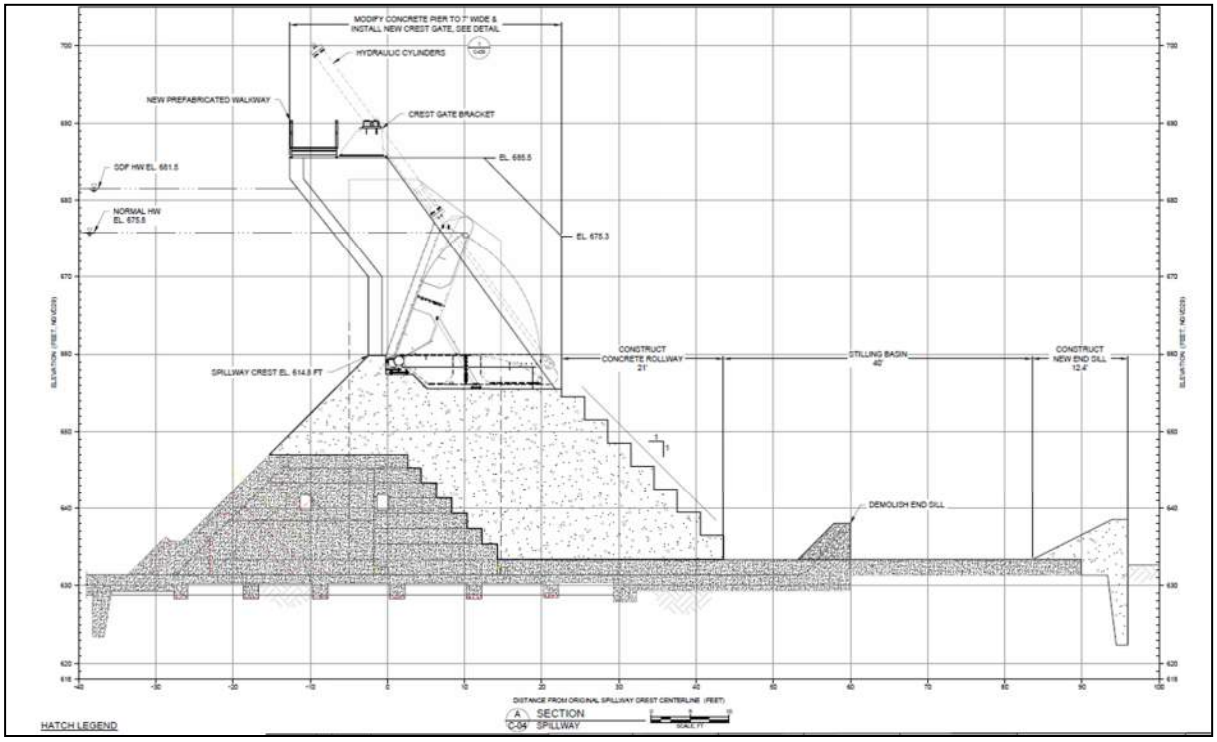
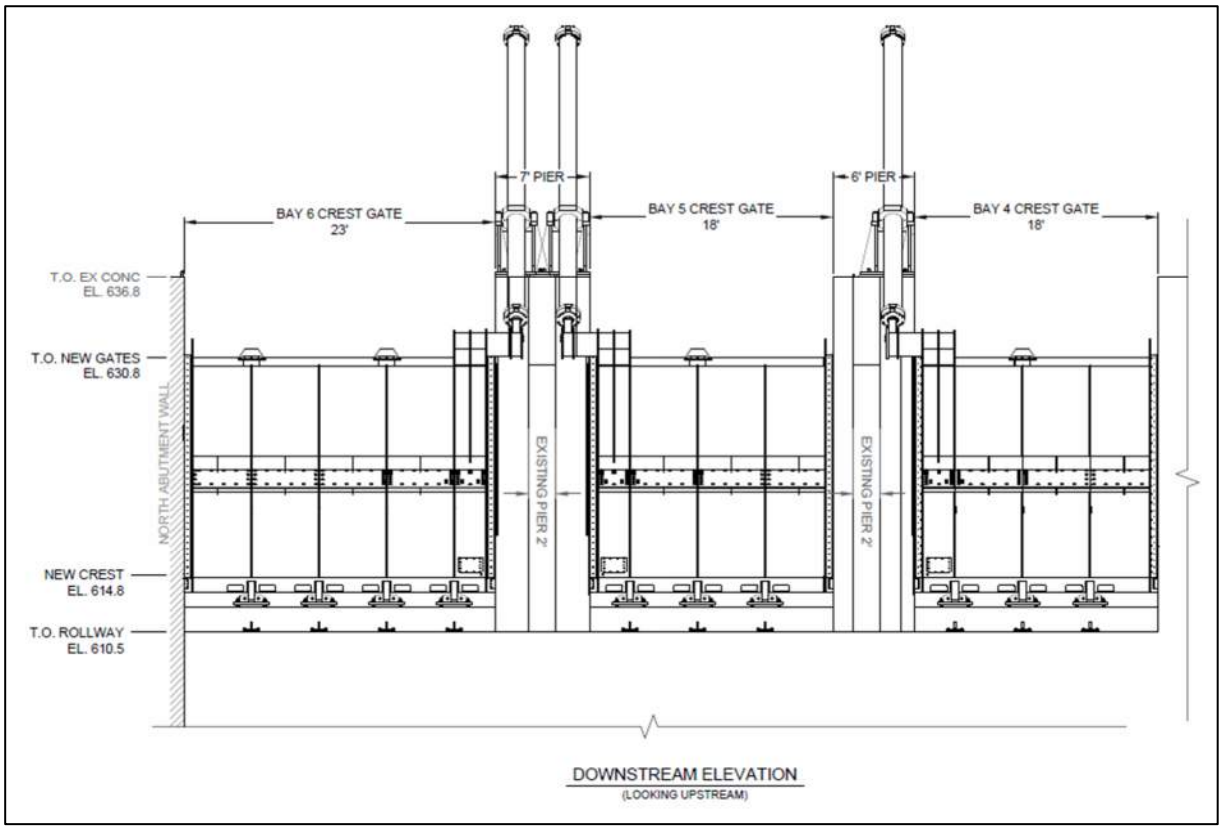


Exhibit 13 – Elevation View of Proposed Tobacco Dam 3-Bay Crest Gates



New Auxiliary Spillway

A new reinforced concrete 250-foot-wide 12-cycle labyrinth auxiliary spillway will be constructed at weir El. 678.0 within the former left embankment of the Edenville Dam to provide additional spillway capacity during the ½ PMF + design storm. The proposed spillway structure will discharge through a 250-foot-wide concrete spillway chute into USBR Type III stilling basin to dissipate energy before entering the discharge channel. To protect the reinforced concrete labyrinth spillway weir walls, the pool will be lowered 3 feet during the winter months.

Exhibit 14 – Plan View of Edenville Dam Auxiliary Spillway Left of Edenville Spillway

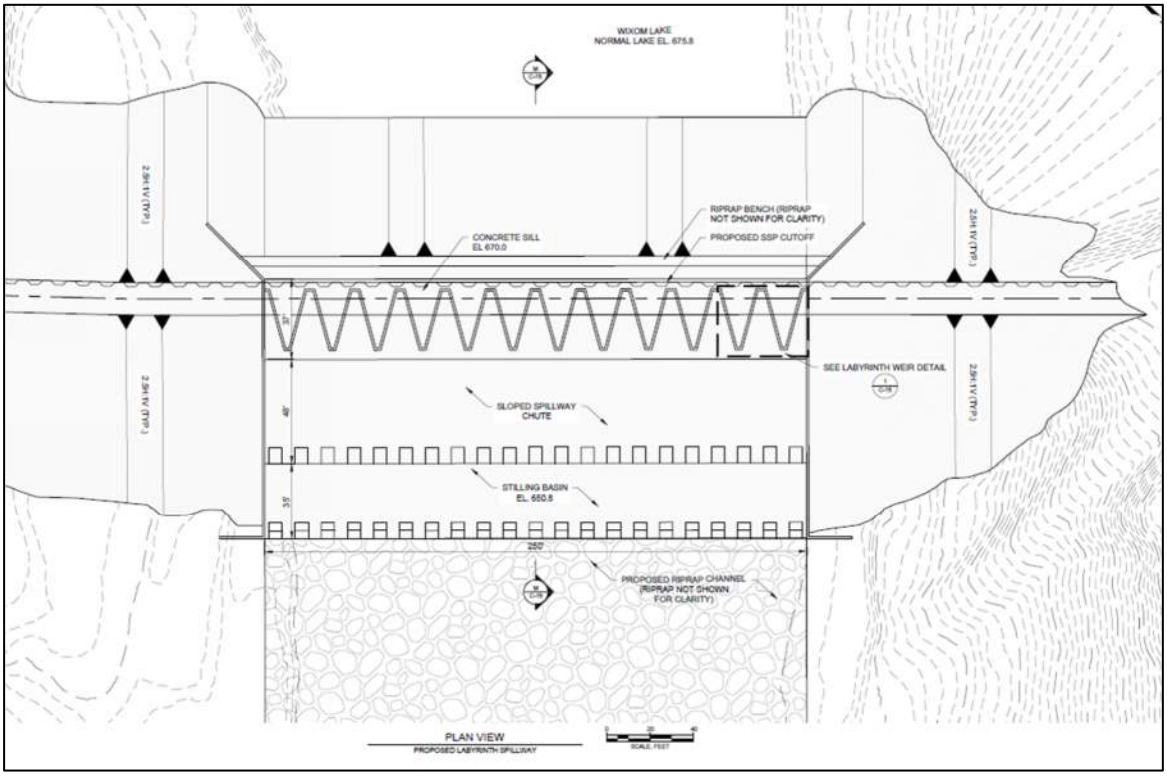
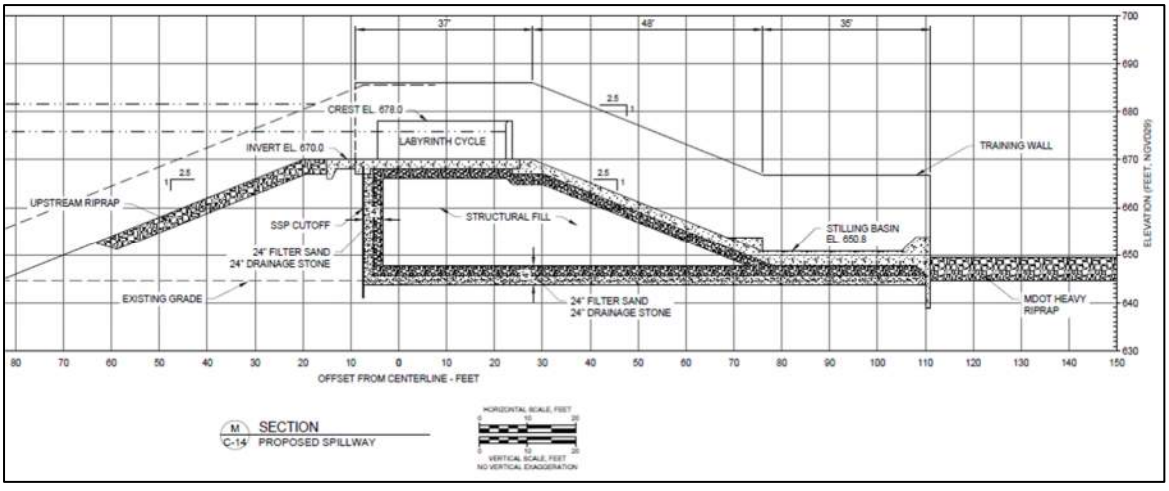


Exhibit 15 – Cross Section View of Edenville Dam Auxiliary Spillway



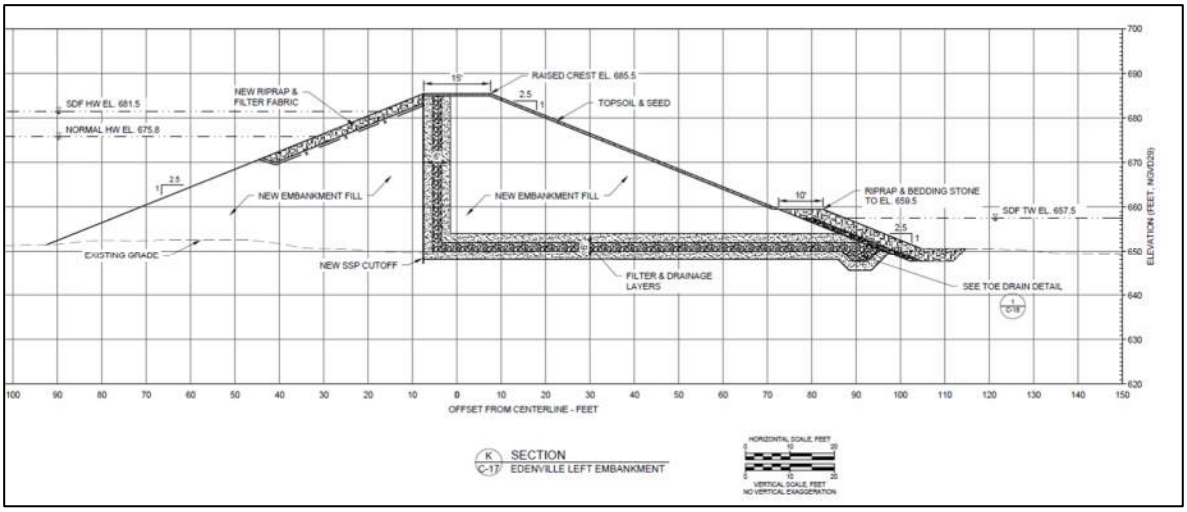
Powerhouse Modifications

The rightmost draft tube bay converted to a low-level outlet to pass base flows in the winter. This will be accomplished by removing the existing generator, turbine shaft, wicket gates and ancillary mechanical and electrical equipment, installing a bulkhead over the runner pit and fixing the runner into place. A new upstream slide gate will be used to control flows at the intake. Remaining sections of hollow bays and water passages will be filled with mass concrete.

Embankment Repairs

The former left embankment will be re-constructed with a minimum 15-foot crest width at El. 685.5 and minimum 2.5H:1V upstream and downstream slopes to provide adequate stability. A steel sheet pile cutoff will be provided along the upstream edge of the crest and be founded in the clay glacial till to provide a continuous seepage cutoff. Proper internal filter and drainage layers will be provided under the downstream embankment shell to provide additional seepage conveyance and protection against seepage-induced internal erosion.

Exhibit 16 – Cross Section View Edenville Dam Left Embankment Reconstruction



All remaining embankments will be raised to El. 685.5 and the crest widened to at least 15 feet. The upstream and downstream slopes will be flattened to improve stability, an upstream steel sheet pile seepage cutoff wall extended into foundation hardpan till and provide internal filter and drainage chimney and blanket drain layers will be provided to protect against seepage-induced internal erosion.

Summary of Opinion of Probable Construction Costs – Edenville Dam

An engineer's OPCC was developed to pass the ½ PMF + design storm with contingency based on the proposed preliminary design. The OPCC includes 25% contingency for all construction items and includes an allowance for site investigations, engineering design, permitting and construction engineering / management costs. The total OPCC for the Tobacco and Edenville Dam spillways to pass the ½ PMF + design storm was approximately **$121** million and is summarized as follows.

Item	Description	Estimated Cost
0.00	General Conditions	$ 6,163,000
1.00	Site Preparation, Cofferdams & 70 ft wide Edenville Bypass Channel	$ 33,250,000
2.00	Site Demolition (Spillway and Powerhouse)	$ 3,418,000
3.00	Edenville Left Embankment Repair and Stabilization	$ 3,489,000
4.00	Edenville Right Embankment Repair and Stabilization	$ 14,535,000
5.00	Tobacco Embankments Repair and Stabilization	$ 12,137,000
6.00	Edenville Crest Gate Spillway and Outlet Works	$ 7,958,000
7.00	Tobacco Crest Gate Spillway and Outlet Works	$ 4,695,000
8.00	Powerhouse Rehabilitation	$ 2,250,000
9.00	Labyrinth Auxiliary Spillway Structure	$ 3,213,000
10.00	Discharge Channel	$ 170,000
11.00	Site Restoration	$ 1,500,000
	Subtotal	$ 92,778,000
	Contingency (25%)	$ 23,195,000
	Construction Subtotal	$ 15,973,000
	Site Investigations, Engineering, Permitting and Construction Management	$ 5,000,000
	Total Estimated Cost	**$ 120,973,000**

Proposed Repairs to Restore Lake Levels at Sanford Dam

The breaching of Edenville Dam during the May 2020 Flood resulted in a cascading breach failure of downstream Sanford Dam. Major damage includes:

- Left and right embankments overtopped.
- Right embankment breached.
- Powerhouse and equipment damaged.
- Fuse plug auxiliary spillway failed.
- Tittabawassee River flows through breach channel (former right embankment).

Exhibit 17 – Aerial View of Sanford Dam Failure

Interim Stabilization Measures

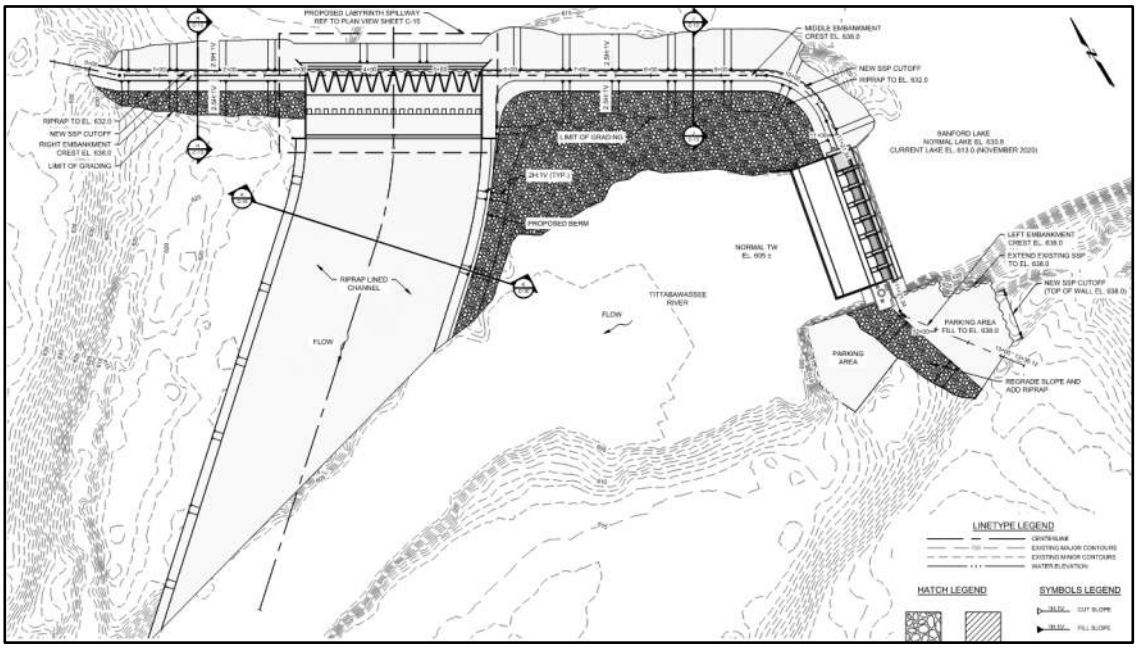
The NRCS has identified that interim repairs, stabilization and sediment removal at Sanford Dam may also be eligible for NRCS Emergency Watershed Protection (EWP) Program funding. Design of interim repairs is planned for 2021. Our goal is to incorporate the majority of the interim stabilization repairs into the permanent, long-term repairs.

Proposed Permanent Repairs to Restore Lake Levels

The following major repairs / reconstruction activities are planned to permanently restore pre-flood lake levels.

- Construct new primary (gated) spillways at the existing spillway location.
- Construction a new labyrinth-type (ungated) auxiliary spillway at the right embankment breach.
- Reconstruct breached embankments.
- Stabilize and repair remaining embankments.
- Develop a new low-level outlet at the existing powerhouse location.

Exhibit 18 – Plan View of Proposed Sanford Repairs



Primary Spillway Modifications

The existing Tainter gate spillway and powerhouse will be partially demolished and the six (6) Tainter gates will be replaced with eight (8) hydraulically operated crest gates at sill El. 614.8 to increase the spillway capacity. The crest gates would range from 16.5-feet-wide to 23-feet-wide by 16-feet-high. The hydraulic gate operators will be supported on new, reinforced concrete piers. The upstream portions of the barrel arches below El. 614.8 will remain and the crest gates and their anchorage embedment will be founded on new mass concrete. The gates will discharge onto a short section of concrete rollway and into a new reinforced concrete stilling basin. The two rightmost powerhouse bays will be converted into an additional crest gate bay and the leftmost draft tube bay converted to a low-level outlet. Remaining sections of hollow bays and water passages will be filled with mass concrete.

Exhibit 19 – Plan View of Sanford Dam Primary Spillway Upgrades

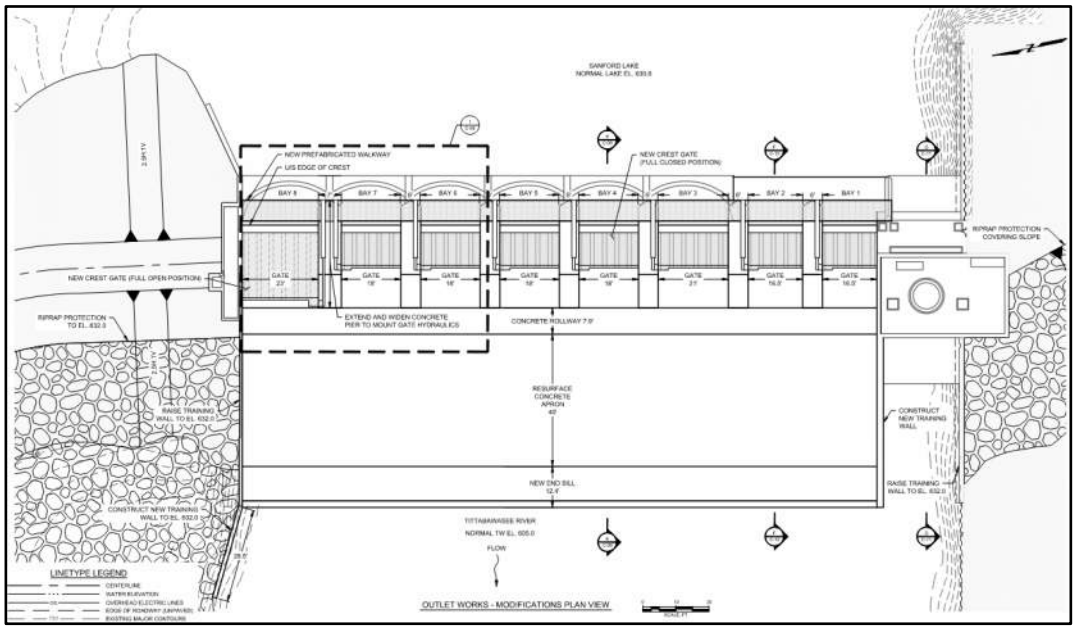
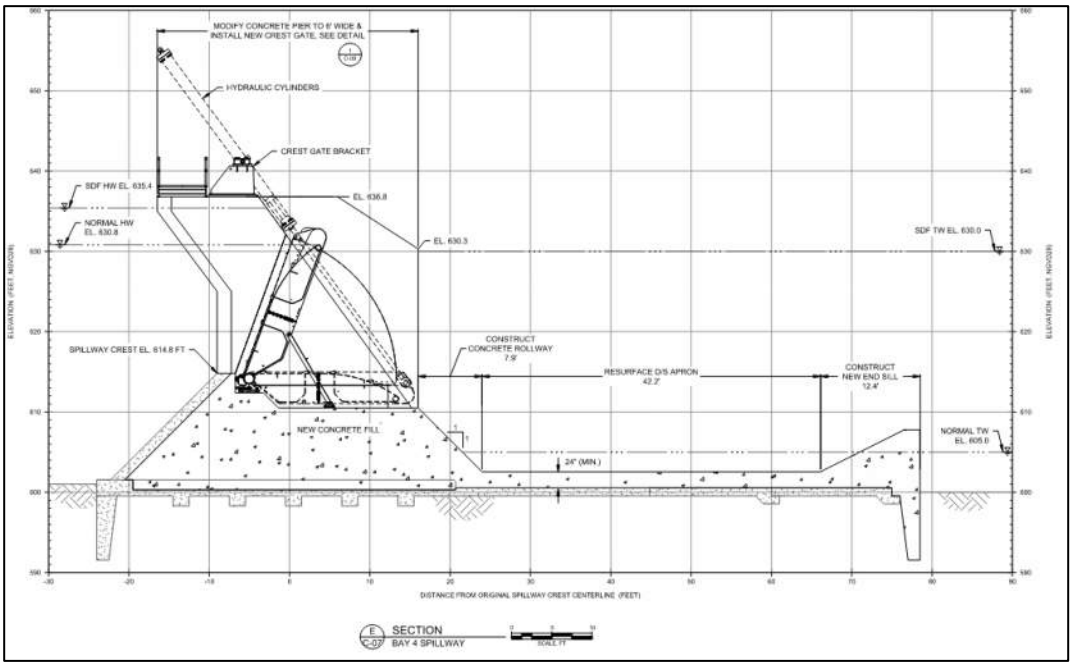


Exhibit 20 – Cross Section View of Sanford Dam Crest Gates



New Auxiliary Spillway

A new reinforced concrete 250-foot-wide 12-cycle labyrinth auxiliary spillway will be constructed at weir El. 632.5 within the former right embankment of the Sanford Dam to provide additional spillway capacity during the ½ PMF + design storm. The proposed spillway structure will discharge through a 250-foot-wide concrete spillway chute into USBR Type III stilling basin to dissipate energy before entering the discharge channel. To protect the reinforced concrete labyrinth spillway weir walls, the pool will be lowered 3 feet during the winter months.

Exhibit 21 – Plan View of Sanford Dam Auxiliary Spillway

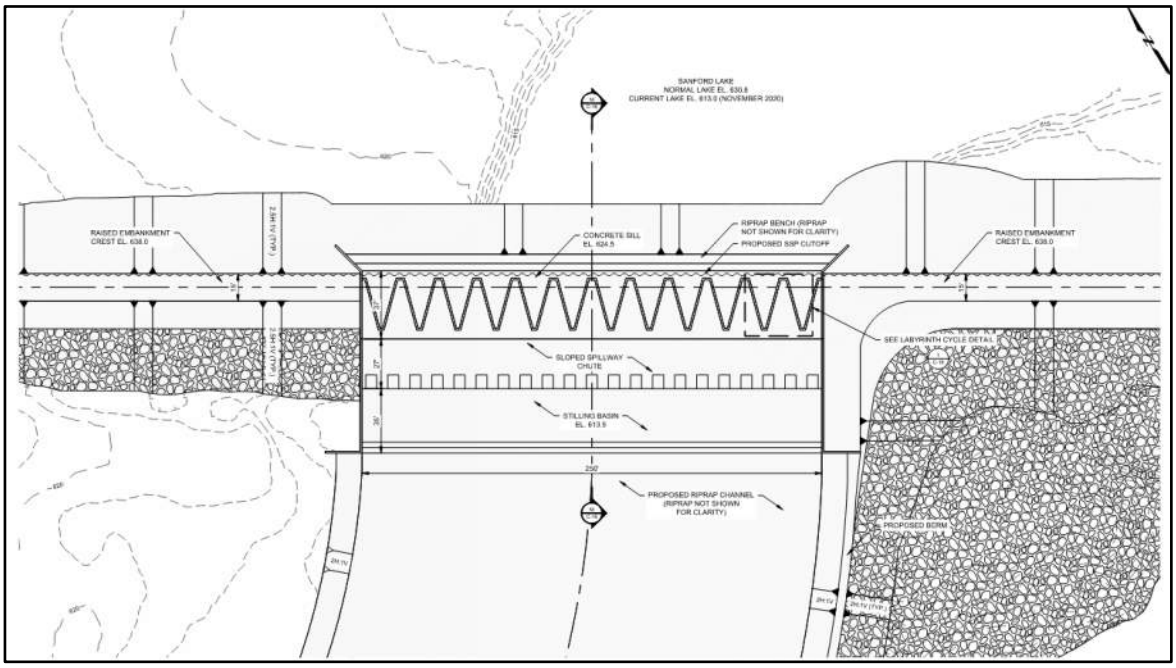
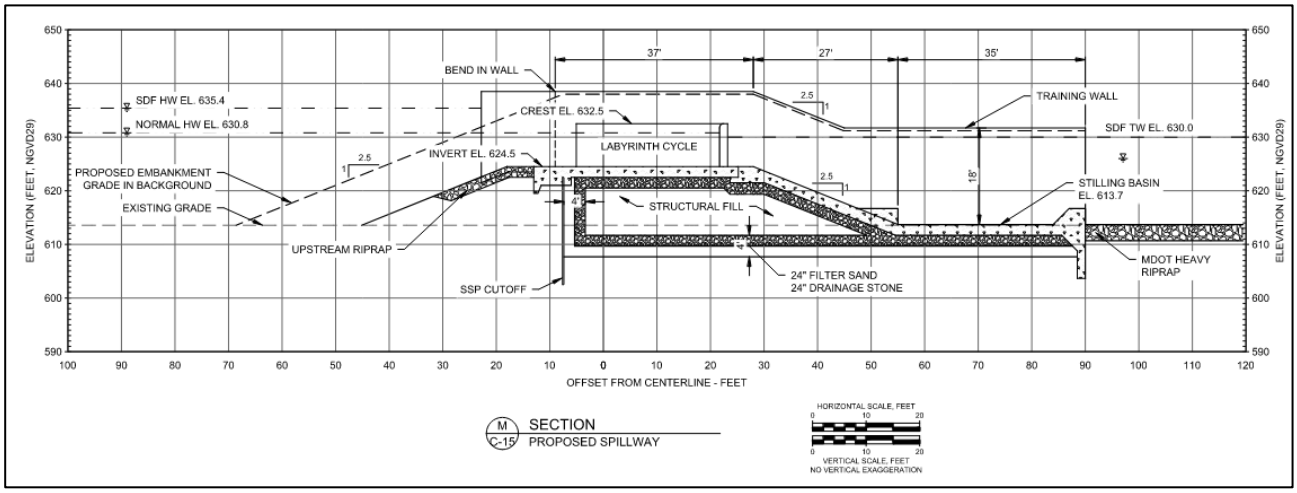


Exhibit 22 – Cross Section View of Sanford Dam Auxiliary Spillway



Powerhouse Modifications

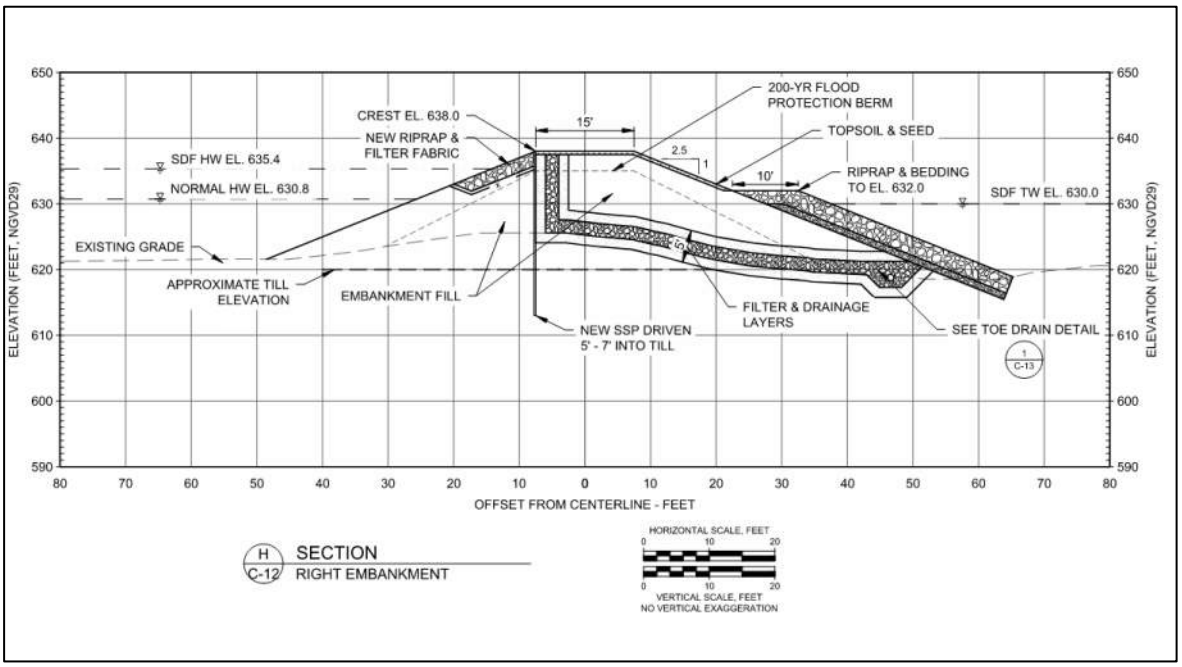
The leftmost draft tube bay converted to a low-level outlet to pass base flows in the winter. This will be accomplished by removing the existing generator, turbine shaft, wicket gates and ancillary mechanical and electrical equipment, installing a bulkhead over the runner pit and fixing the runner into place. A new upstream slide gate will be used to control flows at the intake. Remaining sections of hollow bays and water passages will be filled with mass concrete.

Embankment Repairs

The former right embankment will be re-constructed with a minimum 15-foot crest width at El. 638.0 and minimum 2.5H:1V upstream and downstream slopes to provide adequate stability. A

steel sheet pile cutoff will be provided along the upstream edge of the crest and be founded in the clay glacial till to provide a continuous seepage cutoff. Proper internal filter and drainage layers will be provided under the downstream embankment shell to provide additional seepage conveyance and protection against seepage-induced internal erosion.

Exhibit 23 – Cross Section View Sanford Dam Right Embankment Reconstruction



The left embankment slopes will be raised to El. 638.0 and the crest widened to at least 15 feet. The upstream and downstream slopes will be flattened to improve stability, an upstream sheet pile seepage cutoff and provide internal filter and drainage chimney and blanket layers will be provided to protect against seepage-induced internal erosion.

Summary of Opinion of Probable Construction Costs – Sanford Dam

An engineer's OPCC was developed to pass the ½ PMF + design storm with contingency based on the proposed preliminary design. The OPCC includes 25% contingency for all construction items and includes an allowance for site investigations, engineering design, permitting and construction engineering / management costs. The total OPCC for the Sanford Dam to pass the ½ PMF + design storm is approximately **$51 million** and is summarized as follows:

Item	Description	Estimated Cost
0.00	General Conditions	$ 2,532,000
1.00	Site Preparation and Cofferdams	$ 7,830,000
2.00	Site Demolition (Spillway and Powerhouse)	$ 3,873,000
3.00	Left Embankment Repair and Stabilization	$ 378,000
4.00	Right Embankment Repair and Stabilization	$ 2,887,000
5.00	New Crest Gate Spillway and Outlet Works	$ 13,305,000
6.00	Powerhouse Rehabilitation	$ 2,250,000
7.00	Auxiliary Spillway Structure	$ 3,415,000
8.00	Discharge Channel	$ 1,940,000
9.00	Site Restoration	$ 150,000
	Subtotal	$ 38,560,000
	Contingency (25%)	$ 9,640,000
	Construction Subtotal	$ 48,200,000
	Site Investigations, Engineering, Permitting and Construction Management	$ 3,000,000
	Total Estimated Cost	**$ 51,200,000**

Summary of Probable Costs for Each Dam Site

Dam	Total Estimated Cost (Present Worth)
Secord	$ 25,136,000
Smallwood	$ 17,939,000
Edenville (includes Tobacco)	$ 120,973,000
Sanford	$ 51,200,000
Estimated Total:	**$ 215,248,000**