Feasibility Study

Ontonagon Marina Access

Ontonagon, Michigan

Submitted to:
Village of Ontonagon
315 Quartz Street
Ontonagon, MI 49953

Submitted by:
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Project No. 2506426

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1. Introduction

The Ontonagon Marina is located along the westside of the Ontonagon River within the Village of Ontonagon. It is located roughly 4,200 feet upstream from the end of the piers/revetments that extend into Lake Superior and 1,300 feet upstream of a federally dredged portion of the river. Depths of the dredged portion of the river range from 19 to 24 feet deep. Depths of the portion of the river that has not been dredged range from 6 to 14 feet. See Figure 1-1 and Figure 1-2 for federal dredge limits.

Figure 1-1

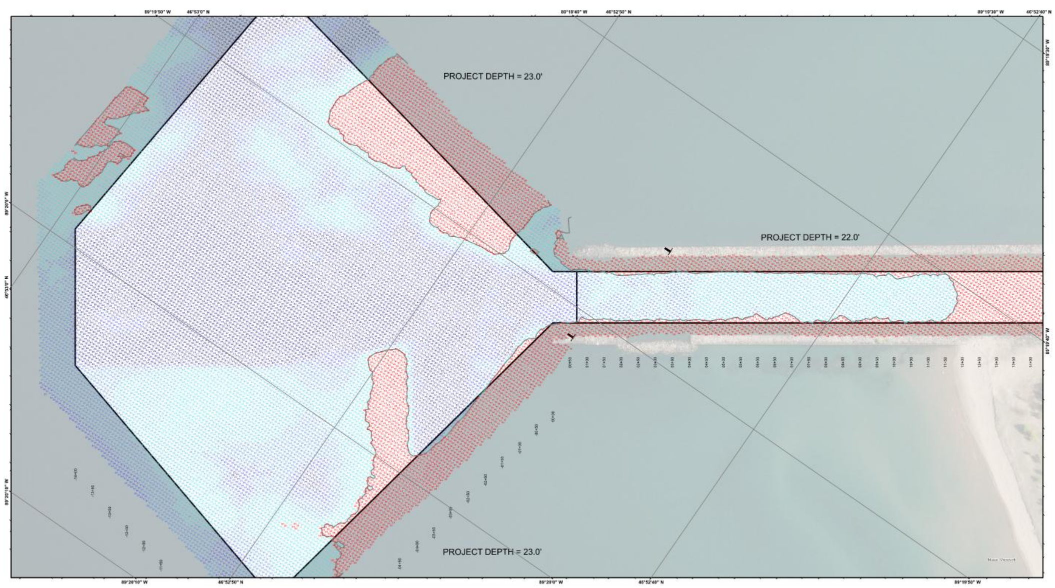
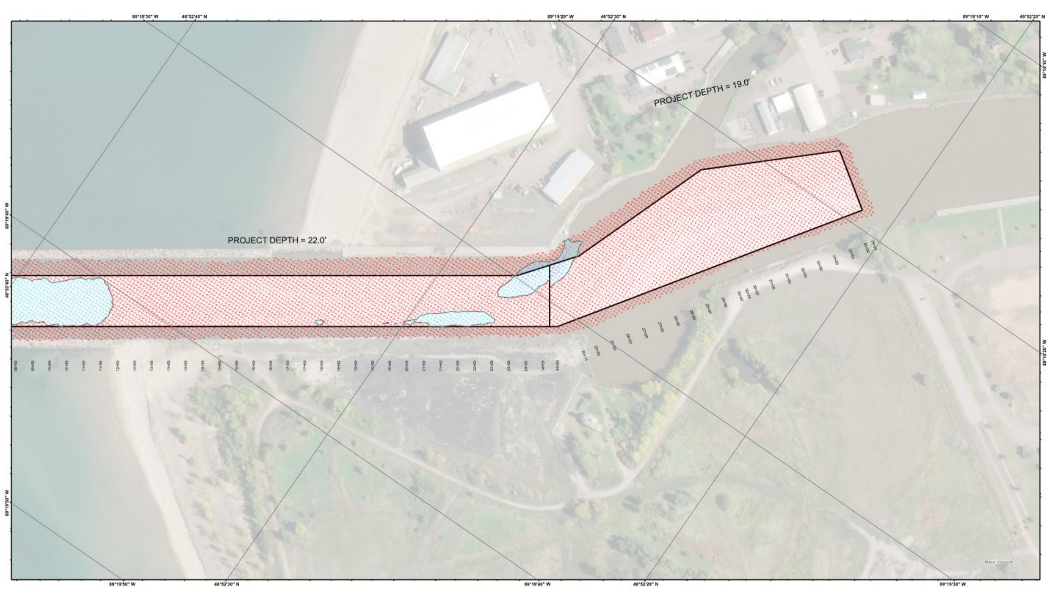


Figure 1-2



The marina serves as a Safe Harbor to enable boaters to take shelter in an emergency situation. It is the only safe harbor for 40 miles to the west (Black River Harbor) and 50 miles to the north east (Keweenaw Waterway), see Figure 1-3 for Safe Harbor locations. Depths within the marina vary between 5 and 8 feet. However, at the mouth of the marina, depths are as shallow as 3 feet. This as a result of sedimentation build up from the Ontonagon River.

Figure 1-3

In 2025, the Village of Ontonagon received a Great Lakes Thriving Communities Grant Making program Grant through the Minneapolis Foundation to conduct a feasibility study to determine the best options to minimize dredging the mouth of the marina. Included in this study is stakeholder input on the marina and mouth as well as a funding investigation to provide the Village options finance the improvements. The Village contracted with GEI Consultants of Michigan, P.C. (GEI) to perform the feasibility study and present the findings to the Village Council/Marina Commission.

2. Background

The marina was constructed in the late 1960's. It is an excavated basin that is roughly 6.3 acres. Facilities at the marina include: fixed pier system, marina building, large parking area, boat ramp with skid piers, shore fishing piers, Travel-Lift to remove vessels from the water, fish cleaning station, playground, and park area. It consists of 31 seasonal slips and six transient spots. Below is aerial image of the marina.

In 2014, the Village received a grant through the Michigan Department of Natural Resources (MDNR) Waterways Program to dredge the marina basin to 8' below low water datum. However, the Village experienced issues with the contractor and the entire scope work was never completed. A survey was completed in 2019 to attempt to determine the amount of sedimentation removed during the dredging process.

As a part of the Thriving Communities grant, a bathymetric survey was completed to establish a baseline for the current sedimentation levels in the marina as well as in the Ontonagon River. The survey showed that the sedimentation levels in the mouth of the marina were almost back to the levels collected in the bathymetric survey performed in 2014. A copy of the 2014 bathymetric survey, 2019 dredging survey, and the 2025 bathymetric survey is included in Appendix A.

Aerial Image Ontonagon Marina

3. Conditions of Existing Marina

3.1. Municipal Marina

3.1.1. Shoreline

The entire perimeter of the marina, minus the mouth and the boat lift area, is lined with vegetated riprap.

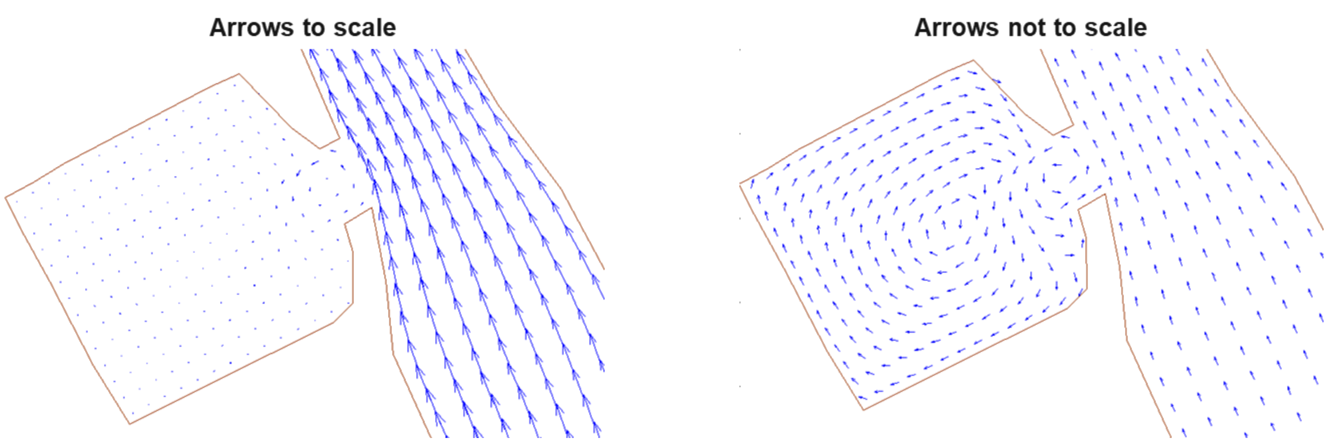
3.1.2. Basin

The original marina was excavated to an average depth of 8 feet. Due to the location and orientation along the Ontonagon River, sedimentation is continuously deposited into the marina. As the river flows past the mouth of the marina, it causes a clockwise swirling effect of the water in the marina. See Figure 2 below showing the direction of flow. This “eddy” current inside the marina has developed shoaling along the northside of the marina and a scour hole in the southeast corner of the marina. As a result of these conditions the current depth of the northside of the marina ranges between 4-6 feet. The depth of the southside of the marina ranges between 5-7 feet, with a 9 foot deep scour hole in the southeast corner. A copy of the 2025 bathymetric survey showing the elevations of the marina bottom is included in Appendix A.

3.1.3. Mouth

The mouth of the marina experiences a sediment swirling effect as well. As the river flows past the mouth, the current comes into the mouth swirls counterclockwise and back out into the river. See Figure 3-1 below. Sediment is deposited on the northside of the entrance, causing shoaling. On the southside of the entrance a scour hole is developing due to the current. The depth of the northside of the mouth ranges between 3-6 feet. Depth on the southside of the marina ranges between 5-8 feet.

Figure 3-1

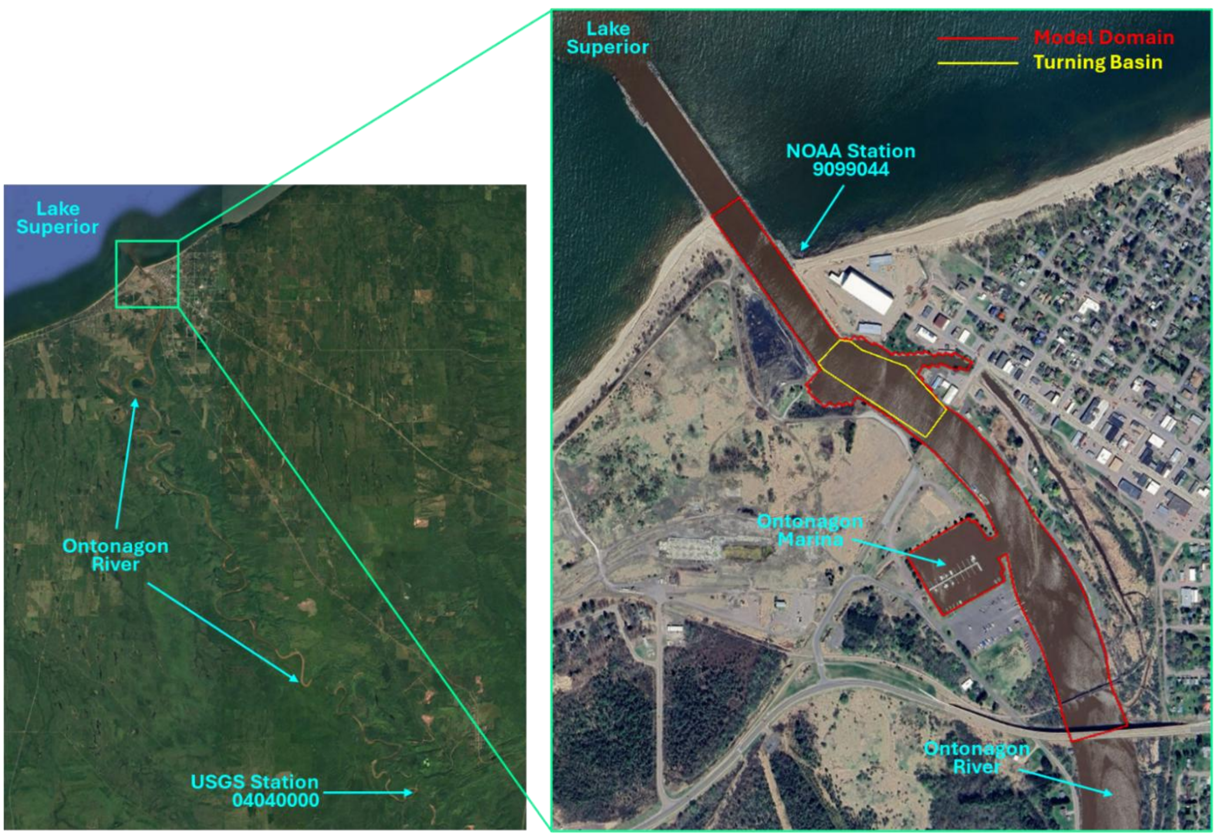


4. Hydrodynamic Modeling

4.1. Model Inputs

The hydrodynamic and sediment transport models require several inputs. These include bathymetry and boundary conditions (water level and suspended sediment concentration [SSC] at the downstream end of the model domain in Lake Superior, river discharge, and SSC at the upstream end of the model domain). These inputs were developed using various data sources as described in this section. Below is Figure 4-1 showing the model domain limits, United States Geological Survey (USGS) Station 04040000, and National Oceanic and Atmospheric Administration (NOAA) Station 9099044. The USGS station measures river discharge also known as the flow rate of the river. The NOAA Station measures the water level of Lake Superior.

Figure 4-1



4.1.1. Bathymetry

Bathymetry measurements from a number of sources were compiled and consolidated to develop model inputs. The data sources include:

- Data collected by United States Army Corps of Engineers (USACE) in 2015
- Data collected by GEI Consultants in 2025 as part of the current project

- Data collected by GEI Consultants in 2019
- Data collected by GEI Consultants in 2014
- Nautical chart from NOAA

The model bathymetry represents longitudinal and lateral variations in bathymetry within the river as well as within the marina. Prominent features include a relatively deep channel along the eastern edge of Ontonagon River and within the turning basin and the navigation channel, and relatively shallow depths within the marina.

4.1.2. Water Level

Given its proximity to Lake Superior, water level within the model domain is largely dependent on water level in Lake Superior. Water level in Lake Superior typically varies over inter-annual scales, seasonal scales, and episodically due to storm surge, seiche events, meteotsunamis, etc. These processes are apparent in the long-term measurements of water level at NOAA Station 909904. Therefore, the hourly measurements of water level were used to specify water level boundary conditions at the downstream end of the model domain, at the mouth of Ontonagon River in Lake Superior.

4.1.3. River Discharge

The USGS maintains several stream gauge locations along the Ontonagon River. The USGS gauge closest to the model domain is at Rockland, Michigan (USGS Station 04040000), approximately 11 miles upstream from the model domain. Daily average measured flows from this USGS gauge were therefore used to specify the river flow rate entering the model domain at the upstream boundary. River discharge shows a seasonal pattern, with low flows during winter and summer, high flows associated with the spring snowmelt, and moderate flows in fall.

Although the river flow measured at Rockland was used as a boundary condition for the model, there are uncertainties associated with the use of flow measurements that far upstream of the model domain. The uncertainties relate to the travel time of the measured flow rate from Rockland to the location of the model boundary, changes in the flow hydrograph over this distance (e.g., peak flow rates during storm events may be attenuated somewhat), impact of out-of-bank flooding, impact of additional runoff and tributaries, etc. Resolving these uncertainties will require significant effort and further analysis.

4.1.4. Suspended Sediment Concentration (SSC)

Unlike river discharge, there is no dataset with continuous SSC measurements available for Ontonagon River. However, there are periodic instantaneous measurements of SSC available at USGS Station 04040000 at Rockland from 1974 onwards. The SSC measurements were paired with river discharge in order to develop a rating curve relating instantaneous sediment load to the instantaneous river flow rate. Subsequently, the rating curve relationship was used with the continuous measured river flow rate to estimate a continuous time-series of SSC. The resulting SSC time-series was used to specify the SSC associated with the river flow entering the model domain at the upstream boundary.

Given the positive correlation with river flow rate noted previously, SSC typically peaks during the spring high-flow period, with maximum estimated SSC of about 3000 mg/L during events in spring 2019 and 2023. Similar to that described for the river discharge boundary condition, there are uncertainties associated with using the estimated SSC at Rockland for the model boundary condition.

In addition to SSC associated with the river flow entering the model domain at the upstream boundary, the model also requires an SSC associated with the water level boundary condition at the downstream boundary. This represents the SSC entering the model domain from Lake Superior during episodic periods of flow reversal such as during storm surge events. Since the input SSC associated with this boundary condition is not expected to impact sedimentation within the marina or the model calibration, it was specified as a nominal constant value of 10 mg/L.

4.2. Model Uncertainties

The preceding sections presented the development, calibration, and application of a hydrodynamic and sediment transport model to assess sedimentation control alternatives within Ontonagon Marina. The model was developed and calibrated using the available data. However, there are some limitations and uncertainties associated with model inputs, model construct, and model calibration that limit the utility of the model. These are listed below in no particular order:

- The hydrodynamic sub-model was not calibrated. Calibration would require water level and/or flow velocity measurements within the model domain.
- The sediment transport sub-model was not calibrated for SSC. Calibration would require SSC measurements within the model domain.
- The sediment transport sub-model was not calibrated for sedimentation in Ontonagon River. Calibration would require two or more consecutive bathymetric surveys in the model domain.
- The hydrodynamic and sediment transport model performance is subject to uncertainty associated with using flow measurements and SSC estimates at a location about 11 miles upstream of the model domain.
- There may be potential three-dimensional patterns in sediment transport that are not captured by the two-dimensional model grid applied here. For instance, a majority of the sediment transport within Ontonagon River may be transported at depth and along the deeper channel along the eastern edge of the river and not be available for transport into the relatively shallow marina.
- The use of a model grid comprised of rectangular cells limits the representation of features such as the bend in the new channel in Alternative 1 and the angled entrance in Alternative 5. These may be better resolved using an alternative model that allows for cells of varying shapes such as triangles, rectangles, pentagons, and hexagons.
- In some areas, such as the relatively narrow and shallow entrance to the marina, propeller wash may provide a scouring mechanism that is not accounted for in the model. This can limit sedimentation in this area in reality and may account for the fact the model tends to overestimate sedimentation in this area under existing conditions.

Typically, numerical models developed for feasibility, engineering design, impacts assessments, and permitting involve comprehensive model calibration to various metrics. This implies the need for further data collection for metrics such as water levels/depths, flow velocity, SSC, and bathymetry within the model domain. Additional SSC data can also support assessment of the need for a three-dimensional model instead of a two-dimensional model. Because of these limitations, the model presented here should be interpreted as a screening-level tool for a preliminary assessment of alternatives for sedimentation control. The model results presented here are qualitatively reliable. However, a more quantitatively reliable model requires additional data and effort to support model setup and calibration. Based on GEI's experience and the industry practice for such problems, GEI recommends further data collection and model development and calibration for a more definitive alternatives analysis, and to support engineering design, impacts assessments, and permitting.

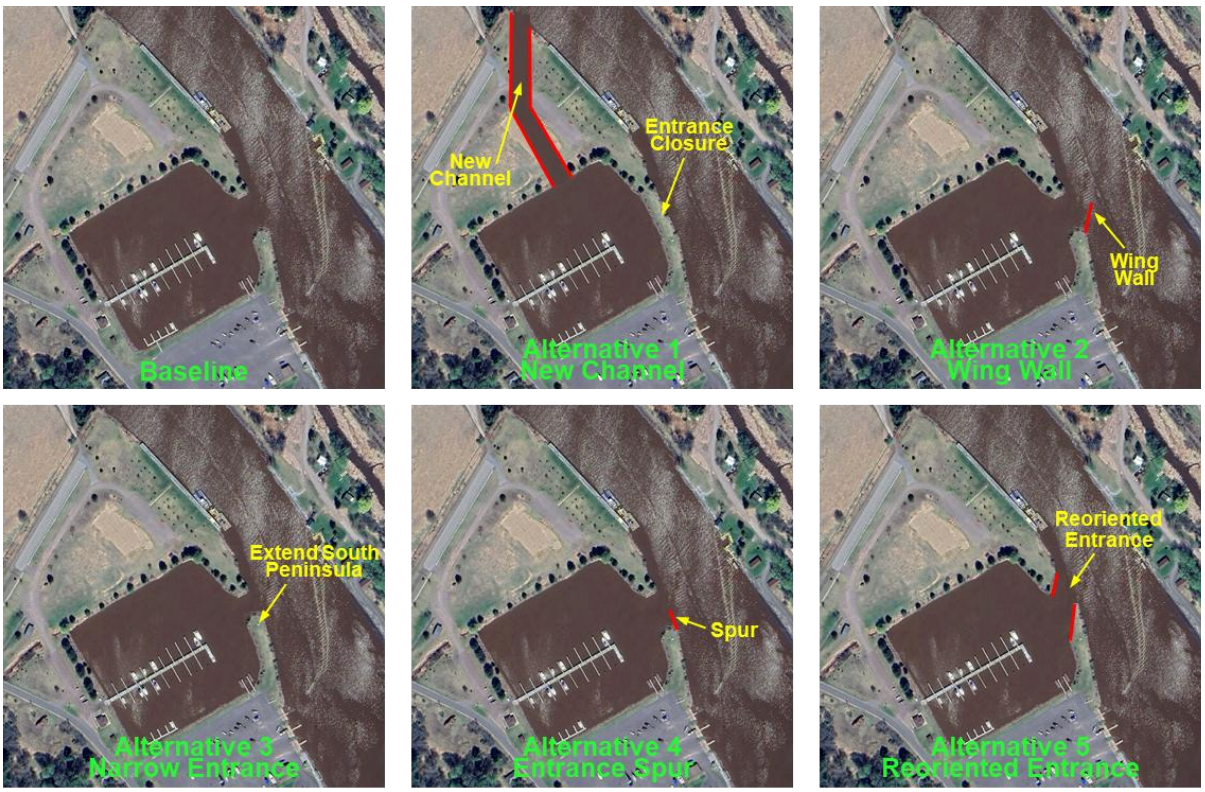
A technical memo further describing the means and methods used to generate the Hydrodynamic Model is included in Appendix B.

5. Alternatives

5.1. Model Application for Alternatives

Several alternatives were developed, incorporated in the model, and assessed for their effectiveness in reducing sedimentation in the marina. Figure 5-1 shows the layout of five sedimentation control project alternatives simulated using the model. In addition, a baseline or existing conditions scenario is also included for comparison to the with-project alternatives. The alternatives include:

Figure 5-1



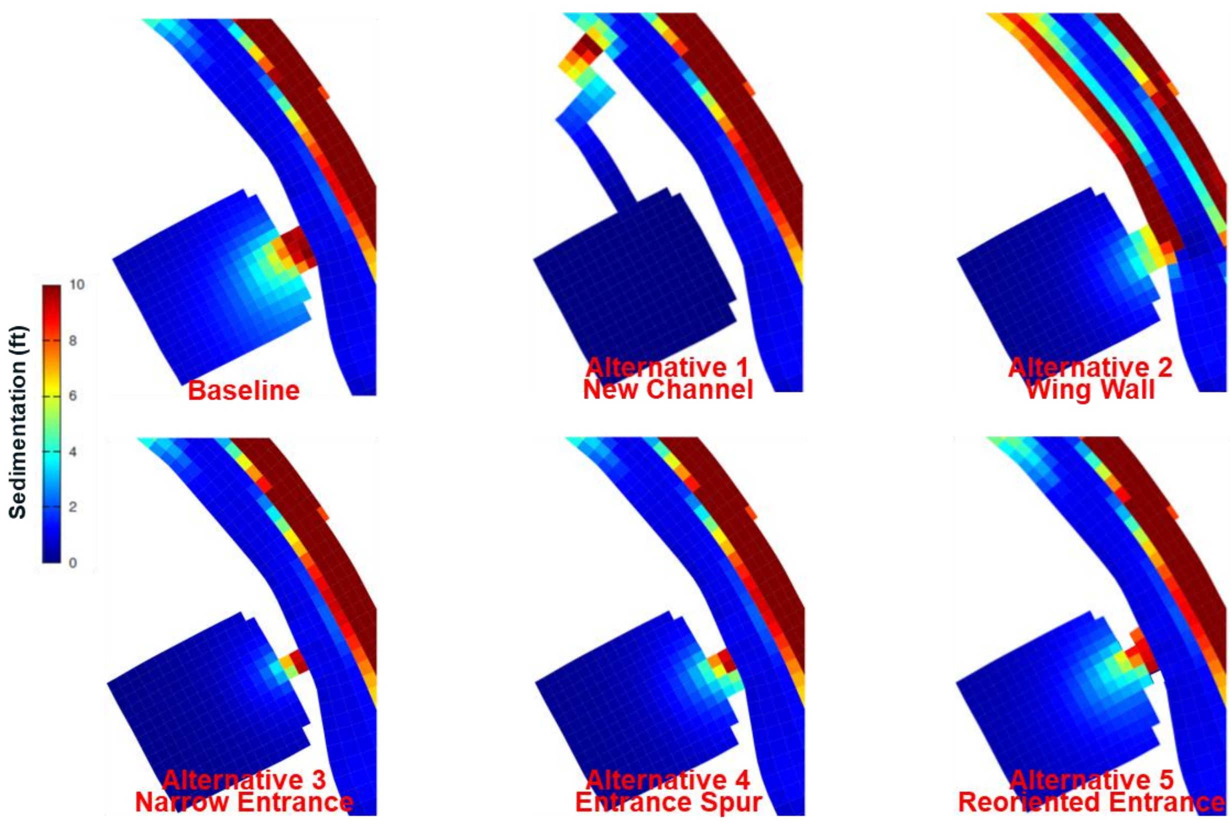
- **Alternative 1, New Channel** – This includes closure of the existing marina entrance and the construction of a new 80 ft wide channel with depth of 10 ft (relative to the IGLD85 Low Water Datum of 601.1 ft) and a new entrance that connects to the turning basin.
- **Alternative 2, Wing Wall** – This involves the construction of a wing wall or current deflection wall at the marina entrance extending 100 ft from the southern peninsula and into Ontonagon River.
- **Alternative 3, Narrow Entrance** – This involves narrowing the existing marina entrance to 80 ft by extending the southern peninsula.
- **Alternative 4, Spur** – This involves constructing a wall extending from the southern peninsula, and effectively narrowing the existing marina entrance to 80 ft.

- **Alternative 5, Reoriented Entrance** – This involves reorienting the existing marina entrance from the current orientation perpendicular to the river to being oriented facing downstream.

Except for Alternative 1, the remaining alternatives are aimed at reducing sedimentation exchange. The model setup was revised to represent the engineering features associated with each individual alternative. Alternatives 1, 3, and 5 were represented by modifying the model to represent the elements associated with each alternative, whereas the wing wall and spur included in Alternatives 2 and 4, respectively, were represented using impermeable structures.

Each project alternative and baseline scenario were run for the same 2019-2025 period previously discussed for the model calibration. Figure 5-2 shows the model-calculated sedimentation over the simulation period for each alternative and the baseline scenario. The results for each with-project alternative can be compared with the baseline scenario to assess its effectiveness in reducing sedimentation. The results are summarized below:

Figure 5-2



- **Alternative 1, New Channel** – This alternative results in the least amount of sedimentation within the marina amongst all alternatives and also relative to the baseline scenario. However, the model results indicate significant sedimentation (in terms of sediment accumulation thickness) at the mouth of the new entrance.
- **Alternative 2, Wing Wall** – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation. However, the model

indicates the potential for downstream impacts within the river, with significant sedimentation along the western shore of Ontonagon River downstream of the marina as compared to the baseline scenario. These impacts are caused by a reduction in flow velocity due to the presence of the wing wall, thus promoting sedimentation.

- **Alternative 3, Narrow Entrance** – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation.
- **Alternative 4, Spur** – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation, although not as effectively as compared to Alternative 3.
- **Alternative 5, Reoriented Entrance** – Although the results for this alternative are somewhat limited by the model grid schematization issues described previously, it does show lesser magnitude of sedimentation at the entrance as well as the areal extent of sedimentation than the baseline scenario.

All the alternatives show relatively less sedimentation (in terms of sediment accumulation thickness and the areal extent of sedimentation) compared to the baseline scenario. Therefore, total sedimentation volume and the need for maintenance dredging is expected to be less than under existing conditions. However, alternatives that involve a change to the hydraulics in the river, such as Alternative 2, can potentially impact sedimentation in the river. Overall, the results of the various alternatives show that it is possible to reduce the magnitude of sedimentation and therefore the frequency of maintenance dredging. However, none of the alternatives would completely remove the need for maintenance dredging. Larger figures showing the alternatives are provided in Appendix C.

An order of magnitude cost estimate was developed for each of the alternatives. Below is Table 5-1 comparing the costs for each alternative. Detailed cost estimates are included in Appendix D.

Table 5-1

Alternative	Cost
Baseline	$ 4,183,130.00
Alternative 1 – New Channel	$ 28,739,380.00
Alternative 2 – Wing Wall	$ 4,095,480.00
Alternative 3 – Narrow Entrance	$ 2,409,690.00
Alternative 4 – Entrance Spur	$ 3,040,130.00
Alternative 5 – Reoriented Entrance	$ 2,478,460.00

6. Stakeholder Input

6.1. Stakeholder Input

GEI conducted stakeholder engagement for the Ontonagon Marina Feasibility Study in two phases: agency consultations with the Michigan Department of Natural Resources, Michigan Department of Environment, Great Lakes, and Energy, and the U.S. Army Corps of Engineers in winter 2026, and a community workshop held May 21, 2026 at the Village office. Engagement objectives included establishing project awareness, identifying regulatory considerations, and aligning technical recommendations with community priorities.

6.1.1. Agency Consultation Findings

First, the DNR does not hold a regulatory role for this project but emphasized early and frequent coordination with EGLE to address concerns related to bottomland coverage and fish habitat. DNR confirmed willingness to consider Ontonagon for waterway grant funding, with pathways including a planning grant and construction funding. Second, EGLE raised no significant environmental concerns with prioritized Alternatives 3, 4, and 5. Per Part 301 requirements, the selected alternative must represent the least environmentally impactful feasible option. Last, USACE recommended narrowing the marina channel using rock or sheet piling, noting that sheet piling carries higher upfront cost but provides greater long-term flexibility for land dredging. Standard EGLE permitting and a potential 408 review are anticipated.

6.1.2. Workshop Findings

Stakeholders were presented with a range of marina use descriptions and asked to identify where activities currently take place, as well as where they would spend more time in the future if the opportunity were available. The workshop identified fishing as the primary current use, supported by four access points and annual tournaments. Land-based boat parking is sufficient, though additional floating docks may be needed. Marina access is limited to vessels with heels under 5.5 feet, and stakeholders indicated entrance narrowing would not affect access. Kayaking takes place on the opposite side of the river and requires no marina-side improvements. For future use, participants prioritized a children’s playground, sports fields, snowshoeing, and primitive camping. Primitive campsites were identified as a viable supplemental revenue source, as restroom facilities already exist on site. Minor electrical improvements, expanded year-round programming, and improved connectivity between downtown and the marina were also identified as meaningful opportunities to increase community engagement and broaden seasonal visitation.

6.1.3. Considerations for Future Planning Efforts

Sediment management remains the primary challenge. A demand assessment is recommended before advancing long-term infrastructure decisions. Key components include regional benchmarking, vessel draft profiling, unmet demand analysis, Great Lakes boating trend review, long-term growth scenarios, and waterfront-to-downtown connectivity planning.

A technical memo further describing the results of the Stakeholder Mapping is included in Appendix E.

7. Funding Investigation

7.1. Background

The Village of Ontonagon, located in Michigan's Upper Peninsula, owns and operates the local marina that is a mile from the confluence of the Ontonagon River and Lake Superior. Significant sediment in the river obstructs access to the Ontonagon Marina, hindering boats from entering due to the blockage at the marina's entrance. The perpetual sedimentation at the marina entrance poses an ongoing issue to serve as a safe harbor and key economic resource for the Village and surrounding rural communities.

The Ontonagon Marina Access Feasibility Study aims to identify optimal long-term sediment control solutions for the marina entrance. This initiative is designed to mitigate access obstructions, sustain critical community uses such as subsistence fishing and economic activities, and uphold the marina's role as a vital safe harbor, particularly as climate conditions contribute to increasingly frequent and unpredictable storms.

The Village experiences financial constraints limiting its ability to allocate funds for public improvements beyond routine maintenance. The Marina Commission operates on a limited annual budget, relying solely on usage fees. Grant funding is necessary to support critical public improvement projects that cannot be accommodated within the Village's limited operating budget.

7.2. Grant Funding Opportunities

GEI has undertaken an investigation of potential external funding opportunities for the Ontonagon Marina Access Feasibility Study. The Village of Ontonagon was awarded a Thriving Communities Grant (TCGM) to fund the feasibility study, with the objective of building capacity for subsequent federal grant applications for design and construction. As part of the funded scope of work, the feasibility study includes evaluating various grant programs that could support both the current feasibility study phase and future construction phases for sediment control and marina access improvements.

The funding investigation revealed key project strengths and opportunities that position implementation activities well for future funding, including:

- The availability of planning funds from multiple federal and state sources, which can be strategically matched to minimize the Village's out-of-pocket expenses for the project.
- Opportunity to reimagine the marina's role as a regional recreational and economic asset to secure the level of support needed for competitive funding.

However, the analysis also identified considerations that may affect implementation funding, including:

- The project's lack of a strong connection to formal hazard mitigation plans —though such a link may exist but was not made available to GEI at the time of review
- Data on the frequency and usage of the Ontonagon River as a safe harbor.

- Administrative burdens that accompany large federal grant requirements.
- Risk of unmanaged or unintentional scope expansion to include additional amenities beyond essential dredging and maintenance activities.

The preliminary analysis indicates that while many grant programs focus on creating disaster resilient infrastructure, the critical aspects of the Ontonagon project—such as climate resilience, recreational access, and community infrastructure improvements—may align with programs like the Better Utilizing Investments to Leverage Development (BUILD) program or other initiatives focused on transportation and hazard mitigation. There are few programs that pay for maintenance dredging, except for the MI EGLE Waterways Program Grants; therefore, support to meet marina sediment control objectives likely must come with clear benefits to habitat and/or economic impact. The Village's commitment to community welfare positions the project favorably for various funding streams. Monitoring upcoming solicitations is crucial to align project phases with available opportunities.

Appendix F includes a summary of investigated funding sources. Program information was sourced from the most recent notice of funding publicly available.

8. Recommendation

In summary, due to the flow and amount of sediment in the Ontonagon River, no solution will completely eliminate sedimentation in the mouth of the marina. However, alternatives did prove to reduce the amount and rate of sedimentation. These alternatives included narrowing the mouth via material or spur wall as well as re-orientating the entrance to come in on more of an angle with the Ontonagon River as opposed to perpendicular. Widening the mouth or removing the north peninsula would increase the amount of sedimentation in the marina and make the issue worse.

Of these alternatives, narrowing the mouth of the Marina with material would provide the Marina with the possibility of dredging out the mouth by land as opposed to the other alternatives which would require a boat or dredging barge. Stakeholders did not raise a concern with narrowing the entrance during the Stakeholder mapping process.

Therefore, GEI recommends narrowing the entrance in order to reduce the sedimentation and frequency of dredging at the marina. The method of which to narrow the entrance should be established as a part of preliminary design of the next phase of this project.

Appendix A Bathymetric Surveys

NOTE:
1. LAKE SUPERIOR LOW WATER DATUM IS 601.10 FEET (IGLD 85)

0 80 160
SCALE, FEET

SOURCE:
1. PLAN BASED ON MAP PREPARED BY TRIMEDIA

Marina Feasibility Study	GEI Consultants	2014 Bathymetric Survey	
Village of Ontonagon Ontonagon, MI	Project 2506426	November 2025	Fig. 2

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NOTE:
1. LAKE SUPERIOR LOW WATER DATUM IS 601.10 FEET (IGLD 85)

0 80 160
SCALE, FEET

SOURCE:
1. PLAN BASED ON MAP PREPARED BY BRAD ANDERSON

Marina Feasibility Study	GEI Consultants	2019 Bathymetric Survey - Area Dredged	
Village of Ontonagon Ontonagon, MI	Project 2506426	November 2025	Fig. 3

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NOTE:
1. LAKE SUPERIOR LOW WATER DATUM IS 601.10 FEET (IGLD 85)

SOURCE:
1. PLAN BASED ON MAP PREPARED BY DAN BRAATZ

0 80 160
SCALE, FEET

Marina Feasibility Study	GEI Consultants	2025 Bathymetric Survey	
Village of Ontonagon Ontonagon, MI	Project 2506426	November 2025	Fig. 1

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NOTE:
1. LAKE SUPERIOR LOW WATER DATUM IS 601.10 FEET (IGLD 85)

SOURCE:
1. PLAN BASED ON MAP PREPARED BY JOHN RECK

0 80 160
SCALE, FEET

Marina Feasibility Study	GEI Consultants	2014/2019 Bathymetric Survey - Combination
Village of Ontonagon Ontonagon, MI	Project 2506426	November 2025 Fig. 4

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NOTE:
1. LAKE SUPERIOR LOW WATER DATUM IS 601.10 FEET (IGLD 85)

0 80 160
SCALE, FEET

SOURCE:
1. PLAN BASED ON MAP PREPARED BY JOHN RECK

Marina Feasibility Study	GEI Consultants	2014/2019/2025 Bathymetric Survey - Depth Differences	
Village of Ontonagon Ontonagon, MI	Project 2506426	November 2025	Fig. 5

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Appendix B Hydrodynamic Memo

Technical Memorandum

990 Lalley Road ● Iron River, MI 49935 ● 906.214.4140

Via Email:	wdupont@villageofontonagon.org
To:	William DuPont, Village of Ontonagon
From:	Rooni Mathew, PhD, PE
cc:	John Reck
Date:	12/23/2025
Re:	Hydrodynamic and Sediment Transport Modeling Ontonagon Marina Access Feasibility Study Ontonagon, MI
Project No.	2506426

The Ontonagon Marina located on the Ontonagon River experiences sedimentation issues requiring periodic dredging to maintain navigational draft for vessels operating in the marina. Figure 1 shows the marina relative to its location in Ontonagon River and Lake Superior along with various features relevant for the analysis presented in this memorandum.

Under a grant from the Great Lakes Thriving Communities Grant Making program, the Village of Ontonagon contracted GEI Consultants to conduct a feasibility study to assist in determining the best option for sedimentation control within Ontonagon Marina. This memorandum includes documentation of the development and calibration[1] of a numerical model of hydrodynamics and sediment transport. Subsequently, the model is applied to assess potential alternatives to control sedimentation within the marina. The following sections present the modeling framework, model domain and computational grid, model inputs, model calibration, model application to assess various alternatives, followed by a discussion of model uncertainties.

Modeling Framework

The primary objective of the modeling analysis presented here was to develop a numerical model capable of representing the key physical processes responsible for sedimentation and for use in assessing potential engineering solutions to reduce sedimentation within the marina. The dominant source of sediment to the marina is considered to be from the Ontonagon River, which is subject to seasonal variations in river flow rate and sediment loading and is influenced by the inter-annual, seasonal, and episodic variations in water level in Lake Superior. Therefore, the model framework needs to include formulations capable of simulating the time-variable fluctuations in water levels, flow rate, and sediment transport. In addition, the model framework needs to be capable of representing the impact of engineering measures aimed at reducing sedimentation within the marina.

[1] Calibration refers to the iterative process of adjusting model parameters such that model results agree with measured values for given metric.

Given the capabilities required to address the modeling objectives, the Delft3D numerical model framework (Lesser et al., 2004) was selected for application. Delft3D is an open-source modeling framework that includes sub-models of hydrodynamics, waves, sediment transport, and water quality and has been applied extensively to address coastal and environmental problems around the world. As part of the analysis presented here, the hydrodynamic and sediment transport sub-models were developed, calibrated, and applied.

Model Domain and Grid

The model domain refers to the spatial extent represented in the model. This is typically a function of (1) the availability of data for key model inputs such as bathymetry and boundary conditions[2], (2) the availability of data for model calibration, (3) computational considerations (model computation time generally increases with increasing model domain size), and (4) the area of interest for the problem to be addressed using the model. Given these considerations, the model domain was defined to include the marina and Ontonagon River from its mouth in Lake Superior to the Michigan Rt 64 bridge (Figure 1). This is an approximately 0.9-mile stretch of Ontonagon River and includes the turning basin and a navigation channel extending from the turning basin to Lake Superior. The model domain was discretized using a two-dimensional grid consisting of approximately 1100 computational grid cells, with an average cell size of approximately 35’ by 35’ within the marina (Figure 2). As seen subsequently, the grid resolution is capable of representing spatial variations in bathymetry, transport, and calculated sedimentation.

Model Inputs

The hydrodynamic and sediment transport models require several inputs. These include bathymetry and boundary conditions at the upstream boundary (at the upstream-most extent of the model domain in Ontonagon River) and at the downstream boundary (at the mouth of Ontonagon River in Lake Superior). Boundary conditions were specified for water level and suspended sediment concentration [SSC] at the downstream boundary, and river discharge and SSC at the upstream boundary. These inputs were developed using various data sources as described next.

Bathymetry

Bathymetry measurements from a number of sources were compiled and consolidated to develop model inputs. The data sources include:

- Data collected by United States Army Corps of Engineers (USACE) in 2015
- Data collected by GEI Consultants in 2025 as part of the current project
- Data collected by GEI Consultants in 2019
- Data collected by GEI Consultants in 2014

[2] Boundary conditions refer to values for various metrics applied at the boundaries, i.e., edges of the model domain and typically based on measured data.

- Nautical chart from the National Oceanic and Atmospheric Administration (NOAA)

Figure 3 shows spatial coverage of these various data sources (with the exception of the NOAA nautical chart which was used for areas in Ontonagon River upstream of the 2025 data coverage) and the interpolated model bathymetry. The model bathymetry represents longitudinal and lateral variations in bathymetry within the river as well as within the marina. Prominent features include a relatively deep channel along the eastern edge of Ontonagon River and within the turning basin and the navigation channel, and relatively shallow depths within the marina.

Water Level

Given its proximity to Lake Superior, water level within the model domain is largely dependent on water level in Lake Superior. Water level in Lake Superior typically varies over inter-annual scales, seasonal scales, and episodically due to storm surge, seiche events, meteotsunamis, etc. These processes are captured in the long-term measurements of water level at NOAA Station 9099044 (Figure 1). Therefore, the hourly measurements of water level were used to specify water level boundary conditions at the downstream end of the model domain, at the mouth of Ontonagon River in Lake Superior. Figure 4 shows the hourly time-series of the water level boundary condition used in the model. The afore-mentioned temporal trends are apparent in the water level data.

River Discharge

The United States Geological Survey (USGS) maintains several stream gage locations along the Ontonagon River. The USGS gage closest to the model domain is at Rockland, MI (USGS Station 04040000), approximately 11 miles upstream from the model domain (Figure 1). Daily average measured flows from this USGS gage were therefore used to specify the river flow rate entering the model domain at the upstream boundary. Figure 5 shows the daily time-series of the river discharge boundary condition used in the model. River discharge shows a seasonal pattern, with low flows during winter and summer, high flows associated with the spring snowmelt, and moderate flows in fall.

Although the river flow measured at Rockland, MI was used as a boundary condition for the model, there are uncertainties associated with the use of flow measurements that far upstream of the model domain. The uncertainties relate to the travel time of the measured flow rate from Rockland, MI to the location of the model boundary, changes in the flow hydrograph over this distance (e.g., peak flow rates during storm events may be attenuated somewhat), impact of out-of-bank flooding, impact of additional runoff and tributaries, etc. Resolving these uncertainties will require significant effort and further analysis.

Suspended Sediment Concentration (SSC)

Unlike river discharge, there is no dataset with continuous SSC measurements available for Ontonagon River. However, there are periodic instantaneous measurements of SSC available at USGS Station 04040000 at Rockland, MI from 1974 onwards. The SSC measurements were paired with river discharge in order to develop a rating curve relating instantaneous sediment load to the instantaneous river flow rate. Subsequently, the rating curve relationship was used with the continuous measured river flow rate to estimate a continuous time-series of SSC. The resulting SSC time-series was used to specify the SSC associated with the river flow entering the model domain at the upstream boundary.

Figure 6 shows the relationship between SSC and river discharge (sediment load on left panel, SSC on right panel). Sediment load was calculated as:

$$L = SSC * Q$$

where, L = sediment load, and Q = river flow rate.

Sediment load is noted to increase with discharge, with a change in the slope of the trend at a flow rate approximately corresponding to the long-term average flow rate of 1430 cubic feet per second (cfs). Sediment load was related to discharge using a "hockey-stick" relationship to represent the change in slope at 1430 cfs, nominally referred to as flood and non-flood regimes. Separate relationships were derived for the flood and non-flood regimes. The calculated loads were also corrected for the bias introduced by fitting the load-discharge relationship in log-space (Ferguson 1986). The rating curve function is:

$$\ln\left(\frac{L}{L_m}\right) = A * \ln\left(\frac{Q}{Q_m}\right) + B + C$$

The parameters *A*, *B*, and *C* depend on whether river discharge is in flood ($Q > Q_m$) or non-flood condition ($Q < Q_m$). The various parameter values in the rating curve were fitted using a least-squares regression and are listed in Table 1. River flow rate Q has units cubic meters per second (m^3/s), and sediment load L has units of metric tons per day (MT/d).

Table 1 Rating curve parameters for the solids loading at Rockland, MI.

Parameter	Non-Flood	Flood
Q_m	1430 cfs or 40.5 m^3/s	
A	1.41	2.19
B	1.80	2.04
C	0.14	0.29
L_m	1.79 MT/d	

The rating curve fit is shown relative to the data in Figure 6, which shows the sediment load rating curve on the left panel, and the SSC back calculated from the rating curve on the right panel. Overall, the fitted rating curve reproduces the river flow-dependent trend as well as the magnitude of SSC at various river flow rates.

As mentioned previously, the rating curve was applied to the measured continuous river flow rate to estimate the continuous SSC time-series at Rockland, MI. Figure 7 shows the resulting SSC time-series, used to specify the SSC associated with the river flow entering the model domain at the upstream boundary. Given the positive correlation with river flow rate noted previously, SSC typically peaks during the spring high-flow period, with maximum estimated SSC of about 3000 milligrams per liter (mg/L) during events in spring 2019 and 2023. Similar to that described for the river discharge boundary condition, there are uncertainties associated with using the estimated SSC at Rockland, MI for the model boundary condition.

In addition to SSC associated with the river flow entering the model domain at the upstream boundary, the model also requires an SSC associated with the water level boundary condition at the downstream boundary. This represents the SSC entering the model domain from Lake Superior during episodic periods of flow reversal such as during storm surge events. Since the input SSC associated with this boundary condition is not expected to impact sedimentation within the marina or the model calibration, it was specified as a nominal constant value of 10 mg/L.

Model Calibration

The model domain as set up using the grid, bathymetry, and boundary conditions described above was calibrated using empirical data. This section describes the model calibration metrics, calibration period, calibration parameters, and the calibration performance.

Calibration Metrics

Sedimentation is the primary metric of interest for application of the model. Given that, and the availability of sufficient data, model performance was calibrated against the measured spatial patterns and magnitudes of sedimentation. Specifically, the model was calibrated by comparing the model-calculated sedimentation to (1) the measured sedimentation within the marina, and (2) the long-term maintenance dredging rate within the turning basin.

The measured sedimentation within the marina is based on comparison of the bathymetry measured at various times. As seen in Figure 3, the 2019 bathymetry data did not cover the entire marina. Therefore, the 2019 bathymetry data was combined with the 2014 bathymetry data to develop a hybrid bathymetry surface. This surface was compared to a surface developed from bathymetry measured in 2025 (coverage of entire marina), resulting in a map of bathymetric change, i.e., the sedimentation during this period. As seen subsequently, the majority of the observed sedimentation is generally within the footprint of the 2019 bathymetry data. This implies that the uncertainty resulting from comparing the hybrid 2014/2019 surface to the 2025 surface to determine sedimentation is not expected to be significant. Therefore, the empirical sedimentation map was compared to the sedimentation calculated by the model as part of model calibration.

The measured long-term sedimentation rate within the turning basin is based on the maintenance dredging volumes reported by the USACE. The maintenance dredging volumes over the period 2010-2024 were summed and annualized to determine the maintenance dredging rate (in units of cubic yards per year [cy/yr]). Since the maintenance dredging rate is effectively the sedimentation rate within the turning basin, the long-term maintenance dredging rate was compared to the sedimentation rate calculated by the model within the turning basin as part of model calibration.

Calibration Period

Given the availability of sedimentation data within the marina over the 2019-2025 time period, the model calibration period was selected to encompass the period of the 2019 and 2025 bathymetry surveys. Accordingly, the model calibration period was defined as February 2019 through October 2025. A single continuous time-variable simulation was performed over this time period with morphological feedback between the hydrodynamics and the changing bathymetry as a result of erosion and deposition.

Calibration Parameters

Model performance and sensitivity were assessed for several key parameters. The majority of model parameters were defined using literature values. These include bottom roughness (Manning n = 0.02), sediment dry density (500 kilograms per cubic meter [kg/m^3]), critical shear stress for deposition (infinite, i.e., always depositing), critical shear stress for erosion (0.5 Pascals [Pa]), and erosion rate parameter (0.0001 kilograms per square meter per second [$kg/m^2/s$]). The use of default values for these parameters was necessary given the lack of suitable data for calibrating these parameters. For instance, calibrating the bottom roughness would require flow velocity and/or water level measurements within the model domain.

Model performance for sedimentation was determined to be primarily sensitive to (1) eddy viscosity and eddy diffusivity, which quantifies the mixing of momentum and SSC horizontally in the water column, and (2) the sediment settling velocity, which quantifies the rate at which suspended sediments deposit from the water column to the sediment bed. Based on model calibration, eddy viscosity and eddy diffusivity were defined as 0.25 square meter per second (m^2/s) and settling velocity was defined as 0.35 meters per second (m/s).

Calibration Performance

Figure 8 shows a comparison of the measured and model-calculated sedimentation within the marina over the model calibration period. The measured sedimentation is shown using contours, with contour values labelled in feet (ft), whereas the model-calculated sedimentation is shown as a color-coded map. The measured sedimentation shows sedimentation in excess of about 3 ft in the vicinity of the marina entrance, sedimentation decreasing with distance towards the center of the marina, and little to no sedimentation in the western half of the marina. The model shows a similar spatial pattern of accumulation, with relatively high sedimentation near the marina entrance, decreasing towards the center of the marina, and little to no sedimentation in the western half of the marina. However, the model tends to over-estimate the sedimentation at the marina entrance by several feet. This artifact in model performance may be indicative of uncertainties associated with the model inputs, model construct, and/or model calibration as discussed subsequently.

Figure 9 shows a comparison of the measured spatial pattern of sedimentation over 2024-2025 within the turning basin along with the model-calculated sedimentation pattern and magnitude over the 2019-2025 simulation. Overall, the model shows spatial patterns of sedimentation that are somewhat consistent with the data. This includes the sedimentation along northwestern side of the turning basin, and the lack of sedimentation along the northeastern edge of the turning basin. However, the model shows sedimentation along the southwestern edge of the turning basin whereas the data shows erosion. This discrepancy may be because the data represents patterns over only 2024-2025, whereas the model results are for 2019-2025. Overall, the volumetric sedimentation rate calculated by the model is 27,780 cy/yr, which is comparable to the measured sedimentation rate, i.e., the long-term maintenance dredging rate, of 27,345 cy/yr.

Despite some of the inconsistencies noted above between the model-calculated and measured sedimentation, the model is expected to be useful and reliable for assessing measures for sedimentation control within the marina. Such assessment of engineering alternatives is typically performed relative to baseline conditions, using the results of model simulations for each engineering alternative as well as the baseline condition. Since the artifacts in model performance impact all simulations, the relative difference between the simulation results can be attributed solely to the impact of the individual engineering alternatives. Furthermore, and as discussed in the following section, the various alternatives for sedimentation control are based on physical principles of hydraulics and with precedence in literature as well as practical experience at similar sites. Therefore, despite some uncertainties, the model is considered to be useful and reliable for assessing potential engineering measures to control sedimentation within the marina.

Model Application for Alternatives

Sedimentation within a system such as the Ontonagon Marina, connected to a freshwater river and with no direct sources of sediment entering the marina, is dependent on sediment delivery from the river. This is also apparent in the spatial pattern of measured sedimentation seen in Figure 8, with the greatest sedimentation observed at the marina entrance, i.e., at the sediment source.

Conceptually, sediment influx in such a setting occurs due to advective and diffusive processes (van Rijn, 2016). Advective processes refer to the filling and draining of the marina due to changes in water level in the river. For instance, an increase in water levels in the river will cause the transport of water and sediment from the river into the marina. Diffusive processes refer to the formation of horizontal eddies at the interface of the relatively low-energy setting within the marina and the high-energy river, leading to the exchange of sediment between the river and the marina. Figure 10 shows such an example of such an eddy, using model results during a 23,000 cfs relatively high flow event in April 2019. The left panel shows velocity vectors scaled by velocity magnitude whereas the right panel shows unscaled vectors. A counterclockwise eddy can be seen at the marina entrance, generated at the interface between the relatively fast currents in the river and relatively slow currents in the marina. The counterclockwise eddy at the marina entrance in turn generates a larger clockwise eddy within the marina.

Advective transport can only be controlled by the construction of a lock or gate, which may not be practical and is therefore not further assessed here. Diffusive exchange can be controlled to a certain extent by using measures such as current deflecting walls, modifying the entrance geometry, etc. (van

Rijn, 2016). Therefore, several alternatives were developed, incorporated in the model, and assessed for their effectiveness in reducing sedimentation in the marina.

Figure 11 shows the layout of five sedimentation control or with-project alternatives simulated using the model. In addition, a baseline or existing conditions or without-project scenario is also included for comparison to the with-project alternatives. The alternatives include:

- Alternative 1, New Channel – This includes closure of the existing marina entrance and the construction of a new 80 ft wide channel with depth of 10 ft (relative to the IGLD85 Low Water Datum of 601.1 ft) and a new entrance that connects to the turning basin.
- Alternative 2, Wing Wall – This involves the construction of a wing wall or current deflection wall at the marina entrance extending 100 ft from the southern peninsula and into Ontonagon River.
- Alternative 3, Narrow Entrance – This involves narrowing the existing marina entrance to 80 ft by extending the southern peninsula.
- Alternative 4, Spur – This involves constructing a wall extending from the southern peninsula, and effectively narrowing the existing marina entrance to 80 ft.
- Alternative 4, Reoriented Entrance – This involves reorienting the existing marina entrance from the current orientation perpendicular to the river to being oriented facing downstream.

Except for Alternative 1, the remaining alternatives are aimed at reducing diffusive exchange and are based on concepts in van Rijn (2016). The model setup was revised to represent the engineering features associated with each individual alternative. Alternatives 1, 3, and 5 were represented by modifying the model grid to represent the elements associated with each alternative, whereas the wing wall and spur included in Alternatives 2 and 4, respectively, were represented using impermeable structures. However, because of the model grid which uses rectangular cells, there is some approximation and schematization in the model representation of Alternatives 1 and 5. For example, as seen in Figure 12 for Alternative 1, the new channel layout follows a stair-stepped layout rather than the angled layout shown in Figure 11. Nonetheless, the model results are expected to be qualitatively reliable.

Each with-project alternative and the baseline scenario were run for the same 2019-2025 period previously discussed for the model calibration. Figure 12 shows the model-calculated sedimentation over the simulation period for each alternative and the baseline scenario. The results for each with-project alternative can be compared with the baseline scenario to assess its effectiveness in reducing sedimentation. The results are summarized below:

- Alternative 1, New Channel – This alternative results in the least amount of sedimentation within the marina amongst all alternatives and also relative to the baseline scenario. However, the model results indicate significant sedimentation (in terms of sediment accumulation thickness) at the mouth of the new entrance.
- Alternative 2, Wing Wall – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation. However, the model indicates the potential for downstream impacts within the river, with significant sedimentation along the western shore of Ontonagon River downstream of the marina as compared to the

baseline scenario. These impacts are caused by a reduction in flow velocity due to the presence of the wing wall, thus promoting sedimentation.

- Alternative 3, Narrow Entrance – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation.
- Alternative 4, Spur – This alternative is effective at reducing both the magnitude of sedimentation at the entrance as well as the areal extent of sedimentation, although not as effectively as compared to Alternative 3.
- Alternative 4, Reoriented Entrance – Although the results for this alternative are somewhat limited by the model grid schematization issues described previously, it does show lesser magnitude of sedimentation at the entrance as well as the areal extent of sedimentation than the baseline scenario.

All the alternatives show relatively less sedimentation (in terms of sediment accumulation thickness and the areal extent of sedimentation) compared to the baseline scenario. Therefore, total sedimentation volume and the need for maintenance dredging is expected to be less than under existing conditions. However, alternatives that involve a change to the hydraulics in the river, such as Alternative 2, can potentially impact sedimentation in the river. Overall, the results of the various alternatives show that it is possible to reduce the magnitude of sedimentation and therefore the frequency of maintenance dredging.

Model Uncertainties

The preceding sections presented the development, calibration, and application of a hydrodynamic and sediment transport model to assess sedimentation control alternatives within Ontonagon Marina. The model was developed and calibrated using the available data. However, there are some limitations and uncertainties associated with model inputs, model construct, and model calibration that limit the utility of the model. These are listed below in no particular order:

- The hydrodynamic sub-model was not calibrated. Calibration would require water level and/or flow velocity measurements within the model domain.
- The sediment transport sub-model was not calibrated for SSC. Calibration would require SSC measurements within the model domain.
- The sediment transport sub-model was not calibrated for sedimentation in Ontonagon River. Calibration would require two or more consecutive bathymetric surveys in the model domain.
- The hydrodynamic and sediment transport model performance is subject to uncertainty associated with using flow measurements and SSC estimates at a location about 11 miles upstream of the model domain.
- There may be potential three-dimensional patterns in sediment transport that are not captured by the two-dimensional model grid applied here. For instance, a majority of the sediment transport within Ontonagon River may be transported at depth and along the deeper channel along the eastern edge of the river and not be available for transport into the relatively shallow marina.

- The use of a model grid comprised of rectangular cells limits the representation of features such as the bend in the new channel in Alternative 1 and the angled entrance in Alternative 5. These may be better resolved using an alternative model that allows for cells of varying shapes such as triangles, rectangles, pentagons, and hexagons.
- In some areas, such as the relatively narrow and shallow entrance to the marina, propeller wash may provide a scouring mechanism that is not accounted for in the model. This can limit sedimentation in this area in reality and may account for the fact the model tends to overestimate sedimentation in this area under existing conditions.

Typically, numerical models developed for feasibility, engineering design, impacts assessments, and permitting involve comprehensive model calibration to various metrics. This implies the need for further data collection for metrics such as water levels/depths, flow velocity, SSC, and bathymetry within the model domain. Additional SSC data can also support assessment of the need for a three-dimensional model instead of a two-dimensional model. Because of these limitations, the model presented here should be interpreted as a screening-level tool for a preliminary assessment of alternatives for sedimentation control. The model results presented here are qualitatively reliable. However, a more quantitatively reliable model requires additional data and effort to support model setup and calibration. Based on GEI's experience and the industry practice for such problems, GEI recommends further data collection and model development and calibration for a more definitive alternatives analysis, and to support engineering design, impacts assessments, and permitting.

Summary

A numerical hydrodynamic and sediment transport model was developed, calibrated, and applied to assess various alternatives for sedimentation control in Ontonagon Marina. The model results indicate that there are several potential options that can serve to reduce sedimentation and thus reduce the need for maintenance dredging within Ontonagon Marina. However, model development and calibration are currently limited by data. Although the model application and results for the various sedimentation control alternatives are qualitatively reasonable and reliable, GEI recommends further data collection to address various model uncertainties. In addition to resulting in a more reliable tool for purposes of the alternatives analysis, a better calibrated model will also be necessary for engineering design, impacts assessments, and permitting of any structural alternatives for sedimentation control.

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van Rijn, L.C. (2016). Harbour Siltation and Control Measures. Downloaded from https://www.leovanrijn-sediment.com

Closing

If you have any questions, please feel free to contact me at 269.568.1688

Sincerely,

GEI CONSULTANTS OF MICHIGAN, P.C.

Rooni Mathew
Senior Water Resources Engineer

John Reck
Project Manager

RM /JRR
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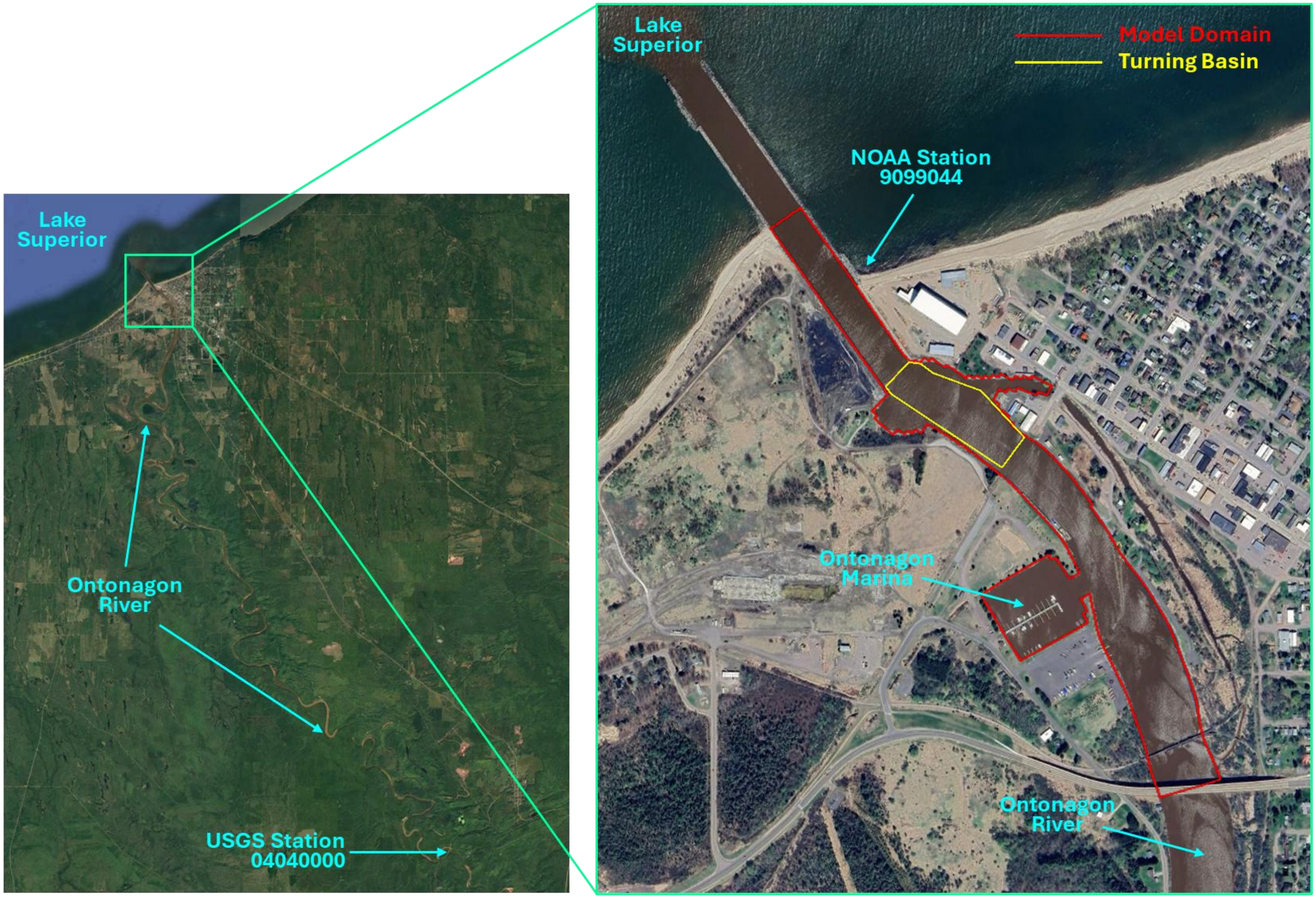


Figure 1 Location map of the Ontonagon Marina, Ontonagon River, and various features relevant for the numerical model development and calibration.

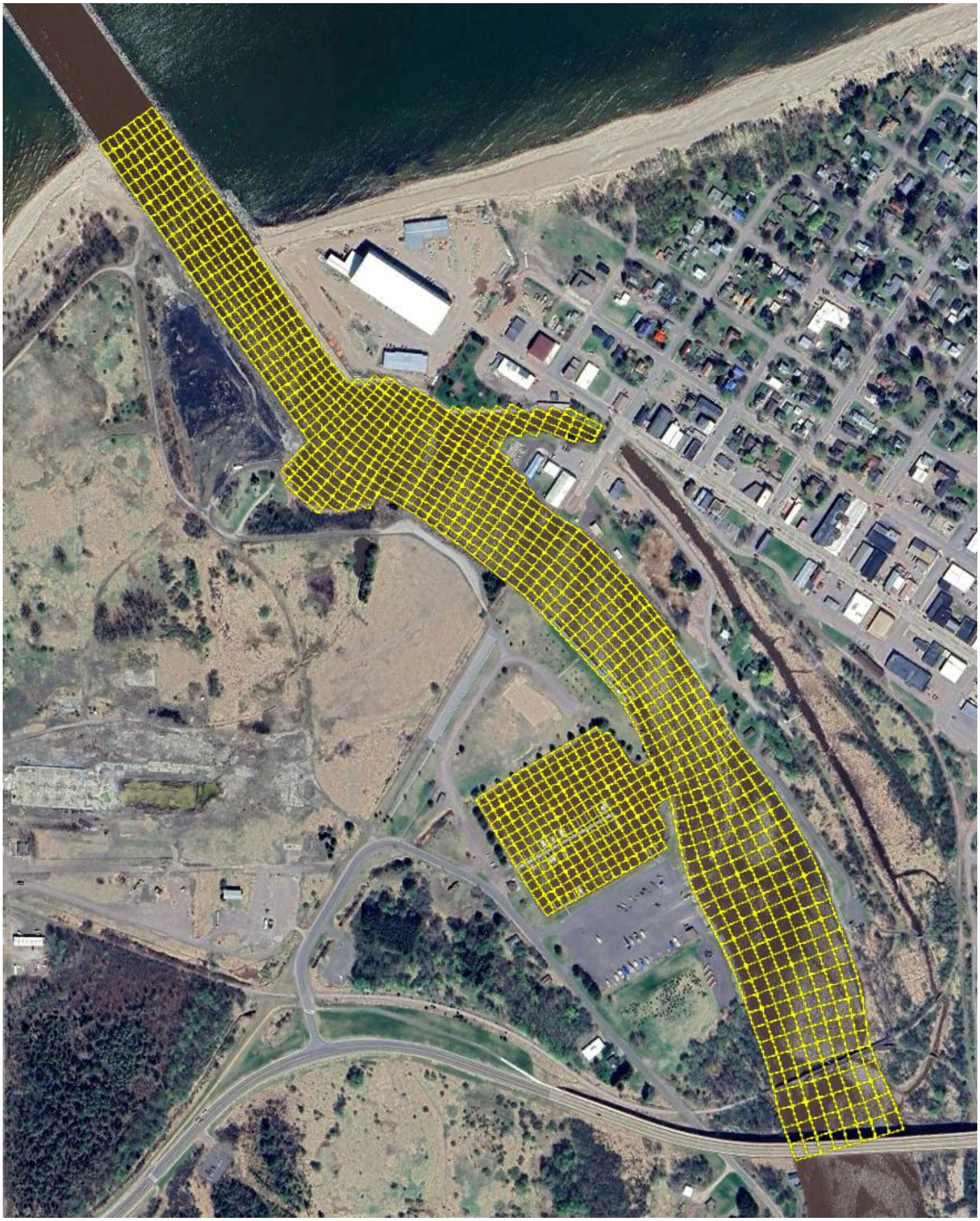


Figure 2 Computational grid for the hydrodynamic and sediment transport model of Ontonagon River and the marina.

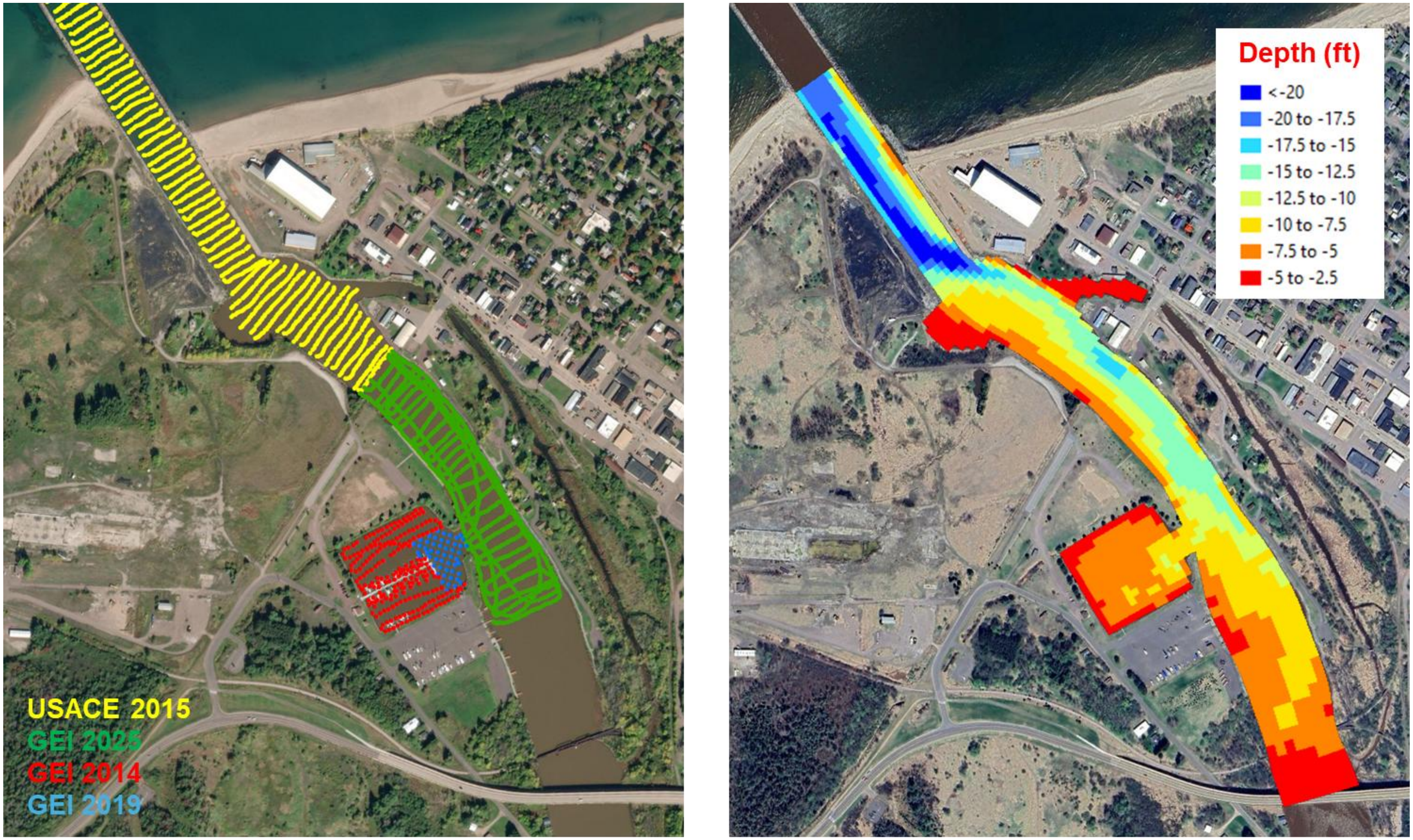


Figure 3 Bathymetry data sources and coverage (left panel) and interpolated model bathymetry (right panel). Depths are relative to the International Great Lakes Datum 1985 (IGLD 85) Low Water Datum elevation of 601.1 ft.

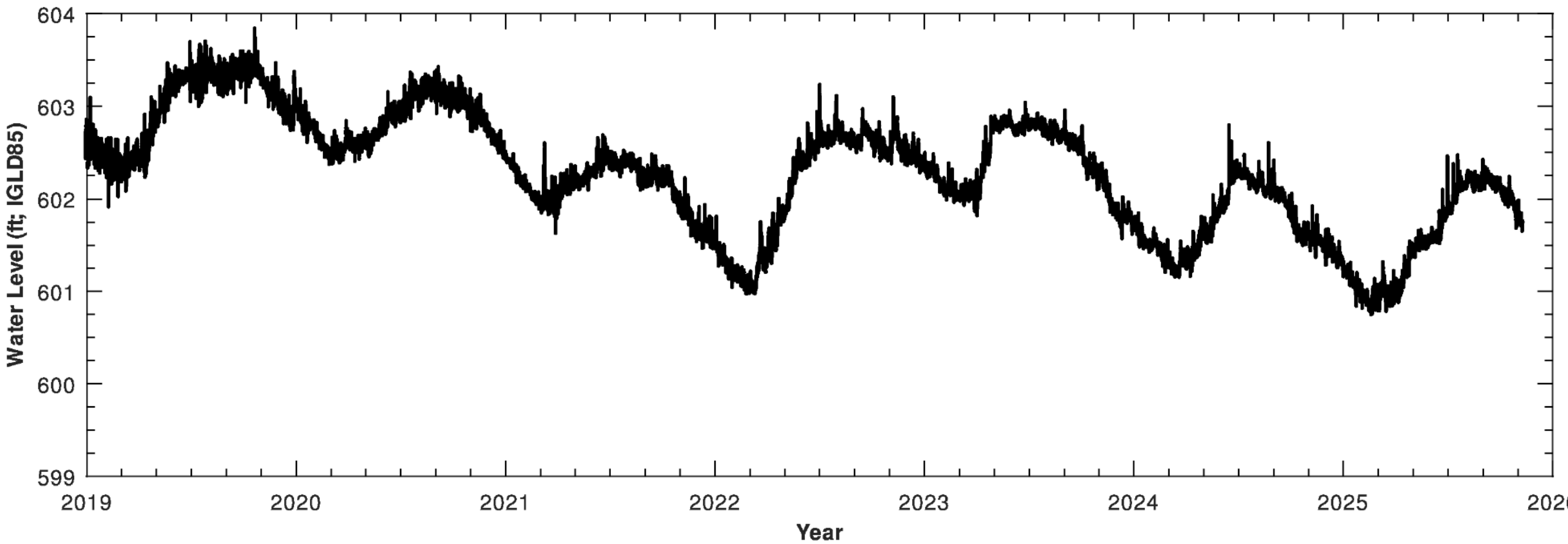


Figure 4 Hourly time-series of measured water level in Lake Superior used for the model's downstream boundary condition. Water levels measured at NOAA Station 9099044 and relative to the IGLD85 datum.

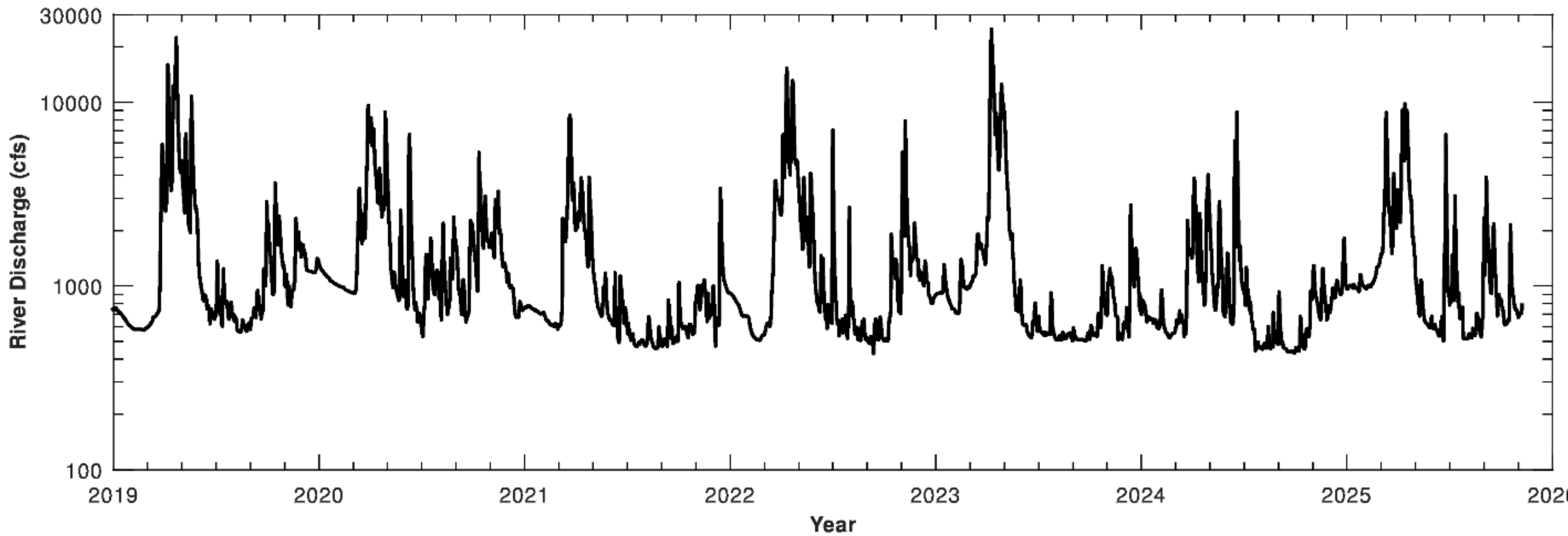


Figure 5 Daily time-series of measured river discharge at USGS Station 04040000 at Rockland, MI used for the model's upstream boundary condition.

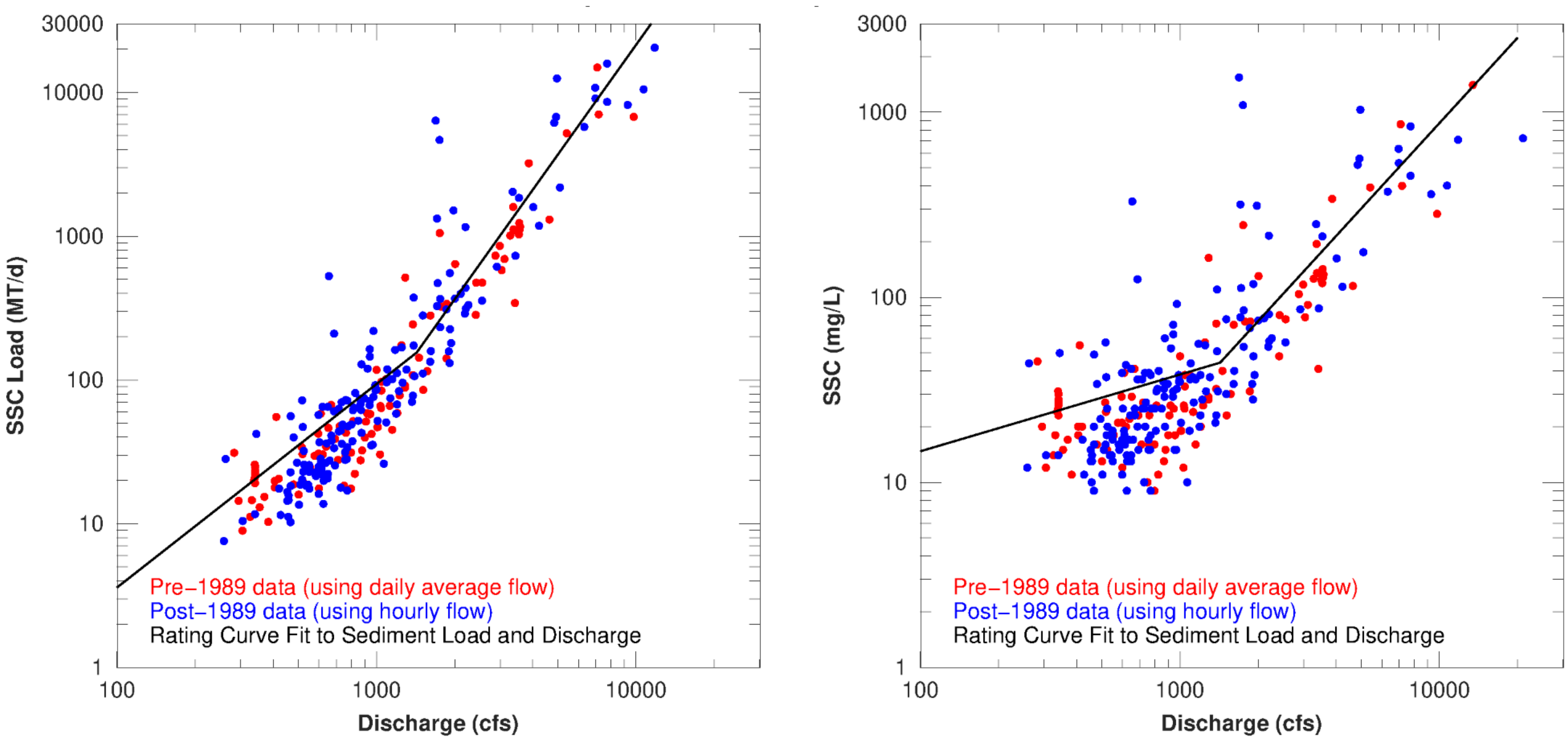


Figure 6 SSC rating curve relationship with river discharge using all available data at USGS Station 04040000 at Rockland, MI

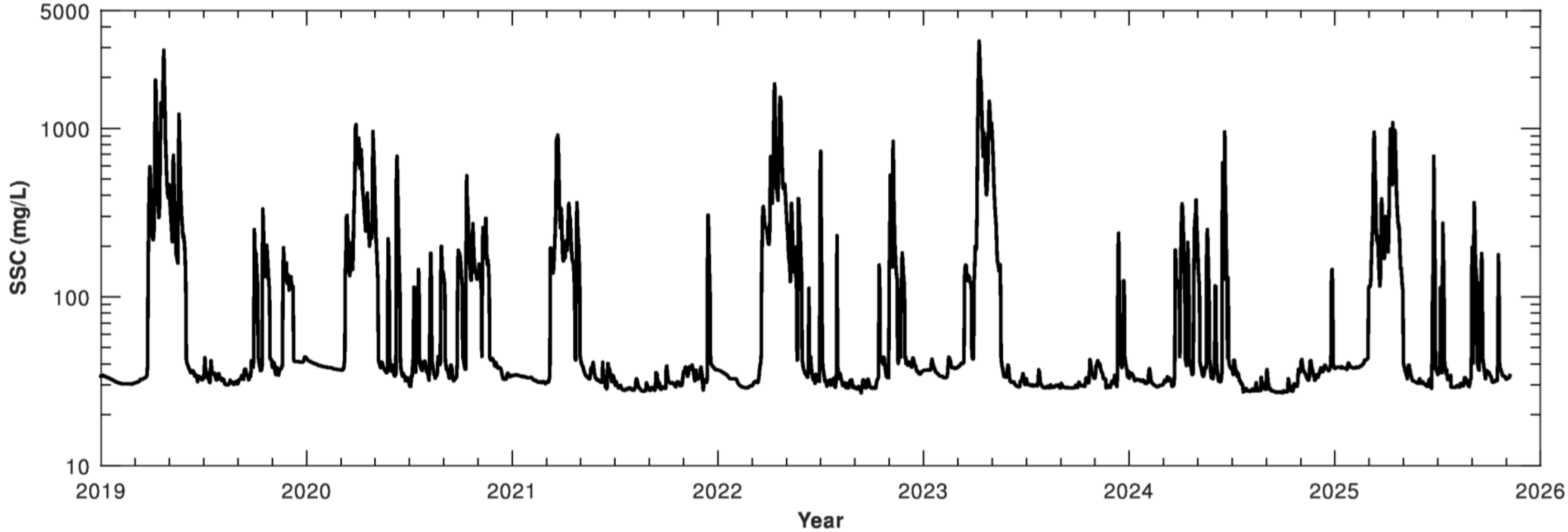


Figure 7 Daily time-series of estimated SSC at USGS Station 04040000 at Rockland, MI used for the model's upstream boundary condition.

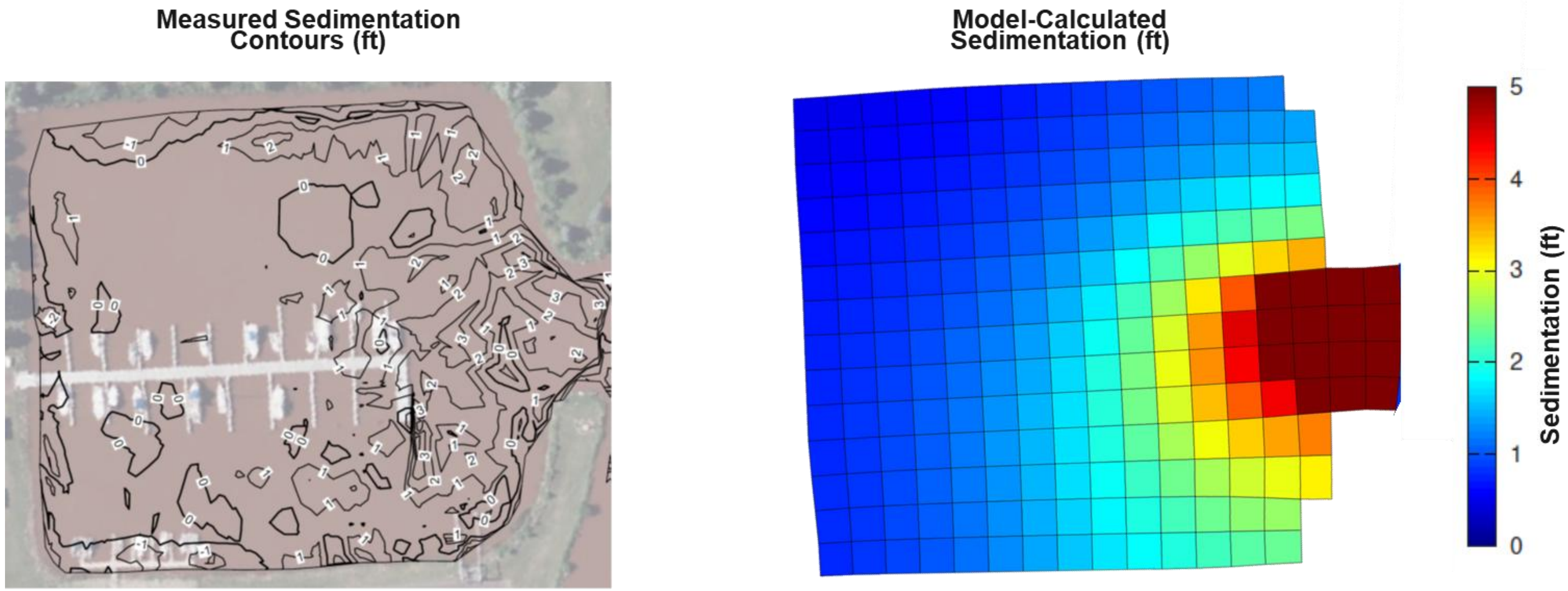


Figure 8 Measured (left panel) and model-calculated (right panel) sedimentation within marina during calibration period.

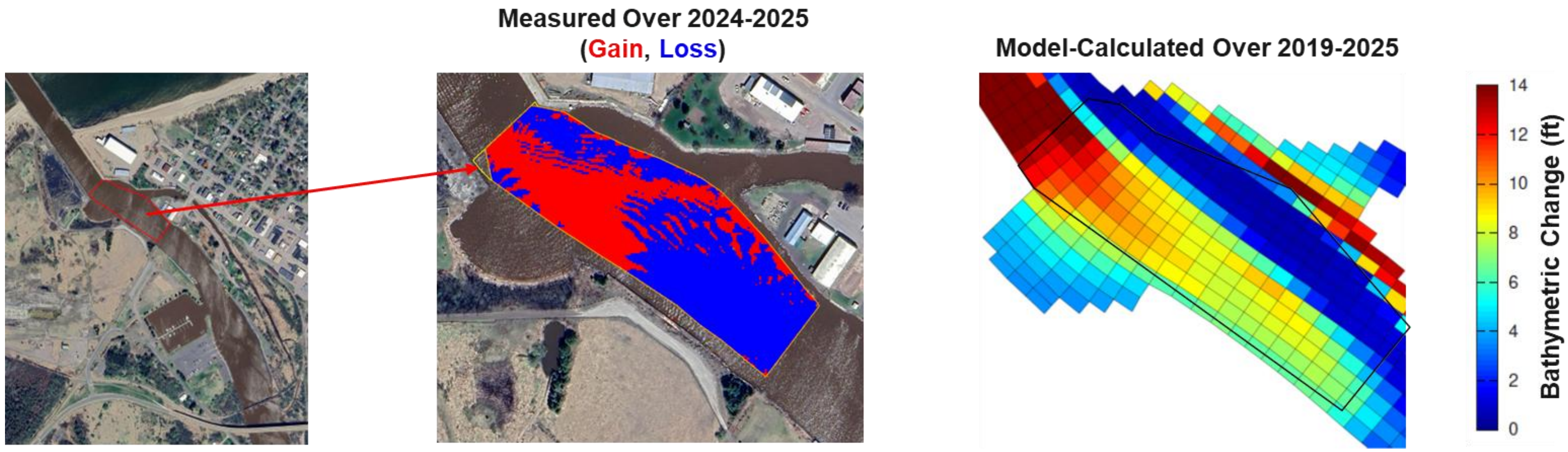


Figure 9 Measured patterns of sedimentation and model-calculated pattern and magnitude of sedimentation in turning basin.

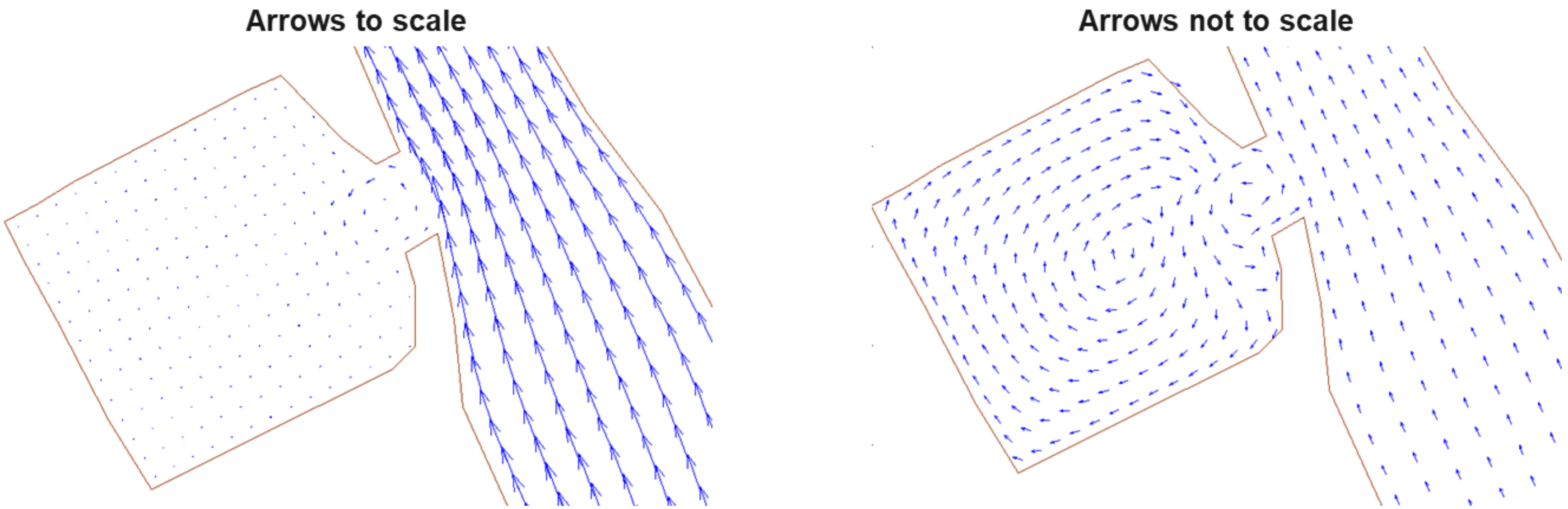


Figure 10 Model-calculated flow velocity vectors during a 23,000 cfs high-flow event in April 2019.

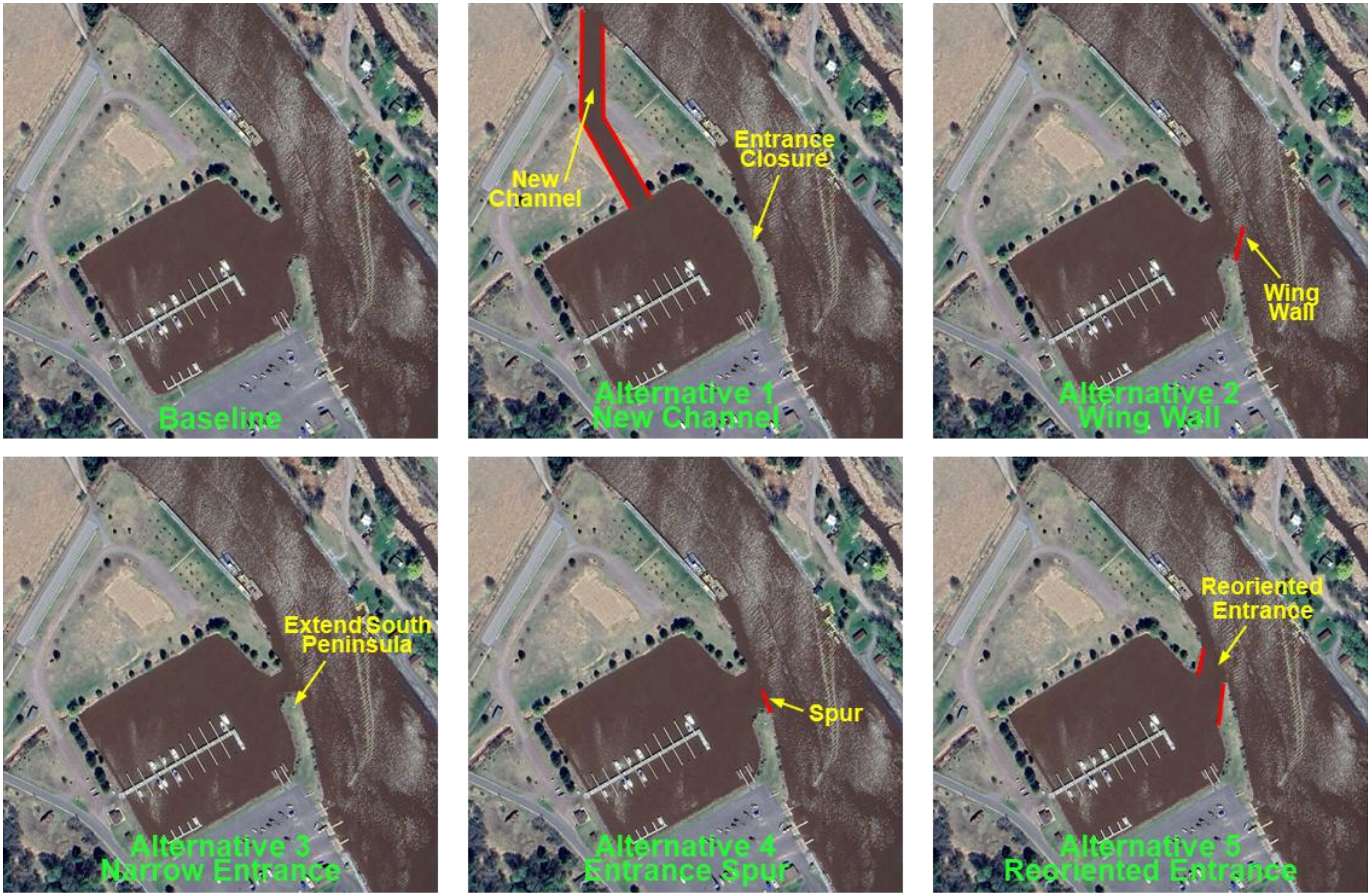


Figure 11 Layout of sedimentation control alternatives assessed using the model.

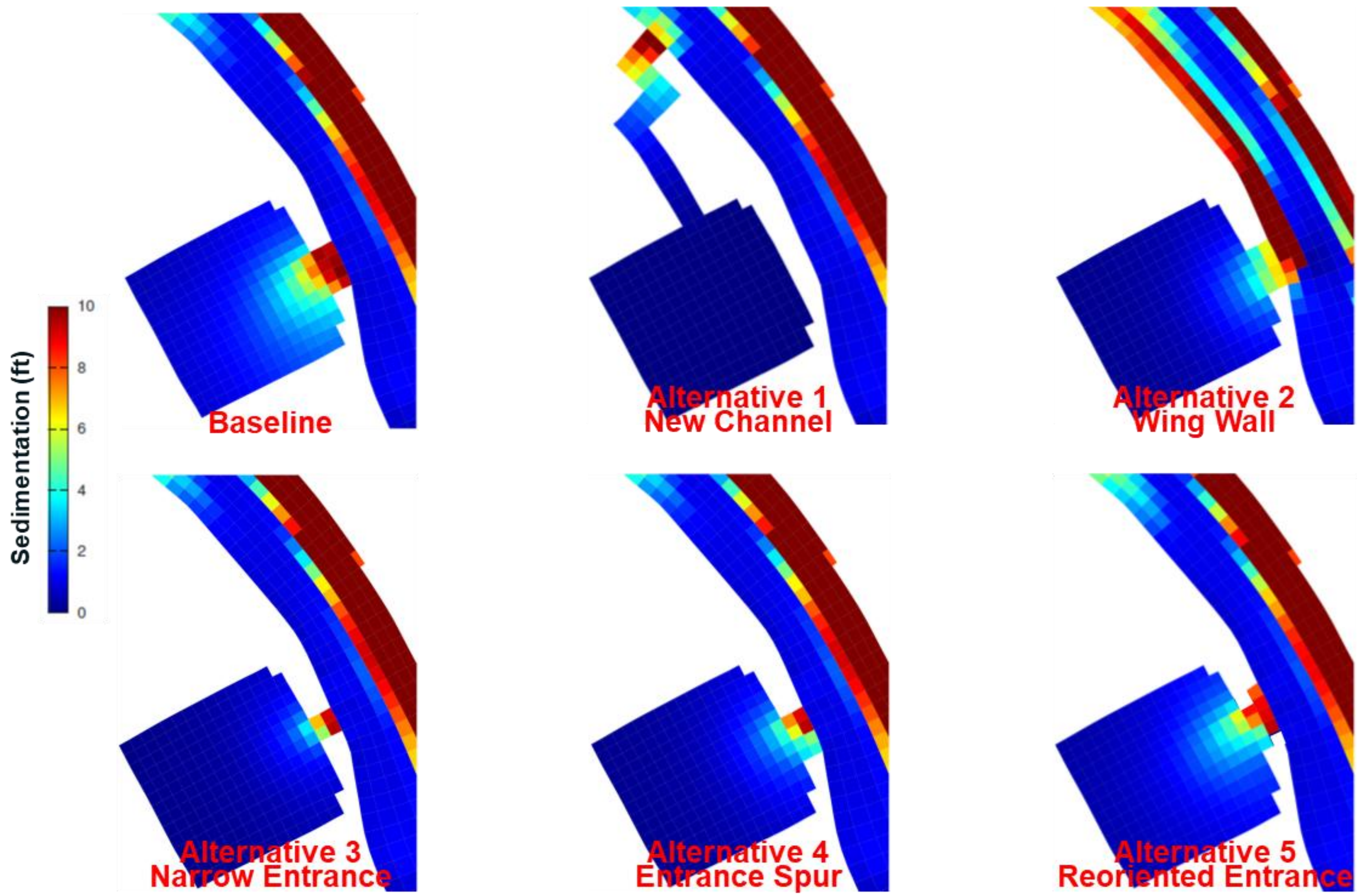
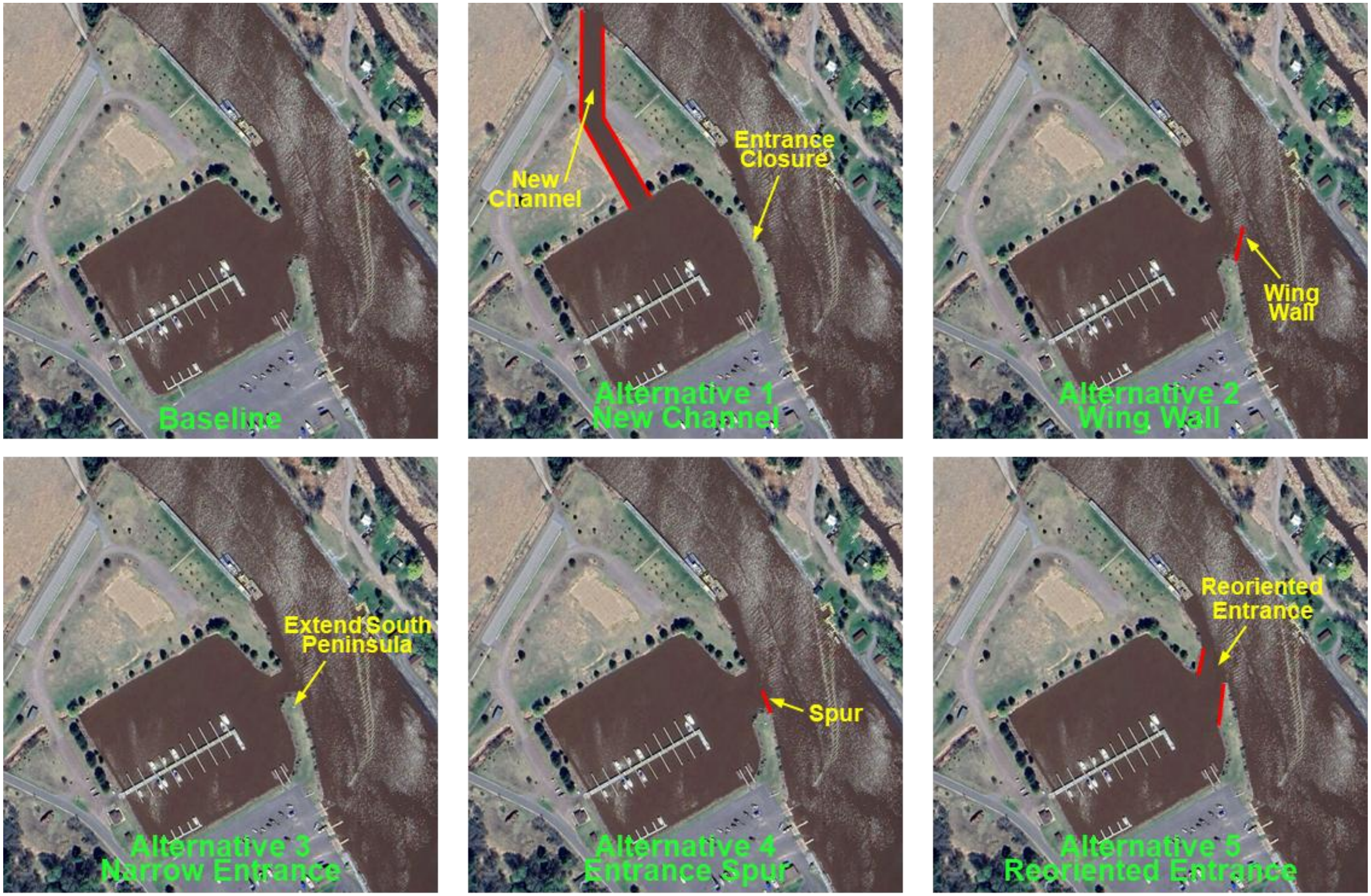
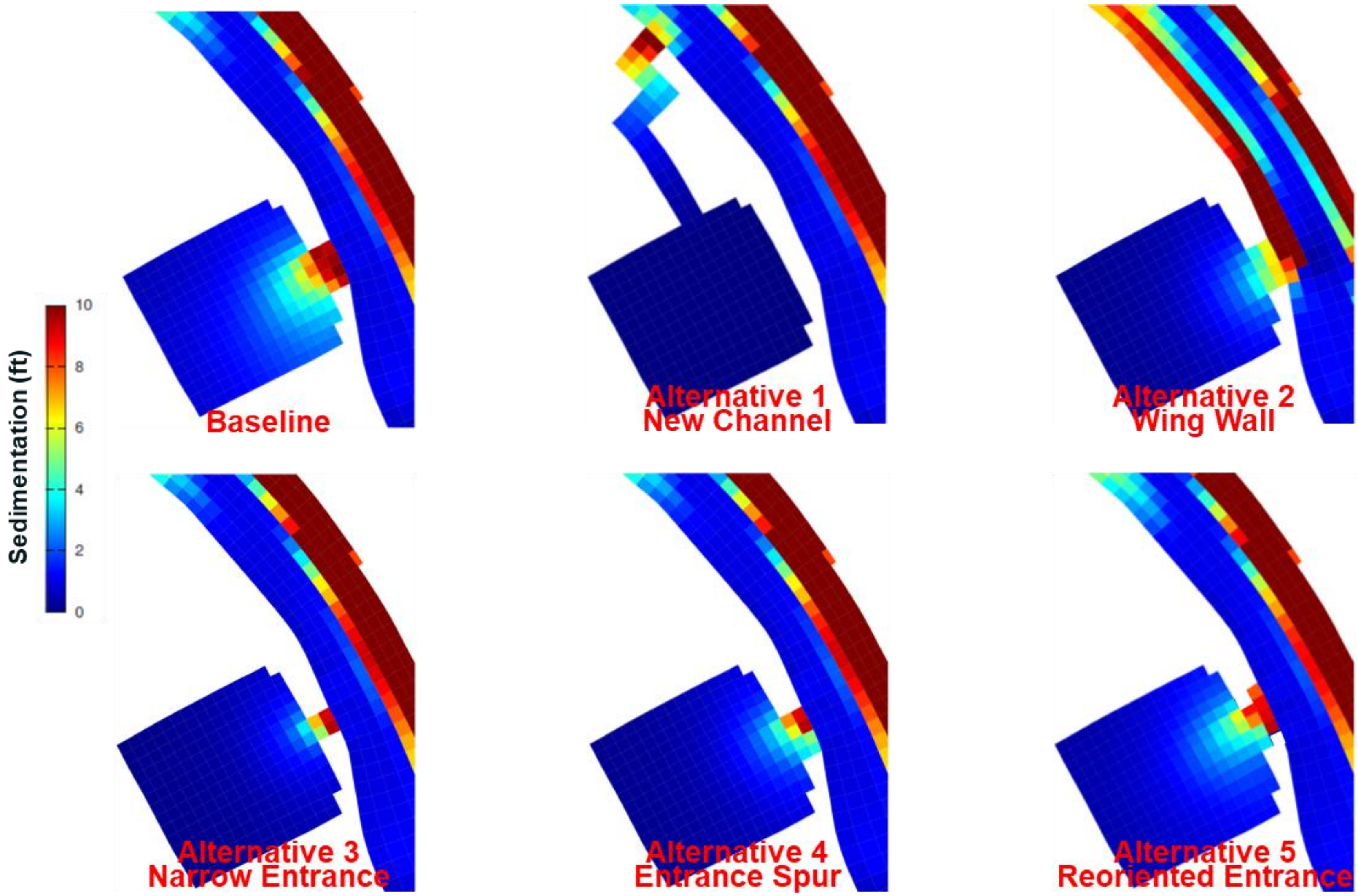


Figure 12 Model-calculated sedimentation for the various alternatives for sedimentation control.

Appendix C Alternative Figures



Marina Mouth Alternatives



Marina Mouth Alternatives – Model Calculated Sedimentation Effectiveness

Appendix D Detailed Cost Estimates

VILLAGE OF ONTONAGON
MARINA FEASIBILITY STUDY
ORDER OF MAGNITUDE ESTIMATE

BASELINE					
Item No.	**Item Description**	**Estimated Quantity**	**Unit**	**Unit Price**	**Extension**
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina and Mouth Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Maring and Mouth Dredging	14,000	CYD	$ 25.00	$ 350,000.00
4	Dewatering/Stockpiling/Loading	28,000	CYD	$ 20.00	$ 560,000.00
5	Trucking	28,000	CYD	$ 25.00	$ 700,000.00
6	Land Application/Disposal	28,000	CYD	$ 15.00	$ 420,000.00
				Construction Total =>	$ 2,630,000.00
				Construction Contingency =>	$ 1,315,000.00
				Construction Project Total =>	$ 3,945,000.00
				Engineering & Design =>	$ 78,900.00
				Permitting & Regulatory =>	$ 157,800.00
				Project Management =>	$ 276,150.00
				Legal & Admin =>	$ 78,900.00
				Engineering & Management Total =>	$ 591,750.00
				Grand Project Total =>	**$ 4,536,750.00**

ALTERNATIVE 1 - NEW CHANNEL					
Item No.	**Item Description**	**Estimated Quantity**	**Unit**	**Unit Price**	**Extension**
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Mouth Dredging	1,400	CYD	$ 25.00	$ 35,000.00
4	Excavation	20,510	CYD	$ 50.00	$ 1,025,500.00
5	Dewatering/Stockpiling/Loading	15,400	CYD	$ 20.00	$ 308,000.00
6	Trucking	15,400	CYD	$ 25.00	$ 385,000.00
7	Land Application/Disposal	15,400	CYD	$ 15.00	$ 231,000.00
8	Sheetpiling	1,390	LFT	$ 10,160.00	$ 14,122,400.00
9	Marina Mouth Fill (Reused from dredging)	2,170	CYD	$ 17.00	$ 36,890.00
10	Rip Rap	650	CYD	$ 83.00	$ 53,950.00
11	Marine Stone Fill Behind Dockwall	3,080	TON	$ 22.00	$ 67,760.00
				Construction Total=>	$ 16,865,500.00
				Construction Contingency =>	$ 8,432,750.00
				Construction Project Total =>	$ 25,298,250.00
				Engineering & Design =>	$ 505,970.00
				Permitting & Regulatory =>	$ 1,011,930.00
				Project Management =>	$ 1,770,880.00
				Legal & Admin =>	$ 505,970.00
				Engineering & Management Total =>	$ 3,794,750.00
				Grand Project Total =>	**$ 29,093,000.00**

VILLAGE OF ONTONAGON
MARINA FEASIBILITY STUDY
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ALTERNATIVE 2 - WING WALL					
Item No.	Item Description	Estimated Quantity	Unit	Unit Price	Extension
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Mouth Dredging	1,400	CYD	$ 25.00	$ 35,000.00
4	Dewatering/Stockpiling/Loading	15,400	CYD	$ 20.00	$ 308,000.00
5	Trucking	15,400	CYD	$ 25.00	$ 385,000.00
6	Land Application/Disposal	15,400	CYD	$ 15.00	$ 231,000.00
7	Sheetpiling	100	LFT	$ 10,160.00	$ 1,016,000.00
8	Marine Stone Fill Behind Dockwall	190	TON	$ 22.00	$ 4,180.00

Construction Total=>	$ 2,579,180.00
Construction Contingency =>	$ 1,289,590.00
Construction Project Total =>	$ 3,868,770.00
Engineering & Design =>	$ 77,380.00
Permitting & Regulatory =>	$ 154,760.00
Project Management =>	$ 270,820.00
Legal & Admin =>	$ 77,380.00
Engineering & Management Total =>	$ 580,340.00
Grand Project Total =>	**$ 4,449,110.00**

ALTERNATIVE 3 - NARROW ENTRANCE					
Item No.	Item Description	Estimated Quantity	Unit	Unit Price	Extension
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Mouth Dredging	1,400	CYD	$ 25.00	$ 35,000.00
4	Dewatering/Stockpiling/Loading	15,400	CYD	$ 20.00	$ 308,000.00
5	Trucking	15,400	CYD	$ 25.00	$ 385,000.00
6	Land Application/Disposal	15,400	CYD	$ 15.00	$ 231,000.00
4	Rip Rap	350	CYD	$ 83.00	$ 29,050.00
5	Marine Stone Fill Behind Dockwall	630	TON	$ 22.00	$ 13,860.00
					$ -

Construction Total=>	$ 1,601,910.00
Construction Contingency =>	$ 800,960.00
Construction Project Total =>	$ 2,402,870.00
Engineering & Design =>	$ 48,060.00
Permitting & Regulatory =>	$ 96,120.00
Project Management =>	$ 168,210.00
Legal & Admin =>	$ 48,060.00
Engineering & Management Total =>	$ 360,450.00
Grand Project Total =>	**$ 2,763,320.00**

VILLAGE OF ONTONAGON
MARINA FEASIBILITY STUDY
ORDER OF MAGNITUDE ESTIMATE

ALTERNATIVE 4 - ENTRANCE SPUR					
Item No.	**Item Description**	**Estimated Quantity**	**Unit**	**Unit Price**	**Extension**
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Mouth Dredging	1,400	CYD	$ 25.00	$ 35,000.00
4	Dewatering/Stockpiling/Loading	15,400	CYD	$ 20.00	$ 308,000.00
5	Trucking	15,400	CYD	$ 25.00	$ 385,000.00
6	Land Application/Disposal	15,400	CYD	$ 15.00	$ 231,000.00
4	Sheetpiling	40	LFT	$ 10,160.00	$ 406,400.00
5	Marine Stone Fill Behind Dockwall	90	TON	$ 22.00	$ 1,980.00
				Construction Total=>	$ 1,967,380.00
				Construction Contingency =>	$ 983,690.00
				Construction Project Total =>	$ 2,951,070.00
				Engineering & Design =>	$ 59,030.00
				Permitting & Regulatory =>	$ 118,050.00
				Project Management =>	$ 206,580.00
				Legal & Admin =>	$ 59,030.00
				Engineering & Management Total =>	$ 442,690.00
				Grand Project Total =>	**$ 3,393,760.00**

ALTERNATIVE 5 - REORIENTED ENTRANCE					
Item No.	**Item Description**	**Estimated Quantity**	**Unit**	**Unit Price**	**Extension**
1	Mobilization	1	LSUM	$ 250,000.00	$ 250,000.00
2	Initial Marina Dredging	14,000	CYD	$ 25.00	$ 350,000.00
3	*Maintenance Mouth Dredging	1,700	CYD	$ 25.00	$ 42,500.00
4	Dewatering/Stockpiling/Loading	15,700	CYD	$ 20.00	$ 314,000.00
5	Trucking	15,700	CYD	$ 25.00	$ 392,500.00
6	Land Application/Disposal	15,700	CYD	$ 15.00	$ 235,500.00
4	Rip Rap	390	CYD	$ 83.00	$ 32,370.00
5	Excavation	300	CYD	$ 50.00	$ 15,000.00
6	Marina Mouth Fill (Reused from dredging)	450	CYD	$ 22.00	$ 9,900.00
				Construction Total=>	$ 1,641,770.00
				Construction Contingency =>	$ 820,890.00
				Construction Project Total =>	$ 2,462,660.00
				Engineering & Design =>	$ 49,260.00
				Permitting & Regulatory =>	$ 98,510.00
				Project Management =>	$ 172,390.00
				Legal & Admin =>	$ 49,260.00
				Engineering & Management Total =>	$ 369,420.00
				Grand Project Total =>	**$ 2,832,080.00**

Appendix E Stakeholder Mapping Memo

Technical Memorandum

990 Lalley Road ● Iron River, MI 49935 ● 906.214.4140

To:	Mr. William DuPont, Village of Ontonagon
From:	John Reck
cc:	Gretchen Trast, John Trast
Date:	June 10, 2026
Re:	Ontonagon Marina Stakeholder Assessment Ontonagon Marina Feasibility Study Ontonagon, Michigan
Project No.	2506426

Summary

The following memorandum summarizes stakeholder engagement activities as part of the Ontonagon Marina Feasibility Study. Engagement included two main parts: interviews were conducted with state agencies in winter 2026 to gather early input from key regulatory stakeholders, while the May 21, 2026 workshop was designed to engage local users. Consultations were conducted with the Michigan Department of Natural Resources, the Michigan Department of Environment, Great Lakes, and Energy, and the U.S. Army Corps of Engineers. A one-hour workshop, held at the Village Offices, was conducted utilizing a mapping exercise to understand current uses of the marina and participants' vision for future uses and benefits, as well as presentation of alternatives.

Outcomes of engagement activities include:

- Project awareness was established among stakeholders regarding the Village of Ontonagon's goal to implement a long-term sediment control solution.
- Open community dialogue provided a deeper understanding of stakeholder values, current uses, and priorities to align technical recommendations with local perspectives.
- Potential permitting challenges for each alternative type were identified to proactively address regulatory considerations early in the feasibility process.
- Opportunities for construction adjustments and funding development were identified to support a more cost-effective approach to viable alternatives.

The following memorandum details the findings from these engagements.

Agency Consultation Findings

The following agencies were consulted as part of the stakeholder engagement process:

- Michigan Department of Natural Resources (MI DNR)
- Michigan Department of Environment, Great Lakes, and Energy (EGLE)
- U.S. Army Corps of Engineers (USACE)

DNR Recommendations

While the DNR does not serve as a regulatory role for the implementation of the alternatives, this consultation was focused on fishery considerations and funding support. The DNR emphasized that EGLE as the lead state permitting agency should be consulted early and often to mitigate any potential concerns around bottomland coverage and fish habitat associated with narrowing the marina entrance.

As for funding considerations, permits are required prior to receiving construction funding from DNR. The DNR confirmed willingness to consider Ontonagon for waterway grant funding despite receiving grant funds previously, with available funding pathways including a planning grant to cover design and permitting, as well as construction funding for implementation. A 50-percent match for the Waterways Grant funding is anticipated; however, there is a possibility to appeal to the DNR to accept a 30-percent match. The reduced match is contingent on state budget and the number of applicants. To be considered for funding, the Village will need to address several outstanding items related to previous waterway grant issues, including long-term staffing strategies, revenue projections, and future expectations for the marina.

EGLE Recommendations

EGLE indicated no significant environmental concerns with prioritized Alternatives 3, 4, and 5 and raised no issues with land dredging, with the primary consideration for any alternative involving entrance narrowing being the maintenance of navigability. Per Part 301 requirements, the selected alternative must represent the least environmentally impactful option among all feasible choices. Both the project and maintenance dredging will require a Joint Permit Application for an Individual Permit. EGLE recommended early engagement with USACE for input on the alternatives and advised contacting DNR Fisheries Biologist to assess the potential environmental impacts of each alternative.

USACE Recommendations

USACE recommended narrowing the marina channel using either rock or sheet piling, noting that while sheet piling represents a higher upfront cost, it would allow for land dredging in the future and offer greater long-term flexibility. From a permitting standpoint, standard EGLE permitting and a potential 408 review are anticipated, with any applicable USACE permits incorporated into the EGLE permit package to streamline the regulatory process. The Village may also have an opportunity to coordinate marina dredging with an ongoing river dredging contract, potentially reducing costs if a mechanical dredging company is hired.

Workshop Findings

The Village identified several key stakeholders for targeted outreach, including a local campground, a nearby gas station, an adjacent landowner, a local development entity, a representative of the UP Sport Fishing Club and Lake Trout Classic, Bad River Band of Lake Superior Chippewa, and the Lac Vieux Desert Band of Lake Superior Chippewa. Out of these targets, four were in attendance including the adjacent landowner, Lake Trout Classic organizer, Harbormaster, and Village Manager. Three additional community members arrived early at the marina commission meeting held immediately following the workshop and provided impromptu feedback to the project team prior to the start of that meeting. While not formally part of the planned workshop, their input contributed additional perspective to the overall engagement effort.

Current Use Identification

Stakeholders were presented with a range of marina use descriptions spanning recreation, boating, and community activity. Uses included water-based activities such as fishing, kayaking, swimming, anchoring and driving boats, as well as land-based activities such as walking, picnicking, sports, and children's play. Community-oriented uses such as gathering with friends, interacting with educational signage, birdwatching, and nature viewing were also presented to capture the full spectrum of how the marina space is experienced and valued by the community.

Fishing

Fishing was the predominant activity discussed and four distinct locations were identified within and adjacent to the marina that fisherman typically access. Species targeted in the river include walleye and pike, while marina fishing yields pike, crappie, and walleye. Annual fishing tournaments take place in early summer, which also includes a children's competition. A fish cleaning station is available on site and not in need of upgrades. Access to fishing from land or via boat was identified as adequate.

Boat Parking and Safe Harbor

Boat parking was documented across four land-based locations, primarily to understand where vessels are staged during peak fishing seasons. Current parking capacity appears sufficient, and an informal management system is in place to handle high-volume periods. Vessels up to 40 feet in length do not attempt to access the marina and typically anchor near the mouth of the marina, while those averaging 60 feet anchor near the lighthouse. Tie-up access along the seawall by the lighthouse is limited to one specific location due to bolts and other features along the wall that could cause vessel damage. The largest vessel recorded seeking safe harbor in the river measured 700 feet, though arrivals of that size are irregular.

Access to the marina is currently limited to boats with heels less than 5.5 feet and any heels bigger than that stay in the river, which is an estimated 20 boats annually. The widest boats that enter the marina are 18 feet wide. Typically, there are no traffic jams and the marina is used by recreational boats only. Therefore, stakeholders suggested there would be no access issues presented by narrowing or adjusting the angle of the marina entrance.

Kayaking

Kayaking activity takes place on the opposite side of the river from the marina, where users launch from a protected slough. No upgrades to marina-side kayak access are considered necessary at this time, as users have established a functional alternative on the slough side.

Nature Viewing

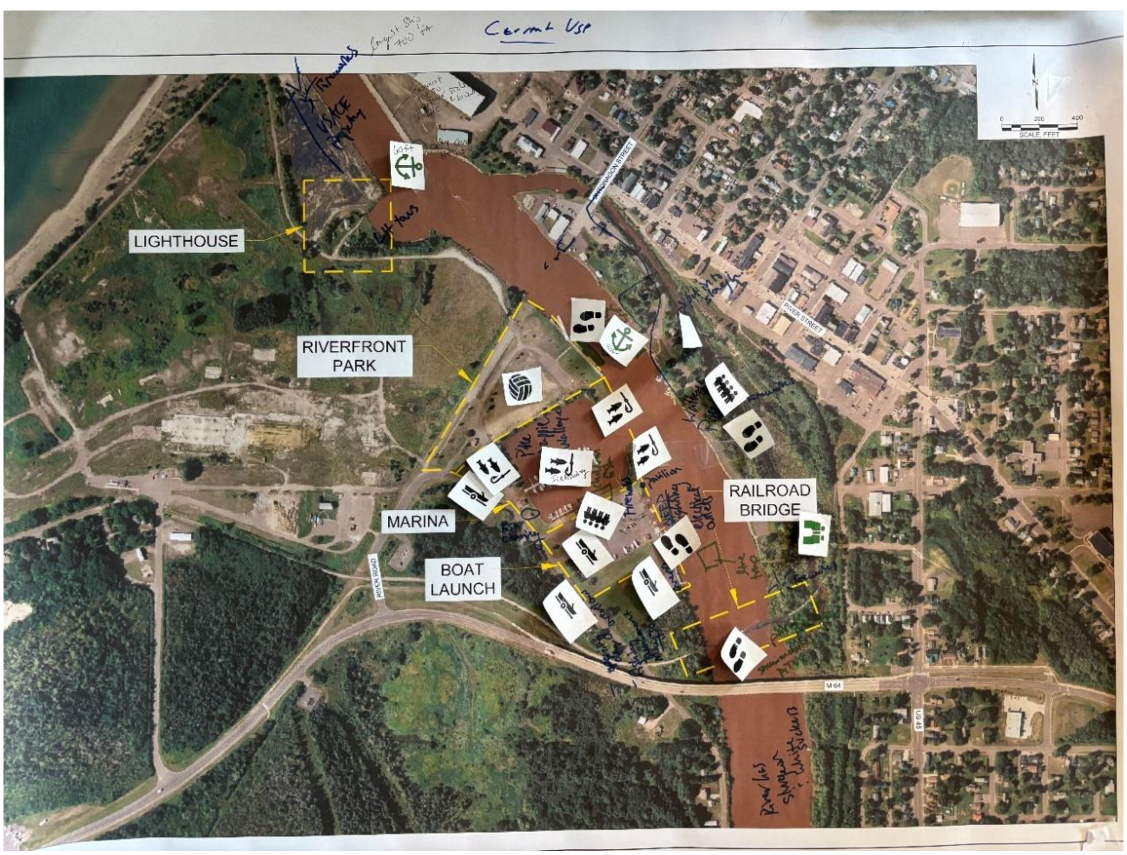
Bird watching occurs across the river near the old railroad bridge, taking advantage of the natural setting in that area.

Community Gathering and Events

A volleyball court adjacent to the marina provides a space for gathering and informal recreation. Fourth of July fireworks are launched from both the marina parking lot and the area near the slough, allowing for flexible event management. Current event operations are well-managed and do not have operational concerns.

Figure 1. Current User Activity Map

This map illustrates the range of activities currently taking place in and around the marina area, based on input from workshop participants.



Future Use Identification

The same options for activities were presented for future uses. Workshop participants identified several future uses for the marina that would expand its programming and community value, including a children's playground, a sports field for soccer, snowshoeing, and camping.

A recurring theme throughout the discussion was the need for additional revenue generation to support marina operations. Primitive campsites were identified as a viable opportunity to encourage extended stays and provide a supplemental revenue source through campsite fees, noting that restroom facilities already exist at the site and primitive sites would not require additional electrical hookups. Participants noted some indication of potential restrictions and further assessment of feasibility will be required.

Minor electrical improvements at the marina were identified as beneficial, with further discussion on voltage capacity and related infrastructure needs recommended as a follow-up item.

Key Themes

Current sediment accumulation represents the primary challenge facing the marina, limiting access and constraining the effectiveness of existing infrastructure. With successful long-term sediment management, current infrastructure appears adequate to meet existing demand. However, should demand increase beyond current levels, the present infrastructure may prove insufficient to support expanded use.

Connectivity Between Downtown and the Marina

Participants identified the lack of accessible infrastructure connecting downtown to the marina as a significant barrier to community use. Resolving this connectivity challenge was viewed as a meaningful opportunity to increase community engagement with the marina. Some participants expressed a perception that marina use may have declined in recent years; however, this was not confirmed by the Harbormaster or the Village Manager, suggesting that any decrease in use, if it occurred, is not a significant concern at this time.

Pedestrian access across the river currently relies on the old railroad bridge, which also sees informal use by snowmobiles and ATVs. This crossing is not a designated pathway and presents safety considerations. It nonetheless functions as the primary means of river crossing in this area, as the Ontonagon Street Bridge, located further downstream, has been removed.

Year-Round Use Opportunities

While the marina is primarily associated with spring, summer, and fall activity, participants identified meaningful potential for expanding its role as a year-round destination. Current winter activities are primarily ice fishing and snowshoeing. Suggested winter activities included expanding snowshoeing and snowmobile trails. Expanding seasonal programming was viewed as an opportunity to revitalize community interest in the marina and increase overall visitation throughout the year.

Considerations for Next Steps

A long-term vision for revitalizing the marina, engaging downtown, and broadening access will require a more thorough understanding of future user demand before meaningful conclusions can be drawn. A comprehensive demand assessment would benefit from examining the following items:

A demand assessment for the Ontonagon Marina may include:

- Regional benchmarking: Review of comparable destinations, such as the Apostle Islands and Houghton, where boater demand is concentrated due to limited access elsewhere.
- Vessel draft profiling: Identification of vessels with heels exceeding 5.5 feet currently bypassing Ontonagon due to depth and access constraints.
- Unmet demand analysis: Evaluation of boaters who would consider Ontonagon if infrastructure limitations were addressed.
- Regional demand patterns: Review of broader Great Lakes boating trends to assess whether infrastructure improvements could redirect traffic to Ontonagon.
- Long-term growth scenarios: Assessment of potential demand increases and corresponding infrastructure capacity needs.
- Waterfront and downtown connectivity: Consideration of how increased marina use could support waterfront revitalization and strengthen ties to downtown Ontonagon.

Standard Limitations and Disclaimer

This report was prepared exclusively for the use of the VILLAGE OF ONTONAGON. The findings and conclusions, if any provided by GEI in this report, are based solely on the information reported to GEI as of the date of this report. Future investigations or additional information not provided to GEI at the time of this report may result in modification of this report. GEI's scope of work did not include verifying the completeness or accuracy of information provided by others. Accordingly, GEI shall not be liable for any damages, costs, or other consequences resulting from reliance on such information if it is later determined to be inaccurate or incomplete. GEI's professional services for this project have been performed in a manner consistent with that degree of skill and care ordinarily exercised by members of the same profession currently practicing in the same locality, performing similar services under similar conditions. GEI makes no other representations and no warranties, express or implied.

If you have any questions, please feel free to contact me at 906.214.4156 or jreck@geiconsultants.com.

Sincerely,

GEI CONSULTANTS OF MICHIGAN, P.C.

John Reck
Project Manager

Gretchen Trast
Grant Program Manager

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Appendix F Funding Source Summary

Grant Program	Funding Agency	Issue Addressed/Objective	Eligible Projects	Eligible Applicant	Max Funding	Local Cost Share Requirements	Important Dates	Last Updated Guidelines
National Coastal Resilience Fund	National Fish and Wildlife Foundation (NFWF) & NOAA	Enhance coastal resilience to storms, flooding, and sea level rise while restoring natural ecosystems and habitats	Nature-based solutions (wetland, dune, reef restoration); floodplain reconnection; resilience planning/design tied to implementation; community capacity building	States, local governments, tribal governments, nonprofits, institutions of higher education	Typically, $100,000 – $10M+ (most awards $1M–$5M)	Match encouraged, not required	Pre-proposal usually due February; full proposal due June	Most recent RFP released January 2026 for FY26 cycle
Coastal Management Grant	Michigan EGLE	Provide substantial technical assistance and strategic grant funding to assist in coastal communities' ability to understand risks, and options to mitigate coastal hazards; create healthy habitats that provide for human use and enjoyment; support coastal eco-tourism opportunities while ensuring for safe public access; and support resilient and sustainable coastal economies."	Planning projects; feasibility, engineering and design projects; low-cost construction projects; Land conservation through acquisition projects	Eligible applicant includes local units of governments, cities, counties, villages, and townships; regional planning agencies; educational institutions, state government agencies; Tribal governments, and not-for-profit organizations	$334,268 for the FY2025 allocation	50% in either cash, federal, or local funding	Request for Proposals (RFPs) are generally due October 1 with an application due date of mid-December	Updated as needed, limited changes year to year
Rebuilding American Infrastructure with Sustainability and Equity (RAISE)	U.S. Department of Transportation (USDOT)	Improve surface transportation infrastructure with focus on safety, sustainability, equity, and economic competitiveness	Roads, bridges, transit, rail, ports, intermodal, complete streets, resilience improvements	State and local governments, tribal governments, MPOs, port authorities, special purpose districts	Urban: up to $25M; Rural: up to $25M (historically minimum $5M urban / $1M rural)	Generally, 20% (can be lower for rural or disadvantaged communities)	NOFO typically released early year (Jan–March); applications due spring (April–May)	Updated annually (e.g., FY2025 NOFO released early 2025)
Waterways Program Grants	Michigan EGLE	Maintain and improve public recreational boating access and state waterways infrastructure	Harbor/dredging projects; dock/pier repair or replacement; boating access site improvements; marina infrastructure	Local governments and public entities that own/manage public boating facilities	Varies; often up to ~$1M+ depending on project type	Typically, 50% local match (may vary by project category)	Applications due April 1	Updated annually by EGLE Waterways Program
Better Utilizing Investments to Leverage Development (BUILD) Grant Program	U.S. Department of Transportation (USDOT)	The goal of the program is to fund projects that will have a significant local or regional impact and improve transportation infrastructure.	Planning/construction for transit and maintenance operations, roadway and bridge reconstruction, multimodal enhancements such as bike lanes and pedestrian facilities, rail line repairs and upgrades, trail development, flood resiliency measures, modernization of port and intermodal facilities, safety and accessibility improvements	State and local governments, tribal governments, MPOs, port authorities Non-profits are ineligible applicants.	• $1 million for rural capital projects • $5 million for urban capital projects • Planning projects do not have a minimum award size	Generally, 20% (can be lower for impoverished or disadvantaged communities)	Typically, January/ February annually	Most recent RFP released December 2025 for FY26 cycle
Building Resilient Infrastructure and Communities "BRIC" and Hazard Mitigation Grant Program (HMGP)	FEMA	Growing hazards associated with climate change, natural disasters	Projects designed to increase resilience and public safety; reduce injuries and loss of life; and reduce damage and destruction to property, critical services, facilities, and infrastructure (including natural systems) from a multitude of natural hazards and the effects of climate change.	Applicant must be State. Subrecipient can be local governments, including cities, townships, counties, special district governments, state agencies and federally recognized tribal governments. Subrecipient must have FEMA approved local Hazard Mitigation Plan.	$2,000,000 annually distributed in amounts from $1M -$50M/ project	25%	Full application due 7/24/2026	NOFO for FY24-25 released on March 25, 2026. Deadline to apply is July 23, 2026