Flood Bay State Wayside Example Vulnerability Assessment GIS Instructions

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Flood Bay State Wayside, Minnesota

Presented to

Minnesota Department of Natural Resources
Division of Ecological and Water Resources
Minnesota's Lake Superior Coastal Program

and

Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office for Coastal Management

Presented by

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1.0   INTRODUCTION

The MN DNR, Minnesota Department of Transportation (MN DOT), and several coastal counties, cities, and towns manage public access sites along the coast of Lake Superior. Many of these public access sites contain natural resources (e.g., fish and wildlife species and their habitats, vegetation) and built resources (e.g., campgrounds, docks, boardwalks, historic buildings, and piers) that are potentially vulnerable to lake level change or other natural hazards. In order to evaluate the vulnerability of these public access sites to natural hazards along the coast of Lake Superior, the MN DNR and NOAA Office for Coastal Management (OCM) have developed a vulnerability assessment protocol (MN DNR and NOAA OCM 2022).

The purpose of developing the vulnerability assessment protocol (MN DNR and NOAA OCM 2022) was to standardize the methodologies and data utilized by site managers in assessing the vulnerability of these public access sites to lake-level change or other natural hazards along the coast of Lake Superior. As described in the vulnerability assessment protocol (MN DNR and NOAA OCM 2022), the protocol workflow and methods include five main steps (Figure 1) as outlined below and further described in the vulnerability assessment protocol instructions:

1.   Exposure Analysis
2.   Sensitivity Analysis
3.   Potential Impact Analysis
4.   Adaptive Capacity Analysis (optional analysis based on site and asset[s])
5.   Vulnerability Analysis
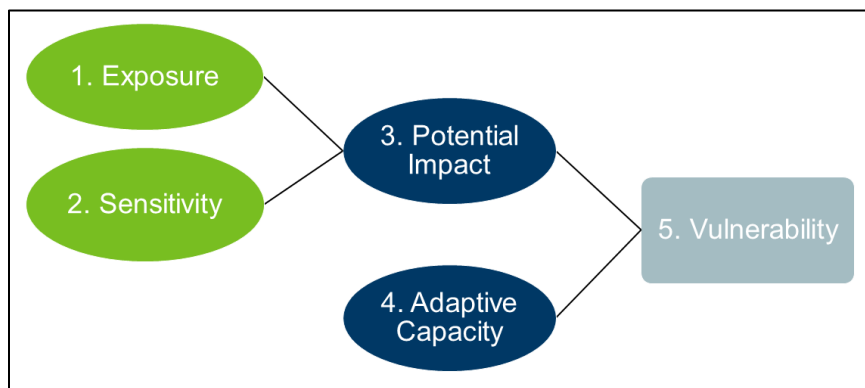
Figure 1.   Vulnerability Analysis Process Adapted from Glick et al. (2011) and NPS (2016)

The process has been standardized, but how to use the process is up to the user. The protocol instructions and spreadsheet that have been provided are meant to be utilized in tandem by site managers to characterize the vulnerability of assets at their site. The process utilizes the best available data which includes all types from intensive GIS data to qualitative information from site managers, and everything in between. **This document describes and provides examples of how to complete the spreadsheet utilizing GIS data or data that is available online utilizing the Flood Bay State Wayside site**. For questions, contact the Coastal Program at mlscp.dnr@state.mn.us.

1.1   Site Background

Flood Bay State Wayside (FBSW) is located on state highway 61 immediately northeast of the city of Two Harbors, Minnesota in Lake County along the north shore of Lake Superior. The site was established in 1963 and features a long stretch of beach and a wetland complex with a small parking lot (Figure 2).

Figure 2.   Flood Bay State Wayside Location Map

The first step in the process is to identify site assets of interest to the site manager. For the FBSW assessment four site assets were identified (Figure 2) including the parking lot, the north beach, the south beach, and the wetlands complex (Table 1).

Table 1. **Flood Bay State Wayside Site Assets**

Asset	ID	Acres
Parking Lot	FB1	0.64
North Beach	FB2	1.1
South Beach	FB3	2.2
Wetlands	FB4	9.0

This document is meant to outline how to complete the process using ArcGIS desktop or similar software. However, users can complete the assessments and input data into the spreadsheet utilizing other available software or tools like Google Earth, QGIS, or similar platforms. Most of the data utilized in the assessment is available online in interactive maps that can be used without the need for GIS software. Furthermore, quantitative data isn't necessary to complete the vulnerability assessment for site managers. Site managers can utilize existing knowledge of the site in the spreadsheet to arrive at the vulnerability assessment that best reflects conditions at the site.

1.2 Asset Polygon or Line

Once the assets have been identified, the user should use GIS to create a polygon or line that outlines the asset as shown in Figure 2 above. Use the *Create Feature Class* (Figure 3) tool and name the feature "Assets_poly" or "Assets_line" depending on the type of assets being identified.
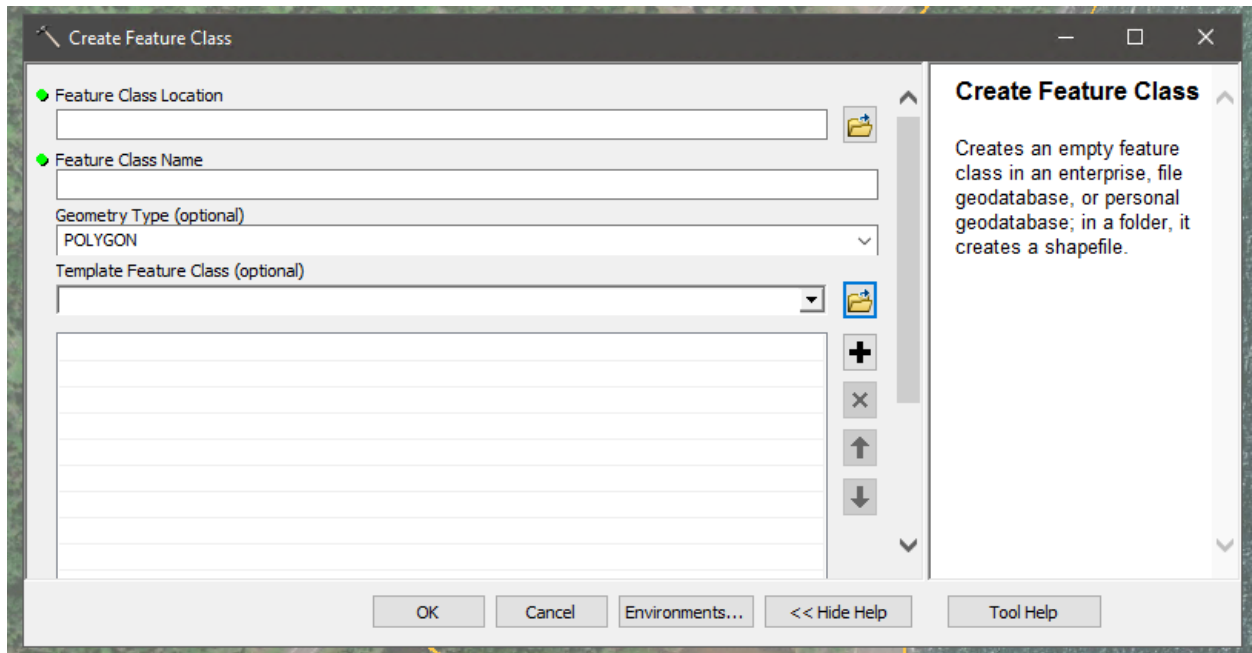
Figure 3. **Create Feature Class Tool**

Once the assets have been delineated, add fields in the attribute table called "ID_1" and another field called "Asset" (Right click on the Assets_poly or Assets_line feature, choose Open Attribute Table, open Table Options, select Add Field) (Figure 4). The ID_1 column and Asset column should match the ID and Asset identifiers that will be used in the vulnerability assessment spreadsheet.
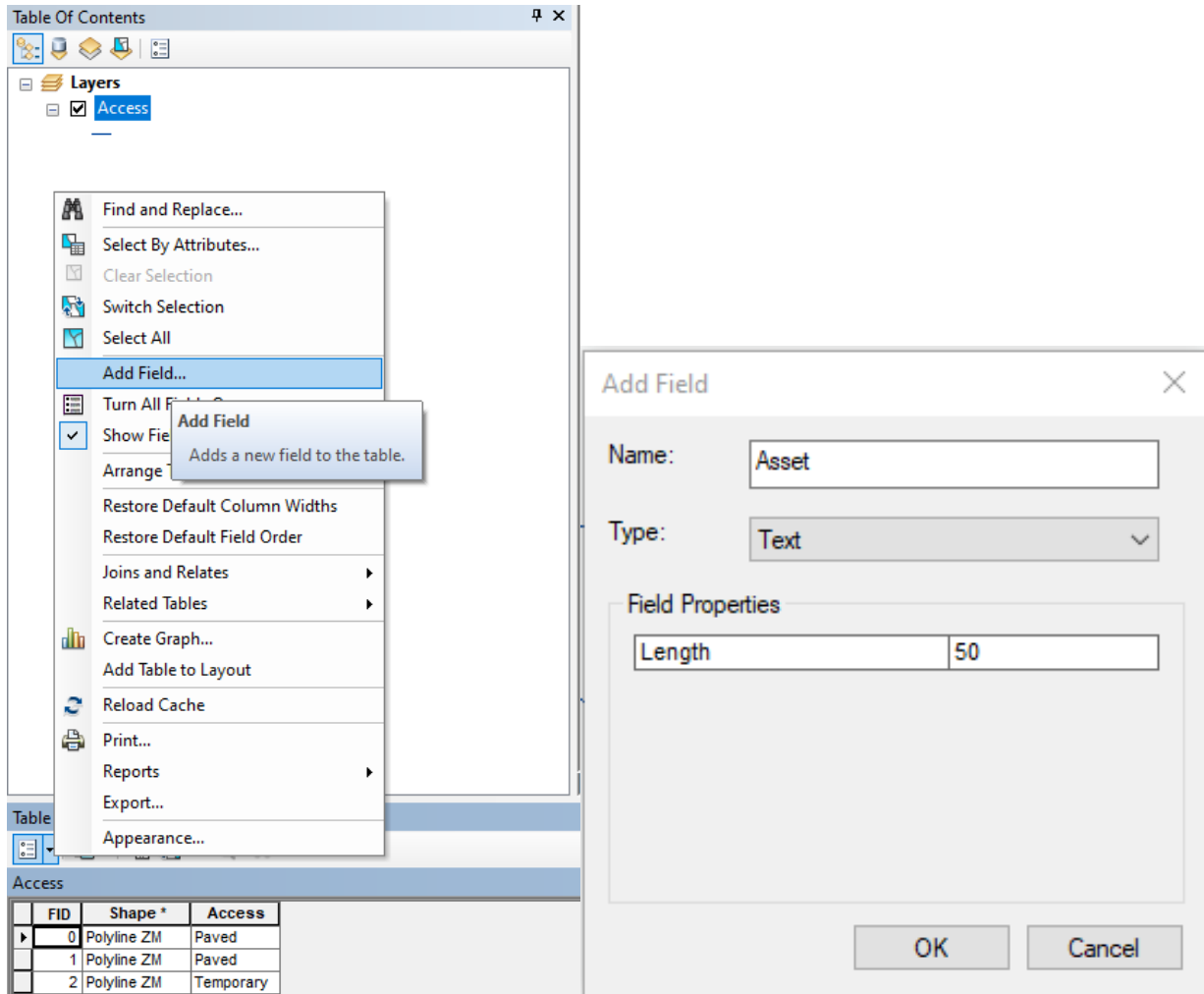
Figure 4.   Screenshot of Adding Field to Attribute Table

2.0   EXPSOURE ANALYSIS

The exposure analysis for the vulnerability assessment characterizes exposure indicators for each of the assets including flooding, storm surge/seiche, lake level rise, historical flooding, erosion, geology, soils, and fish and wildlife habitat. In the spreadsheet, navigate to **Step 1. Exposure DATA** and input the asset ID, asset name, and site in columns A, B, and C respectively (Figure 5). The following subsections describe how to characterize the assets for the exposure analysis indicators in the **Step 1. Exposure DATA** tab.

	A	B	C
1	Step 1. Exposure DATA		
2	ID	Asset	Site
3	FB1	Parking Lot	Flood Bay Wayside
4	FB2	North Beach	Flood Bay Wayside
5	FB3	South Beach	Flood Bay Wayside
6	FB4	Wetlands	Flood Bay Wayside
7	END OF WORKSHEET		

Figure 5.   Asset ID, Name, and Site

2.1   Exposure Analysis Data Online Resources

Below is a list of online resources that are utilized in the exposure analysis and further described in the following subsections. A full list of all available online resources is provided in Section 6.0. Online Resources.

FEMA Flood Map Service Center

https://msc.fema.gov/portal/home

NOAA CO-OP Water Levels

Duluth: https://tidesandcurrents.noaa.gov/stationhome.html?id=9099064

Grand Marais: https://tidesandcurrents.noaa.gov/stationhome.html?id=9099090

Fetch Exposure Index

https://www.glahf.org/data/

USGS StreamStats

https://streamstats.usgs.gov/ss/

Minnesota Natural Resource Atlas

https://mnatlas.org/gis-tool

North Shore Erosion Mapping Tool

https://www.arcgis.com/apps/webappviewer/index.html?id=46cbf323365e488bbc8356563ab53c2a&extent=-10000530.8881%2C6084038.8579%2C-9982186.0013%2C6092915.1078%2C102100

Minnesota Geological Survey

Bedrock geology map: https://conservancy.umn.edu/handle/11299/101466

Surficial geology map:
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=1813f21e8b7f4087bf5f44ef82ab2012&extent=-11302346.3674%2C5364081.8694%2C-9290523.783%2C6321684.9598%2C102100

NRCS Soils Web Mapper

https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

2.2   Flooding Exposure Indicator

The flooding indicator analysis characterizes Federal Emergency Management Agency (FEMA) flood zones, elevation data of the assets, and compares the elevation data to the 500-year flood elevation for Lake Superior.

FEMA flood zone data can be obtained via the FEMA Flood Map Service Center online at: https://msc.fema.gov/portal/home. The FBSW site does not have mapped FEMA flood zone information so the user would select "N/A" for each of the assets in Column D.

Elevation data for the assets can be obtained by hovering over the asset locations in Google Earth. The elevation can also be extracted from LiDAR data in GIS. Use the *Zonal Statistics as Table* tool. Input the Assets_poly or Assets_line as the Feature Zone Data, select Asset as the Zone Field, select the LiDAR data as the Input Value Raster, name the output table as desired, and ensure that ALL statistics type is selected (Figure 6).
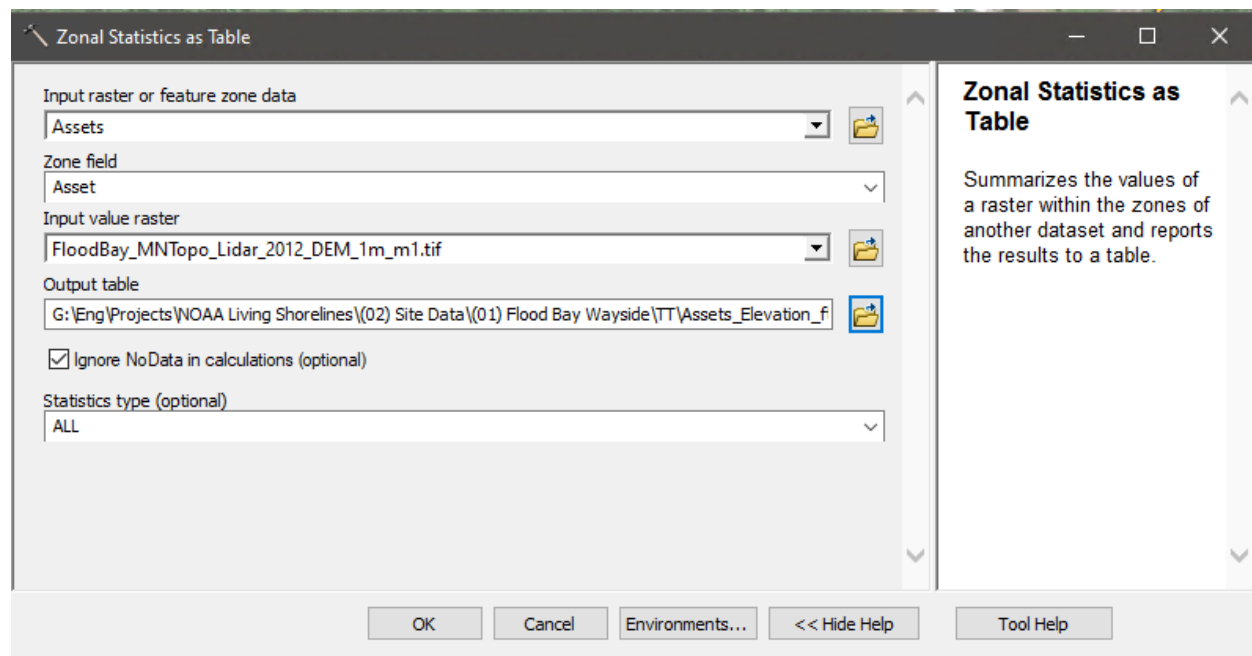
Figure 6.   Zonal Statistics as Table Tool

The tool will create a table with the minimum, maximum, range, and mean elevations from the LiDAR within the asset polygons or along the asset lines. Input the elevation data into Column E for each asset.

Column F will automatically populate by subtracting the elevation of the 500-year flood elevation for Lake Superior (608.4 feet) from the asset elevation (Figure 7).

D	E	F
Flooding Indicator		
FEMA Flood Data	**LiDAR Elevation Data**	**Flood Elevation data**
N/A	614.2	5.8
N/A	608.1	-0.3
N/A	608.2	-0.2
N/A	607.3	-1.1

Figure 7.   Flooding Indicator Data Inputs

2.3   Storm Surge/Seiche Exposure Indicator

The storm surge/seiche indicator analysis characterizes NOAA CO-OP water level data for comparison to the elevation of the asset, Lake Superior bathymetry slope data, and Fetch Exposure Index (FEI) data.

NOAA CO-OP data is obtained online via the Duluth, Minnesota station (9099064) at https://tidesandcurrents.noaa.gov/stationhome.html?id=9099064 or the Grand Marais, Minnesota station (9099090) at https://tidesandcurrents.noaa.gov/stationhome.html?id=9099090. The mean water level at the Duluth station is 601.5 feet and 601.8 feet at the Grand Marais station. This information is populated in Column G based on the proximity of the site to these stations.

Lake Superior bathymetry data is calculated using the *Zonal Statistics as Table* tool again. Create a feature class polygon that extends 1,000 meters perpendicular to the assets (Figure 8). Use this 1,000-meter polygon as the Input Feature Zone Data, select the bathymetry raster as the Input Value Raster. Once the tool runs, input the mean value in Column H.
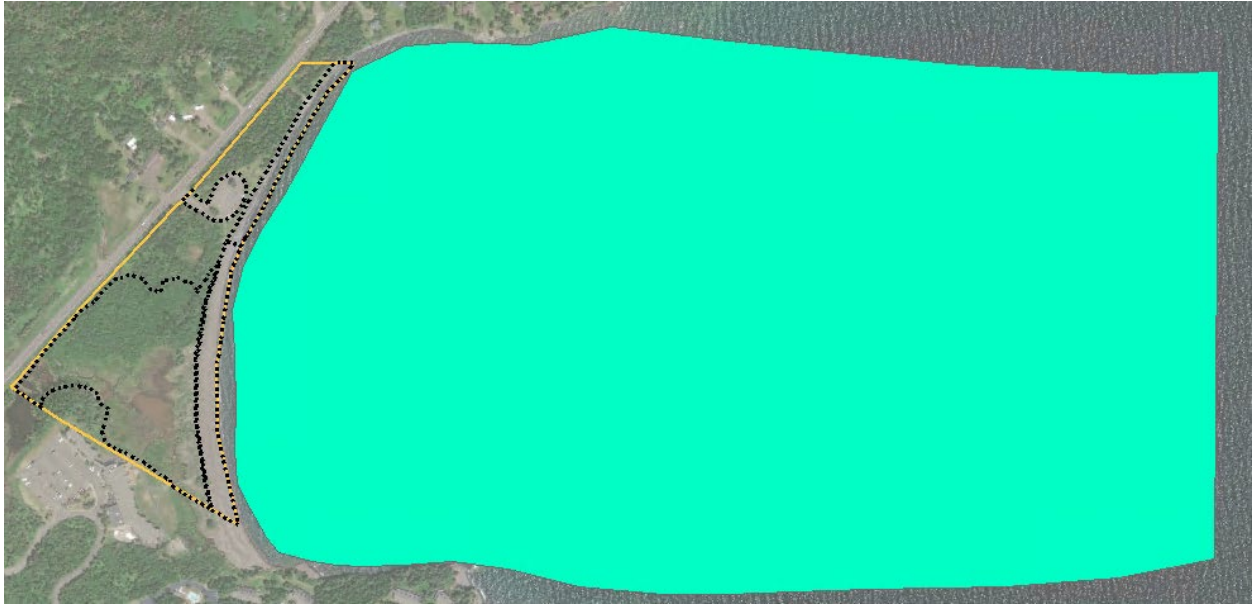
Figure 8.   Bathymetry Data 1,000 Meter Buffer

Fetch Exposure Index data is available for download from the Great Lakes Aquatic Habitat Framework online at https://www.glahf.org/data/. The same 1,000-meter buffer should be utilized with the *Zonal Statistics as Table* tool to calculate the mean Fetch Exposure Index for each asset. Enter the mean index in Column I.

Column J will automatically populate by subtracting the NOAA CO-OP data in Column G from the asset elevation data in Column D (Figure 9).

G	H	I	J
Storm Surge/Seiche Indicator			
NOAA CO-OP Data	**Slope Data**	**Fetch Exposure Index Data**	**Elevation Data**
601.5	2.71	188650	12.7
601.5	2.71	188650	6.6
601.5	2.71	188650	6.7
601.5	2.71	188650	5.8

Figure 9.   Storm Surge/Seiche Indicator Data Inputs

2.4   Lake Level Rise Exposure Indicator

The lake level rise indicator analysis characterizes a comparison of NOAA CO-OP water level data historic minimum and historic maximums and compares the difference in historic minimum and historic maximum to the NOAA CO-OP water level data as compared to the elevation of the asset described above.

NOAA CO-OP data is obtained online via the Duluth, Minnesota station (9099064) at https://tidesandcurrents.noaa.gov/stationhome.html?id=9099064 or the Grand Marais, Minnesota station (9099090) at https://tidesandcurrents.noaa.gov/stationhome.html?id=9099090. Column K is populated with the difference between the minimum and maximum water levels as measured at the stations. Column L will automatically populate by subtracting the information in Column K from the elevation data in Column J (Figure 10).

K	L
Lake Level Rise	
NOAA CO-OP Data	Elevation Data
4.594	8.1
4.594	2.0
4.594	2.2
4.594	1.2

Figure 10.   Lake Level Rise Indicator Data Inputs

2.5   Historical Flood Exposure Indicator

The historical flooding indicator analysis characterizes U.S. Geological Survey (USGS) stream gage and StreamStats data for streams, and NOAA Advanced Hydrologic Prediction Service (AHPS) average annual precipitation data.

USGS StreamStats data is available online at https://streamstats.usgs.gov/ss/. This indicator can only be calculated if streams are present in the site footprint. The FBSW site included two streams (one that empties into the wetlands and another stream on the north side of the site). Follow instructions on using StreamStats to identify the 100-year flood value and input those values into Column M based on the proximity of the asset to the stream (i.e., north beach receives the 100-year flood value for the stream on the north end of the site while south beach receives the 100-year flood value for the stream that empties into the wetlands).

NOAA AHPS average annual precipitation data is available for download online at https://mnatlas.org/gis-tool. Utilize this map to identify the average annual precipitation for the site and input this information into Column N (Figure 11).

Figure 11. Historical Flooding Indicator Data Inputs

2.6 Erosion Exposure Indicator

The erosion indicator analysis characterizes North Shore Erosion Mapping tool data from 2000, and Coastal Erosion Hazard Mapping (CEHM) data.

North Shore Erosion Mapping data is available online at https://www.arcgis.com/apps/webappviewer/index.html?id=46cbf323365e488bbc8356563ab53c2a&extent=-10000530.8881%2C6084038.8579%2C-9982186.0013%2C6092915.1078%2C102100. Utilize the interactive map to identify the mapped erosion hazard for the assets and input the information in Column O.

CEHM data is currently only available in St. Louis County. So, for the FBSW site, Column P would be populated with "Unknown" for all assets (Figure 12). When the data becomes available statewide, a similar tool will be available to identify the erosion hazard for the assets.

2.7 Figure 12. Erosion Indicator Data Inputs

2.8 Geology Exposure Indicator

The geology indicator analysis characterizes bedrock geology data from the Minnesota Geological Survey, and surficial geology data from the Minnesota Geological Survey.

The Minnesota Geological Survey bedrock geology is available online at
https://conservancy.umn.edu/handle/11299/101466. Utilize the map to identify the map unit for the
site assets and select the appropriate type in Column Q.

The Minnesota Geological Survey surficial geology is available via interactive map online at
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=1813f21e8b7f4087bf5f44ef82ab201
2&extent=-11302346.3674%2C5364081.8694%2C-9290523.783%2C6321684.9598%2C102100. Utilize
the map to identify the map unit for the site assets and select the appropriate type in Column R
(Figure 13).

Figure 13.   Geology Indicator Data Inputs

2.9   Soils Exposure Indicator

The soils indicator analysis characterizes the erosion factors data for Natural Resources Conservation
Service (NRCS) mapped soils, and North Shore Red Clay Soils steep slope data.

NRCS soils data is available online at
https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. Zoom into the area of interest (i.e.,
the site) and outline the area of interest. Select Soil Data Explorer from the top tabs. Under this tab,
select the Soil Properties and Qualities tab. In the table of contents on the left, select Soil Erosion
Factors, then select K Factor, Whole Soil, and click the View Rating button. Below the map will be a
table listing the map unit symbol, map unit name, rating, acres, and percent of area of interest (Figure
14). Utilize the map and identify the soils underlying the mapped assets. Input the rating for the soils
for each asset in Column S.

Figure 14. Web Mapper Results for FBSW

North Shore Red Clay Soils steep slope data should be evaluated for each asset based on the majority of the area of interest. For example, the wetlands asset at FBSW falls mostly under the "0-8% Stable" category (Figure 15).

Figure 15.   North Shore Red Clay Soils Steep Slope Data for FBSW

Select this option in Column T (Figure 16).

gSSURGO Data	North Shore Red Clay Soils Data
0.43	0-8%
0	8-15%
0	N/A
0.43	0-8%

Figure 16.   Soils Exposure Indicator Data Inputs

2.10   Fish and Wildlife Habitat Exposure Indicator

The fish and wildlife habitat indicator analysis characterizes scientific and natural area data, state aquatic management area data, native plant community data, site of biodiversity significance data, National Wetlands Inventory (NWI) data, and wildlife management area data.

The majority of these indicators can be identified via the Minnesota Natural Resource Atlas interactive map available online at https://mnatlas.org/gis-tool/. If the assets are located within or adjacent to any of the above areas, select "Yes" in the appropriate columns between Column U and Column Z. If the assets are not located within or adjacent to any of the above areas, select "No" in the appropriate columns between Column U and Column Z (Figure 17).

U	V	W	X	Y	Z
Fish and Wildlife Habitat Indicator					
Scientific and Natural Areas?	State Aquatic Management Areas?	Native Plant Communities?	Site of Biodiversity Signficance?	National Wetland Inventory?	Wildlife Management Area?
No	No	Yes	Yes	Yes	No
No	No	Yes	Yes	Yes	No
No	No	Yes	Yes	Yes	No
No	No	Yes	Yes	Yes	No

Figure 17.   Fish and Wildlife Habitat Exposure Indicator Data Inputs

3.0   SENSITIVITY ANALYSIS

The sensitivity analysis for the FBSW assessment characterizes sensitivity indicators for each of the assets including flood damage potential, storm resistance and condition, historical damage, protective engineering, infrastructure, fish and wildlife habitat, climate, and water quality. In the spreadsheet, navigate to **Step 2. Sensitivity DATA**. The following subsections describe how to characterize the assets for the sensitivity analysis indicators in the **Step 2. Sensitivity DATA** tab.

3.1   Sensitivity Analysis Data Online Resources

Below is a list of online resources that are utilized in the sensitivity analysis and further described in the following subsections. A full list of all available online resources is provided in Section 6.0. Online Resources.

Minnesota Climate Trends

https://arcgis.dnr.state.mn.us/ewr/climatetrends/

3.2   Flood Damage Potential Sensitivity Indicator

The flood damage potential indicator analysis characterizes FEMA flood zones, elevation data of the assets, user input regarding whether the asset is currently elevated, and compares the elevation data to the 500-year flood elevation for Lake Superior.

User input is only needed for Column F. The user needs to identify if the asset is currently elevated. This is meant for the built assets (i.e., buildings, parking lots, trails, etc.). For example, parking lot asset is not currently elevated (i.e., built on stilts to allow for flooding to flow under the asset) so the user would select "No" in Column F for this asset. However, natural assets (i.e., north beach, south beach, and wetlands) are not able to be elevated and would therefore have the user select "N/A" in Column F. All other columns for this indicator are automatically populated from input in the exposure analysis (Figure 18).

D	E	F	G
Flood Damage Potential Indicator			
FEMA Flood Data	**LiDAR Elevation Data**	**Asset Elevated?**	**500 Year Flood Potential?**
N/A	614.2	No	No
N/A	608.1	N/A	Yes
N/A	608.2	N/A	Yes
N/A	607.3	N/A	Yes

Figure 18.   Flood Damage Potential Sensitivity Indicator Data Inputs

3.3   Storm Resistance and Conditions Sensitivity Indicator

The storm resistance and conditions indicator analysis characterizes user input regarding whether the asset has built resistivity to storms, and user input regarding whether the asset has natural resistivity to storms.

Column H requires the user to identify whether or not the asset has built resistivity to storms (i.e., does the parking lot have engineering elements that make it resistant to damage from storms). For the built environment, the answer will be "Yes" or "No". For the natural environment, the answer will be either "Yes" or "N/A". For example, north beach has rip rap installed so the user would select "Yes" but the south beach does not have rip rap installed so the user would select "N/A" because the natural environment is not built to be resistant to storms.

Column I requires the user to identify whether or not the asset has natural resistivity to storms (Figure 19). In this example, the natural environment should have a natural resistivity to storms while the built environment will not necessarily have a natural resistivity. The parking lot is not naturally resistant to storms but the beaches and wetlands are naturally resistant to storms.

H	I
Storm Resistance and Condition Indicator	
Built Resistivity?	Natural Resistivity?
Yes	No
Yes	Yes
N/A	Yes
N/A	Yes

Figure 19.   Storm Resistance and Conditions Sensitivity Indicator Data Inputs

3.4   Historical Damage Sensitivity Indicator

The historical damage indicator analysis characterizes user input regarding whether the asset has sustained damage in the past, and user input regarding the current maintenance level for the asset.

Column J requires user input indicating whether the asset has historically suffered damage from storms and Column K requires user input indicating the current maintenance level of the asset (Figure 20). Natural environment assets should have a maintenance level of "None" while the built environment assets should have either "New", "Good", "Moderate", or "Poor" maintenance levels.

J	K
Historical Damage Indicator	
Historical Damage?	Current Maintenance Level Data
Yes	Good
Yes	Moderate
N/A	None
N/A	None

Figure 20.   Historical Damage Sensitivity Indicator Data Inputs

3.5   Protective Engineering Sensitivity Indicator

The protective engineering indicator analysis characterizes user input regarding whether the asset currently features protective engineering, and user input regarding the current condition of any protective engineering elements.

Column L requires user input indicating whether the asset has protective engineering currently in place and Column M requires user input indicating the current condition of the engineered element

(Figure 21). Natural environment assets should have a current condition level of "None" while the built environment assets should have either "New", "Good", "Moderate", or "Poor" current condition levels.

L	M
Protective Engineering Indicator	
Protective Engineering?	**Engineered Element Condition Data**
Yes	Good
Yes	Moderate
No	None
N/A	None

Figure 21.   Protective Engineering Sensitivity Indicator Data Inputs

3.6   Fish and Wildlife Habitat Sensitivity Indicator

The fish and wildlife habitat indicator analysis characterizes scientific and natural area data, state aquatic management area data, native plant community data, site of biodiversity significance data, NWI data, and wildlife management area data.

No user input is required for this indicator because the data refers to the input from the exposure analysis above.

3.7   Climate Sensitivity Indicator

The climate indicator analysis characterizes increases or decreases in precipitation for the site compared to historic levels, and increases or decreases in temperatures for the site compared to historic levels.

Climate indicator analysis data is available online at https://arcgis.dnr.state.mn.us/ewr/climatetrends/. Select the geographic unit that is available for the site (for FBSW, the Lake Superior – South watershed was the best option). Under Data Options, choose average temperature or precipitation from the drop-down menu. For the time frame, set the time scale to Annual, with month ending as January, data start year as 1895, and data end year as 2022 and click Plot Data. Under Additional Options on the right side of the page, check the box that says Show trend for these years with the year start at 1895 and end at 2022. The plot will now show the trend for either precipitation or temperature on the right side of the graph (Figure 22).
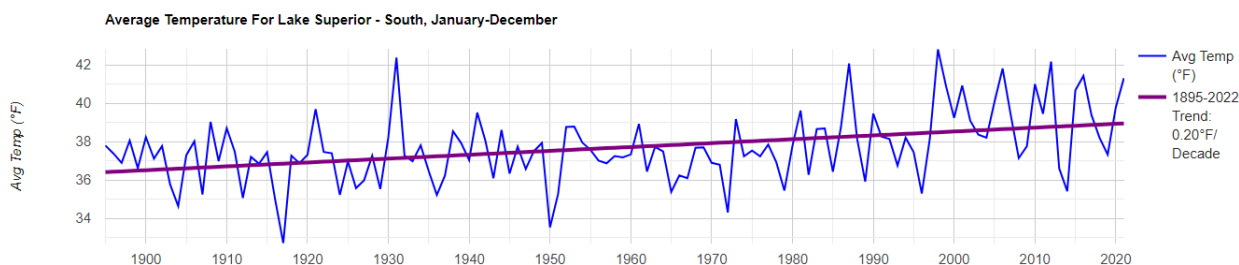
Figure 22.   Climate Trends Plot Example for FBSW

Repeat the same process for temperature or precipitation depending on which was selected first. Input the trend values into Column V for precipitation and Column W for temperature (Figure 23).

V	W
Climate Indicator	
Precipitation Change Data	Temperature Change Data
0.32	0.2
0.32	0.2
0.32	0.2
0.32	0.2

Figure 23.   Climate Sensitivity Indicator Data Inputs

3.8   Water Quality Sensitivity Indicator

The water quality indicator analysis characterizes invasive species (terrestrial and aquatic) data, and buffer protection data for waterbodies on the site.

User input is required in Column X to identify if invasive species (terrestrial or aquatic) have been observed on the site. Invasive species observation data is available online at https://mnatlas.org/gis-tool/. Select either "Yes" or "No" in Column X.

User input is also required in Column Y to identify the buffer protection for waterbodies on the site that might be impacted or be near the assets. Again, buffer protection data is available online at https://mnatlas.org/gis-tool/. Select the appropriate buffer protection based on the available data for the site in Column Y (Figure 24).

X	Y
Water Quality Indicator	
Invasive Species?	Buffer Protection Data
Yes	None
Yes	50 Foot Buffer
Yes	50 Foot Buffer
Yes	50 Foot Buffer

Figure 24.   Water Quality Sensitivity Indicator Data Inputs

4.0   DISCUSSION

The instructions for the rest of the spreadsheet and protocol are provided separately. This document should provide enough information for the user to populate the spreadsheet utilizing either GIS or

other available tools to characterize the vulnerability of the assets identified at the site. For any questions, please contact the Coastal Program at mlscp.dnr@state.mn.us.

5.0 REFERENCES

Glick, P., B.A. Stein, and N.A. Edelson, editors. 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. National Wildlife Federation. Washington, D.C. ISBN 978-0-615-40233-8. Available at: www.nwf.org/vulnerabilityguide

MN DNR and NOAA OCM (Minnesota Department of Natural Resources and National Oceanic and Atmospheric Administration Office for Coastal Management). 2022. Vulnerability_Assessment_Protocol_MDNR_03032022.docx. Word Document submitted to MN DNR and NOAA OCM March 3, 2022.

MN DNR, NOAA OCM, and Tetra Tech, Inc. 2021. Existing Vulnerability Assessments, Datasets, and Data Gaps_10282021.xlsx. Spreadsheet submitted to MN DNR and NOAA OCM October 28, 2021.

NPS (National Park Service). 2016. *Coastal Hazards & Climate Change Asset Vulnerability Assessment Protocol.* Available at: https://irma.nps.gov/DataStore/DownloadFile/665481?Reference=1049253.

6.0 ONLINE RESOURCES

FEMA Flood Map Service Center

https://msc.fema.gov/portal/home

NOAA CO-OP Water Levels

Duluth: https://tidesandcurrents.noaa.gov/stationhome.html?id=9099064

Grand Marais: https://tidesandcurrents.noaa.gov/stationhome.html?id=9099090

Fetch Exposure Index

https://www.glahf.org/data/

USGS StreamStats

https://streamstats.usgs.gov/ss/

Minnesota Natural Resource Atlas

https://mnatlas.org/gis-tool

North Shore Erosion Mapping Tool

https://www.arcgis.com/apps/webappviewer/index.html?id=46cbf323365e488bbc8356563ab53c2a&extent=-10000530.8881%2C6084038.8579%2C-9982186.0013%2C6092915.1078%2C102100

Minnesota Geological Survey

Bedrock geology map: https://conservancy.umn.edu/handle/11299/101466

Surficial geology map:
https://umn.maps.arcgis.com/apps/webappviewer/index.html?id=1813f21e8b7f4087bf5f44ef82ab2012&extent=-11302346.3674%2C5364081.8694%2C-9290523.783%2C6321684.9598%2C102100

NRCS Soils Web Mapper

https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Minnesota Climate Trends

https://arcgis.dnr.state.mn.us/ewr/climatetrends/