

Waukegan Harbor Maintenance Dredging and Placement Waukegan, Illinois

Environmental Assessment Appendix A - Section 404(b)(1) Analysis



U.S. Army Corps of Engineers
Chicago District

June 2019

TABLE OF CONTENTS

I.	<u>Project Description</u>	3
A.	Locations	3
B.	General Description	3
C.	Authority and Purpose	3
D.	General Description of Dredged or Fill Material	4
(1)	General Characteristics of Material	4
(2)	Quantity of Material	4
(3)	Source of Material	4
E.	Description of the Proposed Placement Site(s)	5
(1)	Location	5
(2)	Size	5
(3)	Type of Site	6
(4)	Type of Habitat	6
(5)	Timing and Duration of Discharge	6
F.	Description of Placement Method	6
II.	<u>Factual Determinations</u>	6
A.	Physical Substrate Determinations	7
(1)	Substrate Elevation and Slope	7
(2)	Sediment Type	7
(3)	Dredged/Fill Material Movement	7
(4)	Physical Effects on Benthos	7
(5)	Other Effects	7
(6)	Actions Taken to Minimize Impacts	7
B.	Water Circulation, Fluctuation and Salinity Determinations	7
(1)	Water	8
(2)	Current Patterns and Circulation, Current Flow and Water Circulation	9
(3)	Normal Water Level Fluctuations	9
(4)	Salinity Gradients	9
(5)	Actions That Will Be Taken to Minimize Impacts	10
C.	Suspended Particulate/Turbidity Determinations	10
(1)	Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Placement Site	10
(2)	Effects (degree and duration) on Chemical and Physical Properties of the Water Column	10
(3)	Effects on Biota	11
(4)	Actions Taken to Minimize Impacts	12
D.	Contaminant Determinations	12
E.	Aquatic Ecosystem and Organism Determinations	12
(1)	Effects on Plankton	12
(2)	Effects on Benthos	13
(3)	Effects on Nekton	13
(4)	Effects on Aquatic Food Web	13
(5)	Effects on Special Aquatic Sites	14
(6)	Threatened and Endangered Species	14
(7)	Actions Taken to Minimize Impacts	16

F.	Proposed Disposal Site Determinations	16
(1)	Mixing Zone Determination	16
(2)	Determination of Compliance with Applicable Water Quality Standards.....	16
(3)	Potential Effects on Human Use Characteristic	16
G.	Determination of Cumulative Effects on the Aquatic Ecosystem.....	18
H.	Determination of Secondary Effects on the Aquatic Ecosystem	18
III.	<u>Findings of Compliance or Non-Compliance with the Restrictions on Discharge</u>	18
A.	Adaptation of the Section 404(b)(1) Guidelines to this Evaluation	18
B.	Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem	19
C.	Compliance with Applicable State Water Quality Standards	19
D.	Compliance with Clean Water, Endangered Species, National Historic Preservation and Marine Sanctuaries Acts	19
E.	Evaluation of Extent of Degradation of the Waters of the United States	19
(1)	Significant Adverse Effects	19
(2)	Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems	19
(3)	Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity and Stability.....	20
F.	Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem	20
G.	On the Basis of the Guidelines, the Proposed Placement Sites for the Discharge of Fill Material is:	20
IV.	<u>Bibliography</u>	21
V.	<u>Figures.....</u>	22

I. Project Description

A. Locations

Waukegan Harbor is an authorized Federal navigation harbor located in Waukegan, Illinois on the western shore of Lake Michigan (Figure 1). The harbor is located approximately 40 miles north of Chicago, Illinois and 10 miles south of the Illinois-Wisconsin state line. The Federal navigation channel is comprised of three main areas: Inner Harbor, Outer Harbor, and Approach Channel. The inner harbor is not currently maintained and there are no plans for dredging. Routine navigational maintenance dredging is planned for the Outer Harbor, and has been on-going in the Approach Channel. There is also an area adjacent to the federal harbor known as the Advance Maintenance Area. This area is dredged to form a basin where littoral sand can be deposited before it settles in the federal channel reducing the frequency of dredging the federal channel.

The locations being considered for placement of dredged sand are as follows (Figure 2): City of Waukegan, Waukegan Municipal Beach; City of North Chicago, Foss Beach; Village of Lake Bluff, Sunrise Beach; Village of Glencoe, Glencoe Beach; and City of Evanston, Lee Street Beach, Greenwood Street Beach, and Dog Beach. The existing locations are the Open Water South Placement Area and the littoral zone of Illinois Beach State Park.

B. General Description

The goal of the current action is to conduct routine maintenance dredging in the Outer Harbor, and it is proposed that any sediment dredged would be placed to beneficially maintain the coastline in a near shore littoral zone south or north of the harbor, or placed on the beach at one of the identified locations north or south of the harbor.

The Outer Harbor consists of the area between the North Breakwater and the Inner Harbor piers. The Outer Harbor is 1,050 feet in length with widths ranging from 180-450 feet and covers a surface area of approximately 10 acres. The Outer Harbor has an authorized project depth of -25 feet LWD, although the actual maintenance depth is -22 feet based on local needs and professional judgment.

While USACE regularly performs routine maintenance dredging within the Approach Channel and Advance Maintenance areas, the Outer Harbor has not received maintenance dredging by USACE from the mid-1970s to 2015 due to contamination concerns. In 2015 the Outer Harbor material was dredged and placed upland; the new shoaling consists of sediment washing in from the Approach Channel. It is proposed to now include the Outer Harbor in the routine maintenance program. USACE typically performs maintenance dredging of the Approach Channel and Advance Maintenance areas every year or two with placement at existing near-shore locations.

C. Authority and Purpose

Construction, operation and maintenance of the existing Federal navigation project at Waukegan Harbor was authorized by the River and Harbor Act of 14 June 1880 and by subsequent amendments of 1882, 1902, 1930, 1945, 1965, and 1970. Waukegan Outer Harbor is experiencing shoaling and it is proposed to include the Outer Harbor as part of the routine maintenance of the harbor. Note that “purpose and need” are also discussed in the main EA document.

The Illinois Department of Natural Resources’ (IDNR) Coastal Management Program Illinois Sand Management Working Group focuses on ways to collaborate to protect and restore Illinois’ public Lake Michigan shoreline. The working group includes local (Lake Bluff Park District, Foss Park District in

North Chicago, Glencoe Park District, City of Evanston, City of Waukegan and other municipalities) and state (ILDNR, Illinois State Water Survey, Illinois Environmental Protection Agency) entities, with participation by the USACE as well as other stakeholders. This group has been exploring ways to leverage local resources to address Lake Michigan shoreline issues in a sustainable and cost-effective way. The proposed project includes dredging and sand transport for near-shore or onshore sand placement along with the possibility of installing native plantings and beach monitoring.

D. General Description of Dredged or Fill Material

(1) General Characteristics of Material

Sediment grab samples were collected in the Waukegan Outer Harbor in August 2016. Three grab samples were collected from the most shoaled areas. At the time of sampling, sediment had not accumulated throughout the entire Outer Harbor, however the sediment collected does represent the material that had accumulated.

There are no sources of asbestos or PCBs for the Outer Harbor, and historically the littoral sediment has been free from metals and anthropogenic compounds that would warrant further evaluation. Sediment samples from the Outer Harbor were tested for their percentage of fines, which is equivalent to the amount of the sediment that passes through a #230 sieve. Historical data were reviewed and compared to the data obtained during the August 2016 sediment sampling event to ensure that the sediment from the Outer Harbor falls within the historical range of dredged material quality and is thus suitable for inclusion in routine dredging and placement. The Outer Harbor material is consistent with the sediment found in the Approach Channel. Fines were very low, and much less than 20% passing the #230 sieve (7.5%, 3.2%, and 1.9%).

(2) Quantity of Material

It is typically assumed that an annual average shoaling rate can be estimated based on dredged volumes and time span between dredging activities. On average, USACE has dredged at an average rate of 41,000 cubic yards per year in the Waukegan Harbor area. Over the past several years however, the updrift fillet beach and bypass shoal have reached their maximum capacity and are no longer providing significant sediment storage. As a result, the incoming sediment load approaching the Federal channel has increased to an estimated 71,000 cubic yards per year, which has led to a significant increase in shoaling within the Approach Channel and surrounding areas. This increase in shoaling and sediment accretion has resulted in the need for dredging. The overall total volume of shoaled material is not changing, and is up to 80,000 cubic yards per year.

(3) Source of Material

The littoral drift pattern in the vicinity of Waukegan Harbor is predominately from north to south, with the overall net transport rate (from the Wisconsin state line to Chicago) of approximately 80,000 cubic yards per year. The dredged areas act as sediment traps, where the littoral sediment settles, thus significantly reducing the amount of littoral sediment migrating south of the Harbor. Since the 2015 Outer Harbor dredging event, the area will now require maintenance dredging as in the past, as the historical shoaling pattern re-establishes within the navigation channel. A return to the historical shoaling pattern will necessitate a return to regular dredging in the Outer Harbor. It is anticipated that the total volume of shoaled material will not change, but that the material will be redistributed within the larger area.

E. Description of the Proposed Placement Site(s)

(1) Location

The proposed beach placement sites are a collaborative effort of four Illinois coastal communities – Lake Bluff Park District, Foss Park District in North Chicago, Glencoe Park District, and City of Evanston. The City of Waukegan has also requested materials for their municipal beaches. Additional, similar placement sites between the northern City of Chicago boundary and the Illinois/Wisconsin state line could also be used as placement sites if certain criteria are met, sediment of suitable quality is available, and funding and logistics allow along with compliance with the National Environmental Policy Act. Criteria for placement includes:

- Either within the near-shore littoral zone, defined as less than 18’ of water depth, or upland on an existing beach area.
- The placement location must not have endangered species or historically or culturally significant resources that would be impacted by the sediment placement. Endangered Species Act and State Historical Preservation Office compliance must be verified before a new placement site may be used.
- For in-water placement, the location must not block tributary drainage, marina entrances, dock faces, or other existing natural or manmade features.
- For upland placement, the beach area must be an existing sandy beach recognized by the state, county and/or municipal government and designated as a beach in land use. The beach may be for recreational use or for habitat use, as long as the placement of sand does not destroy any resources.
- Sediment may be placed mechanically or hydraulically, using appropriate mechanic or hydraulic marine or land based equipment; the selected approach will minimize cost and impacts to the beach and beach users.
- For any placement site, all appropriate permitting, including but not limited to Clean Water Act permitting, must be obtained prior to any placement action.

The dredged material from Waukegan Harbor (Outer Harbor, Approach Channel, or Advanced Maintenance Area) would be placed onshore, immediately adjacent to shore (less than 5’ water), or in the littoral zone. Placement is dependent on the quantity requested and is limited to the annual dredging volume or less. A site specific survey will need to be conducted to determine if above criteria is being met.

Material dredged from the Outer Harbor could also be placed at the existing routine placement sites currently in use (Open Water South Placement Area or Illinois Beach State Park).

(2) Size

Waukegan Municipal Beach – There was no specific identification of how much sand would be needed to sustain the beach or specific areas within the beach to place the sand. About 1.56 acres was identified as being viable for placing sand within the beach and surf zone.

Foss Park Beach – The requested amount of sand is about 4,477 cyds. that would cover an estimated 2.27 acres.

Sunrise Beach – The requested amount of sand is about 769 cyds. that would cover about 1.08 acres of beach and surf zone.

Glencoe Beach – The requested amount of sand is about 1,500 cyds. that would cover about 1.16 acres of beach and surf zone.

Lee Street Beach, Greenwood Street Beach, & Dog Beach – The requested amount of sand is about 3,000 cyds. that would cover about 6.27 acres of beach and surf zone.

The Open Water South Placement Area measures 4,000 feet north to south. Illinois Beach State Park covers 6.5 miles of Lake Michigan shoreline.

The total quantity of annual dredging is dependent on shoaling patterns and funding, therefore in any given dredging year not all placement areas may be used. Over the life of the project some placement areas may be reused, or not used at all.

(3) Type of Site

The identified beach placement sites are municipal beaches adjacent to Lake Michigan. Placement would be onshore, immediately adjacent to shore (less than 5' water), or in the littoral zone (less than 18' water). The Open Water South Placement Area is an open water near-shore Lake Michigan area, south of Waukegan Public Marina. The Illinois Beach State Park site is near-shore along the shore of Lake Michigan in open water.

(4) Type of Habitat

The natural habitat at many of these beaches before their development was most likely an open lacustrine shoreline, and likely resembled the beach at IBSP. The beaches were likely sculpted by wave action that caused the movement and drift of littoral sand from north to south along the coastline. IBSP in particular is classified as a dune and swale habitat (Albert et al 2005) where beach ridges are separated by narrow swales, and was formed by the cyclic fluctuations in Lake Michigan water levels over the past several thousand years. Wetlands exist at various distances and connectedness to the lake and as a result the organic soil depth and vegetation are quite variable. This natural condition can be seen fairly well at the IBSP, but at the other municipal beaches the condition no longer exists due to development of the areas. The natural littoral drift cycle has also been disrupted by construction of in water structures that block or severely reduce the north to south sediment flow.

(5) Timing and Duration of Discharge

Dredging occurs at Waukegan Harbor dependent upon shoaling rates and appropriations. Historically, Waukegan Harbor is dredged every year or two, in spring, summer or early fall depending on weather conditions. The length of each individual dredging event varies, but typically lasts approximately one to two months depending on dredging volume, equipment used, weather, and other factors.

F. Description of Placement Method

Material to be placed in the littoral zone is transported via bottom dump scow. Once the scow is in place, the bottom doors open and material is dropped down. Material can also be placed in the littoral zone hydraulically. Material to be placed onshore or near shore (shallow water) is hydraulically pumped as a slurry onto the beach, or can be placed mechanically using a crane.

II. Factual Determinations

A. Physical Substrate Determinations

(1) Substrate Elevation and Slope

The Outer Harbor has an authorized project depth of -25 feet LWD, although the actual maintenance depth is -22 feet based on local needs and professional judgment. The Approach Channel is also maintained at a depth of -22 feet LWD. Material will be placed either onshore, immediately adjacent to shore (less than 5 feet water), or in the littoral zone (less than 18 feet of water).

(2) Sediment Type

The sediment to be dredged is predominantly the result of littoral transport of Lake Michigan sand from areas north of Waukegan Harbor. The sediment in the potential placement areas is primarily of the same type.

(3) Dredged/Fill Material Movement

Littoral transport is the movement of sediments in the nearshore zone by waves and current. Littoral transport travels parallel to the coast in a predominantly north to south direction along the coast of Illinois. Material placed in the littoral zone either moves onto the beach or provides wave energy attenuation from the placement location. Material placed on the beach widens the existing beach for the same goal of wave energy attenuation. Material placed in either type of location will eventually rejoin the overall north to south littoral transport.

(4) Physical Effects on Benthos

Existing periphyton, epibenthic plankton, and benthic macroinvertebrate organisms that currently reside in the substrate of the area to be dredged or placement area(s) would be removed or disturbed when the dredged materials are removed from the water, placed back into the water, or placed on/near beaches. The existing sediment within the dredging area(s) will need to be removed to allow for an adequate navigation depth. After this material is removed it will be transported to a predetermined deposition site as listed above and placed upon the existing sediment in the area. Organisms that typically reside in high wave energy environments near shorelines are generally tolerant of turbid waters and adapted to elevated suspended solids concentrations. As a result, the periphyton, epibenthic plankton, and macroinvertebrate organisms would quickly repopulate, grow, and recolonize on/in the benthos after operations have ended.

(5) Other Effects

There would be no other significant substrate impacts.

(6) Actions Taken to Minimize Impacts

For open water placement a bottom dump scow minimizes resuspension by going into shallow water before opening. For onshore placement the slurry is pumped into a temporary settling basin, which allows the solids to settle out and clear water to return to the lake. No additional special measures would be taken to minimize temporary impacts.

B. Water Circulation, Fluctuation and Salinity Determinations

(1) Water

a) *Salinity*

Lake Michigan is a freshwater lake. The proposed work is not expected to increase or decrease the salinity of the water and will not add salts to the system.

b) *Water Chemistry*

As part of the 2016 Outer Harbor sampling, one elutriate (supernatant) was prepared for each sediment sample, with a settling time of four hours (total of three samples). This method is an approximation of placing the material in the water. Lake Michigan water was used to prepare the elutriate samples. The elutriate (supernatant) samples were tested for Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Sulfate, Chloride, Phosphorus, Ammonia, hardness, temperature, and pH – parameters which have historically been of interest for the routine Approach Channel and Advanced Maintenance work. All of the water quality parameters were less than the historical maximum value measured for the Approach Channel material. Extensive sampling has been conducted at the Approach Channel, and shows that Illinois water quality standards for the open waters of Lake Michigan are met within a mixing zone of 250 ft x 1100ft. Because the sediment from the Approach Channel and Advanced Maintenance has not caused measurable water quality impacts and is suitable for placement, the Outer Harbor material is also expected to be the same. Only short-term and localized increases are likely to occur during placement.

c) *Clarity and Color*

Since the dredged material has a low percentage of fines, it is unlikely to cause any considerable long-term effects on, or changes to the water clarity or color. Short-term, minor, and localized changes to the water clarity and color are expected due to temporary increases in the concentration of suspended solids and turbidity during work.

d) *Odor and Taste*

The dredged materials are not anticipated to cause any considerable long-term effects on, or changes to, the odor or taste of the water. As mentioned above, the placement will likely cause short-term, minor, and localized increases of suspended solids and turbidity. These changes might be associated with slight changes to odors or tastes in the water for organisms in the vicinity of the work area, but any potential changes are expected to be temporary and limited to the work area.

e) *Dissolved Gas Levels*

The dredged materials are not anticipated to cause any considerable long-term effects on, or changes to, the dissolved gas levels in the water. As mentioned above, the placement will likely cause short-term, minor, and localized increases of suspended solids concentrations and turbidity. These increases in the work area may have an effect on the dissolved gas and nutrient levels in the water column, which could adversely impact some of the aquatic plants and organisms near the site. In particular, increases of suspended solids and turbidity could slightly reduce the amount of dissolved oxygen in the water column, and this is because the biological and chemical content of the suspended solids might react with some of the dissolved oxygen. However, the aquatic plants and organisms that have adapted to the dynamic, high wave energy environments near the shoreline are generally tolerant of the turbid waters that occur during storm events, so most of the aquatic plants and organisms should be able to withstand the short-term and minor changes in dissolved gas and nutrient levels. In

addition, the clean sand with low fines content is expected to have a low sediment oxygen demand. Changes to the dissolved gas levels in the water should be temporary and confined to the work area.

f) *Nutrients*

The dredged materials are not anticipated to cause any considerable long-term effects on, or changes to, the nutrient levels in the water. The work may cause temporary, minor, and localized changes to the suspended solids, turbidity, and nutrient levels. These changes could adversely impact some of the aquatic plants and organisms in the vicinity of the work area, but the aquatic plants and organisms along the shoreline should be tolerant of the turbid waters that occur during storm events and should quickly recover. Additionally, Illinois water quality standards for the open waters of Lake Michigan are met within a mixing zone of 250 ft x 1100 ft so any temporary impacts are to a limited area.

g) *Eutrophication*

Eutrophication is commonly caused when water is subjected to prolonged and elevated nutrient levels, particularly nitrogen and phosphorus. The dredging and placement is expected to cause short-term, minor, and localized changes to the suspended solids, turbidity, and nutrient levels, but the nutrient levels should return to Lake Michigan background concentrations shortly after the materials have been placed and the suspended particles have settled from the water column. The changes to suspended solids, turbidity, and nutrient levels are temporary and confined to the work area.

h) *Others as Appropriate*

There would be no other significant water impacts.

(2) Current Patterns and Circulation, Current Flow and Water Circulation

The proposed project will place dredged material in the nearshore, open water, or on the beach. Waukegan Harbor and the proposed placement areas are all part of the same dynamic littoral system of Lake Michigan. Lake Michigan is an enormous lake, and the dredging and placement areas are comparatively small; any placed material will rejoin the overall littoral system after placement. The proposed project will not have a significant adverse effect on the current patterns, flow, direction, velocity, stratification or hydrologic regime of Lake Michigan.

(3) Normal Water Level Fluctuations

Lake Michigan is an extremely large lake that has a huge surface area and contains an immense volume of water. According to the Great Lakes Atlas, (Government of Canada and USEPA 1995), Lake Michigan has a water surface area of 22,300 square miles (57,800 square kilometers) and a volume of 1,180 cubic miles (4,920 cubic kilometers). It can take multiple months, seasons, or even years of persistently wet/dry conditions to cause an impact to the water levels of the Great Lakes (USACE 2013). The USACE, Detroit District, tracks the water levels in each of the Great Lakes, and the primary factors that determine water level changes are precipitation falling on the lake surface, runoff draining to the lake, evaporation from the lake surface, diversions into or out of the lake, and connecting channel inflows and outflows (USACE 2013). The very small volumes of material that would be moved for this project are insignificant in terms of water level impacts to the lake.

(4) Salinity Gradients

Lake Michigan is a fresh water lake, so the effect of the Project on salinity gradients is not

applicable.

(5) Actions That Will Be Taken to Minimize Impacts

For open water placement a bottom dump scow minimizes resuspension by going into shallow water before opening. For onshore placement the slurry is pumped into a temporary settling basin, which allows the solids to settle out and clear water to return to the lake. No additional special measures would be taken to minimize temporary impacts.

C. Suspended Particulate/Turbidity Determinations

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Placement Site

The fines content of the dredged material is very low, with much less than 20% passing the #230 sieve. Since the dredged material has a low percentage of fines, it is unlikely to cause any considerable long-term effects on suspended particulates or turbidity levels. Short-term, minor, and localized increases in the concentration of suspended solids and turbidity are expected during work.

(2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column

a) *Light Penetration*

The activities are expected to cause minor, temporary, and localized increases of suspended solids and turbidity that will likely decrease the clarity of the water and reduce the penetration of light through the water column. These minor, increases are anticipated to be low relative to the increased levels of suspended solids and turbidity that typically result from storm events and adverse weather conditions. The project is therefore not expected to cause any long-term adverse impacts.

b) *Dissolved Oxygen*

Minor, temporary, and localized increases of suspended solids and turbidity might cause a slight reduction in the level of dissolved oxygen in the water. This reduction may be due to the biological and chemical content of the suspended solids, which could react with the dissolved oxygen and slightly lower concentrations in the water column.

c) *Toxic Metals and Organics*

There are no sources of toxic metals for the dredge material.

As discussed in Section II.B.1.b *Water Chemistry*, elutriate (supernatant) samples were tested for among other things Phosphorus and Ammonia. As concluded, the activities might cause minor, temporary, and localized increases of organics. However the project is not expected to cause any long-term adverse impacts. There are no known sources of PCBs or other bioaccumulative compounds for the areas to be dredged.

d) *Pathogens*

Waukegan Harbor

The optional areas for dredged material placement are primarily beaches, but one option for placement

could be an open water area to the south of Waukegan Harbor. Pathogens, particularly disease-causing bacteria and other germs, are a major concern for beaches along urbanized areas of Lake Michigan's coastline. Several municipalities routinely test the water for pathogenic bacteria such as *Escherichia coli* (*E. coli*) during the swimming and recreational boating season. Although *E. coli* is not harmful itself and is naturally occurring in the environment, the bacteria is a potential indicator of sewage contamination and the possible presence of human pathogens (bacteria, protozoa, and viruses) (Whitman and Nevers 2003). Whitman and Nevers (2003) suggest that potential sources include rainwater (sewage) overflows, leaking septic systems, and birds occupying the beach(s).

It has been shown that beach sand can act as a source of bacterial input into coastal waters (Stanford University 2007). Bacteria that is present in dry sand can be released into waterways when submerged in water such as during storm surges or high water levels. One potential source of beach contamination would be excrement from waterfowl that utilize the beach, or an adjacent area (parking lot, lawns, etc.) where rainwater can flow over and onto the beach.

One way to combat bacterial contamination of a beach would be to conduct beach nourishment along the entire length of a beach. This would steepen the beach, increasing the distance to the water table and allowing water to more thoroughly drain from the beach's surface. The dryer sand is not as conducive to bacterial growth and should reduce the overall presence of bacteria in sand and potentially in the water directly offshore of the beach (Kinzelman and Oxley 2013). The nourished beach would likely not experience extended usage by waterfowl as they inhabit lower, wetter areas of the beach. This decreased usage by waterfowl could lead to decreased input sources of pathogenic bacteria coming from birds.

e) *Aesthetics*

The proposed project is not anticipated to cause any long term effects on, or changes to, the aesthetics of the water at the project site. There will likely be some temporary and minor increases of suspended solids and turbidity in the work area, and these increases are commonly associated with short-term and slight decreases of water clarity and/or changes to the color of the water. Nevertheless, these adverse aesthetic impacts should be short-term and minor, and the water is expected to return to a normal clarity and color as the suspended particles settle from the water column. In addition, the visual presence of barges, vessels, backhoes, and other construction equipment in the water or on the beach may generate noise and cause temporary and minor adverse impacts to the aesthetic beauty of the placement sites.

f) *Others as Appropriate*

The proposed project is not expected to have any other adverse effects on the chemical and physical properties of the water column.

(3) Effects on Biota

a) *Primary Production, Photosynthesis*

As discussed above in the discussion of light penetration, primary production generally refers to the fixation of solar energy by phytoplankton for an aquatic ecosystem. The dredging and placement of material will likely cause some minor, temporary, and localized increases of suspended solids and turbidity, but the effects are anticipated to be low relative to the increased levels of suspended solids that typically result from storm events and adverse weather conditions. The aquatic ecosystem in the area is likely comprised of aquatic organisms that typically reside in near shore dynamic, high wave energy environments, so they should be tolerant of turbid waters and adapted to elevated suspended

solids concentrations and turbidity. The project is not expected to cause any significant or long-term adverse impacts to primary production or photosynthesis for the biota.

b) *Suspension/Filter Feeders*

The dredging and placement of material will cause some minor, temporary, and localized increases of suspended solids and turbidity, which could benefit suspension/filter feeders. The effects are anticipated to be low relative to the increased levels of suspended solids and turbidity that typically result from storm events and adverse weather conditions, and the project is not expected to have any long-term effects on suspension/filter feeders.

c) *Sight Feeders*

Persistently high turbidity levels can cause adverse impacts to sight-dependent species because the reduction in clarity can hinder the feeding ability of these species, and thereby limit their growth and increase their susceptibility to disease. The dredging and placement of material is expected to cause minor, temporary, and localized increases of suspended solids and turbidity, but, as mentioned previously, the effects are anticipated to be low relative to the increased levels of suspended solids and turbidity that typically result from storm events and adverse weather conditions. Although there may be minor, temporary, and localized impacts, the project is not expected to have any persistent, long-term, and adverse effects on sight feeders.

(4) Actions Taken to Minimize Impacts

The proposed actions that will be taken to minimize the adverse impacts are the same actions discussed earlier. Although there may be minor and temporary adverse impacts within the local work area, these actions should minimize any broader effects that reside outside the immediate vicinity of the work area.

D. Contaminant Determinations

The most recent Contaminant Determination for Waukegan Outer Harbor was completed in 2017. The sediment was evaluated for consistence with the routine navigational maintenance dredging of the adjacent Approach Channel. It concluded that the sediment in the Outer Harbor originates from the same sources as the material in the Approach Channel, and that the sediment and elutriate were of the same quality.

E. Aquatic Ecosystem and Organism Determinations

(1) Effects on Plankton

Plankton are pelagic, which means they live within the water column itself, as opposed to benthic organisms that live along the bottom (Water Encyclopedia 2016). Plankton generally drift along with the water currents and/or float on or near the water surface, as opposed to nekton, which are active swimmers that can propel themselves through water currents. Plankton are typically divided into phytoplankton, which includes photosynthesizing species like algae that derive energy from sunlight, water, and carbon dioxide, and zooplankton, which consume food in order to derive energy. Although most planktonic species are small and often microscopic, there are large plankton organisms that are still considered to be plankton because they drift with the water current.

Researchers have found that Lake Michigan has experienced substantial and complex changes to the

food-web structure since the 1980s (Vanderploeg et al. 2012, Makarewicz et al. 1998, and Scavia et al. 1988). The paper by Vanderploeg et al. (2012) lists the following changes: (1) a decrease in phosphorus loading, (2) increased control of planktivorous alewife (*Alosa pseudoharengus*) by the introduction of Pacific salmon, (3) the invasion of the visual-feeding spined predatory cladoceran *Bythotrephes longimanus* in the mid-1980s from northern Europe, (4) invasion by a host of Ponto-Caspian species, including zebra (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*) during the 1990s, and (5) loss of the spring phytoplankton bloom in 2007 and 2008 likely caused by intense filtering during winter and spring by quagga mussels following their massive population expansion into deep water starting in 2004.

The many changes, invasive or non-native species, and complex interactions that have occurred in Lake Michigan makes it difficult to assess and/or quantify the effects on different species and the food-web (Vanderploeg et al. 2012). The proposed dredging and placement project will cause some minor, temporary, and localized impacts to some phytoplankton and zooplankton. There are approximately 50+ species of plankton present in the Great Lakes with an estimated average biomass of several milligrams per cubic meter (Vanderploeg et al 2012; INHS 2019; NOAA 1993). Due to the nature of these organisms and large scale of Lake Michigan in comparison to the project site, the impacted populations of plankton in the vicinity should recover quickly, and no considerable long-term effects on plankton communities are anticipated.

(2) Effects on Benthos

Benthos refers to the organisms (plants and animals) that inhabit the bottom of a sea, stream or lake. For the current project, the benthos includes organisms that live on, in, or near the bottom of Lake Michigan. The removal of the dredged sediment material, as well as the placement of the material in open water or near shore areas will cause some minor destruction and temporary adverse effects on the existing benthos in the local work area. However, benthic communities that are established near the shoreline are generally tolerant and adapted to dynamic, high wave and energy environments. As such, the disturbed areas are likely to be recolonized quickly by the same species, and no long term effects or modifications to species diversity or dynamics is anticipated.

(3) Effects on Nekton

Nekton refers to the aquatic life (organisms) that can swim freely and are generally independent of the water currents (Water Encyclopedia 2016). The work activities are expected to cause minor auditory disturbances to nekton in the vicinity of the work area, and some aquatic organisms that are slow or unable to move away quickly enough could be injured or killed during the removal of dredged material or when the material is placed back into the water along or on the shore. However, compared to the tremendous size of Lake Michigan and its extensive shoreline, the work area is small. There might be some minor, temporary, and localized adverse impacts, but the proposed dredging and placement project is not anticipated to degrade or have any permanent or noticeable effects on the nekton or nekton habitat in Lake Michigan.

(4) Effects on Aquatic Food Web

When discussing the effects on plankton, it was previously noted that Lake Michigan experienced substantial and complex changes to the food web since the 1980s (Vanderploeg et al. 2012, Makarewicz et al. 1998, and Scavia et al. 1988). Although it is likely that proposed dredging and placement of material might cause effects on some food web organisms in the vicinity, particularly sedentary organisms along the bottom, the project site(s) is small compared to the extremely large size of Lake Michigan, and the food web organisms near the shoreline should be tolerant and adapted to

dynamic, high wave and energy environments. The food web organisms should repopulate and become reestablished shortly after the project is completed, so any adverse impacts to the aquatic food web are expected to be minor, temporary, and localized. The dredging within the Waukegan Harbor project area and near/on shore placement activities are not expected to have any permanent or considerable long-term effects on the food web structure.

(5) Effects on Special Aquatic Sites

a) *Sanctuaries and Refuges*

There are no sanctuaries or refuges in the vicinity, so this topic is not applicable.

b) *Wetlands*

Brinson (1993) defines wetlands as the following:

“Those areas that are inundated or saturated at a frequency to support, and which normally do support, plants adapted to saturated and/or inundated conditions. They normally include swamps, bogs, marshes, and peatlands.”

The project site is in open freshwater lake habitat and highly trafficked public, municipal beaches. Since there are no identifiable wetland plants in the vicinity of the sites, this topic does not seem to be applicable.

c) *Mud Flats*

There are no mud flats in the vicinity of the site, so this topic is not applicable.

d) *Vegetated Shallows*

No vegetated shallows are in the vicinity of the site, so this topic is not applicable.

e) *Coral Reefs*

There are no coral reefs in freshwater environments, so this topic is not applicable.

f) *Riffle and Pool Complexes*

There are no riffle and pool complexes in the vicinity of the site, so this topic is not applicable.

(6) Threatened and Endangered Species

Federally-listed Threatened, Endangered, Proposed and Candidate Species were reviewed for the project area by the Chicago District. The following federally listed species and their critical habitats are identified by the U.S. Fish and Wildlife Service (USFWS) as occurring within Cook County and Lake County:

- Piping Plover (*Charadrius melodus*) – Endangered – Wide, open, sandy beaches with very little grass or other vegetation
- Eastern Massasauga (*Sistrurus catenatus*) – Candidate – Graminoid dominated plant communities (fens, sedge meadows, peat lands, wet prairies, open woodlands, and shrublands)
- Eastern prairie fringed orchid (*Platanthera leucophaea*) – Threatened – Mesic to wet prairies
- Hine’s Emerald Dragonfly (*Somatochlora hineana*) – Endangered – Spring fed wetlands, wet

meadows and marshes

- Karner Blue Butterfly (*Lycaeides Melissa samuelis*) – Endangered – Pine barrens and oak savannas on sandy soils and containing wild lupines (*Lupinus perennis*), the only known food plant of the larvae
- Mead’s milkweed (*Asclepias meadii*) – Threatened – Late successional tallgrass prairie, tallgrass prairie converted to hay meadow, and glades or barrens with thin soil
- Northern Long Eared Bat (*Myotis septentrionalis*) – Threatened – Hibernates in caves and mines – swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests and woods.
- Pitcher’s Thistle – (*Cirsium pitcheri*) – Threatened – Lakeshore dunes.
- Prairie Bush Clover – (*Lespedeza leptostachya*) – Threatened – Dry to mesic prairie with gravelly soil
- Rattlesnake-master Borer Moth (*Papaipema erynigii*) – Candidate – Undisturbed prairie and woodland openings that contain their only food plant, rattlesnake-master (*Eryngium yuccifolium*)
- Rufa Red Knot (*Calidris canutus rufa*) – Threatened – Coastal Areas or large wetland complexes
- Rusty Patched Bumble Bee (*Bombu affinis*) – Endangered – Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.

Waukegan Harbor is a man-made harbor built in the late 1880s. There is no critical habitat within the immediate area of the dredging portion of the project. It is determined that this dredging project would have “no effect” on listed species or proposed or designated critical habitat. The near-shore and open water placement area is not known to have critical habitat and it is determined that placement of material in this area will have “no effect” on listed species or proposed or designated critical habitat. Direct, on shore placement of material may interfere with Piping Plover and/or its critical habitat. These birds nest on wide, sand and cobble beaches with little vegetation usually between April and September. The major occurrences for the plover in Illinois is the area in and around Illinois Beach State Park including in 2009 when the first nest in 30 years was found. Other beach placement areas have the potential for Piping Plover occurrences, but the other placement areas are/can be popular municipal beaches and not typically conducive to plover nesting habits.

Additionally, the Rufa Red Knot is known to use Lake Michigan Coastal areas as stopover locations during their annual migrations between the Canadian Arctic and the Southern U.S., Caribbean, and South America. Typically, they can be found in the local area between May to September. The Pitcher’s Thistle is known to occur along Lake Michigan dunes of Illinois’ Lake and Cook counties and is sometimes associated with Piping Plover habitats. According to the Fish and Wildlife Service, Pitcher’s Thistle grows on open sand dunes and low open beach ridges, not directly on beaches, and as a result will likely not be impacted by direct on beach placement of dredged material.

State listed species identified by the ILDNR in a letter dated 07 September 2018 that occur within the known placement beach areas are the bearberry (*Arctostaphylos uva-ursi*), golden sedge (*Carex aurea*),

Kalm's St. John's wort (*Hypericum kalmianum*), little green sedge (*Carex viridula*), marram grass (*Ammophila breviligulata*), Richardson's rush (*Juncus alpinoarticulatus*), sea rocket (*Cakile edentula*), and seaside spurge (*Chamaesyce polygonifolia*). All of these species typically occur in areas set back from the immediate shoreline and should not be found in the potential on beach placement zone. Therefore, they are unlikely to be effected by on beach placement of dredged material assuming it is contained to the immediate shoreline area.

Other Wildlife

No other wildlife would be adversely impacted by the proposed maintenance dredging and placement project occurring in and around Waukegan Harbor.

(7) Actions Taken to Minimize Impacts

The proposed actions that will be taken to minimize the adverse impacts to the aquatic ecosystem and organisms are the same actions discussed earlier. There is the potential to include a pre-placement survey of the potential placement area(s) to ensure that any threatened or endangered species are not impacted. Although there may be minor and temporary adverse impacts to the aquatic ecosystem and organisms within the local work area, these actions should minimize any broader effects on the aquatic ecosystem and organisms outside the immediate vicinity of the work area.

F. Proposed Disposal Site Determinations

(1) Mixing Zone Determination

A mixing zone determination was completed as part of the evaluation of Approach Channel material in 2014. The Outer Harbor material is consistent with that found in the Approach Channel. The STFATE numerical mixing model was run with chemical data obtained from elutriate tests performed on dredged material from the Approach Channel. The model results show that water quality criteria was met at the boundaries of a mixing zone measuring 250 ft east-west by 1100 ft north-south. The mixing zone is smaller than the open water placement areas, therefore the proposed placement is understood to comply with the applicable water quality standards.

(2) Determination of Compliance with Applicable Water Quality Standards

None of the proposed materials are expected to be a source of toxic or persistent contamination, and the materials are not anticipated to cause any considerable long-term effects on, or changes to, the water chemistry or quality. Minor, short-term, and localized adverse impacts may occur within the immediate work area due to increases in the concentration of suspended solids and turbidity that are associated with the dredging activities. The Outer Harbor material is consistent with that in the Approach Channel, which is currently maintained under an existing 401 Water Quality Certification. In general, the activities are expected to comply with the applicable water quality standards and no violations are anticipated.

(3) Potential Effects on Human Use Characteristic

a) *Municipal and Private Water Supply*

According to the 2017 Illinois State Water Survey map of the distribution of water use in each Illinois municipality in consideration for material placement has a Lake Michigan water intake. Based on previous modeling, all water quality standards would be met within a mixing zone of 250 ft east-west

by 1100 ft north-south. Therefore, all in water placement areas will be located at least 1000 ft from a water intake. Additionally, the owner of the nearest intakes will be notified prior to the start of dredging each year.

b) *Recreational and Commercial Fisheries*

The dredging and placement activities that occur during the project will not have any effects on the operations of commercial fisheries because there are no commercial fisheries in the near shore vicinity of Waukegan Harbor or the anticipated municipal beaches. There may be very minor, temporary, and localized disruptions for recreational fishing in the immediate vicinity of the project due to the implementation of restrictions around the site to ensure public safety and secure the construction site and equipment.

c) *Water Related Recreation*

It is likely that access to Waukegan Harbor will be impacted during dredging operations as well as beach access. These restrictions could potentially result in some minor, temporary, and localized inconveniences related to harbor accessibility for commercial or recreational boat users in the immediate vicinity of the project either entering/exiting the harbor or in open water areas of the lake. However, the dredging operations are expected to be completed within a reasonably short duration, and the working area around the work barge(s) is expected to be small in relation to the harbor entrance channel and the near shore area of the lake. Additionally, there will likely be an impact to terrestrial access to beaches during placement of dredged material. These restrictions will also potentially result in some minor, temporary, and localized inconveniences at beaches to beach-goers, but should be short in duration.

d) *Aesthetics*

The proposed dredging operations will increase the navigable channel depth and reduce sediment levels in the advanced maintenance area outside of Waukegan Harbor. The work will also include placement of the dredged material at one or more locations between the Illinois/Wisconsin border and the northern border of the City of Chicago. Several placement locations have already been deemed acceptable, but others can be chosen pending they meet criteria outlined in the accompanying EA. The increased channel depth will allow for deeper draft vessels to utilize the harbor. Dredging of the maintenance area will decrease the deposition of sediment in the navigable channel, decreasing the need for frequent extensive dredging operations within the channel itself. Placement of the dredged material on municipal beaches or in near shore open water areas will provide needed nourishment to beaches that are experiencing erosion from the natural process of littoral drift.

During operations, it is likely that the aesthetics of the local area will occasionally be affected by the additional noise and operations of the vessels and heavy equipment while dredging is conducted. This may include the visual presence of barges, vessels, backhoes, and other construction equipment in the water or on the beach. Since the placement areas are at or near to public beaches, the activities may adversely impact the noise and visual aesthetics for these recreational areas. The active dredging and placement of sediment will likely cause short-term and temporary increases in the suspended solids and turbidity of the immediate area. These increases could reduce the aesthetic quality of the water by causing minor and temporary impacts to the clarity or color of the water in the local area. In general, the aesthetic effects are expected to be minor and temporary and should only impact those people and organisms in the immediate vicinity.

e) *Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves*

Several small municipal parks and beaches are located along Illinois' Lake Michigan coast line. While there are some private beaches or parks, many of them are open to public or at least current residents of the municipality that maintains these locations. The project is not anticipated to cause any permanent or long-term effects to the parks or lakefront, but as discussed above, there could be minor and temporary effects on the aesthetics of the local area. Areas that are national or historical monuments, national seashores, wilderness areas, research sites, and similar preserves will not have material placed on them and operations will likely not directly impact those locations if at all.

G. Determination of Cumulative Effects on the Aquatic Ecosystem

The Section 404(b)(1) Guidelines indicate that cumulative effects are the effects attributable to the collective effect of numerous individual dredged or fill material placement events. Although the impact from one particular, individual dredged or fill material placement event may only cause a minor effect on the aquatic ecosystem, numerous individual dredged or fill material placement events could cause a more substantial effect on the aquatic ecosystem.

The Waukegan Harbor Maintenance Dredging and Placement Project is a continuous maintenance project. These operations have historically occurred every year or two depending on sedimentation rates. If sedimentation was allowed to continually occur in the maintenance area and approach channel the natural littoral drift of sand along the coast will deposit several thousand cubic yards of material in the area. This deposition at the harbor will limit the amount that is deposited further south along the coast, effectively eliminating the replenishment process and increasing the near shore erosion rate at several beaches. Placement of sand from the harbor to areas to the south will return sand to the system and continue its movement along the coast, effectively maintaining the process of littoral drift and reducing the impact of erosion on those beaches.

There will likely be impacts to the aquatic community in the immediate area around dredging operations and around placement area(s). However, these disturbances are expected to be small, localized, and temporary. Given this and the overall size of the near shore area of Lake Michigan the aquatic ecosystem should quickly recover from the minor effects, and no long-term permanent, or cumulative effects are anticipated.

H. Determination of Secondary Effects on the Aquatic Ecosystem

According to the Section 404(b)(1) Guidelines, secondary effects are the effects associated with the placement of dredged or fill material, but they are not a direct result from the placement of dredged or fill material. For example, secondary effects may include the effects from activities to be conducted on fast land that was created by the placement of dredged or fill material.

Onshore placement of material may increase the beach width. The additional beach potentially created would be similar to the currently existing beach. Activities on the increased beach are not expected to cause any secondary effects on the aquatic ecosystem.

III. Findings of Compliance or Non-Compliance with the Restrictions on Discharge

A. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation

No adaptation of the Section 404(b)(1) guidelines was made for this evaluation.

B. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem

The “no action” alternative would be to cease dredging operations in and around Waukegan Harbor. This alternative is unacceptable since the Federal Government has determined that there is an economic benefit to the navigational maintenance activities and Congress has authorized and funded the actions. The “no deviation” alternative would be to dredge only the Approach Channel and Advanced Maintenance areas and place at the existing placement sites. This measure is also unacceptable since accumulation in the Outer Harbor would eventually close Waukegan Harbor to boat traffic, and there would be no sand available for beach nourishment at the additional areas. Including dredging of the Outer Harbor as part of the routine maintenance allows commercial and recreational navigation to continue, and the additional beach placement areas allow for sustaining additional beaches and beneficially using the clean sediment.

C. Compliance with Applicable State Water Quality Standards

The Outer Harbor material is consistent with the sediment found in the Approach Channel. All of the water quality parameters were less than the historical maximum value measured for the Approach Channel material. Extensive sampling has been conducted at the Approach Channel, and shows that Illinois water quality standards for the open waters of Lake Michigan are met with a mixing zone of 250 ft x 1100 ft. Because the sediment from the Approach Channel and Advanced Maintenance has not caused measurable water quality impacts and is suitable for placement, the Outer Harbor material is also expected to be the same. Only short-term and localized increases are likely to occur during placement.

D. Compliance with Clean Water, Endangered Species, National Historic Preservation and Marine Sanctuaries Acts

The project is expected to be in compliance with applicable Toxic Effluent Standards under Section 307 of the Clean Water Act; with the Endangered Species Act of 1973; with the National Historic Preservation Act of 1966; and with the Marine Protection, Research, and Sanctuaries Act of 1972 (not applicable because the proposed project is in Lake Michigan, and the Great Lakes are fresh water lakes that are not included in the Act).

E. Evaluation of Extent of Degradation of the Waters of the United States

(1) Significant Adverse Effects

The proposed fill activity is not expected to have any significant, long-term adverse impacts on recreational, aesthetic, and economic values; or on human health or welfare including municipal and private water supplies, recreational and commercial fisheries, plankton, fish, shellfish, wildlife communities (including community diversity, productivity, and stability), or special aquatic sites.

(2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems

It was indicated previously that the work activities may cause minor auditory disturbances to nekton in the vicinity of the work area, and some aquatic organisms that are slow or unable to move away quickly enough could be injured or killed during sediment removal or when the material is placed back into the water. However, these impacts are not considered to be significant because, compared

to the tremendous size of Lake Michigan, the work area is small. There might be some minor, temporary, and localized adverse impacts, but the proposed Waukegan Harbor Dredging Project is not anticipated to degrade or have any permanent or noticeable effects on the nekton or nekton habitat in Lake Michigan.

(3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity and Stability

Lake Michigan is enormous in comparison to the size of the project site, and no long-term adverse effects are expected on aquatic ecosystem diversity, productivity, or stability. Furthermore, it should be noted that the elevated levels of suspended solids would be expected to settle or dissipate within a relatively short time period, and the minor and temporary increases of suspended solids concentrations produced by dredging operations, as well as the placement operations, are expected to be considerably lower than the increased turbidity that would typically result from adverse weather conditions that produce high waves and strong currents.

F. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem

In order to prevent adverse aquatic ecosystem impacts during placement, material to be placed in open water is transported via bottom dump scow. Once the scow is in place, the bottom doors open and material is dropped directly down, minimizing resuspension. Material to be placed onshore is hydraulically pumped as a slurry into a temporary settling basin, which allows the solids to settle out and clear water to return to the lake.

G. On the Basis of the Guidelines, the Proposed Placement Sites for the Discharge of Fill Material is:

Specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize adverse effects on the aquatic ecosystem.

IV. **Bibliography**

Albert, D.A., D.A. Wilcox, J.W. Ingram, T.A. Thompson. 2005. Hydrogeomorphic Classification for Great Lakes Coastal Wetlands. *Journal of Great Lakes Res.* 31 (Supplement 1):129-146

Brinson, M. 1993. "A Hydrogeomorphic Classification for Wetlands." Prepared for the U.S. Army Corps of Engineers, Washington, D.C. Technical Report WRP-DE-4.

Government of Canada and USEPA. 1995. "The Great Lakes: An Environmental Atlas and Resources Book", Third Edition, USEPA Great Lakes National Program Office, Chicago, IL.

INHS 2019. Retrieved information at:

<https://www.inhs.illinois.edu/resources/inhsreports/spring-02/plankton/>

Kinzelman, Julie L. and Tony, Oxley. 2013. Beach Health Assessment for Waukegan Harbor South Beach Waukegan, Illinois.

Makarewicz, J.C., Bertram, P., and Lewis, T.W. 1998. "Changes in Phytoplankton Size-class Abundance and Species Composition Coinciding with Changes in Water Chemistry and Zooplankton Community Structure of Lake Michigan, 1983 to 1992." *Journal of Great Lakes Research*, International Association of Great Lakes Research, Vol. 24, Issue 3, pg. 637-657.

Scavia, D., Lang, G.A., and Kitchell, J.F. 1988. "Dynamics of Lake Michigan Plankton: a Model Evaluation of Nutrient Loading, Competition, and Predation." *Canadian Journal of Fisheries and Aquatic Sciences*. Vol. 45(1): 165-177, <https://doi.org/10.1139/f88-018>.

Stanford University. "Human Waste on Beach: Sticking to the Sand Might Not be Such Good, Clean, Fun for Beachgoers." *ScienceDaily*. ScienceDaily, 9 August 2007. <www.sciencedaily.com/releases/2007/08/070808101649.htm>.

U.S. Army Corps of Engineers. 2017. "Clean Water Act 404b(1) Contaminant Determination Report, Waukegan Outer Harbor, Waukegan Harbor, Waukegan, Illinois", USACE Chicago District, Chicago, IL.

U.S. Army Corps of Engineers. 2014. "Clean Water Act Section 404(b)(1) Contaminant Determination, Approach Channel and Advanced Maintenance Area, Waukegan Harbor", USACE Chicago District, Chicago, IL.

U.S. Army Corps of Engineers. 2013. "Great Lakes Update," Volume 188: 2012 Annual Summary, USACE, Detroit District, Detroit, MI.

Vanderploeg, H.A., Pothoven, S.A., Fahnenstiel, G.L., Cavaletto, J.F., Liebig, J.R., Stow, C.A., Nalepa, T.F., Madenjian, C.P., and Bunnell, D.B. 2012. "Seasonal Zooplankton Dynamics in Lake Michigan: Disentangling Impacts of Resource Limitation, Ecosystem Engineering, and Predation during a Critical Ecosystem Transition." *Journal of Great Lakes Research*, <http://dx.doi.org/10.1016/j.jglr.2012.02.005>.

Water Encyclopedia. 2016. Retrieved information from:

<http://www.waterencyclopedia.com/La-Mi/Life-in-Water.html>

Whitman, R.L. and Nevers, M.B. 2003. "Foresore Sand as a Source of *Escherichia coli* in Nearshore Water of a Lake Michigan Beach." *Applied and Environmental Microbiology*, Vol. 69, No. 9, p. 5555-5562.

V. **Figure**

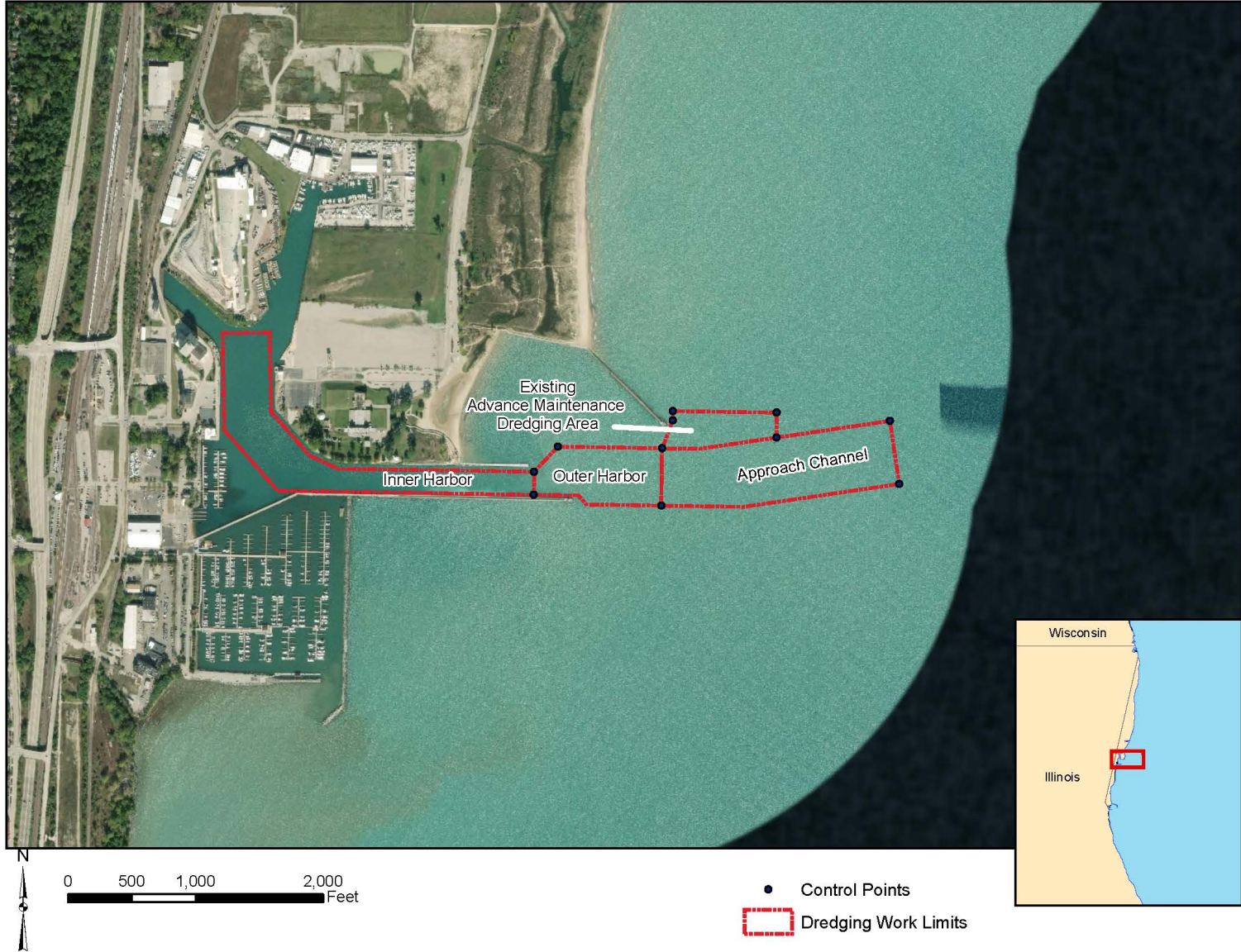


Figure 1: Waukegan Harbor dredging areas.



Figure 2: Existing open water placement area (Red Box). Identified potential placement areas (green dots) & zone of additional potential municipal beach placement areas (black bar) pending meeting placement criteria.