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Aquatic Nuisance Species Research Program

Invasive Species Costs to the USACE Navigation Business Line

A Demonstration Analysis in the Chicago District

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Abstract

Executive Order 13112 requires federal agencies to report invasive species costs to the National Invasive Species Counsel (NISC) annually. NISC then reports to Congress to increase awareness of invasive species and encourage inter-agency cooperation. Since 2005, the US Army Corps of Engineers (USACE) has provided an annual estimate for the Civil Works (CW) business lines.

Traditionally, USACE estimates have been informed by broad assumptions, as many invasive species costs are not itemized. This study sought to develop a method to improve these estimates.

A demonstration analysis was conducted for the Chicago District Navigation Business Line and was used to inform recommendations for a nation-wide analysis. The demonstration revealed invasive species-related costs represent about 0.2% (\$64,000) of the district's Navigation Business Line.

Invasive species costs are subject to many variables, such as the type, prevalence, and impact of invasive species, as well as the number and type of navigation projects. The Chicago District results are not presumed to be indicative of other districts' invasive species costs. Rather, the demonstration informed the development of an invasive species cost estimating method that can be adapted for each CW business line, as well as variations in invasive species and projects across geographic regions.

This report describes the demonstration analysis and presents a defensible framework for quantifying the costs of invasive species to the USACE CW program.

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Preface

This study was conducted for the Headquarters, U.S. Army Corps of Engineers (HQUSACE) under the Aquatic Nuisance Species Research Program (ANSRP) Project Number 22K26J/3C6042, “Invasive Species Costs to the USACE Navigation Business Line.” The program manager was Christine Vanzomeren.

The work was performed by the Ecological Resources Branch of the Ecosystem Evaluation and Engineering Division, US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL). At the time of publication, Mr. Joseph Minter was Chief (CEERD-EEE); Mr. Mark Farr was Chief (CEERD-EE); and Dr. Jen Seiter-Moser (CEERD-EZT) was the Technical Director for Civil Works Environmental Engineering and Sciences. The Deputy Director of ERDC-EL was Dr. Jack Davis and the Director was Dr. Edmond Russo.

Multiple USACE personnel contributed to the success of this study by participating in interviews, meetings, and reviews.

The Commander of ERDC was COL Christian Patterson, and the Director was Dr. David W. Pittman.

1 Introduction

1.1 Background

The National Invasive Species Council (NISC), under Executive Order 13112, conducts an annual request for estimated invasive species costs from all federal agencies for report to Congress. These expenditures are reported to encourage federal cooperation on the invasive species issues that benefit from an interagency approach, highlight, and promote interagency approaches addressing specific invasive species issues, and provide a comprehensive overview of invasive species issues and efforts across the Federal Government. Since 2005, the US Army Corps of Engineers (USACE) Invasive Species Leadership Team (ISLT) has provided an annual estimate of USACE invasive species expenditures to the NISC.

Estimating these costs to USACE programs is challenging because invasive species management is not a separate Civil Works (CW) business line. Therefore, related costs incurred within each business line (navigation, flood risk management, etc.) are often not itemized. To date, annual cost estimates reported to NISC have been informed by broad assumptions about invasive species issues across the nation and estimated as a percentage of the President's budget for each CW business line. The cost of impacts to the navigation business line is estimated as 5% of its annual budget for Operation and Maintenance (O&M) and is represented by the following formula.

$$Exp = [Nav - (R + A) \times 5\%] + (R + A)$$

Exp = invasive species expenditures reported for the navigation business line

Nav = navigation business line O&M budget as appropriated

R = RAG Program budget

A = ANSRP budget

There is much uncertainty surrounding the existing methods used to estimate invasive species impact costs to USACE business lines and their accuracy. The evaluation begins by selecting the navigation business line since this accounts for 42.7% of the annual Civil Works Budget (FY 2019),

and represents numerous designs, construction, and O&M activities across the enterprise. A comprehensive understanding of issues and costs related to invasive species requires the expertise of those involved in the execution of the business line. From a budgetary standpoint, it is difficult to delineate routine, day-to-day operations from those incorporating the prevention, management, and/or control of invasive species without the institutional knowledge of USACE O&M personnel. For example, a budget package includes the repair of lock gates on a navigation structure, but part of that repair requires the removal of invasive zebra mussels.

Despite these challenges, accurately estimating USACE expenditures on invasive species is critical for strategic budget planning and accurate reporting to NISC and Congress.

1.2 Objective(s)

This study aims to provide an accurate and repeatable estimate of invasive species expenditures for the USACE Navigation Business Line that could be scaled to a national level. This report documents a technically sound and defensible method to identify and estimate invasive species costs to USACE Business Lines. The objectives of this foundational study are to: (1) develop and conduct a demonstration analysis estimating the costs of invasive species to a subset of the USACE Navigation Business Line; and (2) establish a recommended method to be employed for a nation-wide analysis.

The scope of the analysis was estimating the cost of impacts due to invasive species on USACE's Navigation Business Line. Secondary or opportunity costs incurred by the navigation industry or other stakeholders were not estimated.

1.3 Approach

This foundational study is intended to present a demonstration analysis of costs associated with invasive species to the Chicago District Navigation Business Line with an expectation to be scaled and, if funded, adapted for a nation-wide assessment.

The study team collaborated with experts across the enterprise to gain an understanding of the available Navigation Business Line data (project types, locations, and annual funding amounts in the President's Budget);

invasive species that could impact navigation projects during their design, construction, operations, and maintenance; and the annual budget development process for navigation projects.

To begin the demonstration analysis, trial interviews were conducted with navigation facility personnel (e.g., lockmasters) to gain a sense of the level of awareness and impact of invasive species issues at project sites. Table 11 lists the personnel interviewed during this phase.

The interviews revealed the fundamental challenge with calculating invasive species expenditures using a survey. Each Project office receives O&M funds covering a breadth of activities keeping the facilities operational throughout the year. These tasks range widely from electric bills to protective clothing to grounds maintenance, but the invasive species management items are only separable from these normal day-to-day activities in a very few cases. Therefore, those interviewed had difficulty identifying and assigning value to invasive species management expenditures. Because of this confusion, it was decided that a survey would be ineffective at identifying invasive species costs.

It was determined a demonstration analysis would be conducted for the USACE Chicago District Navigation Business Line, which was chosen for the following reasons: (1) representation of projects on the inland waterway and Great Lakes navigation systems; (2) an array of invasive species issues in recent years (e.g., Silver and Bighead carp, zebra mussels, etc.); (3) expertise – the Chicago District has led invasive species studies (Chicago Sanitary and Ship Canal Electric Dispersal Barrier System, Great Lakes and Mississippi River Interbasin Study [GLMRIS], and GLMRIS–Brandon Road); and (4) the study team is familiar and has worked closely with Chicago District staff, projects, and invasive species issues. During the demonstration, responses received from Chicago District personnel were used to refine and improve the analysis framework.

2 Analysis Framework

2.1 Overview

Ensuring the full range of invasive species costs were captured, the study team was comprised of economists, engineers, biologists, and planners. Additionally, coordination with operation and maintenance staff including district leadership, facility operators, and program staff was required.

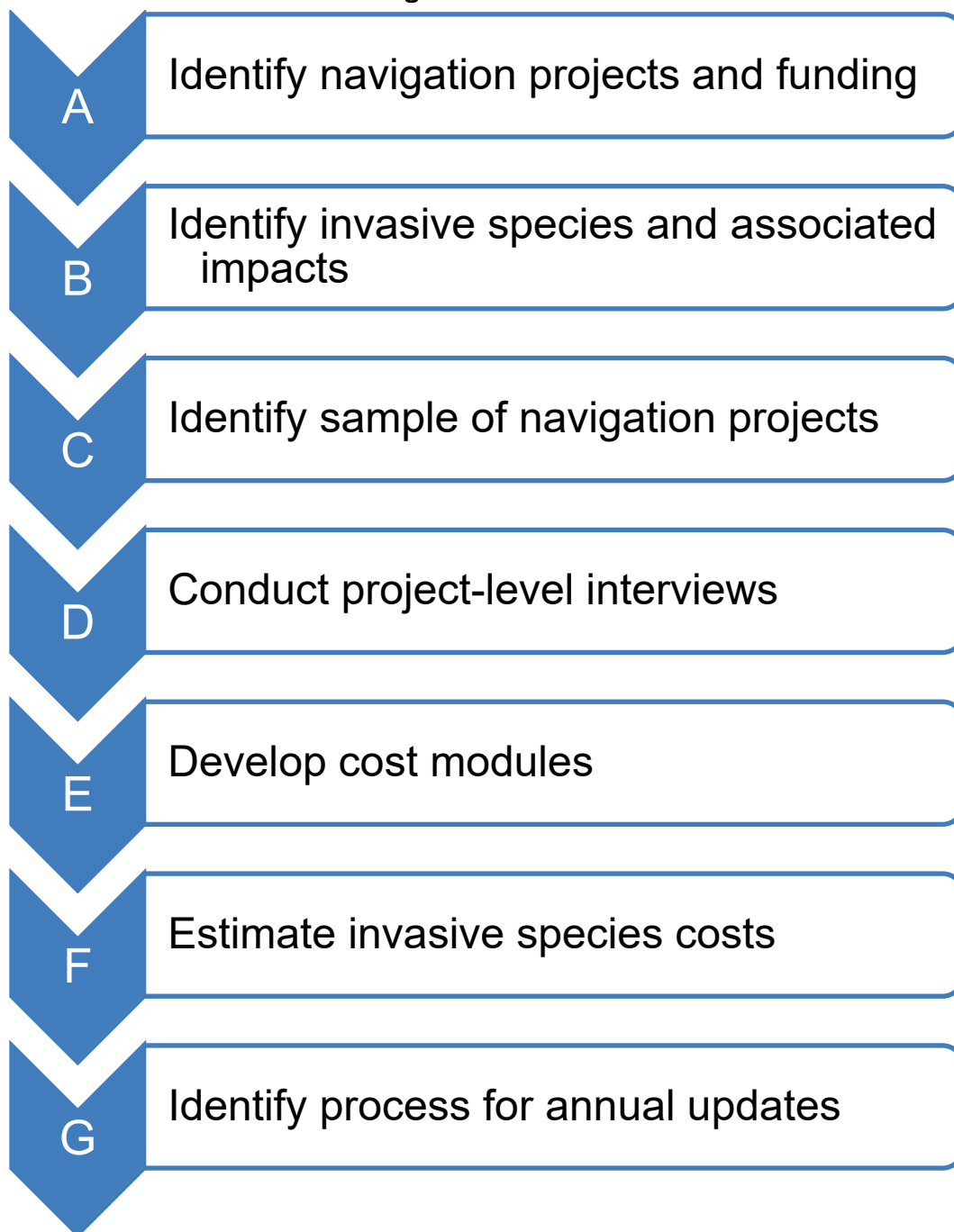
A seven-step analysis framework, denoted in Figure 1, was developed to estimate the cost of invasive species for a subset of the USACE Navigation Business Line (demonstration analysis). It also provides the basis from which a nation-wide analysis for each CW business line would be adapted. A brief overview of each step is provided below and is described in further detail within this report.

- **Step A – Identify navigation projects and funding.** Identify all navigation projects for the region under evaluation (study area) and the funding allocated to that project for the current (or recent) fiscal year, as identified in the Civil Works Budget (CWB) of the USACE. For details about Step A, refer to Chapter 3.
- **Step B – Identify invasive species and associated impacts.** Identify the known invasive species within the study area and the types of impacts they have (or could have) on a navigation project during any phase of the project life cycle. For details about Step B, refer to Chapter 4.
- **Step C – Identify sample of navigation projects.** Identify the subset of navigation projects within the study area for which interviews would be conducted with facility managers and other personnel knowledgeable about the projects. For details about Step C, refer to Chapter 5.
- **Step D – Conduct project-level interviews.** Conduct interviews with personnel (e.g., facility managers) knowledgeable about the project and any invasive species-related issues. For details about Step D, refer to Chapter 6.
- **Step E – Develop cost modules.** Develop cost modules for key cost estimating categories (e.g., labor, equipment, other/miscellaneous and floating plant), magnitudes (none, low, medium, and high), and dollar amounts to streamline the estimation of invasive species costs to the

- navigation projects within the study area. For details about Step E, refer to Chapter 7.
- **Step F – Estimate invasive species costs.** Extrapolate the sample of project-level cost estimates for all navigation projects within a given study area. This resulted in an estimate of the cost of invasive species to the Navigation Business Line within the study area and established the proportion (percentage) of the navigation budget (as identified in the CWB) attributed to invasive species-related issues. For details about Step F, refer to Chapter 8.
 - **Step G – Identify process for annual updates.** Identify a process for updating the estimated invasive species-related costs incurred by the Navigation Business Line within a study area. For details about Step G, refer to Chapter 9.

Figure 1 lays out this process graphically and will be referenced throughout this report.

Figure 1. Framework to estimate costs of invasive species to the Chicago District navigation business line.

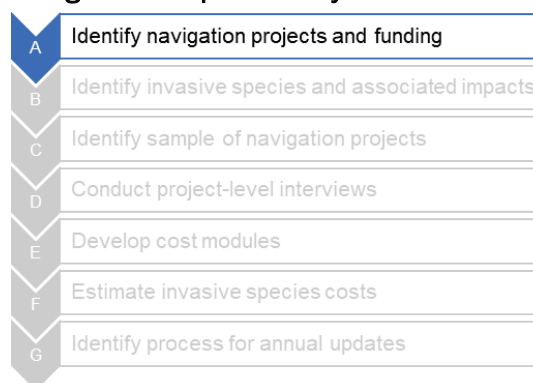


3 Identify Navigation Projects and Funding

3.1 Purpose

This step identified navigation projects for the region under evaluation (study area) and the funding allocated to those projects for the current (or recent) fiscal year, as identified in the Civil Works Budget (CWB) of the USACE.

Figure 2. Step A of analysis framework



3.2 Demonstration analysis data, methods, and key findings

3.2.1 Data

The CWB served as the key data source for this step of the evaluation, regardless of the study area under investigation (e.g., district-level, MSC-level, or all navigation projects).

The Fiscal Year 2019 Civil Works Budget of the U.S. Army Corps of Engineers (February 2019) establishes the scope of the CW program: “The President's Budget for Fiscal Year (FY) 2019 for the Civil Works program of the Army Corps of Engineers funds the development, management, restoration, and protection of the Nation's water, wetlands, and related resources, through studies, the construction, operation and maintenance of projects, the Corps regulatory program, the cleanup of certain sites contaminated as a result of the Nation's early atomic weapons development, and emergency response preparedness.”

Once the demonstration analysis was completed for the FY 2019 CWB amounts, a Microsoft Excel workbook was available at the onset. The Excel workbook presented CWB data in a manner than could be readily viewed, sorted, and filtered for project-level budgetary data. Each row in this

workbook represents a specific ‘Work Package ID’, while each column provides details of the work package.

Excel files used in this evaluation are not released outside the Department of the Army since they contain pre-decisional information. Publicly available CWB information is available by way of the annual CWB of the USACE (United States Department of the Army, Office of the Assistant Secretary of the Army (Civil Works) 2021).

3.2.2 Methods

The correct interpretation of the FY 2019 CWB data was critical for assuring the complete set of navigation projects for the Chicago District were identified. As such, the study team coordinated with the Civil Works Integration Division (CWID) of the Great Lakes and Ohio River Division Headquarters to learn how to interpret the dataset and was provided a data dictionary. In addition to the ‘MSC,’ ‘District,’ and ‘Program Code,’ the key CWB fields used to identify and organize the array of Chicago District navigation projects included in the FY 2019 CWB are provided in Table 1.

Table 1. Subset of Civil Works budget fields.

Field	Definition
Program Name	Name associated with the Program Code. In CW-IFD, it is a display-only data field. Based on the Program Code on which the package is created.
Appropriation	The abbreviation for the Appropriation Account with the commensurate appropriation symbol. The abbreviations are I (3121) - Investigations, C (3122) - Construction, OM (3123) - Operation & Maintenance, MRT-I (3112) - MR&T Investigations, MRT-C (3112) - MR&T Construction, MRT-OM (3112) - MR&T O&M, FCCE (3125), and FUSRAP (3130). Value is based on Program Code/ Appropriation combination on which the work package is created.
Primary Feature Code	Required for all Preconstruction Engineering and Design, Construction, and Operation & Maintenance work packages for which a Capability is entered. Select the Feature Code number which most closely relates to the predominant asset category for the work package.
State	The two-letter abbreviation for the primary state in which the study or project (Program Code) is located. Determined by the "Primary Congressional District" assigned on the P2 Project selected for the package.
Business Program	Abbreviation for Business Program. The Environment, Flood Risk Management, and Navigation Business Lines have Business Programs that distinguish between the types of projects.
NAV Budget Request Pres	The amount of funding for that package included in the President's Budget Request for the Navigation Business Line.

*Definitions have been truncated to exclude text that pertains to instructions to districts regarding how to populate the Microsoft Excel CWB template.

3.2.3 Key findings

The list of the 12 Chicago District navigation work packages included in the FY 2019 CWB are identified in Table 2.

Table 2. FY 2019 CWB for the Chicago District navigation business line.

Program Code	Program Name	Appropriation	Primary Feature Code	State	NAV Budget Request President
008218	LAKE MICHIGAN DIVERSION, IL	OM (3123)	(05) Locks	IL	\$851,000
076517	PROJECT CONDITION SURVEYS, IL	OM (3123)	(12) Navigation Ports and Harbors	IL	\$106,000
019560	WAUKEGAN HARBOR, IL	OM (3123)	(12) Navigation Ports and Harbors	IL	\$1,526,000
002250	BURNS WATERWAY HARBOR, IN	OM (3123)	(12) Navigation Ports and Harbors	IN	\$4,619,100
002410	CALUMET HARBOR AND RIVER, IL & IN	OM (3123)	(12) Navigation Ports and Harbors	IL	\$4,616,000
076518	PROJECT CONDITION SURVEYS, IN	OM (3123)	(12) Navigation Ports and Harbors	IN	\$190,000
045009	CHICAGO HARBOR, IL	OM (3123)	(12) Navigation Ports and Harbors	IL	\$3,583,000
018120	INDIANA HARBOR, IN	OM (3123)	(12) Navigation Ports and Harbors	IN	\$10,998,000
076555	PROJECT CONDITION SURVEYS, WI	OM (3123)	(12) Navigation Ports and Harbors	WI	\$320,000
011270	MILWAUKEE HARBOR, WI	OM (3123)	(10) Breakwaters and Seawalls	WI	\$1,070,000
011270	MILWAUKEE HARBOR, WI	OM (3123)	(12) Navigation Ports and Harbors	WI	\$1,500,000
006910	GREEN BAY HARBOR, WI	OM (3123)	(12) Navigation Ports and Harbors	WI	\$3,920,000
Total					\$33,299,100

The final row of Table 2 provides the total FY 2019 CWB for the 12 Chicago District navigation work packages. This information serves five primary purposes in the demonstration analysis, which are listed below.

1. Identifies the number of work packages (number of rows) and corresponding projects (denoted by unique program codes).
2. Provides an indication as to the relative magnitude of navigation projects in terms of funding, allowing for the study team's determination of which projects are likely to incur relatively higher invasive species related costs (Step C of analysis framework).
3. Informs the identification and selection of the subset of navigation projects for which project-level interviews will be conducted (Step C of analysis framework).
4. Provides a basis for gauging the reasonableness of invasive species related costs estimates by project (Step E of the analysis framework) (e.g., considering the CWB, the project team can ensure invasive species costs estimates are not unreasonably large in relation to each work package).
5. Serves as the denominator of a quotient used to estimate the proportion of invasive species related costs relative to the district's total navigation project costs (Step F of the analysis framework).

3.3 Nation-Wide analysis recommendations and considerations

When beginning the demonstration analysis, a good estimate for the total budget for the navigation business line was important. Upon review of the FY 2019 CWB for the Chicago District's Navigation Business Line data (Table 2) in collaboration with district personnel (Project Managers, Operations Managers, and Facility Managers), several important considerations (listed below) were revealed for using this data in the demonstration analysis as well as any subsequent nation-wide analysis.

- *Complexity and Extent of Data Sets:* The Microsoft Excel version of the CWB is not released outside of the Department of the Army. This pre-decisional dataset is highly detailed; the correct interpretation and use of this dataset and its nuances requires substantial coordination with Civil Works Integration Division (CWID) personnel.

The CWB, for any given fiscal year, is not representative of all Navigation Business Line expenditures. Projects not funded by way of the annual CWB may receive funds through the USACE Work Plan; a

comprehensive evaluation of all CW expenditures for a given year would require the acquisition of both data sets and a mastery of USACE's budgeting process.

- *Cyclical and Periodic Funding Requests:* Some projects are “cyclical” in nature (as opposed to annual), and therefore may not have a CWB request in a given fiscal year. In addition, the CWB for any given fiscal year fluctuates based on the work funded in that year. Consequently, the ‘major maintenance’ efforts would not be listed in the CWB every year.
- *Linking Invasive Species Cost Estimates to CWB Business Line Program Codes and Work Packages:* Estimating invasive species costs as a proportion (quotient) of the annual CWB and Work Plan requires all invasive species related costs (numerator of quotient) are linked to specific projects and work packages (denominator of quotient). This presumes the magnitude of invasive species-related costs are directly proportional to changes in the corresponding funding requests; this may not be the case if annual invasive species related costs are fixed amounts.

In addition, the type and number of work packages vary on an annual basis (e.g., to reflect the absence or inclusion of cyclical and major maintenance). Therefore, if the annual CWB and/or Work Plan used for the evaluation does not include a work package request (e.g., major maintenance), the associated invasive species costs would be absent in the numerator unless the analysis was fully updated on an annual basis to verify new/missing work packages.

- *Annual Reporting Requirements:* USACE must provide an estimate of invasive species costs to NISC on an annual basis; as such, methods to estimate annual, cyclical, and major maintenance costs should be efficient and streamlined.

After reviewing these considerations and evaluating methods to streamline the process, it is recommended the national-level evaluation not rely on estimating invasive species-related costs a proportion (percentage) of each USACE CWB business line. Much effort would be spent on estimating the total budget for the navigation business line rather than understanding the invasive species costs.

Therefore, future efforts should focus on identifying the projects within each Major Subordinate Command (MSC) and estimating the average annual cost of invasive species on those projects. Study teams should obtain a list of program codes (projects) by business line from the CWID for the MSC being evaluated. The program codes define the scope of all projects for all business lines within a given MSC without requiring a detailed understanding of the programmatic and budgetary process.

Key recommendations for Step A of the nation-wide analysis are presented in Table 3.

Table 3. Step A: Summary of recommendations for nation-wide analysis.

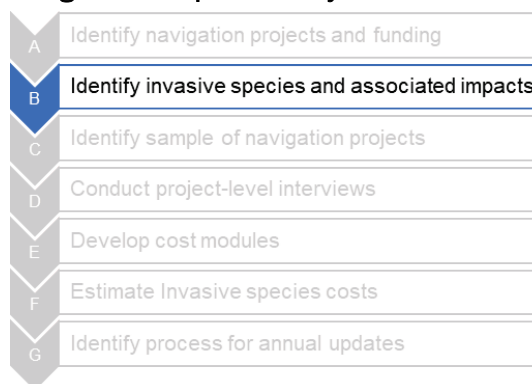
Study Area:	MSC-level
Business Lines	All evaluated concurrently
Project Information	Obtain program codes from MSC Civil Works Integration Division
Cost Estimating Approach	Estimate average annual costs to account for annual variations in the work packages. Estimate costs to business lines (as opposed to work packages).

4 Identify Invasive Species and Associated Impacts

4.1 Purpose

This step identified the known invasive species within the study area and the types of impacts they have (or could have) on a navigation project during any phase of the project life cycle.

Figure 3. Step B of analysis framework.



4.2 Demonstration analysis data, methods, and key findings

Study team members included Chicago District staff familiar with the impacts of invasive species on USACE navigation projects. The team sought to identify the invasive species and their potential impacts within Chicago District inland waterways and along the Lake Michigan shoreline. A list of invasive species was developed and confirmed with a Chicago District biologist and the Invasive Species Leadership Team (ISLT) members from the Mississippi Valley Division and Great Lakes and Ohio River Division.

To facilitate interviews, a fact sheet was developed identifying invasive species relevant to the Chicago District and the impacts of those on navigation infrastructure and operations. See “Supplemental Products” for an example fact sheet. The fact sheet contained the species’ common name, a picture, and listed questions formulated to insight reflection on possible invasive species management and control activities completed at Chicago District facilities. To ensure invasive species impacts were not overlooked, the fact sheet included a comprehensive question: “Do any

plants or animal pests at your facility require control/maintenance or cause damage to the facility?”

The fact sheet was used during project-level interviews (Step D of analysis framework) to inform operations managers and district personnel of these range of species and facilitate the discussion about their project-specific impacts. Table 14 contains more information about this fact sheet.

4.3 Nation-Wide analysis recommendations and considerations

It is recommended an MSC-specific list of invasive species and fact sheet be generated using the Natural Resource Management Assessment, MSC List of Priority Invasive Species, which is informed by the ISLT’s input to the Natural Resource Management Assessment Tool (USACE 2020).

The study team should consult with the ISLT to develop an MSC-specific invasive species fact sheet considering impacts to all USACE CW business lines. This fact sheet could be utilized during all project-level interviews within the given MSC and provide more efficient coordination with the ISLT.

ISLT members from each MSC are aware of invasive species impacts related to each business line within their respective regions. For divisions covering large geographic areas, certain invasive species may be prevalent in one district but not in others; therefore, the ISLT would also be consulted to determine which species are relevant to which districts. Since the target audience for the invasive species fact sheets are USACE operations managers and facility and construction management personnel, the scientific names of species would not be included in the fact sheets, and the list would be organized into categories of like species. For example, Bighead Carp, Silver Carp, and Black Carp would be grouped as “Invasive Carp.” Pictures should be added with questions focusing on the types of possible impacts the invasive species has on the project.

Possible invasive species related costs include management actions, time spent on coordination with invasive species researchers, preparation for congressional or vertical team visits, upward reporting, contract costs for invasive species removal on project sites, and providing facility tours if these actions are related to invasive species interests surrounding their facility. During initial coordination with the MSC, the fact sheet would be reviewed with MSC staff and/or the MSC’s ISLT representative to confirm

the list is complete, common names are those used in that area of the country, and the identified impacts are relevant to their projects.

The following questions should be added to subsequent MSC-specific Invasive Species Fact Sheets:

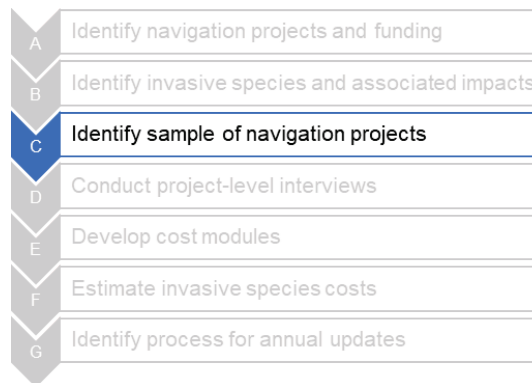
1. Have you or your staff been required to respond to requests for information related to invasive species activities?
2. Have you or your staff been required to give tours or host meetings at your facility or district in which the topic was invasive species?

5 Identify Sample of Navigation Projects

5.1 Purpose

This step identified the subset of navigation projects within the study area for which interviews would be conducted with facility managers and other personnel knowledgeable about the projects.

Figure 4. Step C of analysis framework.



5.2 Demonstration analysis data, methods, and key findings

Although, the Chicago District demonstration analysis included the 12-navigation business line work packages identified in the FY 2019 CWB (Table 2), it is important to note the boundaries were expanded in FY 2020. The Chicago District projects, and corresponding work packages not included in the FY 2019 CWB are excluded from the scope of the demonstration analysis (e.g., T.J. O'Brien Lock and Dam and Lockport Lock and Dam).

5.3 Nation-wide analysis recommendations and considerations

As described in Section 3.3, it is recommended a nation-wide analysis be delineated by MSC and address all USACE CW business lines. This approach would streamline coordination with the ISLT regarding region-specific invasive species impacts (as described in Section 4.3) and allow the study team to gain efficiencies during district-level coordination. A multi-business line analysis would allow the study team to maximize district level coordination at a single time, rather than re-engaging the district multiple times to support invasive species cost studies for each CW business line.

However, substantial resources would be required to conduct interviews with all facility managers within the entire region. As such, it is recommended a sampling strategy of projects by business line be developed to limit the interviews required. Key considerations for developing this strategy for each business line are presented below:

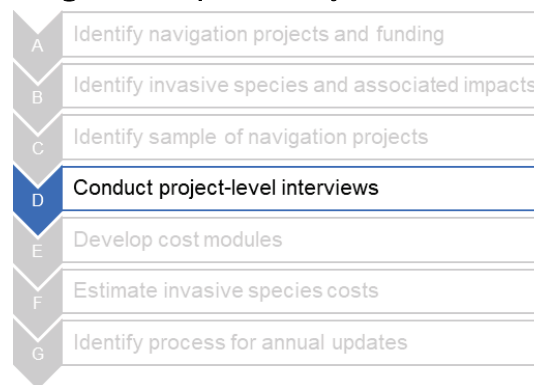
- For the Navigation Business Line, it may be helpful to identify which navigation projects are located on specific waterways/portions of the coast or within certain geographic areas of an MSC. It is recommended this effort be coordinated with the USACE Planning Center of Expertise for Inland Navigation and/or the USACE Deep Draft Planning Center of Expertise to assure the correct delineation of project by waterway or coast.
- Consider information from Step B (Identify Invasive Species and Associated Impacts) such as array of invasive species by type (e.g., plants, animals), geographic locations within the study area, and types of issues the species pose to projects in each business line.
- Consider consulting skilled personnel when developing a sampling strategy to ensure the sample projects included in the MSC-level assessment are representative of the MSC's project inventory and consider the range of invasive species impacts.

6 Conduct Project-Level Interviews

6.1 Purpose

This step consisted of conducting interviews with personnel (e.g., facility managers, project managers, biologists, planners, others) knowledgeable about the project and invasive species-related issues.

Figure 5. Step D of analysis framework.



6.2 Demonstration analysis data, methods, and key findings

Project-level interviews were conducted to obtain and document information about invasive species impacts at project sites to inform a simplified cost estimate (described in Chapter 7). The following methods were used to identify the appropriate Chicago District personnel and conduct the project-level interviews:

- *Coordination with district operations managers:* The study team coordinated with district operation managers to identify facility managers and other personnel knowledgeable about project sites and potential invasive species issues.
- *Notification to project personnel:* The study team requested the district's operations managers notify facility managers and other relevant personnel of the team's intent to schedule an interview.
- *Scheduling interviews:* A web meeting was scheduled with the operations managers and project-specific personnel. In the meeting invite, the study team identified the purpose of the interview, and attached the study fact sheet (Appendix B) and the Chicago District Invasive Species Fact Sheet (Appendix B).
- *Interview Procedures:* Interviews were structured using the following agenda: (a) introductions; (b) study overview; (c) overview of known

invasive species in the Chicago District vicinity; and (d) interview period. Meeting notes were subsequently distributed to all participants.

- *Introductions:* The study team introduced themselves and their role in the study process. Operations managers and project-specific personnel identified their position and role at the project site.
- *Study Overview:* An overview of the study's purpose was provided using the study fact sheet as a visual aid. The study team acknowledged that invasive species costs might be minimal, but the USACE portfolio has many navigation projects, and the total cost of impacts might be large once costs are compiled. It was also noted the results of this effort could inform USACE's and the nation's strategy to address invasive species management and control strategies.
- *Invasive Species Overview:* An overview of the Invasive Species Fact Sheet was provided and highlighted possible actions the facility may have taken in response to invasive species.
- *Interview:* The interview period was conversational in nature and was initiated by the study team's inquiry as to whether the invasive species and/or impacts identified in the fact sheet (or others) had been observed at the project site. Once the project facility manager and/or other project personnel provided their responses, the team asked follow-up questions to better understand the nature of invasive species management actions, equipment and labor needs, personnel responsible for conducting the actions (e.g., project personnel or maintenance fleets), and duration and reoccurrence of the management action(s).

After each interview, meeting notes were shared with personnel for their review and edit, if necessary.

Key findings regarding the interview process are presented below:

- Prior to the interviews, initial outreach of operations managers resulted in similar feedback from facility managers along the lines of "the project does not incur costs due to invasive species." However, the interviews revealed invasive species related actions and costs were incurred at several projects.
- Facility managers were unaware of work category codes that could be used to categorize invasive species management costs and were willing to utilize those codes, if requested.

- Operation and maintenance costs are separated into two groups: 1) routine operation and maintenance and 2) non-routine operation and maintenance. A subset of Chicago District facilities used maintenance crews from the Rock Island District during non-routine maintenance in the prior years (e.g., lock dewatering). Since these work packages were from prior years, and therefore not represented in the FY19 CWB, any associated invasive species costs (e.g., removal of zebra mussels from lock gates) were not included in the invasive species cost estimate for the Chicago District demonstration analysis.
- The interview process was adapted over the course of the demonstration. Initial interviews made use of a detailed template (Table 4) with detailed fields populated during the interview. However, a more conversational interview approach was found to be more efficient and effective, allowing the study team to gather more comprehensive information from the facility managers and eliminate time spent on assuring the appropriate portions of the template were populated. However, the template was still useful to provide ahead of time to prompt facility managers about the kind of information being sought by the study team. The template was also utilized to organize information from each interview and provided to the study team's cost engineer to inform the invasive species cost estimating process (described in Chapter 7).

6.3 Nation-wide analysis recommendations and considerations

The following are the recommendations and considerations for completing a nation-wide analysis using the interview methods utilized during the Chicago District demonstration.

- *Visual Aids:* Develop an MSC-specific invasive species fact sheet.
- *Coordination with Managers:* To identify the appropriate facility managers and project personnel, coordinate with district managers for names of project personnel with working knowledge of project operations, maintenance fleets within the jurisdiction of the division, and planning and construction projects that may be impacted by invasive species. Request that relevant personnel be notified of the upcoming request for an interview and the subject of the interview.
- *Interview Preparation:* Coordinate a mutually convenient time and date with the interviewee and the study team. Having a diverse interview panel (study team) helps ensure the interview is comprehensive. Send meeting invitations and describe the purpose of

- the interview in the invite. Attach the study and invasive species fact sheets.
- Summarizing Interview Information:** Consider using a Microsoft Excel interview template, like the one shown in Table 4, to summarize interview information and identify file names of supporting documentation provided by the interviewees. If multiple species issues exist at a single project, a single column should be used for each species-issue combination. Consider attaching the template to the web meeting invitation to serve as a brainstorming tool for interviewees. This template may be populated with notes during the interview without regard as to whether the information is noted in the appropriate field, as the purpose of the interview is to gain knowledge and capture the information. After the interview has concluded, the study team should edit the information for length and clarity. This summary should be provided to the interviewees to confirm it accurately characterizes the information relayed during interview.

Table 4. Interview summary template.

Project Name	
Species (Common Name)	
Appropriation	
Facility Manager/Project Point of Contact	
Interview Notes (File Name)	
Supporting Materials Provided? (If yes, provide file name)	
Year	
Project Issue Summary	
Activity & Cost Summary (Briefly describe the actions taken to address the issue described above)	
Frequency of Activity (weekly, monthly, annually)	

- Conducting Interviews:** Conduct the interviews for the sample set of projects; refer to Section 6.2 for general tips on completing these. Document if facility managers identified project support from maintenance fleets, and whether these fleets incurred additional costs due to invasive species. Additional interviews with the maintenance fleet should be conducted as needed.

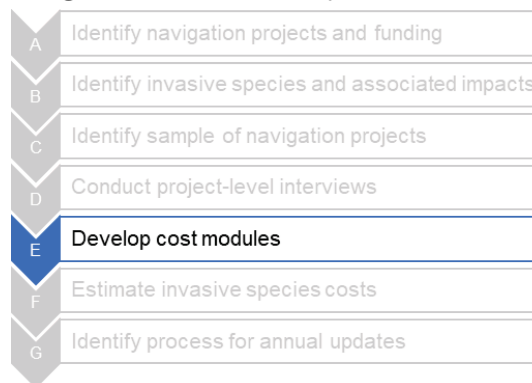
During the Chicago District demonstration analysis, some facility managers began discussing their projects' invasive species response actions prior to the study team finishing the overview of the study and discussion related to invasive species. Allow the facility managers and relevant staff to talk freely. After they have completed sharing information, consider reviewing the invasive species fact sheet to ensure all invasive species efforts are identified.

7 Develop Cost Modules

7.1 Purpose

This step develops cost modules for key cost estimating categories (e.g., labor, equipment, other/miscellaneous and floating plant), magnitudes (none, low, medium, and high) and dollar amounts to streamline the estimation of invasive species costs to the Chicago District Navigation Business Line and allow cost estimates to be generated during interviews with relevant staff.

Figure 6. Step E of analysis framework.



7.2 Demonstration analysis data, methods, and key findings

7.2.1 Data

The FY 2019 CWB comprised 11 program codes for the Chicago District, one of which had multiple Feature Codes (Milwaukee Harbor, WI). Interviews conducted with facility managers (Step D) revealed the presence of up to three invasive species per project site. The impacts (e.g., responses and costs) associated with these varied by project site. Each type of impact per specie was individually documented.

Detailed cost estimates were developed for several site-specific invasive species management actions identified during the project-level interviews (Step D). This provided an indication of the range of invasive species related costs within the Chicago District study area.

7.2.2 Methods

While a detailed cost estimate for all combinations of projects and invasive species could be readily developed for a limited set of combinations for the demonstration analysis, this approach would be inefficient for application at the MSC level (e.g., the FY 2019 CWB for Great Lakes and Ohio River Division (LRD) comprises 601 work packages). To streamline the cost estimating process for larger study areas, ‘cost modules’ were developed to reflect the following primary cost categories: (1) labor; (2) equipment; (3) other/subcontract; and (4) floating plant and repair crew (applicable to major maintenance work). The labor, equipment, and other/subcontract cost modules were further defined by a range of funding amounts (low, medium, high, and none) with each category representing a varying degree of resource needs. Funding amounts required for the floating plant and repair crew is scaled based on the estimated increase in number of days a floating plant or repair crew would be on-site due to invasive species related issues (e.g., scraping zebra mussels off lock gates prior to conducting maintenance).

7.2.3 Key findings

The cost modules are presented in Tables 5 – 8. Note, while Table 8 only shows four different durations (number of days) for the floating plant and repair crew module, this module can be scaled to any number of days. Refer to Appendix A – Cost Modules for further details about the data and methods used to develop each cost module.

Table 5. Labor cost module (FY 2019 price level).

Magnitude	Amount	Description
Low	\$3,800	USACE personnel - 1 person for 1 week
Medium	\$26,400	USACE Crew of 2 to 4 people for 2 weeks
High	\$70,400	USACE Crew of 4 people for 4 weeks

Table 6. Equipment cost module (FY 2019 price level).

Magnitude	Amount	Description
Low	\$400	Minimal equip. for 1-week period (ATV, pickup truck, etc.)
Medium	\$8,600	2 weeks of equip. (small crane, loader, skid steer, etc.)
High	\$29,300	4 weeks of equip. (larger crane, loader, skid steer, water blaster, generator, etc.)

Table 7. Other/subcontract cost module (FY 2019 price level).

Magnitude	Amount	Description
Low	\$500	Minimal cost, debris removal, misc. supplies
Medium	\$2,500	Moderate cost including dumpsters, subcontractors, etc.
High	\$10,000	Extensive use of subcontractor work

Table 8. Floating plant and repair crew cost module (FY 2019 price level).

Magnitude (Days)	Amount	Description
1	\$40,000	Estimated at \$40K/day.
10	\$400,000	Estimated at \$40K/day.
20	\$800,000	Estimated at \$40K/day.
30	\$1,200,000	Estimated at \$40K/day.

Determining the accuracy of the cost modules was completed by comparing the costs developed to detailed invasive species costs estimates for specific project sites using a modular approach.

Table 9 compares the results of the invasive species cost estimating approaches (site-specific and modular) at several Chicago District navigation projects (regardless of if they were captured in the FY 2019 CWB). Site-specific cost estimates ranged from \$750 (mute swans at Indiana Harbor, IN) to \$301,300 (Asian Carp at Starved Rock Lock and Dam). Meanwhile, modular cost estimates ranged from \$3,800 (mute swans at IN Harbor, IN) to \$345,700 (Asian Carp at Starved Rock Lock and Dam).

The modular cost estimating approach overestimated the costs of invasive species at all projects, except for phragmites at Indiana Harbor, IN which was underestimated by 4%. The greatest overestimation of invasive species

costs occurred for those imposing relatively low costs to projects. For example, while the site-specific estimate for the cost of mute swans at IN Harbor was \$705, the modular cost estimate was \$3,800 (overestimated by 407% or \$3,050); therefore, while the relative difference (percentage) between cost estimates was substantial, the actual difference (dollar value) was not considerable.

The greatest site-specific invasive species costs were incurred by major maintenance of the Chicago Harbor Lock (\$118,800 for Quagga Mussel removal and disposal) and Starved Rock Lock and Dam (\$301,300). Corresponding modular cost estimates were \$117,500 (overestimation of \$5,700 or 5%) and \$345,700 (overestimation of \$44,400 or 15%), respectively. As such, the cost modules more accurately reflected the site-specific cost estimating approach for invasive species imposing relatively higher costs to projects.

Table 9. Comparison of site-specific and modular invasive species cost estimates for Chicago District facilities (2019 Prices).

Project	Invasive Species	Site-Specific Cost Estimate	Modular Estimate	Difference	% Difference
Chicago Lock (During Major Maintenance)	Quagga Mussel	\$111,800	\$117,500	\$5,700	5%
Indiana Harbor, IN	Phragmites - Issue 1	\$28,500	\$27,300	-\$1,200	-4%
Indiana Harbor, IN	Phragmites - Issue 2	\$19,100	\$27,300	\$8,200	43%
Indiana Harbor, IN	Mute Swans	\$750	\$3,800	\$3,050	407%
Lockport Lock and Dam	Canadian Bull Thistle	\$2,000	\$3,800	\$1,800	90%
Milwaukee Harbor CDF	Phragmites	\$3,300	\$4,700	\$1,400	42%
Kewaunee Harbor CDF	Phragmites	\$3,300	\$4,700	\$1,400	42%
Manitowoc Harbor CDF	Phragmites	\$3,300	\$4,700	\$1,400	42%
Starved Rock Lock and Dam* (During Major Maintenance)	Invasive Carp	\$301,300	\$345,700	\$44,400	15%
Total (All Projects & Invasive Species)		\$473,350	\$539,500	\$66,150	12%

* Although this facility is outside Chicago District boundaries, the study team learned of these impacts while completing the demonstration. The team included this entry to demonstrate invasive species costs can be significant.

7.3 Nation-wide analysis recommendations and considerations

Using cost estimating modules offers a more efficient alternative to developing a detailed estimate for project-level invasive species-related costs across the nation. The following considerations are presented to improve the accuracy of the modular cost estimating approach and implement this approach for larger study areas (MSC-level evaluations):

- **Cost Module Magnitudes (High, Medium, Low, None)** – As demonstrated by the Chicago District analysis, the greatest percentage difference between the cost estimating approaches was at Indiana Harbor, IN, for which the cost module approach associated with mute swans was 407% greater than the site-specific cost estimate; however, this difference did not correspond with a large dollar amount (\$3,050 in 2019 prices). This is indicative that the cost module estimates may need to be refined or expanded upon (i.e., require additional magnitudes beyond low, medium, high, or none) to assure very low costs are neither considerably inflated nor ignored (assigned a ‘none’ labor magnitude).
- **Conversion of Periodic Costs to Average Annual Costs:** Some costs associated with invasive species are incurred during years in which major maintenance occurs at a given project site. To assure cost modules do not overestimate these costs in any given year, the frequency of major maintenance and associated invasive species costs should be used to develop an average annual estimate.
- **Linking Cost Modules to Project-Level Issues:** The study team utilized project-level interview responses to inform the development of the labor, equipment, other/subcontract, and floating plant and repair crew cost modules. After these modules were developed, the interview notes were used to select the appropriate cost assumptions applicable to each Chicago District project-invasive species combination to complete the module-based estimate.

To maximize the efficiency of cost module allocation, project-level interviews conducted for future study efforts should be structured in a manner allowing for facility managers and other appropriate personnel to participate in selections of cost module magnitudes (high, medium, low, none, and/or number of floating plant or repair crew days) for the project. This would serve to capitalize on the knowledge of facility managers and relevant personnel in the cost estimating process, allow interviewees to view results and provide feedback of the estimated total cost associated

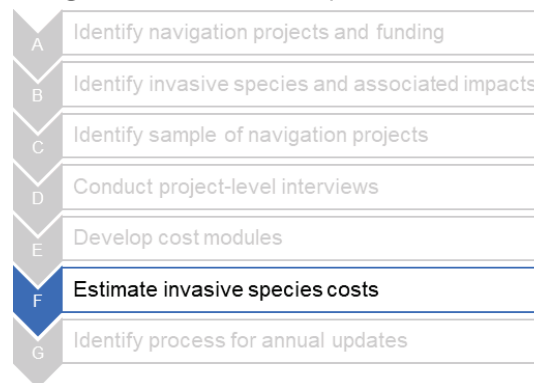
with a given invasive species a, and gain study efficiencies by completing the cost analysis during the interview verses delaying this step. Delaying would require the team to refresh their recollection of the interview by referring to meeting notes and consulting with other team members.

8 Estimate Invasive Species Costs

8.1 Purpose

This step extrapolates the sample of project-level cost estimates to all navigation projects within a given study area. This results in an estimate of the costs of invasive species to the Navigation Business Line within the study area and establishes the proportion (percentage) of the navigation budget (as identified in the CWB) attributed to invasive species-related issues.

Figure 7. Step F of analysis framework.



8.2 Demonstration analysis data, methods, and key findings

A simple Excel spreadsheet was used to capture the cost of invasive species to the CWB. This links the CWB data with interview data gathered throughout the analysis, as shown in Figures 8 – 10. Due to the Chicago navigation budget being relatively small, the team was able to match all interview responses to every navigation line item in the CWB for the Chicago District.

The FY 2019 CWB indicated the Chicago District was budgeted \$33,299,100 for navigation projects, all of which was for Operation and Maintenance. Of that total, an estimated 0.19% was used to address the impacts of invasive species. The most common invasive species addressed was phragmites, which accounted for 94% of the expenditures.

Table 10. LRC FY 2019 cost to navigation.

Appropriation	Budget	Estimated AA Invasive Species Costs	
		Total (\$)	% of Appropriation Total
C (3122)	\$ -	\$ -	0.00%
I (3121)	\$ -	\$ -	0.00%
OM (3123)	\$ 33,299,100	\$ 64,000	0.19%
Total	\$ 33,299,100	\$ 64,000	0.19%

Table 11. Invasive species costs to civil works budget.

Project ID	Program Code	Program Name	Appropriation	District	Primary Feature Code	State	NAV Budget Request President	Invasive Species List Select From Dropdown Menu	NISC Category Select From Dropdown Menu	Labor Level of Effort	Labor Cost	Equipment Level of Usage	Equipment Cost	Other / Misc Level of Usage	Other / Misc Cost	Total Annual Maint.	Total Non-Annual Maint.	Total	Occurrence In Year(s)	% of FY19 CWB	
1068218		LAKE MICHIGAN DIVERSION, IL	OM (3123)	LRC	(05) Locks	IL	\$ 851,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
2070517		PROJECT CONDITION SURVEYS, IL	OM (3123)	LRC	(12) Navigation Ports and Harbors	IL	\$ 106,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
3079560		MAUKEGAN HARBOR, IL	OM (3123)	LRC	(12) Navigation Ports and Harbors	IL	\$ 1,526,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
4072250		BURNS WATERWAY HARBOR, IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 4,619,100	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
5071619		SALUSTY HARBOR AND RIVER, IL & IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 4,616,000	Phragmites / Seed Banks	Control and Management	Low	\$ 3,800	Low	\$ 400	\$ -	None	\$ -	\$ 4,200	\$ -	4,200	1	0.06%
6076518		PROJECT CONDITION SURVEYS, IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 190,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
7045009		CHICAGO HARBOR, IL	OM (3123)	LRC	(12) Navigation Ports and Harbors	IL	\$ 3,383,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
80718120		INDIANA HARBOR, IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 10,968,000	Phragmites / Seed Banks	Control and Management	Medium	\$ 26,400	Low	\$ 400	\$ 500	Low	\$ 27,300	\$ -	27,300	1	0.25%	
80718120		INDIANA HARBOR, IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 26,400	Phragmites / Seed Banks	Control and Management	Low	\$ 3,800	Low	\$ 400	\$ 500	Low	\$ 27,300	\$ -	27,300	1	0.25%	
80718120		INDIANA HARBOR, IN	OM (3123)	LRC	(12) Navigation Ports and Harbors	IN	\$ 3,800	Phragmites / Seed Banks	Control and Management	Low	\$ -	None	\$ -	\$ 3,800	None	\$ -	\$ 3,800	\$ -	3,800	1	0.03%
90776555		PROJECT CONDITION SURVEYS, WI	OM (3123)	LRC	(12) Navigation Ports and Harbors	WI	\$ 320,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
10071270		MILWAUKEE HARBOR, WI	OM (3123)	LRC	(10) Breakwaters and Seawalls	WI	\$ 1,070,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
11071270		MILWAUKEE HARBOR, WI	OM (3123)	LRC	(12) Navigation Ports and Harbors	WI	\$ 1,500,000	Phragmites / Seed Banks	Control and Management	Low	\$ 3,800	Low	\$ 400	\$ 500	Low	\$ 1,400	\$ -	1,400	3	0.09%	
12006910		GREEN BAY HARBOR, WI	OM (3123)	LRC	(12) Navigation Ports and Harbors	WI	\$ 3,920,000	None	None	None	\$ -	None	\$ -	None	\$ -	\$ -	\$ -	\$ -	-	0	0.00%
Totals											\$ 64,200	\$ 1,600	\$ -	\$ 1,000	\$ -	\$ 62,800	\$ 1,400	\$ 64,000		0.19%	

Table 12. LRC FY 2019 invasive species costs.

Invasive Species	Cost
Asian Carp (Silver, Bighead, Black, Common)	\$ -
Rat	\$ -
Bug pests (i.e. American Cockroach)	\$ -
Quagga / Zebra Mussel	\$ -
Phragmites / Seed Banks	\$ 60,200
Purple Loosestrife	\$ -
Monk Parakeet	\$ -
Eurasian watermilfoil	\$ -
Hydrilla	\$ -
Tree of heaven	\$ -
Mute Swans	\$ 3,800
Total	\$ 64,000

- Table 10 breaks down the costs to navigation based on what funding stream they are, i.e., construction, investigations, operation, and maintenance. This table demonstrates that for the LRC analysis, all costs are in the operations and maintenance (O&M) category.
- Table 11 provides the full accounting for each project based on costs derived from the cost module. The level of effort directly correlates to the cost module and is what determines the monetary cost assigned to each cost category, i.e., Labor, Equipment, Misc/Other. The costs are provided as an annual number, which requires each action be assigned an occurrence. For example, does the action occur once a year, or some other duration.
- Table 12 categorizes costs based on the invasive species causing the impact at each project. While there are multiple invasive species in the LRC area of interest, not all species have an impact on the navigation projects. As noted in Figure 10, Phragmites/Seed banks are the primary source of impact.

8.3 Nation-wide analysis recommendations and considerations

8.3.1 Business line considerations

It is important for the study team to recognize some projects related to navigation may not be funded out of the navigation business line and related invasive species costs will be captured under other business lines. For example, the Chicago Sanitary and Ship Canal Dispersal Barrier, located within the navigation channel, is funded under the environmental business line at \$18,920,000 for FY 2019. The entire cost of this project is an invasive species cost, but not accounted for in this analysis because it does not fall under the navigation business line funding.

8.3.2 Estimated cost considerations

This analysis used a cost estimation strategy to determine the impact costs on navigation projects from the invasive species as discussed in Chapter 7. These costs are estimates using the costing module developed for this purpose. Extending this analysis to include navigation projects from around the nation would require further updates to the cost module to capture the regional cost differences.

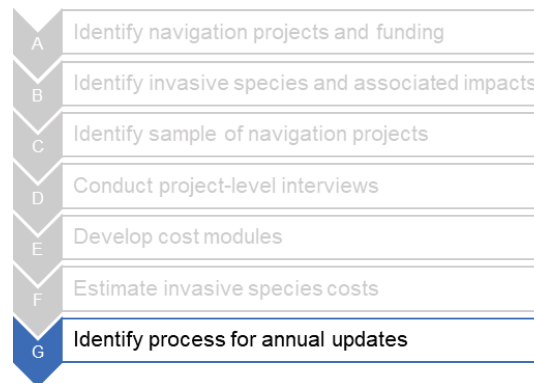
In some cases, actual costs may differ from the estimated cost; however, using this approach is a more efficient method. Based on the number of navigation projects and the results of this demonstration analysis, using a cost module approach toward estimating costs is an improvement to the current method and is a reasonable method for estimating invasive species costs throughout the nation. A comparison of the cost module to actual costed impacts is discussed further in Chapter 7.

9 Identify Process for Annual Updates

9.1 Purpose

This step identifies a process for updating the estimated proportion (percentage) of the CWB Navigation Business Line attributed to invasive species-related costs within a study area.

Figure 8. Step G of analysis framework.



9.2 Demonstration analysis data, methods, and key findings

The Chicago District is subordinate to the LRD. The data, methods, and key findings from the Chicago District demonstration analysis will be incorporated in future efforts to estimate the costs of invasive species to the LRD Navigation Business Line. Recommendations for incorporating and updating information from each step (A-F) of the Chicago District demonstration for inclusion in the LRD-wide evaluation are provided below.

- **Step A: Identify Navigation Projects and Funding** – This demonstration analysis only included projects represented in the FY 2019 CWB. Modifications to the district boundaries in FY 2020 resulted in the transition of several projects from the Rock Island District, Detroit District, and Louisville District to the Chicago District. The study team should verify the project listing for each district is accurate. Utilization of an updated version of the CWB for the LRD-wide evaluation would facilitate this effort.
- **Step B: Identify Invasive Species and Associated Impacts** Once the sample-set of LRD projects is identified, the study team should review the fact sheet to assess whether additional species should be included.

- **Step C: Identify Sample of Navigation Projects** – Interviews were already conducted for all Chicago District Navigation projects (pre- and post-district boundary change). Notes from all interviewees should be reviewed and used to inform the LRD-wide evaluation.
- **Step D: Conduct Project-Level Interviews** – Identify personnel and conduct interviews in the other LRD Districts, using the interviewed personnel from Chicago District to determine those in other Districts. Any additional interviews for Chicago District personnel should be limited to those required to validate whether the district's navigation project list is accurate.
- **Step E: Develop Cost Modules** – The Chicago District cost modules were developed to be sufficiently comprehensive and generic so applicable to a range of study areas and invasive species related costs with minimal modifications. As such, these cost modules should be reviewed to confirm their appropriateness for application to the LRD study region, and if not applicable, modified. Dollar values for module inputs should be updated reflecting the price level of corresponding CWB used to develop the LRD evaluation.
- **Step G: Estimate Invasive Species Costs** – Cost modules assigned to Chicago District projects should be updated to reflect any modifications required to assure their appropriateness for application to the LRD study area and any updates to the price levels of cost module inputs.

9.3 Nation-wide analysis recommendations and considerations

As described in Section 3.3, it is recommended the nation-wide analysis be delineated by MSC and address all CW business lines. Efforts to adapt the Chicago District demonstration analysis for use in an MSC-level evaluation should streamline the ISLT's annual invasive species cost estimating process. The initial effort to estimate the costs of invasive species to a given MSC is expected to require extensive data analysis and interviews. However, these results would be appropriate for use by the ISLT until the completion of a 'periodic update.'

The scope of periodic updates should reflect a level of detail required to assure estimates reported by the ISLT continue to be defensible. The scope of updates should be driven by changes in the key inputs and assumptions used to develop the cost estimates per MSC. These inputs and assumptions include:

- **Price Level** – The Chicago District demonstration analysis made use of the FY 2019 CWB. Therefore, the cost modules were also developed using FY 2019 price levels. Periodic updates should consider price level adjustments to capture the effects of inflation on cost estimates.
- **Change in the type or prevalence of invasive species** – The initial estimate of invasive species costs for each MSC would reflect best available information about the type and their prevalence within the study area. An update to the initial estimate may be required to reflect changes to the type or prevalence of invasive species within a given MSC.
- **Change in the types of invasive species impacts reported** – The initial estimate of invasive species costs for each MSC would reflect best available information about the types of invasive species-related impacts. Consultation with the ISLT would be required to determine whether large invasive species-related projects are being constructed or whether a notable increase in invasive species management costs has occurred in an area of the country. An update to the initial invasive species cost estimate may be required to address the newly impacted regions (MSCs).

Coordination with the ISLT should inform both the scope of periodic updates (updates to price level update and/or updates to assumptions) and frequency (e.g., price level updates annually, and updates to assumptions given new information about the type, prevalence, and impact of invasive species within a given MSC). Coordination with the ISLT would be required to identify such changes and initiate the request for study funds to conduct a periodic update.

10 Study Team, Support Personnel, and Peer Reviewers

Table 13. Study team.

Name	USACE Position and Organization
Courtney Chambers	Research Ecologist, ERDC Environmental Laboratory
Tara Whitsel	Research Biologist, ERDC Environmental Laboratory
Dena Abou-El-Seoud	Senior Economist, Great Lakes and Ohio River Division
Johnna Potthoff	Regional Technical Specialist for Great Lakes Plan Formulation, Chicago District
Greg Boudreaux	Economist, Chicago District
Celia Chagnovich	Environmental Engineer, Chicago District
David Druzicki	Senior Cost Engineer, Chicago District
John Cheek	Technical Manager, Inland Navigation Design Center
Jeffrey Stamper	Technical Manager, Inland Navigation Design Center
Steven Yates	Economist, Planning Center of Expertise for Inland Navigation

Table 14. Scoping interviewees.

Name	Position	USACE Division / Organization	USACE District / Office
Shamel Abou-El-Seoud	Former Chief, Construction, Operations, and Readiness	Great Lakes and Ohio River Division	Chicago District
Nick Barkowski	Fish Biologist	Great Lakes and Ohio River Division	Chicago District
Scott Cieniawski	Project Manager	U.S. EPA	Great Lake National Program Office
Mark Cornish	Supervisory Biologist, Program Management Division	Mississippi Valley Division	Rock Island District
Darrel Davis	Team Lead, Budget Development and Defense	Great Lakes and Ohio River Division	N/A
Christopher Dening	Project Manager	Great Lakes and Ohio River Division	Pittsburgh District
Carin Frank	Assistant District Counsel	Great Lakes and Ohio River Division	Chicago District

Name	Position	USACE Division / Organization	USACE District / Office
Tony Friona	Regional Working Group Co-lead, Great Lakes Restoration Initiative	Great Lakes and Ohio River Division / ERDC	N/A
Perry Jones	Lock Master, Brandon Road Lock and Dam	Mississippi Valley Division	Rock Island District
Chuck Shea	Project Manager, Electric Dispersal Barriers	Great Lakes and Ohio River Division	Chicago District
Gerald Snyder	Lockmaster, Dresden Island Lock and Dam	Mississippi Valley Division	Rock Island District

Table 15. Demonstration analysis interviewees.

Name	Position	Facility	Date of Interview
Damian Allen	Facility Manager, Indiana Harbor and Canal CDF	Indiana Harbor and Canal CDF	1/14/21
Paul Beck	Lockmaster, T.J. O'Brien Lock and Dam	T.J. O'Brien Lock and Dam	12/10/20
Brady Beckman	Supervisory Facility Operations Specialist, USACE Huntington District	LRD Regional Rivers Repair Fleet	2/2/21
Adam Borelli	Operations Project Manager, USACE Chicago District	Chicago Area CDF	12/14/20
Randall Eigenberger	Chief of Maintenance and Repair, USACE Chicago District	Milwaukee, Kewaunee, and Manitowoc Harbor CDFs	2/2/21
Zeke Escobedo	On-site USDA Contractor, Indiana Harbor and Canal CDF	Indiana Harbor and Canal CDF	1/14/21
Mike Fittanto	Project Engineer/Manager, Chicago Area CDF	Chicago Area CDF	12/14/20
Jeff Fuller	Hydraulic Engineer, USACE Chicago District	Lake Michigan Diversion	2/23/21
Brandon Hammel	General Maintenance Supervisor, USACE Rock Island District	LRD Regional Rivers Repair Fleet/MVR Illinois Waterway Project Office, Maintenance Section	2/2/21 and 1/25/21
Jeff MacDonald	Supervisory Civil Engineer, USACE Chicago District	IL, IN, and WI Project Condition Surveys, Burns Waterway	12/14/20 and 2/1/21

Name	Position	Facility	Date of Interview
		Harbor, Waukegan Harbor, Chicago Area CDF	
Chadwick Shaw	Engineering Technician, USACE Chicago District	Fox River Dams	2/1/21
Brandon Strickland	Lock and Dam Repair Supervisor, Lockport Lock and Dam	Lockport Lock and Dam	12/14/20
Scott Uhl	Chief of Maintenance, USACE Rock Island District	MVR Illinois Waterway Project Office, Maintenance Section	1/25/21
Selwyn (Tyrone) Valley	Lockmaster, Chicago Harbor Lock and Dam	Chicago Harbor Lock and Dam	12/15/20

Table 16. Peer reviewers.

Name	Position	USACE Organization
Damian Allen	Facility Manager, Indiana Harbor and Canal CDF	Chicago District
Paul Beck	Lockmaster, T.J. O'Brien Lock and Dam	Chicago District
Brady Beckman	Supervisory Facility Operations Specialist	Huntington District
Kelley Campbell	Programs Lead	South Pacific Division
Mark Cornish	Supervisory Biologist, Program Management Division Center of Expertise	Rock Island District
Jeremy Crossland	Land Use Program Manager	Headquarters
Kareem El-Naggar	Deputy Operations Chief /Navigation Business Line Manger	Great Lakes and Ohio River Division
Robert Germann	Program Manager, Inland Navigation / Flood Risk Management	South Atlantic Division
Jeffrey Stamper	Technical Manager	Rock Island District
Scott Uhl	Chief of Maintenance	Rock Island District

11 Supplemental Products

Several products were developed to facilitate the completion of the Chicago District demonstration analysis. An overview of these products is provided in Table 17 and examples of these products are found in Appendix B.

Table 17. Supplemental products.

Product	Overview	File Name
Study Fact Sheet (Appendix A)	This document provides an overview of the purpose and approach used for the study effort. This document was included as an attachment in the Microsoft Outlook meeting requests to interviewees. The study team provided an overview of the using the fact sheet at the onset of each interview to assure appropriate context was provided for the discussion.	Fact_Sheet_Invasive_Species_Cost_Study_Navigation_Demonstration.pdf
Chicago District Invasive Species Fact Sheet (Appendix B)	This document provides a list of species names and pictures of invasive species and includes questions related to types of possible impacts.	Fact_Sheet_Invasive_Species_Chicago_District.pdf
Project Issue Summary Matrix	This file contains summarized notes of the invasive species issues at each LRC project. It was compiled using notes from facility manager interviews in the style of the interview template introduced in Table 4.	LRC_Project_Issue_Summary.xlsx
Master Workbook	The workbook incorporates the cost module, invasive species list, and the interview responses to estimate cost.	LRC_Invasive_Species_Cost_Estimation_Master_Workbook.xlsx

References

US Department of the Army, Office of the Assistant Secretary of the Army (Civil Works). 2018. “*Fiscal Year 2019 Civil Works Budget of the U.S. Army Corps of Engineers.*” http://cdm16021.contentdm.oclc.org/utils/getfile/collection/p16021_coll6/id/2040

US Department of the Army, Office of the Assistant Secretary of the Army (Civil Works). 2021. “*U.S. Army Corps of Engineers Annual Civil Works Budget and Performance*” <https://www.usace.army.mil/missions/civil-works/budget/>

US Department of the Army. Updated August 2020. *Natural Resources Management Gateway*. Accessed May 14, 2021. <https://corpslakes.erdcdren.mil/employees/nrmassessment/tool.cfm>

Appendix A: Study Fact Sheet

USACE Invasive Species Cost Study: NAVIGATION BUSINESS LINE



- **Annual Reporting Requirement:** Executive Order 13112 requires all federal agencies to report invasive species costs to the National Invasive Species Counsel (NISC).
- **Problem:** Invasive species costs are not itemized but are incurred by each USACE mission.
- **Study Opportunity:** This navigation-focused study will include a demonstration analysis to 1) estimate invasive species costs and 2) document methods for a nationwide evaluation.
- **Study Payoff:** This foundational study will improve USACE's: (1) NISC reporting; (2) understanding of the burden invasive species impose on our mission; and (3) strategic planning.

Annual Reporting Requirement

- NISC compiles invasive species costs reported by federal agencies and reports these estimates to Congress.
- This effort provides an overview of invasive species issues and efforts across the federal government and encourages inter-agency cooperation.
- Since 2005, the USACE Invasive Species Leadership Team has provided an annual estimate of invasive species costs to Civil Works programs.

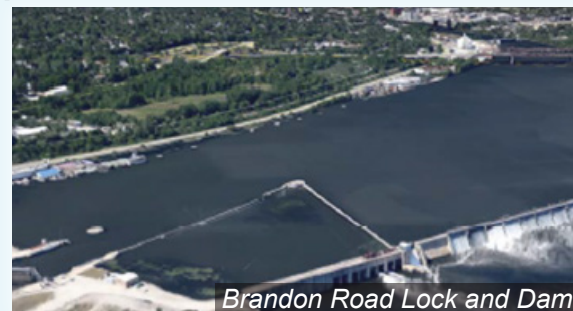
Challenges with Estimating Invasive Species Costs to USACE

- To date, USACE invasive species cost estimates have been informed by broad assumptions.
- Estimating invasive species costs to USACE programs is challenging because these costs are often not itemized.
- Understanding the costs invasive species have on the navigation program is important, as it represents about 40% of the annual Civil Works Budget.
- Improved cost estimates are critical for strategic planning and accurate reporting.

Navigation Study Overview

- Conduct demonstration analysis for a subset of the USACE Navigation Program.
 - Establish defensible method for nation-wide navigation analysis by February 2021.
 - Plan to initiate nation-wide analysis by 2022.
- Hydrilla verticillata

Location of a Possible Invasive Species Control Point



Brandon Road Lock and Dam

Example Invasive Species that Increase the Cost of USACE Navigation Mission



Zebra mussels



Bighead carp



Hydrilla verticillata

Invasive species are non-native species whose introduction does or is likely to cause economic or environmental harm, or harm to human health.






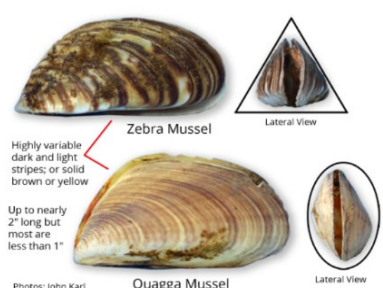



Proven Value Added: Hydropower Completed



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Chicago District

- A similar analysis was conducted for the USACE hydropower program.
- The effort concluded in 2020.
- Findings indicated prior invasive species costs were underestimated by 63%: estimate increased from \$2.6M/year to \$7M/year.

Appendix B: Chicago District Invasive Species Fact Sheet

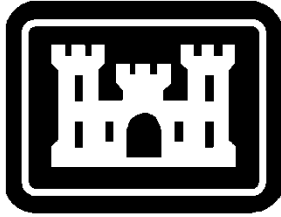
Invasive Species Overview		
Example	Common Name	Description of Possible Impacts to USACE Infrastructure or Operations
	Silver Carp (Asian Carp)	*Have been caught in lock filling/emptying pipes. Maintenance costs? *Staff time spent monitoring passing vessels for dead silver carp? *Staff time spent coordinating with Asian carp researchers? *Staff time spent coordinating tours with visitors/elected officials interested in Asian Carp control?
	Bighead Carp (Asian Carp)	*Have been caught in lock filling/emptying pipes. Maintenance costs? *Staff time spent coordinating with Asian carp researchers? *Staff time spent coordinating tours with visitors/elected officials interested in Asian Carp control?
	Common Carp	*Have been caught in lock filling/emptying pipes. Maintenance costs? *Staff time spent coordinating tours with visitors/elected officials interested in Asian Carp control? *Staff time spent at removing dead carp from around structures?
	Rat	*Chewed wires and damaged equipment/supplies? *Require extermination services? *Staff time spent addressing pest control? *Have staff seen rodents? Large - non native Small - most likely native
	Bug pests (i.e. Asian Lady Beetle, German Cockroach, etc.)	*Require pest extermination? *Require staff time to control? *Which pests?
	Quagga/Zebra Mussel	*Stick to lock gates, pumps, drainage pipes, etc. *Require clearing prior to maintenance/repair. *Staff/contract time required to address mussel removal.
	Phragmites/seed banks	*Staff time and supplies/equipment required to herbicide/mow project areas due to concerns about site visibility? Or control infestation? *Staff time and supplies/equipment required to manage vegetation on sediment management sites (e.g. CDF).
	Purple Loosestrife	*Staff time and supplies/equipment required to herbicide/mow project areas due to concerns about site visibility? Or control infestation? *Staff time and supplies/equipment required to manage vegetation on sediment management sites (e.g. CDF).
	Monk Parakeet	*Build huge stick nests around power lines. *Staff time spent or services procured to remove nests from power lines to reduce the likelihood of power outages caused by nests?

GENERAL QUESTION: Do any plants or animals pests at your facility require control/maintenance or cause damage to the facility?

Invasive Species Cost Categories (ISCC)	
ISCC	Description
Leadership & Coordination	Partner/coordinate with local, State, and Federal agencies and NGOs to manage invasive species at the project, regional and national levels.
Prevention	Actions to prevent the introduction and establishment of invasive species to reduce their impact on the environment, the economy, and health of the United States.
Early Detention and Rapid Response	Developing and enhancing the capacity to identify, report, and effectively respond to newly discovered and localized invasive species.
Control and Management	Containing and reducing the spread of invasive populations through management plan development; actions to eradicate, reduce, quarantine, or limit movement/transport of invasive species; maintenance actions required in response to invasive species impacts on equipment and infrastructure; and coordination with other agencies or groups for control efforts.
Restoration	Establishment of native, appropriate low-impact, non-native, or "transitional" species on sites to prevent recolonization of invasives.
Research	Development, testing, evaluation, and technology transfer for new or adapted biological, physical, chemical, or other control technologies for detection, control, and management of invasive species; development of risk assessment, establishment of research priorities and research program reviews; participation in field testing of new technologies.
Information Management	Input of invasive species information to OMBIL and to project GIS or other project databases.

Invasive species is a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human health

Appendix C: Cost Engineering Appendix and MII Report



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Invasive Species Costs to the USACE Navigation Program

Cost Engineering Appendix

March 10, 2021

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1.1	DEVELOPMENT OF COST MODULES	3
1.2	COST VALIDATION EXERCISE	3
1.3	FUTURE UPDATES	4
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3.1	MCACES ESTIMATE	4

1.0 Basis of Estimate

1.1 Development of Cost Modules

The development of the cost modules was based on the key cost drivers (e.g. labor, equipment, other/miscellaneous and floating plant). Typical items that were identified in the numerous interviews were estimated in detail using the latest MII estimating software.

In order to streamline the process and still maintain enough detail to provide a reasonable estimation of costs, four levels were thought to be adequate (none, low, medium and high) for the Cost Module. All costs are on an annual basis at FY19 price levels.

Labor

Labor costs are based on USACE personnel. An average charge rate of \$110/hour was used.

- Low – USACE personnel - 1 person for 1 week
- Medium - USACE Crew of 2 to 4 people for 2 weeks
- High - USACE Crew of 4 people for 4 weeks

Equipment

Equipment costs are based on USACE EP 1110-1-8 Volume 2 November 2018 Construction Equipment Ownership and Operating Expense Schedule. To determine the average equipment cost, several activities (removing phragmites, zebra mussels, etc.) were estimated using a variety of equipment for each task and an overall average was calculated.

- Low – Minimal equip. for 1 week period (typical equipment would include ATV, pickup truck, etc.)
- Medium – Moderate amount of equipment required for 2 weeks (typical equipment would include small crane, loader, skid steer, etc.)
- High - Large amount of equipment required for 4 weeks (typical equipment would include larger crane, loader, skid steer, water blaster, generator, etc.)

Other/Subcontractor

These costs are relatively low compared to the other items. Similar to the equipment costs, to determine the average costs, several activities (removing phragmites, zebra mussels, etc.) were estimated using a variety of material, disposal costs or subcontractor costs for each task and an overall average was calculated.

- Low – Minimal cost, debris removal, misc. supplies
- Medium – Moderate cost including dumpsters, disposal fees, subcontractors, etc.
- High - Extensive use of subcontractor work (other agencies, outside resources, etc.)

Floating Plant and Repair Crew

Due to the high cost of this item (\$40,000/day) a daily rate was used instead of a range to more accurately capture the estimated costs.

1.2 Cost Validation Exercise

The output of the Cost Module was checked against an estimate of actual costs. Unfortunately, no exact costs exist to use for validation but fairly detailed information was taken from the numerous interviews regarding crew sizes, equipment additional costs incurred, etc. and detailed cost estimates were developed to compare to the Cost Module output for the same items. As with any estimate the individual costs may vary considerably by individual items but the ultimate goal is to have the bottom line total be as accurate as possible.

1.3 Future Updates

There are two recommended ways to update the Cost Module in the future.

Price Level Change using CWCCIS

- The *Civil Works Construction Cost Index System (CWCCIS)*, *Engineering Manual 1110-2-1304* can be used to adjust the Cost Module to the desired FY.

Update to Cost Module

Should a more detailed update be required, it is recommended to have a Cost Engineer update the MII file with the following changes.

- Update the USACE charge rate
- Update the Equipment Book to the latest version available
- Update the Floating Plant and Repair Crew
- If additional tasks are estimated they can be included under the appropriate level. Verify that the Quantity shown in the Level folder has the correct quantity so that the average prices shown are correctly calculated.

2.0 References

U.S. Army Corps of Engineers, 1993, *Engineering and Design Cost Engineering Policy and General Requirements*, *Engineering Regulation 1110-1-1300*, Department of the Army, Washington D.C., 26 March 1993.

U.S. Army Corps of Engineers, 1999, *Engineering and Design for Civil Works Projects*, *Engineering Regulation 1110-2-1150*, Department of the Army, Washington D.C., 31 August 1999.

U.S. Army Corps of Engineers, 2016, *Civil Works Cost Engineering*, *Engineering Regulation 1110-2-1302*, Department of the Army, Washington D.C., 30 June 2016.

U.S. Army Corps of Engineers, 2019, *Civil Works Construction Cost Index System (CWCCIS)*, *Engineering Manual 1110-2-1304*, Department of the Army, Washington D.C., 31 March 2019.

Unified Facilities Criteria, 2011, *Handbook: Construction Cost Estimating*, Unified Facilities Criteria (UFC) 3-740-05, Department of Defense, 1 June 2011.

3.0 Attachments

3.1 MCACES Estimate

This estimate contains 2 parts. The first (MODULES) is the development of cost modules by estimating several invasive species O&M related activities. Based on these estimates an average was used for three Level of Effort costs split into Labor, Equipment and Other/Subcontractor groupings.

- LOW USACE personnel - 1 person for 1 week
- MEDIUM USACE Crew of 2 to 4 people for 2 weeks
- HIGH USACE Crew of 4 people for 4 weeks

The second part (COSTS FOR VALIDATION EXERCISE) is to use the costs developed above and compare them to detailed estimates based on discussions with the field crews at several facilities.

- Chicago Lock
- Indiana Harbor CDF
- TJ O'Brien Lock
- MVR Repair Fleet
- Lockport Lock and Dam
- Milwaukee Harbor CDF
- Kewaunee Harbor CDF
- Manitowoc Harbor CDF

Estimated by LRC

Designed by LRC

Prepared by David E. Druzbecki, Chicago District

Preparation Date 1/6/2021

Effective Date of Pricing 1/6/2021

Estimated Construction Time Days

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Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	Floating Plt	ProjectCost
Project Summary								
001 SITEWORK								
MODULES								
LEVEL								
LOW	4.0	EA	3,740.00 14,960	541.93 2,168	175.00 700	250.00 1,000	0	4,706.93 18,828
MEDIUM	4.0	EA	26,400.00 105,600	8,525.97 34,104	1,325.00 5,300	0.00 0	0	36,250.97 145,004
HIGH	2.0	EA	70,400.00 140,800	29,286.71 58,573	2,350.00 4,700	0.00 0	0	102,036.71 204,073
COSTS FOR VALIDATION EXERCISE								
001 Chicago Lock	1.0	EA	21,120.00 21,120	8,786.01 8,786	1,900.00 1,900	0.00 0	80,000	111,806.01 111,806
Quagga Mussel	1.0	EA	21,120.00 21,120	8,786.01 8,786	1,900.00 1,900	0.00 0	80,000	111,806.01 111,806
002 Indiana Harbor CDF	1.0	EA	44,660.00 44,660	3,101.06 3,101	600.00 600	0.00 0	0	48,361.06 48,361
Phragmites/Seed Banks - Issue 1	1.0	EA	26,400.00 26,400	1,806.44 1,806	300.00 300	0.00 0	0	28,506.44 28,506
Phragmites/Seed Banks - Issue 2	1.0	EA	17,600.00 17,600	1,204.29 1,204	300.00 300	0.00 0	0	19,104.29 19,104
Mute Swans	1.0	EA	660.00 660	90.32 90	0.00 0	0.00 0	0	750.32 750
003 TJ O'Brien Lock	1.0	EA	19,800.00 19,800	7,622.75 7,623	2,200.00 2,200	0.00 0	80,000	109,622.75 109,623
Phragmites/Seed Banks	1.0	EA	2,200.00 2,200	301.07 301	300.00 300	0.00 0	0	2,801.07 2,801
Zebra Mussel	1.0	LS	17,600.00 17,600	7,322.00 7,322	1,900.00 1,900	0.00 0	80,000	106,822.00 106,822
				0.00	0.00	12,500.00		301,300.00

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	Floating Plt	ProjectCost
			8,800.00					
004 MVR Repair Fleet	1.0	EA	8,800	0	0	12,500	280,000	301,300
Starved Rock - Invasive Carp	1.0	LS	8,800	0	0	12,500	280,000	301,300
			1,980.00	0.00	0.00	0.00		1,980.00
005 Lockport Lock and Dam	1.0	EA	1,980	0	0	0	0	1,980
			1,980.00	0.00	0.00	0.00		1,980.00
Canadian bull thistle	1.0	EA	1,980	0	0	0	0	1,980
			2,640.00	361.29	300.00	0.00		3,301.29
007 Milwaukee Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301
			2,640.00	361.29	300.00	0.00		3,301.29
Phragmites/Seed Banks	1.0	EA	2,640	361	300	0	0	3,301
			2,640.00	361.29	300.00	0.00		3,301.29
008 Kewaunee Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301
			2,640.00	361.29	300.00	0.00		3,301.29
Phragmites/Seed Banks	1.0	EA	2,640	361	300	0	0	3,301
			2,640.00	361.29	300.00	0.00		3,301.29
009 Manitowoc Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301
			2,640.00	361.29	300.00	0.00		3,301.29
Phragmites/Seed Banks	1.0	EA	2,640	361	300	0	0	3,301

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
Detailed Estimate								
001 SITEWORK								
MODULES								
LEVEL								
LOW	4.0	EA	14,960	2,168	700	1,000	0	18,828
(Note: For LOW cost items, several one man duties of 40 hours were included and an average was then taken of equipment, Other/Misc. to be used in the cost module.)								
Non-Floating Plant and Repair Crew Items	4.0	EA	14,960	2,168	700	1,000	0	18,828
006A Rat - Low (<40man hours)	1.0	LS	3,520	602	100	0	0	4,222
USR USACE Labor	32.0	HR	3,520	0	0	0	0	3,520
(Note: Includes full charge rate (no markups))								
EP L40CA003 ATV	40.0	HR	0	602	0	0	0	602
USR Misc expense	1.0	LS	0	0	100	0	0	100
007A Bug Pests - Low (<40man hours)	1.0	EA	0	0	0	1,000	0	1,000
USR Exterminator	1.0	LS	0	0	0	1,000	0	1,000
008A Phragmites/Seed Banks - Low (<40man hours)	1.0	EA	3,520	482	300	0	0	4,302
USR USACE Labor	32.0	HR	3,520	0	0	0	0	3,520
(Note: Includes full charge rate (no markups))								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	32.0	HR	0	482	0	0	0	482
USR Herbicide	1.0	LS	0	0	300	0	0	300
009A Purple Loosestife - Low (<40man hours)	1.0	EA	3,520	482	300	0	0	4,302
USR USACE Labor	32.0	HR	3,520	0	0	0	0	3,520
(Note: Includes full charge rate (no markups))								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	32.0	HR	0	482	0	0	0	482
USR Herbicide	1.0	LS	0	0	300	0	0	300
011A Mute Swans - Low (<40man hours)	1.0	EA	4,400	602	0	0	0	5,002
USR USACE Labor	40.0	HR	4,400	0	0	0	0	4,400
(Note: Includes full charge rate (no markups))								
			0.00	15.05	0.00	0.00		15.05

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
EP L40CA003 ATV	40.0	HR	0	602	0	0	0	602
			26,400.00	8,525.97	1,325.00	0.00		36,250.97
MEDIUM	4.0	EA	105,600	34,104	5,300	0	0	145,004
(Note: For MEDIUM cost items, several crews were included and an average was then taken of equipment, Other/Misc. to be used in the cost module. Crew size varies depending on task (2 - 4 men) and for approx. 2 weeks.. For Floating Plant Repair Crew a cost of \$40K/Day was used based on Field interviews.)								
Non-Floating Plant and Repair Crew Items	4.0	EA	105,600	34,104	5,300	0	0	145,004
008B Phragmites/Seed Banks - Medium (80 crew hours - 2 man crew)	1.0	EA	17,600	2,409	750	0	0	20,759
			17,600.00	2,408.59	750.00	0.00		20,758.59
USR USACE Labor	160.0	HR	17,600	0	0	0	0	17,600
(Note: Includes full charge rate (no markups))								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	160.0	HR	0	2,409	0	0	0	2,409
USR Herbicide	1.0	LS	0	0	750	0	0	750
			17,600.00	2,408.59	750.00	0.00		20,758.59
009B Purple Loosestife - Medium (80 crew hours - 2 man crew)	1.0	EA	17,600	2,409	750	0	0	20,759
			17,600.00	2,408.59	750.00	0.00		20,758.59
USR USACE Labor	160.0	HR	17,600	0	0	0	0	17,600
(Note: Includes full charge rate (no markups))								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	160.0	HR	0	2,409	0	0	0	2,409
USR Herbicide	1.0	LS	0	0	750	0	0	750
			17,600.00	2,408.59	750.00	0.00		20,758.59
004B Quagga Mussel - Medium (80 crew hours)	1.0	LS	35,200	14,643	1,900	0	0	51,743
(Note: Assume 1 operator/crane, 1 laborer/waterblaster, 2 laborer cleanup/load into dumpster. Use 80hrs NO STANDBY COSTS INCLUDED)								
USR USACE Labor	320.0	HR	35,200	0	0	0	0	35,200
(Note: Includes full charge rate (no markups))								
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	80.0	HR	0	8,289	0	0	0	8,289
			0.00	103.61	0.00	0.00		103.61
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	80.0	HR	0	6,354	0	0	0	6,354
			0.00	79.43	0.00	0.00		79.43
USR Dumpster rental	1.0	LS	0	0	500	0	0	500
			0.00	0.00	350.00	0.00		350.00
USR Disposal Cost	4.0	EA	0	0	1,400	0	0	1,400
(Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)								
005B Zebra Mussel - Medium (80 crew hours)	1.0	LS	35,200	14,643	1,900	0	0	51,743
(Note: Assume 1 operator/crane, 1 laborer/waterblaster, 2 laborer cleanup/load into dumpster. Use 80hrs NO STANDBY COSTS INCLUDED)								
USR USACE Labor	320.0	HR	35,200	0	0	0	0	35,200
(Note: Includes full charge rate (no markups))								
			0.00	103.61	0.00	0.00		103.61

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	80.0	HR	0	8,289	0	0	0	8,289
			0.00	79.43	0.00	0.00		79.43
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	80.0	HR	0	6,354	0	0	0	6,354
USR Dumpster rental	1.0	LS	0	0	500	0	0	500
			0.00	0.00	350.00	0.00		350.00
USR Disposal Cost (Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)	4.0	EA	0	0	1,400	0	0	1,400
			70,400.00	29,286.71	2,350.00	0.00		102,036.71
HIGH	2.0	EA	140,800	58,573	4,700	0	0	204,073
(Note: For HIGH cost items, several crews were included and an average was then taken of equipment, Other/Misc. to be used in the cost module. Crew size varies depending on task (typically 4 men). For Floating Plant Repair Crew a cost of \$40K/Day was used based on Field interviews.)								
			70,400.00	29,286.71	2,350.00	0.00		102,036.71
Non-Floating Plant and Repair Crew Items	2.0	EA	140,800	58,573	4,700	0	0	204,073
004C Quagga Mussel - High (4 weeks - 160 crew hours)	1.0	LS	70,400	29,287	2,350	0	0	102,037
(Note: Assume 1 operator/crane, 1 laborer/waterblaster, 2 laborer cleanup/load into dumpster. Use 240hrs NO STANDBY COSTS INCLUDED)								
USR USACE Labor	640.0	HR	70,400	0	0	0	0	70,400
(Note: Includes full charge rate (no markups))								
			0.00	103.61	0.00	0.00		103.61
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	160.0	HR	0	16,578	0	0	0	16,578
			0.00	79.43	0.00	0.00		79.43
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	160.0	HR	0	12,709	0	0	0	12,709
USR Dumpster rental	1.0	LS	0	0	250	0	0	250
			0.00	0.00	350.00	0.00		350.00
USR Disposal Cost (Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)	6.0	EA	0	0	2,100	0	0	2,100
005C Zebra Mussel - High (4 weeks - 160 crew hours)	1.0	LS	70,400	29,287	2,350	0	0	102,037
(Note: Assume 1 operator/crane, 1 laborer/waterblaster, 2 laborer cleanup/load into dumpster. Use 240hrs NO STANDBY COSTS INCLUDED)								
USR USACE Labor	640.0	HR	70,400	0	0	0	0	70,400
(Note: Includes full charge rate (no markups))								
			0.00	103.61	0.00	0.00		103.61
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	160.0	HR	0	16,578	0	0	0	16,578
			0.00	79.43	0.00	0.00		79.43
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	160.0	HR	0	12,709	0	0	0	12,709
USR Dumpster rental	1.0	LS	0	0	250	0	0	250
			0.00	0.00	350.00	0.00		350.00
USR Disposal Cost (Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)	6.0	EA	0	0	2,100	0	0	2,100
	1.0	LS	104,280	20,594	5,600	12,500	440,000	582,974

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
COSTS FOR VALIDATION EXERCISE								
(Note: From LRC Project Issue Matrix)								
001 Chicago Lock	1.0	EA	21,120	8,786	1,900	0	80,000	111,806
			21,120.00	8,786.01	1,900.00	0.00		111,806.01
Quagga Mussel	1.0	EA	21,120	8,786	1,900	0	80,000	111,806
			21,120.00	8,786.01	1,900.00	0.00		111,806.01
(Note: Mussel removal happens during dewatering. Dumpsters need to be lowered into the lock by cranes, filled with mussels, and removed. This incurs a disposal fee. The mussels are hosed off the gates, and this can be costly because a lock maintenance crew is on standby until removal is complete (could be up to 70k for a big crew))								
USR USACE Labor	192.0	HR	21,120	0	0	0	0	21,120
(Note: Includes full charge rate (no markups). 4 men, 2 days,24/7)								
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	48.0	HR	0	4,973	0	0	0	4,973
			0.00	103.61	0.00	0.00		103.61
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	48.0	HR	0	3,813	0	0	0	3,813
			0.00	79.43	0.00	0.00		79.43
USR Dumpster rental	1.0	LS	0	0	500	0	0	500
			0.00	0.00	350.00	0.00		350.00
USR Disposal Cost	4.0	EA	0	0	1,400	0	0	1,400
(Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)								
USR Floating Plant and Repair Crew	2.0	DAY	0	0	0	0	80,000	80,000
			0.00	0.00	0.00	0.00		40,000.00
002 Indiana Harbor CDF	1.0	EA	44,660	3,101	600	0	0	48,361
			44,660.00	3,101.06	600.00	0.00		48,361.06
Phragmites/Seed Banks - Issue 1	1.0	EA	26,400	1,806	300	0	0	28,506
			26,400.00	1,806.44	300.00	0.00		28,506.44
(Note: Phragmites grow within the cells of the CDF. Management of these species requires herbicide spraying. Note: herbicide sprays are used to target all plants within CDF; phragmites are one of these plants.)								
USR USACE Labor	240.0	HR	26,400	0	0	0	0	26,400
(Note: Includes full charge rate (no markups). 2 men 3 weeks/yr)								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	120.0	HR	0	1,806	0	0	0	1,806
			0.00	15.05	0.00	0.00		15.05
USR Herbicide	1.0	LS	0	0	300	0	0	300
			0.00	0.00	300.00	0.00		300.00
Phragmites/Seed Banks - Issue 2	1.0	EA	17,600	1,204	300	0	0	19,104
			17,600.00	1,204.29	300.00	0.00		19,104.29
(Note: Phragmites grow atop islands that form within CDF. Islands are piles of sediment that form after a dredging contractor discharges in cell and does not move the discharge pipe in a timely manner.)								
USR USACE Labor	160.0	HR	17,600	0	0	0	0	17,600
(Note: Includes full charge rate (no markups). 2 men 2 weeks/yr)								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	80.0	HR	0	1,204	0	0	0	1,204
			0.00	15.05	0.00	0.00		15.05

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
USR Herbicide	1.0	LS	0	0	300	0	0	300
Mute Swans	1.0	EA	660	90	0	0	0	750
(Note: Once or twice a month, 10 minutes each time.)								
USR USACE Labor	6.0	HR	660	0	0	0	0	660
(Note: Includes full charge rate (no markups). 1 person, 30 min/month)								
EP L40CA003 ATV	6.0	HR	0	90	0	0	0	90
003 TJ O'Brien Lock	1.0	EA	19,800	7,623	2,200	0	80,000	109,623
Phragmites/Seed Banks	1.0	EA	2,200	301	300	0	0	2,801
(Note: Drainage ditch outlines portion of property (thousands of feet)- Phragmites thick in the area. Tjobrien facility is adjacent to waste management facility (landfill). When water level rises, ditch funnels water out)								
USR USACE Labor	20.0	HR	2,200	0	0	0	0	2,200
(Note: Includes full charge rate (no markups). 1 person 2 days)								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	20.0	HR	0	301	0	0	0	301
USR Herbicide	1.0	LS	0	0	300	0	0	300
Zebra Mussel	1.0	LS	17,600	7,322	1,900	0	80,000	106,822
(Note: Mussel removal happens during dewatering. Dumpsters need to be lowered into the lock by cranes, filled with mussels, and removed. This incurs a disposal fee. The mussels are hosed off the gates, and this can be costly because a lock maintenance crew is on standby until removal is complete (could be up to 70k for a big crew). Confirmed by Brady Beckman on 2/2/21.)								
USR USACE Labor	160.0	HR	17,600	0	0	0	0	17,600
(Note: Includes full charge rate (no markups) 40hrs x 4 person crew)								
EP C80LB009 CRANES, HYDRAULIC, TRUCK MTD, 40 TON, 110' BOOM, 8X4	40.0	HR	0	4,144	0	0	0	4,144
EP W25NL001 WATER BLASTER, HIGH PRESSURE, 6,000 PSI, 55 GPM, SKID MTD, W/MODEL 225 PUMP	40.0	HR	0	3,177	0	0	0	3,177
USR Dumpster rental	1.0	LS	0	0	500	0	0	500
USR Disposal Cost	4.0	EA	0	0	1,400	0	0	1,400
(Note: Trucking (2hrs @ \$125/hr) plus disposal fee \$100/lb)								
USR Floating Plant and Repair Crew	2.0	DAY	0	0	0	0	80,000	80,000
004 MVR Repair Fleet	1.0	EA	8,800	0	0	12,500	280,000	301,300
Starved Rock - Invasive Carp	1.0	LS	8,800	0	0	12,500	280,000	301,300
(Note: From Starved Rock Lock and Dam. Fish had to be removed prior to construction work. Pre-dewatering removal was done by DNR contractor for total of \$2500. Post-dewatering removal was done by a crew for 7 straight days at 40k a day for repair crew. Snow fence was installed on valves to prevent carp re-entry. Then, 3 USGS barges were put into the lock and used acoustics to drive out remaining fish.)								

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
USR USACE Labor (Note: Includes full charge rate (no markups) Assume 80hrs lock crew assistance to repair crew/USGS)	80.0	HR	110.00 8,800	0.00 0	0.00 0	0.00 0	0	110.00 8,800
USR DNR Contractor	1.0	EA	0.00 0	0.00 0	0.00 0	2,500.00 2,500	0	2,500.00 2,500
USR USGS Barges (Note: 3 barges, assume 3 days)	1.0	LS	0	0	0	10,000	0	10,000
USR Floating Plant and Repair Crew	7.0	DAY	0.00 0	0.00 0	0.00 0	0.00 0	280,000	40,000.00 280,000
005 Lockport Lock and Dam	1.0	EA	1,980	0	0	0	0	1,980
Canadian bull thistle (Note: Seeds get stuck in air conditioning units. Wouldn't have to clean units as often if it wasn't for thistle. Facility staff have to clean air conditioning units (clean coils every 2mos in summer & fall—cleaning needs attributed to thistle and cottonwood). Standard household size a/c units & window units throughout facility. 2 operators, 2-2.5hrs per cleaning event.)	1.0	EA	1,980	0	0	0	0	1,980
USR USACE Labor (Note: Includes full charge rate (no markups). 3 times/yr 3hrs/ea (2person crew))	18.0	HR	110.00 1,980	0.00 0	0.00 0	0.00 0	0	110.00 1,980
007 Milwaukee Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301
Phragmites/Seed Banks (Note: Cutting entire site takes 2-3 days for 1 person. This happens once every dredge year. Dredging funded in roughly 3-yr cycles.)	1.0	EA	2,640	361	300	0	0	3,301
USR USACE Labor (Note: Includes full charge rate (no markups))	24.0	HR	110.00 2,640	0.00 0	0.00 0	0.00 0	0	110.00 2,640
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	24.0	HR	0.00 0	15.05 361	0.00 0	0.00 0	0	15.05 361
USR Herbicide	1.0	LS	0	0	300	0	0	300
008 Kewaunee Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301
Phragmites/Seed Banks (Note: Cutting entire site takes 2-3 days for 1 person. This happens once every dredge year. Dredging funded in 5-yr cycles.)	1.0	EA	2,640	361	300	0	0	3,301
USR USACE Labor (Note: Includes full charge rate (no markups))	24.0	HR	110.00 2,640	0.00 0	0.00 0	0.00 0	0	110.00 2,640
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	24.0	HR	0.00 0	15.05 361	0.00 0	0.00 0	0	15.05 361
USR Herbicide	1.0	LS	0	0	300	0	0	300
009 Manitowoc Harbor CDF	1.0	EA	2,640	361	300	0	0	3,301

Description	Quantity	UOM	LaborCost	EQCost	MatlCost	DirectSubBid	Floating Plt	DirectCost
Phragmites/Seed Banks	1.0 EA		2,640	361	300	0	0	3,301
(Note: Cutting entire site takes 2-3 days for 1 person. This happens once every dredge year. Dredging funded in roughly 3-yr cycles.)								
USR USACE Labor	24.0	HR	2,640	0	0	0	0	2,640
(Note: Includes full charge rate (no markups))								
EP L40CA003 LOADER, FRONT END WHEEL, SKID-STEER, 0.47 CY, 60" BUCKET	24.0	HR	0	361	0	0	0	361
USR Herbicide	1.0	LS	0	0	300	0	0	300

Acronyms and Definitions

ANSRP - Aquatic Nuisance Species Research Program

CW – Civil Works

CWB - Civil Works Budget

CWID - Civil Works Integration Division

ERDC – Engineering Research and Development Center

ERDC-EL - U.S. Army Engineer Research and Development Center,
Environmental Laboratory

FY – Fiscal Year

GLMRIS - Great Lakes and Mississippi River Interbasin Study

HQUSACE - Headquarters, U.S. Army Corps of Engineers

ISLT - USACE Invasive Species Leadership Team

LRD – Great Lakes and Ohio River Division

MSC - Major Subordinate Command

MVR – Rock Island District

NISC - National Invasive Species Counsel

O&M - Operation and Maintenance

PCXIN - Planning Center of Expertise for Inland Navigation

RAG - Removal of Aquatic Growth

USACE – United States Army Corps of Engineers

Invasive species is an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (2016-2018 National Invasive Species Council Management Plan, E.O. 13751 (2016)).

Alien is used to define a specie that is non-indigenous and known as non-native.

USACE work plan - Following enactment of the Energy and Water Development bill, the Administration develops a USACE work plan, which identifies the amount of additional funding provided to specific studies and projects.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT <p>Executive Order 13112 requires federal agencies to report invasive species costs to the National Invasive Species Counsel (NISC) annually. NISC then reports to Congress to increase awareness of invasive species and encourage inter-agency cooperation. Since 2005, the US Army Corps of Engineers (USACE) has provided an annual estimate for the Civil Works (CW) business lines.</p> <p>Traditionally, USACE estimates have been informed by broad assumptions, as many invasive species costs are not itemized. This study sought to develop a method to improve these estimates.</p> <p>A demonstration analysis was conducted for the Chicago District Navigation Business Line and was used to inform recommendations for a nation-wide analysis. The demonstration revealed invasive species-related costs represent about 0.2% (\$64,000) of the district's Navigation Business Line.</p> <p>Invasive species costs are subject to many variables, such as the type, prevalence, and impact of invasive species, as well as the number and type of navigation projects. The Chicago District results are not presumed to be indicative of other districts' invasive species costs. Rather, the demonstration informed the development of an invasive species cost estimating method that can adapted for each CW business line, as well as variations in invasive species and projects across geographic regions.</p> <p>This report describes the demonstration analysis and presents a defensible framework for quantifying the costs of invasive species to the USACE CW program.</p>					
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