US Army Corps of Engineers®
Pittsburgh District

October 2014
(Revised May 2016)

Upper Ohio Navigation Study, Pennsylvania

Final Feasibility Report and Integrated Environmental Impact Statement

Opening celebration at Montgomery Locks and Dam - 1936

Emsworth, Dashields, and Montgomery Locks and Dams

The Ohio River Canalization stamp was issued 19 October 1929. First day sale took place at Cairo, Ill., Evansville, Ind., Louisville, Ky., Cincinnati, Ohio, Wheeling W.Va., and Homestead and Pittsburgh, Pa. …it may seem a little odd that the subject selected for the picture was Locks and Dam 5 on the Monongahela (built 1907-10). Monongahela towboat pilot and author Richard Bissel states in his book, The Monongahela, that the photograph on which the engraving was based was taken on 4 October 1920.

from: Ohio River Navigation, Past – Present – Future, U.S. Army Corps of Engineers, Ohio River Division, Cincinnati, Ohio, 1979.

Its issuance commemorated the completion of the Ohio River canalization project that started in Pittsburgh with Davis Island Lock and Dam (No. 1) and concluded with No. 53. At the time of issuance, Emsworth and Dashields Locks and Dams had already replaced original Lock and Dam Nos. 1-3. Montgomery Locks and Dam replaced Nos. 4-6 in 1936.

DEPARTMENT OF THE ARMY
PITTSBURGH DISTRICT, CORPS OF ENGINEERS
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REPLY TO
ATTENTION OF

Upper Ohio Navigation Study, Pennsylvania

Final Feasibility Report and Integrated Environmental Impact Statement

UPPER OHIO NAVIGATION STUDY, PENNSYLVANIA

FINAL ENVIRONMENTAL IMPACT STATEMENT

OCTOBER 2014 (REVISED MAY 2016)

Note to Readers:

The Upper Ohio Navigation Study's Draft Feasibility Report and integrated Draft Environmental Impact Statement (EIS) was circulated for a 45-day National Environmental Policy Act (NEPA) public review period in 2014 (April 18 - June 2). The finalized report (prepared October 2014) included minor revisions to address the comments received through the public review and the concurrent Independent External Peer Review. The Corps of Engineers then performed a policy review on the final report, which led to further minor revisions incorporated into the final report's "revised May 2016 version."

The Final Feasibility Report's Recommended Plan, including both its features and costs as presented in the 2014 Draft Report, remain unchanged.

Minor revisions to the Feasibility Report and EIS will be found in the following sections:

Without-Project Condition and With-Project Condition (increased lock closure durations after major failures analysis)

Main Report Sections 4.5 & 4.6; Economic Appendix, Attachment 9

Air quality

Main Report, Section 4.6.9.3.2; Environmental Appendix – Clean Air Act

Environmental Justice

Main Report, Section 3.3.2.15 & Section 4.6.9.3.6;
Environmental Appendix – Environmental Justice

Endangered Species status update

Main Report, Section 3.3.2.11

National Historic Preservation Act, Section 106 (executed Memorandum of Agreement)

Main Report, Section 5.1.4.2; Cultural Resources Appendix

Responses to DEIS public comments

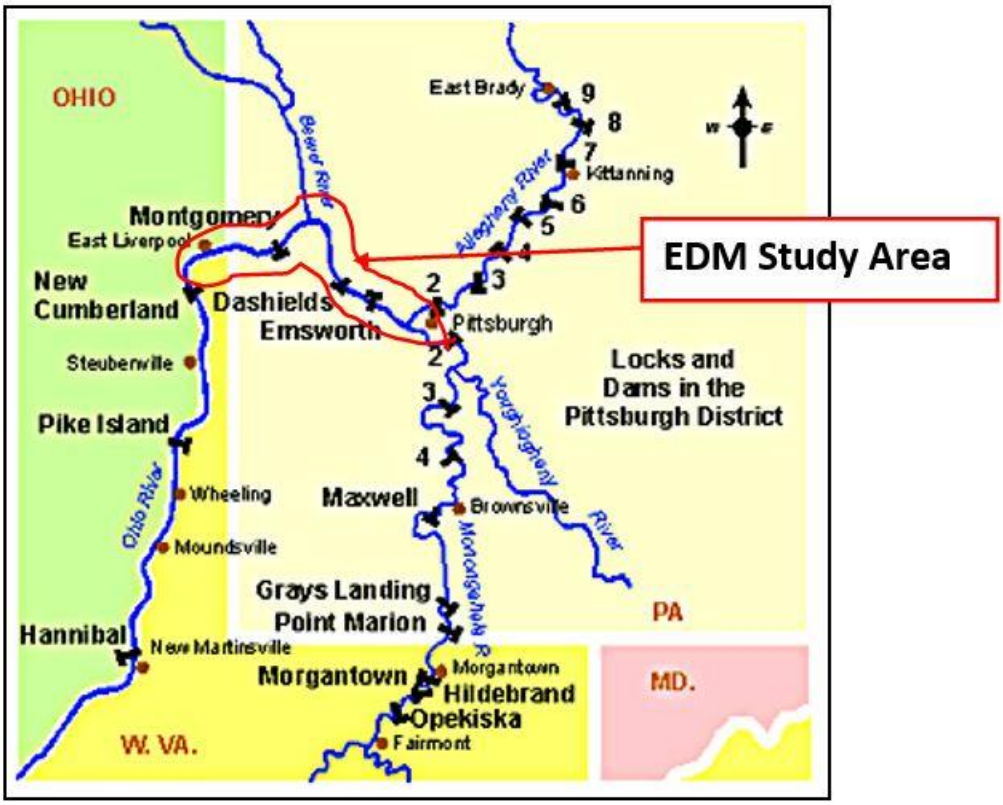
Main Report, Section 7.2; Environmental Appendix – Public Review Comments and Responses

EXECUTIVE SUMMARY

THE STUDY

The Upper Ohio Navigation Study, PA (UONS), is a feasibility-level study to identify the best long-term plan for maintaining safe, reliable, efficient, and sustainable navigation on the Upper Ohio River through the analysis period of 2025 - 2074. The study addresses Emsworth, Dashields, and Montgomery Locks and Dams (collectively EDM), originally completed in 1922 to 1936. These facilities provide navigable conditions on the first 31.7 miles of the 981-mile Ohio River and are central in position to the Port of Pittsburgh and the U.S. Army Corps of Engineers Pittsburgh District's 23 locks and dams on the Allegheny, Monongahela, and Upper Ohio rivers (**Figure ES-1**).

FIGURE ES-1 Pittsburgh District Locks and Dams



The Study's feasibility report and integrated environmental impact statement document the formulation and evaluation of plans that address the **critical structural condition of the lock walls, lock capacity issues, and ecosystem needs** in the study area**.** The report recommends for Congressional authorization the construction of one new lock at each facility. This

recommended plan is justified as the National Economic Development (NED) Plan, and is consistent with protection of the environment.

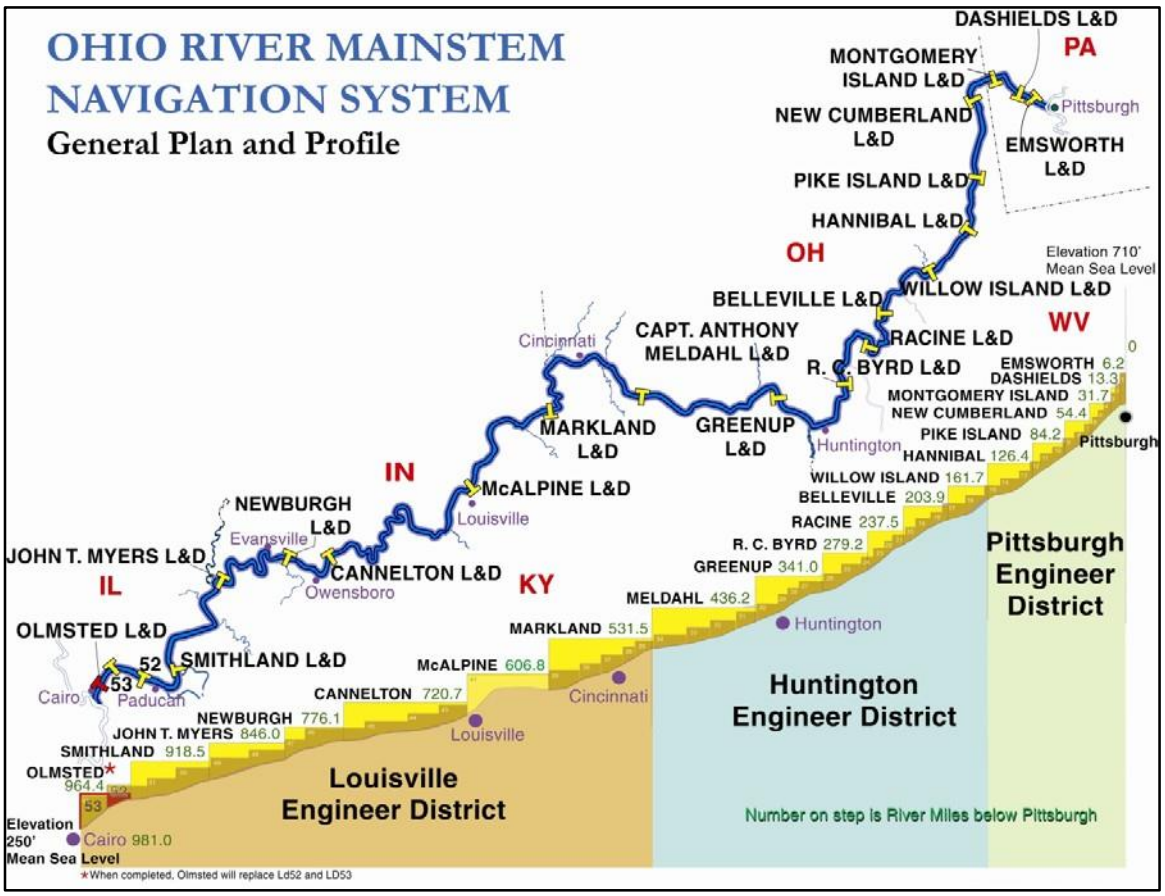
The new lock chambers will be the same size as the original main chambers (110' wide by 600' long), and will be constructed in the footprint of the original auxiliary chambers. The original main chambers will continue to operate during construction and then be retained and maintained with a "reactive maintenance" policy.

THE NAVIGATION PROJECTS

EDM Historically

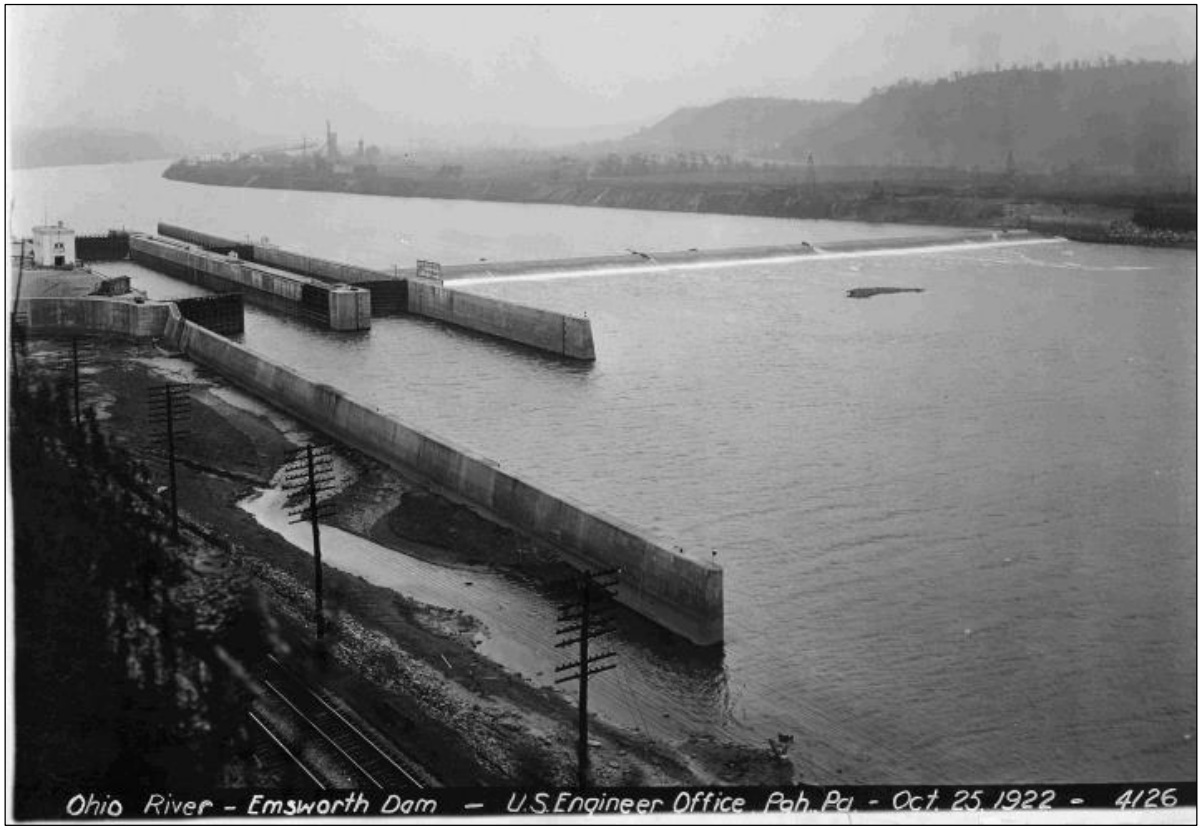
EDM form the head of the Ohio River Navigation System (**Figure ES-2**), originally conceived as a series of low-head movable dams based on the innovative 1875 design of Lock and Dam No. 1 in Pittsburgh. When the last of the original series (Nos. 52 and 53) were finished in 1929, the Emsworth (**Figure ES-3**) and Dashields projects had already replaced the oldest facilities (Nos. 1-3) at the head of the river. Completion of Montgomery in 1936 replaced original Lock and Dam Nos. 4-6. The EDM facilities retained the 1875 standard lock chamber size, but introduced the system's first non-navigable dams

FIGURE ES-2 Ohio River Navigation System (original 1929 system shown in brown steps)



and the first (smaller) auxiliary lock chambers. The last of the original numbered facilities are currently being replaced with the new Olmsted Locks and Dam, under construction. This leaves EDM as the oldest facilities remaining to be addressed in the post-1955 system Ohio River modernization program.

FIGURE ES-3 Emsworth Locks and Dam (1922)



EDM were nearing the end of their 50-year economic life in the 1970s, when Pittsburgh District first recommended their replacement. The District was approved to complete major rehabilitations of EDM in the 1980s to extend their useful life another 20 ± years, allowing additional time to obtain replacement authorization. During this period, the Great Lakes and Ohio River Division conducted and completed the Ohio River Mainstem System Study (ORMSS). This Study's System Investment Plan recommended completion of an Upper Ohio River Feasibility study to define a recommended EDM replacement project for the next Water Resources Development Act. The UONS is that feasibility study.

EDM Today

Emsworth (**Figure ES-4**) and Montgomery dams (**Figure ES-5**) are non-navigable, gated dams of the vertical-lift type. Montgomery Dam was the first gated dam built on the Ohio River. Emsworth's vertical lift gated dams are 1938 replacements of the original [1922] fixed crest weirs. Emsworth has two dams that span the river's main channel and back channel at Neville Island.

FIGURE ES-4 Emsworth Locks and Dams today

FIGURE ES-5 Montgomery Locks and Dam today

Dashields Dam (r.m. 13.3) is the only fixed-crest, uncontrolled overflow structure on the Ohio River (**Figure ES-6**), and it maintains a normal pool elevation of 692.0 for 7.1 miles upstream to Emsworth Dams at river mile (r.m.) 6.2. Emsworth maintains a normal pool elevation of 710.0 to the head of the Ohio River, and extends 11.2 miles up the tributary Monongahela River and 6.7 miles up the Allegheny River. Downstream of Dashields Dam, Montgomery Dam (r.m. 31.7) maintains a normal pool elevation of 682.0 for 18.4 miles.

FIGURE ES-6 Dashields Locks and Dam today

The paired locks at each of the EDM facilities consist of a landward main chamber (110'x 600') and a smaller riverward auxiliary chamber (56' x 360'). The EDM main chambers are half the length of typical Ohio River main [1200'] chambers constructed after 1955 (**Figure ES-7**). The EDM main chamber locks are also shorter than the typical 84' x 720' main chamber locks of the tributary Monongahela River Navigation System. EDM auxiliary chambers are the system's smallest locks, incapable of handling more than one barge at a time during main chamber closures.

FIGURE ES-7 Ohio River Navigation Lock Typical Sizes

The EDM projects allow producers and consumers to move large quantities of cargo into and through the Pittsburgh area at relatively low cost without worsening congestion and environmental impacts related to land-based transportation modes. Coal and aggregate (stone, sand, and gravel) firms are primary producers, while electric utilities and steel mills are the primary consumers of commodities that move through EDM. Coal accounts for 63 percent of EDM traffic and 59 percent of system traffic. Aggregates account for 18 percent of EDM traffic; the aggregates are comprised of lime/limestone used in electric generating plants pollution control units and building materials used in construction. Collectively, coal and aggregates account for 81 percent of EDM traffic and 75 percent of system traffic.

The EDM projects also benefit water supply and recreational needs in addition to the authorized navigation purpose. There are dozens of facilities along the banks of the Upper Ohio River comprising terminals and fleeting areas to accommodate commercial navigation, docks, boat ramps and marinas for recreation boating, water intake structures for industry, and outfalls that serve numerous communities in the Upper Ohio River area.

Historically, Corps of Engineers navigation facilities were viewed as beneficial to the environmental problems typical on the Upper Ohio River. They provided much needed reservoirs of water that helped meet the significant water consumption demands of municipal and industrial facilities, and diluted the early pollution problems before treatment methods were implemented. Emsworth, Dashields, and Montgomery dams in particular, are excellent flow aerators that provide significant quantities of oxygen to offset the high biological and chemical oxygen demands in the upper river. However, with general improvements in regional water quality, new environmental thinking has shifted its focus onto limitations of the navigation facilities. Pools created by dams have less ecological diversity than free-flowing rivers, and dams are now generally perceived as barriers to fish movement. The challenge in the present navigation study is to identify regional environmental issues that will be considered problems over the coming century without losing sight of the historical benefits provided by the navigation system.

STUDY PURPOSES

The **primary purpose** of the UONS is to **address problems and opportunities** related to the **structural reliability and capacity** of EDM Locks and Dams. This study has determined the best plan for maintaining safe and reliable navigation on the Upper Ohio River over a 50-year period from 2025 to 2074. This plan, called the National Economic Development (NED) plan, will maximize economic development benefits consistent with protecting the environment.

The current study follows after several Corps reports that focused on concerns over the physical condition and capacity limitations at EDM. The 1962 *"Preliminary Report on Proposed Plan of Improvement"* was followed by the 1971 feasibility-level *"Report on Replacement - Emsworth, Dashields and Montgomery Locks and Dams - Ohio River, Pennsylvania."* Most recently, the results of the Ohio River Mainstem System Study

(ORMSS) indicated that physical improvements to EDM were economically justified in the near term and provided rationale for timely completion of this study.

In accordance with current Corps policy and guidance, **problems and opportunities for ecosystem restoration projects** were included as a study purpose along with navigation. Ecosystem restoration projects are typically evaluated as to the non-monetary benefits they provide, which are termed National Ecosystem Restoration (NER) benefits, and require cost sharing with a non-federal sponsor. Potential ecosystem restoration projects may either be integral to or independent of the navigation facilities. In formulating a plan that would combine navigation and ecosystem restoration components, any interdependence between the two may lead to necessary tradeoffs in the level of benefits both provide. The best "combined plan" may not be the simple combination of the individually best NED and NER plans, unless the two are completely independent.

PROBLEM AREAS AND PLANNING OBJECTIVES

Navigation Problems and Opportunities

The EDM facilities were constructed in the 1920s-1930s and their present reliability is seriously compromised by deteriorated structural concrete and antiquated operating systems. Specific navigation problem and opportunity statements are:

Navigation Problem 1: Concrete walls and foundations are in a state of deterioration with significant likelihood of conditions developing that will require extensive repairs and lengthy lock closures **(Figures ES-8, -9).**

Navigation Problem 2: Obsolete mechanical and electrical equipment is difficult to maintain and repair due to age and unavailability of replacement parts.

Navigation Problem 3: Locks are significantly smaller than elsewhere on the Ohio River, particularly the auxiliary chambers. These small locks create inefficiencies for navigation industry, especially during extended closures of the main chambers, and increase their cost of doing business.

Navigation Problem 4: Substandard approach conditions at some higher than normal flows at EDM, and the Emsworth filling and emptying system design can create difficult navigation conditions.

Navigation Opportunity: Incorporation of procedures and low cost features to aid navigation may increase lockage throughput efficiencies that in turn would reduce navigation costs.

The deteriorated concrete walls and obsolete mechanical equipment increase the likelihood of conditions necessitating unscheduled closure of the main (110' x 600') chambers at each of these three facilities. These closures could be weeks or months, particularly if they involve the concrete walls. Whenever the land chamber is closed, all traffic is forced to use the very small auxiliary (56' x 360') chambers, which dramatically increases lockage and delay times that in turn translates to higher transportation costs to industry.

FIGURE ES-8 Concrete lock wall deterioration

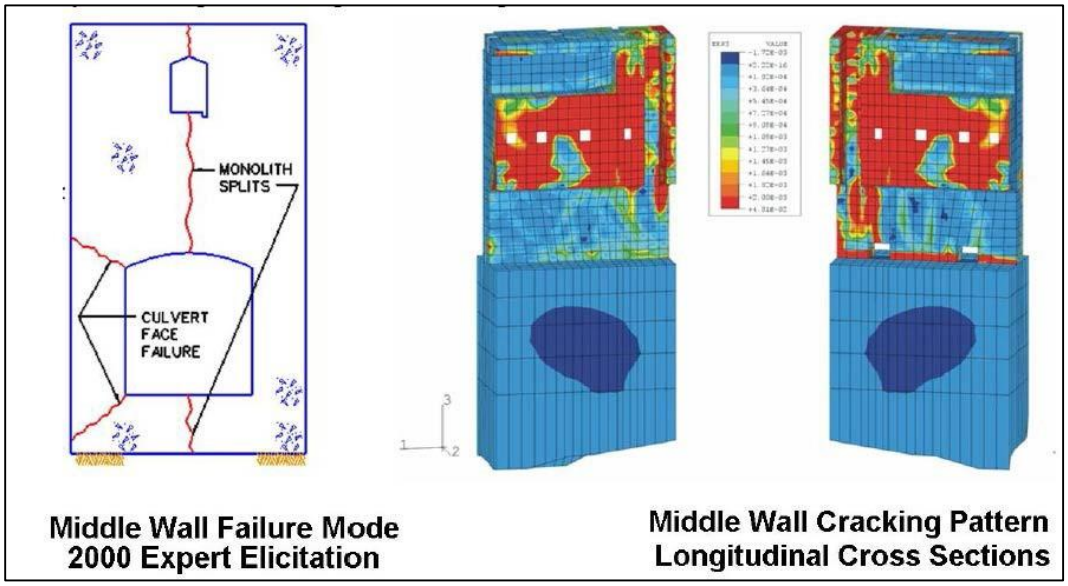


FIGURE ES-9 Montgomery Middle Lock Wall longitudinal cracking

A tow with 5-10 barges can single-lock (one lockage cycle) through an EDM main chamber in about 45 minutes. By comparison, EDM auxiliary chamber lockages (e.g., during main chamber closure) of the same size tow would require five cycles and over three hours. Typical delays at EDM when the main chamber is open, i.e., during normal operations, are only about 0.5-1.0 hour. During twelve extended main chamber closures in the 1990s and 2000s, ranging between four and 33 days, commercial tows experienced average delays of

seven to 37 hours. The additional delays during main chamber closures translate into increased costs to industry and may even force some shippers to divert traffic to more costly and likely more polluting land-based modes. The diversions off-river would also result in added congestion and costs to existing users of those modes.

Ecosystem Problems and Opportunities

The Upper Ohio River is highly modified from a natural, unregulated river system due to the presence of the navigation system and historic effects of intensive industrial and municipal development. These man-made features have led to degraded ecosystem functions and values of both water quality and sediment quality, reduced riparian and riverine habitat diversity, and reduced diversity of riverine flora and fauna.

The Corps ORMSS report identified a number of potential ecosystem restoration opportunities along the entire river to address degraded ecosystem functions and values, awaiting further study under various Corps' authorities. The ORMSS Programmatic Environmental Impact Statement (PEIS) was centered on a system-wide Cumulative Effects Assessment (CEA) to determine effects on the sustainability of Ohio River resources from all past, present, and foreseeable future activities on the river, including but not limited to the navigation facilities. Ten Valued Environmental Components (VECs) were categorized for analysis, six of which were considered to be highest priority: Water and Sediment Quality, Fish, Mussels, Riparian/Floodplain Resources, Health and Safety, and Recreation. The four other VECs included Air Quality, Transportation and Traffic, Socio-Economic Resources, and Cultural Resources.

The ecosystem problem and opportunity statements for this study are:

Ecosystem Problem: Nine of ten VECs examined in the ORMSS have identified sustainability concerns.

Ecosystem Opportunity: Identify ways to improve sustainability of VECs and formulate NER and combined plans through the Upper Ohio Navigation Study.

UONS Planning Objectives

Objective 1. Identify and evaluate all reasonable alternatives for maintaining safe, reliable, efficient, and sustainable navigation on the Upper Ohio River (comprised of the existing Emsworth, Dashields and Montgomery Locks and Dams) over the analysis period of 2025 – 2074.

Objective 2. Identify and evaluate reasonable opportunities for ecosystem restoration projects in the study area, consistent with navigation planning and interests of non-federal cost-sharing partners.

Objective 3. Assure that any recommended project is consistent with protection of the Nation's environment, and that unavoidable impacts to environmental, cultural, or social resources are minimized or mitigated to the extent justified.

STUDY PROCESSES

This study is a feasibility-level planning effort that seeks to determine if there is an economical means of improving the performance of EDM from economic, engineering, and environmental perspectives. Plans are to be formulated and evaluated that include navigation (NED), ecosystem (NER), or elements of both in a Combined Plan in accordance with current Corps guidance. Planning follows the general guidance for economic evaluation of navigation projects outlined in Engineer Regulation (ER) 1105-2-100 dated April 22, 2000, as amended in 2004 and 2007, and other Engineering Circulars (ECs), including EC 1105-2-404 that address combined plans. Several economic and environmental models used in the evaluation of plans have been certified or are undergoing certification in accordance with EC 1105-2-407. The Environmental Impact Statement (EIS) for this study is a tiered document under the National Environmental Policy Act (NEPA) from the ORMSS PEIS finalized in 2011.

The UONS EIS is integrated into the UONS Main Report. The U.S. Coast Guard agreed to be a cooperating agency in the NEPA process. NEPA scoping, navigation stakeholder meetings, and an Interagency Working Group (IWG) consisting of federal and state natural resource agencies and non-governmental organizations were pursued in this study as part of the collaborative planning process.

ENGINEERING, ECONOMICS, AND ENVIRONMENTAL MODELS

The major variables in developing a long-range plan for EDM are the physical condition of critical lock and dam components and traffic demand. Forecasts of both variables are uncertain giving rise to the need for a risk-based analysis to insure that the study conclusions and recommendations cover the plausible range of future scenarios. Engineering reliability models were used to analyze lock component reliability and capture the uncertainty of lock and dam performance by building upon or using similar models developed for ORMSS or developing new models, while accommodating forecasted traffic demand. One engineering model developed for this study was used for the lock miter gates. These models developed hazard rates for critical lock and dam components that are annual probabilities of failure given that no failure (and attendant repair or replacement) has occurred previously.

Economic evaluations for the UONS were made using a modified version of the state-of-the-art analytical model developed and used for ORMSS that incorporated the uncertainty of traffic forecasts and the reliability of lock components into a procedure to optimize reinvestment strategies. The Ohio River Navigation Investment Model (ORNIM) used in this analysis determined system-wide benefits and costs of different reinvestment alternatives through the integration of engineering, economic, and environmental inputs. For the UONS, ORNIM was modified to consider elastic demand for barge transportation. Several models were used to provide input to ORNIM, including the Greenmont Energy Model used to predict utility demands for coal, a major source of traffic through EDM, and the Barge Costing Model.

Environmental analyses employed three models to evaluate impacts and benefits of project features. In the ORMSS, the impacts of commercial navigation within the navigation pools on aquatic habitat and fish were evaluated using the Navigation Predictive Analysis Technique (NAVPAT). The results of these analyses were incorporated into the UONS by reference through NEPA tiering. The Fish Passage Connectivity Index (FPCI) model was used to evaluate the effectiveness of various fish passage alternatives at each navigation dam. This model was used to fulfill an ORMSS commitment to evaluate fish passage opportunities. The third model, Habitat Suitability Indices and Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service, was employed in both the ecosystem restoration planning process and in the evaluation of lock construction impacts and mitigation measures.

FORMULATION AND EVALUATION

Major Rehabilitation

Major rehabilitation was a measure considered for both the Without-Project Condition and With-Project Condition (WPC). Major Rehabilitation (MR) is defined as major project feature restoration consisting of structural work intended to improve reliability or efficiency of major components on a Corps operated and maintained facility (Engineering Pamphlet 1130-2-500). Rehabilitation extends over at least two full construction seasons and requires over $20 million in capital outlays for Inland Navigation Projects, and will not consist of routine or deferred maintenance funded in the Corps Operation and Maintenance, General budget appropriations.

Comprehensive MR was performed at EDM in the 1980s primarily to address deteriorated lock wall concrete and concerns with wall stability. This work was limited in scope to avoid lengthy closures of the main chambers, and consequently it was not possible to replace or repair all cracked concrete or restore stability to standards of acceptable reliability. Wall repairs were therefore limited to removal of six inches to one foot of deteriorated concrete, resurfacing of top and vertical faces, and installation of either passive anchors (mobilized only by wall movement) or active (pre-stressed) anchors. Due to concerns with the structural cracking of interior concrete and remaining life of the anchors, the long-term solution for the EDM lock walls involves wholesale in-kind monolith replacements.

The District conducted a preliminary assessment of MR involving total wall construction for this study and concluded that it could be implementable but very costly, both in terms of impacts to commercial navigation and the capital investment. Even under optimal conditions with simultaneous work at all three facilities and adequate funding, there would be at least 2.5-year closures of the main (land) chambers and 2.0-year closures of all chambers. As a consequence of these closures, the navigation and associated industries would suffer a negative $1.4 billion impact. Under a more realistic scenario of limited funding driving sequential construction, impacts would be significantly multiplied. There is little difference in construction cost between a MR wall replacement and new chamber construction to offset these severe navigation industry costs.

The preliminary assessment concluded that MR was too costly to be included in the WOPC. By comparison, With-Project alternatives involving construction of a new main chamber in the auxiliary chamber footprint maintain navigation through the existing main chamber with no river closures and little to no delays. The District performed a low-level analysis confirming the economic inferiority of a MR alternative as opposed to new lock construction and therefore eliminated MR from consideration as a WPC measure.

Without-Project Condition (WOPC)

The WOPC is the most likely condition expected to exist in the future in the absence of implementation of water resource project investment alternative(s). The future WOPC constitutes the benchmark against which alternative plans are evaluated.

The WOPC for navigation at EDM was formulated using maintenance, low-cost structural and operational efficiency measures that have proven effective over time, as well as considering the implementability of scheduled replacement of components critical to the operation of these facilities (i.e., concrete walls, and electrical and mechanical machinery). Two WOPC navigation futures were evaluated for each traffic scenario, one termed Reactive Maintenance (RM) (also called Fix as Fails, or FAF) and the other Advanced Maintenance. With Reactive Maintenance, no scheduled component replacements were allowed. It further assumed that component replacements can be made only after it fails, however, no proactive maintenance is performed, i.e., components are not repaired or replaced in anticipation of failure. With Advanced Maintenance, scheduled component replacements were allowed if economically justified (i.e., benefits were greater than costs). However, the budget implications of component replacements were a key consideration in the determination of the WOPC, as the availability of the funding to accomplish these scheduled replacements may be very limited. The WOPC also includes completion of authorized improvement projects anywhere on the Ohio River (Olmsted, Greenup, and J.T. Myers Locks).

As in ORMSS, multiple traffic forecasts were used to account for uncertainty in projecting future commodity shipments through locks. Three economic forecasts were developed for coal and non-coal commodities. For coal, the primary commodity served by EDM, the High Case scenario assumed relatively high long-term economic growth coupled with low levels of nuclear plant development and high gas prices. The Base Case or Mid Forecast Scenario assumed moderate economic growth along with moderate growth in nuclear plant development. The Low Case Scenario was founded on relatively low levels of economic growth with high levels of nuclear plant development. For non-coal commodities, the scenarios were developed using statistical assumptions for variations of the High and Low from the Base estimate. The resulting growth rates of traffic in the EDM reach between 2006 and 2070 with these three scenarios were 0.35 percent for the Low, 0.32 percent for the Mid, and 1.69 percent for the High. The Mid Forecast Scenario was used in the economic analysis of the WOPC and alternative With-Project Condition plans.

The WOPC is also the NEPA No Action alternative. The future WOPC for ecosystem restoration planning will be essentially the same as present under normal operating conditions at EDM.

Economic Analysis of the WOPC

The benefits of the waterway system are determined by the transportation rate savings the system affords. The WOPC benefits are estimated as the difference in total transportation costs necessary to move the system tonnage by the existing water routes versus what it would cost to move the same tonnage by the lowest cost alternative of all overland routings. Under Reactive Maintenance, the resulting life cycle costs were highly influenced by unreliable components in the main (land) chambers. The average annual (screening level) cost to replace components after failure for RM in the Mid Forecast Scenario ($20.2 million) was greater than the remaining sum of all other average annual maintenance costs ($17.2 million). The lost average annual navigation annual benefits due to repairing or replacing failed components were over $300 million, or over 62 percent of the total navigation benefits provided by the existing system. In spite of these high costs after failure, the average annual net benefits of EDM with RM remain comfortably positive at over $105 million.

Allowing for scheduled replacement of components resulted in numerous economically justified component replacements in the main (land) chambers with optimal timings before 2020, including the land and middle walls. The total cost of these replacements alone would be over $1 billion, mostly for the walls that would each require two years or more to replace. This cost does not account for the added delay cost to industry (lost navigation benefits). As a consequence, scheduled replacement of components was deemed too costly to include in the WOPC, but it was considered in the formulation of With-Project Condition plans. Therefore, the WOPC for EDM was deemed to consist of Reactive Maintenance only.

Environmental Sustainability in the WOPC (NEPA No Action Alternative)

Continued operation of the facilities in their historic configuration would retain the secondary beneficial aspects of their operation, including water supply, reaeration, and recreation. However, it would also prolong the historic ecosystem impacts attributed to the navigation system such as altered flow patterns, degraded aquatic habitat, and impaired riverine connectivity.

The navigation WOPC carries with it the increasing likelihood of extended lock closures with reactive maintenance, and even the possibility of loss of pool from lock wall failure. The prolonged closure of a main chamber would lead to tow queuing and impacts to aquatic habitat due to lockage delays through auxiliary chambers. This could also lead to diversion to overland traffic and its attendant impacts. A loss of pool would necessitate the diversion to overland traffic, and would also have severe consequences to the pool's aquatic life and the region's water supply. Since the Corps will take every reasonable precaution to avoid pool loss, and to restore the pool as quickly as possible if it were lost, the likelihood of this occurrence is remote and its impact highly difficult to forecast.

Of the study area's Valued Environmental Components, only two are not expected to be sustainable in the future. Riparian/Floodplain Resources is expected to remain unsustainable, and Mussels will remain marginally sustainable. Significant effects to these two categories have occurred from a number of activities including, but not limited to, water pollution from municipalities and industries; acid mine drainage; instream extraction of sand and gravel;

construction and operation of high-lift locks and dams; disruptions to mussel beds due to barge fleeting areas, queuing, disposal of dredged materials, and conversion of habitat for agriculture, residential, commercial, and industrial uses. Habitat conversions are expected to continue in the future as development in or adjacent to the river continues to occur.

With-Project Condition (WPC)

Navigation Plans

As navigation is the primary purpose of this study, the first step was identification of the navigation plan that maximizes net economic benefits to the nation from among a set of final plans evaluated with ORNIM. This plan is referred to as the National Economic Development (NED) plan. All final plans were then evaluated considering the degree they addressed the stated planning objectives as well as the magnitude and significance of the impacts of each final plan in the areas covered by the criteria set forth in the Principles and Guidelines (P&G). The best plan meeting all criteria is identified as the Preferred Navigation Plan.

WPC navigation plans were formulated by identifying measures not implementable in the WOPC that adequately address a problem or realize an opportunity and thereby help to realize an objective. One measure carried forward, the scheduled replacement of components, has already been discussed under the WOPC. Small-scale improvements were also considered, but none were found adequate to address the primary problem, i.e. unreliable walls and other critical components. The only other suitable measure to complement scheduled replacement is the construction of new larger lock chambers to replace the small auxiliary river chambers, and possibly the replacement of the land chambers. The same three traffic projections apply to the evaluation of WPC plans (i.e. there is no induced traffic with larger locks).

A number of measures were eliminated from detailed consideration in the WPC. The permanent removal of one of the facilities (Dashields) was screened out after assessment of economic, engineering, and environmental factors associated with implementing resultant pool elevation changes. A measure to implement congestion fees was eliminated as it would not address the primary problems of unreliable main chambers locks and small auxiliary chambers. The measure to close or decommission any of the land chambers after construction of a new river chamber was eliminated from consideration based on the criticality of maintaining two-lock facilities in this important navigation system. In addition, consideration was given to guidance provided in ER 1165-2-132 for feasibility studies that at least one alternative plan be formulated to avoid contaminated sites (containing hazardous, toxic or radiologic wastes, abbreviated HTRW) consistent with project objectives.

Five navigation plans were carried forward for economic analysis: Advanced Maintenance, three Lock Modernization Plans involving one new chamber at each facility, and one Lock Modernization Plan involving two new chambers at each facility.

Advanced Maintenance Alternative (AMA) - consisted of all economically justified component replacements identified earlier. This plan represents the best plan to maintain the existing lock footprints.

Lock Modernization Alternative (LMA) Plans – consisting of the same work at each of Emsworth, Dashields, and Montgomery Locks and Dams.

- **LMA 7 -** one new river chamber (110' wide by 600' long);
- **LMA 8 -** one new river chamber (110' wide by 800' long);
- **LMA 9 -** one new river chamber (110' wide by 1200' long);
- **LMA 1 -** two new chambers (110' wide by 600' long).

Plans LMA 7, 8, & 9 would construct the new river chamber in the footprint of the existing auxiliary chamber, allowing the existing main land chamber to remain operational during construction. Upon completion, the existing land chamber would be retained with Reactive Maintenance (RM). LMA 1 would construct the two new chambers in the footprint of the existing chambers. Due to similar traffic volumes at each of the three facilities, no LMA plan addressed different lock sizes between facilities. Based on analyses of different lock chamber lengths, the 600' length was selected as the best lock size in consideration of the Mid Forecast Scenario.

The screening level first costs of the lock modernization plans are presented in **Table ES-1**. These costs are for the new lock construction only, and do not include any maintenance costs including costs to replace components either under advanced maintenance or after a failure.

TABLE ES-1

Screening Level First Costs for Final Lock Modernization Plans (October 2009 price level)

Plan Designation	Plan Description	Screening Level First Costs
LMA 1	Two new 600' chambers with lagged start of 2nd chamber	$2,102,390,000
LMA 7	New 600' river chamber & RM old land chamber	$1,479,332,000
LMA 8	New 800' river chamber & RM old land chamber	$1,749,824,000
LMA 9	New 1200' river chamber & RM old land chamber	$2,135,398,000

Phase I and II HTRW Environmental Site Assessments (ESA) were conducted for the upland areas in close proximity to each facility proposed to accommodate construction batch plants and equipment laydown. The ESA investigations indicated that there is sufficient land available to support construction of the proposed locks and to develop a Real Estate Plan that maximizes avoidance of contaminated areas. HTRW investigation will continue in the Preconstruction, Engineering, and Design (PED) phase prior to acquisition of any real property.

The economic analysis of the final five plans is shown in **Table ES-2** for the Mid Forecast Scenario, where the incremental net benefits are relative to the WOPC. For all LMA plans, **the optimal timing of river chamber construction that maximizes net benefits is at the very beginning of the analysis period** (or as soon as possible).

TABLE ES-2

Summary of Economic Analyses – All Plans
Mid Forecast Scenario (October 2009, $ Million)

Plan Designation	Incremental Net Benefits	Ranking
LMA 7	$224.7	1
LMA 1	$219.3	2
LMA 8	$208.2	3
LMA 9	$181.2	4
AMA	$171.3	5

The NED Plan is LMA 7, consisting of one new 600' river chamber at each site and Reactive Maintenance of the existing land chambers. Further, as a consequence of providing new, totally reliable 600' chambers, the number of days that the main chambers are closed dramatically decline, thereby reducing the occurrences of high delay events.

Ecosystem Restoration Planning and Potential Combined Plans.

Formulation of the WPC considered potential ecosystem restoration projects that could be included with the navigation NED plan as a Combined Plan. Since all of the potential restoration alternatives evaluated were physically and functionally independent of the navigation facilities, there were no tradeoffs to evaluate between the NED and NER accounts. The potentially interested non-federal sponsor indicated, however, their desire to proceed with further ecosystem restoration planning under existing authority (e.g., Sec. 1135 of WRDA 1986) rather than under the future authorization of a combined navigation/ecosystem restoration study recommendation. Consequently, the UONS report documents the ecosystem restoration study process and results, but **does not recommend a Combined Plan**.

Detailed Analysis of the Final WPC Navigation Plans

The final navigation plans were ranked in terms of realizing objectives and the Principles and Guidelines (P&G) system of account and evaluation criteria.

The system of four accounts includes National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). A brief definition of the accounts is:

NED: This account measures contributions to national economic development (NED) and are increases in the net value of the national output of goods and services, expressed in monetary units.

EQ: Beneficial effects in this account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in this account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.

RED: This account registers changes in the distribution of regional economic activity that result from each alternative plan. Two measures are used in the account: regional income and regional employment.

OSE: This account is a means of displaying and integrating into water resource planning information on alternative plan effects from perspectives that are not reflected in the other three accounts. Categories include: urban and community impacts; life, health, and safety factors; displacements; long-term productivity and energy requirements and energy conservation.

The evaluation criteria are Completeness, Effectiveness, Efficiency, and Acceptability. They are defined as:

Completeness: The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness: The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency: The extent to which an alternative is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

Acceptability: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

The five final plans and the WOPC were rated and ranked across the planning objectives, P&G System of Accounts, and Evaluation Criteria. A summary of the final ranking is in **Table ES-3**. Plans LMA 7 and LMA 1 stand out as the two best plans across all criteria. Plan LMA 7 maximally satisfies the Planning Objectives of all the final five plans for the Mid-Forecast Scenario. Plans LMA 7 and LMA 1 are the two best in meeting the Principles and Guidelines (P&G) System of Accounts criteria. Plan LMA 1 is the best in terms of meeting the P&G evaluation criteria.

LMA 1 has an advantage over LMA 7 in providing two totally reliable 600' chambers versus a single new chamber. However, assuming that the existing land chambers of LMA 7 are fixed after failure, the additional first cost of $600+ million for plan LMA 1 is not justifiable. Therefore, Plan LMA 7 is the preferred navigation plan. Since no ecosystem restoration plan

was carried forward for a combined plan, Plan LMA 7, becomes the recommended plan for implementation.

Table ES-3: Summary of Final Plan Evaluation

<table>
<tr><th>Ranking</th><th>Planning Objectives</th><th>System of Accounts</th><th>Evaluation Criteria</th></tr>
<tr><td>1</td><td>LMA 7</td><td rowspan="2">LMA 1 & 7</td><td>LMA 1</td></tr>
<tr><td>2</td><td>LMA 1</td><td rowspan="2">LMA 7 & 8</td></tr>
<tr><td>3</td><td rowspan="2">LMA 8 & 9</td><td>LMA 8</td></tr>
<tr><td>4</td><td>LMA 9</td><td>LMA 9</td></tr>
<tr><td>5</td><td>AMA</td><td>AMA</td><td>AMA</td></tr>
<tr><td>6</td><td>WOPC</td><td>WOPC</td><td>WOPC</td></tr>
</table>

Environmental Acceptability

The recommended plan is environmentally acceptable and is in compliance with all relevant environmental laws, executive orders, and Corps environmental policies at this stage of planning. The requirements of Section 404(r) of Public Law 92-500, as amended, have been met.

The study report is a tiered document under the ORMSS PEIS for compliance with the National Environmental Policy Act. The ORMSS made five environmental commitments for future feasibility studies, each of which was fulfilled in the UONS. These included evaluation of fish passage opportunities, continuation of interagency consultation, riverine habitat characterization, incorporation of sustainability planning, and development of a National Ecosystem Restoration Plan. Site specific resource studies and evaluations were also conducted to identify impacts associated with the recommended plan and reasonable alternatives. Mitigation for aquatic impacts at all three lock locations is proposed at a single site, the Montgomery Slough [embayment] (**Figure ES-10**). Terrestrial impacts at each of the lock's construction support areas will be mitigated by onsite revegetation plans.

The recommended plan includes an environmentally sustainable design feature involving the evaluation and implementation of design or operational modifications to the new navigation structures. The purpose of this feature is to improve native fish passage efficiency through normal project operation, if feasible, in place of separable fish passage structures that were evaluated and determined to be infeasible at EDM. Improving native fish passage while at the same time blocking movement of aquatic nuisance species is a problematic issue that will require further consultation with resource protection and management agencies during the design phase.

The recommendations of the U.S. Fish and Wildlife Service have been addressed. These include the recommendations made for the ORMSS in its Fish and Wildlife Coordination Act 2(b) report, and those in a Planning Aid Report specific to the Upper Ohio River. The study integrated the Corps Environmental Operating Principles and is consistent with all of them. Resource sustainability was specifically addressed through a study area-specific cumulative effects assessment, and through the inclusion of an environmentally sustainable design component with the recommended plan.

FIGURE ES-10 Montgomery Slough (embayment)

The potential development of alternative disposal sites for excavated and dredged materials and demolition debris is deferred to the project's PED phase. The study identifies the use of commercial, permitted disposal facilities for feasibility and costing purposes. Allied with this deferred consideration is the beneficial use of dredged material, e.g. for island erosion stabilization at the Ohio River Islands National Wildlife Refuge. At an opportune time before construction, the Corps will evaluate alternative disposal sites/methods in the interest of cost reduction and environmental benefits.

Cultural resource compliance with Section 106 of the National Historic Preservation Act is integrated into the UONS report and Environmental Impact Statement. Adverse effects to the three historic lock and dam facilities are addressed through mitigation stipulations in a Memorandum of Agreement executed November 12, 2014, and filed with the Advisory Council on Historic Preservation. The need for further archaeological study of one of the three construction support areas is identified and will be pursued after authorization under the terms of the Programmatic Agreement Regarding the Modernization of the Ohio River Navigation System.

STUDY CONCLUSIONS

This analysis has determined that Plan LMA 7 delivers the largest positive average annual system net benefits (i.e. the NED Plan), is the preferred plan accounting for Corps evaluation criteria, and is environmentally acceptable. **Therefore, Plan LMA 7 is recommended for implementation**. This plan involves construction of a new 110' x 600' river lock as soon as possible to replace the small auxiliary river lock at each site and retention of the existing land chambers with Reactive Maintenance.

The total first cost of the Plan is $2,320,082,000 (October 2014 price level). This estimate, prepared at a greater level of detail than the screening level costs, used the Corps Microcomputer Aided Cost Estimation System and contingencies that incorporate risk factors. The total first cost represents the sum of costs for Emsworth ($737,141,000), Dashields ($800,691,000), and Montgomery ($782,250,000). This cost accounts for both the level and timing of expenditures required to complete the project. Contingencies at each site were determined that would provide an 80-percent confidence that actual costs would be equal to or below calculated costs. The economic evaluation of this plan was updated using the certified costs at the October 2014 Price Level and an interest rate of 3⅛ percent. Average incremental annual costs are $83.2 million, average incremental annual benefits for the Mid-Forecast Scenario are $355.7 million, and average incremental annual net benefits are $272.5 million. The incremental Benefit to Cost Ratio is 4.3 to 1.

STUDY RECOMMENDATIONS

1. Plan LMA 7 is recommended for authorization;
2. The Project Cost of $2.32 billion would be cost-shared jointly by the General Fund (50 percent) and the Inland Waterways Trust Fund (50 percent); and
3. All construction would begin in FY 2019 after a two-year Preconstruction Engineering and Design (PED) effort.

Upper Ohio Navigation Study, Pennsylvania Final Feasibility Report and Integrated Environmental Impact Statement[1] – Main Report –

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LIST OF ACRONYMS

AC Acoustic Class
AES Analysis of Environmental Sustainability
AM Adaptive Management
AMA Advanced Maintenance Alternative
AMD Acid Mine Drainage
ARA Advanced Replacement Alternative
AST Above-ground Storage Tank
ATR Agency Technical Review (formerly Independent Technical Review)
AWO American Waterways Operators
BCERE Baseline Cost Estimate for Real Estate
BEA Bureau of Economic Analysis
BOD Biological Oxygen Demand
BMP Best Management Practices
CAA Clean Air Act

CAAA Clean Air Act Amendments
CE Cumulative Effect
CEA Cumulative Effects Assessment
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CEQ President's Council on Environmental Quality
CG Construction General Funding Account
CO Carbon Monoxide
COA Code of Account
CS Clear Skies
CSO Combined Sewer Overflows
CSw/o Hg Clear Skies without Mercury Limits
CWA Clean Water Act
DCP Data Collection Platform
DINAMO The Association for Development of Inland Navigation in America's Ohio Valley
DO Dissolved Oxygen
EDM Emsworth, Dashields, and Montgomery Locks and Dams
EIS Environmental Impact Statement
EJ Environmental Justice
ERDC U.S. Army Corps of Engineers Research and Development Center
EO Executive Order
EOP Environmental Operating Principles
EP Engineer Pamphlet
EQ Environmental Quality
ER Engineer Regulation
ERNS Emergency Response Notification System
ERP Ohio River Ecosystem Restoration Program
ES Environmental Sustainability
ESA Environmental Site Assessment
FAF Fix as Fails (= Reactive Maintenance (see RM))
FEMA Federal Emergency Management Agency
FERC Federal Energy Regulatory Commission
FIRM Flood Insurance Rate Map
FIS Flood Insurance Study
FONSI Finding of No Significant Impact
FY Fiscal Year (period between 1 Oct-30 Sep; e.g., "FY11" = 1 Oct 2010 – 30 Sep 2011)
GSA General Service Administration
H&S Health and Safety
HEP Habitat Evaluation Procedures (USFWS)
HQ-TSF High Quality Trout Stocked Fishery
HQUSACE U.S. Army Corps of Engineers Headquarters
HSI Habitat Suitability Indices
HTRW Hazardous, Toxic, and Radioactive Waste
HU Habitat Unit
IAIA International Association for Impact Assessment

IWG Interagency Working Group
IWTF Inland Waterways Trust Fund
JTU Jackson Turbidity Unit
L/D Locks and Dams or Lock and Dam
LM Lock Modernization
LMA Lock Modernization Alternative
LPMS Lock Performance Monitoring System
LRD Great Lakes and Ohio River Division
LRN U.S. Army Engineer District, Nashville
LUST Leaking Underground Storage Tank
m^2 square meters
MCACES Microcomputer Aided Cost Estimating System
MII Second Generration of MCACES
MIwb Modified Index of Well Being
MGQCS Miter Gate Quick Changeout System
MR Major Rehabilitation
MRA Major Rehabilitation Alternative
MRER Major Rehabilitation Evaluation Report
MS Marginally Sustainable
MSA Metropolitan Statistical Area
MTBE methyl-tert-butyl-ether
NAAQS National Ambient Air Quality Standards
NAVPAT Navigation Predictive Analysis Technique
NCRS National Resource Conservation Service
NED National Economic Development
NEPA National Environmental Policy Act of 1969
NER National Ecosystem Restoration
NES National Environmental Sustainability Plan
NFIP National Flood Insurance Program
NGO Non-Governmental Organizations
NGVD National Geodetic Vertical Datum
NHL National Historic Landmarks
NHPA National Historic Preservation Act
NOx Nitrous Oxides
NPDES - National Pollutant Discharge Elimination System
NRHP National Register of Historic Places
NRC National Research Council of the National Academy of Sciences
NS Not Sustainable
NSP Navigation Stewardship Program
NTU Nephalometric Turbidity Unit
NWI National Wetlands Inventory
O_3 Ozone
O&M Operations and Maintenance
OHW Ordinary High Water

ORNIM Ohio River Navigation Investment Model
ORFIn Ohio River Fish Index
ORINWR Ohio River Islands National Wildlife Refuge
ORMSS Ohio River Mainstem System Study
ORNS Ohio River Navigation System
ORSANCO Ohio River Valley Water Sanitation Commission
ORV Ohio River Valley
OSB Oversight Board
OSE Other Social Effects
P&G Economic and Environmental Principles and Guidelines for Water and Related LandResources Implementation Studies
PABHP Pennsylvania Bureau for Historic Preservation
PADEP Pennsylvania department of Environmental Protection
PCBs Polychlorinated Biphenyls
PDT Product Delivery Team
PED Preconstruction Engineering and Design
PEIS Programmatic Environmental Impact Statement
PFBC Pennsylvania Fish and Boat Commission
PGC Pennsylvania Game Commission
PGN Planning Guidance Notebook
pH A measure of acidity and/or alkalinity
PLA Primary Laydown Area
PM Particulate Matter
PMP Project Management Plan
PNDI Pennsylvania Natural Diversity Inventory
PDT Project Delivery Team
PSU Pennsylvania State University
PWC Personal Water Craft
QC Quality Control
RCRA Resource Conservation and Recovery Act
RED Regional Economic Development
REDM Real Estate Design Memorandum
REMR Repair, Evaluation, Maintenance, and Rehabilitation Program
REP Real Estate Plan
RFFA Reasonably Foreseeable Future Action
RFR Riparian/Floodplain Resources
r.m. river mile
RM Reactive Maintenance (synonymous with “Fix as Fails” (see FAF))
RMA Reactive Maintenance Alternative
ROD Record of Decision
ROW Right of Way
SF Significance Factor
SHPO State Historic Preservation Officer
SIP System Investment Plan

SLA Secondary Laydown Area
SO2— Sulfur Dioxide
SSO Sanitary Sewer Overflows
TES Threatened and Endangered Species
TMDL Total Maximum Daily Load
TSS Total Suspended Solids
UB Utility Based
UBH Utility Based High
ug/L Micrograms per Liter
UMR/IWW Upper Mississippi River/Illinois Waterway
UONS Upper Ohio Navigation Study, Pennsylvania
USACE U.S. Army Corps of Engineers
USEPA U.S. Environmental Protection Agency
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
UST Under-ground Storage TankVEC Valued Environmental Component
VOC Volatile Organic Compound
WOPC Without-Project Condition
WPC With-Project Condition
WWF Warm Water Fishery
YOY Young of Year (fish)

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1 STUDY AUTHORITY

The basic authority for the Upper Ohio Navigation Study, Pennsylvania (Upper Ohio Study), is contained in the resolution adopted by the Committee on Public Works of the United States Senate dated May 16, 1955:

> Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports on the Ohio River published in House Document No. 306, Seventy-fourth Congress, First Session, House Committee on Flood Control Document No. 1, Seventy-fifth Congress, First Session, and related reports, with a view to determining whether any modifications in the present comprehensive plan for flood control and other purposes in the Ohio River basin is advisable at this time.

Further authority was provided through a resolution adopted by the U.S. House of Representatives Committee on Public Works and Transportation on March 11, 1982:

> Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors established by the Section 3 of the River and Harbor Act approved June 13, 1902, is hereby requested to review the reports on the Ohio River published as House Document No. 492, 60th Congress, First Session, and House Document No. 306, Seventy-fourth Congress, First Session, and other pertinent reports with a view to determine whether any modification in the authorized plan for modern barge navigation and other purposes on the Ohio River is advisable at this time with particular emphasis on need for improvement or replacement of Emsworth Locks and Dam, Ohio River Mile 6.1; Dashields Locks and Dam, Ohio River Mile 13.3; Montgomery Island Locks and Dam, Ohio River Mile 31.7; and other locations where obsolete or inadequate facilities impede the orderly flow of commerce.

Additional general study authority is contained in Public Law 91-611, Section 216, 1970:

> The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

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2 STUDY REQUIREMENTS

The guiding goal of the Upper Ohio Navigation Study is to identify the best long-term comprehensive program for maintaining safe and reliable navigation through Emsworth, Dashields, and Montgomery Locks and Dams (collectively EDM), the three upper locks on the Ohio River, while striving to achieve environmental sustainability. Consistent with this goal, the specific needs, purposes, scope, objectives, and constraints are described below.

2.1 Purpose (*Need for Action)

2.1.1 Navigation

Emsworth, Dashields, and Montgomery Locks and Dams (placed in operation in 1921, 1929, and 1936, respectively) are among the oldest navigation facilities of the Ohio River Navigation System. Their present reliability is seriously compromised by deteriorated structural concrete and antiquated operating systems. A failure of a critical component of these facilities could cost the Federal government up to $200 million and close one or both locks up to three years. The risk of component failure is high and will only increase with time. Extended closures of the larger land chamber (110’ wide and 600’ long) at any of these three facilities would impose significant traffic delays, as all commercial tows would have to lock barges individually through the small river chamber (56’ x 360’). Delays increase transportation costs and may cause significant impact to aquatic habitat from tow queuing in lock approaches. In addition to reliability concerns, the EDM locks have the smallest capacity of the Ohio River Navigation System. The EDM main chambers are equivalent in size to the smaller (110’ x 600’) auxiliary chambers on the modernized Ohio River Navigation System where main chambers measure 110’ x 1200.’ The EDM auxiliary chambers are the smallest in the System.

The major navigation problem areas investigated in this study are poor structural condition, small locks (particularly the auxiliary river locks), hydraulic conditions in the locks and approach conditions, and old and obsolete mechanical and electrical equipment. Of these problem areas, the first two are the most severe and the greatest detriments to efficient and effective navigation over the next 50+ years.

2.1.2 Ecosystem Restoration

The Upper Ohio River is highly modified from a natural, unregulated river system due to the navigation system and effects of intensive industrial and municipal development. These man-made features have led to degraded ecosystem functions and values related to water quality, sediment quality, reduced riparian and riverine habitat diversity, and reduced diversity of riverine flora and fauna. The relatively recent environmental protection laws have resulted in significant improvements to many of these resources, but not to all. The Corps Ohio River Mainstem System Study (ORMSS) identified a number of potential ecosystem restoration opportunities to address degraded ecosystem functions and values, awaiting further study under various Corps authorities (see ORMSS report in Appendices).

2.2 Feasibility Study Scope

2.2.1 National Economic Development (NED) Planning

The primary purpose of the Upper Ohio Navigation Study is to address problems and opportunities at Emsworth, Dashields, and Montgomery Locks and Dams (EDM). This study will determine the best plan for maintaining safe and reliable navigation on the Upper Ohio River (comprising the EDM facilities) over a 50-year period of analysis as developed in the **Economics Appendix**. This plan, called the National Economic Development (NED) plan, will maximize economic development benefits consistent with protecting the environment.

Navigation plans include the continued operation of the existing infrastructure until failure, the scheduled replacement of components prior to failure at the existing locks, and the construction of new and possibly larger locks. Navigational maintenance activities include routine or day-to-day maintenance, cyclical maintenance, replacement or repair of major lock components, and major rehabilitation of those components. The focus of maintenance and major rehabilitation is to restore the functioning of existing lock components, not on construction of larger locks.

Operational efficiency and low-cost structural improvements for navigation include measures where the Corps has authority to construct, and generally costing less than $10 million in capital costs. The major benefit of these measures is increased performance of the locks by reducing the times to process commercial traffic. Measures to improve operational efficiency include lockage policies during periods of high congestion. Examples of small-scale improvements include:

- Installation of permanent mooring buoys or cells near lock approach points (which could enhance tow mooring in queuing situations and possibly speed up double-cut processing);
- Extension of guide or guard walls to improve lock approach times;
- Implementation of traffic management policies whereby the Corps would schedule arrivals of commercial tows at some or all Ohio River locks in an attempt to reduce delays during main chamber closures.

Full consideration of maintenance and operational efficiency and low-cost structural measures is made both without and with large-scale and costly lock modernization improvements in an attempt to maximize project performance prior to recommending any large-scale investments.

Examples of lock modernization improvements considered include:

- Reducing the number of locks and dams in the Upper Ohio River;
- Provision of replacement locks at the three oldest facilities on the Ohio River, namely Emsworth, Dashields, and Montgomery Locks & Dams.

2.2.2 National Ecosystem Restoration (NER) Planning

In accordance with current Corps policy and guidance, the problems and opportunities for ecosystem restoration projects involving a non-federal cost sharing partner were addressed as part of the navigation study. Restoration features are typically evaluated as to the non-monetary benefits they provide, which are termed National Ecosystem Restoration (NER) benefits.

Potential ecosystem restoration projects may include those that could be integral to or independent of the navigation facilities. In formulating an overall recommended plan that combines both navigation and ecosystem restoration components, any interdependence between the two may lead to necessary tradeoffs in the level of benefits both provide. The best "combined plan" may not be the simple combination of the individually best NED and NER plans, unless the two are completely independent.

2.3 Study Area

The study area includes navigation pools either controlled or influenced by the three navigation locks and dams on the Ohio River in Pennsylvania. This area includes the Ohio River from the New Cumberland Locks and Dam at r.m. 54.3 upstream to the first navigation facilities on the tributary Allegheny River (Lock and Dam 2 at Allegheny River mile 6.7) and Monongahela River (Braddock Locks and Dam at Monongahela River mile 11.5). For ecosystem restoration (NER) planning, the study area also extends laterally from the river corridor and riparian areas to the adjacent floodplain for considering habitat connectivity.

FIGURE 2-1: Upper Ohio Navigation Study Area

2.4 Environmental Impact Statement Scope

2.4.1 National Environmental Policy Act (NEPA)

An Environmental Impact Statement (EIS) is integrated into the Upper Ohio Navigation Study report to document the consideration of environmental impacts for both navigation and ecosystem restoration alternatives in compliance with NEPA and its implementing regulations (40 CFR 1500-1508). For ease of reference, the contents of the recommended EIS format (40 CFR 1502.10) are designated with asterisked (*) headings, e.g. "2.1 Purpose (*Need for Action)."

The Upper Ohio Navigation Study EIS is a tiered document (40 CFR 1508.28) from the final Programmatic Environmental Impact Statement (PEIS) of the Ohio River Mainstem System Study (ORMSS), which was concluded with a Record of Decision signed on July 8, 2011. The ORMSS PEIS addressed system-wide impacts associated with a recommended System Investment Plan (SIP) for maintaining safe, environmentally sustainable, and reliable navigation on the Ohio River through 2070. A major focus of the SIP/PEIS was a comprehensive Cumulative Effects Assessment that evaluated the impacts from past, present, and reasonably foreseeable future actions on ten categories of Valued Environmental Components. The ORMSS SIP/PEIS is appended to this feasibility report.

2.4.2 National Historic Preservation Act (NHPA)

This Upper Ohio Navigation Study report also integrates all documentation relevant to compliance with Section 106 of the National Historic Preservation Act (Public Law 89-665, as amended) and its implementing regulation, 36 CFR 800. Integration of Section 106 compliance requirements into the NEPA process is under the provision of 36 CFR 800.8(c). Appropriate notification of NEPA integration was provided to the Advisory Council on Historic Preservation and the Pennsylvania Bureau for Historic Preservation by letter dated December 16, 2009.

The District is also complying with the NHPA through a program alternative Programmatic Agreement under 36 CFR 800.3(a)(2). The *Programmatic Agreement Regarding the Modernization of the Ohio River Navigation System* was executed in 2009 between the Advisory Council on Historic Preservation, the Corps of Engineers (three District Offices), and the six State Historic Preservation Officers bordering the Ohio River. A full copy of the Programmatic Agreement is provided in the **Cultural Resource Appendix**. The major features of the agreement are summarized in its stipulation headings:

I. Completion of Historic Property Surveys

II. Identification and Treatment of Archaeological Properties

III. Identification and Treatment of Above-Ground Historic Properties

IV. Public Outreach and Education

V. Review of this Programmatic Agreement

2.4.3 Clean Water Act

Information on the effects of the discharge of dredged or fill material into the waters of the United States, including application of the Section 404(b)(1) Guidelines, is included in this report and the **Environmental Appendix**.

While the Corps will seek water quality certification from Pennsylvania, it has ensured that this EIS contains sufficient information regarding water quality effects, including consideration of the Section 404(b)(1) Guidelines, to meet the EIS content requirements of Section 404(r), should that exemption be invoked.

Section 404(r) of the CWA provides that the discharge of dredged or fill material, as part of the construction of a Federal project specifically authorized by Congress, is not prohibited by or otherwise subject to regulation under State programs approved under this section, or Sections 301(a) and 402 of the Act, so long as: (1) information on the effects of such discharge, including consideration of the Act's 404(b)(1) guidelines, is included in the EIS, and (2) the EIS has been submitted to Congress before the actual discharge, and prior to authorization of the project or the appropriation of project construction funds, 33 USC 1344(r).

2.5 Study Objectives

There are three objectives guiding this study.

Objective 1. Identify and evaluate all reasonable alternatives for maintaining safe, reliable, efficient, and sustainable navigation on the Upper Ohio River (comprised of the existing Emsworth, Dashields and Montgomery Locks and Dams) over the analysis period of 2025 – 2074. The metric used to distinguish between alternatives is the difference between the total benefits accrued by the navigation industry who utilizes the Upper Ohio Navigation System, comprised of Emsworth, Dashields and Montgomery locks and dams, and the federal cost to operate and maintain the Upper Ohio River Navigation System. This objective responds to the study authorities cited above.

Objective 2. Identify and evaluate reasonable opportunities for ecosystem restoration projects in the study area, consistent with navigation planning and interests of non-federal cost-sharing partners. This objective responds to the general study authority contained in Public Law 91-611, Section 216, 1970, for improving the quality of the environment in the overall public interest, and to Corps of Engineers current policies and guidelines for ecosystem restoration and Environmental Operating Principles.

Objective 3. Assure that any recommended project is consistent with protection of the Nation's environment, and that unavoidable impacts to environmental, cultural, or social resources are minimized or mitigated to the extent justified. Impact analyses will include direct, indirect, and cumulative effects under the National Environmental Policy Act, and will address provisions of all relevant environmental and cultural resource protection federal statues, executive orders, and their implementing regulations.

2.6 Study Constraints and Assumptions

Presented below are two constraints and three assumptions that will equally guide the full range of alternative plans (Without-Project and With-Project) that are formulated and the evaluations of those plans.

Constraint #1: There will be no change to authorized nine-foot deep Ohio River channel

Deepening the Ohio River channel might be one way to increase the freight-handling capacity of the system (more tons per tow-surface-area). Since the completion of the Ohio River canalization project in 1929, the U.S. Government has maintained a 9-foot deep x 300-foot wide navigation channel between the lock and dam projects.

Deepening the channel would require combinations of the following:

- Extensive and on-going dredging of long segments of the river, including areas currently not requiring maintenance dredging;
- Raising the minimum "Normal Pool" levels – which would require modifications to many or all the lock and dam structures.

Thus, deepening of the channel was not considered for a number of reasons, particularly:

- No precedence for channel deepening has ever been established in recent Ohio River infrastructure feasibility reports (the Greenup and Myers authorization report in 2000). All current structures and those under construction are designed expressly for an authorized 9-foot channel depth. The depth over the lock gate sill is designed for tows that accommodate this channel depth.
- There is no reason to believe such a deepening would be cost-effective, due to the associated expense of modifying 19 locks and dam structures to safely allow deeper drafted vessels to lock through.
- The environmental consequences of pool elevation changes and deepening, requiring dredging to levels well below current river strata, are assumed to be a serious negative impact to benthic organisms, fish, and riparian wildlife and vegetation. Also, the environmental impacts associated with disposal of large amounts of dredged materials would be a significant problem.

Constraint #2: Maximum lock size considered is 110' wide x 1200' long (nominal dimensions)

Constraint #2 is in some ways similar to Constraint #1 in that it is governed by the natural geometry of the river itself. Locks larger than the nominal size of 110' x 1200' were not considered, based on previous input from commercial navigation interests, as well as being consistent with the existing maximum lock chamber sizes currently in use.

Natural river geometry tends to limit tow sizes to about 108' wide x 1200' long along most of the river, particularly in bend-way areas. Occasionally, a few companies run double-wide

(30-barge) tows along portions of the lower Ohio and Tennessee Rivers, particularly during higher water periods. However, these tows arrange in advance to pass through the locks in 108'x1200' (or smaller) configurations.

Assumption #1: The Ohio River Mainstem (below EDM) and other navigable tributaries in the Ohio River System will remain canalized

The study recognizes the Ohio River mainstem ecosystem is highly modified and likely to remain for the foreseeable future, due to mainstem impoundment by the Corps that began in the late 19th century and is continuing into the 21st century. Floodplain development, which encompasses extensive industrial, commercial, and residential use and infrastructure essential to transportation and community services, is based on existing pool levels created by the system of high-lift dams begun in the mid-20th century. Returning the river to its pre-impoundment state would have profound environmental, economic and engineering implications. It is therefore considered unrealistic, if not impossible, to return the floodplain to pre-development conditions.

Assumption #2: All locks and dams on Ohio River tributaries are modeled as operating at full capacity

Navigation benefits of all plans will be determined assuming that all other locks required to serve the traffic through EDM are operating at full capacity. No reliability analyses will be conducted at locks and dams other than EDM on the Ohio River or any of the Ohio River tributaries. In other words, all projects except EDM are modeled as operating with no unscheduled closures due to failures of major lock components.

Assumption #3: All authorized improvements on the Ohio River Basin are included in all analyses

The following Ohio River projects listed below are included in all alternative plans considered in this study. For simplification in this analysis, all of these projects are assumed complete by the year 2012.

Lower Monongahela River Project. The Water Resources Development Act (WRDA) 1992 authorized this project comprising construction of a two 84' x 720' lock chambers at the old Monongahela River Locks and Dam (L/D) 4 (renamed Charleroi L/D) project at Mon River mile 41.5, the removal of Monongahela River L/D 3 at Mon River mile 23.8, and construction of a new gated dam at the old Monongahela River L/D 2 (renamed Braddock L/D) at Mon River mile 11.2. Construction began in 1995 at Braddock L/D.

Greenup L/D, Ohio River mile 341.0. WRDA 2000 authorized the extension of the existing 110' x 600' auxiliary lock to 1200' such that the new project will have twin 110'x1200' locks.

J.T. Myers L/D, Ohio River mile 846.0. WRDA 2000 authorized the extension of the existing 110' x 600' auxiliary lock to 1200' such that the new project will have twin 110'x1200' locks. For simplicity in this analysis, this project is assumed complete in year 2012.

Olmsted L/D, Ohio River Mile 964.6 – 2018. WRDA 1988 authorized this project consisting of the construction of a new facility with two 110' x 1200' lock chambers that will replace Lock and Dam #52, Ohio River mile 938.9, and Lock and Dam #53, Ohio River mile 962.6.

Kentucky L/D, Tennessee River Mile 22.4. WRDA 1996 authorized this project consisting of the construction of a new 110' x 1200' lock chamber riverward of the existing 110'x600' lock chamber. Construction began in 1998.

Chickamauga L/D, Tennessee River Mile 471.0. The Fiscal Year 2003 Energy and Water Appropriations Bill authorized this project consisting of the construction of a new 110'x600' lock chamber to replace the existing 56'x360' lock chamber.

Markland L/D, Ohio River mile 531.5. A major rehabilitation of the locks involving the replacement of the miter gates and valves is on-going.

3 EXISTING CONDITIONS

3.1 Navigation Projects

The three existing navigation facilities on the Upper Ohio River in Pennsylvania are the primary focus of study - Emsworth Locks and Dams, Dashields Locks and Dam, and Montgomery Locks and Dam. Emsworth Locks and Dams is located at river mile (r.m.) 6.2 and maintains the "Pittsburgh Pool" at elevation 710.0. The Pittsburgh Pool extends to into the two Ohio River tributaries, the Monongahela River (11.2 miles) and the Allegheny River (6.7 miles). Emsworth is situated at Neville Island and has two dams, the main channel dam at mile 6.2 and the backchannel dam at mile 6.8. Dashields Locks and Dam is located at r.m. 13.3 and maintains a pool elevation of 692.0 for a distance of 7.1 miles. Montgomery Locks and Dam is located at r.m. 31.7 and maintains a pool elevation of 682.0 for a distance of 18.4 miles. As of January 2014, there are three active permits authorizing the study of hydroelectric power plants by non-Federal entities at Emsworth (one at each dam) and at Montgomery[2]. The position of these three locks and dams in relation to other Pittsburgh District navigation facilities is shown below.

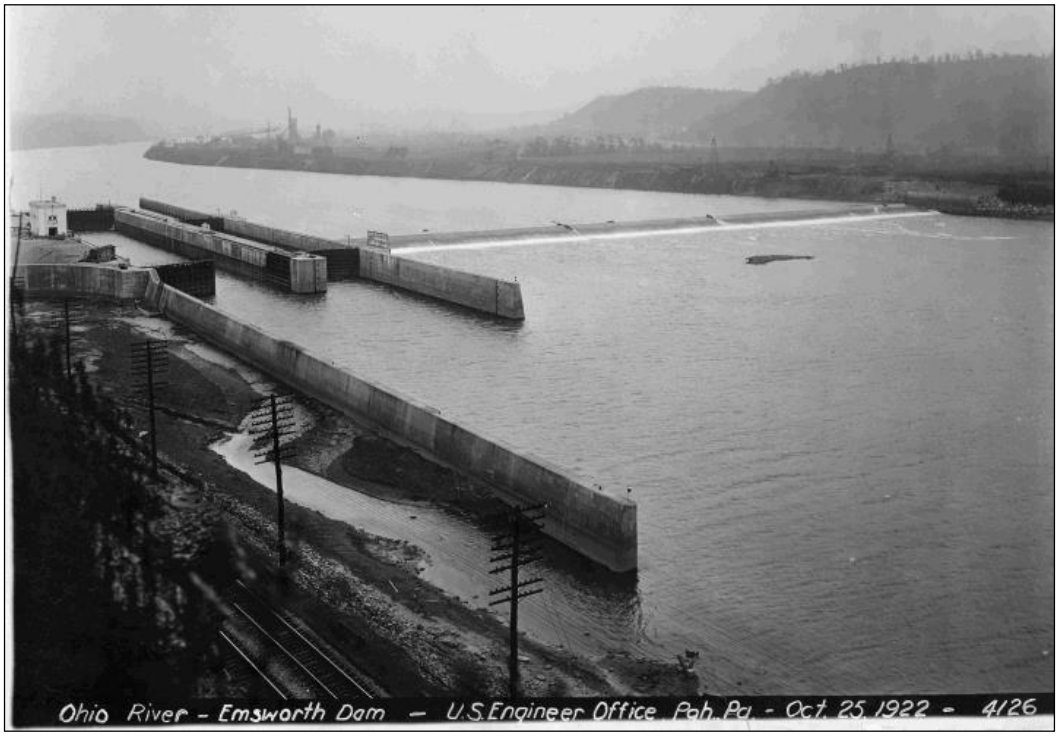
FIGURE 3-1: Pittsburgh District Navigation Facilities

[2] The Federal Power Act (Section 4f) authorizes the Federal Energy Regulatory Commission (FERC) to issue permits for the purpose of enabling prospective applicants for a hydropower license to secure data and perform studies to determine project feasibility. A license issued by the FERC would authorize the applicant to construct and operate the hydropower plant subject to conditions stipulated in the license and other documents.

3.1.1 Emsworth Locks and Dams

The Emsworth Locks and Dams project consists of two locks and two dams (mainchannel and backchannel) situated at Neville Island in Allegheny County, Pennsylvania. This facility replaced the 1885 Davis Island Lock and Dam (the first Ohio River mainstem navigation project) and the 1906 Ohio River Lock and Dam 2. The original 1922 Emsworth Dams were fixed-crest structures (**Photo 3-1**). These dams were replaced in 1938 with new vertical-lift gated dams that provided a higher (+7') and more stable pool at Pittsburgh, and permitted the removal of Allegheny Locks and Dam 1 and Monongahela Locks and Dam 1. Emsworth's original fixed-crest dams were modified and retained as the new apron/stilling basin.

Photo 3-1: Emsworth Locks and Mainchannel Dam, 1922



The overall length of the main channel dam, from the river-face of the River Wall to the river-face of the abutment wall is 967.42', including a 34.42' weir with a crest at elevation 709.0[3], adjacent to the River Wall. The back channel dam has an overall length of 750' between the river-faces of the two abutment walls. The navigation pool, elevation 710.0, is controlled by eight gated sections in the main channel and six in the back channel, each 100' long with a damming height of 12 feet above the sill at elevation 698.0. The vertical lift between the lower pool, at elevation 692.0, and the upper pool, elevation 710.0, is 18 feet. All of the original gates and the scour protection downstream of both dams are being replaced as part of the on-going major rehabilitation project of Emsworth Dams.

[3] Elevations refer to NADV88 elevations (typical).

The Emsworth Locks are dual, adjacent, parallel chambers located on the right bank of the river's main channel at r.m. 6.2. The main chamber occupies the landward position and has clear dimensions of 110' x 600.' The riverward auxiliary chamber has clear dimensions of 56' x 360.' The upper guide wall was extended approximately 500' when the gated dam was constructed. Also, the upper and lower guard walls were extended when the gated dam was constructed by a series of individual sheet-pile cells.

The original Emsworth Locks and Dams was the first of the second generation facilities whose design marked a significant departure from the original (1885-1929) single lock and movable wicket dam facilities. The concrete fixed crest dams (spanning the main channel and back channel at Neville Island) signaled an end to open river navigation on the upper river. The two-lock configuration was a direct consequence of the fixed crest dam, providing for the first time on the Ohio River an auxiliary lock to maintain navigation in place of open river conditions when the larger main chamber was closed for maintenance.

When replacing the fixed-crest dams in 1938, the District used the vertical lift-gate design developed for Montgomery Dam (**Photo 3-2**). One of Emsworth's 14 gates was of a different, experimental design. The "Sidney Gate," developed by Pittsburgh District engineer William Sidney, combined advantages of both vertical lift and tainter gates. This Sidney Gate was first used as a full scale experiment in the back channel dam at Emsworth (1938) and remained in use

Photo 3-2: Emsworth Main Channel Gated Dam, 1938

until the 2008 major rehabilitation of that structure. Post-World War II Ohio River project modernization incorporated tainter gate technology instead of vertical lift or fixed crest dams to replace the remaining Ohio River wicket dams. Sidney Gates remain in use at two of the District's Monongahela River navigation dams.

A total of 18.71 acres is being used as support land for the project. There are 15.25 acres of fee land (owned by the US Government), including 3.83 acres on the right bank and 10.14 acres on the left bank of the main channel, and 1.28 acres on the back channel. A total of 2.79 acres are easements used in support of the project, including 1.34 acres of Permanent Road Easements and 1.45 acres of flowage easements. There are four existing licenses totaling 0.67 acres and consist of a tract for a sewer line (0.04 acres), a private grade crossing, pedestrian tunnel and parking area (0.51 acres), a grade crossing (0.08 acres), and a grade crossing (0.04 acres).

Photo 3-3: Emsworth Locks and Dams, Aerial Looking Downstream

LOCKS: Two parallel locks, main lock 110' by 600', auxiliary lock 56’ by 360'.

DAMS: Non-navigable, gated dams on main & back channels. Main Channel Dam (river mile 6.2, center of photo) comprised of 8 vertical-lift gates, each 100’ in length, with one fixed weir with 34’ open crest. Top length of dam is 967’. Back Channel Dam (river mile 6.8, photo upper left) composed of 6 vertical-lift gates, each 100’ in length. Top length of dam is 750’. Lift is 18.0’. Operation Commenced: 1921. Gated Dam constructed 1938.

3.1.2 Dashields Locks and Dam

The Dashields Locks and Dam project consists of an uncontrolled overflow fixed-crest dam and dual locks situated in Allegheny County, Pennsylvania (**Photo 3-4**). It was constructed from 1927 to 1929 to replace the original Lock and Dam No. 3 at Osborne. The overall length of the existing fixed crest dam is 1,585 feet from the river face of the river wall to the river face of the abutment wall on the right bank, and the crest elevation is 692.0. The vertical-lift between the lower pool, elevation 682.0, and upper pool, elevation 692.0, is 10 feet. The Dashields Locks are dual, adjacent, parallel chambers located on the left bank of the river at r.m. 13.3. The main lock chamber occupies the landward position with clear dimensions of 110’ x 600’ in length. The

adjacent smaller chamber occupies the riverward position with clear dimensions of 56’ x 360’ in length.

Photo 3-4: Dashields Locks and Dam, 1930

The Dashields project retains its original dam and locks configuration, and is the only Ohio River navigation facility that has a fixed crest dam. Formerly, Emsworth also had fixed crest dams, which were replaced with vertical lift gated dams. Dashields Dam is therefore the only remaining representative of the brief transition era (1922-1934) between the original wicket dams (1885-1929) and (1934-present) movable crest dams.

A total of 18.16 acres is being used as support land for the project. There are 9.30 acres of fee land owned by the U.S. Government for this project, and 8.76 acres are easements used in support of the project. Further research into the status of the U.S. Government owned lands is necessary to determine the types of easements owned in the Dashields pool. There are two existing licenses consisting of a pipeline (0.13 acres) and a private grade crossing over CSX railroad tracks with the acreage being undefined.

Photo 3-5: Dashields Locks and Dam, Aerial

LOCKS: Two parallel locks, main lock 110' by 600', auxiliary lock 56' by 360'

DAM: Fixed Crest Weir, top length of dam 1585'. Lift is 10.0'. Operation Commenced: 1929.

3.1.3 Montgomery Locks and Dam

The Montgomery Locks and Dam project, consisting of a controlled spillway dam and dual locks, are situated in Beaver County, Pennsylvania (**Photo 3-6**). These structures were constructed between 1932 to 1936 to replace the original Locks and Dams Nos. 4, 5, and 6 at Legionville, Freedom, and Merrill, respectively.

The existing dam is comprised of a controlled spillway consisting of 10 vertical-lift, gated sections. Each section is 100 feet in length with a sill at elevation 667.0, and an uncontrolled overflow spillway section consisting of two fixed weir sections, one 109.5 feet in length adjacent to the abutment wall and the other 109.25 feet in length adjacent to the river wall, both with the crest at elevation 680.33. The overall length of the dam, from the river-face of the river wall to the river-face of the abutment wall is 1,378.75 feet, including the fixed-crest weirs and gated spillways. The vertical-lift between the lower pool at elevation 664.5 and the upper pool, at elevation 682.0, is 17.5 feet. Two of the original vertical-lift dam gates (Nos. 4 and 8) were destroyed in a 2006 tow boat accident and have been replaced with new gates designed to modern standards.

Photo 3-6: Montgomery Locks and Dam, 1936

The Montgomery Locks are dual, adjacent, parallel chambers located on the left bank of the river at r.m. 31.7. The main lock chamber occupies the landward position with clear dimensions of 110’ x 600’ in length. The adjacent smaller chamber occupies the riverward position with clear dimensions of 56’ x 360’ in length. After the lock was placed into service, the upper guide and guard walls were extended by approximately 500’ to provide better approach conditions.

Montgomery Dam is one of only two vertical lift-gate dams on the Ohio River (the other being the Emsworth Dams). It retains eight of ten original gates and all of the original operating equipment. Apart from minor modifications to the piers in the 1980s and the two replacement gates, the dam retains its original configuration and appearance. The locks also retain their original 1934 configuration, but were slightly modified in the 1980s rehabilitation that included addition of new operating buildings.

A total of 86.92 acres is being used as support land for the project. There is a total of 6.11 acres of fee land owned by the U.S. Government for this project. A total of 80.81 acres are easements used in support of the project. These easements are further broken down into 0.41 acres for a Permanent Road Easement and 80.41 acres of flowage easements.

Photo 3-7: Montgomery Locks and Dam, Aerial

LOCKS: Two parallel locks, main lock 110' by 600', auxiliary lock 56’ by 360'.

DAM: Non-navigable dam comprised of 10 vertical-lift gates, each 100’ in length, with two fixed weirs with a 109.5’ and 109.25’ open crest lengths. Top length of dam is 1,379’. Lift is 17.5’. Operation Commenced: 1936.

3.2 Upper Ohio River Ecosystem

Although once a pristine environment, the Ohio River has gone through a prolonged degradation process from historic settlement, municipal/industrial growth, and little constraining regulation. In its worst state, the river was incapable of supporting a desirable aquatic community. Beginning around 1970, passage of key environmental legislation was instrumental in reversing the degradation and initiating the long road to recovery of aquatic resources of the upper Ohio River. Most of the early environmental requirements dealt with restoring the Nation's water quality. The Clean Water Act employs a variety of regulatory and non-regulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Presently, the majority of the study area is characterized by extensive industrial, urban, and suburban land uses along the river. The region has a long history of extensive development and use for commercial purposes, and the Pittsburgh area was well known historically for its role in

the industrial revolution, especially its steel making capacity. During the earliest years of the Nation, Pittsburgh was the major gateway to the western territories. With the Ohio River flowing from east to west, and water as a primary means of transportation, Pittsburgh was a logical starting point for explorers and settlers venturing west.

3.2.1 Emsworth Pool

Emsworth is the uppermost pool on the Ohio River mainstem and has a surface area of approximately 2,880 acres. The Ohio River Valley Water Sanitation Commission (ORSANCO) describes the fish population of Emsworth Pool to be in exceptional condition, with the 42 species collected indicating a diverse community. Sunfishes and black basses (Centrarchidae) were the most common family. Bluegill and smallmouth bass were the two dominant species in the pool accounting for 27.4 percent of the total individuals collected. Several Pennsylvania state-listed threatened or endangered species were collected from the pool in moderate abundances. River shiners (*Notropis blennius*) and silver chubs (*Macrhybopsis storeriana*) were considered endangered and collections yielded one and 26 individuals, respectively. Three species of threatened status were collected. There were 97, 20, and 8 individuals of smallmouth buffalo (*Ictiobus bubalus*), mooneye (*Hiodon tergisus*), and skipjack herring (*Alosa chrysochloris*), respectively. Based on Pennsylvania's list of imperiled species, the Ohio River proper and the lower portions of the Allegheny and Monongahela rivers provided suitable conditions for these species. An average of 157.9 individuals (excluding gizzard shad and emerald shiners) was collected at each site in Emsworth Pool. The two most abundant fishes (i.e., bluegill and smallmouth bass) were also collected in considerably higher proportions than in other pools. In comparison to other pools, the fish community was in outstanding condition (ORSANCO Report *"A Biological Study of the Emsworth Pool of the Ohio River,"* 2007).

3.2.2 Dashields Pool

Dashields Pool is downstream of Emsworth Locks and Dams, and has a surface area of approximately 1,216 acres. ORSANCO surveyed the Dashields Pool as recently as 2008. The habitat assessments show that in Dashields Pool there was a dominance of class 'B' habitats indicating that most sites had a moderate composition of coarse substrates. Class 'C' habitats were also relatively abundant indicating that there was a moderate composition of fine substrates (sand, fines, and hardpan). The instream habitat in the pool appeared adequate to sustain healthy fish populations due to the abundance of woody cover and heterogeneous substrates. However, Dashields Pool is unique because there are no major tributaries emptying into the pool. This could restrict the pool's ability to harbor a healthy fish assemblage as tributaries serve as refugia, spawning, and nursery areas for many Ohio River fishes. Additionally, Dashields Pool is potentially subject to numerous negative industrial and anthropogenic influences within its relatively small size (7.1 miles). The overall average quality score in Dashields Pool was 1.7 (out of 5), indicating the pool is in poor biological condition. The data collected in 2008 indicated that the Dashields Pool did not meet the biocriteria established by ORSANCO's Biological Water Quality Subcommittee and failed to meet (support) its aquatic life-use designation.

An average of 74.1 individuals (excluding gizzard shad and emerald shiner) was collected at each site in Dashields Pool which ranked third worst in comparison to other Ohio River pools. If gizzard shad and emerald shiners were not included, the Dashields Pool had the lowest average number of individuals per site (81.9 individuals) than any other pool assessed as of 2008. In addition to the information collected for MORFIn purposes, benthic trawling conducted within Dashields Pool produced Tippecanoe darters (*Etheostoma tippecanoe*). Trawls also yielded these darters in Hannibal Pool. These are thought to be the first records of Tippecanoe darters to be collected from the mainstem of the Ohio River. This species is listed in the state of Pennsylvania as threatened (ORSANCO Biological Survey Report, 2008).

3.2.3 Montgomery Pool

Montgomery Pool is downstream of Dashields and has a surface area of approximately 3,008 acres. The following information is taken from the ORSANCO (2006) Biological Survey Report for the Montgomery Pool.

Intensive habitat surveys at 15 sampling locations revealed that the bottom substrate in the Montgomery Pool was mostly composed of sand and gravel, with some portions of cobble and fines with a small percentage of boulders. However, there was some variation among the individual sites. The percentages of substrate variables were used to give each site a habitat classification of ‘A’, ‘B’, or ‘C’. The Montgomery Pool was dominated by class ‘A’ habitats, which account for 60 percent of the samples. The remaining 40 percent of the samples was classified as class ‘B’ habitats and no class ‘C’ habitats sampled in the pool. Woody cover was present in 12 of the 15 sites sampled, but only seven sites had cover at more than 10 percent of the area. Riparian land use was primarily industrial and forest.

ORFIn scores were calculated for each of the sites sampled. The maximum score achieved by any site in this pool out of a possible 65 was 49, and the minimum was 23. By comparing observed and expected ORFIn scores, ORSANCO assessed each site as either passing or failing. All but two of the 15 sites sampled in 2006 scored higher than the minimum expected scores and received passing evaluations; 87 percent of the sites were in passing condition with an estimated precision of +/- 14 percent. Five sites (33%) received a good condition rating, eight sites (54%) were found to be in fair condition and two (13%) were in poor condition.

The fish population of Montgomery Pool appears to be in fair to good condition. The 41 species collected indicate a diverse population. It is unexpected for smallmouth buffalo and sauger to outnumber the shad and minnows, since forage fish normally outnumber other species. Their absence, as well as others, may be attributed to high flows observed during sampling. The habitat assessments show that Montgomery Pool has slightly more ‘A’ habitats than ‘B’ habitats and few, if any, class ‘C’ habitats. While much of the substrate is sand and gravel, there are enough larger substrates to provide good habitat for the fish population. The woody cover present at many of the sites also supplements the habitat available.

Data collected in 2006 indicate that the Montgomery Pool is in fair to good condition. The analysis indicates that the estimated percentage of the pool in failing condition is 13.3 percent (+/- 14%). This estimate overlaps the threshold (25%) established to determine if a pool meets its aquatic life use designation, creating some uncertainty. Normally the pool would require

additional sampling to confirm that it is indeed in passing condition. However, ORSANCO biologists have decided to accept the Montgomery Pool as meeting its aquatic life use designation, focusing more on the estimate of 13.3 percent than on the range of precision. Biologists have concluded that limited resources are better spent assessing new areas of the Ohio River and are willing to accept this assessment. This decision was supported by the members of the ORSANCO Biological Water Quality Subcommittee.

3.2.4 Montgomery Slough

A significant resource within Montgomery Pool that deserves special mention is Montgomery Slough, which is also known as the Montgomery Embayment and Ohioview Peninsula. Although relatively small (about 90 acres including lands and water), this is the most significant backwater/embayment area within the study area. It has been considered for incorporation into the Ohio River Islands National Wildlife Refuge (ORINWR).

Photo 3-8: Montgomery Slough

The site consists of a 24-acre shallow embayment with depths of four feet or less enclosed by a modified floodplain peninsula. The latter has been used as a dredged disposal containment area in the past (about 1975-2004). The narrow (141-foot) mouth of the embayment joins the Ohio River on the right bank immediately above Montgomery Dam within the dam's restricted access zone. Boat access to the embayment must be coordinated with the Montgomery Locks and Dam Lockmaster, and is only allowed under certain flow conditions.

The Pennsylvania Fish and Boat Commission conducted an electrofishing survey of the Montgomery Slough embayment in September 1979. In a December 14, 1979, letter to the US Fish and Wildlife Service, the Commission stated:

> "Since this embayment is the only such area along the Ohio River in Pennsylvania, it does carry with it particular significance being that it is a one-of-a-kind ecosystem. Although the specific fish species found in the embayment may be found at other places in the river system, the entire aquatic environment is unique in the fact that no other area along the Ohio River in Pennsylvania has the aquatic plant life and wetland habitat association."

In October, 2009, an extensive field investigation of the Montgomery Slough area was conducted as part of the present study (see **Ecosystem Restoration Appendix**). This investigation found that the site contains a mixture of Low, Medium and High Quality habitats. The bottomland hardwood forest area covers approximately 23 percent of the site and provides mature hardwood forest habitat for both resident and migratory wildlife species. Dominant vegetation species include native species with minimal areas of invasive species noted during the field reconnaissance. The bottomland hardwood forest area provides High Quality habitat for wildlife in its present condition.

The upland modified area covers approximately 37 percent of the Study Site and currently provides a mix of early succession forest, open field and immature bottomland forest. This area was considered Prime Farmland prior to the placement of dredge disposal, which significantly altered the natural drainage patterns, elevation, and vegetation species present in this area. As a result, this area provides Low Quality habitat to wildlife due to the disturbed conditions and the dominance of invasive plant species. The palustrine emergent wetland area covers less than one percent of the Study Site, but provides habitat for aquatic and terrestrial species immediately adjacent to the open water embayment. This area provides Medium Quality habitat to wildlife in its present condition. The open water area covers approximately 22 percent of the Study Site and provides Medium Quality habitat to wildlife in its present condition. Herbaceous vegetation was present along the shoreline and included purple loosestrife which is considered a noxious weed in Pennsylvania.

3.2.5 New Cumberland Pool

New Cumberland Pool is downstream of Montgomery Dam. The following information is taken from the ORSANCO (2005) Biological Survey Report for the New Cumberland Pool.

In 2005, fish population data were collected from 15 randomly selected locations throughout the length of the New Cumberland Pool. These collections produced 50 taxa, representing ten different families. Seven of these taxa are Pennsylvania State-listed either as threatened, endangered, or of special concern. These include longnose gar (*Lepisosteus osseus*), mooneye (*Hiodon tergisus*), skipjack herring (*Alosa chrysochloris*), silver chub *(Macrobopsis storeriana*), smallmouth buffalo (*Ictiobus bubalus*), river redhorse (*Moxostoma carinatum*), and channel darter (*Percina copelandi*). Two of those seven (river redhorse and channel darter) are also given special status in Ohio. At the species level, the most abundant species were freshwater drum (*Aplodinotus grunniens*) and gizzard shad (*Dorosoma cepedianum*), which comprised

28.8 percent and 23.6 percent of the catch respectively. The dominance of these two species was directly reflected at the family level. The drum family (Sciaenidae) dominated in abundance, making up 25.6 percent of the total catch, followed by the shad and herring family (Clupeidae) which made up 21.0 percent of the catch.

Intensive habitat surveys at each of the 15 sampling locations revealed that the bottom substrate in the New Cumberland pool was almost equally composed of sand, gravel, cobble, and fines with a smaller percentage of boulders. However, there was some variation among the individual sites. The percentages of substrate variables were used to give each site a habitat classification of 'A', 'B', or 'C'. The New Cumberland Pool was dominated by class 'A' habitats, which account for two-thirds of the samples. The remaining third of the samples was classified as class 'B habitats. There were no class 'C habitats sampled in the pool. Woody cover was present in 14 of the 15 sites sampled, riparian land use was primarily industrial, and barge influence was present throughout the majority of the pool.

ORFIn scores were calculated for each of the sites sampled. The maximum score achieved by any site in this pool was 55, and the minimum score was 37. By comparing observed and expected ORFIn scores, ORSANCO assesses each site as either passing or failing. All 15 sites sampled in 2005 scored higher than the minimum expected scores and received passing evaluations. With 100 percent of the sites passing, the pool was also assessed as passing. Six sites received an excellent condition rating, five sites were found to be in good condition and four were in fair condition.

3.3 *Affected Environment[4]

3.3.1 General Study Area & Resources

3.3.1.1 Study Area Defined

The study area includes the three locks and dams on the Ohio River in Pennsylvania, and extends through the pools either influenced or controlled by these navigation dams. This expands the study area downriver from the Pennsylvania/Ohio state line at r.m. 40.0 to the New Cumberland Locks and Dam at r.m. 54.3, and upriver from the Pittsburgh Point to Allegheny River Lock and Dam 2 (Allegheny River mile 6.7) and to Braddock Locks and Dam (Monongahela River mile 11.5). For ecosystem restoration (NER) planning, the study area extends laterally from the river corridor and riparian areas to the adjacent floodplains for considering habitat connectivity.

3.3.1.2 Resources and Sustainability

The resources considered in this study and the concept of environmental sustainability were derived principally from the Corps ORMSS. This study's Programmatic Environmental Impact Statement (PEIS) focused on a cumulative effects assessment (CEA) of the entire mainstem navigation system. Within the CEA, environmental sustainability was used as an "ultimate test"

[4] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

for determining the significance of cumulative effects on resources categorized as "valued environmental components" (VECs). Environmental sustainability, as used in the Corps Environmental Operating Principles, is defined as "a synergistic process whereby environment and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations." The selection of VECs and the evaluation of their sustainability was a joint effort between the Corps and many non-federal participants in an ORMSS Interagency Working Group.

3.3.1.3 Upper Ohio River Valued Environmental Components

The term, "Valued Environmental Component," as used in this study report refers to resources considered in a cumulative effects assessment required under the National Environmental Policy Act. This does not infer that other resources addressed in this study are not valuable; only that they were not individually considered within the cumulative effects context. Wildlife would be an example of a federally recognized valuable resource that was not included as a VEC. Outside of the cumulative effects context, many of the VEC resources, for example "water quality," were also considered in direct and indirect impact analyses.

The Upper Ohio River VECs, as defined through input from a study-specific Interagency Working Group, are: Water Quality, Sediment Quality, Fish, Mussels, Riparian Resources, Recreation, Transportation and Traffic, Air Quality, Health and Safety, Socioeconomics, and Cultural Resources. These are identical to those defined in the ORMSS PEIS, with the exception that ORMSS Water/Sediment Quality VEC was split into separate VECs in the Upper Ohio Study.

3.3.1.4 Climate Change

3.3.1.4.1 The National Picture

The current state of climate science and current and future impacts of climate change on major U.S. regions and key sectors of the U.S. economy are summarized in *Climate Change Impacts in the United States: The Third National Climate Assessment (May 2014)*[5]. In the nation's northeast region, which includes Pennsylvania (Chapter 16, Northeast), the focus is on consequences of increased temperatures, coastal and river flooding on residents, coastal infrastructure, agriculture, fisheries, and ecosystems. This region has experienced an increase in average temperature, and a greater increase in extreme precipitation than any other region in the nation. In the Midwest (Chapter 18. Midwest), which includes the Ohio and Upper Mississippi River valleys, there is evidence of increasing annual precipitation with wetter winters and springs, drier summers, an increase in extreme precipitation events, and changes in snowfall patterns. Historical patterns of regional precipitation and streamflow are no longer considered to

[5] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

be appropriate guides for design of water infrastructure for flood control, navigation, and other purposes. Enhancing resilience of such systems to heavy precipitation events is viewed as an appropriate response to offset impacts.

With respect to transportation at the national level, (Chapter 5, Transportation), states:

> Climate change will affect transportation systems directly, through infrastructure damage, and indirectly, through changes in trade flows, agriculture, energy use, and settlement patterns. If, for instance, corn cultivation shifts northward in response to rising temperatures, U.S. agricultural products may flow to markets from different origins by different routes. If policy measures and technological changes reduce greenhouse gas emissions by affecting fuel types, there will likely be significant impacts on the transportation of energy supplies (such as pipelines and coal trains) and on the cost of transportation to freight and passenger users.

The report indicates that inland rivers may experience more extreme weather events (flooding and drought) that has shut down navigation intermittently, as observed on the Mississippi and Missouri River Basins in recent years. While alternative modes like truck and rail might eventually alleviate some of river navigation disruption, this is not always possible in the near term, and would run counter to initiatives for reducing greenhouse gas emissions through more fuel efficient transportation modes. The importance of transportation network redundancy and infrastructure resilience to adverse weather conditions is stressed in regards to governmental actions to address climate change.

3.3.1.4.2 The State-Level Picture

Studies recently published by the Pennsylvania Department of Environmental Protection (e.g., *Pennsylvania Climate Change Action Plan (2009)*, its 2013 Update, the *Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations*, and *2013 Pennsylvania Climate Impacts Assessment Report Update)* indicate that over the next 20 years projected climate change for Pennsylvania is very likely to be warmer and wetter. Likely changes in precipitation will translate to impacts in snowpack, runoff, soil moisture/drought, evapotranspiration, groundwater, stream temperature, floods and water quality.

A generally warmer regional climate anticipates greater extremes with intensity of precipitation and with longer dry periods. The most significant effects predicted for stream and wetland communities are increased water temperature and increased variability of the water environment. The latter may be reflected in changing seasonal patterns of water levels, reduced stream flows during dry periods, larger floods and longer droughts.

Groundwater recharge will increase due to a reduction in frozen soil and higher winter precipitation in the form of rainfall when plants are not active and evapotranspiration is low. The frequency of short- and medium-length soil moisture droughts is projected to increase during summer and fall due to the less frequent rainfall and increased evapotranspiration (higher temperatures raise plant metabolism, which then requires more water). Summer floods and stream flow variability are projected to increase, given the greater intensity of rainfall events, while floods caused by rain-on-snow events are expected to decrease, given less snowpack.

Increases in the frequency of severe weather events, in which heavier than normal precipitation is experienced, should increase the number and severity of flash floods along smaller streams. This would likely have impacts on soil and nutrient runoff, increases in rates of soil erosion and translate into infrastructure concerns for state and local government regarding stormwater management (e.g. culvert, road and bridge sizing/construction, combined sewer overflows, etc.). There may be an increased utilization and reliance on irrigation systems for residential, commercial, and agricultural purposes. Industry and power generation are consumptive users of water for process needs and cooling. The Commonwealth can expect increased periods of demand for water resources at times when the supply is constrained relating to resource allocation and/or limitation issues.

Greenhouse gas (GHG) emissions are of concern in connection of human influence on climate change. Activities in Pennsylvania accounted for approximately 4.0 percent of total U.S. gross GHG emissions (based on 2000 U.S. data). Increases in Pennsylvania's gross GHG emissions from 1990 to 2000 increased by only two percent compared to a 14 percent increase in national gross emissions, although Pennsylvania's economy grew by 57 percent versus 40 percent for the nation during the same period. Statewide GHG emissions related to all transportation fuel use rose from 1990 to 2000 at an average annual growth rate of 1.1 percent, but declined from 2000 to 2010 at an average annual rate of 3.8 percent.

The significant majority of all statewide GHG transportation fuel emissions in 2010 were from on-road vehicles usage. In the other transportation modes, aviation fuels accounted for seven percent of the total, while all other transportation sources (railroad, marine vessels, and other natural gas and liquefied petroleum gas-fueled vehicles used in transport applications) accounted for only five percent. Marine vessels include not only tow boats using the inland navigation system, but also those vessels using the ports of Philadelphia and Erie.

The *Pennsylvania Climate Change Action Plan Update and Appendix* (December 2013) presents a number of initiatives to further reduce GHG emissions from the state's freight transportation sector. Recognizing the superior efficiency of water transport, (40 percent more efficient than rail), two recommended initiatives are to shift more freight from truck and rail to water, and to improve port infrastructure and cargo handling equipment.

3.3.1.4.3 The U.S. Army Corps of Engineers Response

The primary and overarching climate change policy document for the U.S. Army Corps of Engineers (USACE) is the USACE Climate Change Adaptation Policy Statement, signed by Assistance Secretary of the Army (Civil Works), Ms. Jo-Ellen Darcy, on 3 June 2011:

> It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects. USACE shall continue undertaking its climate change adaptation planning, in consultation with internal and external experts and with our Districts, Divisions, and Centers, and shall implement the results of that planning using the best available - and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change information into the actionable basis for adapting its Civil Works and Military Programs missions to climate change impacts. Furthermore, USACE shall consider potential climate change impacts

> when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

The USACE Climate Change Adaptation Policy Statement complies with Section 8(i) of *Executive Order 13514* and is in accordance with the *Guiding Principles* put forth in the Federal Interagency Climate Change Adaptation Task Force in its October 2010 *Report to the President*. From this policy, the Corps developed the *USACE 2013 Climate Change Adaptation Plan*, which presents information about agency vision, goals, and strategic approaches; progress on priority areas; and information about planning, integrating, and evaluating adaptation. One of the adaptation priority areas is developing policy and guidance for infrastructure resilience in the areas of nationwide vertical datums, sea level change, and hydrology.

Regarding the latter, the Corps recently issued *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Design, and Projects*, Engineering and Construction Bulletin No. 2014-10 (2 May 2014). This guidance requires a qualitative analysis considering both past and potential future changes to relevant hydrologic inputs. The intent of this analysis is to inform the decision process related to future without project conditions, formulation and evaluation of the performance of alternative plans, or other decisions related to project planning, engineering, operation, and maintenance.

The USACE is also participating in an Ohio River Basin pilot study with the Ohio River Basin Alliance (a consortium of basin interests), the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration. The central question being addressed in this study is whether regional climate change mitigation/adaptation strategies, collaboratively developed with the Alliance and formulated using Integrated Water Resources Management principles, can be made operational within the Ohio River Basin to counter the anticipated water resources, ecological, and infrastructure impacts of climate change.

3.3.1.4.4 Relationship to the Upper Ohio Navigation Study

A navigation system of locks and dams is intended by design to provide reliable navigation depths across a wide range of flows. It accomplishes this through a series of navigation dams designed to maintain minimum depths in low flow periods, and to maintain a relatively stable pool through dam gate operations to pass higher flows. In the Upper Ohio River basin, navigation dams are supplemented with a system of headwaters reservoirs that mitigate impacts of high flows and augment low flows. As a result, the Upper Ohio Navigation System is designed to be resilient to variations in seasonal flows.

The degree to which this system can accommodate more extreme weather events than anticipated in the system's design is a question that would require an evaluation of the system's dams and their operational capabilities. The Upper Ohio Navigation Study, however, is a condition-driven study of the lock chambers for passing river traffic through three of the system facilities, not of the dam structures that pass the river's flows. Climate change is not a significant determining factor in an evaluation of and decision between lock maintenance or replacement alternatives. Compliance with Engineering and Construction Bulletin No. 2014-10 and any subsequent forthcoming guidance that might be relevant to lock design will be addressed in the detailed design or operational phases.

The purpose of the Upper Ohio Navigation Study is to identify the best long-term plan for maintaining safe, reliable, efficient and sustainable navigation on the Upper Ohio River. Maintaining a reliable river system as an alternative to air, rail, and road systems provides network diversity as a strategy against climate-driven impacts. A reliable navigation system also furnishes the most fuel-efficient mode of transporting bulk materials, which supports national efforts to reduce greenhouse gas emissions. The magnitude of the fuel efficiencies gained in using the waterways over land-based transportation is reflected in the relative economic benefits provided by the various lock modernization alternatives.

3.3.2 Locks & Dams/River Corridor

3.3.2.1 Geology

The study area falls within the unglaciated Pittsburgh Low Plateau section of the Appalachian Plateaus Province. The Appalachian Plateaus Province is characterized by relatively flat-lying, predominately sedimentary rocks that are higher in elevation and younger in age than surrounding provinces. The Pittsburgh Low Plateau section is typified by undulating surfaces, narrow shallow valleys, and less folding and uplifting than adjacent sections of the Appalachian Plateau. Drainage patterns are generally dendritic with both the Allegheny and Beaver rivers serving as major drainageways for Late Wisconsinin glacial outwash.

The sedimentary bedrock found in Allegheny and Beaver counties consists of sandstone, coal, shale, limestone, and siltstone, which may be visible along embankments. Bedrock geology for these areas consists of the Conemaugh Group, an upper Pennsylvanian-age deposit, and the Allegheny Group, a middle Pennsylvanian-age deposit. The Allegheny Group represents upper delta plain facies while the Conemaugh Group is associated with lower delta plain facies.

The Conemaugh Group is divided into the stratigraphically higher Casselman Formation and the lower Glenshaw Formation; Ames limestone separates these two formations. The Casselman Formation is comprised of cyclic sequence of shale, sandstone, siltstone, limestone, and red beds (reddish-colored sedimentary rocks such as sandstone, siltstone or shale that were deposited in hot climates under oxidizing conditions) formed in the lower delta environment. Thin, non-persistent coal beds are also present. The Glenshaw Formation is identified by widespread limestone and shale units found in the stratigraphic succession.

3.3.2.2 Physiography and Hydrology

3.3.2.2.1 Ohio River Basin Characteristics

The Ohio River has tremendous influence upon the Pittsburgh, Huntington, and Louisville regions of the Corps Great Lakes and Ohio River Division. The total drainage area of the Ohio River Basin is 203,943 square miles. The Ohio River is formed by the confluence of the Allegheny and Monongahela Rivers in Pittsburgh, Pennsylvania; it then stretches approximately 981 miles prior to emptying into the Mississippi River near Cairo, Illinois. The river is unique in that its mileage is measured from its headwaters rather than from its mouth like most rivers.

The Pittsburgh District, often referred to as the Headwaters District, is comprised of the Ohio River Drainage Basin above New Martinsville, West Virginia. The downstream limit of the

Pittsburgh District is at r.m. 127.2. The District covers an area of approximately 26,000 square miles and manages 16 flood control and multipurpose reservoirs with a combined capacity of over 3 million acre-feet, 42 local flood control projects, and 23 navigation locks and dams built upon 328 miles of navigable waterway. Of these 23 locks and dams, six of them were built in the Ohio River; all of them however, along with the flood control reservoirs and local flood control projects, directly contribute to the hydrology of the Ohio River.

Prior to the construction of a system of Corps of Engineers reservoirs on its tributaries, flows in the Upper Ohio River were completely unregulated. Extreme flows of record ranged from 1,206 cubic feet per second, (cfs) the mean monthly minimum flow of record at Emsworth in October 1930, to a peak flow of 574,000 cfs at Dashields Dam in March 1936. By comparison, the highest and lowest daily mean flows at Dashields Dam in 2010 were 204,000 cfs (January 26) and 4,110 cfs (September 2). The present Corps reservoir system was constructed between 1934 and 1987. These include four reservoirs in the Beaver River drainage, three in the Monongahela River drainage, and nine in the Allegheny River drainage. These reservoir projects allow for the regulation of flow for a proportion of the total drainage area. In addition to flood risk management, their purposes include low-flow augmentation for navigation, water quality, and recreation.

Navigation dams on the Ohio River function differently than the headwater reservoir dams in that they do not store floodwaters for controlled release. They are designed to maintain a minimum pool elevation for navigation purposes and to pass all inflow by raising their gates above the dam sill in proportion with increasing flow. This gate control will maintain a relatively stable pool elevation until all of the gates are raised above the water surface, after which further flow increases cause the river to rise. Dashields Dam, being a fixed crest dam, maintains a minimum pool elevation for navigation at the crest height of the dam. As the flow of the river increases, the pool elevation increases proportional to the level of flow.

3.3.2.2.2 General Topography

The topography of the Ohio River Valley varies greatly from its origin in Pittsburgh to its mouth at the Mississippi River. The main stem of the Ohio River flows in a general southwesterly direction, falling 429 feet in its 981-mile course from Pittsburgh to Cairo. The floodplain is rather narrow in certain areas, owing largely to the river's creation at the southern edge of Ice Age glacial action.

In the Pittsburgh District, the valley floor averages about 0.8 miles in width and the natural gradient of the streambed is about 1.0 feet per mile. Present stream banks generally average 20 to 25 feet in height except in the Emsworth pool where they average 10-15 feet. Several islands are found in the Ohio River and the highly industrialized Neville Island is located in the Emsworth and Dashields pools.

The floodplain averages more than one mile in width between Cincinnati and Louisville. At Louisville, the Ohio River floodplain widens to approximately four miles and then contracts to one mile below the Salt River. However, a floodwall around Jefferson County and the city of Louisville in Kentucky along with New Albany and Jeffersonville, Indiana floodwalls, limits the width to about a mile. Near the mouth, the Ohio River floodplain again widens to about six to

eight miles. Elevations vary from 100 to 600 feet below the plateaus surrounding the valley. The only falls are at Louisville, where a 26-foot difference in water surface between the upper and lower pools existed prior to canalization.

Tributaries in the Ohio River Basin vary from steep mountain streams that cascade with rapids to sluggish, meandering marsh-like areas. These slopes may range from more than 100 feet per mile at the headwaters to less than two-tenths of a foot per mile in the flat areas near the main stem. Generally, the streams are significantly steeper toward the headwaters and flatten a great deal down at the mouth. Post-glacial changes in stream patterns, local layers of hard rock and distribution of tributaries may cause local modifications in profiles.

3.3.2.2.3 Upstream Reservoir and Flood Protection Projects

The substantial length of the Ohio River combined with the unusual storm patterns native to the region creates a capability for record floods occurring in one district with little to no flooding in the other districts. The exception to this was the January 1937 flood, which affected the entire basin stretching from Pittsburgh to Cairo. This flood left one million homeless, 385 dead, and caused property damage reaching $500 million dollars, and in concurrence with the Great Depression. The rise in industry tow traffic combined with the massive impact of this basin-wide flood stirred the need for a more regulated system throughout the Ohio River Basin. Over the next 50 years, the Corps Ohio River Division had gone from having just a few scattered reservoir projects to the present coordinated support system of 72 flood control and multipurpose projects throughout the Pittsburgh, Louisville, and Huntington Districts. This does not include projects in the Nashville District, which influence the lower reach of the Ohio River below the Cumberland and Tennessee Rivers.

3.3.2.2.4 Stream Gage Stations and Records

Flood records at the confluence of the Allegheny and Monongahela Rivers in Pittsburgh have been obtained at Fort Duquesne from as early as 1765. Later, when navigation became a more dominant mode of transportation, gages were established on the Monongahela River wharf.

The collection of systematic hydrologic records on the Ohio River dates back to the flood heights recorded at Pittsburgh in 1806. At first, only hydrologic events of unusual magnitude, extent or duration were recorded. It was not until 1855 that the U.S. Army Signal Corps began to record daily observations for continuous data availability. Each district currently maintains a database of hydrologic information for their respective reach at the locks and dams along the Ohio River. In addition, the U.S. Weather Bureau, the U.S. Geological Survey, and many community flood control projects have gages that provide continuous record.

The Pittsburgh District staff gages are located on the upper and lower lock walls at Emsworth, Dashields, Montgomery, New Cumberland, Pike Island, and Hannibal Locks and Dams. Measurements have been taken by lock personnel since the time of construction in three-hour increments; hourly during high water events. Each dam has a critical river height at which these hourly readings are recorded and this procedure continues until the river recedes below this stage.

Digital automatic stage records are available for the Ohio River at Pittsburgh's "Point" gage, the upper and lower pools at Emsworth, New Cumberland, Pike Island, and Hannibal Locks and Dams. Data Collection Platform (DCP) gages are located on the Ohio River at Emsworth, East Liverpool, New Cumberland, Pike Island, Wheeling, Dilles Bottom, and Hannibal Locks and Dams. The stage readings are automatically recorded and transmitted to the Pittsburgh District's data storage system using satellite telemetry. This record keeping technique began in the early 1980's.

River stage readings have been recorded at the United States Geological Survey gaging station, Ohio River at Sewickley, Pennsylvania since October 1933. Currently, an automatic continuous recording DCP gage with satellite telemetry is located on the upstream side of Dashields Locks and Dam. This station has a fixed-crest dam control, which merits it with a good stage-discharge relationship.

3.3.2.2.5 Additional Historic and Recorded Floods

Aside from the January flood of 1937, the highest known floods in the Pittsburgh District occurred prior to the construction of flood control projects. For instance, March 15,1907 reached a peak of 732.7 feet above National Geodetic Vertical Datum (NGVD,) January 9,1763 with a peak of 735.1 (NGVD) and March 18,1936, a peak of 740.2 feet above NGVD at the Pittsburgh "Point." Today, 12 Corps reservoirs in the Allegheny and Monongahela River basins provide flood risk reduction to the Ohio River basin. In addition, four reservoirs in the Beaver River basin (built 1943-1967) assist in reducing flood stages for the Ohio River's Montgomery Pool and on downstream.

The March 1936 St Patrick's Day Flood also occurred prior to the completion of any Pittsburgh District flood risk reduction dams. The base flow for the Ohio River on March 9, 1936 was 50,100 cfs. Water content of the snow in the district was from 2 inches to more than 4 inches in the mountains. Melting snow and about 0.65 inches of precipitation caused a rise on March 12 and 13 at which time the "Point" gage reached 25.8 feet and was above flood stage for 21 hours. Essentially all snow was melted at this time. Although the flow receded to 99,300 cfs on March 16, between 2.5 to 5 inches of rain fell on March 16-17, the heaviest rainfall in the Lower Allegheny basin. This elevated the Ohio River at Pittsburgh to a crest of 46 feet (740.2 feet above NGVD and 557,000 cfs,) the river remained above flood stage for 84 hours. Had the present system been in place, the crest would have been reduced by at least 10.7 feet. A third rise occurred on March 25 and 26, during which the river was above flood stage for 32 hours, cresting at 30.6 feet. Total runoff for the month of March 1936 was 8.74 inches at Pittsburgh.

The June 23,1972 flood, a result of Tropical Storm Agnes, produced the all-time highest stage at the Pittsburgh "Point" using the current reservoir system. The Ohio River flow on June 20 was 23,700 cfs at the "Point." From June 20 through 26, the Allegheny River Basin received 4 to 12 inches of rainfall and the Monongahela River Basin received from 3 inches to over 12 inches. The Ohio River crested at Pittsburgh at 35.85 feet (730.0 feet above NGVD and 380,000 cfs,) and remained above flood stage for 86 hours. It would have been 12.1 feet higher without the current reservoir system. The runoff during the flood at Pittsburgh was 4.65 inches for the period June 21 to July 15, 1972.

3.3.2.2.6 Stage and/or Discharge Frequency Relationships

Over the years flow measurements have been made to develop rating curves at gage locations to show the relationship between stage and flow. The obtained stage data that includes high-water marks provide information that forms the basis for the historical flood profiles. In Pittsburgh District studies, the natural discharge frequency flows were developed using 118 years of record (1855-1972) for the Ohio River at Pittsburgh. Floods that occurred during and after the construction of the current reservoir system were adjusted to reflect natural peak discharges that would have occurred without the flood reduction dams. The natural frequency thus obtained was subsequently adjusted for the reduction of the current reservoir system as applicable to produce a reduced discharge frequency. At Montgomery, New Cumberland, Pike Island, and Hannibal Locks and Dams, records kept since the dams began operating were used in the frequency determination. These records were based on long term estimates from the existing Dashields Locks and Dam and Lock and Dam 12 which was removed in 1975. The Ohio River flood probability frequencies, from the 1 percent chance exceedance flood through the 0.2 percent chance exceedence flood, were adjusted in agreement with Corps of Engineers Ohio River Division in 1976.

The Ohio River flow frequencies for less than the 10-year flood frequencies in the Pittsburgh District were developed using data from the period between 1966 and 1997. The Ohio River at Dashields flow records were used to compute the actual and reduced discharge frequency. From the stage and stream flow data, stage-discharge relationships have been developed for all of the existing navigation dams and at other points along this reach of the river.

3.3.2.2.7 Ordinary High Water

Ordinary High Water (OHW) is a line on the bank of a body of water that marks the boundary of those lands capable of navigational servitude. Physical facilities with supportive intent toward navigation may be placed and maintained on such lands. The line of ordinary high water, as applied to rivers, separates what property belongs to the riverbed from that which belongs to the owner of adjacent land. This line is determined by normal conditions rather than by unusual flooding events.

3.3.2.3 Floodplains

Under Executive Order (E.O.) 11988, Flood Plain Management, it has been determined that all project alternatives would be located in the one-percent-annual-chance (formerly termed 100-year) floodplain. There are, by necessity, no practicable alternatives to river navigation structures outside of the floodplain. Disposal of dredged and excavated material will generally occur outside the one-percent-annual-chance floodplain.

The one-percent-annual-chance floodplain in the Emsworth study reach varies in width from approximately 50 to 100 feet, in the Dashields study reach from 30 to 1150 feet, and in the Montgomery study reach from 30 to 125 feet. Most of the floodplain is urban in nature – a mix of residential, commercial, and industrial uses. Some of the low land areas are brush covered and unused.

Both Emsworth and Dashields Locks and Dams are located within Allegheny County and Montgomery Locks and Dam is located within Potter and Raccoon Townships, Beaver County. The Federal Emergency Management Agency (FEMA), under guidelines of the National Flood Insurance Program (NFIP), has published Flood Insurance Studies (FIS) for Allegheny County and Potter Township, Beaver County. Raccoon Township also participates in the NFIP. The NFIP and FIS aid Allegheny County, Potter Township, and Raccoon Township in their regulation of development within the floodplain and are used to promote sound land use and floodplain development. Maps delineating the one-percent-annual-chance and the 0.2-percent-annual-chance (formerly termed 500-year) flood boundaries as well as the floodway along the Ohio River are included in each FIS. The floodway is the channel of the stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the one-percent-annual-chance flood can be carried without substantial increases in flood heights.

3.3.2.4 Bathymetry and Benthic Substrate

The substrates of the upper Ohio River include a mixture of the substrate types found in the Allegheny and Monongahela rivers. The south flowing Allegheny River drains both glaciated and non-glaciated portions of the Appalachian Plateau Physiographic Province. Generally, the substrates of the Allegheny River are composed of glacial till and gravel. The north flowing Monongahela River flows through primarily softer, sedimentary geology. The substrates that develop from this parent material typically dissociate to sands and other fine substrate materials. Substrates of the upper Ohio River are, therefore, composed of a mixture of the material carried in the two contributing rivers (USACE 2001).

A Biological Study of the Emsworth Pool of the Ohio River (ORSANCO 2007) characterized the substrate types at 15 sample points as including boulder, cobble, fines, gravel, hardpan, and sand. A Biological Study of the Dashields Pool of the Ohio River (ORSANCO 2008) characterized the substrate types at 13 of 15 sample points as boulder, cobble, fines, gravel, sand, and other. A Biological Survey of the Montgomery Pool (ORSANCO 2006) characterized the substrate types at 15 sample points as including boulder, cobble, fines, gravel, hardpan, and sand. A Biological Study of the New Cumberland Pool of the Ohio River (ORSANCO 2004) characterized the substrate types at 15 sample points within the New Cumberland Pool. Substrate types observed within the New Cumberland Pool included: boulder, cobble, fines, gravel, and sand.

Substrate types of the upper Ohio River were qualitatively characterized during 2008 as part of the data collection effort associated with a native mussel screening survey. Percent substrate compositions were characterized at each sample point. The substrate data for each pool were then averaged. **Table 3-1** summarizes the data presented in the report entitled, Native Mussel Screening Survey Upper Ohio River Navigation.

TABLE 3-1: Substrate Types Observed in Upper Ohio River Pools

Pool	Substrate Type - Percent of Total						
	Boulder (>10.1”)	Cobble (2.5-10.1”)	Gravel (0.08-2.5”)	Mud (fine mix) (<0.08”)	Sand (0.003-0.08”)	Silt (<0.003”)	Other
Emsworth	17.0	25.0	30.0	11.0	- -	- -	17.0
Dashields	14.0	22.0	24.0	13.0	13.0	11.0	3.0
Montgomery	15.0	14.0	18.0	- -	- -	34.0	19.0
New Cumberland	16.0	19.0	22.0	8.0	- -	19.0	16.0

Water quality and sediment quality conditions of the river are very closely tied together. Sediment quality is greatly influenced by water quality conditions and sediment quality can affect water quality through the re-suspension of pollutants that may be contained in sediments that are agitated. Discharges of heavy metals, polychlorinated biphenyls, phenols, and chlordane can result in the contamination of stream sediments. Historical land uses along the river resulted in the significant contribution of these types of pollutants to the upper Ohio River. The deposition of heavy metals has been attributed to coal mining activities and iron and steel manufacturing. **Table 3-2** lists some of the legacy pollutants that have been associated with sediments of the upper Ohio River.

TABLE 3-2: Legacy Pollutants

Pollutant	Application or Source
Barium	Iron/steel manufacturing
Cadmium	Iron/steel manufacturing
Chlordane	Pest control
Chromium	Iron/steel manufacturing
Copper	Iron/steel manufacturing
Iron	Iron/steel manufacturing/drainage from coal mining
Lead	Iron/steel manufacturing Iron/Steel Manufacturing
Manganese	Drainage from coal mining
Mercury	Coal powered utilities and manufacturing
Nickel	Iron/steel manufacturing
PCBs	Various commercial and industrial uses
Phenols	Various industrial uses
Zinc	Iron/steel manufacturing

Of the legacy pollutants identified to occur within sediments of the upper Ohio River, total maximum daily load (TMDL) standards have been developed for two of these pollutants by the Pennsylvania Department of Environmental Protection (PADEP). The pollutants with established TMDL standards are chlordane and polychlorinated biphenyls (PCB). The limits established by the PADEP for each of these pollutants are 0.05525 lbs/day and 0.00442 lbs/day, respectively. Chlordane was widely used in the past as a broad-spectrum agricultural pesticide

as well as for termite control. PCBs were used for a number of applications including insulating fluids for electrical transformers, cutting oils, and carbonless paper. Both substances are now banned in the United States.

3.3.2.4.1 Upper Ohio Navigation Study Benthic Survey

To support the Corps ORMSS commitments to identify, describe, and quantify riverine habitat in the study area, and pursue feasibility-level development of potential ecosystem restoration projects for the Upper Ohio Navigation Study, the District collected new bathymetry with side-scan sonar data from the Ohio River (r.m. 0.0~40.0). After computer analyses of these data, seven discrete acoustic classes of benthic substrate were delineated across the study area. These acoustic classes were then ground-truthed to determine their degree of association with actual substrate types. The ultimate objective of these staged efforts was to link acoustic classes to riverbed substrate types on existent ESRI shape files for use in river habitat evaluations.

Bathymetry and side-scan sonar data were collected and analyzed using a GIS-corrected SeaBat Multibeam Echo-sounder (MBES) with side-scan during August 2008. Raw bathymetric and side-scan data were edited and incorporated into ESRI-GIS shape files using HYPACK®/HYSWEEP®, and the seven discrete acoustic classes developed using Quester QTC CLAMS™ software, resulting in a final product of point data in ESRI ArcMap, portrayed as broad colored maps of acoustic classes potentially representing different substrate types.

Benthic substrate ground-truthing of the seven discrete acoustic classes was performed at 258 Corps-selected (i.e. non-random) sample stations within 15 sub-areas (labeled as “tiles”, see report in the Environmental Appendix) of the study area during August and September 2009. (Nineteen of the sample stations represented potential ecosystem restoration sites, sampled to gain information on site-specific aquatic habitat.) Sample sub-areas included the head, tail, and center of each pool, with the exception of New Cumberland Pool, where sampling ended above the Ohio state line. Underwater digital imagery was collected in conjunction with benthic substrate sampling using a 36 x 28 cm VanVeen grab with additional integral weights, following a two-stage sampling protocol (to address existence of fine-scale variation at any given sample site). Sediment samples were visually examined and the upper 3 cm retained for laboratory analyses. Ancillary observations of biological relevance were also made (e.g., mussels).

Laboratory analyses of grain size distributions (modified Wentworth scale) revealed that most samples were fines (61%, n = 258) and other grain sizes with substantial fines content (17%). Sand dominant samples comprised a small proportion of the total (14%), with only 15% of the total number of samples comprised of coarse grained sediments as the dominant fraction (i.e., their fines comprised less than 10% of the total sample). Cobbles were dominant in 5% of the samples, with only one boulder-dominant sample (detection of cobble/boulder substrates was likely reduced by grab-sampler limitations).

Generally, based on grain size, there are three groups of acoustic classes (ACs) that are significantly different: ACs 1, 2, and 3 are distinct from the others, with coarse grained sediments; ACs 4, 5, 6, and 7 are distinct from ACs 1-3, having fine grained sediments, with AC5 further characterized as lacking the medium sand found in ACs 4, 6, and 7.

Examined individually, each AC has the following distinguishing characteristics: AC1 is coarse-grained with samples that are cobble and samples that are fines—this class may have the "hardest" bottom of the coarse-grained substrates; AC2 is coarse-grained with samples that are fines; AC3 is coarse-grained with samples that are medium sand and fines—it has the deepest sampling depths, highest frequency of laminate structure, and the widest range of substrate types; AC4 is fine-grained with the most samples comprised of fines and some samples comprised of medium sand—it is the deepest of the fine-grained acoustic classes; AC5 is fine-grained with most samples comprised of fines, with medium sand absent from this class, but hypothesized to be a "skin" of fine grained sediment over hard pan or bedrock; AC6 is fine-grained with most samples comprised of fines and other samples that are medium sand or coarse gravel, primarily restricted to shallower depths; and AC7 is fine-grained with most samples comprised of fines and other samples that are coarse gravel or medium sand. The shallower depth of penetration suggests AC7 is a "harder" bottom substrate than AC6.

Even though coarse-grained sediment was dominant in ACs 1-3, fines or sand were observed at low frequency. Conversely, coarse-grained substrates were found in low frequencies in the fine-grained acoustic classes. The ground-truthing performed for this effort indicates that more complex statistical analyses will be necessary if stronger correlation between the acoustic sonar survey data and the sediment data is desired.

The distribution of dominant grain sizes varies substantially both among and within pools. Samples from Emsworth pool were almost entirely fine-grained substrates while New Cumberland pool was skewed toward coarse-grained substrates. The spread of particle sizes observed in samples from Dashields and Montgomery were wider than observed elsewhere.

TABLE 3-3: Benthic Substrate Particle Size Distribution by Pool

Pool	Acreage (% of pool)			Total Acreage
	Acoustic Class 1-3 (coarse)	**Acoustic Class 5** (fine over coarse)	**Acoustic Class 4, 6-7** (fine)	
Emsworth	767 (94.7)	4 (0.50)	39 (4.8)	**810**
Dashields	860 (97.9)	1 (0.11)	17 (1.9)	**878**
Montgomery	2,483 (94.5)	5 (0.2)	139 (5.3)	**2,627**
New Cumberland	1,109 (93.3)	1 (0.1)	79 (6.6)	**1,189**
Total Acreage	**5,219**	**11**	**274**	**5,504**

3.3.2.5 River Connectivity

The term "connectivity," used in conjunction with rivers, has multiple meanings. To urban planners it refers to efforts to integrate the life of the city (i.e., human activity) with its riverfront. To ecologists it is an indicator of healthy river ecosystems, a measure of natural integrity. In this study, "connectivity" is used in the latter sense, describing a system in which fish and other biota move freely, fulfilling essential seasonal and life stage-specific habitat needs.

Many fish species require the continuous nature of natural river habitats—from main channels, to secondary channels, to tributaries, to floodplains—for feeding, shelter, movement between

seasonal habitats, and spawning. Navigation dams, such as those on the Ohio River, modified river habit through the creation of a series of impoundments that act as barriers to longitudinal movement, up and down rivers. Thus, dams have imposed limits on the extent of habitat formerly accessible to fish, as well as on the diversity and quality of available habitats. Historically, this has contributed to the decline in diversity and abundance of many fishes, and is likely hampering their ability to return to areas, like the Upper Ohio, formerly affected by severe water quality degradation.

The value of connectivity extends beyond fish species. One of the more valuable life-forms found in rivers are unionid mussels. Most unionid species have a temporary parasitical larval stage that is dependent upon certain host species of fish. Once the larvae have matured to an independent stage, they drop off their host fish, often at great distances from where they originated. In this manner, unionids expand their range, but are highly dependent upon both the availability of specific host species of fish and the ability of these fish to move freely longitudinally. It follows that the paucity of unionids in the upper Ohio River is related to conditions that affect their host species.

It is generally held that healthy ecosystems are robust, supporting some degree of diversity and high productivity. As a rule, ecologists favor high connectivity to promote biodiversity, and the standard often held for large riverine systems is the condition observed historically before human intervention. For rivers dedicated to commercial navigation improvements, however, a return to permanent open river conditions is not an option. The goal of the Upper Ohio Navigation Study with regard to riverine connectivity is to support the commitments made in the Corps ORMSS. These goals include the "evaluation, and if feasible construction, of fish passage strategies at each lock and dam along the Mainstem during studies for lock modernization…" and development of ecosystem restoration alternatives that can be combined and authorized with a lock modernization plan.

In any plans for restoring impaired connectivity, there are potential hazards posed by invasive exotic species, pollutants, or diseases that deserve careful consideration. With respect to invasive species, E.O. 13112 – Invasive Species (1999) directs "that each Federal agency whose actions may affect the status of invasive species shall… : (1) identify such actions; (2) …(i) prevent the introduction of invasive species; …(iv) provide for the restoration of native species and habitat conditions in ecosystems that have been invaded ; … and (3) not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species…unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions." Concern over increasing opportunities for invasive species, such as Asian carp (e.g., *Hypophthalmichthys spp*.), need to be weighed against those same values for native species. The exotic Asiatic clam (*Corbicula fluminea*) and zebra mussel (*Dreissena polymorpha*) are examples of invasives in the Upper Ohio that have either occupied empty niches in areas formerly occupied by natives, or out-competed native residents in areas where they are established.

There has been a general consensus among Pennsylvania resource agencies and environmental groups that restoring connectivity in Commonwealth rivers would benefit native species. Issues related to Asiatic carp and potential opportunities for spread of other invasives were considered while planning for fish passage strategies at Upper Ohio navigation facilities.

3.3.2.6 Riparian Resources & Islands

3.3.2.6.1 Riparian Resources

Most of the land along the Ohio River in Pennsylvania is highly modified by industry, transportation, and municipal development, leaving few large expanses of open land or forest adjacent to the river. A majority of these lands do contain thin strips of forested riparian corridors parallel to the river as well as some forested wetlands, embayments, and uplands. The dominant vegetation type in the upland areas of the Upper Ohio River Valley is mixed mesophytic forest. There are a total of about 15 to 20 dominant tree species within this vegetation type, including tulip popular (*Liriodendron tulipifera*), silver maple (*Acer saccharinum*), sugar maple (*A. saccharum*), American beech (*Fagus grandifolia*), American basswood (*Tilia americana*), various oaks (*Quercus* spp.), hickories (*Carya* spp.) and willows (*Salix* spp.). The lower canopy is dominated by sassafras (*Sassafras albidum*), dogwood (*Cornus* spp.), eastern hophornbeam (*Ostrya virginiana*), eastern redbud (*Cercis canadensis*), sourwood (*Oxydendrum arboretum*), magnolia (*Magnolia* spp.), and serviceberry (*Amelanchier* spp.). Shrubs and herbs are abundant and diverse, and include witch-hazel (*Hamamelis virginiana*), pawpaw (*Asimina triloba*), black haw (*Viburnum* spp.), elderberry (*Sambucus canadensis*), wild grape (*Vitis rotundifolia*), and greenbrier (*Smilax* spp.).

Along the floodplains of the Ohio River in this region, bottomland hardwood forests are the natural climax community. Much of this habitat type has been eliminated by industrial, residential, and agricultural development. The remaining riparian area is often less than a few hundred feet in width. This habitat type has the classic four layered plant structure. Dominant tree species in the overstory include: silver maple, American sycamore, eastern cottonwood (*Populus deltoids*), black willow (*Salix nigra*), slippery elm (*Ulmus rubra*), and boxelder (*Acer negundo*). Dominant species in the lower canopy include: hackberry (*Celtis occidentalis*), black locust (*Robinia pseudoacacia*), American elm (*U. Americana*), green ash (*Fraxinus pennsylvanica*), pawpaw, and black walnut (*Juglans nigra*). Shrubs include spice bush (*Lindera benzoin*), and Virginia creeper (*Parthenocissus quinquefolia*). Additional associated woody species found along riparian areas of the Ohio River in 1983 included staghorn sumac (*Rhus typhina*) and poison ivy (*Toxicodendron radicans*).

Much of the river shoreline in Pennsylvania consists of numerous industrial, commercial and residential developments. Due to these land disturbances various invasive and non-native plant species have replaced native species of the original mesophytic forest along the riparian areas of the Ohio River. Such non-native and invasive plant species found along the Ohio River in Pennsylvania now include Northern catalpa trees (*Catalpa speciosa*), tree-of-heaven (*Ailanthus altissima*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), Japanese knotweed (*Fallopia japonica*), mile-a-minute vine (*Polygonum perfoliatum*), garlic mustard

(*Alliaria petiolata*), reed canary-grass (*Phalaris arundinacea*), Russian olive (*Elaeagnus angustifolia*), Japanese honeysuckle (*Lonicera japonica*), and others.

The Corps completed a study of the Upper Ohio River floodplain in 2000 using newly acquired color aerial photography, historic geographic information system (GIS) datasets, and on-the-ground field work. Study area boundaries extended from the Pittsburgh Point to New Cumberland Locks and Dam, approximating the boundaries of the Upper Ohio Navigation Study. These data were compared to 1954 aerial photography to define past and present conditions and assess changes over that 50-year period. This comparison of historical and current aerial imagery was effective in identifying changes in land use and land cover.

The following general conclusions from the 50-year comparison were drawn:

- There were relatively large increases in areas occupied by transportation, recreational, industrial, and commercial land uses
- There were corresponding decreases in areas in agricultural, residential, and open disturbed categories.
- There was an increase in the linear distance of shrub and unvegetated shoreline cover and a decrease in herbaceous and forest cover.
- Overall, changes in the land use and cover appeared to be concentrated near the shoreline.
- The surface area of islands decreased by 36 percent (factors include rise in navigation pool elevations and shoreline erosion).
- There has been a notable increase in the number of structures and facilities associated commercial and recreational use of the river, indicating the current importance of the river for navigation and recreation activities.
- The area of wetlands increased during the study period due to the inundation of low-lying habitats when the river navigation pools were elevated.

Land use on the floodplain of the upper Ohio River continues to be strongly influenced by industrial and urban development. This was the case in both 1954 and 2000. Three related classes, industrial and commercial, residential and recreational, and open disturbed, were the most important land use features in both 1954 and 2000 (**Table 3-4**). In 1954 these three classes comprised more than 5,164 ha, or 44.5 percent of the land use categories; in 2000, the same three classes included 5,635.5 ha, or nearly 48.4 percent, and increase of about five percent. At the same time, the area in agricultural use decreased by nearly 84 percent. The area of forestry and wildlife also decreased, but by a lesser amount, approximately 16 percent. While these changes may appear relatively large, particularly for agricultural use, the overall percentage of these land uses on the floodplain was relatively small in 1954, only about five percent for agriculture and 12 percent for forestry and wildlife. Therefore, these changes are relatively insignificant relative to changes in other land use classes, e.g., highway corridors.

TABLE 3-4: Land Use Categories, Surface Area and Percent Change Upper Ohio River Floodplain (1954 and 2000)

Land Use Class	Year				Change: 1954-2000 (ha)	% Change
	1954		2000			
	Area (ha)	% Area	Area (ha)	% Area		
Agriculture	533.4	4.6	86	0.7	-447.4	-83.9
Forestry & Wildlife	1,363.7	11.7	1,146.5	9.9	-217.1	-15.9
Highways	258.3	2.2	433.9	3.7	175.6	68
Industrial & Commercial	1,739.9	15	2,626.3	22.6	886.4	50.9
Open disturbed	1,312.5	11.3	1,042.3	9	-270.1	-20.6
Open water	3,538.5	30.5	3,735.5	32.1	197	5.6
Railroads	760.7	6.5	598.1	5.1	-162.7	-21.4
Residential & recreational	2,112.5	18.2	1,966.9	16.9	-145.6	-6.9
Total	**11,619.5**	**100**	**11,635.5**	**100**		

Railroads and highways, two transportation classes, displayed opposite trends. The area occupied by railroads decreased by 21 percent, while the area occupied by highways increased by 68 percent. It is likely that the decline in area for railroads was greater than 21 percent, because some corridors included as railroads corridors may have been abandoned even though rails and crossties were still present. Further, much of the loss in railroad land use was due to abandonment of railroad yards. The change in transportation mode on the floodplain was expected and consistent with national trends in highway construction and abandonment of rail lines.

The total area for lock and dam facilities declined because of the replacement of Ohio River Nos. 7, 8, & 9 by New Cumberland Locks and Dam (1959). At the same time, the surface area of riverine habitats, which included the Ohio River mainstem, embayment areas, and associated streams on the floodplain, increased by 4.1 percent. This increase was due to the installation of the higher head New Cumberland Dam replacing the three relatively low head dams. In addition to riverine areas, open water habitats increased through addition of a number of industrial treatment ponds. The number of treatment ponds increased from three in 1954 to 44 in 2000. Flat-water habitats increased by 197 ha, or more than 5.6 percent between 1954 and 2000.

A notable change in land use was a nearly 51 percent increase in the area of industrial and commercial use, an expansion of 886.4 ha. At the same time, there was a combined decline in open disturbed space, agriculture, and forestry and wildlife totaling approximately 935 ha. This indicates a trend in increased industrial and commercialization on the floodplain even though there was a marked decline in the steel and related industries.

The predominant upland land cover class in both 1954 and 2000 was artificial-anthropogenic, or areas on which the cover was maintained by human directed activities, e.g., turf grass areas (**Table 3-5**). These areas remained basically unchanged between 1954 (54 percent) and 2000

(56 percent). Forest cover, a relatively small portion of the floodplain, decreased from eight percent to approximately seven percent during this period. Scrub/shrub and herbaceous dominated cover showed a similar change.

For both 1954 and 2000, the total area occupied by palustrine wetland habitats was relatively small, 64.8 ha and 151.0 ha, respectively (**Table 3-5**). These figures include an increase in habitats classified as having unconsolidated bottom, which were mostly associated with industrial treatment impoundments. The increase is also related to an increase in elevation of navigation pools, which created backwater and palustrine habitats.

TABLE 3-5: Land Cover Classes, Surface Area and Percent Change (1954 and 2000)

Land Cover Class	Year				Area Change: 1954-2000 (ha)	%Change: 1954-2000
	1954		2000			
	Area (ha)	% Total Area	Area (ha)	% Total Area		
Palustrine Emergent	16.5	0.1	7.6	0.1	-8.9	-53.8
Palustrine Forested	16.4	0.1	62.6	0.5	46.2	281
Palustrine Scrub-Shrub	8.5	0.1	15.8	0.1	7.3	86
Palustrine Unconsolidated Bottom (Natural)	17.4	0.1	65	0.6	47.5	273.2
Palustrine Unconsolidated Bottom (Com/Ind)	5.9	0.1	42.9	0.4	37	623.7
Riverine	3534.5	30.4	3680.7	31.5	146.2	4.1
Upland Forested	935.3	8	803.2	6.9	-132.1	-14.1
Upland Herbaceous	332.2	2.9	72.2	0.6	-260	-78.3
Upland Scrub/Shrub	445.3	3.8	417.5	3.6	-27.7	-6.2
Upland Unvegetated	25.4	0.2	29.2	0.3	3.8	14.9
Artificial-Anthropogenic	6289.4	54.1	6481.2	55.5	191.8	3
Locks & Dam	1.6	>0.1	2	>0.1	0.4	24.1
Total	**11628.5**	**100**	**11679. 9**	**100**	**51.4**	**1157.9**

Quantitative measurements of stream bank, or riparian cover, were calculated by measuring linear dimensions of shoreline cover. Of the five cover types reported in **Table 3-6**, forest was the predominant cover in 1954 (106 km or 47 percent). Other vegetative cover types, herbaceous and shrub, were much less important. By 2000, the linear distance of shoreline covered by forest

TABLE 3-6: Changes in Streambank Cover Upper Ohio River Between 1954 and 2000

Streambank Cover	Year				Distance Change: 1954-2000 (km)
	1954		2000		
	Linear Distance (km)	% Total Distance	Linear Distance (km)	% Total Distance	
Forest	105.9	46.6	48.1	22.4	-57.8
Herbaceous	29.1	12.8	26.3	12.2	-2.8
Shrub	47.6	21	69.1	32.2	21.5
Unvegetated	44.6	19.6	71.2	33.2	26.6
Total	**227.1**	**100**	**214.6**	**100**	

had decreased by 58 percent. Replacing forest as riparian cover were shrub communities and unvegetated embankment that included riprap, concrete walls, and bare earth. Based on field ground-truthing observations, bare shoreline habitats often occurred where there was evidence of unstable shorelines.

Table 3-7 reports an inventory of shoreline and in-stream structures. There were notable increases in the number of facilities that support commercial and recreational use of the river: marinas, boat launching ramps, private boat docks, water intake structures, and mooring areas. Declining in number were ferries and icebreakers.

TABLE 3-7: Shoreside Facility Summary Upper Ohio River (1954 and 2000)

Facility	Number by Year	
	1954	2000
Approach Points	3	14
Boat Dock	70	264
Boat Launching Ramps	10	21
Ferry	4	2
Fleeting Areas	126	211
Icebreakers	40	29
Intakes	4	10
Marinas	0	29
Mooring Sites	198	393
Multi-slip Docks	1	30

3.3.2.6.2 Islands

The Ohio mainstem study area (r.m. 0 – 40) has five islands. Brunot, Davis, and Neville islands lie within the first 10 miles below Pittsburgh, and Phillis and Georgetown islands lie between r.m. 35 – 38. Brunot and Neville are the largest of these islands. Historically, they were primarily agricultural, but for many decades have been heavily industrialized. Davis Island, at the head of Neville Island, is undeveloped except for some settling ponds connected to Neville

Island industry. Davis Island has the distinction of being the location of the first lock and dam on the Ohio mainstem from 1885 – 1922. The lock was situated on the right descending bank, and the abutments for the main channel and back channel dams were at Davis Island. There are no obvious visible remains of the lock and dam, which was replaced by Emsworth Locks and Dams built a few miles downriver at Neville Island in 1922.

Phillis and Georgetown islands are situated on bends in the river below Montgomery Locks and Dam, in the New Cumberland Pool. These two islands are part of the Ohio River Islands National Wildlife Refuge, headquartered in Williamstown, West Virginia. The refuge was established in 1990 to protect, restore, and enhance habitat for wildlife native to the river's floodplain. Phillis (39 acres±) and Georgetown (16.2 acres±) are the two upriver-most island properties of the refuge, which includes another 18 islands and three mainland tracts in West Virginia, and two islands in Kentucky. The refuge protects about 3,200 acres of land and underwater habitats, and may acquire additional properties in the future.

The lower Monongahela River has no islands. The lower Allegheny River has two islands: Herrs Island is situated between r.m.2-3, and Sixmile Island is located between r.m. 6.2 and Lock and Dam 2 (r.m. 6.7).

Prior to creation of the navigation system (pre-1885), there were many more islands in the study area. Zadock Cramer, in *The Navigator* (1814, p. 25), states, "The numerous islands that are interspersed in this river, in many instances add much to the grandeur of its appearance, but they embarrass navigation considerably, particularly in low water, as they occasion a great many shoals and sandbars." Little was done to eliminate these navigation hazards prior to establishment of a federal interest in interstate navigation through the 1824 River Act. Even with this, however, little more than removal of large boulders and snags was accomplished in the upper river through the Civil War due to limited and sporadic federal funding. Planning for structural navigation improvements began in earnest in the 1870s, resulting in the Davis Island Lock and Dam (1885) and completion of the Ohio River Navigation System in 1929. In the upper river, this system was designed to provide navigable conditions of six-foot minimum depth. Locks and dams were often situated at the islands and/or shoals where navigation conditions were most perilous, and which often provided bedrock for securing foundations.

The first generation navigation dams on the Ohio River were movable wicket dams adapted from French technology. The dams were raised during periods of low flows to maintain navigable depths, and were lowered when natural flows were sufficient to allow open river navigation. Early navigation on the upper river was typically suspended in the winter, and the dams were lowered all winter to avoid complications with icing preventing dam operations. Open river conditions, therefore, with no navigation pool being maintained, prevailed seasonally until construction of Emsworth's fixed crest concrete dams in 1922. Emsworth, followed closely by construction of Dashields Dam, signaled a major change in river navigation, providing for the first time permanent pools and an end to open river navigation practices. Replacement of the original six wicket dams in Pennsylvania with three higher lift dams (Emsworth, Dashields and Montgomery) also permanently submerged the lower islands, shoals and riffles that were seasonally exposed, even with the early navigation dams.

Cramer mentions eight islands in the study area in 1814. He does not mention Davis Island in this count, apparently attributing it to being part of Neville Island. By name, Cramer describes the islands descending from Pittsburgh as, "Hamilton's (now Brunot's) island, No. 1," "Irwin's (now Neville's) island, No. 2," "Hog island, No. 3, just below and joined to No. 2 by a bar," "Dead-man's island, No.4, and ripple," "Crow's island, No. 5, divided by a gut," "No. 6, first island below Beaver," "No. 7, second island about one mile long," and "No. 8 Grape island, half a mile long" (pp. 73-78). Brunot and Neville islands remain today, while Hog Island was submerged at the toe of Neville Island by the Dashields Pool. Dashields Dam (1929) was built on the bedrock at Dead-man's Island, submerging the island in the process. A 1914 topographic map shows Crow's Island and another Hog's Island immediately downstream along the left bank at Aliquippa. The narrow backchannels of these islands have since been filled in, joining them to the mainland. Island No. 6, later known as Montgomery Island, was submerged with the construction of Montgomery Dam at its location. Phillis (No. 7) and Georgetown (No. 8, Grape) islands remain and are part of the Ohio River refuge system.

3.3.2.7 Wetlands

A large proportion of the wetlands found along the upper Ohio River were modified following the advent of the modern lock and dam system. The increase in water elevation resulted in the creation of embayments throughout this area. Embayments occur at the mouths of tributary streams as a result of increased navigation pool elevation. These embayments provide a majority of the wetland and shallow water habitat in the floodplain of the upper Ohio River. **Table 3-8** shows the embayments found within the geographic scope of the study area from the New Cumberland Dam upstream to the Emsworth (Pittsburgh) Pool.

The National Wetland Inventory (NWI) shows 55 wetlands along the Ohio River within the geographic scope of the study. Two of the most dominant NWI wetland types include the Ohio River channel PUBHx (palustrine, permanently flooded wetlands with an unconsolidated bottom that lie in a channel or basin excavated by humans), and artificial ponds PUBKx (palustrine, artificially flooded wetlands with an unconsolidated bottom, that lie in a channel or basin). PUBKx is mostly associated with industry. Another, less dominant, wetland type commonly found within the study area is the PFO1A (forested, palustrine, temporarily flooded wetlands dominated by broad-leaved deciduous trees) type wetland habitat.

TABLE 3-8: Study Area Major Embayments

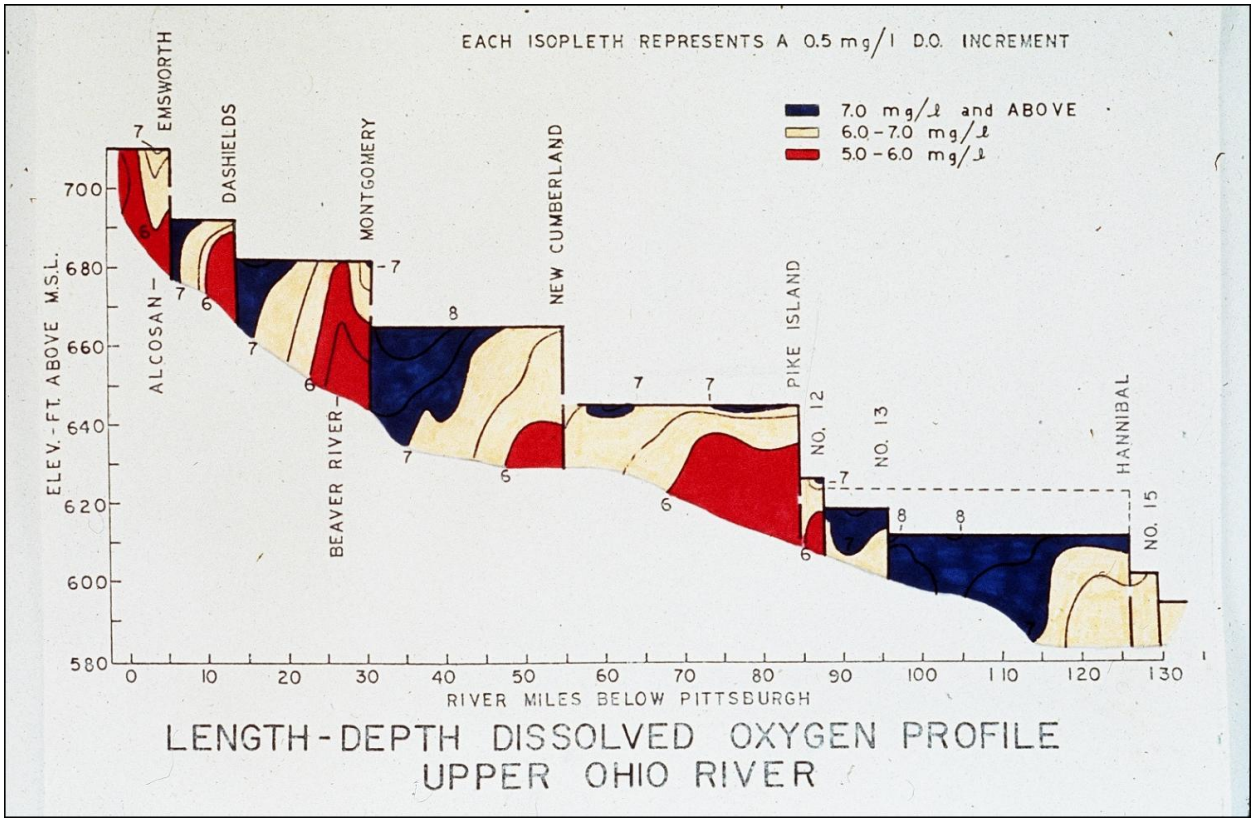
Embayment	Location
Little Beaver Creek	New Cumberland Pool, r.m. 39.5
Ohioview Peninsula (Montgomery Slough)	Montgomery Pool, r.m. 31.6
Raccoon Creek	Montgomery Pool, r.m. 29.6
Chartiers Creek	Emsworth Pool, r.m. 2.7

3.3.2.8 Water Quality

The Pittsburgh District's first comprehensive water quality study of the Upper Ohio River dams was undertaken in 1974. The results of this study indicated that the navigation dams

significantly influence the dissolved oxygen concentrations of the river. At flow levels of 10,000 cfs, Emsworth Main Channel Dam contributed 65,000 pounds of oxygen per day, Dashields Dam added 30,000 pounds per day, and Montgomery Dam, 97,000 pounds per day. The influence of Montgomery is clearly visible for more than 15 miles downstream. Its reaeration capability is particularly valuable in drawing from low DO concentration stratum in the Montgomery Pool, largely derived from the Beaver River, and causing it to be supersaturated by discharge across the step weirs below the dam gates. (An Evaluation of the Effects of Mainstem Navigation Dams on the Water Quality of the Upper Ohio River, Pittsburgh District, USACE, June 1975, p.11). The oxygen provided by gate discharges at Emsworth and overflow of the fixed Dashields Dam are critical to assimilation of the oxygen demand from the Allegheny County Sanitary Authority (ALCOSAN) sewage treatment plan discharge at r.m. 3 above Emsworth, as well as other sources (**Figure 3-2**).

FIGURE 3-2: Upper Ohio River Dissolved Oxygen Profile



Water quality is defined as the integration of physical, chemical, and certain biological parameters of the aquatic environment and their evaluation in relation to human health and aquatic ecological resources. A majority of the water quality information presented in the following section was obtained from the Ohio River Valley Water Sanitation Commission (ORSANCO) reports, monitoring, and surveys. ORSANCO was established on June 30, 1948 as an interstate commission representing eight states and the federal government. The objective of

ORSANCO is to control and abate pollution in the Ohio River Basin. To accomplish this goal, ORSANCO operates programs to improve water quality such as: setting wastewater discharge standards; performing biological assessments; monitoring for the chemical and physical properties of the waterways; and conducting special surveys and studies.

ORSANCO represents an agreement and commitment among the member states. It is a function of the Commission to support and coordinate efforts by the states to fulfill their obligations under the Ohio River Valley Water Sanitation Compact. ORSANCO works with the member states to develop and carry out monitoring and assessment programs to determine the degree to which the desired uses are met and then develops strategies to address interstate pollution issues. Additionally, the physical, chemical, and biological water quality standards implemented by each member state must meet those criteria developed by ORSANCO. Another responsibility of ORSANCO is to provide information to federal, state, and local governmental agencies; elected officials; water purveyors; interested parties; and the public at large on water quality conditions in the Ohio River and the lower reaches of its tributaries. This responsibility has led to the availability of vast amounts of data concerning the physical, chemical, and biological water quality conditions within the Ohio River Basin.

3.3.2.8.1 Water Quality Indicators

To characterize the existing water quality conditions within the study area, the following indicators of water quality were evaluated: 1) DO, 2) pH, 3) fecal coliform bacteria, 4) turbidity and total suspended solids, and 5) nitrogen and phosphorus.

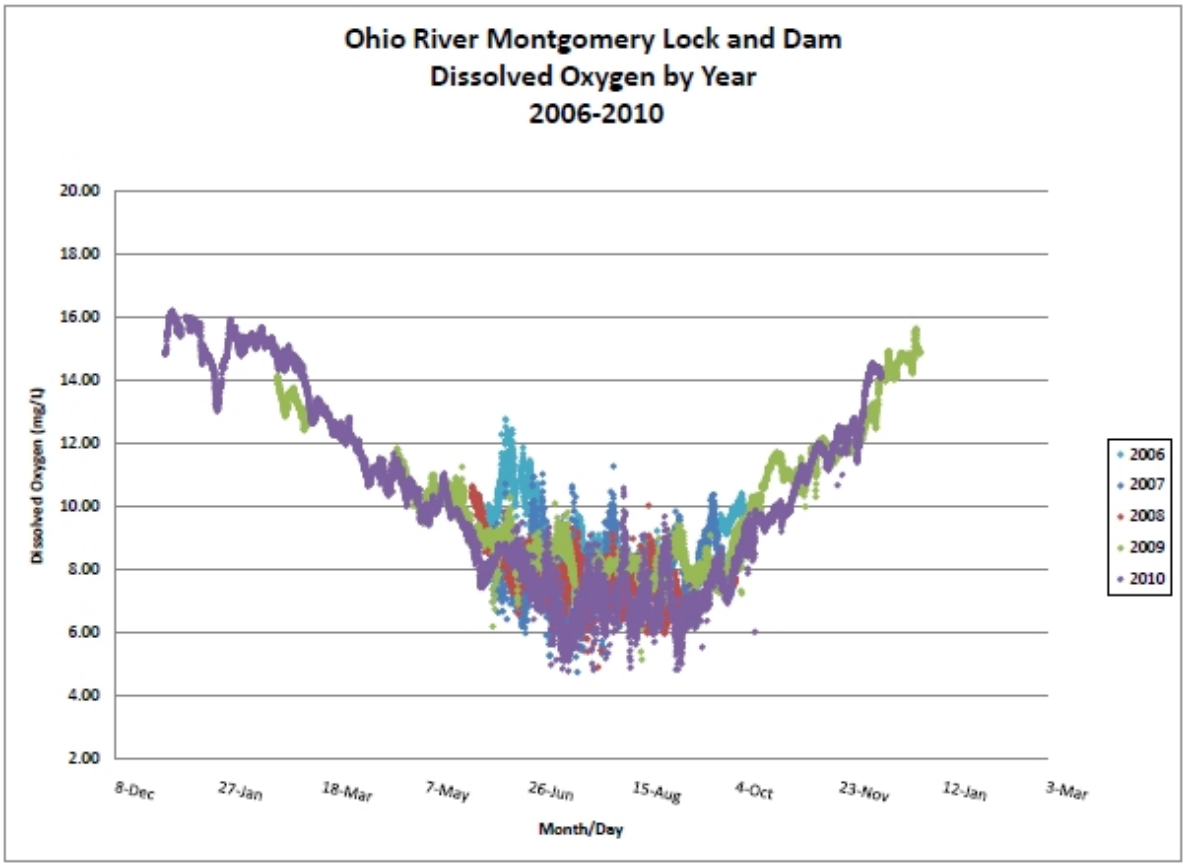
Dissolved Oxygen

Dissolved oxygen is an essential indicator when assessing the health of aquatic ecosystems. Most aquatic ecosystems require 5.00 to 6.00 milligrams per liter (mg/l) of DO to support diverse populations of aquatic life. ORSANCO's current minimum DO standard for the protection of aquatic life is an average of at least 5.00 mg/l for each calendar day, with the minimum concentration being not less than 4.00 mg/l. During the April 15 to June 15 fish spawning season, a minimum DO concentration of 5.00 mg/l must be maintained. Sufficient DO levels are especially crucial to fish spawning success. These ORSANCO DO standards are consistent with standards of the states along the Ohio River. This is true for both Pennsylvania and Ohio water quality standards.

Since the 1970s, the USACE has operated the Emsworth and Montgomery dams to manage the energy of their discharges to promote efficient gas exchange and re-aeration of discharged waters. These operations principally involve schedules of gate operations designed to promote tailwater turbulence and air entrainment during low flow periods.

Year-round DO trends in the Upper Ohio are displayed in **Figure 3-3** of readings at Montgomery Dam compiled between 2006-10. Fall and winter levels are typically above 12 mg/l and decline to between 5 to 6 mg/l during the warmer low flow months.

FIGURE 3-3: Annual Dissolved Oxygen Patterns, Montgomery Locks and Dam



DO levels were measured during recent ORSANCO biological studies within the New Cumberland, Emsworth, and Dashields pools. These studies were conducted during stable low-flow conditions typical of the Ohio River during the summer and early fall. The mean DO level within the Emsworth Pool was 8.96 mg/l and measurements ranged from 8.00 to 10.55 mg/l. The mean DO level within the Dashields Pool was 8.53 mg/l and measurements ranged from 7.71 to 9.46 mg/l. The mean DO level within the New Cumberland Pool was 9.34 mg/l and measurements ranged from 8.00 to 11.20 mg/l. These DO levels are well above the minimum DO level of 5.0 mg/l required during spawning season, the most critical time to fish throughout the year. These results can be found in **Table 3-9**.

TABLE 3-9: Dissolved Oxygen (DO) Measurements, EDM Pools

Emsworth		Dashields		New Cumberland	
River Mile	DO (mg/l)	River Mile	DO (mg/l)	River Mile	DO (mg/l)
2.2 (A)	9.00	6.7	8.00	32.8	9.29
5.0 (A)	9.00	7.7	8.29	36.0	11.20
5.7 (A)	8.00	8.1	7.71	36.5	N/A
2.6 (M)	8.85	8.4	8.09	37.2	11.20
4.5 (M)	9.02	8.4	9.21	39.9	9.40
4.8 (M)	9.00	9.1	9.44	40.2	9.00
5.7 (M)	9.00	9.4	9.28	41.4	9.00
6.3 (M)	8.90	9.8	8.89	42.5	8.90
9.1 (M)	8.79	10.0	9.46	44.2	8.90
10.8 (M)	8.71	10.6	9.08	45.3	N/A
0.2 (O)	10.55	10.8	9.01	46.4	9.70
1.9 (O)	9.36	11.3	7.89	46.8	8.10
4.0 (O)	9.25	11.6	7.89	48.3	9.00
4.3 (O)	9.00	12.0	7.89	51.6	9.70
5.1 (O)	8.00	12.5	7.89	53.4	8.00
Mean DO	**8.96**	**Mean DO**	**8.53**	**Mean DO**	**9.34**
A = Allegheny, M = Monongahela, O = Ohio Rivers					

pH

During biological studies conducted within the New Cumberland, Montgomery, Emsworth, and Dashields pools (ORSANCO 2004, 2006, 2007, and 2008, respectively), pH levels were measured. These studies were conducted during stable low-flow conditions typical of the Ohio River during the summer and early fall. The mean pH level within Emsworth Pool was 7.20 and measurements ranged from 5.20 to 8.10. The mean pH level within Dashields Pool was 7.80 and measurements ranged from 6.97 to 8.56. The mean pH level within the Montgomery Pool was 7.60 and measurements ranged from 7.40 to 8.00. The mean pH level within the New Cumberland Pool was 7.41 and measurements ranged from 7.20 to 7.80.

The pH range defined by ORSANCO's and PADEP's water quality standards is from 6.0 to 9.0. All but one (Emsworth r.m. 4.3) of the pH measurements were within this acceptable range. These results can be found in **Table 3-10**.

TABLE 3-10: pH Levels in the Ohio River
Emsworth, Dashields, Montgomery, and New Cumberland Pools

Emsworth		Dashields		Montgomery		New Cumberland	
River Mile	pH	River Mile	pH	River Mile	pH	River Mile	pH
2.2 (A)	6.40	6.7	8.08	13.7	7.40	32.8	7.36
5.0 (A)	6.40	7.7	8.38	14.1	7.40	36.0	7.20
5.7 (A)	7.60	8.1	7.97	15.8	7.40	36.5	7.36

Emsworth		Dashields		Montgomery		New Cumberland	
River Mile	**pH**	**River Mile**	**pH**	**River Mile**	**pH**	**River Mile**	**pH**
2.6 (M)	7.90	8.4	8.34	16.6	7.70	37.2	7.20
4.5 (M)	7.70	8.4	6.97	19.3	7.70	39.9	7.42
4.8 (M)	6.70	9.1	6.97	22.0	7.60	40.2	7.38
5.7 (M)	6.70	9.4	6.97	23.1	7.50	41.4	7.50
6.3 (M)	7.10	9.8	8.56	26.0	8.00	42.5	7.40
9.1 (M)	7.60	10.0	7.65	27.0	7.70	44.2	7.40
10.8 (M)	7.60	10.6	7.65	27.1	N/A	45.3	N/A
0.2 (O)	8.10	10.8	7.65	27.3	N/A	46.4	7.38
1.9 (O)	8.00	11.3	7.95	27.6	N/A	46.8	7.32
4.0 (O)	8.00	11.6	7.95	28.7	N/A	48.3	7.47
4.3 (O)	5.20	12.0	7.95	30.1	N/A	51.6	7.80
5.1 (O)	7.50	12.5	7.95	30.4	N/A	53.4	7.58
Mean pH	**7.20**	**Mean pH**	**7.80**	**Mean pH**	**7.60**	**Mean pH**	**7.41**
A = Allegheny, M = Monongahela, O = Ohio Rivers							

Fecal Coliform Bacteria

The occurrence of fecal coliform bacteria in aquatic environments indicates water has been contaminated with fecal matter of humans or other animals. Fecal coliform indicates the presence of organisms that may cause gastrointestinal illness. Consequently, the presence of fecal coliform is an indicator of a potential health risk for humans exposed to such water.

Bacteriological water quality has historically been and still is a serious issue within the upper Ohio River. Since the late 1950s, the development of sewage treatment plants throughout the region has alleviated pollution from domestic and industrial waste that previously discharged directly to local waterways, resulting in improved bacteriological water quality in the upper Ohio River. However, although the construction of water treatment plants has helped reduce the amount of sewage released into the upper Ohio River, releases of untreated sewage continue to degrade local water quality and impair the value of habitat, recreation, and public water supplies. The main sources of this untreated sewage are from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and failing sewers.

In 1970, ORSANCO began to require that all municipal wastewater treatment facilities provide secondary treatment. Subsequently, coliform bacteria levels in the Ohio River were expected to decline. This decline did not occur in the river overall, although decreases did occur in the upper 100 miles. Complicating matters somewhat during the 1970s, ORSANCO began reporting only fecal coliform levels as a better indicator of sewage contamination. In 1976, ORSANCO adopted the new federal drinking water standard of 2,000 col/100 mL, a standard that has remained to this day. By 1978-79, ORSANCO reported nearly 100 percent compliance in the lower two-thirds of the river and compliance about 75 percent of the time in the upper 100 miles, where problems had previously been most acute.

ORSANCO fecal coliform bacteria monthly sampling data (May 1992/2001 – October 2008) downstream from Pittsburgh along the river are presented in **Table 3-11**. These data indicate

that the percent of samples exceeding the standard has not improved over the past 16 years and that this is still an issue in the upper Ohio River. This will continue to be an issue until SSOs are eliminated and the effects of CSOs are managed properly. The lower percentage of exceedances observed in 2007 is most likely due to fewer wet events throughout the summer months.

TABLE 3-11: Fecal Coliform Sampling Exceedances in Pittsburgh (May 1992/2001 – October 2008)

	River Mile 1.4				River Mile 4.3			
	1992-2005	2006	2007	2008	2001-2005	2006	2007	2008
Total Samples	397	27	29	30	381	81	87	90
Number Exceeding Standard	194	15	9	16	196	41	29	51
Percent Exceeding Standard	**49**	**56**	**31**	**53**	**51**	**51**	**33**	**57**

Turbidity and Total Suspended Solids

The Allegheny River is naturally the clearest of the three rivers surrounding Pittsburgh. The Allegheny's substrate is unique due to its close vicinity to the ice margin in the time of the glaciers. Because of these glaciers, the substrate of the Allegheny River consists of well-rounded, unweathered pebbles; sharp, angular sand; small amounts of silt and clay; and boulders. As the glaciers melted, much of the fine material was washed into the Ohio River and then into the Mississippi River. The Monongahela is much more dominated by finer substrates. This is due to much of its bed being composed of sedimentary rocks. The Ohio River substrate is a mixture of the material carried by the Allegheny and Monongahela rivers. Therefore, the substrate of the Ohio River tends to be coarser than the Monongahela River, but finer than the Allegheny River. Since finer substrates are more easily suspended within the water column, the Monongahela River is typically the most affected by high levels of turbidity while the Allegheny River is typically the least affected. In addition to the substrate compositions of these rivers, certain activities also influence the turbidity levels. The two most influential human activities include barge traffic and dredging. Additionally, turbidity levels are increased where large tributaries enter these rivers.

ORSANCO's 2000 Pollution Control Standards include no specific turbidity or TSS standard for protection of aquatic life, but generally state that waters discharged to receiving waters be free from materials that will settle to form objectionable sludge deposits or suspended materials that will be unsightly or deleterious.

Nitrogen and Phosphorus

Nitrogen and phosphorus are nutrients that stimulate growth of algae and aquatic plants that provide food for fish. Major sources of nitrogen and phosphorus entering rivers include

municipal and industrial wastewater, septic systems, agricultural runoff, and atmospheric deposition. Nitrate and phosphate are the forms of these elements most readily available for plant growth.

Nitrate is the fully oxidized form of nitrogen and, except under polluted conditions, is the form normally occurring in streams. Ammonia (NH_3) is the most common form of nitrogen in sewage and is toxic to aquatic life in relatively low concentrations. In flowing water, bacteria convert ammonia to nitrites and nitrates. An ORSANCO study of long-term water quality trends from 1977 through 1987 indicated a strongly decreasing trend in ammonia nitrogen and a decreasing trend in total nitrogen, primarily related to wastewater treatment plant improvements and stringent discharge permit requirements.

ORSANCO water quality criteria to protect human health are 10 mg/L for nitrite + nitrate nitrogen and 1.0 mg/L for ammonia nitrogen. Recent ORSANCO data from four sampling stations are summarized in **Table 3-12** and **Table 3-13**. These sampling locations were located on the Allegheny River at –r.m. 7.4, the Monongahela River at –r.m. 4.5, the Beaver River –r.m. 5.3, and the Ohio River at r.m. 54.4. The average nitrite - nitrate nitrogen concentrations from 2002 to 2009 at each of these locations were 0.723, 0.853, 1.253, and 0.988 mg/L, respectively. The average ammonia nitrogen levels were 0.074, 0.090, 0.113, and 0.088 mg/L, respectively. These averages are well below the standards set to protect human health for both nitrite + nitrate nitrogen and ammonia nitrogen. Additionally, none of the seasonal averages for each sampling location from 2002 to 2009 has exceeded these water quality criteria.

TABLE 3-12: Nitrite - Nitrate Nitrogen Concentrations (mg/L) Measured on the Allegheny, Monongahela, Beaver, and Ohio Rivers from 2002 to 2009

	Pittsburgh r.m. 7.4 (Allegheny)	S. Pittsburgh r.m.4.5 (Monongahela)	Beaver Falls r.m. 5.3 (Beaver)	New Cumberland r.m. 54.4 (Ohio)
2009 (Spring)	0.634	0.687	1.028	0.808
2008 (Fall)	0.450	0.878	1.140	0.801
2008 (Spring)	0.607	0.572	1.104	0.772
2007 (Fall)	0.555	0.940	1.687	1.037
2007 (Spring)	0.743	0.884	1.123	0.913
2006 (Spring)	0.628	0.858	1.280	1.100
2005 (Fall)	0.366	0.836	1.293	0.994
2005 (Spring)	0.906	0.891	1.026	0.914
2004 (Fall)	0.555	0.783	1.093	0.853
2004 (Spring)	1.417	1.627	1.593	1.525
2003 (Fall)	0.247	0.287	1.413	1.280
2003 (Spring)	0.967	0.890	1.143	0.973

	Pittsburgh r.m. 7.4 (Allegheny)	S. Pittsburgh r.m.4.5 (Monongahela)	Beaver Falls r.m. 5.3 (Beaver)	New Cumberland r.m. 54.4 (Ohio)
2002 (Fall)	1.043	1.000	1.277	1.007
2002 (Spring)	1.003	0.813	1.343	0.853
Average	**0.723**	**0.853**	**1.253**	**0.988**

TABLE 3-13: Ammonia Nitrogen Concentrations (mg/L) Measured on the Allegheny, Monongahela, Beaver, and Ohio Rivers from 2002 to 2009

	Pittsburgh r.m. 7.4 (Allegheny)	S. Pittsburgh r.m. 4.5 (Monongahela)	Beaver Falls r.m. 5.3 (Beaver)	New Cumberland r.m. 54.4 (Ohio)
2009 (Spring)	0.073	0.107	0.100	0.117
2008 (Fall)	0.110	0.143	0.200	0.117
2008 (Spring)	0.047	0.067	0.103	0.077
2007 (Fall)	0.053	0.080	0.093	0.160
2007 (Spring)	0.147	0.060	0.103	0.067
2006 (Spring)	0.043	0.083	0.120	0.087
2005 (Fall)	0.037	0.060	0.080	0.047
2005 (Spring)	0.040	0.080	0.060	0.057
2004 (Fall)	0.083	0.063	0.050	0.063
2004 (Spring)	0.087	0.120	0.203	0.110
2003 (Fall)	0.087	0.047	0.080	0.057
2003 (Spring)	0.057	0.087	0.093	0.040
2002 (Fall)	0.030	0.060	0.067	0.077
2002 (Spring)	0.143	0.207	0.230	0.163
Average	**0.074**	**0.090**	**0.113**	**0.088**

ORSANCO has not established a standard for total phosphorus, although the United State Environmental Protection Agency (USEPA) recommends a maximum limit of 1.0 mg/L for flowing waters. A strongly decreasing trend in total phosphorus observed basin-wide during ORSANCO's 1977-1987 long-term study was attributed to the switch to phosphate-free detergents. Recent ORSANCO data from four sampling stations are summarized in **Table 3-14**. These sampling locations were located on the Allegheny River at r.m. 7.4, the Monongahela River at r.m. 4.5, the Beaver River r.m. 5.3, and the Ohio River at r.m. 54.4. The average total phosphorus concentrations from 2002 to 2009 at each of these locations were 0.060, 0.121,

0.186, and 0.047 mg/L, respectively. These averages are well below the USEPA recommended levels to protect human health for total phosphorus. Additionally, none of the seasonal averages for each sampling location from 2002 to 2009 has exceeded this water quality criterion.

TABLE 3-14: Total Phosphorus Concentrations (mg/L) Measured on the Allegheny, Monongahela, Beaver, and Ohio Rivers from 2002 to 2009

	Pittsburgh r.m. -7.4 (Allegheny)	S. Pittsburgh r.m. -4.5 (Monongahela)	Beaver Falls r.m. -5.3 (Beaver)	New Cumberland 54.4 (Ohio)
2009 (Spring)	0.062	0.047	0.142	0.080
2008 (Fall)	0.012	0.034	0.126	0.034
2008 (Spring)	0.013	0.050	0.082	0.027
2007 (Fall)	0.018	0.020	0.156	0.032
2007 (Spring)	0.044	0.049	0.161	0.032
2006 (Spring)	0.033	0.044	0.261	0.053
2005 (Fall)	0.032	0.057	0.108	0.036
2005 (Spring)	0.145	0.261	0.241	0.045
2004 (Fall)	0.064	0.055	0.196	0.050
2004 (Spring)	0.209	0.090	0.246	0.057
2003 (Fall)	0.030	0.061	0.060	0.048
2003 (Spring)	0.081	0.106	0.102	0.047
2002 (Fall)	0.032	0.073	0.072	0.055
2002 (Spring)	0.067	0.743	0.647	0.060
Average	**0.060**	**0.121**	**0.186**	**0.047**

3.3.2.8.2 Attainment of Ohio River Designated Uses

Section 305(b) of the Clean Water Act of 1972 (CWA) requires biennial water quality assessments of designated uses. The Ohio River has four designated uses: 1) warm water aquatic life, 2) public water supply, 3) contact recreation, and 4) fish consumption. **Table 3-15** summarizes the three classifications (i.e., fully supporting, partially supporting, and not supporting) ORSANCO has developed to describe attainment of these uses.

TABLE 3-15: Assessment Criteria for Ohio River Designated Uses

Aquatic Life Use
Fully supporting: No pollutant exceeds criteria in as much as ten percent of the samples collected. Ohio River Fish Index (ORFIn) scores do not indicate aquatic life impairment.

Partially supporting: One or more pollutants exceed criteria in as much as ten percent of the samples collected. ORFIn scores indicate aquatic life impairment.
Not Supporting: One or more pollutants exceed criteria in greater than 25 percent of the samples collected. ORFIn scores indicate severe aquatic life impairment.
Public Water Supply Use
Fully supporting: No pollutant exceeds criteria in as much as ten percent of the samples collected.
Partially supporting: One or more pollutants exceed human health criteria in 11-25 percent of samples collected. OR frequent intake closures are necessary to protect water supplies due to instream concentrations exceeding finished water maximum contamination levels (MCLs). OR frequent non-routine additional treatment is necessary to protect water supplies due to instream concentrations exceeding finished water MCLs.
Not supporting: One or more pollutants exceed human health criteria in greater than 25 percent of samples collected. OR source water quality causes MCL violations that result in noncompliance with provisions of the Safe Drinking Water Act.
Contact Recreation Use
Fully supporting: Monthly average or instantaneous maximum bacteria criteria are exceeded during fewer than 10 percent of the recreation season months (May – October).
Partially supporting: Monthly average or instantaneous maximum bacteria criteria are exceeded during 11-25 percent of the recreation season months.
Not supporting: Monthly average or instantaneous maximum bacteria criteria are exceeded during more than 25 percent of the recreation season months.
Fish Consumption Use
Fully supporting: No fish consumption advisories are in effect.
Partially supporting: Restricted fish consumption advisories are in effect or dioxin or mercury data indicate impairment.
Not supporting: "No Consumption" advisories are in effect for all commonly consumed species.

Table 3-16 shows the results of the ORSANCO biennial assessments. The data displayed are for the portion of the Ohio River that is within the boundaries of Pennsylvania (r.ms 0 to 40.2). The attainment of designated use varied greatly among the four designations and varied less temporally within each use. Aquatic Life Use was the only designation to meet its criteria throughout Pennsylvania for all four biennial reports. Fish Consumption Use was the only designation to be impaired throughout Pennsylvania for all four biennial reports. This was the result of high levels of polychlorinated biphenyls (PCBs) and dioxins. This result was consistent throughout the entire Ohio River mainstem. Results for Contact Recreation Use changed over the time period of the four reports. While in 2000 and 2001 only 6.2 miles were listed as impaired, in 2002 and 2003 as well as 2006 and 2007 all 40.2 miles were listed as impaired.

This was due to high levels of bacteria throughout this reach of stream. CSOs are one of the biggest contributing factors to the high levels of bacteria. The results for Public Water Supply Use were very good overall. Although there has been an increase in impaired miles since the 2000 and 2001 biennial report, only 4.0 miles have been listed as impaired in the last two biennial reports referenced. These miles were found to be impaired due to high levels of fecal coliform. This was the case for approximately half of the Ohio River mainstem.

TABLE 3-16: Impaired Ohio River Miles in Pennsylvania According to Attainment Use Designations (Ohio River Miles 0 – 40.2)

Biennial Sampling Years	Aquatic Life Use*	Public Water Supply Use*	Contact Recreation Use*	Fish Consumption Use*
2006 & 2007	0	4.0	40.2	40.2
2002 & 2003	0	4.0	40.2	40.2
2000 & 2001	0	0	6.2	40.2
1998 & 1999	0	0	25.4	40.2
*Miles Impaired				

3.3.2.9 Fish and Wildlife

3.3.2.9.1 Fish

Rapid growth of the human population in the upper Ohio River Basin during the first half of the 20th century led to larger inputs of domestic sewage, industrial effluents, and acid mine drainage. The combined effects of these pollutants led to a depleted fish fauna dominated by tolerant species. By 1950, the abundance of intolerant species such as lampreys, sturgeons, paddlefish, bigeye chub, muskellunge, sauger, and blue sucker were greatly reduced, while tolerant species such as the gizzard shad, emerald shiner, freshwater drum, bullhead catfish, and introduced common carp had increased in abundance within the Upper Ohio and Lower Allegheny. Conditions within the Monongahela River were even worse than the other two rivers. In 1948, fish had almost entirely disappeared from the Monongahela River due to acid mine drainage, steel mill effluent, and other pollutants.

Improving Trends

In the last half of the 20th century, actions of ORSANCO and implementation of the Clean Water Act of 1972 and its amendments led to considerable progress in the subsequent recovery of many fish species in the Ohio River. **Table 3-17** compares the ten most abundant fishes collected in the Ohio River for two different time periods and collection methods. Emerald shiner, gizzard shad, and freshwater drum are the three most abundant species on both lists. Species that occur on the 1991-2001 list that did not appear on the earlier list include sauger, bluegill, temperate basses, and silver chub. Absent from the more recent list are the pollution-tolerant common carp and bullheads, as well as skipjack herring and white crappie.

TABLE 3-17: Ten Most Abundant Ohio River Fish Species

Rank	Lock Chambers (rotenone) (1957-1980)	Electrofishing (1991-2001)
1	Emerald shiner	Gizzard shad
2	Gizzard shad	Emerald shiner
3	Freshwater drum	Freshwater drum
4	Mimic shiner	Sauger
5	Channel catfish	Mimic shiner
6	Common carp	Bluegill
7	Bullheads (all species)	Channel catfish
8	Skipjack herring	Morone spp. (temperate basses)
9	White crappie	Threadfin shad
10	Threadfin shad	Silver chub

Numerous studies conducted since the introduction of the Clean Water Act in 1972 have demonstrated a positive trend in the abundance and diversity of fishes through the upper Ohio River system. ORSANCO reviewed lock chamber rotenone fish sampling data from the late 1960s to the early 1980s, demonstrating a positive trend along the river. Sport and commercially valuable fish species exhibited the greatest increase in diversity and abundance even though these species tend to be more intolerant of pollution than other species. Fish diversity increased by 40 percent in the upper river compared to only 13 percent in the middle section. These improvements are credited to increased pH and dissolved oxygen concentrations, as well as decreased levels of toxic materials in the river. Many species that were extirpated from the upper river during the worst decades of pollution have redistributed to portions of the river approximating their historical ranges. Between 1984 and 1989, 18 fish species extended their range in an upstream direction, as shown in **Table 3-18.**

TABLE 3-18: Upstream Fish Range Extensions, Ohio River

Fish Species	1970-1983 Distribution (Ohio River Mile)	1984-1988 Distribution (Ohio River Mile)
Paddlefish	427-981	341-981
Spotted gar	846-981	560-981
Threadfin shad	390-981	341-981
Mooneye	260-981	54-981
Grass pickerel	597-981	54-981
River carpsucker	54-981	35-981
Highfin carpsucker	170-981	54-981
Northern hogsucker	35-604	13-604
Smallmouth buffalo	54-981	35-981
Silver redhorse	35-981	13-981
Rosyface shiner	35-981	13-981
Striped bass	126-981	13-981
Silverjaw minnow	54-287	35-605

Fish Species	1970-1983 Distribution (Ohio River Mile)	1984-1988 Distribution (Ohio River Mile)
River chub	54-470	35-560
Striped shiner	54-518	35-605
Fathead minnow	161-279	77-560
Brook silverside	54-260	35-981
Banded darter	35-494	13-560

Fish samples collected from 1973-1985 in the upper and middle river suggested that range extensions (i.e., re-establishment) of such river species as the paddlefish, mooneye, spotted gar, river carpsucker, smallmouth buffalo, and white bass were most likely direct responses to improvements in water quality in the upper Ohio River.

Recent Biological Studies

Recent ORSANCO biological studies were conducted within the New Cumberland, Montgomery, Dashields, and Emsworth pools in 2004, 2006, 2008, and 2007, respectively. These studies collected data on fish, habitat, water quality (temperature, dissolved oxygen, conductivity, and pH) and flow, and ORFIn metrics at 15 sites throughout each of the pools. The Ohio River Fish Index, or ORFIn, is a method of measuring the health of fish communities in the Ohio River. Fish were collected at night utilizing the boat electrofishing and benthic trawling techniques at multiple sites. In addition, each pool was evaluated to determine if it meets its aquatic life designation. These ORSANCO studies provide a general overview of the current overall water quality and fish characterization of the upper Ohio River. A total of 62 fish species was collected from the four pools studied. Of these 62 species, seven are listed by Pennsylvania as threatened, endangered, or of special concern: the mooneye, silver chub, spotted sucker, longear sunfish, warmouth, river shiner, and skipjack herring.

The results of these surveys are summarized below:

New Cumberland Pool – the fish survey resulted in 35 species of fish including one PA endangered species, the silver chub. The dominant species collected within this pool included the mimic shiner, emerald shiner, golden redhorse, and gizzard shad. These species comprised 22 percent, 14 percent, 13 percent, and 10 percent of the total catch. Habitat surveys revealed that fines (38 percent) dominated the bottom substrate of the New Cumberland Pool. Other substrate included 23 percent gravel, 17 percent sand, 16 percent cobble, and six percent boulder. The average temperature, dissolved oxygen, conductivity, and pH were 25.1°C, 9.33 mg/L, 390 µS/cm, and 7.41, respectively. ORFIn results scored on average 9.9 points below what was expected at each site, with all but four sites failing. The poor ORFIn results were not fully understood. Fish metrics such as Great River Species, Percent Simple Lithophils, and Percent Piscivores were all lower than had been anticipated. It is expected these scores were the result of high flows and poor weather conditions during the survey. The poor conditions may have caused decreased capture efficiency of fish. The results of this study indicated the New Cumberland Pool did not meet its aquatic life designation.

Montgomery Pool – the electrofishing survey resulted in the collection of 41 fish species. Five of these species are listed as either endangered, threatened, or of special concern in Pennsylvania. These species included the mooneye, silver chub, spotted sucker, longear sunfish, and warmouth. The dominant species were smallmouth buffalo (12.9 percent) and sauger (12.8 percent). It was unusual for these species to outnumber shad and minnows. This was most likely due to high flow conditions during the surveys. Habitat surveys revealed the Montgomery Pool substrate was mostly sand (33 percent) and gravel (27 percent) with a small percentage of boulders. Water quality sampling did not show any poor or unusual water conditions throughout the pool. Of the 15 sites sampled, only two were in poor condition and did not meet their expected ORFIn scores. Approximately 87 percent of the sites were in passing condition. The results of this study indicated the Montgomery Pool did meet its aquatic life designation.

Dashields Pool - the electrofishing survey resulted in the collection of 31 fish species and one hybrid taxa. Five of the 31 species are listed as endangered, threatened, or of special concern in PA. These species were the silver chub, smallmouth buffalo, mooneye, river redhorse, and longnose gar. The three most dominant species were the sauger (15.6 percent), logperch (13.5 percent, and smallmouth bass (13.2 percent). Habitat surveys revealed the substrate of the Dashields Pool was mostly composed of sand (30.0 percent) and gravel (29.6 percent), with a smaller percentage of cobble and fines. Water quality sampling did not show any poor or unusual water conditions throughout the pool. Unlike the other pools within the study area, the Dashields Pool was assessed using the modified ORFIn (MORFIn). Five (38%) of the 13 sites assessed within the Dashields Pool scored less than the minimum expected MORFIn scores and were assessed as either poor or very poor. The results of this study indicate the Dashields Pool did meet its aquatic life designation.

Emsworth Pool – the electrofishing survey resulted in the collection of 42 fish species. Four of the 42 species are listed as endangered, threatened, or of special concern in PA. These species were the silver chub, river shiner, skipjack herring, and mooneye. The three most dominant species were the bluegill (14.5 percent), smallmouth bass (12.9 percent), and sauger (10.8 percent). Habitat surveys revealed the substrate of the Emsworth Pool was mostly composed of sand (37.4 percent) and gravel (30.2 percent), with smaller percentages of cobble and fines. Water quality sampling did not show any poor or unusual water conditions throughout the pool. The ORFIn scores for all 15 sites were passing. The results of this study indicate the Emsworth Pool did meet its aquatic life designation.

Current and Future Concerns

Although the second half of the 20th century marked dramatic improvements to water quality and fish abundance in the study area, there are still several issues threatening the populations of fish in the rivers of the project area. As has been the case throughout the history of these rivers, the biggest threat to fish is the degradation of water quality. Current factors and actions that could adversely affect water quality include: acid mine drainage; oil and gas exploration and production; industrial waste or spills; sedimentation and contamination caused by urban runoff; and thermal pollution from cooling water discharges. Other threats include the obstruction of

fish migration by navigational dams, introduced and invasive fish species, and fish contamination.

The navigational dams on the Ohio River will continue to affect fish assemblages river wide. All of these dams create, at minimum, partial obstacles to fish migration. The degree to which dams affect upstream migration on the Ohio River varies considerably between dams and species. The best available option for upstream movement is considered to be through the lock chamber, which is unlikely to be a viable means of population level fish passage. A study of the ability of fish species to pass through dam gates during open river conditions concluded that the current potential for fish passage at Pittsburgh District dams is low. This effect was even more pronounced at the Emsworth, Dashields, and Montgomery (EDM) locks and dams, where there is little or no opportunity for fish passage.

As a part of the *Upper Ohio Navigation Study, Pennsylvania*, the Upper Ohio Interagency Working Group (UOIWG), in conjunction with the United States Fish and Wildlife Service (USFWS), is in the process of preparing an EDM Fish Passage Summary. The goal of this project is to improve the historic connectivity for populations of riverine fishes and mussels in the Upper Ohio River Basin. The project will include the preliminary engineering evaluation of passage alternatives relative to the navigational structures, evaluation of the biological effectiveness of the remaining alternatives, and preliminary engineering requirements and costs for construction of the alternatives.

Invasive species may have the greatest potential to threaten the fishes of the upper Ohio River. Invasive species compete, and sometimes outcompete, native species for vital resource provided by the river. Invasive species also destroy habitat utilized by native species and even consume the eggs of fish that are considered very valuable to the river. Although the upper Ohio River has not been affected by invasive species to the same extent as lower portions, the potential of these species to travel upstream is a possibility. Asian carp (bighead, silver, black, and grass) are potentially the biggest threat to the biotic integrity of the upper Ohio River. In portions of the Mississippi River, Asian carp comprise 95 percent of total biomass of the river. These fishes compete with native filter feeders, and in the case of the black carp feed on native mussel and snail species.

Several management and control plans have been or are being designed to impede the upstream distribution of Asian carp. Illinois, Indiana, Ohio, and Pennsylvania have all included Asian carp within their aquatic invasive species management plans. In addition, the USFWS and Aquatic Nuisance Species Task Force have organized an Asian Carp Working Group and have submitted a management and control plan for Asian carp in the United States.

In addition to the introduced carp species, another species of concern is the white perch. Only nine individuals were collected during the Emsworth, Montgomery, and New Cumberland fish surveys conducted by ORSANCO. However, the white perch is a prolific spawning species and therefore has the potential to establish a sizeable population in a short period of time . White perch also adversely affect other fish species through direct competition for food and the predation of eggs. White perch are known to consume the eggs of white bass, alewife,

freshwater drum, and walleye. Future monitoring will be necessary to determine if the white perch population is increasing within the Ohio River and if it is threatening native species.

Federal and state agencies currently publish fish consumption advisories applicable to the Allegheny, Monongahela, and Ohio rivers. Advisories based on PCB contamination in the Upper Ohio study area have been issued for consumption of carp, flathead catfish, channel catfish, white bass, hybrid-striped bass, sauger, walleye, largemouth bass, smallmouth bass, and freshwater drum. The following website links may be consulted for more detailed information.

http://water.epa.gov/scitech/swguidance/fishshellfish/fishadvisories/advisories_index.cfm

http://www.depweb.state.pa.us/portal/server.pt/community/fish_consumption/10560

http://www.fish.state.pa.us/fishpub/summary/sumconsumption.pdf

3.3.2.9.2 Larval Fish

The larval stages of most fishes are considered to be the most vulnerable and sensitive portion of their life history to certain events. However, little information was available regarding their abundance and distribution within the upper Ohio River. Documenting abundance and distribution provide insight into the location of spawning from which inferences can be made regarding the sources of recruitment. To gather baseline information to support the study's environmental evaluations, the Corps supported a larval and young-of-year (YOY) fish survey through the US Geological Survey's Pennsylvania Cooperative Fish & Wildlife Research Unit at State College. Pennsylvania State University (PSU) ichthyologists gathered and assessed information on the presence and distribution of larval and YOY fishes within the study area, and suggested restoration opportunities.

PSU sampled multiple sites between Ohio River mile 40.0 (Ohio state line) and the first navigation structures on both the Allegheny and Monongahela rivers during August/September 2008, and March/April, June/July, and August/September 2009. Certain aquatic habitats were targeted, based on prior knowledge regarding larval and YOY fishes, including: islands, associated backchannels, tributary mouths, and the Montgomery Embayment (Slough). Lock chambers and areas immediately below dams were not sampled in this study. A variety of techniques were used to determine the presence of all potential larval and YOY fishes, including: light traps, metered plankton nets, seines and trawls (benthic, mid-water column, and surface). Most notable of these techniques was a new electric benthic trawl, developed by PSU, which promised successful high-diversity results based on previous studies.

Collection counts from 29 sites totaled 27,473 individual specimens, representing 61 species (Emsworth Pool-11,693; Dashields-3,448; Montgomery-7,320; New Cumberland-5,012). Only seven of the 61 species collected were represented only by adult forms, indicating successful spawning in the study area for most of these species.

Pennsylvania state-listed "Threatened" or "Endangered" species were among those species collected. Larval or YOY specimens were collected for the silver chub (*Macrhybopsis storeriana*)—endangered in PA; and the mooneye (*Hiodon tergisus*), goldeye (*H. alosoides*), skipjack herring (*Alosa chrysochloris*), bluebreast darter (*Etheostoma camurum*), and Tippecanoe darter (*E. tippecanoe*)—all threatened in Pennsylvania. Also collected were larval or

YOY specimens for one candidate and one soon-to-be listed species: respectively, the bowfin (*Amia calva*) and the river darter (*Percina shumardi*). PSU concluded that all of the above species are spawning in the study area.

Larval or YOY specimens of 15 species of sport fishes were also collected during surveys, including: northern pike (*Esox lucius*), flathead catfish (*Pylodictis olivaris*), channel catfish (*Ictalurus punctatus*), rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), smallmouth bass (*Micropterus dolomieu*), spotted bass (*M. punctulatus*), largemouth bass (*M. salmoides*), black crappie and white crappie (*Poxomis nigromaculatus & annularis*), white bass (*Morone chrysops*), striped bass (*M. saxatilis*), yellow perch (Perca flavescens), sauger (*Stizostedion canadense*), and walleye (*S. vitreum*). PSU concluded that all of the above sportfish species are spawning in the study area.

3.3.2.9.3 Wildlife

Migratory Birds

The Ohio River is a significant water area for numerous migratory waterfowl and shorebirds. Ospreys (*Pandion haliaetus*) are not currently known to breed in western Pennsylvania; however they are likely to be observed as spring and fall migrants through the project area. The USFWS reported numerous waterfowl observed along the Pennsylvania reach of the Ohio River during January 1983. Among the species observed were American black ducks (*Anas rubripes*), mallards (*Anas platyrhynchos*), common goldeneye (*Bucephala clangula*), common merganser (*Mergus merganser*), and scaup (*Aythya* spp.). Gulls (*Larus* spp.) were abundant during this field visit and a flock of approximately 15-20 great blue herons (*Ardea herodias*) were seen along the river near the Montgomery Locks and Dam.

The bottomland hardwood forested floodplains along the Upper Ohio River Valley are commonly utilized by cavity-nesting migratory bird species such as wood ducks (*Aix sponsa*), great horned owls (*Bubo virginianus*), eastern bluebirds (*Sialia sialis*), goldeneyes, and mergansers. The forest structure in habitats of floodplains along the Upper Ohio Valley provides the proper canopy and insect life required to support migratory songbirds like the warbling vireo (*Vireo gilvus*), northern oriole (*Icterus parisorum*), Carolina wren (*Thryothorus ludovicianus*), wood thrush (*Hylocichla mustelina*), and numerous warblers.

The following game bird and raptor species have been reported from the Pittsburgh and surrounding areas: wild turkey (*Meleagris gallopavo*), American woodcock (*Scolopax minor*), Canada goose (*Branta canadensis*), barred owl (*Strix varia*), eastern screech owl (*Otus asio*), northern harrier (*Circus cyancus*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentiles*), red-tailed hawk (*Buteo jamaicensis*), and American kestrel (*Falco sparverius*).

Allegheny and Beaver counties, through which the upper Ohio River flows, have recorded confirmed and suspected breeding of at least 125 species of migratory birds. No state or federally-listed bird species were recorded during this time period for this study; however, a second Breeding Bird Atlas project was recently concluded to document Pennsylvania's avian fauna. This project spanned 2004-2008 with the goal of being "the most extensive survey of the

state's nesting birds ever attempted." Additional information can be found on the 2nd Pennsylvania Breeding Bird Atlas website at http://www.carnegiemnh.org/atlas/home.htm.

Mammals

The upland mesophytic forested areas along the Upper Ohio River Valley are commonly utilized by a wide variety of mammals, such as white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridanus*), raccoon (*Procyon lotor*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), and eastern gray squirrel (*Sciurus carolinensis*). Bottomland hardwood forests along the floodplains of the Ohio River in this region provide good habitat for furbearers such as the muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), and beaver (*Castor canadensis*), as well as cavity-nesting species such as the eastern fox squirrel (*Sciurus niger*) and raccoon. Understory areas within bottomland hardwood forests provide habitat for northern short-tailed shrew (*Blarina brevicauda*), Norway rats (*Rattus norvegicus*), and white-tailed deer.

Other mammals likely to utilize various habitats of the Upper Ohio River include the eastern chipmunk (*Tamias striatus*), star-nosed mole (*Condylura cristata*), deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), opossum (*Didelphis virginiana*), masked shrew (*Sorex cinereus*), striped skunk (*Mephitis mephitis*), meadow vole (*Microtus pennsylvanicus*), long-tailed weasel (*Mustela frenata*), and woodchuck (*Marmota monax*). Bats which forage along riparian areas and over waterways of the Upper Ohio River include the big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), Indiana bat (*Myotis sodalis)*, red bat (*Lasiurus borealis*), little brown bat (*M. lucifugus*), eastern small-footed bat (*M. leibii*), and eastern pipistrelle (*Pipistrellus subflavus*).

Reptiles and Amphibians

The habitat types along the corridors of the Ohio River in Pennsylvania are likely to support reptiles such as the northern fence lizard (*Sceloporus undulatus hyacinthinus*), copperhead (*Agkistrodon contortrix*), black racer (*Coluber constrictor*), five-lined skink (*Eumeces fasciatus*), black rat snake (*Elaphe obsolete*), eastern garter snake (*Thamnophis sirtalis sirtalis*), eastern hognose snake (*Heterodon platirhinos*), eastern milk snake (*Lampropeltis triangulum triangulum*), eastern ribbon snake (*Thamnophis sauritus*), smooth green snake (*Opheodrys vernalis*), brown snake (*Storeria dekayi*), northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*), northern water snake (*Nerodia sipedon*), queen snake (*Regina septemvittata*), ringneck snake (*Diadophis punctatus*), stinkpot (*Sternotherus odoratus*), eastern box turtle (*Terrapene Carolina*), painted turtle (*Chrysemys picta*), snapping turtle (*Chelydra serpentine*), spotted turtle (*Clemmys guttata*), and wood turtle (*Glyptemys insculpta*). Embayments of the Upper Ohio River also support map turtles (*Graptemys geographica*).

In addition, aquatic habitat types in and along the corridors of the Ohio River in Pennsylvania are likely to support the following amphibian species: American bullfrog (*Rana catesbeiana*), gray tree frog (*Hyla versicolor*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), wood frog (*Rana sylvatica*), hellbender (*Cryptobranchus alleganiensis*), red-spotted newt (*Notophthalmus viridescens viridescens*), northern spring peeper (*Pseudacris crucifer crucifer*),

four-toed salamander (*Hemidactylium scutatum*), long-tailed salamander (*Eurycea longicauda*), marbled salamander (*Ambystoma opacum*), northern dusky salamander (*Desmognathus fuscus*), red salamander (*Pseudotriton rubber*), spring salamander (*Gyrinophilus porphyriticus*), northern two-lined salamander (*Eurycea bislineata*), eastern red-backed salamander (*Plethodon cinereus*), northern slimy salamander (*Plethodon glutinosus*), spotted salamander (*Ambystoma maculatum*), and American toad (*Bufo americanus*). Embayments of the Upper Ohio River also support northern leopard frogs (*Rana pipiens*).

3.3.2.10 Aquatic Invertebrates

Historically, one of the most diverse assemblages of freshwater mussels in the United States occurred in the Ohio River. However, the industrialization and urbanization of the upper Ohio River corridor resulted in severe negative impacts on the mussel populations of the river. With the creation of ORSANCO and the passage of the Clean Water Act, the subsequent improvement to the water quality conditions of the upper Ohio River began to allow the opportunity for mussel re-colonization of the river. The Endangered Species Act of 1973 (ESA) provided additional protection for listed mussel species.

At least three freshwater mussel surveys have been conducted within portions of the project study area in recent times. These include:

Greenup Lock and Dam (r.m. 341.0) to Pittsburgh (r.m. 0.0) – Taylor, 1980;

Upper Ohio River Mussel Database – Ecological Specialists, Inc. (ESI), 2000; and

Native Mussel Screening Survey, Upper Ohio Navigation Study – EnviroScience (ES), 2009, (see report copy in **Environmental Appendix**).

In the 1980 study conducted by Taylor from the Greenup Lock and Dam to Pittsburgh, no living mussels were collected in the Pennsylvania reach of the river. Only sub-fossil shells were found in this reach of the river. The Upper Ohio River Mussel Database compiled by Ecological Specialists, Inc. enumerated the mussel beds (a natural aggregation of mussels) observed within the pools of the upper Ohio River (r.m. 0 – 431). Of the pools within the project area (Emsworth, Dashields, Montgomery, New Cumberland), no mussel beds were observed; however, 41 mussels representing eight species were collected from the New Cumberland Pool.

A recent survey (summer 2008) of the Emsworth, Dashields, Montgomery, and New Cumberland pools identified eight species of native mussels. The limits of the study investigated for this survey included the Ohio River from r.m. 0 - 35. Thirty-five non-random sampling points were investigated for this qualitative screening-level survey. The sample points were selected as high probability areas for habitat/substrate composition that would likely support mussel populations. As a result of the survey, 110 live mussels representing six species were collected. Specimens of two additional species (freshly dead were collected during the investigation. **Table 3-19** lists the species collected during this survey, the number of individuals by species, as well as their federal and state statuses.

It is noted in the report for this survey that the mussel population within the study area "is relatively low in terms of density and diversity" in comparison to other mussel populations found in the middle Ohio River and within the navigable pools of the Allegheny River. This report

goes on to state that, "Assuming 50 percent efficiency, mussel density rarely reached or exceeded an estimated 0.4 mussels/m^2." Of the species collected during this survey, the most dominant species included the pink heelsplitter (*Potamilus alatus*), the mapleleaf (*Quadrula quadrula*), and the threehorn wartyback (*Obliquaria reflexa*), with the pink heelsplitter being the most dominant.

Two additional species were identified in the study area that warrant special note. These include the fawnsfoot (*Truncilla donaciformis*) and the deertoe (*Truncilla truncata*). These species warrant special note because the Pennsylvania status of the fawnsfoot is "unknown" and the deertoe is currently listed as extirpated within Pennsylvania. Additionally, the deertoe and threehorn wartyback are proposed by the USFWS, Pennsylvania Fish and Boat Commission (PFBC), and the Adaptive Management Group as species indicative of flowing water and large river habitats. These two species are also suggested as sensitive indicator species by the USFWS.

TABLE 3-19: Native Mussels Survey of Upper Ohio River Collected During 2008

Common Name	Scientific Name	Number of Individuals	Federal Status / State Status
Emsworth Pool			
Fatmucket	*Lampsilis siliquoidea*	1	– / –
Pink heelsplitter	*Potamilus alatus*	1*	– / Candidate rare
Dashields Pool			
Fluted-shell	*Lasmigona costata*	1	– / –
Fragile papershell	*Leptodea fragilis*	2*	– / Candidate rare
Threehorn wartyback	*Obliquaria reflexa*	5, 1*	– / Proposed extirpate
Pink heelsplitter	*Potamilus alatus*	13	– / Candidate rare
Mapleleaf	*Quadrula quadrula*	22	– / Proposed threaten
Fawnsfoot	*Truncilla donaciformis*	2	– / Condition undeter
Montgomery Pool			
Fragile papershell	*Leptodea fragilis*	4*	– / Candidate rare
Threehorn wartyback	*Obliquaria reflexa*	1	– / Proposed extirpate
Pink heelsplitter	*Potamilus alatus*	14, 5*, 2**	– / Candidate rare
Mapleleaf	*Quadrula quadrula*	2	–

Common Name	Scientific Name	Number of Individuals	Federal Status State Status
			Proposed threaten
New Cumberland Pool			
Fragile papershell	*Leptodea fragilis*	3**	– Candidate rare
Threehorn wartyback	*Obliquaria reflexa*	2, 10*	– Proposed extirpate
Pink heelsplitter	*Potamilus alatus*	30, 1*, 4**	– Candidate rare
Mapleleaf	*Quadrula quadrula*	17, 90*	– Proposed threaten
Deertoe	*Truncilla truncate*	2*	– Proposed extirpate
*Fresh dead shell			
**Weathered dead and sub-fossil shell			

This project area is also within the range of eleven federal species of special concern. These include 11 endangered or threatened species, and one species of concern. **Table 3-20** describes these species.

Freshwater mussels feed on organic particles, algae, and minute plants and animals, which they siphon out of the water. Because of their limited mobility, adult mussels are subject to a variety of environmental factors that can restrict their distribution and reproductive success. The availability of suitable fish hosts to ensure dispersal of juvenile mussels and completion of their life cycle is critical to their reproductive success. The limited mobility of mussels and their relatively long life spans make mussel populations good environmental indicators.

TABLE 3-20: Endangered Species Candidate Species and Mussel Species of Concern

Species	Common Name	Habitat	Federal Status
Cyprogenia stegaria	Fanshell	Lotic	Endangered
Epioblasma torulosa rangiana	Northern riffleshell	Lotic	Endangered
Lampsilis abrupta	Pink mucket	Lotic	Endangered
Obovaria retusa	Ring-pink	Lotic	Endangered
Plethobasus cooperianus	Orange-foot pimpleback	Lotic	Endangered
Pleurobema clava	Clubshell	Lotic	Endangered
Pleurobema plenum	Rough pigtoe	Lotic	Endangered
Plethobasus cyphyus	Sheepnose	Lotic	Endangered
Villosa fabalis	Rayed bean	Lotic	Endangered
Epioblasma triquetra	Snuffbox	Lotic	Endangered
Quadrula cylindrical	Rabbitsfoot	Lotic	Threatened

Species	Common Name	Habitat	Federal Status
Simpsonaias ambigua	Salamander mussel	Generalist	Species of Concern
Lotic – typical of flowing water and gravel and cobble substrates; Lentic – minimal flow; sand or silt substrates; Generalist – occurs in both habitat types.			

3.3.2.11 Endangered and Threatened Species

The U.S. Fish and Wildlife Service provided the following comments pursuant to the Endangered Species Act of 1973 in December 2009, as updated in February 2012 and again in March 2015. The Ohio River is inhabited by multiple federally listed endangered mussel species, including the clubshell (*Pleurobema clava*), northern riffleshell (*Epioblasma torulosa rangiana*), rayed bean (*Villosa fabalis*), fanshell (*Cyprogenia stegaria*), orange-foot pimpleback (*Plethobasis cooperianus*), pink mucket (*Lampsilis abrupta*), ring-pink (*Obovaria retusa*), rough pigtoe (*Pleurobema plenum*), snuffbox (*Epioblasma triquetra*), and sheepnose (*Plethobasus cyphyus*). The Ohio River is also within the range of the federally listed threatened mussel species, the rabbitsfoot (*Quadrula cylindrica cylindrica*).

The following listed mussel species are believed to or known to occur in Pennsylvania, the rayed bean, clubshell, sheepnose, northern riffleshell, and rabbitsfoot. The pink mucket, fanshell and orange-foot pimpleback are found in Ohio River navigation pools downstream of the study area, and are considered extirpated from Pennsylvania. The District's screening-level mussel survey undertaken in the study area in 2008 located no listed individuals. Following project authorization and at an appropriate time in advance of the initiation of construction, the District will consult with the Service and Pennsylvania natural resource protection agencies on the need for and scope of site-specific mussel surveys to assess their future status in the proposed areas of disturbance.

The proposed project is within the range of the endangered Indiana bat (*Myotis sodalis*). Winter cave habitat (hibernaculum) has been documented in Beaver County. Summer habitat occurs throughout Pennsylvania in forested or wooded areas near water. Its distribution is strongly correlated with major rivers such as the Ohio River.

The study area is in the range of the formerly federally listed Bald Eagle (*Haliaeetus leucocephalus*) and the Peregrine Falcon (*Falco peregrinus anatum*). The Peregrine Falcon was delisted in 1999 and the Bald Eagle in 2007. They are still protected by the Migratory Bird Treaty Act, and the Bald Eagle is further protected under the Bald and Golden Eagle Protection Act.

Species having Pennsylvania state level endangered and threatened status are addressed separately in the Work Areas section under Affected Environment.

3.3.2.12 Wild and Scenic Rivers

The Ohio River is neither listed or being studied for listing as part of the National Wild and Scenic Rivers System. There is one nationally designated river in the study area, Little Beaver Creek, which enters the Ohio River at r.m. 39.6. The lower 33 miles of this river is designated a

National Scenic River, but most of the river is in Ohio; only the mouth and lower mile are situated in Pennsylvania. The Pennsylvania portion of the Little Beaver Creek is not included as part of the Pennsylvania Scenic River System.

3.3.2.13 Air Quality

Air quality refers to ambient or outdoor air that is safe to breathe by all members of the general population, including young children, elderly citizens, and other "at risk" individuals such as asthmatics. Specific standards are used to assess the levels at which air quality is measured and health protected. National Ambient Air Quality Standards (NAAQS) have been established by the United States Environmental Protection Agency for the following categories of air pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3), and sulfur dioxide (SO_2).

Areas failing to meet one or more of the NAAQS are identified as being in non-attainment. Non-attainment areas may be individual communities or multi-county regions, depending on the type and extent of the pollution problem. Non-attainment areas typically cross state lines wherever population centers are located near such borders. In general, regional conditions in the Ohio River Valley reflect the national pattern for overall improvement in air quality. **Table 3-21** illustrates the progress of the five counties in the study area that were designated as being in non-attainment since 1992.

TABLE 3-21: Air Quality Non-Attainment Counties Study Area Summary

County	Pollutant	Area Name	Years in Non-Attainment	Re-designation to Attainment
Pennsylvania				
Allegheny	CO	Pittsburgh, PA	1992 - 2002	1/13/2003
Allegheny	1-hr O_3	Pittsburgh-Beaver Valley, PA	1992 - 2001	9/02/2005
Allegheny	8-hr O_3	Pittsburgh-Beaver Valley, PA	Subpart 1 (Basic)[a] 1992 - 2008	--
Allegheny	PM_{10}	Clairton & 4 Boroughs, PA	1992 - 2003	10/14/2003
Allegheny	SO_2	2-mile radius of Hazelwood, PA	Maintenance [b] 1992 - 2008	--
Beaver	1-hr O_3	Pittsburgh-Beaver Valley, PA	1992 - 2001	9/02/2005
Ohio				
Columbiana	1-hr O_3	Columbiana Co., OH	1992 - 1994	3/10/1995
Jefferson	1-hr O_3	Steubenville, OH	1992 - 1994	3/10/1995
Jefferson	PM_{10}	Jefferson Co., OH	Maintenance [b] 1992 - 2008	--
Jefferson	SO_2	Jefferson Co., OH	Maintenance [b] 1992 - 2008	--
West Virginia				
Hancock	PM_{10}	Weirton,	Non-attainment 1992-2008	--

County	Pollutant	Area Name	Years in Non-Attainment	Re-designation to Attainment
Pennsylvania				
Allegheny	CO	Pittsburgh, PA	1992 - 2002	1/13/2003
Allegheny	1-hr O_3	Pittsburgh-Beaver Valley, PA	1992 - 2001	9/02/2005
		New Manchester-Grant Mag. District (Hancock), WV		
Hancock	SO_2	Weirton, New Manchester-Grant Mag. District (Hancock), WV	Maintenance [b] 1992 - 2008	--
[a] Areas designated "Basic" non-attainment under Subpart 1 of Part D under Subchapter I of the CAA are areas with a 1-hour ozone designation value (at the time of designation) that is below the level of 0.121 ppm				
[b]Maintenance Areas are geographic regions previously designated as non-attainment for a specific pollutant and subsequently re-designated to attainment at a later date. These areas are required to develop a maintenance plan under Section 175A of the CAA and undergo regional and project level conformity determinations until the area formally achieves attainment status as designated by USEPA.				

The status of air quality in the study area as of March 2014 is summarized in **Table 3-22**. Within the study area, the Pittsburgh-Beaver Valley area in Pennsylvania is designated as being in Subpart 1 (Basic) nonattainment for ozone (based on the 2008 8-hour standard). Portions of five counties around the study area are designated as being in non-attainment for SO_2. Of those five counties, only that portion of Beaver County actually falls within the study area, with the Mon Valley area of Allgeheny County lying upstream of the study area and the Ohio/West Virginia counties lying downstream of the study area. Ten counties in the three states are designated as being in non-attainment for $PM_{2.5}$. Portions of Allegheny County, Pennsylvania, and Jefferson County, Ohio, are designated as being in maintenance for $PM_{10.}$ All counties in the study area are in attainment for NO_2.

TABLE 3-22: Air Quailty Non-Attainment Pollutants Summary By Counties

State	Non-attainment Area Name	Counties	Classification[1]
Designations for 2008 8-hour O_3 Standard			
Pennsylvania	Pittsburgh-Beaver Valley	Allegheny Armstrong Beaver Butler Fayette Washington Westmoreland	Subpart 1 (Basic)[a]
Designations for 2010 SO_2			

Pennsylvania	Allegheny Co. (Boroughs of Braddock, Dravosburg, East McKeesport, East Pittsburgh, Elizabeth, Glassport, Jefferson Hills, Liberty, Lincoln, North Braddock, Pleasant Hills, Port Vue, Versailles, Wall, West Elizabeth, & West Mifflin; Cities of Clairton, Duquesne, & McKeesport; and Townships of Elizabeth, Forward, & North Versailles)	Allegheny (p)	Nonattainment
	Beaver Co (Boroughs of Industry, Shippingport, & Midland; and Townships of Brighton, Potter, & Vanport)	Beaver (p)	Nonattainment
Ohio	Steubenville-Weirton, OH-WV (Cross Creek, Steubenville, Warren, & Wells Townships, Steubenville City)	Jefferson (p)	Nonattainment
West Virginia	Marshall Co. (Clay, Franklin, & Washington Tax Districts)	Marshall (p)	Nonattainment
	Steubenville-Weirton, OH-WV (Cross Creek Tax District)	Brooke (p)	Nonattainment
Designations for 1987 PM_{10} (p = partial)			
Pennsylvania	Clairton & 4 Boroughs (City of Clairton, and Liberty, Lincoln, Port Vue, and Glassport Boroughs)	Allegheny	Maintenance [b]
Ohio	Jefferson Co.	Jefferson (p)	Maintenance [b]
Designations for 2006 $PM_{2.5}$ (p = partial)			
Pennsylvania	Pittsburgh-Beaver Valley	Allegheny (p) Armstrong (p) Beaver Butler Greene Lawrence (p) Washington Westmoreland	Nonattainment[c]
	Liberty – Clariton, PA (*Lincoln Borough, Clairton City, Glassport, Liberty, & Port Vue Boroughs)*	Allegheny (p)	Nonattainment
West Virginia	Steubenville-Weirton, OH-WV	Brooke Hancock	Nonattainment[c]
Designations for 1971 Carbon Monoxide (p = partial)			
Pennsylvania	portions of City of Pittsburgh	Allegheny (p)	Maintenance
Designations for 2008 Lead (p = partial)			
Pennsylvania	Lower Beaver Valley (Townships of Potter, Vanport & Center)	Beaver (p)	Nonattainment
[1]No Upper Ohio River counties or sub areas are designated nonattainment for NO_2.			

[a] Areas designated “Basic” non-attainment under Subpart 1 of Part D under Subchapter I of the CAA are areas with a 1-hour ozone designation value (at the time of designation) that is below the level of 0.121 ppm.
[b]Maintenance areas are geographic regions previously designated as nonattainment for a specific pollutant and subsequently re-designated to attainment at a later date. These areas are required to develop a maintenance plan under Section 175A of the CAA and undergo regional and project level conformity determinations until the area formally achieves attainment status as designated by USEPA.
[c]Areas where air pollution levels persistently exceed the NAAQS are designated "nonattainment" for that specific pollutant. These areas must take specific emission reduction measures to reach compliance with the NAAQS.

The Clean Air Act Amendments of 1990 (CAAA) were further designed to curb three major threats to the nation's environment and to the health of millions of Americans: acid rain, urban air pollution, and toxic air emissions. Emission standards and emission reduction programs at the national or multi-state regional level will play a critical role in helping all local programs achieve their air quality objectives. While most of these programs are currently in some stage of implementation, other program elements and impacts will be realized in the near to long-term future.

3.3.2.14 Human Health, Safety, and Noise

Health and safety concerns are related to issues of worker health and safety, commercial and recreational boater safety, and general population health. Health and safety impacts can occur during construction site activities at the locks and dams; boating accidents, spills, and operational practices associated with commercial navigation; spills or related impacts from other sources; and recreational boating accidents.

Industrial activities located on or conducted in proximity to the river pose a public health risk from pollution point sources; production and disposal of hazardous wastes; and spills of potentially hazardous or polluting materials associated with the transfer, storage, and use of the materials. Past industrial activities have contributed to the creation of contaminated sites and landfills that pose ongoing threats to groundwater, surface water, and public health. When raw materials, products, and wastes are transported by barge, rail, or truck, these materials are subject to spillage while in transit, especially when they arrive at material transfer points.

Contamination from industrial sites, landfills, and underground storage tanks is decreasing in the study area. Although much contamination has been eliminated because industrial and similar type facilities have shut down, regulations have tightened, making significant pollution a thing of the past. Additionally, old brownfield sites are being redeveloped into cleaner, more environmentally friendly areas, correcting past mistakes from pollution that have affected public health.

Good water quality is essential for contact recreation activities such as boating, swimming, and water skiing. Public water supplies and fish consumption are also reliant on good water quality. Water quality in the study area is improving. Nothing has been more vital to water quality improvements than the Clean Water Act and the ORSANCO Compact. These agreements have

resulted in vast improvements to water quality and will continue to help maintain and improve water quality throughout the upper Ohio River. The treatment of acid mine drainage and municipal and industrial wastes will also continue to be important to maintaining and improving water quality.

According to the United States Coast Guard (USCG) and the Pennsylvania Fish and Boat Commission, only 5 to 10 percent of actual boating accidents are reported. However, trends indicate that both accident and fatality numbers are decreasing in the study area. These decreases could be related to a decrease in the number of registered boats, which should mean a decrease in the number of boats on the waterways, thus, creating fewer opportunities for unsafe boating. According to the USCG, new laws and regulations have also contributed to making boating safer, helping decrease the number of boating accidents and fatalities.

3.3.2.15 Socioeconomic Profile (Environmental Justice)

3.3.2.15.1 Environmental Justice Background and Principles

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." The Executive Order (EO) makes clear that its provisions apply fully to programs involving Native Americans.

The Council on Environmental Quality (CEQ) has oversight of the Federal government's compliance with EO 12898 and the National Environmental Policy Act (NEPA). CEQ, in consultation with the US Environmental Protection Agency (EPA) and other affected agencies, developed NEPA guidance for addressing requirements of the EO.[6] This guidance was developed to further assist Federal agencies with their NEPA procedures so that environmental justice (EJ) concerns are effectively identified and addressed.

The CEQ has also identified six general principles for consideration in identifying and addressing EJ in the NEPA process which include: (1) area composition (demographics); (2) data (concerning cumulative exposure to human health or environmental hazards); (3) interrelated factors (recognize the interrelated cultural, social, occupational, or economic factors); (4) public participation; (5) community representation; and (6) tribal representation.

3.3.2.15.2 Key Definitions

The following definitions are used by the CEQ in guidance on key terms of the EO:

Low-income population: Low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the Bureau of the Census' Current Population

[6] Council on Environmental Quality. 1997. *ENVIRONMENTAL JUSTICE, Guidance Under the National Environmental Policy Act*. Additionally, the EPA has developed a series of environmental justice resources including: *Final Guidance for Consideration of Environmental Justice in Clean Air Act 309 Reviews*, July 1999, and *Policy and Procedures for the Review of Federal Actions Impacting the Environment*.

Reports, Series P-60 on Income and Poverty. In identifying low-income populations, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect.

Minority: Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

Minority population: Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. In identifying minority communities, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a geographically dispersed/transient set of individuals (such as migrant workers or Native American), where either type of group experiences common conditions of environmental exposure or effect. The selection of the appropriate unit of geographic analysis may be a governing body's jurisdiction, a neighborhood, census tract, or other similar unit that is to be chosen so as to not artificially dilute or inflate the affected minority population. A minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds.

Disproportionately high and adverse human health effects: When determining whether human health effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

(a) Whether the health effects, which may be measured in risks and rates, are significant (as employed by NEPA), or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death; and

(b) Whether the risk or rate of hazard exposure by a minority population, low-income population, or Indian tribe to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group; and

(c) Whether health effects occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards.

Disproportionally high and adverse environmental effects: When determining whether environmental effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

(a) Whether there is or will be an impact on the natural or physical environment that significantly (as employed by NEPA) and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated tribes when those impacts are interrelated to impacts on the natural or physical environment; and

(b) Whether environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority populations, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group; and

(c) Whether the environmental effects occur or would occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards.[7]

3.3.2.15.3 Identification and Analysis Specific to the Upper Ohio Navigation Study

An EJ analysis contains three general, but fundamental steps. First, an agency must determine whether EJ populations are present. To do so, an agency must establish project boundaries, obtain residential demographics, and conclude whether EJ populations reside within or adjacent to the project impact area. Next, if an EJ population is present, the potential effects of the project on that population must be identified. Effects on EJ populations must be compared with effects on non-EJ populations within the project area, and analyzed to determine whether those effects are disproportionately high and/or adverse to the EJ population. Finally, avoidance, minimization, and mitigation (including consideration of project benefits) of any disproportionately high and/or adverse effects should be addressed.

3.3.2.15.4 Defining the Geographic Area of Effect

For purposes of EJ analysis, the area of effect is centered on each of the existing navigation facilities where the physical construction activities will occur. The broader Upper Ohio Study Area inclusive of the entire river corridor was initially defined to encompass all potential alternatives for both navigation and ecosystem restoration projects. However, as navigation alternatives involving new locations or pool changes were eliminated early in the study, along with potential ecosystem restoration projects, the area of potential effect for navigation projects evaluated in detail was reduced to the existing facilities and their supporting work areas.

The Upper Ohio River corridor is a close mix of heavy industrial, transportation, and municipal development. Emsworth and Dashields navigation facilities are in the most heavily developed part of the river corridor within 12 miles of Pittsburgh. Further downriver, Montgomery Locks and Dam is situated in a similar, but somewhat less intensively developed area (see **Figures 3-4, 3-5, 3-6**).

At all three facilities, a one-mile radius from the center of the navigation facility was considered appropriate to define EJ communities and evaluate potential impact concerns. A one-mile radius from the center of the navigation facility was selected because it encompasses the construction work area alternatives where the project's land-based activities will occur, and also is a reasonable distance for consideration any impacts emanating from the construction areas (e.g. air quality, noise).[8]

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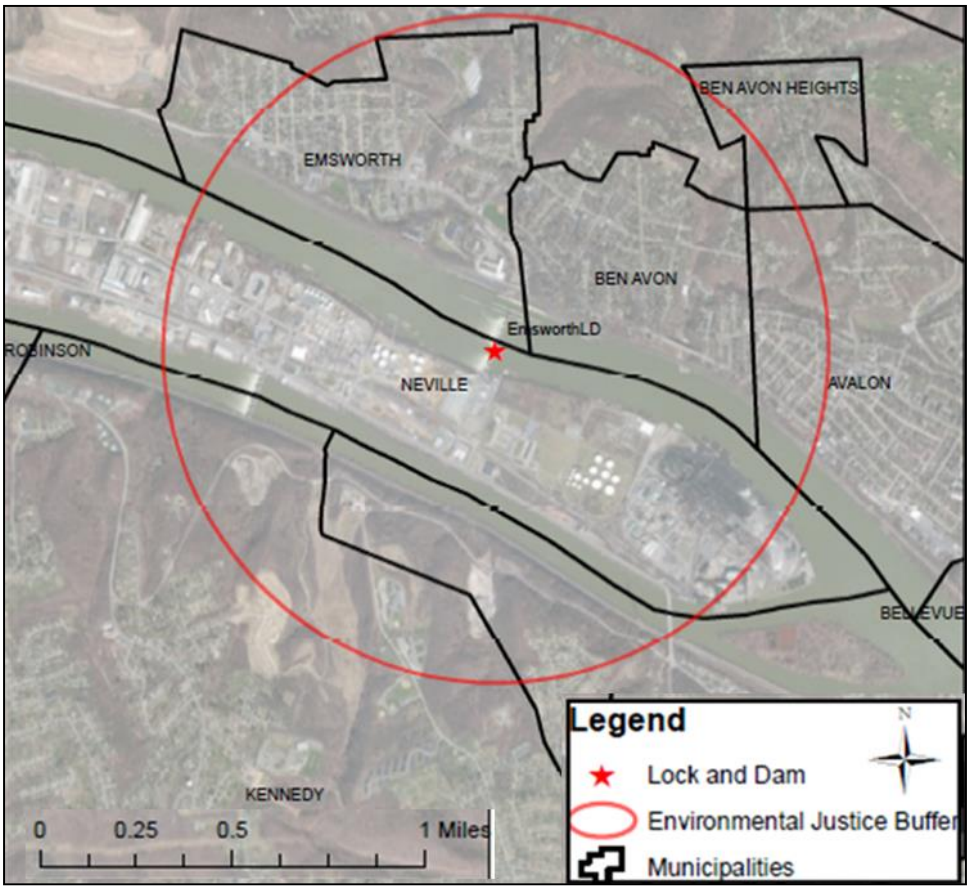
[7] Ibid. Appendix A, pp. 25-27.

[8] As described elsewhere in the feasibility report, analysis of material disposal alternatives is deferred. We are committed to evaluating specific alternative disposal sites/methods at a future date, which will include performance

FIGURE 3-4: Emsworth Locks and Dams, Environmental Justice Potential Area of Effect



and completion of all relevant NEPA environmental and socioeconomic analyses, including EJ, in conjunction with specific site selection and transportation routes.

FIGURE 3-5: Dashields Locks and Dam,
Environmental Justice Potential Area of Effect

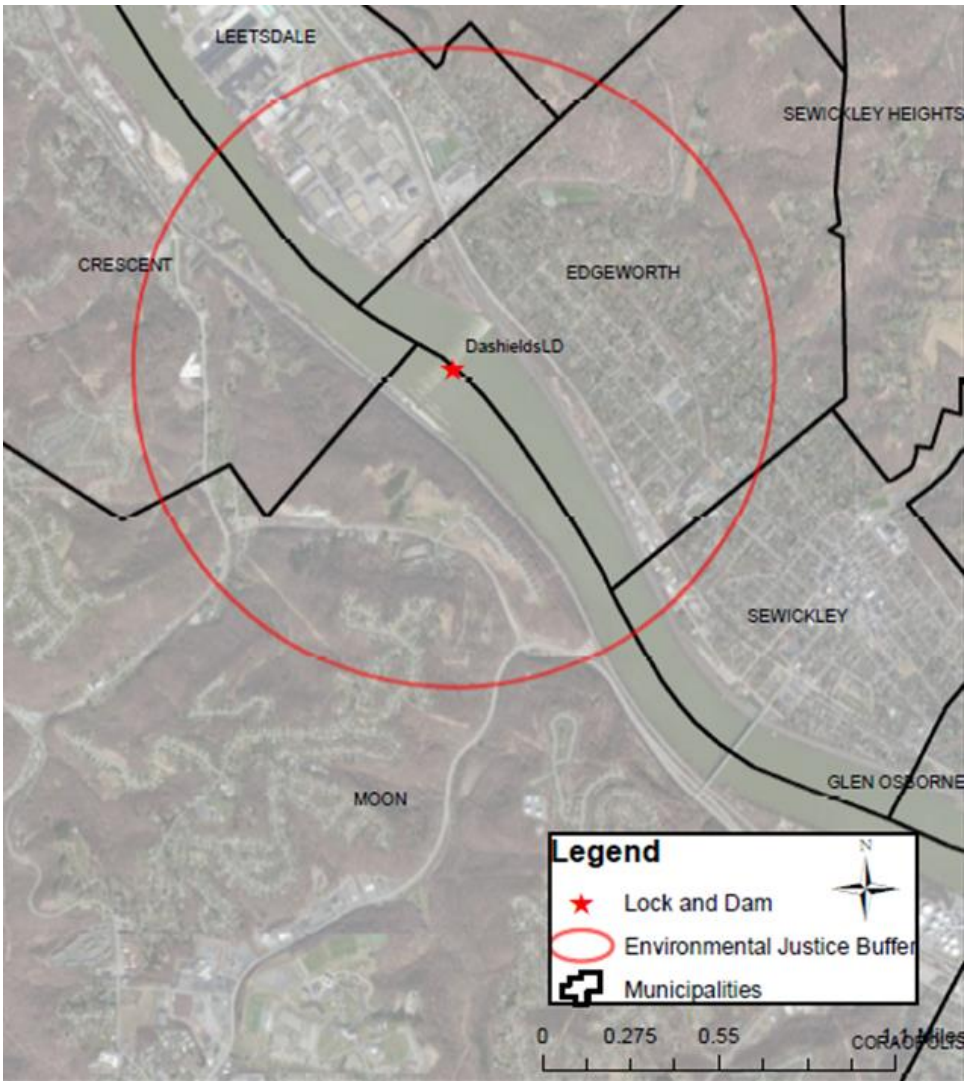
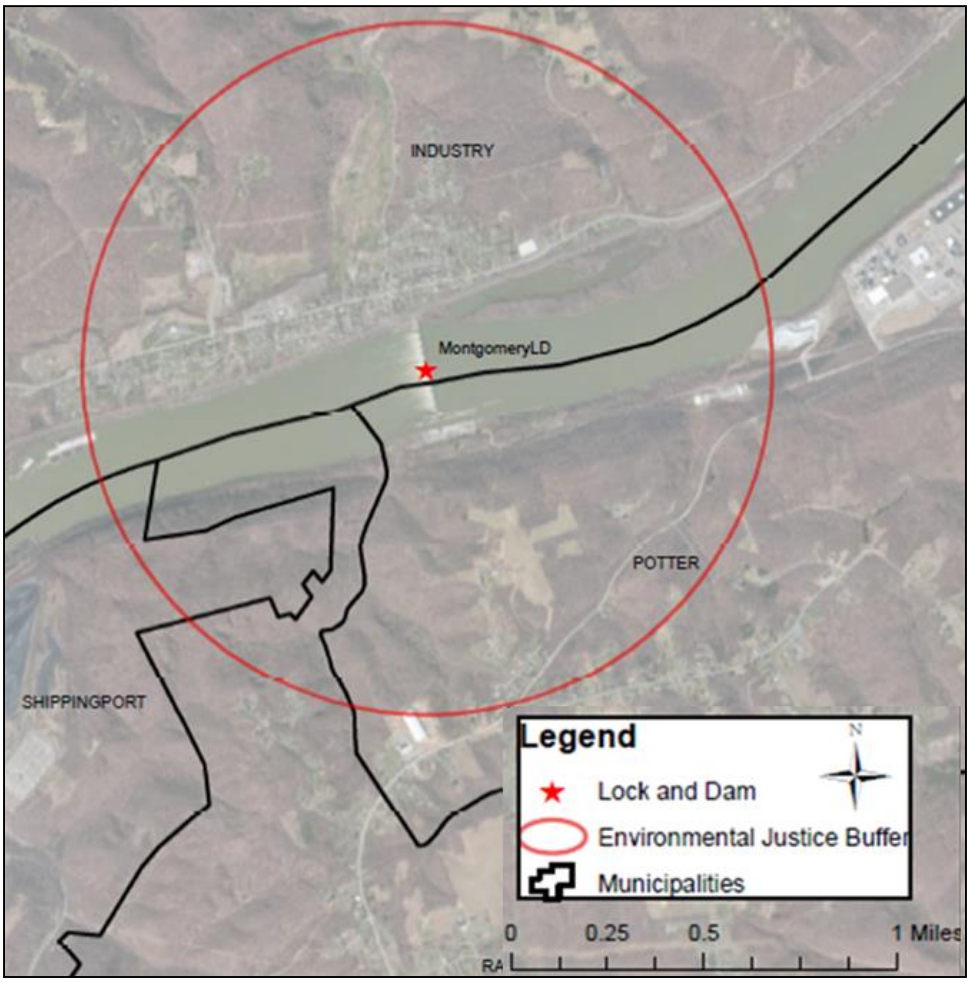


FIGURE 3-6: Montgomery Locks and Dam, Environmental Justice Potential Area of Effect



3.3.2.15.5 Defining Environmental Justice Populations

The Corps consulted US Census data (www.census.gov) and Southwestern Pennsylvania Commission (SPC) community profile reports (www.spcregion.org) to characterize the communities of the area of effect. The SPC is an organization that supports transportation planning in the 10-county Southwestern Pennsylvania region. This region is inclusive of the Allegheny and Beaver counties, within which the Upper Ohio study area is located, and the counties bordering the Upper Ohio's tributary Allegheny River and Monongahela River Navigation Systems.

Population and income characteristics of the SPC region differ from state averages[9]. The SPC region's percentage of persons living below poverty levels is slightly lower, and minority populations are significantly lower than state averages. For purposes of EJ analysis, the availability of SPC regional statistics provide a more suitable baseline against which to compare local community populations to determine if their minority and low income populations are "meaningfully greater" than the general population.

3.3.2.15.6 Study Area Characteristics Based on US Census 2010 Data

Pennsylvania and Regional Characteristics

The 10-county SPC region contains 20 percent of the state's population. In general, the region's population is older (both median and over 65) and has a lower median household income compared to the state. The region's individual and aggregate minority population percentage is significantly lower than the state level, and the percentage of persons below the poverty level is also lower. The SPC regional statistics were used for community comparison and EJ analysis.

Based on a radial distance of one mile from the navigation facility center, all communities or any part falling within that one-mile perimeter were included in the community characterizations. Emsworth Locks and Dams has a total of eight communities, Dashields five, and Montgomery four. Community statistical data relevant to Upper Ohio EJ issues contained in the 2010 US Census and SPC's municipal profile reports (based on use of 2010 Census Summary File), were reviewed and compiled into **Table 3-23** for comparison with SPC regional and state-level statistics. Communities qualifying for analysis as EJ communities are highlighted in the table with light-blue shading.

Implementation guidance for the EO states that EJ minority populations exist where either "the minority population of the affected area exceeds 50 percent" or "the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis." The statewide percentage for total minority population is 20.5 percent; the SPC region is 12.4 percent. None of the SPC communities reflect a minority population over 50 percent. What is "meaningfully greater" requires case-specific consideration. The Corps took a conservative approach in considering different values to define "meaningfully greater" and selected a value of 10 percent over the both the SPC minority and low income values to designate an EJ community. Avalon, Neville, Stowe, and Leetsdale all exceed the SPC's values (plus 10 percent) for minority and/or low income populations. Were any lesser increase above the SPC averages used as the threshold, the data show that there would not be any change in the outcome of EJ community classification, confirming the selected approach.

[9] Southwestern Pennsylvania Commission website (http://www.spcregion.org/reg_all.shtml#muns), by Allegheny County municipal profile, and (http://www.spcregion.org/reg_beav.shtml#muns) by Beaver County municipal profile.

TABLE 3-23. Upper Ohio River Communities Environmental Justice Statistics

AREA	POPULATION		INCOME	
Navigation Project & nearby Municipalities	Total	Minority (%)	Median House-hold income	Persons below poverty (%)
Emsworth Locks and Dams				
Avalon	4,705	13.2	$34,880	**17.7**
Ben Avon	1,781	7.0	$84,875	2.7
Ben Avon Heights	371	3.0	$136,250	1.3
Emsworth	2,449	9.0	$45,250	6.4
Kennedy	7,672	3.6	$62,965	7.9
Kilbuck	697	2.7	$81,071	4.0
Neville	1,084	12.8	$37,500	**18.0**
Stowe	6,362	**22.7**	$33,579	**25.1**
Dashields Locks and Dam				
Crescent	2,640	6.0	$57,025	7.4
Edgeworth	1,680	4.3	$142,917	2.7
Leetsdale	1,218	**14.9**	$36,726	5.3
Moon	24,185	11.4	$69,713	8.2
Sewickley	3,827	12.4	$54,121	6.7
Montgomery Locks and Dam				
Industry	1,835	4.5	$49,911	8.9
Potter	548	1.6	$52,292	10.7
Raccoon	3,064	2.5	$57,094	8.7
Shippingport	214	5.6	$37,250	4.8
SPC 10-county region	**2,574,959**	**12.4**	**$49,562**	**12.1**
SPC region values +10%		**13.6**		**13.3**
Pennsylvania	**12,702,379**	**20.5**	**$52,267**	**13.1**

XX	Values ≥ "SPC value +10%" - designating an EJ community

TABLE 3-24 (deleted)

Draft EIS Table 3-24 deleted from Final EIS

Emsworth Locks and Dams

Of the eight communities within a one-mile radius of Emsworth Main Channel Dam, three communities (Avalon, Neville, and Stowe) qualify for consideration as EJ communities. Stowe

is the only community to qualify under both the minority and low income criteria. Avalon and Neville qualify under the low income criteria.

Dashields Locks and Dam

Of the five communities within a one-mile radius of Dashields, only Leetsdale qualifies as an EJ community on the basis of its minority population.

Montgomery Locks and Dam

None of the four communities within a one-mile radius of Montgomery Locks and Dam qualify as EJ communities. Minority and poverty levels are well below the regional and state values.

3.3.2.16 Cultural Resources

3.3.2.16.1 Study Area - General

Cultural resources within the study area represent human behaviors and occupations over many centuries, including both pre-contact and historic period uses. People are believed to have been present in and continually used the study area since at least 14,000 BP (Before Present). Previously identified cultural resources demonstrate the central role of the Ohio River as a transportation artery and resource extraction area during both the pre-contact and historic periods.

Previously recorded pre-contact period cultural resources include: 74 generally dated archaeological sites, three petroglyphs, and two earthworks. The overwhelming majority of previously recorded pre-contact period sites in the study area are open habitation sites without a specific chronological assignation, while a few are listed as having both pre-contact and historic period components.

Historic period cultural resources are represented both in the archaeological record as sites as well as in the built environment as records and structural remains. Previously recorded historic period cultural resources include: 80 archaeological sites, one cemetery, 31 National Register of Historic Places (NRHP)-listed properties, 69 NRHP-eligible properties, and four National Historic Landmarks. The previously recorded historic period archaeological site types represent domestic, industrial, and military uses of the region. In addition to these previously recorded archaeological and historic structures cultural resources, there are numerous historic markers in the study area that denote places of historical significance and interest despite the absence of physical remains. The historical markers present in the study area relate to many aspects of both Native American and Euro-American history and recollect locations of important industrial, military, religious, and sporting events as well as Native American towns and burial mounds, and the homes of important artists, politicians, and military persons.

Cultural resources potentially present in the study area include both pre-contact and historic period archaeological sites and historic period structures. Based on the presence of previously identified pre-contact period archaeological sites, the presence of known Indian trails/paths, and 18th century Indian towns in the study area, additional as of yet unidentified pre-contact period

archaeological sites may be present. The expectation for preserved pre-contact period remains in the study area would be higher in less industrialized portions of the study area away from the extensive historically occupied/utilized areas immediately surrounding Pittsburgh. Some pre-contact period archaeological remains may be submerged along the river banks or on former islands due to the changes in river and pool water levels over time. As has been proven in the past for projects located in urban/industrialized areas (e.g., Pittsburgh Light Rail project located in downtown Pittsburgh, and the USACE construction of Braddock Dam at Leetsdale), pre-contact period archaeological remains may continue to be preserved beneath these historic and modern period uses.

As of yet unidentified historic period cultural resources could represent every aspect of historic development in the region such as mills, wharves, bridges, military encampments, residences, mill towns, and commercial and industrial structures. Archaeological components as well as structures associated with these events/activities, as well as others not mentioned, may be present in the study area.

Based on the proposed improvements to the Upper Ohio Navigation System at the three lock and dam locations, the types of cultural resources which will most likely be affected include any that are located within the rivers themselves, either as inundated resources which were once above the raised pool elevations or those that are currently within the river due to their function (e.g., locks, dams), and those located on or immediately adjacent to the river banks or on the lowest floodplain elevations, including resources such as pre-contact period sites (e.g., artifacts, cultural features, burials) or historic period archaeological remains or structures associated with military, industrial, commercial, and/or transportation related activities.

3.3.2.16.2 Study Area – Area of Potential Effect

Each of the existing navigation facilities has minimal land holdings necessary for operations on both river banks in the immediate area of the facility. For each facility, the in-river and river corridor Area of Potential Effect (APE) includes the navigation structures, all associated federal lands, and the river immediately upstream and downstream of the dam. The general vicinity of these APEs and their relationship to the alternative construction support areas are shown on **Figures 3-7, 3-8, & 3-9** (see also **Cultural Resource Appendix,** project maps).

3.3.2.16.3 Navigation System – Locks and Dams

Identification of Historic Properties (36CFR800.4)

The Corps has inventoried the Ohio River locks and dams and evaluated their historic significance within the context of the Ohio River Navigation System. These historical studies were conducted in support of the Ohio River Mainstem System Study System Investment Plan. They included historic property inventories of properties related to the navigation system, research on the historic context of the system, and completion of NRHP Multiple Property Documentation and individual nomination forms. Inventories extended to both former as well as the existing lock and dam facilities associated with three current Corps Districts: Pittsburgh, Huntington, and Louisville. The information compiled was transferred to state historic inventory forms according to the location of each resource.

The Ohio River Context Study explored three areas of potential historic significance associated with the Ohio River Navigation System, including 1) the engineering of the system, 2) political factors and military influences, and 3) community and economic development. The information developed through the inventory and context studies served for the preparation of the Multiple Property Documentation Form for the navigation system, and individual nomination forms for qualifying properties. These forms were prepared for planning purposes, and to date none of these forms have been formally processed to the National Park Service.

The Ohio River Navigation System presently consists of 20 mainstem lock and dam structures located on the 981-mile Ohio River mainstem, and the Louisville and Portland Canal. The river traverses through or along six states from Pittsburgh, Pennsylvania, to Cairo, Illinois. The Ohio River, in an unimproved state, was the first major westward artery encountered by migrant European settlers and traders in the early 18th Century, and has held a significant role in American history as a political boundary and a route for commerce and westward settlement. From a historical standpoint, the significance of the Ohio River Navigation System is based upon how improved transportation affected the economic development of Pittsburgh and other river cities along the waterway to the Gulf of Mexico and the settlement of the American West, and upon how the early engineering methods on the Ohio influenced future lock and dam designs. Subsequent improvements over time have enhanced the system to allow reliable and cost-efficient transportation of raw materials, basic manufactured products, and consumer goods.

From an engineering design perspective, the present Ohio River Navigation System is significant both for its individually notable engineering features and as a complex that shows the evolution of lock and dam technology from the 1920s to the present within the contexts of technology for locks and dams design and construction techniques.

From its onset in 1885, the Ohio River Navigation System has pioneered important developments in inland river lock and dam technology. Davis Island Lock and Dam pioneered the rolling lock gate, the world's largest lock chambers (at 110' x 600'), and a movable, wicket dam based on French technology. This structure, designed by Corps engineer, Col. William E. Merrill, established the design pattern for all 52 locks and dams to comprise the completed system in 1929. The wicket dam was its first application in America, concurrent with Merrill's application on the Kanawha River in West Virginia.

With changing navigation patterns and maintenance problems with movable dams, the replacements for the first generation movable dams in the upper river employed fixed crest concrete weirs in the 1920s (at Emsworth and Dashields) and vertical lift gates in the 1930's (at Emsworth and Montgomery). Pittsburgh District engineer William Sidney developed a hybrid gate combining advantages of both vertical lift and tainter gates. One "Sidney gate" was first used in the back channel dam (1938) at Emsworth as a full scale experiment and remained in use until the 2008 major rehabilitation of that structure. Post-World War II modernization of the remaining wicket dams employed tainter gate technology in place of the vertical lift gates or fixed crest dams. The existing first, second, and third generation dams possess significance as tangible examples of evolving dam technology. In its variety of dam types and dam technology, the Ohio River Navigation System is unmatched among waterways of the United States.

The existing locks in the Ohio River Navigation System exemplify the evolution of lock technology. Early structures, such as Emsworth, employ through-the-wall filling and emptying with separate culverts for each individual filling and emptying valve. Later locks used longitudinal culverts controlled by a smaller number of larger valves. The most recently constructed locks show the results of laboratory testing in which discharge systems are used to prevent turbulence in the lock chamber and scour of the lock walls. The existing locks also demonstrate the use of steel wall armor in the interior of the lock chambers. This armor, now used on most navigation locks in the United States, was first introduced in the first generation numbered locks on the Ohio River. The most recently constructed locks use tainter valves in a reverse configuration. Older locks use standard tainter valves, butterfly valves, or in the case of the inactive McAlpine chamber, Stoney valves. The presence of the variety of valves and filling systems provides significance in lock technology.

The Ohio River system is also significant for its role in the development of valve operating machinery. Several complexes on the Ohio were sites of early successful use of wire rope operating machinery for reverse tainter valves. The locks of the Ohio River Navigation System demonstrate changes in twentieth century lock, culvert and valve technology. Only a few other navigation systems of the United States, notably the Monongahela River, clearly illustrate this technological evolution.

The evolution of construction technology employed with Ohio River Navigation System has also played a significant role in inland river navigation history. A version of wood framed cofferdam took the name, “Ohio River box cofferdam” and was the standard for use on the Ohio and other inland rivers into the 1920s and later. The construction of Dashields Dam in 1927-29 first used sheet steel cofferdam cells on the Ohio after early applications, including the recovery of the *USS Maine* from Havana Harbor, showed its potential. Subsequent projects illustrate the continued evolution of cofferdam and caisson technology on the Ohio River. The construction of the Newburgh Locks and Dams included the use of sub-cofferdams within a main cofferdam to permit safe excavation for piers in the sandy river bottom. Other potential aspects of significance in construction technology include the first use in American lock and dam construction of long-span cableways to move construction materials to the project site and the development of timber pile construction techniques to firmly anchor locks and dams in the sandy bottom of the lower Ohio River. Technology pioneered on Ohio River projects later became the norm for lock and dam construction elsewhere.

Historical Significance of Upper Ohio Locks and Dams

Emsworth Locks and Dams is eligible for listing to the National Register of Historic Places, as previously determined between the Pittsburgh District and the PA SHPO (December 14, 2000). Montgomery Locks and Dam is eligible for listing to the National Register of Historic Places, as determined between the Pittsburgh District and the PA SHPO (April 25, 2013). Documentation is provided in the **Cultural Resources Appendix**. The District recommends in this report that Dashields Locks and Dam is also an eligible property under National Register Criteria A & C, as detailed below. The District requests that the PA SHPO concur in this recommendation.

Emsworth Locks and Dams

The Emsworth Locks and Dams is a second generation facility, constructed between 1919-22, to replace the original Lock and Dam Nos. 1 & 2. Its design marked a significant departure from the original single lock and movable wicket dam facilities. The concrete fixed crest dams (spanning the main channel and back channel at Neville Island) signaled an end to open river navigation on the upper river. The two-lock configuration was a direct consequence of the fixed crest dam, providing for the first time on the Ohio River an auxiliary lock in place of open river conditions to maintain navigation when the larger main chamber was closed for maintenance.

Emsworth is atypical because the dam is in two segments to span the river's main channel and back channel created by Neville Island. The facility originally consisted of two fixed crest dams, one on the main channel and a shorter one on the back channel. These were later modified to serve as the spillways for the 1935-38 replacement vertical lift gate dams. The dams are undergoing a major rehabilitation (2008-2013) to replace all of the original lift gates, their operating machinery and machinery houses. The original ca. 1922 locks are still in use, although modified by a 1980s major rehabilitation, and other mechanical replacements. The gate operating system has been converted from compressed air to hydraulic power. A new administration office and lock operator building was constructed on the site in 1988, but a ca. 1937 power house structure has been retained on the riverside lock wall.

Emsworth Locks and Dams was formally determined eligible for the NRHP between the Pittsburgh District and the PABHP in 2000 prior to the undertaking of the dams' rehabilitation (see Cultural Resources Appendix - PABHP letter dated December 14, 2000, Re: ER 00-3443-003-B, COE: Rehabilitation of Emsworth Locks and Dams, Emsworth, Allegheny Co.). The dams' rehabilitation project resulted further in a 2001 Memorandum of Agreement stipulating mitigation involving Historic American Engineering Record documentation, preservation of project archives, and interpretive website development.

Emsworth is individually eligible for the National Register of Historic Places under Criteria A (Broad Patterns of American History) and C (Architectural Significance). Emsworth Locks and Dams is significant under Criterion A as it has maintained the navigation pool for metropolitan Pittsburgh since the completion of the original fixed-crest dam in 1922. The facility provided much-needed river transportation that supported Pittsburgh industries, especially during the industrial booms of World War II and the 1950s. Additionally, construction of the 1935–1938 vertical-lift dams that replaced the original fixed-crest dams was part of a federal New Deal relief program that sought to address high unemployment in the Pittsburgh area.

The two vertical-lift gate dams, the two locks, gate machinery, and the 1927 power house are historically significant architectural resources under Criterion C for technological and engineering advancements. The existing Emsworth Locks are the original 1919–1922 locks. Although the lock walls have been raised, and valves, gates, and operating machinery have been replaced over the years, these locks are still filled and emptied using the same system of through-the-wall culverts originally installed in 1919–1922. Subsequent locks constructed elsewhere after World War II use a different design for filling and emptying culverts, so the Emsworth Locks therefore represent an earlier stage of technology that is no longer in use. The Emsworth

Locks were also the first set of paired locks built on the Ohio River, and are the river's oldest main channel operating locks.

Only two vertical-lift gate dam facilities were constructed on the Ohio River: Montgomery Dam and Emsworth Dams. Evidence indicates that these may represent one of the earlier uses of vertical-lift gates on a major Corps of Engineers river engineering project. The original gated back channel dam also had one example of a "Sidney"-type lift Tainter gate. The Emsworth Sidney gate was the first full-scale version of a Sidney gate to be used in a river engineering project in the United States. Because the Sidney gate at Emsworth performed satisfactorily, the Pittsburgh District used Sidney gates at Point Marion Dam and Dam 4 on the Monongahela River in the 1950s and 1960s. Emsworth Dams are eligible for the National Register under Criterion C for engineering significance as one of only two vertical-lift gate dams built on the Ohio River, as early examples of Ohio River gated high dam technology, and for the innovative use of a Sidney gate on the back channel dam.

Non-contributing elements of the site include the 1988 office and lock operations buildings, service cranes added to both dams in recent years, and the recently constructed metal sheds on top of the dam that house the gate machinery.

Dashields Locks and Dam

Dashields Locks and Dam, located at r.m. 13.3, opened in 1929 in conjunction with the completion of the Ohio River canalization project. This facility retains its original two locks and fixed-crest concrete gravity dam. Aside from modifications of equipment such as operating machinery, lock valves, and lock gates, the facility remains much as it was originally constructed. This structure is now the only fixed-crest concrete dam on the Ohio River. Construction of three new buildings on the locks, including a new office, appears to be the most significant change made to the facility.

Dashields Locks and Dam is eligible for the NRHP under Criteria A and C. Dashields Dam has maintained a portion of the nine-foot Ohio River slackwater navigation system since its completion in 1929. The facility provided much-needed river transportation that supported upper Ohio River industries through the Depression era, and the industrial booms of World War II and the 1950s. The locks and dam retain a high level of integrity, and the facility is recommended as individually eligible for the National Register under Criterion A. The fixed-crest concrete dam, the two locks, and one remaining 1927–1929 lock building are contributing elements at this site. The 1988 office and lock operations buildings are non-contributing elements of the site. Dashields Locks and Dam is also a contributing element of the historically significant Ohio River Navigation System.

Dashields is the only fixed-crest concrete dam on the Ohio River since the fixed-crest Emsworth Dams were replaced with gated structures in 1938. All more recent Ohio dams have movable crest gates. Dashields is, therefore, the only remaining representation of the second-generation dam design that replaced the original movable wicket dams. By the early 1930s, gated high-lift dams became the standard on the Ohio River. The locks at Dashields are also the original 1927–1929 structures. Only a small number of pre-World War II locks are still operating on the Ohio River. Although the gates, valves, and operating equipment have been changed, these locks are

still filled and emptied using the same culvert system originally installed in 1927–1929. Since subsequent locks constructed after World War II use a different design for the filling and emptying culverts, the Dashields locks represent an earlier stage of technology that is no longer in use at other locks and dams. These locks are recommended as eligible for the National Register under Criterion C for engineering significance as examples of pre-World War II lock technology on the Ohio River. Dashields Dam is also recommended as eligible for the National Register for its engineering significance as the only remaining fixed-crest dam on the Ohio River, and as a representation of the stage of Ohio River dam engineering that formed a transition between the movable dams of the early twentieth century and the gated high-lift dams of the 1930s–1970s.

Montgomery Locks and Dam

Constructed between 1932 and 1936, Montgomery Dam was the first gated high-lift dam on the Ohio River. This high lift dam permitted the removal of three of the original wicket dams at Lock and Dam Nos. 4, 5, & 6. The facility consists of a vertical-lift gated dam with a series of concrete piers and 10 steel gates flanked on either end by a small fixed-crest concrete weir. There are two locks at this facility: the main 110' x 600' lock chamber and a smaller 56' x 360' auxiliary lock chamber. Lock rehabilitation in the 1980s added a new office building to the facility, and raised the lock walls one foot. Some of the lock gates, valves, and lock gate machinery have been replaced over the years as part of routine maintenance and upgrades. The Dam piers and machinery houses were modified in the 1980s rehabilitation, and two of the lift gates were recently replaced with modern gates following damage from a 2006 breakaway barge accident. Otherwise, the facility essentially retains its original form.

Montgomery Locks and Dam is eligible for the NRHP under Criteria A and C. Montgomery Dam has maintained a portion of the Ohio River Navigation System and has provided much-needed river transportation that supported upper Ohio River industries during the industrial booms of World War II and the 1950s. Montgomery Locks and Dam is recommended as individually eligible for the National Register under Criterion A for its role in maintaining an important portion of the Ohio River Navigation System since 1936. Specifically, the vertical-lift gate dam, including gate machinery and the two locks, are recommended as historically significant resources at this site. Non-contributing elements of the site include the office building, a service crane on top of the dam, and sheds that house metal gate machinery on top of the dam. The facility is also a contributing element of the historic Ohio River Navigation System.

The existing Montgomery Locks are the original 1932–1936 locks. Although the lock walls have been raised and valves, gates, and operating machinery have been replaced over the years, these locks are still filled and emptied using the same system originally installed in 1932–1936. Since subsequent locks constructed after World War II use a different design for the filling and emptying culverts, the Montgomery Locks represent an earlier stage of technology that is no longer in use. Only a relatively small number of pre-World War II locks are still in use on the Ohio River. These locks are eligible for the NRHP under Criterion C for engineering significance as examples of pre-World War II lock technology.

Montgomery Dam was the first gated high-lift dam on the Ohio River. Only two vertical-lift gated dam facilities were constructed on the Ohio River: Montgomery Dam and Emsworth Dams. Evidence indicates that Montgomery may represent one of the earliest uses of vertical-lift gate dams on Corps of Engineers river engineering projects. The Montgomery Dam is eligible for the National Register under Criterion C for engineering significance as the first gated high-lift dam on the Ohio River.

3.3.2.17 Recreation and Aesthetics

River-based recreational activities include, but are not limited to, fishing, pleasure boating, water-skiing, and swimming. Pleasure boating includes the use of privately owned or rented motorboats, personal watercraft (PWC), and non-powered watercraft (canoes, kayaks, sail boats) as well as sightseeing, dining, and related activities aboard commercial watercraft. Additionally, the upper Ohio River and its riparian environs provide a setting for a broad range of shore-oriented activities that include hiking, biking, fishing, festivals, regattas, and fireworks displays.

A current inventory of recreational features related to the study area river pools shows that there are 15 public facilities and 29 private facilities. This information was derived from appendices (Small Boat Harbors, Ramps, Landings, etc.) found in the USACE Navigation Charts and supplemental information obtained through the Pennsylvania Fish and Boat Commission, Ohio Department of Natural Resources, and West Virginia Department of Motor Vehicles. Summary information about the facilities is presented in **Table 3-25**.

TABLE 3-25: Summary of River Recreational Facilities

Pool	River	Public Number/Type	Private Number/Type
Emsworth	Monongahela	5 / ramps, moorings	2 / ramp, excursions
Emsworth	Allegheny	2 / moorings	10 / ramps, moorings, clubs
Emsworth	Ohio	None	5 / ramps, moorings, clubs
Dashields	Ohio	2 / ramps, moorings	5 / ramps, moorings, clubs
Montgomery	Ohio	3 / ramps	1 / ramp, club
New Cumberland	Ohio	3 / ramps	6 / ramps, moorings, clubs
	Totals	**15**	**29**

The USACE maintains records of all boat traffic that utilizes its locks. Some boaters routinely lock through as part of their touring and sightseeing experience. Others only do so as a necessity to get from available launching or marina facilities to a more desirable area. Still others avoid the locks altogether, especially as new marinas are established that facilitate more home pool boating without the necessity of travelling though locks. These recreational boat lockages are shown in **Table 3-26.**

TABLE 3-26: Recreational Lockages, EDM

Lock & Dam	Year							
	2000	2001	2002	2003	2004	2005	2006	2007
Emsworth	2,739	3,140	3,222	2,302	1,998	2,948	2,328	2,392
Dashields	2,093	2,677	2,215	1,769	1,625	1,612	1,316	1,399
Montgomery	1,756	1,899	1,123	998	861	971	759	884
Totals	**8,588**	**9,717**	**8,562**	**7,072**	**6,488**	**7,536**	**6,409**	**6,682**

Allegheny County has been Pennsylvania's leading county in terms of boat registrations for a number of years. Annual boat registrations for the five counties within the study area are shown in **Table 3-27**. Boat registrations reached a peak of approximately 44,000 in the year 2000, with Allegheny County accounting for two-thirds of the boat registrations in the study area.

Though non-motorized boats are not registered, and it is difficult to obtain accurate statistics on their use, interest in canoeing and kayaking has been increasing in the area. The best evidence of that comes from Venture Outdoors, a local non-profit organization that began tracking kayakers in 2004. That year, approximately 1,600 people kayaked on the rivers around downtown Pittsburgh. Last year, the number had grown to slightly less than 9,000.

TABLE 3-27: Recreational Boat Registrations in the Study Area

County	Year									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Allegheny	25,531	29,194	29,358	28,898	28,476	27,932	27,179	26,373	25,702	25,382
Beaver	5,641	6,556	6,732	6,689	6,525	6,490	6,377	6,156	6,010	5,912
Columbiana	4,104	4,119	4,276	4,155	4,218	4,295	4,287	4,250	4,239	4,259
Hancock	957	716	815	923	644	798	861	802	765	656
Jefferson	2,955	2,867	2,859	2,797	2,737	2,755	2,598	2,530	2,472	2,488
Totals	**39,188**	**43,452**	**44,040**	**43,462**	**42,600**	**42,270**	**41,302**	**40,111**	**39,188**	**38,697**

The status of Pittsburgh's major rivers as a fishing destination was dramatically illustrated by the arrival of the Bassmaster Classic tournament in 2005. It was reaffirmed in August 2009 when the Forest L. Wood Cup Championship, a four-day bass fishing tournament that pays the winning angler $1 million and has a total purse of $2 million, was held around Pittsburgh. Also, the largest flathead catfish caught in Pennsylvania during 2008 (over 37 pounds) was caught in the Ohio River. While boat fishing has generally been able to remain steady, bank-fishing opportunities remain constrained because access to the river is limited by railroads, industrial sites, steep terrain, narrow banks, other obstacles, and a lingering negative community bias against fishing on the river.

Waterfront settings also provide opportunities for a broad spectrum of land-based recreation. Within the study area, in addition to a burgeoning trail network, the riverfront setting has proven a popular location for parks, sports stadiums, museums, and a major hotel/shopping complex. Although no studies have been completed since 2006, anecdotal evidence indicates that usage has been growing. Representatives from several organizations involved with recreation along the Ohio River, including the Southwest Pennsylvania Commission, Venture Outdoors, the Beaver Rowing Club, Friends of the Riverfront, and Riverlife, have indicated that numbers are steadily increasing.

Several local and regional planning initiatives have also addressed, in part, many environmental concerns that affect the Ohio River. The plans having the most potential to have a positive impact on recreation resources in the study area include Pittsburgh's Riverfront Development Plan, the Allegheny County Comprehensive Plan, the Allegheny County Comprehensive Parks Master Plan, the Beaver County Greenways and Trails Plan, the 3 Rivers 2nd Nature (3R2N) Project, Natural Infrastructure of Southwest Pennsylvania, Columbiana County Land Use Task Force Plan, and Pennsylvania's Greenways – An Action Plan for Creating Connections.

In addition to these planning initiatives, the success of several existing special events indicates that recreational opportunities associated with the upper Ohio River are continuing to improve. Among these events are the Three Rivers Arts Festival, Pittsburgh Three Rivers Regatta, Pittsburgh Triathlon, Head of the Ohio, and Pittsburgh Dragon Boat Festival. Together, these events bring hundreds of thousands of people annually to the river.

Overall, recreational opportunities along the Ohio River have increased in many ways, but decreased in others. New parks, trails, and marinas have been built, but boat registrations – while still relatively strong, especially in Allegheny County – are decreasing. At the same time, however, interest in non-motorized boating is growing. Recreational lockages through the Emsworth, Dashields, and Montgomery dams have also decreased. While professional fishing tournaments have been held in the study area in recent years, there continues to be a somewhat negative bias in the Ohio River community regarding recreational fishing in the river.

3.3.2.18 Traffic and Transportation

Transportation is the movement of goods and people along the upper Ohio River and its associated facilities. Traffic is defined as the amount of activity found within the transportation system. The Ohio River Navigation System consists of the Ohio River mainstem and navigable portions of eight tributaries. The mainstem serves as a collector of system traffic for distribution points within and outside the Ohio River Basin.

The Ohio River is an important artery of the nation's inland waterway system, providing for commercial navigation in the eastern third of the country. Since the 1970s, coal has accounted for over 50 percent of the tonnage of commodities shipped on the Ohio River mainstem each year. Coal transport historically has been most prevalent on the upper portion of the Ohio River. The primary markets for coal shipments are domestic electric utility plants. Coal traffic also moves to coal blending facilities, industrial facilities, and coking facilities. Significant amounts of crushed limestone, sand and gravel, and building stone are shipped on the Ohio River, accounting for approximately 18 percent of traffic at mainstem locks in 2003. These

construction materials typically are extracted as close as possible to their market areas; therefore, aggregate traffic on the Ohio River is frequently short-haul and may be entirely within one pool.

The total commodity traffic of the EDM locks and dams to the Ohio River mainstem for the period 1970 to 2000 is shown in **Table 3-28**. During this 30-year period, the uppermost projects experienced the lowest growth rates of all the Ohio River projects.

Lock-level commodity traffic growth was hampered in the 1990s by a reduction in the transport of coal. Since 1990, the growth rate for the Emsworth and Montgomery lock and dams has been less than 0.1 percent. Dashields has experienced a negative growth rate over this period. Since 2000, tonnage through EDM has declined, and total tonnage has regressed to pre-1980 volumes.

TABLE 3-28: Historic Traffic Demand, EDM & Ohio River Mainstem (1970-2000)(Million Tons)

Project	Year				Annual % Growth	
	1970	1980	1990	2000	1970 - 2000	1990 - 2000
Emsworth	19.6	20.0	21.8	21.9	0.4	0.1
Dashields	20.2	21.0	23.2	22.4	0.3	-0.4
Montgomery	17.4	20.4	25.0	25.2	1.2	0.1
Ohio River Mainstem	126.8	160.7	225.7	236.5	2.1	0.6

Approximately eight of every ten tows locked through the main chamber in 2007. Tows generally use the main chamber even when they could one-cut through the auxiliary chamber, due to the better approach of the main chamber and the lock operator's greater familiarity with the main chamber. At EDM, the small size of the auxiliary chambers makes use of them under normal operating conditions impractical. The lengths of the main locks are 600 feet at EDM. Tows that measure between 600 feet and 1,200 feet in length comprise approximately 90 percent of the tows on the lower Ohio River, but only 45 percent of the tows on the upper Ohio River. Tows of this size can lock through the lower locks as a single tow, but must double lock through EDM. In order to prevent the need to double lock through the smaller locks, towing companies often reconfigure their tows with one less barge, placing the towboat into the empty slot.

Table 3-29 compares the tonnage, tons per tow, and barges per tow of the fleet at all Ohio River mainstem locations in 1999. As this table indicates, EDM processed approximately half the tonnage of the middle and lower Ohio River projects. Likewise, the tons per tow and the barges per tow at EDM are approximately half that of the lower projects. Average tow sizes are relatively constant from Hannibal to Smithland, and drop off significantly as they approach Emsworth.

TABLE 3-29: Ohio River Projects Fleet Comparison

Project	Tonnage (Thousand Tons) (1999)	Tons per Tow (1999)	Barges per Tow (1999)	Average % of Tows Greater than 600 Feet in Length (1998 – 2002)
Emsworth	23,800	4,700	5.6	38%
Dashields	24,800	5,300	6.5	44%
Montgomery	26,900	5,700	6.7	48%
New Cumberland	35,000	7,900	8.5	71%
Pike Island	42,700	8,600	9.1	75%
Hannibal	49,200	11,200	10.7	84%
Willow Island	46,200	11,500	10.6	84%
Belleville	50,100	12,300	11.2	87%
Racine	50,800	11,900	10.8	85%
R.C. Byrd	54,900	11,400	10.7	86%
Greenup	72,800	10,900	10.8	89%
Meldahl	65,900	12,000	11.3	93%
Markland	56,400	11,400	10.2	89%
McAlpine	No Data	No Data	No Data	80%
Cannelton	56,900	12,300	10.8	88%
Newburg	65,200	11,100	10.7	85%
Myers	71,400	11,900	11.2	90%
Smithland	83,100	11,300	10.6	90%

Table 3-30 summarizes the capacities and processing times for most of the projects on the Ohio River. Capacities and processing times computed for full operation refer to normal lock operation with no closures. The capacities and times reported for the main chamber assume a 365-day closure of the auxiliary chamber. Likewise, the capacities and times computed for the auxiliary chamber assume a 365-day closure of the main chamber. The capacity at full operation of EDM is approximately one-third the capacity of the other projects on the Ohio River. With a yearlong closure of the main chamber, the auxiliary chamber would process approximately one-quarter that of the other projects. The processing times at these three locks are also significantly longer than at the other locks. Processing times through the main chambers are longer because many tows must double lock. Processing times through the auxiliary chambers are significantly longer, since only one barge can lock through at a time.

TABLE 3-30: Capacity and Processing Times, Ohio River L/Ds

Project	Project Capacities (Million Tons)			Processing Times at Capacity (Minutes/Tow)		
	Full Operation	Main Chamber	Auxiliary Chamber	Full Operation	Main Chamber	Auxiliary Chamber
Emsworth*	48.7	42.9	11.1	64.0	70.1	174.0
Dashields*	51.5	48.1	14.3	59.9	63.5	196.3
Montgomery*	50.3	43.2	11.5	71.3	73.9	217.4
New Cumberland	132.9	78.5	44.5	48.1	54.1	82.0
Pike Island	151.2	99.5	47.5	44.9	48.2	85.9
Hannibal	152.1	103.1	52.4	63.2	55.6	102.7
Willow Island	155.1	107.5	54.2	50.6	53.7	100.6
Belleville	167.2	114.6	56.3	63.0	54.7	105.6
Racine	151.1	110.5	54.0	51.2	53.7	102.4
Greenup	144.2	113.3	54.3	62.6	50.0	96.4
Meldahl	151.0	116.3	55.5	59.8	49.5	97.9
Markland	160.5	119.0	57.1	56.6	48.5	93.4
Cannelton	162.1	124.0	59.0	63.6	50.1	99.9
Newburg	169.8	135.6	61.7	42.9	43.9	87.9
Myers	170.6	137.3	63.6	39.4	38.3	82.8
Smithland	264.4	143.4	132.9	38.9	39.3	38.0
* Without helper boats in main chamber						

Table 3-31 summarizes the traffic and delays by chamber for 2007. Except for a few anomalies in the data for this time period, average delays are relatively consistent from year to year. (Anomalies are usually caused by significant maintenance requiring extended main chamber closures.) Delays are generally highest at EDM and on the lower Ohio. Delays at the uppermost locks and dams can be attributed to the small size of the locks; delays at the lowermost locks and dams occur due to high traffic levels.

TABLE 3-31: Traffic and Delays by Chamber, Ohio River L/Ds (2007)

Project	Tows			Delays - Hrs/tow		
	Main	Aux.	Total	Main	Aux.	Weighted Average
Emsworth	3242	516	3758	0.93	0.79	0.91
Dashields	3187	408	3595	0.46	0.03	0.41
Montgomery	3160	399	3559	0.99	0.03	0.89
New Cumberland	2703	910	3613	0.28	0.04	0.22
Pike Island	3258	907	4165	0.27	0.05	0.22
Hannibal	3533	973	4506	0.44	4.74	1.37
Willow Island	3581	538	4119	0.43	0.04	0.38
Belleville	3885	382	4267	0.50	0.02	0.46

Project	Tows			Delays - Hrs/tow		
	Main	Aux.	Total	Main	Aux.	Weighted Average
Racine	3947	451	4398	0.68	0.03	0.61
R.C. Byrd	4422	347	4769	0.73	0.04	0.68
Greenup	5681	251	5932	0.98	0.12	0.94
Meldahl	4859	180	5039	0.99	0.15	0.96
Markland	4000	400	4400	0.76	5.26	1.17
McAlpine	5027	1	5028	1.25	0.00	1.24
Cannelton	4574	454	5028	0.75	4.82	1.12
Newburg	5893	594	6487	0.69	0.04	0.63
Myers	5400	465	5865	0.69	0.02	0.63
Smithland	3336	3620	6956	0.25	0.40	0.33
L/D 52	6972	2277	9249	5.71	9.30	6.60
L/D 53	6804	235	7039	0.78	0.29	0.76
Total	**87464**	**14308**	**101772**			
Percent of Total	**86%**	**14%**				

There are several terminals and intermodal facilities in the study area that currently meet the demand for goods movement and transfer of commodities. **Table 3-32** provides a list of those facilities.

TABLE 3-32: Major Riverfront Terminals and Intermodal Facilities

Site	River	Mile	Location	Size	Rail Available
Gordon Terminal Services	Ohio	3.2L	McKees Rocks	--	No
McKees Rocks Industrial Enterprises		4.0L		90 ac	Yes
Mol-Dok Co.		14.1R	Leetsdale	20 ac	Yes
Three Rivers Aggregates		14.4L	Glenwillard	10 ac	No
Port of BeeMac		14.5R	Leetsdale	--	Yes
Pittsburgh Intermodal Terminals		16.5	Ambridge	30 ac	Yes
Aliquippa Terminals		16.8L	Aliquippa	31 ac	Yes
Gordon Terminal Services		21.1L	Coraopolis	--	No
Colona Transfer		23.5L	Monaca	60 ac	Yes
Industry Terminal and Salvage Co.		33.2R	Industry	--	No
Kinder Morgan		33.5R		40 ac	Yes
S.H. Bell		40.1R	E. Liverpool	85 ac	Yes
S.H. Bell (Braddock)	Monongahela	9.9R	Braddock	7 ac	Yes
Josh Steel		10.1R		--	Yes

Site	River	Mile	Location	Size	Rail Available
Gulf Materials Dock		10.2R		5 ac	Yes
None	Allegheny	--	--	--	--
L=left; R=right; ac=acres					

While these intermodal facilities are important to the overall transportation system now, they would be more so in the event of reduced lock service. Lock closures would likely divert some commodities shipments to surface transportation facilities. The effects of these transfers, known as external effects or externalities, would increase fuel usage, pollution, accidents, and roadway deterioration; some shipments would not occur, while others would be reduced or shipped less distance.

Inland water transportation is one of the safest, environmentally friendly modes of transportation. Products moved by barge incur the lowest transportation cost per ton-mile of all freight modes. Barge transportation is also the most energy efficient mode for carrying large quantities of bulk commodities, expending about three-fourths the energy per ton-mile as rail. Barge transportation results in the lowest air emissions on a ton-mile basis and experiences the least number of accidental spills of all surface transportation modes.

3.3.2.18.1 Proximity to Airports

Federal Aviation Administration Advisory Circular No. 150/5200-33, Subject: Hazardous Wildlife Attractants on or Near Airports (May 1, 1997) provides guidance on locating certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public use airports. The increase in wildlife populations, increase in air traffic and use of larger power plants all combine to increase the risk, frequency, and potential severity of wildlife-aircraft collisions. Siting criteria recommended in the circular lists a distance of 5 statute miles for approach or departure airspace, if the wildlife attractant may cause hazardous wildlife movement into or across the airspace.

There are two public use airports in the study area, Pittsburgh International Airport (PIT) in Allegheny County, and Beaver County Airport (BVI), Beaver Falls. Dashields Locks and Dam is the only navigation facility within the 5-mile radius of either airport (3.8 miles to PIT). Emsworth is 6.1 miles from PIT, and Montgomery is 7.35 miles from BVI and 11.7 miles from PIT. The river in the vicinity above and below Dashields Locks and Dam also has the potential to be within a 5-mile radius from PIT (for consideration in siting any ecosystem restoration project).

3.3.2.19 Hazardous, Toxic, and Radioactive Waste Issues

Hazardous, Toxic, and Radioactive Waste (HTRW) evaluations were not performed for the in-river areas of the new lock locations. All riverbed materials to be excavated and disposed from the construction footprint of each replacement lock chamber will undergo due diligence, and if necessary, tested and characterized upon removal for disposal at a commercially available, properly permitted site. HTRW evaluations performed at the upland construction support areas are addressed below under **Section 3.3.3.5**.

3.3.3 Construction Support Areas/Upland

A major component of a Corps of Engineers project is the identification of the lands necessary for the contractor to adequately perform the work, the acquisition of those lands, and the ability to make those lands available to all prospective bidders. Large and complex civil works construction projects, especially inland navigation facilities, typically require land-based work areas for construction support. Federally-owned property at each of the EDM Project's three locks is the minimum necessary to support normal operations and does not provide sufficient area to support a construction project. The EDM Project therefore requires additional land of sufficient size to construct and operate a concrete batch plant at each of the three lock sites.

The District's search for suitable lands proximate to each lock was complicated by the regional topography and highly industrialized history of the EDM Project's location. The Ohio River corridor between Pittsburgh, Pennsylvania, and Steubenville, Ohio, is historically among the most intensively industrialized areas in the country. From the middle of the 19th Century through the end of the 20th Century, this corridor was the world's hub of metallurgical production, in addition to large glass, chemical, and other industrial manufacturing operations. The limited quantity of developable floodplains, combined with legacy and continuing industrial use, has left very few unoccupied areas in the proximity of USACE navigation projects. The remaining properties which might be suitable for Corps use likely are industrial or formerly industrial and will require appropriate investigation prior to use by the project.

There were six potential construction support areas identified during this study encompassing a total of 12 parcels of land in Allegheny and Beaver counties, Pennsylvania. For each of the Upper Ohio Locks and Dam facilities there is a Primary and a Secondary work and laydown area identified (see Environmental Appendix). Each of these areas was identified for its suitability to provide all necessary work area support for potential construction needs. The primary site would be the initially preferred site, but if unavailable or unsuitable when needed, the secondary site would become the alternative location.

3.3.3.1 Site Selection Criteria

Over the past several decades, the Corps has increasingly utilized an "onsite" batch plant method to support its major navigation construction projects. Corps construction standards for concrete composition, production rates, and delivery require an area of suitable topography as close to the site as possible. Utilizing onsite batch plants is preferable to existing, commercially available batch plants (ready-mix plants) for several reasons. First, adequate volume and timely concrete delivery is critical to avoiding structural problems. Delivery time impacts concrete already placed, as well as that being readied for placement. Once concrete ingredients are mixed, there is a limited and definitive amount of time to get the fresh concrete to its final point of placement. Second, USACE specifications for concrete mixtures are complex and varied, requiring the use of many ingredients not typically available at ready-mix plants. The complexity of the mixtures and the frequent need for large volumes of concrete required by navigation projects typically exceed the capabilities of ready-mix concrete batch plants. Third, the delivery system associated with an onsite batch plant has several advantages, including but not limited to: minimizing delivery time; reducing truck traffic and navigation impacts; and reducing the potential for equipment breakdowns, maintenance, and air pollution. Thus, proximity of the concrete batch

plant to the construction site is of paramount concern to efficiency, quality, and construction safety.

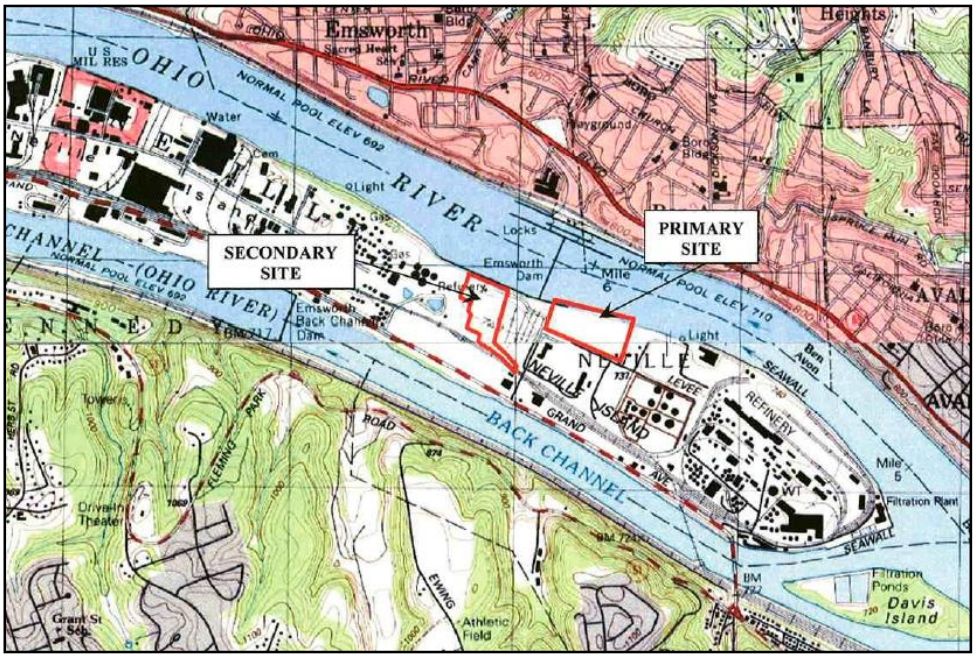
The EDM Project also requires land to support materials and equipment storage, to provide space to pre-fabricate and/or assemble components of temporary or permanent Project features, and to provide areas for onsite Government and contractor offices and parking. This approach minimizes impacts to navigation and the potential for high water events to adversely affect construction progress.

General criteria for selecting and evaluating potential work areas included the need for about six acres for a concrete batch plant, additional space for trailers, material laydown, and access that can accommodate large construction vehicles and tractor trailers. Distance from the existing locks was considered with respect to the method and timing of concrete delivery from the batch plant, and no sites over one-mile distant were considered. The District's search gave primary consideration to lands previously used, on a temporary basis, for initial Project construction (1920s and 1930s) and/or major rehabilitations in the 1980s. The District ultimately identified two properties near or adjacent to each of the three locks that could provide sufficient area for a concrete batch plant, construction materials and equipment storage, and associated offices, parking, and site access. These properties underwent Phase I and Phase II Environmental Site Assessments (ESA) in accordance with the Corps HTRW Policy. Suitability of federal land holdings at each facility was considered first before expanding the search to adjacent lands and then to other lands with increasing distance from the facility. Lands involved with original lock and dam construction and for the 1980s rehabilitations were given preference over lands with no prior Corps involvement.

3.3.3.1.1 Emsworth

The lack of suitable undeveloped lands in the vicinity of Emsworth allows few opportunities for selection of potential work areas. Emsworth's locks are on the right descending bank, which is a steeply sloping hillside providing no space for work areas. Neville Island forms the left bank on which the minimal federal land holding for the dam abutment does not provide adequate work space. In the vicinity of the project, Neville Island is intensively developed with petroleum and chemical industries. The only areas currently having sufficient open space near the dam were identified as the primary and secondary work areas (**Figure 3-7**). The primary site is a 17.2-acre parcel upstream of the dam abutment, the lower portion of which was temporarily acquired by the Corps in the 1980s for the locks rehabilitation project. The property is currently undeveloped, but it is proposed to undergo a voluntary clean-up action under PaDEPs Land Recycling and Environmental Remediation Standards Act Program (Act 2). The secondary site, located immediately downstream from the dam abutment, is approximately 15 acres and is partially developed with bulk storage tanks.

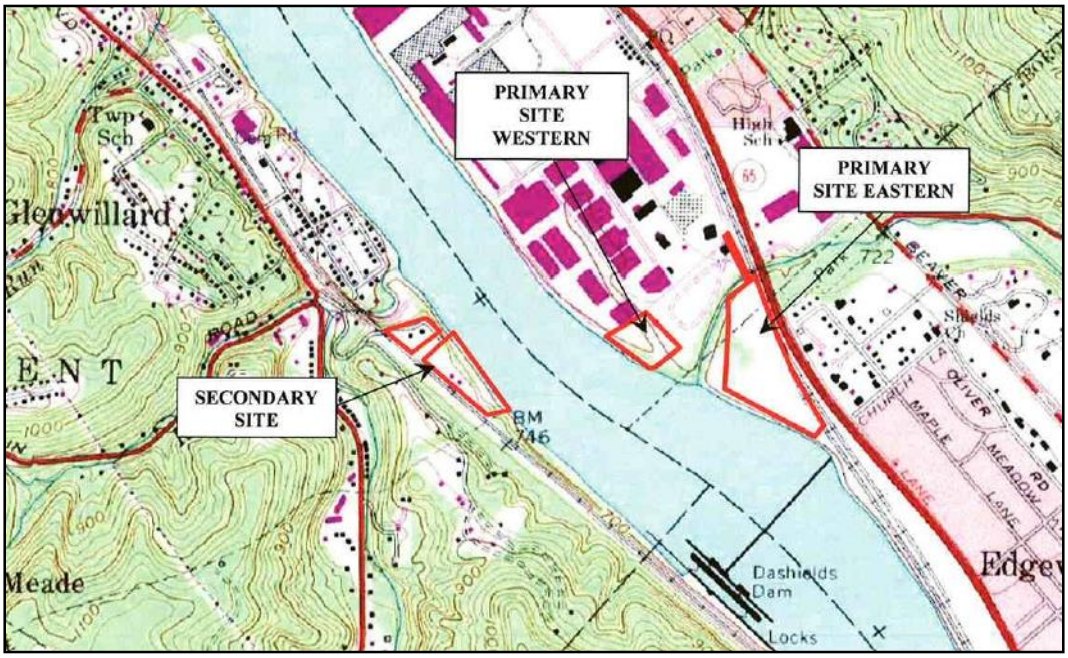
FIGURE 3-7: Emsworth Locks Alternative Construction Support Areas



3.3.3.1.2 Dashields

As with Emsworth Locks, Dashields has inadequate space in the minimal federal land holdings to accommodate batch plant and laydown requirements. Dashields locks are situated along the left descending bank at the base of a steeply sloped hillside with no space for a work area. On the opposite bank, upstream of the dam abutment, active rail lines at the river's edge isolate a narrow bench from access and potential usage as a work area. Immediately downstream from the dam abutment is about 19 acres of undeveloped land. This was identified as the primary site (eastern component, **Figure 3-8**). Access to this site that would accommodate construction vehicles would have to be developed through Leetsdale Industrial Park due to high use rail lines separating the site from Rt. 65. A second parcel identified as a primary site occupies about five acres in an area of Leetsdale Industrial Park temporarily acquired for a work area supporting the 1980s Dashields locks rehabilitation. This (western) site has insufficient space to accommodate the total anticipated batch plant and laydown requirements for the proposed project, and is being considered as a potential supplement to the main work area, if needed.

FIGURE 3-8: Dashields Locks Alternative Construction Support Areas

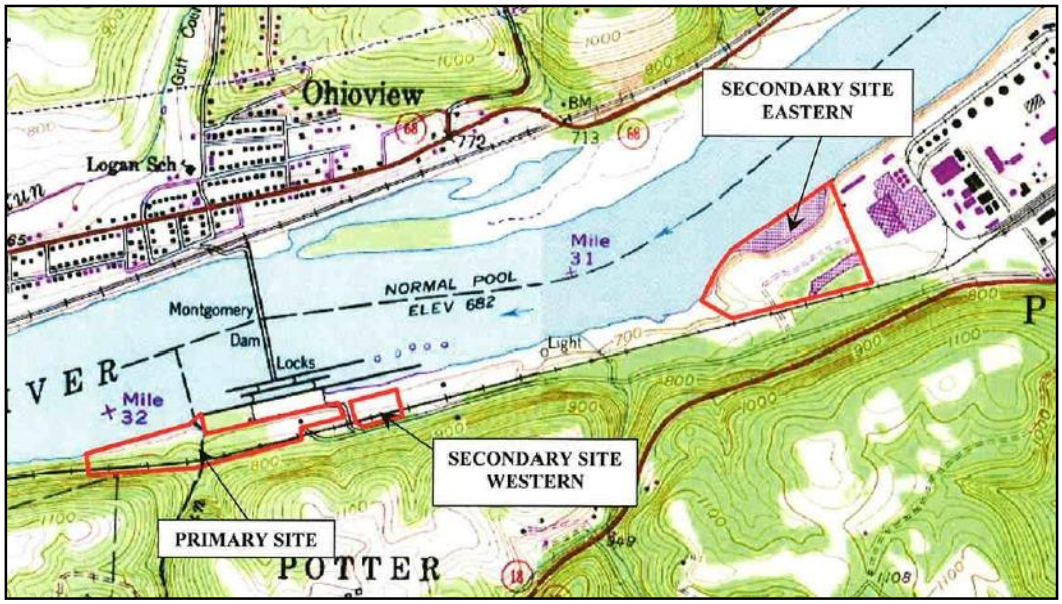


No undeveloped property suitable as a secondary site was found within one mile of the project, so consideration was given to lands contiguous with a small (0.5-acre) Corps property situated on an elevated bench about 0.8 miles downstream of Dashields locks. This property forms part of Shouse Park, a developed recreational facility and field. Included in the overall secondary site's boundary is the Township's former sewage treatment plant and lands. The Corps property was formerly part of about 2.5 acres occupied by the Dashields locktenders dwellings, which were abandoned in the 1970s. About 0.5 acres was retained for project parking and related purposes until it was leased in connection with Shouse Park. Total acreage identified for a secondary site is about 8.0 acres (**Figure 3-8**). Access to this site by McCutcheon Way involves an active rail crossing.

3.3.3.1.3 Montgomery

The search for potential work areas at Montgomery was restricted to the left descending bank (lock side). The right bank upstream of the dam is the ecologically sensitive Montgomery Slough and floodplain, and downstream of the dam is a steep bank and narrow bench occupied by active rail lines. The 22-acre site identified as the primary site (**Figure 3-9**) was largely used for construction of the project in the 1930s. Now in private ownership, the site's subsequent minor development is inactive, and the site is essentially overgrown. The site is moderately sloped at the base of a steep hillside and is bordered on the uphill side by a rail line. No other opportunities downstream of the locks are available as the narrow bench of the primary site attenuates into a steep hillside a short distance below the locks. Proximity of the primary site to the locks and its former disturbance ranked this site as a primary alternative.

FIGURE 3-9: Montgomery Locks Alternative Construction Support Areas



The secondary site consists of two separate areas, a western and eastern component (**Figure 3-9**). A 3.7-acre wooded area immediately upstream of the primary site and project access road comprises the western component, which would have an advantage of proximity to the work site but inadequate space for a 6-acre batch plant. It was included in the study as an option for supplementing the selected batch plant work area, if needed. The main secondary site is located about one mile upstream of the locks and occupies about 32 acres adjacent to a gypsum plant and other upstream industrial development. Its recent and current use, over a portion of the total site, appears to be bulk gypsum storage. Aerial photographs show commercial/industrial development at this (eastern component) site from 1952. Access to all of the sites would be from the main locks and dam access road off Rt. 18.

The number of parcels (individual owners) and total acreage of the alternative work areas are listed in **Table 3-33**.

TABLE 3-33: EDM Construction Support Areas, Real Estate Parcels

Project/Work Area	Number of parcels/owners	acreage
Emsworth Primary	1	17.2
Emsworth Secondary	3	15.0
Dashields Primary	3	24.9
Dashields Secondary	1	8.2
Montgomery Primary	3	22.2
Montgomery Secondary	1	32.3

3.3.3.2 Terrestrial & Riparian Habitat

3.3.3.2.1 Emsworth Primary

The Emsworth Primary site is bordered to the north by the Ohio River and can be characterized as previously disturbed due to historical clearing and modification of the ground surface. The entire site is vegetated with opportunistic and invasive species (some areas are more dense than others) that include Tree of Heaven *(Ailanthus altisima)*, smooth sumac (*Rhus glabra*), common buckthorn (*Rhamnus carthartica*), tall goldenrod (*Solidago canadensis*), Japanese knotweed (*Fallopia japonica*), common mullein (*Verbascum thapsus*), and Canada thistle (*Cirsium arvense*). Habitats present on the site include upland scrub/shrub and herbaceous/shrub habitats, a wooded riparian fringe, and maintained utility ROW. The upland shrub/scrub habitat on the site is comprised of the species mentioned above and totals approximately 11 acres. The herbaceous/shrub habitat comprised of sparse shrub vegetation and grasses (*Panicum spp., Dicanthelium spp*.) totals 1.5 acres. The riparian area (0.5 acres) on the riverbank along the northern edge of the site is comprised of Tree of Heaven, sycamore (*Platanus occidentalis*), black locust (*Robinia pseudoacacia*), and red maple (*Acer rubrum*). The pipeline and powerline ROWs (1.19 acres) along the southern border of the site is periodically mowed as indicated by the dense groundcover of goldenrod, common mullein, and lack of dense stands of shrubs as observed on the rest of the site.

This site is subject to human activity on an occasional basis at this time, and is bordered to the east by similar type habitats; therefore, the site has connectivity to habitats on the adjacent property.

3.3.3.2.2 Emsworth Secondary

The Emsworth Secondary site is largely disturbed and comprised of cleared areas where staging and storage of materials and fluid containers occur. Vegetated areas occur in the southern and northern portions of the site. Herbaceous/shrub habitat (0.78 acres) in southern portion of the site is primarily comprised of goldenrod, common ragweed (*Ambrosia spp*.), common buckthorn, common burdock (*Arctium lappa)*, grasses (*Aristida, spp*., *Panicum spp*.), broomsedge (*Andropogon virginicus*), and asters (*Aster spp*.). The shrub/scrub habitat (1.08 acres) located along the northern portion of the site is comprised primarily of Japanese knotweed, barberry, common buckthorn, Tree of Heaven, box elder, and smooth sumac.

The southern portion of the Emsworth Secondary site consists primarily of the railroad and adjacent vegetation adapted to disturbed areas including blackberries (*Rubus spp*.), goldenrods, common buckthorn, Tree of Heaven, smooth sumac, and Johnson grass (*Sorghum halepense*).

This site is subjected to heavy equipment and other vehicular movement, noise from the roads, and businesses surrounding the site. This site is not contiguous with a low impact area.

3.3.3.2.3 Dashields Primary

Dashields Primary eastern site

The site is bordered to the south by the Ohio River and is currently used to store compost. The on-site inspection revealed that demolition materials such as brick and concrete have been

dumped at this site. Several piles of debris were found within the wooded areas and contained brick, concrete, tile, bathroom porcelain materials, etc. Vegetated areas identified onsite include forested uplands (7.1 acres), the riparian zone adjacent to the Little Sewickley Creek (0.1 acres), and the riparian zone adjacent to the Ohio River (0.7 acres). The vegetation in the forested upland areas (7.11 acres) is primarily comprised of Norway maple (*Acer platanoides*), mockernut hickory (*Carya tomentosa*), box elder (*Acer negundo*), Tree of Heaven, smooth sumac, common privet (*Ligustrun vulgare*), and common buckthorn. Some of the trees, located along the river, (Norway maples and hickories) are at least 70 years of age, as indicated by review of historical aerials and on-site inspection. The riparian zone is comprised primarily of sycamore, silver maples, black locust, Tree of Heaven and Japanese knotweed. In addition to these areas, non-forested areas (8.49 acres) where storage of compost and demolition materials occur on the site include shrubs (common buckthorn, common privet, barberry), herbaceous and forb species (Japanese knotweed, Joe-pye weed, thistles, ragweed [*Ambrosia spp*.], goldenrod), and grass species (broom sedge, *Panicum sp*., Johnson grass etc.), typical of disturbed areas. This site is subjected to irregular industrial equipment activity, and vehicular traffic due to compost and material storage. Habitat connectivity would occur with the riparian habitat adjacent to Little Sewickley Creek located to the west.

Dashields Primary western site

The site is currently used to store two small trailers and equipment, and to stage piles of soil, crushed concrete, and railroad ties on the southwest portion of the site. Surface material such as gravel is an indication that this site has been prepared for industrial purposes in the past. The areas that are vegetated occur on the southeast portion of the site, which is comprised of an open fallow field (0.79 acres) and a tree-line (0.37 acres) adjacent to Little Sewickley Creek. Vegetation in this area consists primarily of Tree of Heaven, smooth sumac, sycamore, box elder, goldenrod, and Japanese knotweed.

This site is located in close proximity to industrial activity, and subjected to earth moving, equipment maintenance and vehicular traffic. Habitat connectivity would occur with the riparian habitat adjacent to Little Sewickley Creek located to the east.

3.3.3.2.4 Dashields Secondary

The site is bordered to the north by the Ohio River, and is primarily used as a ball park on the western site and playground/picnic area, road maintenance center, and an equipment staging area on the eastern site. The playground/picnic area (parkland habitat) has been landscaped to incorporate large shade trees comprised of American basswood (*Tilia americana*), hickory (*Carya sp*.) and sugar maple (*Acer saccharum*) that are approximately 60-70 years of age. The river bank is comprised of a 0.80 acre scrub/shrub habitat primarily vegetated by Japanese knotweed and the 0.45 acre riparian area is comprised of sycamore, black locust tree, and red maple. Forested areas on the northeast border of the western site (0.38 acres) and in the southeastern portion of the eastern site (0.85 acres) consist of Japanese knotweed, sycamores, red oak (*Quercus falcata*), black locust, red maple, Tree of Heaven, common buckthorn, and common privet.

These sites are frequently disturbed by road maintenance operations, vehicular traffic, and human activity in the ball park and picnic area. The railroad and roads may serve to disrupt habitat continuity with forested areas locate to the south of the sites.

3.3.3.2.5 Montgomery Primary

West of Squirrel Run

The Primary site west of Squirrel Run is comprised of approximately six acres of mature hardwood forest vegetated primarily by American elm (*Ulmus americana*), blue beech (*Carpinus americana*), red maple (*Acer rubrum*), Norway maple, American elm, hickories (*Carya sp.*), witch hazel (*Hammamelis virginiana*), and ferns (*Thelypteris spp.*). Riparian zones (2.27 acres) include the river bank and the edges of Squirrel Run. The slope adjacent to the Ohio River (the riparian zone) is primarily vegetated by sycamore, sweet gum (*Liquidambar styraciflua*), black locust, eastern hophornbeam (*Ostrya virginiana*), Japanese knotweed, and *Sesbania spp*. The riparian zone adjacent to Squirrel Run is primarily comprised of sycamore, silver maple, hickories, blue beech and American elm with a very dense understory component primarily comprised of Japanese knotweed. The hardwood forest is approximately 70 years of age or greater, as determined from the 1939 aerial and onsite inspection.

East of Squirrel Run

The primary site east of Squirrel Run is comprised of a mature hardwood forest (approximately six acres), with trees as old as 70 years or older. Approximately 0.91 acres of area were cleared of trees at one time, but are presently overgrown with fallow field species such as goldenrod, Joe-pye weed, American burnweed (*Erechities hieracifolia*), and common mullein.

The Montgomery Primary site is contiguous with adjacent forested land that is of Medium to High Quality. Based on the age of trees, vegetation composition, abundance of wildlife and proximity to water resources, the Montgomery Primary site provides Medium to High Quality forested habitat for wildlife.

3.3.3.2.6 Montgomery Secondary

Eastern 32.3-Acre Site

Habitats identified on the 32.3-acre Secondary site include the riparian zone on the river bank, the palustrine forested wetlands around the pond, and forested areas along the ridge. The gypsum piles are used by bank swallows for nesting. The river bank (2.33-acres) riparian vegetation includes sycamore, black locust, American elm, silver maples, barberry, and common buckthorn. Vegetation on the forested ridge along the railroad is comprised of Tree of Heaven, smooth sumac, common buckthorn, and common privet. The forested areas (10.66 acres) are comprised of Norway maples, blue beech, hickories, box elder, witch hazel, tulip poplar (*Liriodendron tulipifera*), American elm, silver maple, redbud *(Cercis canadensis)* and dogwood *(Cornus spp.)*. The bottomland hardwoods (1.56 acres) adjacent to the river (0.75 acres) is comprised of American elm, shellbark hickory, sugar maple, black willow, *Viburnun spp*., beauty berry (*Callicarpa americana*), lizard's tail (*Saururus cernuus*) and sensitive fern

(*Onoclea sensibilis*). The forested wetland and pond area on the site may provide habitat for reptiles and amphibians as well as for water birds, birds of prey, migratory birds and the mammals mentioned above.

The site is subjected to activity associated with movement and storage of the synthetic gypsum, and vehicle traffic from the industry located to the east and railroad noise to the south. However, the site is contiguous with mature forest lands to the west and south across the railroad and Montgomery Dam Road.

Western 3.7-Acre Site

This is a forested (3.7-acre) site with trees that are approximately 60-70 years or older. The primary overstory components are Norway maple, hickories, and blue beech. Understory components include redbud, *Viburnum spp*., dogwood, and ferns.

3.3.3.3 Wildlife

3.3.3.3.1 Emsworth Primary

Evidence of wildlife utilization of the site was noted. Eastern Cottontail (*Syvilagus floridanus*) was observed and bedding areas used by White-tailed Deer (*Odocoileus virginianus*) were observed on the eastern portion of the site. The shrub/scrub and right of way (ROW) areas provide Medium Quality habitat in general, including migratory birds which forage on the berries from the shrubs. It also provides cover for Eastern Cottontail, mice *(Microtus spp*.), rats (*Rattus spp.*), snakes and deer due to the limited extent of natural areas on the heavily developed Neville Island. It also provides a foraging area for predatory birds. The riparian areas provide High Quality habitat for migratory birds, predatory birds, snakes and small mammals such as Opossum (*Didelphis marsupialis*), Raccoon (*Procyon lotor*), mice and rats.

3.3.3.3.2 Emsworth Secondary

No wildlife was observed on the Emsworth Secondary site during the field view and no evidence of usage of the site such as scat, tracks, or bedding areas were observed. This may be due to the rail and industrial activity in the immediate area. The shrub/scrub area on the northern portion of the site likely provides Low to Medium Quality habitat for migratory and predatory birds, raccoons, opossum, rabbit, mice, rats, and snakes. The herbaceous and shrub area in the southern portion of the site likely provides Low to Medium Quality foraging habitat for birds and habitat for small mammals (mice, rats, voles).

3.3.3.3.3 Dashields Primary

Wildlife observed on the Dashields Primary eastern and western sites includes: Common Grackle (*Quiscalus quiscula)*, Red-Tailed Hawk (*Buteo jamaicensis)*, and Eastern Cottontail. The forested and riparian areas provide Medium Quality roosting and nesting habitat for migratory and predatory birds; cover and nesting habitat for snakes, rabbit, opossum, raccoon, mice, rats, and squirrels. The non-forested area where compost activity occurs among the scattered shrubs provide Low Quality foraging habitat for migratory birds and provides cover for rabbits and other small mammals such as mice and rats. The fallow field areas provide Low Quality

foraging habitat for migratory birds, mice, rats, and snakes. It also provides a foraging area for predatory birds.

3.3.3.3.4 Dashields Secondary

Wildlife observed at the Dashields Secondary eastern and western sites include Northern Mockingbird (*Mimus polyglottos*), Common Grackle, and American Robin (*Turdus migratorius*). The forested and shrub edges of the sites may provide Medium Quality habitat for migratory and predatory birds, and small mammals such as rabbits, opossum, raccoon, mice and rats. The Picnic area provides Medium Quality habitats for migratory birds, chipmunks and squirrels. The riparian areas provide birds with High Quality habitat for foraging and nesting.

3.3.3.3.5 Montgomery Primary

Wildlife observed on the Montgomery Primary site includes: chipmunks (*Tamia striatus*), Gray Squirrel *(Sciurus carolinensis)*, deer, Eastern Cottontail, several species of birds including Blue Jay *(Cyanocitta cristata)*, Northern Cardinal *(Cardinalis cardinalis)*, American Robin, Carolina Chickadee *(Poecile carolinensis)*, Carolina Wren *(Thryothorus ludovicianus)*, and several rainbow darters *(Etheostoma caeruleum)* and crayfish (*Cabarus sp*.) within Squirrel Run.

The hardwood forest provides Moderate to High Quality habitat for chipmunks, squirrels, rabbits, raccoons, opossum, weasels, red and grey fox, snakes, migratory birds, birds of prey and deer. The riverfront and beach front provide High Quality foraging and nesting habitat for predatory and migratory birds, small mammals and nesting areas for turtles. Squirrel Run provides a water source for wildlife in general and spawning habitat for fish, reptiles and amphibians. In addition, the fallow field area and areas around the old house may provide Medium Quality habitat for small mammals and foraging areas for predatory birds.

3.3.3.3.6 Montgomery Secondary

Wildlife observed on the Montgomery Secondary site include: Bank Swallows (*Riparia riparia*) that nest in the synthetic gypsum mound, Brown Thrasher (*Toxostoma rufum*), and Common Grackle. The forested uplands are considered moderate to High Quality habitat and provide habitat for deer, red and grey fox, small mammals (weasels, chipmunks, squirrel, mice, voles, rats, raccoon, opossum), snakes, migratory birds, and birds of prey. The forested waterfront edge (riparian zone) is considered High Quality habitat and may provide habitat and roosting areas for predatory and migratory birds. The wetland and pond area are considered High Quality habitat and may provide habitat for reptiles and amphibians as well as for water birds, birds of prey, migratory birds and the mammals previously mentioned.

3.3.3.4 Wetlands

3.3.3.4.1 Emsworth Primary

The wetland delineation and stream identification survey conducted for the site determined that no wetlands or streams occur within the Emsworth Primary site. The Ohio River borders the site to the north. According to the Natural Resource Conservation Service (NRCS) soil survey, the entire site is comprised of Urban Land Series soils which are not considered hydric (an indicator used to determine wetlands). In addition, the NWI map indicates that wetlands do not occur

within the site. The Ohio River is classified as a Warm Water Fishery (WWF) by the Pennsylvania Department of Environmental Protection (PaDEP, PA Code Title 25 Chapter 93).

3.3.3.4.2 Emsworth Secondary

No wetlands or streams were identified within the Emsworth Secondary site; however, the Ohio River borders the site to the north. The Ohio River is classified as a WWF (PA Code Title 25 Chapter 93). According to the NRCS soil survey, the site is comprised of Urban Land Series soils which are not considered hydric (an indicator used to determine wetlands). In addition, the NWI map illustrates that wetlands do not occur within the site.

3.3.3.4.3 Dashields Primary

The wetland delineation and stream identification survey conducted for the site determined that no wetlands were found within any part for this site; however, Little Sewickley Creek bisects the northwest out-parcel of the eastern site. The creek has been delineated to establish its proximity to the site.

The Ohio River is classified as a WWF and Little Sewickley Creek is classified as a High Quality Trout Stocked Fishery (HQ-TSF) (PA Code Title 25 Chapter 93). According to the NRCS soil survey, both sites are comprised of Urban Land Series soils and are not considered hydric, (an indicator used to determine wetlands). In addition, the NWI map, shows no wetlands within the Primary sites.

3.3.3.4.4 Dashields Secondary

The wetland delineation and stream identification survey conducted for the site determined that no wetlands or streams were located within the site. The Ohio River is classified as a WWF at this location according to the PA Code Title 25 Chapter 93. According to the NRCS soils survey, both sites are comprised of Urban Land and Rainsboro Silt Loam Series soils, and the soils are not considered hydric (an indicator used to determine wetlands). In addition, the NWI mapping did not indicate that wetlands occur within the Secondary site.

3.3.3.4.5 Montgomery Primary

Squirrel Run was delineated within the Montgomery Primary site and is an intermittent stream. Squirrel Run exhibited very low flow, clear water, a rocky substrate, with few pools. The wetland delineation and stream identification survey conducted for the site determined that no other surface waters or wetlands occur within the Primary site. Both the Ohio River and Squirrel Run are classified as a WWF waters.

According to the NRCS soil survey, the site is comprised of Conotton Gravelly Loam Series soil and the soils are not considered hydric (an indicator used to determine wetlands). In addition, the NWI map does not indicate wetlands occurring within the Primary site.

3.3.3.4.6 Montgomery Secondary

An isolated wetland and pond (approximately 2.3 acres total) were delineated on the Montgomery Secondary 32.3-acre eastern site. This site was excavated over 30 years ago and is

recorded on the 1979 USGS topographic map of the site. No wetlands or streams were found within the Montgomery Secondary western site.

According to the NRCS soil survey, the 32.3-acre site is comprised of Urban Land-Conotton Complex Series Soils and is considered partially hydric (an indicator used to determine wetlands). The Secondary western site is comprised of Conotton Gravelly Loam Series soils and is not considered hydric. The NWI map does not indicate wetlands occurring within the site but, does show an open water/pond in the area where the pond and wetland were delineated. The Ohio River adjacent to the site is classified as a WWF (PA Code Title 25 Chapter 93).

3.3.3.5 HTRW

Seven properties underwent Phase I Environmental Site Assessments (ESA) in accordance with the requirements of USACE Engineer Regulation (ER) 1165-2-132, *Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects*. The properties of interest are located in industrial areas, and the Phase I ESA identified past industrial use and areas of recognized environmental conditions (REC) at or adjacent to each of the six potential lock construction support areas, as well as at the Montgomery Slough identified as a fish and wildlife mitigation area.

Phase II ESAs were conducted at five (5) of those properties. Rights-of-entry to conduct investigations were not provided for the Emsworth Primary and Dashields Secondary work area properties, so those properties were not investigated beyond the Phase I ESAs. The Phase II ESA was prepared in accordance with ER 1165-2-132, *Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects,* for the feasibility phase of this project. ER 1165-2-132 requires appropriate consideration of CERCLA all appropriate inquiry standards, and for purposes of the UONS, the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2) was also considered. The purpose of the environmental site assessment was to provide defendable quantitative data to document, prior to property acquisition, if CERCLA regulated substances exist at each of the subject properties, and at what levels of potential concern.

At properties where CERCLA regulated substances are identified at potential levels of concern, the purposes of the assessment expanded to include procurement and evaluation of the quality and quantity of information, (including but not limited to quantitative chemical data), appropriate to:

- Support development of a proposed real estate plan that maximizes avoidance of potentially contaminated areas and provides the lands necessary to support efficient construction of each of the three proposed lock facilities;
- Support a preliminary evaluation of potential human health risks if no remedial actions are implemented for the lands identified in the real estate plan;
- Identify prudent measures to minimize any potential CERCLA liability and support safe use of each property as a construction support area; and
- Provide a basis for estimating the cost of potential additional project requirements to maximize avoidance of contaminated areas.

At each of the properties investigated, a judgmental approach to sample design using multiple lines of evidence was implemented. Test pits and borings were biased to collect samples for field and laboratory analyses from the locations most likely to be impacted by the presence of CERCLA and Act 2 regulated chemicals at each of the properties investigated. The Pennsylvania Department of Environmental Protection (PADEP) developed Health Standard Medium Specific Concentration (MSC) standards and tables under Act 2 based upon residential and non-residential property use exposure scenarios. These criteria were used as the basis for comparison of site-specific results for regulated substances in soil to support a preliminary human health evaluation relative to the intended future use of the properties as construction support areas. Soil samples collected and submitted for the presence of CERCLA hazardous substances were also screened for the substances listed in Act 2 (regulated substances or chemicals) and compared to the PADEP MSC human health criteria. Groundwater was not sampled for this report.

Prior to use in the assessment, the quality of the data was assessed relative to accuracy, precision, representativeness, completeness, comparability and sensitivity criteria established in the Abbreviated Sampling and Analysis Plan for the investigation and standard protocol. All chemical laboratory results for Semi-Volatile Organic Compounds (SVOCs), metals, herbicides, pesticides, polychlorinated biphenyls (PCBs) and radioactive isotopes were deemed to have met the project data quality objectives. Therefore, those results were deemed suitable quantitative data for use in directly comparing the site specific results to the residential and non-residential human health MSC Table values established under the Act 2 to determine if CERCLA regulated substances exist at each of the subject properties, and at what levels of potential concern to human health and the environment. Regulated substances at concentrations above residential or non-residential standards are identified as chemicals of potential concern (COPC).

Regulated chemicals were detected in soil at each property investigated. Metals and SVOCs were the only types of regulated chemicals detected at potential levels of concern, and there was general consistency in the types and levels of these substances across each of the properties investigated. Common metals associated with slag (arsenic, aluminum, iron, manganese, and lead) were the primary metals of potential concern identified in the assessments, and concentrations of iron and manganese were identified above MSC values established for the protection of groundwater at several locations. No regulated herbicides, pesticides, PCBs, or radioactive isotopes were detected above PADEP residential or non-residential MSC criteria at any of the sites investigated.

Polycyclic aromatic hydrocarbon (PAH) compounds were detected at each site investigated. PAHs are a class of SVOCs that result from incomplete combustion and have been found closely associated with wastes from coke and steel manufacturing processes. One of those compounds that is a carcinogen, benzo(a)pyrene, was found above its PADEP residential MSC value at each site investigated and was the primary PAH associated with each of the properties.

While generally within non-residential MSC criteria, the sample results provide reasons to believe each of the properties has been impacted by regulated chemicals.

Based on consideration of the multiple lines of evidence collected for the investigations, the ESAs identified undeveloped land of sufficient size and topography to use as a construction support area for each of the three new locks. The portions of the Emsworth Secondary, Dashields Primary (East and West), and Montgomery Primary properties identified in the proposed real estate plan maximize avoidance of contaminated areas by excluding portions of the properties with COPCs that exceed non-residential MSC values.

The Phase II ESA report meets the objective of ER 1165-2-132 at this stage of the project, provides the quantity and quality of information to account for potential HTRW-related cost impacts to the project, supports prudent risk management for acquisition and use of the subject properties for the intended purpose, and recommends additional required and suggested actions prior to acquisition.

The Phase II ESA recommends that in the next phase of project development, an updated or new Phase II Environmental Site Assessment be developed to meet CERCLA's all appropriate inquiry standards, especially in view of the fact that acquisition of an interest in any of the three subject parcels would almost certainly be some years into the future. All Appropriate Inquiry (AAI) is a USEPA regulation that requires, among other things, completion of an assessment within 6 to 12 months of property acquisition. Prospective purchasers of real estate must follow AAI to successfully invoke CERCLA's landowner liability defenses, if necessary. Before acquisition, the appropriate regulators will be contacted to establish the condition of the property prior to any USACE occupancy and assurance regarding any regulatory plans for the property with regard to remediation.

3.3.3.5.1 Emsworth Primary

Emsworth Primary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Emsworth Primary Site. The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Emsworth Primary Site.

Emsworth Primary Phase II ESA

A Phase II Environmental Site Assessment was not performed for the Emsworth Primary Site because a right-of-entry was not obtained from the owner.

3.3.3.5.2 Emsworth Secondary

Emsworth Secondary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Emsworth Secondary Site. The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Emsworth Secondary Site.

Emsworth Secondary Phase II ESA

The Phase II Environmental Site Assessment for the Emsworth Secondary Site indicates there is sufficient land available to support construction of the proposed lock and to develop a Real Estate Plan that maximizes avoidance of contaminated areas. Given that property acquisition of the subject parcel would almost certainly be some years in the future, an updated assessment is required prior to acquisition to meet the CERCLA all appropriate inquiry standards established by USEPA.

Recommended Plan

The Emsworth Secondary Site is included as part of the Recommended Plan.

3.3.3.5.3 Dashields Primary

Dashields Primary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Dashields Primary Sites (East and West). The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Dashields Primary Sites (East and West).

Dashields Primary Phase II ESA

The Phase II Environmental Site Assessment for the Dashields Primary (East and West) site indicates there is sufficient land available to support construction of the proposed lock and to develop a Real Estate Plan that maximizes avoidance of contaminated areas. Given that acquisition of the subject parcel would almost certainly be some years in the future, an updated assessment is required prior to acquisition to meet the CERCLA all appropriate inquiry standards established by USEPA.

3.3.3.5.4 Dashields Secondary

Dashields Secondary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Dashields Secondary Site. The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Dashields Secondary Site.

Dashields Secondary Phase II ESA

A Phase II Environmental Site Assessment was not performed for the Dashields Secondary Site because a right-of-entry was not obtained from the owner.

Recommended Plan

The Dashields Primary Site (East and West) is included as part of the Recommended Plan.

3.3.3.5.5 Montgomery Primary

Montgomery Primary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Montgomery Primary Site. The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Montgomery Primary Site.

Montgomery Primary Phase II ESA

The Phase II Environmental Site Assessment for the Montgomery Primary location indicates there is sufficient land available to support construction of the proposed lock and to develop a Real Estate Plan that maximizes avoidance of contaminated areas. Given that acquisition of the subject parcel would almost certainly be some years in the future, an updated assessment is required prior to acquisition to meet the CERCLA all appropriate inquiry standards established by USEPA.

3.3.3.5.6 Montgomery Secondary

Montgomery Secondary Phase I ESA

In accordance with Corps of Engineers regulations, a Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was performed at the Montgomery Secondary Sites (East and West). The Phase I Environmental Site Assessment identified recognized environmental conditions (REC) at the property. A Phase II Environmental Site Assessment was recommended at the Montgomery Secondary Sites (East and West).

Montgomery Secondary (East) Phase II ESA

Following completion of the Phase II Environmental Site Assessment for the Montgomery Secondary (East) Site, no real estate is proposed to be acquired at this time.

Montgomery Secondary (West) Phase II ESA

A Phase II Environmental Site Assessment was not performed for the Montgomery Secondary (West) Site because a right-of-entry was not obtained from the owner.

Recommended Plan

The Montgomery Primary Site is included as part of the Recommended Plan.

3.3.3.6 Floodplains

For the Emsworth Primary Site: FEMA's Flood Insurance Rate Map (FIRM) Panels 189 & 327 for Allegheny County, PA, dated 10/4/1995 indicate that the river bank and up to 100 feet inland from the site boundary is within the Ohio River floodway. The remaining portion of the site lies outside of the one-percent- and 0.2-percent-annual-chance floodplains.

For the Emsworth Secondary Site: FEMA's FIRM Panels 189 & 327 for Allegheny County, PA, dated 10/4/1995 indicate that the edge of the 12.5-acre site is within the one-percent-annual-chance floodplain. The remaining portion of the site lies outside of the one-percent- and 0.2-percent-annual-chance floodplains.

For the Dashields Primary Site: FEMA's FIRM Panel 162 for Allegheny County, PA, dated 10/4/1995 illustrates that the river bank of the western 5.2-acre site extending landward approximately 100 feet is within the floodway. The remaining area of the 5.2-acre site is within the one percent annual chance floodplain. The northern corner and a narrow strip (approximately 50 feet) of the river bank within the 19.2-acre eastern site are also within the one percent annual chance floodplain. The remaining area within the eastern site is within the 0.2 percent annual chance floodplain.

For the Dashields Secondary Site: FEMA's FIRM Panel 162 for Allegheny County, PA, dated 10/4/1995 illustrates that the floodway extends 150 feet into the secondary eastern site. The remainder of the site is outside of the one percent and 0.2 percent annual chance floodplains.

For the Montgomery Primary Site: FEMA's FIRM Panel 1 for Potter Township, Beaver County, PA, dated 12/2/1988 and Flood Hazard Boundary Map for Raccoon Township, Beaver County, PA, dated 8/20/76 indicate that portions of the 18.5-acre site along the river are located within the floodway, fringe area of the one percent annual chance floodplain, and the 0.2 percent annual chance floodplain. The FIRM for the area within Potter Township (approximately 11.1 acres) indicates that the portion of the site bordering the Ohio River is located within the one percent annual chance floodplain and within the computed floodway. The one percent annual chance floodplain protrudes south into the site along Squirrel Run for a distance of approximately 300 feet. Squirrel Run, an intermittent tributary to the Ohio River, serves as the boundary line between Potter and Raccoon Townships. Although no detailed information (such as a FIRM) is available for the portion of the site within Raccoon Township (approximately 7.4 acres), a Flood Hazard Boundary Map, dated 8/20/76, is available for this portion of the site. This map identifies much of this area as Zone "A" (Special Flood Hazard Areas without computed base flood elevations – indicative of the approximate one percent annual chance floodplain).

For the Montgomery Secondary Site: FEMA's FIRM Panel 1 for Potter Township, Beaver County, PA, dated 12/2/1988, illustrates that the Secondary western site is outside of the one percent and 0.2 percent annual chance floodplains. The river bank and bluff along the entire length of the Secondary eastern site is located within the floodway. In addition, a small strip on the east and west side adjacent to the floodway is located within the 0.2 percent annual chance floodplain. The majority of the eastern site is located outside of the one percent and 0.2 percent annual chance floodplains.

Note that for all sites, use of the designated floodway area is not permitted for structures or for storage of project materials. No encroachment of the computed floodway is permitted.

3.3.3.7 Endangered & Threatened Species

Most of the primary and secondary work areas were subjected to a field survey in July 2009 to delineate cover habitat types and make pedestrian observations on species presence. The Montgomery Secondary Area, a gypsum bulk material handling and processing facility, was not

included in the field surveys. Field observations did not identify any federally listed threatened or endangered species in any of the surveyed areas. Each of the alternative work areas was also covered through literature search and a Pennsylvania Natural Diversity Inventory (PNDI) environmental review. Their results follow below:

3.3.3.7.1 Emsworth Primary

According to the Pennsylvania Natural Diversity Inventory (PNDI) environmental review, no federal or state listed threatened or endangered species, or special concern species are known to exist within the Emsworth Primary site. The PNDI review includes the U. S. Fish and Wildlife Service's (USFWS) recommendation that a 100 to 300-foot buffer from the river's edge be retained as a conservative measure.

3.3.3.7.2 Emsworth Secondary

According to the Pennsylvania Natural Diversity Inventory (PNDI) environmental review, no federal or state listed threatened or endangered species, or special concern species are known to exist within the Emsworth Secondary site. The PNDI review includes the USFWS recommendation that a 100 to 300-foot buffer from the river's edge be retained as a conservative measure.

3.3.3.7.3 Dashields Primary

According to the PNDI environmental review, several aquatic species of concern have the potential to occur in the area (**Table 3-34**). These include one Pennsylvania listed threatened species, skipjack herring (*Alosa chrysochloris*), and three special concern mussel species. The PNDI response includes the USFWS recommendation that a 100 to 300-foot buffer be retained from the streams as a conservative measure.

3.3.3.7.4 Dashields Secondary

According to the PNDI review, the PFBC has identified the aquatic species listed in **Table 3-34** as potentially occurring in the site vicinity. These include one Pennsylvania listed threatened species, skipjack herring, and three special concern mussel species. The Pennsylvania Department of Conservation and Natural Resources (PADCNR) identified a species of Sunflower (*Helianthus hirsutus*) as a Special Concern Species under their jurisdiction that may occur on this site. Correspondence with the DCNR indicated that this species is typically found on shaley slopes, upland meadows, or dry roadside banks and that surveys are recommended if any of those habitats occur within the site. Any activity conducted regarding this species would be conducted as a Voluntary Conservation Measure only. The PNDI response includes the USFWS recommendation that a 100 to 300-foot buffer be retained from the river as a conservation measure.

TABLE 3-34: Endangered and Threatened Species – Dashields Sites

Scientific Name	Common Name	Current State Status	Proposed State Status	Federal Status
Alosa chrysochloris	Skipjack herring	Threatened	Threatened	None
Leptodea fragilis	Fragile papershell	Special Concern Species	Special Concern Species	None
Potamilus alatus	Pink heelsplitter	Special Concern Species	Special Concern Species	None
Vilosa iris	Rainbow mussel	Special Concern Species	Endangered	None
Helianthus hirsutus	Sunflower*	Special Concern Species	Special Concern Species	None

* Sunflower is only a concern for the Dashields Secondary site.

3.3.3.7.5 Montgomery Primary

According to the PNDI environmental review, several aquatic and terrestrial species identified in **Table 3-35** have the potential to occur near or within the area of the Montgomery site boundaries. These include one state-listed endangered species (black bullhead, *Amerius melas*), one state-listed threatened species (skipjack herring), three state-listed special concern mussels, and one state-listed special concern avian species (Prothonotary Warbler, *Prothonotaria citria*). Further consultations with PFBC and the Pennsylvania Game Commission (PGC) are currently underway. The Prothonotary Warbler inhabits forested areas adjacent to water bodies for foraging and nesting activities. The PNDI review includes a USFWS recommendation that a 100 to 300-foot buffer be retained from the streams as a conservation measure.

3.3.3.7.6 Montgomery Secondary

According to the PNDI environmental review, four aquatic species under the jurisdiction of the PFBC may potentially occur near or within the area of Montgomery site boundaries (**Table 3-35**). These include one Pennsylvania listed endangered species (black bullhead), one Pennsylvania threatened species (skipjack herring), and three special concern mussel species. The USFWS recommends that a 100 to 300-foot buffer be retained from the river's edge as a conservation measure.

TABLE 3-35: Endangered and Threatened Species – Montgomery Sites

Scientific Name	Common Name	Current State Status	Proposed State Status	Federal Status
Alosa chrysochloris	Skipjack herring	*Threatened*	*Threatened*	*None*
Amerius melas	Black bullhead	*Endangered*	*Endangered*	*None*
Leptodea fragilis	Fragile papershell	*Special Concern Species*	*Special Concern Species*	*None*

Scientific Name	Common Name	Current State Status	Proposed State Status	Federal Status
Potamilus alatus	Pink heelsplitter	*Special Concern Species*	*Special Concern Species*	*None*
Quadrula quadrula	Mapleleaf	*Special Concern Species*	*Threatened*	*None*
Prothonotaria citria	Prothonotary Warbler*	*Special Concern Species*	*Special Concern Species*	*None*

* Prothonotary Warbler a concern only at the Montgomery Primary site.

3.3.3.7.7 Status Update 2014

In response to the public review of the *Draft Feasibility Report and Integrate*d *Environmental Impact Statement*, the Pennsylvania Department of Conservation and Natural Resources responded with a review of the Pennsylvania Natural Diversity Inventory (PNDI) data files, and provided the following table of updated information for "Ohio River NFS, EIS; Emsworth, Dashields, and Montgomery Locks and Dams, Beaver County, PA." This information is valid for two years, and will need to be updated accordingly as the project proceeds. The complete response is provided in the *Final FeasibilityReport* **Appendices, Public Review Comments and Pittsburgh District Responses.**

SpeciesName	ComonName	Survey Period	Habitat	GENDESC	LASTOBS
Desmodium glabellum	Tall Tick-trefoil	fl. June-Aug	wooded roadside banks and open woods	ALONG S SIDE OF OHIO RIVER. ALONG TRANSMISSION CORRIDOR.	9/24/1974
Dicentra eximia	Wild Bleeding-hearts	fl. June-july	rich woods and cliffs	2002-11-13: Below high tension power line, wooded NE slope upper end of ravine (U05MOR01).	11/13/2002
Meehania cordata	Heartleaf Meehania	flowers May-July	banks and wooded slopes	RAVINE WITH MATURE BEECH & SUGAR MAPLE, ELM SPP. & BLACK BIRCH CANOPY & ASSOCIATED PLANT SPECIES. FERNS: POLYSTICHEM ACROSTICHOIDES, WOOD FERN SPP., SMILACINA RACEMOSA, TRILLIUM GRANDIFLORUM, VIOLA SPP (WHITE), GLECHOMA HEDERACEA, COLLINSONIA CANADENSIS, (SEE ATTACHED SHEET).	6/18/1992
Scutellaria saxatilis	Rock Skullcap	Flower July-Aug.	low woods, rocky stream banks and roadsides	1ST & 3RD COLONIES: ASSOCIATED PLANT SPECIES INCLUDE ACER SACCHARUM, ACER RUBRUM, ULMUS AMERICANA, BETULA LENTA, STAPHYLEA TRIFOLIA, COMMELINA COMMUNIS, RUBUS ALLEGHENIENSIS, WOOD FERN SPP, GRASS SPP, MOSS SPP. 2ND COLONY: QUERCUS RUBRA, FRAXIMUS AMERICANA, TILIA AMERICANA, BETULA LENTA, RHUS RADIANS, GRASS SPP, MOSS SPP, WOOD FERN SPP. DICENTRA EXIMIA FOUND AT ALL 3 COLONIES BUT BELIEVED INTRODUCED.	6/4/1992

Public review comments from the Pennsylvania Fish and Boat Commission included the statement that, "some fish species listed in the report are no longer listed as threatened or endangered, i.e., Smallmouth Buffalo, Longnose Gar, Mooneye, River Redhorse, Silver Chub, and Skipjack Herring under 58 Pennsylvania Code Chapter 75."

3.3.3.8 Cultural Resources

The District conducted a Phase I-level cultural resources assessment at each of the six potential construction support areas identified for this study. The Area of Potential Effect (APE) includes the same work area boundaries shown on **Figures 3-9, -10, & -11** (see also **Cultural Resource Appendix**).

3.3.3.8.1 Emsworth Primary

Background research indicates that there are two previously recorded archaeological sites within a one-mile radius of the proposed Emsworth Primary construction support area, but none within it. Only the locks and dam facility itself is recorded for the historic architectural resources in the vicinity of Emsworth. The landscape at the Emsworth Primary construction support area has been severely altered by previous industrial activity. The main industrial use of this land during the mid-twentieth century was above ground petroleum storage and monitoring wells are currently spaced across the parcel to monitor for groundwater contamination. No previously recorded archaeological sites or architectural or historic resources of greater than 50 years of age are present. Due to the heavy disturbances at this location, there is an extremely low potential for any intact cultural resources to be present that would be affected by any project related activity.

3.3.3.8.2 Emsworth Secondary

Two previously recorded archaeological sites are known within a one-mile radius of the proposed Emsworth Secondary construction support area, and neither are on Neville Island. Only the locks and dam facility itself is recorded for the historic architectural resources in the vicinity of Emsworth. Prior to 1950, this land was primarily farmland. In the 1950s and 1960s there was some commercial activities at this location but starting in 1967 there was intensive industrial development of this area that continues to this day. No previously recorded archaeological sites are present at this location and because of the heavy disturbances, there is an extremely low potential for any intact cultural resources to be present that would be affected by any project related activity.

A railroad was constructed along the southern edge of this parcel in 1939 as part of the Pittsburgh & Ohio Valley Railway, a service line, which connected the industries along Neville Island. It is currently owned by CSX. As a resource over fifty years of age, the railroad was investigated for its potential to be listed on the National Register of Historic Places (NRHP). While this railroad has association with industrial development of southwestern Pennsylvania, it lacks significance under any of the criteria for listing on the NRHP, and therefore no further cultural resource efforts are warranted.

3.3.3.8.3 Dashields Primary

The Dashields Primary construction support area consists of three parcels along the Ohio River, all of which have been heavily disturbed by commercial and industrial use. No previously recorded sites are present within the Dashields Primary proposed construction support areas, but there are six archaeological sites recorded nearby along the Ohio River. Limited subsurface testing during the Phase I assessment confirmed the presence of modern fill over at least six feet

of consolidated slag deposits. Edgeworth Borough utilizes the area to stockpile mulch and other materials. Background research indicated that there are three architectural or historic resources near to this area, including the locks and dam facility itself and the Edgeworth Historic District. The historic district boundaries are reported to include this area as being within Borough limits, but the fieldwork does not justify this inclusion. Due to the heavy disturbances at these locations, there is an extremely low potential for any intact cultural resources to be present that would be affected by any project-related surface activity. Should future work area plans require excavation to depths below the slag deposits, further archaeological survey would be required.

3.3.3.8.4 Dashields Secondary

The eastern portion of the Dashields Secondary construction support area has been significantly disturbed by industrial development, a sewage treatment plant, and a township maintenance facility. By contrast, the western portion was residential from the 1800s through ca. 1980, when a township park with a baseball field was built. No previously recorded sites are present within the Dashields Secondary proposed construction support area, but there are six archaeological sites recorded across the Ohio River.

Subsurface testing of the western portion of the parcel conducted during the Phase I assessment indicates that the park area was artificially leveled with fill deposits. An intact buried A horizon is present below the fill and yielded Site 36AL600, a multi-component prehistoric to historic archaeological site. The historic component may be related to the Corps lock tenders residences that were located within the park area from 1933 until they were razed in 1973. Shovel tests produced 11 prehistoric and 18 historic artifacts. A late Archaic Brewerton side notched projectile point fragment was recovered from the buried A horizon. Should the Dashields Secondary construction support area be selected for use and Site 36AL600 cannot be avoided, a Phase II archaeological investigation will be necessary in order to determine if the site is potentially eligible for listing on the NRHP.

3.3.3.8.5 Montgomery Primary

Background research for the proposed Montgomery Primary construction support area indicates 15 previously recorded archaeological sites within a one-mile radius, including 36BV131, which covers the eastern half of this study area. Montgomery Locks and Dam is the only historic architectural resource recorded for the general vicinity of this study area.

The Montgomery Primary construction support area is located on the terraces of the Ohio River, just south of the Montgomery Locks and Dam. Squirrel Run cuts across the western end of the parcel and was relocated during construction of Montgomery Locks further to the west to empty into the Ohio River downstream of the lock wall. Records indicate that the area west of Squirrel Run has never been developed. Preliminary Phase I testing within this portion of the study area yielded a small lithic scatter, Site 36BV357. The NRHP eligibility of this site will be determined following geomorphological testing at this location. There was a house just east of Squirrel Run from ca. 1876-1904 but the Phase I pedestrian reconnaissance indicates that all evidence of this structure has been removed. A railroad line was in place across the southern limits of this study area by 1952 and is still in use today.

The northernmost reaches of this construction support area, east of Squirrel Run were partially disturbed during the construction of Montgomery Locks and Dam. However, much of the terraces, particularly the southern portions, were not impacted by this construction. Background research indicated the presence of a house owned by R. Kenyon in 1876 that is likely the same stone house present during the construction of the dam and known as the Emerick House in Corps records. The Phase I study identified remnants of the Kenyon-Emerick House, including a partial stone foundation, stone rubble piles, a possible driveway trace leading to a possible associated garage structure ruin. During the course of the Phase I study this garage (evaluated as having no historical significance) was destroyed by fire.

The Kenyon-Emerick House site cluster is located within the boundaries of the previously recorded prehistoric site 36BV131. This site was recorded by a collector as a large prehistoric scatter along the Ohio River but was never professionally tested. The recorded boundaries included the disturbed construction support areas of the original Montgomery Locks construction. Shovel testing during the current study yielded only one prehistoric artifact (a biface fragment) within the previously identified boundaries. The current study has redefined 36BV131 to include the historic component and reduced the site size based on the subsurface testing results. Should the Montgomery Primary construction support area be selected for use and Site 36BV131 cannot be avoided, a Phase II archaeological investigation will be necessary in order to determine if the site is potentially eligible for listing on the NRHP.

3.3.3.8.6 Montgomery Secondary

Background research for the proposed Montgomery Secondary construction support area indicates 15 previously recorded archaeological sites within a one-mile radius including one site, 36BV55, which covers a large portion of this study area. This site was recorded by a collector and not investigated by a professional. Montgomery Locks and Dam is the only historic architectural resource recorded for the general vicinity of this study area. Due to present industrial activity, this area was not included in the Phase I field investigations.

The Montgomery Secondary construction support area consists of a single parcel located along the Ohio River east of the Montgomery Locks and Dam that has been severely altered by decades of industrial activity. Records show that a late-nineteenth century structure was present on this land and remained until between 1939-1952 when aerial photographs document extensive cut and fill, and the beginning of industrial development which removed all evidence of this structure. Because of the documented extreme disturbance from historic development, it was determined that site 36BV55 or any other archaeological materials would have no integrity requiring further investigation.

3.3.4 Recreation & Aesthetics

The Dashields Secondary area is partially occupied by Crescent Township Park, which consists of pavilions, ballfields and supporting structures. A portion of the underlying lands are owned by the Corps (site of the former Dashields residences) and leased to the township.

4 PLAN FORMULATION (*ALTERNATIVES)

4.1 Planning Process

The primary purpose of this study is navigation and as such requires identification of the National Economic Development (NED) plan. The NED plan is generally defined as that plan that reasonably maximizes economic development benefits consistent with protecting the environment. Corps guidance EC 1105-2-404, *Planning Civil Works Projects under the Environmental Operating Principles*, requires that the planning process includes the formulation of plans that produce both national economic and ecosystem restoration benefits, or "combined" plans. The purpose for this additional formulation is to achieve an appropriate balance between the economic and ecosystem restoration benefits provided by a plan. However, an important point for this study is that the NED plan will be the benchmark for evaluation of combined plans that include both navigation and ecosystem restoration measures.

Plan formulation is an iterative process in which a number of alternative plans are developed to alleviate or eliminate problems, meet needs, and realize opportunities. The Corps planning process consists of the following six steps that are also defined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (also known as the Principles and Guidelines[10] or P&G). Corps implementation of the P&G is spelled out in ER 1105-2-100, known as the *Planning Guidance Notebook.*

Step 1 – Identifying existing problems and opportunities relevant to the project scope

Step 2 – Inventorying and forecasting conditions relevant to project scope (without a major federal action) during study period, possibly updating problems and opportunities

Step 3 – Formulating alternative plans to address problems and opportunities

Step 4 – Evaluating alternative plans

Step 5 – Comparing alternative plans

Step 6 – Recommending a plan

Problems and opportunities are identified in Step 1. Planning objectives that address those problems and opportunities are developed in Step 2. Future conditions for the existing navigation system are forecast to help quantify problems and opportunities. Reasonably foreseeable actions by others as well as by the Corps are considered in forecasting future conditions without a Federal project. The result of step 2 is identification of the Without-Project Condition (WOPC). As this study considers an existing navigation system (EDM) and associated ecosystem, the determination of the WOPC in Step 2 involves the evaluation of measures available to the Corps under its existing authorities to maximize the efficiency and

[10] "*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*", U.S. Water Resources Council, March 10, 1983.

effectiveness of the existing locks and dams and to address ecosystem problems and opportunities.

All navigation and ecosystem measures used to formulate alternative plans must address all aspects of one or more of the study objectives identified in Section 2.5. The WOPC is considered the "no action" plan in accordance with the National Environmental Policy Act (NEPA). Additional measures not available for the WOPC that address all aspects of one or more of the study objectives are identified. An initial array of alternatives is formulated consisting of combinations of these measures to improve upon the WOPC in Step 3. An evaluation will be conducted in Step 4 to determine what alternatives are worthy of more detailed analysis. Those that have high costs relative to benefits and or adverse impacts may be eliminated based on conceptual level design. The result of Step 4 is identification of a final array of alternatives to be considered for implementation. Final plans are compared through evaluation using the System of Accounts including costs and benefits, evaluation criteria, and the extent that they satisfy the Planning Objectives. In addition, consideration will be given to guidance provided in ER 1165-2-132 for feasibility studies that at least one alternative plan be formulated to avoid contaminated sites (containing hazardous, toxic or radiologic wastes, abbreviated HTRW) to the maximum extent possible consistent with project objectives. The best plan is identified in Step 6.

In the final evaluation process of both navigation and combined plans in Step 4, an array of the best plans are evaluated that considers a system of accounts based on four factors:

1) (contribution to) national economic development,
2) environmental quality,
3) regional development, and
4) social well-being.

In accordance with Corps Guidance EC 1105-2-409, *Planning in a Collaborative Environment*, any of the formulated plans may be selected as the best plan in its respective category if it has, on balance, net beneficial effects after considering all plan effects in consideration of these four accounts. The array of plans will include the WOPC as well as the best "with-project" plan(s) comprised of the best plan for a number of defined alternatives. The final comparison will involve the best plan from both categories, and again will be based on the system of accounts, evaluation criteria (completeness, efficiency, effectiveness, and acceptability) and extent they satisfy the Planning Objectives.

The six-step process outlined above is followed twice, once to determine the NED Plan and another to identify the best combined plan. The NED plan and the best combined plan are compared to determine the plan to be recommended for implementation.

4.2 Problems and Opportunities

4.2.1 Navigation Problems and Opportunities

4.2.1.1 Structural Condition

Problem Statement: Concrete walls and foundations are in a state of deterioration with significant likelihood of conditions developing that will require extensive repairs and lengthy lock closures. Operating facilities in an advanced deteriorated state pose safety concerns for both users and project staff.

The concrete lock walls pose the greatest risk of significant lock closures at these locks and dams. The walls are old structures whose ages range from 78 years at Montgomery to 92 years at Emsworth. Specific areas of concern at each facility include **foundations**, **wall stability, concrete deterioration**, **structural cracks, and internal stresses** in these walls. The locks and dams were constructed using substandard practices as evaluated from the current state of practice for lock wall structures. The walls either do not have any, or only very limited, steel reinforcing bars used to control cracking and the growth of cracks within concrete. In addition, the walls were constructed without using air-entrained concrete that provides resistance to freeze and thawing cycles. Both of these practices are the current standards of practice, and have been the current state of practice for at least the past six decades.

Foundation deficiencies are due to the original construction practice of setting the monoliths on the top of rock. This led to steeply sloping and stepped up bases, closeness to weak underlying strata seams, setting the bases of critical monoliths on a rock ledge in a “perched” condition, and poor contact between the base of the lock walls and the rock. The consequence of this practice leads to high stresses due to non-uniform foundation loading, which, if not corrected, could result in failure of the rock or failure of the wall by overturning or sliding. Construction procedures used to overcome such problems also raise reliability concerns, including consolidation grouting to correct open joints and the use of caissons.

Wall stability deficiencies at Emsworth were aggravated in 1937 by a 7-foot upper pool raise, and certain critical monoliths are known to have moved. Such displacement is evidence that the load resisting capacity of the structure has already been exceeded in places. The anchoring provided at these facilities during the major rehabilitation fell short of meeting present-day criteria and may not be performing even their design function. At Dashields, the Upper and Lower Guide Walls were not stabilized and are failing as evidenced by significant movement.

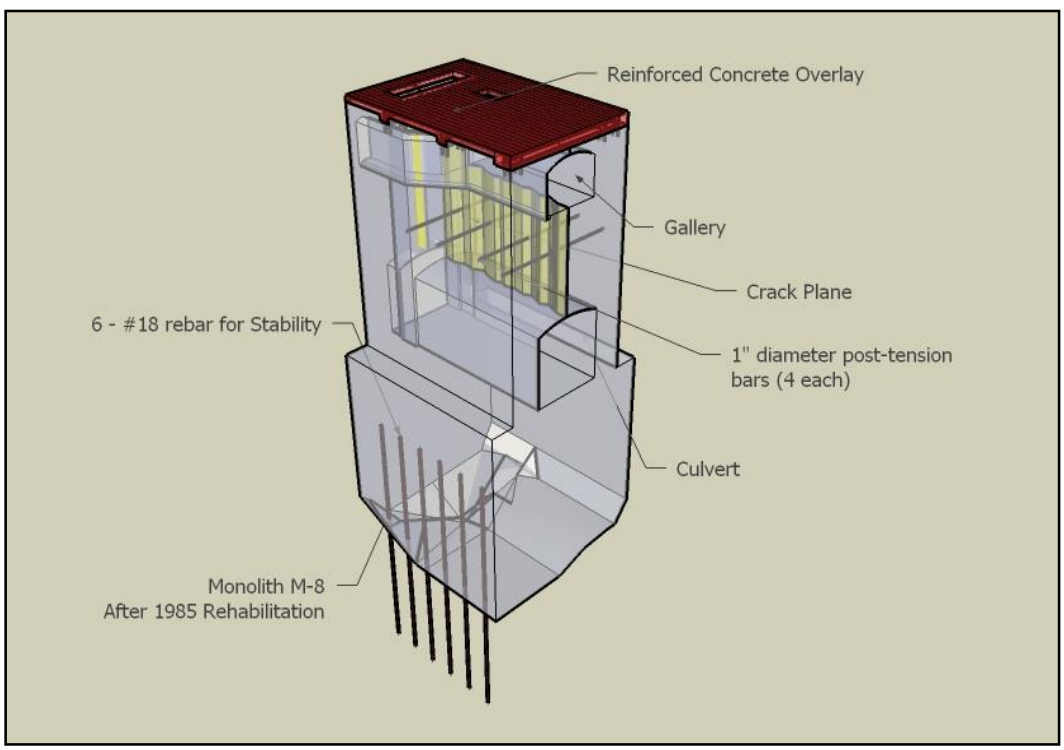
Cracking and deterioration are typical concerns with any concrete placed before the advent of air-entrainment in 1950, which includes virtually all of the existing concrete at EDM. Additional concerns with the concrete at EDM are the construction practices at these projects were subject to far less quality control than current standards. The deteriorated condition of the concrete, and concerns with wall stability, were the rationale for the 1980s major rehabilitations at each site. These rehabilitations had the overall purpose of extending the useful life of the locks for an additional 25 years, when it was estimated a long range plan for lock modernization would be determined. At EDM, the major rehabilitations were limited in scope to avoid lengthy closures

of the main 600' chambers, during which time all traffic would be forced through the small auxiliary chamber (see discussion of small locks in Section 4.2.1.2).

The selected work for EDM was therefore determined by balancing the work with associated project cost and main lock closure periods that were acceptable to the navigation industry. Under these constraints, it was not possible to replace or repair all cracked concrete or restore stability of those walls to standards to acceptable reliability. Only limited repairs to the severely deteriorated walls were accomplished, which included the removal of six inches to one foot of deteriorated concrete and resurfacing with a reinforced concrete overlay on horizontal surfaces and shotcrete (spray applied concrete) for vertical surfaces, installation of passive anchors (mobilized only by wall movement) and in some areas active anchors (anchors with a pre-load) for additional stabilization measures, and limited crack repairs using the installations of grouted steel bars. The objective of this work was to slow the rate of concrete deterioration. These superficial treatments provided some protection to the underlying and deteriorating concrete, but they tend to mask the true nature and condition of the walls.

Figure 4-1 shows the anchoring and refacing details of major rehabilitation work and notes the area susceptible to cracking. These anchors were not designed to provide a long-term solution to wall stability. A major factor limiting their effectiveness is that the anchors, protected with only

FIGURE 4-1: Middle Wall Monolith M-8, Montgomery Locks
Post 1986 Rehabilitation Condition



a single layer of corrosion protection material, extend through a corrosive coal seam. As the lock walls were not rebuilt, internal cracking could not be addressed, but a new surface of air entrained concrete was provided to limit the exposure of the underlying concrete from the freeze-thaw mechanisms and thus slow down the rate of cracking. The superficial treatments provided some protection to the underlying and deteriorating concrete but they tend to mask the true nature and condition of the walls.

These measures have slowed deterioration for nearly 30 years at EDM but future long-term effectiveness is a major concern. Recent field observations indicate that water is reaching the deteriorated concrete, causing the concrete to become saturated and susceptible to additional deterioration. As noted previously, there are cracks throughout various monoliths at each of the projects. At Emsworth, there are structural cracks (cracks due to excessive tensile stresses that threaten the durability of walls) in areas around gate anchorages. At Montgomery, there are six monoliths with open vertical cracks that communicate directly between the pipe gallery and filling culvert, and most middle wall monoliths have open vertical cracks between the ceiling of the pipe gallery and the top of the lock wall. Additional horizontal open cracks occur in the walls of the monoliths, with some extending to the faces of the walls at the lock chamber. At Montgomery and Dashields, there are additional "working" cracks located within the middle wall extending from the ceiling of the culvert upward to the gallery above the culvert, which is allowing significant amount of water to push upward from the culvert into the gallery during each lockage cycle. Any of these cracks could propagate and cause the lock wall to split into two pieces. Concerning wall stability, effectiveness of the wall anchors cannot be confirmed due to installation during lock operations, during which chamber pool levels fluctuate, thereby inducing uncertain anchor loads. Further, the drilling has left little room to accommodate additional anchors of these walls for stabilization.

Additional discussion related to the major rehabilitations and current condition at these sites can be found in the **Engineering Appendix**.

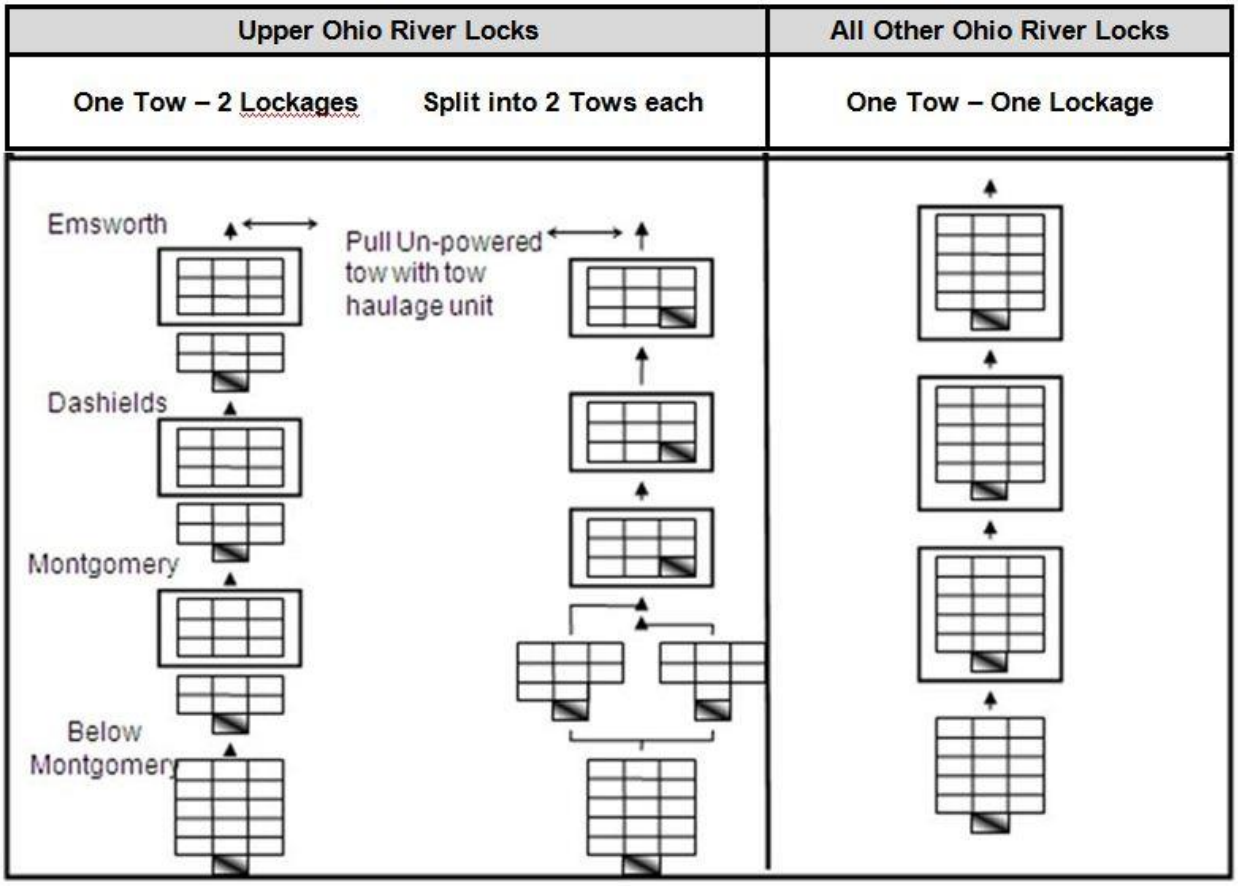
4.2.1.2 Small Locks

Problem Statement: Locks are significantly smaller than elsewhere on the Ohio River, particularly the auxiliary chambers. These small locks create inefficiencies for navigation industry, especially during extended closures of the main chambers, and increase their cost of doing business.

The 600' long main chambers at EDM are half as long as all other Ohio River main chambers and 120' shorter in length than the main chamber immediately upstream on the Monongahela River. These small main chambers create a bottleneck situation where towing companies are forced to consider options that add to their costs to lock through these main chambers and deliver their cargoes on time and in a cost-effective manner. These options described in the **Economics Appendix** include: 1) ship in a 15-barge tow and double lock through each of the projects; 2) ship in a 15-barge tow to points below or above the area where the barges are configured into two smaller tows that can each single lock through the projects; 3) ship in a 15-barge tow to points below or above the choke point where the cargo can be off-loaded for overland delivery; and 4) ship overland over the entire route.

Figure 4-2 shows the implications of locking through the small main chambers on the upper Ohio River versus the larger main chambers on the rest of the Ohio River. This figure depicts a 15-barge tow proceeding upstream, able to single lock through all 110' x 1200' locks below Montgomery. This tow must break into two separate "cuts" or "double-lock" to transit through any or all of the main locks at EDM. The process to double lock requires the tow to moor, reassemble and push nine barges into the main chamber. Those barges are "pulled" out of the chamber by a tow haulage unit (or traveling kevel) so that the nine barges are clear of the chamber and moored against the upper or lower guide wall. The tow then reassembles to the six remaining barges and locks through normally. The nine-tow unit is then reassembled to the other six and the tow proceeds on. A double lock through these facilities takes over two hours on average, compared to 45 minutes or so required to single lock through any of the other main chambers elsewhere on the Ohio River.

FIGURE 4-2: Waterway Options for Locking Thru Ohio River Main Chambers Tows Greater than 600' in Length



The 56' x 360' auxiliary chambers are about one-fourth the size of the typical Ohio River auxiliary chamber. These chambers were more efficient in the early 1900's when the dominant barge size was 175'x26' (two could be accommodated with a tow). Today, however, the

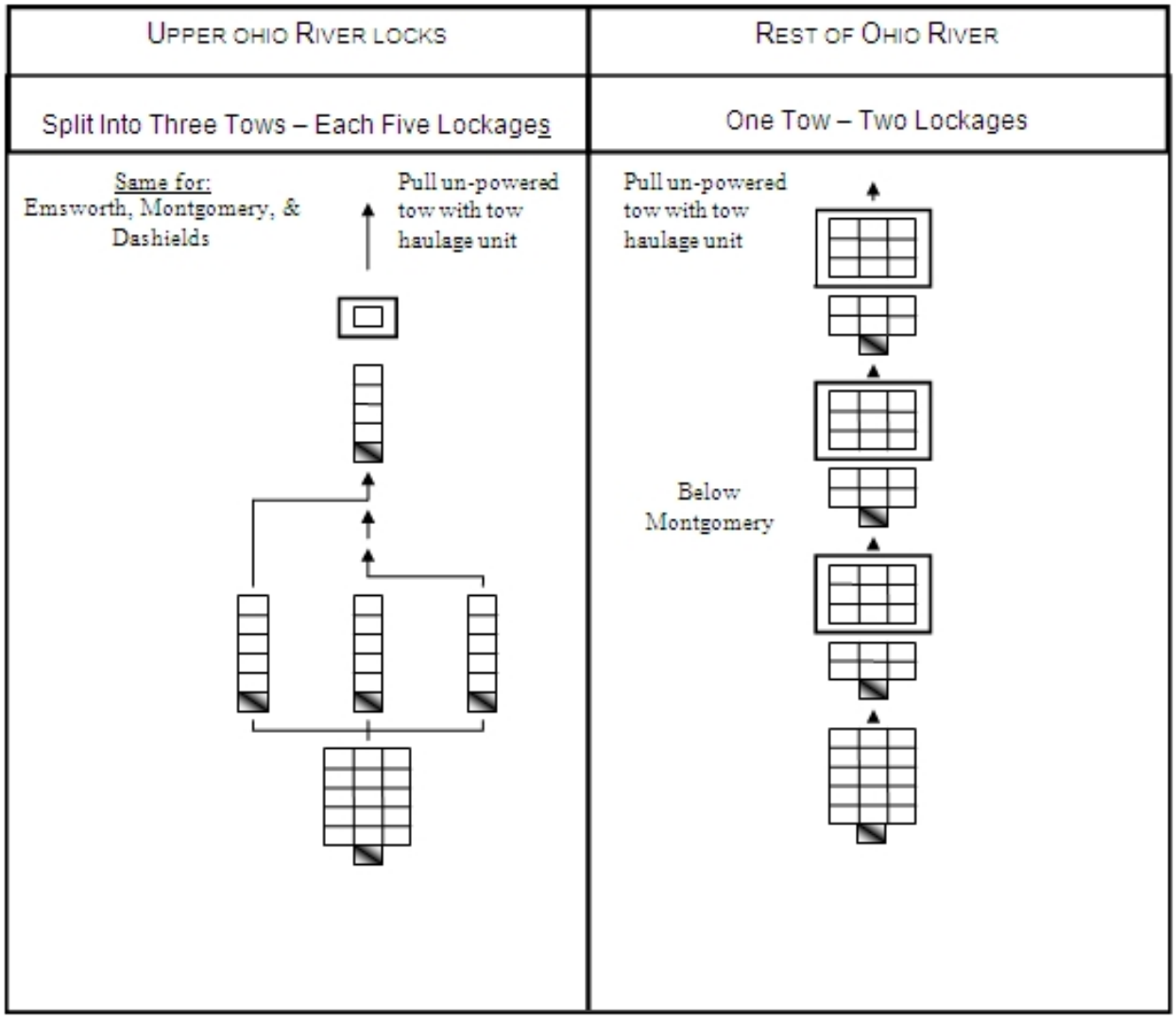
prevalent barge size is 195'x35' (only one can be accommodated with a tow). The shift to larger barges has, in effect, reduced the capacity of the small chamber. These very small auxiliary chambers at EDM are currently a problem whenever a main chamber must be closed for more than a few days (say, for maintenance or inspection) and all traffic is confined to locking through an auxiliary. During these times, tows that can lock through are limited to one to two barges, and the total number of cuts (lockage cycles) per tow are limited to five. A 5-10 barge tow that can single-lock (one lockage cycle) through the main chamber and require around 45 minutes to lock through requires five cycles and over three hours to lock through the auxiliary. The impacts to traffic during these closures are increased lockage times and quite likely excessive delays waiting in line during the main chamber closures. **Table 4-1** shows recent main chamber closures at EDM and the average delays to commercial tows. Continued deterioration of structural and mechanical components could lead to even higher frequency of extended main chamber closures in the future.

TABLE 4-1: Extended EDM Main Chamber Closures, 1986-2013

Year	Project	Duration in Days	Number of Tows	Avg. Tow Delay (Hrs)
2013	Emsworth*	32.8	250	7.8
2013	Montgomery	10.6	75	21.9
2012	Emsworth*	38.1	294	1.9
2012	Dashields	10.5	121	10.6
2010	Emsworth	21.6	149	29.0
2009	Dashields	17.4	112	6.0
2009	Emsworth	19.6	124	9.4
2008	Dashields*	8.4	95	3.7
2007	Emsworth	4.3	58	12.2
2006	Dashields	7.5	60	7.2
2002	Montgomery	16.6	178	32.7
2002	Montgomery	10.7	130	33.6
2001	Emsworth	8.7	105	18.0
1999	Emsworth	5.5	81	9.2
1998	Emsworth	8.6	100	15.3
1997	Emsworth	6.9	84	14.1
1997	Dashields	33.3	385	22.5
1996	Emsworth	6.1	96	31.2
1995	Emsworth	7.1	100	17.8
1994	Emsworth	29.9	299	36.4
1989	Dashields	59.3	809	15.7
1988	Dashields	48.5	651	4.8
1988	Dashields	14.2	204	11.0
1986	Dashields	11.3	151	3.1
1986	Montgomery	45.3	570	24.3
Source: PCXIN in LRH.				

Figure 4-3 shows the implications of a 15-barge tow locking through any of the auxiliary chambers on the upper Ohio River versus the larger main chambers on the rest of the Ohio River. The process is similar to that described to double lock through any of the EDM main chambers except that each tow must be separated into three tows of five barges each since only one barge can be locked at a time through these very small chambers and the maximum of five cuts of five cuts per tow. Processing the original 15-barge tow through any of the auxiliary chambers required about 12 hours. This same tow would be able to single or double lock through any of the other Ohio River auxiliary chambers.

FIGURE 4-3: Waterway Options for Locking 15-Barge Tows Thru Ohio River Auxiliary Chambers



Extended closures of any of these main chambers, even if scheduled (and coordinated with industry at least one year in advance) and especially if unscheduled due to component failure,

induce added costs to the shipping and towing industries. These potential added costs to both shippers and carriers are due to many factors as noted in **Table 4-2**.

TABLE 4-2: Categories of Additional Costs to Industry Arising From Extended Main Chamber Closures

Shippers	Carriers
Adjust Stockpiles	Delays at Lock (Lost Revenue)
Switch To All-Overland Mode	Moor Barges, Use Towboats Elsewhere
Switch To Different Waterway	Participate in Industry Self-Help (e.g., helper boats)
Switch Product Source	Avoid Lock
Temporarily Cease Operations	
Alter Production	
Switch Production To Another Facility	
Purchase Product, Rather Than Produce	
Demurrage	
Lost Sales	

As an example of the potential magnitude of these costs, consider an extended closure in September and October of 2003 at Greenup Locks and Dam at r.m. 341.0 on the Ohio River. What was scheduled as an 18-day scheduled closure turned into a 52-day scheduled/unscheduled closure when serious cracking of the lock gates was discovered. Added costs to carriers due to delays of about 27,000 hours at the lock were over $13 million. An Institute of Water Resources-sponsored survey conducted by the USACE Planning Center of Expertise for Inland Navigation in the Huntington District found at least another $30 million in costs to shippers resulting from shifts to rail or truck, sourcing shifts, lost sales and additional equipment. In the present business environment of just-in-time delivery of goods and commodities, any closure interrupts production, forces movements onto other transportation modes, and increases costs which are then passed along to the consumer. On the Upper Ohio, the 26-day closures at Montgomery in 2002 resulted in $2.6 million in added costs to industry (delays only).

One additional aspect of costs not considered above will be explored by this study, that being externality costs arising from added congestion caused when river traffic is forced onto the highways and rail. These costs include additional delays not only to diverted traffic, but to all existing traffic on the land route. The avoided congestion costs are allowable in NED-based evaluations of improvement plans. Only the added delays are allowable, not added impacts such as air pollution and accidents arising from increased traffic. For a more detailed discussion of externalities, see the **Economic Appendix**.

4.2.1.3 Hydraulic & Approach Conditions

Problem Statement: Substandard approach conditions at some higher than normal flows at EDM, and the Emsworth filling and emptying system design can create difficult navigation conditions.

There are concerns with navigation hydraulic conditions caused by filling and emptying of the Emsworth chambers and with approaches to these locks. There is inadequate depth over the lower guard and gate sills in each chamber to accommodate modern tows at each site. At Emsworth, there is an outward draft through the ported upper guard wall and guard wall extension that becomes a problem at relatively low flows. The unique filling system at Emsworth causes hydraulic conditions within both chambers that are detrimental to the lockage procedure. Fifteen filling ports that are asymmetrically located at the upstream end of the chambers, oriented at 90-degree angles to the centerline of the chambers, produce an eddy effect within the chambers that causes tows, barges and recreation boats to pull away from the chamber wall. As a result, the tow must be moored to the walls with hawser lines to prevent it from striking the miter gates. These lines must be able to resist the forces generated by the moving tow. The resisting forces generated in the line are defined as hawser forces. The eddy effect produces hawser forces on the lock walls (transmitted through lines securing the transiting craft to the walls) that are greater than were originally designed.

A modified operating procedure that requires significant attention of the operators has been implemented to control the rate of chamber filling and emptying to mitigate the adverse eddy effects. The standard operating procedure relies greatly on the operator's attention and performance of the control pads. Human error or sudden failure of the control will result in adverse currents and failure of mooring lines while the filling and emptying operation is underway. Such events have occurred recently, resulting in the failure of mooring lines, which pose a serious safety risk to deck hands and lock personnel, and causes the tow to be thrown into the downstream miter gates.

The length and location of approaches, coupled with out-draft conditions creating tow maneuverability problems are a concern at each site. Approach conditions to the Emsworth locks were worsened somewhat by the 7-foot pool raise in 1938. At Dashields and Montgomery, approaches that were not designed to accommodate modern tows sizes create navigation complications at higher flows. This problem is particularly noticeable in the upper approach at Montgomery where the combination of approach angle and the river current creates an especially difficult situation. The current District policy at Montgomery locks is for operators to meet all tows at the end of the upstream guide wall and assist them into the main lock chamber. Industry (on a company by company basis) has established separate procedures that utilize helper boats under certain high water conditions, but the Corps does not provide any helper boat assistance under higher flows. There were commercial tow accidents at Montgomery during high flows in 2005 and 2006 emphasizing the care that must be taken in navigating these locks. The accident in 2005 resulted in multiple fatalities.

The Pittsburgh District has implemented two efforts to increase safety of tows approaching and exiting these locks. The first was the installation of the Real Time Current Velocity monitoring

equipment at Emsworth and Montgomery in 2009. This second was the development of flow thresholds or "trigger points" at each of the three facilities that mandate temporary lockage procedures or restrictions.

4.2.1.4 Mechanical and Electrical Components

Problem Statement: Obsolete mechanical and electrical equipment are difficult to maintain and repair due to age and unavailability of replacement parts. These facilities do not include the most modern navigation aids such as floating bitts that could enhance the safety of operating procedures.

Many mechanical and electrical components at these three locks and dams are either the original equipment dating back to the construction in the 1920s and 1930s where the manufacturer is no longer in business or the part is no longer manufactured. When replacement parts are not available, existing parts must be retooled by Corps personnel at the Pittsburgh Engineering Warehouse and Repair Station (PEWARS). These components are very costly to maintain. Specific examples of problematic components include lock hydraulic system, valves, flow controls, and pumps.

4.2.1.5 Operational and Low-Cost Structural Opportunities

Opportunity Statement: Procedures and low-cost features to aid navigation may increase lockage throughput efficiencies that in turn would reduce navigation costs.

Low-cost features include largely operational structural measures (generally costing less than $10 million and below the minimum cost threshold of major rehabilitation projects), considerably less than lock expansion or new lock options that could enhance the operational efficiency (or throughput) of these locks.

4.2.1.6 WOPC - Remaining Problems and Opportunities

Many of the problem areas for navigation cannot be adequately addressed in the WOPC. Restoring the reliability of the lock walls prior to failure is well beyond the affordability of federal budgets in the WOPC, and all traffic must still use the very small auxiliary chambers during any main chamber closure. Reliability may be addressed, but only after component failure. As shown in **Table 4.16**, repairs or replacement of failed lock components equate to over $20 million and the associated lost navigation benefits are over $300 million (68% of total benefits) on an annual equivalent basis at a 4 1/8 % interest rate.

Several other problems could be somewhat alleviated after a major wall failure, particularly the middle walls where most of the mechanical equipment is housed. If a completely new wall is constructed after a major failure, there is an opportunity to install modern mechanical and electrical equipment in the new wall that would be simpler to maintain than the antiquated equipment. There would still be restrictions as the new equipment would need to be compatible with the remaining older equipment.

At Emsworth, there is the additional opportunity to address the difficult hydraulic conditions in the lock chambers if the middle wall is completely replaced after failure. However, the difficult approach conditions at these three facilities would not be addressed.

All remaining problems can only be addressed by With-Project Alternatives. Lastly, the evaluation of the WOPC did not lead to the identification of any additional problem areas.

4.2.2 Ecosystem Problems and Opportunities

Problem Statement: Nine of ten Valued Environmental Components (VECs) examined in the ORMSS have identified sustainability concerns.

Opportunity Statement: Identify ways to improve sustainability of VECs and formulate NER and combined plans through the Upper Ohio Navigation Study.

Historically, Corps navigation facilities were viewed as beneficial to the environmental problems typical to the Upper Ohio. They provided much needed reservoirs of water that helped meet the significant water consumption demands of municipal and industrial facilities, and diluted the early pollution problems before treatment methods were implemented. Emsworth, Dashields, and Montgomery in particular, are excellent flow aerators that provide significant quantities of oxygen to offset the high biological and chemical oxygen demands in the upper river. However, with general improvements in regional water quality, new environmental thinking has shifted its focus onto limitations of the navigation facilities. Pools created by dams have less ecological diversity than free-flowing rivers, and dams are now generally perceived as barriers to fish movement. Returning the river to a free-flowing condition is not a reasonable alternative, either from the viewpoint of losing commercial navigation or from the loss of water quality benefits provided by the dams and their pools. Consequently, the challenge in today's relatively fast-changing regional environment is to identify the issues that will be considered problems over the coming century without losing sight of the historical benefits provided by the navigation system.

The ORMSS Programmatic Environmental Impact Statement (PEIS) was centered on a system-wide Cumulative Effects Assessment (CEA) to determine effects on the sustainability of Ohio River resources from all past, present and foreseeable future activities on the river, including but not limited to the navigation facilities. These were developed through extensive consultation with resource agencies and input from the interested public. Ten valued environmental components (VECs) were categorized for analysis, six of which were considered to be highest priority: Water and Sediment Quality, Fish, Mussels, Riparian/Floodplain Resources, Health and Safety, and Recreation. The other four VECs included Air Quality, Transportation and Traffic, Socio-Economic Resources, and Cultural Resources.

A team of national and regional experts on aquatic and riparian resources of the Ohio River was assembled to identify ecological functions that have been compromised along the river and the causes of compromise. Most of the causes adversely affecting the higher priority VECs are attributable to historic municipal and industrial development along the river dating from the mid-1800s. Significant improvements to public health and safety began with water supply treatment in the early 1900s to remove water-borne pathogens, and further improvements were realized in the late 1900s with implementation of the Clean Water Act requirements. Recovery from the near-total loss of the fishery and mussel populations due to water pollution has been slow, but recent improvements are encouraging.

For the ORMSS, the study team of experts developed a list of 26 high-priority ecosystem opportunities to restore or enhance ecosystem functions benefiting the VECs, without regard to responsibilities or means. They are:

1) Enhance fish passage around or through dams
2) Dismantle unneeded federal tributary dams
3) Dismantle unneeded non-federal tributary dams
4) Increase seasonal flooding in grasslands, bottomland hardwood forests, and other habitats
5) Allow flows to mimic natural regimes including seasonal and extreme floods and droughts
6) Restore unique mainstem habitats such as canebrakes, river bluffs and mussel beds
7) Protect tailwaters and provide structures to serve as refugia for fish
8) Create spawning shoals and other in-stream features to enhance habitat diversity in navigation pools
9) Identify and expand areas of submerged and emergent aquatic vegetation
10) Protect and manage mussel populations and their habitat on a site-specific basis
11) Mark critical locations to prevent mooring near mussel beds or special shoreline areas
12) Mark shallow mussel beds to reduce direct impacts of tow traffic
13) Provide the navigation industry with charts showing locations of sensitive resources and include rationale for avoiding such resources
14) Protect existing aquatic habitats, restore lost habitats and diminished resources
15) Reintroduce native fauna and expand the range and populations of native fauna from reduced levels
16) Control exotics, including minimization of existing populations and prevention of new introductions
17) Reduce bacterial contamination from combined sewer overflows
18) Address point and non-point sources affecting aquatic nutrient balance
19) Minimize catastrophic contamination events through reduction of spills, accidents, and improvement of spill response procedures
20) Continue remediation of CERCLA, brownfields, and other contaminated sites
21) Reconnect and restore streams with floodplains on the mainstem and tributaries
22) Protect or restore riparian habitat diversity, including islands, on the mainstem and tributaries

23) Maintain or restore tributary deltas and connections between rivers and embayments

24) Reforest lower reaches of tributaries to reduce siltation into embayments and Mainstem

25) Restore wetlands in upper ends of embayments to reduce siltation and create fish and wildlife habitat

26) Conduct economic evaluation of watershed functions and benefits

The Upper Ohio Navigation Study incorporates the findings of the ORMSS regarding environmental sustainability opportunities, with further refinement on those features specifically applicable to upper river ecosystem characteristics and functions. Based on the results of the ORMSS, the following opportunities appear to be most applicable to the Upper Ohio River:

a) Identification and protection of sensitive habitat areas for native mussels from potentially adverse navigation impacts

b) Operational adjustments to vary seasonal normal pool elevations to partially mimic natural unimpounded flow regimes

c) Consider structural features to maximize environmental benefits, e.g. flow reaeration, fish passage, and water level management

d) Improvement of aquatic habitat through preservation of tailwaters, creation of structure or spawning shoals with appropriate disposal materials

e) Protect or restore riparian habitat diversity through use of natural materials for erosion protection

These opportunities can be addressed through the requirement to develop a National Ecosystem Restoration plan and combined NED/NER plan, and through potential mitigation project features for fish and wildlife impacts of the recommended plan.

4.3 Prior Navigation Project Reports

The current Upper Ohio River Feasibility Study commenced in fiscal year (FY) 2003 with Congressionally directed funds. This effort follows several studies by the Pittsburgh District that focused on concerns over the physical condition and capacity limitations at these three locks and dams. The *"Preliminary Report on Proposed Plan of Improvement"* (September 1962) was followed by the feasibility-level *"Report on Replacement - Emsworth, Dashields, and Montgomery Locks and Dams - Ohio River, Pennsylvania,"* (April 1971). Although a plan that involved reducing the number of projects in this reach from three to two by eliminating Dashields (a "two-for-three" plan) was found to have the highest net benefits, a "three-for-three" plan that included new 110' x 1200' and 110' x 600' locks at each site and a new gated dam at Emsworth and Montgomery was actually recommended. However, the report was returned to the District by the Ohio River Division [now Great Lakes and Ohio River Division] without action. The return endorsement stressed the need for a system analysis (the techniques of which were undefined) in accordance with the then current requirements of the Assistant Secretary of

the Army for Civil Works before any navigation improvements could be recommended by the District.

In light of that delay in report processing, the District concluded that rehabilitating major features at each facility was necessary to ensure adequate operation until the decision on the appropriate modernization could be made. Engineering Condition Survey and Structural Investigation Reports were completed in 1976 for Emsworth and in 1977 for Montgomery. Reconnaissance Reports for Major Rehabilitations of these projects were completed in 1977 for Emsworth, in 1982 for Montgomery, and 1984 for Dashields. Actual major rehabilitation work at each project is described in the next section.

Other studies specific to EDM were completed in conjunction with the Ohio River Mainstem System Study (ORMSS). Evaluations were also carried out for the ORMSS, the results of which will serve as a starting point for analyses and may be updated or supplemented with additional analyses as described herein. These reports provided a solid foundation for investigations carried out for this Feasibility Study.

A comprehensive list of specific studies and reports to date that are pertinent to this study appears below:

4.3.1 EDM Replacement Studies

September 1962 – *Pittsburgh-Montgomery Locks and Dam River Reach, Ohio River, Pennsylvania, Preliminary Report on Proposed Plan of Improvement*, U.S. Army Corps of Engineers, Pittsburgh District

April 1971 – *Report on Replacement, Emsworth, Dashields and Montgomery Locks and Dams, Ohio River, Pennsylvania*, U.S. Army Corps of Engineers, Pittsburgh District

4.3.2 EDM Major Rehabilitation Reports

August 1977 – *Reconnaissance Report for Major Rehabilitation, Emsworth Locks and Dams, Ohio River, Pennsylvania*, U.S. Army Corps of Engineers Pittsburgh District

July 1982 – *Reconnaissance Report for Major Rehabilitation, Montgomery Locks and Dam, Ohio River, Pennsylvania*, U.S. Army Corps of Engineers Pittsburgh District

January 1984 – *Reconnaissance Report for Major Rehabilitation, Dashields Locks and Dam, Ohio River, Pennsylvania*, U.S. Army Corps of Engineers, Pittsburgh District

July 2001 – *Emsworth Dams Major Rehabilitation Evaluation Report and Final Environmental Assessment*, U.S. Army Corps of Engineers, Pittsburgh District

4.3.3 EDM Condition and Concept Design Reports

4.3.3.1 Ohio River Mainstem System Study

September 1998 – *100% Submittal, Conceptual Design of Emsworth, Dashields, and Montgomery Locks and Dams, Three for Three Plans*, prepared by INCA Engineers for the U.S. Army Corps of Engineers, Pittsburgh District

September 1998 – *Ohio River Mainstem System Study, 100% Submittal, Conceptual Design of Emsworth and Montgomery Locks and Dams, Two for Three Plans,* prepared by INCA Engineers for the U.S. Army Corps of Engineers, Pittsburgh District

January 2001 – *Ohio River Mainstem System Study, Emsworth, Dashields, and Montgomery Locks and Dams Condition Report,* prepared by Dodson-Stilson, Inc. for the U.S. Army Corps of Engineers, Pittsburgh District

4.3.3.2 Upper Ohio Navigation Study

July 2006 – *Condition Assessment of Dashields and Montgomery Dams,* Prepared by DLZ for the U.S. Army Corps of Engineers, Pittsburgh District.

August 2006 – *Evaluation of Fatigue Cracking on Upper Ohio Lock Miter Gates,* prepared by Anatech Corp. for the U.S. Army Corps of Engineers, Pittsburgh District.

April 2008 – *Dashields Dam and Abutment – Reliability and Risk Assessment Study,* prepared by INCA Engineers for the U.S. Army Corps of Engineers, Pittsburgh District.

September 2008 – *Structural Modeling and Analysis of Emsworth Locks Filling and Emptying System,* prepared by INCA Engineers for the U.S. Army Corps of Engineers, Pittsburgh District.

October 2008 – *Reliability and Risk Assessment of Lock Miter Gates on Upper Ohio River,* prepared by Anatech for the U.S. Army Corps of Engineers, Pittsburgh District.

December 2008 – *Structural Modeling and Analysis of Concrete Lock Walls: Emsworth, Dashields, Montgomery Locks,* prepared by Anatech for the U.S. Army Corps of Engineers, Pittsburgh District.

January 2009 – *Final Report – Reconnaissance Survey of Commercial Disposal Sites for Excess Materials,* prepared by D'Appolonia for the U.S. Army Corps of Engineers, Pittsburgh District.

May 2009 – *Emsworth Locks and Dam Proposed New Chamber Layout,* prepared by INCA Engineers for the U.S. Army Corps of Engineers, Pittsburgh District.

4.3.4 Navigation Reports for the Upper Ohio Navigation Study

July 2000 – *Impacts of Diversion of Traffic Off of the River System Due to Unreliable Lock Service at the Upper Ohio River Navigation Projects, Emsworth, Dashields and Montgomery Locks and Dams,* prepared by Gannett Fleming, Inc. for the U.S. Army Corps of Engineers, Pittsburgh District

January 2001 – *Impacts on Traffic Volumes due to Modernization of Emsworth, Dashields and Montgomery Locks,* prepared by the Tennessee Valley Authority for the U.S. Army Corps of Engineers, Pittsburgh District

February 2005 – *Upper Ohio River Projects, Proposed Procedure to Establish the Baseline Economic Condition for the Concrete Structures,* Pittsburgh District

July 2009 – *Time Series Forecasts of Ohio River Traffic,* prepared by M. Thoma and W. W. Wilson, University of Oregon for the U.S. Army Corps of Engineers, Huntington District.

August 2009 – *Economic and Job Effects Of Possible Ohio River Closures, Emsworth, Dashields and Montgomery Projects,* prepared by Linare Consulting for the U.S. Army Corps of Engineers, Pittsburgh District

September 2009 – *Forecast Of Coal and Sorbent Materials Traffic Demands for the Ohio River Navigation System, Final Report,* prepared by Leonardo Technologies, Inc. for the U.S. Army Corps of Engineers, Huntington District.

4.3.5 Condition Surveys[11]

August 1976 – Miscellaneous Paper C-76-8, *Engineering Condition Survey and Structural Investigation of Emsworth Locks and Dams, Ohio River*, Pace, Carl E., Concrete Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station

March 1977 – *Engineering Condition Survey and Structural Investigation of Montgomery Locks and Dam, Ohio River,* prepared for U.S. Army Engineer District, Pittsburgh, by Pace, C.E., Peatross, J.T. Jr., Concrete Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station

September 1984 – *Repair, Evaluation, Maintenance and Rehabilitation Research Program, Technical Report REMR-CS-1, Engineering Condition Survey of Concrete in Service,* Stowe, R.L., Thornton, Jr., H.T., U.S. Army Corps of Engineers Waterways Experiment Station

June 1986 – *Condition Survey of Emsworth Locks and Dams Ohio River, prepared for U.S. Army Corps of Engineers, Pittsburgh District,* by Stowe, R.L., Poole, T.S., Structures Laboratory, U.S. Army Corps of Engineers, Structures Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station

November 1987 – *Condition Survey of Dashields Locks Ohio River, prepared for U.S. Army Engineer District, Pittsburgh,* by Stowe, R.L., Wong, G.S., Structures Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station

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[11] The Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program was initiated in 1984 and was brought to completion in 1998. Technology developed under this 14-year effort focused on seven problem areas: concrete and steel, geotechnical, hydraulic, electrical and mechanical, environmental, coastal, and operations management. The primary goal of this research effort was to develop affordable technology that would extend the service life of the Nation's aging infrastructure. Technology transfer is available in the forms of bulletins, technical notes, material data sheets, technical reports, and videos. To locate information about technology developed under this program, search the Repair Materials Database or the Bibliography Database at web site http://www.wes.army.mil/REMR/remr.html.

February 1988 – *Condition Survey of Montgomery Locks and Dams Ohio River,* prepared for U.S. Army Engineer District, Pittsburgh, by Stowe, R.L., Structures Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station

4.3.6 Other EDM Condition Assessment Reports

July 2000 – *Ohio River, Emsworth, Dashields and Montgomery Locks and Dams, Condition Report,* prepared by DLZ Corporation for the U.S. Army Corps of Engineers, Pittsburgh District

September 2000 – *Expert Elicitation for Concrete Monoliths at Emsworth, Dashields and Montgomery Locks and Dams, Ohio River,* U.S. Army Corps of Engineers, Pittsburgh District

November 2006 – *Validation of Expert Elicitation for Concrete Monolith Walls for Emsworth, Dashields, and Montgomery Locks, Ohio River, PA*

4.3.7 Ohio River or Ohio River System Navigation Reports

January 1983 – *History of Navigation in the Ohio River Basin,* Michael C. Robinson for the National Waterways Study, U.S. Army Engineer Water Resources Support Center, Institute for Water Resources

July 2000 – *Impact of Increased Truck Traffic Due to Chickamauga Lock Closure,* Center for Transportation Research, The University of Tennessee

2010 – *Great Lakes and Ohio River Navigation Systems Commerce, 2004* (updated every other year)

July 2011 – *Ohio River Mainstem Systems Study (ORMSS), System Investment Plan/Programmatic Environmental Impact Statement, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia,* U.S. Army Corps of Engineers, Louisville, Huntington, Pittsburgh

4.3.8 Environmental and Cultural Resource Reports

A number of environmental and cultural resource study reports on baseline conditions, impact evaluations, and formulation of mitigation were generated specifically to support the Upper Ohio Navigation Study. Copies of these reports are incorporated for reference in the Environmental and Cultural Resource appendices of this Integrated Report.

There are also a number of previous environmental and cultural resource studies that are relevant to the Upper Ohio Navigation Study. A listing of these study reports is provided in the Environmental and Cultural Resource appendices. These include, in part, earlier USFWS Planning Aid Reports, navigation system operations and maintenance environmental impact statements, regulatory (sand and gravel dredging) environmental impact statements, FERC hydropower environmental impact statements, and studies connected to the Ohio River Mainstem System Study.

4.4 Key Determinants for Navigation Alternatives

Key determinants of the future economic and environmental performance of the existing navigation system and all navigation investments and alternatives include the projected future level of use (i.e. traffic served) by each lock, the capacity of the locks to process traffic, the performance or reliability of the critical components that must function properly for the locks to remain open, and the environmental ramifications of the traffic and project operation. Each of these areas is discussed below, including consideration of current and potential future conditions.

Corps of Engineers guidelines as presented in the *Principles and Guidelines*[12] have long recognized that uncertainty is inherent in all phases of the analysis of waterway investments. As such, this analysis provides information regarding the level of uncertainty associated with the values estimated for a number of the key determinants addressed below, including traffic demand projections, lock performance descriptors (capacity and lock availability), and structural reliability. Estimating values for these inputs rests upon a large set of variables, many of which are unique to the input being estimated as summarized below and addressed in more detail in the Economics and Engineering appendices.

4.4.1 Traffic

This section presents the current traffic demand forecasts for the Ohio River for the planning period. As a backdrop to presenting future forecasts, recent traffic and trends are summarized. Three alternative traffic demand forecasts, simply designated as low, medium, and high, are then presented.

4.4.1.1 Existing Traffic and Current Trends

Table 4-3 shows annual commodity traffic at the Emsworth, Dashields, and Montgomery (EDM) projects compared to the Ohio River and the overall Ohio River System for the period 1980-2012. EDM traffic has declined while system traffic has increased over the entire time period, although even system traffic has declined since 2005. The decreases are largely traced to reduced consumption of coal by electric generating plants with economic market conditions as a secondary contributing factor. It is noted that the general growth starting in 1980 was due to the substitution of coal for oil and gas by electric generating plants (a by-product of the Iranian revolution in 1979) while the opposite type of substitution is true today. Similar types of paradigm shifts are likely in the future, although the specific consequences are unknown.

TABLE 4-3: Historic Traffic - EDM, Ohio River and the ORS (Million Tons)

Year	Emsworth	Dashields	Montgomery	Ohio River	ORS
1980	20.0	21.0	20.4	174.9	200.5
1990	22.4	23.9	25.7	225.7	260.3

[12] "*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*", U.S. Water Resources Council, March 10, 1983.

Year	Emsworth	Dashields	Montgomery	Ohio River	ORS
2000	21.9	22.4	25.2	236.5	271.8
2003	19.8	20.5	22.1	228.8	259.8
2004	18.9	19.6	20.6	239.0	269.9
2005	20.8	21.3	23.0	249.2	280.8
2006	20.6	20.7	20.4	241.5	270.7
2007	19.4	20.2	19.3	230.9	260.2
2008	21.3	21.8	20.8	230.8	259.2
2009	15.7	16.5	16.4	207.2	229.5
2010	15.3	16.4	18.3	220.6	245.2
2011	14.9	16.0	17.4	215.1	239.6
2012	16.0	17.2	18.3	n.a.	n.a.

Table 4-4 shows the breakdown of 2012 traffic by commodity group. Coal accounts for 63 percent of EDM traffic and 59 percent of system traffic. Aggregates account for 18 percent of EDM traffic; the aggregates are comprised of lime/limestone used in electric generating plants pollution control units and building materials used in construction. Collectively, coal and aggregates account for 81 percent of EDM traffic and 75 percent of system traffic.

TABLE 4-4: EDM Commodity Traffic, 2012
(Thousand Tons)

Types	Emsworth	Dashields	Mont-gomery	EDM Reach	Ohio River	ORS
Coal	12,333	12,333	12,318	13,150	122,514	140,172
Petroleum	298	945	928	1,003	13,440	13,771
Crude Petroleum	-	-	-	-	604	604
Aggregates	1,723	2,197	2,263	3,722	37,872	40,038
Grains	5	5	5	5	12,621	12,909
Chemicals	449	449	604	604	9,550	10,489
Ores/Minerals	274	274	826	826	6,053	6,151
Iron/Steel	314	368	641	641	7,559	8,308
Others	565	594	761	762	6,300	6,657
Total	**15,961**	**17,165**	**18,346**	**20,713**	**216,513**	**239,099**

4.4.1.2 Traffic Demand Forecasts

Traffic demands projected for this study represent the "unconstrained" traffic that would result if there were zero closures due to scheduled or unscheduled maintenance or repairs. They represent the upper bounds of future traffic. Actual traffic will be determined through economic modeling that incorporates scheduled maintenance and allows for unexpected failures, both of

which could require lock chamber closures. As these closures become more frequent and/or lengthy, some of this traffic may be diverted off of the waterway and to more costly but reliable alternate land modes.

Waterway traffic forecasts were developed for this study by Leonardo Technologies Incorporated (LTI) and Drs. Wes Wilson and Marc Thoma from the University of Oregon. The forecasts were divided between coal and non-coal commodities. Most of the attention in this forecasting effort was devoted to utility steam coal, given that utility steam coal regularly forms nearly 50 percent of total system traffic. LTI developed the coal forecasts and concurrently developed forecasts for sorbent materials used in coal desulfurization. The utility steam coal forecasts were developed using linear programming techniques that incorporated alternative assumptions with respect to levels of economic growth; future environmental regulations, including strict carbon dioxide emissions limitations; nuclear plant additions; and natural gas prices. Drs. Wilson and Thoma developed the non-coal forecasts using statistical time series techniques. Base case (medium), high and low forecasts were developed for all of the forecasts.

The forecast traffic numbers are displayed in **Table 4-5**. In every case, total traffic increases over the forecast horizon. The low case appears to be nearly flat, and in fact, coal traffic is reduced by nearly half over the forecast horizon. The range in the forecasts for 2070 is between 292 million tons in the low case and 485 million tons in the high case. The base case reaches a level of about 429 million tons. Annual growth ranges from 0.1 percent to 0.9 percent. Base Case growth is about 0.7 percent.

TABLE 4-5: Traffic Scenario Forecasts, Ohio River System

	2006	2010	2020	2030	2070	Annual Growth
High Case	270.7	286.3	351.5	378.9	485.1	0.9
Mid Case	270.7	283.6	334.4	329.9	429.2	0.7
Low Case	270.7	282.2	300.9	289.1	291.6	0.1

Coal continues to dominate the traffic picture at the system level over every forecast scenario, but coal's share of total traffic diminishes in every case as a share of total traffic. That happens because electric generation from other fuels gains share at the expense of coal.

Total traffic demands for the ORS, the Ohio River main stem and the Upper Ohio reach as well as EDM locks are displayed in **Tables 4-6 and 4-7**. Traffic demand is the projected future traffic that could realize a cost savings if navigation system constraints are not considered. In other words, it is the traffic that could be expected to materialize in the absence of navigation system constraints.

TABLE 4-6: Projected Traffic Demands – EDM Combined, Ohio River, and ORS (million tons)

	EDM Reach			Ohio River			ORS		
	High	Base Case	Low	High	Base Case	Low	High	Base Case	Low
Actual									
1980	NA	NA	NA	174.9	174.9	174.9	200.5	200.5	200.5
2006	24.8	24.8	24.8	241.5	241.5	241.5	270.7	270.7	270.7
Projected									
2010	29.4	27.5	27.7	259.1	255.6	254.8	286.3	283.6	282.2
2020	32.1	32.0	34.1	319.4	301.8	279.2	351.5	334.4	300.9
2030	42.1	29.0	38.5	346.5	297.9	272.7	378.9	329.9	289.1
2040	54.8	39.5	36.3	400.0	327.5	254.3	436.7	360.2	268.1
2050	57.8	36.9	33.9	430.5	358.1	272.9	470.2	388.7	291.7
2060	54.7	38.3	32.2	434.3	381.1	283.7	479.4	413.3	298.8
2070	72.4	30.3	31.0	432.2	397.9	277.5	485.1	429.2	291.6
Annual Growth									
1990-06	-	-	-	1.25	1.25	1.25	1.16	1.16	1.16
2006-70	1.69	0.32	0.35	0.91	0.78	0.22	0.92	0.72	0.12

SOURCE: COE Waterborne Commerce Statistics; Planning Center for Expertise in Inland Navigation.

TABLE 4-7: Projected Traffic Demands – Emsworth, Dashields, Montgomery (million tons)

	Emsworth			Dashields			Montgomery		
	High	Base Case	Low	High	Base Case	Low	High	Base Case	Low
Actual									
1980	20.0	20.0	20.0	21.0	21.0	21.0	20.4	20.4	20.4
2006	20.6	20.6	20.6	20.7	20.7	20.7	20.4	20.4	20.4
Projected									
2010	24.4	22.7	22.9	24.9	23.2	23.4	25.8	24.1	24.3
2020	25.6	24.6	26.8	26.3	25.2	27.4	28.1	28.1	30.5
2030	34.9	22.1	30.1	35.6	22.9	30.7	37.9	24.8	34.7
2040	45.2	31.2	27.3	46.0	32.0	28.1	50.2	34.9	32.0
2050	47.5	29.3	23.8	48.4	30.1	24.6	52.7	32.1	29.2
2060	43.3	29.9	22.5	44.4	30.9	23.4	49.3	33.1	27.1
2070	60.7	21.9	21.2	61.8	23.0	22.2	66.6	24.7	25.6
Annual Growth									
1980-06	0.11	0.11	0.11	-0.06	-0.06	-0.06	0.00	0.00	0.00
2006-70	1.70	0.10	0.05	1.72	0.16	0.11	1.86	0.30	0.35

SOURCE: COE Waterborne Commerce Statistics; Planning Center for Expertise in Inland Navigation

The Ohio River mainstem typically accounts for 85-90 percent of the traffic on the Ohio River System. Ohio River traffic trends, accordingly, are generally reflective of the overall system. For the Ohio River, the range in the forecasts for 2030 is between 272.7 million tons in the Low Case and 346.5 million tons in the High Case. By 2070, the range is between 277.5 and 432.2

million tons for these same scenarios. Annual growth rates for the 2006-2070 period range between 0.22 and 0.91 percent, compared to the historical (1980-2006) growth rate of 1.25 percent.

Forecast results for the Upper Ohio reach show substantially different patterns from the Ohio River and the overall system. Because of coal switching and interactions that arise in different scenarios, the rank ordering of the forecast scenarios is not necessarily the same as the Ohio River and ORS ordering in any given year.

As described in the **Economics Appendix**, utility steam coal traffic dominates the traffic picture on both the ORS and the EDM reach, accounting for about 47 percent of total 2006 traffic in the first instance and 40 percent in the second. As a result, future expectations for utility steam coal traffic largely defined the most probable future forecast scenario. In developing the high and low case utility steam coal forecast scenarios, a convergence of several factors were modeled that would be expected to produce plausible "best case" and "worst case" forecasts of steam coal consumption and waterborne coal traffic. For example, in the high case, it is assumed that high economic growth would coincide with low levels of nuclear plant development and high natural gas prices. In the low case, it is assumed that low economic growth would coincide with high levels of nuclear plant development and strict carbon dioxide emission reduction requirements as outlined in the Waxman-Markey bill. In reality, it is considered unlikely that such factors would coincide to produce high and low utility coal consumption and waterborne coal traffic. For this reason, the baseline or "mid level" forecast scenario for utility steam coal is considered to be the closest to a "most likely" future scenario. **Economic analyses to compare alternative plans and to determine the National Economic Development plan are based on the mid forecast.**

4.4.2 Lock Capacity

A lock's capacity (typically measured in tons per year) is largely determined by factors including lock chamber dimensions, approach conditions, the size of tows and barges, recreation craft traffic, process (empty and fill) times, average barge loading, and lock availability. Of these, chamber dimensions and lock availability are the most important. Larger chambers can process larger tows in single operations, or "cuts", leading to a greater throughput "capacity," typically measured in tons that could be moved through a project in any given year. Availability refers to the total time that a chamber is "open for business," including those times during a lockage or when sitting idle, or at all times except when the chamber is not available to lock vessels, i.e. "closed." Availability is strongly influenced by lock component reliability (less reliable locks require more downtime for repairs, thereby decreasing availability). The size of the locks and the processing times are essentially constants, while the sizes of the tows in terms of the numbers that require one-cut and two-cut lockages vary little over time. For this study, lock capacities were estimated using discrete event simulations based upon statistical analysis of tow operator behavior and actual lock operations, including potential lock closures, and are used to estimate traffic-delay or transit relationships at all locks.

Locks may be rendered inoperable due to a variety of reasons, including the following categories recorded in the Corps Lock Performance Monitoring System: collision/accident, debris, flood, fog, hardware malfunction, ice, vessel interference, other, rain, river current/out draft, snow,

testing and maintenance tow detained by Corps or Coast Guard, tow malfunction or breakdown, tow staff elsewhere occupied, and wind. Many types of interruptions are beyond the control of the Corps, such as fog and other weather-related events[13], termed Random Minor closures. However, closures due to scheduled maintenance of lock components, or unscheduled maintenance, or replacement after a component failure typically produce the greatest disruption to service because they are typically the longest in duration.

The towing industry adjusts their fleet of barges to more efficiently accommodate the navigation system. Current trends are for increased use of barges that are 200' in length and the phasing out of the older, shorter standard barges. For a more detailed discussion of barge fleeting in the Upper Ohio navigation system, see the **Economics Appendix**. The lock capacities at EDM have been updated to account for anticipated future barge fleets and are shown in **Table 4-8**.

TABLE 4-8: EDM Annual Lock Capacities with Minor Closures

Project	Main Chamber (Mil. Tons)	Auxiliary Chamber (Mil Tons)	Both Chambers (Mil Tons)
Emsworth	42.9	11.1	48.7
Dashields	48.1	14.3	51.5
Montgomery	43.2	11.5	50.3

The higher capacities at the Dashields chambers relative to the similar sized chambers at Emsworth and Montgomery are due to faster filling and emptying times associated with the smallest differential between the upper and lower pool elevations (head), smallest volume of recreation traffic, and slightly higher ton per tow values.

A system of locks and dams requires frequent maintenance, ranging from inspections, small adjustments or repairs performed annually, or on some cycle to replacement of major components. Maintenance actions can be proactive – repair a component before it becomes inoperable (preventative maintenance), or reactive – repair or replacement after a component fails. It is also necessary to take lock chambers out of service and dewater locks at scheduled intervals to allow for inspection and/or to perform repairs or replacements of lock components such as filling and emptying valves and lock gate components.

Lock and/or dam maintenance or repair often requires work vessels and procedures that interfere with and delays the passage of vessels through the navigation system. The maintenance or repair of some components, including concrete lock walls and miter gates, require chamber dewaterings. These are not only costly, in and of themselves, but incur additional and sometimes much higher costs to industry in the form of added delays when extended main chamber closures

[1] The Pittsburgh District Corps of Engineers is partnering with the Port of Pittsburgh Commission on their "SmartLock" project by making lock facilities available at Emsworth, Dashields and Montgomery Locks on the Ohio River for installation of recently developed state-of-the-art navigation technology to assist safe navigation of the lock in low visibility conditions of darkness, fog, rain, and snow. For more info, see the Commission's web page http://www.port.pittsburgh.pa.us/home/index.asp?page=12

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force traffic through the smaller auxiliary chamber. This is particularly critical at locks where the traffic levels exceed the capacity of the auxiliary chamber.

As any structure ages, the natural deterioration process dictates that scheduled maintenance requirements increase just to keep components operational. However, the likelihood of component failure (i.e., hardware malfunction) increases as a component ages even with increased scheduled or cyclic maintenance, resulting in more frequent and costly repairs and replacements. In other words, lock components and the lock itself become more unreliable. In addition to the costs to complete the work, significant costs in the form of added delays to the commercial towing industry are incurred during extended closures of the main chambers at any project when all traffic is forced through the auxiliary chambers, particularly at EDM due to the very small auxiliary locks.

The goal of preventive maintenance is to avoid component failures and the need for lengthy unscheduled repairs. Unscheduled maintenance (repair or replacement) costs and lock closures due to component failure are higher than for scheduled events due to the unexpected and emergency conditions. The Corps provides advanced notice of a year or more for most scheduled chamber closures, providing industry with time to adjust operations to minimize addition costs. Such advanced notice is not possible after a component failure for which a prolonged lock closure cannot be avoided. This has begun to occur on a more frequent basis for Ohio River lock chambers (such as the Markland and Greenup main chamber failures that occurred in 2009). These failures resulted in national inspections that have revealed additional component issues that could result in failures and lock closures if not addressed. Downward pressure on staffing and maintenance funding could be a factor in the recent trend of increasing minor component failures. The capacities in **Table 4-8** for any chamber are reduced in years when chambers undergo scheduled or unscheduled maintenance or component replacement after a component failure. Component reliability is a major consideration in this study.

4.4.3 Reliability

Reliability can be loosely defined as a measure of safety or assurance of adequate performance of a structural component. Structural strength properties may also be a function of time, usually in degrading fashion. Structural integrity is adversely impacted by factors including structural deterioration of members due to factors including corrosion and fatigue. Failure modes for the walls are not expected to be a sudden collapse but rather localized areas of distress at first with slow progression and observable by the project staff as these facilities are operated 24-hours a day 7 days a week, providing the opportunity to take action to avoid injury to users and staff.

The age of a structure is not the only factor in the deterioration process, but the older a structure is the more operating cycles is has undergone, thus, fatigue also is an important determinant with corrosion in the reliability of the lock components such as miter gates, culvert valves, and operating machinery. Increasing age of any lock or dam component usually correlates to increasing levels of deterioration, depending upon prior maintenance levels and repair work. Other factors that impact component reliability include the level of preventative maintenance and repairs and the original design parameters incorporated into the original construction. Failure of critical components necessary to operate the locks or dams could cause significant lock closures

during repair or replacement activities that in turn could significantly lower capacities shown in **Table 4-8** during the year of the failure.

Upper Ohio components of concern include lock walls, miter gates, miter gate operating machinery, miter gate sills, filling and emptying valves and associated machinery, and the hydraulic system. Future reliability (and thereby unreliability) values will be estimated for each of these components. Expressed as annual conditional probabilities or **hazard rates**, the unreliability in a future year represents the chance that a component will fail in that year, given that it has not failed before that year. Components may have more than one failure mode, each with different repair costs and lock closure impacts. When there are multiple failure modes, the relative likelihood of occurrence (p-value) is estimated using engineering judgment[14]. Details on the calculation of all hazard and p-values are presented in the **Engineering Appendix**. Many of the mechanical and electrical components were replaced during major rehabilitation projects during the 1980's. **Table 4-9** lists the components considered for reliability analyses for this study and **Table 4-10** displays the construction dates for the walls and installation dates for the existing equipment. Most equipment was replaced during the Major Rehabilitations at these projects during the 1980's. Wall nomenclature is annotated in **Photo 4-1**.

TABLE 4-9: Upper Ohio Lock Components Reliability Analysis

Component	Emsworth L/D		Dashields L/D		Montgomery L/D	
	Main	Auxiliary	Main	Auxiliary	Main	Auxiliary
Gates	X		X		X	
Gate Machinery	X	X	X	X	X	X
Hydraulic	X	X	X	X	X	X
Valve Machinery			X	X	X	X
Mid Wall Fill Valves	X					
Mid Wall MT Valves	X					
River MT Valves		X				
River Fill Valves		X				
Electrical	X	X	X	X	X	X
Guard Wall				X		
River Wall						X
Land Wall	X		X		X	
Guide Wall	X		X			
Middle Wall	X	X	X	X	X	X

[14] The probability of any particular mode of failure in year (t) is the product of the hazard rate in year t {h(t)} and the p-value for the failure mode in that year.

TABLE 4-10: Wall Construction and Latest Equipment Installation Dates

Component	Installation Date		
	Emsworth	Dashields	Montgomery
Lock and Guide Walls	1920	1928	1935
Lock Miter Gates	1981 (Main) 1984, 94 (Aux)	1988 (Main) 1988 (Aux)	1985 (Main) 1985 (Aux)
Lock Gate Operating Machinery	1984	1988	1986
Hydraulic System	1984	1988	1986
Electrical System	1984	1988	1986
Filling & Emptying Valves	1984	1988	1986
F&E Valve Machinery	1984	1988	1986
Dam, Dam Gates, Scour Protection, and Abutment	1937, Being Repaired or Replaced	*1928, 1988-Scour Protection	1935, Gates being replaced as O&M funds are available

*****Fixed Crest Dam (no gates)

Photo 4-1: Lock Wall Component Nomenclature

Reliability assessments were performed for all lock components except the culvert valves at Dashields and Montgomery. These valves have a good record of performance and are routinely replaced through cyclic maintenance (see discussion of maintenance activities in Section IV). Dam components at Emsworth and Montgomery were not analyzed with reliability analysis. At Emsworth, both the main and auxiliary channel dams are being repaired as part of an on-going major rehabilitation, including the stilling basins, gates, and dam abutments. After these repairs are completed, currently scheduled for 2014, no failures of any dam component are anticipated throughout the analysis period.

At Montgomery, two of the ten dam gates that were destroyed in a 2006 navigation accident have been replaced and the remaining eight will be replaced with Operations and Maintenance (O&M) funding as those funds become available. Two gates are currently being fabricated and scheduled to be delivered by the end of FY14. Both gates are expected to be installed by contract in FY15, although one is dependent upon additional funding as expected.

Reliability analyses were conducted for Dashields Dam components. The fixed crest dam section was determined to be reliable throughout the analysis period for planning purposes, susceptible only to unforeseen and extremely unlikely erosive effects below the dam. The dam abutment was determined to be susceptible to failure and requiring rehabilitation measures.

The risk inherent with any component is generally the product of probability of failure and consequences of failure in terms of repair cost and lock chamber closure(s). District concerns with the integrity of lock and guide wall concrete that in turn could lead to sudden failure of these walls and the severe consequences of failures that close the main chamber (or both chambers) make those walls by far the greatest impediment to the continued efficient and effective operation of the existing facilities. Walls that are integral to the continued operation of the main chambers include the land, middle and guide (approach) walls.

An example of hazard rates is shown in **Table 4-11** for the Emsworth middle wall. This wall has two potential failure modes, one requiring a major repair of the anchorages $P_1(t)$ and the other a total wall replacement $p_2(t)$ due to a failure of the wall around a culvert. The total hazard rate is divided into rates for these two failure modes for each year, equal to the product of the total hazard rate and the respective p value. For example, in year 2020 the rates are 0.0111 and 0.0082, respectively. After a failure of a gate anchorage, the wall is repaired such that subsequent failure of anchorages is presumed negligible (i.e. will not occur). Future hazard rates are lowered to account for this repair. For example, if the anchorages fail and are repaired in the year 2020, the hazard rate in 2021 is lowered from 0.0200 to 0.0129 as reflected in the right side of **Table 4-11**, where all $p_1(t)$ values equal zero after anchorage repair. The only failure possible after year 2020 would require replacement of the entire wall. If the wall fails near the culvert face , the wall is replaced in its entirety and all future hazard rates are reduced to zero as the new wall is presumed not to fail through the remainder of the analysis period. The h(t) and p(t) values for all components are presented in the **General Engineering Appendix**.

TABLE 4-11: Hazard Rates for Emsworth Middle Wall

Year	Emsworth L&D						
	Middle Wall - Original Tree				Middle Wall - Post Anchorage Repair		
	Hazard Rate h(t)	Branch Probability			Hazard Rate h(t)	Branch Probability	
		$p_1(t)$	$p_2(t)$			$p_1(t)$	$p_2(t)$
2005	0.0081	0.5675	0.4325		0.0040	0.0000	1.0000
2006	0.0100	0.5675	0.4325		0.0058	0.0000	1.0000
2007	0.0106	0.5675	0.4325		0.0062	0.0000	1.0000
2008	0.0113	0.5675	0.4325		0.0067	0.0000	1.0000
2009	0.0119	0.5675	0.4325		0.0072	0.0000	1.0000
2010	0.0125	0.5675	0.4325		0.0077	0.0000	1.0000
2011	0.0132	0.5675	0.4325		0.0081	0.0000	1.0000
2012	0.0138	0.5675	0.4325		0.0086	0.0000	1.0000
2013	0.0145	0.5675	0.4325		0.0091	0.0000	1.0000
2014	0.0152	0.5675	0.4325		0.0096	0.0000	1.0000
2015	0.0158	0.5675	0.4325		0.0100	0.0000	1.0000
2016	0.0165	0.5675	0.4325		0.0105	0.0000	1.0000
2017	0.0172	0.5675	0.4325		0.0110	0.0000	1.0000
2018	0.0179	0.5675	0.4325		0.0114	0.0000	1.0000
2019	0.0186	0.5675	0.4325		0.0119	0.0000	1.0000
2020	0.0193	0.5675	0.4325		0.0124	0.0000	1.0000
2021	0.0200	0.5675	0.4325		0.0129	0.0000	1.0000
2022	0.0207	0.5675	0.4325		0.0133	0.0000	1.0000
2023	0.0215	0.5675	0.4325		0.0138	0.0000	1.0000
2024	0.0222	0.5675	0.4325		0.0143	0.0000	1.0000
2025	0.0230	0.5675	0.4325		0.0148	0.0000	1.0000
2026	0.0238	0.5675	0.4325		0.0153	0.0000	1.0000
2027	0.0246	0.5675	0.4325		0.0158	0.0000	1.0000
2028	0.0254	0.5675	0.4325		0.0163	0.0000	1.0000
2029	0.0262	0.5675	0.4325		0.0168	0.0000	1.0000
2030	0.0269	0.5675	0.4325		0.0170	0.0000	1.0000
2031	0.0282	0.5675	0.4325		0.0180	0.0000	1.0000
2032	0.0289	0.5675	0.4325		0.0183	0.0000	1.0000
2033	0.0298	0.5675	0.4325		0.0188	0.0000	1.0000
2034	0.0307	0.5675	0.4325		0.0193	0.0000	1.0000
2035	0.0317	0.5675	0.4325		0.0199	0.0000	1.0000
2036	0.0326	0.5675	0.4325		0.0204	0.0000	1.0000
2037	0.0337	0.5675	0.4325		0.0209	0.0000	1.0000
2038	0.0347	0.5675	0.4325		0.0215	0.0000	1.0000
2039	0.0358	0.5675	0.4325		0.0221	0.0000	1.0000
2040	0.0369	0.5675	0.4325		0.0226	0.0000	1.0000
2041	0.0380	0.5675	0.4325		0.0232	0.0000	1.0000
2042	0.0392	0.5675	0.4325		0.0238	0.0000	1.0000
2043	0.0404	0.5675	0.4325		0.0244	0.0000	1.0000
2044	0.0417	0.5675	0.4325		0.0250	0.0000	1.0000
2045	0.0430	0.5675	0.4325		0.0257	0.0000	1.0000
2046	0.0443	0.5675	0.4325		0.0263	0.0000	1.0000
2047	0.0458	0.5675	0.4325		0.0270	0.0000	1.0000
2048	0.0472	0.5675	0.4325		0.0276	0.0000	1.0000
2049	0.0488	0.5675	0.4325		0.0283	0.0000	1.0000
2050	0.0504	0.5675	0.4325		0.0290	0.0000	1.0000
2051	0.0521	0.5675	0.4325		0.0297	0.0000	1.0000
2052	0.0539	0.5675	0.4325		0.0305	0.0000	1.0000
2053	0.0557	0.5675	0.4325		0.0313	0.0000	1.0000
2054	0.0577	0.5675	0.4325		0.0321	0.0000	1.0000
2055	0.0598	0.5675	0.4325		0.0329	0.0000	1.0000
2056	0.0620	0.5675	0.4325		0.0337	0.0000	1.0000
2057	0.0643	0.5675	0.4325		0.0346	0.0000	1.0000
2058	0.0668	0.5675	0.4325		0.0355	0.0000	1.0000
2059	0.0695	0.5675	0.4325		0.0365	0.0000	1.0000
2060	0.0724	0.5675	0.4325		0.0375	0.0000	1.0000

In all cases, the consequences of work conducted after a failure (repair cost and lock closure duration) are more severe than if scheduled and conducted under non-emergency conditions. As an example, the consequences of repair or replacing the Emsworth Middle Wall after a failure (emergency) and if scheduled are shown in **Table 4-12**. The scheduled and emergency consequences of all component failures are shown in the **General Engineering Appendix**. In general, the risks of wall failures (product of hazard rate and consequence) are by far the greatest at all three facilities.

TABLE 4-12: Hazard and Consequence of Failure Data, Emsworth Middle Wall

Failure Mode	Repair Costs	Lock Closures
Miter Gate Anchorage	Emergency $13 mil Scheduled $10 mil	Emergency 8 mo. Main & Aux. Scheduled 5 mo. Main & Aux.
Culvert Face	Emergency $140 mil Scheduled $116 mil	Emergency 36 mo. Main & Aux. Scheduled 24 mo. Main & Aux.

4.4.4 Environmental Issues

The key planning determinate for environmental issues is to insure that the recommended plan is consistent with environmental protection as expressed in law, and in Corps planning guidance and environmental policy. This guidance and policy also allows ecosystem restoration project formulation to accompany navigation formulation to determine opportunities for a recommended plan that incorporates both features of these Corps mission areas. A further determinate is the environmental commitments made in the Corps ORMSS (see Appendices) that are binding upon this Upper Ohio River Navigation study.

Potential impacts associated with various lock modernization alternatives from construction and from future operations were considered throughout the planning process. Mitigation was formulated for non-negligible impacts that could not be avoided or minimized through project design. Consistent with planning guidance and the Corps Environmental Operating Principles, opportunities for ecosystem restoration and for enhancing natural resource sustainability were considered in addition to navigation alternatives. These opportunities were identified through a cumulative effects assessment of “Valued Environmental Components” and their sustainability. Resources identified as less than sustainable were mussels, riparian habitat, and socioeconomic resources. Opportunities for incorporating fish passage strategies at the navigation facilities were also evaluated as an ORMSS commitment.

4.5 Future Without-Project Condition (WOPC), [*No Action Plan[15]]

4.5.1 WOPC Defined

The traditional Corps definition of the Without-Project Condition (WOPC) is the most likely condition expected to prevail throughout the analysis period in absence of additional project (Congressional) authorizations. The WOPC is vitally important as it serves as the basis against which impacts of project improvements or additions requiring Congressional authorization are measured. The formulation process used to define the WOPC for navigation facilities in this study will closely parallel that used in the Ohio River Mainstem System Study.

First, to address inherent difficulties in predicting future traffic demands at specific locks, multiple scenarios are postulated that represent a reasonable range of futures of unconstrained traffic demand. Scenarios are not evaluated with respect to numerical probability, so a single most probable WOPC is not identified. This scenario-based approach is consistent with the P&G, the procedural and analytical framework for Corps feasibility studies. The WOPC is determined for each traffic scenario and will not necessarily represent the status quo in terms of Corps operations and maintenance of the existing system in the absence of new investment. The WOPC is, in effect, determined for each traffic scenario which will allow the best plan to be identified for each scenario in evaluation of With-Project Condition (WPC). The Navigation WOPC is the baseline for determination of the National Economic Development (NED) Plan.

Four basic steps are used to determine the WOPC. The first step in determining the WOPC is to assess the life of existing critical components, including concrete walls and the mechanical and electrical equipment. This is done through the evaluation of a “reactive maintenance” (RM), that essentially runs the components until they physically fail and require replacement that completely addresses a failure mode. Lesser maintenance performed annually or on pre-determined cycles is also included, however such maintenance is relatively low cost and cannot be counted on to indefinitely prolong component life. Hazard functions are developed for critical lock and dam components that could fail and cause costly repairs and lock closures.

The economic results of RM are determined in the second step using Monte Carlo simulation techniques. These results are life-cycle costs including the expected repair costs and lock closures due to component failures that add navigation delays and the navigation or NED benefits, estimated for all three traffic scenarios using Monte Carlo simulation techniques. Based on these results, particularly the timing of failures observed in the simulations, scheduled replacements are formulated for components to determine if and when such “advanced maintenance” could improve the economic performance provided by RM, again for each traffic scenario. Repair costs are lower, associated lock closures are of lesser duration and less costly to the navigation industry for scheduled events than for unscheduled failures due to preparation time, advance acquisition of materials and advance notice to industry with scheduled events. Components are replaced to avoid failures and the associated costly consequences. More costly

[15] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

investments such as Major Rehabilitations that bundle multiple component replacements are considered too costly for the WOPC. Optimal timings of replacements are determined in the third step with Monte Carlo simulation as before.

The WOPC is determined in the fourth step, based on the list and timing of economically justified individual component replacements, and based on considerations of budget realities and lock closure consequences associated with these potential component replacements. All economic evaluations are made with the Ohio River Navigation Investment Model (ORNIM).

The WOPC for ecosystem environmental and cultural resources analyses is determined by assessing the existing and future conditions through the cumulative effects analysis on defined Valued Environmental Components. These resources include water and sediment quality, air quality, fish, mussels, riparian resources, cultural resources, and others. The cumulative effects analysis considers the reasonably foreseeable future actions both by the Corps and by others (federal, state, local, private, etc.) in developing future resource projections.

The WOPC also includes all authorized improvements in the Ohio River Basin that are either under construction or are pending appropriation. Projects on the Ohio River include Olmsted Locks and Dam and McAlpine Locks and Dam, currently under construction, and Greenup and Myers Locks and Dams, currently in the Preconstruction Engineering and Design stage. The assumptions for incorporating these projects into the WOPC for economic modeling purposes are noted in Section 7.4 of the **Economics Appendix**.

4.5.2 Navigation WOPC

4.5.2.1 WOPC Measures Considered and Carried Forward

Formulation of Navigation Without-Project Alternatives begins with identification of measures designed for the Corps and industry to address problems and realize opportunities to the maximum extent under existing authorities and budgets. There are two basic types of measures. One set deals with maintenance of the major components, and the other includes operational and low-cost structural measures to improve efficiency in the lockage process, particularly during congested periods. Measures that effectively contribute to efficiency contribute to Planning Objective 1.

4.5.2.1.1 Navigation - Maintenance

Maintaining the operation of any lock and dam facility requires a variety of measures ranging from routine actions performed every year to major work that could necessitate dewatering of a lock chamber to allow for repairs or replacement of various project components. Major work may involve scheduled or unanticipated or unscheduled work. Each of the measures described in this section have been implemented at Corps locks and dams.

The operation and maintenance of locks and dams is critical to maximizing the performance of the infrastructure. Operation includes lockage procedures and prioritization or order of lockages that usually involve first-come-first served during “normal operations” when locks are open. Lock operations become more critical at any of the EDM facilities when the main chamber is closed for an extended period of time and all traffic must use the very small auxiliary locks. This

study will consider all operation measures to safely increase processing times, especially during main chamber closures.

Two types of scheduled maintenance are considered, where scheduled maintenance allows for notification of the navigation industry and other interested parties at least one month in advance, but usually a year or more in advance of such work. Pre-notification of extended main chamber closures is crucial to allow for users to rearrange schedules and so to minimize adverse impacts of lock closure. One is **routine maintenance** required annually. **Cyclic maintenance** is periodically required at intervals of more than one year for critical components to maintain operability. Cyclic maintenance does not significantly increase long-term reliability.

The critical components for each of the three Upper Ohio River projects include lock gates and associated sills and hydraulic machinery, and filling and emptying valves. Along with the concrete lock walls, these components are also susceptible to failure and unscheduled repairs and associated lock closures as addressed in Reliability discussions below.

Normal Operations and Maintenance

Normal operations and maintenance (O&M) include activities performed each and every year necessary to operate the project without impacting traffic. Actions carried out under this category are typically handled by hired labor, but small contracts are used where feasible. Annual operating cost categories include all project site labor, overhead, equipment costs, and minor maintenance such as low-cost painting. Also included are minor contract actions such as services for grass cutting, etc. There are normally few, if any, environmental impacts associated with this category of operating costs. Routine maintenance has no effect on reliability (hazard rates).

It is inevitable that “Random Minor” events causing many of the closures will occur independent of maintenance and require the District to unexpectedly close a lock chamber for a very short duration, ranging from several hours up to several days. These events oftentimes involve the malfunction of equipment that can be repaired without the full repair fleet or the need to repair miscellaneous items, such as floating mooring bitts or wall armor. Random Minor closures and associated random minor maintenance costs also reflect lock closures for periodic testing of lock equipment by either on-site or contract personnel and not the large repair fleet. Random Minor closures also occur for other reasons such as debris in lock, tow malfunctions, accidents, etc. Currently at EDM, these closures typically result in closures of each chamber of 3-5 days per year. Random Minor costs will be accounted for separately in economic analyses of all alternatives in this study.

Current annual expenditures for routine operations and maintenance at EDM are about $2.0 to $2.5 million.

Scheduled Maintenance

Scheduled maintenance includes periodic lock chamber inspections or relatively minor maintenance and repair activities that close a chamber. Similar activities may also apply to dam components including dam gates, operating machinery, and pier concrete, but traffic is typically

not impacted. Inspections and maintenance of lock components typically require chamber dewaterings that can close a chamber from 10 to 15 days. Significant maintenance dewaterings are required for major repairs to components such as miter gates, culvert valves, and/or operating machinery. Such inspections are performed at EDM as required every 7 to 10 years. Cyclical maintenance procedures typically do not improve reliability or reduce long term failure probabilities (hazard rates) associated with fatigue/fracture and the end of useful design life; therefore it is assumed that cyclical maintenance does not have a significant effect on the overall reliability of the structures[16]. The District operates the *Monallo III* to accomplish major maintenance throughout the District. In addition, the District can use the Division boat *MV Shreve*. Examples of lock components during recent scheduled maintenance are shown below in **Photos 4-2 – 4-5**. Recent maintenance budgets have been virtually flat-lined resulting in increasing maintenance backlogs.

Photo 4-2: Miter Gate Sill, Emsworth Auxiliary Chamber

[16] This is mainly due to the fact that the failure modes are primarily associated with fatigue and fracture of critical members (miter gates and valves in particular)

Photo 4-3: Emptying Valve Machinery, Emsworth Main Chamber

Photo 4-4: Hydraulic Machinery, Emsworth

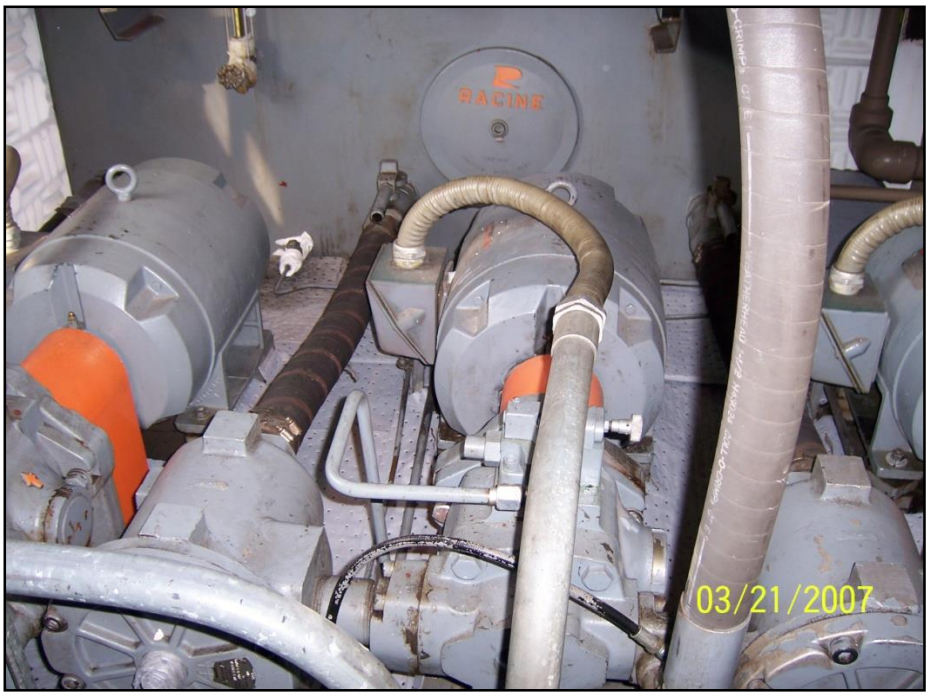


Photo 4-5: Miter Lock Gate Machinery (Arm)

Scheduled dam maintenance costs are attributed to maintenance of dam components (dam gates, operating machinery, concrete piers, etc.). This maintenance is critical to navigation, but does not require a closure because the repair fleet can tie up outside the river wall keeping lock chambers open to traffic. Reliability modeling was not performed on dam components because it was not part of the Project Management Plan (PMP). Deterministic scheduled dam maintenance costs are estimated from engineering judgment and are the same in all maintenance and improvement plans analyzed. Dam maintenance costs are included in the analysis to account for the full cost of operating the system.

Unscheduled Lock Repairs

Unscheduled repair or replacement of major lock components previously identified are necessitated by malfunctions, and are undertaken with little or no advance notice to industry. These repairs may require extended closures of one or even both lock chambers, and are separate from the random minor closures described under routine maintenance and any cyclical maintenance. The unscheduled repairs of major lock components are in effect reactive maintenance. The major lock components included in this repair category include miter gates and machinery, filling and emptying valves, and machinery, hydraulic and electric systems. The probability of these closures is provided by the hazard rates discussed in **Section 4.4.3**. An unscheduled lock closure occurred at Emsworth in 2000 due to the failure of a pin connecting the gate to the gate anchorage assembly.

Advanced (Scheduled) Component Replacement

As the projects age (Emsworth, Dashields and Montgomery will be over 124 years old by the year 2060), many of the major components will need to be replaced in order to keep the chamber usable for passing traffic. Past experience on Ohio River system locks has indicated that items such as miter gates, culvert valves, etc., tend to need replacement (called advanced maintenance in this report) after about 40 to 70 years of operation. The costs to replace the major mechanical and electrical components considered in this study are generally in the range of $3 - $10 million. Advanced replacement of the walls would be significantly higher, total replacement would be $100-$200 million, and would necessarily include encased mechanical and electrical equipment.

Major Rehabilitation

Major rehabilitation (MR) involves component replacement and/or repair work that costs more than a monetary threshold ($20 million for inland navigation projects in 2016) and extends over at least two full construction seasons. Additional details on requirements of MR projects are provided in Engineering Pamphlet (EP) 1130-2-500. This work typically involves major renovation or replacement of several of the major components defined for this study. Such work can also be viewed as "bundling" of replacement or renovation of the major components. Such bundling is normally more economic in terms of lower costs and less lock down-time than replacing components individually.

4.5.2.1.2 Assessment of Maintenance Measures

Routine and cyclical maintenance are necessary for continued operation and maintenance of the lock and dam system. Unscheduled repairs of component failures will also be required in a timely fashion to keep the system operating and is also carried forward. If components are not repaired, the locks and eventually the Upper Ohio River system would become ineffective in serving the navigation industry. These measures are critical to Planning Objective 1 and will be carried forward to occur as needed throughout the analysis period.

Historically, lock improvement studies for ORS locks and dams have assumed unconstrained funding for component replacements and major rehabilitation in developing the WOPC. However, recent history shows that the budgets for these more expensive forms of maintenance cannot be presumed to be provided as requested in a timely fashion. Therefore, for purposes of this analysis, replacement of any major component is not assumed to automatically be included in the WOPC. The budget implications of any component replacement, even though economic, will be considered before included in the WOPC. The economic advantage of replacing components is lower future maintenance costs as well as lower upfront costs and associated chamber closures. The navigation cost due to an extended lock closure is usually higher than the respective repair cost.

An assessment of economic scheduled component replacements will be necessary to determine which, if any, will be appropriate for inclusion in the without-project alternative plan based primarily on budget considerations. The upfront replacement costs are also less costly than in an unscheduled or emergency scenario. The reason for this is that emergency repairs are made under an extreme pressure to reopen as soon as possible and in many if not all cases before plans

for such repairs can be developed. For example, a major failure of the main chamber miter gate machinery requiring that the machinery be replaced would cost an estimated $11.3 million and require a 7-month main chamber closure. Replacement of this same machinery under non-emergency conditions would cost $7.3 million and require a two-month main chamber closure time. The savings to the navigation industry in lower transportation delays due to fewer lock closure days could be many times more than the lower repair cost. In addition to these cost savings, replacement of any old component eliminates the chances of failure of that component throughout the remainder of the planning period. Component replacements will be carried forward for further consideration in the WOPC. The costs and durations for the component replacements at all three facilities can be found in the event trees presented in the **General Engineering Appendix**.

Traditionally, a comprehensive major rehabilitation includes replacement or repair to major mechanical and electrical components, resurfacing the top of lock walls and relining of vertical lock wall faces, such as was performed at these three facilities in the 1980s. As noted in Section 4.2.1.1, the primary concern at these three facilities is the lock walls. The rehabilitation work is now 25-30 years old, beyond the intended extension of useful life. Due to the remaining structural cracks and questionable effectiveness of anchors in the lock walls at all three facilities, the only long-term solution for the walls would involve wholesale in-kind monolith replacements. Wall replacement costs in a major rehabilitation would be in the hundreds of millions of dollars. Although major rehabilitation could effectively contribute to Planning Objective with total wall replacement, it is dropped from further consideration from the WOPC due to the high construction costs and disruptive effects on traffic. It will be considered as a possible With-Project measure. **Table 4-13** summarizes the assessment of maintenance measures for the WOPC.

TABLE 4-13: WOPC Maintenance Measures Carried Forward or Dropped

Summary of Maintenance Measures Carried Forward in WOPC
Routine Maintenance & Random Minor Repairs
Scheduled Lock and Dam Maintenance
Unscheduled Repairs
Component Replacements Within Budget Limitations
Maintenance Measures Dropped From Consideration in WOPC
Expensive Component Replacements
Major Rehabilitation

4.5.2.1.3 Navigation – Operational & Low-Cost Structural Measures

The Corps seeks to maximize project throughput by implementing lockage policies and providing facilities that complement the lock and dam structures for the benefit of industry. Similarly, industry takes various actions to increase efficiencies of their operations in response to Corps maintenance activities. This section briefly describes the operational and low-cost structural measures that are currently implemented followed up with several not in use but worth considering for future implementation.

Operational & Low-Cost Structural Measures Currently Implemented.

N-Up/N-Down

This strategy involves locking a given number (N) of tows in the same direction, then allowing the same number to proceed in the opposite direction. It takes advantage of the efficiency of proceeding with several successive "turnback"-style lockages rather than running tows through in alternate directions when queued on either side of the lock. Use of this strategy has been proven to lower delays over a "first-come-first-served" policy at virtually zero cost. This is a supply-side measure.

Helper Boats: Industry Self Help

The use of helper boats by industry complements the N-up and N-down lockage policy. Helper boat operations are a collaborative effort between industry and the Corps. Due to traffic levels and fleet size, industry implements a helper boat policy any time a main chamber is closed on the Ohio. Industry helper boat operation significantly reduces lockage times for multi-cut lockages and typically works as follows: the last towboat to arrive at a congested project in the direction opposite of an on-going lockage operation will disconnect from its barges and move up to the lock, where it serves as a helper boat by assisting the tow locking through the project by extracting un-powered cuts of barges from the lock chamber. It will then move the barges for re-fleeting so that reconstruction of the tow does not interfere with lockage operations. Re-fleeting can occur at the locks on walls upstream or downstream of the lock gates, at mooring facilities or at private docks depending upon the situation. Helper boat operations are provided to each tow until all barges have moved through the lock. To be effective, the policy requires tows queued in both directions above and below the project. This is another supply-side measure that enhances capacity during a closure. The use of helper-boats by industry effectively maximizes the capacity of the small 360'x 56' auxiliaries on the upper Ohio.

Advanced Notice of Main Chamber Closures

The District develops draft two-year repair and maintenance schedules for work that will impact lock operation. The schedule is sent to representatives of the navigation industry for their review and comments. Depending on the comments the schedule may be revised or a follow-up meeting held for further discussion and input. For highly complex jobs, the District will meet with the navigation industry about six months beforehand for specific discussions. It should be noted that repairing component failures requires adjustment to scheduled work that in turn requires more short term, close coordination with the navigation industry.

Tow Haulage

Tow haulage systems are relatively low-cost pieces of equipment that can be used to expedite the two-cut lockage process when there are no other towboats to pull the unpowered cut out of the chamber. Such units are not necessary at any 1200' long lock as double cuts through those chambers are not permitted. There are two principal types of tow haulage systems: permanent and portable. Permanent units consist of rail tracks located directly alongside the chamber on top of the walls and a moveable tie-down unit that moves on the rails. The unpowered barges are tied to the moveable tie-down unit by a cable, and the unit moves along the rails to pull the

barges out of the chamber. Portable systems consist of two winches that are anchored atop the upstream and downstream guide walls. The winches "crank" the cable, pulling the barges out of the chamber. The second set of barges, which are powered by a towboat, can then enter and lock through the chamber. Upon completion of the second lockage, the first and second cuts are reconnected along the guide wall.

There are permanent tow haulage systems at the main chambers at Emsworth, Dashields, and Montgomery. Double lockages through these main chambers are a common occurrence even during normal times. During the period 1998-2002, double lockages at these locations constituted between about 16 and 22 percent of all commercial lockages at each of these projects (as reported in the ORMSS SIP).

Lockage Policies During High Water

At Emsworth and Dashields, when the total dam gate opening reaches 65 feet at Emsworth, precautions are put into effect for up bound knockout lockages (i.e. towboat set adjacent to barge in tow). At Montgomery, the special precautions for up bound knockout tows are implemented when the total gate opening at Montgomery reaches 40 feet. When the total gate opening is between 64 and 75 feet, the first cut of a double lockage cannot exceed 400 feet unless a helper boat is used. When the gate opening exceeds 75 feet, all double lockages require helper boats.

Mooring Cells

Mooring cells are structures that provide vessels a place to tie off while waiting for their turn to lock through. There are six cells that serve Emsworth (three upstream and three downstream), four that serve Dashields (two upstream and two downstream) and five that serve Montgomery (three upstream and two downstream).

Industry Adjustment during Main Chamber Closures

The objective of the towing industry during main chamber closures is to supply their customers to as near normal cycles of delivery as possible. They will try to accomplish this by pre- and post-closure shipping to build and/or replenish stockpiles, shipping via other routings for all or part of the trip, making deliveries from alternative sources, and rearranging their shipping plans to minimize trips through the projects.

At all times, shippers attempt to minimize the time they are pushing empty barges by arranging shipments in both directions. Their success depends on the demand for different types of commodities in the different origin and destination regions. If all movements were one-way with no backhauls, then the percent of loaded barges and empty barges through a project would each be 50 percent. The statistics on percent loaded through the projects show that, in general, the percent of loaded barges is significantly higher than 50 percent, which indicates a significant number of backhauls. The percent loaded is highest at the projects along the lower Ohio River, where the opportunities for backhauls are greater than on the upper Ohio River, where one-way coal traffic is more dominant. However during closures, the shippers on the upper river make temporary arrangements amongst themselves to maximize the throughput of the project in terms of tonnage since they are limited in terms of barges.

Towing companies also attempt to reduce the number of trips through projects where delays are significant. In some cases, they will employ their equipment in assembling barges above and below the congestion point so that they are prepared to get back onto their delivery schedules as quickly as possible once the main chamber is reopened. Arrival frequencies during extended closures have been observed to be less than during normal operations even without adjustments by industry due to limits on the numbers of tows and barges. The greatest reductions in tow arrival rates are at locks that are near major ports plus have significant delays during closures. These projects are the three upper projects near Pittsburgh and the mid river projects near Huntington.

Other Measures Implemented by the Corps

The Corps and industry maintain flexibility in dealing with delay situations, and often test new measures to try to decrease processing times. For example, the downstream approach area at Dashields was shortened during a recent main chamber closure by placing an anchored barge midway in the official approach area to serve as a temporary mooring area. The purpose was to reduce the time required for tows to approach the lock. Another test was a two-stage closure at Montgomery with about five days between the closures to clear the queues. During the first stage, work that required only a lowered water level was performed. Once this was completed, the chamber was refilled and opened for use. After the queue was cleared, the chamber was closed and de-watered to work on the gates and sills. Thus, instead of one continuous 26-day closure, there were two closures with the first lasting eight days and the second 18 days. This was successful in clearing the queue and thereby reducing the overall level of delays experienced during the closure.

Other measures by the Corps intended to increase efficiencies and reduce delays during main chamber closures include prioritizing commercial over recreational lockages, which reduces the demand by recreational boaters during those periods of heavy congestion, and; making available lockage reports on the Corps web page. Information contained in lockage reports, which is updated every few hours, includes the number of tows waiting in queue and river flow conditions at each facility. These low-cost measures have proved useful and are accepted by the navigation industry and recreational boating public.

Operational & Low-Cost Structural Measures Not Currently Implemented.

An example of a low-cost structural measure is extension of the guide walls, guard walls, or middle wall at any project. Extensions to these walls have the potential of reducing interference between tows that are concurrently using the main and auxiliary chambers of any project. The interference reduction has the potential to more efficiently pass traffic when traffic reaches the level where both chambers are highly utilized. Another type of measure that is contrary to maintaining the system would be to close a lock chamber down at a predetermined time or after a critical component fails. This latter strategy would in effect be Federal Disinvestment.

4.5.2.1.4 Assessment of Operational & Low-Cost Structural Measures

Due to their proven effectiveness, all operational and low-cost structural measures currently implemented and utilized by the Corps and the towing and shipping industries as described

above effectively contribute to Planning Objective 1 and will be carried forward in the WOPC for all traffic scenarios. However, there are no additional operational and low-cost structural measures deemed appropriate at any of these facilities in the WOPC. The lockage policies during high water are expected to remain in effect throughout the planning period.

Additional permanent tow-haulage units are not considered appropriate at the 56' x 360' auxiliaries at Emsworth, Dashields, and Montgomery. These chambers can only lock one or two barges at a time and often times (during main chamber closures) tows require more than two cuts. During those times, industry self-help is much quicker than tow haulage. Further, as queues quickly develop, there is usually a steady supply of helper boats. Portable units could still be used as needed at these small locks.

The currently available mooring cells upstream and downstream of Emsworth, Dashields, and Montgomery are sufficient to serve available tows at most times, with the possible exception of very extended main chamber closures when long delays could develop. Additional permanent mooring cells are not considered necessary. Temporary (spud barge) facilities may be set up as in the past if excessive delays are expected, particularly during extended closures of any main chamber.

Guide and guard wall extensions are not expected to reduce delays when the main chamber is closed at EDM for maintenance (and when interference between chambers is not a problem as only one chamber is operational). These extensions could address approach problems, but they do not address structural and stability problems with existing walls, so they were not carried forward as part of the WOPC.

To summarize, the **Table 4-14** lists the operational and low-cost structural measures included and dropped from the WOPC.

TABLE 4-14: WOPC Operational And Low-Cost Structural Measures Carried Forward or Dropped

Measures Carried Forward	
Operational	**Low-Cost Structural**
N-up/N-Down Lockage Policy	Existing Tow Haulage
Advanced Notice of Main Chamber Closures	Mooring Cells
Adjustment of Shipment Schedules by Industry	Temporary Mooring Facilities During Main Chamber Closures
Industry Self Help	
Measures Dropped From Analysis	
Operational	**Low-Cost Structural**
Additional Mooring Cells	Guide/Guard Wall Extensions
	Additional tow haulage units

4.5.2.2 Navigation WOPC Evaluation

Determination of the Without-Project Condition requires two iterations of economic evaluations. The first is a "baseline" condition where all structures and equipment are utilized and are not replaced until failure. This strategy uses a reactive maintenance policy and is called the Reactive Maintenance Alternative (RMA). The second run then considers scheduled replacements of components individually (except in the case of wall replacement where enclosed mechanical and electrical equipment would also be replaced). The WOPC would allow for replacement of all components that are economic and deemed reasonable given budgetary considerations. There is no non-structural alternative since all non-structural or low-cost structural measures not currently implemented were dropped from consideration.

4.5.2.2.1 Evaluation Methodology

The principal factors driving the costs and benefits of the WOPC are the traffic demands at each lock and the performance of critical lock components required to keep the chamber open. Traffic projections were discussed in **Section 4.4.1.2**. The hazard rates defined in **Section 4.4.3** are used to determine repair or replacement needs through use of the Ohio River Navigation Investment Model (ORNIM), developed by Oak Ridge National Laboratory, Oak Ridge, Tennessee, for the Corps of Engineers specifically for the evaluation of alternative Ohio River navigation system investments. This model consists of a suite of four modules that integrate economic, engineering and environmental considerations. NIM analyzes EDM as a system model used to keep track of component performance and traffic interactions and in turn estimate the NED benefits and costs of all alternatives being evaluated, including the WOPC. NIM is used to determine tonnages of traffic served by each lock (i.e. the equilibrium traffic) from which system transportation rate savings are estimated for each alternative.

For a navigation project investment, NED benefits are composed primarily of the reductions in transportation costs attributable to the improved waterway system. The reduction in transportation costs is achieved through increased efficiency of existing waterway movements, shifts of waterway and overland traffic to more efficient modes and routes, and shifts to more efficient origin-destination combinations. Further benefits accrue from induced (new output/production) traffic that is transported only because of the lower transportation cost deriving from an improved project, and from creating or enhancing the potential for other productive uses of the waterway, such as the generation of hydropower. National defense benefits can also be realized from regional and national growth, and from diversity in transportation modes. In many situations, lower emissions can be achieved by transporting goods on the waterway. The "*... basic economic benefit of a navigation project is the reduction in the value of resources required to transport commodities*"[17] remains the conceptual basis of NED benefits for inland navigation.

Traditionally, this primary benefit for barge transportation is calculated as the cost savings for barge shipment over the long-run least costly all-overland alternative routing. This benefit estimation is referred to as the waterway transportation rate-savings, and it also accounts for any

[17] Planning Guidance Notebook, ER 1105-2-100, U.S. Army Corps of Engineers, 22 April 2000, page 6-55.

difference in transportation costs arising from loading, unloading, trans-loading, demurrage, and other activities involved in the ultimate point-to-point transportation of goods. A newer way to estimate this primary benefit is to define the movement willingness-to-pay for barge transportation with a demand curve (instead of the long-run least-costly all-overland rate) and then calculate a waterway transportation surplus (consumer surplus). Either way, the primary benefit for federal investment in commercially-navigable waterways (benefits with a plan as opposed to benefits without a plan) ends up as a transportation cost reduction. These reductions in transportation costs can be classified as:

- Cost Reduction Benefits – transportation cost savings that accrue to existing movements that move on the waterway under both With-Project Condition and Without-Project Condition, generated by a reduction in the economic cost of using the waterway. This can occur from reduced trip delays (expanded lock capacity and/or policies that reduce congestion) and/or increased shipping efficiencies (larger tow-size and/or heavier barge loadings).

- Shift-of-Mode Benefit – transportation cost savings accrue to movements that only move on the waterway under the With-Project Condition. These movements are transported on a different transportation mode at a higher cost under the Without-Project Condition; the benefit is the difference between the costs of using the alternative mode without the project and the costs of using the waterway with the alternative under consideration.

- Shift of Origin-Destination Benefit – This type of benefit accrues if the project results in a shift in the origin of a commodity. The benefit is the difference in total costs of getting the commodity to its place of consumption with and without the project. If a project results in a shift in the destination of a commodity, the benefit is the difference in net revenue to the producer with and without the project. The shift of origin-destination benefit cannot exceed the reduction in the transportation charges achieved by the project.

- Induced Movements Benefit – This type of benefit applies if a commodity or additional quantities of a commodity are transported only because of lowered transportation charge with the project. The quantities are limited to increases in production and consumption resulting from lower transportation costs. An increase in waterway shipments resulting from a shift in origin or destination is not included. The new movement benefit is defined as the increase in producer and consumer surplus; practically, it can be measured as the delivered price of the commodity less all associated economic costs, including all of the costs of barge transportation other than those of the navigation project. This benefit cannot exceed the reduction in the transportation charges achieved by the project.

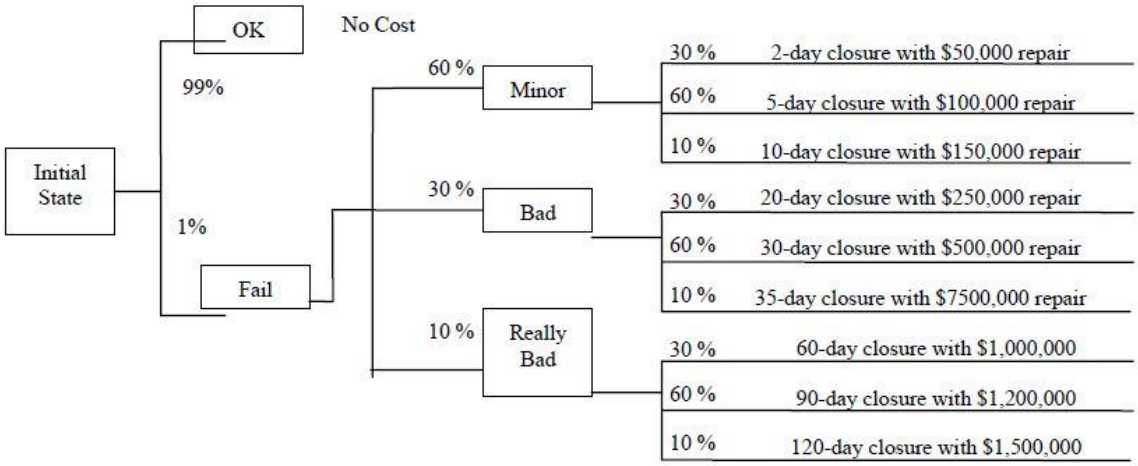
The Reactive Maintenance Alternative (RMA) defers all repairs and replacement of critical components until after failure, or reacts after component failure. The key outputs of the economic analysis of this alternative are the costs due to unexpected failures of the major components, both to repair or replace the failed component and the associated lock chamber closure times and associated navigation delay costs directly attributable to the closures. The critical inputs to this analysis are the hazard rates for each component, where a hazard rate for a given year is defined as the probability of failure during a given year assuming that no failure

had occurred up to the beginning of the year, the potential failure scenarios and their likelihoods (given that a failure occurs), and the economic consequences associated with those scenarios.

All reliability models are developed to look at "significant" levels of failure that result in closure of a chamber and have an effect in the overall economic evaluation. For example, modeling of fuses in an overall electrical system is not warranted because their failure is not a major consequence in terms of money or safety. However, electrical power controls are modeled because their failure can have a major impact on both navigation and replacement costs. This same process is applied to all major components analyzed using reliability methods. The reliability models attempt to address failure mechanisms that are not addressed by routine maintenance, such as fatigue life and loss of strength due to corrosion. Therefore, it is assumed that overall reliability of major components such as miter gates and culvert valves are not significantly affected by routine or cyclical maintenance. Such maintenance helps to keep gates aligned and in proper working order but it does not address issues such as fatigue life and corrosion. For more details on how the reliability results are incorporated into the economic models refer to Section 7 of the **Economics Appendix**.

The basic economic evaluation process for the reactive maintenance Without-Project Condition to account for costs of potential component failures can be represented by a repair "event tree" as shown in **Figure 4-4**. The probability of <u>any</u> failure for year (t) is given by the hazard rate, 1% in this case. Conversely, the probability that there are no failures in year (t) is given by one minus the hazard rate, or 99% here. The potential degrees of failure (noted as Minor, Bad and Really Bad in this illustration) and the necessary repair cost and associated chamber closure requirements are assigned probabilities based upon engineering judgment.

FIGURE 4-4: Example Event Tree



Consequences include both repair costs and additional delay costs incurred by the shipping and the towing industries. The added delay costs in turn depend upon the traffic demand at the affected facility. In this example, there are three possible repair options for each degree of

failure. In the event tree below, repairs to address a minor failure of the component would cost between $50,000 and $150,000 and involve a lock closure of between 2 and 10 days. The worst failure mode would cost between $1.0 and $1.5 million and involve a lock closure of between 60 and 120 days. The added navigation delay costs are not shown but would be added to the repair cost for each outcome based on the traffic demand and associated lock closure. Event trees for all components are displayed in the **Engineering Appendix**.

Several assumptions and information affecting development of the repair strategy and consequence computation/consideration that was considered in the event tree development includes:

1. When the main chamber is closed to navigation for any of the event tree repair scenarios described, all navigation traffic must go through the auxiliary chamber. The opposite is assumed to any scenarios for the auxiliary chamber. When a failure occurs to the middle wall, both the main and auxiliary chamber are closed all navigation traffic; essentially a total river closure occurs.
2. The total consequences is the summation of the repair costs, and the delay costs imposed on the navigation industry. It is assumed the delay costs imposed on the navigation industry will account for the vast majority of the total consequence cost.
3. The repaired or replaced wall section are constructed in accordance with the latest construction procedures, practices and industry standards, but not constructed to the latest Corps design standards because the lock walls could not get larger or wider unless new modernized locks are built a different location than directly within the footprint of the exiting walls. The walls are essentially replacements-in-kind. In addition upgrades (i.e. floating mooring bitts, different type of filling/emptying system, different type of miter gates etc) to the locks are not included.
4. Scheduled conditions assumes that planned engineering and construction contracts are started in order to acquire long lead time and critical features prior to the scheduled shutdown of the chamber. This will minimize the closure duration.

The RMA also includes all maintenance and operational measures retained.

4.5.2.2.2 Evaluation of Reactive Maintenance Alternative

The reactive maintenance plan was evaluated using NIM to estimate the Federal costs to keep the projects operating and the associated navigation benefits for all traffic scenarios. ORNIM uses engineering reliability data to predict emergency repair/replacement closures on an average annual basis. These unscheduled closures reduce system capacity and cause navigation delays that reduce system transportation rate savings by increasing waterway costs. Costs are segregated into the maintenance categories discussed above. The navigation delay costs generated during lock closures due to cyclic scheduled maintenance and unscheduled component failures are also tabulated.

Upper Ohio System Costs

NIM was run to estimate expected annual Federal costs to operate and maintain EDM under a fix-as-fails or reactive maintenance scenario. The average annual expected Federal cost at EDM from 2012-2068 is $37.4 million. **Table 4-15** displays the expected annual Federal costs at EDM from reactive maintenance broken out into improvement costs, scheduled repair costs, unscheduled repair costs, random minor maintenance costs and normal O&M costs. There are no scheduled improvement plans at EDM under the reactive maintenance scenario. Scheduled repair costs include periodic maintenance inspections. Unscheduled repair costs utilize engineering reliability data. Random minor costs are taken from operations data, and normal O&M is the "fixed" cost of operating the project independent of the project passing traffic, i.e. overhead.

TABLE 4-15: Annual Federal Costs at EDM, Reactive Maintenance (2012-2068, 4 1/8%, October 2009, $ Million)

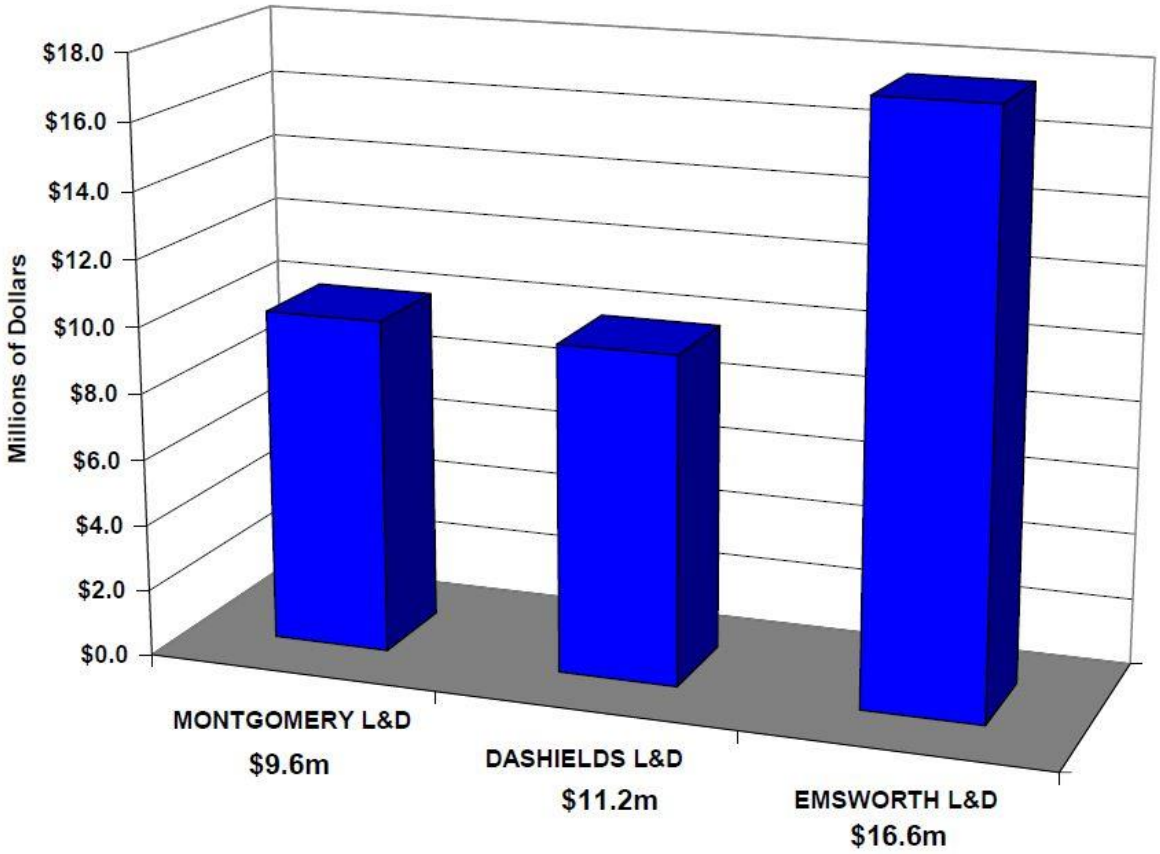
Cost Category	Annual Federal Cost
Scheduled Lock Improvement	---
Scheduled Repair	$ 8.4
Unscheduled Repair	$20.2
Normal O&M	$ 8.0
Random Minor	$ 0.8
Total Costs	**$37.4**

Scheduled maintenance is for mechanical and electrical equipment only. Due to the extremely high costs to repair wall failures, almost all of the unscheduled repair cost is associated with the walls. The scheduled lock maintenance and unscheduled lock repair costs comprise 77 percent of the total annual Federal cost at these projects and represent potential cost savings that can be realized with a more proactive maintenance strategy or new lock construction, options that will be considered later in With-Project Alternatives.

The Corps is authorized by Congress to provide efficient navigation on the Ohio River. Reactive maintenance would result in more frequent unscheduled component failures and lock closures than proactive maintenance where the intent is to replace components prior to failure. Work under scheduled conditions would be less costly and entail shorter lock chamber closures than analogous work after a failure. Therefore, a proactive maintenance would provide ample opportunity for maintenance improvements, upon which all stakeholders depend.

Figure 4-5 displays the contribution of average annual Federal costs for a reactive maintenance strategy at each facility. The increased costs at Emsworth are due to higher unscheduled repair costs and reflect poorer reliability than the other two facilities.

FIGURE 4-5: Average Annual Federal Costs – EDM Reactive Maintenance Plan (2012-2068, 4 1/8%, October 2009, $ Million)

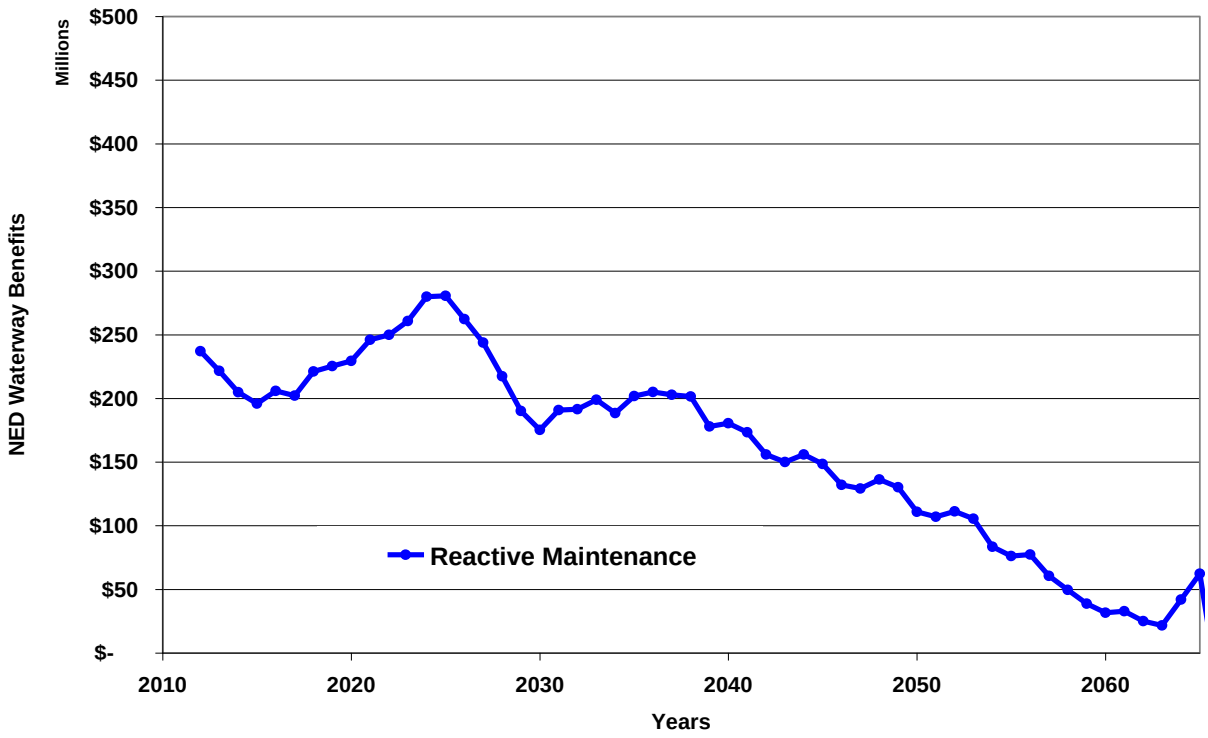


Upper Ohio System Benefits

The primary benefit for Federal investment in the inland waterways is the collective transportation savings for barge shipment over the least-costly alternative routing. The benefit is referred to as the transportation surplus. Corps regulations recognize transportation savings or cost reduction as a National Economic Development (NED) benefit. NED benefits are calculated from equilibrium waterway traffic transportation savings net of any reduced transportation savings from congestion or delay due to scheduled or unscheduled repair closures.

Figure 4-6 displays Upper Ohio NED waterway transportation savings for the reactive maintenance strategy. Annual savings are $ 142.7 million – using a 4.125 percent interest rate and a 2018 base year.

FIGURE 4-6: NED Waterway Benefits – EDM Reactive Maintenance Plan (Mid Forecast)



System Economics – Reactive Maintenance

Table 4-16 summarizes average annual system waterway benefits and costs for a reactive maintenance strategy at EDM for the mid forecast scenario. Total system benefits are equilibrium waterway transportation surplus net of any transportation losses from unscheduled repair closures and external costs of diverted traffic. The Base Waterway Transportation Surplus is the consumer surplus (savings) that would be realized by shippers under the normal operation of the waterway if there were no scheduled or unscheduled closures. Reductions to this surplus due to scheduled and unscheduled closures are itemized separately. While scheduled maintenance closures reduce system transportation surplus (benefits), the overwhelming benefit loss comes from unscheduled closure impacts. Unscheduled closures cause increased lock transit times (delays) and caused some traffic to divert to a more costly short-run land diversion cost. These unscheduled traffic diversions have also been identified to have externality costs (see Attachment 5 of the Economics Appendix). Externalities are effects of existing or proposed projects that are not normally evaluated as standard economic and environmental effects. Externalities evaluated for this study include roadway congestion, fuel usage, accident, air pollution, and employment. While increased delay costs from unscheduled closures are significant, the higher short-term land transportation rates cause the greatest reduction to system

benefits. The externality costs incurred during unscheduled closures due primarily to inefficient truck trips through congested areas are relatively insignificant.

TABLE 4-16: Average Annual Costs and Benefits, EDM Reactive Maintenance Mid Forecast (2012-2068, 4 1/8%, October 2009, $ Million)

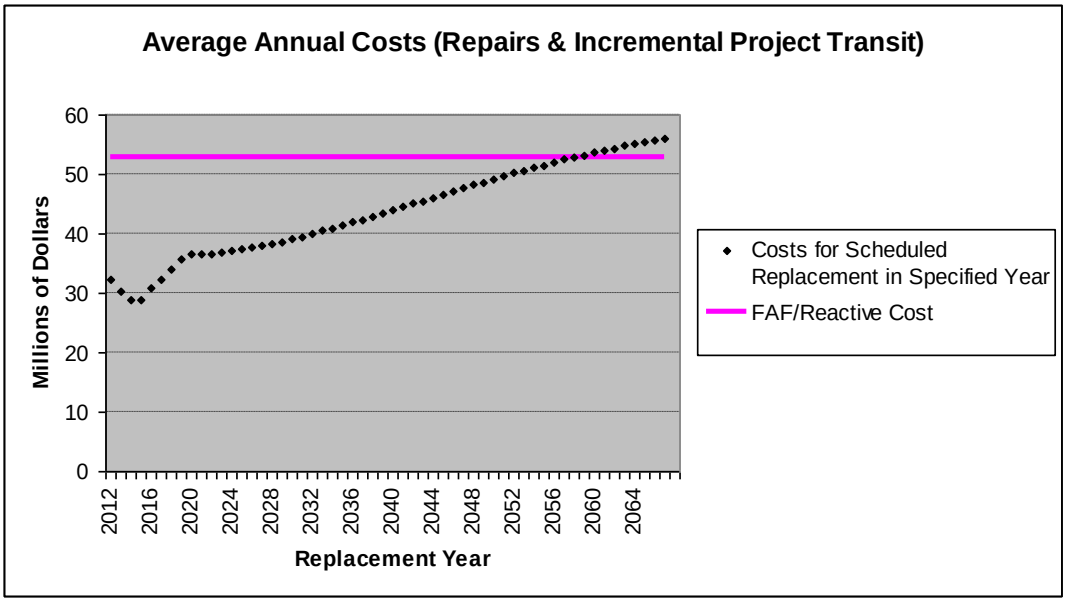
Upper Ohio System - EDM	Average Annual
New Lock with Fix as Fails (FAF) Benefits	
Base Waterway Transportation Surplus (full operations)	$475.0
Reduced Surplus from Scheduled Closures	-$23.6
Land transportation costs Incurred from Unscheduled diversions	-$209.3
Reduced Surplus from Unscheduled Closures	-$95.8
Externality Costs Incurred	-$3.6
Total System Benefits	$142.7
New Lock with FAF Costs	
Scheduled Lock Improvements	$0.0
Scheduled Lock Maintenance	$8.4
Unscheduled Lock Repair	$20.2
Normal O&M	$8.0
Random Minor	$0.8
Total System Costs	$37.4
Net Benefits	$105.3
BCR	**3.8**

Total system costs are the expected annual expenditures needed to maintain upper Ohio navigation infrastructure under the reactive maintenance strategy. These costs represent the costs to the Federal government to maintain, repair, or improve the waterway system under the reactive maintenance policy. Scheduled capital improvement costs are shared 50-50 with the Inland Waterways Trust Fund (IWTF). There are no scheduled improvement costs in reactive maintenance. Scheduled maintenance costs are what the Federal government pays for the periodic maintenance of EDM. Unscheduled repair costs are the Federal costs associated with the unscheduled repair of lock components. Normal O&M is the day-to-day recurring cost to staff and supply the project regardless of the project's ability to accommodate any traffic – things like on-site labor, utility costs, cutting grass, etc. Random minor costs mostly involve lock testing. Annual system benefits are $142.7 million. Annual system costs under reactive maintenance are estimated at $37.4 million. Annual net benefits are $105.3 million. This shows the expected value (benefit) of the existing upper Ohio infrastructure with a reactive maintenance strategy.

4.5.2.2.3 Determination of Economically Justified Components

Each component was analyzed separately to determine if a scheduled replacement would be more efficient than the reactive maintenance strategy and, if it is, the optimal timing. To help explain the process, the results of the evaluation for the Emsworth middle wall are shown in **Figure 4-7**.

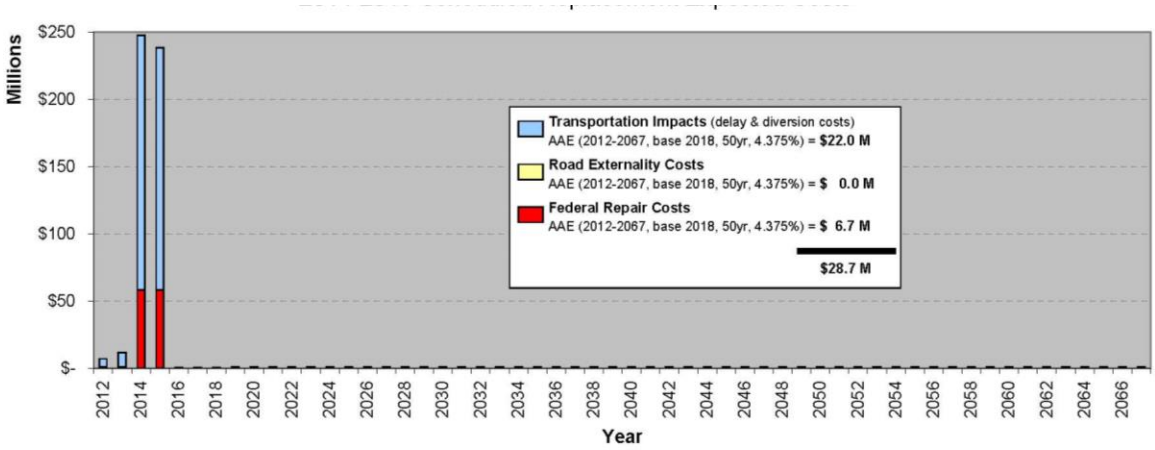
FIGURE 4-7: Emsworth Middle Wall Scheduled Replacement Analysis



The horizontal line at approximately $52.8 million is the annualized cost of maintaining the Emsworth middle wall with no scheduled replacement (i.e. fix-as-fails), and includes both the annualized repair and transportation impact costs. The repair cost is included in the unscheduled lock repair tabulation and transportation impacts are included in the namesake category in **Table 4-16**. The costs for scheduled replacement in **Figure 4-7** are minimized in the year 2014 at approximately $28.7 million, a 45 percent savings over fix-as-fails for this component. The costs related to this scheduled replacement are shown in **Figure 4-8**.

Repair costs and associated transportation impact costs associated with replacement in 2014 are incurred during 2014 and 2015. Costs in years 2012 and 2013 are residual risks of wall failure in those years prior to the scheduled repair.

FIGURE 4-8: Emsworth Middle Wall Scheduled Replacement In 2014 and 2015 Expected Costs



This same analysis was performed for all components studied with reliability and for each traffic scenario. The final optimal timings for replacement of all components for each traffic forecast are shown in **Tables 4-17, 4-18, and 4-19**.

TABLE 4-17: Economically Optimal Component Replacements, Low Forecast

Chamber / Component	Upper Ohio Project		
	Emsworth	Dashields	Montgomery
MAIN			
Gates	2014	RM	2014
Gate Machinery	2015	2015	2015
Hydraulic	2014	2015	2014
Valve Machinery	-----	2015	2015
Mid Wall Fill Valves	2015	-----	-----
Mid Wall MT Valves	2015	-----	-----
Electrical	2015	2015	2015
Land Wall	2014	2014	2014
Guide Wall	2014	RM	-----
Middle Wall	2015	2015	2015
AUXILIARY			
Gate Machinery	RM	RM	RM
Hydraulic	RM	RM	RM
Valve Machinery	-----	RM	RM
River Fill Valves	2034	-----	-----
River MT Valves	2040	-----	-----
Electrical	RM	RM	RM
River Wall	-----	-----	RM
Guard Wall	-----	RM	-----

TABLE 4-18: Economically Optimal Component Replacements, Mid Forecast

Chamber / Component	Upper Ohio Project		
	Emsworth	Dashields	Montgomery
MAIN			
Gates	2012	RM	2014
Gate Machinery	2015	2015	2015
Hydraulic	2012	2015	2012
Valve Machinery	-----	2015	2015
Mid Wall Fill Valves	2030	-----	-----
Mid Wall MT Valves	2014	-----	-----
Electrical	2012	2015	2012
Land Wall	2014	2014	2014
Guide Wall	2013	RM	-----
Middle Wall	2015	2015	2015
AUXILIARY			
Gate Machinery	RM	RM	RM
Hydraulic	RM	RM	RM
Valve Machinery	-----	RM	RM
River Fill Valves	2034	-----	-----
River MT Valves	2040	-----	-----
Electrical	RM	RM	RM
River Wall	-----	-----	RM
Guard Wall	-----	RM	-----

TABLE 4-19: Economically Optimal Component Replacements, High Forecast

Chamber / Component	Upper Ohio Project		
	Emsworth	Dashields	Montgomery
MAIN			
Gates	2023	RM	2021
Gate Machinery	2021	2021	2013
Hydraulic	2020	2022	2020
Valve Machinery	-----	2020	2019
Mid Wall Fill Valves	2022	-----	-----
Mid Wall MT Valves	RM	-----	-----
Electrical	2019	2012	2012
Land Wall	2016	2017	2016
Guide Wall	2014	2013	-----
Middle Wall	2012	2015	2014
AUXILIARY			
Gate Machinery	RM	RM	2068
Hydraulic	RM	RM	2064
Valve Machinery	-----	RM	2067
River Fill Valves	2035	-----	-----
River MT Valves	2040	-----	-----
Electrical	RM	RM	2029
River Wall	-----	-----	RM
Guard Wall	-----	2035	-----

Components for which no scheduled replacement would have a lower cost than reactive maintenance are noted as "RM." Components with gray highlight indicate that they were deemed reliable throughout the analysis period (i.e. have a negligible chance of failure) and therefore do not require any replacement.

4.5.2.3 Navigation WOPC Identified

The optimal replacement dates for the land, middle, and guide walls at each facility dramatically demonstrate that the most economically efficient strategy involves systematic replacement of almost every wall forming the main chambers at each site and Emsworth's guide walls. Scheduling the replacement of any one of these walls probably would be much more costly and require lock chamber or project closures that far exceed that required for any major rehabilitation ever undertaken by the Corps. It is not realistic to expect that these replacements, costing over $1 billion, would be part of the WOPC and represent the most likely future condition without a Federally authorized project. Additional authorization would be required to support this costly reconstruction strategy. **Therefore, the WOPC for the Upper Ohio River Study does not include any scheduled replacements and is represented by the Reactive Maintenance Alternative Plan.** Components would be replaced on an as-need basis only after failure. Lock sizes and locations of all chambers would remain the same. All of these components would be appropriate for the Advanced Maintenance Alternative to be discussed as a With-Project Alternative .

4.5.3 Ecosystem WOPC

The future Without-Project environmental condition will be essentially the same as present under normal operating conditions. Continued operation of the facilities in their historic configuration would retain the secondary beneficial aspects of their operation, including water supply, reaeration, and recreation. On the other hand, it would prolong the historic ecosystem impacts attributed to the navigation system such as altered flow patterns, degraded aquatic habitat, and loss of riverine connectivity.

However, the navigation WOPC carries with it the increasing likelihood of extended lock closures for reactive maintenance, and even the possibility of loss of pool from lock wall failure. The prolonged closure of a main chamber would produce tow queuing impacts to aquatic habitat due to lockage delays through auxiliary chambers and could lead to diversion to overland traffic and its attendant impacts. Loss of pool would necessitate the diversion to overland traffic, and would also have severe consequences to the pool's aquatic life and the regional's water supply. Since the Corps will take every reasonable precaution to avoid pool loss, and to restore the pool as quickly as possible if it were lost, the likelihood of this occurrence is remote and its impact highly difficult to forecast.

4.6 Future With-Project Navigation Alternative Plans

Navigation With-Project Condition (WPC) alternatives must be formulated to address the remaining problems in the WOPC. In effect, WPC alternatives are formulated using a stepwise approach that optimizes increasingly more aggressive maintenance policies and culminating with new lock investments at Emsworth, Dashields, and Montgomery.

The purpose of a U. S. Army Corps of Engineers planning analysis "*... is to estimate changes in national economic development that occur as a result of differences in project outputs with a plan, as opposed to national economic development without a plan*"[18]. This is accomplished through a federally mandated National Economic Development (NED) analysis which is "*... generally defined as an economic cost-benefit analysis for plan formulation, evaluation, and selection that is used to evaluate the federal interest in pursuing a prospective project plan.*"[19] NED benefits are defined as "*... increases in the net value of the national output of goods and services, expressed in monetary units ...*" Benefit categories are as discussed for the WOPC.

With-Project Condition formulation of alternatives for this study can be grouped in two stages. The first considers higher cost maintenance over that allowed for in the WOPC for the existing locks deemed too costly for the WOPC. Advanced maintenance of critical components would increase the reliability of these locks. The best plan resulting from the formulation and evaluation of plans in this stage is the most efficient strategy for operating and maintaining the Upper Ohio navigation system with existing lock sizes. The second stage includes options to construct new and possibly larger locks that would increase reliability and capacity, these are included in the formulation of Lock Modernization Alternative plans. With project plans will be evaluated in order of increasing investment to facilitate economic analysis and to demonstrate the incremental effectiveness of more costly investments.

With-Project Condition plans that address the navigation problems will be formulated and evaluated in order to identify the National Economic Development (NED) Plan. Plans that address both navigation and ecosystem problems and opportunities will then be formulated and evaluated. The best plan addressing both types of problems and opportunities, called combined plans, will be identified. The last step is to compare the best combined plans and to recommend a plan for implementation. The evaluation of plans involving both navigation and ecosystem measures will be based on the degree of interdependence or degree of trade-off involving any lost navigation benefits with increased ecosystem benefits in the combined plan. Traffic projections for all possible WPC plans are not expected to vary significantly from the WOPC projections, therefore the scenarios and projections in **Table 4-7** will apply to the WPC analyses.

4.6.1 General Evaluation Methodology and Guidelines

The primary guidance document that sets out principals and procedures for evaluating federal interest is the *Principles and Guidelines* (P&G). Corps guidance for implementing P&G is found in the *Planning Guidance Notebook*[20] with additional discussions of NED analysis documented in the *National Economic Development Procedures Overview Manual*[21]. For inland navigation analysis, the focus is on the evaluation and comparison of the existing waterway

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[18] Planning Manual, IWR Report 96-R-21, U.S. Army Corps of Engineers, November 1996, page 56.

[19] National Economic Development Procedures Manual Overview, IWR Report 09-R-2, U.S. Army Corps of Engineers, June 2009, page 1.

[20] Planning Guidance Notebook, ER 1105-2-100, U.S. Army Corps of Engineers, 22 April 2000.

[21] National Economic Development Procedures Manual Overview, IWR Report 09-R-2, U.S. Army Corps of Engineers, June 2009.

system with three basic alternative measures: 1) increase capacity (decrease transit times and thereby reduce delay costs); 2) increase reliability (replace or rehabilitate aging structures, thereby reduce the probability of structural failure and its consequences); and /or 3) reduce demand (e.g. congestion fees). The P&G provides general guidance for doing the benefit assessment, but leaves open opportunities to improve the analytical tools used as new data and computational capabilities are developed.

A broad range of improvement measures are identified to address navigation concerns at EDM remaining in the navigation WOPC. All options that have practical application, reasonable development costs and significant beneficial economic effects were carried forward for more detailed evaluations. The detailed evaluations considered navigation benefits and associated environmental or ecosystem impacts. Alternatives are developed by layering improvement measures at each project through time after assessing the system-wide benefits and costs.

As with the WOPC, maintenance, operational efficiency and low-cost structural measures are identified, except that options may now include investment decisions involving proactive maintenance. The last type of measure is capacity-increasing improvements at all locks and dams, including lock extensions and new locks, for which Congressional Authorization would be required for implementation. Measures are evaluated to determine those to be carried further to formulate alternatives. After an initial formulation of alternatives, a preliminary evaluation of those alternatives involving larger locks is conducted to determine the final array to carry forward for detailed analysis.

The established framework for the economic evaluation of alternative plans is described in the Principles and Guidelines. Estimating the contributions to National Economic Development (NED) benefits is accomplished by comparing With-Project and the WOPC plans to determine the incremental benefits or disbenefits of the WPC.

4.6.2 Continued Operation of the Upper Ohio River System

The study area has changed significantly since the construction of the Ohio River Navigation System nearly one hundred years ago. What began as an area dominated by coal and steel production, which used the system for water supply and transportation, has evolved into an area whose economy is largely dependent on the provision of health care and education. The latter are obviously less dependent on the existence of a waterway transportation system than are steel and coal production. The question then becomes whether continued maintenance of the navigation system is warranted given the potentially large investment that will be needed to modernize the aged projects.

Navigation impacts within the Upper Ohio study area are largely dependent upon developments in the coal market, which in turn depend on developments in the electric generating industry. This is the area of highest uncertainty and volatility which could result in significant increases or decreases in the volume of barge traffic. Due to concerns over global warming, it is the objective of many decision makers in the area of electric generation to minimize the use of coal-fired plants and increase ‘green’ and gas-fired plants. The effects on barge transportation of coal could be negative and greatly diminish the utility of the waterborne transportation system.

Many government and private entities have analyzed the situation in detail and are generally in agreement that coal will continue to be a significant player in the electric generating market for two reasons: 1) it is cost competitive; and 2) it is reliable in the sense that it can produce electricity when needed, and not just when the wind blows or the sun shines. The 2009 forecasts by the Department of Energy (DOE) are for an 0.8 percent annual increase in electricity demands and an annual increase in coal-fired generation of 0.7 percent, or nearly the same. Specific projections of the location of additional coal-fired capacity is not readily available, but the recent pattern has been to construct additional capacity at or near existing capacity to minimize community opposition and to take advantage of existing transmission lines. This would mean that much of the additional capacity in the region would be located along the navigation system.

The DOE also forecasts an annual increase in Northern Appalachian coal production of 1.9 percent, which reflects the adequacy of the area's coal deposits to not only sustain but increase their share of the steam coal market. It would appear, therefore, that increases in steam coal shipments on the Upper Ohio could reasonably range between 0.7 percent and 1.9 percent a year, given DOE forecasts of annual growth in coal-fired generation and Northern Appalachian coal production. Since steam coal accounts for about one-half of Upper Ohio tonnage, this equates to a growth rate of 0.35 percent and 0.95 percent annually even with no growth in other traffic. However, one reason for the projected growth in Northern Appalachian coal usage is increased demand from power plants installing scrubbing units. Scrubbing units also require significant volumes of lime/limestone in an amount equal to between 5 percent and 15 percent of coal consumption and the possible increase in traffic to between 0.5 percent and 1.0 percent annually.

Of course, there are a host of other factors that determine traffic levels, and these were considered in the analysis documented in the **Economics Appendix**. The data indicate that the waterway system remains an important element in the economy of the study area, despite the closure of the area's steel industry and the disfavor of coal-fired electricity generation. Therefore, this study was conducted within the basic premise that the Upper Ohio Navigation System will be maintained for the foreseeable future.

4.6.3 Measures Considered and Carried Forward, Navigation WPC

4.6.3.1 Maintenance

All maintenance, low-cost structural, and operational efficiency measures considered for the Fix-as-Fails (Reactive Maintenance) alternative (WOPC), namely routine maintenance, cyclical maintenance, unscheduled repair of failed components, and scheduled replacement of individual components, will also be assessed in the formulation of WPC plans.

Major Rehabilitation has been shown to be effective in prolonging the useful life of ORS locks and dams and will be carried forward for formulation of WPC alternatives. However, there are restrictions on viable rehabilitations at these three projects. Due to the poor condition of the lock walls at each of these projects, a complex major rehabilitation strategy is required. The basic principle of major rehabilitation is to restore reliability or modernize while maintaining essentially the same lock capacity.

The other measures screened from the WOPC analysis, additional mooring cells and guard and guide wall extensions, are not expected to be useful as stand-alone measures. They will be considered, however, for implementation along with the lock modernization measures, either as permanent or temporary (during construction) measures.

4.6.3.1.1 Assessment of Maintenance Measures

All operational and low-cost structural measures carried forward for the WOPC alternative due to their proven effectiveness would also be beneficial in WPC alternatives and therefore are retained for evaluation in the WPC. Guide and guard wall extensions are dropped from consideration as a stand-alone WPC measure as problems with the existing walls are not addressed. However, this measure would be considered for inclusion with advanced maintenance (i.e. replacement) of those walls. Traffic scheduling by the Corps is not considered appropriate for the same reasons described for the WOPC.

Component Replacements Not Included in WOPC

None of the economically justified component replacements are included in the WOPC. Therefore the Advanced Maintenance Alternative comprises all of these replacements shown in **Tables 4-17, 4-18, & 4-19.**

Major Rehabilitation

Preliminary assessment of major rehabilitation involving in-kind wall replacement (in their original footprint) at these three facilities determined that such work is implementable; however it would be extremely costly and require multiple years of lock or river closures. Navigation impacts would be minimized if work at all three sites were conducted simultaneously and sufficient funding provided to minimize work durations. Work could be staged to involve work on the land walls first, closing the land chambers, and then the middle walls which would prevent any navigation through these three facilities. The minimum durations of total closure would therefore be approximately 2.5 years for the land chambers and 2.0 years of no traffic or river closure if all work was performed concurrently. If done sequentially, the best case durations would multiplied by a factor of three. In any case, the added costs to industry even in the best case scenario, which can also be viewed as lost navigation benefits, would amount to hundreds of millions of dollars. Construction costs would approximate those of new lock alternatives not constrained to existing footprints (discussed in Section 4.6.3.3.1). The District performed a low-level analysis and confirmed the economic inferiority of this measure to the new lock construction. This measure is therefore eliminated from consideration as a WPC measure.

Maintenance measures carried further and those dropped from the analysis are shown in **Table 4-20.**

TABLE 4-20: WPC Maintenance Measures Carried Forward or Dropped

Maintenance Measures Carried Forward in WPC
Routine Maintenance
Cyclical Maintenance
Unscheduled Repairs
Scheduled Component Replacements
Maintenance Measures Dropped From Consideration in WPC
Major Rehabilitation

4.6.3.2 Operational and Low-Cost Structural Measures

All operational efficiency measures currently implemented and carried forward for the WOPC will also be considered for the WPC. These measures include N-up/N-down lockage policy, helper boats operated by industry, coordination between the Corps and industry prior to any extended main chamber closure, existing tow haulage units and mooring cells, industry adjustments during main chamber closures, and various other miscellaneous measures. Two additional measures not currently implemented are considered for WPC plans that are classified as "demand management" measures, congestion fees and Corps-imposed traffic scheduling. As cited by the Transportation Research Board's Committee for the Study of Freight Capacity for the Next Century, traffic demand management is a means of forestalling expensive capital investments as these policies encourage shippers to shift to other arrival schedule, route, mode and/or product source options. Demand management measures could therefore reduce system delays. These measures are summarized below.

4.6.3.2.1 Congestion Fees

Under ordinary circumstances in navigation studies, a nonstructural with-project alternative to lock replacement in the form of a lock congestion fee is considered and evaluated. Since this measure would require additional congressional authorization, it is categorized as a with-project alternative. This measure calls for the management of traffic demand at a lock through the imposition of a lockage fee. This fee is designed to influence the shipper with very marginal waterway savings to shift their traffic to an alternate overland mode, thereby reducing the amount of lock congestion and increasing the rate savings of the remaining shippers. The fee would thus serve as a device for rationing lock use to the movements with the highest marginal rate savings. The result would be to increase total rate savings net of delay costs for shippers that remain on the system. The congestion fee alternative typically includes the use of helper boats at a lock, when justified.

4.6.3.2.2 Corps-Imposed Tow Scheduling

Price-related traffic demand management measures are not currently used on the mainstem. Corps-imposed tow scheduling is one example. Locks nearing their practical capacity limits can benefit from a traffic-scheduling program that assigns tow arrival times. The goal of such a scheduling program is to reduce delays and their associated costs. Using lock scheduling to

reduce delays that occur due to random arrivals during the normal course of using the Ohio River mainstem is not currently practiced and is generally opposed to by the shipping industry.

4.6.3.2.3 Assessment of Operational and Low-Cost Structural Measures

All operational and low-cost structural measures carried forward for the WOPC alternative due to their proven effectiveness in contributing to Planning Objective 1would also be beneficial in WPC alternatives and therefore are retained for evaluation in the WPC. Guide and guard wall extensions are dropped from consideration as a standalone WPC measure as problems with the existing walls are not addressed. However, this measure would be considered for inclusion with new lock construction. Traffic scheduling is also dropped for the same reasons described for the WOPC.

Congestion Fees

As the name implies, a congestion fee is designed to relieve congestion at a lock(s) by diverting the marginal movements and thereby increasing the sum of all benefits to remaining traffic. In the case of Emsworth, Dashields and Montgomery, traffic has remained essentially flat for more than 30 years and traffic has been well below project capacities. Congestion at these facilities has not been problematic except in instances of main chamber closures, when all traffic is forced to use the smaller auxiliary chambers. Furthermore, it is considered unlikely that future traffic will approach levels that would make congestion fees an attractive alternative.

Another, more salient issue is that the imposition of congestion fees does nothing to address the main chamber condition and reliability problems identified previously or the auxiliary lock capacity problem when the main chamber is down. In the final analysis, only structural alternatives are capable of addressing these problems. For these reasons, an evaluation of a congestion fee alternative to a structural plan was not undertaken.

Corps-Imposed Traffic Scheduling

Using lock scheduling to reduce delays that occur during the normal operation of the upper Ohio is not currently practiced and has not been evaluated. A preliminary research effort into the physical practicality and economic feasibility of lock scheduling was conducted during the Ohio River Mainstem System Study (2006). Its findings were inconclusive and further funding for this effort has ceased. It is therefore far from certain that this measure would effectively contribute to Planning Objective 1 and is dropped from further consideration.

Summary

None of the measures considered that are not currently implemented are retained in the WPC. **Table 4-21** summarizes the results of this assessment.

TABLE 4-21: WPC Operational And Low-Cost Structural Measures Carried Forward or Dropped

Measures Carried Forward	
Operational	**Low-Cost Structural**
N-up/N-Down Lockage Policy	Tow Haulage
Advanced Notice of Main Chamber Closures	Mooring Cells
Adjustment of Shipment Schedules by Industry	Temporary Mooring Facilities During Main Chamber Closures
Industry Self Help	
Measures Dropped From Analysis	
Operational	**Low-Cost Structural**
Traffic Scheduling	Guide/Guard Wall Extensions

4.6.3.3 Lock Modernization Measures

Lock modernization measures involve new lock construction either at new or existing sites, or the elimination of a facility. These measures have the potential to significantly increase the capacity of the Upper Ohio River navigation system.

4.6.3.3.1 New Locks at Existing Sites

Construction of one or two new and larger locks at any site could replace any of the existing small locks at EDM or small auxiliary locks at other sites to increase lock capacity. At any site, there are three options, replace either the land or river chamber or both chambers. The existing dams would be retained to the degree practical but would be shortened to accommodate a wider lock footprint. Any lost hydraulic capacity due to the shortened dam would need to be assessed.

4.6.3.3.2 Closure of Land Lock Chambers

This measure is called a “lock modernization” measure as it would be applied only in conjunction with the construction of a new river lock. It would involve closing (or decom-missioning) the old land chamber at any site retained after the new chamber is constructed. This would leave a single chamber to serve all traffic for the remainder of the analysis period. Two strategies are possible: a scheduled (i.e., planned) closure, or an unscheduled closure after a major failure such as a catastrophic wall failure.

4.6.3.3.3 Locks and Dams at New Sites

This measure would involve construction of a new project at a new site to replace either one or two existing locks and dams (facilities) and would address all problems at either one or two existing facilities. This measure will require that one new facility is completed before closure and removal of the existing facility(s). The movement of these facilities would involve pool changes over some distance of river.

4.6.3.3.4 Third Locks

This measure would involve the construction of a third lock, either landward of the land chamber or riverward of the river chamber. An additional lock chamber at any site would increase the capacity to process traffic and thereby reduce traffic delays.

4.6.3.3.5 Lock Extensions

This measure includes extensions of any of the lock chambers at EDM since they are all less than 1200' in length. Any lock extension would increase capacity and reduce overall transportation costs.

4.6.3.3.6 Facility Removal

This study considers the elimination of one of the three existing locks and dams in the Upper Ohio River study area. The April 1971 Replacement Report, cited in **Section 4.3**, identified Dashields Locks and Dam as the likely candidate for removal. This facility is the only fixed crest dam on the Ohio River and creates the shortest navigation pool on this river system.

4.6.3.3.7 Assessment of Lock Modernization Measures

Closure of Land Lock Chamber

As noted above, the land chamber must be retained until the river chamber is constructed to keep the river open. The question arises as to the need for the old 600' chamber after the new river chamber is constructed, especially in light of the potential need for spending up to $100 million to $200 million to make costly wall repairs. The major, if not only, benefit of this measure would be the reduction of operation and routine and cyclic maintenance costs and the avoidance of high repair costs to replace failed components as there would be fewer components to operate and maintain.

Although there would be some savings in maintenance costs due to fewer components to maintain, the importance of redundancy on the Upper Ohio River navigation system cannot be overstated. While the Corps maintains other single lock projects, there are important distinctions to draw between them and the Upper Ohio projects. There is no seasonality in traffic demand on the Upper Ohio. The EDM projects operate 365 days per year unlike the Upper Mississippi Locks, which are closed during the winter. The Upper Mississippi closures offer unconstrained opportunities for maintenance, repairs, and dewatering without impact to commercial navigation.

It is important to note that an additional new lock is authorized at five additional project sites along the Upper Mississippi system, recognizing the valuable insurance offered by redundancy. The EDM projects are high-lift structures with a filling and emptying system designed for navigation, unlike the multi-purpose, no-lift locks on the Gulf Intracoastal Waterway (GIWW) which are as much for flood control and saltwater intrusion as they are intended for navigation. The more complex designs of the EDM locks make them more vulnerable to longer-term outages for repairs than that of the GIWW. The GIWW includes multiple water routings which enable traffic an opportunity to remain on the water and route around lock outages. Furthermore, the EDM projects are positioned between the Monongahela River and the Ohio River mainstem, both of which are two-lock navigation systems. Converting the Upper Ohio projects from two

locks to one will depart from a time-tested standard system configuration, and under the high traffic projection scenario will create a traffic bottleneck between the two systems.

A reversion to a one-lock system on the Upper Ohio River would introduce significant public safety risk factors that have not been an issue with the two-lock system. The Port of Pittsburgh is nationally significant in terms of commercial and recreational traffic. In 2007, Emsworth Locks had the second-largest number of recreational lockages on the Ohio River. The ability to use the auxiliary chamber for the majority of the recreational lockages permits the separation of recreational and commercial traffic in approaches, minimizing interactions and potential collisions. The dynamics of this situation and potential for accidents would change significantly if only a single chamber were available. A hierarchy of lockage privileges regulates how traffic is processed, i.e., government vessels before excursion vessels before commercial vessels before recreational vessels. With two lock chambers, queuing and competition for lockages between commercial and recreational vessels can be segregated by chamber, minimizing safety risks in the approaches. With only a single chamber, recreational vessels queuing in the lock approach would have to yield upon arrival of any other higher priority vessel. The potential for accidents, particularly vessel accidents involving fatalities, will be significantly increased over historical conditions. The seriousness of this situation was recently exemplified by the 2009 collision of a barge and Duck tour boat in Philadelphia.

While this safety issue would essentially be localized to the three Upper Ohio facilities, an additional risk involving the District's Repair Fleet could have regional consequences affecting the District's entire navigation system. The District maintains more facilities than any other Corps District, with 23 locks and dams on the Allegheny, Monongahela, and Ohio Rivers. Eighteen of these are upstream and five are downstream from the Pittsburgh District's fleet, warehouse and repair shops (PEWARS) housed on Neville Island between Emsworth and Dashields Locks and Dams. If Emsworth and Dashields were reverted to single-lock projects, the closure of either would prevent the fleet from moving through that project to access other facilities. The closure of both, either through a combination of scheduled and unscheduled events or an accident, would paralyze the fleet altogether. Unlike commodities shipped on the river, the repair fleet cannot be transferred to alternative modes of transportation to respond to incidents, and the original purpose of providing a second chamber for emergencies remains valid. Between 1982 and 1999, there were a total of 76 vessel collisions/accidents at these three facilities. Although closures resulting from these events are usually of short duration, the potential for extended closures arises if major lock and dam components are damaged and the fleet is unable to respond. The 2006 barge accident at Montgomery Locks and Dam that severely damaged two dam gates would have resulted in the loss of pool were it not for an extended period of high river flow while the fleet installed emergency bulkheads.

Any restriction on the mobility of the repair fleet responding to unscheduled lock and dam failures or accidents increases the potential magnitude and duration of negative consequences. The three Upper Ohio projects represent critical links in the steady flow of coal to electric power plants and steel mills in the Pittsburgh metro region. The coal trade includes Pennsylvania, West Virginia, Virginia, and Ohio Valley coals moving from mines down river on the Ohio to basin power plants, as well as Appalachian coal moving inbound to the Pittsburgh region for blending.

Coal destined to the United States Steel Corporation's Mon Valley Works – Clairton Plant, the largest coking facility in North America, supports the nation's steel industry. These industries have small reserves that can quickly be depleted if the demand for their product increases quickly and significantly, e.g. electric power demands during heat waves. Interruptions to navigation complicate matters by restricting the companies' ability to restock coal and thus maintain production since alternative modes lack the capacity of the normal waterway system. The low-cost transportation offered by an efficient, reliable navigation system insures that these mines and mills continue to operate and provide important electric power, raw materials, finished products and jobs within the region and nation. Any interruption in the flow of coal traffic on the Upper Ohio impacts these vital industries and national security. A recent outage at Montgomery Locks resulted in additional costs exceeding $1 million per week to restore coal deliveries to Clairton.

Shutting down the river as a result of any closures of the Upper Ohio locks would force significant numbers of trucks and trains onto an already congested overland transportation network in the Pittsburgh metro area, at significant cost to the public in terms of increased pollution, traffic delays, accidents, etc. Even more severe economic and environmental consequences would result from an extended loss of pool, which would affect the large number of municipalities and industries that rely on the upper river pools for water supply and treated waste disposal. Queuing of commercial river traffic in response to an unscheduled lock closure would lead to potentially adverse impacts to environmentally sensitive tailwater areas. Avoidance of these impacts is one of the environmental benefits attributed to construction of a more reliable navigation system as recommended in the Ohio River Mainstem System Study.

Local industry representatives who routinely use the Upper Ohio locks have indicated in previous discussions that they would object to one-lock projects as failing to satisfy their requirements for safe and reliable navigation system on the Ohio River. A single lock at each of these three locations is perceived as creating an operational bottleneck between projects upstream (Monongahela River Navigation System) and downstream that have two longer chambers. Upstream-bound tows configured for 1200' locks below Montgomery must refleet for sake of efficiency into packages that can negotiate a 600' chamber in a single lockage. However, with twin 600' chambers, 1200' tows would have the option of using both simultaneously for a more efficient double lockage. The lack of 1200' chambers and reversion to single-lock facilities are both perceived as detrimental to the regional economic competitiveness of southwestern Pennsylvania, the second largest inland port region in the country. A second chamber also provides flexibility for scheduling maintenance activities.

Reducing the number of chambers at EDM would also be contrary to on-going initiatives in the Pittsburgh area to enhance the ability of the navigation system to serve the navigation industry. The Corps Institute for Water Resources and Engineering Research and Development Center are trying to locate the necessary funds to install an Automated Information System in this area similar to the system currently being tested in New Orleans. That system is capable of electronically recording information at locks and vessel locations in the New Orleans area. These systems promise to improve the accuracy of data collected and, through their tracking capabilities, enhance the safety of vessel operation in the vicinity of the locks. Vessel queues

and order will be known at a much greater distance from our lock projects and the current practice of passing tows to get to the lock first will be unnecessary. The result of this technology (used in Europe already) will be increased safety, security, greater fuel efficiency, and reduced emissions.

The measure to decommission any land chamber at any time therefore does not adequately address the safety and reliability aspects of Planning Objective 1 and is dropped from consideration. Only plans that retain two locks at all three sites throughout the analysis period are carried forward for further analysis.

New Locks at Existing Sites

Based on engineering investigations performed for ORMSS and this study, including INCA (1997) and INCA (2008), any new locks would be constructed within the existing lock footprint to the maximum practical degree such that one chamber would be available for navigation at all times. Lock locations riverward of the existing locks have been determined in prior studies to be impractical (primarily) due to the added costs and difficulties in construction of the locks and modification of the existing dams to restore hydraulic capacity and the resulting changes in navigation conditions.

Three dimensions are considered appropriate for new lock construction at any of these sites, all 110’ wide and either 600’, 800’, or 1200’ long. The standard Ohio River lock chamber is 110’ wide. Six hundred feet is the shortest chamber length deemed appropriate for 21st century Ohio River locks. Eight hundred feet would efficiently accommodate modern 200’ long (jumbo) barges. Twelve hundred feet is the maximum lock length on the Ohio River (and nationwide). In all cases, the river chamber will become the new main lock and the land chamber the auxiliary lock.

Other Lock Modernization Alternative plans include two new locks at the existing sites. In light of current and projected traffic, there is no need for an auxiliary (land) chamber longer than 600’, so a new landside lock would be limited to 110’ x 600’. Major Rehabilitation of any auxiliary (land) chamber components after construction of a new river chamber is not deemed worthy of economic analysis due to the assumed reliability of the new river chamber components. There are nine remaining possible combinations of new lock construction and maintenance of the existing land chamber at any site as listed in the following table.

Options 1 – 3 are the three two-new-lock combinations given the constrained land lock size. The remaining six strategies involve maintenance of the existing land chamber after conversion to an auxiliary chamber. The basic question to answer with Options 4-9 is what level of maintenance is justified for the old land chamber after it is converted to a new auxiliary chamber upon completion of a new river chamber. The new river chamber would lessen the need for a second chamber since the new components would not be subject to failure.

TABLE 4-22: Lock Modernization Options at Each Facility Initial Assessment

Option #	Main (River Chamber)	Auxiliary (Land Chamber)
1	New 110 x 600	New 110 x 600
2	New 110 x 800	New 110 x 600
3	New 110 x 1200	New 110 x 600
4	New 110 x 600	Advance Maintenance Existing
5	New 110 x 800	Advance Maintenance Existing
6	New 110 x 1200	Advance Maintenance Existing
7	New 110 x 600	Reactive Maintenance Existing
8	New 110 x 800	Reactive Maintenance Existing
9	New 110 x 1200	Reactive Maintenance Existing

Independent of the strategy taken, the new lock footprint would be wider with two 110' wide chambers such that modifications would be necessary to the three dams. The impacts to the dam at any site are the same with 600' or 1200' long locks. At Emsworth the fixed crest weir adjacent to the locks and gate bay one must be removed to accommodate the locks. At Montgomery, only the fixed crest weir adjacent to the locks would be removed to accommodate the wider locks, the abutment side weir would also be removed and converted to a gate to restore lost hydraulic capacity. The fixed crest dam at Dashields would be shortened. Hydraulic assessments of the existing Emsworth and Montgomery Dams have adequate excess hydraulic capacity such that existing flood frequencies would not be increased with the shorter dams. At Dashields, the lost hydraulic capacity would be restored by installing one gate with a lower crest than the existing dam. Scheduled maintenance costs for the new lock components will be less than for the existing components.

Demolition of either or both chambers and construction of new chambers would generate over one million cubic yards of excess material for disposal, consisting of concrete, river sediment and rock. Early in the study, it was agreed that properly licensed commercially available disposal sites will be specified at each facility, which would eliminate the need for designing and costing government disposal sites. The District conducted a reconnaissance survey of commercial disposal sites in Pennsylvania, Ohio, and West Virginia deemed to be within reasonable proximity to EDM. Disposal sites to accept material from each facility were evaluated and ranked according to eight criteria[22]. The highest ranked disposal area(s) and specified means of transportation of materials to each of these sites for each facility were considered sufficient for feasibility cost estimating purposes. In addition, any new construction

[22] The eight criteria were total estimated unit cost of transport and disposal; estimated available capacity during projected construction periods;., limitations on materials accepted for disposal (if any).; transport route, material handling, loading and offloading; anticipated travel route congestion, estimated increase in traffic accidents and fatalities on transportation routes utilized, estimated air quality impacts, and environmental justice.

would require a staging area exclusive to each site to accommodate a concrete batch plant and construction equipment.

The decision to construct one or two new locks at any facility will depend upon a comparison of the costs to construct a new land chamber versus the costs to either maintain it or close it down. **Figure 4-9** shows a lock replacement strategy for two new twin 600' long chambers at Emsworth locks while **Figure 4-10** shows the strategy for one new 110' x 600' river chamber and retention of the land chamber.

A key constraint for all construction plans is to maintain navigation through the existing land chamber during construction of the new river chamber to avoid river closure. Using the same footprint means that the new middle wall will be constructed between the existing middle and river walls at each site. At Emsworth, complications arise since the filling and emptying system for the land chamber extends under the floor of the river chamber. Prior to the commencement of construction of the new river chamber, the existing emptying system for the land chamber must be modified by converting an old penstock in the wall to an emptying culvert. This work would require a six-week closure of both chambers. Details of all concepts are presented in the **Engineering Appendix** for **Emsworth**. A potential problem with the Emsworth strategy is that this penstock (and surrounding concrete) is considered to be in very poor condition and the durability highly questionable, however it would be the only means for emptying the Lock Modernization Options 4 through 9. The engineering assessment at this time is that there is a possibility that this penstock may not be counted on to provide a reliable emptying system for the entire analysis period.

FIGURE 4-9: Emsworth New Twin Locks (110' x 600')

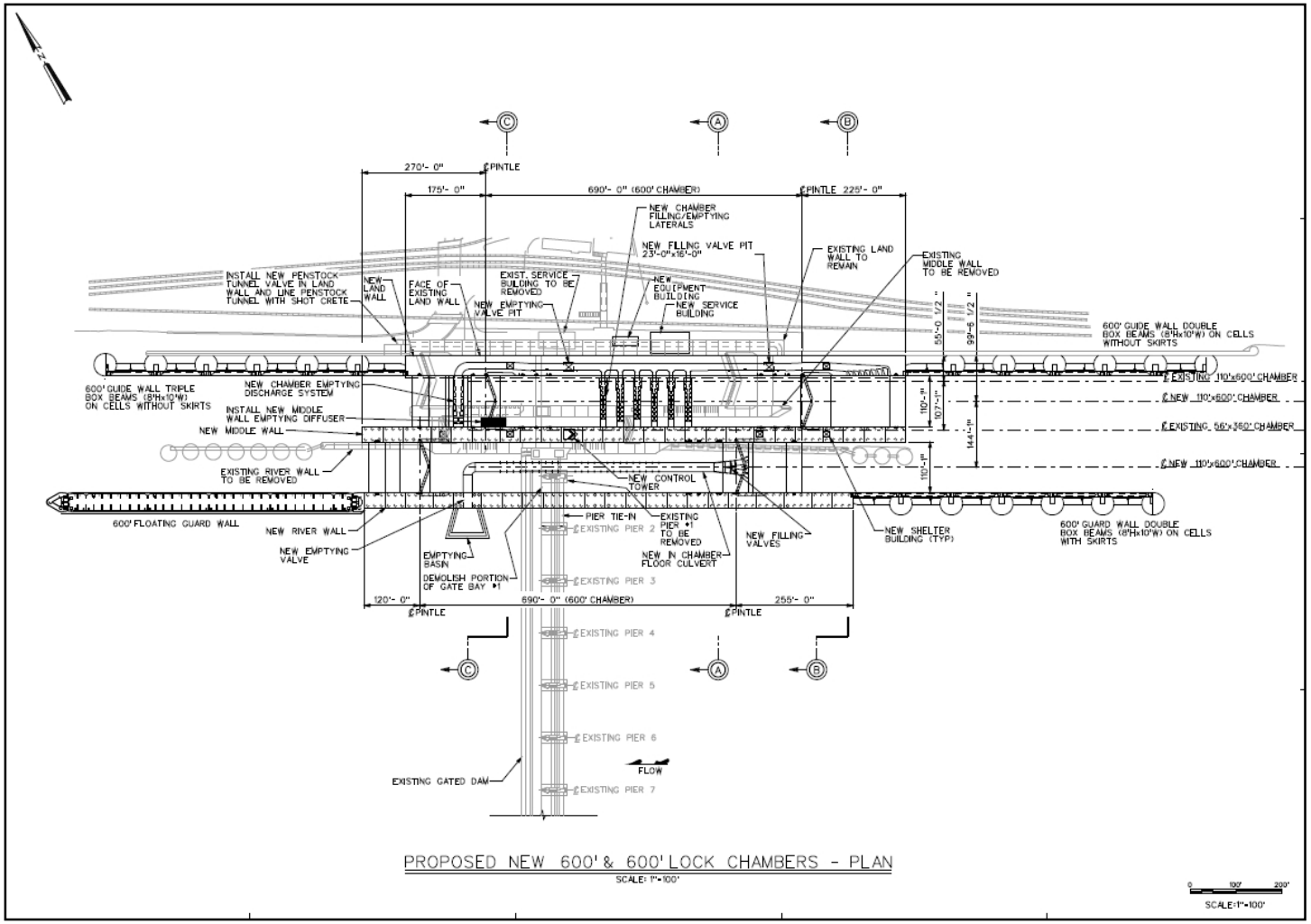
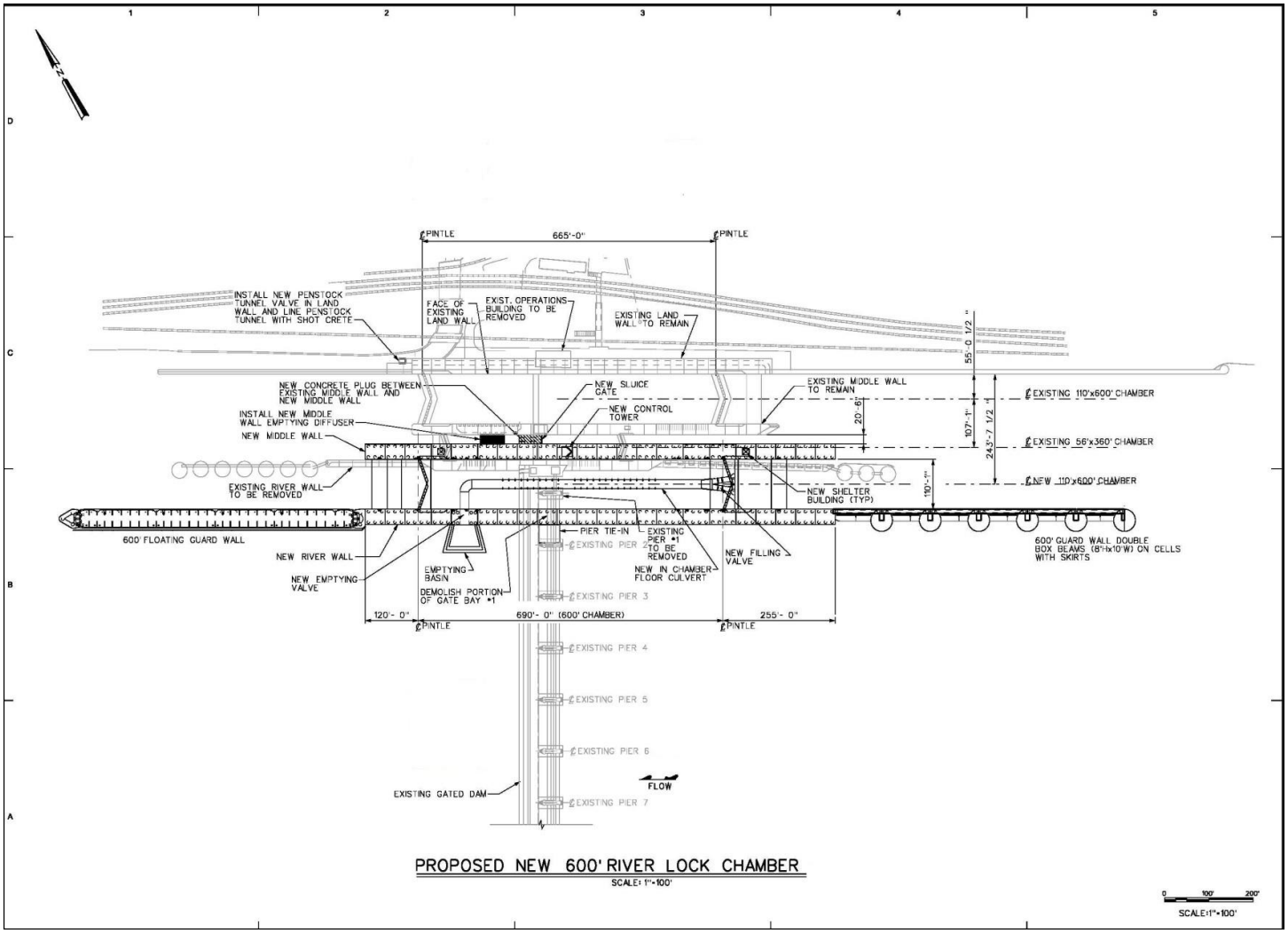


FIGURE 4-10: Emsworth New 110' x 600' Chamber, Retaining Land Chamber



Accounting for the new lock sizes being considered for new river and land locks and the potential decommissioning of the land chamber, there are six possible strategies with one or two new locks at each site. The options along with the associated lock chamber and project capacities are noted in **Table 4-23**. Note that the modern 600' chambers have somewhat higher capacities than the existing chambers. The existing 600' capacities reflect those for the existing main (land) chambers in the this table.

TABLE 4-23: Capacities for Lock Modernization Options at EDM

Project	Lock Modernization Option(s)	Full Operation (mil tons)	Main Chamber (mil tons)	Auxiliary Chamber (mil tons)
Emsworth	New 600 Main, Existing 600 Aux[1]	77.8	43.1	42.9
	New 800 Main, Existing 600 Aux[2]	100.0	59.4	42.9
	New 1200 Main; Existing 600 Aux[3]	121.0	77.5	42.9
	New 600 Main; New 600 Aux	91.5	47.9	47.9
	New 800 Main; New 600 Aux	100.8	57.2	47.9
	New 1200 Main; New 600 Aux	122.9	77.3	47.9
Dashields	New 600 Main; Existing 600 Aux	90.7	49.6	48.1
	New 800 Main; Existing 600 Aux	102.2	59.3	48.1
	New 1200 Main; Existing 600 Aux	130.7	79.6	48.1
	New 600 Main; New 600 Aux	91.6	49.6	49.6
	New 800 Main; New 600 Aux	103.4	59.3	49.6
	New 1200 Main; New 600 Aux	132.0	79.6	49.6
Montgomery	New 600 Main; Existing 600 Aux	79.8	43.7	43.2
	New 800 Main; Existing 600 Aux	97.9	55.8	43.2
	New 1200 Main; Existing 600 Aux	116.0	70.9	43.2
	New 600 Main; New 600 Aux	80.8	43.6	43.6
	New 800 Main; New 600 Aux	99.1	55.8	43.6
	New 1200 Main; New 600 Aux	117.4	70.9	43.6

[1]Corresponds to Lock Modernization Options 4 and 7 (same for Dashields and Montgomery)
[2]Corresponds to Lock Modernization Options 5 and 8 (same for Dashields and Montgomery)
[3]Corresponds to Lock Modernization Options 6 and 9 (same for Dashields and Montgomery)

Locks and Dams at New Sites

Locks and dams at new sites are not considered applicable for detailed consideration in this analysis due a multitude of issues described below. Therefore, this measure was eliminated from more detailed studies.

The total cost of a new site construction would involve both new locks and dam and include the demolition of existing structures. This cost would be much greater than constructing new locks at the existing sites, even accounting for future maintenance of the existing dams, particularly since they are either being rehabilitated (Emsworth), being studied for possible rehabilitation (Montgomery), or deemed adequate for the long term (Dashields). This construction would also impact a larger area of river than construction at the existing facilities.

In addition to the new project construction costs and impacts at the new sites, there would be pool changes for some defined distance between the old and new facilities. Where the pool would be lowered, dredging would be required to assure that the authorized navigation pool (300' wide x 9' deep) is maintained. Where the pool would be raised, there would be shoreline and shoreside facility inundation possibly requiring adjustments or relocations funded by the owners. Publicly owned facilities might qualify for project funds through a discretionary authority. Any movement of existing facilities would require extensive taking of lands in order to acquire the necessary project property and access easements. The taking and or relocation of shore side facilities such as landings, outfalls and intakes, boat ramps, marinas, and submarine crossings would likely be necessary to accommodate any pool changes and the construction of the new facilities. Pool changes could affect other negative impacts such as bank stability, bridge clearances and bridge piers. The following negative factors are associated with pool changes, some of these issues were raised at public meetings for this study:

- Public and community opposition to potential impacts to existing facilities
- Potential impacts to riparian wetlands
- Concern over potential for dredge material contamination
- High potential for cultural resources impacts in areas impacted by construction and pool changes
- Impacts to river flow velocities and navigation conditions, particularly where the pool is lowered
- Potential impacts to bank stability and scouring of bridge piers where the pool is lowered
- Reduced river width in reaches where the pool is lowered that could result in encroachment of existing fleeting areas towards the new navigation channel that could in turn give rise to safety issues and a need for re-permitting or even abolishing some existing fleeting areas

- Potential violations of bridge vertical clearance requirements in reaches where the pool is raised. For example the I-79 highway bridge is located 2.5 miles downstream of Emsworth.

In summary, construction of new locks at the existing sites as discussed above would be much less costly and involve less environmental and possibly cultural impacts. In other words, construction of new locks at the existing sites "dominates" the construction of new locks and dams.

Third Locks

Due to limits imposed by roads and active railroad lines along the banks of EDM, the only practical location for a third lock would be in the river (riverward of the river chambers). Construction of a third lock at any of the facilities would require the removal of dam bays or fixed crest from each facility and would significantly reduce the dam capacity to pass flow. It was determined from preliminary hydraulic investigations that the loss of a single gate bay at Emsworth or Montgomery could be restored by the conversion of the fixed crest portion of the dams to a gates bay. Similarly, at Dashields, the loss of a small portion of the fixed crest dam could be restored by constructing a new single gate bay with lower sill elevation. For a third lock option, two gate bays at both Emsworth and Montgomery would be eliminated and a much more significant portion of the fixed crest dam would be removed. The lost additional capacity of the dams could not be restored by the previously mentioned measures and would require significant modification of dam sills, dam gates and weirs. This added cost is expected to be much greater than the benefits gained by increasing the lock capacity by adding an additional lock Construction of new locks in the footprint of the existing locks is much better than (i.e. dominates) construction riverward. In summary, this measure is clearly inferior to constructing the new locks at the existing sites within the existing footprints. Therefore, this measure was eliminated from more detailed studies.

Lock Extensions

This measure would involve extension of existing walls to form longer chambers and involve the construction of new gate monoliths at one end, and possibly the abandonment of and replacement of existing electrical and mechanical equipment with more modern technology. Several options would be available to fill and empty the chambers: the existing filling and emptying systems could be retained to serve the new chamber; abandoned; or supplemented with a new system to provide modern filling and emptying times. The major factor against this measure is the retention of the existing walls. Lock extensions would not satisfactorily address the structural and stability problems that led to very high risk costs in the WOPC. The extended locks would retain the significant risk inherent with the existing locks and be subject to high maintenance costs as in the Reactive Maintenance Alternative. Therefore, this measure was eliminated from consideration.

Facility Removal

Dashields was determined to be the only viable candidate for removal for several reasons. The Dashields pool length (7.1 miles) is the shortest and the head provided by the Dashields Dam (10 feet) is the smallest on the Ohio River. Removal of Emsworth or Montgomery would require pool adjustments accommodating 17.5 or 17 feet of head from upper to lower pool, respectively. The Emsworth gated dams are critical for retaining the pool at the "Point" at Pittsburgh at the head of the Ohio River. Such control would be completely lost without construction of a new gated dam at Dashields. Retention of Montgomery is also viewed as critical to maintaining efficient navigation on the Upper Ohio River. From here on, all discussions in this main report of the alternative that would remove a lock and dam will specify Dashields as the facility that would be removed.

Removal of Dashields would entail pool changes and associated dredging and shoreside facility relocations, as well as additional concerns to address at Emsworth and Montgomery to accommodate those changed pools. The initial detail to be addressed is the range of pool changes to be considered. In all cases, the Dashields pool would either be retained or lowered and the Montgomery pool either retained or raised. Estimated dredging and shoreside relocation costs that would be required for a number of Montgomery pool raises between zero and five feet (and a corresponding drop of Dashields pool of between ten and five feet, respectively). It was determined that the pool change scenarios that would minimize total costs would correspond to an increase in the Montgomery pool of one foot (with the new Montgomery and Dashields pool elevations at 683 feet NGVD). All plans that involve removal of Dashields will only consider new pool levels in this range.

The significant amount of dredging associated with the pool lowering would have serious environmental impact implications for water quality and aquatic habitat. Accompanying these adverse impacts would be the permanent loss of the dam and its associated tailwater, which is a highly valued habitat area in a channelized river. These significant adverse impacts to aquatic habitat values and the dam's reaeration capability could not be mitigated in-kind, nor could the large scale of the impacts be mitigated except at high cost.

Pennsylvania communities along the river subject to pool lowering include Emsworth, Neville Island, Glenfield, Coraopolis, Sewickley and Stoops Ferry. Pennsylvania communities along the river subject to pool raise include Leetsdale, Glenwillard, Wireton, Ambridge, South Heights, Aliquippa, West Aliquippa, Baden, Conway, Colona, Monaca, Freedom, East Rochester, Rochester, Bridgewater, Vanport, Josephtown, Potter Township and Beaver. A maximum pool raise for the Montgomery pool was identified as five feet based on restrictions caused by the railroad bridge near the mouth of the Beaver River. The existing clearance of this bridge is 18.2 feet at normal pool, reducing it by more than five feet is viewed as unsatisfactory and would require the bridge to be raised. Based on an assessment in the late 1990's, approximately 67 publicly owned and dozens of privately owned shore side facilities would need to be adjusted along the existing Dashields and Montgomery pools, at an estimated total cost of over $200 million.

Restrictions on some river front development would be likely necessary to limit the encroachment of frontage towards the receding waterline, since the physical extension of facilities riverward of their current location would place them into the floodplain/floodway hazard areas, and it is possible that any such encroachment may be prohibited by current FEMA regulations. Also, the safety buffer between the navigation channel and existing fleeting areas would be reduced by the lower navigation pool, and it is highly likely that re-permitting of some facilities will be necessary to reduce the width to which they can moor barges and plant. There will also be a need for dredging side channels for maintenance of access to the docks. As for the effects of the lower pool on back channel facilities near Emsworth many fleeting areas would be seriously impacted and it is doubtful they could remain operational without significant capital expenditures on the part of the owners. Abutments for three bridges in the Dashields Pool could be affected and are not included in those costs. Municipalities would likely anticipate assistance through Section 111 authority.[23]

The impact to the Emsworth Locks would be that the existing chambers would be rendered essentially useless as clearances over existing lower lock gate sill would be reduced to between five and six feet and the clearance over the lock chamber to between six and seven feet. (Existing clearance over the lower gate sill is 12.6 feet at normal lower pool elevation and clearance over the floor elevation is 13.7 feet at normal lower pool elevation.) Therefore, in order to retain two fully functioning chambers at Emsworth, two completely new lock chambers would need to be constructed if Dashields is removed and the recommended new pool levels adopted. This eliminates any possibility of considering the options cited earlier for building one new chamber and retaining the existing main chamber for the “new” auxiliary chamber. Further consideration of this alternative is NOT available if Dashields is removed and the recommended pool change levels are adopted.

At this elevation, no alternations would be required to Montgomery Locks except that any existing lock walls remaining in the final lock modernization plan may require additional stabilization to accommodate higher hydrostatic loads arising from a one-foot increase in the upper pool. Impacts to Emsworth Locks and Dams would be far more substantial arising from a nine-foot drop in the lower pool. Without use of Section 111 authority, municipalities would be responsible for adjustment or relocation of any publicly owned facilities.

However, the greatest impact associated with the removal of Dashields may be to the Emsworth Dams, where a nine-foot downstream pool drop would necessitate the construction of a completely new dam apron and stilling basin along the full reach of both the main and back channel dams. This modification would require the complete removal of the existing timber-founded dam apron and replacement of the newlyconstructed scour protection system of the on-going Major Rehabilitation project.

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[23] In 1958 and as modified in 1965, Congress granted the Chief of Engineers discretionary authority to make compensation at project expense for such adjustments, not withstanding the navigation servitude vested in the federal government, where the facility is owned by an agency of government and used in a governmental function. This authority is granted by Section 111 of 72 Stat. 303, as amended by Section 309, 79 Stat. 1094 (33 U. S. C. 633).

Lastly, eliminating Dashields would reduce Corps operations and maintenance costs and reduce commercial towing travel times now spent waiting to lock through and locking through Dashields. As this measure entails a host of issues requiring assessment to weigh benefits and costs of retaining Dashields, it will be carried forward to the alternative formulation phase.

Summary

To summarize the analysis of With-Project Lock Modernization Measures, construction of new locks at the existing sites and retention of two chambers at each remaining lock and dam facility will ensure that the most efficient lock modernization plan is identified. Dashields is carried forward as a candidate for removal. A summary of navigation modernization measures carried forward and eliminated is contained in **Table 4-24**.

TABLE 4-24: WPC Lock Modernization Measures Carried Forward or Dropped

Lock Modernization Measures Carried Forward in WPC
New 110’ x 600’, 110’ x 800,’ or 110’ x 1200’ Lock To Replace 56’ x 360’ Lock & Repair Existing 110’ x 600’ Lock
New 110’ x 600’ Land Chamber
Eliminate Dashields Locks and Dam
Component Replacements Within Budget Limitations
Lock Modernization Measures Dropped From Consideration in WPC
Lock Extensions
Major Rehabilitation
Third Locks (At Any Project)
Widths of New Locks at EDM Less Than 110’
Lengths of New Locks Shorter than 600’ or Longer than 1200’
Eliminate Emsworth Locks and Dams
Eliminate Montgomery Locks and Dams
Closure of any Land Chamber

4.6.4 Formulation of With-Project Navigation Alternative Plans

With-Project Alternatives are formulated by combining the maintenance and lock modernization measures in a fashion starting from minimum to maximum investment (or cost). Three basic alternatives are put forward for With-Project analysis, three involving only proactive maintenance, and the third including proactive maintenance and lock modernization. All of these alternatives will include the maintenance and operational

efficiency measures that formed the reactive maintenance or Without-Project Condition alternatives, as those measures constitute the minimum basic actions by the Corps to keep these facilities operational and to reasonably maximize lock throughput for any lock configuration. The least costly is the fix-as-fails or reactive maintenance (replacement) alternative, followed by Advance Maintenance, and Lock Modernization. Fix-as-fails maintenance is identified as the WOPC as previously determined.

The ***Advanced Maintenance Alternative*** (AMA) allows for a lower level of proactive maintenance that includes all replacement of major components that were deemed too costly to replace in the Without-Project Condition and if economically justified. Any AMA plan would involve at least one scheduled component replacement and reactive maintenance for all other components. All potential component replacements are assumed to be fundable and that funds are made available in a timely manner.

The last two are variations of the ***Lock Modernization Alternative*** involving either three or two locks. Either of these alternatives would require construction and Inland Waterway Trust Fund contributions while increasing the capacity of the Upper Ohio River system, therefore they are noted on the same level. The "***3-Lock Modernization Alternative***" (3-LMA) involves new lock construction and retention of all three locks and dams. Any 3-LMA plan would involve at least one new lock constructed at any site. The "***2-Lock Modernization Alternative***" (2-LMA) involves the removal of a lock and dam and may involve new lock construction at the remaining two facilities.

There are several possible Lock Modernization Alternative Plans with three sites and three lock sizes considered for new construction. For example, a plan could involve the construction of a new 110' x 600' river chamber at Montgomery and the retention of the remaining five lock chambers according to an advanced maintenance policy. Other plans could include construction of new 110' x 1200' river chambers at each site and retention of the three land chambers according to a reactive maintenance policy. Still others could involve different lock sizes for the river chambers. However, due to the closeness of traffic projected through all three projects for each scenario (see **Table 4-7**), only those lock modernization plans involving the same size of new lock construction at all three sites will be carried forward for analysis. This also precludes new lock construction at only one or two sites. Therefore nine LMA plans are carried forward for analysis based on the options in **Table 4-22**. These plans will be identified throughout this report and appendices using the number system in **Table 4-22**. For example, LMA Plan 1 consists of two new 110' x 600' chambers at all three facilities, and LMA Plan 9 consists of a new 110' x 1200' river chamber at all three facilities and the retention of all three land chambers according to a reactive maintenance policy.

For all With-Project Alternatives, the aggregate of all proactive maintenance and new lock measures will be captured in a new Scheduled Lock and Dam Improvements cost category.

4.6.5 Comparison of the 2-LMA and 3-LMA Plans

The purpose of this comparison between the 2-LMA and 3-LMA lock modernization alternatives was to determine the need to carry both forward for detailed analysis in this

feasibility study. The full analysis is provided in the **Two Lock Modernization Analysis Appendix** and will be summarized here.

The evaluation process considered at concept (or venture) level the full spectrum of modernization plans involving new locks at both existing and new locations within the study area. A sequence of evaluations is presented that reasonably limits the analysis to new locks at the existing sites and shows conclusively that the best 2-LMA strategy involves eliminating Dashields Locks and Dam.

Building on these findings, the next issue resolved was the best elevation of the new longer pool that would be formed between Emsworth and Montgomery Locks and Dams. The pool elevation selected was that which minimized the total costs for three major impact areas: dredging, adjustment of facilities both within the river and along the banks, and bank stabilization. This new pool elevation was 683, requiring a nine-foot drop in the existing 7.1 mile long Dashields pool and a one-foot rise in the existing 18.7-mile long Montgomery pool. Over 3 million cubic yards of dredging would be required within the existing Dashields pool to maintain a 300-foot wide navigation channel, the minimally acceptable width using Corps criteria (and width that minimizes dredging costs). As a result of the required pool adjustments, 99 private and 26 public facilities would require adjustment or relocation. Within the Dashields pool alone, approximately six miles of shoreline of the main channel and four miles of shoreline on the back channel would require bank stabilization measures. The total cost of these factors for this optimum pool level was over $600 million. There would also be a potential adverse impact to four of twelve bridges that span the Ohio River in the Dashields and Montgomery pools, costs for this potential work was not included. (The 3-LMA would require minimal dredging, facility relocations, and bank stabilization only in association with the new construction, work which for the most part would also be part of the 2-LMA.)

The final important aspect of the analysis was selection of lock sizes. Four plans involving one or two larger locks at each site were selected based on cost and lock capacity considerations. Two comparisons involved locks with twin 110’ x 600’ locks at all sites (three in the 3-LMA and two for the 2-LMA). The second set of two comparisons involved facilities with one 110’ x 1200’ and one 110’ x 600’ lock chamber. The rationale for including these lock size combinations (rather than picking the lock sizes at each facility deemed most probable to be recommended) is that they represent a range of capacity and cost improvements. Consideration of a range of improvement types is crucial to ensure that ample information is assessed in this very important decision.

For each of the four comparisons, engineering, real estate, environmental, economic, and other general factors were evaluated. In all four comparisons, the 3-LMA fared better in all general categories. Overall, the 2-LMA fared far worse economically, costing far more and adding little to navigation benefits. The benefit-cost ratios of the 2-LMA compared to the 3-LMA (not to the Without-Project Condition) ranged from 0.09 to 0.17. There were several other compelling arguments against the 2-LMA as follows:

- The total cost of the 2-LMA including non-Federal costs to accommodate facility adjustments was higher in all four cases, ranging from $220-$640 million.
- The 300' channel will represent significant safety concerns to mariners during high river flows.
- The lower Dashields pool will be narrowed, requiring many terminals to reconfigure further out into the river, requiring re-permitting and possible restrictions on the new facilities due to reduction in buffer between these terminals and the navigation channel.
- A more detailed assessment of the 2-LMA would add at least two more years and additional funding requirements to the study.
- Construction of the 2-LMA would require about ten more years than the 3-LMA.
- Representatives from the navigation industry support elimination of the 2-LMA due to the longer study time, longer design and construction durations, higher construction cost, and safety concerns with the 300' navigation channel.
- There would be severe environmental impacts owing to channel dredging and disposal in the 2-LMA, problems that would not be inherent to the 3-LMA that does not change pool elevations.
- Further refinement project implementation will consider alternate construction techniques that could lower lock and dam construction costs, costs associated with pool adjustments are far less likely to come down.

The conclusion drawn from this comparison is that there is overwhelming evidence that the 2-LMA should be eliminated from further study. Furthermore, the Pittsburgh District presented this analysis in a Feasibility Scoping Meeting with navigation industry stakeholders on September 5, 2007, and there was overall consensus among all Corps participants and industry stakeholders that the 2-LMA be eliminated from further consideration. Note that elimination of the 2-LMA includes all possible plans that could be formulated under this alternative, including all possible lock size combinations of new lock configurations at the Emsworth and Montgomery facilities.

In summary, the 3-LMA is preferred to the 2-LMA as it would provide a more efficient and acceptable navigation system (Study Objective 1) and with less environmental impacts (Study Objective 3). In terms of the four accounts evaluation criteria, the 3-LMA outranks the 2-LMA in terms of efficiency, effectiveness, and acceptability, while being equal in terms of completeness. **Therefore, the 2-LMA was eliminated from consideration.** As all lock modernization alternative plans will now maintain three sites, they will be designated as LMA plans. The alternative pyramid is shown in **Figure 4-11.**

FIGURE 4-11: Pyramid of Alternatives

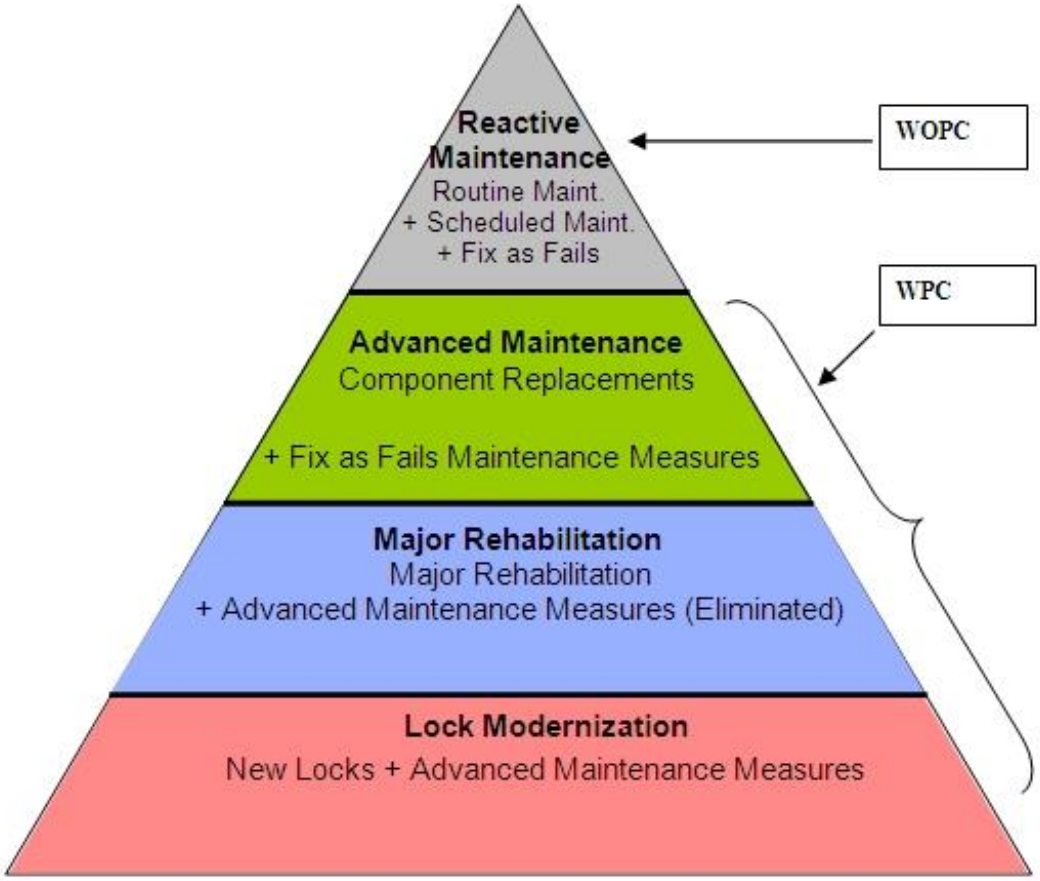


Table 4-25 summarizes measures included in plans for the Reactive Maintenance Alternative (WOPC) and the WPC Alternatives.

TABLE 4-25: Measures in Each Alternative

Alternative Plans Includes Measures:	Reactive Maintenance Alternative (RMA)	Advanced Maintenance Alternative (AMA)	Lock Modernization Alternative (LMA)
Routine Maintenance	X	X	X
Cyclic Maintenance	X	X	X
Unscheduled Component Replacement	X	X	X
Scheduled Component Replacement		X	X
N-up/N-down Lockage	X	X	X

Alternative Plans Includes Measures:	Reactive Maintenance Alternative (RMA)	Advanced Maintenance Alternative (AMA)	Lock Modernization Alternative (LMA)
Industry Self-Help	X	X	X
Adjustments by Industry During Main Chamber Closures	X	X	X
Mooring Cells (existing)	X	X	X
Tow Haulage (existing)	X	X	X
Coordination with Industry	X	X	X
New Locks At Existing Sites			X

4.6.6 Summary of With-Project Plans Carried Forward for Analysis

In summary, **Table 4-26** lists the Advanced Maintenance, Major Rehabilitation, and Lock Modernization Plans that are carried forward for analysis and the allowable work at each site.

TABLE 4-26: Plan Designations and Descriptions

Plan Designation	Emsworth	Dashields	Montgomery
Advanced Maintenance	Advanced Maint (both chambers)	Advanced Maint. (both chambers)	Advanced Maint. (both chambers)
LMA 1	New 110'x600' River; New 110'x600' Land	New 110'x600' River; New 110'x600' Land	New 110'x600' River; New 110'x600' Land
LMA 2	New 110'x800' River; New 110'x600' Land	New 110'x800' River; New 110'x600' Land	New 110'x800' River; New 110'x600' Land
LMA 3	New 110'x1200' River; New 110'x600' Land	New 110'x1200' River; New 110'x600' Land	New 110'x1200' River; New 110'x600' Land
LMA 4	New 110'x600' River; Advanced Maint Land	New 110'x600' River; Advanced Maint	New 110'x600' River; Advanced Maint
LMA 5	New 110'x800' River; Advanced Maint. Land	New 110'x800' River; Advanced Maint. Land	New 110'x800' River; Advanced Maint. Land

Plan Designation	Emsworth	Dashields	Montgomery
LMA-6	New 110'x1200' River; Advanced Maint. Land	New 110'x1200' River; Advanced Maint. Land	New 110'x1200' River; Advanced Maint. Land
LMA 7	New 110'x600' River; Reactive Maint. Land	New 110'x600' River; Reactive Maint. Land	New 110'x600' River; Reactive Maint. Land
LMA 8	New 110'x800' River; Reactive Maint. Land	New 110'x800' River; Reactive Maint. Land	New 110'x800' River; Reactive Maint. Land
LMA 9	New 110'x1200' River; Reactive Maint. Land	New 110'x1200' River Reactive Maint. Land	New 110'x1200' River; Reactive Maint. Land

Concept costs for the various construction strategies involving new locks at EDM that would serve as components to the plans LMA 1 through LMA 9 are noted in **Table 4-27**.

TABLE 4-27: Screening Level Costs And Construction Durations For New Lock Construction Options At EDM

Project	Lock Modernization Option(s)	Cost Oct 2009 Level (Million $)[1]	Construction Duration (Years)
Emsworth	110 x 600 River Chamber; Existing Land Chamber (Reactive or Advance Maintenance)[2]	$435	6
	110 x 800 River Chamber; Existing Land Chamber[3]	$512	7
	110 x 1200 River Chamber; Existing Land Chamber[4]	$628	8.5
	110 x 600 River Chamber 110 x 600 Land Chamber	$617	8.5
	110 x 800 River Chamber 110 x 600 Land Chamber	$704	9.5
	110 x 1200 River Chamber 110 x 600 Land Chamber	$820	11
Dashields	110 x 600 River Chamber; Existing Land Chamber	$462	6
	110 x 800 River Chamber; Existing Land Chamber	$551	7
	110 x 1200 River Chamber; Existing Land Chamber	$671	8.5
	110 x 600 River Chamber 110 x 600 Land Chamber	$643	8.5

Project	Lock Modernization Option(s)	Cost Oct 2009 Level (Million $)[1]	Construction Duration (Years)
	110 x 800 River Chamber 110 x 600 Land Chamber	$732	9.5
	110 x 1200 River Chamber 110 x 600 Land Chamber	$856	11
Montgomery	110 x 600 River Chamber; Existing Land Chamber	$582	6
	110 x 800 River Chamber; Existing Land Chamber	$687	7
	110 x 1200 River Chamber; Existing Land Chamber	$837	8.5
	110 x 600 River Chamber 110 x 600 Land Chamber	$842	8.5
	110 x 800 River Chamber 110 x 600 Land Chamber	$947	9.5
	110 x 1200 River Chamber 110 x 600 Land Chamber	$1,102	11

Notes:
[1] All concept level costs include 7% for PED and 7% for S&A applied to unburdened construction cost and 25% contingency
[2] Corresponds to Lock Modernization Options 4 and 7 (same for Dashields and Montgomery)
[3] Corresponds to Lock Modernization Options 5 and 8 (same for Dashields and Montgomery)
[4] Corresponds to Lock Modernization Options 6 and 9 (same for Dashields and Montgomery)

Key assumptions for the screening level estimates at each site are provided in the site specific Engineering Appendices are noted below.

All new lock designs and assumed construction strategies incorporated the following project features and constraints:

- New locks would remain within existing project footprint to the maximum extent practicable.
- Navigation traffic would be maintained in the existing main chamber until the first chamber is entirely complete and in service.
- The new middle and river walls must be constructed riverward of the existing middle and river walls, respectively.
- The primary construction laydown areas at Dashields and Montgomery and the secondary construction laydown area at Emsworth are utilized. These work areas have been subjected to Phase I and Phase II Environmental Site Assessments (ESA). The Phase II ESA Report identified undeveloped land of sufficient size and topography to use as a construction support areas for each of the three new locks that maximizes avoidance of potentially contaminated areas. However, prior to the acquisition of any interest in real property, additional HTRW investigation is required in the next phase of project development.

- Lock wall designs are based on in-the-wet construction methodology using a cofferbox construction technique being used at the on-going new Charleroi Locks (a feature of the authorized Lower Mon Project).
- The designs presented for the approach walls use a combination of fixed and floating approach walls. The fixed wall design is based on the detailed design and successful construction of the walls at London Lock, Marmet Locks and Winfield Locks all located on the Kanawha River. These types of fixed walls are also fully designed for the upper guard wall at Charleroi currently under construction, and are planned for the new Chickamauga Lock on the Tennessee River. The floating approach wall design is based on the detailed design and successful construction of the walls at Olmsted Lock on the Ohio River. This floating wall was fully designed and construction plans and specifications were developed for the Charleroi Lower Guard Wall, and are planned for the lock extensions at the Greenup Locks and JT Meyers Locks on the Ohio River. Details of all wall designs are provided in the Engineering Appendices.
- Dewatering will occur within temporary cofferdams and cofferboxes which will provide protection from normal and elevated pools. Cofferboxes will be utilized to construct the majority of the lock monoliths for the river, middle, and approach walls while cofferdams will be constructed for the remaining river and middle lock monoliths, the entire land wall, dam gate sections, and connection of the dam to the river monoliths.
- The requirement for borrow material has been anticipated for this project for estimation purposes. Adequate material should be brought in from predetermined sites to use for the cofferdam cell fill and berms.
- Projects are “land locked” by active railroads or topography on both sides.
- The designs must provide a feasible and constructible project.

The Screening Level Estimates for option selection were prepared to an equivalent price level of October 1, 2009. The unit prices used for these estimates were developed from recent Independent Government Estimates (IGE’s) for similar types of work, supplemented by unit prices developed for the on-going Monongahela River Locks and Dams 2, 3 and 4 Project) using prior previous Micro-Computer Aided Cost Estimating System (MCACES) and MII (second generation of MCACES) estimates and updated prices for similar items of work from previous projects. The primary IGE’s used for development of unit prices were Charleroi Locks and Dam, Contract 1 (River Wall), Charleroi Locks and Dam, Upper and Lower Guard Wall, Emsworth Locks and Dams Main Channel Rehabilitation, and Emsworth Locks and Dam, Back Channel Left Abutment Stabilization. The IGE costs were adjusted to add profit and account for General Requirements work not specifically included in the estimates. The primary MII estimates used for development of the unit prices for screening costs were the Total Project Cost estimates for Charleroi Locks and Dam, Completion of River Chamber and Charleroi Locks and Dam, Land Chamber. The Charleroi Total Project Cost estimates were October 1, 2009 cost level and complied with the procedures contained herein for

development of the Feasibility Level Estimate. Where screening level estimate assumptions differ from those for the Feasibility Level Estimate, the differences are described for each feature.

Unit prices were developed from the various sources for the specific items of work in the screening level estimates. Unit prices were adjusted to account for general requirements not included in Contractor's overhead items and profit where information was obtained from Independent Government Estimates without profit.

Costs for scheduled and emergency repairs and replacements of critical components (Options 4 through 9) used for economic analysis were also based on unit prices developed in the same manner with contingencies of 15-30 percent. These costs are not included in the Lock Modernization Option costs.

4.6.7 Economic Evaluation and Identification of Navigation NED Plan

4.6.7.1 Advance Maintenance Alternative Plan

The Advanced Maintenance Alternative includes all economically justified component replacements in **Tables 4-17 thru 4-19** since none were included in the WOPC. It is clear from those tables that component replacements at all three projects' main chambers are economically justified early on in the study period. At each facility, most of the economically optimal main chamber component replacements including lock walls would occur prior to 2020 for all scenarios, highlighting the poor structural conditions. The scheduled replacement of the walls would require a 2-2.5 year closure of either the main chamber or both chambers, closures never attempted before and therefore would likely be extremely controversial. The higher forecasts accelerate the replacement dates for some of the components.

It is important to note that the AMA plan that includes all component replacements in **Tables 4-17 thru 4-19** represents the most efficient of all possible AMA plans, where each AMA plan is distinguished by specific component replacements and timings. It can be argued that this plan should be best in terms of the four system of accounts, National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The best advanced maintenance plan is obviously the best in terms of NED benefits as that was the primary criterion on which it was selected. Replacing components before the optimal timing could reduce risk and the number of failures but at a higher economic cost than necessary, which represents a misallocation of public resources which could have adverse OSE. Replacing components prior to failure could have a marginal increase in EQ account owing to less lock closure durations and navigation impacts associated with queuing, but this advantage would not be significant. Replacing components after their optimal date would lessen the economic cost but increase the risk and number of failures, thereby lowering the EQ and OSE accounts somewhat. The alternative AMA plans would be very nearly equal in terms of the RED accounts. Therefore, it is logical to carry the optimal AMA plan forward in consideration of the system of accounts. The same logic applies to the optimal timing of new lock construction in LMA plans described later.

Table 4-28 displays the expected annual Federal costs at EDM from advanced maintenance broken out into improvement costs, scheduled repair costs, unscheduled repair costs, random minor maintenance cost and normal O&M costs. The average annual expected Federal cost at EDM with an advanced maintenance strategy from 2012-2068 is $76.8 million.

TABLE 4-28: Average Annual Federal Costs, Advanced Maintenance Alternative Component Replacement (2012-2068, 4 1/8%, October 2009, $ Million)

Cost Category	Annual Federal Cost
Scheduled Lock Improvement	$57.1
Scheduled Repair	$ 7.8
Unscheduled Repair	$ 3.1
Normal O&M	$ 8.0
Random Minor	$ 0.8
Total Costs	**$76.8**

Figure 4-12 displays the average annual Federal costs for the advanced maintenance strategy at EDM. The Federal costs include normal O&M, random minor maintenance, scheduled lock maintenance and unscheduled lock repair costs. The scheduled lock improvements are economically justified component replacements displayed in **Tables 4-17 thru 4-19**. Again, Emsworth is the higher cost project. Unscheduled lock repair costs and scheduled lock maintenance costs are lower because of proactive component replacement efficiencies. High maintenance needs are seen on the upper Ohio projects where over 70 percent of the annual Federal costs over the next 50-60 years are economically justified component replacement.

System benefits are the equilibrium transportation savings net of any transportation losses caused by congestion delay or diversion due to scheduled improvement and unscheduled repair closures. **Figure 4-13** compares advanced and reactive maintenance benefits for the mid-traffic forecast scenario. The deep reduction in advanced maintenance benefits early on in the study period results from overlapping partial and total river closures during wall replacements.

FIGURE 4-12: Average Annual Federal Costs, Advanced Maintenance Plan Component replacement (2012-2068, 4 1/8%, October 2009, $M)

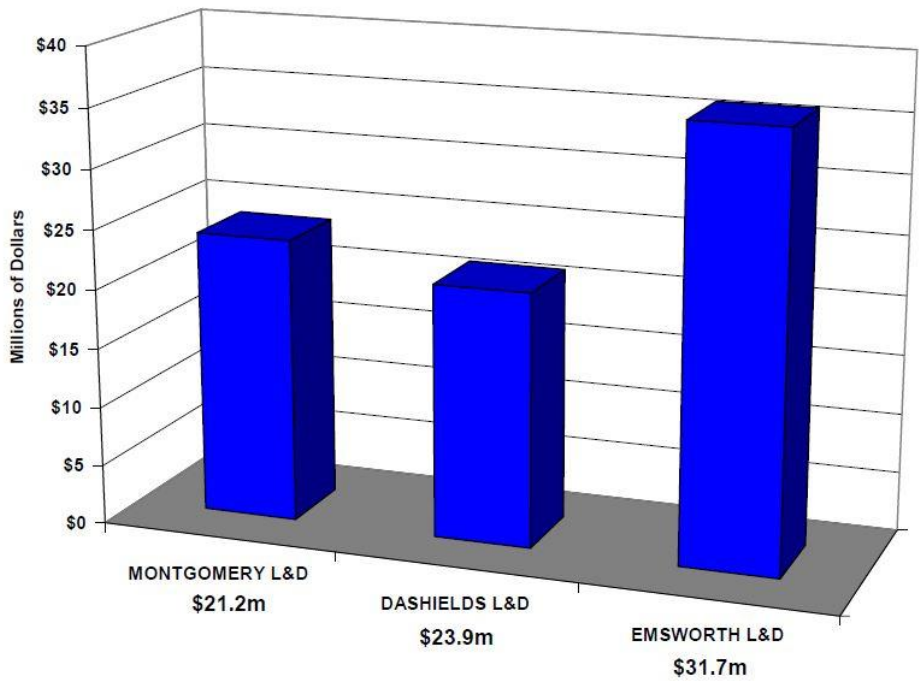
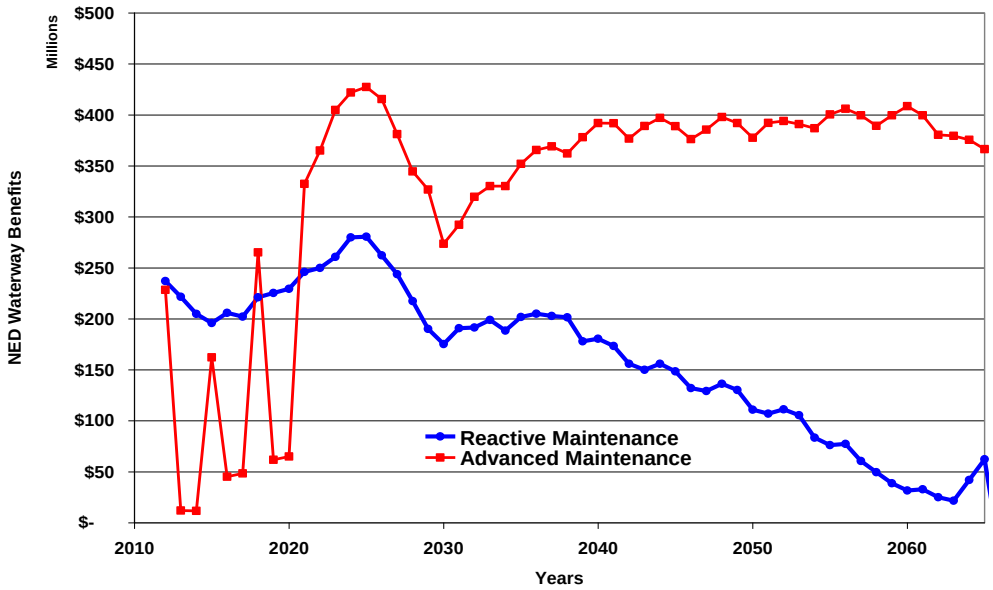


FIGURE 4-13: NED Waterway Benefits, Advanced Maintenance Plan (Mid Forecast)



4.6.7.1.1 System Economics – Advanced Maintenance Alternative (AMA) Plan

Individual component replacement optimization was done at the project level in a system context. The simultaneous effect of multiple piecemeal component replacements at each project and between each project is captured by locking the recommended replacements for all projects and re-equilibrating the transportation system. Given the results of individual up front component replacement analysis, ORNIM was run to calculate the expected system component replacement costs under each traffic forecast scenario. **Table 4-29** summarizes annual system benefits and costs for an advanced maintenance strategy for the mid-forecast scenario, showing both total and incremental system benefits and costs. The incremental system benefits and costs are incremental with respect to the Without-Project Condition. Although investment decisions are ordinarily made based on incremental system benefits and costs, total system benefits and costs are displayed at the request of HQ.

TABLE 4-29: Average Annual Costs and Benefits, Advanced Maintenance Mid Forecast (2012-2068, 4 1/8%, October 2009, $ Million)

Upper Ohio System - EDM	Average Annual
Advance Maintenance Benefits	
Base Waterway Transportation Surplus (full operations)	$475.0
Reduced Surplus from Scheduled Closures	-$87.0
Land transportation costs Incurred from Unscheduled diversions	-$26.5
Reduced Surplus from Unscheduled Closures	-$7.9
Externality Costs Incurred	-$0.2
Total System Benefits	$353.4
Advance Maintenance Costs	
Scheduled Lock Improvements	$57.1
Scheduled Lock Maintenance	$7.8
Unscheduled Lock Repair	$3.1
Normal O&M	$8.0
Random Minor	$0.8
Total System Costs	$76.8
Net Benefits	$276.6
BCR	**4.6**
Incremental Benefits	$210.6
Incremental Costs	$39.4
Incremental Net Benefits	$171.3
BCR (Incremental)	**5.4**

Advanced maintenance buys down risk with higher scheduled improvement costs that are 50 percent cost shared with the Trust Fund. Scheduled improvement costs for this alternative

include justified up-front component replacements. Incremental annual benefits for advanced maintenance are $210.6 million, incremental annual costs are $39.4 million and the associated net benefits are $171.3 million.

4.6.7.2 Lock Modernization Alternative Plans

Lock Modernization Alternative plans were analyzed in three groupings in order of increasing investment (up-front) costs. The first two involve construction of one new lock at each site and retention of the existing land chamber for use as the auxiliary chamber and with either a reactive or advanced maintenance strategy for the existing land chambers. The upfront cost of each of these groups is for the new river chamber only. The third group involves construction of two new lock chambers at each site.

4.6.7.2.1 Group 1 – New River Chamber and Land Chamber Maintained with Reactive Maintenance

New 600’, 800’, and 1200’ river lock chambers at EDM were modeled with the existing 600’ chamber maintained in a reactive maintenance mode (LMA Plans 7, 8 and 9, respectively) during and after construction. The new chambers would be constructed in the footprint of the existing 360’ auxiliary chamber. Putting the replacement lock in the footprint of the existing auxiliary chamber requires all traffic to use the existing land chamber until the new lock becomes operational. Closure of the land lock during this time results in total river closure.

System Costs for Group 1

Table 4-30 shows expected annual Federal costs for the new lock at EDM alternative for these three alternatives that maintain the existing 600’ chambers in a reactive maintenance mode as a backup. The optimal timing of the new river chamber at each facility is at the beginning of the analysis period (2012 for this analysis), highlighting the need for new main chambers. Federal expenditures vary with lock size and range between $103.2 and $130.5 million a year. New lock construction costs are captured in the Scheduled Lock Improvement category. Compared to the WOPC (reactive maintenance), new river locks at EDM lower future unscheduled lock repair ($17.6-17.7 million vs. $20.2 million) and scheduled lock maintenance costs ($4.2-$4.7 million vs. $8.4 million).

TABLE 4-30: Annual Federal Costs, LMA 7, LMA 8 and LMA 9 New 600', 800' and 1200' River Locks (2012-2068, 4 1/8%, October 2009, $ Million)

Cost Category	Annual Federal Cost		
	Lock Modernization Alternative Plan		
	LMA 7	LMA 8	LMA 9
Lock Improvements	$72.2	$84.0	$100.1
Scheduled Repair	$4.7	$4.5	$4.2
Unscheduled Repair	$17.6	$17.6	$17.7
Normal O&M	$8.0	$8.0	$8.0
Random Minor	$0.6	$0.6	$0.6
Total	**$103.2**	**$114.8**	**$130.5**

The screening level first costs of these plans are shown in **Table 4-31** by Code of Accounts.

TABLE 4-31: Screening Level Cost by Code of Accounts, LMA 7, 8, & 9 (October 2009 price level, $000)

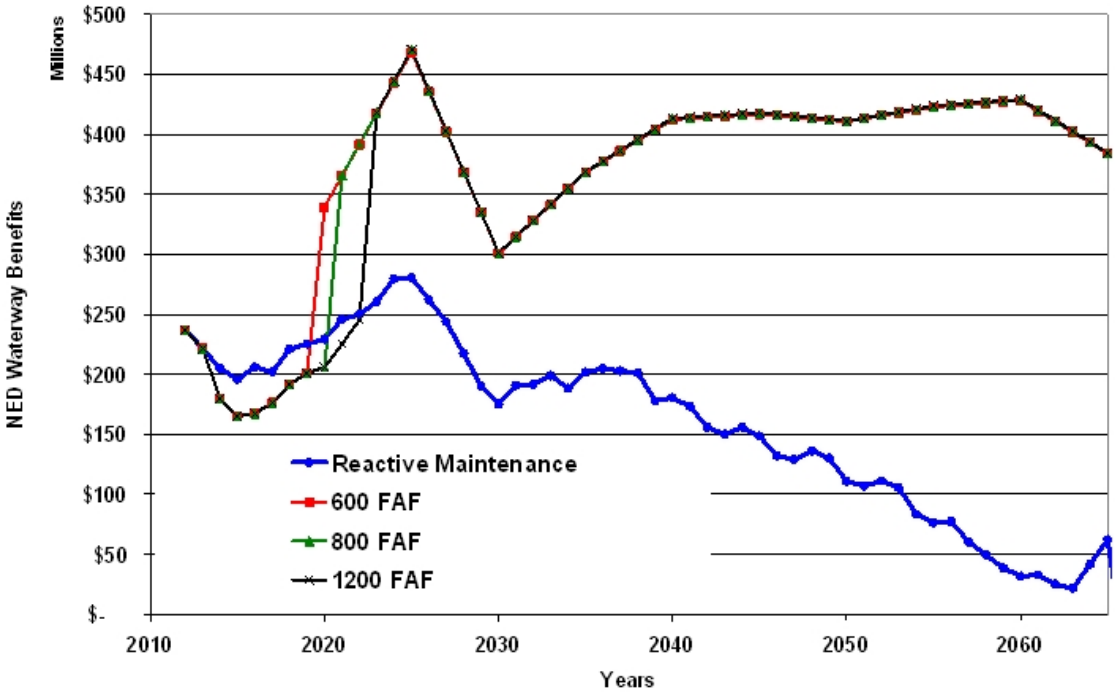
Code of Account		Screening Level Cost		
		Lock Modernization Alternative Plan		
		LMA 7	LMA 8	LMA 9
4	**Dams**	$56,364	$56,364	$56,364
5	**Locks**	$1,262,353	$1,503,083	$1,846,619
30	**PED**	$83,396	$98,850	$120,677
31	**CM**	$77,219	$91,528	$111,738
	Total	**$1,479,332**	**$1,749,824**	**$2,135,398**

Note: Lands and Damages not shown as they rounded down to an insignificant amount. Totals may not sum due to rounding

System Benefits for Group 1

System benefits are the equilibrium transportation savings net of any transportation losses caused by congestion delay or diversion due to scheduled improvement and unscheduled repair closures. **Figure 4-14** displays mid forecast transportation benefits for the reactive maintenance strategy and for the new 600' (LMA 7), 800' (LMA 8), and 1200' (LMA 9) locks at EDM. The with-project alternative plans show lower transportation savings during construction of the new lock. This is due to intermittent river closures when the existing 600' chamber closes for repair during construction of the new chamber.

FIGURE 4-14: NED Waterway Benefits, LMA 7, 8, & 9, and RM (New 600', 800', 1200' River Locks and Reactive Maintenance) (Mid Forecast)



System Statistics for Group 1

Table 4-32 summarizes mid forecast average annual system benefits and costs of constructing new 600' (LMA 7), 800' (LMA 8), and 1200' (LMA 9) locks at EDM while maintaining the existing 600' chambers. Incremental annual benefits range between $274.2 million with the 1200' lock, and $290.4 million with the 600' lock. Incremental annual costs range between $65.7 million with the 600' lock and $93.1 million with the 1200' lock. The resulting incremental net benefits over the WOPC range from $181.2 million with the 1200' lock and $224.7 million with a new 600' river lock at EDM.

TABLE 4-32: Average Annual Costs and Benefits, LMA 7, LMA 8, and LMA 9 Mid Forecast (2012-2068, 4 1/8%, October 2009, $ Million)

Upper Ohio System - EDM	New Lock (Average Annuals)		
	600' LMA 7	800' LMA 8	1200' LMA 9
New Lock with Fix as Fails (FAF) Benefits			
Base Waterway Transportation Surplus (full operations)	$475.0	$475.0	$475.0
Reduced Surplus from Scheduled Closures	-$0.7	-$0.6	-$0.6
Land transportation costs Incurred from Unscheduled diversions	-$33.4	-$38.1	-$47.8
Reduced Surplus from Unscheduled Closures	-$6.8	-$7.0	-$8.3
Externality Costs Incurred	-$0.9	-$1.0	-$1.3
Total System Benefits	$433.2	$428.3	$416.9
New Lock with FAF Costs			
Scheduled Lock Improvements	$72.2	$84.0	$100.1
Scheduled Lock Maintenance	$4.7	$4.5	$4.2
Unscheduled Lock Repair	$17.6	$17.6	$17.7
Normal O&M	$8.0	$ 8.0	$ 8.0
Random Minor	$0.6	$0.6	$0.6
Total System Costs	$103.2	$114.8	$130.5
Net Benefits	$330.0	$313.5	$ 286.4
BCR	4.2	3.7	3.2
Incremental Benefits	$290.4	$285.5	$ 274.2
Incremental Costs	$65.7	$77.3	$93.1
Incremental Net Benefits	$224.7	$208.2	$181.2
BCR (Incremental)	4.4	3.7	2.9

4.6.7.2.2 Group 2 – New Lock Chambers with Advanced Maintenance of Land Chamber

The engineering reliability analysis indicates that an advanced maintenance strategy on the existing 600' chamber after construction of the new lock chamber would result in the complete replacement of the lock walls, gates, gate machinery, and hydraulic and electrical equipment – essentially a new chamber. This plan was not deemed practical and was not evaluated. Therefore, LMA Plans 4, 5, and 6 are eliminated from the analysis. Instead the formulation moved onto twin chamber construction alternatives.

4.6.7.2.3 Group 3 – Two New Locks – Twin 600' Locks

The analysis for Group 1 clearly demonstrates that the best size for a new river lock at all three sites is 110' x 600'. Therefore, the only appropriate lock configuration at each site for plans involving two new locks is twin 110' x 600' (or abbreviates as twin 600's), or plan

LMA 1. The optimal construction schedule at each site would involve commencing construction of the new river 600' lock chambers at the beginning of the analysis period (2012 for this analysis). The new land chamber at each site would be started upon completion of the new river chamber (2020 for this analysis).

System Costs for Group 3

Table 4-33 shows the expected annual Federal costs for Plan LMA 1 at $109.3 million. Compared to the WOPC (reactive maintenance), new river locks at EDM lower future unscheduled lock repair ($6.9 million vs. $20.2 million) and scheduled lock maintenance costs ($1.2 million vs. $8.4 million).

TABLE 4-33: Annual Federal Costs, LMA 1
(2012-2068, 4 1/8%, October 2009, $ Million)

Cost Category	Annual Federal Cost LMA 1
Lock Improvement	$92.8
Scheduled Repair	$ 1.2
Unscheduled Repair	$ 6.9
Normal O&M	$ 8.0
Random Minor	$ 0.4
Total	**$109.3**

The first costs of the new locks are shown in **Table 4-34** by Code of Accounts.

TABLE 4-34: Screening Level Cost by Code of Accounts, LMA 1
(October 2009 price level, $000)

Code of Account		Screening Level First Cost LMA 1
4	**Dams**	$56,364
5	**Locks**	$1,817,099
30	**PED**	$118,866
31	**CM**	$110,061
	Total	**$2,102,390**

Note: Lands and Damages not shown as they rounded down to an insignificant amount. Totals may not sum due to rounding.

System Statistics for Group 3

Table 4-35 summarizes the mid forecast annual benefits and costs of constructing dual 600' locks at EDM. Incremental annual benefits for this alternative are $291.2 million and

incremental annual costs are $71.9 million. The resulting incremental net benefits are $219.3 million.

TABLE 4-35: Average Annual Costs and Benefits, LMA 1
Mid Forecast
(2012-2068, 4 1/8%, October 2009, $ Million)

Upper Ohio System - EDM	Average Annual Dual 600' Locks (LMA 1)
New Dual 600' Lock Benefits	
Base Waterway Transportation Surplus (full operations)	$ 475.0
Reduced Surplus from Scheduled Closures	-$ 0.7
Land transportation costs Incurred from Unscheduled diversions	-$ 33.2
Reduced Surplus from Unscheduled Closures	-$ 6.4
Externality Costs Incurred	-$ 0.9
Total System Benefits	$ 433.9
New Dual 600' Lock Costs	
Scheduled Lock Improvements	$ 92.8
Scheduled Lock Maintenance	$ 1.2
Unscheduled Lock Repair	$6.9
Normal O&M	$ 8.0
Random Minor	$ 0.4
Total System Costs	$ 109.3
Net Benefits	$ 324.6
BCR	**4.0**
Incremental Benefits	$ 291.2
Incremental Costs	$71.9
Incremental Net Benefits	$219.3
BCR (Incremental)	**4.1**

4.6.7.3 Identification of the NED Plan

Table 4-36 lists the incremental annual net benefits by rank for each investment plan evaluated under the mid-case scenario. Net benefits are incremental with respect to those that would be realized under the Without-Project Condition. From this array, the optimum investment plan, i.e. the plan that maximizes net benefits, calls for installation of a new 600' lock chamber with reactive maintenance of the existing 600' lock (LMA 7). This plan becomes the NED plan. All of the other plans, as well, would be economically justified since they result in positive incremental net benefits.

TABLE 4-36: Incremental Annual Net Benefits (2012-2068, 4 1/8%, October 2009, $ Million)

Plan Designation	Plan Description	Rank	Incremental Net Benefits
LMA 7	New 600' river chamber & RM* old land chamber	1	$224.7
LMA 1	Two new 600' chambers with deferred start of 2nd chamber	2	$219.3
LMA 8	New 800' river chamber & RM* old land chamber	3	$208.2
LMA 9	New 1200' river chamber & RM* old land chamber	4	$181.2
AMA	Advance Maintenance	5	$171.3

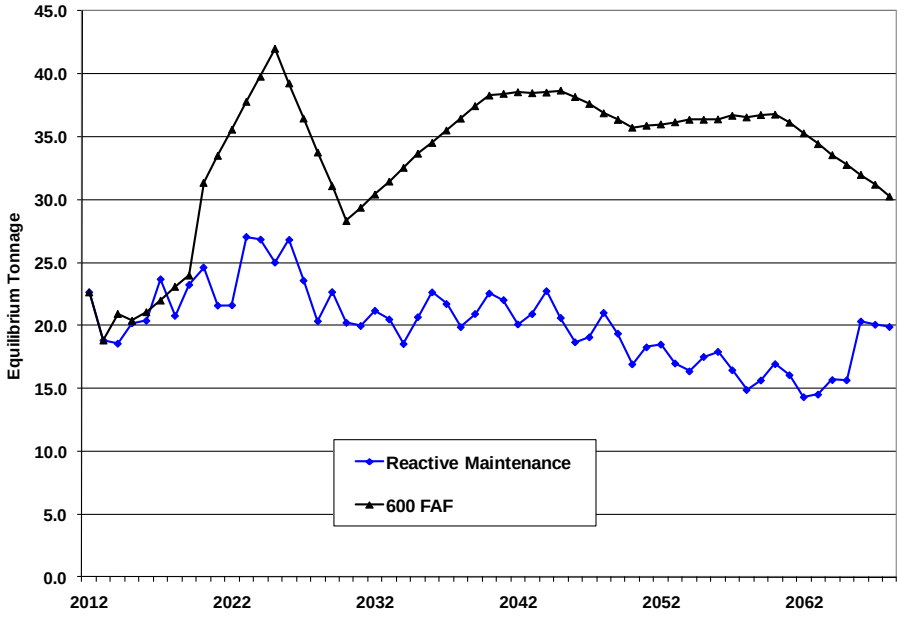
* RM denotes Reactive Maintenance

4.6.7.4 Economics of the NED Plan

4.6.7.4.1 Equilibrium System Traffic

Figure 4-15 displays equilibrium system traffic accommodated under reactive maintenance (WOPC) and under the NED plan which calls for new 600' chambers with reactive maintenance (RM) of the old 600' locks (LMA 7). Gaps represent incremental diverted traffic between the plans. Under the NED plan, with the old 600' chambers open as auxiliaries, the upper Ohio would largely avoid periodic river closures.

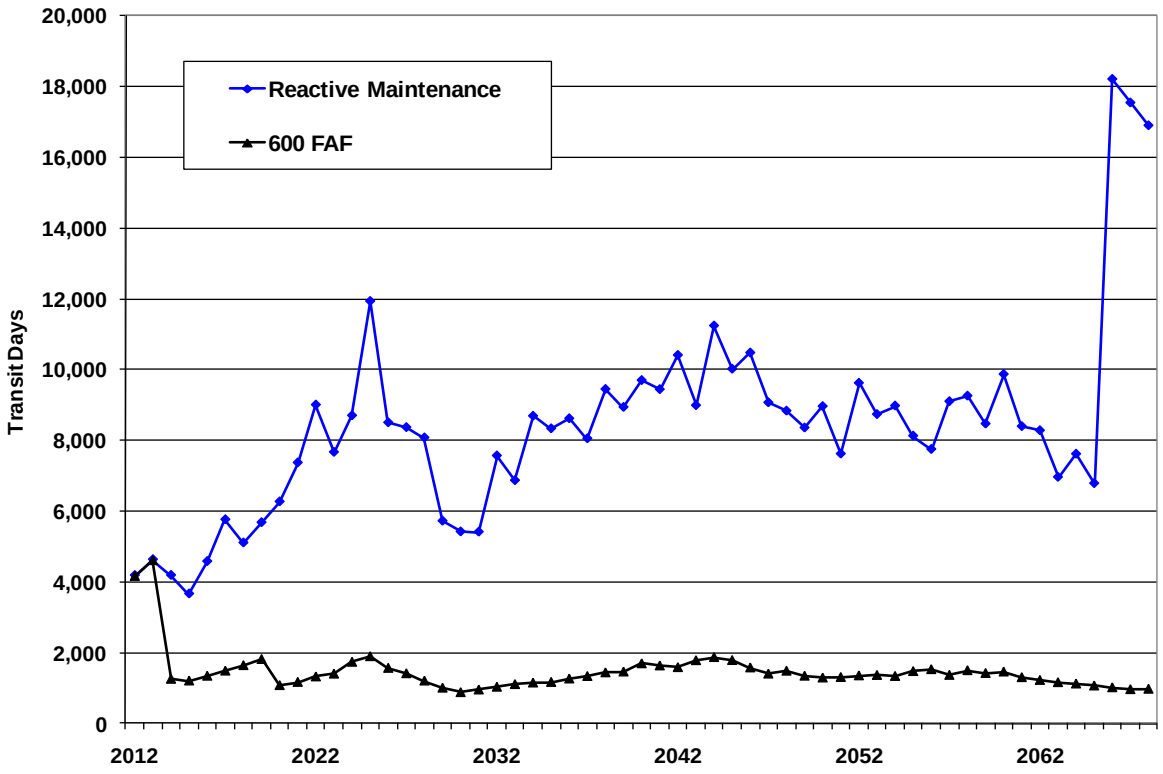
FIGURE 4-15: Equilibrium System Traffic – Mid Forecast (Million Tons)



4.6.7.4.2 System Transit Days

Figure 4-16 compares system equilibrium traffic transit time for the modeled forecast traffic scenario between reactive maintenance and the NED plan calling for new 600' chambers and reactive maintenance of the old chambers (LMA 7). NED plan benefits are derived from a more efficient transportation system because of improved reliability and increased capacity. Capacity increases with fewer closures at the new chambers.

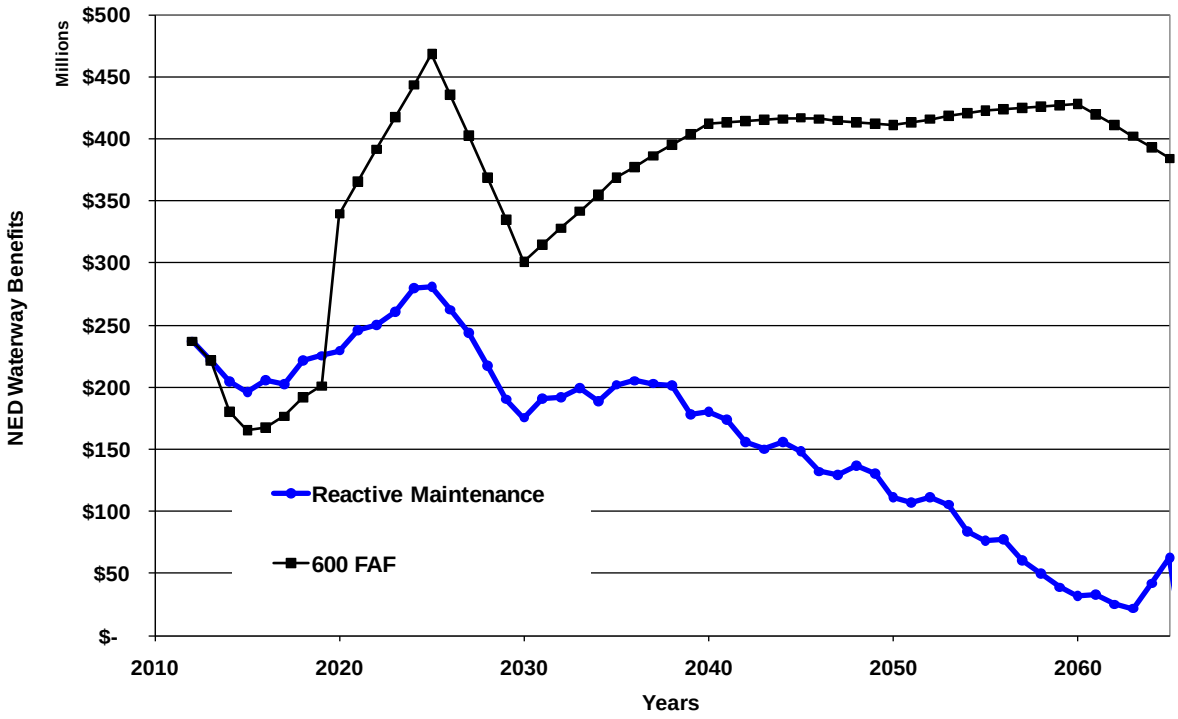
FIGURE 4-16: Transit Days to Accommodate Equilibrium Traffic Mid Forecast



4.6.7.4.3 System Savings

Figure 4-17 displays the mid forecast traffic scenario system transportation savings for reactive maintenance (WOPC) and the NED plan, which includes new 600' chambers and reactive maintenance of the existing chambers (LMA 7). Equilibrium transportation savings represent system benefits in accordance with ER 1105-2-100. The gaps between reactive maintenance and the NED plan represent system benefits attributable to the new chambers. Again, because the NED plan continues to maintain the existing 600' chamber, the dis-savings associated with the river closures from future scheduled de-waterings of the new chamber are largely avoided.

FIGURE 4-17: Equilibrium System Savings – Mid Forecast



4.6.7.4.4 Incremental Net Benefits

The incremental benefits of the NED plan, LMA 7, are shown in **Table 4-36** as $224.7 million and the incremental benefit to cost ratio is 4.4 (**Table 4-32**).

4.6.8 Sensitivity Analyses

4.6.8.1 Introduction

The preceding economic analyses were based largely on the results of the mid-level forecast scenario. The alternative plans for improving the existing Federal projects at EDM were evaluated, as well, using the high and low forecast scenarios. Also**,** in light of the uncertainty surrounding future market and navigation conditions, certain other analyses were considered for the purpose of identifying the sensitivity of NED plan selection to changes in key variables. These included limiting the growth of traffic to the initial 20 years in the forecast period, use of the current OMB interest rate of 7 percent, the impact of price elasticity of demand estimates for waterway transportation and the use of the current fleet. The results of these analyses are presented in this section. Details of all sensitivity analyses are provided in the **Economics Appendix** and are summarized below.

4.6.8.2 High and Low Traffic Forecasts

The ranking of plans by NED benefits was very insensitive to the low and high forecasts as shown below. The only change was the exchange of positions of LMA 7 and LMA 1 for the high forecast.

TABLE 4-37: Incremental Annual Net Benefits* by Traffic Forecast (2012-2068, 4 1/8%, October 2009, $ Million)

Plan Description/Designation	Incremental Net Benefits/Ranking					
	Rank	Low Case	Rank	Mid Case	Rank	High Case
LMA 7 (New 600' river chamber & RM* old land chamber)	1	$186,4	1	$224.7	2	$295.9
LMA 1 (Two new 600' chambers with deferred start of 2nd chamber)	2	$180.8	2	$219.3	1	$299.8
LMA 8 (New 800' river chamber & RM* old land chamber)	3	$170.2	3	$208.2	3	$288.1
LMA 9 (New 1200' river chamber & RM* old land chamber)	5	$144.3	4	$181.2	4	$263.1
AMA (Advance Maintenance)	4	$151.9	5	$171.3	5	$219.7

*Note: RM denotes Reactive Maintenance

4.6.8.3 No Growth and 20-Year Limited Growth in Traffic Demand

Two additional traffic scenarios were considered to determine the impacts on economic performance of LMA 7 relative to the WOPC, a no-growth of traffic beyond 2007 and a no-growth beyond 20-years into the period of analysis. This required economic ORNIM runs for both LMA 7 and the WOPC. Both scenarios resulted in lower annual net benefits than the mid scenario analysis presented in **Table 4-36**. No growth beyond 2007 reduced the incremental annual net benefits over the WOPC from $290.4 million to $169.4 million, a 42% reduction. The incremental benefit to cost ratio is reduced from 4.4 to 2.6. No growth beyond 2027 reduced these benefits to $248.3 million, a 14% reduction, and the incremental benefit to cost ratio is reduced to 3.8. While the net benefits of LMA 7 have been reduced for both scenarios, this plan is robust in that it remains economically justified for both cases.

4.6.8.4 Alternative Interest Rate

The economics of Plan LMA 7 were evaluated using the interest rate that the Office of Management and Budget (OMB) typically requires for post authorization reporting, which is currently 7 percent.

Under the OMB interest rate, incremental annual benefits of Plan LMA 7 decrease by $48.7 million (compared to the traditional analysis in **Table 4-36**) to $241.7 million and the incremental annual costs increase by $41.5 million to $107.2 million. Therefore, the resulting incremental net benefits diminish by $107.2 million to a level of $134.4 million. The NED plan remains justified with positive net benefits and a BCR of 2.3 to 1.

4.6.8.5 Price Responsive Demand

In the traditional navigation system analysis framework, individual origin-destination commodity movements are modeled with the assumption that the bulk of the individual movements are relatively unresponsive (price inelastic) to changes in waterway transportation costs that arise because of system constraints. The series of commodity movements, in this instance, forms a so-called fixed quantity demand curve. The traffic diversions that produce system equilibrium traffic are diversions of all or portions of the marginal movement, i.e. the lowest rate saver.

A more accurate analytical process reflects the fact that all of the origin-destination movements could potentially be responsive (price elastic) to changes in waterway transportation costs due to system constraints. This series of commodity movements forms a price responsive demand curve. Current navigation system analysis methods, including the analyses conducted for the Upper Ohio study, reflect price responsiveness on the part of the individual commodity movements.

A sensitivity test conducted for the current study compares results obtained for Plan LMA 7 using current methods based on price responsive movement demand with results generated using the traditional methods based on fixed quantity movement demand. In this instance, incremental benefits increase by $39.2 million (compared to the benefits with the traditional analysis in **Table 4-32**) to $223.9 million with fixed quantity movement demand. Incremental costs remain unchanged. Incremental net benefits increase by $39.2 million to $159.0 million and the BCR increases to 3.5 to 1.

4.6.8.6 Change in Fleet Assumptions

The term “fleet” refers to the towing equipment, meaning towboats and barges as well as the tow sizes and tow configurations used in inland navigation modeling. Tow sizes and tow configurations are usually selected by the model. Barge fleet assumptions are normally specified by the analyst. The upper Ohio is generally the only part of the ORS where narrow barges, i.e. standards and stumbos, continue to be used. As part of this study, a separate study was conducted to determine the characteristics of the future barge fleet on this river segment. As a result, it was determined that standard and stumbo barges would gradually be phased out in favor of jumbo barges.

In inland navigation system modeling, the normal procedure is to model both the WOPC and the alternative improvement plans using the future anticipated barge fleet. One of the Corps requirements for sensitivity tests is to model the WOPC and the alternative improvement plans using the current fleet. The change from current fleet to future fleet assumptions increases incremental benefits by $112.6 (compared to the benefits with the traditional analysis in **Table 4-32**) million to $184.7 million. Incremental costs decrease by $0.5 million to $64.9 million. Incremental net benefits increase by $113.1 million to $118.9 million and the BCR increases to 2.8 to 1.

4.6.8.7 Conclusion

The NED Plan, LMA 7, is shown to be very robust in that it is the NED plan for two of the three forecast scenarios and remains economically preferred to the WOPC for all sensitivities considered. Plan LMA 1, consisting of two new 600' chambers at all three sites, is the NED plan for the high forecast. This is further evidence that the 600' lock remains the most appropriate main chamber lock size for the Upper Ohio River for the analysis period.

4.6.9 *Environmental Consequences of Navigation Plans[24]

4.6.9.1 Measures Not Carried Forward

A number of potential navigation measures were eliminated from detailed consideration early in the navigation study for reasons other than environmental impacts. However, a preliminary assessment of environmental impacts was considered in the decisions on whether to pursue these measures. This assessment concluded that the impacts of the various measures were equivalent to or far exceeding those impacts associated with the recommended plan.

Those measures having greater impacts were ones involving major pool elevation adjustments in the study area, which included the Three-for-Three replacement at new sites and the Two-for-Three replacement involving removal of Dashields Locks and Dam. The Two-for-Three measures were given considerable attention in the study based on long-term O&M cost savings and potential navigation benefits from having fewer facilities and longer navigation pools. The impacts that would have resulted from the significant (9-foot) Dashields pool lowering - dredging and disposal requirements (3 million cubic yards), shoreside facility relocations, and the loss of highly valuable dam tailwater habitat - provided strong support with other engineering and navigation objections against pursuing this measure. Likewise, a Three-for-Three replacement at new sites would have entailed pool level changes between the old and new facilities, and a much greater area of construction impacts at three new sites, as well as removal and disposal of the three existing facilities.

Other measures considered were major rehabilitation of existing main chambers, and third locks at the existing facilities. These measures would not involve new construction sites or pool elevation changes. However, in that they involve major construction at the existing sites, they would not be dissimilar in the level and types of environmental impacts associated with the recommended plan. It was concluded that all of the measures eliminated from further planning had no significant environmental advantages over the plans considered in detail.

4.6.9.2 Lock Modernization Measures (In-River Impacts)

4.6.9.2.1 One versus Two New Chambers (Group 1 vs. Group 3)

The array of lock modernization alternatives carried forward for detailed analysis consisted of essentially two groups, distinguished by whether a new main chamber is accompanied by

[24] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

constructing a new auxiliary chamber (Group 3) or by maintaining the existing main (land) chamber (Group 1). Within each group are the three variations on the length of the new 110'-wide main chamber, either 600, 800, or 1200 feet in length.

There is little difference between the two groups in the way of environmental impacts. They are identical in that they both involve construction of new locks in place of the present river chamber. One of the main distinctions is in the length of the construction periods, i.e. whether they would conclude with completion of the first new chamber or extend through construction of a second chamber at each facility. Similar work area restoration would occur at the end of construction, regardless of length. If only one new chamber is authorized, the existing land chamber would be maintained until a major failure necessitates its closure. There would be potential for queuing impacts during any period of auxiliary chamber closure, while various options from abandonment to rehabilitation are being considered. However, with a new, reliable main chamber it is unlikely that any prolonged queuing would occur.

Without a significant difference perceived between the two groups, the impact analysis focused on Group 1 and on the differences between the various new chamber lengths. In-river impact differences between new chambers ranging from 600 to 1200 feet in length are of primary concern, as the upland work area requirements would be the same for any alternative lock length. In-river construction impacts of the Group 3 (two new chambers) alternatives would not differ meaningfully from the Group 1 alternatives, and may be inferred from the discussions of Group 1.

4.6.9.2.2 One New Chamber & Maintain Land Chamber (Group 1)

Aquatic Habitat

Aquatic Habitat Impact Evaluation Methodology

Potential aquatic and terrestrial impacts, as well as mitigation alternatives, were evaluated using the United States Fish and Wildlife Service's Habitat Evaluation Procedures (HEP). HEP is a habitat-based system that uses species Habitat Suitability Index (HSI) models to assess impacts and potential mitigation for comparison between alternatives. Through application of the HSI models, an HSI is assigned to each habitat type for each evaluation species, which is then multiplied by the total acreage of that habitat to obtain an output of Habitat Units (HU).

Data Sources and Assumptions

Input data used in the HEP Study was primarily obtained from existing sources: Corps geographic information system (GIS) data files, Corps and ORSANCO water quality data, the UONS Ecosystem Restoration Study (June 2010), and the UONS Natural Resources Assessment, Potential Work and Laydown Areas (December 2009).

The aquatic study area for the HEP Study was determined to include the entire EDM Pools, as well as the upper 3,000 feet of the New Cumberland Pool: approximately 7,200 total acres. The aquatic evaluation species included the Gizzard shad, Channel catfish, Smallmouth buffalo, Smallmouth bass, Spotted bass, Common shiner, Paddlefish, Flathead catfish, and

Walleye. These were selected to address the varied habitats present in the lock construction areas immediately above and below the dams, and to represent a cross-section of species having life history requirements relevant to the habitat types being evaluated at the locks as well as in the adjacent pools. The lack of available HSI models for darters was noted, and the Common shiner was selected as a surrogate species for other shiners occurring in the study area for which HSI models are not available. Species model issues and the selection of the final array for evaluation were discussed in detail with the Interagency Working Group. The Group consensus was that the selected models would adequately capture habitat impacts relevant to the Upper Ohio River fish community.

Impacts associated with each lock alternative include the footprint of the proposed lock chamber and the re-establishment of new sail line channels in and out of each new lock chamber. Impacts for the construction of the new lock chamber and new guard and guide walls vary depending upon the size of the lock alternative. The construction of a new 110' x 600' lock chamber and new guard walls results in an impact to 4.8 acres of riverine habitat; the construction of a new 110' x 800' lock chamber and new guard walls impacts 6.2 acres of riverine habitat; and the construction of a new 110' x 1200' lock chamber and new guard walls impacts 9.0 acres of riverine habitat. Impacts associated with the re-establishment of new sail line channels, assumed to be 200 feet wide and extending 2,000 feet above and below each lock are the same for each lock alternative, totaling close to 18.2 acres.

The existing lock chambers and the riverine habitats converted to new lock chambers were assumed to have zero habitat value. The sail line channels into and out of the locks were assumed to have a lower overall habitat value than the surrounding pool or tailwater habitat. The upstream pool sail line channel was rated at 90 percent of the pool HSI value and the tailwater sail line channel rated at 70 percent of the tailwater HSI value.

Aquatic Habitat Impact Results

The following equations summarize the WPC calculations for each of the lock alternatives and show the number of HUs lost by subtracting the WOPC from the WPC.

WPC-600 ALTERNATIVE IMPACT SUMMARY

WOPC	=	3,477.60 HUs
WPC-600	=	3,465.37 HUs
Total Loss for all three Locks	=	12.23 HUs

WPC-800 ALTERNATIVE IMPACT SUMMARY

WOPC	=	3,477.60 HUs
WPC-800	=	3,463.34 HUs
Total Loss for all three Locks	=	14.26 HUs

WPC-1200 ALTERNATIVE IMPACT SUMMARY

WOPC	=	3,477.60 HUs
WPC-1200	=	3,459.28 HUs
Total Loss for all three Locks	=	18.32 HUs

Riparian Resources

None of the lock modernization alternative plans involve pool elevation changes or alternation of shoreline approach conditions that would affect riparian or upland resources.

Wetlands

None of the lock modernization alternatives involve pool elevation changes or alteration of shoreline approach conditions that would affect riparian or shoreline wetlands.

Air Quality

The potential impacts to air quality are primarily associated with construction activities. These are discussed in a separate section, below. With the adoption of any of the alternatives plans for new lock chambers, there would be a decrease in diesel fuel emissions over the WOPC associated with queuing anticipated at the small auxiliary chambers during main chamber closures.

Hydrology

None of the lock modernization alternatives will affect existing navigation pool elevations or involve relocation of dams to affect the length of existing pools. The replacement of the existing small auxiliary chambers with larger main chambers will encroach into the existing dams. At the Emsworth and Montgomery gated dams, it has been determined that more aggressive dam operating schedules would eliminate any potential for backwater effects from the shortened dams. At the Dashields fixed crest dam, any potential for backwater effects would be eliminated through the addition of a new gated section.

If cofferdam construction is employed, the potential for backwater effects during high flows is increased due to the temporary presence of the cofferdam structure in the river. The extent of this backwater effect is highly dependent upon flows experienced during construction period and upon the specific size and design of the cofferdam. The potential extent of these impacts will not be evaluated until detailed design and construction practices are finalized. All reasonable mitigative measures will be employed to minimize the backwater effect of any temporary construction measures.

Navigation dams maintain pools to provide authorized navigable depths. They do not provide flood retention benefits and pass all incoming flow. The recommended plan will not change the authorized navigable depth, the normal pool elevations, or affect passage of flows.

Water Quality

Each of the dams has historically provided water quality benefits primarily through reaeration of flows and maintaining a reservoir of water in the navigation pools. The dams' reaeration capacity will not be significantly reduced by the minor shortening necessary to accommodate the new, wider locks.

Water quality impacts during construction will be restricted to minor and temporary disturbances to sediment and turbidity during placement and removal of sheet pile

cofferdams, or during in-the-wet underwater excavation and construction. Any construction work that is confined within dewatered cofferdams would have no further impacts. In-the-wet construction involves periodic underwater excavation that will generate turbidity and localized sedimentation. These activities may take place at various times throughout the construction period. They may precede construction, such as in preparatory excavation for cofferdam placement or they may involve the replacement of dam erosion protection displaced for lock wall construction. These activities are typically confined to the immediate vicinity of the new construction, and experience has demonstrated that their impacts are of short duration and limited extent. No seasonal restrictions have been imposed on this method of in-river work in the past due to its sequential, multi-construction-season nature and the limited extent of its influence in the immediate vicinity of the existing project.

The feasibility-level design for the alternative lock replacement structures and associated dam modifications include underwater excavation for temporary cofferdam and cofferbox placement, removal of accumulated sediments at the mouth of Lowries Run (at Emsworth Locks), and placement of rock berms at the new lock guard walls. These activities are described in CWA 404(b)(1) evaluations for each facility (see **Environmental Appendix**). Appropriate mitigation measures for aquatic habitat impacts of the new lock chambers are included in the recommended plan. The use of clean rock fill, upland disposal of excavated materials, and employment of construction best management practices will minimize adverse impacts to adjacent waters.

Each construction contractor is required to prepare and implement a government-approved Environmental Protection Plan. This Plan identifies actions for the prevention/control of pollution and habitat disruption that may occur to the environment during construction and associated activities. The control of environmental pollution and damage requires consideration of land, water, and air; biological and cultural resources; and includes management of visual aesthetics; noise; solid, chemical, gaseous, and liquid waste; radiant energy and radioactive material, fuels and lubricants, contractor-generated hazardous waste, as well as other pollutants.

Before starting any major phase of the work, the contractor develops an Activity Environmental Analysis. This analysis evaluates potential environmental consequences of the activity and the techniques which will be utilized to accomplish the work in an acceptable manner. The analysis includes (a) the phase or activity of work (b) the potential environmental consequences of the activity, (c) precautionary actions to prevent adverse environmental impacts, (d) actions in the event of an environmental incident, and (e) the appropriate reference to Federal, state or local standards, regulations or laws.

As part of the Environmental Protection Plan, the contractor also prepares the following specific resource protection plans:

Erosion and sediment control plan - identifies the type and location of the erosion and sediment controls to be provided. The plan must include monitoring and reporting requirements to assure that the control measures are in compliance with the erosion and sediment control plan, Federal, State, and local laws and regulations.

Work area plan - shows the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas including methods for protection of features to be preserved within authorized work areas.Drawings showing locations of proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on the site.

Traffic control plan - includes measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather. The Plan includes measures to minimize the amount of mud transported onto paved public roads by vehicles or runoff.

Spill Control Plan - addresses the procedures, instructions, and reports to be used in the event of an unforeseen spill of a substance regulated by 40 CFR 68, 40 CFR 302, 40 CFR 355, and/or regulated under State or Local laws and regulations.

Non-hazardous solid waste disposal plan - identifies methods, locations, and schedules for solid waste disposal, and includes a recycling and solid waste minimization plan that lists measures to reduce consumption of energy and natural resources to comply with and to participate in Federal, State, Regional, and local government sponsored recycling programs to reduce the volume of solid waste at the source.

Air pollution control plan - details provisions to assure that dust, debris, materials, trash, etc., do not become airborne and travel off the project site.

Contaminant prevention plan - identifies potentially hazardous substances to be used on the job site; identifies the intended actions to prevent introduction of such materials into the air, water, or ground; and details provisions for compliance with Federal, State, and local laws and regulations for storage and handling of these materials.

Waste water management plan - identifies the methods and procedures for management and/or discharge of waste waters that are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, and disinfection water.

Contractors implement specific environmental protection practices and measures to reasonably minimize the discharge of sediment-laden water and contact water from concrete curing activities, and prevent the redeposition of sediment, underwater excavated material, and drill cuttings into the river. Such measures include, but are not limited to, the following:

a. Precluding the heaping of spoil (underwater excavated material, drill cuttings, etc.) on barges or other floating structures.

b. Employing collection hoppers or drip troughs; and fashioning excavation buckets and drilling tools to minimize the loss of spoil when passing excavation tools over water.

c. Equiping barges with filtered sumps to pre-filter free water before discharging the water from the barge; ensuring that the barges are in good working condition and do not leak.

d. Passing all water and water-sediment slurries from airlifting activities and from pumping activities associated with shaft dewatering, cofferbox dewatering, concrete curing and other activities through a filtered sump or similar system before discharging the water to the river.

Fleeting Areas

Barge fleeting and mooring areas reduce aquatic habitat values through increased scour from tow props and from coverage of large surface areas with barge fleets. The larger fleeting areas occur below Montgomery Locks where upbound tows transiting the lower river's 1200-foot chambers have to reconfigure to pass through the upper river's 600-foot chambers. Were the larger main chamber alternatives (800-ft or 1200-ft) recommended, there may be an indirect inducement for fleeting areas to move further upriver. However, with no change in main chamber length being recommended, there is no direct incentive for relocation of fleeting areas, and it would be speculative to anticipate their impacts. Since fleeting and mooring areas are regulated by Department of the Army permits, any impacts associated with establishing new (non-Corps of Engineers) permitted facilities would be addressed in the applicant's permit conditions rather than in this study.

Sediment Quality

None of the lock modernization alternatives would generate any contamination that would adversely affect sediment quality. Removal and disposal of riverbed sediment will be subject to chemical testing to substantiate suitability of quality for the selected disposal method. These tests will be performed and coordinated with the appropriate regulatory agencies in advance of their disturbance and disposal.

Mussels

There will be no effect on native mussels from construction activities, based on their current status in the project area. If the construction start is delayed into the future, the need for additional mussel surveys in advance of construction will be evaluated in consultation with federal and state natural resource agencies.

Endangered and Threatened Species

There will be no effect on federally endangered or threatened species, or their critical habitat, from construction activities, based on their current status in the project area. If the construction start is delayed into the future, the need for additional surveys in advance of construction will be evaluated in consultation with federal and state natural resource agencies.

Socioeconomics EJ

For the detailed impact analysis, see "Construction Support Areas (Upland Impacts)." Community characteristics have been identified and analyzed in conformance with EO 12898 and its relevant federal implementation guidance. This analysis characterized four of the communities within one mile of the navigation facilities as EJ communities under one or both of the EJ criteria (minority, low-income). We determined that project impacts to these EJ community populations would be neither significant, nor disproportionately high and/or adverse on human health or the environment.

Floodplains

Executive Order (E.O.) 11988, Flood Plain Management, requires the considerations of alternatives to Federal actions located in floodplains to avoid or minimize adverse effects and incompatible development in the floodplains. Because there are no non-structural alternatives which would maintain safe and reliable river navigation, the structural alternatives are the only practicable alternatives consistent with the law and the E.O. Therefore, the District has designed its action to minimize potential harm within the floodplain in accordance with Section 2(a)(2) of the E.O. The public review requirement of the E.O. is being satisfied through circulation of the environmental impact statement.

The structural alternatives will be designed to cause no increases in flood elevations or changes to the computed floodways. Lower frequency flood elevations may actually be slightly reduced, with the difference progressively lessening until, at the one-percent-annual-chance interval, the flood elevations will be nearly identical. Documentation for this "no-change" hydraulic modeling will be addressed/provided after project authorization.

As none of the alternatives would increase the one-percent-annual-chance flood heights, the flood boundaries along the Ohio River, published in the FIS for Allegheny County, PA and for Potter Township, Beaver County, PA, should not require any revision. Floodway boundaries should also remain unchanged.

Transportation and Traffic

All of the lock replacement alternatives considered in detail would provide for the continuation of safe, reliable river traffic over the 50-year analysis period. The documented fuel efficiencies of river shipment over rail and road traffic would result in less fuel consumption for movement of the same volume of goods. It also provides for a move diverse transportation network and competitive environment to encourage efficiencies and savings of time and fuel. Overland traffic congestion that might occur with the WOPC and more frequent main chamber closures would be avoided with implementation of any of the lock replacement alternatives.

Health and Safety

Under the WOPC, recreational boater safety will be potentially compromised during periods of main chamber closings due to commercial tow queuing at lock approaches, which would

lead to congestion and competition for lockages through the small auxiliary chambers. These potential impacts will be avoided with any of the lock replacement alternatives that will provide reliable structures. Maintaining safe reliable river traffic would also avoid the potential for diversion of material movement by road causing overland congestion and safety issues with motorists and pedestrians.

HTRW

Riverbed materials to be excavated and disposed from the construction footprint of each replacement lock chamber will undergo due diligence, and if necessary, tested and characterized upon removal for disposal at a commercially available, properly permitted site.

Recreation

Lock modernization and the modest level of future commercial traffic growth will not have any effect on river-based recreation. Under the WOPC, the anticipated queuing of commercial tow traffic at the small auxiliary locks during main chamber closures would effectively eliminate the opportunity for recreational lockages during the closure period. These impacts would not occur with new, more reliable locks and the larger auxiliary chambers.

Cultural Resources (36CFR800.5 Assessment of Adverse Effects)

Locks and Dams

Emsworth, Dashields, and Montgomery Locks and Dams are considered eligible for the National Register of Historic Places under Criteria A and C. Criterion A is associated with broad patterns of American history, and Criterion C relates unique characteristics of architecture or engineering.

The ORMSS Programmatic Agreement Section III.B. requires a determination of effect and treatment for National Register listed and eligible properties. An effect to a historic property is defined as undertakings which may alter certain characteristics of a property that make it eligible for inclusion on the National Register of Historic Places. The process of determining effects takes into account the alteration of features impacting a property's location, setting, or use – depending upon the property's significant characteristics [36 CFR 800.9(a)]. An undertaking becomes an adverse effect when it diminishes the integrity of the property's location, design, setting, materials, workmanship, feeling, or association [36 CFR 800.9(b)].

All of the EDM lock and dam modernization alternatives would remove the existing auxiliary chambers, portions of the dams, original support buildings, and affect the lock configuration. Within Criterion A, actions undertaken to maintain the authorized navigation purposes of these facilities as intended by Congress are not considered to be adverse.

Within the context of Criteria C, modernization of the three existing locks and dams constitutes an adverse effect. Criterion C is "The quality of significance in American … engineering … is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and …

embody distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction." Under Criterion C, there will be a number of adverse effects to both the contributing elements of the Ohio River Navigation System and to the system as a whole. From an architectural standpoint, modernization will result in the removal of unique engineering systems dating back to the 1920s, and altered aesthetic appearance within the Ohio Valley viewshed.

There are no feasible measures to avoid or minimize the adverse effects to the system from the proposed modernization project as it must occur to ensure that inland navigation along the Ohio River continues. Impacts to the seven aspects of integrity are summarized in the following table. Appropriate treatment for the adversely affect properties is addressed under **4.6.9.9.3 Cultural Resource Mitigation Measures.**

TABLE 4-38: National Register Criterion C - Assessment of Effects

Characteristic	Criterion C, Architectural Integrity
Location	No effect – no change in location.
Design	Adverse effect – replacement of river chamber and dam elements.
Setting	No effect – no change to setting.
Materials	No effect – no change to materials.
Workmanship	Adverse effect - elimination of unique features at all three sites.
Feeling	Adverse effect - change from historic configuration (110 x 600 & 56 x 360) – the original pattern of the two-lock arrangement. Modernization will alter the visual aesthetics.
Association	No effect – association and function remain unchanged.

4.6.9.3 Construction Support Areas (Upland Impacts)

4.6.9.3.1 Terrestrial Habitat

Terrestrial Habitat Impact Analysis Methodology

Potential aquatic and terrestrial impacts, as well as mitigation alternatives, were evaluated using the United States Fish and Wildlife Service's Habitat Evaluation Procedures (HEP). HEP is a habitat-based system that uses species Habitat Suitability Index (HSI) models to assess impacts and potential mitigation for comparison between alternatives. Through application of the HSI models, an HSI is assigned to each habitat type for each evaluation species, which is then multiplied by the total acreage of that habitat to obtain an output of Habitat Units (HU).

Input data used in the HEP Study was primarily obtained from field visits (August 2010), and existing sources: USACE geographic information system (GIS) data files, and the UONS Natural Resources Assessment, Potential Work and Laydown Areas (December 2009).

The terrestrial study area for the HEP Study included a Primary Laydown Areas (PLA) and Secondary Laydown Area (SLA) for each site. However, it was determined that the SLAs need not be evaluated with HEP since the areas of disturbance could be confined to avoid any areas having substantial wildlife habitat or value, as based on prior site characterization studies and confirmed in field visits on August 2010.

The terrestrial species which were selected for modeling purposes included the Eastern cottontail, Black-capped Chickadee, and the Yellow Warbler. These models appeared to be the best fit of the available HSI models for species inhabiting the varied open field, shrub/scrub, and early forest habitats that characterize the primary work areas. Discussions with the Interagency Working Group on terrestrial species selection resulted in a general consensus that these were appropriate species to model, with the possible substitution of the New England cottontail for the Eastern Cottontail. Further research into this suggestion concluded that the study area was outside the range of the New England cottontail, and that Eastern cottontail model would meet the needs of the habitat impact evaluation.

The Study Team evaluated terrestrial impacts for the PLA-WPC (With Project Condition) alternatives that included:

Emsworth PLA – 4.90 acres. Without Project Condition (WOPC) condition is mixed herbaceous old field and shrub-scrub, early succession tree mosaic.

Dashields PLA – 6.75 acres. WOPC condition is mixed herbaceous old field and shrub-scrub, early succession tree mosaic.

Montgomery PLA – 7.00 acres. WOPC condition is mixed late succession shrub thickets and pole stage timber.

Terrestrial Habitat Impact Results

For purposes of this study, it was assumed that the entire PLA site would be disturbed during construction, and was assigned a WPC HU value = 0. Therefore the net loss of HUs for each PLA-WPC is equal to the HU value of the PLA-WOPC. Net losses of terrestrial HUs by PLA can be summarized as follows:

Emsworth PLA – Net Loss of HUs = 2.65

Dashields PLA – Net Loss of HUs = 3.98

Montgomery PLA – Net Loss of HUs = 4.27

4.6.9.3.2 Air Quality

The potential impacts to air quality are primarily associated with construction activities. These would vary in duration between the alternatives, based on slightly longer construction

periods anticipated for the 800 and 1200-foot chamber lengths over a 600-foot length. The types of impacts would not vary significantly between alternatives.

Construction activities would generate fugitive dust emissions from site preparation and from the construction equipment, and emissions from construction equipment and concrete batch plant. Dust emissions would be controlled through best management practices for dust suppression. A concrete batch plant will be constructed and operating during most of the anticipated six -year construction period for each facility. Corps experience with these facilities has concluded that they emit well under 100 tons per year of fine particulate matter and are therefore exempt from general conformity requirements under the Clean Air Act.

In order to comply with Section 176 of the Clean Air Act and to demonstrate *de minimis* thresholds under 40 C.F.R. §93.150(b), the Pittsburgh District completed emission calculations for relevant criteria pollutants in a report titled, *Upper Ohio Navigation Study, Pennsylvania, Clean Air Act Conformity Applicability Evaluation* (see **Environmental Appendix**). The emissions were calculated for construction activities as well as the operation of central mix concrete batch plants using established USEPA methods and data on type of construction equipment, annual concrete production, and annual hours of operation. This evaluation demonstrated that the federal action would not exceed the emission levels in 40 CFR 93.153 (b).

4.6.9.3.3 Water Quality

Protection of water resources on or adjacent to the construction support areas is addressed through site permitting, best management practices, and controls developed by each contractor in an Environmental Protection Plan. A description of the contents and coverage of an Environmental Protection Plan is included under Section 4.6.9.2 Lock Modernization Measures (In-River Impacts), 4.6.9.2.2 “Water Quality.” Permitting controls and practices specific to an upland site include:

Erosion and Sedimentation controls during site development and construction (e.g. silt fences, slope stabilization, sediment traps/ponds, diversion channels/swales, and vegetative cover),

Effluent monitoring and reporting,

Spill prevention and response plan,

Site maintenance/cleanliness (sweeping),

Dust control,

Truck wash, and

Regular site assessment (inspection and reporting).

4.6.9.3.4 Wetlands

None of the lock modernization alternatives involve pool elevation changes or alteration of shoreline approach conditions that would affect riparian or shoreline wetlands. The 2.3-acre

pond/wetland area at the Montgomery Secondary work area would not be impacted, as the overall site (32.3 acres) is sufficiently large to allow site development to avoid the wetland.

4.6.9.3.5 Endangered and Threatened Species

The construction support areas are within the range of the federally designated Indiana bat. Management measures to avoid impacting this species typically include the avoidance and minimization of tree clearing, or the timing of clearing activities to avoid the summer roosting period. The Corps will minimize clearing of riparian areas and maintain a 100-foot or greater buffer between site development and the river at the construction support areas. Any necessary clearing activities will be timed to occur outside of the summer roosting period. Specific measures and timing will be coordinated with the USFWS prior to implementation.

A number of state-designated species were noted in the vicinity of the Dashields and Montgomery primary and secondary work areas. Implementing a 100-foot or greater buffer between development and the river is a conservation measure that should avoid or minimize any impacts to any of the aquatic species. The management measures undertaken to avoid and minimize impacts to Indiana bat habitat will also apply to protection of the Prothonotary Warbler, a state species of concern.

4.6.9.3.6 Socioeconomics Environmental Justice (EJ)

Now that four EJ communities have been identified within the impact area, the project impacts to these communities may be evaluated. Impacts of the project's navigation alternatives are primarily associated with the temporary construction activities. The navigation project proposes to replace the auxiliary, river chamber with a new larger lock chamber at each facility. As such, the primary construction activities are confined to the river, with the exception of the adjacent land-based support areas (each about six acres) for concrete production and storage. There are no residential areas in the immediate vicinity of the recommended plan's preferred construction support areas. Both Emsworth and Dashields support areas are in an historically and presently industrialized setting. No direct physical impacts to community populations are anticipated in these areas, no cumulative impacts, or any degradation of aesthetics. The primary impact of any significance to the local communities from construction is considered to be temporary increases in ambient noise, which radiates in all directions from the source. In this industrial/transportation corridor, there are high ambient levels of existing noise. There will be no significant air quality issues, as the air quality analysis of the concrete batch plant operations has determined *de minimus* levels.

The intent of an EJ analysis is to determine whether there may be disproportionately high and adverse human health or environmental effects of minority populations, low-income populations, or Indian tribes. CEQ guidance for determining disproportionate effects is cited in the above "definitions." The US Department of Transportation (USDOT) uses a simplified definition for **disproportionately high and adverse effect** on minority and low income populations as "an adverse effect that (1) is predominantly borne by a minority population and/or a low-income population, or (2) will be suffered by the minority population and/or low-income population and is appreciably more severe or greater in magnitude than the

adverse effect that will be suffered by the non-minority population and/or non-low income population."[25] This analysis will use the simplified USDOT definition.

As it is population impacts that are of concern, we considered the location and relationship of the residential areas in the EJ communities as shown in the aerial photographs (**Figures 1-3**) to the impact radius. In many cases, as described below, residential areas of the identified EJ communities are situated outside of the impact perimeter. Impacts to industrialized or undeveloped areas of these EJ communities were not considered to be a significant issue requiring analysis.

Emsworth Locks and Dams

Because the residential areas of Neville and Stowe do not lie within the perimeter radius, and there will be no impact to these EJ communities. A small portion of Avalon is near the outer limit of the radius, while two non-EJ communities, Emsworth and Ben Avon, lie closer to the center of the perimeter than Avalon. All of these communities are situated within a heavily developed industrial and transportation corridor and are acclimated to high ambient noise levels. As a standard mitigating practice for navigation construction projects in populated areas, as with the Emsworth Dams major rehabilitation project conducted between 2009-14, noise-generating activities are limited to daylight hours. Also, the relatively high, steep ridges characterizing much of the Upper Ohio River corridor deflect river-level noise upward mitigating its impact on the majority of residential areas situated beyond the ridge slopes.

Temporary construction noise limited to daylight hours will not be a significant intrusion to the existing condition. In this respect, Avalon may experience some increased noise, but will not bear a disproportionate share of the environmental effect, and no mitigation or further EJ analysis is required.

Dashields Locks and Dam

The EJ community of Leetsdale lies partially within the Dashields impact radius. Most of this affected area consists of an industrial park, but also holds a shopping plaza, school, and a small residential area at the perimeter of the radius. The majority of the residential area of Leetsdale, however, lies outside the one-mile perimeter. A heavily used railroad mainline and highway separate the industrial park and river from the other community resources. Adjacent to Leetsdale and closer to the navigation facility lies the residential community of Edgeworth. The undeveloped land riverward of the transportation lines in Edgeworth is the preferred primary construction support area for Dashields. Both communities are situated within a heavily developed industrial and transportation corridor and are acclimated to high ambient noise levels. The non-EJ community of Edgeworth will bear more of the noise impacts than will Leetsdale, but in both cases, temporary construction noise limited to daylight hours will not be a significant change to the existing condition. Leetsdale will not bear a

[25] U.S. DOT Order 5610.2, *Order to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated April 15, 1997.

disproportionate share of the environmental effect, and no mitigation or further analysis is required.

Montgomery Locks and Dam

Because the populations that are the subject of the EO are not present, it is reasonable to conclude that the proposed action will not have a disproportionately high and adverse human health or environmental effect on low-income populations, minority populations, or Indian tribes, and that no further environmental justice review was warranted for this portion of the project.

Public Involvement

Details of overall study coordination are provided in feasibility report **Section 7.** Press releases and legal notices were placed in all of the major newspapers serving the Upper Ohio Valley for the NEPA scoping meetings held in Monaca and Coraopolis in 2006. The draft Feasibility Report was sent to all riverside community public news media, libraries, and elected officials councils, and supervisors in the overall study area.

Conclusions

Community characteristics have been identified and analyzed in conformance with EO 12898 and its relevant federal implementation guidance. This analysis characterized four of the communities within one mile of the navigation facilities as EJ communities under one or both of the EJ criteria (minority, low-income). We determined that project impacts to these EJ community populations would be neither significant, nor disproportionately high and/or adverse on human health or the environment.

4.6.9.3.7 HTRW

The Phase I Environmental Site Assessments identified recognized environmental conditions (REC) at each of the primary and secondary sites, and recommended additional site investigation. After the Phase II Environmental Site Assessments were completed, the primary construction laydown areas at Dashields and Montgomery, and the secondary construction laydown area at Emsworth, were recommended. The Phase II ESA Report identified undeveloped land of sufficient size and topography to use as a construction support areas for each of the three new locks that maximizes avoidance of potentially contaminated areas. However, prior to the acquisition of any interest in real property, additional HTRW investigation is required in the next phase of project development.

4.6.9.3.8 Cultural Resources (36CFR800.5 Assessment of Adverse Effects)

Work Areas – General

Preliminary cultural resources investigations coordinated with the PASHPO indicate that the Emsworth Primary, Emsworth Secondary, and Dashields Primary construction support areas will not require additional studies and there will be no impacts upon historic properties should these areas be utilized for batch plants, laydown, or other construction support activities.

Dashields Secondary Work Area

Preliminary cultural resources investigations at the Dashields Secondary construction support area resulted in the identification of archaeological site 36AL600 within the minimally disturbed western portion of the parcel. Should this construction support area be utilized during construction and Site 36AL600 cannot be avoided, a Phase II archaeological study will be required to further define the site boundaries and determine the National Register eligibility of the site. Should the Phase II result in a recommendation of eligibility, then a Phase III data recovery investigation will be required to mitigate for the loss of the eligible historic property.

Montgomery Primary Work Area

Preliminary cultural resources investigations at Montgomery Primary construction support area resulted in the identification of archaeological site 36BV357. The landform that contains archaeological site 36BV357, located within the extreme western portion of the Montgomery Primary construction support area, has the potential for deeply buried intact cultural deposits and if this area will be utilized during construction, geomorphological testing would be required in order to assess all potential impacts of using this area during construction.

Preliminary cultural resources investigations also redefined previously recorded archaeological site 36BV131 within the main portion of the Montgomery Primary construction support area. If this construction support area is to be utilized during construction and site 36BV131 cannot be avoided, a Phase II archaeological investigation will be necessary in order to determine if the site is potentially eligible for listing on the NRHP. If 36BV131 is deemed as eligible for the National Register, a Phase III data recovery study would be required to mitigate for the loss of the historic property.

Montgomery Secondary Work Area

Although the current surface of the Montgomery Secondary Area has been severely altered, there may be intact subsurface cultural deposits which would potentially be adversely affected by construction of a batch plant and associated sedimentation ponds in the event this area is utilized for construction support. Therefore, geomorphological testing would be required to determine the presence or absence of such deposits and to determine the potential impacts of using this area during construction.

4.6.9.4 Navigation Traffic Impacts

Commercial tow traffic along the Upper Ohio River has the potential to impact fish through aquatic habitat alteration. The Corps has conducted substantial research on the potential for commercial tows to disturb bottom substrates and interfere with fish reproduction, recruitment, and feeding. This was applied in the ORMSS to consideration of potential impacts throughout the mainstem across various traffic scenarios. The Upper Ohio Navigation Study is adopting the analyses and conclusions of the ORMSS PEIS through NEPA tiering regarding impacts of commercial tows on aquatic resources.

The ORMSS Study concluded that it "successfully quantified habitat required for various life stages of the primary fish assemblages of the Ohio River, as well as the impacts of future navigation activity scenarios to these habitats" (PEIS p. 10-90). It was further concluded that "The failure of the model to demonstrate substantial future impacts from navigation are most likely overwhelmingly related to the ability of the Ohio River to absorb the predicted additional navigation induced impacts without significantly influencing existing fishery resources within an already highly modified ecosystem" (PEIS, p. 10-91).

Although consideration was given to further site specific analyses during the Upper Ohio study, it was determined that following through with the analyses would not produce results that would vary significantly from those of ORMSS. The decision not to complete further analyses was based on the observations that the updated traffic forecasts were within the ranges used in ORMSS and that the forecast traffic growth is relatively low. An additional consideration was that the sensitivity of the NAVPAT model would be inadequate to distinguish between the relatively similar impacts associated with the array of navigation alternatives. The ORMSS results are discussed below.

The Navigation Predictive Analysis Technique (NAVPAT) model was the tool used in the ORMSS to "provide quantitative results, which can be used to assess positive or negative effects of tow movement on available aquatic habitat quality" (SIP/PEIS, p.10-79). NAVPAT generally links the transient effects of tow movements to the quality and quantity of habitat available to selected fish species/life stages. The ORMSS recognized that the primary benefit of running NAVPAT was "to examine for trends and compare among alternatives to determine relative degree of impacts rather than using as absolute predictions of actual effects" (PEIS Env App, NAVPAT Report, p. 15).

The habitat relationships for the ORMSS NAVPAT were developed by an interdisciplinary team of Corps, FWS, and state natural resource agency biologists. Five fish species and eight life stages representing different reproductive, recruitment, and feeding groups were evaluated by each pool, by three river reaches (upper, middle, lower), and summarized by the entire Ohio River mainstem (PEIS, pp. 10-79 - 10-81).

The results showed that increases in navigation traffic through 2070 "will negatively, but rather modestly, impact certain groups of fishes, especially swiftwater spawning fishes." "Except for Paddlefish-Larval, Freshwater Drum-Larval, and Sauger-Larval [groups], predicted losses of habitat units for the Ohio River will be negligible to slight. The slight to moderate losses in habitat units for Paddlefish-Larval, Freshwater Drum-Larval, and Sauger-Larval are probably balanced by the great abundance of these three types of habitats all along the river" (PEIS, p. 10-89). The original assumption of 100 percent larval mortality contributing to these slight to moderate habitat unit loss projections was subsequently demonstrated to be an overestimate. It was then concluded that a modest decline in these habitats would not likely be a population limiting factor.

4.6.9.5 Cumulative Effects

4.6.9.5.1 Context of Cumulative Effects Studies

As defined by the Council on Environmental Quality (CEQ), cumulative effects are the result of "the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (CEQ 1997). The policy of the United States Army Corps of Engineers (USACE) relative to addressing cumulative effects is an outgrowth of the National Environmental Policy Act (NEPA) and CEQ guidance.

Each proposed water resource development activity is but a piece of a large-scale program. The combined beneficial and adverse economic, environmental and social impacts of individual projects, each of which may be relatively minor, can have a significant regional or national impact. At each level of the evaluation and review process it is necessary to assess the cumulative beneficial and adverse effects of individual project impacts (USACE Engineer Pamphlet 1165-2-1, 1999).

The assessment of cumulative effects provides a review of the past, current, and anticipated environmental impacts from multiple actions and programs of the USACE; other federal, state, and local governmental agencies; and private entities. By concentrating on the resource under investigation, environmental sustainability can be the ultimate test for determining the significance of cumulative effects. Thus, the impact to a resource is significant if the cumulative effects exceed the sustainability of that resource. Environmental sustainability is defined by the USACE as "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations."

The goal of the cumulative effects analysis is to assess the potential cumulative impact of modernization of the Upper Ohio Navigation System on resources, ecosystems, and human communities of concern. The analysis addresses the accumulation of meaningful impacts to these resources from the modernization of the navigation system in concert with impacts from other past, present, and reasonably foreseeable future actions (RFFAs) by USACE and others. A considerable amount of existing data and a number of reports were reviewed throughout the process. New data were also gathered during recent field surveys and by contact with local planning groups and resource agencies. The key environmental resources that were analyzed include water quality/sediment quality, fish, mussels, and riparian areas. Human uses related to river-based recreation, transportation and traffic, air quality, health and safety, socioeconomics, and cultural resources were also analyzed.

4.6.9.5.2 Analysis of Environmental Sustainability

By addressing measurable factors (for the most part quantifiable factors, but in some cases, qualitative), known as indicators of sustainability, a determination on whether or not a resource is currently sustainable, was sustainable in the past, or will be sustainable in the future was developed. Three definitions of environmental sustainability were used for the analysis:

- Not sustainable – conditions for the selected indicators do not reflect conditions that would facilitate attainment of acceptable standards or would not maintain existing standards in concert with collective impacts of proposed activities.
- Marginally sustainable – conditions for the selected indicators are such that attainment of acceptable living conditions and quality of life are accomplished for the majority, but not all, of the potentially affected populations. However, the conditions of indicators are somewhat tenuous both in location and likelihood of occurrences (in other words, the conditions are borderline for environmental sustainability, and there are uncertainties regarding specific quantitative measures).
- Sustainable – conditions for the selected indicators are such that attainment of acceptable living conditions and quality of life are accomplished for essentially all of the potentially affected populations in the project area, and such standards are maintained in concert with foreseeable future activity. Further, conditions of the indicators exceed regulatory thresholds, and various governmental programs are in place to respond to any potential erosion of values related to the resource.

Figure 4-18 illustrates the concept of sustainability. When the forces supporting sustainability are strong, the health of the resources is strong. When those forces are weak or being diminished, then the health of the resource decreases and its existence is threatened.

FIGURE 4-18: Environmental Sustainability

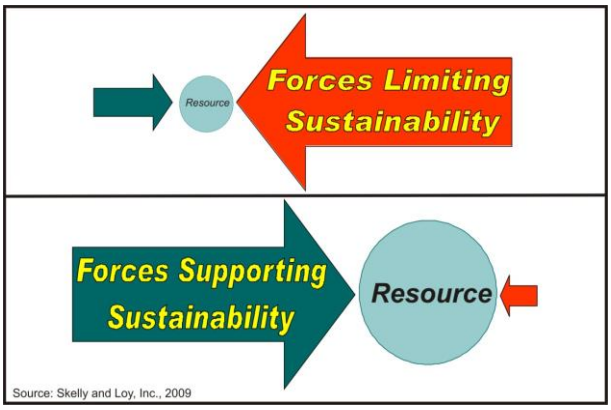


Table 4-39 summarizes the findings on environmental sustainability for each VEC. The findings are based on a thorough analysis of past and present conditions as well as an examination of future trends, plans, and the regulatory climate.

TABLE 4-39: Findings on Environmental Sustainability

Valued Environmental Component	Time Period		
	Past	Present	Future
Water Quality	Not Sustainable	Marginally Sustainable	Sustainable
Fish	Not Sustainable	Sustainable	Sustainable
Mussels	Not Sustainable	Marginally Sustainable	Marginally Sustainable
Riparian Resources	Not Sustainable	Not Sustainable	Not Sustainable
Recreation	Not Sustainable	Sustainable	Sustainable
Transportation and Traffic	Sustainable	Marginally Sustainable	Sustainable
Air Quality	Not Sustainable	Sustainable	Sustainable
Health and Safety	Not Sustainable	Marginally Sustainable	Sustainable
Socioeconomics	Sustainable	Marginally Sustainable	Marginally Sustainable
Cultural Resources	Not Sustainable	Sustainable	Sustainable
Sediment Quality	Not Sustainable	Marginally Sustainable	Sustainable

The following sections present the respective synopses which form the basis for the sustainability conclusions. The respective CEA chapters for each VEC can be found in the Appendix. These chapters provide a temporal and geographic extent to frame the analysis, a thorough discussion of past, present and future condition of each VEC, a list of RFFAs that affect them and an assessment of their sustainability. The CEA appendix also contains a discussion of the methodologies used.

Water Quality

Baseline

Until about 1970, the water quality of the upper Ohio River was in a degraded state characterized by low dissolved oxygen (DO) concentrations, low pH levels, high bacterial contamination, high nitrogen concentrations, and remobilization of potentially toxic chemicals associated with river sediments. Few pollution reduction, control programs, or regulatory programs were in place during this period and depauperate aquatic populations and diversity were observed.

Positive Forces Affecting Water Quality

The greatest positive forces affecting water quality are the regulatory mandates currently in place. The primary contributors to the poor water quality conditions of the past were the largely untreated and uncontrolled point and non-point pollutant discharges from growing

municipalities, mining, and various types of industries and land uses along the river. As a result of improved government regulations and changes in the socioeconomic climate, these contributors have been largely addressed. DO concentrations are now typically above the 5.0 mg/L standard, pH levels are between the 6.0 to 9.0 standard, and nitrogen concentrations meet current water quality criteria. The results of algae (plankton) and aquatic macroinvertebrate biological surveys in the five most recent decades have demonstrated steady improvements in aquatic ecological resources, with the improvements paralleling water quality improvements.

Negative Forces Affecting Water Quality

The negative forces affecting water quality in the upper Ohio River are related to wastewater discharges to the river, CSOs/SSOs, existing and potential discharges of acid mine drainage, dredging operations, legacy pollutants, and development affecting riparian resources. The Monongahela River Mine Pool is a potentially significant problem that has not yet been adequately addressed by all entities. The Monongahela Mine Pool presents a great deal of uncertainty. Under certain circumstances, it could significantly degrade the river's ecosystem. Compounding the uncertainty of the situation, however, is not knowing where the discharges will appear. If the discharge is confined to the Monongahela River, flows from the Allegheny River would neutralize the effects.

The influence of wastewater discharges and dredging operations are buffered through existing regulations and permit conditions, but are still potential threats to water quality. CSOs/SSOs still affect the water quality on wet days and any future development could lead to additional sources of pollution. Although water quality is improving overall, some indicators have not seen any change. Bacteriological water quality remains a serious problem. Specifically, recent ORSANCO fecal coliform bacteria monthly sampling data indicated that the number of exceedances has not improved over the past 16 years and that this is still an issue for the upper Ohio River. CSOs/SSOs still exist despite consent decrees and significant funding to rectify past problems. Additionally, TMDLS – and the potential improvements they represent – have not been finalized.

Incremental Impact of EDM of Water Quality

The incremental impacts of EDM improvements on water quality will be limited but generally positive. Although there could be impacts during construction, they will be temporary in nature and duration. By reducing congestion of the river through providing more reliable infrastructure and more capacity in the auxiliary chamber, impacts from barge queuing at smaller, auxiliary chambers when the main chamber is closed would be reduced.

Finding

Water quality in the Pittsburgh area has been improving steadily over many decades and, at this time, the environmental sustainability of water quality is classified as marginally sustainable. In the future, the existing environmental regulations such as the CWA and water quality standards set by ORSANCO should further improve water quality. Despite past improvements, however, the Monongahela River Mine Pool remains a major uncertainty and could reverse future improvements. There is the possibility that it could discharge into local

waterways and negatively impact the aquatic system, yet, a number of agencies are working together to identify and implement solutions. Any impacts that would result from this would most likely be confined to the Monongahela River and have limited impacts to the upper Ohio River. Therefore, if water quality continues to improve, it is expected to reach full sustainability in the future.

Fish

Baseline

In the time period from settlement to the mid-20th century, degraded conditions of water quality and modification of the river structure through construction of the modern lock and dam system resulted in severe impacts on fish in the upper Ohio River. As a result, conditions were not sustainable. From the mid-20th century to the late 20th century, however, water quality conditions began to improve, however. Awareness of the Ohio River's ecological importance led to the development of ORSANCO in 1948. The Clean Water Act of 1972, the Endangered Species Act of 1973, and other programs and regulations served as catalysts for improved water quality and allowed fish to recolonize the river from refuges and through restocking efforts. This allowed some fish communities to return to earlier conditions.

Positive Forces Affecting Fish

By far the most positive force affecting the fish resource is the regulatory mandate to meet water quality standards. These mandates have come from numerous laws and from ORSANCO. Other regulatory efforts that provide positive benefits have been mine reclamation standards and remediation of abandon mine discharges within the basin. The resulting improvement in water quality is allowing the resource agencies to restock fish species and for native fish to recolonize from the lower river and tributaries. Consequently, densities, biomass, and fish community diversity have increased measurably.

Recent biological studies conducted within the New Cumberland, Montgomery, Dashields, and Emsworth pools have shown mixed, but generally favorable results in terms of habitat and reproductive viability. In the New Cumberland Pool, ORFIn scores average 9.9 points below what was expected. In the Montgomery Pool, approximately 87 percent of the sampled sites were in passing condition. In the Dashields Pool, 62 percent of the sites met their aquatic life designation. And in the Emsworth Pool, all 15 sampled sites met their aquatic life designation.

A shrinking human population surrounding the upper Ohio River will also be a positive force affecting fish. A smaller population leads to less domestic waste and less pressure to develop the riparian and wetland habitats that act as filters for water flowing into the river and potential habitat at specific life stages for fish.

Negative Forces Affecting Fish

The negative forces that are affecting fish in the upper Ohio River are related to existing and potential discharges of acid mine pool water, navigation-related activities, invasive species, wastewater discharges to the river, CSOs/SSOs, dredging operations, lateral connectivity

issues between pools due to the navigation structures and the development impacts on riparian resources.

Although there are programs in place to remediate acid mine drainage, the Monongahela River Mine Pool is potentially a great problem that has not yet been adequately addressed by all entities. Of all issues facing the area that are related to the Ohio River environment, the Monongahela Mine Pool is the most uncertain, yet , a number of agencies are working together to identify and implement solutions. Any impacts that would result from this would most likely be confined to the Monongahela River and have limited impacts to the upper Ohio River due to the dilution effect from the Allegheny River confluence.

Abiotic stressors can also be important negative factors affecting fish if they increase in density or frequency. Although new development increases access to the upper Ohio River, development could interfere with the natural ecosystem and pose potential threats to the health of fish. Barge queuing, fleeting areas/barge storage, and commercial boating also have negative impacts to fish through accidental toe-ins or substrate strikes and increased sedimentation and pollution associated with such activities. Accidents and spills result in a potential negative impact through the introduction of a pollutant directly to the river that could harm fish and their habitat. Cooling water intake structures at power stations create problems associated with entrainment and impingement of young fish. Development of hydropower on USACE dams also has the potential for entrainment of fish and lowering of available DO.

Biotic stressors, such as invasive species, also threaten the fish of the upper Ohio River. Invasive species compete with native species for vital resources provided by the river. Invasive species also destroy habitat utilized by native species and sometimes consume the eggs of fish that are considered valuable to the river. Although the upper Ohio River has not been affected by invasive species to the same extent as lower portions, the potential of these species, especially Asian carp (bighead, silver, black, and grass), to travel upstream is a possibility and is being closely monitored. There is some doubt, however, that the most notable species in this group, the Silver Carp, will colonize the upper river due to a lack of suitable spawning habitat and water parameters.

A number of the negative forces affecting fish populations of the upper Ohio River are buffered or minimized by existing regulations, potential permitting conditions, improved project planning in order to minimize environmental impacts, and potential emergency response plans.

Incremental Impact of EDM on Fish

The incremental impacts of EDM improvements will be limited and generally positive, but navigation investments are expected to have both positive and negative effects on the fish of the upper Ohio River. Modernized locks would reduce shutdowns and allow for more efficient movement of commercial traffic from one pool to another. The longer auxiliary locks would reduce queuing when the main chamber is closed. As traffic becomes more efficient and potential conflicts are eliminated, negative environmental impacts would be reduced and positive impacts strengthened.

If the recommended plan for rehabilitation of EDM includes approach and channel dredging/disposal, and pool maintenance, short term negative impacts on fishes could result in the upper Ohio River through sedimentation. Some substrates that provide both habitat and spawning grounds could be lost but would be replaced through site specific mitigation. Additionally, the operation of the locks and dams would result in continued impediments to longitudinal connectivity, particularly for those species of fish that do not use the locks to move between pools. This may adversely affect spawning success, mussel recruitment and possibly genetic diversity, and may reduce viability by restricting access to various important habitats. Fish passage efficiencies are being considered as part of this project that could reduce the impediment of dams on fish movement between pools.

Finding

Subsequent to the creation of ORSANCO and enactment of the Clean Water Act, water quality standards led to improved conditions of the river. Thus, the current status of fish as evidenced by the re-colonization of fish species, including intolerant species, is considered sustainable. In the future, the growing awareness of current and potential threats to fish, along with the regulatory environment that mandates water quality standards, will help fish in the upper Ohio River maintain a sustainable condition.

Mussels

Because they play an important role in the breakdown and compartmentalization of organic matter, mussels are a crucial part of the river's natural filter system. Historically, nearly 80 species of freshwater mussels populated the entire mainstem of the Ohio River. However, the industrialization and urbanization of the upper Ohio River during the 19th and 20th centuries extirpated mussel populations in the upper river, and mussels were clearly not sustainable.

Positive Forces Affecting Mussels

Positive forces affecting mussels of the upper Ohio River are water quality improvements, increased public awareness of the importance of mussel populations to healthy, functioning aquatic systems, the establishment of the Ohio River Islands National Wildlife Refuge, and the existing regulatory environment. Potential ecosystem restoration projects targeting valuable aquatic habitat and facilitating fish passage around the navigation dams would also benefit mussels. All of these forces combine to improve habitat and support life stages, not only for mussels but also for other aquatic organisms that contribute to the health of native mussels.

Water quality provides the greatest positive influence on mussels. By regulating the pollutants discharged to the environment, negative effects on water quality, sediment quality, and mussel habitat are minimized. There are many parts of the regulatory environment working for environmental improvements. Consent decrees to eliminate CSO and SSO systems provide a significant positive influence on sediment quality by removing polluting systems. Monitoring programs regularly test water quality to ensure that entities with permitted discharges are following the conditions of their respective permits. Permitting

programs administered by the USACE protect the health of water and sediment quality through project evaluation.

Most mussel species require a fish host to complete their life cycle. Although there have been many changes in the fish population throughout the past, fish are rebounding, offering additional opportunities to host mussels. While not all fish serve as hosts, as fish populations increase, so too may mussel populations. The establishment of the Ohio River Islands National Wildlife Refuge provides a refugia for mussels downstream of the project area and increases awareness of this resource. Enhancement of islands create suitable habitat for new mussel beds which provide a genetic source of re-colonization upstream. Under ORMSS, the USACE has committed to the evaluation, and if feasible, implementation of increasing fish passage around its locks and dams which historically has isolated mussel populations between pools and has decreased genetic diversity.

During recent river surveys, mussels were observed in a broad range of habitat types, at an average depth of 11.5 feet, and a maximum depth of 26 feet. Nearly 50 percent of the mussels collected were observed greater than 150 feet from the shoreline. Additionally, live mussels were associated, in general, with substrates composed of silt, sand, gravel, cobble, boulder, and other materials (e.g., mud, wood, bedrock).

Negative Forces Affecting Mussels

Numerous biotic and abiotic stressors are affecting mussel populations negatively. Biotic stressors which affect native freshwater bivalves include natural predators, human predation, and non-native, invasive species. Non-native invasive species pose a significant risk to the populations of native freshwater mussels. Abiotic stressors include habitat modification, point source pollution, and non-point source pollution. Habitat modification includes activities such as dam building, channel dredging, in-stream sand and gravel mining, snag removal, and increased siltation.

The primary food source for mussels is provided by organic material suspended in the water column and siphoned through the animal; however, there remains some uncertainty as to the source of the food that is consumed by mussels. Additional research into this aspect of mussel biology is required to provide a definitive understanding of mussel feeding. Until then, it will be difficult to determine the best conservation practices for mussels and potential food sources may remain unprotected.

Other negative forces affecting mussels are wastewater discharges to the river, existing and potential discharges of acid mine drainage, and legacy pollutants in sediment. Commercial boating, barge queuing, and mooring/fleeting areas also provide potential negative influences on mussels by removing or disturbing habitat. Potential accidents and spills associated with shipping and industry along the river also have the potential to negatively affect mussel habitat.

Incremental Impact of EDM on Mussels

The incremental impacts of EDM improvements will be limited and generally positive. Modern, locks would allow for more efficient movement of commercial traffic from one pool

to another. Navigation aids, both at the locks and dams and throughout the pools, provide positive influences on mussels through the direction of barges to remain within the navigation channel, minimizing the opportunity for unexpected substrate strikes or unnecessary propeller wash. Enhancement of fish passage at EDM could provide a significant positive influence on mussel populations by increasing the efficiency of passage through the dam for host fish.

Finding

From the mid 20th century to the present, water quality conditions have improved. The programs and regulations that have served as catalysts for improved water quality have led to a re-colonization of the upper Ohio River by freshwater mussels. A greater understanding of the biology of freshwater mussels has also been beneficial to mussel populations of the river. Greater public awareness on the importance of freshwater mussels will further benefit mussel populations of the river. Mussel populations, although recovering, are low with low diversity in the upper Ohio River. The presence of the navigation pools means that the river is maintained in an unnatural state of altered depths and lower flow velocities. The substrates used by the mussels are largely covered to varying depths with silt. These conditions suggest the current status of mussels may be marginally sustainable.

The future sustainability of mussels, however, is unclear. A recent survey of the Emsworth, Dashields, Montgomery, and New Cumberland pools identified only eight species of native mussels within this area. Some mussel species more tolerant of changes in habitat are rebounding, which would suggest full sustainability is possible; but, even though there is a greater understanding of freshwater mussels, a significant amount of critical habitat has been lost. Despite other ecological improvements that have benefitted other environmental resources, mussel habitat is unlikely to return easily. While regulations are in place that will help to prevent the loss of additional mussel populations, there is still uncertainty about whether or not all populations will rebound or simply hold to existing levels. Additionally, the effects of invasive species like the zebra mussel, altered depths and flow velocities are still unknown. Consequently, there is unlikely to be a significant change in the current status of mussels and conditions will remain marginally sustainable well into the future.

Riparian Resources

Human activities have resulted in loss of much of the historic woodlands and native vegetation along the upper Ohio River. Woodlands have been dissected by roads and fragmented through development patterns. In the past, fill has also been used to encroach on the river channel and to elevate regularly flooded riparian areas for development. Such processes have changed the appearance of woodlands and affected the ecological functionality of riparian resources. Construction of dams on the Ohio River resulted in navigation pools that inundated many historic riparian areas. Where natural banks remained, riparian growth was often cut down or crowded out. The disturbed shorelines have been largely revegetated by invasive species. The consequence of these past practices has been to limit the functionality of the area's floodplains and create unsustainable conditions for riparian resources.

Positive Factors Affecting Riparian Resources

The regulatory environment provides the best opportunity for strengthening the health of riparian resources. Though there are no regulations that directly govern riparian resources, the goals of other regulations (e.g., water quality improvement) indirectly contribute to creating a positive effect on riparian resources. Some regulations offer opportunities to maintain hydrologic connections between riparian areas and adjacent water bodies. Other regulations protect the capacity of water storage in the floodplain, encourage biological diversity, and support the reduction of pollution. Additionally, the growing awareness that riparian resources, especially evidenced with the Ohio River Islands National Wildlife Refuge and (in the state of Ohio) the *Nature Works Program*, contribute to healthy, functioning aquatic systems offers opportunities to protect the existing riparian resources, albeit indirectly. This awareness plays a supporting role in protecting the hydrologic connections between riparian areas, pollution reduction, and increased biodiversity.

There has also been a growing concern regarding invasive species which are out-competing native vegetation along streambanks. Executive Order 13112 was issued in 1999 and establishes the National Invasive Species Committee represented by 13 federal departments and agencies and calls for a National Species Management Plan. Finally, the preparation of cumulative effect assessments as part of the NEPA process has made agencies look at resources in a more systemic manner. This expanded view of resource impacts will serve to bring public attention to these endangered resources.

Negative Factors Affecting Riparian Resources

The existing functional floodplain of the upper Ohio River is a fraction of its condition prior to settlement or industrialization of the region. All indicators of sustainability are declining and could disappear with unchecked development, and further development of riparian areas is likely to occur. Unless specific design elements that protect riparian areas are incorporated into new projects, riparian resources will continue to erode. Of all the resources examined during the cumulative effects assessment, riparian resources are in the most danger. They will also be the hardest to restore.

Unfortunately, there are no regulations or programs in place aimed specifically at stemming the loss of riparian resources or restoring areas already lost to development. Extensive development along the upper Ohio River acts as both a consumer of riparian resources and a limiting factor to the functioning floodplain. This development consists of residential, commercial, and industrial areas as well as rail and road transportation corridors. Much of this development was placed on fill to elevate it above areas that were regularly flooded. Consequently, this development reduces the capacity of water storage in the floodplain, reduces the capacity of riparian areas to intercept pollution, and limits biodiversity.

All of the existing riparian areas along the upper Ohio River have been attacked by invasive species. Some invasive species were introduced intentionally, providing ornamentation or inexpensive means of providing groundcover. Without adequate control, these species often escape from their intended environment and spread. Freed from their natural bounds, they proliferate in new, more habitable areas and crowd out native species. This in turn causes a

deterioration of all habitats and limits biodiversity and valued ecological functions. If left unchecked, invasive species could alter the dynamics and diversity of the native ecosystem. Although there is a National Invasive Management Plan in place that focuses on prevention, detection, and control, these programs have not received the funding or the attention to make a difference along this stretch of river.

Incremental Impact of EDM on Riparian Resources

The incremental impacts of EDM improvements on riparian resources will be limited. Some loss of riparian areas adjacent to the EDM improvements could occur with future construction adjacent to the laydown areas on the abutment end of the dam. There would also be temporary impacts during and after construction as vegetation reestablishes in the temporarily disturbed areas. Some of these temporary impacts could potentially cause slight changes to the diversity of the few existing riparian areas.

Finding

In the early to mid twentieth century to the present, unsustainable conditions have occurred with respect to riparian areas. Compounding past losses, invasive vegetative species are widespread and threaten to choke the limited riparian areas that are present. Unfortunately, many land use practices that contributed to the loss of riparian areas are continuing, even if to a lesser degree. Although there is some growing awareness of the ecological services performed by riparian resources, coupled with an increasing demand for river corridor enhancement, specific environmental regulations and institutional programs are not in place to stem fragmentation and loss. Consequently, riparian resources are likely to remain in an unsustainable condition into the future.

Recreation

The upper Ohio River is a popular setting for recreation. Interest in the river has produced marinas and landings, trails and parks, special events, and entertainment facilities. Events that draw large crowds and activities attract much attention, but solitude and quiet relaxation are some of the most important values associated with river recreation. Although recreation resources were considered not sustainable in the past, primarily because of water quality issues, opportunities for recreational activities on and along the river have grown steadily since the early 1970s.

Positive Forces Affecting Recreation

The opportunity to recreate on the river has increased dramatically in the last twenty years. Although the general decline of the region's industrial base in the past contributed to unemployment, and population has been shrinking, the economy has shifted to a commercial, educational and medical service base. Typically, those who work have more leisure time available to them than in the past. As a result, both the public and private sectors have developed additional recreational outlets, providing people with more opportunities to pursue various recreational activities. With the creation of new hiking trails throughout the region, and an effort to link those trails together, accessibility to river-related recreation has improved. When coupled with resource protection and the significant environmental

improvements, these new facilities have become even more attractive because of their volume and modern appearances.

Both the City of Pittsburgh and Allegheny County have been aggressively working to bring people to the river. The city has constructed riverside amenities along both sides of the urban triangle that has opened the views to the river. River taxis are now available and many sports fans access the North Shore stadiums by boat.

Although there have been declines in motorized boating in the area, other outdoor facilities and pursuits are experiencing increasing numbers of participants. Within the project area there are many dramatic natural and urban viewscapes that contribute to the attractiveness of parks and trails. Water-based recreation, especially the growing trend in non-motorized boating, is very popular throughout the study area. New trails and parks raise environmental awareness and opportunity, which in turn contributes to healthy river corridor habitats.

Negative Forces Affecting Recreation

Although greatly improved, there are still some water quality issues that affect recreational users of the river, especially if contact with the water is expected. Most notably are the CSO/SSOs during and immediately following rain events when sewage is allowed to enter the rivers untreated. Also, water quality related to Marcellus Shale drilling has become a concern. Other deterrents to recreation are industry based. Commercial barge traffic, although sensitive to personal water-based recreation users, are sometimes in conflict with them. Commercial traffic does move slow enough, however, that these conflicts are easily avoided. There are many that enjoy watching these tows move up and down the river. Sand and gravel dredging also uses areas of the river in a way that precludes boater access and the resulting removal of substrate has long-term impacts to fish habitat. Additionally, natural events, such as flooding, poor weather, or surface freezing restrict the use of the river to certain times of the year.

Incremental Impact of EDM on Recreation

The incremental impacts of EDM improvements will be limited and generally positive. Modern locks would allow for more efficient movement of commercial traffic from one pool to another. This would lessen potential conflicts between commercial and recreational traffic and increase safety and accessibility while locking between pools. EDM improvements would result in short-term negative impacts during construction, but these would be limited to potential lockage restrictions, as the immediate vicinity of the dams is a restricted access area under normal conditions.

Findings

Opportunities for recreational activities on and along the river have grown steadily since the early 1970s. Water quality, accessibility, maintenance of recreation facilities, and an expanding selection of recreation choices are the primary factors affecting current trends in recreational activity. There appear to be no significant impediments to recreation on the upper Ohio River, but there may be a shift to different types of recreation. Although boat registrations and recreational lockages have decreased over the past several years, existing

parks and access facilities along the urban pools are still heavily used. A variety of public agencies and private organizations are actively developing new riverfront parks, greenways, trailways, boating access, and mixed-use riverfront projects. Currently, recreation is sustainable due to water quality improvements related to ORSANCO, the Federal Water Pollution Control Act, the Clean Water Act, a decline in industrial activity, and a shift in the primary types of river recreation. Some of this growth may be attributable to convenience, but the recent era of integrated riverfront planning has increased available recreational choices.

Community planning and development of recreation facilities will continue to expand. Additionally, water quality improvements, habitat protection, and restoration efforts will continue to enhance recreation experiences. Although socioeconomic projections show a decreasing population over the next decade and boat registrations and lockages have declined, an improved standard of living is expected to result in high demand for recreational opportunities, and the slow shift from use of the river for motor-boating recreation to other forms of river-related recreation is expected to continue. Consequently, the future of recreation resources appears to be sustainable.

Transportation and Traffic

With the development of railroads in the mid-19th century and their year-round utility, commercial river traffic declined at a slow but steady pace. The latter decades of the 19th century and early decades of the 20th century, however, included a period of heavy industrial development along the middle and upper Ohio River that centered on the iron and steel industry in Pittsburgh. Commerce on the river grew steadily through the 1930s and 1940s while development of diesel towboats and larger barges created opportunities for larger scale, more efficient movement of commodities. A new generation of high-lift dams raised the pool levels and decreased the number of required lockages to move up and down the river. As a result, transportation and traffic were sustainable in the past.

Positive Forces Affecting Transportation and Traffic

Improvements at EDM will enhance transportation and traffic on the river by improving the reliability of the navigation infrastructure and increasing capacity of the auxiliary chambers, thereby decreasing delays and reducing congestion. Also, the projected upper Ohio traffic demand for river transportation will grow throughout the forecast period of 60 years under all three economic scenarios. Growth in river transport will reduce the burden on road and rail transport. These latter two modes are land based, less efficient, release more pollutants, and have greater chance of conflict with passenger transportation.

Negative Forces Affecting Transportation and Traffic

Barge traffic, although reliable, is slow, and commodities are limited to those that are not time-sensitive or that may be stockpiled. Commodities are also limited to those that may be shipped in bulk, such as coal, gravel, and scrap metal. Destinations of commodities transported by barge are limited to industrial sites or multi-modal transfer sites immediately adjacent to the river.

The use of coal is a major contributor to the near term viability of the navigation system contributing 74% of the current commodities being transported in the upper river. The Greenhouse Initiative, agreed to by 10 northeastern states including Pennsylvania,addresses coal as a fuel source. Long-term use of coal is bracketed by economic scenarios described elsewhere in this report. Under both the base case and low growth scenarios, coal transport will grow for the next 30 years and decline thereafter. Under the high growth scenario, coal will grow throughout the 60-year analysis period. Regardless, traffic moved will not decline under any of the three scenarios from its current tonnage.

Incremental Impact of EDM on Transportation and Traffic

Implementing improvements at EDM would have a significant long-term positive effect on transportation and traffic. Modern main locks will improve the reliability of the system through the region. Larger auxiliary locks will improve the efficiency of the system when the main chambers are closed for repair and maintenance. The combination will reduce congestion and delays. Construction would have no short-term negative effects since the existing main chambers will remain open throughout construction. Given the age of these existing main chambers, however, any unscheduled closure could create a significant impact depending on the duration.

Findings

In the time period from 1950 to 2008, the capacity of the upper Ohio system was adequate for the traffic moving through these locks except when the auxiliary chamber was used due to main chamber closure. Due to the smaller main chambers, through tows need to reconfigure their tows or break their tows thereby reducing efficiencies. Significant short-term delays are encountered when the single-barge-sized auxiliary locks are used during repair and maintenance periods. Nonetheless, in 2007, approximately 20 million tons of material moved through each of the EDM locks, a considerable social and environmental cost-savings from using other transportation systems. The system, however, is well past its design life and funding to replace these structures in a timely manner is not available. The lack of replacement dollars has taken a toll on the entire Ohio River System with a notable waiting time for those projects that have not begun construction. This delay in funding could result in a structure failure that could close the upper river to all navigation for a significant period of time depending on the nature of the failure. Thus, based primarily on this reliability question, the sustainability of the transportation and traffic is currently considered to be marginally sustainable.

As a result of future navigation investment actions, capacity and reliability problems at the existing locks and dams would be addressed and constraints to water-borne transportation removed. Consequently, the sustainability of the transportation and traffic would improve to a fully sustainable condition.

Air Quality

Pittsburgh was known as the “Smoky City” by the 1800s and persisted in that designation through the Pittsburgh Renaissance of the 1950s. Heavy coal burning for industry, railroad

engines, residential, and commercial heating combined with local topographical and climatic factors that often produced temperature inversions trapping the smoke pollution in the area. Between 1940 and 1960, much of the dense smoke from the area's atmosphere was eliminated through local pollution control efforts. By the late 1950s, smoke control legislation led to the elimination of the blatant ash and soot pollution that required street lights to be on at high noon. Nonetheless, high levels of nitrogen and sulfur dioxide and micro-dust pollution continued, especially in river valley mill towns.

Extensive highway development from 1945 through 1970 contributed to the growing popularity of the automobile for personal transportation as well as development of an extensive commercial trucking industry. Leaded gasoline and diesel fuel from these mobile sources added concentrations of pollutants to the air. Localized impacts of smog (ground level ozone), particulate matter, and lead all contributed to a not sustainable condition for air quality in the past.

Positive Forces Affecting Air Quality

Air quality monitoring, pursuant to the Clean Air Act, is currently conducted at several locations in the Pittsburgh area. The Allegheny County Health Department (ACHD) operates a 24-hour monitoring station network throughout Allegheny County to collect air quality data on particulates (dust and smoke), O_3, SOx, NOx, CO, and lead, as well as other special chemicals (such as benzene) and weather data. The ACHD reports that emissions of all criteria pollutants from point sources in Allegheny County declined from 1996 to 2006. Local trends indicate that there would not be significant cumulative air quality concerns, and future air quality would be expected to improve from decreased point source emissions. The passage of the American Clean Energy and Security Act of 2009, calling for a reduction of carbon dioxide and other greenhouse gases by 20 percent from 2005 levels by 2020 and 83 percent by mid-century, would further result in cleaner emissions and cleaner air in the future.

Additionally, USEPA is addressing emissions from marine engines in two ways, through their fuels and through their emission limits. In May 2004, as part of the Clean Air Nonroad Diesel Rule, USEPA finalized new requirements for non-road diesel fuel that will decrease the allowable levels of sulfur in fuel used in marine vessels by 99 percent. These fuel improvements, began to take effect in 2007, and are expected to create immediate and significant environmental and public health benefits by reducing PM from new and existing engines. In March 2008, USEPA finalized a three part program that will dramatically reduce emissions from marine diesel engines below 30 liters per cylinder displacement. These include marine propulsion engines used on vessels from recreational and small fishing boats to towboats, tugboats, and Great Lake freighters, and marine auxiliary engines ranging from small generator sets to large generator sets on ocean-going vessels. The rule is expected to cut PM emission from these engines by as much as 90 percent and NOx emissions by as much as 80 percent when fully implemented.

Negative Forces Affecting Air Quality

Although existing and future regulations under the CAA will reduce the emissions from existing coal-fired power plants, their continued operation will continue to have a negative

effect on the air quality of the region. Fuels used in automobile and diesel vehicles are expected to run cleaner and emit fewer emissions but will remain a major source of air pollution. As older cars and trucks leave the vehicle mix and are replaced by more fuel-efficient vehicles with advanced pollution controls, the level of emissions will be reduced but again will remain a major source of air pollution.

Temporary air quality impacts from diesel sources directly attributable to lock extension activities would increase in proportion to delay times created by the construction activity. However, overall air quality conditions will improve following construction.

Incremental Impacts of EDM on Air Quality

No significant air quality concerns have been identified as a result of the project. The EDM project will likely improve air quality because of improved boat and barge traffic flow through the area and the potential to remove some truck or rail freight from the overall transportation system. This conclusion is based upon a combination of considerations related to: (1) the small contributions of the waterway navigation system to annual emission inventories in the study area when compared with industry and transportation emissions, and (2) the existence of the CAA and its comprehensive requirements for air pollutant source control measures, pollutant caps, and the attainment of ambient air quality standards. Further, additional reductions in NO_x emissions from marine diesel engines are anticipated by the USEPA.

Findings

Due the requirements of the CAA of 1970 and subsequent amendments in 1990, the air quality in the region has shown a steady improvement in recent decades and is currently sustainable. In the future, it is expected that air quality in the project area will further improve as a result of the continuation of source control and other pollution reduction programs; thus, it will be maintained in a sustainable condition.

Health and Safety

Prior to the 1970s, health and safety issues represented a broad spectrum of risk factors. Construction and workplace conditions were generally more dangerous than at present; spills and discharges from commercial navigation, river-oriented industries, and untreated municipal effluents contributed to a variety of public health risks; and little or no information was available to advise the public of ambient risk levels associated with river-oriented activity. Thus, health and safety was characterized as not sustainable.

Positive Forces Affecting Health and Safety

Since the 1970s, regulatory programs have been put in place to improve the environment. These regulatory programs include laws and regulations for facilities that process, store, and transport hazardous materials; facilities that discharge into the rivers; education requirements for employees that handle hazardous wastes; navigational improvements for both commercial and recreational traffic on the rivers; increase in education of recreational and commercial

boaters; and an increase in the numbers and types of national and statewide fish consumption advisories.

While in the past, spills on the river were likely to occur anywhere, they are now generally concentrated in major port areas and industrial areas. These are locations where the volume of activity and type of operation increase the probability of incidents. Nonetheless, regulations are in place to limit spills and respond quickly.

Boating accidents are also decreasing. Over the past 20 years, accidents for recreational boating have dropped nationally from a high of about 8,000 in the late 1990s to about 5,000 two years ago. Locally (Ohio, Pennsylvania, and West Virginia), there were 382 boating accidents in 1999 and 211 in 2008. Although the decline was not at a uniform rate over the intervening years, the occurrence of accidents is trending downward.

Water quality is improving which has been beneficial in regard to water-borne disease and introduction of contaminants into the biological system. Nothing has been more vital to water quality improvements than the Clean Water Act and the ORSANCO Compact. These agreements have resulted in vast improvements to water quality and will continue to maintain and improve water quality throughout the upper Ohio River. The treatment of acid mine drainage and municipal and industrial wastes will continue to be important to maintaining and improving water quality.

Negative Forces Affecting Health and Safety

As the quality of the natural environment continues to improve and regulatory programs that have been put in place continue, there would appear to be few forces negatively affecting health and safety. Conflicts could arise, however, if the amount of traffic on the river increases and more shorelines are developed, which could lead to the potential for more spills and accidents. Also, although regulations regarding sewage and other types of discharges into the river have been initiated, untreated sewage discharging into the river, especially during rain events where flow levels are higher than the capacity of the treatment facility, is still an issue. Unfortunately, there is not enough funding currently available to correct this situation throughout the area.

Incremental Impacts of EDM on Health and Safety

For the most part, the incremental impacts of EDM improvements will be positive. Modern locks would allow for more efficient movement of commercial traffic from one pool to another. This would increase safety and accessibility. Longer auxiliary locks are more efficient because they will allow barges to pass through the locks quicker, eliminating queuing at the locks when the main chamber is closed. As barges move through the system quicker, there will be less conflict with other commercial traffic and recreational boaters by decreasing congestion at the locks. Not only will more efficient locks decrease congestion, they will eliminate the need to break up barge loads into smaller units. One-barge restrictions, a potential cause of accidents because of the need to hook up and unhook barges, will be lifted. Once barges are hooked together, they could possibly stay connected as they travel from one pool to another.

There is a potential for negative effects during construction, however. Worker safety is the most critical area of potential risk, but construction sites can also create situations where onlookers are not careful and disregard safety measures in place to reduce risk. The potential for negative temporary effects related to noise or accidental discharges into the water system also exist during construction.

Findings

Improvements to water quality, reduced risks of spills and faster responses, improved workplace safety standards, and effective safety standards for recreational boating have all combined to make the Ohio River area a safer place to work, live, and play. Brownfields sites have been cleaned and in many cases redeveloped for more benign uses. Improved conditions have also contributed to reduced risk factors associated with contact recreation and fish consumption. However, problems associated with continued exceedances of biological standards, persistence of some contaminants associated with fish consumption, and mixed signals regarding fish consumption standards result in a present classification of marginally sustainable.

With respect to the future, most issues are expected to reach a sustainable condition, primarily because the long term effect of laws and regulations put in place over the past 40-50 years will continue to bear fruit. Additionally, there is a renewed emphasis from society, in general, to improve health and safety for recreation users and workers. Some of the efforts required for continued improvement, such as rehabilitation of sanitary sewer systems to eliminate CSOs and SSOs, or reduction of mercury emissions from coal combustion, however, will require significant investments and a longer period of time to achieve results.

Socioeconomics

Pittsburgh's location at the confluence of the Monongahela, Allegheny and Ohio Rivers served it well during its early years, although railroads came to dominate transportation in the area between 1850 and the early 1900s. After construction of the navigation system on the Ohio River between 1885 and 1929, however, river commerce regained its importance, especially as water transport of bulk commodities proved more cost-effective than rail. By the mid-1950s, the Ohio River Navigation System had helped to sustain lower costs for the coal, electric utility, and steel industries. Thus, in the past, the socioeconomic environment of the area was fully sustainable.

However, the area's population and economic base began to decline in the 1960s. In the late 1970s and early 1980s, over 100,000 steel workers lost their jobs. By 2000, Pittsburgh's population had dropped to levels not seen since before the Second World War. Though population decline and the loss of many industrial operations have continued through today, Pittsburgh is transitioning from manufacturing to a service-based economy.

Positive Forces Affecting Socioeconomics

The area is supported by a fully developed economic infrastructure. This economic infrastructure includes rail, highway, river, and air transportation, modern communication capabilities, and affordable and reliable utilities including coal-fired electricity generation that

depends directly on the river navigation system. While much of the infrastructure is aging, the government, local communities, and individuals have recognized the need to replace old and deficient infrastructure. To accomplish this, management of resources is occurring routinely. Plans and programs are in place to make replacement a reality. The social system is also well established, with a generally healthy and technically skilled population. Quality of life appears to be good for most residents and businesses.

Ongoing investments in social and economic infrastructure should have a positive impact on socioeconomic resources. Most primary infrastructure investments in the region have already been accomplished. Expansion plans for much of this system continue, but a relatively stable population contributes to reduced demand for additional primary infrastructure. Thus, future improvements to this system would focus primarily on maintenance or replacement.

Improved water quality has contributed to increased redevelopment of riverfront areas, especially as recreational settings. Growing interest in environmental amenities in residential and commercial settings contributes to community-oriented projects that combine floodplain and habitat enhancement, open space, recreational activities, and stormwater management.

Negative Forces Affecting Socioeconomics

Although the area currently enjoys a high quality of life, the entire region continues to lose population. Even though population loss may have bottomed-out, projections still show a future population much less then the area's peak in the early 1960s. Trends do not clearly indicate whether or not the population that remains necessarily can support social, economic, and physical infrastructure created for a much larger population and its related economy. Problems could arise if future populations cannot support the infrastructure or manage future resource levels.

Disparity among communities throughout the region is also expected to continue into the foreseeable future. While incomes and educational attainment are high in Allegheny County, they are measurably less in outlying counties. As a result, Allegheny County will have better opportunities to accrue benefits from future improvements. This could lead to future negative impacts, especially to environmental justice populations, if the regional core is strengthened but not the ring around it.

Incremental Impact of EDM on Socioeconomics

Although lock extension or rehabilitation of EDM would result in the creation of temporary employment for construction workers, the long-term positive impacts to efficiency of the navigation industry and reduced shipping costs are the principal justifications for navigation improvements. A more efficient navigation system would support the economy of the region and create many new job opportunities.

Temporary employment of construction workers would be a benefit as would be the purchase of construction equipment and materials. Short-term local income and revenues could increase as a result of this employment. Construction dollars spent in the region would have a multiplier effect and support additional jobs. On-site or nearby uses may be closed or

curtailed during construction. No long-term changes to population, property values, or local tax collections are expected.

For the most part, the incremental impacts of EDM improvements will be positive. Modern, more reliable locks would allow for more efficient movement of commercial traffic from one pool to another. This would lessen transportation shipping times and increase safety and accessibility. As traffic becomes more efficient, cost savings could be transferred to other sectors of the economy.

Findings

The general socioeconomic status for the present is marginally sustainable. The region offers a reasonably healthy mix of industrial, commercial, financial, education, and health care services, even though the population in the area has continued to decline. Concurrently, more manufacturing jobs have left the area, leaving many people unemployed or underemployed. This loss of people and jobs has created a somewhat tenuous socioeconomic situation. Although the area seems to be adapting to fewer people and fewer jobs, trends are not clear yet as to whether those losses will be managed to avoid a gradual decline in socioeconomic health.

The population is expected to decline over the next several decades. Although the area is attempting to "reinvent" itself as a medical, educational, and high-technology area, the trade-off between these new industries and the old manufacturing-based economy may not be sufficient to stem the tide of further socioeconomic loss. Additionally, with some exceptions, educational attainment in the area generally lags behind the states of Ohio, Pennsylvania, and West Virginia. If population loss does not stabilize, there is a danger that there could be too few people and too few jobs to support them. Consequently, environmental sustainability into the future is likely to remain as marginally sustainable.

Cultural Resources

Because consideration of the identification, recordation, and preservation of cultural resources is mandated by laws, sustainability of cultural resources directly follows the evolution of historic preservation legislation. The consequences of laws and regulations have improved the consistency of the identification, recordation, and preservation of cultural resources as well as the total numbers and types of cultural resources that are considered. In addition, private and non-profit historic preservation groups, amateur and professional archaeological societies, and museums have been positive forces in the continued sustainability of cultural resources.

Changing economic conditions and political climates, however, could affect cultural resources, especially through the lessening of protections contained in legislation. In addition, when the economy is not robust, less funding is typically available to historic preservation groups that contribute to the local and regional sustainability of cultural resources.

The environmental sustainability of cultural resources prior to the implementation of the National Historic Preservation Act (NHPA) in 1966 was not sustainable. There was little public knowledge of, or interest in, preserving our shared cultural past; no regulatory

mechanism to promote or fund historic preservation; and no widespread efforts to identify, record, or preserve cultural resources. With the advent of the NHPA and subsequent legislation, public education, and increased funding mechanisms, the sustainability of cultural resources has increased.

Positive Forces Affecting Cultural Resources

Positive forces affecting cultural resources would be those activities that add to the numbers and types of eligible or listed cultural resources through increased investigation; improve the physical condition, integrity, and stability of cultural resources; and decrease the level of effort necessary to minimize impacts from unavoidable future actions.

The regulatory historic preservation environment has a positive impact on the recordation and preservation of cultural resources within the region. The consequences of laws and regulations have improved the consistency of identification, recordation, and preservation of cultural resources as well as the total numbers and types of cultural resources that are considered. In addition, the increased expenditures of public funding for cultural resource compliance research have increased public interest and awareness.

Furthermore, private and non-profit historic preservation interest groups and amateur and professional archaeological societies and museums are positive forces in the continued sustainability of cultural resources. Many of these groups existed in the region before regulatory legislation became the main catalyst for historic preservation, and they will likely continue to have a presence in the future.

Negative Forces Affecting Cultural Resources

Changing economic conditions and political climates are the major negative forces affecting cultural resources, especially through the lessening of protections contained in legislation. It is expected that the body of legislation regulating historic preservation within the federal realm will continue in place for the foreseeable future; however, private interest groups looking to reduce what they would consider regulatory burdens often provide the catalyst for changes to that legislation. In addition, when the economy is not robust, less private and government funding is available to private and non-profit historic preservation groups with missions that contribute to the local and regional sustainability of cultural resources.

Incremental Impacts of EDM on Cultural Resources

In terms of proposed changes to EDM, the incremental impacts will be limited to the physical structures themselves, and to supporting work areas. The Emsworth Dams are presently undergoing a major rehabilitation for dam safety purposes, which was coordinated under Section 106 of the National Historic Preservation Act (NHPA) with the PHMC. Unavoidable adverse effects were identified, and a Memorandum of Agreement (MOA) between the USACE and PHMC was executed identifying appropriate mitigation. Further compliance with the NHPA for EDM will be under the terms of a Programmatic Agreement for the Ohio River Mainstem System Study executed between the Advisory Council on Historic Preservation, the three Corps of Engineers district offices and the six states bordering the Ohio River. This agreement requires the identification, evaluation and appropriate treatment

of affected cultural resources. Continued coordination between USACE, PHMC, other interested parties, and the public will be necessary during the continued planning and implementation of the proposed changes to ensure that the incremental impacts are addressed.

Like any action which directly affects the built environment, navigation investments are expected to have mixed effects on cultural resources located in the upper Ohio River. While the replacement of the EDM structures would negatively affect the historic physical aspects of the lock and dam and potential work area resources, these effects can be mitigated. In lieu of preserving the actual historic physical structures, alternative methods of information retrieval may be used to continue to build the body of knowledge about the resources.

Findings

Currently, cultural resources are sustainable due to the existence of federal and some state and local legislation providing for the consideration, identification, recordation, and preservation of varied types and unlimited quantities of cultural resources. Accompanying funding mechanisms have allowed increased public participation in and awareness about the importance of preserving cultural resources. This increased awareness by governmental agencies, interested parties, and the public resultant from regulatory legislation has led to the consideration of cultural resource types that would not have been considered previously, and in larger numbers than would have been possible before.

It is expected that legislation regulating historic preservation within the federal realm will continue for the foreseeable future, and, therefore, cultural resources will continue to be identified, recorded, and preserved, maintaining or improving their sustainability. However, changes to this legislation will likely happen and be based on changing economic conditions and political climates. Gauging these factors will be a good indicator of potential upturns or downturns in cultural resource sustainability for the future. Nonetheless, cultural resources are expected to remain sustainable in the future.

Sediment Quality

Prior to 1948, less than one percent of the communities along the Ohio River serviced by sewers treated their wastewater. In a heavily industrialized river corridor, the lack of wastewater treatment resulted in significant impacts to sediment quality. Severe negative effects on the river were already evident early in the 20th century and conditions reflected that sediment quality was not sustainable.

Positive Forces Affecting Sediment Quality

The greatest positive influence on sediment quality has been those beneficial forces working toward improved water quality. As water quality conditions have improved, so too has sediment quality. Point source and non-point source pollution control programs are in place and proving to be effective.

Consent decrees to eliminate CSO and SSO systems will provide a significant positive influence on sediment quality through the removal of these types of polluting systems from the environment. Monitoring programs to regularly test air and water quality ensure that the

entities with permitted discharges are following the conditions of their respective permits. Permitting programs administered by the USACE will protect the health of sediment quality through project evaluation.

The redevelopment of brownfields along the river provides a potential opportunity for the removal or isolation of potential contaminants from accessing river flows. As brownfields sites are cleaned up for redevelopment, potential sediment pollutants will be either encased or hauled away to appropriate disposal areas. Additionally, the industry that is present along the river has been changing over the years from heavy manufacturing (coke operations and steel manufacturing) to light manufacturing (cleaner, high-tech processing, distribution, and warehousing, as well as commercial developments). This results in a subsequently less impact on sediment quality.

Increased public awareness through environmental education will continue to provide further knowledge of the importance of sediment quality to a healthy, functioning aquatic system. The Ohio River Islands National Wildlife Refuge System and Nationwide Rivers Inventory provide a positive influence on sediment quality through protection of undeveloped or environmentally significant features of the river. The Endangered Species Act provides a positive influence also through protection of habitat for listed species. Ecosystem restoration efforts also provide a positive influence through various habitat restoration projects that may improve sediment quality conditions. The industrial activities along the river have been waning over the years. This provides an additional positive influence on the sediment quality conditions of the river.

Negative Forces Affecting Sediment Quality

The negative forces affecting sediment quality are primarily related to wastewater discharges to the river, existing and potential discharges of acid mine drainage, legacy pollutants, dredging operations, and commercial navigation and related activities.

Incremental Impacts of EDM on Sediment Quality

The incremental impacts of EDM improvements would be generally positive. They are anticipated to be limited to the disposal of potentially contaminated dredged material from the area of impact. Aside from the presence of legacy pollutants, it can be assumed that water quality improvements have resulted in corresponding improvements in sediment quality and that this VEC is marginally sustainable. In the future, although more stringent regulations regarding discharges to the river are likely to be implemented, nothing is specifically being done to address legacy pollutants. Consequently, sediment quality will likely remain as marginally sustainable for the foreseeable future.

4.6.9.5.3 Summary of Potential Cumulative Impacts

The study area is generally moving from not sustainable conditions to sustainable. Of the eleven VECs examined, nine were not sustainable in the past. Of those, all but two (riparian resources and mussels) are expected to be fully sustainable in the future. Conditions in the present remain mixed, however, with one VEC experiencing a not sustainable condition (riparian resources), six VECs experiencing marginally sustainable conditions (water quality,

mussels, transportation and traffic, health and safety, socioeconomics, and sediment quality), and four VECs experiencing sustainable conditions (fish, recreation, air quality, and cultural resources). In the future, riparian resources are likely to continue in a not sustainable condition, while mussels and socioeconomics may experience marginally sustainable conditions.

Overall, conditions in the area are improving and the health of the VECS is growing stronger. There are many reasons for this, but the principal factors among them are that existing laws, regulations, and programs are having their intended effects, more environmentally sensitive projects and programs are being designed, changing socioeconomic conditions have resulted in less stress on the environment, educational awareness has increased; and society has shown a greater desire for a better environment. As a result, the cumulative effect of the proposed improvements associated with the Upper Ohio Navigation Study is not significant. Although there will be incremental impacts of the project, the overall effect will be generally positive.

4.6.9.6 Beneficial Use of Dredged Materials

Corps environmental restoration policy directs that "Feasibility studies for …modifications to existing navigation projects shall include an examination of the feasibility of using dredged material for ecosystem restoration" (EP 1165-2-1, 19-26). This examination is also supported by Corps planning policy (ER 1105-2-100, 3-2.b.(7)). The Corps has specific authorities, e.g. Water Resources Development Act of 1992, Section 204, Beneficial Uses of Dredged Material, that direct the Secretary of the Army to carry out projects that have ecological benefits in connection with dredging of an authorized navigation project. Beneficial use is defined as the use of dredged material as a resource instead of disposing of it as waste at a commercial facility. Section 204 requires non-federal cost sharing of the incremental cost increase of beneficial use over the base, least cost, environmentally acceptable, disposal plan. Under principles of sound engineering practice, the Corps may also carry out beneficial use projects using disposal materials (not limited only to dredged materials) as a navigation project cost, if that use would not increase disposal costs over the base plan.

The Recommended Plan will generate over 1.1 million cubic yards of disposal materials from the modernization of EDM. Material to be disposed includes soil and riverbed materials, rock material and concrete material. Detailed estimates of disposal quantities generated by demolition and excavation at each site are in the engineering appendix.

For feasibility level planning, it was assumed that all disposal materials will be placed at a commercially available disposal facility that is properly permitted to accept the materials. Sufficient capacity for disposal at one or more properly permitted, commercially available facilities has been identified through a reconnaissance survey of commercial disposal sites. This approach defers planning for potential cost-saving disposal measures, i.e. a government-provided disposal site or beneficial use projects, to a future time closer to initiation of actual construction. This deferred planning approach is reasonable in view of possible delay between congressional authorization and appropriations, particularly from the viewpoint of availability of suitable lands and changed environmental conditions.

However, to comply with Corps policy for examining the feasibility of using dredged material for ecosystem restoration, the District identified options currently available for possible future consideration. In particular, the District has been working with the Ohio River Islands National Wildlife Refuge on a potential cooperative effort to use dredged and excavated materials from another District project for erosion stabilization at their Phillis and Georgetown Islands in the New Cumberland Pool. Other options for beneficial use of disposal materials investigated in this study include specific aquatic ecosystem restoration projects, in-river disposal (filling dredge holes), and brownfields redevelopment. Using the material to fill in abandoned mines could also be considered for future beneficial use of disposal material.

4.6.9.6.1 Ohio River Islands National Wildlife Refuge

The manager of the Ohio River Islands National Wildlife Refuge (Refuge) approached the District in 2006 with a request for assistance in providing suitable dredged materials for erosion stabilization at their Phillis and Georgetown Islands. The Refuge has documented significant erosion and loss of surface acreage at these their upstream-most islands, as well as other islands further downstream. The Corps Huntington District has assisted the Refuge in design and construction of erosion protection schemes at some of their islands within the Huntington District boundaries, and provided similar design support for Phillis and Georgetown Islands in the Pittsburgh District (between Ohio River miles 36 – 40). The Refuge's request was to offer their islands as dredged material disposal sites if the disposal were constructed to serve as erosion stabilization.

The Refuge supplied all necessary Authorization for Entry permissions, and obtained all necessary Section 404 and 401 permits and certifications in support of the anticipated dredged material placements. The District looked at all possible sources of dredged materials from its ongoing projects that could be used in support of the erosion stabilization scheme. The primary source of materials was the ongoing major rehabilitation of Emsworth Dams scour protection. Costs of transportation and placement to the islands, however, were not the least cost environmentally acceptable disposal alternative. Consequently, the District was unable to justify the islands as the preferred disposal site. Lack of time did not permit the District to pursue searching for a non-federal sponsor to consider authorization and cost-sharing of the increased cost increment under Section 204 authority.

The District supports pursuit of any cooperative environmental restoration project with the Refuge that is consistent with Corps authority and policy. Post-authorization planning for material disposal will include opportunities for cooperation with the Refuge. In addition to least cost environmentally acceptable options and Section 204 of WRDA 1992, Section 906(e) of WRDA 1986 provides that for any project measures recommended to Congress to enhance fish and wildlife resources, the first costs of such enhancement shall be a Federal cost when … "(3) such activities are located on lands managed as a national wildlife refuge." Corps policy under current budgetary constraints does not support implementation of subsection 906(e).

4.6.9.6.2 Brownfield Reclamation

According to www.epa.gov/brownfields, brownfields "are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and working lands." Brownfield development usually occurs on land that was previously used for industrial purposes.

Clean unregulated materials resulting from lock construction activities could be used beneficially to aid the remediation of brownfield sites within or close to the project area. Brownfield sites may require on-site fill material to properly grade the area, or to cap areas of the site eliminating any direct contact with potentially hazardous soils already located on the brownfield.

Within the project area, many opportunities for brownfield development occur along the riverfront which could result in similar or decreased transportation costs relative to conventional upland disposal at a commercial facility. According to www.pittsburghgreenstory.org, the flat riverside acreage within the Pittsburgh area facilitated the placement of large industrial facilities along the riversides due to ease of barge and train travel for manufactured goods. In the 1970's and 1980's when the steel industry within the area started to decline and many facilities closed, western Pennsylvania was left with thousands of acres of prime riverfront industrial property.

Based on uncertainty in brownfield development availability along with authorization and construction schedule, any specific planning for brownfield site usage will be deferred to post-authorization PED. The future potential use of disposal material from lock construction as brownfields material will depend on three significant factors:

1. Commercial availability of any private or public brownfield development in the project area during the timeframe needed for disposal.
2. Liability indemnification.
3. Quality of disposal materials determined by material testing.

4.6.9.6.3 In-River Disposal (Filling Deep Holes)

Another alternative to disposal at a commercial facility is the use of in-river disposal and potential filling of legacy commercially dredged holes. The potential for environmental impacts of in-river disposal is dependent upon the type of dredging and disposal operation used, the physical characteristics of the disposal material, and the hydrodynamics of the disposal location. If a significant amount of material is to be disposed in-river, backwater and floodplain impacts may also need to be further evaluated. The specification of in-river disposal sites will be subject to the Clean Water Act, Section 404(b)(1) guidelines.

Bathymetric surveys using multi-beam side-scan sonar were carried out along approximately 35 miles of the Ohio River from the point at mile zero to just downstream of Montgomery Dam at mile 35. The surveys have revealed that some of the area has been impacted by

commercial sand and gravel dredging operations. It is possible that the conditions within the deeper dredged areas are low in dissolved oxygen which results in poor habitat value for most aquatic species.

Most of the costs associated with in river disposal are transportation-related costs. For this reason, the bathymetric surveys were reviewed within close proximity to the Emsworth, Dashields and Montgomery Locks where construction will take place and generation of disposal materials will occur. The results of the review indicated that the highest capacity for deep hole disposal is in the New Cumberland Pool, directly below Montgomery Dam and in the Montgomery Pool directly above Montgomery Dam. Deep holes below the dam can reach depths of 36.5 feet. Deep holes above the dam can reach depths of 50.0 feet.

The Montgomery and Dashields Pools have much less distinctive deep holes, providing more even depths and contours. Depths within this area can reach 22-24 feet which may not be of significant depth to create poor dissolved oxygen conditions for aquatic species. Similarly, very shallow areas are found below the Emsworth Dams. For this reason, in-river disposal is not favorable within close proximity to the Dashields and Emsworth Dams.

Pools 4 and 5 along the Allegheny River (outside of the project area) exhibit similar conditions as those found near to the Montgomery Dam. Pools 4 and 5 of the Allegheny River have been previously dredged at some locations to bedrock depths or approximately 60 feet. In 1997, the Pennsylvania Department of Environmental Protection measured anaerobic conditions at the bottom of some holes and took grab samples which indicated accumulation of fine silt and organic matter in a state of decomposition. The holes also were found to serve as sinks for large decomposing branches and limbs which further degraded the dissolved oxygen. The results of the analyses determined that the dredge holes do not provide habitat that is suitable for sustaining aquatic life.

Within the Pools 4 and 5 of the Allegheny River, the depths of the dredge holes are such that the normal river current does not flush them out. By filling the holes to a level that allows normal river hydraulics to flush them out, there is a possibility to restore water quality and create beneficial aquatic habitat. If no suitable locations are found within the Ohio River reach of the project, it may be beneficial to take the material to the Allegheny pools that are in need of the material.

Environmental impacts of filling in dredge holes through in river disposal could include temporary water quality impacts during placement which could increase turbidity through short term suspended sediment increases. Long term environmental impacts could include improvement of benthic habitat and water quality within the dredge holes. Implementation of this beneficial use will depend upon transportation costs of the materials and which dredge holes would environmentally benefit from material placement.

4.6.9.6.4 Abandoned Mine Lands

Legacy coal mines within southwest Pennsylvania have a large impact on water quality within the area. The main impact to water quality from abandoned mines is from acid mine drainage (AMD). According to the United State Geological Survey, abandoned coal mines have impacted more than 3,000 miles of surface and ground water within the state of Pennsylvania.

Since bituminous coal deposits are found underlying the majority of western Pennsylvania, AMD is especially prevalent in tributaries leading into the project area. In the past, before the passing of coal mining laws, once mining activities were concluded, pumping to keep the mine dry ceased, and the mines filled up with water over time. AMD drainage is normally caused by oxidation processes which result in highly acidic discharges.

Some coal mines in southwest Pennsylvania also cause subsidence of the land above the mines through shifting of the overburden. This can lead to environmental damages including hydrologic impacts to surface and groundwater. Reclamation of abandoned mines through placement of material would help alleviate associated water quality issues with AMD and mine subsidence problems affecting surface and groundwater flow. Negative impacts of mine reclamation such as bat habitat impacts will need to be further evaluated on a location basis before implementation.

4.6.9.7 Fish Passage Strategies Study

The Upper Ohio Navigation Study evaluated fish passage strategies at each EDM lock and dam facility in fulfillment of the Corps commitment in the ORMSS PEIS: "Evaluation, and if feasible, construction of fish passage strategies at each lock and dam along the Mainstem during studies for lock modernization and major rehabilitation." This evaluation was also consistent with Section 216 of the River and Harbor and Flood Control Act of 1970, which provides that the Corps undertake studies to review the operation of completed federal projects and recommend project modifications, "…when found advisable … for improving the quality of the environment in the overall public interest."

4.6.9.7.1 Need for Fish Passage Strategies

The ORMSS commitment to evaluate fish passage strategies responded to the Corps environmental policies supporting environmental sustainability and recognition of the navigation system's role in cumulative environmental impacts. The ORMSS cumulative effects assessment used resource sustainability as a measure of the overall effect of cumulative impacts attributable to the Corps and/or others on valued environmental components. Sustainability is a key element of the Corps Environmental Operating Principles, under which the Corps accepts responsibility and accountability for our activities that impact the viability of natural systems. These operating principles direct the Corps to strive to achieve environmental sustainability and to seek ways and means to assess and mitigate cumulative impacts to the environment. ORMSS introduced the concept of sustainability-focused mitigation measures to describe measures that are oriented less towards in-kind resource replacement and more towards enhancing the environmental sustainability of ecosystems.

Canalization of the Ohio River mainstem began with completion of Davis Island Lock and Dam (#1) in 1885 at the head of the river in Pittsburgh. Another 50 locks and dams built on the Davis Island pattern were completed over the 981-mile length of the river by 1929. This first generation of navigation structures consisted of low-lift movable wicket dams with single lock chambers. The movable dams when raised provided a minimum navigable depths during low flows (7 feet before 1910 and 9 feet afterwards), and when lowered during periods of

high flows allowed open-river navigation. Even before the system was completed to the mouth of the river, Emsworth, Dashields, and Montgomery Locks and Dams replaced old #s 1-6. These replacement facilities were the initial second generation facilities having fixed crest or gated dams that eliminated open river conditions. All but the last two wicket dams have been replaced since 1955 with present system of 18 high lift dams.

The ORMSS documented that the Corps high-lift Ohio River navigation dams are an impediment to the long-distance movement of fishes. The ORMSS report, "Upstream Fish-Passage Opportunities at Ohio River Mainstem Dams," prepared by the USGS (Knights et al. 2003, see ORMSS Appendix) considered the influence of the 20 mainstem dams on longitudinal connectivity. Factors considered included fish life histories and swimming speeds, fish spatial and temporal distribution, dam characteristics, and flow velocities. They concluded that the frequency of open river conditions conducive to upstream fish passage is low at Pittsburgh District dams, low to moderate at Huntington District dams, and low to high at Louisville District dams. The "inability of some species to complete their life cycle because required habitats are separated by generally impassable dams [particularly Pittsburgh District dams] has undoubtedly affected abundance and distribution of these fishes in the Ohio River" (Knights et al. 2003, p. 18).

The USGS study inferred from observations on abundance and distribution of species found only in the lower or middle reaches or those species extirpated from the system, that the navigation dams may be a limiting factor. The "great river fishes," such as paddlefish, lake sturgeon, blue sucker, and skipjack herring, that are known to be highly migratory and orient to strong current, once had a greater abundance and broader distribution. The improvement in water quality that has permitted the return of other species to the Upper Ohio River has not resulted in all of the former species returning, indicating other limiting factors. Any attempt to quantify the effect of dams on the fishery through comparison of pre- and post-dam conditions, however, would be unsuccessful because of the inability to distinguish between the effects of all the large river system stressors that occurred previous to or concurrent with the navigation systems. Nonetheless, the report states that despite these uncertainties, recent literature on ecological structure and function of large rivers shows that longitudinal connectivity is important not only to fishes, but also to other river biota, such as freshwater mussels.

Freshwater mussels are an institutionally recognized as a significant resource that is affected by impaired longitudinal connectivity. Five federally endangered species are currently known to exist in the Ohio River mainstem. The ORMSS concluded that native mussels will remain in a marginally sustainable condition due to a number of stressors considered in the cumulative effects assessment. One of the significant limiting factors is the inability, or at least reduced ability, to disperse to other navigation pools due to the general lack of host fishes having freedom to move without impaired connectivity. The status of mussels is therefore closely linked to the status of their host fishes.

The ORMSS cumulative effects assessment concluded that the Ohio River fish resource status is improving from marginally sustainable to sustainable. While this determination applies to the overall fishery, the "great river fishes," which are a highly migratory fish assemblage,

have not recovered in the upper Ohio River. The future sustainability of this group, particularly in the upper river, appears to be dependent upon freer movement between pools that can only be accomplished through fish passage strategies through or around the navigation dams.

In addition to the USGS, other agencies and NGOs support the need for and importance of fish passage strategies on the Upper Ohio River. The USFWS ORMSS Coordination Act Report (2009) fully supported the need for improving river connectivity in association with three areas of concern, i.e., *Riverine Habitat, Mussel Fauna, and Fish Fauna*. Benefits of improved connectivity are linked to both migratory/highly mobile fish species and to mussels during their early life stage. The USFWS further stated in their report that concerns about invasive fish species using fish passage improvements should not hinder or prevent the Corps from vigorously installing fish passage.

The Pennsylvania Fish and Boat Commission's "Three Rivers Management Plan" (2011) affirms that the lock and dam system "impedes upstream movement for many fish species considered to be migratory" (p. 3). One of their identified *Priority 1 - Proposed Management Actions* is to "provide recommendations to the USACE with input on fish passage structures and habitat enhancement mitigation projects proposed at the Emsworth, Dashields, and Montgomery Locks and Dams on the upper Ohio River" (Stewardship Goal 5.1.2, p. 47). The Nature Conservancy has also stated their support to the Corps for the need of fish passage strategies, particularly on the upper Ohio River, to benefit the expansion of "great river fishes" and freshwater mussels to their former ranges.

The USGS study determined that the impediment to connectivity is greatest at the upper river (EDM) dams where the river slope is steeper and dams more closely spaced. Emsworth and Montgomery gated dams are fully open on the order of only one day per year. Dashields, a fixed crest dam, would only be passable rarely during extremely high flows when the tailwater elevation is nearly that of the headwater. Fish passage through locks during normal operations may occur, but is not likely a major passageway given unsuitable flow patterns through and around the lock chambers to attract fish into or lead them out of the chambers. For those that make their way into the confinement of a lock chamber, tow prop entrainment and mortality are more likely than in the open river.

Mitigation vs. Restoration

The District evaluated Corps of Engineers existing ecosystem restoration and fish and wildlife mitigation authorities to determine under which of these fish passage strategies may be authorized. As explained below, it was determined that fish passage strategies are consistent with these authorities, but that separable fish passage structures could not be justified under either authority due to their high cost and maintenance requirements.

Ecosystem restoration

Ecosystem restoration is one of the primary missions of the Corps civil works program. The purpose of restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Its intent is to partially or fully reestablish the

attributes of a naturalistic, functioning and self-regulating system. In this respect, the Ohio River navigation dams' degradation of naturalistic river system functions (e.g. connectivity) make them suitable candidates for restoration projects involving fish passage strategies.

The Corps may participate in the study, design, and implementation of ecosystem restoration projects at Corps facilities under Congressional authorities that include Section 1135 (WRDA 1986) and the Ohio River Ecosystem Restoration Program (WRDA 2000). The estimated costs of structural fishways, however, far exceed the federal funding limits placed on Section 1135 projects ($5 million per project). This would place responsibility for the majority of the construction costs, as well as all of the operation and maintenance responsibilities onto the non-federal sponsor, and no potential sponsor came forward in the planning process with an interest in taking on a fish passage project. The Ohio River Ecosystem Restoration Program has no similar project funding limitations, but Congress has not funded this program since its authorization. Consequently, the Corps restoration program would not be likely to lead to a potential structural fish passage project at this time.

Mitigation

Mitigation for adverse project impacts to significant fish and wildlife resources is a long-established principal and authority in environmental law and Corps policy. Corps mitigation policy states that damages to all significant ecological resources, both terrestrial and aquatic, be avoided and minimized to the extent practicable, and that any remaining unavoidable damages be compensated to the extent possible. Damages are defined in terms of differences in habitat values between future without-project and with-project conditions. Mitigation must be cost effective and incrementally justified to ensure that the recommended project will not have more than negligible adverse impacts on ecological resources. With respect to the EDM study, mitigation policy requires consideration of the recommended project's impacts, not historic system impacts.

Although historic impacts may not be considered, mitigation for new projects can include alternatives that address connectivity issues. Mitigation alternatives often take on the nature of in-kind replacement of lost or reduced-value resources, but Corps mitigation policy also directs a broad watershed-based, ecological approach. This may be expressed in terms similar to those connected with ecosystem restoration, i.e. ecosystem function, structure, and dynamic processes. The distinction between restoration and mitigation is in when they are applied. Restoration looks at reversing historic impacts, while mitigation is forward-looking to eliminate or lessen future impacts. Both, however, are forward-looking in the sense that they seek to offset impacts that would occur in the future.

The ORMSS report introduced the concept of "sustainability-focused mitigation measures" to describe measures that are oriented less towards in-kind resource replacement and more towards enhancing the environmental sustainability of ecosystems. This grew out of the cumulative effects assessment performed for the navigation system as part of the ORMSS NEPA impact analysis, which used resource sustainability as a measure of the overall effect of cumulative impacts attributable to the Corps and/or others on valued environmental components. Sustainability is also a key element of the Corps Environmental Operating

Principles, under which the Corps accepts responsibility and accountability for its activities that impact the viability of natural systems. These Principles direct the Corps to strive to achieve environmental sustainability and to seek ways and means to assess and mitigate cumulative impacts to the environment.

As a result, fish passage strategies would be supportable as "sustainability-focused mitigation measures" for EDM project impacts. To be implementable, however, their benefits must commensurate with anticipated project impacts, and they must be cost effective and justified incrementally among all other mitigation alternatives. The EDM recommended plan's aquatic impacts amount to 12.2 Habitat Units, whereas the preferred rock ramp fish passage strategy yields a total of 1,991 Habitat Units for all three projects. Even if rock ramps were structurally and hydraulically feasible, their high construction and maintenance costs would prevent them from being cost effective or incrementally justified among the other mitigation alternatives considered. Consequently separable fish passage structures cannot be justified at EDM under the Corps' mitigation policy.

4.6.9.7.2 Study of Fish Passage Strategies

The Upper Ohio fish passage study was an interagency effort undertaken with the assistance of the fishery biologists of the U.S. Fish and Wildlife Service's Carterville Fish and Wildlife Conservation Office, Illinois, and engineers of their Region 5 Office, Hadley, Massachusetts. The District and the USFWS used the Interagency Working Group as a study resource and received much valuable input from the participants. The full report on the fish passage study is included in the Environmental Appendix and is summarized below.

Study Goal

"Improve historic connectivity for populations of riverine fishes and mussels in the Upper Ohio River Basin." Included in the objectives to pursue this goal were:

a) restoration of fish passage for the full spectrum of native fishes during all seasons,

b) achieve greater spatial distribution and abundance of native fish and mussels in the Upper Ohio River pools,

c) provide rapids and riffles for spawning and macroinvertebrate habitat, and

d) provide for low-maintenance fish passage.

Other objectives reflected Corps mitigation requirements for monitoring to evaluate success, and adaptive management for improving subsequent projects.

Benefits

Increased opportunity for upriver fish movements through Upper Ohio River dams would provide fish with access to additional habitats in the upper pools and their tributaries. This would contribute to increased reproductive success, survival and growth of juveniles, genetic diversity and population-level responses of increased geographic range and abundance. Increased habitat utilization could lead to a more diverse, abundant, and genetically enriched

fish community in the Upper Ohio River that is more resilient to environmental disturbances. Increased opportunity for upriver fish movements will also have benefits for native mussel populations. An improved fishery would also lead to recreational fishing benefits.

Methodology

The study team applied the Fish Passage Connectivity Index (FPCI) to evaluate the ecosystem outputs of alternative measures. This model was developed by the Corps for use on the Upper Mississippi River and Illinois Waterway System, and was adapted for the Ohio River species. Outputs were calculated in terms of the effectiveness of a particular alternative for passing a species of fish upstream. Thirty focal species were used in our study. The model only considers upstream movement of adults between two pools. It does not consider system-wide analysis of multiple dams and pools, or downstream movements.

The output of the model basically displays the relative effectiveness of the fish species' ability to find and use each fish passage alternative, and allows a relative comparison of effectiveness between alternatives. These effectiveness indices can be translated into habitat units gained based upon the product of the index and the acreage of habitat available in the upper pools for each species, averaged the group of species. It is a habitat-based model that measures the ability to access habitat rather than the creation of or change in habitat values.

Fish passage strategies included both structural and non-structural alternatives. The non-structural alternatives were No Action, Fish Lockage, and Dam Gate Manipulations. Structural alternatives included Nature-like Fishways (rock ramp and nature-like fishways), Technical Fishways (Pool pass, Slot pass, Denil pass, and Fish lock/elevator). Dam removal, another structural alternative, would effectively eliminate the impediment but was eliminated from consideration as being inconsistent with maintenance of the navigation system.

Supporting Hydroacoustic Study

To support the conceptual-level design of potential fish passage structures for the Upper Ohio Navigation Study, the Corps performed preliminary hydroacoustic surveys in the tailwaters below Emsworth Dams (Main Channel and Back Channel), Dashields Dam, and Montgomery Dam. Three surveys were performed by the Corps St. Louis District survey crew using mobile hydroacoustic surveys and hydraulic assessments to provide information on the size of fish, their numbers, location, and concurrent hydraulic conditions. Three one-day surveys were conducted under differing seasonal and flow conditions in October 2008, April 2009, and June 2009. The full survey report is attached to the Integrated Report's **Environmental Appendix**.

Surveys indicated relatively low fish densities below all structures on the dates surveyed, with the greatest densities observed during the October 2008, lower flow period. In spite of relatively low densities, some patterns were evident. Densities were consistently highest below Montgomery Locks and Dam with all surveys. Fish density below Emsworth Backchannel Dam occasionally surpassed that of both Emsworth Main Channel Dam and Dashields Dam.

Below the gated dams at Montgomery and Emsworth Main Channel, more fish were observed near the bank opposite the locks in lower-velocity current. Below Dashields Dam, fish did not exhibit a preferred area, being detected across the width of the river. This may be related to relatively low-velocity, mixed-direction currents across the fixed-crest Dashields Dam, as opposed to flows controlled through gate openings. Fish may have exhibited a slight tendency to move up the right bank-side of the river below Dashields opposite the locks. The relationship to fish densities and bathymetry was not examined in this study, but may be a significant factor in design and siting of a fish passage structure.

Tailwater river levels, flow conditions, and dam gate openings all may have effects on fish distribution. Riverbed bathymetry and structure are also factors that will have to be considered in further fish distribution study. Additional surveys will be necessary during differing flow conditions over an extended time period to corroborate and refine these initial findings to a level of certainty suitable for fish passage structural design. If fish species associated with the relative size classes are to be determined, fish collection would have to be undertaken with the hydroacoustic surveys.

Fish Passage Study Findings

Many of the alternative fish passage strategies could provide varying degrees of improved connectivity at Emsworth, Dashields, and Montgomery Locks and Dams. The non-structural alternative of assisted fish lockage would have the least cost, but also provides the lowest projected increase in passage efficiency. The District has experience with assisted fish lockage at its low-use Allegheny River Locks and Dams with apparent success. Due to the frequent commercial and recreational lockages at the Ohio River facilities, separate fish lockages have not been conducted as with Allegheny River facilities. Whether more fish would pass through Ohio River locks by separate fish lockages in addition to boat lockages is uncertain, but either or both are reflected in the relatively low FPCI value. Of the structural group of alternatives, rock ramps provide the greatest efficiencies at the lowest overall costs (2009 price levels). These are summarized in **Tables 4-40** through **4-42.**

TABLE 4-40: Fish Passage Alternatives, Emsworth Locks and Dams

Measures Considered	Efficiency Gained (FPCI)	Habitat Units Gained	Annualized Costs (x000)	Annualized Cost/HU Gained
Rock ramp – Main Channel Dam gate bay (H)	0.30	895	$1,119.8	$1,251
Rock ramp – Back Channel Dam gate bay (I)	0.26	775	$1,119.8	$1,445
Fish lock – Main Channel Dam (D)	0.15	439	$1,445.2	$3,292
Vertical slot fishway – Main Channel Dam (B)	0.13	389	$1,821.2	$4,682
Fish lock – Back Channel Dam (E)	0.11	342	$1,445.2	$4,226

Measures Considered	Efficiency Gained (FPCI)	Habitat Units Gained	Annualized Costs (x000)	Annualized Cost/HU Gained
Vertical slot fishway – Back Channel Dam (C)	0.10	301	$1,821.2	$6,050
Fish lockage (auxiliary lock) (A)	0.02	64	No cost	No cost
Nature-like fishway – Dam bypass, Neville Island (F)	0.24	Not evaluated due to land requirements		
Rock ramp – Dam by-pass, Neville Island (G)	0.26	Not evaluated due to land requirements		

* Annualized Costs for these analyses include the initial construction costs, interest during construction (assuming one year for construction), operations & maintenance costs over a 50-year period, and a 4.125% interest rate.

TABLE 4-41: Fish Passage Alternatives, Dashields Locks and Dam

Measures Considered	Efficiency Gained (FPCI)	Habitat Units (HU) Gained	Annualized Costs (x000)	Annualized Cost/HU Gained
Rock Ramp – below fixed crest, north end (E)	0.26	315	$807.3	$2,563
Vertical Slot fishway – below fixed crest, north end (B)	0.13	158	$967.7	$6,125
Fish Lock – below fixed crest, north end (C)	0.15	178	$1,238.7	$6,959
Fish Lockage (auxiliary lock) (A)	0.02	26	No cost	No cost

TABLE 4-42: Fish Passage Alternatives, Montgomery Locks and Dam

Measures Considered	Efficiency Gained (FPCI)	Habitat Units (HU) Gained	Annualized Costs (x000)	Annualized Cost/HU Gained
Rock Ramp – below north fixed crest (E)	0.26	781	$1,085.2	$1,390
Fish Lock – below north fixed crest (C)	0.15	442	$1,397.2	$3,161
Vertical Slot fishway – below north fixed crest (B)	0.13	392	$1,821.2	$4,646
Fish Lockage (auxiliary lock) (A)	0.02	64	No cost	No cost

USFWS engineers provided conceptual-level designs based on prior experience and using general structural information on the lock and dam facilities. Numerous constraints were identified in the study report that would factor into a feasibility evaluation. These included preservation of navigation, structural integrity of the locks and dams, preservation of the dams' hydraulic capacity, land limitations, future hydropower development issues, biological design issues and others. Those alternatives requiring land, such as nature-like fishways around the dam abutments, were not considered in detail because of unsuitable terrain or existing infrastructure.

Rock ramps provide the best value considering first construction and total operations and maintenance costs over a projected 50-year life. Other structural alternatives have more than twice the cost per unit of fish passage efficiency attributed to each alternative. The conceptual structures and their costs were developed by USFWS engineers and were subjected to review by Corps engineers. It was recognized that these conceptual designs would need to undergo further detailed engineering and environmental design, if authorized, which could lead to significant changes. An adaptive management process, that would likely recommend sequential construction and monitoring, was also anticipated if recommended for authorization.

Fish Passage and Invasive Species Issues

The fish passage study team approached the study with a consensus that invasive species, such as the Asian carp complex, would reach and pass through the study area through navigation locks, with or without fish passage facilities. This view was based on experience of the Corps Mississippi River districts with Asian carp, and with their own planning experience for fish passage facilities at Mississippi Lock and Dam 22 and Melvin Price Locks and Dam. It was also supported by the recommendations of the joint USFWS Regions' Coordination Act Report for the ORMSS. Improving access of native fish throughout the river and optimizing their ability to fill available ecological niches is viewed as the lessening of opportunities for invasive species to gain a foothold.

The Pennsylvania Invasive Species Council has an objective to "…minimize the introduction and spread of aquatic invasive species into and through Pennsylvania" (Pennsylvania Invasive Species Council's *Aquatic Invasive Species Management Plan*, 2007). In view of the potential for aquatic invasive species to spread through the aid of fish passage structures, the District requested a position from the Council on whether passage structures would be inconsistent with their objectives. The Council responded by letter dated August 31, 2010 (see Environmental Appendix) recognizing the complexity of issue and requesting additional information upon which to issue a position on fish passage structures.

The Council is developing an action plan to lessen the probability of Asian carp or other threats spreading into our river systems, and fish passage structures on the Ohio River dams may significantly impact the development and implementation of that plan. The Council stated five concerns, which may be summarized as follows:

- What is the specific risk of fish passage structures facilitating passage by invasive species, particularly Asian carp?
- What documentation is available on the impediment of Ohio River navigation dams to fish movement and on current fish movement between dams, by both native and invasive species?
- How might fish passage facilities be designed to selectively pass native species?
- How might fish passage facilities be designed to be modified or closed pending future invasion by Asian carp or other species?
- Apart from the impediment of dams, are there other environmental factors that may influence the successful movement of native or invasive fishes?

The Corps is unable to address and answer all of these comments in the present level of study. If fish passage strategies are authorized, post-authorization design studies would consider and may be able to address a number of the Council's concerns.

Engineering Feasibility Evaluation of Fish Passage Alternatives

Pittsburgh District engineers performed a multi-disciplined review of the USFWS conceptual designs from an engineering, operational, and dam safety perspective. The focus of this review was on the rock ramps, as the preferred design, but also considered the other structural concepts. They identified a number of highly complex technical issues that rendered structural fish passage alternatives not feasible or highly infeasible.

In the recommended navigation plan, the Emsworth and Montgomery gated dams would each lose one gate due to replacement of the 56'-wide locks with wider 110' chambers. Adding a fish passage rock ramp in one of the Emsworth and Montgomery dam gate bays would effectively eliminate the flow capacity of a second gate. The dams are considered to have surplus water discharge capacity that could accommodate the loss of a single gate, but not two gates. Therefore, the loss of a second gate would likely result in unacceptable increases in water surfaces.

Emsworth and Montgomery Dams are founded on timber piles, which are highly susceptible to undermining with some of the fish passage concepts. Emsworth Dams have newly installed scour protection and abutment combination walls that cannot be partially removed to accommodate any fish passage structure immediately downstream of the dam.

Large-scale rock ramps on big river dams are an unproven technology, and they appear to be susceptible to instability from high flows, ice and debris. District navigation dams also experience problems with runaway barges, which could also impact fish passage structures and cause uncontrolled releases of water through the dam/structure. Long-term maintenance and annual operations requirements would be increased over present navigation operations and maintenance levels. Access to structures at the dam abutments is problematic for lock and dam attendants, and security/safety issues were identified in relation to fishermen and boaters.

4.6.9.7.3 Conclusion of Fish Passage Study

The study of conceptual fish passage strategies undertaken for the Upper Ohio Navigation Study concluded the following:

1) There is a documented need for fish passage strategies at Emsworth, Dashields, and Montgomery Dams as a consequence of dam design and hydrologic conditions.
2) Structural fish passage alternatives examined at a concept level could benefit upstream movement of the 30 fish species evaluated in the model study.
3) Nature-like by-passes and rock ramps would provide more benefits at lower cost than technical fishways.
4) Fish lockages have the lowest passage efficiency, but as a non-structural alternative also have no associated structural costs.

The subsequent review by Corps engineers of the USFWS concept-level, **traditional fishway alternatives** considered in the above study resulted in a determination that they were **infeasible** at Emsworth, Dashields and Montgomery Locks and Dams **from an engineering and operational perspective.** The various issues affecting feasibility are attributable to the constraints involved with retrofitting older dams, particularly in combination with dam modifications required to accommodate modernized locks. These include:

1) All of the structural fish passage alternatives would adversely affect the hydraulic capacity of the dam and likely cause increased backwater effects.
2) All of the structural fish passage alternatives would have significant structural issues that would affect dam stability without major reconstruction of the dam.
3) Operational issues with accessibility, ice and debris removal, and facility safety and security were identified.
4) Increased operations and maintenance responsibilities at the navigation facilities for fish passage structures would adversely impact the District's ability to meet our primary mission of navigation under current and projected fiscal limitations.
5) Nature-like by-pass alternatives are not feasible at the Upper Ohio facilities due to terrain and existing floodplain development constraints.

The above Corps analysis did not address whether the feasibility issues with the conceptual fish passage designs were irresolvable. However, given the nature of the constraints forming these issues, it is highly likely that any engineering solution to further modify the dams or the fishways would necessarily involve significant additional costs without any increase in benefits to connectivity. It was concluded that further evaluation of traditional fish passage structure designs would not lead to a feasible project recommendation.

Despite the infeasibility of separable fish passage structures as sustainability focused mitigation or as ecosystem restoration projects, evaluation of fish passage strategies is not limited to separable structural alternatives alone. Strategies could include the operation and design of the navigation facilities themselves. Special operations of low-use locks

specifically for fish passage have been successful in the Pittsburgh District as well as at other Corps projects. Also, incorporation of environmentally sustainable design concepts into engineered structures is supported by the Corps Environmental Operating Principles. A commitment to pursue both of these strategies in navigation feature design is described in **4.6.9.8 Environmentally Sustainable Design**.

4.6.9.8 Environmentally Sustainable Design

4.6.9.8.1 Concept

For decades, it has been Corps policy to take a leadership role in carrying out the goals and objectives of the national policy to protect and enhance the quality of our nation's water resources. In 2002, the Chief of Engineers, General Robert B. Flowers, merged various aspects of these goals and objectives into a set of Environmental Operating Principles to guide the Corps into the 21st century using the concept of environmentally sustainable development. This concept strives to apply the best science and engineering technology to achieve synergy among environmental, economic, and social interests. It applies to the full spectrum of Corps activities, including planning, design and construction, operations and maintenance, regulatory, research and development, and others.

4.6.9.8.2 Need and Opportunity

The ORMSS report previously documented sustainability issues with valuable aquatic resources, i.e., mussels and certain migratory fishes. These resource issues have been substantiated to the Corps by numerous agencies and public interest groups, with recommendations to improve resource sustainability through reducing the navigation structures' impediment to connectivity. This led to the Corps commitment in the ORMSS report to evaluate, and if feasible construct fish passage strategies during subsequent feasibility studies.

The study to recommend new locks at EDM presents an opportunity to apply the Environmental Operating Principles into the design of the new navigation features themselves. Having established the importance of river connectivity to the future sustainability of certain valuable aquatic resources, the focus of the design modifications would be on features to improve fish passage efficiency through normal project operations. Each new lock presents an opportunity to develop or improve lock design features that would support navigation traffic as well as optimize their efficiency for attracting and passing fish. Furthermore, the recommended addition of a gated segment to the fixed-crest Dashields Dam presents a potential opportunity to design the gate and its operation to accommodate upstream fish movements through the dam.

4.6.9.8.3 Commitment

The District will evaluate and, if feasible, incorporate engineering design and operational modifications into the navigation features for the purpose of improving fish passage efficiencies through these facilities. This commitment is consistent with the ORMSS commitment to evaluate fish passage strategies. It is also consistent with the Corps Environmental Operating Principles and the concept of environmentally sustainable

development. It will be pursued through the standard engineering detailed design phase to the extent that it does not increase traditional engineering design and construction costs, in support of environmental quality in civil works project design. As such, it will not be dependent upon justification under ecosystem restoration or mitigation authorities. Any improvements to standard lock and dam design as a result of this undertaking could have far reaching future applications to reduce connectivity issues throughout the Corps extensive inland river navigation system without reliance on separable fish passage structures.

In making this commitment, the District consulted with the Corps Engineering Research and Development Center (ERDC). Their research into published literature and Corps experience allowed them to conclude that "development of a fish passage system simultaneously with lock expansion and improvement activities is a potentially viable alternative and should be pursued" (see Technical Note: Planning Guide for Fish Passage at Pittsburgh District Dams, David L. Smith and John M. Nestler, 2012, in Environmental Appendix, Fish Passage Study). "It may even be possible to build a system that preferentially passes desirable aquatic species and selectively impedes (but not completely blocks) the passage of ANS [Aquatic Nuisance Species]."

The District acknowledges the concern of the Pennsylvania Invasive Species Council that improved fish passage at navigation projects could also be detrimental in facilitating the spread of Aquatic Nuisance Species, such as the Asian carp complex. This issue and the District's correspondence with the Council is discussed in **4.6.9.7 Fish Passage Strategies Study, *Fish Passage and Invasive Species Issues*** (see also **Environmental Appendix**, Invasive Species Issues). Among the Council's concerns are specific questions relevant to any evaluation and implementation of navigation design modifications for improving fish passage:

- What is the specific risk of fish passage structures facilitating passage by invasive species, particularly Asian carp?
- How might fish passage facilities be designed to selectively pass native species?
- How might fish passage facilities be designed to be modified or closed pending future invasion by Asian carp or other species?

The District is unable to address and answer these questions in the present level of study. Should the District proceed with navigation design modifications, these issues will be considered and fully coordinated with the Council and its member agencies.

4.6.9.9 Mitigation Measures

4.6.9.9.1 Lock Construction Aquatic Habitat Mitigation

The goal of the aquatic mitigation alternatives is to provide enhancements or benefits to the aquatic ecosystem to replace the habitat loss as measured by the HEP analysis. Corps of Engineers policy is that mitigation planning will be accomplished in a watershed context. The ultimate goal of the watershed approach is to maintain and improve the quality and quantity of the natural resources in the watershed. This policy is further developed specific to the Ohio

River Navigation System in the ORMSS Record of Decision commitment to adopt sustainability focused mitigation measures for future actions. The ORMSS report identified 26 high priority ecosystem needs that could be considered in either ecosystem restoration or mitigation planning for addressing systemic and watershed issues. Some of these ecosystem needs were addressed in formulation of potential projects through the UONS Ecosystem Restoration Study (June 2010).

In accordance with Corps policy and commitments, the Study Team evaluated a variety of mitigation alternatives, including both in-kind replacement and sustainability focused measures. The sustainability focused measures considered were the best buy and cost-effective buy ecosystem restoration alternatives from the UONS Ecosystem Restoration Study. Other in-kind measures were developed by the Study Team specifically as mitigation measures, considering suggestions from the Interagency Working Group.

The UONS Ecosystem Restoration Study evaluated several ecological restoration options within the study area, two of which were determined to be "best buy" alternatives: the Montgomery Slough Option #1, and the Georgetown Island Foreshore Dike (FSD) Option M. Both of these best-buy alternatives are located in the Montgomery Pool. There were no ecosystem restoration options in the Dashields Pool or the Emsworth Pool that were rated as a best buy or as a cost-effective buy in the Incremental Cost Analysis to warrant further consideration. The habitat benefits provided by either of the two ecosystem restoration alternatives would be significantly more than necessary to compensate for the calculated habitat losses from lock construction.

The Montgomery Slough, locally known as the Montgomery embayment and Ohioview Peninsula, is a unique embayment habitat type in the Pennsylvania reach of the upper river. The USFWS has designated this resource for purposes of their mitigation policy as Resource Category 1, "Habitat is of high value for evaluation species and is unique and irreplaceable." This designation was first indicated to the Corps in the USFWS January 1985 Planning Aid Report and was repeated in their April 2009 Planning Aid Report Update. The only other resources sharing this premier designation in the upper river are Phillis and Georgetown islands, both of which are protected as part of the Ohio River Islands National Wildlife Refuge. The Pennsylvania Fish and Boat Commission describes the embayment as a one-of-a-kind ecosystem, unique in the Ohio River in Pennsylvania for its association of aquatic plant life and wetland habitat. Reflecting the USFWS designations, the Western Pennsylvania Conservancy and the Pennsylvania Natural Heritage Program give an "exceptional" ranking to the Phillis and Georgetown islands and the Ohioview Peninsula Biological Diversity Areas of the Upper Ohio River.

The embayment supports one of the few thriving populations of centrarchids ("panfishes") in the upper river. The ecological value of the embayment, however, extends well beyond the fishery to the wetlands, riparian habitat, palustrine forest and immature bottomland hardwood habitats of the shoreline, and to the wildlife they support. The last remaining silver maple-American sycamore stand in the Pennsylvania portion of the Ohio River is found on the peninsula. The riparian area that surrounds the embayment is a part of the Riparian Resources Valued Environmental Component (VEC). Of the 11 VECs evaluated in the Upper Ohio

Navigation Study's cumulative effects assessment, Riparian Resources is the only one classified as "Not Sustainable" in all three timeframes - past, present, and future.

One of few institutional programs available to stem the future fragmentation and degradation of remaining riparian habitat is the purchase of privately owned lands for public management. Were the Ohioview Peninsula placed into federal ownership, the ecological values of the embayment and surrounding riparian habitat could be protected from future development and this local resource would be preserved in a sustainable condition.

The Ohioview Peninsula and embayment is identified for future acquisition in the Ohio River Islands National Wildlife Refuge's presently unapproved, updated Land Protection Plan. The District and Refuge staffs have discussed the possibility of the District acquiring the property for implementing mitigation and subsequently transferring the property to the Refuge for long term management and protection through established interagency federal land transfer procedures.

In anticipation of acquiring the Ohioview Peninsula to implement mitigation in the riparian areas and embayment, the District conducted Phase I & II environmental site assessments and a screening level ecological risk assessment for the property. CERCLA hazardous substances were present in the assessment area. Corps policy states that areas containing HTRW should be avoided where practicable. Therefore, the District elected to abandon the land-based mitigation component with its land protection and riparian invasive species management benefits, but retain the aquatic component. The majority of the mitigation plan's ecological benefits are tied to the embayment (98%), and the results of the screening level ecological risk assessment supported pursuing the aquatic component, which has no real estate acquisition requirement.

The original Montgomery Slough (Option #1) plan's aquatic component involved placement of Large Woody Debris (LWD) fish habitat structures across 10 of the 24 embayment acres. The benefits gained from this plan significantly exceeded the aquatic habitat losses from lock construction (38.69 HU gained vs. 12.23 HU loss). Consequently, a scaled-down, 30-percent version of Option #1 was reformulated to closer approximate the level of impact. The scaled-downed plan involves three acres of improvements instead of 10 acres, and substituted for LWD the concept of the Pennsylvania Fish and Boat Commission's design for Short Vertical Plank Structure placed at 30/acre.

To supplement the array of ecosystem restoration measures considered as mitigation alternatives, the Study Team considered pool-specific FSDs to be the most practical in-kind mitigation measure. One rock FSD, providing a vertical shallow water structure and cover and creating an artificial slackwater embayment, was considered within each of the Emsworth, Dashields, and Montgomery Pools. Due the economy of scale in construction costs, it was determined that the shorter FSDs (460' & 485' linear measurement) would cost more per Habitat Unit (HU) gained than the longer 540-linear foot ("WPC-1,200-M") FSD alternative. Consequently, only the WPC-1,200-M FSD was carried forward in the cost effectiveness analyses to represent the most competitive FSD alternative. The costs of the

ecosystem restoration alternatives (Montgomery Slough Option 1, and the Georgetown Island FSD Option M) were taken from the UONS Ecosystem Restoration Study (June 2010).

Aquatic Mitigation Cost Effectiveness/Incremental Cost Analysis

Habitat Unit outputs for the mitigation alternatives were calculated and ranked with their associated costs (**Table 4-43**). All but the Montgomery Slough Option 1 (30%) alternative furnish far more Habitat Units than necessary to meet the target of 12.23 HU loss from all lock construction. While the other alternatives may have a lower cost per HU furnished, their total cost is much greater due to their producing three or more multiples of the required amount of HUs. The Montgomery Slough Option 1 (30%) alternative is the least cost alternative.

TABLE 4-43 Aquatic Mitigation Alternatives Ranking by HU Outputs

Mitigation Alternatives	Initial Costs ($)	HU Outputs	Annualized Costs ($)	Cost/HU ($)
Site 14 Montgomery Slough Option 1 (aquatic component only @ 30%)	$146,799	**11.54**	$6,259	$542
Site 14 Montgomery Slough Option 1	$331,094	**38.69**	$14,116	$365
Site 5 Option M-Davis Island FSD	$5,606,719	**77.13**	$239,035	$3,099
Site 10 Option M-Ambridge FSD	$2,138,331	**87.41**	$91,165	$1,043
Site 13 Option S-Four Mile Run FSD	$315,861	**98.59**	$13,466	$137
WPC-1,200-M FSD	$1,526,000	**99.56**	$65,059	$653
Site 18 Georgetown Island Option M	$1,802,313	**178.18**	$76,839	$431

Selection of the Recommended Aquatic Mitigation Plan

The Montgomery Slough Option 1 (30%) alternative is the lowest cost alternative that reasonably meets the mitigation target (12.23 HUs). No other alternative, including the original Montgomery Slough Option 1 alternative, satisfies the mitigation target at a lower annualized cost. Further refinement of the Montgomery Slough Option 1 to more closely match the mitigation target was not deemed necessary considering the general assumptions and level of significance involved in the calculations. Rounding the Option 1 (30%) alternative's HU gain and 12.23 HU loss to whole HUs would resolve the difference. The recommended aquatic mitigation plan is therefore the Montgomery Slough Option 1 (30%), which is described in further detail under **Section 5**.

4.6.9.9.2 Construction Support Area Terrestrial Habitat Mitigation

The Study Team conducted a HEP analysis of three options of conventional site restoration activities (landscaping, natural succession, etc.) at each PLA to determine if these restoration efforts would mitigate the terrestrial habitat impacts resulting from the use of the PLA during construction. As described in **3.3.3. Construction Support Areas** and **4.6.9.3 Construction**

Support Area (Upland Impacts), secondary work areas would have negligible habitat impacts due to their minimal habitat value. Site restoration limited to planting a wildlife habitat herbaceous mix (equivalent to WPC-M – Option #3 below) would be sufficient to compensate for any lost habitat values.

WPC-M - Option #1 – This option includes a moderately intensive landscaping restoration that had a Year 15 targeted community of 50 percent early succession forest, 25 percent shrub thicket, and 25 percent herbaceous old field. Trees would be planted at a density of 60 per acre and the shrubs would be planted at a rate of 200 per acre. The entire site would be planted with a wildlife habitat herbaceous mix to stabilize the site and establish the old field community. Habitat values for this treatment were modeled at Year 15 and growing Year 30.

WPC-M - Option #2 – This option includes a moderately intensive landscaping restoration that had a Year 15 targeted community of 75 percent shrub thicket and 25 percent herbaceous old field. Shrubs would be planted at a density of 600 per acre. The entire site would be planted with a wildlife habitat herbaceous mix to stabilize the site and establish the old field community. Habitat values for this treatment were modeled at Year 15 and growing Year 30.

WPC-M - Option #3 – This option includes no woody species landscaping and allows the site to naturally succeed as colonized by local native species. The entire site would be planted with a wildlife habitat herbaceous mix to stabilize the site and establish the old field community. Habitat values for this treatment were modeled at Year 15 and growing Year 30.

The total cost estimate for these options is based on the cost of the plants and shrubs as well as a mobilization and labor cost. When broken down, the cost of the plants and shrubs was estimated to be approximately one third of the total cost per acre of its respective option. Additionally, the Study Team estimated that the mobilization and labor costs combined would be approximately ten percent of the cost of the vegetation. The costs of each option are summarized in **Table 4-44** below.

TABLE 4-44: Cost Effectiveness Analysis, Terrestrial Mitigation

	Option #1	Option #2	Option #3
HU gained per Acre	.55	.54	.48
Cost per Acre	$38,400	$37,800	$1,500
Cost per HU	$69,818	$70,000	$3,125

The HUs gained with each option at each site are summarized in **Table 4-45** along with HUs lost during lock modernization construction.

TABLE 4-45: Terrestrial Mitigation Options, HUs Gained

	Emsworth PLA	Dashields PLA	Montgomery PLA
Option #1	2.70	3.71	3.85
Option #2	2.63	3.62	3.76
Option #3	2.37	3.26	3.38
Compare - HUs Lost	**-2.65**	**-3.98**	**-4.27**

* Highlighted values approximate a 90 percent replacement of HUs

Selection of the Recommended Mitigation Plan

Due to the conservative assumptions used in the analysis and the industrialized settings, the District recommends a 90 percent HU replacement as an acceptable mitigation target. The recommended mitigation plan is therefore Option #3 at Emsworth, Option #2, at Dashields, and Option #1at Montgomery.

Costs (90 percent replacement of HUs):

Emsworth Option #3 - $7,350.

Dashields Option #2 - $255,150.

Montgomery Option #1 - $264,600.

This recommended mitigation plan addresses the primary laydown areas identified at each of the three locks. As of March 2014, use of the Emsworth secondary area is proposed rather than the primary area. Site restoration of the secondary area would be the same Option #3 plantings recommended for the primary area with no difference in cost. Should future circumstances require the District to substitute the secondary areas at Dashields and Montgomery for the recommended primary areas, habitat impacts would be negligible and Option #3 site restoration would be used. Overall mitigation costs would be reduced proportionally.

4.6.9.9.3 Cultural Resources Mitigation

The ORMSS Programmatic Agreement Section III.B.2. requires that the Corps, in consultation with the appropriate SHPO and the Advisory Council on Historic Preservation, develop proper treatments for Register-listed and eligible historic properties adversely affected by the Project. Mitigation plans are to be detailed in a Memorandum of Agreement in consultation with the SHPO and the Advisory Council. Plans are to be made available to interested parties, and comments be made available to be taken into account by the SHPO and Advisory Council.

By letters dated February 18, 2011, the District sent a draft MOA to the SHPO and Advisory Council for review and comment. The Council responsed by letter dated March 24, 2011, declining further participation in the consultation to resolve adverse effects. They advised that the MOA and any supporting documentation is to be filed with the Council in order to

complete the Section 106 requirements. The SHPO responded by letter dated March 18, 2011 with suggestions for clarification. Accordingly, the District revised the draft MOA and provided a copy to the SHPO by letter dated June 6, 2012 for review. Copies of correspondence and the revised draft MOA were circulated for public review in the Cultural Resources Appendix of the Draft EIS.

The revised draft MOA contained three stipulations as appropriate mitigation – documentation, interpretation, and National Register of Historic Places nomination. Documentation of Emsworth, Dashields, and Montgomery Locks and Dams for inclusion in the Historic American Engineering Record (HAER) will be performed in consultation with the National Park Service. This will supplement the prior HAER documentation of Emsworth Dams done for the dams rehabilitation project. Interpretation will include four elements – 1) an historical scholarly research and publication of the 1929 Ohio River Navigation System and the particular contributions of the Pittsburgh District on the Upper Ohio River, 2) the preparation and publication of a popular article on the EDM facilities, 3) internet web site information, and 4) interpretive signage in the project vicinities. Submittal of National Register nominations for the EDM properties and a Multiple Property Documentation Form for the Ohio River Navigation System will formalize the eligibility determinations and historic context study performed for the ORMSS study.

Pittsburgh District removed the National Register nomination component from the final MOA, which was executed in 2015. A copy of the executed MOA is included in the Cultural Resources Appendix (see also Section 5.1.4.2 Cultural Resources Mitigation).

4.6.10 Identification of the Preferred Navigation Plan

The formulation of With-Project Alternatives has examined the costs and benefits of achieving safe and reliable navigation for the future 50-year period of analysis by (1) seeking to extend the useful service life of the existing 110’ x 600’ locks at EDM, and (2) by investing in new locks of either 600’, 800’, and 1200’ in length. As described above, nine Lock Modernization Alternative Plans involving the construction of new locks (LMA 1 through LMA 9), the Advanced Maintenance Alternative, and the Without-Project Condition (Reactive Maintenance) were investigated for each of the three lock sites at low, medium, and high traffic scenarios.

Only LMA plans with the same construction strategy (i.e. same lock sizes and new lock construction) at all three sites were carried forward for economic analysis. Each Lock Modernization Alternative plan involves either retains the existing (110’ x 600’) land chamber or replaces it with a new 110’ x 600’ land chamber. The Advanced Maintenance and WOPC plans would retain all existing chambers. These plans were screened to the final six on the basis of benefits and costs as described in Section 4.6.7, specifically LMA 1, LMA 7, LMA 8, LMA 9, Advanced Maintenance, and the WOPC (Reactive Maintenance). **This analysis has determined that a new lock to replace the small auxiliary river lock at each site delivers the largest positive net average annual system benefits, with a new 600’ lock at each location maximizing the net benefits and forming the NED plan for all traffic scenarios. The net benefits of the final plans were shown in Table 4-36.**

The plan which maximizes net benefits involves continued operation of the old 600' chambers as auxiliaries with Reactive Maintenance (assuming no scheduled component replacements). It must be emphasized that the engineering risk and reliability assessment of the existing land chambers found that major component failure or wall section failure is likely very early during the period of analysis. Even as auxiliary chambers, their safe and reliable operation is highly questionable.

4.6.10.1 System of Accounts Evaluation

4.6.10.1.1 National Economic Development (NED) Account

The 1983 Principles and Guidelines (P&G) established four accounts to facilitate evaluation of alternatives in Federal water resources planning: National Economic Development (NED), Environmental Quality (EQ); Regional Economic Development (RED); and Other Social Effects (OSE). The NED account is the only required account.

The NED account measures contributions to National Economical Development and are the increases in the net value of the national output of goods and services, expressed in monetary units.[26] The net benefits of any plan are the amount that the benefits exceed its costs. Positive net benefits indicate the plan is economically feasible to implement; negative net benefits denote that it is not economically feasible. All of the final plans, including the WOPC, make a positive and significant contribution to the NED. A second way of displaying net benefits is as the incremental difference over the WOPC (**Table 4-46**).

[26] P&G Section II(b)

TABLE 4-46: Summary of Economic Analyses, Alternative Ranking Mid Traffic Scenario

Plan Description/Designation (RM = Reactive Maintenance)	Incremental	
	Ranking (Mid Case)	Net Benefits
LMA 7 (New 600' river chamber & RM old land chamber)	1	$224.7
LMA 1 (Two new 600' chambers with deferred start of 2nd chamber)	2	$219.3
LMA 8 (New 800' river chamber & RM old land chamber)	3	$208.2
LMA 9 (New 1200' river chamber & RM old land chamber)	4	$181.2
AMA (Advance Maintenance)	5	$171.3

4.6.10.1.2 Environmental Quality (EQ) Account

The EQ account is a means of displaying and integrating into water resources planning that information on the effects of alternative plans on significant EQ resources and attributes of the NEPA human environment that is essential to a reasoned choice among alternative plans. Significant means likely to have a material bearing on the decisionmaking process. Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.[27] The purpose of evaluating EQ is to identify significant beneficial and adverse effects of alternative plans on significant EQ resources discussed in **Section 4.6.9**.

4.6.10.1.3 Regional Economic Development (RED) Account

The RED account registers changes in the distribution of Regional Economic Activity that result from each alternative plan. Two measures are used in the account: regional income and regional employment.[28] All of the lock modernization plans would make positive contributions to the RED account to both measures.

4.6.10.1.4 Other Social Effects (OSE) Account

The OSE account is a means of displaying and integrating information on alternative plan effects from water resource planning perspectives that are not reflected in the other three accounts. Categories include: urban and community impacts; life, health, and safety factors; displacements; long-term productivity and energy requirements and energy conservation.[29]

[27] P&G Section VII.1.7.3(a)(2&3)

[28] P&G, Section VII.1.7.4(a)(1)

[29] P&G, Section VII.1.7.5(a)(1)

The potential for total project closure will be considered under this account, since such an event could prevent the Corps repair fleet from responding to an unscheduled failure at another lock and dam anywhere in the Pittsburgh District which in turn could increase those hazards to the general public. Impacts due to construction activities including the hauling of excess materials to disposal areas will also be considered.

These accounts are assessed for each of the final plans below.

Plan LMA 7: New 600', Fix as Fails Existing Land Chamber

NED: The maximally efficient plan, higher than the WOPC and all other WPC plans in terms of net benefits. A fully reliable chamber will be available at all three sites throughout the 50-year period of analysis.

EQ: The new river chambers will serve to virtually eliminate occurrences of long queues and diverted traffic to land based modes that would be experienced by an extended unscheduled failure of a critical component of the existing land chambers. Replacement of locks at their existing locations will minimize construction impacts over plans that would involve new locations or the elimination of a facility with its attendant pool lowering and dredging impacts. The minimized lock construction impacts have been evaluated and appropriate mitigation proposed so that overall impacts to fish and wildlife will be negligible. Included in the mitigation are recommendations for navigation facility improvements to facilitate fish passage. Adverse effects to the historic integrity of the locks and dams cannot be avoided with the modernization alternatives. These have been evaluated and addressed through appropriate mitigation recommendations.

RED: Regional employment and income would be enhanced due to during construction of the new chambers. These new main chambers would also lower transportation costs, which in turn, result in increased income to shippers and ultimate savings to consumers. The resulting improved navigation system would also enhance the competitiveness of industries reliant on the commodities shipped through the Upper Ohio River locks. As noted previously, most traffic through this system uses all three locks so most shipments would benefit from improvements at all three facilities. The availability of a second chamber at EDM, even if in less than reliable status, reduces the negative perception regarding loss of regional economic competitiveness due to only one operating lock.

OSE: The availability of a reliable main chamber at all three facilities will lessen the potential for a total river closure at any site compared to the WOPC. Although component repairs may become increasingly problematic for the existing 600' land chambers, they will be auxiliary chambers and navigation impacts to repair unscheduled component failures will be small unless they occur during a scheduled closured of the new chamber. The chances of such an unfortunate occurrence should be very small as any scheduled closure of the river chamber will be 30 days or less. (The average number of days that any of the new river chambers will be closed for scheduled maintenance during the period of analysis is less than four.) The Corps could reduce the likelihood of this occurrence by inspecting and making repairs as necessary to the land chamber components prior to any scheduled closure of the river chamber. There would not be any relocation of residences or businesses required for

any lock modernization plan although a few utility line relocations could be required in association with batch plant and staging areas. There should not be any impact on the potential for hydropower at any facility. Therefore, the OSE account would be increased

Plan LMA 1 : New Twin 600's With New 600' Land Chamber Opened Just Before First Scheduled Dewatering of New River Chamber

NED: Ranked second in terms of net benefits. Slightly less efficient than plan LRM 7 due to higher initial construction cost and relatively unused capacity of new land chamber, The new 600's are designed and constructed with features that will enhance the constructability of the second new locks at EDM. It is most important for one new lock to be finished and operational at each of the three lock sites before investment in a second set of new chambers begins.

EQ: Similar to LMA 7. The construction of a second new chamber in the footprint of the existing land chamber will generate greater amounts of disposal material, but will otherwise not have significant impacts over LMA 7. These impacts will be offset somewhat by two totally reliable chambers that will eliminate virtually all potential for unscheduled closures. This plan is preferable over LMA 7 under the high traffic scenario, in that it would not incur lockage delays and thereby maximize waterborne commerce attributes of fuel efficiency and reduced air pollution.

RED: Slightly higher than plan LMA 7 due to higher construction costs.

OSE: Slightly higher positive effects than LMA 7 as two totally reliable chambers will virtually eliminate the potential for the repair fleet to be isolated from other projects.

Plan LMA 8: New 800', Fix as Fails Existing Land Chamber

NED: Ranked third in terms of net benefits. A relatively less efficient plan than plan LMA 7 due to higher initial construction costs. The greater capacity than for plan LMA 7 does not add enough benefits to compensate for the higher costs.

EQ: Similar to plan LMA 7. Slightly higher impacts due to larger construction footprint and greater disposal quantities but slightly less impacts through lowering the probability of queuing of tows with larger main chamber.

RED: Slightly more positive impacts than LMA 7 due to higher construction cost and lower delay times due to larger lock size.

OSE: Similar to plan LMA 7.

Advanced Maintenance of Existing Chambers

NED: Ranked fourth in terms of net benefits.

EQ: This alternative would likely involve substantial queues of navigation traffic at the locks for extended periods to time during either scheduled or unscheduled repairs or replacement of wall components. This would be detrimental to fuel efficiency, air quality, and the near shore

and riverine environment as queuing of tows occurs along the shoreline in approaches upstream and downstream of the locks at each location.

RED: This alternative would not easily ensure a safe and reliable navigation system for the Upper Ohio River during the future 50-year period of analysis due to the steady stream of replacement or rehabilitation projects at the three locations. Substantial reinvestment in the 360' auxiliaries would be required during the future period of analysis. Regional competitiveness would be harder to sustain with this approach to long term reinvestment to the Upper Ohio navigation system.

OSE: During anticipated times of both chamber closures the Repair Fleet would not be able to lock through. Only by maintaining two operating locks at EDM during the future period of analysis can the primary consideration of Repair Fleet mobility at all times be achieved.

Plan LMA 9: New 1200', Fix as Fails Existing Land Chamber

NED: Ranked fifth in terms of net benefits. Less efficient plan than LMA 7 and LMA 8 due to considerably higher initial construction costs and excess capacity that does not generate much benefits.

EQ: Slightly greater negative impacts during construction than LMA 7 and LMA 8 due to larger footprint and greater disposal quantity. However, the longer locks would minimize lock transit times and be the most efficient alternative in terms of fuel consumption and pollution.

RED: Slightly greater than LMA 7 and LMA 8 due to higher construction cost and larger river lock that would enhance regional competitiveness of related industries.

OSE: The same as LMA 7 and LMA 8 since one totally reliable chamber would be provided throughout the analysis period.

Without-Project Condition, Reactive Maintenance of Existing Chambers

NED: The least efficient final plan in terms of net benefits. The WOPC would seriously jeopardize the continued safe and reliable operation of the navigation facilities at EDM. The existing 600' chambers are at risk of being out of service for extended periods on an unscheduled basis at each of the three EDM project locations. Component replacements would not be initiated until operational problems (failures) are experienced that cannot be addressed through the normal Operations & Maintenance funding cycles.

EQ: This alternative would likely involve substantial queues of navigation traffic at the locks for extended periods to time during either scheduled or unscheduled maintenance. This would be detrimental to fuel efficiency, air quality, and the near shore and riverine environment as queuing of tows occurs along the shoreline in approaches upstream and downstream of the locks at each location. Frequent commercial waterway traffic disruptions are expected during the future 50-year period of analysis under this alternative, with negative impacts from diversion of waterway traffic to land modes.

RED: Regional competitiveness would be very difficult to sustain with this approach to long term reinvestment to the Upper Ohio navigation system.

OSE: Similar to the Advanced Maintenance Alternative plan in that during repair or replacement of the middle wall both chambers would be out of service. Traffic would have to be diverted overland with all attendant highway, fuel consumption and pollution impacts.

TABLE 4-47: P&G System of Accounts, Alternatives Ranking

Rank	Account			
	NED	EQ	RED	OSE
1	LMA 7	LMA 1 & LMA 9	LMA 9	LMA 1
2	LMA 1		LMA 1	LMA 7 & LMA 8 & LMA 9
3	LMA 8	LMA 7	LMA 8	
4	LMA 9	LMA 8	LMA 7	
5	AMA	AMA	AMA	AMA
6	WOPC	WOPC	WOPC	WOPC

4.6.10.2 Criteria Evaluation

The 1983 Principles and Guidelines (P&G) for Federal water resources planning also defines four criteria to be considered in the formulation of alternative plans. These are:

Completeness: The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness: The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency: The extent to which an alternative is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

Acceptability: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

Table 4-48 below provides a graphical depiction of the alternatives plans and how they rate with respect to the "other accounts" criteria as assessed above. A narrative of the graphical depictions, a brief discussion of the rating, and the rating system are provided. The colors rank from best to worst - Blue, Green, Yellow, Red.

Efficiency: The extent to which an alternative is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

Blue – The NED plan or incremental net benefits within 5% of NED for the mid traffic scenario

Green – Within 6 - 20% of the NED Plan incremental net benefits for the mid traffic scenario

Yellow – Within 21 – 40% of the NED Plan incremental net benefits for the mid traffic scenario

Red – Less than 60% of NED incremental net benefits for the mid traffic scenario

Effectiveness: The extent to which an alternative plan alleviates the specified problems and achieves the specified objectives and opportunities.

Blue – Maximum effectiveness with two new operating locks

Green – Moderate effectiveness due to some reliance on old lock but with one new lock

Yellow – Low effectiveness due to heavy reliance on old lock(s) or on one new lock through portion of analysis period

Red – Minimum effectiveness due to total reliance on old lock(s) or only one new lock through entire analysis period

Two reliable locks are rated higher than one. New lock construction with lock modernization plans rated higher than piecemeal construction under Advanced Maintenance.

Completeness: The extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. All plans account for Federal and non-Federal investments. IWTF assumed to be available. Navigation dis-benefits placed upon non-Federal interests suggested as the distinguishing feature.

Blue – Fully complete in terms of meeting navigation objective

Green – Moderately complete in terms of meeting navigation objective

Yellow – Partially complete in terms of meeting navigation objective

Red – Minimally complete in terms of meeting navigation objective

Acceptability: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

Blue- Highly acceptable to regional stakeholders in terms of efficiency and effectiveness

Green – Moderately acceptable to regional stakeholders in terms of efficiency and effectiveness

Yellow – Minimally acceptable to regional stakeholders in terms of efficiency and effectiveness

Red – Not acceptable to regional stakeholders in terms of efficiency and effectiveness

Two reliable locks are rated higher than one and a larger river lock is more acceptable than smaller.

TABLE 4-48: Evaluation Criteria Matrix

Plan	Criterion			
	Efficiency	Effectiveness	Completeness	Acceptability
LMA 7 (New 600' river chamber & RM old land chamber)	B	G	Y	Y
LMA 8 (New 800' river chamber & RM old land chamber)	G	G	Y	G
LMA 9 (New 1200' river chamber & RM old land chamber)	R	G	Y	B
LMA 1 (Two new 600' chambers with deferred start of 2nd chamber)	G	B	B	G
AMA (Advanced Maintenance)	R	Y	Y	R
Without-Project, Reactive Maintenance (RM)	R	R	R	R

Overall Criteria Ranking (assuming all criteria are equal weight):

1) LMA 1
2) LMA 7 & LMA 8
4) LMA 9
5) AMA
6) WOPC

4.6.10.3 Realization of Planning Objectives

All five final WPC plans satisfy the three Planning Objectives to a greater extent than the WOPC. This should be expected since all measures incorporated into these plans that cannot be included in the WOPC enhance one or more of these objectives. All of these plans provide a safer, more reliable and efficient navigation system with three new main chambers that will provide more hours of main chamber operation than the WOPC, thereby fully satisfying the objectives.

4.6.10.3.1 Objective 1.

All WPC plans provide sufficient capacities to accommodate all future traffic when both chambers are open. The lock modernization plans avoid costly scheduled closures and

rerouting of traffic for considerable periods through the very small river chambers with Advanced Maintenance. Plan LMA 7 provides this capacity with the highest net benefits and is therefore the best plan for Objective 1.

4.6.10.3.2 Objective 2

This objective was fully addressed with the ecosystem restoration plans formulated and evaluated during the Upper Ohio study, although no restoration plan is recommended in combination with the navigation plan. The potential non-federal sponsor desired to pursue one of the formulated plans under an existing ecosystem restoration authority, rather than under a new navigation authorization.

4.6.10.3.3 Objective 3.

All WPC plans were formulated to be consistent with protection of the nation's environment. Unavoidable impacts are mitigated to the extent possible, and all impacts were evaluated. All lock modernization plans will avoid excessive commercial vessel queues to the maximum extent by providing reliable main chambers, and thereby avoid environmental impacts associated with queuing that would be associated with the WOPC and Advanced Maintenance. The three lock modernization alternatives are virtually equivalent in their environmental impacts and therefore equally satisfy Objective 3.

Overall Planning Objective Ranking:

1) LMA 7
2) LMA 1
3) LMA 8 & LMA 9
5) AMA
6) WOPC

4.6.10.4 Conclusion

All lock modernization alternatives are superior to the Advanced Maintenance and WOPC Reactive Maintenance alternatives when evaluated under the System of Accounts, P&G Criteria and Planning Objectives. This evaluation shows that Plans LMA 1 and 7 are the two best modernization plans, providing either one or two new, reliable 110' x 600' chambers at each of the three facilities throughout the analysis period.

The economic evaluation demonstrated that Plan LMA 7 is the NED plan. The cost of Plan LMA 7 is over $600 million less than Plan LMA 1, and provides the greatest Incremental Net Benefits. Environmental impacts of Plan LMA 7 have been identified and appropriate mitigation included in the plan. In view of the above assessment, Plan LMA 7 is also the Preferred Navigation Plan.

4.7 Future With-Project Ecosystem Restoration Alternative Plans

4.7.1 General Methodology and Guidelines

The specific procedures for the formulation and evaluation of combined plans is provided for in Engineering Circular 1105-2-404 (1 May 03), "Planning Civil Work Projects under the Environmental Operating Principles." All ecosystem restoration measures considered in this study are separate and independent from the navigation measures included in the recommended navigation plan. Further, the preferred navigation plan would not have any impact on ecosystem problems and opportunities. Therefore, the formulation and evaluation of these measures are not impacted by the recommended navigation plan and the remaining ecosystem problems and opportunities are those identified for the ecosystem WOPC. The formulation process is similar to that used for navigation; measures are identified to address the remaining problems, the measures are screened and either dropped from consideration or retained, plans are formed by individual measures or combinations of measures that are retained, plans are evaluated (in terms of costs and benefits) and compared against the WOPC and against each other, and the best plan identified as the National Ecosystem Restoration plan. The major difference lies in the evaluation technique since ecosystem benefits are not monetary.

4.7.2 Measures to Address Ecosystem Restoration Problems

The Corps investigated opportunities for ecosystem restoration projects in connection with the navigation study. Implementation of ecosystem restoration projects requires a non-Federal partner to cost share in the project. The Western Pennsylvania Conservancy submitted a letter of interest in cost sharing ecosystem restoration to the Corps on June 12, 2008 (Enclosure 2). The letter stated in part:

> "Western Pennsylvania Conservancy is aware that this letter serves as an expression of interest and intent, and is not a contractual obligation and either party may discontinue the study process at any stage before construction begins. In the case of WPC as a non-federal sponsor, funds to cover the required 35% of project implementation are not presently identified and will represent a fund-raising challenge. With that in mind, WPC is recommending the Corps proceed with Phase 2 NER study efforts on the Upper Ohio River Navigation Project due to the potential ecosystem restoration benefits for the region, with the hope that 35% matching funds will be available to WPC to support a suitable NER project feature. With the necessary acquired funding, WPC will then execute a future Project Cooperation Agreement(s) as a non-Federal sponsor and provide a 35% cost share, inclusive of LERRD"

On the basis of that expression of interest, the Corps proceeded with ecosystem restoration planning. Potential project alternatives were initially selected from the list of ecosystem sustainability enhancement measures developed in the Ohio River Mainstem System Study (ORMSS)(see **ORMSS Appendix**). During the course of ORMSS, the Corps assembled a team of national and regional experts on the topic of aquatic and riparian resources of the Ohio River. Through a series of workshops, the group identified the ecological functions that

have been compromised along the river (ORMSS Table 6-4). The group also identified a list of actions needed to move the ecological resources/functions toward a desirable state, unconstrained by how the actions might come about or who would implement those actions (ORMSS Table 6-5). These actions primarily include approaches that address restoration of habitat variety, recovery of 'missing' habitat components, reestablishing functions and connectivity, removing outdated infrastructure, and generally finding ways of compensating for the effects of infrastructure that must remain. These actions were further categorized in ORMSS Table 9-10 into 26 opportunities for enhancing ecosystem sustainability and their potential authorities for implementation.

4.7.3 Screening of Ecosystem Restoration Measures

Through a series of discussions among the Corps, the Western Pennsylvania Conservancy, and the Pennsylvania Fish and Boat Commission, the list of ORMSS measures was reviewed and shortened to eliminate measures either not relevant to Upper Ohio resources (e.g. canebrakes) or those requiring specific authority (e.g., combined sewer overflows or brownfield remediation). Remaining project types of interest to the potential cost-share sponsors were then identified, which included various aquatic habitat improvement measures and riparian habitat improvement measures. Study area visits in combination with examination of aerial photography and bathymetry data were used to identify several potential project sites. From these discussions and activities, the list of candidate sites and restoration measures in **Table 4-49** was developed**.**

TABLE 4-49: Upper Ohio Feasibility Study Ecosystem Restoration Sites

Upper Ohio Feasibility Study Ecosystem Restoration Sites			
Site	**Pool**	**≈ River Mile(s)**	**Project Type**
1, Brunot Island Floodplain Restoration	Emsworth	1.5 – 2.9	Vernal Pool Wetlands, invasive removal, native plantings, etc.
2, Sauger Spawning Habitat Enhancement, d/s of Brunot Island	Emsworth	3	Contouring and Substrate Enhancement
4, Davis Island Floodplain Restoration	Emsworth	4.5 - 5.2	Vernal Pool Wetlands, invasive removal, native plantings, etc.
5, Davis Island Foreshore Dike, LB of Back Channel	**Emsworth**	**4.5 – 5.2**	**Dike built parallel to bank, creating aquatic habitat behind dike**
6, Sauger Spawning Habitat Enhancement, u/s of Neville Island	Emsworth	3.9 – 5	Contouring and Substrate Enhancement
7, Neville Island Foreshore Dike, LB of Back Channel	Dashields	8.8 - 9	Dike built parallel to bank, creating aquatic habitat behind dike
9, Sauger Spawning Habitat Enhancement, d/s of Dashields Dam	Montgomery	14.5	Contouring and Substrate Enhancement
10, Ambridge Foreshore Dike, RB	**Montgomery**	**17.6 – 17.9**	**Dike built parallel to bank, creating aquatic habitat behind dike**

Upper Ohio Feasibility Study Ecosystem Restoration Sites			
Site	**Pool**	**≈ River Mile(s)**	**Project Type**
11, Gravel Bar at Mouth of Beaver Creek	**Montgomery**	**25.5**	**Contouring and Substrate Enhancement**
12, Foreshore Dike, LB	Montgomery	27.2 – 27.9	Dike built parallel to bank, creating aquatic habitat behind dike
13, Fourmile Run Foreshore Dike, RB	**Montgomery**	**29.7 – 30.5**	**Dike built parallel to bank, creating aquatic habitat behind dike**
14, Montgomery Slough	**Montgomery**	**31 – 31.9**	**Vernal Pool Wetlands, invasive removal, native plantings, etc., dredging**
15, Floodplain Restoration, Phyllis Island	New Cumberland	35 – 35.7	Vernal Pool Wetlands, invasive removal, native plantings, etc.
16, Phyllis Island Foreshore Dike	**New Cumberland**	**35 – 35.7**	**Dike built parallel to bank, creating aquatic habitat behind dike, protection of island habitat**
17, Floodplain Restoration, Georgetown Island	New Cumberland	37.5 – 37.8	Vernal Pool Wetlands, invasive removal, native plantings, etc.
18, Georgetown Island Foreshore Dike	**New Cumberland**	**37.5 – 37.8**	**Dike built parallel to bank, creating aquatic habitat behind dike, protection of island habitat**
19, Gravel Bar Enhancement, RB	Dashields	12.9 – 13.15	Contouring and Substrate Enhancement

Normal font = Low Priority
Bold font = High Priority

Overall study schedule and funding constraints limited the time and resources available to consider all 17 sites, necessitating prioritization for detailed analysis. Any of the following criteria, if applicable, was cause to eliminate a site from detailed consideration: inability to obtain right-of-entry (Sites 1 & 4), lack of available bathymetry data (Site 7), proximity of potential future commercial sand and gravel extraction activities (Sites 2 & 9), proximity of commercial riparian/floodplain development (Site 12), availability of larger similar sites (Sites 2, 9 and 19), or weaker aquatic habitat components (Sites 1, 4, 15, & 17). Dashields Pool was poorly represented in the list of sites due to local land use/land management and development of the river banks severely limiting potential. The elimination of Sites 7 & 19 left the Dashields Pool without any potential restoration alternative for evaluation.

In conclusion, the remaining sites of interest to the potential cost-share sponsors covered a range of ecosystem restoration techniques and offered the greatest improvement potential. The following eight high priority sites (below) went through detailed analysis:

Site 5 (Emsworth Pool) - Davis Island Foreshore Dike, Back Channel (both island and main shorelines),

Site 6 (Emsworth Pool) - Dredge Hole Contouring and Substrate Enhancement Upstream of Neville Island,

Site 10 (Montgomery Pool) - Ambridge, Foreshore Dike, Right Bank,

Site 11 (Montgomery Pool) - Gravel Bar Enhancement at Mouth of Beaver Creek,

Site 13 (Montgomery Pool) - Fourmile Run, Foreshore Dike, Right Bank,

Site 14 (Montgomery Pool) - Montgomery Slough Restoration,

Site 16 (New Cumberland Pool) - Phyllis Island, Foreshore Dike/Ring Dike, and

Site 18 (New Cumberland Pool) - Georgetown Island, Foreshore Dike/Ring Dike.

Within the above sites, two of the sites have multiple options. Two options for foreshore dikes are evaluated for Site 13, Fourmile Run. Option S would place the inner toe of the dike approximately one foot deep, and Option M would place the inner toe approximately three feet deep. Two options of habitat improvement are considered at Site 14, Montgomery Slough. Option 1 would be to install Large Woody Debris (LWD) in the embayment portion of the site and remove exotic vegetation (e.g., purple loosestrife) from the riparian zone. Option 2 would be to install LWD, remove exotic vegetation, and dredge a channel in center of embayment with a hydraulic dredge, disposing the material in previously used upland site and shaping the disposal site to create vernal pool wetlands.

The initial step in evaluating alternatives was selection of species to use as indicators of ecosystem response to alternatives under consideration. While species other than those chosen for the analysis would also benefit from restoration improvements, selected taxa provide an adequate representation of responses necessary for evaluation of benefits. For this evaluation, three species for each site were identified to use in evaluation of most restoration measures.

4.7.3.1 Selection of Evaluation Species

The initial step in identification of evaluation species was to review the list developed as part of fish passage investigations for the UONS navigation improvements component of the study. This list was developed by an Interagency Working Group assembled by the Corps of Engineers to ensure that all aspects of the overall study involved agencies and organizations interested in the environment of the area as well as the processes and recommendations of the effort (i.e., the stakeholders). Following review of the list of species targeted for fish passage, the list was narrowed by determining those for which Habitat Suitability Index (HSI) models were available and had been approved for use by the Corps of Engineers. Final selection of evaluation species was based on review of their habitat requirements and expectations that restoration measures would produce habitat changes that could be measured and compared among alternatives. HSI models produced by the US Fish and Wildlife Service were chosen as the basis for determining responses to restoration measures. These models have been widely used for such analyses for over 20 years. To meet planning model certification requirements of the Corps of Engineers, only HSI models that have been approved for use were considered. **Table 4-50** includes a list of the evaluation species for alternative sites.

TABLE 4-50: Ecosystem Restoration Evaluation Species

Species Selected	Foreshore Dikes	Deepwater Sites	Gravel Bar	Embayment	Wetland
channel catfish	X				
smallmouth bass	X				
white crappie	X			X	
paddlefish		X			
walleye		X			
flathead catfish		X			
walleye			X		
white bass			X		
spotted bass			X		
largemouth bass				X	
bluegill				X	
black bullhead					X
red-winged blackbird					X
wood duck					X

4.7.3.2 Ecosystem Restoration Outputs

For each ecosystem restoration option at a given site, present conditions are described and quantified. This provides the baseline or the initial attributes for the Without-Project Condition (WOPC). For the WOPC, as well as for each With-Project Condition (WPC), ecosystem outputs are projected for the initial time frame and for the 5, 25, and 50 year time frames. There must be a constant unit of measure to compare habitat changes. Most habitats are currently measured as acres; therefore, the standard unit is acres. From these estimates, average annual ecosystem outputs are then calculated. Average annual ecosystem outputs are considered project benefits and are expressed in non-monetary terms.

4.7.3.2.1 Offsite Benefits

Construction of ecosystem restoration measures would primarily improve spawning and nursery habitats for evaluation species as well as for production of other aquatic life forms. As individuals grow, they would migrate from treatment areas and disperse to other riverine habitats. Improvements in the fish community would accrue to some degree throughout the pool. Although data are not available to quantify these "off site" improvements, conservative assumptions are used to estimate such benefits. A logical assumption is that benefits from an improvement decrease with increasing distance from the location of the improvement. This assumption is used in the present study while recognizing that fish are highly mobile and any of the evaluation species would be capable of moving throughout the pool. Further, because the list of potential evaluation species was compiled from those targeted for fish passage, it is

highly likely that several individuals would migrate to other pools of the Ohio River. For purposes of estimating aquatic benefits, it was assumed that most benefits would accrue within the 500 acres adjacent to the location of the improvement, and fewer benefits would be manifested throughout the remainder of the pool.

4.7.3.2.2 Evaluation of Ecosystem Restoration Costs

Costs for each measure are determined based on design parameters and are expressed in monetary terms. Costs include initial implementation as well as operation and maintenance. Costs are annualized to provide a basis for comparison among alternatives. For example, alternative X will produce Y ecosystem benefits/year at a cost of Z dollars/year.

With the exception of the Montgomery Slough alternative, there are no real estate costs associated with the high priority, in-river sites. Either of the two options considered at Montgomery Slough would entail need for access over approximately 60 acres of lands surrounding the embayment. This acreage is comprised of three parcels having a single owner. Each of the parcels is located in the floodplain and is encumbered by flowage easements from the Corp of Engineers obtained in the 1940's.

4.7.3.2.3 Cost Effectiveness/Incremental Cost Analysis

Incremental analysis follows the procedures in ER 1105-2-100 (Planning Guidance Manual), IWR Report 96-R-21, and IWR Report 97-R-4. The most cost effective combinations of features are combined in Future WPC Alternatives. Habitat Units for each alternative are then compared to average annual costs (including O&M) for that alternative to determine those alternatives or combinations of alternatives that are cost effective and are determined to be justified and recommended in accordance with prevailing Corps of Engineers policy.

To assist in cost effectiveness/incremental cost analysis, IWR has made software available that allows hundreds of iterations of detailed assessments to be run quickly. The computer program IWR-PLAN is available with instructions at: www.pmcl.com/iwrplan/. For the UONS Ecosystem Restoration analysis, the HQUSACE certified version of IWR-PLAN was used. The following is a table that shows both average annual costs (in thousands) and average annual benefits.

TABLE 4-51: Ecosystem Restoration Alternative Cost and Benefit Comparison

Alternative	Cost (Average Annual$)	Benefits (Average Annual Ecosystem Outputs)
No Action Plan	0	0
Davis Island FSD	277,965	3,287.77
Ambridge FSD	106,012	5,416.56
Beaver River Gravel Bar	55,911	4,296.86
Fourmile Run FSD Option S	197,212	3,058.18
Fourmile Run Option M*	**15,659**	**6,409.96**
Montgomery Slough Option 1*	**28,313**	**4,882.69**
Montgomery Slough Option 2	70,448	4,993.69
Phyllis Island FSD	115,330	4,729.85

Alternative	Cost (Average Annual$)	Benefits (Average Annual Ecosystem Outputs)
Georgetown Island FSD	89,353	4,509.10

* Best Buy Plans

Summary and Results of the Cost Effectiveness/Incremental Cost Analysis

Of the WPC alternatives, two were determined to constitute "Best Buy Plans. These were:

- Fourmile Run Foreshore Dikes, Option M
- Montgomery Slough Option 1

Three other WPC plans were determined to be "Cost Effective." These were:

- Ambridge Foreshore Dikes
- Fourmile Run Foreshore Dikes, Option S
- Montgomery Slough Option 2

Four WPC plans were determined to not be "Cost Effective." These were:

- Davis Island Foreshore Dikes
- Beaver River Gravel Bar
- Phyllis Island Foreshore Dikes
- Georgetown Island Foreshore Dikes.

4.7.3.3 Ecosystem Restoration Project Components

The NER project measures are proposed as those comprising the two best buy plans, foreshore dikes, Option M at Fourmile Run, and the Montgomery Slough, Option 1. The combination of these two best buy plans should be another best buy plan and are policy compliant. The total average annual cost of these measures is about $44,000 with a total average annual benefit of about 11,300 ecosystem output units.

4.7.4 *Environmental Effects of Ecosystem Measures[30]

4.7.4.1 Terrestrial Resources

Foreshore dikes. All foreshore dike (FSD) alternatives would require a tie-in to the bank. In some cases there would be multiple tie-in points per site. There would be some minor temporary disturbance to the riparian vegetation and associated erosion at each tie-in location. These sites would be left to revegetate and proper construction BMPs would be utilized. Terrestrial impacts due to the construction of FSDs would be minor. Additional monitoring

[30] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

would also be proposed to ensure bank stabilization is not aggravated as a result of the FSD construction, particularly at tie in and downstream of breaks in the dikes.

Montgomery Slough. Both ecosystem restoration options of the Montgomery Slough alternative (dredging and no dredging) would involve clearing of approximately 15 acres of upland scrub-shrub forested area. Woody debris would be placed in the water habitat of the slough for aquatic habitat improvements. Under the dredging option, dredged material containment cells totaling 15 acres would be constructed in the cleared area. The containment cells would drain and allowed to re-establish vegetation over time. Invasive exotics would be removed initially and would be managed over time.

Gravel Bar near mouth of Beaver River. There would be no terrestrial impacts under this alternative.

4.7.4.2 Aquatic Resources

Foreshore Dikes. Temporary sedimentation may be caused by construction; however impacts would be lessened by proper Best Management Practices (BMPs) such as, use of a turbidity curtain or erosion control on the bank tie-ins. Construction of FSDs would completely alter the substrate under their footprint. The substrate in the dike footprints is of various types of cobble, gravel, and sand. Construction of FSDs would provide pool habitat, which provides various forms of nursery, resting, and feeding habitat for fish. The spaces in between the rocks formed by the riprap will also provide shelter for juvenile fishes and other forms of aquatic fauna. The dikes will also reduce erosion of the shoreline where they are constructed and cause less sedimentation of the aquatic habitat outside of the dikes. Quality mussel beds are not anticipated within the footprints of the sites based on recent mussel surveys. However, should any of the alternatives be pursued, mussel surveys would be conducted as a part of the Plans and Specs phase. If mussels were discovered they would be addressed per the mussel protocol for the Ohio River, likely requiring avoidance or relocation. Despite short-term impacts FSDs alternatives would ultimately benefit aquatic resources.

Montgomery Slough. During construction temporary turbidity may be caused however, impacts would be lessened by proper BMPs. Design of the containment areas and methods of dredging would be key considerations. Under both options, new woody debris habitat structure would be created. Under the dredging option, deeper areas would be created which could provide important over-wintering habitat for fish species. Aquatic habitat impacts would be temporary and ultimately would be beneficial.

Gravel Bar near mouth of Beaver River. This alternative would produce minor temporary turbidity associated with construction. Boulder piles would provide various additional habitat types. Same as was stated for the FSD alternatives, quality mussel beds are not anticipated within the footprint of the gravel bar based on recent mussel surveys. However, should the alternative be pursued, mussel surveys would be conducted as a part of the Plans and Specs phase. If mussels were discovered they would be addressed per the mussel protocol for the Ohio River, likely requiring avoidance or relocation. Effects to aquatics would be ultimately beneficial.

4.7.4.3 Wetlands

Foreshore Dikes. Construction of FSDs would have no effect on existing wetlands. However, long term, some of the areas behind the dikes may fill in and create improved riparian and/or wetland habitat. Minor positive effects to wetlands from these alternatives may occur over time.

Montgomery Slough. Small areas of wetlands are located within this project site (back of the slough). These areas would be avoided and not be affected by carrying out either option. Under both options, vernal pool wetlands would be constructed in the cleared areas to create additional wetland habitat. The containment area would likely develop some wetland pockets with time. Vernal pool habitat types are important to amphibians and other animal and bird species. Effects to wetlands from this alternative would be beneficial.

Gravel Bar near mouth of Beaver River. No effects to wetlands would occur due to this alternative.

4.7.4.4 Recreation

Foreshore Dikes. These alternatives would create pool habitat that would be used by various game fishes. Therefore better fishing opportunities may be provided for both bank and boat fishermen. The outer face of the FSD would provide habitat for smallmouth and other fishes. No other recreational effects are apparent.

Montgomery Slough. No specific recreational components are planned with this alternative; however, the nature of the area would be conducive to activities such as hiking and bird-watching. Opportunity for walking trails, fishing, and public education could be considered. Limited canoeing opportunities could be created if access is allowed from the land; however, exiting the embayment by boat would generate some safety issues due to the close proximity to Montgomery Dam. Upon exiting the embayment to the river, the waterway is within the area prohibited for boat traffic due to the dam. If this alternative is pursued, signage and or booms would be placed across the mouth of the embayment to avoid inadvertent boating accidents.

Gravel Bar near mouth of Beaver River. Habitat would be provided for fish and therefore may present more fishing opportunity.

4.7.4.5 Cultural Resources

Foreshore Dikes. There were no recorded archaeological resources or mapped historic-era resources associated with Ambridge, Four Mile Run, and Georgetown Island. Davis Island has a high potential to contain intact archaeological remains (on the river bottom and along the riverbanks) associated with the former Davis Island Lock and Dam, a NRHP-listed resource. Two previously recorded prehistoric archaeological sites were documented on Phillis Island, but erosion has destroyed portions of these sites (and the island). It is unlikely that the submerged proposed ring dike will impact intact archaeological deposits, but it will help protect the intact portion of these sites on the island by halting or greatly reducing the rate of erosion.

Limited archaeological investigation of the riverbank tie-in location (pedestrian reconnaissance and judgmentally placed shovel test pits), and review of interpreted side-scan sonar images, are required for all foreshore dike alternatives prior to any ground-disturbing activities in order to avoid any unknown resources.

Montgomery Slough. A previously recorded stratified Early Woodland through Late Woodland stratified prehistoric village site (36BV9) covers most of the site. Limited subsurface testing indicated that most of the site is disturbed or buried by past fill activities, but an intact area of Site 36BV9 is present. This portion of the site would be avoided. Cultural resources should not be affected by either option for Montgomery Slough. If avoidance was not feasible, then the site would be evaluated for its potential for listing to the NRHP under Criterion D.

Gravel Bar near mouth of Beaver River. There was no potential for architectural structures over 50 years of age within any of the nine APEs. There were no recorded archaeological resources or mapped historic-era resources associated with the site, which is located entirely within the river. No additional archaeological investigations are recommended except to review interpreted side-scan sonar images to confirm that there are no submerged resources over 50 years of age within these study areas.

4.8 With-Project Combined Plan Formulation

4.8.1 Preliminary Combined Alternative Plans and Trade-off Analysis

None of the ecosystem restoration measures considered in this evaluation were integral to or dependent upon the federal navigation facilities. None of the ecosystem restoration plans would have any impact upon commercial navigation within the pools or at the lock facilities. As a consequence of this independence, the combining of one or more of the ecosystem restoration measures with any of the navigation alternatives would not diminish either plan's costs or benefits. With no basis for a trade-off analysis, the best Combined Plan is therefore defined as the best NED plan in combination with the best NER plan.

4.8.2 Conclusion – Preliminary Combined Plan

The independence of the ecosystem restoration and navigation plans means that implementation of an ecosystem restoration project is not strictly dependent upon authorization of a Recommended Combined Plan. In view of this independence, the potential non-federal sponsor declined the opportunity to participate in a Combined Plan, instead electing to pursue an ecosystem restoration project under the existing Section 1135 WRDA 1992 authority. Without an interested non-federal sponsor for the ecosystem restoration component of a Combined Plan, there was no further consideration given to formulation of a Combined Plan.

5 THE RECOMMENDED PLAN

5.1 Plan Components

The navigation project recommended for authorization consists of replacing each of the auxiliary 56’ x 360’ river chambers at Emsworth, Dashields, and Montgomery Locks and Dams with new 110’ x 600’ chambers. The wider replacement lock chambers will necessitate removal of one gate bay at Emsworth Main Channel Dam and at Montgomery Dam. At the fixed-crest Dashields Dam, the recommended plan includes shortening the fixed crest dam and installing one hydraulically operated gate and appurtenant facilities. Separable fish and wildlife mitigation measures, cultural resource mitigation measures, environmentally sustainable design features, and deferred consideration of beneficial use of dredged and disposal materials are addressed. Concurrent PED and construction timeframes where chosen to provide the most efficient schedule with the ability to achieve full project benefits at the earliest date possible.

5.1.1 Emsworth

The major work features and schedule of study and construction at Emsworth in the selected plan are described below.

New river chamber study and construction to occur during FY 2017 – FY 2025:

- Conduct Preconstruction Engineering and Design (PED) FY 2017 – 2018. Studies include hydraulic modeling and subsurface exploration.
- Demolition of the entire existing concrete river wall with the upper and lower guard walls.
- Demolition of the small concrete fixed crest weir adjacent to the existing river wall.
- Demolition of the concrete dam pier #1.
- Demolition of the steel vertical lift gate #1 and a portion of the concrete gate sill #1.
- Removal of the dam apron and downstream scour protection in the immediate area from the existing river wall to downstream of pier #2.
- Construction of concrete batch plant for Emsworth project features at nearby site.
- Modification of the existing middle wall emptying system with an outlet diffuser structure.
- Installation of a new emptying valve at the downstream end of the land wall within Lowries Run and shotcrete lining the lower half of the existing penstock tunnel within the land wall.

- Temporary removal and subsequent reinstallation of gate #2 to facilitate the new river wall connection to the existing dam.
- Removal of the dam apron and downstream scour protection in the immediate area from the existing river wall to approximately downstream of pier #2.
- Construction of the new river wall and new middle walls within cofferboxes on a drilled shaft foundation.
- Construction of the through the sill filling and emptying system (and all lock appurtenances) within the temporary river chamber cofferdam closures.
- Construction of a new middle wall operations building and a new land wall maintenance building.
- Construction of 600-ft upstream and downstream guard walls.
- Disposal of 328,800 c.y. of materials at a commercial landfill.

5.1.2 Dashields

The major work features and schedule of study and construction at Dashields in the selected plan are described below.

New river chamber study and construction to occur during FY 2017 – 2025:

- Conduct Preconstruction Engineering and Design (PED) FY 2017 – 2018. Studies include hydraulic modeling and subsurface exploration.
- Demolition of the entire existing concrete river wall with the upper and lower guard walls.
- Demolition of a section (255’) of the existing fixed crest dam.
- Construction of concrete batch plant for Dashields project features at nearby site.
- Construction of the new river wall and new middle walls within cofferboxes on a drilled shaft foundation.
- Construction of the through the sill filling and emptying system (and all lock appurtenances) within the temporary river chamber cofferdam closures.
- Construction of a Braddock-styled tainter gated dam section (one bay and two piers) with approximate sill elevation 689.7 adjacent to the new river wall within the river chamber cofferdam with sill elevation.
- Construct a new middle wall operations building.
- Construction of 600-ft upstream and downstream guard walls.

- Repair and stabilization of the existing abutment.
- Disposal of 276,300 c.y. of materials at a commercial landfill.

5.1.3 Montgomery

The major work features and schedule of study and construction at Montgomery in the selected plan are described below.

New river chamber study and construction to occur during FY 2017 – 2025:

- Conduct Preconstruction Engineering and Design (PED) FY 2017 – FY 2018. Studies include hydraulic modeling and subsurface exploration.
- Demolition of the entire existing concrete river wall with the upper and lower guard walls.
- Demolition of the concrete fixed crest weir adjacent to the existing river wall.
- Demolition of the concrete dam pier #1.
- Demolition of the steel vertical lift gate #1 and a portion of the concrete gate sill #1.
- Demolition of the dam apron and downstream scour protection in the immediate area from the existing river wall to cut line in gate bay #1.
- Demolition of service bridge in existing gate bay # 1.
- Construction of concrete batch plant for Montgomery project features at nearby site.
- Installation of new pier #1 on new river wall monolith.
- Installation of gate sill, dam apron, and downstream scour protection in the immediate area of the new river wall to cut line in gate bay #1.
- Installation of a new gate in gate bay #1.
- Installation of new machinery houses and machinery on new pier # 1 and existing pier #2.
- Installation of new walkway bridge in new gate bay # 1 and stair access from new river wall.
- Temporary removal and subsequent reinstallation of gate #2 to facilitate the new river wall connection to the existing dam.
- Construction of the new river wall and new middle walls within cofferboxes on a drilled shaft foundation.

- Construction of the through the sill filling and emptying system (and all lock appurtenances) within the temporary river chamber cofferdam closures.
- Construct a new middle wall operations building.
- Construction of 600-ft upstream and downstream guard walls.
- Disposal of 525,600 c.y. of materials at a commercial landfill.

5.1.4 Environmental Features and Commitments

The following fish and wildlife mitigation project features, implemented as described below, are sufficient to address project impacts associated with the recommended plan at the present level of design and at the present time. As the project is implemented, the District will review detailed design plan and specification packages and real estate acquisitions to determine whether compliance with the National Environmental Policy Act and other environmental laws and regulations is adequate or needs to be supplemented. If supplemental compliance is required to address project changes or changes in environmental conditions, the District, in accordance with current Corps policy, will implement reasonable measures to avoid impacts and will justify appropriate mitigation of non-negligible impacts through cost-effectiveness/incremental cost analysis. The District will need to anticipate construction contract advertisement and award schedules to provide adequate lead time to conduct compliance surveys and consultation in order to assure timely compliance in advance of advertisement.

At an appropriate time in advance of construction, the District will update Endangered Species Act (ESA) consultation and undertake any surveys (e.g., native mussel surveys) necessary to address relevant environmental compliance requirements.

The recommended plan anticipates additional cultural resource survey at the Montgomery primary work area. This survey should be conducted as soon as possible following real estate acquisition to allow adequate time for any necessary follow-on survey and/or data recovery work prior to construction. Any future changes in project work area boundaries or disposal sites will be subject to cultural resource compliance, and may require surveys in advance of acquisition and/or construction. The District will need to allow adequate lead time to perform the necessary studies and consultation to assure compliance in advance of construction impacts.

In order to simplify cost estimating and environmental compliance during the feasibility study, the District designated properly permitted, commercially available sites to receive all of the dredged/excavated materials. In doing so, the District recognized that there will be opportunities to consider alternative disposal sites and/or beneficial uses of these materials at an appropriate time closer to construction. This led to the “beneficial use of dredged materials’ commitment below, which lists suggested possible alternatives to be considered. Other alternatives may present themselves in the future that are not currently available or cannot be anticipated. The intent of evaluating alternative disposal sites is to take advantage of opportunities to lower project costs while providing environmental benefits and/or reducing

project impacts. The District will need to undertake environmental and cultural resource compliance investigations in advance of any decision to pursue one or more disposal alternatives. The District will need to allow adequate lead time to perform the necessary studies and consultation to assure compliance in advance of development of plans and specifications for the construction work generating the disposal requirement.

5.1.4.1 Fish and Wildlife Mitigation

5.1.4.1.1 Lock Construction Aquatic Habitat Mitigation

Proposed plan

The District will place Large Woody Debris (LWD) in a 3.0-acre area of the Montgomery Slough [embayment] to improve fish habitat value (**Figure 5-1**). For additional detail of the following aquatic mitigation and monitoring activities, see **Environmental Appendix, Fish and Wildlife Mitigation, Monitoring, and Adaptive Management.**

Plan components

Structure description.

LWD is typically defined by biologists as logs with a minimum diameter of four inches and a minimum length of six feet that protrude or lay within a stream channel. Their multiple purposes include fish habitat, channel and bank stability (in flowing streams), and biological diversity. LWD extending above the water surface also provides perching/resting habitat for birds and reptiles. Natural forms of LWD can be categorized as whole trees, logs, and root wads. Various types of engineered LWD have also been developed by the Pennsylvania Fish and Boat Commission. The mitigation cost estimate is based upon Commission designs and spacing recommendations for “Porcupine Crib” and “Short Vertical Plank Structure.” The specific form or forms of LWD to be used at the Montgomery embayment will be developed in consultation with federal and state resource agencies prior to installation.

FIGURE 5-1: Montgomery Slough, Ohio River, r.m. 30.5 – 31.6

Preconstruction studies.

Baseline survey of the embayment will determine areas suitable for LWD placement.

Construction.

LWD will be placed in one installation as soon as practicable before project construction. Monitoring and adaptive management will allow for replacement or supplementation of failed/underperforming material during the initial five-year monitoring period, and following a final monitoring at the end of the construction period. Contingency costs have been included under adaptive management to permit total replacement of these natural material features having an estimated functional life of about 25 years.

Design considerations

Dam and Navigation Safety.

There will be no effect to the Montgomery Dam structure or function, or to navigation by the aquatic mitigation.

Floodway/Floodplain Impacts.

No adverse effect on the floodway or on the floodplain will result from the aquatic mitigation.

Public Access and Security.

River access to the entrance to the Montgomery embayment is within the Montgomery Dam restricted zone and requires Lockmaster approval.

Construction considerations

Standard construction and best management practices will apply. No unusual construction practices will be required. Access to the embayment will be from the river. No dredging or disposal is included in this mitigation plan. Placement of aquatic habitat enhancement structures is addressed in Nationwide Permit (NWP) 27, Aquatic Habitat Restoration, Establishment, and Enhancement Activities, and in Pennsylvania Department of Environmental Protection, Bureau of Watershed Management, General Permit BDWW-GP-1, Fish Enhancement Structures, which will be complied with in the project's detailed design phase.

Operations and Maintenance Considerations

No routine operation and maintenance requirements are anticipated involving Montgomery Locks and Dam staff. The District Planning Office will manage the monitoring, adaptive management, and consultation requirements by a combination of contract and hired labor.

Schedule for Design and Construction

Implementation of the aquatic mitigation will occur in advance of the lock construction activities that will incur the aquatic impacts.

Real Estate Requirements

The aquatic mitigation will require no real estate acquisition.

Monitoring

The purpose of monitoring is to verify success as defined in terms of the mitigation objectives and criteria developed to measure success. The Corps planned monitoring efforts will include a baseline survey in Year 0, followed by post-installation surveys in Years 1, 3, 5, and at the close of construction.

Mitigation Objectives

The following mitigation objectives are applicable to aquatic habitat mitigation:

1. Improve aquatic habitat diversity in the Montgomery embayment through placement of woody structure, and
2. Document lessons learned and apply adaptive management for subsequent projects.

Ecological Success Criteria

Success will be described in terms of physical condition of the placed structures. Success will be achieved if 75 percent of the structures are intact and performing as installed at the close of the construction period.

Monitoring Studies

Physical performance of the LWD will be evaluated in terms of direct visual observations of placement stability, material permanence, changes in flow and sedimentation characteristics.

Pre-installation

Baseline survey for depth and substrate suitability.

Post-installation

Visual surveys of installed structures to assess condition, substrate surveys to verify any changes in sedimentation/depth of structures that would diminish performance.

Coordination and Public Involvement

The District will consult with appropriate federal and state natural resource management agencies following each monitoring effort. The District will prepare and transmit a written report for agency review describing the District's evaluation of the ecological success of the mitigation based on the success criteria, evaluation of the likelihood of achieving ecological success as defined in the mitigation plan, and the projected timeline for achieving that success. The District anticipates that continuation of the Upper Ohio Navigation Study Interagency Working Group will be essential to this requirement.

Adaptive Ecosystem Management

The adaptive management plan is supplementation or replacement of LWD measures that are not performing as intended, based on periodic monitoring observations. Adaptive management may be implemented following any of the planned monitoring events from initial installation to the close of project construction. The goal is to retain at least 75 percent of the structures in a condition that would allow them to function as designed.

Aquatic Mitigation Costs

The following table lists the costs of mitigation, monitoring, adaptive management, and agency consultation requirements.

TABLE 5-1: Aquatic Mitigation Costs ($) (October 2014 Cost Level)

Activity	Cost
Mitigation	139,806
Monitoring	72,085
Adaptive Management	139,806
Agency Consultation	19,660
Total	**371,357**

5.1.4.1.2 Lock Construction Terrestrial Habitat Mitigation

Proposed Plan

For additional detail of the following terrestrial mitigation and monitoring activities, see **Environmental Appendix, Fish and Wildlife Mitigation and Monitoring.**

Emsworth Secondary Laydown Area (SLA), Option #3 – The entire site would be planted with a wildlife habitat herbaceous mix (native species) to stabilize the site and establish the old field community. This option includes no woody species landscaping and allows the site to naturally succeed as colonized by local native species. This plan is also applicable to the Emsworth Primary Laydown Area (PLA) should it become available for use.

Dashields PLA, Option #2 – The entire site would be planted with a wildlife habitat herbaceous mix (native species) to stabilize the site and establish the old field community. Shrubs would be planted at a density of 600 per acre. This option includes a moderately intensive landscaping restoration that has a Year 15 targeted community of 75 percent shrub thicket and 25 percent herbaceous old field.

Montgomery PLA, Option #1 – The entire site would be planted with a wildlife habitat herbaceous mix (native species) to stabilize the site and establish the old field community. Trees would be planted at a density of 60 per acre and the shrubs would be planted at a density of 200 per acre. This option includes a moderately intensive landscaping restoration that has a Year 15 targeted community of 50 percent early succession forest, 25 percent shrub thicket, and 25 percent herbaceous old field.

Plan Components

Site restoration and plantings will be performed at each lock construction work and laydown area at the conclusion of the each respective construction period. Best practice sedimentation and erosion protection plans will be used.

Design/Schedule Considerations

Restoration plans involving more than a herbaceous plant mix will be developed in consultation with federal and state resource agencies, and with the private landowner. It is anticipated that all restoration and plantings will be made at the same time, with consideration being given to proper planting seasons to maximize survival.

Real Estate Considerations

All restoration work will be on lands acquired for lock construction support. In order to provide for required monitoring and adaptive management practices, the period of the federal easement on the private properties will be extended beyond the end of the construction period by five years.

Monitoring

The purpose of monitoring is to verify success as defined in terms of the mitigation objectives and criteria developed to measure success. The Corps planned monitoring efforts will include post-implementation surveys in Years 1, 3, and 5.

Mitigation Objectives

The following mitigation objectives are applicable to terrestrial habitat mitigation for construction site impacts:

1. Meet the long-term targeted cover percentages for vegetative cover types based on documented vegetation and growth,
2. Minimize invasive species encroachment in the site restoration through monitoring and adaptive management practices, and
3. Document lessons learned and apply adaptive management for subsequent projects.

Ecological Success Criteria

Success will be described in terms of native plant survival in planted proportions and minimum invasive species incursion (< 5% coverage), as estimated by visual observations.

Monitoring Studies

Visual observations and estimates of vegetative cover types and proportions during the growing season will be made to document percent coverage and growth during Years 1 and 3 following initial plantings. Should any adaptive management measures be necessary in Years 1-3, monitoring in Year 5 is a contingency to verify success of the additional measures.

Coordination and Public Involvement

The District will consult with appropriate federal and state natural resource management agencies following each monitoring effort. Consultation will consist of a written report for agency review describing the District's evaluation of the ecological success of the mitigation based on the success criteria, evaluation of the likelihood of achieving ecological success as defined in the mitigation plan, and the projected timeline for achieving that success. The District anticipates that continuation of the Upper Ohio Navigation Study Interagency Working Group will be essential to this requirement.

Adaptive Management

Provisions for adaptive management on the construction site restorations consist of remedial restoration and/or supplemental plantings to insure survival and proper cover proportions to meet the restoration targets.

Terrestrial Mitigation Costs

The following table lists the costs of mitigation, monitoring, adaptive management, and agency consultation requirements.

TABLE 5-2: Terrestrial Mitigation Costs ($) (October 2014 Cost Level)

Activity	Cost			Cost Subtotal
	Emsworth	Dashields	Montgomery	
Mitigation	9,559	329,225	352,300	691,084
Monitoring	52,019	51,613	52,426	156,058
Adaptive Management	13,005	19,355	19,660	52,019
Agency Consultation	5,635	5,591	5,679	16,906
Totals	**80,218**	**405,784**	**430,065**	**916,067**

5.1.4.2 Cultural Resources Mitigation

5.1.4.2.1 Further Identification, Evaluation and Effect Study Commitments

In accordance with the Ohio River Mainstem System Study Programmatic Agreement Regarding the Modernization of the Ohio River Navigation System (ORMSS PA) (see Section 2.4.2 and Cultural Resources Appendix), a Phase I archaeological survey was conducted for the work areas, resulting in a recorded archaeological site within the Montgomery primary work area. In the event that this area is used for construction and the archaeological site cannot be avoided, it will require Phase II archaeological and geomorphological evaluation to determine National Register of Historic Places (NRHP) eligibility. Should these studies result in a NRHP eligibility determination, a Phase III data recovery would be required to mitigate for adverse impacts in accordance with the ORMSS PA. Mitigation requirements would be addressed in a separate Memorandum of Agreement for consultation with the Pennsylvania State Historic Preservation Officer (SHPO) and Advisory Council on Historic Preservation.

If, at a future time, the project work areas are changed, the Area of Potential Effect will be redefined in accordance with the ORMSS PA and through consultation with the SHPO, which may result in additional cultural resources surveys.

5.1.4.2.2 Memorandum of Agreement for Treatment of Effects to Historic Locks and Dams

In accordance with the ORMSS PA, the Pittsburgh District developed a draft Memorandum of Agreement (MOA) addressing treatment of adverse effects to the historic lock and dam properties and consulted with the SHPO and the Advisory Council. The comments received from the SHPO and the Advisory Council were addressed in a revised MOA, executed in November 2014 and filed with the Advisory Council in January 2015. A copy of the executed MOA is included in the **Cultural Resources Appendix**. Following project authorization, and subject to the availability of funds, the District will initiate the stipulated mitigation measures. These include documentation for inclusion in the Historic American Engineering Record, publication of historical articles, and implementation of interpretive signage and internet information.

5.1.4.3 Beneficial Use of Dredged Materials

The District will evaluate options for disposal of dredged and excavated material, and of concrete rubble for environmental benefit. This will be done at a time closer to construction, when the specific quantities and nature of material are better estimated, and environmental conditions of possible placement locations may be evaluated in detail. Under principles of sound engineering practice, the Corps may implement beneficial use disposal projects using excess materials (not limited only to dredged materials) as a navigation project cost, if that use would not increase disposal costs over the base plan. The Corps also has specific authorities, e.g. Water Resources Development Act of 1992, Section 204, Beneficial Uses of Dredged Material, that direct the Secretary of the Army to carry out projects that have ecological benefits in connection with dredging of an authorized navigation project. Section 204 requires non-federal cost sharing of the incremental cost increase of beneficial use over the base, least cost, environmentally acceptable, disposal plan.

5.1.4.3.1 Ohio River Islands National Wildlife Refuge

The District has been working with the Ohio River Islands National Wildlife Refuge on a potential cooperative effort to use suitable dredged and excavated materials for erosion stabilization at their Phillis and Georgetown Islands in the New Cumberland Pool. The manager of the Ohio River Islands National Wildlife Refuge (Refuge) approached the District in 2006 with a request for assistance in providing suitable dredged materials for erosion stabilization at these islands. The Refuge has documented significant erosion and loss of surface acreage at many of their islands.

The District supports pursuit of any cooperative environmental restoration project with the Refuge that is consistent with Corps authority and policy. Section 906(e) of WRDA 1986 provides that for any project measures recommended to Congress to enhance fish and wildlife resources, the first costs of such enhancement shall be a Federal cost when … "(3) such activities are located on lands managed as a national wildlife refuge." Current Corps policy does not provide for implementation of subsection 906(e). This policy will be re-examined in the future when planning for material disposal.

5.1.4.3.2 Brownfield Reclamation

Based on uncertainty in brownfield development availability along with authorization and construction schedule, any specific planning for brownfield site usage will be deferred to post-authorization PED. The future potential use of disposal material from lock construction as brownfields material will depend on three significant factors:

Commercial availability of any private or public brownfield development in the project area during the timeframe needed for disposal.

Liability indemnification.

Quality of disposal materials determined by material testing.

5.1.4.3.3 In-River Disposal (Filling Deep Holes)

Another alternative to disposal at a commercial facility is the use of in-river disposal and potential filling of legacy commercially dredged holes. The potential for environmental impacts of in-river disposal is dependent upon the type of dredging and disposal operation used, the physical characteristics of the disposal material, and the hydrodynamics of the disposal location. If a significant amount of material is to be disposed in-river, backwater and floodplain impacts may also need to be further evaluated. In-river placement of any dredged or excavated material must comply with Pennsylvania Department of Environmental Protection dredging guidelines. The specification of in-river disposal sites will also be subject to the Clean Water Act, Section 404(b)(1) guidelines.

5.1.4.3.4 Abandoned Mine Lands

Legacy coal mines within southwest Pennsylvania have a large impact on water quality within the area. The main impact to water quality from abandoned mines is from acid mine drainage (AMD). Reclamation of abandoned mines through placement of material would help alleviate associated water quality issues with AMD and mine subsidence problems affecting surface and groundwater flow. Negative impacts of mine reclamation such as bat habitat impacts will need to be further evaluated on a location basis before implementation.

5.1.4.4 Environmentally Sustainable Design

5.1.4.4.1 Environmental Design Objectives

The following objectives, derived from the fish passage study, are applicable to design and operational modifications to navigation structures to improve the efficiency of fish passage:

1. Restore fish passage for the full spectrum of native species during all seasons.
2. Achieve greater spatial distribution and abundance of native fish and mussels in the Upper Ohio River pools.
3. Provide for low maintenance fish passage.
4. Document lessons learned and apply adaptive management for subsequent projects.
5. Provide for flexibility in design and operational strategies to permit selective passage and/or blockage.

5.1.4.4.2 Proposed plan

The District will evaluate and implement feasible design and/or operational modifications to the navigation features of Emsworth, Dashields, and Montgomery Locks and Dams to improve the efficiency of fish passage through these facilities. These design and operational features will be evaluated concurrent with detailed engineering design phase of the new navigation features to the extent that they do not increase traditional engineering design and construction costs.

The proposed plan does not include separable fish passage structures considered in the fish passage study (see **Environmental Appendix**). The Reader is referred to the Main Report,

Section 4.6.9.7 Fish Passage Strategies Study, for the full discussion and conclusion of the fish passage study, including invasive species issues.

5.1.4.4.3 Plan components

Structure description.

The design/operational modifications to be considered to improve fish passage will include, but not be limited to, the new lock filling and emptying systems, sill design, and the new Dashields dam gate design and operation schedule. Other types of design/operational modifications may be considered at the old main (land) lock chambers.

Preconstruction studies.

Structural lock and dam design, and hydraulic modeling studies are anticipated.

Sequential construction.

Design and construction of fish passage modifications will be concurrent with the navigation design and construction schedule.

5.1.4.4.4 Design considerations

Dam Safety.

No compromise of dam safety will be allowable in design modifications for fish passage improvement.

Navigation Safety.

No compromise of navigation safety will be allowable in design modifications for fish passage improvement.

Floodway/Floodplain Impacts.

No adverse effect on the floodway or on floodplain will be permissible in the design modifications for fish passage improvement.

Public Access and Security.

No change in project security or public access will be considered in the design of modifications for fish passage improvements. As the modifications will not include separate fish passage structures having potential opportunity for segregated access, the prevailing public access and site security requirements will be maintained.

5.1.4.4.5 Construction considerations

Construction of any lock and dam design modifications for improving fish passage will be integrated into lock and dam construction. Standard construction and best management practices will apply.

5.1.4.4.6 Operations and Maintenance Considerations

Anticipated design modifications are not anticipated to require any additional maintenance considerations not traditionally associated with lock and dam facility operations. The intent is to operate the locks to pass fish as well as boat traffic during peak migration seasons, primarily spring and fall months. This may require additional lock operations, but not more than could be accommodated with existing staffing levels.

5.1.4.4.7 Schedule for Design and Construction

Design and construction of modifications for fish passage improvements will be concurrent with the lock and dam design and construction.

5.1.4.4.8 Real Estate Requirements

There are no separable real estate requirements for fish passage improvements.

5.2 Design and Construction Considerations

All new lock designs and assumed construction strategies incorporated the following project features and constraints:

- New locks would remain within existing project footprint to the maximum extent practicable.
- Navigation traffic would be maintained in the existing main chamber until the first chamber is entirely complete and in service.
- The new middle and river walls must be constructed riverward of the existing middle and river walls, respectively.
- Lock wall designs are based on in-the-wet construction methodology using a cofferbox construction technique being used at the on-going new Charleroi Locks (a feature of the authorized Lower Mon Project).
- The designs presented for the approach walls use a combination of fixed and floating approach walls. The fixed wall design is based on the detailed design and successful construction of the walls at London Lock, Marmet Locks and Winfield Locks all located on the Kanawha River. These types of fixed walls are also fully designed for the upper guard wall at Charleroi currently under construction, and are planned for the new Chickamauga Lock on the Tennessee River. The floating approach wall design is based on the detailed design and successful construction of the walls at Olmsted Lock on the Ohio River. This floating wall was fully designed and construction plans and specifications were developed for the Charleroi Lower Guard Wall, and are planned for the lock extensions at the Greenup Locks and JT Meyers Locks on the Ohio River. Details of all wall designs are provided in the Engineering Appendices.
- Dewatering will occur within temporary cofferdams and cofferboxes which will provide protection from normal and elevated pools. Cofferboxes will be utilized to construct the majority of the lock monoliths for the river, middle, and approach

walls while cofferdams will be constructed for the remaining river and middle lock monoliths, the entire land wall, dam gate sections, and connection of the dam to the river monoliths.

- The requirement for borrow material has been anticipated for this project for estimation purposes. Adequate material should be brought in from predetermined sites to use for the cofferdam cell fill and berms.
- Projects are “land locked” by active railroads or topography on both sides.
- Designs use innovative wall types using in-the-wet or within limited cofferdams.
- The designs must provide a feasible and constructible project.
- An interdisciplinary Value Engineering (VE) Team performed a VE study of the recommended plan at the Pittsburgh District Office from 13-17 May 2013. The Team identified twelve conceptual "cost avoidance" measures appropriate for a feasibility-level study that could reduce life-cycle costs. None of the conceptual measures were evaluated at a level of detail sufficient for integration into the Feasibility Study’s Recommended Plan or cost estimate. The District will give these VE measures further consideration during the Pre-Construction, Engineering, and Design (PED) and/or Construction phases. The VE Report is included in the Engineering Appendix.

5.3 Real Estate Considerations

USACE Real Estate policy suggests that the Corps, not the Corps’ construction contractor, acquire all real estate interests necessary for batch plants, lay down areas, etc. The Uniform Relocation Assistance and Real Property Acquisition Policies Act, 42 USC § 4601 et seq., provides guidance on the acquisition of private land for federal projects. Although portions of the acquisition work, e.g., title and appraisal, may be contracted to the appropriate professionals in the marketplace, the only third parties who can acquire land for federal or federally-funded projects are local sponsors who have land holding authority and capability (Water Resources Development Act of 1986, Pub. L. No. 99-662 and Engineer Regulation 405-1-12, Real Estate Handbook). The Real Estate Handbook provides that “[i]n no instance … should a contractor be required to provide lands, easements or rights-of-way (LER) for the project in support of borrow or disposal” (ER 405-1-12, para. 12-9). Though this section specifically addresses borrow areas/disposal sites, the concept is applicable to real estate acquisition for other purposes.

Lands and interests required for the construction of the recommended plan include three staging areas, one for each facility. The estates to be acquired are standard temporary work area and road easement estates as prescribed in EC 405-1-11. Lands owned by the United States at each facility may also be used for temporary offices and storage of materials, but additional real estate will be needed at all three locations for the batch plant and staging area. Access is also needed to the Emsworth and Dashields sites. Each of the locations is located adjacent or downstream from the locks and dam at Emsworth, Dashields, and Montgomery. There is no known opposition from the current landowners at this time concerning the

easement acquisition. The owners include public and private entities. For all of the sites that are of interest, the owners have been contacted to obtain right of entries and did not object to the Corps using their sites. A brief discussion of the recommended areas follows.

The District performed Phase I and Phase II Environmental Site Assessments at each of the recommended work areas. These investigations indicate there is sufficient land available to support construction of the proposed locks and to develop a Real Estate Plan that maximizes avoidance of contaminated areas. Given that acquisition of the subject parcels would almost certainly be some years in the future, an updated assessment is required prior to acquisition to meet the CERCLA all appropriate inquiry standards established by USEPA.

5.3.1 Construction Staging Area at Neville Island (Emsworth Site)

Located on the left bank immediately downstream from the Emsworth main channel dam abutment on an undeveloped tract, this area would be acquired as a temporary work area and road easement for the construction of a batch plant and staging area and access to the staging area for the new lock at Emsworth. The area contains approximately 6.61 acres and is a single ownership. Land access to the site will be a temporary road easement of 0.45 acres. Potable water, sewage disposal and electricity are not currently supplied to the site; however the surrounding area is served by public water and sewer and electrical utilities.

5.3.2 Construction Staging Area at Edgeworth Borough (Dashields Site)

Located on the right bank immediately downstream of the Dashields dam abutment on three parcels, all undeveloped, these areas would be used for construction, staging, and access to the staging area for the new lock at Dashields. The two parcels comprise 13.36 acres and will be temporary work area and road easements. Land access to the site is by existing roads and a temporary road easement of 0.52 acres through the Buncher Industrial Park. Potable water, sewage disposal and electricity are not currently supplied to the site; however the surrounding area is served by public water and sewage and electrical utilities.

5.3.3 Construction Staging Area at Potter Township (Montgomery Site)

Located on the left bank immediately adjacent and downstream of the dam on two undeveloped parcels, these parcels would be obtained as a temporary work easement for the construction staging for the new lock at Montgomery. This area comprises approximately 11.11 acres and has two private owners. Potable water, sewage disposal and electricity are not currently supplied to the site; however the surrounding area is served by private water and sewage and public electrical utilities.

5.4 Operations and Maintenance Considerations

Operation and maintenance for the new locks will consist of the same measures currently used as described in **Tables 4-20** and **4-21**. Maintenance requirements of major components in the new chambers will be reduced. The maintenance requirements for major components of the existing land chamber will be the same as in the Without-Project Condition. They will be fixed and possibly replaced after failure. Maintenance requirements for components replaced after failure will also be reduced.

Modifications to the dams will require alterations to operations in order to provide adequate hydraulic capacity and so avoid increased frequency of high water events that impact navigation. The most significant change will be at Dashields with the new gated structure. Flood (i.e. out of bank) frequencies will not be impacted.

Any inclusion of design modifications to the new navigation structures for enhancing native fish passage (or blocking invasive fish passage) proposed as environmentally sustainable design may lead to new operational practices. The intent is that fish passage (or blockage) measures would be accommodated through normal lock operations with existing staffing levels.

5.5 Plan Accomplishments

The authorized plan ensures the continuance of reliable and cost effective navigation on the Upper Ohio River for a 50-year period after implementation.

5.6 Project Financing

Authorization is requested for all project costs totaling **$2,320,082,000** (October 2014 Cost Level) based on the MII model estimate. The preparation of the Feasibility Level Estimate for the preferred plan, denoted as the Project Cost below, was in accordance with guidelines and policies included in "ER 1110-1-1300 – Cost Engineering Policy and General Requirements" dated 26 March 1993, "ER 1110-2-1302 – Engineering and Design – Civil Works Cost Engineering" dated 15 September 2008, UFC 3-700-02A – Construction Cost Estimates" dated 01 March 2005, and "ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works" dated 30 September 2008. A detailed description of these estimates is provided in the Engineering Appendix for each site.

The following are the major assumptions made in preparing this cost estimate:

1. The construction will proceed in accordance with the General Construction Sequence shown on the drawings.
2. The upstream and downstream portions of the River Wall and most of the Middle Wall for the new Main Chamber will be constructed in the wet using cofferbox construction.
3. The central portion of the River Wall and remaining portions of the Middle Wall for the new Main Chamber, as well as the dam modifications will be constructed in the dry using steel sheet pile cofferdams and closures.
4. The Upper and Lower Guard and Guide Walls will be constructed in the wet.
5. No Real Estate would be needed to construct the new lock, however, Real Estate will be required for concrete batch plant and contractor's laydown area.
6. The primary Batch Plant/Laydown Area will be used for Dashields and Montgomery facilities and the secondary area will be used for the Emsworth facility.
7. The project account "30 Engineering & Design" has been developed from each Corps department for the Construction Cost estimate.

8. The project account "31 Construction Management (Supervision & Administration)" has been developed from Construction Management Branch for the Construction Cost estimate.

Table 5-3 presents a final detailed breakdown of the Project Cost by Code of Account (COA).

The project cost of the recommended plan accounts for the both the level and timing (schedule) of expenditures required to complete the project. Key drivers of cost and schedule uncertainties that have the greatest impact on contingencies were determined. The primary cost drivers in order of importance are:

1) "Estimate & Schedule, General Assumptions" (general assumptions made during the development of the estimate),
2) "Acquisition, Strategy Change" (change to the currently assumed contract acquisition strategy (best value: tradeoff)),
3) "Acquisition, Bid Competition" (inadequate contractor bid competition),
4) "Acquisition, Design Build" (switching to design-build construction method), and
5) "Funding Constraints" (inefficient construction due to funding caps).

The primary drivers of the work schedule (not including the receipt of funds), in order of importance, are:

1) "Estimate & Schedule, General Assumptions" (general assumptions made during the development of the schedule),
2) "PED Estimate and Schedule Assumptions" (delays to the Planning, Engineering and Design schedule),
3) "Availability of Land for Work Areas" (insufficient adjacent land available to support construction),
4) "Failure of Lock" (failure of the land chamber or lock during construction), and
5) "Acquisition, Design Build" (switching to design building construction method).

TABLE 5-3: Recommended Project Cost by Code of Accounts (October 2014 Cost Level)

Code of Account	Item	Project Cost ($1,000)
1	**Lands and Damages***	**$3,491**
	Emsworth	$1,228
	Dashields	$1,402
	Montgomery	$861
4	**Dams**	**$54,267**
	Emsworth	6,990
	Dashields	24,935
	Montgomery	22,341
5	**Locks**	**$1,794,089**
	Emsworth	577,968
	Dashields	609,729
	Montgomery	606,392
6	**Fish and Wildlife**	**$1,287**
	Emsworth	80
	Dashields	406
	Montgomery	801
18	**Cultural Resource Preservation**	**$674**
	Emsworth	224
	Dashields	224
	Montgomery	226
30	**Preconstruction, Engineering and Design (PED)**	**$281,438**
	Emsworth	92,154
	Dashields	100,529
	Montgomery	88,756
31	**Construction Management**	**$184,836**
	Emsworth	58,496
	Dashields	63,466
	Montgomery	62,873
	Total	**$2,320,082**
	Emsworth	737,141
	Dashields	800,691
	Montgomery	782,250

* This entry shows the certified cost of Lands and Damages as of 26 August 2014. During the cost certification process, ongoing reassessment of real estate requirements reduced both the acreage and duration requirements, which lowered the overall real estate costs. Current (October 2014) Lands and Damages estimate is $1,947,000 (rounded), reduced from $3,491,000.

Funding constraints delaying the start date of the project, requiring the contracts to be split into multiple contracts or preventing them from being constructed concurrently were not included in the risk analysis. The PDT feels that cost-time adjustments will be mitigated through application of inflation factors in accordance with the requirements of limit calculations in Section 902 of WRDA 1986. The actual start date of each project will define the appropriation amount. Therefore, the cost and schedule model focuses on risk events which occur during the project as well as ones which extend the duration of the project once started. This risk analysis does capture the risks associated with funding "caps" which limit construction production during the project. This would be a situation in which limited funds per year decrease the contractor's capabilities which results in schedule slippages and claims. Risks associated with inflation above the amount allowed by WRDA 902 limit calculations are also included in this analysis, such as excessive fuel or material price increases.

All COA costs include a contingency that was calculated by identifying and assessing the effects of the key cost and schedule risk drivers. All contingencies were calculated to provide an 80 percent confidence that the actual costs of each COA are equal to or below the calculated costs. The calculated COA contingencies resulted in the following overall contingency at each site: Emsworth 28 percent, Dashields 27 percent, and Montgomery 29 percent. Details of this analysis are described in Attachment D of each site specific **Engineering Appendix**.

The economics of the recommended plan were recomputed using the feasibility cost and an update of screening level benefits (details provided in the **Economics Appendix**). The screening and feasibility economic analyses are shown in **Table 5-4**. The incremental annual cost increases to $83.2 million and the incremental annual benefit of the project recommended for authorization increases to $355.7 million. The overall result is an increase in the incremental net benefits to $272.5 million, and an increase in the Incremental Benefit to Cost Ratio to 4.3.

TABLE 5-4: Screening Level and MII Costs
Incremental Average Annual Costs and Benefits
(2017-2074, 3 1/8%, Million $)

	Screening Level Oct 2009 $M	Project Cost Oct 2014 $M
Incremental Costs	$53.0	$83.2
Incremental Benefits	$311.1	$355.7
Incremental Net Benefits	$258.1	$272.5
BCR	5.9	4.3

5.7 Policy and Resource Conformance

5.7.1 Consistency with Corps of Engineers Campaign Plan

The Corps of Engineers Campaign Plan comprises four goals and multiple objectives. The recommended plan supports each of these objectives is discussed below:

Goal 1: Ready For All Contingencies: Deliver USACE support to combat, stability and disaster operations through forward deployed and reach back capabilities.

Objective 1.a. Ready, responsible and reliable.

The analytical approaches used to assess the navigation and ecosystem restoration measures were designed to enhance the ability of the Upper Ohio River inland waterway system to reliably and efficiently serve the country's transportation needs consistent with protection of the environment.

Objective 1.b. Support the Operating and Generating Force

By providing a more reliable navigation system, Emsworth, Dashields and Montgomery Locks and Dams will provide better support to assist the nation's military and to assist in disaster reclamation whenever called upon.

Objective 1.c. Establish human resources and family support programs that promote readiness and quality of life.

The inland navigation system promotes the quality of life through more efficient bulk materials transportation that results in lower electric utility generation costs in the upper Ohio River region. The work force in industries that rely on these locks and dams to remain competitive in a demanding global economy will be better served by a more effective transportation system.

Objective 1.d. Institutionalize USACE capabilities in interagency policy and doctrine.

The recommended plan will showcase the USACE ability to carry out its navigation mission

Goal 2: Engineer Sustainable Water Resources: Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.

Objective 2.a. Deliver integrated, sustainable, water resources solutions.

The recommended plan ensures provision of effective navigation for future commercial traffic on the Upper Ohio through 2074. This study also considered ecosystem restoration opportunities, fulfilled the environmental commitments of the Corps Ohio River Mainstem System Study Record of Decision, and considered resource sustainability consistent with the Corps Environmental Operating Principles. The recommended plan and environmental features were developed in collaboration with navigation stakeholders and the Interagency Working Group.

Objective 2.b. Implement collaborative approaches to effectively solve water resource problems.

The navigation alternatives and environmental features were developed in collaboration with navigation stakeholders, an Interagency Working Group comprised of natural resource agencies and organizations, and public involvement through NEPA scoping.

Objective 2.c. Implement streamlined and transparent regulatory processes to sustain aquatic resources.

The navigation study does not involve processes associated with the Corps regulatory program.

Objective 2.d. Enable Gulf Coast recovery.

The recommended plan will ensure continuation of reliable inland navigation transportation that serves the Nation's interior and coastal ports.

Goal 3: Delivering Effective, Resilient, Sustainable Solutions: Deliver innovative, resilient, sustainable solutions to the Armed Forces and the Nation.

Objective 3.a. Deliver sustainable infrastructure via consistent and effective military construction and real estate support to customers.

The new locks will be available to serve the Armed Forces and the Nation during times of war and peacetime.

Objective 3.b. Improve protection, resilience and lifecycle investment in critical infrastructure.

The recommended plan represents the most economically efficient way to recapitalize the existing navigation system in consideration of all lifecycle benefits and costs.

Objective 3.c. Deliver reliable infrastructure using a risk-informed asset management strategy.

A risk-informed asset management strategy was incorporated into the development of project costs and coordinated with asset management staff.

Objective 3.d. Develop and apply innovative approaches to delivering quality infrastructure.

The recommended plan incorporates design and construction features based on the latest technology that incorporates best practices based on recent construction within the Pittsburgh District and elsewhere.

Goal 4: Recruit and Retain Strong Teams: Build and cultivate a competent, disciplined, and resilient team equipped to deliver high quality solutions.

Objective 4.a. Identify, develop, maintain, and strengthen technical competencies.

This study enhanced the capabilities of the product delivery team by providing invaluable experience in the areas of applied navigation modeling, fish passage plan formulation and collaborative planning.

Objective 4.b. Communicate strategically and transparently.

Corps management and the navigation and environmental stakeholders were updated throughout the study process and at key milestone points including the NEPA Scoping Meetings, Feasibility Scoping Meeting and Alternative Formulation Briefing.

Objective 4.c. Standardize business processes.

This study was implemented in full accordance with the Corps template for Planning Studies embodied in ER 1105-2-100.

Objective 4.d. Establish tools and systems to get the right people in the right jobs, then develop and retain this highly skilled workforce.

Implementation of this study involved staff from multiple Corps District offices and centers of expertise, and was subjected to multiple levels of internal and external review. The product delivery team's skills and their management insights were enhanced by the knowledge, skills and capabilities of all involved.

5.7.2 Conformance with Corps Environmental Policies

5.7.2.1 Environmental Operating Principles

EOP 1. Foster sustainability as a way of life throughout the organization.

The Upper Ohio Navigation Study gave particular attention to cumulative impact analysis of valued resources' sustainability. The navigation system's historic impacts on riverine connectivity affecting fishery diversity and native mussels are of particular concern. The intent of the District's recommendation of "environmentally sustainable design" for the proposed replacement navigation structures is to improve connectivity for native species through normal lock and dam operations. In place of "add-on" separable fish passage structures that are expensive to operate and difficult to justify, the Corps could foster sustainability through potential modifications to the design and future operations of the navigation structures themselves, so long as these modifications do not increase project costs. An added benefit of this design approach would be gaining insight in how our structures have historically functioned as an impediment to fish passage for application in blocking undesired invasive species movement (e.g. Asian carp). The navigation study further recommends beneficial disposal practices for dredged and excavated materials, to be resolved at an appropriate time prior to construction initiation.

EOP 2. Proactively consider environmental consequences of all Corps activities and act accordingly.

In responding to the draft Fish and Wildlife Coordination Act Report on the Ohio River Mainstem System Study (ORMSS), the Great Lakes and Ohio River Division acknowledged the comprehensive discussion of the river's resources and recommendations to achieve environmental sustainability for these resources. The Corps further accepted responsibility and accountability for impacts of actions under our jurisdiction, and confirmed resource sustainability as an environmental goal that is consistent with the Corps Environmental Operating Principles and ecosystem restoration mission and policies. The ORMSS System Investment Plan/Programmatic Environmental Impact Statement (SIP/PEIS) committed the Corps to addressing navigation systemic issues in future site specific studies.

The Upper Ohio Navigation Study tiered from the ORMSS PEIS and fully addressed all of the environmental commitments made in the ORMSS Record of Decision. We also gave sustainability issues full consideration in assessing and mitigating impacts of our recommended plan. All mitigation features were incrementally justified. We fully coordinated our studies and impact analyses with an Interagency Working Group established for this study.

EOP 3. Create mutually supporting economic and environmental solutions.

The District considered ecosystem restoration projects (NER plan) that might form a Combined Plan recommendation. All restoration alternatives considered were by their nature fully independent of the navigation NED plan and did not influence NED plan formulation. Lacking a non-federal cost-sharing partner having interest in participating in the NER component, this was dropped from the study. The recommended NED plan is fully supported by environmental impact analyses, and all non-negligible impacts are mitigated through incrementally justified options.

EOP 4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.

The Upper Ohio Navigation Study fully addresses project impacts to comply with all relevant environmental and cultural resource laws and regulations. Full compliance will be achieved following public review of the report under the National Environmental Policy Act.

EOP 5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

Environmental issues associated with the preferred and alternative construction work areas were fully considered in evaluating potential impacts and cost risks. A present commitment to make beneficial use of disposal materials is deferred to closely precede construction in order to take advantage of future options that may not be currently available. Acknowledgment of systemic environmental issues led to consideration of system-oriented mitigation options with other traditionally accepted in-kind replacement options. The historic and systemic riverine connectivity issue was addressed in the environmentally sustainable project design recommendation that may influence these projects throughout their lifetime.

EOP 6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.

The District made full use of available information and tiered from the Ohio River Mainstem System Study Programmatic Environmental Impact Statement. We also established an Interagency Working Group of concerned federal and state resource agencies, resource advocate organizations, academia, and other professionals to provide input and feedback through our environmental study process. This group met quarterly over about a 3-year period during project formulation.

EOP 7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

Following the NEPA scoping notices and meetings, the District-created Interagency Working Group met regularly during project formulation to provide input on the study's environmental issues. The voluntary participation of Group members was greatly valued by District environmental staff and proved to be highly beneficial to project formulation. The draft study report with integrated environmental impact statement will be circulated for public review and all comments will be addressed.

5.7.2.2 Ecosystem Restoration Policies

The Upper Ohio Navigation Study conforms to Corps policies for environmental restoration and protection as described in EP 1165-2-1 (30 Jul 99). Opportunities for ecosystem restoration in the study area were identified and evaluated for inclusion in a recommended plan for navigation improvements. The focus of restoration projects was on the aquatic and riparian environment principally involved with the hydrologic regime of the watershed modified by the navigation system. The goal of restoration projects was resource sustainability, as identified through cumulative effects assessments, consistent with the Corps Environmental Operating Principles.

5.7.2.3 Fish and Wildlife Mitigation Policies

Traditional impact evaluations and mitigation were conducted for compliance with the Clean Water Act, the Fish and Wildlife Coordination Act, and Section 906(d), Water Resources Development Act of 1986. Fish and wildlife mitigation was formulated and is recommended so that the recommended project will have negligible adverse impacts on fish and wildlife. Cost and benefits of alternative mitigation schemes have been incrementally evaluated so that the recommended plan represents the least cost method of compensating for negatively impacted values. A monitoring plan, appropriate to the mitigation schemes, has been developed and included in the recommendation.

5.7.2.4 Beneficial Use of Dredged Material Policies

The recommended NED plan will generate concrete rubble, common excavation, and riverbed excavation materials for disposal. Opportunities for beneficial reuse of these materials have been considered and described in the study. Current policy requires non-federal cost-sharing for any increased cost of beneficial reuse above the base plan disposal cost. Beneficial reuse alternatives that would result in a cost savings over the base plan may be implemented without cost-sharing. Federal lands are considered first for beneficial reuse, and the District has coordinated closely with the Ohio River Islands National Wildlife Refuge on their interest in receiving any materials suitable for their management purposes.

5.7.2.5 Invasive Species Policies

The Corps nationwide policy on invasive species (CECW-ZA Memorandum dated June 2, 2009) complements the National Invasive Species Act (NISA) and meets the spirit of the National Invasive Species Management Plan. With regards to civil works planning activities, Corps policy requires that planning documents "address invasive species concerns in their analysis of project impacts." Collaboration with Federal, State, and local agencies is to be maintained in developing those analyses.

The NISA, which reauthorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act (1990), "aims chiefly to prevent unintentional introductions of aquatic species via the ballast water of ships, especially into the Great Lakes." (Union of Concerned Scientists, The National Invasive Species Act, An Information Update by the Union of Concerned Scientists. August 2002). The 1990 Act established the Aquatic Nuisance Species Task Force, which in turn established six regional panels consisting of representatives of states, Indian Tribes, non-governmental organizations, commercial interests, and neighboring countries. Pennsylvania is represented in two regions, the Mid-Atlantic and the Great Lakes regions. The majority of the Ohio River drainage that lies downstream of Pennsylvania falls within the Mississippi River Basin region.

The ANS Task Force prepared a Strategic Plan (2007-2012) with five goals generally summarized as Prevention, Detection and Monitoring, Control, Research, and Communication, Education and Outreach. The Corps supports the ANS Task Force through participation on the regional panels.

The National Invasive Species Management Plan (2008-2012) is a product of the National Invasive Species Council. E.O. 13112 (1999) established the NISC with membership consisting of the secretariat-level representatives from a number of federal agencies, and its Invasive Species Advisory Committee made up of non-federal stakeholders. The Council maintains a permanent staff to coordinate activities of Council membership, and to provide overall direction on national and international invasive species policy development. Their Management Plan consists of five strategic goals: 1) Prevention, 2) Early Detection and Rapid Response, 3) Control and Management, 4) Restoration, and 5) Organizational Collaboration.

The Upper Ohio Navigation Study alternatives may impact invasive species in three ways. Construction of replacement facilities may introduce species through unintentional importation of species through construction equipment and materials. Improvement of habitat connectivity across navigation facilities through fish passage techniques may facilitate expansion of invasive species range. Ecosystem restoration projects may target invasive species for control measures.

5.7.3 *Relationship Between Short Term Uses of the Environment and the Maintenance of Long Term Productivity[31]

The concept of this NEPA requirement is addressed in the ecosystem restoration plan formulation, sustainability-focused fish passage study, and the cumulative effects assessment, which focused on the sustainability of valuable environmental resources of the study area. Long term productivity (sustainability) was one of the study objectives, and guided much of the thinking regarding mitigation of construction impacts. The recommended plan will either be beneficial or neutral to long term productivity of regional resources.

[31] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

Short term uses of the environment include construction impacts to the river and upland work areas. The impacts from these activities have been identified in the study, and all necessary mitigation formulated to reduce impacts to a negligible level. Whether these short term impacts and the projects that result will have an effect on long term productivity was addressed in the cumulative effects assessment. This assessment identified that long term productivity is of concern to the marginally sustainable regional resources of native mussels, riparian habitat and socioeconomics.

Improved, reliable river transportation through modernized locks will benefit the long term socioeconomic environment through reduced transportation costs, which correlates to reduced energy costs. The long term status of riparian habitat will not be directly affected by lock construction, and new locks are not expected to induce growth in river traffic or in development of riverside navigation support facilities. Opportunities that would improve riparian habitat were considered in the ecosystem restoration planning study component, and in the potential for material disposal at the Ohio River Islands National Wildlife Refuge. Long term status of native mussels would appear to be most influenced by water quality trends and the historic impacts associated with the navigation system, such as habitat modification (impoundment and tow scour) and impaired riverine connectivity. Maintaining a reliable navigation system will have long term benefits to mussels by minimizing tow queuing (scour) impacts to aquatic habitat associated by lockage delays. Implementation of fish passage strategies would further benefit mussels to the degree that their fish host species have improved ability to move upstream.

5.7.4 *Irreversible or Irretrievable Commitments of Resources

Construction of the recommended plan will involve the commitment of materials, labor and energy, and lands. The short term commitment of lands for construction support will have short term, reversible impacts. The long term commitment of lands to the navigation facilities would be theoretically reversible were the navigation system to be removed. This is unlikely, however, given congressional commitment to maintaining a viable inland navigation system. The investment in construction labor and energy will lead to overall long term savings in these resources through maintaining a reliable commercial navigation system for transportation of bulk materials. Construction materials, including concrete, aggregates and steel, are irretrievable during the life of the structures, which may be anticipated to be 50 – 100 years based on experience. Upon future replacement, these materials may be recyclable.

5.7.5 U.S. Fish and Wildlife Service Recommendations

In April 2009, the USFWS submitted a Planning Aid report Update for the Upper Ohio Navigation Study, which updated resource status and significance information from earlier reports provided by the Service in the 1980s. This Update listed "additional information needs that should be pursued as the Corps continues its study of navigation modernization in the Upper Ohio River." The Corps responded to these needs (FWS #s 1-6) as described below:

<u>FWS 1.</u> In order to avoid and minimize impacts to the aquatic environment of the Ohio River to the maximum extent practicable, the Corps should avoid impacts to high quality habitat

areas (i.e., resource categories 1-3) as classified by the Service's Mitigation Policy to the maximum extent practicable. This can be accomplished by providing pre-construction plans of each lock chamber/dam reconfiguration to the Service and other resource agencies for their review and comment. Upon review of said plans, the Service may be able to provide ideas or methodologies regarding construction techniques which would further avoid and minimize impacts to the aquatic environment.

> **Corps Response:** The nature of the recommended plan to construct a replacement lock chamber at each existing facility will involve some impact to the tailwater created by the dam, a high quality habitat. These impacts have been quantified, and are fully addressed in the recommended mitigation plan. As project design and construction methodologies are finalized after authorization, the Corps will continue to consult with the Service with a view to minimizing impacts.

FWS 2. Following completion of the feasibility study and prior to construction of the proposed project the Corps should contact the Service's Pennsylvania and West Virginia field offices to determine whether federally-listed species may be impacted by the project.

> **Corps Response:** The Corps will continue to consult with the Service in advance of construction on endangered species status.

FWS 3. The Corps should conduct Habitat Evaluation Procedures (HEP) Analyses for both aquatic and terrestrial habitats which may be impacted by the proposed project in order to determine amounts of habitat losses and mitigation needs. The HEP should be conducted with Service personnel, and any mitigation needs should be evaluated by the Service to determine their appropriateness.

> **Corps Response:** The Corps employed HEP in impact analysis and mitigation planning for both aquatic and terrestrial habitats. The work was performed by a Corps contractor, and the planning, analyses, and results were fully presented at meetings of the Upper Ohio Interagency Working Group for discussion.

FWS 4. The Corps should investigate the potential of both structural and non-structural techniques to improve fish passage and mussel hosts in the upper Ohio River. The Corps should continue to work cooperatively with the Service and other resource agencies in the development of fish passage techniques at each of the three locks and dams (Emsworth, Dashields, and Montgomery). The construction of fish passage structures at each of the three locks and dams is an important priority for migrating fish species such as the paddlefish and the sturgeon.

> **Corps Response:** The Corps acknowledges the high priority the Service places on improving riverine connectivity at our navigation facilities. We employed USFWS biologists and engineers to lead a fish passage strategies study during the navigation study, and also involved the Interagency Working Group. This study considered and ranked conceptual designs for separable fish passage structures at each navigation facility, and also non-structural lock operations (i.e. "fish lockages"). The Corps engineering evaluation of the favored rock ramp concept determined it would not be technically feasible at our existing navigation dams. Any further engineering evaluation to address the technical issues would only lead to dam modifications involving much

higher costs, and no increase in benefits or a means of justifying the costs of construction and long-term fish passage structure operations.

The Corps recommended navigation plan includes "environmentally sustainable design" for the new locks and Dashields dam gate to consider potential design modifications to the new navigation structures themselves to lessen the impediment to fish passage historically experienced at these facilities. The Corps anticipates further consultation with Service fish passage experts in this design process.

FWS 5. The Corps should work cooperatively with the Service, ORSANCO, Pennsylvania Fish and Boat Commission, and other resource agencies to provide for benthic trawling sampling on the upper Ohio River to better evaluate the status of the under-sampled bottom dwelling fishes.

Corps Response: The Corp worked with ORSANCO to perform benthic trawling in the Dashields pool during the study, and retained fisheries biologists from Pennsylvania State University through the Pennsylvania Cooperative Fish and Wildlife Research Unit to perform larval fish surveys supporting interpretation of results from the NAVPAT modeling effort.

FWS 6. The Corps should conduct analyses on the upper Ohio River in the project area to help address system-wide aquatic impacts within the three EDM pools associated with lock modifications of the Upper Ohio Navigation Study. One such methodology utilized by the Corps' Huntington District on lock improvements/widening is the Navigation Predictive Analysis Technique (NAVPAT). NAVPAT is a computer model which analyzes certain shear forces of fleet configurations on selected fish species in navigational pools. Although NAVPAT is not a methodology which predicts absolute impacts, it can be used as a planning level tool to rank alternatives (USFWS March 2008). The analysis tool utilized for this project should be the best scientific information/model available in order to most accurately determine system-wide aquatic impacts. The Service should be an active participant in the selection of evaluation species and habitat models for the analysis.

Corps Response: The Upper Ohio Navigation Study tiered from the Ohio River Mainstem System Study (ORMSS) Programmatic Environmental Impact Statement under the National Environmental Policy Act. ORMSS used NAVPAT to assess in-pool traffic impacts at a gross level throughout the 981-mile Ohio River. Impacts in the upper river pools were found to be insignificant, although somewhat greater than the middle and lower river segments.

The Upper Ohio Study planned to use NAVPAT to further refine the upper river ORMSS analysis and verify whether additional data at closer intervals would confirm or modify the ORMSS findings. Initial efforts included an upgrade of the model software for less labor-intensive data entry, and a larval fish survey for use in interpretation of model results. As the navigation study progressed, it became evident that traffic projections showed no significant change and that alternatives were distinguished only by different chamber lengths. NAVPAT does not have the sensitivity to distinguish between such subtle differences or the capability to determine absolute impacts to the fishery. Since it was determined that further use of the model would not lead to any meaningful result, no additional data were collected or input for model runs. The Upper Ohio Study adopted

the results of the ORMSS report that found barge traffic has an insignificant in-pool impact.

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6 PLAN IMPLEMENTATION

6.1 Institutional Requirements

The only institutional issues that need to be addressed prior to implementation of specific project features includes negotiation of land purchase for three batch sites associated with new lock construction and possibly compensation for the relocation of a utility line if the currently identified primary batch plant site for construction at Montgomery is used. The District has developed a cost estimate that should facilitate future negotiations if needed. None of these actions are expected to pose any delays to project implementation.

6.2 Division of Responsibilities and Cost Sharing

Authorization is requested for all project feature costs totaling $2,320,082,000 (October 2014 Cost Level). Fifty percent of this amount ($1,160,041,000) would come from the Inland Waterways Trust Fund (IWTF) and 50 percent out of the General Fund (GF) of the United StatesTreasury. Under current legislation, following construction, all routine Operations and Maintenance associated with the constructed facilities will be funded from the General Fund of the United States Treasury.

The cost of the recommended plan is based on assumed timing of investments as noted in Section 5.1. Appropriately, feasibility reports do not dictate the timing of the authorization or future appropriation for this or any Corps project. The implementation schedule for this project could be impacted by nationwide project prioritization. Delays in implementation will result in increases in cost to construct the features described in Section 5.1 by the appropriate inflation factors allowed by current Corps of Engineers costing and budgetary processes.

6.3 Views of non-Federal Sponsor(s) and Any Other Agencies Having Implementation Responsibilities

The UONS and recommended construction will not have a traditional non-Federal Sponsor, but rather, 50 percent of the construction funding will be provided by a federal tax on carrier fuel (IWTF), and the remaining 50 percent will be provided by the Treasury. Notwithstanding further legislative changes, the recommended plan assumes this 50/50 cost share. Following authorization, the Inland Waterways Users Board (IWUB) may have a significant role in establishing the priority of the Upper Ohio Locks reconstruction in relation to all other authorized Inland Navigation construction and/or Major Rehabilitations. Congress, however, ultimately controls the priority through the Authorization and Appropriation processes.

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7 SUMMARY OF COORDINATION, PUBLIC VIEWS, AND COMMENTS

7.1 Coordination and Public Outreach

The public outreach and communications process formally started with publication of a Notice of Intent (Federal Register / Vol. 71, No. 189 / Friday, September 29, 2006, p. 57487) to prepare an environmental impact statement in compliance with the National Environmental Policy Act (NEPA). This notice announced and was closely followed by a series of NEPA public scoping meetings in the study area in October 2006. Scoping meetings also were publicized through a press release, legal ads in major regional newspapers, and letters of invitation to potentially interested agencies and individuals. Meeting participants were given a study fact sheet and were encouraged to provide written comments or submit questions by regular mail or e-mail to a mailbox established specifically for the study: ohiorivernfs@usace.army.mil. Further information on the study was maintained on a study website at: http://www.lrp.usace.army.mil/pm/upper_ohio.htm.

An Interagency Working Group (IWG) for this study composed of State and Federal natural resource agencies and non-governmental organizations was created by the District Environmental Team in November 2007. Eleven meetings were held between December 2007 and September 2011. The overall intent for this group was scoping and working through environmental issues and studies relevant to baseline conditions, navigation impacts, and potential ecosystem restoration projects. The meetings rotated between various locations from Pittsburgh to near Wheeling, West Virginia.

Other formal meetings involving navigation industry stakeholders conducted to date include the feasibility scoping (FSM) meeting held September 4 and 5, 2007, and District updates to the Freight Forum, Southwest Pennsylvania Commission, at their semi-annual meetings.

Coordination under the National Historic Preservation Act has been conducted with the Pennsylvania Bureau for Historic Preservation, and future coordination is planned with the Steel Industry Heritage Corporation (managers of the Rivers of Steel National Heritage Area), and the Historical Society of Western Pennsylvania (Senator John Heinz Pittsburgh Regional History Center).

Internal coordination meetings between the District, Division and Headquarters offices, “In-Progress Review (IPR) meetings,” have been held on an as needed basis. IPR meetings to date have been held February 2, 2006, July 2, 2007, February 4, 2010, and March 18, 2104. On June 30, 2010, the Corps held their Alternative Formulation Briefing (AFB), which reviewed the plan formulation review process and the recommended plan.

The U.S. Environmental Protection Agency published the Notice of Availability for the Draft Environmental Impact Statement in the **Federal Register**, Vol 79, No. 75/Friday, April 18, 2014. The 45-day comment period officially ended on June 2, 2014, but the District accepted comments through June 5, 2014. A listing of the recipients who received the mailing of the Draft Feasibility Report follows below.

7.2 Public Views and Comments

The District received agency review responses from the US Department of the Interior and the US Environmental Protection Agency, the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, and the Pennsylvania Department of Conservation and Natural Resources. Organization and individuals responding were The Nature Conservancy, the Port of Pittsburgh Commission, Campbell Transportation Company, Inc., and Murray American Transportation, Inc. All review letters and District responses are reproduced in the report's **Environmental Appendix: Public Review Comments & Responses**.

In general, the navigation stakeholders support the project with the anticipation of an expeditious authorization and funding of construction.

The Nature Conservancy and the Pennsylvania Fish and Boat Commission both stated concerns over the navigation facilities' continuing impediment to native fish passage, and that fish passage at the locks and dams "is critical to the recovery of the Ohio River" (PFBC). The Nature Conservancy strongly urges the Corps to consider rock ramps as a structural option for improvement of fish passage in future studies, and the Commission recommends "assisted fish lockages" be incorporated into the facilities' operations schedule.

The US Environmental Protection Agency rated the DEIS an EC-2 (Environmental Concerns/Insufficient Information). Among their comments were four main concerns: fish passage, environmental justice assessment, climate change, and impacts associated with borrow and waste material. The Pennsylvania Department of Environmental Protection commented on the need for air quality analysis.

To address the insufficient information issues, the District amended the Final Feasibility Report and Integrated Environmental Impact Statement to include an **air quality analysis** (main report text and a new appendix), and a revised and updated the **Environmental Justice Assessment** (main report text and appendix).

The **borrow and waste material** issue is deferred to future detailed design, with a commitment for future NEPA review and beneficial use considerations. Regarding the long-standing **cumulative impact to certain fish and mussel species** from the navigation system's impediment to connectivity, the Distict evaluated fish passage strategies and determined that no separable fish passage projects were justifiable under existing mitigation or ecosystem restoration authorities.

7.3 *List of Agencies, Organizations & Persons to Whom the EIS is Sent[32]

FEDERAL AND STATE ELECTED OFFICIALS

OHIO

United States Senate

Honorable Sherrod Brown

Honorable Rob Portman

Governor of Ohio

Honorable John R. Kasich

PENNSYLVANIA

United States Senate

Honorable Robert P. Casey, Jr.

Honorable Pat Toomey

United States House of Representatives

Honorable Mike Doyle

Honorable Bill Johnson

Honorable David McKinley

Honorable Tim Murphy

Governor of Pennsylvania

Honorable Tom Corbett

Pennsylvania Senate

Honorable Wayne Fontana

Honorable Matt Smith

Honorable Elder A. Vogel, Jr.

Pennsylvania House of Representatives

Honorable Daniel J. Deasy

Honorable Nick Kotic

Honorable Mark Mustio

Honorable Adam Ravenstahl

Honorable Erin Molchany

Honorable Jake Wheatly, Jr.

[32] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

WEST VIRGINIA

United States Senate

Honorable Joe Manchin

Honorable Jay Rockefeller

Governor of West Virginia

Honorable Earl Ray Tomblin

NATIVE AMERICAN TRIBES

Absentee-Shawnee Tribe of Oklahoma
Cayuga Nation
Delaware Tribe of East Oklahoma
Delaware Nation
Oneida Executive Committee
Oneida Indian Nation
Oneida Nation of Wisconsin
Onondaga Nation
Seneca Nation of Indians
Seneca-Cayuga Tribe of Oklahoma
St. Regis Mohawk Tribe
Tonawanda Seneca Nation
Tuscarora Nation

LOCAL ELECTED OFFICIALS

Allegheny County, Chief Executive
Office of the County Council, Allegheny County
Mayor of Pittsburgh
Pittsburgh City Council
Beaver County Commissioner
Mayor of Bellevue Borough
President, Bellevue Borough Council
Mayor of Avalon Borough
Avalon Borough Council
Mayor of Ben Avon Borough
President, Ben Avon Borough Council
Mayor of Emsworth Borough
President, Emsworth Borough Council
President, Kilbuck Township Supervisors

Secretary, Kilbuck Township
Mayor of Glenfield Borough
President, Glenfield Borough Council
Mayor of Haysville Borough
President, Haysville Borough Council
Mayor of Osborne Borough
President, Osborne Borough Council
Mayor of Sewickley Borough
President, Sewickley Borough Council
Mayor of Edgeworth Borough
President, Edgeworth Borough Council
Mayor of Leetsdale Borough
President, Leetsdale Borough Council
Mayor of McKees Rocks Borough
President, McKees Rocks Borough Council
Chairman, Stowe Township Supervisors
Chairman, Kennedy Township Board
Secretary, Kennedy Township
Chairman, Robinson Township Board
Secretary, Robinson Township
Chairman, Neville Township Board
Secretary, Neville Township
Mayor of Coraopolis Borough
President, Coraopolis Borough Council
Chairman, Moon Township Supervisors
Manager, Moon Township
President, Crescent Township Council

FEDERAL AGENCIES

Advisory Council on Historic Preservation, Washington, DC
Federal Aviation Administration, Eastern Region Regional Administrator, Jamica, NY
U.S. Coast Guard
- Captain of the Port, Pittsburgh, PA
- Marine Enforcement and Protection Division, Washington, DC

U.S. Department of Agriculture
- State Conservationist, Harrisburg, PA
- National Agricultural Library, Beltsville, MD
- Natural Resource Conservation Service, Washington, DC

APHIS PPD/EAD, Riverdale, MD
U.S. Department of Housing and Urban Development,
Pennsylvania State Office, Philadelphia, PA
Environmental Review Division, Washington, DC
U.S. Department of Transportation
Director, Inland Waterways Gateway, St.Louis, MO
Division Administrator, Harrisburg, PA
Transportation Engineer, Harrisburg, PA
U.S. EPA, Region III, Philadelphia, PA
NEPA Program Leader
Regional Administrator
U.S. EPA, Region III, Wheeling, WV
U. S. Department of the Interior
Office of Environmental Policy and Compliance, Washington, DC
National Park Service, Northeast Regional Director, Philadelpia, PA
U.S. Fish and Wildlife Service
Carterville NFWCO, Marion, IL
Ohio Field Supervisor, Reynoldsburg
Pennsylvania Field Supervisor, State College
West Virginia Field Supervisor, Elkins
Northeast Fishery Center Complex, Lamar, PA
Ohio River Islands National Wildlife Refuge, Williamstown, WV
U.S. Geologic Survey
Water Science Center, Pittsburgh, PA
Eastern Regional Office , Kearneysville, WV
Ohio River Basin Commission, Lexington, KY
Ohio River Valley Water Sanitation Commission, Cincinnati, OH

STATE AGENCIES

INDIANA

Indiana Department of Natural Resources
Division of Historic Preservation and Archaeology, Indianapolis

OHIO

Ohio Department of Natural Resources, Columbus
Ohio Environmental Protection Agency, Columbus

PENNSYLVANIA

Pennsylvania Department of Community and Economic Development, Pittsburgh, Harrisburg
Pennsylvania Department of Conservation and Natural Resources, Pittsburgh

Pennsylvania Department of Environmental Protection, Pittsburgh, Harrisburg, Coal Center
Pennsylvania Department of Transportation, Harrisburgh, Bridgeville, Clearfield
Pennsylvania Fish and Boat Commission, Somerset, Bellefonte, Harrisburg
Pennsylvania Game Commission, Harrisburg, Bolivar
Pennsylvania Historical and Museum Commission, Pittsburgh, Ambridge, Harrisburg
WEST VIRGINIA
West Virginia Department of Environmental Protection, Charleston
West Virginia Division of Natural Resources, South Charleston

CITY/COUNTY ORGANIZATIONS

OHIO
Columbiana County Port Authority, East Liverpool
PENNSYLVANIA
Allegheny County Conservation District, Pittsburgh
Allegheny County Economic Development, Pittsburgh
Allegheny County Emergency Management, Pittsburgh
Allegheny County Health Department, Pittsburgh
Allegheny County Public Works Department, Pittsburgh
Beaver County Chamber of Commerce, Beaver
Beaver County Community Development Program, Beaver Falls
Beaver County Conservation District, Beaver
Beaver County Corporation for Economic Development, Beaver
Beaver County Department of Public Works, New Brighton
Beaver County Emergency Services, Ambridge
Beaver County Planning Commission, New Brighton
Community Development Program of Beaver County, Beaver
Chief, Emergency Management, Pittsburgh
Pittsburgh Department of Public Works, Bureau of Transportation and Engineering
Pittsburgh Water and Sewer Authority
Greater Pittsburgh Chamber of Commerce, Pittsburgh
ALCOSAN, Pittsburgh

ORGANIZATIONS AND PUBLIC

Anthony J.	Alexander	Pennsylvania Power Company	Akron	OH
Thomas A.	Allegretti	The American Waterways Operators	Arlington	VA
Dave	Argent, Ph.D.	Biological and Environmental Science Department, Calif. Univ. of PA	California	PA
Myron	Arnowitt	Clean Water Action	Pittsburgh	PA

Gerry	Balbier	RiverQuest	Pittsburgh	PA
Nancy	Barber		Monaca	PA
Frank	Barber		Monaca	PA
William R.	Barr	Madison Coal & Supply Amheart Industries Inc.	 Charleston	W V
Thomas	Baxter	Friends of the Riverfront	Pittsburgh	PA
Charles	Bier	Western Pennsylvania Conservancy	Pittsburgh	PA
Richard	Blank	Blank River Services	Elizabeth	PA
Jon	Bloom	New Brighton Boat Club	New Brighton	PA
Jacquelyn	Bonomo	Western Pennsylvania Conservancy	Pittsburgh	PA
Scott	Brown	First Energy Corp	Akron	OH
R.J.	Brown	RJ Brown Towing Company	Tarentum	PA
Earl H.	Brown, Jr.	Civil & Environmental Consultants, Inc.	Pittsburgh	PA
Thomas	Bryan	Frank Bryan Inc.	Pittsburgh	PA
Lynn M.	Busatto	Industry Terminal and Salvage Company	Industry	PA
August R.	Carlino	Steel Industry Heritage Corporation	Homestead	PA
Jack	Cataldo	Jim Kenney Boat Marina	Wellsville	OH
Eric J.	Chapman	Western Pennsylvania Conservancy	Pittsburgh	PA
Jared L.	Cohen	Carnegie Mellon University	Pittsburgh	PA
Cheryll A.	Cranmer	Waterways Assoc. of Pittsburgh	Lyndora	PA
Tony	Cygan	Cianbro Corporation	Baltimore	MD
Donald	Depp	West View Municipal Authority	Pittsburgh	PA
Gwen	DiPietro		Pittsburgh	PA
	Director	Greater Pittsburgh Aquatic Club	Pittsburgh	PA
	Director	Groveton Boat Club	Coraopolis	PA
	Director	Heinz Endowments - Environmental Section	Pittsburgh	PA
	Director	Allstates Marine	Sewickley	PA
	Director	B&L Marina	Coraopolis	PA
	Director	Branchport Boat Club	Pittsburgh	PA
	Director	Bridgewater Landing Marina	Bridgewater	PA
	Director	C&E Marina	Sewickley	PA
	Director	Captains Quarters Marina	Beaver	PA
	Director	Island Boat Club	Pittsburgh	PA
	Director	New Brighton Boat Marina	New Brighton	PA
	Director	Newport Marina, Inc.	Pittsburgh	PA
	Director	Peggy's Harbor	Pittsburgh	PA
	Director	River Rose Marina	New Brighton	PA
	Director	Rochester Boat Club	Rochester	PA
	Director	Skippers Haven Yacht Club	Toronto	OH

John A.	Dziubek, P.E.	Michael Baker Jr. Inc.	Beaver	PA
Dick	Ehringer	Mon River Towing, Inc.	Belle Vernon	PA
	Environ. Scientist	Hatch Mott MacDonald	Pittsburgh	PA
Thomas M.	Feldman	Free Flow Power	Boston	MA
Brad L.	Goodballet	Applied Civil Solutions Inc.	East Liverpool	OH
Barbara	Grobe	Sierra Club - Allegheny Group	Pittsburgh	PA
James	Guttman	Mon River Towing, Inc.	Belle Vernon	PA
J. Brett	Harvey	CONSOL Energy Inc.	Canonsburg	PA
Martin T.	Hettel	AEP River Operations	Belle Chasse	LA
Gerald D.	Holder	University of Pittsburgh	Pittsburgh	PA
Lisa	Hollingsworth-Segedy	American Rivers	Pittsburgh	PA
Joe	Holtman	Reliant Energy	Philadelphia	PA
Anne	Hong	Hatch Mott MacDonald	Pittsburgh	PA
Ben	Huber	American Commerical Barge Line Company	Jeffersonville	IN
Dan	Hufton	Pennsylvania American Water Company	McMurray	PA
David	Johnson	Imperial Towing, Inc.	Imperial	PA
Geraldine M	Jones	California University of Pennsylvania	California	PA
Mark	Killar	Western Pennsylvania Conservancy	Pittsburgh	PA
William G.	Kimmel	California University of Pennsylvania	California	PA
Mike	Koryak	Koryak Environ. and Health Consultants, LLC	Wexford	PA
Roy	Kraynyk	Allegheny Land Trust	Sewickley	PA
Bill	Kunze	The Nature Conservancy, PA Chapter	Harrisburg	PA
Anita	Lasek		Crescent Twp	PA
Wayne T.	Lithrow		Pittsburgh	PA
	Manager	Glenfield Delray Marina	Glenfield	PA
	Manager	Knotical Haven	Rochester	PA
	Manager	Bo's Light House	Toronto	OH
	Manager	Dockers Pleasure	Rochester	PA
Dick	Marcus	General Materials Terminals	Baden	PA
Dan	Martin	Ingram Barge	Nashville	TN
John	Martino	Beaver County Transit Authority	Rochester	PA
Don	Mattzie	Linare Consulting	Pittsburgh	PA
Jeffery S.	Maze, P.E.	Pennsylvania American Water Company	McMurray	PA
James	McCarville	Port of Pittsburgh Commission	Pittsburgh	PA
Molly	Mehling	Chatham University	Pittsburgh	PA
Vicky	Michaels	Raccoon Creek Watershed Association Independence Marsh Foundation Inc.	Clinton	PA
David	Miller	University of Pittsburgh	Pittsburgh	PA

John	Miloser	River Harbor Marina	New Brighton	PA
Granger	Morgan	Carnegie Mellon University	Pittsburgh	PA
Dewitt	Peart	Pittsburgh Regional Alliance	Pittsburgh	PA
Bill	Pegher	Canal Barge Company, Inc.	New Orleans	LA
Robert A.	Piotrowsky	Institute of Water Resources	Alexandria	VA
Theo	Polce		Monaca	PA
Guy	Polce		Monaca	PA
	President	Freedom Serbs	Rochester	PA
	President	Michael Baker, Jr. Inc.	Moon Twp	PA
	President	Orion Power Midwest, LLC	Elrama	PA
	President	TECO Transport	Tampa	FL
Marty	Reuss		Palymra	VA
Suzanne	Richert		Wytheville	VA
Mea	Scholl	RAM Terminals	New Kensington	PA
John	Schombert	3 Rivers Wet Weather	Pittsburgh	PA
John	Schombert	Three Rivers Wet Weather, Inc.	Pittsburgh	PA
Lisa	Schroeder	Riverlife	Pittsburgh	PA
Robert	Shimp, Ph.D.	Ohio River Foundation	Cincinnati	OH
Marilyn	Skolnick	Sierra Club	Monroeville	PA
Jacob G.	Smeltz	Electric Power Generation Association	Harrisburg	PA
John	Sofranko		Coraopolis	PA
John	Stark	The Nature Conservancy	Dublin	OH
Jay	Stauffer, Jr., Ph.D.	Pennsylvania State University	University Park	PA
Peter	Stephaich	Campbell Transportation Company	Houston	PA
Tom	Swor		Frankewing	TN
Joel V.	Tarr	Carnegie Mellon University	Pittsburgh	PA
Sue	Thompson		Pittsburgh	PA
Robert L.	Vogel	Duquesne Light Company	Pittsburgh	PA
Samatha	Walter		Monaca	PA
Emily	Warner	Freshwater Conservation Program	Blairsville	PA
Rob	Webb	Crounse Corporation	Paducah	KY
Matt	Woodruff	Waterways Council, Inc.	Arlington	VA
Rex	Woodward	Premier Marine Salvage	Pittsburgh	PA
Davitt	Woodwell	Pennsylvania Environmental Council	Pittsburgh	PA
Russell	York	Buncher Company	Pittsburgh	PA
Donna	Zingaro		Enon Valley	PA
James R.	Zubik, Jr.	River Salvage Company, Inc.	Pittsburgh	PA
		M/G Transport New Orleans	Metairie	LA

MEDIA

The Jeffersonian, Cambridge, OH
WTOV TV, Steubenville, OH
WTAJ TV, Altoona, PA
Beaver County Times, Beaver, PA
Tribune-Democrat, Johnstown, PA
WATM TV, Johnstown, PA
Leader Times, Kittanning, PA
Latrobe Bulletin, Labrobe, PA
Valley Independent, Monessen, PA
New Castle News, New Castle, PA
KDKA TV, Pittsburgh, PA
KQV AM Radio, Pittsburgh, PA
Pittsburgh Business Times, Pittsburgh, PA
Pittsburgh Post-Gazette, Pittsburgh, PA
Pittsburgh Tribune-Review, Pittsburgh, PA
WPGH TV, Pittsburgh, PA
WPXI TV, Pittsburgh, PA
WTAE TV, Pittsburgh, PA
Herald, Sharon, PA
Valley News Dispatch, Tarentum, PA
Herald Standard, Uniontown, PA
Observer-Reporter, Washington, PA
Dominion Post, Morgantown, WV
WTRF TV, Wheeling, WV

LIBRARIES

ALLEGHENY COUNTY

Allegheny County Library Assoc, Pittsburgh
Andrew Bayne Memorial Library, Pittsburgh
Andrew Carnegie Free Library, Carnegie
Avalon Public Library
Baldwin Borough Public Library
Bethel Park Public Library
Braddock Carnegie Library
Brentwood Library

Bridgeville Public Library
C C Mellor Memorial Library, Edgewood
Carnegie Free Library of Swissvale
Carnegie Library of Homestead
Carnegie Library of McKeesport
Carnegie Library of Pittsburgh
Clairton Public Library
Comm Library of Castle Shannon
Community Library Of Allegheny Valley, Natrona Heights
Coraopolis Memorial Library
Crafton Public Library
Dormont Public Library
F.O.R. Sto-Rox Library, McKees Rocks
Green Tree Public Library, Pittsburgh
Hampton Community Library, Allison Park
Jefferson Hills Public Library
Lauri Ann West Memorial Library, Pittsburgh
Monroeville Public Library
Moon Township Public Library
Mount Lebanon Public Library
N. Versailles Public Library
Northern Tier Regional Library, Gibsonia
Northland Public Library, Pittsburgh
Oakmont Carnegie Library
Pleasant Hills Public Library
Plum Borough Library
Scott Township Public Library
Sewickley Public Library
Shaler North Hills Library, Glenshaw
South Fayette Twp Library
South Park Township Library
Springdale Free Public Library
Upper St Clair Township Library
Western Allegheny Comm Library
Whitehall Public Library
Wilkinsburg Public Library
William E. Anderson Library of Penn Hills

BEAVER COUNTY

Laughlin Memorial Library, Ambridge
Baden Memorial Library, Baden
Beaver Area Memorial Library, Beaver
Beaver County Bookmobile, Beaver Falls
BF Jones Memorial Library, Aliquippa
Carnegie Free Library, Beaver Falls
Carnegie Library, Midland
Center Express Library, Aliquippa
Chippewa Branch Library, Beaver Falls
Community College of Beaver County, Monaca
Monaca Public Library, Monaca
New Brighton Public Library, New Brighton
Rochester Public Library, Rochester

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8 RECOMMENDATIONS

Having carefully considered the economic, environmental, social, engineering, and public safety aspects associated with maintaining and modernizing commercial navigation facilities on the Upper Ohio River, I recommend that Plan LMA 7, which provides for a new river lock with dimensions of 110' x 600' at each of Emsworth, Dashields, and Montgomery Locks and Dams and includes appropriate mitigation, be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable. Preconstruction Engineering and Design for all chambers would be conducted during FY 2017-2018. Construction of all chambers would occur during FY 2019-2025.

The total estimated project first cost, based on October 2014 price levels and conditions, is $2,320,082,000. Fifty percent of this amount ($1,160,041,000) would come from the Inland Waterways Trust Fund (IWTF) and 50 percent out of the General Funds (GF) of the Treasury.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program or the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications, and will be afforded an opportunity to comment further.

2 Sep 14
Date

Bernard R. Lindstrom
Colonel, Corps of Engineers
District Engineer

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9 *LIST OF PREPARERS[33]

Name	Discipline/Expertise	Experience	Role in EIS Preparation
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Ashley Petraglia, USACE Pittsburgh	environmental resource specialist	3 yrs	Beneficial usage of disposal materials
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[33] Asterisked (*) headings designate sections of an environmental impact statement required by the CEQ Regulations (40 CFR 1500-1508) implementing the National Environmental Policy Act, and integrated into the navigation feasibility report.

Name	Discipline/Expertise	Experience	Role in EIS Preparation
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10 *INDEX & GLOSSARY

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GLOSSARY

Alternative — set of measures implemented at various times throughout the planning period to address problems and needs.

ATR — Agency Technical Review (formerly Independent Review), a procedure followed by the Corps to ensure overall quality of a variety of products ranging from planning studies to construction projects. All ATRs involve review by qualified independent personnel not affiliated with the development of the product being reviewed for the purpose of confirming the Corps studies are done in accordance with clearly established professional principles, practices, codes and criteria.

Cumulative Impact — the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what governmental agency or person undertakes such actions.

Environmental Sustainability — capability of remaining in a healthy and viable state for future generations. ES is identified in the Corps recently published Environmental Operating Principles as “a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation

and maintenance to improve the quality of life for present and future generations" (U.S. Army Corps of Engineers, 2002).

Measure — action designed to address problems or needs that can be implemented as part of an alternative.

System Investment Plan — Master plan or timetable for implementing maintenance of major lock and dam components, non-structural efficiencies and low-cost structural measures, and establishing budgets for future major rehabilitation and lock modernization feasibility studies for Ohio River navigation projects. These activities would supplement routine or day-to-day maintenance and cyclic maintenance activities that are required to keep any navigation facility operational. Major rehabilitation studies would be required for costly maintenance projects meeting requirements for that program. Feasibility studies would be required for Congressional authorization of the construction of larger locks. This plan also addresses high priority ecosystem needs for the Ohio River.

Valued Environmental Components — significant environmental resources based on political, legal, public, and professional significance considerations. The following ten VECs were identified for the Ohio River Mainstem System Study: 1) water and sediment quality, 2) fish, 3) mussels, 4) riparian and floodplain resources, *5)* health and safety and 6) river-based recreation, 7) air quality, 8) transportation and traffic, 9) socioeconomics and 10) cultural resources. The first six of these were considered more significant and received greater emphasis in the environmental sustainability analysis.

Ohio River Ecosystem Restoration Program — Authorized by the Water Resource Development Act of 2000, this program would identify and prioritize ecosystem needs for the Ohio River corridor consistent with current law and Corps policy. Non-Federal sponsors would fund 35 percent of site-specific project first costs and 100 percent of operation, maintenance, repair, rehabilitation, and replacement. Projects would be designed by a partnership composed of representatives from government resource agencies, universities, and other environmental concerns. This program would involve monitoring, evaluating and managing the Ohio River ecosystem. A corridor-wide ecosystem needs assessment and strategy, or Program Implementation Plan, would be developed initially to refine ecosystem goals and prioritize restoration efforts. As of the date of this report, this program has not been funded.

Programmatic Environmental Impact Statement — one type of environmental documentation stipulated by Council of Environmental Quality regulations that can be used to assess the implications of policies and programs of federal agencies or actions that are similar in nature or broad in scope.

National Economic Development Plan — that plan that reasonably maximizes the economic value to the nation consistent with sound environmental design principles.

National Ecosystem Restoration Plan — that plan that reasonably maximizes ecosystem quality of environmental resources under consideration in a cost effective manner.