Olmsted Locks and Dam Project
Lessons Learned


U.S. Army Corps of Engineers
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1 Executive Summary

In 1985, the United States Army Corps of Engineers (USACE) Louisville District completed the Lower Ohio River Navigation Feasibility Study IL-KY (Mouth to Cumberland River). This study recommended the replacement of Locks and Dams 52 and 53 with the Olmsted Locks and Dam Project, which is located at Ohio River Mile 964.4 between Ballard County, Kentucky and Pulaski County, Illinois. The resultant project featured twin 1,200' by 110' locks and a new dam consisting of five 110' wide tainter gates, a 1,400' wide navigable pass controlled by 140 boat-operated wickets, and affixed weir extending to the Kentucky bank. The project was subsequently authorized for construction by the Water Resources Development Act of 1988 at a cost of $775,000,000. Section 2007(a) of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) (Public Law 113-121 – June 10, 2014) (Inland Waterways Oversight – Report), required “a report regarding the lessons learned from the experience of planning and constructing the Olmsted Project and how such lessons might apply to future inland waterway studies and projects” as the Olmsted project experienced significant cost and schedule increases during construction. This report focuses on capturing those programmatic lessons learned from the Olmsted project that have application to other major construction projects undertaken by the Corps of Engineers.

The following programmatic lesson learned should be assessed and applied to future inland waterway studies and projects:

a. The incorporation of certified cost estimates from USACE Walla Walla's Cost Engineering Center of Expertise should be used early on and throughout a project to prevent the development of inaccurate and unrealistic project cost and schedule expectations.

b. During the feasibility, planning and design stages of future projects (and individual contracts) appropriate research and more thorough assessments should be completed before selecting methods of construction (e.g. In-The-Wet) as innovation always presents a higher risk relative to the individual project that bears its implementation but also presents the greatest opportunity on a programmatic basis for continuous improvement.

While contemporaneous studies quantitatively supported an In-The-Wet decision for the Dam construction method, it should not be lost that seeking a viable alternate to the traditional (cofferdam) method of delivery was also prevalent amongst USACE, Navigation Industry Stakeholders and Appropriators. The Dam Contractor was allowed to determine specific means and methods within the In-The-Wet approach. However, projects on the scale of Olmsted require years of design and study to ensure all requirements are satisfactorily met. Without the benefit of this hard scope, contractors simply do not have enough information to submit a bid with any degree of certainty.

1 The initial Feasibility cost, estimated at the end of the planning phase, assumes that all engineering, real estate and construction funds will be available at the beginning of the project. This is never the case in a large project (> $100 million).
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Future projects should continue development of appropriate design studies, numerical and physical modeling, industry engagement, formal cost and schedule risk analysis, etc., for quantitative context. Alignment of project specific context and more robust/formalized District Quality Control (DQC), Agency Technical Review (ATR) and Independent External Peer Reviews (IEPR) USACE policy, implemented coincident with Olmsted’s execution, will drive improved project delivery.

c. All projects throughout design, acquisition and construction should give adequate consideration to the anticipated worst and best case scenario of the funding stream. Additionally, USACE must continue to appropriately identify and explain how the funding stream impacts the project cost and schedule so that this information can be communicated vertically within USACE, with cost sharing partners, users, the public, and members of Congress.

d. The lack of a cost-loaded schedule\(^2\) during design also played a role in not identifying the significant up-front costs that would need to be funded on the project. While the contractor identified them in its proposal, the Government was not in a position to shift payment of these costs earlier in the schedule. This is a common problem across all major Federal construction projects and therefore not unique to Olmsted, although in the case of Olmsted, it was exacerbated because of the significant “means and methods” infrastructure build-out.

e. Acquisition of a very large and complex navigation project must emphasize the importance of an accurate assessment of market conditions and construction risks. The Government must determine the appropriate contracting method (firm-fixed-price, cost reimbursable, etc.) based upon all factors. As with the Olmsted Dam contract, if the initial solicitation process returns unfavorable results, the Government should re-assess whether it is prudent to continue with the originally planned contracting strategy or re-evaluate if the solicitation (including the design’s constructability) should be altered to promote a successful award and contract execution. Such a strategy should be based upon realistic assumptions of risks (e.g. funding stream, river conditions, material and equipment availability, etc.).

f. An assessment of how the Architect/Engineer’s (A/E’s) construction experience (especially for innovative construction methods) would dictate (or limit) installation methodology is recommended. It may be inappropriate for future projects to assume that an A/E’s recommended method of construction is the best manner to perform the work. Like for Olmsted, the constructability of the final design for all projects needs to be reviewed to ensure it reflects industry standards/input.

g. USACE would benefit from better recognition of the additional administration and oversight of cost reimbursement contracts. Secondly, before awarding future cost reimbursement contracts (or any acquisition method), USACE should determine the

\(^2\) Cost-loaded schedule describes the resourcing (dollars) to individual activities for a time-phased presentation of expected/planned expenditures.
available Government expertise to manage such a project, ensure appropriate staffing and identify additional training needed for improved contract administration.

h. Projects must have the ability to track cost and schedule changes in a timely manner and have management practices in place to mitigate those changes. Inland waterway projects must have the ability to identify changes early so they can support timely mitigation measures.

i. Vertical Integration and stakeholder engagement is necessary to communicate changes/opportunities throughout the life of the project. Without this involvement from the beginning, the team will be unable to incorporate timely decisions and thereby limit both cost and schedule impacts. The involvement of stakeholders early and continuously throughout the project is essential to determine the best course of action for handling various unexpected issues (funding concerns, contractor performance, unforeseen planning/design concerns, changes in market conditions, etc.). As highlighted by the Olmsted project, all projects should understand the necessity of vertical integration and emphasize the importance of informing the industry/stakeholders in a timely manner (e.g. formal partnering).

j. Engineering Construction Bulletin (ECB) 2014-14 “USACE Mega-Project or Program Management: Additional Program, Project, Engineering and Construction Management Controls” requires for enhanced project delivery teams, recruitment and staffing should continue to be incorporated on future projects. This ECB is the output of an initiative to address and ensure adequate project controls by emphasizing best management practices. The scale, construction method, and acquisition strategy of a project like Olmsted dictate the necessity of a more experienced and skilled staff for successful execution. Attributes which fall under the purview of this policy include projects with: significant cost and duration; unique, complex acquisition/delivery method; national significance; critical completion date or funding constraints; coordination of multiple prime contractors; coordination of multiple design agents/stakeholders; and overlapping/dependent project phases. Specific USACE projects designated as such are specifically listed by name and published as part of the bulletin.

k. When the originally estimated project construction duration increases, USACE must identify the impacts of the associated time growth in a timelier manner. For projects with an anticipated duration beyond five years or otherwise designated (i.e. Mega-Project), the Project Delivery Team should formally review on an annual basis with Enterprise “certification” occurring every two years. At a minimum these items should be evaluated for potential impacts:

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3 Current Mega Project Guidance is ECB No. 2016-16, Updated USACE Mega Projects Guidance issued 26 May 2016.
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- Construction personnel turnover (Government and Contractor) and associated Knowledge Management challenges

- Availability/depth of key design and Architect/Engineer (A/E) staff to provide engineering/design support during construction

- Changes in regulations/requirements (e.g. safety manuals, environmental requirements, technical regulations, security requirements, etc.)

- Outdated technology; requirement to update technology on the project (e.g. hydraulic controls, interfaces, and other system components).

1. It is recommended that future contracts address the life cycle cost and analyze the equipment cost risk associated with extended durations. As with the Olmsted Dam contract, this will be ongoing throughout the life of the contract.

m. It is recommended that future projects develop a transition plan associated with key personnel, especially those projects with extended durations. As with the Olmsted Dam contract, this will be ongoing throughout the life of the contract.

n. Finally, future projects should capture lessons learned and the historical knowledge of subject matter experts, in Qualtrax or other USACE acceptable database.

USACE will implement these recommendations through the new Inland Navigation Design Center (INDC). The INDC is a mandatory center of expertise. The establishment of a center found direction under the USACE Civil Works Transformation initiative. Command and control of the center is provided by Commander, Mississippi Valley Division (MVD). Execution of the Center’s functions is accomplished jointly by the Rock Island and Pittsburgh Districts. HQUSACE also established the Inland Navigation Design Oversight Committee (INDOC), which provides oversight and guidance for the INDC. The mission of the INDC is to provide engineering, design, and review services for studies, new locks, new navigation dams, major rehabilitation of inland navigation locks and dams, and select inland navigation lock and dam O&M projects.

The INDC serves as a national Mandatory Center of Expertise (MCX) that provides technical advice, oversight, and design production during planning, design, construction and O&M of all aspects of inland navigation design projects across USACE, including currently authorized projects. The INDC will be the designer of record, assign and approve the lead engineer, and provide engineering and design services for major capital projects including new locks, new navigation dams, and major rehabilitation of locks and navigation dams. The INDC ensures that independent review of all new construction, major rehabilitations, and O&M for inland navigation lock and dam projects are accomplished in accordance with USACE regulations,
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policy and guidance. The INDC is the HQUSACE and ERDC primary point of contact for all inland navigation engineering and design related issues and resource needs.

This report will be posted on the national lessons learned database. The report will also be available on the Olmsted SharePoint site.
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2 Introduction

2.1 Project Background
In 1985, the United States Army Corps of Engineers (USACE) Louisville District completed the feasibility study for the Lower Ohio River Navigation. The study, which included an Environmental Impact Statement, recommended the replacement of Locks and Dams 52 and 53 with the Olmsted Locks and Dam Project, which is located at Ohio River Mile 964.4 between Ballard County, Kentucky and Pulaski County, Illinois. Reference Exhibit 1 below.

![Location Map](image)

Exhibit 1 - Location Map

The project features twin 1,200’ by 110’ locks and a new dam consisting of five 110’ wide tainter gates, a 1,400’ wide navigable pass controlled by 140 boat-operated wickets, and affixed weir extending to the Kentucky bank. The project was authorized for construction by the Water Resources Development Act of 1988 at a cost of $775,000,000. Initial construction funding was provided by the Energy and Water Development Appropriations Act of 1991.

A contract for cofferdam construction for the lock walls was awarded in 1993 with the lock wall construction awarded in 1995 and completed in 2002. The floating approach walls and operating bulkheads were completed in 2005. In July 1997, the final decision was made to construct the new dam using the innovative In-The-Wet construction method. In 2002, the Louisville District requested proposals for this contract as a firm fixed-price contract, but received no offers. When the contract was re-advertised as a cost-reimbursable contract, the District received responsive proposals, and the contract was awarded to Washington Group/Alberici (WGA) Joint Venture on 28 January 2004.
2.2 The Main Project Features

The dam structure consists of the following main features (reference Exhibit 2 Project Rendering above):

- A tainter gate dam section comprised of five 110' wide bays between six 37' high reinforced concrete pier structures. Five 54' radius spillway tainter gates will span and be supported by the six dam piers. A gate machinery house will be located on top of each pier and contain the machinery and controls necessary to operate the gate. A 116' long stilling basin with baffle blocks will be constructed immediately downstream of the tainter gate section. A service bridge will be constructed to provide above-the-water access from the lock to all the dam piers. The sixth and final concrete pier structure was completed in the 2014 low water season. The first of five tainter gates was erected in the 2014 low water season. It is anticipated the final tainter gate will be erected in 2018, assuming favorable river conditions and continued capability funding.

- A right boat abutment serves as the access structure for the operation boat to access the wicket gates in the navigable pass. It is a 55' wide and 103.5' long concrete monolith on pile foundation. The main structure for the right boat abutment was placed in the 2014 low water season.
• A left boat abutment is located at the fixed weir end of the navigable pass. It is a 165’ wide and 41.5’ long concrete monolith on pile foundation. The left bank training wall will also be part of the left boat abutment and that will be a concrete monolith 60’ wide and 103.5’ long and will connect directly to the 1400’ navigable pass concrete monoliths. This work will be built in a cofferdam, and foundation work will begin in 2016.

• A 1,400’ long navigable pass consists of eleven and a half concrete monoliths that are 120’ wide and 103.5’ long. It employs 140 boat-operated wicket gates to maintain a hinged pool elevation of 300.0 feet at Paducah, KY. When the tailwater elevation is 300.0 feet or higher, the wicket gates are to be fully lowered. The first two monolith shells were placed in the 2014 low water season.

• A fixed weir extends from the Kentucky (south) bank to the left boat abutment. The weir consists of three 63’ diameter sheetpile cells and a cutoff wall to form the permanent dam. This feature of work was completed in 2002.

Specifically for the dam construction, the Contractor started from the Illinois side of the river adjacent to the locks and is incrementally advancing toward the Kentucky side. The dam construction activities are comprised primarily of foundation preparation in the river (material excavation, bedding stone placement, compaction, and foundation pile installation), building concrete shells in the precast yards and subsequently placing those shells in the river. These shells are transported to the river by lifting them with a super gantry crane (5,000 ton capacity). The gantry crane places the shells on a cradle that slides into the river via a rail system. Once transported down the rail into the river, the catamaran barge picks the shell. The catamaran barge places the shell ("sets" the shell) in the river (i.e. In-The-Wet) on previously driven foundation piles. The dam construction activities primarily comprise of the following main stages:

• Prefabrication of the precast concrete segments in a precast yard on the Illinois side of the river adjacent to the completed lock walls.

• Preparation of the river bed and construction of the dam foundation.

• Transport of the precast concrete segments to the river via a super gantry crane and cradle/rail system.

• Transport and placement of the precast concrete segments on previously driven foundation piles.

• Placement of concrete (both underwater concrete and conventional mass concrete).

• Installation of gates, access bridges, mechanical and electrical device.
• Navigation control (such as new river dikes and mooring cells).

The overwater construction work is performed from Mid-June to November in each year, while the precast concrete segments may be fabricated year-round weather permitting.

2.3 Prior Studies/Reports

The following studies and reports were reviewed in the development of these lessons learned:

a. Inland Navigation Construction Selected Case Studies: Marmet Locks & Dam; Monongahela River Locks and Dams 2, 3, 4; Olmsted Locks and Dam – July 2008


c. Review of Project Controls for the Olmsted Locks and Dam Project – April 2012

d. Olmsted In-the-Dry Study – May 2012
3 Lessons Learned – Dam Design Considerations

3.1 Engineering Considerations of the Construction Method

During the design, extensive screening studies were performed for selection of the optimum construction method for the project. The screening studies evaluated various construction methods with regard to their effects on construction schedule and cost, constructability and risks, navigation, and environment. For the Dam portion, the final decision was made to employ the In-The-Wet construction using heavy-lift equipment for installation of large precast concrete shell segments, which would be filled with tremie concrete on the site.

An additional design study was conducted in 2012 to validate whether it would be more expedient/cost effective to sustain the In-The-Wet method or build the remainder of the navigable pass using traditional cofferdam construction techniques. This study revealed that the Stage 3 as defined below was not the best alternative since the work, which required construction of two cofferdams, extended the construction schedule and had similar cost.

This section provides a brief review of the considerations given in the dam design study phase and the lessons learned based upon the experience gained since then. The Dam contract was designed by the A/E joint venture of Jacobs Gerwick.

3.1.1 The Conventional Cofferdam Construction vs. the In-The-Wet Construction Method

The conventional cofferdam construction method was perceived to include a minimum of three construction stages for the dam in this project:

a. The Stage 1 includes the construction of approximately four and one-half tainter gate bays adjacent to the lock.

b. The Stage 2 completes the remaining part of the tainter gate structure, the right boat abutment structure and the first 240' of the 1400' navigable pass structure.

c. The Stage 3 construction includes the remaining 1,160 feet navigable pass plus the left training wall and the left boat abutment that extends into the river from Kentucky.

In each stage, the construction involves installation of a sheetpile cofferdam, construction of the permanent dam structure within the cofferdam, and subsequent removal of the cofferdam. This staged cofferdam method has a successful history. However, the cofferdam construction at the Olmsted Dam Project would encounter more difficult conditions than normally encountered with this type of construction. Accordingly, some of the cost and schedule drivers of the In-The-Dry (cofferdam) method, which was ultimately not selected, are included below for perspective when evaluating risk profiles.

a. The river staging at the dam site is complex and uncertain, which increases the risk of floods overtopping the cofferdam. After the cofferdams are placed in the river, any
extension in the dam construction duration substantially increases the risk that the cofferdam will be overtopped.

b. Since the cofferdam blocks the river flow, there would be a significant increase in river flow and turbulence around the cofferdam. Hydraulic model studies predicted that the maximum velocity of the river flow could be as high as 14.9 feet per second (fps) in Stage 1, 10.9 fps in Stage 2, and 10.5 fps in Stage 3 construction. Also, the swell head for the construction would be only marginally acceptable for navigation. In December through May, 95% of navigation passes would require use of a helper boat.

c. The high river flow velocity greatly increases the scour protection requirements for the cofferdam. Both flow deflectors and rip-rap are required for each stage of cofferdam. In addition, significant scour protection requirements would be needed just to protect the foundation for the future structures to be built. Olmsted is pile founded and the soils below it are very erodible as evidenced by the fact that the lock cofferdam scoured a hole in the dam footprint 30' deep by 200' wide and 1000' long.

d. Suspended sediments in the river may be up to 200 ppm. With the cofferdam in the river, the navigation dredging requirement can be very high. It is estimated that the dredging volume would be 250,000 cubic yards for Stage 1, and 2.25 million cubic yards for Stage 2 and Stage 3 construction, assuming no delay of construction schedule.

e. The Federally listed endangered mussels downstream of the site are susceptible to river sediment and shoaling. These adverse actions must be minimized for protection of the mussels.

In comparison, the selected In-The-Wet construction can readily address these same issues without any special difficulty. This is because the innovative construction requires neither cofferdam nor blockage of the river during the construction. In general, the marine construction activities take place during the months of June through November, during which the river flow velocity is below 4 feet per second for 95% of the time. The plan required no flow deflector or scour protection during the construction. Only the permanent rip-rap for the dam is required, which is about 25% of the rip-rap for the staged cofferdam construction. Furthermore, the In-The-Wet construction alleviates the navigation traffic problem by reducing the river flow, scour, and dredging associated with additional sediment during construction, which has the added benefit of reducing the sediment deposition and shoaling, which are harmful to mussel population.

However, the innovative In-The-Wet construction method for the Dam portion of the Olmsted project is unprecedented in its large scale and high complexity; therefore the innovative design and construction cannot depend on “rule of thumb” of past experience. Many engineering solutions have been identified, evaluated, and carefully developed from concepts to details, including workable construction means. The use of innovation and new technologies invariably involves a steep learning curve and appropriate model development and testing, which are associated with high costs.
Furthermore, it was initially thought the In-The-Wet construction schedule would be highly
dependent on the size, configuration and capacity of the precast yard, however with the benefit of
hindsight, the Olmsted precast yard was adequately sized to support marine activities and had
little to no impact upon the overall construction schedule. Challenges to date on Olmsted have
revealed that the construction schedule is highly sensitive to critical path river activities4
(productivity and operational environment) and availability of specialized equipment. Once
enough resources are available to do foundation preparations in the river during the limited low
water season, the precast yard can keep up with the construction method. However, the precast
yard could limit the flexibility to expedite construction even if the funding is available since the
precast yard size is fixed.

In the Dam portion, both the conventional construction and innovative construction have their
own advantages and disadvantages. It is probable that the conventional method is best suited for
construction of some parts of the dam, while the In-The-Wet construction is best suited for other
parts of the dam (e.g. the left boat abutment). It is noted that the Olmsted method of construction
selection did evaluate cofferdam, In-The-Wet and a combination of both.

3.1.2 The In-The-Wet Construction Methods

All of the In-The-Wet construction methods involve prefabrication of precast concrete dam
segments on shore and installation of the segments at the dam site using marine technologies. The
feasibility studies evaluated the following three innovative methods:

- **The heavy lift-in method** utilizes large lift equipment to transport and install the precast
dam segments and is the selected method for the Olmsted Dam. The size of the precast
segments is maximized in order to reduce the marine operations in the river and allow the
necessary marine work to be completed in the 5.5 month work window every year. The
largest segment with its lift frame weighs 5,000 tons. Therefore, the lift equipment for
these segments had to be specially purchased for the Olmsted Dam Project.

- **The light lift-in method** is similar to the heavy lift-in method except that the maximum
size of each precast segments is controlled so that its weight is under approximately 600
tons. Thus, the existing lift equipment in the inland waterways can be used to install the
segments. The disadvantage of this method is that it requires a substantially larger number
of precast segments to complete the construction.

- **The float-in method** utilizes floating precast dam segments. The float-in method is
applicable only to the tainter gate bays. It is not practical to use this method for the
navigable pass due to its special structural configuration relative to the river depth at the

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4 Critical path analysis denotes identification of those activities which represent the longest path necessary to com­
plete a project. In the case of Olmsted, it runs through marine activities attributable to both production rates (e.g.
pile driving and shell set down) and operational environment (river velocity and elevation). Although some correla­
tion exists between the two, they also can behave independently and employ different risk mitigation strategies such
as resourcing additional equipment and personnel (production) or mobilizing/demobilizing more frequently during
periods of hydraulic volatility (operational environment).
dam site. Special lift equipment (floating crane) would still be needed to construct the navigable pass.

The three methods were evaluated in terms of their construction safety, risks of major accidents or construction claims, exposure to river risks, impact on navigation, track records, reliability of construction schedule, practicality to meet installation/construction tolerances, effects on competitive construction bidding, and effects on cash flow. The three methods received relatively similar ranking, but the heavy lift-in method had the least marine operations. While the heavy lift-in method had the lowest estimated cost, the estimated cost differences were insignificant and within the margin of error. The decision was to pursue the heavy lift-in method for the final design.

The construction of the precast yard and purchase of lift equipment incurred substantially higher cost than initially estimated as discussed below. The screening studies may not have given sufficient credit to the light lift-in method in the following aspects:

a. The light lift-in method takes advantage of the existing lift equipment that has been readily available to the inland river contractors. It minimizes the necessity of purchasing new construction equipment for this project, and is likely to offer a more attractive bid package to marine contractors. It is noted there were indicators the heavy lift-in equipment was available along the coast, and there was the potential to attract these contractors with this bid package. In reality, the heavy lift-in method did not attract any coastal contractors.

b. The light lift-in method requires no special launching facility from the precast yard to deliver the precast dam segments, while large launching facilities, such as the marine skidway, would be required for both the heavy lift-in and float-in methods.

c. The light lift-in precast segments can be handled relatively easily in the precast yard. This would provide more flexibility with equipment handling and maneuvering the segments, and could incur less cost in design and construction of the precast yard.

On the other hand, it is realized that the light lift-in method involves a substantially larger number of precast dam segments than the heavy lift-in method (on an order of 8 times). If the light lift-in method had been adopted, it would have still been an engineering challenge to structurally tie the individual segments together and meet the design requirements in this highly seismic area. Furthermore, the impact to the schedule for the additional lifts would likely cause schedule delays since all placements of the segments are river dependent. It is noted that minimal use of the light lift-in method was implemented in the project with the training walls, bridges and upper piers, but these segments were not on the river bottom but on other previously set segments.

One significant design change made during construction was related to the manner in which the heavy lift in shells were cast and moved on land. It was originally anticipated that they would be moved around on sleds, however design issues related to sled deflection could not be overcome which resulted in changing to a heavy lift crane on land (Super Gantry Crane) in addition to the
heavy lift in the river (catamaran barge). Since this decision was made, it has proven itself to be invaluable because it added flexibility to the shell construction program that didn't exist with the sleds.

For example and to provide scale, fabrication of the Super Gantry Crane and Catamaran Barge cost approx. $30M alone not counting infrastructure to support same. To date 33 Shells (some weighing up to 5,000 tons) have been successfully placed with no major issues. A single "issue" with a particular shell requiring re-casting could impact the project up to 6 to 12 months depending on when during the construction season it occurred with an associated cost of $15M to $30M.

Overall, while these changes may have increased the initial cost, they also considerably reduced the risk exposure while advancing an innovative construction method. It would have been beneficial to perform a comprehensive risk analysis of the innovative construction in the design stage rather than making significant design changes during construction. It is suggested that future projects perform an in-depth cost and schedule risk analysis (CSRA) with the guidance and oversight of the Cost Center of Expertise, Walla Walla District per current Corps policy.

3.2 Cost Estimate in the Design

There were significant discrepancies between the engineers' cost estimate and the project construction cost incurred and projected into the future. In the analysis, the cost discrepancies primarily come from the following sources:

a. A significant economic advantage with the innovative construction method comes from its speedy project delivery, assuming that the project will be fully-funded. It should be noted that the cost overrun could have been even greater with conventional cofferdam construction.

b. Time allowed by the A/E's schedule has since been recognized as being grossly inaccurate. We now know that a realistic schedule would be more than twice the A/E's original forecasted construction schedule and is largely attributable to the Contractor's means and methods determination (engineering cycle) and the subsequent build-out of the associated infrastructure (approx. 5 years). USACE can increase the certainty of its construction schedule forecast by further definitizing atypical construction requirements prior to award. It is noted that Olmsted is somewhat of an anomaly as most of the USACE project portfolio closes virtually all of the engineering/design effort prior to award with minimal support required thereafter. The difficulties of building in the river and the technical requirements to perform this unique method of construction were also underestimated. Staffing of a dedicated project scheduler is part of the USACE Mega-project initiative reducing the reliance on contracted single party expertise.

c. The A/E's cost estimate underestimated various aspects of the contractor's schedule constraints associated with seasonal cyclic work. Given the ever-changing conditions of the river, the appropriate risk analysis needs to be performed on future projects, especially those involving innovative construction methods. USACE now employs a formal Cost and
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Schedule Risk Analysis (with 80% certainty) to better capture and evaluate risks on all designated Mega-Projects. This evaluation mandates an internal (Agency Technical Review) peer review.

d. Since the award of the contract in 2004, the construction market has gone through significant changes due to several unforeseen factors. The Hurricane Katrina damage restoration created a severe shortage in marine construction equipment. The selected contractor brought very little equipment of his own to the project, and a lot of the equipment is specialized just for this method, thus nearly all marine equipment for the project has to be purchased. As estimated in the Olmsted Post Authorization Change Report (PACR), these market conditions drove an estimated $82M cost increase and 1 - 2 year schedule increase.

e. The domestic and international construction booms during 2004 through 2010 created high demand for basic construction materials and resulted in high escalation cost. In the first 5 years after award of the Dam contract, steel and cement costs increased several hundred percent. Material and the aforementioned equipment costs in aggregate represent approximately $300M of direct and schedule driven cost impacts given the constrained funding.

It is also noted the 1997 engineer’s estimate (without escalation), which influenced the decision to construct the dam In-The-Wet, and later 2004 Government Estimate, were nearly 50% and 70% respectively of the market pricing received in 2004. Again, it is recommended future projects perform an in-depth cost and schedule risk analysis (CSRA) and certified cost estimate through USACE Walla Walla's Cost Engineering Center of Expertise. This is also a requirement of the ECB 2014-14 issued in June 2014.

3.3 Engineering during Construction

The contract design defines a general construction erection plan for the precast concrete dam segment. The geometry for the precast segments for both the tainter gate and navigable pass sections were defined as a part of the erection plan. The design of these segments considered overall structural geometry, segment size and weight, and the handling and placement of the segments including the lift frame. The segments were designed for loading conditions anticipated during the various construction stages including the dry and buoyant self-weight, weight of the lift frame, river flow induced pressure, dynamic impact during erection, and hydrostatic pressures and tremie concrete pressure on the precast segments.

The contract design drawings, however, provide only a concept design of precast yard and launching facilities for the precast dam segments. The design assumed that the precast yard erection load conditions would not govern the design of the precast segments.

The final design of the precast yard and launching facilities was completed during the construction, which made several major changes to the design concept for the lift-in construction, including:
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- Five precast concrete slabs-on-grade are used as the precast bed for casting the precast dam segments in lieu of using a steel cradle on railways
- The precast dam segments are moved with a gantry crane in the precast yard
- The catamaran crane barge is re-designed to lift the precast segment in a partially submerged rather than in the submerged condition

These changes allowed future flexibility to maneuver and set the segments without “blocking” them behind other segments. Both the precast dam segments and the marine lift equipment were consequently re-designed for lifting in-the-dry condition. Overall, these design changes reduced the construction risks during the fabrication and installation of the precast dam segments.

Since many design features of the precast concrete segments and heavy lift equipment are closely related to the precast yard and launching facilities, it would have been much more effective to complete the design of the prefabrication and launching facilities during the design phase rather than as a part of the construction phase. The potential downfalls to this would have been not involving the construction contractor to take advantage of their experience. As an example, one of the most significant issues related to the design of the prefabrication facility was raised by the contractor trying to determine how to deal with deflection induced loads on the forms and the partially cast concrete segments.

There are several other significant lessons that have been learned as a result of the first 6 years of dam construction to include the following:

a. Precast concrete shells had to be completely sealed to keep tremie concrete from flowing out of the openings and into the river.

b. The significant challenge of how to gage where the tremie concrete was going during placements was solved using a unique bubbler system.

c. Precast pier shells significantly reduced the available work area for the tainter gate trunnion support steel which led to changing to a continuous concrete placement. The uninterrupted placement is considered outside the norm of placing concrete in multiple lifts.

d. The super gantry crane has provided numerous advantages because of its ability to lift one shell over another to provide flexibility in the precast yard.

e. The tainter gate portion of the dam required a deep hole be excavated at the bottom of the river for the foundations. Since the foundation work spanned multiple seasons, these excavations filled-up multiple times with sediment before a tainter gate precast shell was placed in the river. This required the contractor to perform several additional excavations and cleanings. Accordingly, the impact of this "annual" differing site condition was
underestimated, and had it been more accurately captured, may have influenced the evaluation of proposed construction methods for this feature of work.

Additional detailed construction lessons learned were previously captured in the enterprise level database. It is planned for additional information to be captured in the future. USACE is also utilizing lessons learned from the construction of Olmsted by incorporating them where applicable in the rewrites of our engineering design manuals. Two specific manuals, Engineering Manual (EM) 1110-2-2906 on Piling and EM 1110-2-2611 on the use of Pre-Fabricated Elements, have or are in the process of being updated.

In conclusion, these changes (some of which were improvements to the construction methodology) are attributable to the fact that the plan developed by the A/E had little input from contractors. By leaving the final design up to the contractor, the contractor was able to evaluate the risk and finalize the fabrication and installation using the method he was more comfortable with for installing the shells. Future projects need to assess how the A/E’s construction experience (especially for innovative construction methods) would dictate (or limit) the installation methodology. It may be inappropriate to assume an A/E’s method of construction is the best manner to perform the work. USACE has implemented both assignment of a project “Lead Engineer” solely responsible for all technical outcomes on a project and staffing of an “Inland Navigation Design Center (INDC)” to provide a centralized repository of expertise and oversight.
4 Lessons Learned – Dam Contracting/Acquisition

4.1 Firm Fixed Price Contracting

The Dam construction contract was initially intended to be a fixed-price contract. Louisville District conducted a market survey and held outreach meetings and pre-bid meetings with the contractors interested in the project. During these meetings, the innovative design as well as the innovative construction means and methods were presented. Six construction firms or joint ventures indicated their interest in offering a bid on this project.

Concerns with the overall budget began with this initial advertisement of the dam construction contract. After the fixed-price bid package was issued for competitive bidding, the interested firms expressed their concerns with construction risk exposure in this project. As a result, USACE modified certain contract terms and specifications. The intent of the modifications was to address identified risks by the Government assuming more of it. Even after these modifications to the solicitation, none of the firms offered a bid for the fixed-price contract. Even the second advertisement as a cost reimbursable contract had limited competition, as indicated by the number of proposals received (2), and required an extended construction period.

The Olmsted Dam contract is unique in several aspects that adversely impacted the fixed-price contracting:

a. The Dam is very large in scale and complexity. This situation limited the qualified bidders to a very few large construction companies who have the necessary resources and bonding capacity. As the market demand for the large construction projects increases, the large firms can be easily attracted to more profitable projects of shorter durations and with less risk. Engagement opportunities (e.g. industry forums) are emphasized to solicit feedback, implement best practices and develop a larger cadre of capable contractor partners.

b. The construction risks at the project site are high: River stage fluctuation can at times be rapid and significant (approximately 30 feet fluctuation within a few days); suspended sediment in the river can be up to 200 ppm; traveling sand waves 10 feet in height regularly pass through at the site; and potential for severe erosion is very high.

c. The project prescribes In-The-Wet construction and requires the use of heavy lift equipment in the river. This innovative construction method is unprecedented for navigation structures in the inland waterways and can be perceived by contractors as an additional risk.

d. Contracting for a very large and complex navigation project must give high priority to an accurate assessment of the market conditions and provide sufficient accommodation for anticipated construction risks. If the project is assessed to contain high uncertainties and risks in construction, the Government needs to develop a strategy for risk sharing with the contractor. The strategy should be based upon realistic assumptions of risks by the Government and proper equitable compensations for the contractors. If there is inadequate
contractual limitation on the risks involved in a project, the end result is a lack of interest from the construction industry and little or no competition for the contract.

e. USACE is actively building upon its relationship with large construction contractors with surveys, partnering engagements and two step procurements. New acquisition strategies are being explored like Early Contractor Involvement (ECI) to solicit contractor input prior to award, and USACE has a robust small business program in place to grow the next generation of large businesses.

4.2 Cost Reimbursable Contract

Since no bids for the firm-fixed-price contract were received, the contract solicitation was modified to a cost reimbursable basis. The intent of the modification was to further reduce the contractor’s risk to a minimum, while still providing the contractors with incentive for competitive bidding and performance. Two bids for the cost reimbursable contract were received, and the contract was awarded to Washington Group/Alberici Joint Venture in 2004.

The cost reimbursable contract has provided sufficient flexibility to the construction management to adjust the construction schedule according to the funding stream. Had the fixed-price contract been awarded, the increases in project costs, extension of the construction schedule, and annual funding allocations that differed from those included in planning documents would have resulted in major construction modification and/or claims.

However, the cost reimbursable contract created new administrative problems that are typically not present in the fixed-price contracts. USACE field office administration and oversight of a cost reimbursement contract is substantially greater than a fixed-price contract. The field office is heavily involved in the everyday operations and decisions of the contractor. Additional duties include such things as: acquisition review, property control, earned value (EVMS) review, voucher review of all costs, and a more detailed schedule review. Additionally, USACE has to expend administration efforts to track and record the contractor’s performance in many areas (e.g., productivity and cost) and also evaluate the contractor on a monthly basis. The purpose of the evaluation is to determine the incentive bonus (i.e. award fee) for the contractor for a cost reimbursement type contract. These added administrative efforts increase the USACE/Contractor staff needs and accordingly increase the overhead/administrative burden (approx. $5M annually on a project the scale of Olmsted). In addition to tracking construction performance, one of the biggest challenges of Cost Reimbursement has been how to properly incentivize the contractor to manage the contract with the appropriate supervision and overhead expenses. Production (schedule) goals need to be carefully balanced against cost, quality and safety metrics and while being revisited prior to each award fee period to ensure contractor behavior aligns with Government objectives. Future contracts should consider the additional administration and oversight of cost reimbursement contracts and weigh this with the associated benefits of that contract method. Also, before awarding future cost reimbursement contracts (or any method of contract), USACE should determine the available expertise to manage such a project and what additional training will be needed to administer the contract.
5 Lessons Learned – Dam Construction

5.1 Extended Construction Schedule

The construction schedule has consequently been extended from the A/E’s estimate of five years to eight years at award. The current schedule shows a dam contract completion date of March 2019, which will be just over 15 years. The extended timeline presented a series of challenges in the construction planning, management, and cost control, including:

a. Construction management overhead is about $30 million per year. In addition to the typical project cost items such as insurance, bond and office overhead, some other major factors also contribute to the overhead cost: (a) the cost reimbursable contract increased the administration cost for overseeing the construction performance and tracking the schedule and costs; (b) the use of the innovative construction method required considerable engineering efforts during construction and field verification through demonstration testing and (c) the use of the innovative construction method and equipment required increased management costs for the contractor through his attempts to retain highly trained employees that are knowledgeable on the equipment and procedures.

b. Construction equipment: The A/E’s initial plan was to rent most construction equipment for 4-6 years. The extension of the construction schedule changed the economy of equipment renting vs. purchasing. It became more economical to purchase the majority of the equipment. This measure increased the up-front project cost. Furthermore, all of these significant up-front costs came early in the project during a time of reduced funding. As it is, the equipment cost (additional maintenance and replacement of equipment as it ages) has increased with the construction duration. It is recommended that future contracts address the life cycle cost and analyze the equipment cost risk associated with extended durations. As with the Olmsted Dam contract, this will be ongoing throughout the life of the contract.

c. This innovative construction method is a linear process and provides little flexibility to subsequently accelerate the project schedule. The precast yard determined the number of precast dam segments to be fabricated each year; and the dam construction must proceed from one end of the dam to the other. Even if the project conditions are sufficient to expedite the work at a later time, the construction management and methodology have difficulty speeding up the work to take advantage of funds being available.

d. The In-The-Wet method does have an added benefit of accommodating an extended schedule, versus a conventional cofferdam, as this innovative method does not create a sustained navigation hazard for the duration of the construction activity.

e. Also with an extended construction schedule, key technical personnel in the project team inevitably changed over time. Given the complexities of this project, construction management has difficulty retaining consistent technical support over a contract of this duration.
f. It is also difficult to maintain consistent construction management and knowledge transfer for both the contractor and USACE. Future projects should develop transition plans for key personnel to address turnover on projects with extended durations.

g. Another impact of an extended construction schedule involves the potential changes in regulations/requirements (e.g. safety manuals, environmental requirements, technical regulations, security requirements, etc.), and technology leading to a requirement to update technology on the project (e.g. hydraulic controls, interfaces, and other system components). Regulatory changes and technological improvements will have impacts on contracts with extended durations.

h. Extended duration impacts the cost of the overall project if it requires unexpected operation and maintenance cost for previously accepted structures/property (e.g. buildings, locks, hydraulic controls, other real property, etc.). The Olmsted Locks, Miter Gates, Culvert Valves, Operating Bulkheads and Approach Walls will have been completed for over 15 years before the Olmsted Locks and Dam becomes operational. The additional cost to maintain previously completed structures over this extended time was not anticipated. The maintenance and sustainability cost for accepted work should be considered on future projects, especially if those projects experience significant time growth.

5.2 Market Conditions and Cost Growth

Since the completion of the A/E’s dam design in 2001 and the award of the construction contract in 2004, there have been major changes in market conditions (representing approx. $300M direct cost impact or almost 10% of the project total cost) including:

a. The domestic construction market has been increasingly tight, as many construction companies and fabricators are fully occupied with other major civil construction projects. These conditions were exacerbated by the Hurricane Katrina restoration in New Orleans.

b. There has been a severe shortage of skilled labor and construction equipment, such as steel fabricators and barges. The severity of the shortage has fluctuated, but as with market conditions, it intensified during the Hurricane Katrina restoration.

c. The domestic and international markets have driven up construction material costs. Many suppliers refused to lock in prices and demanded escalation clauses be included in the contract. In 2002 to 2007, some examples of cost escalation in construction materials include:

- Cement cost increased by approximately 90%.
- Fabricated steel cost increased by approximately 300%.
- Rip rap cost increased by 100% to 200%.
• Fuel cost increased by approximately 300%.

• Lumber cost increased by approximately 83%.

d. In addition to the construction material cost escalations, the cost of insurance and bonding increased by approximately 230%.

e. Subsequent fuel increases from 2008 – 2013 had significant cost implications for the project.

The importance of recognizing potential changes in future market conditions and developing a solid strategy to project the escalation is critical. Escalation of construction material cost and bonding is always volatile, and the project cost increase becomes more out of balance when the construction schedule is substantially extended.

5.3 Construction Management

Construction management of this project faced many challenges including a cost reimbursable contracting method, and implementation of the innovative construction method, the lack of optimum funding, and cost escalation. Overall, the construction management demonstrated competence and flexibility in keeping the project moving forward. Nevertheless, there are some lessons to be learned, including:

a. The lack of valuable cost estimating during the feasibility, the authorization, the initial independent government estimate in 2003 and up until the Post Authorization Change Report (PACR) compounded the inability to effectively identify cost growth (risk management). The certified cost estimate in November 2011 associated with the PACR development (revised April 2012) became the first clear measuring tool for managing project cost growth by identifying and mitigating risk referred to by USACE as formal Cost and Schedule Risk Analysis and is now mandatory for all projects in excess of $40M and initially implemented back in 2007 in ECB No. 2007-17.

b. The lack of effective scheduling. Similar to cost, the lack of Government expertise to review and assess the impacts to the schedule (whether from additional design efforts, inefficient funding, poor productivity, etc.) on a contract of this complexity was not addressed early enough in the project.

1) Also, as noted in the “Review of Project Controls for the Olmsted Locks and Dam Project” report prepared independently by LMI in April 2012,

"Thus, the dam contract was an anomaly that the project team was ill-prepared to deal with. To its credit, the team recognized this problem and took corrective action by pro-actively and energetically instituting methods and techniques in contract management, construction management, and cost management to control project costs. It continually sought to improve those methods and techniques, many of which were
and continue to be industry best practices. Additionally, all of the methods and techniques were consistent with prevailing USACE and Department of Defense guidance. Thus, although it is a valid criticism that the team was initially ill-prepared to manage a cost-reimbursable contract, this shortcoming was not a significant factor in explaining cost and schedule overruns.

c. There was a need for additional research to be performed during design before moving forward with a new, innovative method. Given the unique aspects of In-The-Wet construction, USACE should have required detailed simulations of the conditions and construction methods before completing the design and moving forward to solicitation. The final design should have been supported with extensive modeling of the same conditions. Future projects should consider the potential risks of new, innovative construction methods as they relate to overall impacts (cost and schedule). These projects should also determine the appropriate level of modeling and design to understand the risk associated with the selected construction method.

d. In addition to the lessons addressed above, future mega-projects should review and adhere to the requirements/tenets outlined in ECB 2014-14 issued in June 2014.
Lesson Learned Report on the Olmsted Locks and Dam Project

6 Overall Project Cost Growth

The Olmsted Locks and Dam project has incurred significant cost increase since the original authorization. Although cost increases to the authorization came from both previously completed contracts (to include the lock cofferdam, lock walls, floating approach walls, operating bulkheads, fixed weir, etc.) and the current dam contract, the considerable cost growth of the project beyond the project’s authorized limit has occurred during the Dam contract. That said, the overall project cost growth is attributable to various sources, including:

a. The extended construction schedule, its associated overhead/escalation, and unpredictable funding alignment during certain timeframes.

b. The market condition changes, such as the construction material cost escalation and the shortage of the labor and equipment.

c. The contractors’ omissions in the original bid. This includes contractors seriously underestimating how the ever-changing nature of the river would impact productivity, as well as the risk of working under volatile market conditions, and omissions associated with the lack of coordination and communication between the A/E and construction contractor.

d. The changes from the original design, such as differing site conditions, equipment requirements, construction methodology and other features not clearly captured in the design.

The construction management needs to maintain a high priority on cost control, even though most of the major contributing factors to cost growth are not within the control of the construction management organization. Unless the project is well-funded and market conditions are stabilized, the project will continue to incur substantial cost growth even at later stages (i.e. throughout the construction phase) of the project.
Lesson Learned Report on the Olmsted Locks and Dam Project

7 Summary

The main lessons to be learned to date are listed below.

The following programmatic lesson learned should be assessed and applied to future inland waterway studies and projects:

a. As with the Olmsted Dam contract, future projects will need to evaluate the risk of receiving less than optimum or uncertain funding and any correlation to utilization of an innovative construction method. Furthermore, the impacts and opportunities of optimal funding, cost and schedule escalation and reliance on realistic estimating products are compounded if the innovative method necessitates a cost reimbursement contract vehicle.

b. When the originally estimated project construction duration increases, USACE must evaluate all the impacts of the associated time growth. For the Olmsted Project, the extended duration of this project has created impacts not normally associated with other projects. For projects with an anticipated duration beyond five years, annual review by the Project Manager, coincident with the Project Management Plan update, should address:

- Loss of historical knowledge with the turnover of staffing. Organizational efficiency is also impacted with loss of key personnel (Contracting Officer, Lead Engineers, Resident Office personnel, Contractor personnel, etc.)

- Key design personnel can easily become one-deep “experts” on the project, and when contracted A/E services are utilized, hinder professional development of Government design personnel. While original members of the design team add considerable legacy value over time, management of these same resources must be deliberate to build the bench behind them and sustain technical competency.

- Changes in regulations/requirements (e.g. safety manuals, environmental requirements, technical regulations, security requirements, etc.)

- Outdated technology; requirement to update technology on the project (e.g. hydraulic controls, interfaces, and other system components).

c. Both the conventional construction and innovative construction have their own advantages and disadvantages for the Olmsted Dam Project. But, the innovative construction methods used on this project are unprecedented in scale and complexity. Therefore, during the feasibility, planning and design stages of future projects (and individual contracts) appropriate research and thorough assessments should be completed before selecting methods of construction (e.g. In-The-Wet). Future projects should also consider the appropriate studies (design level), modeling, discussions with industry, formal cost and schedule risk analysis, etc., that should be completed. Robust
District Quality Control (DQC), Agency Technical Review (ATR) and Independent External Peer Reviews (IEPR) should be emphasized and incorporated on all projects as dictated by USACE policies and regulations.

d. Inaccurate cost and overly optimistic schedule estimates for the Olmsted project established expectations that were unrealistic to accomplish. Both the Government’s estimate leading to authorization and the A/E’s estimate for the Dam contract did a poor job of reflecting the risk associated with a project of this complexity. Although the cost growth is attributable to the various events (inefficient funding, material cost escalation, equipment shortage, etc.), the overly optimistic estimate of a shorter construction schedule also contributed to the cost overrun. It is also noted that USACE’s confidence of contractors’ price proposal was misplaced. The incorporation of certified cost estimates from USACE Walla Walla's Cost Engineering Center of Expertise should be used early on and throughout a project to prevent the development of inaccurate and unrealistic project cost and schedule expectations.

e. The lack of a cost loaded schedule during design also played a role in not identifying the significant up-front costs that would need to be funded on the project. While the contractor identified them in his proposal, the Government was not in a position to shift payment of these costs earlier in the schedule. This is a common problem across all major Federal construction projects and therefore not unique to Olmsted, although in the case of Olmsted, it was exacerbated because of the significant “means and methods” infrastructure build-out.

f. Acquisition and contracting for a very large and complex navigation project must give high priority to an accurate assessment of the market conditions and construction risks. The Government must determine the appropriate contracting method (firm-fixed-price, cost reimbursable, etc.) based upon all factors. As with the Olmsted Dam contract, if the initial solicitation process returns unfavorable results, the Government should reassess whether it is prudent to continue with the originally planned contracting strategy or re-evaluate if the solicitation (including the design’s constructability) should be altered to promote a successful award and contract execution. Such a strategy should be based upon realistic assumptions of risks (e.g. funding stream, river conditions, material and equipment availability, etc.)

g. Vertical Integration and stakeholder engagement is necessary to communicate changes/opportunities throughout the life of the project. Without this involvement from the beginning, the team will be unable to incorporate timely decisions and thereby limit both cost and schedule impacts. The involvement of stakeholders early and continuously throughout the project is essential to determine the best course of action for handling various unexpected issues (funding concerns, contractor performance, unforeseen planning/design concerns, changes in market conditions, etc.). As highlighted on the Olmsted project, all projects should understand the necessity of vertical integration, and emphasize the importance to inform the industry/stakeholders in a timely manner (e.g. formal partnering).
h. Engineering Construction Bulletin (ECB) 2014-14 “USACE Mega-Project or Program Management: Additional Program, Project, Engineering and Construction Management Controls” requirements for enhanced project delivery teams, recruitment and staffing should be incorporated on future projects. During the initial phases of the project/contract, the need for specific integrated project team members (Contracting Officer, Real Estate, etc.) located at the project site should be reviewed.

i. Changes to the final design (some of which were improvements to the construction methodology) should have input from contractors. Changes were attributable to delays and cost increases because the plan developed by the A/E had little input from contractors. By leaving the final design up to the contractor, the contractor was able to evaluate the risk and finalize the fabrication and installation using the method he was more comfortable with for installing the shells. The A/E’s limited construction experience could not dictate the installation methodology; therefore it would also be inappropriate to assume the A/E’s method of construction was the best manner to perform the work. An assessment of how the A/E’s construction experience (especially for innovative construction methods) would dictate (or limit) installation methodology is recommended. It may be inappropriate for future projects to assume that an A/E’s recommended method of construction is the best manner to perform the work. Like for Olmsted, the constructability of the final design for all projects needs to be reviewed to ensure it reflects industry standards/input.

j. Future contracts would benefit by recognizing the additional administration and oversight of cost reimbursement contracts and weighing this against the associated benefits of that contract method. Secondly, before awarding future cost reimbursement contracts (or any method of contract), USACE should determine the available expertise to manage such a project and ensure appropriate staffing and what additional training will be needed to properly administer the contract.

k. It is recommended that future contracts address the life cycle cost and analyze the equipment cost risk associated with extended durations. As with the Olmsted Dam contract, this will be ongoing throughout the life of the contract.

l. It is recommended that future projects develop a transition plan associated with key personnel, especially those projects with extended durations. As with the Olmsted Dam contract, this will be ongoing throughout the life of the contract.

m. Finally, future projects should capture lessons learned and the historical knowledge of subject matter experts, in Qualtrax or other USACE acceptable database.

This report will be posted to the enterprise Lessons Learned/Inland Navigation Design Center (INDC) database and available on the Olmsted SharePoint site.