



February 2017

ARMY CORPS OF ENGINEERS

Factors Contributing to Cost Increases and Schedule Delays in the Olmsted Locks and Dam Project

GAO Highlights

Highlights of [GAO-17-147](#), a report to congressional committees

Why GAO Did This Study

The Corps is responsible for planning and constructing the Olmsted Locks and Dam project on the Ohio River, 17 miles upstream from the Mississippi River. The project will replace two locks and dams, which are beyond their design lives, with new locks and a new dam. According to the Corps, more tonnage passes through Olmsted annually than any other place in the nation's inland navigation system. The Water Resources Development Act of 1988 authorized the Olmsted project at a cost of \$775 million. The Corps estimated construction would take 7 years. In 2012, the Corps submitted a PACR to Congress, seeking to increase the Olmsted project's authorized cost to \$2.918 billion, with an estimated completion date of 2024.

The Water Resources Reform and Development Act of 2014 included a provision for GAO to report on why the Olmsted project exceeded its budget and was not completed as scheduled, among other things. This report examines (1) the factors that the Corps and others have identified as contributing to cost increases and schedule delays and (2) what is known about the costs of benefits foregone because of project delays. GAO compared the factors cited in the PACR and three relevant Corps and consultant reports, examined the Corps' economic analyses and developed an estimate of construction interest incurred because of project delays, and interviewed Corps officials and industry representatives.

GAO is not making recommendations in this report. The Department of Defense had no comments to add to the report.

View [GAO-17-147](#). For more information, contact Anne-Marie Fennell at (202) 512-3841 or fennella@gao.gov.

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What GAO Found

Reports by the U.S. Army Corps of Engineers (Corps) and consultants it hired identified the construction method, contract type, and other factors as primary contributors to cost increases and schedule delays in the Olmsted Locks and Dam project. Specifically, the 2012 Corps' post-authorization change report (PACR) and a 2012 consultant report identified the Corps' 1997 selection of an innovative in-the-wet method to construct the dam as a contributing factor. With this method, concrete sections of the dam, or shells, are built on shore, carried out into the river, and set in place in the riverbed. The Corps decided to use this method based on projections that it would cost less and allow the project to be completed sooner than the traditional in-the-dry method using temporary, watertight structures, or cofferdams, to drain the riverbed to allow work. However, the Corps' initial cost estimate was low and did not adequately consider such things as river conditions that slowed construction. A 2012 Corps study compared the in-the-wet and in-the-dry methods and found that continuing to use the in-the-wet method would cost more but would allow the project to be completed sooner. Based on this study, the Corps continued to use the in-the-wet method. In addition, the PACR and a 2008 consultant report found that the Corps' decision to use a cost-reimbursement contract for the dam construction after receiving no offers for a firm fixed-price contract contributed to increased administrative and overhead costs. The reports noted that managing a cost-reimbursement contract was more cost- and time-intensive than managing a firm fixed-price contract, which the Corps typically uses. The Corps and consultant reports also identified other contributing factors, including limited funding; market condition changes, such as unexpected and significant increases in the price of construction materials; and design changes during the dam construction in response to soil conditions and other issues.

The benefits foregone because of delays at Olmsted are uncertain, primarily because the Corps' estimates for the project are no longer relevant or are of limited use for estimating the benefits that might have been generated had the project opened as planned in 2006. The Corps estimated the benefits associated with the project several times, including in a 1990 study. Corps officials said, however, that the benefit estimates from this study are no longer relevant for estimating benefits foregone because of past project delays. In particular, the 1990 study did not anticipate the regulatory and market factors that reduced the demand for coal shipments on the Ohio River, beginning in the 1990s. In the 2012 PACR, the Corps updated its benefit estimates based on a revised opening date of 2020, but they are of limited use for estimating benefits foregone for several reasons. For example, the analysis was based on assumptions about barge forecasts that may not represent the actual traffic that transited the locks and dams during past delays. According to Corps economists, the additional interest incurred during construction because of project delays is another type of benefit foregone because it represents the hypothetical return or "benefit" that could have been earned by investing the money in some other use. GAO found that the difference in interest estimated in 1990 and in the PACR to be about \$400 million, which represents an estimate of the additional interest associated with such factors as changes in the project design that led to the construction delays and increased construction costs.

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Abbreviations

Corps	U.S. Army Corps of Engineers
EPA	Environmental Protection Agency
PACR	post-authorization change report
WRDA	Water Resources Development Act
WRRDA 2014	Water Resources Reform and Development Act of 2014

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February 16, 2017

The Honorable John Barrasso
Chairman
The Honorable Tom Carper
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Bill Shuster
Chairman
The Honorable Peter A. DeFazio
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The U.S. Army Corps of Engineers (Corps) is responsible for planning and constructing the Olmsted Locks and Dam project, which is on the Ohio River, 17 miles upstream from the Mississippi River. The project will replace two locks and dams, which are beyond their design lives and unreliable, with a new set of locks and a new dam. The project is in a key location. Virtually all barge traffic moving between the Ohio River and its tributaries and the Mississippi River system must pass through this stretch of river. According to Corps documents, more tonnage passes through Olmsted annually than any other place in the nation's inland navigation system.¹

The Water Resources Development Act (WRDA) of 1988 authorized the Olmsted project at a cost of \$775 million (in October 1987 price levels), with the costs of construction shared equally between funds appropriated to the Corps and from the Inland Waterways Trust Fund.² At the time, the

¹The U.S. inland waterway, or navigation system, comprises the navigable waterways of the Mississippi River and its tributaries, the Ohio River basin, the Gulf and Atlantic Intracoastal Waterways, and the Columbia River, among others. Navigation on this system is made possible by locks and dams. Locks provide navigation access through dams, by which vessels are lifted or lowered depending on the direction of travel. The Corps estimates that approximately 91 million tons of waterborne commerce passes through this area each year.

²Pub. L. No. 100-676, § 3(a)(6), 102 Stat. 4012, 4013 (1988). The Inland Waterways Trust Fund was established to help pay for construction and rehabilitation for navigation on the U.S. inland and intracoastal waterways. The trust fund is funded by a fuel tax levied on commercial towing and other companies using the inland and intracoastal waterways.

Corps estimated construction would take 7 years. The Corps also estimated benefits, such as transportation cost savings, associated with the project. However, once the project was going to exceed its maximum authorized cost, the Corps prepared and submitted a post-authorization change report (PACR) to Congress in 2012, seeking to increase the Olmsted project's authorized cost to \$2.918 billion (in October 2011 price levels), with an estimated operational date of 2020 and completion date of 2024.³ The Corps submitted the PACR for an independent external peer review before it was submitted to Congress.⁴ Subsequently, the Continuing Appropriations Act, 2014, increased the project's authorized cost to \$2.918 billion.⁵

In recent years, the Olmsted project used the majority of trust fund appropriations, which constrained the amount available for other projects on the inland navigation system. The Consolidated Appropriations Act, 2014, reduced the trust fund's cost share for the Olmsted project from 50 to 25 percent for fiscal year 2014.⁶ For subsequent fiscal years, the Water Resources Reform and Development Act of 2014 (WRRDA 2014) further reduced the trust fund's share to 15 percent. According to a congressional committee report accompanying the bill, since the project impacts the pace of other projects in need of recapitalization, the committee recommended a change in cost share to speed the pace of other projects on the inland navigation system.⁷ The act also expressed the sense of Congress that the annual appropriation for the Olmsted

³See U.S. Army Corps of Engineers, *Locks & Dams 52 and 53 Replacement Project (Olmsted Locks and Dam) Illinois and Kentucky, Post Authorization Change Report* (revised April 2012). A PACR is a decision document that may be required when project features have changed significantly or if the estimated costs have changed substantially after Congress authorizes a Corps project. Operational date refers to the date the project can be used for navigation purposes. Completion date refers to the date the existing locks and dams have been removed, all equipment has been removed from the site, and all work has been completed and accepted by the government.

⁴An independent external peer review is conducted by a panel of experts external to the agency whose work product is being reviewed. The purpose of the review is to provide an independent assessment of the adequacy and acceptability of the methods, models, and analyses used.

⁵Pub. L. No. 113-46, div. A, § 123, 127 Stat. 558, 562 (2013).

⁶Pub. L. No. 113-76, div. D, tit. I, 128 Stat. 5, 153 (2014).

⁷H.R. Rep. No. 113-246, at 65 (2013).

project should not be less than \$150 million until construction is completed.⁸

WRRDA 2014 included a provision for us to report on why the Olmsted project exceeded its budget and was not completed as scheduled, among other things.⁹ This report examines (1) the factors that the Corps and others have identified as contributing to cost increases and schedule delays and (2) what is known about the costs of benefits foregone because of project delays.

To determine what factors the Corps and others have identified as contributing to cost increases and schedule delays, we focused on increases in the Olmsted project's estimated cost and schedule from authorization to the 2012 PACR, which documented the factors contributing to the Olmsted project's authorized cost increasing to \$2.918 billion.¹⁰ We visited the project site in October 2015 to familiarize ourselves with the project and to interview Corps officials on the Olmsted project delivery team to obtain information on such things as the project's chronology, costs, schedule, engineering methods, project management, and reasons for cost increases and schedule delays. Based on our discussions with Corps officials and our previous work,¹¹ we identified two Corps reports and two consultant reports prepared for the Corps that discussed the reasons for cost increases and schedule delays in the Olmsted project, including the Corps' 2012 PACR,¹² a 2008 Corps report,¹³ a 2008 consultant report,¹⁴ and a 2012 consultant report.¹⁵ We

⁸Pub. L. No. 113-121, § 2006(a)(3), 128 Stat. 1193, 1267 (2014).

⁹Pub. L. No. 113-121, § 2007(c), 128 Stat. 1193, 1268 (2014).

¹⁰We did not examine the changes in the project's estimated cost and schedule that occurred after the 2012 PACR.

¹¹GAO, *Army Corps of Engineers: Cost Increases in Flood Control Projects and Improving Communication with Nonfederal Sponsors*, [GAO-14-35](#) (Washington, D.C.: Dec. 20, 2013).

¹²U.S. Army Corps of Engineers, *PACR*, 2012.

¹³U.S. Army Corps of Engineers, Great Lakes and Ohio River Division, *Inland Navigation Construction, Selected Case Studies, Olmsted Locks and Dam* (July 17, 2008).

¹⁴Ben C. Gerwick, Inc., *Olmsted Dam Project, Lessons Learned Report*, U.S. Army Corps of Engineers (March 2008).

¹⁵LMI, *Review of Project Controls for the Olmsted Locks and Dam Project*, Report CE209T1 (April 2012).

reviewed these reports using criteria such as whether the conclusions are consistent with the findings, and determined that they were sufficiently reliable as evidence of the factors that the Corps and others have identified as contributing to cost increases and schedule delays. We did not verify the numbers cited in the reports we reviewed. We identified and compared the factors cited in the PACR and those cited in relevant reports to identify discrepancies or omissions, if any, in the PACR. We interviewed Corps headquarters and district officials and current and former members of the Inland Waterways Users Board knowledgeable about the project to clarify information in the PACR,¹⁶ discussed factors cited in the PACR and other reports, and obtained documentation where necessary to clarify information about factors cited in the PACR compared with other reports we reviewed. We also reviewed the comments of the PACR's independent external peer review panels to determine the extent to which the Corps addressed these comments in the final PACR and associated cost estimate.

To determine what is known about the costs of benefits foregone because of delays in the construction of the Olmsted Locks and Dam project (e.g., the delay in benefits because of a change in the project operational date), we examined the Corps' analyses of the Olmsted project's benefits and costs and compared them with economic guidance, including the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*.¹⁷ To develop an estimate of one type of benefit foregone because of project delays—the additional interest during construction—we compared in the same present value terms the Corps' 1990 estimate of interest during construction with its 2012 estimate. According to the Corps economists, the additional interest is a benefit foregone because it represents the hypothetical return or “benefit” that could have been earned by investing the money in some

¹⁶The Inland Waterways Users Board is a federal advisory committee established by statute. The 11 board members represent various regions of the country and a spectrum of the primary users and shippers utilizing the U.S. inland and intracoastal waterways system for commercial purposes. The board's duties include making recommendations to the Secretary of the Army and to Congress regarding construction and rehabilitation priorities and spending levels.

¹⁷U.S. Water Resources Council, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Washington, D.C.: Mar. 10, 1983). These principles and guidelines govern how federal agencies evaluate proposed water resource development projects. Since 1983, they have provided direction to federal agencies when evaluating and selecting major water projects, including projects related to navigation, storm resilience, wetland restoration, and flood prevention.

other use. We selected this component because it was quantifiable, using available information that we determined was sufficiently reliable for purposes of this report. We interviewed Corps economists to obtain information on the Corps' analyses and application of benefit-cost analysis to Corps projects. We did not independently assess whether the potential benefits of the Olmsted project would outweigh its costs.

We conducted this performance audit from July 2015 to February 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

This section discusses the Corps' organizational structure; the Olmsted Locks and Dam project; the project's timeline, maximum project cost, funding, and construction method; and the economic benefits and costs of navigation projects.

Corps Organizational Structure

Located within the Department of Defense, the Corps has both military and civilian responsibilities.¹⁸ Through its Civil Works program, the Corps plans, designs, constructs, operates, and maintains a wide range of water resources projects for purposes such as navigation, flood control, and environmental restoration. The Civil Works program is organized into three tiers: headquarters in Washington, D.C.; eight regional divisions that were established generally according to watershed boundaries; and 38 districts nationwide. The eight divisions, commanded by military officers, coordinate civil works projects in the districts within their respective geographic areas. Corps districts, also commanded by military officers, are responsible for planning, engineering, constructing, and managing projects in their districts. Each project has a project delivery team of civilian employees that manages the project over its life cycle. Each team is led by a project manager and comprises members from the planning, engineering, construction, operations, and real estate functions. The

¹⁸The Corps' Military program provides, among other things, engineering and construction services to other U.S. government agencies and foreign governments. This report only discusses the Civil Works program.

Louisville District, located within the Great Lakes and Ohio River Division, is responsible for managing the Olmsted project.

In addition, the Civil Works program maintains a number of centers of expertise to assist Corps division and district offices.¹⁹ One of these centers is the Cost Engineering and Agency Technical Review Mandatory Center of Expertise located in Walla Walla, Washington. This center provides technical support and assistance to the districts on cost engineering issues, such as developing cost estimates and performing agency technical reviews of cost estimates included in all decision documents.

Project Description

The Olmsted Locks and Dam project is located at Ohio River Mile 964.4 between Ballard County, Kentucky, and Pulaski County, Illinois (see fig. 1). The project replaces Locks and Dams 52 and 53, which were completed in 1928 and 1929, respectively. Temporary 1,200-foot-long lock chambers were added in 1969 at Locks and Dam 52, and in 1979 at Locks and Dam 53. Because of their antiquated design and age, these structures are unable to meet current traffic demands without significant delays, according to Corps documents. Corps documents also stated that the existing structures have deteriorated and are overstressed during normal operating conditions. The temporary locks at Locks and Dams 52 and 53 have significantly passed their 15-year design life.

¹⁹The centers of expertise assist the Corps divisions and districts in the planning, design, and technical review of civil works projects. The Corps established the centers to consolidate expertise, improve consistency, reduce redundancy, and enhance institutional knowledge, among other things. For a full list of the Corps' centers of expertise, see <http://www.usace.army.mil/about/centersofexpertise.aspx>.

Figure 1: Location of the Olmsted Locks and Dam Project



Sources: U.S. Army Corps of Engineers (information); Map Resources (map). | GAO-17-147

The Olmsted project consists of two 110-by-1,200-foot locks adjacent to the Illinois bank, and a dam composed of five 110-foot-wide tainter gates,²⁰ a 1,400-foot-wide navigable pass controlled by 140 boat-operated wickets,²¹ and a fixed weir²² extending to the Kentucky bank

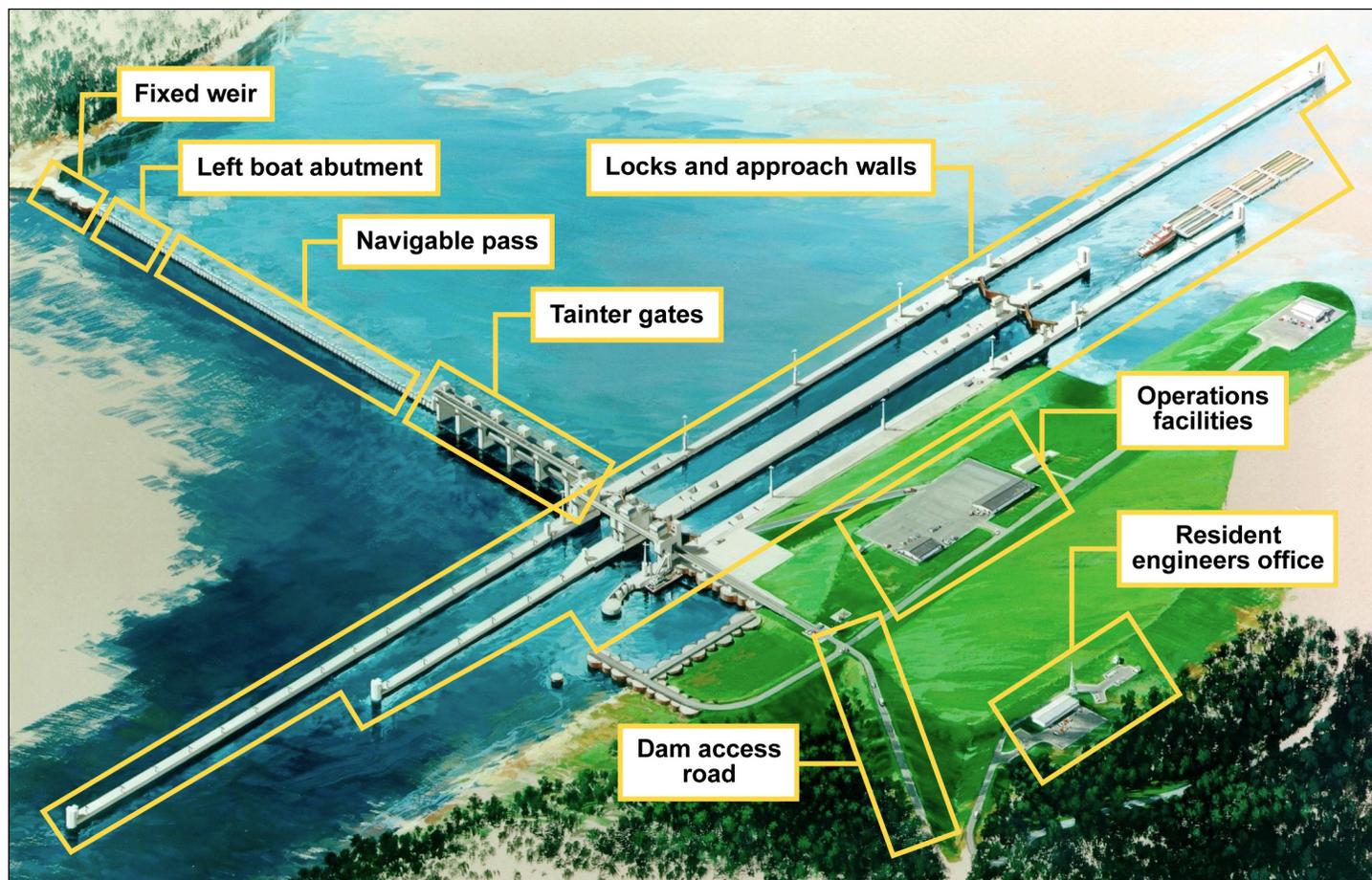
²⁰A tainter gate is a type of floodgate used in dams to control water flow.

²¹A wicket is a rectangular panel of wood or iron hinged to a sill and propped vertically to form a dam. The prop is hinged and can be tripped to drop the wickets flat on the sill to form a navigable pass.

²²A weir is a low dam that is built across a river to raise the water level, divert the water, or control its flow.

(see fig. 2). A lock and dam enable vessels to navigate through a shallow or steep section of river. A lock is an enclosed chamber in a waterway with watertight gates at each end, for raising or lowering vessels from one water level to another by admitting or releasing water. A dam is a barrier that is built across a stream or river to obstruct the flow of water, creating a pool of water deep enough to allow boats and barges to move upstream or downstream. Once the Olmsted dam is completed, the wickets will be raised during periods when the river is low to maintain the upper pool and lowered at other times to form a navigable pass, allowing river traffic to pass through without going through a lock. The tainter gates can be raised or lowered to adjust water flow without adjusting the dam.

Figure 2: Artist Rendering of the Olmsted Locks and Dam Project

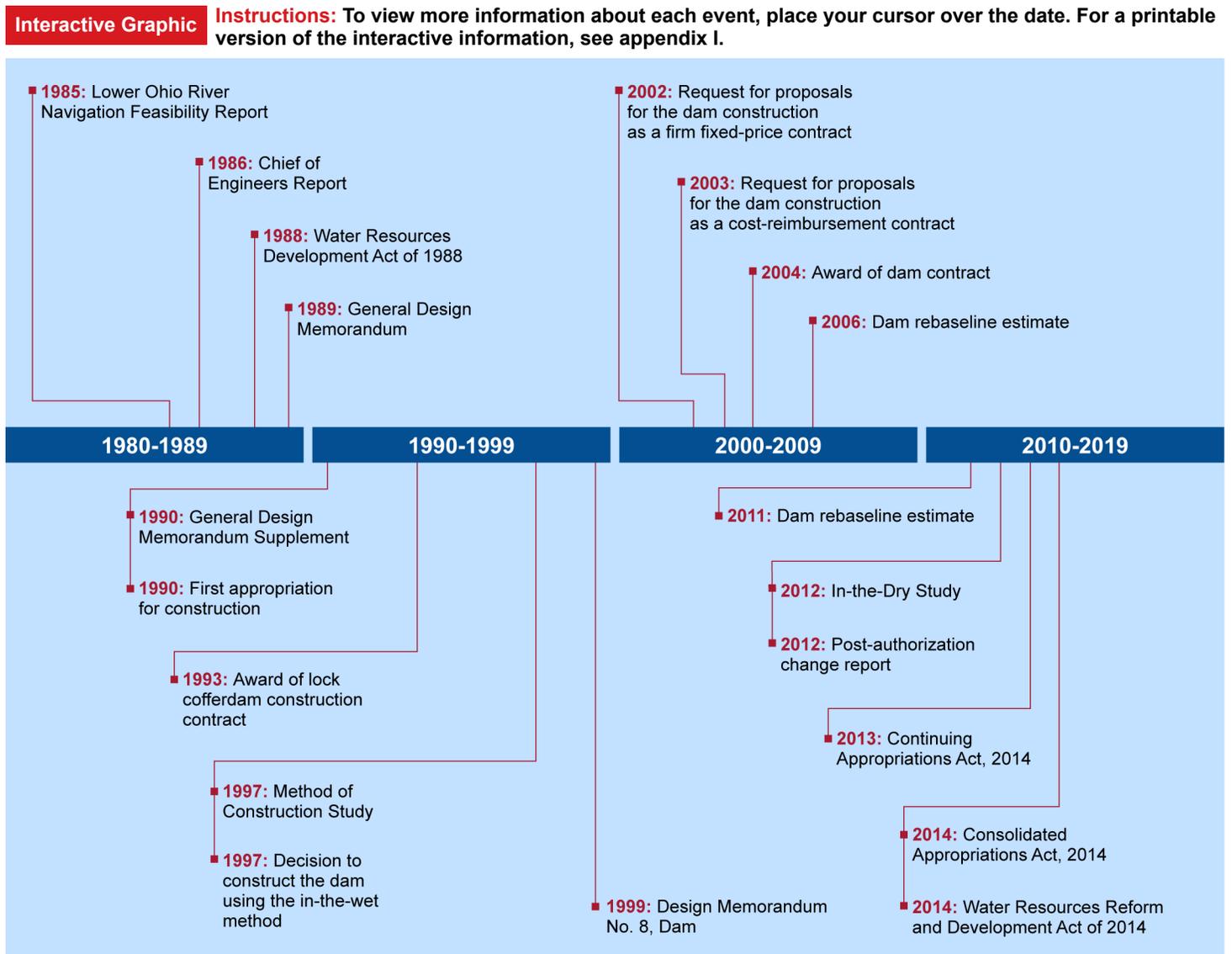


Source: U.S. Army Corps of Engineers. | GAO-17-147

Project Timeline

Figure 3, an interactive graphic, shows a timeline of key events in the Olmsted Locks and Dam project.

Figure 3: Timeline of Key Events in the Olmsted Locks and Dam Project, 1985-2014



Source: GAO analysis of U.S. Army Corps of Engineers information. | GAO-17-147

WRDA 1988 authorized construction of the Olmsted project at a cost of \$775 million (in October 1987 price levels) based on the report of the Chief of Engineers, dated August 20, 1986. The authorized cost was based on the detailed baseline cost estimate for the recommended plan presented in the 1985 Lower Ohio River Navigation Feasibility Report. At the time of authorization, the Corps estimated that construction would take 7 years. As with all civil works projects, the authorized cost does not include inflation and is based on the assumption that the project will receive the maximum amount of appropriations that can be efficiently and effectively used each year. The Corps received its first appropriation for construction in fiscal year 1991, and awarded the first major construction contract in 1993 for the construction of the lock cofferdam.²³

Maximum Project Cost

When Congress authorizes a specific amount of money for a project, this authorized project cost provides the basis for the project's maximum cost. Section 902 of WRDA 1986, as amended,²⁴ defines the maximum project cost as the sum of (1) the authorized cost, with the costs of unconstructed project features adjusted for inflation; (2) the costs of modifications that do not materially alter the scope of the project, up to 20 percent of the authorized cost (without adjustment for inflation); and (3) the cost of additional studies, modifications, and actions authorized by WRDA 1986 or any later law or required by changes in federal law. The maximum cost is known as the 902 limit.

Each district with an ongoing construction project is to update the 902 limit established for the project to account for inflation every time the district calculates a new cost estimate or benefit-to-cost ratio. If the project's estimated costs are approaching the 902 limit, the project delivery team may start preparing a PACR to seek an increase in the project's authorized cost. If the project's actual costs reach its 902 limit before congressional action, construction must stop until the project gets a new authorization that increases its costs and therefore its 902 limit.

Funding

The Corps' Civil Works program typically receives an appropriation annually through the Energy and Water Development Appropriations Act

²³A cofferdam is a temporary structure that surrounds a construction site to prevent water from flooding the site during construction.

²⁴Pub. L. No. 99-662 § 902, 100 Stat. 4082, 4183 (1986) (codified as amended at 33 U.S.C. § 2280).

or an omnibus appropriations act. These acts have typically appropriated a sum to each civil works appropriation account, including investigations,²⁵ construction, and operation and maintenance, to fund projects related to the nation's water resources. Accompanying congressional reports often specifically list individual projects and the amount directed to each project.

When the Olmsted project was first authorized in WRDA 1988, its construction costs were to be shared equally between funds appropriated to the Corps and from the Inland Waterways Trust Fund.²⁶ The trust fund receives a portion of the revenue from a fuel tax levied on commercial towing companies using the inland and intracoastal waterways.²⁷ The trust fund is administered by the U.S. Department of the Treasury. However, after congressional appropriation of revenues from the fuel tax and Office of Management and Budget apportionment, the Corps is responsible for determining the timing and amount of trust fund expenditures. By 2009, however, the Olmsted project was using the majority of trust fund appropriations, which constrained the amount available for other projects on the inland navigation system. In 2014, two laws were enacted that reduced the trust fund's contribution for Olmsted construction costs from 50 to 25 percent in fiscal year 2014 and then to 15 percent in subsequent years.

In-the-Wet versus In-the-Dry Construction Methods

The Olmsted dam is being constructed using a construction method called in-the-wet, in which concrete sections of the dam, known as shells, are built on shore and then carried out into the river and set in place in the riverbed. At Olmsted, the shells are lifted by a wheel-mounted super gantry crane—the largest crane of its kind in the world and capable of lifting 5,100 tons—along rails and taken to the shore. The shells are then floated out onto the river by a catamaran barge that has a capacity of 4,500 tons and lowered onto foundations installed in the riverbed.

²⁵The investigations account is available for such things as studies for water resource projects authorized by statute and preconstruction preliminary engineering and design work leading up to developing the plans and specifications for the first significant construction contract.

²⁶The Inland Waterways Trust Fund generally pays not more than half of the cost of construction and rehabilitation of inland waterways infrastructure.

²⁷The fuel tax rate has changed during the course of the Olmsted project. For example, in 1988, the fuel tax rate was \$0.10 per gallon. After March 31, 2015, the fuel tax rate was \$0.29 per gallon.

This method differs from traditional in-the-dry construction, which uses cofferdams to drain the riverbed to allow work, such as building the Olmsted locks. A cofferdam is a temporary, watertight structure that surrounds a construction site to prevent water from flooding the area. Cofferdams can vary in design from simple earthen dikes heaped up around a construction site, to more complicated and costly structures constructed of steel sheet piling.

Economic Benefits and Costs of Navigation Projects

Federal guidance serves as the key source for the Corps' analyses of the benefits and costs associated with alternative plans for achieving water and related land resource objectives.²⁸ Based on this guidance, the Corps is to identify the project plan that would provide the greatest net benefit to society. Moreover, the Corps is to identify and clearly describe areas of risk and uncertainty so that it can make decisions knowing the reliability of the estimated benefits and costs and of the effectiveness of alternative plans.

To estimate benefits and costs, the Corps compares the economic conditions expected under the proposed alternatives with those expected without the project (i.e., business as usual) during the period of analysis (e.g., 50 years). Potential benefits include any reduction in the transportation cost for barge traffic expected to use the waterway over the analysis period. Potential costs include the outlays made to construct the project (e.g., for labor and materials) and interest during construction, which represents the hypothetical return or "benefit" that could have been earned by investing the money in some other use.²⁹ To calculate the interest cost, compound interest is added to the construction costs incurred during the construction period, at the applicable project discount rate, from the date the expenditures are incurred to the beginning of the period of analysis (i.e., the date the project begins to generate benefits). Federal policy establishes the discount rate for this purpose. According to

²⁸U.S. Water Resources Council, *Principles and Guidelines*.

²⁹Corps documentation notes that the interest cost is a hidden, unpaid cost that must be accounted for when evaluating costs. In addition, the Corps considers the interest incurred as a result of additional construction spending during project delays to be a foregone benefit because the return or benefit that could have been generated had those funds been invested in some other use is "foregone".

Corps planning guidance for civil works projects, the total investment cost of the project equals construction cost plus interest during construction.³⁰

The Corps has conducted several analyses of the Olmsted project's benefits and costs, beginning with a feasibility study in 1985. The Corps later updated its estimates in 1990 (*Benefit Update*)³¹ and in 2012 (PACR). According to Corps economists, the PACR analysis of benefits and costs was thoroughly reviewed, within the Corps and by an independent peer review panel. Also in 2012, the Corps used the PACR analysis to examine the benefits and costs associated with changing the construction method for the dam from the in-the-wet method to the more traditional in-the-dry method.³²

The Corps and Consultant Reports Identified the Construction Method, Contract Type, and Other Factors as Primary Contributors to Cost Increases and Schedule Delays

Reports by the Corps and others³³ identified the in-the-wet construction method, the contract type, and other factors as primary contributors to cost increases and schedule delays in the Olmsted project, most of which were associated with constructing the dam. The PACR and the 2012 consultant report identified the selection of the in-the-wet method to construct the dam as contributing to cost increases and schedule days. In addition, the Corps' decision to use a cost-reimbursement contract contributed to increased management costs, according to the PACR and the 2008 consultant report. The reports by the Corps and others also identified other key factors that contributed to cost increases and schedule delays, including limited funding, changes in market conditions, and design changes.

³⁰U.S. Army Corps of Engineers, *Planning Guidance Notebook*, Engineer Regulation 1105-2-100 (Apr. 22, 2000).

³¹U.S. Army Corps of Engineers, *Olmsted Locks & Dam (Replacement of Locks & Dams 52 & 53) Benefit Update* (October 1990).

³²U.S. Army Corps of Engineers, *Olmsted Dam In-the-Dry Study* (May 31, 2012).

³³U.S. Army Corps of Engineers, *PACR*, 2012; U.S. Army Corps of Engineers, *Inland Navigation Case Studies*, 2008; Gerwick, *Lessons Learned Report*, 2008; and LMI, *Review of Project Controls*, 2012.

Selection of the In-the-Wet Method and Accompanying Construction Challenges Identified as Contributing to Project Cost Increases and Schedule Delays

The Corps' 1997 decision to construct the Olmsted dam using the in-the-wet method was based on projections that this method would cost less and would allow the project to be completed more rapidly than the traditional in-the-dry method. The Corps had originally planned to construct the Olmsted project using an in-the-dry method using four cofferdams. However, the Olmsted project was the subject of many studies and reviews seeking to improve on the authorized plan by incorporating innovative design and construction methods, according to the PACR. One of these methods was in-the-wet construction, which had been used to construct tunnels and bridges in a marine environment, but which had not been used to construct a project such as Olmsted in a river environment.

In the early to mid-1990s, the Corps commissioned several studies to look at different ways to construct the dam, including using the in-the-wet method. One study examined using a mobile cofferdam instead of a conventional fixed cofferdam.³⁴ Another study looked at alternate methods for constructing the tainter gate section of the dam.³⁵ A third study performed a life cycle cost analysis of five different alternatives of dam types and construction methods, including in-the-dry, in-the-wet, and a combination of the two methods.³⁶ A fourth study, issued in December 1997, evaluated and compared using the in-the-wet and in-the-dry construction methods, as well as using a combination of both methods to provide a basis for deciding between the methods.³⁷ This study found that using the in-the-wet method under two different construction schedule scenarios would cost either \$54.9 million less and allow the project to be

³⁴Ben C. Gerwick, Inc., Glosten Associates, Hsieh Wen Shen, George Filz, and J.M. Duncan, *Mobile Cofferdam Construction Alternative*, U.S. Army Corps of Engineers (December 1993).

³⁵Ben C. Gerwick, Inc. and H.W. Shen, *Feasibility Study of Construction of Optional Tainter Gate Section by Alternate Methods*, U.S. Army Corps of Engineers (June 1994).

³⁶Black & Veatch, *Olmsted Dam Life Cycle Cost Analysis*, U.S. Army Corps of Engineers (April 1995).

³⁷Sverdrup/Gerwick Joint Venture, *Method of Construction Study*, U.S. Army Corps of Engineers (December 1997).

completed 2 years earlier or about \$63.2 million less and be completed 5-1/2 years earlier.³⁸

Prior to the issuance of the 1997 study, the Corps established a team of Corps engineers, program managers, and others to review the study and recommend a construction method. The team members evaluated specific project components, including structural engineering, cost estimating, and design. The team said in a July 1997 document that it would be feasible to construct the dam with either the in-the-wet or in-the-dry method. However, using the in-the-wet method option would more likely allow the project to be completed 1-1/2 to 2 years earlier than using the in-the-dry method and the estimated cost savings would be approximately \$40 million. Some team members expressed concerns with the in-the-wet method, including three engineers, one of whom stated that the in-the-wet method's foundation would be more expensive than the foundation required for the in-the-dry method, another who expressed doubts over whether the project would be finished according to schedule, and another who noted that the Corps' Louisville District had little or no experience using the in-the-wet method. The Corps district decided to use the in-the-wet method, citing four reasons—lower cost, shorter construction schedule, less impact on navigation during construction, and the potential for fewer negative environmental impacts. At the time, the Corps' decision to select in-the-wet as the method of construction was not required to undergo an agency technical review or an independent external peer review.³⁹

The PACR stated that the independent government estimate for the in-the-wet dam construction was low and that cost increases resulted from

³⁸The study found that constructing the dam using the in-the-wet method would cost about \$248.4 million if completed in 3 years or cost about \$256.7 million if completed in 6 years, and using the in-the-dry method would cost about \$311.6 million if completed in 8-1/2 years.

³⁹In 2005, the Corps established procedures for determining when to conduct an agency technical review or independent external peer review. See U.S. Army Corps of Engineers, *Planning Peer Review of Decision Document*, Engineering Circular 1105-2-408 (May 31, 2005). In addition, section 2034 of WRDA 2007, as amended, requires independent external peer review for certain Corps project studies.

several factors that were not known at the time of the contract award.⁴⁰ These include certain river conditions that slowed construction,⁴¹ the effect of the site's seismic conditions on fabricating the shells, and funding constraints. Also, the 2012 consultant report stated that the independent government estimate, prepared in 2003, inadequately characterized the uncertainty and risk in pursuing an innovative in-the-wet construction method and set expectations of project cost and duration far too low.⁴² The Corps agreed with the consultant's findings and recommendation that the agency undertake research and development to generate more robust cost and schedule estimates when using novel technology such as in-the-wet construction.

According to the PACR, the construction challenges associated with the in-the-wet construction method were overcome but required "a lot more effort than ever could have been envisioned." Also, according to a Corps official, there was a learning curve associated with the in-the-wet method and one-of-a-kind infrastructure that cost more than the Corps thought. For example, according to the PACR, as the project design continued following the 1989 General Design Memorandum, the Corps planned to construct a hydraulic wicket dam. In May 1994, the Corps awarded a contract to construct a full-sized prototype of the dam to test how the gate would operate and to test maintenance procedures, and this contract was completed in December 1995. This modeling revealed the complexity of the design, and the Corps revised the design to construct tainter gates and boat-operated wickets instead. In addition, the PACR stated that the in-the-wet method required specialized equipment that increased costs, such as the super gantry crane and the catamaran barge, which have minimal salvage value.

⁴⁰The independent government estimate is the formal, approved cost estimate prepared by the government to support a contract award. According to a Corps engineer regulation, the estimate must be prepared in as much detail as if the government were competing for award. The estimate will represent the "fair and reasonable" cost to the government. See U.S. Army Corps of Engineers, *Engineering and Design Civil Works Cost Engineering*, Engineer Regulation 1110-2-1302 (Sept. 15, 2008).

⁴¹A district official clarified that river elevations and velocities affected constructing the dam using the in-the-wet method. Certain activities associated with the method, such as having divers work in the river, were constrained when the river's elevation exceeded 306 feet and velocities were over 4 feet per second, primarily because of safety considerations.

⁴²LMI, *Review of Project Controls*.

In January 2012, the Corps' Deputy Commanding General for Civil and Emergency Operations directed the Great Lakes and Ohio River Division to explore alternative construction methods and to present recommendations to Corps headquarters by June 1, 2012. In providing this direction, the Deputy Commanding General stated that the in-the-wet construction method had proven more expensive and time-consuming than originally envisioned. Among other things, the division was to develop concept-level designs for in-the-dry construction that could be used to develop a reliable cost estimate, and to compare that estimate to the in-the-wet estimate.

The Corps completed its review of the in-the-wet versus in-the-dry methods in a May 2012 study, which underwent agency technical review and was certified by its Cost Engineering and Agency Technical Review Mandatory Center of Expertise. The study concluded that constructing the dam components using the in-the-dry method was a technically feasible alternative. The study found that continuing to use the in-the-wet method would cost more than switching to the in-the-dry method, but it would allow the project to be operational sooner. Specifically, the study estimated that the in-the-dry method would cost \$2.810 billion compared to the PACR's \$2.918 billion estimate of performing the work with the in-the-wet method. However, the study found that using the in-the-dry method would result in the project not being operational until 2022, which is 2 years later than the PACR's estimated operational date of 2020.

A June 2012 Corps internal memorandum stated that based on the findings of the in-the-dry study, the Great Lakes and Ohio River Division recommended continuing to use the in-the-wet construction method for Olmsted. The memorandum stated that if the Corps changed course and used the in-the-dry method, it would require that a new contract be awarded. As a result, potentially two contracts would be ongoing for a period of time, which would likely exceed available funds and cause a delay. The memorandum also stated that because the Corps does not have the authority to use incremental funding or a continuing contracts

clause,⁴³ it would need to award another cost-reimbursement contract for the in-the-dry construction.⁴⁴ The Deputy Commanding General for Civil and Emergency Operations directed the division to explore the possibility of soliciting opinions of industry rather than prescribing the construction method. In response, a Corps official presented the study's findings in an August 2012 meeting of the Inland Waterways Users Board, which is composed of members of industry. This official said that the division recommended using the in-the-wet construction method, in part based on the Corps having learned from its experience with the construction and having become more efficient at setting shells. This official also stated that the contractor was about to begin setting shells for the navigable pass and, compared to the shells for tainter gates, these shells were smaller, lighter, and uniform in size, which would allow the contractor to set them more quickly. Board members stated that they deferred to the Corps as the engineering experts to decide on the method of construction. A Corps official said that the Corps decided to continue using the in-the-wet method in November 2012.

⁴³Incremental funding occurs when the Corps provides budgetary resources for a project based on obligations estimated to be incurred within a fiscal year when such budgetary resources are provided for only part of the project's estimated cost. Continuing contract authority allows an agency to enter into, and commit the federal government for, the full amount of a contract that spans more than 1 fiscal year, even though the agency may not have sufficient appropriations to cover the full contract amount at the time that the contract is awarded. A continuing contract contains a clause that allows the contractor to continue to work even when appropriated funds are not available and earn simple interest on the self-financed amount. The Energy and Water Development Appropriations Act of 2006 restricted the way the Corps could use continuing contracts and subsequent annual appropriations acts have also contained this restriction.

⁴⁴Cost-reimbursement contracts provide for payment of allowable incurred costs specified in the contract. These contracts establish an estimate of total costs for the purpose of obligating funds and establish a ceiling that the contractor may not exceed except at its own risk without the approval of the contracting officer.

Corps' Decision to Use a Cost-Reimbursement Contract Seen as a Source of Increasing Management Costs

The Corps' decision to use a cost-reimbursement contract for the dam construction after not receiving offers for a firm fixed-price contract contributed to increased administrative and overhead costs,⁴⁵ according to the PACR and the 2008 consultant report. In September 2002, the Corps requested proposals for the dam construction contract as a firm fixed-price contract—the contract type the agency typically uses for civil works projects—but received no offers. According to the 2008 Corps report and the 2012 consultant report, the agency received no offers because the construction method was innovative, the river conditions were too risky, and the contractor could not get bonding.⁴⁶ The Corps amended the request for proposals to include, among other things, a provision that the government would pay a stipend for satisfactory and reasonable contractor proposals, but received no offers.

⁴⁵A firm fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places maximum risk and full responsibility for all costs and resulting profit or loss on the contractor.

⁴⁶A bond is a document signed by a third party, generally a bank or insurance company, promising to assure the contractor's fulfillment of its obligations under the government contract by assuring payment of any loss sustained by the government if the contractor's obligations are not met. The bond protects the government against losses resulting from the contractor's failure to meet its contractual obligations. Before a federal agency awards a federal construction contract exceeding \$150,000, contractors are generally required to provide performance and payment bonds.

After considering different options, the Corps decided to request proposals for a cost-reimbursement contract rather than a firm fixed-price contract. According to a district official, the construction of Olmsted dam was not practical for a firm fixed-price contract because of the risks to the contractor in undertaking a complex project and the unknowns associated with the in-the-wet construction method. Specifically, the Corps requested proposals for a cost-plus-award-fee contract,⁴⁷ rather than a cost-plus-incentive-fee⁴⁸ or a cost-plus-fixed-fee⁴⁹ contract, because according to a Corps official, it was the best fit for the project. According to the Federal Acquisition Regulation, an award fee contract is suitable for use when the work to be performed is such that it is neither feasible nor effective to devise predetermined objective incentive targets applicable to cost, technical performance, and schedule.⁵⁰ Alternatively, an incentive fee contract should be used when cost and performance targets are objective and can be predetermined, allowing a formula to adjust the negotiated fee based on variations relative to the targets. A district official stated that a cost-plus-incentive-fee contract was not appropriate because targets could not have been reasonably determined since the in-the-wet construction method had never been attempted before. Difficult river conditions provided additional risks to the contractor. According to the Corps official, a cost-plus-fixed-fee contract would not have provided sufficient incentive for the contractor because the fee would not change.

In May 2003, the Corps requested proposals for the dam construction as a cost-plus-award-fee contract and received two offers, and awarded the contract in January 2004 to a joint venture. According to a Corps cost

⁴⁷A cost-plus-award-fee contract is a cost-reimbursement contract that provides for a fee consisting of a base amount fixed at inception of the contract and an award amount that the contractor may earn in whole or in part during performance that is sufficient to provide motivation for excellence in contract performance.

⁴⁸A cost-plus-incentive-fee contract is a cost-reimbursement contract that provides for the initially negotiated fee to be adjusted later by a formula based on the relationship of total allowable costs to total target costs. The adjustment to the fee can be an increase or decrease and is intended to provide an incentive for the contractor to manage the contract effectively.

⁴⁹A cost-plus-fixed-fee contract is a cost-reimbursement contract that provides for payment to the contractor of a negotiated fee that is fixed at the inception of the contract. The fixed fee does not vary with actual cost, but may be adjusted as a result of changes in the work to be performed under the contract. This contract type permits contracting for efforts that might otherwise present too great a risk to contractors, but it provides the contractor only a minimum incentive to control costs.

⁵⁰48 C.F.R. § 16.401(e)(1)(i).

analysis of the proposals, the winning proposal included a lower maximum award fee of 5 percent, capped overhead costs, and had more overall budgeted cost savings than the other proposal. The winning proposal was \$564 million, which was more than 25 percent higher than the independent government estimate.⁵¹ However, the Corps' Office of the Chief Counsel said that the statutory prohibition on the Corps awarding a contract for river and harbor improvements with a price that exceeds 125 percent of the independent government estimate did not apply to the Olmsted dam contract because it was a cost-reimbursement contract.⁵²

The PACR and the 2008 consultant report noted that the effort to manage a cost-reimbursement contract is more cost- and time-intensive than managing a firm fixed-price contract. For example, the PACR stated that there are additional activities associated with a cost-reimbursement contract, such as audit services, voucher reviews, and award fee evaluation boards. The PACR estimated that the Corps' cost of construction management for these additional activities increased by more than \$74 million (in October 2011 price levels), in part because the change in completion date had extended the construction schedule. The 2008 consultant report stated that the cost-reimbursement contract necessitated a substantial amount of administrative effort to track, record, and evaluate the contractor's performance, and that doing so increased the Corps' staff needs by approximately 40 percent. A district official said that the Corps hired 3 additional staff and the contractor hired 10 to 15 additional staff to perform these administrative tasks.

In 2009, we reviewed federal agencies' use of cost-reimbursement contracts and found that they involve significantly more government oversight than do fixed-price contracts, which means the government incurs additional administrative costs on top of what it is paying the

⁵¹The independent government estimate for the Olmsted dam contract was \$414 million, but in the course of reviewing the proposals it received, the Corps discovered a mathematical error in the estimate. While Corps documents discuss the need to revise the independent government estimate, Corps attorneys said that the estimate was not revised. Instead, the Corps used the corrected amount—\$423 million—in evaluating the proposals it received. The winning proposal was more than 125 percent of both the initial and corrected amount of the independent government estimate.

⁵²33 U.S.C. § 624(a)(2). Neither the PACR nor the three Corps and consultant reports we reviewed for this report analyzed whether this prohibition applies to cost-reimbursement contracts, and such analysis was outside the scope of our reporting objectives.

contractor.⁵³ For example, we found that the government must determine that the contractor's accounting system is adequate for determining costs related to the contract and update this determination periodically. In addition, we found that contractor costs need to be monitored—known as cost surveillance—to provide reasonable assurance that efficient methods and effective cost controls are used.

Another cost associated with the cost-reimbursement contract is evaluating the contractor's award fee. For each evaluation period, the Corps is to assess the contractor's performance against explicit criteria relating to cost, schedule, quality, and safety and environmental compliance, as set forth in the award fee plan. The 2012 consultant report found that the Olmsted project team did not have the experience to manage a cost-reimbursement contract, but that the team had instituted management methods and techniques to control project costs, many of which were industry best practices and consistent with Corps and Department of Defense guidance.⁵⁴ The Corps agreed with the report's recommendation that if the Corps plans to use a cost-reimbursement contract for other civil works projects, the agency needs to identify training required for project members when it develops the acquisition strategy. The report also concluded that the Corps' management of the cost-reimbursement contract was not a significant factor in explaining the project's cost and schedule overruns, and Corps officials we interviewed agreed.

Within the last few years, the Corps has taken actions to help improve its management of civil works projects, including Olmsted. In 2012, the Corps designated Olmsted as a mega-project because of its cost, importance, and complexity, among other things. The Corps issued guidance in 2012 on managing mega-projects.⁵⁵ According to the 2012 guidance, the Great Lakes and Ohio River Division is to provide progress reports to Corps headquarters and an integrated project schedule and cost estimate that the project team updates monthly. Corps officials said

⁵³GAO, *Contract Management: Extent of Federal Spending under Cost-Reimbursement Contracts Unclear and Key Controls Not Always Used*, [GAO-09-921](#) (Washington, D.C.: Sept. 30, 2009).

⁵⁴LMI, *Review of Project Controls*.

⁵⁵U.S. Army Corps of Engineers, *Additional Engineering and Construction Management Controls for USACE Mega-Projects*, Engineering and Construction Bulletin 2012-2 (Jan. 31, 2012).

that the Corps created its Integrated Project Office in 2012 to help increase its management focus on Olmsted. In 2016, the Corps updated its mega-project guidance to require quarterly reports on such things as analysis of risk.⁵⁶ The Corps also has daily, weekly, and monthly meetings to discuss how the dam contractor is staying on schedule, controlling cost, and managing risks. In 2014, the Corps adopted a recommendation from a 2010 report prepared by navigation industry representatives and Corps navigation experts to prioritize new construction and rehabilitation projects based on an examination of factors such as economic return, risk-based analysis, and the estimated cost and construction schedule.⁵⁷ As a result, the Corps made Olmsted its top priority construction project. In the Corps' March 2016 capital investment plan, prepared in response to WRRDA 2014, Olmsted remained its top priority construction project.⁵⁸

Other Key Factors Identified as Contributing to Cost Increases and Schedule Delays

The reports by the Corps and others also identified other key factors that contributed to cost increases and schedule delays, including limited funding, changes in market conditions, and design changes.

Limited Funding

The Olmsted project's authorized cost was based on the Corps' assumption that each year the agency would receive the maximum amount of funding that it could efficiently and effectively spend. However, according to the reports by the Corps and others, the Olmsted project was significantly underfunded in some years, which contributed to cost increases and schedule delays. Specifically, according to these reports, the amount the Corps allocated for the Olmsted project from its annual appropriation, together with the amount appropriated from the Inland Waterways Trust Fund, was less than optimal for construction, and in 2004 and 2005, the Corps reprogrammed appropriations from Olmsted to another project. Incremental funding from the Inland Waterways Trust

⁵⁶U.S. Army Corps of Engineers, *Updated USACE Mega Projects Guidance*, Engineering and Construction Bulletin 2016-16 (May 26, 2016).

⁵⁷Inland Marine Transportation System Capital Investment Strategy Team, *Inland Marine Transportation System (IMTS) Capital Projects Business Model, Final Report, Revision 1* (Apr. 13, 2010).

⁵⁸U.S. Army Corps of Engineers, *Inland and Intracoastal Waterways Twenty-Year Capital Investment Strategy* (March 2016).

Fund also contributed to delays and increased costs, according to the 2012 consultant report.

According to the Corps reports, limited funding resulted in delayed contract awards and increased contract durations to conform to the funding received. For example, according to the PACR, the approach wall contract was awarded 2 years later than originally planned because of limited funding,⁵⁹ which delayed the award of the dam contract by 2 years.⁶⁰ About 2 months before the award of the Olmsted dam construction contract, the Corps told the offerors to develop revised estimates based on the assumption that \$17.5 million would be available the first year, with \$80 million available each year thereafter, which increased proposal costs by \$18.2 million and added 1 year to the completion date, according to the PACR. However, according to the reports by the Corps and others, during the first 2 years of the dam contract, the project had less funding than assumed. Specifically, according to the 2012 consultant report, the dam contract received approximately \$5 million of the anticipated \$17.5 million in 2004. The other funds were reprogrammed to the McAlpine locks,⁶¹ which the Corps viewed as urgent because their failure would cause the Ohio River navigation system to fail. In 2005, funds were again reprogrammed, with the dam contract receiving approximately \$47 million of the anticipated \$80 million for the year. However, according to the 2008 Corps and 2012 consultant reports, reprogramming was curtailed significantly in fiscal year

⁵⁹Approach walls are walls that facilitate entry into and exit from the lock chambers.

⁶⁰According to a district official, the staging of the approach wall, a key feature of the locks, and the dam occupied the same footprint. Since the approach wall construction would interfere with the dam construction, the dam contract had to be awarded when there would be no interference from the approach wall construction.

⁶¹The McAlpine Locks and Dam project is on the Ohio River at Louisville, Kentucky. The Water Resources Development Act of 1990 authorized a construction project at the McAlpine Lock and Dam. The project replaced two auxiliary locks that were completed in 1921 and 1930 with a new 1,200-foot lock. The new lock was completed and opened in April 2009, which gave the McAlpine project twin 1,200-foot locks for tow traffic.

2006 in accordance with the Energy and Water Development Appropriations Act and accompanying congressional committee reports.⁶²

Also, according to a Corps headquarters official, in fiscal year 2003, the balance of the Inland Waterways Trust Fund, which generally pays half of the construction costs of navigation and rehabilitation projects, started to decline because so many projects were under construction. The official said that from fiscal years 2005 to 2009, there was a sharp decrease in the balance of the trust fund as fuel tax revenues started to decline, and that by fiscal year 2009, the fund was nearly depleted. As a result, expenditures from the fund were limited to the amount of annual fuel tax revenues collected for that particular year. According to the 2012 consultant report and the headquarters official, the Olmsted project was funded on a monthly basis, and this incremental funding also contributed to delays and increased costs. For example, incremental funding caused the 2009 shell fabrication season to be split between 2009 and 2010, according to the 2012 consultant report.

Changes in Market Conditions

According to the reports by the Corps and others, changes in construction market conditions contributed to increases in the cost of the dam. After the Corps awarded the dam contract in January 2004, unexpected and significant increases in the price of construction equipment and materials occurred. According to the PACR and the consultant reports, the 2005 hurricane season, which included Hurricanes Katrina and Rita, created a scarcity of barges and cranes at the time when the contractor was trying to mobilize the necessary equipment to construct the dam. Specifically, according to the 2012 consultant report, most of the barges scheduled for use in building the dam were under construction in shipyards along the Gulf Coast when the hurricanes struck. As a result, barge production slowed tremendously and prices doubled as the demand for existing barges increased because of the hurricane restoration efforts.

⁶²The restrictions on reprogramming in the fiscal year 2006 appropriations act and accompanying congressional committee reports were a response, in part, to a GAO report. See GAO, *Army Corps of Engineers: Improved Planning and Financial Management Should Replace Reliance on Reprogramming Actions to Manage Project Funds*, [GAO-05-946](#) (Washington, D.C.: Sept. 16, 2005). Subsequently, the Corps has issued guidance on program and project management policies and practices to ensure compliance with applicable reprogramming requirements.

Also, according to the reports by the Corps and others, domestic and international construction booms created a high demand for construction materials after the award of the construction contract. The Corps reports presented data from the U.S. Department of Labor's Bureau of Labor Statistics, which showed that the price of construction materials increased significantly after 2004. According to the 2008 consultant report, from 2002 to 2007, the price of fabricated steel increased about 300 percent, the price of cement increased about 90 percent, the price of riprap increased by 100 to 200 percent,⁶³ and the price of fuel increased about 300 percent. In addition, insurance and bonding cost increased about 230 percent. Since the dam construction contract was awarded in January 2004, the contractor's proposal did not include these increases in the cost of materials.

Design Changes

The reports by the Corps and others identified design changes during the dam construction as contributing to increased costs. However, the reports do not provide the amount by which the changes increased costs.⁶⁴ Examples of design changes included the following:

- The consultant reports cited the use of a super gantry crane instead of sleds to move the precast shells into the river as a design change that contributed to increased cost.⁶⁵ The Corps' 2016 Lessons Learned Report stated that the change was made because design issues related to sled deflection⁶⁶ could not be overcome.⁶⁷
- The PACR and the 2012 consultant report cited the need to reinforce the site for the shell precast yard and the marine skidway as

⁶³Riprap is a layer of loose stone placed over a soil surface to protect it from the erosive forces of water.

⁶⁴A district official said that the agency does not track costs in a way that could provide this information.

⁶⁵Sleds are the platforms on which the precast shells are assembled.

⁶⁶Deflection refers to the degree to which a structural element is displaced under a load.

⁶⁷U.S. Army Corps of Engineers, *Olmsted Locks and Dam Project Lessons Learned, Report for Compliance with Requirements of Section 2007(a) of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) (Public Law 113-21 – June 10, 2014) (Inland Waterways Oversight – Report)* (Sept. 6, 2016).

contributing to increased cost.⁶⁸ According to the PACR, after awarding the construction contract, it was determined that the soil conditions at the site for the precast yard and the marine skidway were inadequate to support the foundation loads and that an extensive amount of piling was required to support their weight.

- The Corps reports and the 2012 consultant report cited the need to address slope stability issues on the shore as contributing to increased cost. The Corps reports stated that an active slide was observed during monitoring of the Illinois bank at the site of the locks. A district official said that the Corps observed the slide. Defining the extent of the slide problem and determining the best solution required additional effort. The Corps reports stated that these problems also added to the effort required to design and build the precast yard and marine launching facility.
- The PACR cited the need to increase the length of the foundation piles for the tainter gate portion of the dam and to conduct additional excavation because of sand waves as contributing to increased cost.⁶⁹ According to a district official, sand waves are constantly migrating downriver to the construction site, and as sand collects on the footprint of the foundation, the riverbed has to be excavated so that shells can be set correctly, which increases cost.

Total Cost of Benefits Foregone from Project Delays at Olmsted Is Uncertain

The total cost of benefits foregone from project delays that have occurred at Olmsted is uncertain, primarily because the estimates that the Corps developed for the project are no longer relevant or are of limited use for estimating the benefits that might have been generated had the project become operational as planned in 2006. The extent to which the project incurs another type of benefit foregone—the additional interest during construction incurred because of the longer construction period—depends on economic factors, such as the project discount rate.⁷⁰

⁶⁸The marine skidway is a path formed of two parallel rails for sliding the precast shells to the river.

⁶⁹Sand waves are underwater dunes formed by sand transported by the river's current.

⁷⁰The project discount rate is the interest rate that is used to convert the future stream of benefits and costs into a lump sum present value amount.

Benefits That the Olmsted Project Would Have Generated Had It Become Operational as Planned Are Uncertain

The benefits that the Olmsted project would have generated had it become operational as planned in 2006 are uncertain, primarily because the estimates that the Corps has made are no longer relevant or are of limited use for this purpose. The Corps analyzed the benefits and costs associated with the project several times, including in a 1990 study.⁷¹ In that study, for example, the Corps estimated that the project would begin generating average annual benefits of about \$920 million in 2006.⁷² According to the PACR, the Olmsted locks and dam project once operational would reduce the cost of shipping products on the Ohio River by processing barge shipments more efficiently than the two existing locks and dams. Corps officials said, however, that this estimate is no longer relevant for estimating the benefits foregone from past project delays. In particular, as noted in the PACR, the 1990 study did not anticipate the regulatory and market factors that reduced the demand for coal and coal shipments on the Ohio River, beginning in the 1990s.⁷³ In addition, because the 1990 study did not assess the uncertainty associated with key assumptions, such as the barge traffic forecast, it cannot be used to assess what the benefits might have been, beginning in 2006, under lower barge traffic forecast assumptions. In general, fewer barge shipments mean less congestion and delay and lower benefits from replacing the existing locks and dams, if all else remains the same.⁷⁴

In 2012, the Corps updated its analysis of the benefits and costs associated with the Olmsted project, based on a revised operational date of 2020.⁷⁵ The Corps estimated, for example, that the project would generate average annual benefits of about \$875 million per year over 50 years, beginning in 2020.⁷⁶ The Corps used the analysis to estimate the

⁷¹U.S. Army Corps of Engineers, *Benefit Update*, 1990.

⁷²The estimate, which is included in the 2012 PACR, is based on 2011 price levels and a 7 percent discount rate.

⁷³The PACR indicates that ever-tightening environmental restrictions, conversions to natural gas, and a loss of export markets reduced coal shipments by about 28 million tons from 1986 through 2005.

⁷⁴We did not independently assess whether the potential benefits of the Olmsted project would outweigh its costs.

⁷⁵U.S. Army Corps of Engineers, *PACR*, 2012.

⁷⁶The estimate is based on 2011 price levels and a 7 percent discount rate. More specifically, the estimate is an average annual value calculated by discounting and amortizing the benefits expected over the 50-year analysis period.

benefits foregone from potential delays in the future, should the project opening be delayed again. In a June 2012 presentation before the Inland Waterways Users Board, for example, the Corps indicated that a pause in construction at Olmsted (e.g., to shift funding to other Corps projects) could delay its opening 4 years to 2024, which could result in benefits foregone of about \$3.5 billion (\$875 million each year).⁷⁷

The updated estimates from the PACR could be viewed as rough estimates of the benefits foregone since the delayed 2006 opening, but the estimates are of limited use for this purpose for several reasons. First, the PACR economic analysis assesses whether the potential benefits of the Olmsted project would outweigh its remaining costs. Corps economists said that the analysis was not designed to estimate the benefits foregone from project delays that occurred in the past, and as a result, the benefit estimates would be less reliable when used for that purpose.

Second, the PACR estimates were based on assumptions about economic conditions expected in the future and may not represent the economic conditions that existed when past project delays occurred.⁷⁸ For the PACR analysis, the Corps assumed that the existing locks and dams would need to be closed for repairs several times over the period of analysis (i.e., beginning in 2020) and that this would reduce the volume of shipments that could transit the locks during those closures. As a result, transportation cost savings could be generated by replacing the existing facilities with the Olmsted project, which is expected to be closed less often. These assumptions, however, may not align with the actual performance of the existing locks and dams in the past. For example, Corps economists said that the existing facilities have performed more reliably than expected, in part because funds were expended to maintain

⁷⁷U.S. Army Corps of Engineers, *Presentation to Inland Waterway Users Board, Olmsted Locks & Dam—Status, PACR, Funding Alternatives, Cost Update, and Construction Methodology* (June 6, 2012).

⁷⁸More generally, because the estimates are average annual values based on a 50-year analysis period, they may not precisely capture the benefits foregone in any specific year. In addition, the benefits foregone are essentially benefits delayed, since the analysis period is 50 years, regardless of when the project opens. Because of the time value of money and discounting, however, the delayed benefits are worth less than if they had been generated earlier, as originally planned.

them in an operating condition.⁷⁹ Moreover, changes in the PACR assumptions about the reliability of the existing locks and dams can significantly affect the benefit estimates.⁸⁰ As a result, the PACR benefit estimates would be less reliable as a measure of benefits foregone if the assumptions about the expected performance of the existing facilities do not align with their actual performance in the past.

Third, the benefit estimates, which are based on forecasts of barge shipments through the locks beginning in 2020, may not represent the actual traffic that transited the locks and dams in the past. For example, the PACR assumed that barge shipments through Locks and Dam 52 would reach about 113 million tons in 2020 and grow thereafter.⁸¹ This tonnage is greater than the roughly 94 million tons that the PACR indicates were shipped through the same locks in 2006—the year that the Olmsted project was projected to open. In addition, according to Corps documentation, barge shipments through the existing locks have generally fallen since 2006. Barge traffic is a key input in the benefit analysis because it is used in estimating the effect of congestion and delay at the locks and the transportation cost savings expected to be generated by replacing the existing structures with the Olmsted project. The PACR indicated that the benefit estimates are extremely sensitive to changes in barge traffic assumptions, but did not present the benefits associated with alternative traffic forecasts.

Finally, the barge traffic forecasts on which the PACR benefit estimates are based were developed in the early 2000s. However, the forecasts do not incorporate factors that have reduced the demand for barge

⁷⁹For example, the 1990 *Benefit Update* assumed that the existing locks and dams would need to be closed for 2 years each in the 2010–2018 time frame for major rehabilitations. Such closures would increase congestion and delay, if all else remains the same, and the transportation savings from replacing them with the Olmsted project. However, none of the expected closures occurred to date, according to Corps economists, and none are planned, according to the Corps' 2012 in-the-dry study.

⁸⁰For example, the Corps' 2012 in-the-dry study, based on the PACR analysis, found that changing the construction method would delay the project opening for 2 years and result in benefits foregone of about \$32 million per year, at a 4 percent discount rate, under a "best" case scenario in which the existing locks and dams operate fully with no extended closures during the delay.

⁸¹For Locks and Dam 53, the forecast is for 94 million tons in 2020; according to the PACR, 81 million tons were shipped through its locks in 2006.

shipments, particularly for coal, since the forecasts were developed.⁸² According to the PACR, for example, coal is the dominant commodity in terms of volume on the Ohio River System. In 2015, we found that coal's share of electricity generation had declined from 2001 through 2013, partly because of plant retirements brought about by comparatively low natural gas prices and the potential need to invest in new equipment to comply with environmental regulations.⁸³ In addition, in 2014, we found that power companies plan to retire an even greater percentage of coal-fired generating capacity than expected earlier.⁸⁴ The panel that conducted the peer review of the PACR in 2010 found that the traffic forecasts should be updated to include more recent actual barge traffic (i.e., for years 2006 through 2009) and that additional sensitivity testing should be conducted to analyze uncertainty associated with coal-related environmental issues.⁸⁵ In addition, Corps officials said that barge shipments containing coal are expected to continue to decline over the short and medium terms, but that shipments for some other commodities, such as those related to natural gas production, have increased.

⁸²The benefit estimates in the PACR are based on a forecast that reflects the Clear Skies Initiative, which was proposed by the Bush Administration in 2002 as a way to reduce power plant emissions. That initiative, however, was not enacted. The Environmental Protection Agency (EPA) has issued other rules recently, such as the Clean Power Plan, to regulate emissions from electricity-generating units that if upheld in court, could also affect demand for coal and coal shipments.

⁸³GAO, *Electricity: Generation Mix Has Shifted, and Growth in Consumption Has Slowed, Affecting System Operations and Prices*, [GAO-15-524](#) (Washington, D.C.: May 29, 2015).

⁸⁴GAO, *EPA Regulations and Electricity: Update on Agencies' Monitoring Efforts and Coal-Fueled Generating Unit Retirements*, [GAO-14-672](#) (Washington, D.C.: Aug. 15, 2014).

⁸⁵In response to the peer review comments, the Corps reviewed additional traffic forecast scenarios, including one that reflected stricter limitations on coal-related emissions. However, the benefits associated with these forecasts were not included in the PACR.

Another Type of Benefit Foregone—Additional Interest Incurred during Construction—Depends on Factors Such as the Project Discount Rate

According to Corps economists, another type of benefit foregone is the additional interest during construction incurred as a result of project delays. Corps guidance states that costs incurred during the construction period should be increased by adding compound interest at the applicable project discount rate from the date that expenditures are incurred up to the year the project begins operation. The interest represents the hypothetical return or “benefit” that could have been earned by investing the money in some other use.⁸⁶ Delays that increase the construction period can also increase the interest because interest is compounded over a longer construction period. The Corps’ 1990 study assumed that the construction period would last from 1991 to 2006, and the PACR extended the time frame for the construction to 2024.⁸⁷

To illustrate the potential effect of past delays on the interest cost during construction, we compared the Corps’ estimate of interest during construction from the PACR with its estimate of the interest during construction from the 1990 study. The interest estimate in the PACR represents the interest cost expected over the entire construction period estimated by the Corps, including delays, from 1991 through 2024. The interest estimate from the 1990 study represents the interest expected over a shorter construction period, from 1991 through 2006 (i.e., updated in terms of price level and present value using a 4 percent project discount rate). We found the difference in interest to be about \$400 million, which represents the additional interest associated with factors such as changes in the project design, spending levels, and market conditions that led to the construction delays and increased construction costs. For the PACR analysis, for example, the Corps estimated that the Olmsted project would incur about \$1.3 billion in interest during construction by the time construction was completed in 2024.⁸⁸ Based on the 1990 study, the Olmsted project was expected to incur about \$900

⁸⁶Corps documentation indicates that the interest cost is a hidden, unpaid cost that must be accounted for when analyzing project economic costs.

⁸⁷According to the PACR, the construction period is expected to last beyond the opening date of 2020, until 2024, in order to dismantle the existing facilities.

⁸⁸The estimate is based on about \$2.9 billion in construction costs at 2011 price levels and the 4 percent project discount rate in effect at the time of the PACR. More specifically, the Corps added compound interest to actual and expected construction spending from 1986 through 2019. The Corps discounted to 2019 the interest on the spending expected during the remainder of the construction period through 2024.

million in interest during construction.⁸⁹ Nonetheless, the estimate of additional interest would change if factors such as the project discount rate were changed. For example, the additional interest cost would be about \$300 million, based on the 7 percent discount rate that Office of Management and Budget economic guidance indicates should be used for evaluating proposed federal investments.⁹⁰

Agency Comments

We provided a draft of this report to the Department of Defense for review and comment. We received a written response from the department, reprinted in appendix II. The department said it appreciates the opportunity to review the report and it has no comments to add to the report.

⁸⁹The estimate is based on about \$1.4 billion in construction costs at 2011 price levels and a 4 percent discount rate. The PACR included the 1990 *Benefit Update* construction cost and interest during construction estimates, in 1990 price levels, with a base year of 2005. To enable comparison with the PACR estimates, we inflated the 1990 cost estimates to 2011 price levels using the Consumer Price Index (following the PACR approach) and added compound interest at a 4 percent rate to 2005. We then compounded the total interest to 2019, to make it comparable to the PACR estimates.

⁹⁰Office of Management and Budget, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, OMB Circular No. A-94 Revised (Oct. 29, 1992). The additional interest—based on a comparison of the 1990 *Benefit Update* and the 2012 PACR studies—is lower under the higher discount rate because the 1990 *Benefit Update* assumed greater construction spending over its construction period than actually occurred (i.e., at the same price level). The Corps PACR interest estimate is based on actual spending during this period. Consequently, when comparing the two studies, adding compound interest at the higher discount rate results in a lower estimate of additional interest because of project delays.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or fennella@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff members who made key contributions to this report are listed in appendix III.

A handwritten signature in black ink that reads "Anne-Marie Fennell". The signature is written in a cursive style with a long horizontal line underneath the name.

Anne-Marie Fennell
Director, Natural Resources and Environment

Appendix I: Full Text for Figure 3, Timeline of Key Events in the Olmsted Locks and Dam Project, 1985–2014

The following information appears as interactive content in figure 3 when viewed electronically.

- **1985: Lower Ohio River Navigation Feasibility Report**

The Louisville District of the U.S. Army Corps of Engineers (Corps) completed the Lower Ohio River Navigation Feasibility Report. The report recommended replacing Locks and Dams 52 and 53 with a single project consisting of a new set of locks and a new dam. Construction was estimated to take 7 years.

- **1986: Chief of Engineers Report**

The Chief of Engineers completed a report recommending that Congress authorize the construction of the Olmsted project. The report provided a detailed baseline cost estimate for the recommended plan presented in the 1985 feasibility report.

- **1988: Water Resources Development Act of 1988**

The Water Resources Development Act of 1988 authorized construction of the Olmsted project at a cost of \$775 million based on the Chief of Engineers Report, with the costs of construction shared equally between funds appropriated to the Corps and from the Inland Waterways Trust Fund. At the time of authorization, the Corps estimated that construction would take 7 years.

- **1989: General Design Memorandum**

The Louisville District issued its design plan for the Olmsted project. The plan estimated the total project cost to be \$801 million (October 1988 price levels) and construction to take about 12 years.

- **1990: General Design Memorandum Supplement**

The Louisville District issued a modified project design plan resulting from comments on the General Design Memorandum and from changes in the dam configuration and project scope as presented in the General Design Memorandum.

- **1990: First appropriation for construction**

The Corps received its first appropriation for construction of the Olmsted project.

- **1993: Award of lock cofferdam construction contract**

The first major contract was awarded for the construction of the lock cofferdam.

- **1997: Method of Construction Study**

A consultant study compared the in-the-wet and in-the-dry construction methods and found that the in-the-wet method would cost less, provide the greatest schedule flexibility, and be just as reliable as in-the-dry construction. For these reasons, the study recommended that the Corps select the in-the-wet method to construct the dam.

- **1997: Decision to construct the dam using the in-the-wet method**

The Louisville District decided to construct the dam using the in-the-wet method because of lower cost, shorter construction schedule, reduced impact on navigation during construction, and potential for fewer negative environmental impacts. It was estimated that it would take 6 years to construct the dam.

- **1999: Design Memorandum No. 8, Dam**

The Louisville District issued its proposed design for the Olmsted dam, which incorporates changes made after the completion of the General Design Memorandum and Supplement.

- **2002: Request for proposals for the dam construction as a firm fixed-price contract**

The Corps requested proposals for the dam construction contract as a firm fixed-price contract, but received no offers.

- **2003: Request for proposals for the dam construction as a cost-reimbursement contract**

The Corps requested proposals for the dam construction as a cost-reimbursement contract and received two offers.

- **2004: Award of dam contract**

The Corps awarded the dam construction contract to a joint venture contractor. The winning proposal was \$564 million. The dam was estimated to be completed in 8 years.

- **2006: Dam rebaseline estimate**

A rebaseline estimate increased the total estimated cost of the dam construction contract by approximately \$81.6 million.

- **2011: Dam rebaseline estimate**

A rebaseline estimate extended the schedule by 4 to 5 years and increased the cost of the dam construction contract by approximately \$551.1 million.

- **2012: In-the-Dry Study**

The Corps conducted a study to determine whether to complete the dam using the in-the-wet construction method or the in-the-dry method. The study estimated that continuing to use in-the-wet construction would cost more, but would allow the project to be completed sooner. For this reason, the Corps decided to complete the dam using the in-the-wet method.

- **2012: Post-authorization change report**

Because the project would exceed its maximum authorized cost, the Corps submitted a post-authorization change report to Congress in 2012, seeking an increase in the Olmsted project's authorized cost to \$2.918 billion, with an estimated completion date of 2024.

- **2013: Continuing Appropriations Act, 2014**

The Continuing Appropriations Act, 2014, increased the Olmsted project's authorized cost to \$2.918 billion.

- **2014: Consolidated Appropriations Act, 2014**

The Consolidated Appropriations Act, 2014, provided that for fiscal year 2014, 25 percent of the funding proposed for the Olmsted project would be derived from the Inland Waterways Trust Fund.

- **2014: Water Resources Reform and Development Act of 2014**

The Water Resources Reform and Development Act of 2014 specified that beginning with fiscal year 2015, only 15 percent of the Olmsted project's construction costs are to be paid from the Inland Waterways Trust Fund.

Appendix II: Comments from the Department of Defense



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
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JAN 19 2017

Ms. Anne-Marie Fennell
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Ms. Fennell:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-17-147, "ARMY CORPS OF ENGINEERS: Factors Contributing to Cost Increases and Schedule Delays in the Olmsted Locks and Dam Project", dated 3 January, 2017 (GAO Code 100202).

The Department appreciates this opportunity to review the report. There are no recommendations for DoD and the Department has no comments to add to the draft report.

Sincerely,

A handwritten signature in black ink, appearing to read "Eric V. Hansen".

Eric V. Hansen
Deputy Assistant Secretary of the Army
(Civil Works) for Management and Budget

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Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Anne-Marie Fennell, (202) 512-3841 or fennella@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Vondalee R. Hunt (Assistant Director), Marie Bancroft, Timothy Guinane, and Susan Malone made key contributions to this report. Important contributions were also made by Michael Armes, Martin (Greg) Campbell, Patricia Farrell Donahue, Jason Lee, Oliver Richard, Dan Royer, Jeanette Soares, Kiki Theodoropoulos, and William T. Woods.

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