

GANNETT FLEMING

BUCKEYE LAKE STATE PARK
WEST BANK DAM IMPROVEMENTS
VALUE ENGINEERING STUDY

Prepared for the
Ohio Department of Natural Resources

Final Report
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1	Buckeye Value Engineering Study - Summary Of Potential Cost Savings

ACKNOWLEDGEMENTS

A thank you is given to the entire design team from DLZ Ohio, Inc. for their briefings and for providing detailed information in response to questions both before and during the review and value engineering study.

The review and value engineering study was conducted by a team consisting of representatives of Gannett Fleming Engineers and Architects, PC, a representative of the Ohio State Parks, and local residents. Messrs. Arthur Walz and Terry Hampton of Gannett Fleming Engineers and Architects, PC facilitated the review and prepared the report. Other team members were as follows:

Frank Foster	Member – Resident
Ed Franks	Member – Ohio Division of Parks & Recreation
Ray Karlsberger	Member - Resident
Victoria Wolfe	Member - Resident
Ken Reber	Member - Owner (mother-in-law is a Resident)

Other participants that provided valuable input were:

Kreig Babbert	Substitute for Ray Karlsberger
Denise Larr	Substitute for Victoria Wolfe
Beth Pineda	Substitute for Victoria Wolfe
Merv Bartolow	Observer – Buckeye Lake Civil Association

EXECUTIVE SUMMARY

This report documents the results of the value engineering study and project review of the design and the 50% submittal of the construction plans prepared by DLZ Ohio for the West Bank Dam Improvements to the existing West Bank Dam at Buckeye Lake, Ohio. In addition to a value engineering study, the team was asked to review several aspects of the design (alternatives considered and the one selected, the selection of soil parameters used as design values, the method of drainage downstream of the new dam, and the predicted settlement of the fill behind the sheet pile).



Photograph 1. The Existing West Bank Dam

The West Bank Dam improvement project is the first phase of a multi-phase project to address safety, regulatory, and operational deficiencies over the entire 4.2-mile-long Buckeye Lake Dam. The existing West Bank Dam is shown in Photograph 1. ODNR has stated that the design concept used for the West Bank Dam Improvement will be used for approximately 80% of the entire dam project. Therefore, the cost savings identified through this Value Engineering Study can be realized over most of the dam. The project studied consists of constructing a new stand-alone sheet pile dam for a length of about 5,150 feet along the west bank of Buckeye Lake. The contract is basically for the construction of a sheet pile dam with accompanying dredging and granular backfill. Concrete will be placed between the two sheet pile walls to provide

imperviousness to the new structure and protection for the primary sheet pile. The major cost items are the sheet piling (\$2.624 million), followed by the causeway and granular backfill (\$755,500), concrete between the sheet piles (\$377,000), the dredging (\$288,000), and the sidewalk (\$264,000). Therefore, from a value-engineering standpoint, options to these components were examined. A summary of the potential cost savings for both the West Bank Dam Improvement and the remainder of the project are shown in the following table.

Item	West Bank Phase	Remainder of Project	Total Project
Reduction of concrete between sheet piles from 4 ft to 3 ft	\$145,730	\$356,822	\$502,552
A 1-ft reduction in width between existing wall and new sheet pile wall	\$43,850	\$107,250	\$151,100
Replace sidewalk with Armorflex	\$26,142 \$4,803,	\$64,048 \$11,767	\$90,190 \$16,570
Totals	\$215,722 \$194,383	\$528,120 \$475,839	\$743,842 \$670,222

The review concluded that the design for this project by DLZ Ohio, Inc. was comprehensive and has considered the full range of options for the improvements. The soil parameters and selected design values are appropriate for this type of project. The selected alternative for the stand-alone dam is the best to meet the project requirements. The value-engineering portion of the study produced three recommended areas where potential savings can be realized while maintaining the project purpose and functions.

Sheet Pile Dam

Recommend: Reducing the width between the sheet piles from 4 feet to 3 feet would reduce cost and not impact the integrity of the dam. Normal widths for concrete cutoff walls range from 2 feet to 3 feet. This reduction of 1 foot will result in a savings of about \$145,730 for the West Bank project. The current plan requires welded shear studs (labor intensive) to provide bonding of the concrete to the sheet piles. This method of bonding should be reviewed, and welded studs may not be necessary. If the studs can be eliminated, it could result in additional project savings, which would be reflected in a lower unit price for the sheet piling.

Concrete Sidewalk

Recommend: If it meets ADA requirements, replace the 8-foot-wide concrete sidewalk for the entire length of the West Bank project with “Armorflex,” an Armortec product (or similar product), in lieu of the concrete. This will provide an equivalent bearing surface for vehicles, and grass grows in the lattice of the pavers, which provide a natural appearance. The cost in place of “Armorflex” would range from \$5.50 to \$6.00 per square foot. For the West Bank project, this would relate to a cost of \$238,023 to \$259,362, respectively, or a savings somewhere between \$4,800 and \$26,142, depending on the contract unit price. If the Armorflex

surface will not meet ADA requirements, a portion of the sidewalk width may be able to be modified to provide a partially solid surface for sidewalk purposes and partially open surface for grass growth. Even if this provides little or no savings, the aesthetics and usage of an 8-foot-wide concrete sidewalk is a major concern of the residents and should be considered in the decision to modify this element of the project. It should be noted that the existing north bank sidewalk is in disrepair at many locations, and the west bank sidewalk is incomplete. Due to severe site constraints, it would likely be less expensive to construct a new sidewalk of appropriate standards on the new dam rather than on its existing alignment.

Width Between the Old and New Dam

The distance from the existing masonry wall of the dam to the new sheet pile structure is currently designed to be 20 feet, as a requirement of ODNR for access and flood fighting actions. The 20-foot-clear width has been determined by ODNR to be the minimum necessary to allow construction, maintenance, and emergency vehicles adequate space to maneuver considering the drop-off into the lake on one side and the barrier posed by trees and the encroachments of private property owners on the other side. Twenty feet is consistent with Corps of Engineers criteria for a new levee project. ODNR has indicated that part of the clear width can be obtained from the existing dam, and it appears possible at a few locations to incorporate portions of the existing dam into the project without removing large numbers of trees and encroachments. This 20-foot width (16-foot as measured between the masonry wall and downstream sheet pile) is a major concern of the residents. They favor a reduction in the width between the existing wall and the new interior wall to somewhere in the range of 10 to 14 feet, as opposed to 16 feet, but they object to the removal of trees and encroachments from the surface of the existing dam to provide the 20 feet of clear width required by ODNR. Another key factor that controls this top width is the width needed to enable contractors to construct the project without having to rely upon barges, which adds significant cost that adds no value to the final product.

ODNR has estimated that a minimum width of 15 feet is necessary to provide contractors an opportunity to construct the project without relying upon barges. However, the distance needed for a safe threshold for particle acceleration from sheet pile driving operations must also be considered. The effects induced by vibrations at existing houses from sheet pile driving are difficult to evaluate. The greater the distance the sheet pile driving occurs from a structure, the less the vibration magnitude experienced. A recommendation of this study is, therefore, to perform additional tests to more accurately determine an appropriate distance for minimizing the risks of damages caused by vibrations. If some reduction in the constructed width is possible, the cost savings per foot of width would be about \$42,510 per mile. This savings does not consider the effects narrowing the work site for the contractor and shifting the construction closer to the trees and encroachments will have on costs.

Prior to this study, ODNR was aware that the area residents who have homes on the dam strongly object to elements of the recommended design that would result in changes to the appearance of the dam and in improved access to the dam. Their concerns about this have been expressed in a statement included in the Introduction of this report. This issue was a focal point of some members of the team throughout the study, and it was the primary reason, along with potential cost savings, for suggestions to eliminate the pedestrian sidewalk and reduce the width of the structure. Regarding the potential cost savings, a project without a sidewalk and having

less width than specified by ODNR could reduce costs, but will not provide the essential access function these elements were intended to provide.

Other Items

All of the conclusions and recommendations pertaining to this review and value engineering analysis have been summarized into the following categories: **Project Design, Operation and Maintenance Impacts**, and **Project Impacts**. The team believes the VE process should be applied to future phases as well. In general, the process has been productive. All ideas were encouraged. The resident members identified a number of issues that are documented and presented as **Other Considerations**.

Upon completion of this study, the members of the team who were residents still had concerns and objections to the project. The major objections are with 1) the 20-foot clear width required by ODNR (16-foot backfill width between the existing dam wall and the interior sheet pile of the new dam) and 2) the construction of an 8-foot-wide access road or walkway adjacent to the sheet pile. Their prepared statement is presented in the Introduction.

1.0 INTRODUCTION

This report contains the conclusions and recommendations from the value engineering (VE) study conducted for the Ohio Department of Natural Resources (ODNR) on the Phase 1 50% submittal design of the construction plans for the Buckeye Lake, Ohio, dam improvements. Phase 1 consists of improvements to the West Bank Dam, which is nearly one mile in length. ODNR has stated that this design concept will be used for approximately 80% of the entire dam project; therefore, the recommendations developed through this study may be applied to the remaining phases.

In addition to a VE study, the team was asked to review several aspects of the design (range of alternatives considered and the one selected for the improvement, the selection of soil parameters used as design values, the method of drainage downstream of the new dam, and the predicted settlement of the fill behind the sheet pile). The VE process of investigation to obtain the best functional balance between cost, reliability, and performance in a project was applied to this project. Prior to beginning this study, Messrs. Hampton and Walz were given a series of briefings and made a site visit. They also attended a public meeting on October 23, 2003. The entire team was given a detailed briefing of the design by DLZ Ohio, Inc. on November 4, 2003. Two workshop sessions were conducted on November 4 and 5, 2003, and again on December 9, 2003. During these workshops, a task flow methodology was followed. During the information phase, the team members identified many ideas and issues related to the project design. The conclusions and recommendations pertaining to the VE analysis have been summarized into the following categories: **Project Design, Operation And Maintenance Impacts, And Project Impacts**. The resident members identified a number of issues that are documented and presented as **Other Considerations**.

ODNR provided the following guidance at the onset of this study

“The goals for the project are to bring the dam up to current dam safety standards; improve access to the dam; and, to minimize the impacts of the project upon the community.” This Value Engineering Study was initiated by ODNR as a means of identifying costs savings and of improving the public’s knowledge of the project by educating their appointed representatives about the recommended design and jointly examining alternatives that meet the goals of the project. The goal of improving access has presented the most contentious issue for ODNR as it is seen by many area residents as conflicting with the goal of minimizing impacts upon the community. Nevertheless, ODNR feels that since this is a publicly funded project, access cannot be overlooked.”

Upon completion of this study, the West Bank residents who were members of the team still had concerns and objections to the project. They prepared the following statement, which has been reviewed and approved by the Buckeye Lake Area Civic Association:

“The Buckeye Lake residents who have invested many hours toward the completion of this Value Engineering Study have gained an in-depth understanding of the technical design, as well as the safety and aesthetic aspects of this project. As we represent nearly 90 homes directly affected by the first phase of the project, we feel it is our duty to insist on a reasonable resolution to the major concerns identified by the team. At this time, all the participants of the VE committee cannot agree with many of the major points of the DLZ 50% Design. The West Bank residents feel an adequate and safe design can be completed with less funds, reduced construction time and with minimal impact to the property owners, while maintaining the historic and aesthetic character of the lake.

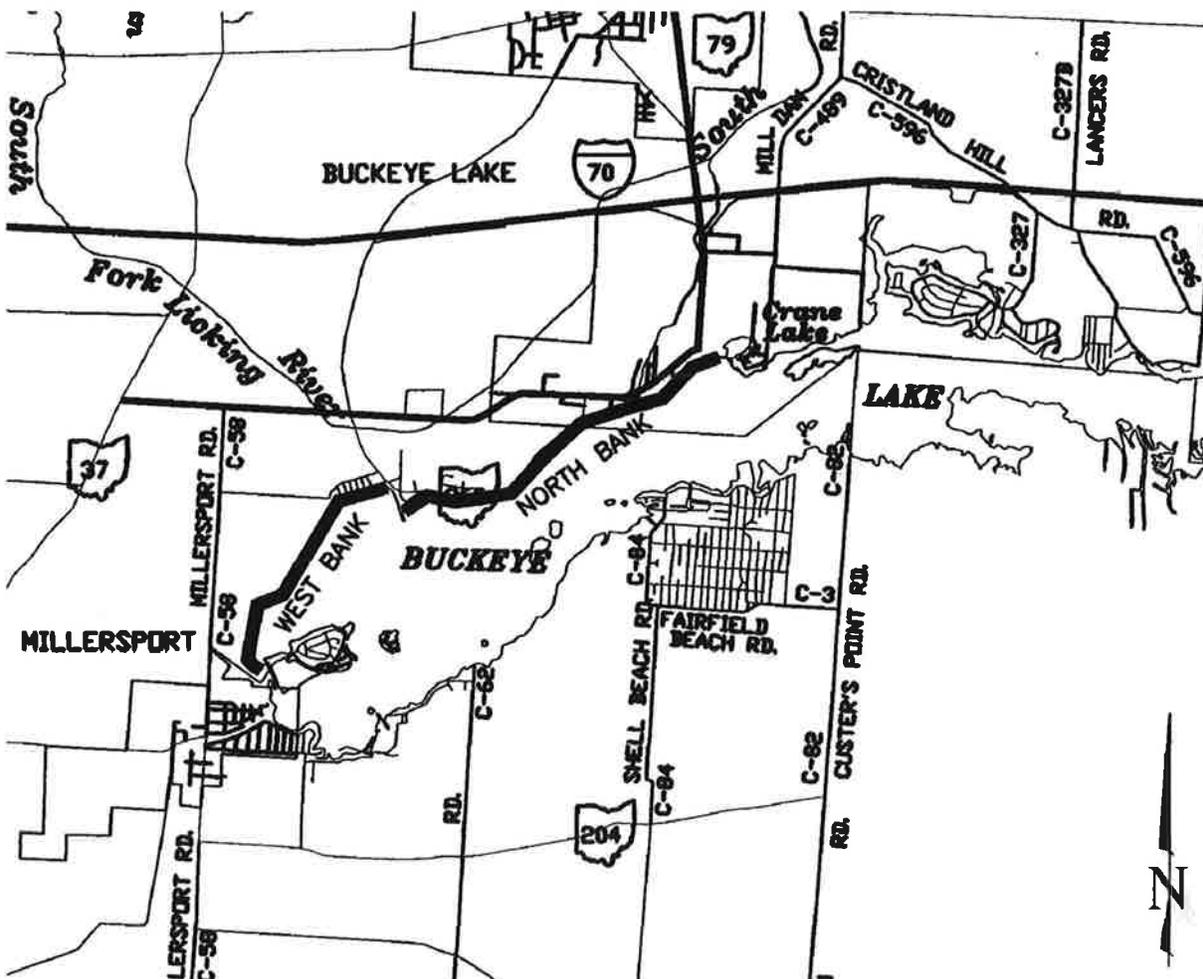
The information contained in this report is not to be considered an endorsement of the DLZ 50% Design by many of the homeowner’s representative members of the Value Engineering (VE) Committee. A number of the participants, in fact, objected to major points of the design. The two major points are: 1) the 16 foot backfill width between the existing dam wall and the new sheet pile dam and 2) the construction of an 8-foot-wide access road or walkway adjacent to the sheet pile.

These members of the VE Committee are in agreement with the proposed design change of a 2 feet to 3 feet wide double sheet pile concrete filled dam improvement that would be built in front of the existing dam wall. The disagreement is centered about how far in front of the existing dam wall this new structure needs to be built. ODNR is saying this new dam structure needs to be 4 feet wide and moved out 16 feet, making the overall added dam width total 20 feet. The West Bank resident members of the VE committee state that a 20-foot extension is an expensive over-design that drastically changes the character of the lake front and reduces both security and privacy.

Many of the other points as listed in the body of the VE report are the result of brainstorming by the committee and include many good ideas that could save taxpayers dollars and offer compromise to the existing 50% design that if implemented could help remediate some of the West Bank home owner objections. ODNR and DLZ should give serious consideration to all these suggestions and give special attention to the West Bank resident’s major objections to the dam width and the 8-foot-wide roadway.”

2.0 BACKGROUND

Buckeye Lake is located in Licking, Fairfield, and Perry counties approximately 25 miles east of Columbus, Ohio. Records indicate that construction of the dam began in 1825 and ended in 1832. The earth embankment that impounds the lake is located on the west and northwest portion of the reservoir and is approximately four miles long. The maximum height of the embankment is about 15 feet. At some point during the project's history, a masonry wall was constructed along the upstream slope of the entire embankment to protect it from wave erosion. The lake has a surface area of approximately 2,700 acres at normal pool elevation 892.25. The total drainage area of the lake is 44.1 square miles. The lake is fed by several small streams and by a feeder canal that extends from the Town of Kirkersville to the west side of the reservoir.



Plan of Buckeye Lake Dam

The dam is generally divided into two parts: West Bank and North Bank. The West Bank extends from the south end of the dam near Liebs Island north to about Mud Island and is

characterized by a relatively low-height embankment (2 to 8 feet high) for the majority of this dam segment length and a masonry wall visible along the upstream face of the embankment. The North Bank extends from near Mud Island to Picnic Point.

The embankment along North Bank is generally higher (6 to 15 feet high) for the majority of this dam segment length, and a sheet pile wall is visible along the upstream face of the embankment. The sheet pile wall was installed to replace the rock wall and serves to protect the earth embankment from erosion. It was constructed at different times, but generally between 1948 and 1982. In 1992, a small portion of new sheet pile wall was installed. A new sheet pile wall was installed in 2000 along a 500-foot-long section of North Bank near Mud Island.

The outlet works for the lake consist of two spillways on the north shore. The primary spillway is located near State Route 79 and consists of a concrete sluiceway with a crest elevation of 884.85 feet. An Amil gate is located at the crest of the sluiceway to control water flow. The gate is set to be in the full-open position when the pool is at elevation 892.2 feet. There is a staff gage located near the primary spillway, which is used to measure the pool elevation. The gage's zero datum is at elevation 891.75 feet. There is also an intake structure that controls the flow to a 60-inch-diameter pipe that outlets into the stilling basin. The invert elevation of the pipe is 881.8 feet. The secondary, or emergency, spillway is located near Sellers Point and consists of an ungated concrete gravity weir. The crest of the weir is at elevation 892.2 feet and is approximately 460 feet long. An intake structure controls flow to two pipes: a 30-inch-diameter pipe that outlets into the abandoned Ohio Canal and a 60-inch-diameter pipe that outlets into the stilling basin. The invert elevation for both pipes is at 883.9 feet.

The discharge for the reservoir is into the South Fork Licking River, a tributary of the Muskingum River. The project is presently used for public recreation and is operated and maintained by the ODNR, Division of Parks and Recreation.

The Ohio Division of Water has classified the dam as a Class I structure. Currently, the project does not meet the spillway capacity criteria for a Class I structure, and analyses show that it will overtop during the design storm event. The dam has been protected from overtopping in the past through emergency operations by placement of sandbags by Division of Parks and Recreation staff.

Since the mid 1980s, several studies and evaluations of the dam have been performed. These include:

- A spillway adequacy and embankment stability and seepage study performed by Dodson-Lindblom Associates in 1987.
- Mapping and an evaluation of the sheet pile wall performed by Dodson-Lindblom Associates between 1989 and 1995.
- A stability study performed by Paul C. Rizzo Associates between 1996 and 1997.
- Design Documents developed by DLZ, Inc. from 2002 through 2003.

3.0 VALUE ENGINEERING PROCEDURE

Value engineering is a systematic method of investigation to obtain the best functional balance between cost, reliability, and performance in a project. During this process, two workshop sessions were conducted on November 4 and 5, 2003, and again on December 9, 2003. A technical review of the design documentation was conducted primarily by the Gannett Fleming representatives. The VE process that was followed is an organized approach for reviewing the design, searching out high-cost areas in the design, and developing alternate solutions for consideration. The process contains the following five key steps:

- Information Phase
- Speculation or Creative Phase
- Analysis Phase
- Development Phase
- Recommendation Phase

These five steps are briefly described by the following:

3.1. Information Phase

At the beginning of this VE study, Mr. Hampton and Mr. Walz were given detailed briefings of the project background and the history of decisions that have influenced the development of the design by DLZ Ohio, Inc. This was followed by a site visit and attendance of a public meeting on October 23, 2003. During the initial two-day team meeting on November 4 and 5, 2003, considerable time and effort were spent in reviewing the design and documenting the issues developed by the residents. A second team meeting was held on December 9, 2003, to finalize the conclusions and recommendations. These have been summarized into the following categories: **Project Design, Operation And Maintenance Impacts, Project Impacts, And Other Considerations** and are presented in the conclusions and recommendations.

3.2. Speculation or Creative Phase

During this phase, the VE team brainstormed possible alternatives to provide the necessary functions within the project at a lesser cost. Judgment of the ideas was not included.

3.3. Analysis Phase

In this phase, the team analyzed, categorized, and ranked the ideas and issues. Due to the public concern about this project, all of the ideas from the speculation phase were documented, analyzed, and carried into the next phase.

3.4. Development Phase

During this phase, the ideas and concerns were developed into narrative form. Those pertaining to the value engineering are listed in the conclusions and recommendations under **General**,

Project Design, and Operations and Maintenance Impacts. The concerns of the homeowners were also developed and are summarized under **Project Impacts and Other Considerations.**

3.5. Recommendation Phase

This report serves to document the conclusions and recommendations by the team.

4.0 NARRATIVE

The West Bank Dam Improvements contract consists basically of the construction of a sheet pile dam with accompanying dredging and granular backfill. Concrete will be placed between the two sheet pile walls to provide imperviousness to the new structure. The major cost item is the sheet piling (\$2.624 million) followed by the causeway and granular backfill (\$755,500), concrete between the sheet piles (\$377,000), the dredging (\$288,000), and the sidewalk (\$264,000). ODNR has stated that this design concept will be used for approximately 80% of the entire dam project; therefore, the recommendations developed through this study may be applied to the remaining phases.

The full range of options other than the double row of sheet pile was examined. The sheet pile design was thought to be the best design alternative. Other cost-effective measures worthy of consideration are the thickness of concrete between the sheet pile walls, a substitution for the concrete sidewalk, and minimizing the distance from the existing masonry wall of the dam to the new sheet pile structure (currently at 16 feet as per ODNR requirement).

4.1 Critical Flood Analysis

An initial concern was raised by several team members regarding the need for a critical flood analysis of the proposed structures. They felt that the results of this analysis may indicate that no modification would be required. To address this concern, the following presentation on a critical flood analysis was made to the group.

A critical flood analysis involves computer modeling of a dam failure to determine the effects of the failure at and downstream of the dam. The type and size of the failure must be credible (i.e., something that is known to have occurred at some location previously). At Buckeye Lake, there are two dams to consider in this regard: the existing rock and mortar wall – earth embankment dam and the proposed new concrete-filled double row sheet pile dam. The critical flood is defined as a dam failure flood flow that causes a differential flood elevation from just prior to failure of the dam to after failure of the dam of less than 2 feet or where the flood failure flow velocity (ft/sec) times the flood failure differential depth (ft) is less than seven (7) ft²/sec. The flooding failures are to be evaluated up to and including the probable maximum flood (PMF). A dam is considered a single structure, so if the criteria are not met at any one location on the dam, the dam as a whole must be upgraded.

For the existing Buckeye Lake Dam, floods up to and including the PMF would overtop the rock and mortar wall – earth embankment dam. With overtopping of the earth embankment, erosion would occur, followed by dam failure causing differential flooding downstream of the dam in excess of 2 feet. Erosion would likely begin at a low spot in the crest (Elevation 894.5 feet FMSM, July 2003) or internal erosion within the embankment along a structure foundation due to elevated pool water levels. The elevation of the tailwater (downstream water surface elevation) before failure in many locations would be zero, since there is no way for the spillway discharge water to reach the toe (downstream edge) of the embankment dam in those locations.

A general rule of thumb is that the water elevation in the breached area or just downstream of a dam just after failure is four-ninths (4/9) of the elevation difference between headwater (pool elevation) and tailwater of the dam. The dam is eight plus (8+) feet high in places along the West Bank and 13.5 feet along the North Bank; thus, the differential elevation can be expected to be approximately 3.6 feet and 6.0 feet, respectively, after failure in the breach of the dam and just downstream.

In addition, the velocity of the water in a breached section of a dam can be expected to be at critical velocity (in excess [by whole number multiples] of 2 feet per second); thus, the product of velocity times depth would exceed 7 ft²/sec as well. This would dictate a critical flood design enhancement to the existing dam to the PMF elevation (896.68 feet mean sea level (msl) as calculated by FMSM Engineers, Inc., November 29, 2000) so that no overtopping could occur. The FMSM Engineers, Inc., 50% PMF Analysis of the Buckeye Lake Dam, July 2003 concludes, "The current combination of spillway capacity and lake storage (dam height) does not unambiguously satisfy the conditions necessary for the 50% PMF to be considered the Critical Flood for regulatory and design purposes because the incremental water surface elevation exceeded the 2.0 ft criterion for the most conservative breach parameters analyzed." Also, the available information does not resolve questions concerning the potential for additional loss of life, health, or property with regard to the fate of the structures built into the dam in the event of overtopping flow, erosion, and dam breaching.

The proposed new dam is, however, designed to withstand an overtopping flood. The description of this dam extends from the waterside of the front sheet pile to the backside of the back sheet pile wall (approximately 6 feet as depicted in the current plans). Since the new dam is designed to be able to withstand the required overtopping (i.e., up to and including the PMF) without failure according to DLZ, a design flood of less than the PMF is allowable with these conditions met. Consequently, a design flood height for the new dam of 40% of the PMF would be considered allowable. The new dam would still overtop during higher floods (those being extremely infrequent) and, under those circumstances, the old dam embankment would likely experience erosion, and some of the residences may experience some damage. The FMSM Engineers, Inc., 50% PMF Analysis of the Buckeye Lake Dam, July 2003 concludes "we do not believe additional analysis to determine the Critical Flood in accordance with the regulations is warranted, considering that a new, stand-alone structural dam with a crest elevation of 895.0 is being designed." This conclusion is still valid for the crest elevation of the present design of 894.5 feet mean sea level (msl) as long as the constructed dam is based upon a design of the dam that will withstand overtopping up and including the PMF.

4.2. Project Criteria

4.2.1. ODNR's Critical Flood Guidelines state that the recommendations of the Federal Energy Regulatory Commission (FERC) and the U.S. Army Corps of Engineers should be followed in selecting the dam breach parameters to be used in the analysis. The time to failure used in the analysis was 0.5 hours, not the most conservative 0.1 hours. The parameter analysis only compared elevations 2,700 feet downstream of the breach as the closest location.

4.2.2. The design guidance from ODNR was that the new dam must withstand the predicted overtopping without failure and that an access width of 20 feet should be provided for

operational and flood fighting activities. As a frame of reference, the Corps of Engineers' top width requirements are 25 feet and 24 feet, respectively, for embankment and concrete dams and a 10-foot top width for a levee plus 10 feet for access immediately adjacent to the landside toe of the levee. The Buckeye Lake Dam project is considered to be more representative to a Corps levee. The existing Buckeye Lake dam does not have 10 feet of clear access immediately adjacent to the landside toe because the downstream face of the dam is privately owned and heavily developed for most of its length as shown on Photograph 2



Photograph 2. The Existing Dam, Trees And Location Of Houses

The design and contract documents for improvements to the West Bank Dam have been prepared by DLZ Ohio, Inc. The VE was performed on the design documentation and 50% completion of the plans and specifications.

During the initial briefing of the team, ODNR stated:

“They are aware through multiple public meetings and one-on-one interviews that many area residents strongly object to two elements of the recommended design. The first is the 20-foot clear width requirement and the second is the 8-foot wide sidewalk that will serve double-duty as a pathway for official vehicles only. Both of these elements were included in the design to achieve the goal of improved access. Many area residents object to these elements because they believe a wide structure will encourage non-residents to recreate on the dam and reduce the privacy and security of the residents. ODNR has required vehicular access

capability because encroachments upon the state-owned half of the existing dam are so dense in some locations that it is virtually impassible by vehicle.”

Pedestrian sidewalks currently exist along the dam. There is a sidewalk along the full length of the north bank; however, it is in disrepair at many locations (see Photograph 3.). The west bank sidewalk is not contiguous and as such the general public uses it rarely, if at all. ODNR proposes to construct a new sidewalk as part of this project. This will result in placement of the sidewalk further away from the homes on the dam, but many west bank residents do not see this as an advantage because they believe strongly that a new contiguous sidewalk will invite more pedestrian activity in front of their homes.



Photograph 3. Existing sidewalk

5.0 REVIEW OF THE PROJECT DESIGN

During this VE study, the previous studies, design documentation, and the contract documents (50% completion) were reviewed. In particular, the range of alternatives and selected plan, the parameters and design values used, drainage plan, and predicted settlement were reviewed. It is concluded that the design for this project is comprehensive and has considered the full range of options for the improvements. The selected alternative is the best to meet the project requirements. Other conclusions related to the design are as follows:

5.1. Design Values

The review indicated that the soil parameters and selected design values used are appropriate for this type of project. The double row sheet pile as the selected alternative is the best plan for this project to withstand the designated overtopping. The consideration in question within the team is location placement of the wall. It is recommended that the design team at DLZ be satisfied that when the project is overtopped, the potential scour (headcutting, erosion, and sloughing) will not jeopardize the stability of the new dam.

5.2 Settlement

Settlement of the fill and foundation (particularly any loose silts and sands below the dredge line) under the causeway and granular fills can be expected. It is estimated that at least 90% of this settlement will occur between the construction seasons as planned. Some additional or secondary consolidation will occur in the foundation over time. Lowering the dredge line to coincide with the stiff foundation soils would reduce this secondary settlement. However, this would add cost (dredging and causeway fill) to the project

5.3. Drainage

5.3.1. The proposed system consists of 4-inch schedule 80 PVC pipes with a screen and flap gates spaced every 100 feet. Since the invert is at elevation 892.6 feet, the new fill would remain saturated to the invert elevation. Existing data indicate that the phreatic surface through the present embankment is low, and there is no reason to suspect that this approach would worsen any existing situation. With the sheet pile cutoff and flap gates on the proposed drainage relief pipes, the water elevation in the existing embankment may not get quite as high as it did in the past. Problems have been reported when the lake gets to elevation 895.00. Due to possible water backup during rising lake levels, it is not a good idea to connect drainpipes or sumps from the residences to the pipe stubs through the proposed new dam discharging to the lake. Such practice should be prohibited and enforced. Likewise, discharge of present outlets to the lake into a zone of drainage fill that meets filter criteria and has adequate carrying capacity to accommodate the discharge from the outlet pipes should be added. The number of residences (a total of approximately 90 homes from Liebs Island to Mud Island) connecting to pipes (e.g., roof drains, sump pumps, etc.) that flow into the lake is estimated to be approximately 40 to 45. An inventory of the existing outlets should be made and included in the contract documents. Also,

the backside sheet pile wall may need corrosion protection because of a wet condition contact with air at the PVC drainage pipe stubs on 100-foot centers.

5.3.2. The only other option that the team could recommend is to provide a storm sewer drain of perforated pipe in this “bathtub” area with a collector pipe to a pump station that discharges either to the lake or some other water course. Provisions for maintenance (e.g., cleanout and component replacement) of the system should be provided. Discharge existing pipes through the existing dam into a filter gradation gravel to take discharge. Use a filter design drainage fill. Keep bank run fines from clogging drainage fill. Up to three pump stations for discharge to the lake with water treatment may be required. A permit from the state or the U.S. EPA may be required to discharge stormwater into the lake. With such a system, the pipe stubs through the sheet pile every 100 feet could be eliminated.

The drainage design and modifications discussed in 5.3.1 and 5.3.2 are feasible. However, it is recommended that additional alternatives be investigated to determine if it is possible to provide a drainage system that does not rely upon lift stations, or require as many pipe penetrations through the dam with flap gates to prevent backflow from the reservoir during high water periods, which are operation and maintenance concerns.

6.0 CONCLUSIONS & RECOMMENDATIONS:

6.1. Potential Cost Savings

The review indicated that there are three primary areas where potential savings can be realized while maintaining the project purpose and functions. A summary of the potential cost savings are shown in Table 1.

Item	West Bank Phase	Remainder of Project	Total Project
Reduction of concrete between sheet piles from 4 ft to 3 ft	\$145,730	\$356,822	\$502,552
A 1 ft reduction in width between existing wall and new sheet pile wall	\$43,850	\$107,250	\$151,100
Replace sidewalk with Armorflex	\$26,142	\$64,048	\$90,190
	\$4,803,	\$11,767	\$16,570
Totals	\$215,722	\$528,120	\$743,842
	\$194,383	\$475,839	\$670,222

Table 1. Summary of Potential Cost Savings

6.1.1. Sheet Pile Dam. Recommend reducing the width between the sheet piles. Normal widths for concrete cutoff walls range from 2 feet to 3 feet. This width can be accomplished and has been constructed in this manner at other sites in the past. A reduction in the width between the sheet piles from 4 feet to 3 feet would reduce cost and not impact the integrity of the dam. This reduction of 1 foot will result in a savings of about \$145,730. Bonding of the concrete to the sheet pile should consider methods other than welded studs (labor intensive). The current plan requires welded shear studs (labor intensive) to provide bonding of the concrete to the sheet piles. The method of bonding of the concrete to the sheet pile should be reviewed, and welded studs may not be necessary. This approach should produce savings that would be included in the sheet pile cost.

6.1.2. Width Between the Old and New Dam. The second area where a potential cost savings could be realized is some reduction in the width between the existing masonry wall and the new sheet pile structure. The residents are in favor of a reduction from 20 feet to somewhere between 14 to 16 feet. Consider reducing the proposed top width (excluding the sheet pile and concrete) dimension of 16 feet to somewhere in the range of 10 to 14 feet on the lakeside of the existing dam to the new sheet pile structure. A reduced top width may reduce project costs without impacting the integrity of the dam safety aspect of the project design. However, the cost savings achieved by reducing the overall width may be negated by costs for additional tree trimming/removals and demolition of encroachments. This may also require the removal of more temporary causeway material or adversely affect some bids by reducing the contractor's work area. ODNR has required a total clear width of 20 feet for access and flood fighting

activities and has indicated that a portion of the clear width can come from the existing dam. There are few locations where segments of the existing dam have not been heavily encroached upon. Utilization of sections of the existing dam should be further investigated in those areas where impacts upon trees and private encroachments will be minimal and the construction will not be made significantly more complicated. Other key factors that control this top width are the width needed for construction equipment and the distance needed for a safe threshold for particle acceleration from sheet pile driving operations. The effects of induced vibrations at existing houses from sheet pile driving are difficult to evaluate. The greater the distance from a structure the sheet pile driving occurs, the less the vibration magnitude experienced. However, if some reduction in the width is acceptable to ODNR, the cost savings would be about \$43,580 per foot of width.

6.1.3. Concrete Sidewalk. The third area is the 8-foot-wide concrete sidewalk, which is intended for access along the project by providing a solid surface for pedestrian traffic and an all-weather base for vehicle traffic. We recommend using a product such as “Armorflex,” an Armortec product, in lieu of the concrete sidewalk (see photographs 4 – 6). This will provide an equivalent bearing surface for vehicles, and grass grows in the lattice of the pavers, which provides a natural appearance. Photographs 4 - 6 show placement on the downstream slope of a small dam. The cost in place would range from \$5.50 to \$6.00 per square foot. This would relate to a cost of \$238,023 to \$259,362, respectively, or a savings somewhere between \$4,800 and \$26,142, depending on the contract unit price.

ODNR has indicated – “That if the Armorflex surface will not meet ADA requirements for a pedestrian sidewalk, a portion of its width may be able to be modified to provide a partially solid surface for sidewalk purposes and partially open surface for the vehicular applications and grass growth. Even if this provides little or no savings, the aesthetics and usage of a solid eight-foot wide concrete sidewalk is a major concern of the residents and should be considered in the decision to modify this element of the project. It should be noted that the existing north bank sidewalk is in disrepair at many locations and the west bank sidewalk is incomplete. Due to severe site constraints, it would likely be less expensive to construct a new sidewalk of appropriate standards on the new dam rather than on its existing alignment.”



Photograph 4. Placement of Armorflex



Photograph 5. Initial Stage Of Vegetation Growth



Photograph 6. Full Vegetation

6.2. Recommendations for the Project Design:

6.2.1. Because of the project length and variation in foundation conditions, we recommend additional borings along the alignment and between selected houses, material testing, and geophysical exploration. The results of the additional exploration and analyses will determine the embedment depth of the sheet piling to be shown on the final contract drawings. The results from the geophysical will give a correlation to the existing data and evaluation from Vibra-Tech from the pile test and an indication of vibrations and potential liquefaction of the foundation in the vicinity of the houses. This information will confirm the required top width dimension. If this is inconclusive, an additional pile test should be considered. Consider installing piezometers near the houses to verify the phreatic surface at the house foundations. There are a limited number (one every 200 feet) of soil borings in the one-mile section of the existing dam from Liebs Island to Mud Island. Because of composition and saturation of the in-situ foundation soils, the potential for liquefaction during the driving of the sheet piles should be evaluated. The results of this evaluation will provide input to the additional exploration. The foundation soils along the alignment may be different from the soils in the Mud Island area where previous vibration testing was accomplished. Therefore, the contract documents should require vibration measurements (longitudinally and laterally) in critical areas, as well to address liquefaction potential.

6.2.2. The construction sequence was discussed by the team. It is desirable to complete the project in a short period to minimize inconvenience to the residents and still provide adequate time for settlement and deflection of the downstream sheet pile wall. The following construction sequence is suggested by the VE group as the fastest way to complete the work in the designated area, but we realize that it may contain flaws when the realities of construction are considered. Dock removal followed immediately by dredging should begin following the end of the boating season on or about September 10. This process should be completed before the lake is at its minimum winter pool so that backfill for construction traffic can begin on or before the lake reaches its minimum level. Lowering the lake earlier than the typical November 15 date, possibly November 1, should be considered. Furthermore, lowering the lake more than the typical 36 inches should be considered as well to allow for some flexibility for the contractor should the area receive significant precipitation during the initial phase of the project, possibly raising the lake level, thus delaying construction. The downstream row of sheet piling should be installed immediately following or, if possible, in conjunction with the initial fill work. The backfill should be installed just behind the sheet pile driving process to allow for maximum settling time and, therefore, maximum deflection of the downstream sheet piling. ODNR has indicated that a 15-foot construction width needed for the equipment and construction operations is critical for this project. Completing the above portion prior to raising the lake level in the spring would allow for work to continue throughout the summer.

While the final settlement occurs, excavation of the overfill and the final dredging of the area between the sheet piles can be accomplished during summer pool water levels. The upstream row of sheet piling should be installed immediately upon reaching desired deflection of the downstream sheet piling. Dock pilings should also be installed as the upstream sheet is installed to allow for private construction of docks as quickly as possible so that they can be used immediately upon completion of the West Bank Improvement area.

6.2.3. The potential for pile kick-out - This should be calculated for the lakeside sheet pile during the loading by the backfill concrete (e.g., fill, concrete, vehicle loadings, combination loads, etc.). Top ties at the top to keep sheet pile together during concrete filling are recommended.

6.2.4. It was noted that the epoxy has flaked off at water line on the existing sheet piles. Check coal-tar epoxy coating life cycle, check manufacturers' data, and determine if it is cost effective versus uncoated sheet pile. Consideration should be given to using an oxidized steel pile or a plastic sheet pile (Plascolite or similar product) that is manufactured locally for the outside wall. This consideration must include the structural requirements of the outer wall, the product life (ODNR needs 75 years), the ability to withstand impact loading, and the ability to be repaired.

6.2.5. Corner Configuration – sheet 8 and sheet 39 – Marina type of dock would obstruct the view of the residents; individual docks are preferable. The existing 50% design, with as many of the above considerations as possible, seems to be the best and safest approach. Several alternatives were considered, and nothing appeared to be any better. It was noted that sheet 8 shows 9 sets of H-piles. Consider finding out who wants H-piles and who doesn't to save money.

6.2.6. Low Crest Structures - Low Crest at Structures 12636, 12646, and 12656 (stations 109+00 to 111+00) - possibly use higher fill, not short concrete wall (tripping hazard). Those residents will have to be contacted and design options worked out.

Low Crest at Structures 13232, 13244, 13252, 13260, and 13284 (stations 147+ 50 to 151+ 70.98) – plans call for fill. Those residents will have to be contacted and design options worked out.

6.2.7. Delineation curb for encroachment limits – Recommend utilization of a frost-protected property corner markers instead of paving slabs. They would be less obtrusive and reduce cost.

6.2.8. Quality of Pruning – ODOT specification 666.01-08 is cited. Recommend that the General Notes include a narrative and additional pruning requirements. Consider using portions of the National Arbor Association specifications in the note. The note should also indicate a clear height of 60 plus feet over the pile driving sites, not 20 feet over the roadway. The plans should identify the trees to be pruned and the amount. Recommend that a representative of the ODNR urban forestry staff be involved in supervision of the pruning.

6.2.9. Check ADA for requirements of sidewalk for wheelchair usage. If not required, consider other acceptable alternatives or down scoping of the project by removal of the sidewalk. If the sidewalk is required, it would certainly be less costly to install it at the time of construction than later.

6.3. Operation & Maintenance (O & M) Impacts

6.3.1. It is understood that an O & M Manual will be prepared. The manual should include a flap gate inspection, maintenance, and repair and replacement schedule to prolong proper operation. For future contracts, consideration should be given to other options rather than the pipe stub and flap gates. If pipes are the solution, the spacing should be selected based on their performance in this contract.

6.3.2. The project O & M budget must reflect the level of effort required for maintenance and dam safety vegetation management/grass cutting, as well as trash management. As part of the program for monitoring the structural performance of this project, the piezometers installed for the design should be read on a frequent periodic basis during the life of the project. Therefore, the budget should include funding for the required contract or state personnel to read piezometers; collect data; plot, review and evaluate data; and recommend actions.

6.4. Additional Comments

6.4.1 Project Impacts

6.4.1.1. Security - a significant issue to the homeowners at present. The resident team members are concerned that increased width will encourage more traffic and reduce their security. They believe that no sidewalk and a reduced width of the new structure will help minimize this concern, although increased law enforcement observation may also alleviate this concern.

6.4.1.2. Privacy – The resident team members are concerned that increased traffic will reduce their privacy, and they suggest providing signage in addition to the split rail fence and gate, or other barrier, which will be used to prevent unauthorized vehicular access to the dam. They suggested the following signage "Private residences beyond this point."

6.4.1.3. Trespassing – The resident team members are concerned that the increased width of the new structure will increase the problem of trespassing on private property.

6.4.1.4. Walkways – Walkways to private docks from the residences – desired by residents. Recommend ODNR clarify its position.

6.4.1.5. Boathouse – On page 17 of the plans, check for survey of design layout features (i.e., encroachment). An encroachment here is not consistent with the project. This may be a unique situation. Will there be a change of use for the boathouse? There is a liability issue if it remains on state property. If the property is deeded to the landowner, there is not an issue.

6.4.1.6. Transfer of Ownership – Regarding the possible transfer of ownership of the present state-owned property behind masonry wall after the new structure is completed, the state should clarify this position as soon as possible, preferably before the project starts.

6.4.2. Other Considerations and General Comments from the Resident Team Members

6.4.2.1. Sellers Point Flooding Fix – A project to relieve some of the flooding problems downstream of the Sellers Point spillway on the Licking River is in progress, but not yet complete. It involves widening the channel and cleaning the channel of debris and vegetation that would cause flood levels to be higher than tolerable. The resident team members were not sure if the project is completed or not. It is their understanding that the river project is in design, but not under construction at the present time. If not complete, is there an effect on the new dam construction?

6.4.2.2. Since the flows that pass the new spillway at Sellers Point do not cause an 85% submergence of the depth of flow over the spillway crest, there is no adverse impact on pool elevations in Buckeye Lake during flooding. Thus, there would be no adverse effect on the design plan development for the new dam. The downstream flooding condition would be lessened with improved downstream channel hydraulics.

6.4.2.3. The Licking River Flow Capacity Project is needed to reduce flooding effects downstream of the dam under existing development conditions. This project will likely be constructed long before the dam upgrade project due to the size of the dam project and funding constraints. It is expected to take 8 to 10 years to complete the dam project after the first phase of construction gets started.

6.4.2.4. Communications – Communications of all facts and decisions between ODNR and the residents are still a concern of the residents.

6.4.2.5. The residents affected by future construction phases may have different desires and interpretations of needs than those involved with the West Bank area and phase of the project that was studied. The team believes the VE process should be applied to future phases as well. In general, the process has been productive. All ideas were encouraged.

**BUCKEYE LAKE STATE PARK
WEST BANK DAM IMPROVEMENTS**

TABLE 1

VALUE ENGINEERING STUDY
SUMMARY OF POTENTIAL COST SAVINGS

West Bank project length	5,150	lf				
Remainder of Project	12,590	lf				
1 Reduction of concrete between sheet piles from 4 ft to 3 ft						
	section	total				
	sq ft	sq ft	cy	price	amount	
West Bank						
Dredging	2	10,300	381	30	\$11,430	
Structural excavation	7	36,050	1,335	30	\$40,050	
Lean mix concrete	25% savings			377,000	\$94,250	
						savings \$145,730
Remainder of Project						
Dredging	2	25,180	933	30	\$27,990	
Structural excavation	7	88,130	3,264	30	\$97,920	
Lean mix concrete	25% savings			923,650	\$230,912	
						savings \$356,822
2 A 1-foot reduction in width between existing wall and new sheet pile wall						
	section	total				
	sq ft	sq ft	cy	price	amount	
West Bank						
Dredging	2	10,300	381	30	\$11,430	
Causeway fill	4.5	23,175	858	20	\$17,160	
Granular fill	4	20,600	763	20	\$15,260	
						savings \$43,850
Remainder of Project						
Dredging	2	25,180	933	30	\$27,990	
Causeway fill	4.5	56,655	2,098	20	\$41,960	
Granular fill	4	50,360	1,865	20	\$37,300	
						savings \$107,250

TABLE 1

VALUE ENGINEERING STUDY
SUMMARY OF POTENTIAL COST SAVINGS

3 Concrete Sidewalk

	West Bank		Remainder of Project	
Sidewalk cost	4803 sy	\$264,165		\$647,204
	cost/sf			
Armorflex materials placement	3.50			
	2.00 to 2.50			
43,277 sf				
		savings		savings
Cost @ \$5.50	\$238,023	\$26,142	\$583,156	\$64,048
Cost @ \$6.00	\$259,362	\$4,803	\$635,437	\$11,767