Review and Assessment of the Indianapolis North Levee System, Rocky Ripple Area

Marion County, Indiana

Prepared for:
City of Indianapolis
Department of Public Works

February 2017

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EXECUTIVE SUMMARY

PURPOSE

The purpose of the study is to provide technical support to the City of Indianapolis regarding the selected Westfield alignment of the proposed next phase of the Indianapolis North Flood Damage Reduction Project, including an assessment of the information that is the basis of the alignment selection and to assess a possible range of options related to Rocky Ripple flood protection. The analyses include engineering, economic, and environmental assessments to determine if identified alternatives are compatible with Corps and FEMA requirements. It is noted that the US Army Corps of Engineers (USACE) expects to advertise construction of the selected Westfield alignment in the first quarter of 2017 with construction completion by December 2018.

LOCATION

The Rocky Ripple community is located between the White River and the IWC Canal in Marion County, Indiana. A levee system along the White River provides some flood protection (estimated to overtop at about a 20 year storm event), but it is in a significantly deteriorated condition.

BACKGROUND

The ongoing Indianapolis North Flood Damage Reduction Project includes a series of levees, floodwalls and drainage works to reduce flood risks for over 2000 buildings in the Broad Ripple area of Indianapolis. Construction has been completed for phases 3A and 3C of the project. Unexpected soil conditions required re-alignment of phase 3B, which provides the southern (downstream) levee tie-off to high ground necessary to complete the line of protection. Three alternative phase 3B alignments were considered by the USACE in their 2012 Draft Supplemental Environmental Impact Statement (DSFEIS), including a reevaluation of an alternative that would provide protection for the Rocky Ripple community.

As shown in Figure 1 and Figure 2 the USACE Rocky Ripple alternative ties into the southern end of the Riviera Club property and then parallel to the Citizens Water Canal, with the section constructed with 310 ft. of concrete T-wall and 160 ft. of steel sheet pile I-wall. Following the 470 LF that parallels the canal, the floodwall turns west and south following the path along the White river and around the Town of Rocky Ripple. It then turns eastward along the north side of the Butler University ball fields, crossing the Citizens and typing into high ground on the Butler University campus. The USACE concept level cost (2013 Price Level) was $45.1 million, about $33.5 million more than the selected Westfield alignment. While the Rocky Ripple alternative would provide flood protection for an additional 315 buildings, USACE determined that the b/c ratio of this alternative to be less than 1.0 and therefor ineligible for consideration as a federal project under USACE policy

The preferred USACE alignment Final Supplemental Environmental Impact Statement (FSEIS) and agreed to by the City of Indianapolis in December of 2015 would extend the line of protection across the Central Canal (owned by CEG) and southward between the canal and Westfield Boulevard. This preferred alignment would exclude the community of Rocky Ripple from the protected area.

As part of comments made on the DSEIS, residents of the Rocky Ripple area expressed concern about the limits of flood protection. Within the study area, 315 buildings vulnerable to flood damage were identified, of which all but four are residences. Approximately three quarters of the buildings are single-story residences, and almost all were constructed in the period 1920-1968. The only non-residences identified in the Town of Rocky Ripple are the town hall and one private business, both of which are located in buildings structurally similar to single-story residences. A further two non-residential buildings were identified in the Butler University Athletic Fields.

ALTERNATIVE PLANS CONSIDERED AND EVALUATED

The USACE Plan for Rocky Ripple was reviewed in detail to identify potential cost savings that might make the project economically viable. The T-walls along the White River comprise over $17 million of the $48 million (2016 price level) total construction cost of the USACE Rocky Ripple alternative that was considered in the FSEIS.

Based on the findings in the 2011 Christopher Burke LLD. Rocky Ripple Levee Inspection Report, rebuilding the existing Rocky Ripple levee system was evaluated as a possible cost effective alternative to the T-walls included in the USACE design that was rejected as not being economically viable.

Three alternatives that would provide flood risk management reduction for Rocky Ripple plans were analyzed.

- Alternative 1 – follows the alignment of the USACE Rocky Ripple alternative plan that USACE considered in the ROD, but utilizes a levee (instead of the T-wall that USACE proposed). Levee with crest that provides 300 yr. protection plus 2.4 ft. of freeboard comparable to and compatible with the USACE 300 year plan (Figure 6). Alternative 1 was assumed to be implemented by USACE to complete the North Indianapolis Flood Control Project, if shown to be economically viable. The estimated cost of Alternative 1 is about $45.2 million, which is about $2.7 million less than the USACE Rocky Ripple Alternative that was considered in the 2013 FSEIS. The "incremental cost" to include flood protection for the Rocky Ripple over the cost of the USACE selected Westfield alignment ($12.3 million <2016 Price level>) is about $ $32.9 million for Alternative 1.

- Alternative 2 – provides for a levee with a crest at the 100 yr. flood level with 3 ft. of freeboard to meet FEMA criteria. It assumes USACE construction of the Westfield alignment to complete the Indianapolis North Flood control project, and would be constructed as a "stand-alone" project to protect the community of Rocky Ripple as well as the Butler University West Campus, as shown in Figure 7. The estimated cost of Alternative 2 is about $46.4 million,

- Alternative 3 – provides for a levee with a crest at the 100 yr. flood level with no freeboard and does not meet FEMA criteria. It assumes USACE construction of the Westfield alignment to complete the Indianapolis North Flood control project, and would be constructed as a "stand-alone" project to protect the community of Rocky Ripple as well as the Butler University West Campus, as shown in Figure 7. The estimated cost of Alternative 3 is about $39.6 million.

The estimates include the costs to relocate applicable buildings, and to remove and dispose of decks, retaining walls, and bought-out residential and municipal buildings that are located within the levee footprint and associated clear zone.

Table 1 compares the annualized benefits, costs and the BCRs for the three alternatives. Alternative 1 has a BCR of 0.8, while "stand-alone" Alternatives 2 and 3 have BCRs of 0.6 and 0.5, respectively.

This analysis does not take into account that there would be at least a four year delay in completing the Indianapolis North flood damage Reduction Project if USACE was to reconsider its selected plan to include the Rocky Ripple component. Design of the Westfield alignment is mostly complete and the funding is in place to award and complete construction by the end of 2018.

Table 1. Benefits, Costs and Benefit to Cost Rations of Alternatives 1, 2 and 3

Plans Summary	Alternative 1: USACE implemented 300-year protection (2.4 ft freeboard)	Alternative 2 Stand-Alone 100-year protection (3 ft freeboard))	Alternative 3 Independent Stand-Alone 100-year protection (0 ft freeboard))
Total Benefits	$1,238,000*	$1,205,000	$933,000
Annual Amortized Cost	$1,323,000	$1,864,000	$1,591,000
Annual O&M	$282,500	$282,500	$281,000
Total Annual Cost	$1,605,500	$2,146,500	$1,872,000
BCR	0.8**	0.6	0.5

*Benefits without adjustment for delay. Adjusted for delays, benefits are $486,600.
**BCR without adjustment for delay. The BCR is 0.3 when adjusted for delay.

For USACE to reconsider a plan that includes Rocky Ripple would require additional engineering, environmental and cultural studies, another public review and comment process, and detailed design of the new plan that would delay project completion by at least 4 years. The delay would leave about 2,000 buildings vulnerable to flooding that would have otherwise been mitigated by the completed Westfield alignment. This loss of benefits is about $18 million over the four year period, or about $715,000/yr. on an annualized basis. Taking into account the delay costs reduces the annualized benefits for Alternative 1 to $486,800 which lowers the BCR to 0.3.

In calculating the project benefits, it was assumed that that the existing Rocky Ripple levee would continue to provide about a 20 year level of protection over the 50 year period of analysis. As mentioned, the existing levee is in poor condition. It is estimated that the cost to rehabilitate the levee to provide the current level of protection would cost about $5.4 million. Should the Rocky Ripple levee fail to function, the annual damages would more than double to $3.3 million, and also create significant life-safety issues.

Non-structural measures such as raising, relocating or acquiring buildings that are in the flood plain were also evaluated, and determined not to be economically viable

KEY FINDINGS

- The existing Rocky Ripple levee is in a seriously deteriorated condition. The analyses indicates that the levee currently has a 5% or greater annual chance of overtopping (20 year level of protection) and there is about a 92% change that the levee will be overtopped at least once over the next 50 years.

- The levee has not been evaluated for stability and seepage which may indicate that the levee is subject to structural failure in addition to overtopping. An investigation of the levee embankment and foundation materials should be undertaken to determine the conditions of the embankment. The soil data may then be used to perform a stability and seepage analyses and to refine design requirements for rehabilitation or replacement of the existing levee.

- Use of an earthen levee provides cost savings as compared to the extensive use of floodwalls in the USACE Rocky Ripple Alternative considered in the FSEIS in 2013. However, there would be greater real estate requirements associated with reconstructing the levee, in lieu of the T-wall that was proposed in the USACE plan.

- Alternative 1, which was assumed to be constructed by the USACE, would require requesting the USACE to re-open the alternatives assessment and delay initiating construction. The design of the previously selected Westfield alignment is mostly complete and the funds are in place to complete construction of the Indianapolis North Flood Damage Reduction Project by the end of 2018, which would provide protection to over 2,000 buildings

- To reconsider a USACE plan that includes protection of the Rocky Ripple community would result in a delay of at least 4 years in completing the project. This would leave those 2,000 buildings vulnerable to flooding during that time. The loss of benefits would be approximately $715,000 on an average annual basis.

- When the loss of benefits is taken into account, the incremental BCR for Alternative 1 is 0.4, making this alternative not economically viable for USACE implementation.

- A decision to complete the Indianapolis North project without USACE participation would still have approximately a 4 year time frame for completion of environmental documentation, acquisition of lands and easements, project design and construction. Even if the community were to complete the project to USACE or FEMA standards, the division of design and construction responsibilities would make obtaining levee certification/ accreditation of the entire project difficult.

- “Stand-alone” Alternatives 2 and 3 also have BCR’s of less than 1, as do non-structural alternatives such as retrofitting homes and buy outs of homes and buildings that are located in the flood plain.

- If the existing levee were to be damaged or fail for any reason, the community of Rocky Ripple would be exposed to more frequent flooding. If levee repairs are not completed. The average annual damage due to flooding would more than double.

- Given the badly deteriorated condition of the existing Rocky Ripple levee further analyses of the levee are needed. Rehabilitation of the existing levee could be eligible for inclusion in the USACE Rehabilitation Inspection Program (RIP). Participation in the RIP provides access to Federal funds for repair of storm damage to the levee if it is damaged in an extreme flood event.

- Decisions regarding long-term plans to upgrade the Rocky Ripple Levee will require more detailed engineering design assessments, including collection of existing embankment and soils data. Factors to be considered include: community acceptability; environmental impacts, costs; design reliability safety, performance of the project and the residual risks.

RECOMMENDATIONS

- Continue coordination with the Rocky Ripple community to refine the design requirements and select a long term levee upgrade or replacement plan that improves community resilience, public safety and would also be eligible for inclusion in the USACE Rehabilitation Inspection Program (RIP).

- City of Indianapolis and Town of Rocky Ripple to define next steps to undertake boring, stability, and seepage analyses of the existing Rocky Ripple Levee to determine its stability and identify specific areas that may be vulnerable to failure.

- Utilize soils data to refine the design requirements for rehabilitation or replacement of the existing levee per CBBEL levee inspection report.

- Progress to schedule advertisement and construction award of the Westfield Alignment, which would complete the Indianapolis North Flood Damage Reduction Project, in order to ensure that flood risk management for the over 2,000 buildings within the Line of Protection is not delayed or compromised.

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1 INTRODUCTION

1.1 Purpose

The purpose of the study is to provide technical support to the City of Indianapolis regarding the selected Westfield alignment of the proposed next phase of the Indianapolis North Flood Damage Reduction Project, including an assessment of the information that is the basis of the alignment selection and to assess a possible range of options related to Rocky Ripple flood protection. The analyses include engineering, economic, and environmental assessments to determine if identified alternatives are compatible with Corps and FEMA requirements. It is noted that the USACE expects to advertise construction of the selected Westfield alignment in the first quarter of 2017 with construction completion by December 2018.

1.2 Location

The Rocky Ripple Levee system is built on the West Fork White River in Marion County, Indiana. It extends from the walking path located adjacent to the Indianapolis Central Canal behind the Butler University Athletic Fields up to the West Fork of the White River, southwest of Westfield Boulevard, where the Line of Protection (LOP) follows the Left Bank of the River and ties into high ground behind Ripple Road. A project area map is shown in Figure 1.

1.3 Background

The ongoing Indianapolis North Flood Damage Reduction Project includes a series of levees, floodwalls and drainage works to reduce flood risks for over 2000 buildings in the Broad Ripple area of Indianapolis. Construction has been completed for phases 3A and 3C of the project. Unexpected soil conditions have required re-alignment of phase 3B, which provides the southern (downstream) levee tie-off to high ground necessary to complete the line of protection. Three alternative phase 3B alignments were considered by the USACE. In addition, a prior alternative around Rocky Ripple was re-evaluated. The preferred USACE alignment identified in the FSEIS and agreed to by the City of Indianapolis in December of 2015 would extend the line of protection across the Central Canal (owned by CEG) and southward between the canal and Westfield Boulevard. This preferred alignment would exclude the community of Rocky Ripple from the protected area.

As part of comments made on the FSEIS, some residents of the Rocky Ripple area expressed concern about the limits of flood protection. Within the study area, 315 buildings vulnerable to flood damage were identified, of which all but four are residences. Approximately three quarters of the buildings are single-story residences, and almost all were constructed in the period 1920-1968. The only non-residences identified in the Town of Rocky Ripple are the town hall and one private business, both of which are located in buildings structurally similar to single-story residences. A further two non-residential buildings were identified in the Butler University Athletic Fields.

The plans developed by the USACE included removal of 5,265 linear ft. of the existing levee and installation of a pile supported T-wall in its place (Figure 2). The USACE plan included many other features including 3,200 feet of levee, the acquisition and removal of 43 buildings and an additional 22 properties with outbuildings, and construction of a sanitary sewer collector and a package treatment plant.

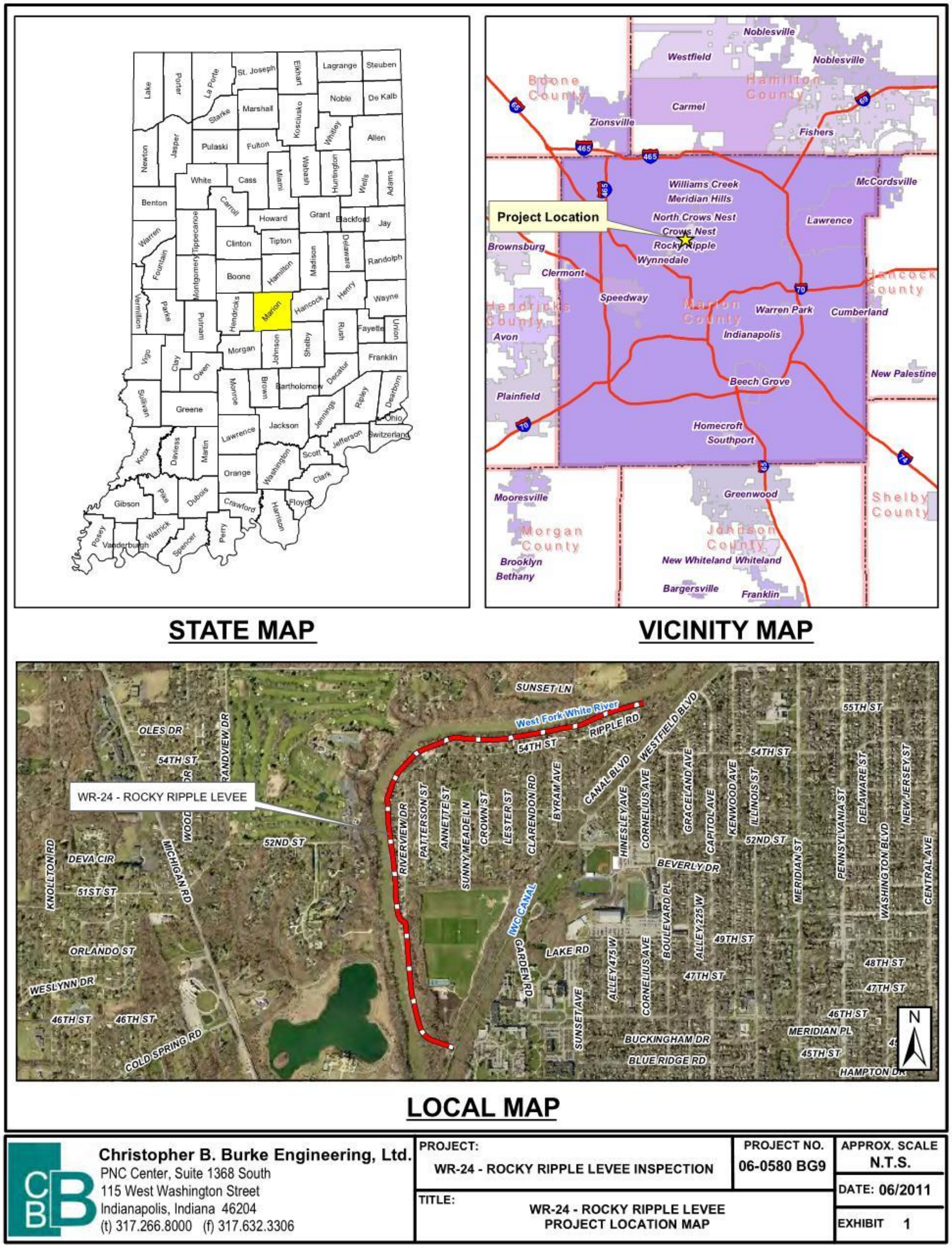

Figure 1. Location Map

The FSEIS indicated that the Benefit to Cost Ratio (BCR) of protecting the Rocky Ripple community was 0.83 at 2013 price level and a 3.75% discount rate. For the USACE to recommend constructing any separable increment of a project it must provide at least $1 in benefit for every $1 in cost. Since the incremental BCR was below 1.0, the USACE concluded that the additional cost of constructing the Rocky Ripple alternative did not meet the standard for cost effectiveness.

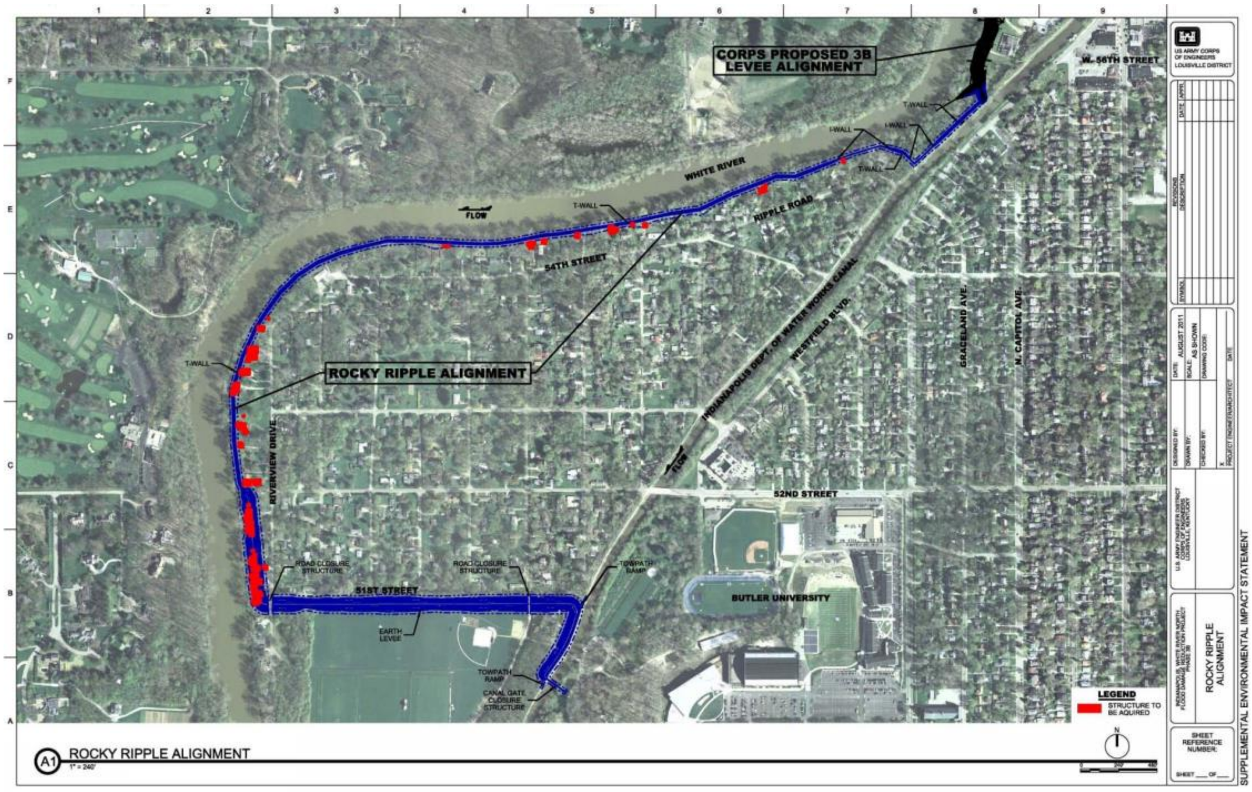

Figure 2. USACE Rocky Ripple Alignment Alternative (from 2013 FSEIS)

1.4 Overview of the Scope of Work

- Review Existing Data and Reports
- Re-evaluate Plans to Incorporate Rocky Ripple into the USACE Plan
- Identify and Evaluate Other Levee Options
- Identify and Evaluate the Potential for Non-structural Flood Damage Reduction with FEMA Grants or Other Funding Sources.
- Assess Implementation Constraints and Timelines

2 EXISTING DATA REVIEW

Existing documents and studies related to the proposed Westfield alignment selection and Rocky Ripple flood protection, were compiled, reviewed, and assessed.

2.1 USACE documents pertaining to Rocky Ripple Alternative

- General Reevaluation Report and Final Environmental Impact Statement, Indianapolis North Flood Damage Reduction Project, September 1996.
- Draft Supplemental Environmental Impact Statement (DSEIS) for the Indianapolis North Flood Damage Reduction Project in Indianapolis, Indiana, USACE, Louisville District, June 2012
- Final Supplemental Environmental Impact Statement (FSEIS) for the Indianapolis North Flood Damage Reduction Project in Indianapolis, Indiana, USACE, Louisville District, June 2013
- USACE Record of Decision for Indianapolis North flood Damage Reduction Project , Marion County, Indiana, June 27, 2014
- USACE Rocky Ripple Alternative Supplemental Concept-Level Economic Analysis

The FSEIS evaluated three alternatives to complete the Phase 3B Alignment, including a Rocky Ripple Alternative that was designed to minimize the footprint of real estate acquisitions and the demolition of buildings, while providing flood protection for a 300-year flood event. The design included approximately 9,335 total linear feet (LF) of floodwall and earthen levee; a gated-structure across Citizens Water Canal; sewer gatewell structures; roadway and pedestrian closure gates; pumping stations; the acquisition and demolition of 43 buildings, including 22 residences; the clearing and grubbing of trees and other deep-rooted vegetation to a distance of 15 feet from both sides of the floodwall; the partial or complete removal of approximately 50 residential septic system lateral fields; and construction of a sanitary sewer system, including construction of a package sewer treatment plant and installation of approximately 5,600 LF of 8-inch sewer pipe (Figure 2).

The estimated cost of the Rocky Ripple alternative was $45,093,000 (2013 Price Level), including an incremental cost of $33,481,000 to provide protection for the Rocky Ripple community. With an incremental BCR of 0.83, this alternative was deemed economically unfeasible for the purpose of USACE funding criterion.

The USACE Plan for Rocky Ripple was reviewed in detail to identify the high cost items, such as the T-Wall along the White River and real estate costs. The T-walls along the White River comprise over $16 million of the $43 million total construction cost of the Rocky Ripple alternative, while the Real Estate costs are over $5 million. The report was also reviewed to assess possible cost savings, such as constructing levees instead of floodwalls, and relocating the buildings on the existing levee.

2.2 Hydraulic Models

A preliminary analysis of the hydrologic and hydraulic data available was conducted in order to prepare a HEC-RAS model to evaluate the Rocky Ripple levee system. This data included a USACE HEC-RAS model covering the Rocky Ripple area, which was a revised version of a 1979 FIS Study HEC-2 model. As such, the USACE HEC-RAS model was a straight line model (cross sections were not georeferenced). The levee heights were above the 500-year event.

The Effective Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM, Panel 135 – see Figure 3) for Marion County, IN (April 19, 2016) were reviewed to identify the location of the sections in the model. The Rocky Ripple area and existing levee is located on the left bank of White River between lettered cross-sections AM (station 238.2) and AT (station 240.2) or between Michigan Road and Kessler Boulevard.

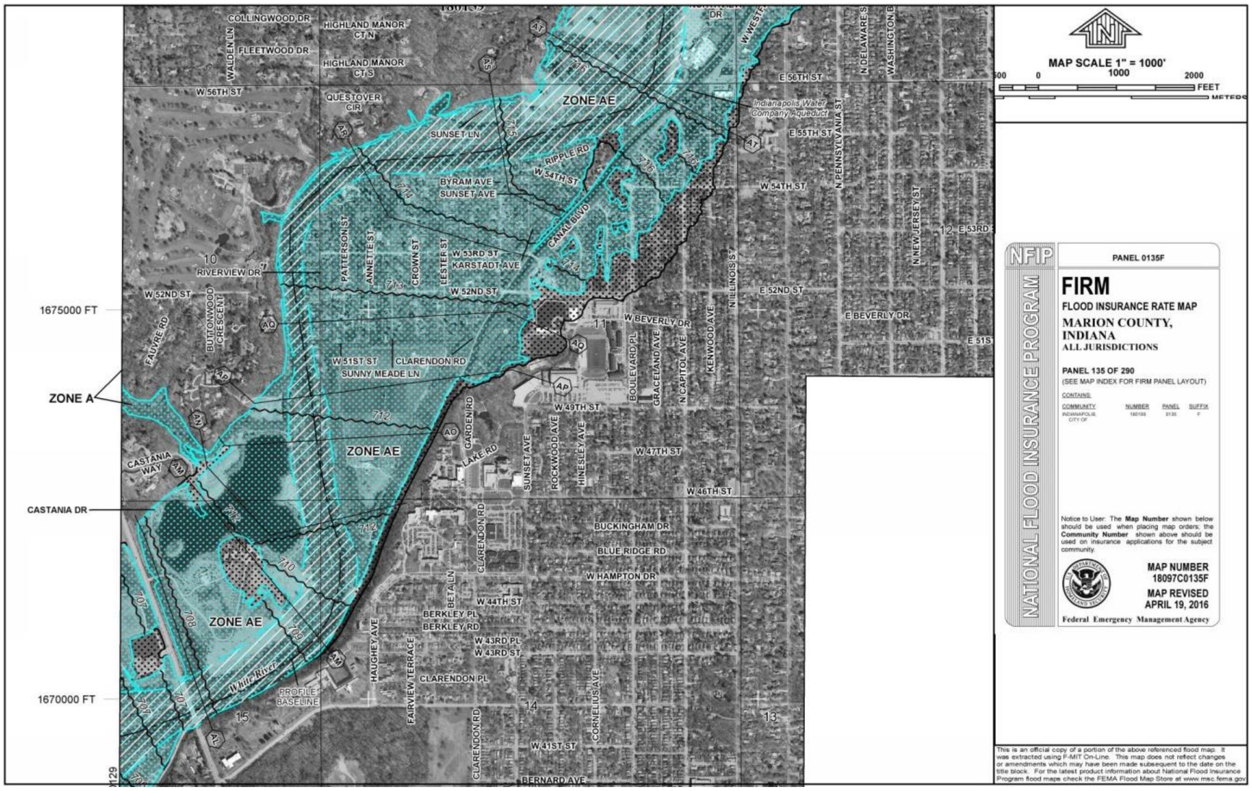

Figure 3. Effective FIRM

The original HEC-RAS model used in the USACE project analysis modelled the levees and areas behind the levees, throughout study area, as obstructions (Figure 4). This resulted in the e USACE model overstates the level of protection and benefits that would be provided by the Rocky Ripple Alternative that was considered. This resulted in the USACE model yielding annual benefits of about $220,000 greater than the benefits calculated based on the hydraulic model developed as part of this study

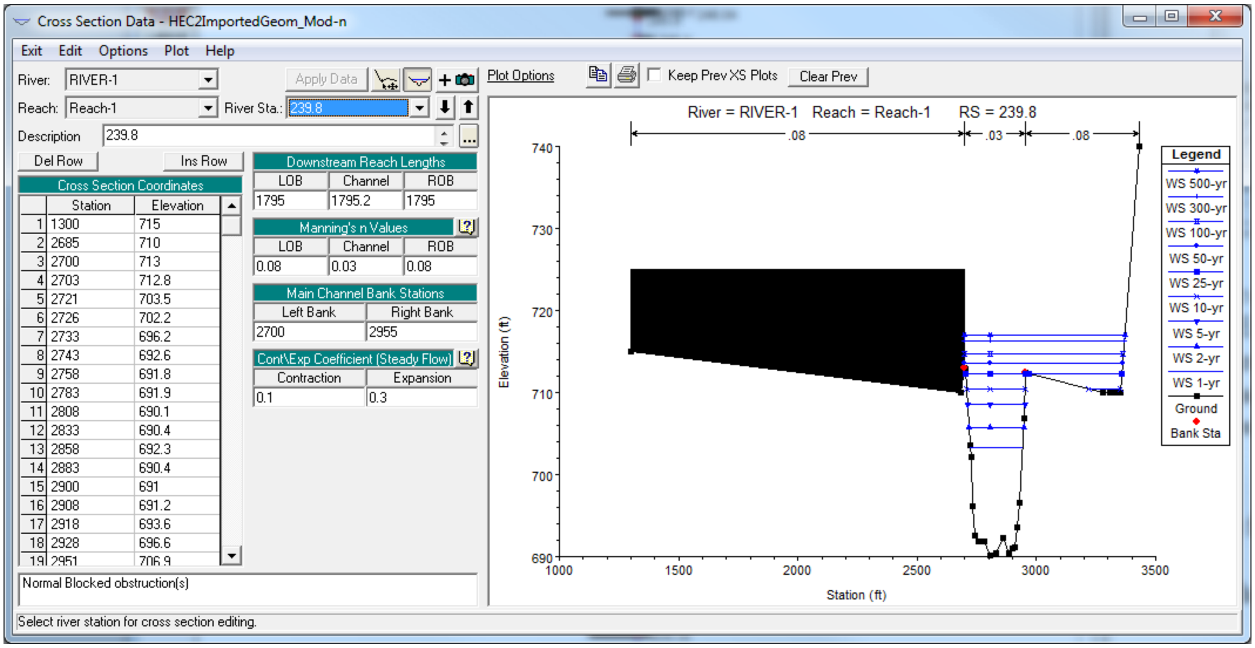

Figure 4. White River Original Existing HEC-RAS Section (AS) at Rocky Ripple

For the area of interest, the HEC-RAS model cross-sections were revised to more accurately reflect the existing levee at RR as presented in the report by Christopher B. Burke Engineering, LLC (CBBEL) titled *WR-24 Rocky Ripple Levee Real Estate Limits Study, Revised Project Summary Memorandum (2nd Revision)* dated April 29, 2014. The revised sections were modeled with the levee features as shown in Figure 5.

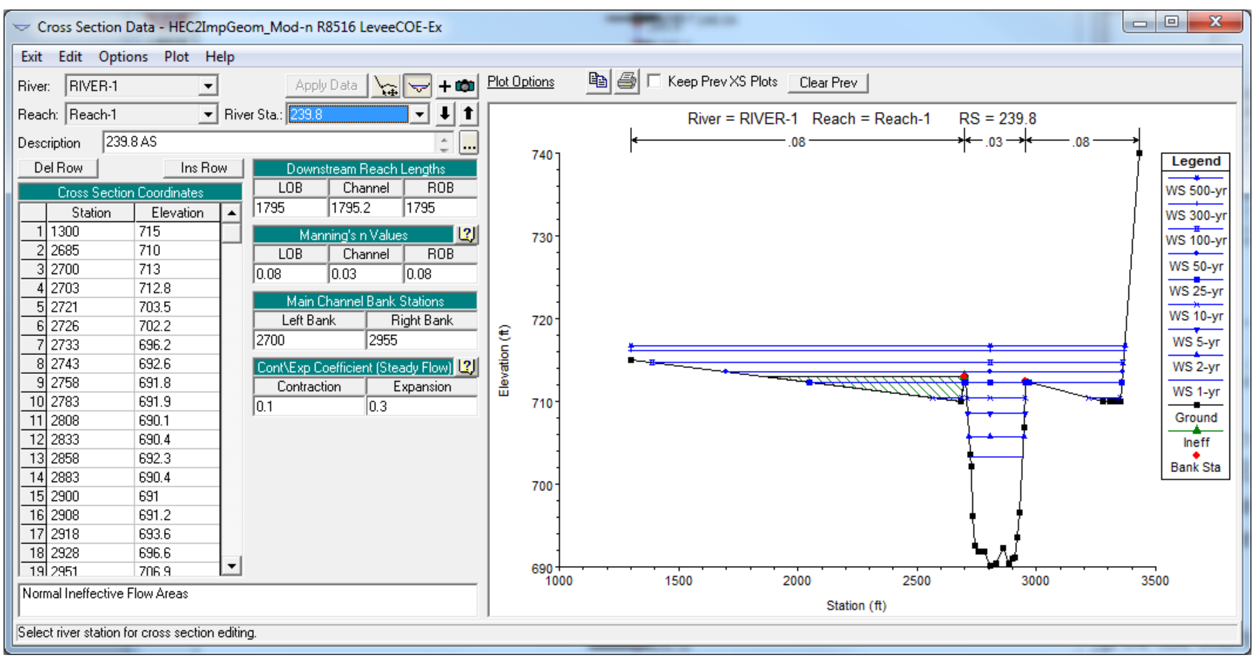

Figure 5. White River Revised Existing HEC-RAS Section (AS) at Rocky Ripple

The revised model more accurately reflected the Existing Conditions at RR; however, the overall change from obstructed overbank to ineffective flow below the existing levee height only impacted the model by +/- 0.05 feet at each section for the 100-year event. The revised Existing Conditions model became the starting point for the analysis of the alternatives.

2.3 Levee Inspection Report

The *WR-24- Rocky Ripple Inspection Report*, prepared by Christopher B. Burke Engineer, Ltd (CBBEL). (September 2011), was reviewed and its findings and recommendations appeared to be accurate and appropriate. The report indicated deficiencies including the presence of buildings such as homes, garages, and decks, and structures like retaining walls within and adjacent to the existing levee, as well as holes, burrows, depressions, and extensive vegetation growth (trees and brush) throughout the levee and clear zone. The report also identified a deteriorated existing interior drainage system located near station 0+50 and a 36-inch diameter interceptor sewer located near levee station 7+80 to be exposed to the elements.

The inspection report estimated that the existing levee would overtop at an approximate 5% Annual Chance Exceedance (20-year event) and that the annual damage estimates would more than double if the levee was permanently breached. The inspection report also developed a partial levee reconstruction and rehabilitation plan for the existing levee that includes:

- Reconstructing/restoring approximately 8,600 linear feet of levee
- Improving the interior drainage system by adding a check valve, sluice gate and concrete headwall
- Adding a closure gate at the interceptor sewer with an allowance for roadway improvements.

CBBEL estimated the cost for the partial levee reconstruction and rehabilitation plan to be approximately $4,087,000.

2.4 USACE HEC-FDA Flood Damage Reduction Benefit Model

The 2013 USACE report referenced a HEC-FDA model used to compute flood damages in that report. Since the model itself could not be provided to AECOM, a new HEC-FDA model was generated from scratch. In addition to output from hydraulic analyses, the HEC-FDA model requires an inventory of buildings vulnerable to flooding in the study area, and the assignment of appropriate depth-damage functions which facilitate the calculation of dollar damages for each building during flood events of a range of frequencies.

AECOM developed a base file of vulnerable buildings using the limited building data provided by USACE, linked to publicly available LIDAR and local tax assessment data. Additional building characteristics were identified from public online sources such as Google Street view. These were verified and revised based on site inspections. Using the building data gathered as described above, a depreciated building replacement value was derived for each building and its contents, using current square foot cost information published by RS Means, and in accordance with current flood damage estimation best practice. An average number of vehicles per residence was developed using the most recently published Census information. The average value for the vehicles was determined using publicly available valuation information, and this data was included in the building inventory.

Using this methodology, the total depreciated building replacement value for the 315 buildings identified in the study area was estimated to be $68,473,000, with an additional $3.2 million worth of vulnerable motor vehicles in the study area. For comparison, available tax records from Marion County provided by the USACE indicate a total improved value of approximately $25 million for properties in the study area.

The depth-damage functions used in this analysis were mostly drawn from the Generic Depth-Damage Relationships for Residential Structures with and without basements derived by the USACE of Engineers (Economic Guidance Memorandum 04-01, 10 October 2003 and EGM 01-03, 4 December 2000). These functions have become the standard flood depth-damage functions for use in studies of this nature for single-family residential and similar buildings since their release. For the small number of non-residential buildings in the study area, depth-damage functions were selected from functions developed for use in the Passaic River Basin in the years 1980-1982. In recent years it has become accepted practice for USACE flood risk reduction projects to use a combination of the EGM 01-03 and EGM 04-01 functions for most residential buildings and the PRB functions for non-residential buildings.

Expected annual damages calculated using HEC-FDA version 1.4 for the without-project condition are summarized in Table 2 below. The estimated total without project annual damage of $1,262,300 is within 10% of damage estimated by the prior USACE analysis.

Table 2. Without Project Condition Annual Average Damages

Damage Category	**Annual Average Damage**	**Percent**
Residential Buildings	$1,097,500	87%
Non-Residential Buildings	$21,600	2%
Motor Vehicles	$142,200	11%
Total	***$1,262,300***	***100%***

The existing levee is estimated to provide a level of protection such that it would be overtopped by a flood event of between 4% and 5% annual chance of exceedance (i.e. 20- to 25-year flood). To illustrate the impact of the existing levee being overtopped, Table 3 presents the number of buildings in the study area which would experience flooding during the 4% (25-year) and 1% (100-year) annual chance exceedance events.

Table 3. Impact of Existing Levee Overtopping

Flood Depth at Main Floor (Feet)	**4% Annual Chance Exceedance (25-Year) Event**	**1% Annual Chance Exceedance (100-Year) Event**
Below main floor	49	30
<1	65	37
1	28	9
2	52	14
3	49	28
4	64	53
5	31	45
>5	26	129
Total	**315**	**315**

During a 1% annual chance exceedance (‘100-year’) event 40% of the residences in Rocky Ripple would be flooded to a depth greater than five feet above the main floor. This presents a major risk to life and safety and would result in long-term displacement for many residents.

3 TECHNICAL APPROACH

3.1 Structural Measures

Based on the findings in the CBBEL Rocky Ripple Levee Inspection Report, there appeared to be an opportunity to partially rebuild the existing 8,600 ft. levee system in a manner that would greatly reduce the need for T-walls, and potentially significantly reduce the project cost.

Three alternatives that would provide floor risk management reduction for Rocky Ripple plans were analyzed.

- Alternative 1 –follows the alignment of the USACE Rocky Ripple alternative plan that USACE considered in the ROD, but utilizes a levee (instead of the T-wall that USACE proposed). Levee with crest that provides 300 yr. protection plus 2.4 ft. of freeboard comparable to and compatible with the USACE 300 year plan (Figure 6).
- Alternative 2 – provides for a levee with a crest at the 100 yr. flood level with 3 ft. of freeboard to meet FEMA criteria (Figure 7).
- Alternative 3 – provides for a levee with a crest at the 100 yr. flood level with no freeboard and does not meet FEMA criteria (Figure 7).

Table 4 compares the Level of Protection, amount of Freeboard, and whether it could be FEMA certified for flood insurance purposes.

Table 4. Comparison of Alternatives

	USACE Rocky Ripple Alternative	Alternative 1	Alternative 2	Alternative 3
Protection Level	300 yr	300 yr	100 yr	100 yr
Freeboard	2.4 feet	2.4 feet	3 feet	0 feet
Meets FEMA Criteria	Yes	Yes	Yes	No

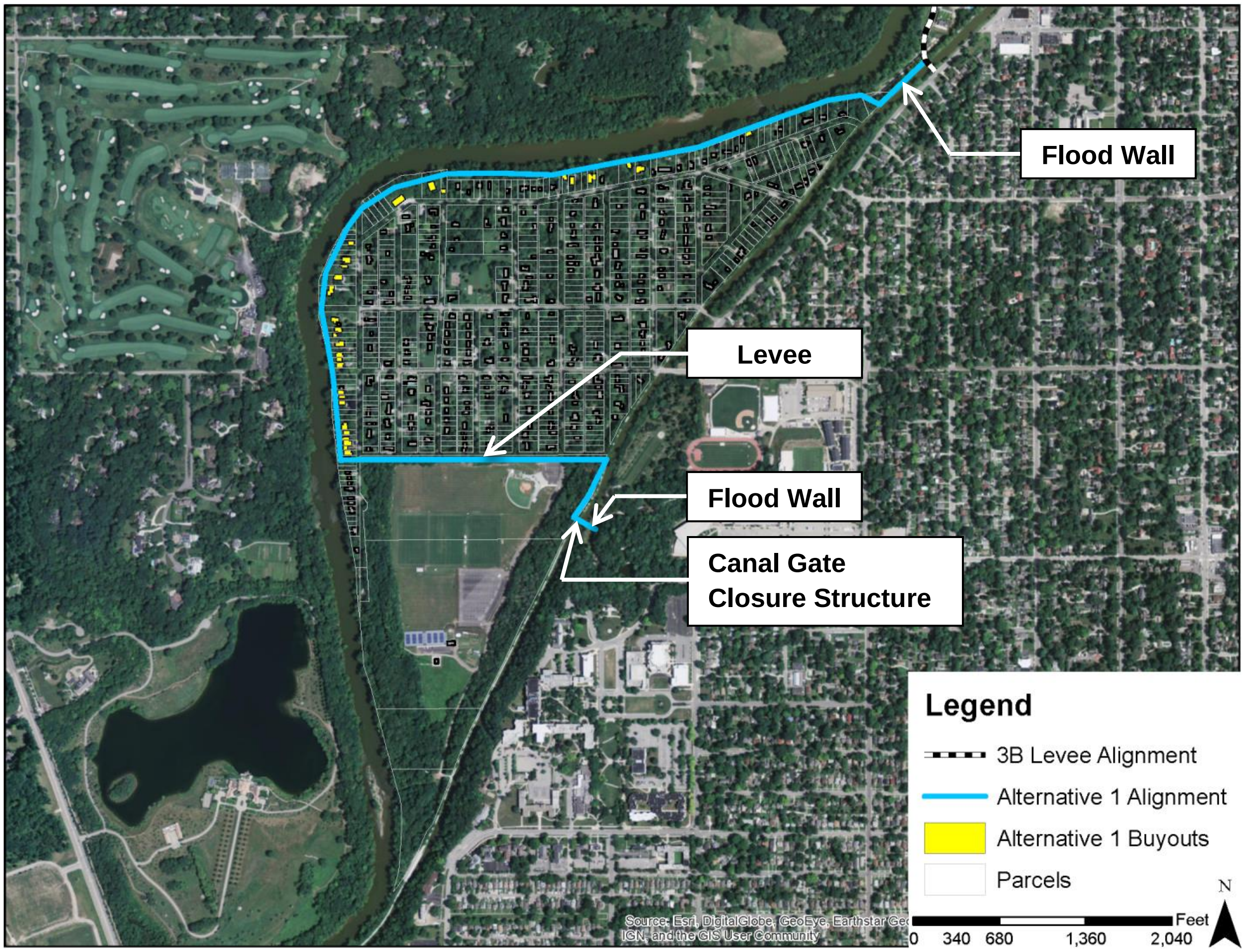

Figure 6. Proposed Alignment for Alternative 1

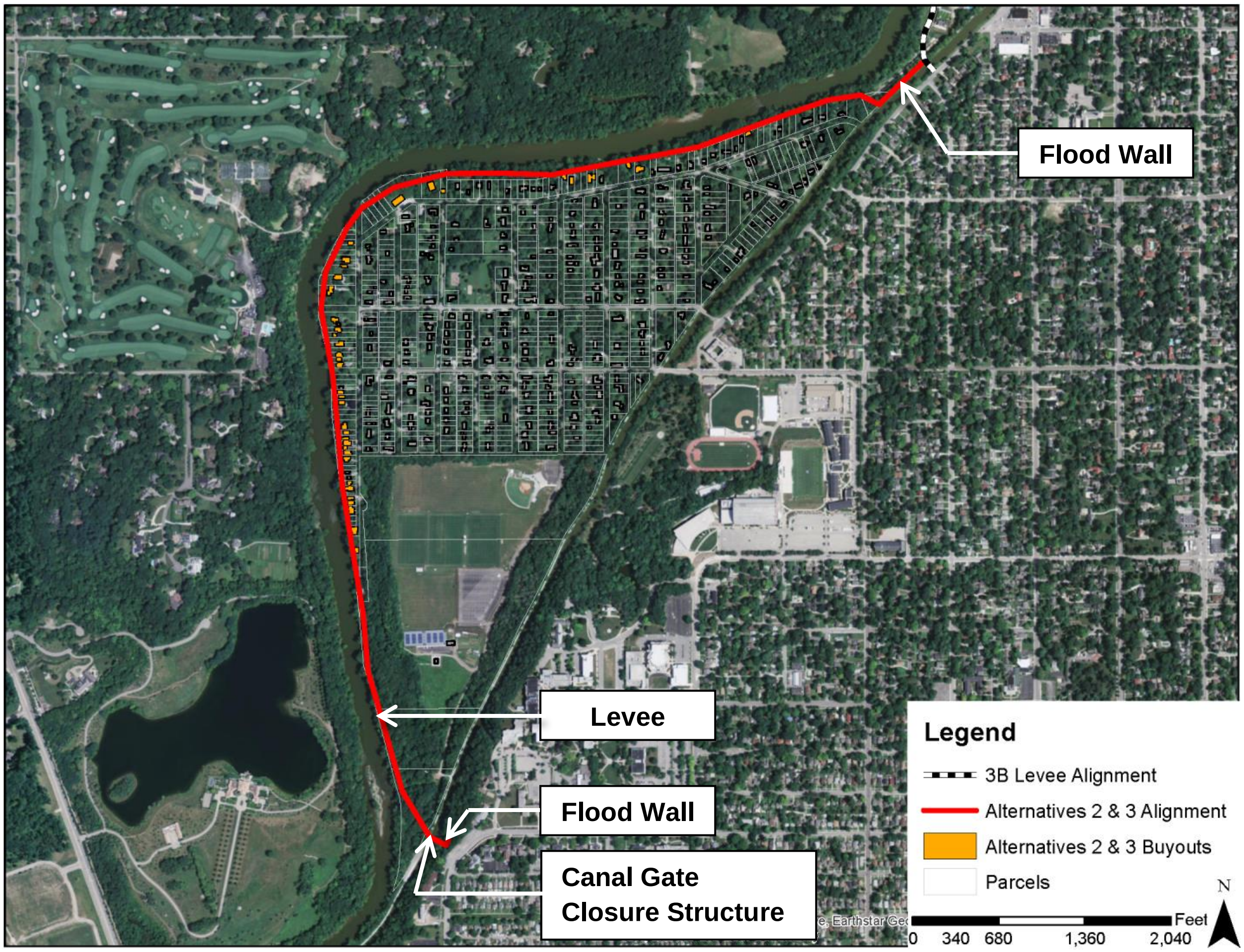

Figure 7. Proposed Alignments for Alternatives 2 and 3

These alternatives will also require a non-structural component to relocate/raise applicable buildings, and to remove and dispose of decks, retaining walls, and bought-out residential and municipal buildings that are located within the levee footprint and associated clear zone.

Another possible option that is outside the scope of this is the levee reconstruction and rehabilitation concept identified in the Rocky Ripple inspection report, which was discussed in Section 2. CBBEL estimated the cost for the partial levee reconstruction and rehabilitation plan to the existing level of protection to be approximately $4,087,000. AECOM's update of CBBEL's estimate (that assumes none of material in the existing levee can be reused, per USACE recommendation, and also assumes a borrow site about 20 miles away), is $5.4 million (see Table A-7).

Existing Levee Removal

Quantities for removing the existing levee were derived from Real Estate Limit drawings prepared by Christopher B. Burke Engineer, Ltd to obtain the existing grade at the top and protected side bottom of the existing levee. Additional data was obtained from the levee inspection report prepared in 2011 Christopher B. Burke Engineer, Ltd. From these documents it was determined that the existing levee is approximately 8,600 feet long, 6 to 8 feet wide, 2 to 10 feet high with side slopes ranging from 2 to 3:1. Based on this information a conservative trapezoidal levee footprint consisting of an 8-foot top width, 2.5:1 side slopes and an assumed topsoil thickness of 5-inches was used to obtain levee removal quantities. It was assumed that all of the soils would be removed and hauled away. The approximate volume of embankment material to be removed ranges from approximately 14600 cubic for the USACE alternatives to 35,100 cubic for the stand-alone alternatives.

The real estate impact drawings and inspection report were also used to determine miscellaneous quantities such as existing drainage features, access roads and buildings located within the levee.

Levee Design Section

The levee design improvement/rehabilitation was developed based on typical USACE design to a level of detail that would allow preliminary cost estimates to be performed. The design is based upon a trapezoidal-shaped earthen structure with 3:1 side slopes and 10-foot wide top width designed to act as a barrier against flooding. The design includes removal of the existing levee and removal or relocation/raising of existing buildings located within the levee footprint. Design features are described in the following paragraphs and shown in Figure 8. A second levee design alternative considered but not evaluated for this project was maintaining the existing levee with rehabilitation. As shown in Figure 9 the new levee system would be keyed into the existing levee.

- The levee is assumed to have an impervious core to prevent deeper seepage of floodwater through the levee. The depth of the core is assumed to be equal to the levee height with a maximum depth of six feet.
- The levee top elevation was set based upon the results of the hydrologic and hydraulic for the Rocky Ripple Levee alternatives.
- The levee section includes a cutoff for the entire length of the levee. The impervious core will extend from the top of the levee to approximately six feet below grade to prevent seepage through and under the levee.
- An interior drainage analysis was not performed this project. Typically, drainage outlets (24 inch RCP with a flap valve and sluice gate) are set at approximately 400 foot intervals along the Line of Protection. In addition, the stand-alone levee alternatives 3 and 4 identified in Section 3 will require removal and replacement of the existing drainage structure located at Station 0+50.

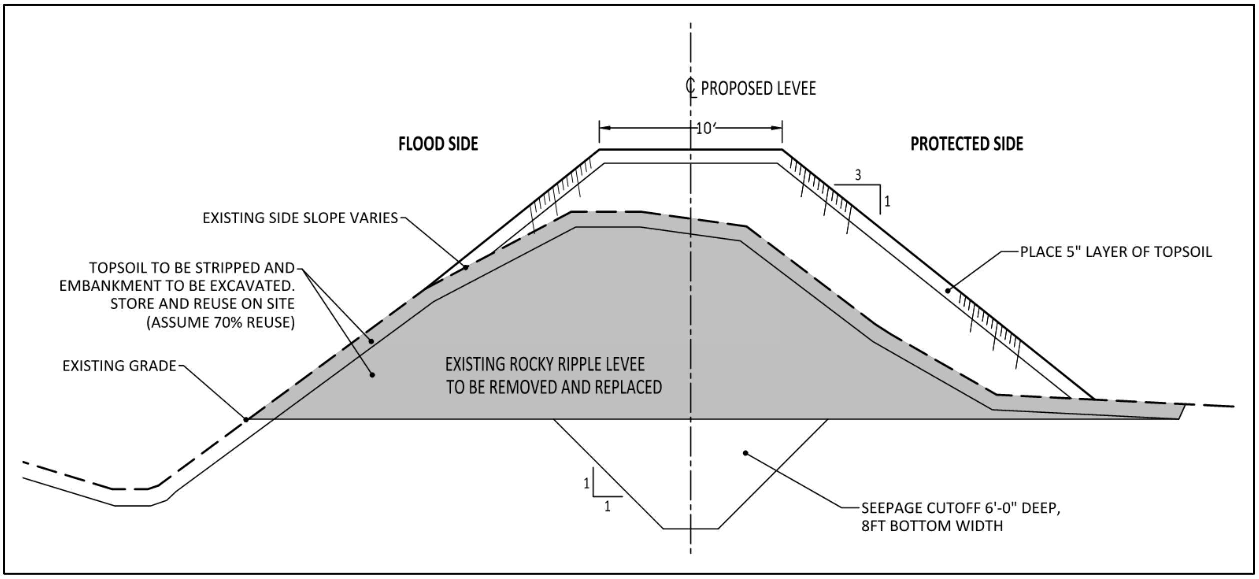

Figure 8. Typical Levee Section (Assuming Removal of Existing Levee)

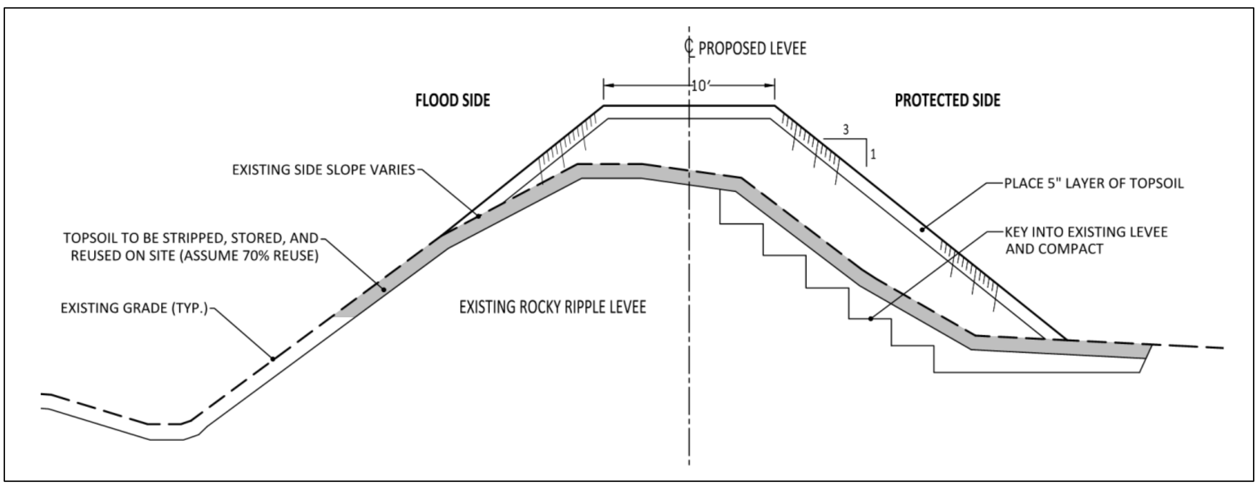

Figure 9. Levee Keyed into Existing Levee

Levee Placement Quantities

As discussed in the levee design section, the geometry of the proposed levee system is 10-foot wide with 3:1 side slopes and includes a 15-foot wide clear zone. Based on the recent experiences by USACE in construction the 3B levee it was assumed that none of the earthwork quantities (topsoil, excavation and embankment fill) could be reused and would need to be hauled away. It was assumed that the nearest borrow site is outside the County and about 20 miles away. In addition a compaction factor of 90 percent was assumed for levee compaction.

The approximate volume of embankment material needed for constructing the new levee ranges from 67,000 cubic for the 100 year level of protection to 120,600 cubic for the 300 year level of protection (plus freeboard).

Real Estate Considerations (Levee Area)

A review of available drawings, reports and aerial mapping identified numerous buildings located within the existing levee footprint and 15-foot clear zone. These buildings, along with other buildings located within the proposed levee easement, were evaluated to determine which buildings could be relocated within their property limits, and which could be raised to meet FEMA standards and a minimum setback of 25 feet from the property line. Buildings which could not fit within their property limits would be acquired. Buildings were reviewed to determine whether or not the cost of relocation and raising exceeded the depreciated building value and land costs.

The raised foundation costs were determined using relocation costs developed for the Fire Island Project in 2013. Costs were adjusted as described in the basis of estimate. Only two of the 37 buildings considered were deemed to be cost effective. A cost of $15 per square feet for relocating buildings was used based upon information obtained from Wolfe House & Building Movers in Indiana.

Basis of Estimate

Cost estimates were developed at a 2016 price level for labor equipment and material. Costs for the partial removal and rehabilitation of the levee were updated from 2011 to 2016 dollars using cost update factors.

- Preliminary costs for structural alternatives were based upon RS Means Heavy Construction Cost Data for 2016 and costs utilized from the recent Green Brook Flood Control Project. Costs from RS Means were adjusted by 93% for the City Indianapolis and by 83% to adjust the unit cost used from the Green Brook Project located in Bound Brook, New Jersey.
- Preliminary costs for raising buildings were developed by using elevation costs developed for Fire Island New York (2013), as part of the Corp's Fire Island to Montauk Point project. These costs were adjusted to 2016 dollars and the City Indianapolis using RS Means city cost index.
- Contingencies - Based upon recent cost estimates completed for other USACE projects, contingencies were set to 35 percent.
- Construction Management - The cost for construction management or supervision and administration activities from pre-award requirements through final contract closeout for structural measures was calculated at 8 percent of land and construction costs (after contingency).
- Productivity Assumed that all materials in the levee would be excavated and disposed offsite and that the borrow site would be 20 miles away. A swell factor of 30% was used to develop hauling quantities, and a compaction factor of 90% was assumed for levee compaction.
- Mobilization/Demobilization - Mobilization and demobilization were assigned a lump sum cost of 2.5% due to the multiplicity of activities required to accomplish these items.

3.2 Nonstructural Measures

Section 73 of the Water Resources Development Act of 1974 (PL 93-251) requires Federal agencies to give consideration to non-structural measures to reduce or prevent flood damage. Non-structural measures are building retrofit treatments designed to reduce flood damage and risks to existing development, without significantly altering flood limits.

Building Retrofits

Table 5 summarizes the assumptions that were made during the assignment of nonstructural treatments to individual buildings in the study area.

Table 5. Assumptions for Assigning Nonstructural Treatments

General Assumptions	Flood velocity is negligible.
	Debris impacts will not be considered.
	There are limited areas designated as "V-Zone" by FEMA, subject to 3-foot breaking waves. The majority of back bay areas are considered non-V-Zone and thus not subject to wave and erosion impacts.
	All buildings selected for treatment will be protected to the 100-year level, plus two feet of freeboard, in compliance with local floodplain management ordinances.
	Buildings elevated in non-coastal areas will be raised (finished floor elevation) to the 100-year water surface plus 1 foot of freeboard.
	Flooding is gradual (no flash flooding).
Foundation Walls	All basement foundation types are assumed to be unreinforced, 8" concrete masonry units (CMUs).
Raised Buildings (Crawlspace)	No utilities are located in the crawlspace.
	Wet flood proofing of raised buildings includes the elevation of utilities only, and where necessary, the installation of vents or louvers to allow adequate venting.
Slab-On-Grade Buildings	Wet flood proofing is possible if the expected flood elevation is below the main floor (shallow flooding). This alternative includes the elevation of utilities only.
	Consistent with USACE flood proofing guidance, buildings will not be dry flood proofed for flooding depths greater than 2 feet plus one foot of freeboard for a maximum 3 feet of dry flood proofing protection (See Attachment 1 for supporting calculations).
Buildings With Basements	All basements are unfinished and contain major utilities.
Bi-Levels	The lower portion of the first floor walls are masonry construction.
	The foundation is slab-on-grade.
	The main floor can be raised separately from the lower level by lifting off the sill of the masonry wall.
Raised Ranches	The first floor (lower) walls are masonry.
	The foundation is slab-on-grade.
	The main floor can be raised separately from the lower level (similar to a building with a basement).
Split-Levels	The lower level is slab-on-grade.
	The lower portion of the lower level walls are masonry construction.
	The main floor level is raised over a crawl space.
	The main floor and upper level can be separated from the lower level by raising at the sill.

A computerized algorithm was used to identify the most feasible and appropriate nonstructural treatments for individual buildings and to calculate construction costs based on the cost of applying those treatments to representative reference buildings. The principal assumptions in the algorithm are illustrated in Table 6. The costs nonstructural treatments were derived from of unit costs for representative buildings from prior similar USACE projects with adjustments to account for regional variations.

Table 6. Nonstructural Treatments for Estimating Unit Costs

Typical Building Type	Flood Level	Protection Level		Flood Proofing Alternative
		Condition 1	**Condition 2**	
Slab-On-Grade	>= Main Floor	Ground < 3	n/a	Sealant & Closures
		Ground >= 3	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC
		>= Main Floor	Ground < 3	Sealant & Closures
			Ground >= 3	Elevate Building
Basement-Subgrade	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Fill Basement + Utility Room
		>= Main Floor		Elevate Building
Raised (Crawlspace)	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC + Louvers
		>= Main Floor	n/a	Elevate Building
Basement-Walkout	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground < 3	Interior Floodwall
			Ground >= 3	Raise Lower Floor + Space
		>= Main Floor	n/a	Elevate Building
Bi-Level/Raised Ranch	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground <= 3	Sealant & Closures
			Ground >3	Raise Lower Floor + Space
		>= Main Floor	n/a	Elevate Building
Split Level	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground < 3	Sealant & Closures
			Ground >=3	Elevate Building
		>= Main Floor	n/a	Elevate Building

Acquisition

USACE regulations require that for the purpose of estimating benefits and costs, acquisition costs must be estimated under a flood-free condition, which requires extensive appraisals. Thus, for planning purposes acquisition costs have been computed as the sum of the depreciated building replacement value plus an assumed land value and a demolition cost of $15,000. Based on publicly available information, an average lot value of $13,000 was assumed for the purposes of this analysis.

3.3 Hydraulic Analyses

The purpose of the analysis was to:

- Establish West Fork White River water levels based on existing levee conditions.
- Determine whether resultant water surface elevations (WSEL) from a modified levee at Rocky Ripple would restrict permitting of levee modifications (an increase >0.1 foot for the 100-year event or 1% annual chance of exceedance event). The proposed levee modifications included:
    - Alternative 1: Alternative USACE plan to protect Rocky Ripple: levee with crest at 300 year flood level with 2.4) feet of Freeboard (certified level of protection),
    - Alternative 2: Independent Rocky Ripple Plan (assumes construction of Westfield alignment) levee crest at 100-year flood level with three (3) ft. of freeboard.

- Alternative 3: Independent Rocky Ripple Plan (assumes construction of Westfield alignment) levee crest at 100-year flood level with zero (0) ft. of freeboard.
- Determine necessary levee heights at Rocky Ripple for the three improvement alternatives
- Use revised levee heights determined from the modeling effort for cost and economic analyses.

Model Review and Revision

The revised Existing Conditions model was the starting point for the analysis of the alternatives.

Results

The existing steady state HEC-RAS model for White River was evaluated and adjusted, based on available data, to represent current conditions of White River at Rocky Ripple as the Base Model for evaluation of the impacts of proposed Rocky Ripple levee alternatives.

Key findings are that none of the alternatives considered have raised WSEL by more than 0.1 foot, as shown in Table 7, and fall within stream encroachment permitting limits.

Table 7. Rocky Ripple Levee Alternatives' WSEL Impacts (White River)

Location	Section/ River Station	100-year Event WSEL*				300-year Event WSEL*			
		Existing	Alternative USACE Plan	Stand-alone Rocky Ripple Plans		Existing	Alternative USACE Plan	Stand-Alone Rocky Ripple Plans	
			Alt 1 300yr + 2.4	Alt 2 100yr+3	Alt 3 100yr		Alt 1 300yr + 2.4	Alt 2 100yr+3	Alt 3 100yr
u/s	AT 240.2	716.0	716.1	716.1	716.1	717.4	717.7	717.7	717.6
		Increase=	0.1	0.1	0.1	Increase=	0.3	0.3	0.2
RR	AS 239.8	714.7	714.7	714.7	714.7	716.1	716.2	716.2	716.1
		Increase=	0.0	0.0	0.0	Increase=	0.1	0.1	0.0
RR	AR 239.46	713.8	713.8	713.8	713.8	715.1	715.2	715.2	715.2
		Increase=	0.0	0.0	0.0	Increase=	0.1	0.1	0.0
RR	AQ 239	712.4	712.4	712.4	712.4	713.6	713.7	713.7	713.7
		Increase=	0.0	0.0	0.0	Increase=	0.0	0.0	0.0
RR	AP 238.83	712.5	712.5	712.5	712.5	713.9	713.8	713.8	713.8
		Increase=	-0.1	-0.1	-0.1	Increase=	-0.1	-0.1	-0.1
RR	AO 238.7	712.1	712.1	712.1	712.1	713.4	713.4	713.4	713.3
		Increase=	0.0	0.0	0.0	Increase=	-0.1	-0.1	0.0
RR	AN 238.5	711.7	711.7	711.7	711.7	713.0	713.0	713.0	713.0
		Increase=	0.0	0.0	0.0	Increase=	0.0	0.0	0.0
d/s	AM 238.2	710.0	710.0	710.0	710.0	711.2	711.2	711.2	711.2
		Increase=	0.0	0.0	0.0	Increase=	0.0	0.0	0.0

*Elevations in Feet NAVD88.

The USACE flood protection project design is expected to provide up to a 300-year level of protection. The impact upstream of up to 0.3 feet is comparable to the original USACE analysis and represents a slight increase of approximately 0.06 feet over the USACE alignment that did not include Rocky Ripple.

4 PLAN EVALUATIONS

4.1 Structural Alternatives

Table 8 shows a comparison of the costs of Alternatives 1, 2 and 3 with the USACE Rocky Ripple Alternative that was considered in the USACE 2013 FSEIS (updated to 2016 Price Levels), but not selected The Alternative 1 alignment is similar to the USACE Rocky Ripple alternative, with levees assumed to be used instead of T-walls, and was also assumed to be implemented by USACE to complete the North Indianapolis Flood Control Project, if shown to be economically viable. The estimated cost of Alternative 1 is about $45.2 million, which is about $2.7 million less than the USACE Rocky Ripple Alternative. The “incremental cost” represents the additional cost to include flood protection for the Rocky Ripple as compared to the cost of the USACE selected Westfield alignment, which was estimated to be about $12.3 million (2016 Price level). The incremental cost was about $35.5 million for the USACE Rocky Ripple alternative and about $32.9 million for Alternative 1.

Alternatives 2 and 3, which mostly follow the alignment of the existing Rocky Ripple levee, were considered “stand-alone” projects for the community of Rocky Ripple that assumed construction of the Westfield alignment by USACE to complete that the North Indianapolis Flood Control Project. The estimated cost of Alternative 2 is $46.4 million, while the estimated cost of Alternative 3 is $39.6 million (The detailed cost estimates for Alternatives 1-3 are found in Tables A-3 through A-5 in Appendix A).

Table 8. Cost Comparison of Alternatives with USACE Rocky Ripple Alternative

	USACE Rocky Ripple Alternative from 2013 FSEIS (2016 PL)	Alternative 1: USACE implemented 300-year protection (2.4 ft. freeboard)	Alternative 2: Stand-alone 100-year protection (3 ft. freeboard)	Alternative 3: Stand-alone 100-year protection (0 ft. freeboard)
Total Cost	$47,799,000	$45,239,000	$46,405,000	$39,607,000
Incremental Cost	$35,490,000	$32,930,000		

Table 9 shows the real estate requirements for Alternatives 1, 2, and 3. For Alternative 1 28 buildings (27 residences and 1 municipal building) would be acquired and demolished, and 3 buildings relocated, In addition 22 properties without buildings would need to be obtained and permanent easements acquired for an additional 39 properties. For stand-alone Alternatives 2, 36 buildings would be acquired and demolished, 2 buildings relocated, 31 properties without buildings would need to be obtained and permanent easements acquired for an additional 38 properties. For stand-alone Alternatives 2, 35 buildings would be acquired and demolished, 3 buildings relocated, 30 properties without buildings would need to be obtained and permanent easements acquired for an additional 39 properties.

If a T-wall was used instead of a levee in the residential areas, under a modified Alternative 2, about 32 buildings would need to be acquired and demolished, 2 buildings relocated, 23 properties without buildings would need to be obtained and permanent easements acquired for an additional 29 properties.

Table 9 Real Estate Requirements for Alternatives 1-3

Real Estate Requirements	Alternative 1: USACE implemented 300-year protection (2.4 ft. freeboard)	Alternative 2: Stand-Alone 100-year protection (3 ft. freeboard)	Alternative 3: Stand-Alone 100-year protection (0 ft. freeboard)
# buidlings to be acquired and demolished.	28	36	35
# of buidlings to be Relocated	3	2	3
# of vacant lots to be acquired.	22	31	30
# permanent easements to be obtained	39	38	39

Table 10 compares the annualized benefits, costs and the BCRs for the three alternatives considered using the federal interest rate of 2.875%. In addition to flood damage reduction to buildings and associated motor vehicles, benefits realized by the reduction of costs to clear and dispose of flood debris have been included for each evaluates alternative. These benefits have been uniformly estimated as 3% of the damage reduction benefits, based on prior similar USACE analyses

As discussed in Section 3.3, the results of the hydraulic analyses indicate that none of the levee alternatives would result in an increase in the 100 year event WSEL by more than 0.1 feet as shown in Table 7.

In calculating the project benefits, it was assumed that that the existing levees would continue to provide the current level of protection over the 50 year period of analysis. As pointed out in the discussion of the Rocky Ripple Levee inspection report, the existing levee is in in poor condition and rehabilitating the existing levee is estimated to cost $5.4 million. Should the levee no longer function the annual damages would more than double to $3.3 million, and also create significant life-safety issues.

As shown in Table 10, Alternative 1 has a BCR of 0.8, while stand-alone Alternatives 2 and 3 had BCRs of 0.6 and 0.5, respectively.

Table 10. Economic Analysis of the Three Alternatives*

Plans Summary	Alternative 1: USACE implemented 300-year protection (2.4 ft freeboard)	Alternative 2 Stand-Alone 100-year protection (3 ft freeboard))	Alternative 3 Stand-Alone 100-year protection (0 ft freeboard))
Total Benefits	$1,238,000**	$1,205,000	$933,000
Annual Cost	$1,323,000	$1,864,000	$1,591,000
Annual O&M	$282,500	$282,500	$281,000
Total Annual Cost	$1,605,500	$2,146,500	$1,872,000
BCR	0.8***	0.6	0.5

*Based on 50-year period of analysis and 2.875% interest rate.
**Benefits without adjustment for delay. Adjusted for delays, benefits are $486,600.
***BCR without adjustment for delay. The BCR is 0.3 when adjusted for delay.

This analysis does not take into account that there would be at least a 4 year delay in completing the Indianapolis North Flood Damage Reduction Project if USACE were to reconsider its selected plan to include the Rocky Ripple component. Design of the Westfield alignment is mostly complete and the funding is in place to award and complete construction by the end of 2018.

For USACE to reconsider a plan that includes Rocky Ripple would require additional engineering, environmental and cultural studies, another public review period, and detailed design of the new plan. This delay would leave about 2,000 buildings vulnerable to flooding that would have otherwise been mitigated by the completed Westfield alignment. This loss of benefits is about $18 million over the four year period, or about $715,000/yr. if annualized over a 50 year period (sees Table A-8)

When factoring the delay loss of benefits, the annualized benefits for Alternative 1 drop to $486,800, which yield a BCR of 0.3

4.2 Non-Structural Alternatives

Section 73 of the Water Resources Development Act of 1974 (PL 93-251) requires Federal agencies to give consideration to non-structural measures to reduce or prevent flood damage. The plans considered as part of the Non-structural analysis were individual building retrofits that are designed to reduce damage and risks to existing development, without significantly altering flood limits, and Buyouts, which involve acquiring properties and demolishing the buildings.

Retrofits:

The retrofit measures considered would elevate the main floor of existing buildings to the regulatory elevations. A range of plans were evaluated for incrementally larger floodplains and higher ground elevations, which utilized unit costs from prior USACE projects with local adjustments. When the algorithm described in Section 3.2 was applied to the buildings in the study area, almost every building in the dataset was assigned the elevation retrofit. The only exceptions were a handful of buildings already sufficiently elevated, to which minor additional floodproofing treatments were assigned. Figure 10 shows the number of buildings that are impacted at each elevation. It also shows that the costs for building retrofits at each elevation exceed the benefits, which indicates that there is no cost effective retrofit plan for any elevation.

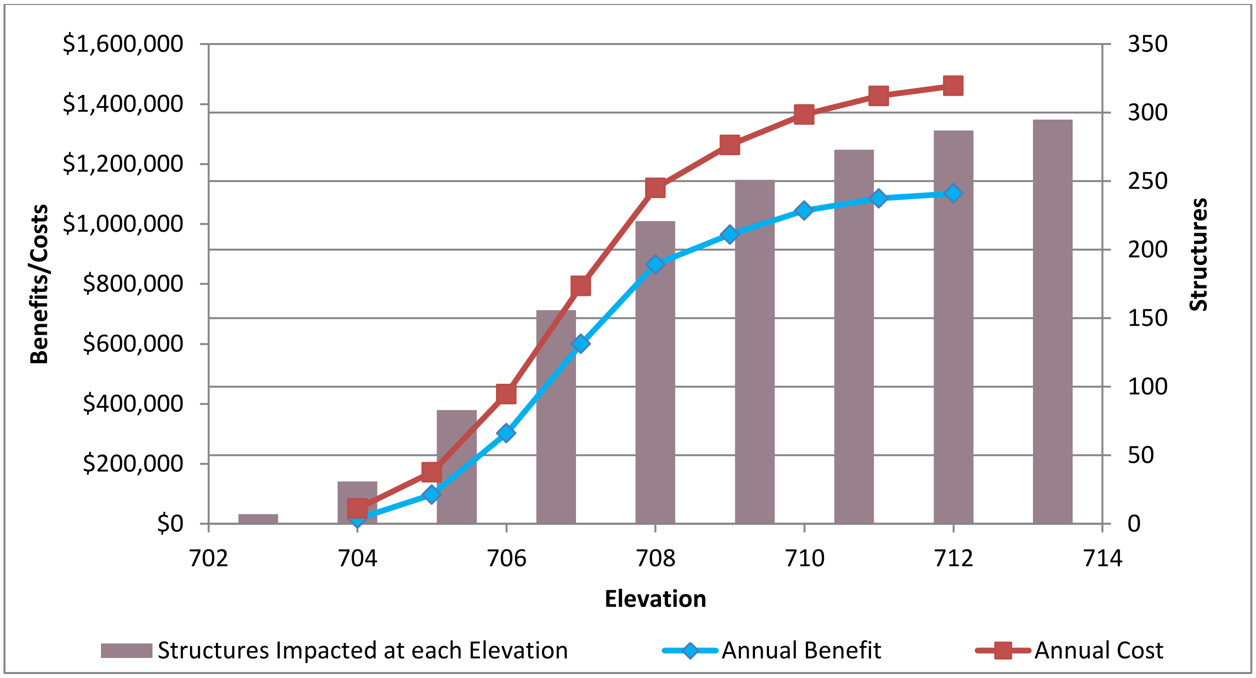

Figure 10: Nonstructural Retrofits Benefits and Costs

Buyouts

The basic cost of potential buyout plans was based on the building depreciated replacement values plus assumed average lot value in Rocky Ripple and also the cost to demolish the buildings. It was assumed that post-acquisition, the land is given over to open space or recreational use in perpetuity. Similar to the analysis for non-structural plans, a range of buy-out plans were evaluated for incrementally larger floodplains and higher ground elevations. Figure 11 shows the number of buildings that are impacted at each elevation. It also shows that the costs for building buy-outs at each elevation exceed the benefits, which indicates that there is no cost effective buyout plan for any elevation.

Table 11 presents a summary of the benefits and costs for nonstructural retrofit and acquisition plans covering the 4% annual chance exceedance (the “25-year”) floodplain, which covers more than 90% of the buildings in the study area.

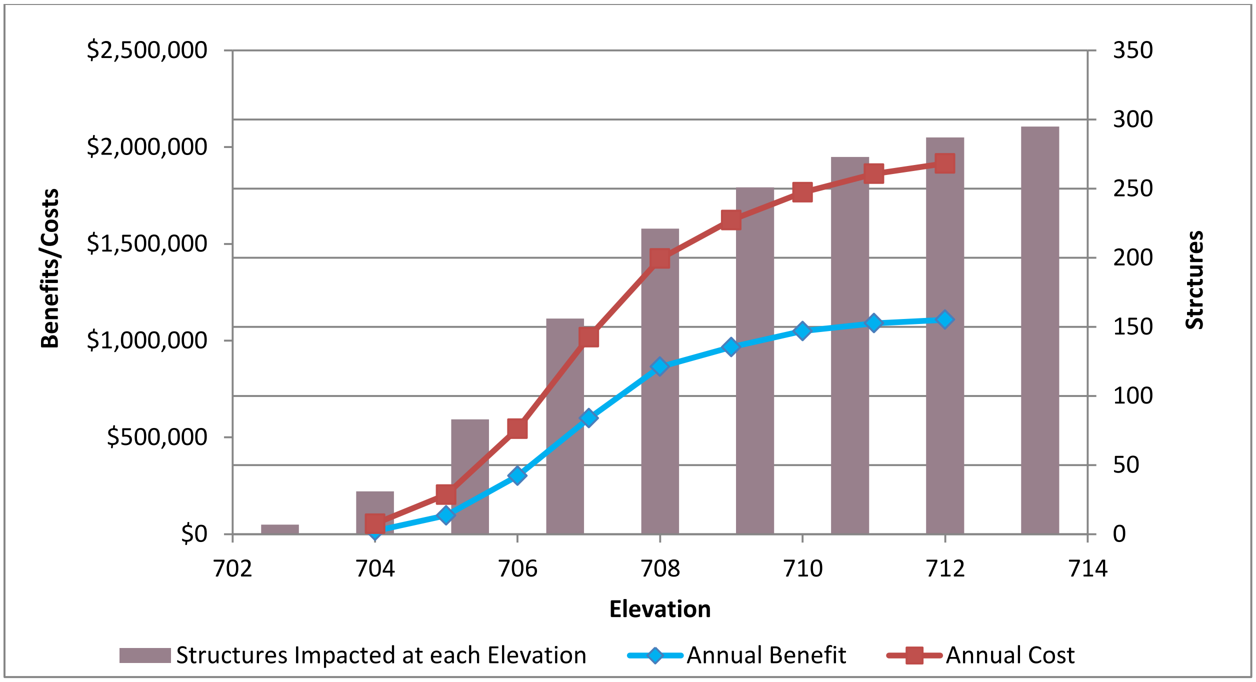

Figure 11: Buyout Plans Benefits and Costs

Table 11. Summary of Nonstructural Analyses

Damages / Benefits / Costs	25-Yr Floodplain Nonstructural Retrofit	25-Yr Floodplain Acquisition
Without Project	$1,262,000	$1,262,000
Residual Damage	$176,764	$171,776
Annual Benefits	$1,085,236	$1,090,224
Emergency/Debris	$33,000	$33,000
Total Benefits	$1,118,236	$1,123,224
First Cost	$37,594,000	$49,075,000
IDC	$2,197,000	$2,867,000
Investment Cost	$39,791,000	$51,942,000
Annual Cost*	$1,510,000	$1,971,000
Annual O&M	$0	$0
Total Annual Cost	$1,510,000	$1,971,000
Net Benefits	-$391,764	-$847,776
BCR	0.74	0.57

4.3 Performance and Reliability of the Line of Protection

Standard practice in the evaluation of flood risk reduction projects featuring a line of protection such as a levee or floodwall requires that the analysis should quantify the performance of the project and evaluate the residual risk. For this project the performance of the alternatives is to be reported in terms of:

- The long-term risk of exceedance
- The conditional-non-exceedance probability

The long-term risk of exceedance is the probability that the design stage for each alternative will be exceeded at least once in the specified durations of 10, 30, and 50 years. The conditional non-exceedance probability measures the likelihood that the project will not be exceeded by a specified hydrologic event. For this analysis the conditional non-exceedance probability has been computed for each alternative only for the 1% annual chance exceedance event (the 100-year flood). The results of these analyses are presented in Table 12.

Table 12. Project Performance Analysis - Line of Protection

Performance and Reliability Criteria		Existing	Alternative 1 300-Yr + 2.4'	Alternative 2 100-Yr + 3'	Alternative 3 100-Yr
Long Term Exceedance Probability	10 Years	43%	0.7%	2%	11%
	30 Years	81%	2.1%	5%	30%
	50 Years	94%	3.5%	8%	45%
Conditional Non-Exceedance Probability of Event	100-Year	6%	99.5%	98%	50%

5 KEY FINDINGS

- The existing Rocky Ripple levee is in a seriously deteriorated condition. The analyses indicates that the levee currently has a 5% or greater annual chance of overtopping (20 year level of protection) and there is about a 92 % change that the levee will overtopped at least once over the next 50 years.

- The levee has not been evaluated for stability and seepage which may indicate that the levee is subject to structural failure in addition to overtopping. An investigation of the levee embankment and foundation materials should be undertaken to determine the conditions of the embankment. The soil data may then be used to perform a stability and seepage analyses and to refine design requirements for rehabilitation or replacement of the existing levee and to evaluate requirements for alternative floodwall or levee designs to increase the elevation of the existing levee system.

- Use of an earthen levee provides cost savings for the respective 3 plans as compared to the extensive use of floodwalls in the USACE Rocky Ripple Alternative considered in the FSEIS in 2011. However, there would be greater real estate requirements associated with reconstructing the levee, in lieu of the T-wall that was proposed in the USACE plan. The evaluation of alternative wall designs, such as cantilevered I-walls or composite-walls requires more extensive foundation analysis than is possible with the available soil data.

- Alternative 1, which was assumed to be constructed by the USACE, would require requesting the USACE to re-open the alternatives assessment and delay initiating construction. The design of the previously selected Westfield alignment is mostly complete and the funds are in place to complete construction of the Indianapolis North Flood Damage Reduction Project by the end of 2018, which would provide protection to about 2,000 buildings

- To reconsider a USACE plan that includes protection of the Rocky Ripple community would result in a delay of at least 4 years in completing the project. This would leave those 2,000 buildings vulnerable to flooding during that time. The loss of benefits was estimated to be $715,000 on an average annual basis.

- When the loss of benefits is taken into account, the incremental BCR for Alternative 1 is 0.4, making this alternative not economically viable for USACE implementation.

- A decision to complete the Indianapolis North project without USACE participation would still have approximately a 4 year time frame for completion of environmental documentation, acquisition of lands and easements, project design and construction. Even if the community were to complete the project to USACE or FEMA standards, the division of design and construction responsibilities would make obtaining levee certification/ accreditation of the entire project difficult.

- Stand-alone Alternatives 2 and 3 also have BCR's of less than 1, as do non-structural alternatives such as retrofitting homes and buy outs of homes and buildings that are located in the flood plain.

- If the existing levee were to be damaged or fail for any reason, the community of Rocky Ripple would be exposed to more frequent flooding if levee repairs are not completed. The average annual damage due to flooding would more than double.

- Given the badly deteriorated condition of the existing Rocky Ripple levee further analyses of the levee are needed. Rehabilitation of the existing levee could be eligible for inclusion in the USACE Rehabilitation Inspection Program (RIP). Participation in the RIP provides access to Federal funds for repair of storm damage to the levee if it is damaged in an extreme flood event.

- Decisions regarding long-term plans to upgrade the Rocky Ripple Levee will require more detailed engineering design assessments, including collection of existing embankment and soils data. Factors to be considered include: community acceptability, environmental impacts, costs, design reliability safety, performance of the project and the residual risks.

6 RECOMMENDATIONS

- Continue coordination with the Rocky Ripple community to refine the design requirements and select a long term plan to upgrade or replace the existing levee to increase community resilience, and public safety. This assessment should include preliminary design and evaluation of alternative levee or wall sections such as T-wall, I-wall or composite-walls to identify the most cost efficient acceptable plan.

- City of Indianapolis and Town of Rocky Ripple to define next steps to undertake boring, stability, and seepage analyses of the existing Rocky Ripple Levee to determine its stability and to identify specific areas that may be vulnerable to failure.

- Utilize soils data to refine the design requirements for rehabilitation or replacement of the existing levee per CBBEL levee inspection report and the stability analysis. The short term repairs should be completed in a manner that is compatible with the longer term objectives and that would also make the levee system eligible for inclusion in the USACE Rehabilitation Inspection Program (RIP).

- Progress to schedule advertisement and construction award of the Westfield Alignment, which would complete the Indianapolis North Flood Damage Reduction Project, in order to ensure that flood risk management for the over 2,000 buildings within the Line of Protection is not delayed or compromised.

APPENDIX A TECHNICAL DETAILS

Table A-1. USACE Cost Estimate for Rocky Ripple Alternative

Item	Notes	USACE 2013 Analysis
Lands and Damages	From Real Estate Division documentation	$5,035,000
Borrow Site	Assume 10 acres required at $30k/acre; approximately 11 core borings needed with Geotechnical Investigations report $25,000	$325,000
Utility Relocations	5,600 LF of 8" sanitary sewer; Package sewage treatment plant; 600 LF 4" force main to White River; Demolish existing septic tanks and lateral fields	$849,000
Earthen Levee	3,200 LF; 12 ft average height above grade; 68,000 cy embankment	$4,462,000
I-wall	160 LF; Along canal; 6 ft average height above grade; Steel sheet piling seepage cutoff below grade; With toe drain	$369,000
	400 LF; Along White River near intersection of Canal Blvd and Ripple Rd; 6 ft average height above grade; Steel sheet piling seepage cutoff below grade; With toe drain; Interspersed along T-Wall	$923,000
T-wall	310 LF; Along canal; 9'6" average height above grade; Founded on steel H-piling; Steel sheet piling seepage cutoff wall; With toe drain	$904,000
	5265 LF; Along White River near intersection of Canal Blvd and Ripple Rd to near intersection of W 52rd St and Riverview Dr; Average height 12 ft above grade; With toe drain	$15,350,000
Closure	30 ft wide; In levee at Riverview Dr (Incl 225 sf closure parts storage building)	$295,000
	30 ft wide; In levee at Lester St (Incl 225 sf closure parts storage building)	$295,000
	3 ea, 8 ft wide; In floodwall; At three locations to be determined for local access to the White River shoreline (Includes closure parts storage buildings)	$84,000
Gatewell Structure	1 ea for 72" storm sewer pipe running under the Canal; North of Canal Blvd and Ripple Rd intersection	$413,000
	1 ea for 36" sanitary sewer pipe running along east side of the Canal; Near Holcomb Carillion at Butler University	$121,000
	Assume 3 ea, 36" storm pipes in Rocky Ripple community	$363,000
Demolition	15,000 cy of existing levee embankment	$437,000
	43 buildings; 22 residences with outbuildings	$990,000
Canal Gate Structure	64 ft wide; Ties into Levee at Butler University athletic fields levee south of West 51st St	$3,037,000
Pump Station	3 Total, (2 ea at 150/200 GPM); (1 ea at 300/400 GPM); (2 ea at 400/600 GPM); for 9,335 LF of protection	$1,036,000
Stream Bank Protection	6000 LF along banks of White River; 8,000 cy of 18-in rip rap stone on 6-in aggregate base	$2,368,000
Construction Management	Estimated at 7% of the construction cost of the project components.	$2,261,000
Planning Engineering & Design	Estimated at 15% of the construction cost of the T-Walls, Gate ClosureStructures, Pipe Gate Wells and Lift/Pump Stations; 10% of theconstruction cost of I-Walls; Demolition, and Utility Relocations; 5% of the construction cost of Relocated Canal Gate Structure plus 75,000 for Agency Technical Review plus 1.9% of the construction cost for Independent External Peer Review.	$5,176,000
TOTAL		**$45,093,000**

Table A-2. Detailed Cost Comparison

Item	USACE Item Cost 2013 dollars	USACE Cost updated to 2016 dollars	Alternative 1 (USACE implemented 300-year protection with 2.4 ft of freeboard)	Alternative 2 (100-year protection Standalone with 3 ft of freeboard)	Alternative 3 (100-year protection Standalone with 0 ft of freeboard)
Lands and Damages	$5,035,000	$5,337,100	$9,727,700	$10,117,868	$9,786,318
Borrow & Disposal Site	$325,000	$344,500	included in earthen levee estimate		
Utility Relocations	$849,000	$899,940	$337,500	$337,500	$337,500
Earthen Levee	$4,462,000	$4,729,720	$14,666,800	$15,582,700	$10,411,700
I-wall	$1,292,000	$1,369,520	$1,369,500	$391,140	$391,140
T-wall	$16,254,000	$17,229,240	$958,240	$1,277,650	$1,277,650
Closure	$674,000	$714,440	$625,400	$0	$0
Gatewell Structure	$534,000	$566,040	$566,040	$437,780	$437,780
Interior Drainage (ACOE Assumed storm pipes for Rocky Ripple under Gatewell Structure)	$363,000	$384,780	$2,126,250	$2,126,250	$2,126,250
Demolition	$1,427,000	$1,512,620	$920,526	$2,037,885	$2,037,885
Canal Gate Structure	$3,037,000	$3,219,220	$3,219,220	$3,219,220	$3,219,220
Pump Station	$1,036,000	$1,098,160	$1,098,160	$1,098,160	$1,098,160
Lift Station	$0	$0	$0	$0	$0
Stream Bank Protection	$2,368,000	$2,510,080	$2,510,080	$2,510,080	$2,510,080
Mobilization and Demobilization			$709,943	$725,459	$596,184
Construction Management	$2,261,000	$2,396,660	$2,037,536	$2,082,068	$1,711,048
Planning Engineering & Design	$5,176,000	$5,486,560	$4,366,149	$4,461,574	$3,666,532
TOTAL	**$45,093,000**	**$47,798,580**	**$45,239,044**	**$46,405,333**	**$39,607,448**
Westfield Blvd Alignment Plan	**$11,612,000**	**$12,308,720**	**$12,308,720**		
Implementation Cost of Alternative	**$33,481,000**	**$35,489,860**	**$32,930,324**	**$46,405,333**	**$39,607,448**

Note: Sewer and Septic Cost not included in Utility relocations for Alternatives 1, 2 & 3.

Table A-3. Detailed Cost Estimate Alternative 1: USACE Implemented 300YR

Rocky Ripple Levee Alternative 1 - 300 Year LOP With Freeboard						
Description	**Estimated Quantities**	**Units**	**Unit Cost**	**Estimated Cost**	**Contingency**	**Estimated Cost with Contingency**
Existing Levee Embankment						
Clearing and Grubbing	3.2	AC	$ 23,000.00	$ 73,600.00	40%	$ 103,040.00
Remove Existing Embankment	14,449	CY		$ 507,700.00	40%	$ 710,780.00
Excavation	*14,449*	*CY*	*$ 2.90*	*$ 41,902.10*	40%	$ 58,662.94
Hauling/Disposal Excavated soil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*18,784*	*CY*	*$ 24.80*	*$ 465,835.76*	40%	$ 652,170.06
Remove Existing Leve Embankment Topsoil	1,813	CY		$ 76,218.52	40%	$ 106,705.93
Stripping	*1,813*	*CY*	*$ 9.80*	*$ 17,767.40*	40%	$ 24,874.36
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*2,357*	*CY*	*$ 24.80*	*$ 58,451.12*	40%	$ 81,831.57
Estimated Existing Earthen Levee Demolition Cost				$ 657,518.52	40%	$ 920,525.93
Construct Proposed Levee Embankment						
Clearing and Grubbing	14.5	AC	$ 23,000.00	$ 333,500.00	40%	$ 466,900.00
Excavation For Subgrade Inspection	58,333	CY		$ 4,152,100.00	40%	$ 5,812,940.00
Excavation	*58,333*	*CY*	*$ 2.90*	*$ 169,165.70*	40%	$ 236,831.98
Haul/Dispose (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell, Means cost $14.80)	*75,833*	*CY*	*$ 24.80*	*$ 1,880,655.92*	40%	$ 2,632,918.29
Purchase Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*58,333*	*CY*	*$ 12.00*	*$ 699,996.00*	40%	$ 979,994.40
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell, Means cost $14.80)	*75,833*	*CY*	$ 14.80	*$ 1,122,326.92*	40%	$ 1,571,257.69
Handle, Place & Compact Purchased Fill	*58,333*	*CY*	*$ 4.80*	*$ 279,998.40*	40%	$ 391,997.76
Embankment Fill	117,956	CY		$ 4,251,100.00	40%	$ 5,951,540.00
Embankment Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*117,956*	*CY*	*$ 12.00*	*$ 1,415,472.00*	40%	$ 1,981,660.80
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell, Means cost $14.80)	*133,343*	*CY*	*$ 14.80*	*$ 2,269,473.44*	40%	$ 3,177,262.82
Handle, Place & Compact Embankment Fill	*117,956*	*CY*	*$ 4.80*	*$ 566,188.80*	40%	$ 792,664.32
Topsoil				$ 952,500.00	40%	$ 1,333,500.00
Stripping	*9,842*	*CY*	*$ 9.80*	*$ 96,451.60*	40%	$ 135,032.24
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*12,795*	*CY*	*$ 24.80*	*$ 317,306.08*	40%	$ 444,228.51
Purchase Topsoil	*9,842*	*CY*	*$ 29.40*	*$ 289,354.80*	40%	$ 405,096.72
Haul Purchased topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*12,795*	*CY*	*$ 14.80*	*$ 189,360.08*	40%	$ 265,104.11
Handle/Place Topsoil	*9,842*	*CY*	*$ 6.10*	*$ 60,036.20*	40%	$ 84,050.68
Finish Grading	70,298	SY	*$ 0.90*	$ 63,300.00	35%	$ 85,455.00
Seeding	70,298	SY	*$ 1.80*	$ 126,500.00	35%	$ 170,775.00
Erosion Control Blanket	70,298	SY	*$ 2.40*	$ 168,700.00	35%	$ 227,745.00
Remove 48" and 60" CMP	0	LF	$ 20	$ -	35%	$ -
Install 60" RCP	0	LF	$ 214	$ -	35%	$ -
Install 48" Tideflex TF-1 Check Valve at Station 0+50	0	LS	$ 37,800.00	$ -	35%	$ -
Install 48" Sluice Gate at Station 0+50	0	EA	$ 41,200.00	$ -	35%	$ -
Construct Sluice Gate Chamber and headwall for 48" Interior Drainage Pipe	0	EA	$ 81,200.00	$ -	35%	$ -
Install Gate on Interceptor Sewer	0	EA	$ 31,200.00	$ -	35%	$ -
Construct Chamber on Interceptor Sewer	0	EA	$ 43,000.00	$ -	35%	$ -
Construct Gravel Access Road (Say 3000 linear feet, 12-foot wide)	4	MSY	$ 18,500.00	$ 74,000.00	35%	$ 99,900.00
Silt Fence (river side of levee & stockpile areas)	11,500	LF	$ 2.70	$ 31,100.00	35%	$ 41,985.00
Remove Gravel Access Road/Existing Road & Parking lots	0	SY	$ 5.30	$ -	35%	$ -
Roadway Demolition and Removal (say 50% of 7700' long x12' wide roadway)	5,133	SY	$ 11.50	$ 59,000.00	35%	$ 79,650.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 4" base)	5,133	SY	$ 34.20	$ 175,500.00	35%	$ 236,925.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 2" surface along entire road)	10,267	SY	$ 11.50	$ 118,100.00	35%	$ 159,435.00
Estimated Earthen Levee Construction Cost				$ 10,505,400.00	39.61%	$ 14,666,800.00

Rocky Ripple Levee Alternative 1 - 300 Year LOP With Freeboard

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Utility Allowance for unknown utility costs	1	Allowance	$ 250,000	$ 250,000.00	35%	$ 337,500.00
Utility Allowance for unknown utility costs						
I-Wall (160 feet along canal & 400 feet along White River)	1	EA	$ 1,369,500	$ 1,369,500.00		$ 1,369,500.00
Estimated I-Wall Construction Cost						
T-Wall (310 feet along canal for Riviera Club)	1	EA	$ 958,240	$ 958,240.00		$ 958,240.00
Estimated T-Wall Construction Cost						
Canal Gate Structure	1	EA	$ 3,219,220	$ 3,219,220.00		$ 3,219,220.00
Canal Gate Structure Cost						
Pump Station	1	EA	$ 1,098,160	$ 1,098,160.00		$ 1,098,160.00
Pump Station Cost						
Stream Bank Protection	1	EA	$ 2,510,080	$ 2,510,080.00		$ 2,510,080.00
Stream Bank Protection Cost						
Closure Gates	1	EA	$ 625,400	$ 625,400.00		$ 625,400.00
Closure Gate Cost						
Gatewell Structure	1	EA	$ 566,040	$ 566,040.00		$ 566,040.00
Gatewell Structure Cost						
Interior Drainage (Assume (1) 24" structure every 400 linear feet)	21	EA	$ 75,000	$ 1,575,000.00	35%	$ 2,126,250.00
Estimated Interior Drainage Construction Cost						
Land, Building Acquisition, Demolition and Relocation Cost						
Building Acquisition (Building and Parcel costs for 27 residential and 1 municipal propertiy)	1	LS	$ 3,581,330.00	$ 3,581,330.00	40%	$ 5,013,862.00
Building Demolition (Assume $25,000 per unit)	28	EA	$ 25,000	$ 700,000.00	35%	$ 945,000.00
Uniform relocation assistance (Assume $40,000 per residential structure)	27	EA	$ 40,000	$ 1,080,000.00	35%	$ 1,458,000.00
Survey (Assume $5,000 per lot)	28	EA	$ 5,000	$ 140,000.00	35%	$ 189,000.00
Administration fee (Assume $10,000 per unit)	28	EA	$ 10,000	$ 280,000.00	35%	$ 378,000.00
Land Acquisition (Parcel costs only for 22 properties)	22	EA	$ 13,000	$ 286,000.00	35%	$ 386,100.00
Survey (Assume $5,000 per lot)	22	EA	$ 5,000	$ 110,000.00	35%	$ 148,500.00
Administration fee (Assume $10,000 per unit)	22	EA	$ 10,000	$ 220,000.00	35%	$ 297,000.00
Land Easement for Levee (Assume $2,000 per lot)	39	EA	$ 2,000	$ 78,000.00	35%	$ 13,500.00
Building Relocation/raising *(3 structures, move within property limits & raise 2 feet above the 100-year WSEL)*	1	LS	$ 500,732.00	$ 500,732.00	35%	$ 675,988.20
Uniform relocation assistance (Assume $40,000 per residential structure)	3	EA	$ 40,000	$ 120,000.00	35%	$ 162,000.00
Survey (Assume $5,000 per lot)	3	EA	$ 5,000	$ 15,000.00	35%	$ 20,250.00
Administration fee (Assume $10,000 per unit)	3	EA	$ 10,000	$ 30,000.00	35%	$ 40,500.00
Estimated Land, Building Acquisition, Demolition and Relocation Cost				$ 7,141,062.00	35%	$ 9,727,700.20
Construction Mobilization/Demobilization (Assume 2.5% of Construction Cost)				$ 709,942.90		$ 709,942.90
Total Estimated Construction Cost (including Land, Building Acquisition, Demolition and Relocation)				$ 31,185,563.42		
Total Estimated Construction Cost with Contingencies						$ 38,835,359.03
Planning, Engineering, and Design (Assume 15% of Cost)				$ 4,366,148.82		$ 4,366,148.82
Construction Management (Assume 7% of Cost)				$ 2,037,536.12		$ 2,037,536.12
Estimated Services Cost				$ 6,403,684.94		$ 6,403,684.94
Estimated Total Project Cost						$ 45,239,043.97

Table A-4. Detailed Cost Estimate Alternative 2: Stand-Alone 100YR Protection (3ft Freeboard)

Rocky Ripple Levee Alternative 2 - 100 Year LOP With 3 Feet of Freeboard (Stand Alone Alternative)

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Existing Levee Embankment						
Clearing and Grubbing	3.2	AC	$ 23,000.00	$ 73,600.00	40%	$ 103,040.00
Remove Existing Embankment	35,088	CY		$ 1,233,000.00	40%	$ 1,726,200.00
Excavation	*35,088*	*CY*	*$ 2.90*	*$ 101,755.20*	40%	$ 142,457.28
Hauling/Disposa; Excavated soil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*45,614*	*CY*	*$ 24.80*	*$ 1,131,237.12*	40%	$ 1,583,731.97
Remove Existing Leve Embankment Topsoil	3,545	CY		$ 149,031.80	40%	$ 208,644.52
Stripping	*3,545*	*CY*	*$ 9.80*	*$ 34,741.00*	40%	$ 48,637.40
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*4,609*	*CY*	*$ 24.80*	*$ 114,290.80*	40%	$ 160,007.12
Estimated Existing Earthen Levee Demolition Cost				$ 1,455,631.80	40%	$ 2,037,884.52
Construct Proposed Levee Embankment						
Clearing and Grubbing	15	AC	$ 23,000.00	$ 345,000.00	40%	$ 483,000.00
Excavation For Subgrade Inspection	60,300	CY		$ 4,292,200.00	40%	$ 6,009,080.00
Excavation	*60,300*	*CY*	*$ 2.90*	*$ 174,870.00*	40%	$ 244,818.00
Haul/Dispose (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*78,390*	*CY*	*$ 24.80*	*$ 1,944,072.00*	40%	$ 2,721,700.80
Purchase Fill	*60,300*	*CY*	*$ 12.00*	*$ 723,600.00*	40%	$ 1,013,040.00
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*78,390*	*CY*	$ 14.80	*$ 1,160,172.00*	40%	$ 1,624,240.80
Handle, Place & Compact Purchased Fill	*60,300*	*CY*	*$ 4.80*	*$ 289,440.00*	40%	$ 405,216.00
Embankment Fill	123,495	CY		$ 4,450,800.00	40%	$ 6,231,120.00
Embankment Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*123,495*	*CY*	*$ 12.00*	*$ 1,481,940.00*	40%	$ 2,074,716.00
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*160,544*	*CY*	*$ 14.80*	*$ 2,376,043.80*	40%	$ 3,326,461.32
Handle, Place & Compact Embankment Fill	*123,495*	*CY*	*$ 4.80*	*$ 592,776.00*	40%	$ 829,886.40
Topsoil				$ 986,200.00	40%	$ 1,380,680.00
Stripping	*10,190*	*CY*	*$ 9.80*	*$ 99,862.00*	40%	$ 139,806.80
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*13,247*	*CY*	*$ 24.80*	*$ 328,525.60*	40%	$ 459,935.84
Purchase Topsoil	*10,190*	*CY*	*$ 29.40*	*$ 299,586.00*	40%	$ 419,420.40
Haul Purchased topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*13,247*	*CY*	*$ 14.80*	*$ 196,055.60*	40%	$ 274,477.84
Handle/Place Topsoil	*10,190*	*CY*	*$ 6.10*	*$ 62,159.00*	40%	$ 87,022.60
Finish Grading	72,781	SY	*$ 0.90*	$ 65,500.00	35%	$ 88,425.00
Seeding	72,781	SY	*$ 1.80*	$ 131,000.00	35%	$ 176,850.00
Erosion Control Blanket	72,781	SY	*$ 2.40*	$ 174,700.00	35%	$ 235,845.00
Remove 48" and 60" CMP	60	LF	$ 20	$ 1,200.00	35%	$ 1,620.00
Install 60" RCP	20	LF	$ 214	$ 4,300.00	35%	$ 5,805.00
Install 48" Tideflex TF-1 Check Valve at Station 0+50	1	LS	$ 37,800.00	$ 37,800.00	35%	$ 51,030.00
Install 48" Sluice Gate at Station 0+50	1	EA	$ 41,200.00	$ 41,200.00	35%	$ 55,620.00
Construct Sluice Gate Chamber and headwall for 48" Interior Drainage Pipe	1	EA	$ 81,200.00	$ 81,200.00	35%	$ 109,620.00
Install Gate on Interceptor Sewer	1	EA	$ 31,200.00	$ 31,200.00	35%	$ 42,120.00
Construct Chamber on Interceptor Sewer	1	EA	$ 43,000.00	$ 43,000.00	35%	$ 58,050.00
Construct Gravel Access Road (Say 3000 linear feet, 12-foot wide)	4	MSY	$ 18,500.00	$ 74,000.00	35%	$ 99,900.00
Silt Fence (river side of levee & stockpile areas)	11,500	LF	$ 2.70	$ 31,100.00	35%	$ 41,985.00
Remove Gravel Access Road/Existing Road & Parking lots	5,015	SY	$ 5.30	$ 26,600.00	35%	$ 35,910.00
Roadway Demolition and Removal (say 50% of 7700' long x12' wide roadway)	5,133	SY	$ 11.50	$ 59,000.00	35%	$ 79,650.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 4" base)	5,133	SY	$ 34.20	$ 175,500.00	35%	$ 236,925.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 2" surface along entire road)	10,267	SY	$ 11.50	$ 118,100.00	35%	$ 159,435.00
Estimated Earthen Levee Construction Cost				$ 11,169,600.00	39.51%	$ 15,582,700.00

Rocky Ripple Levee Alternative 2 - 100 Year LOP With 3 Feet of Freeboard (Stand Alone Alternative)

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Utility Allowance for unknown utility costs	1	Allowance	$ 250,000	$ 250,000.00	35%	$ 337,500.00
Utility Allowance for unknown utility costs						
I-Wall (160 feet along canal for Riviera Club tie-off)	1	EA	$ 391,140	$ 391,140.00		$ 391,140.00
Estimated I-Wall Construction Cost						
T-Wall (310 feet along canal for Riviera Club tie-off & assume 100 LF for downstream tie-off)	1	EA	$ 1,277,650	$ 1,277,650.00		$ 1,277,650.00
Estimated T-Wall Construction Cost						
Canal Gate Structure (Assume Gate is required similar to ACOE gate. Use ACOE cost updated to 2016 dollars)	1	EA	$ 3,219,220	$ 3,219,220.00		$ 3,219,220.00
Canal Gate Structure Cost						
Pump Station	1	EA	$ 1,098,160	$ 1,098,160.00		$ 1,098,160.00
Pump Station Cost						
Stream Bank Protection	1	EA	$ 2,510,080	$ 2,510,080.00		$ 2,510,080.00
Stream Bank Protection Cost						
Gatewell Structure	1	EA	$ 437,780	$ 437,780.00		$ 437,780.00
Gatewell Structure Cost						
Interior Drainage (Assume (1) 24" structure every 400 linear feet)	21	EA	$ 75,000	$ 1,575,000.00	35%	$ 2,126,250.00
Estimated Interior Drainage Construction Cost						
Land, Building Acquisition, Demolition and Relocation Cost						
Building Acquisition (Building and Parcel costs for 35 residential and 1 municipal propertiy)	1	LS	$ 4,539,671.00	$ 4,539,671.00	40%	$ 6,355,539.40
Building Demolition (Assume $25,000 per unit)	36	EA	$ 25,000	$ 900,000.00	35%	$ 1,215,000.00
Survey (Assume $5,000 per lot)	36	EA	$ 5,000	$ 180,000.00	35%	$ 243,000.00
Administration fee (Assume $10,000 per unit)	36	EA	$ 10,000	$ 360,000.00	35%	$ 486,000.00
Land Acquisition (Parcel costs only for 31 properties)	31	EA	$ 13,000	$ 403,000.00	35%	$ 544,050.00
Survey (Assume $5,000 per lot)	31	EA	$ 5,000	$ 155,000.00	35%	$ 209,250.00
Administration fee (Assume $10,000 per unit)	31	EA	$ 10,000	$ 310,000.00	35%	$ 418,500.00
Land Easement for Levee (Assume $2,000 per lot)	38	EA	$ 2,000	$ 76,000.00	35%	$ 102,600.00
Building Relocation/raising *(2 structures, move within property limits & raise 2 feet above the 100-year WSEL)*	1	LS	$ 372,910.00	$ 372,910.00	35%	$ 503,428.50
Survey (Assume $5,000 per lot)	2	EA	$ 5,000	$ 10,000.00	35%	$ 13,500.00
Administration fee (Assume $10,000 per unit)	2	EA	$ 10,000	$ 20,000.00	35%	$ 27,000.00
Estimated Land, Building Acquisition, Demolition and Relocation Cost				$ 7,326,581.00	38.10%	$ 10,117,867.90
Construction Mobilization/Demobilization (Assume 2.5% of Construction Cost)				$ 725,459.11		$ 725,459.11
Total Estimated Construction Cost (including Land, Building Acquisition, Demolition and Relocation)				$ 31,436,301.91		
Total Estimated Construction Cost with Contingencies						$ 39,861,691.53
Planning, Engineering, and Design (Assume 15% of Cost)				$ 4,461,573.54		$ 4,461,573.54
Construction Management (Assume 7% of Cost)				$ 2,082,067.65		$ 2,082,067.65
Estimated Services Cost				$ 6,543,641.20		$ 6,543,641.20
Estimated Total Project Cost						$ 46,405,332.73

Table A-5. Detailed Cost Estimate Alternative 3: Stand-Alone 100YR Protection (0ft Freeboard)

Rocky Ripple Levee Alternative 3 - 100 Year LOP With No Freeboard (Rocky Ripple Stand Alone Alternative)

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Existing Levee Embankment						
Clearing and Grubbing	3.2	AC	$ 23,000.00	$ 73,600.00	40%	$ 103,040.00
Remove Existing Embankment	35,088	CY		$ 1,233,000.00	40%	$ 1,726,200.00
Excavation	*35,088*	*CY*	*$ 2.90*	*$ 101,755.20*	40%	$ 142,457.28
Hauling/Disposa; Excavated soil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*45,614*	*CY*	*$ 24.80*	*$ 1,131,237.12*	40%	$ 1,583,731.97
Remove Existing Leve Embankment Topsoil	3,545	CY		$ 149,031.80	40%	$ 208,644.52
Stripping	*3,545*	*CY*	*$ 9.80*	*$ 34,741.00*	40%	$ 48,637.40
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*4,609*	*CY*	*$ 24.80*	*$ 114,290.80*	40%	$ 160,007.12
Estimated Existing Earthen Levee Demolition Cost				$ 1,455,631.80	40%	$ 2,037,884.52
Construct Proposed Levee Embankment						
Clearing and Grubbing	10.8	AC	$ 23,000.00	$ 248,400.00	40%	$ 347,760.00
Excavation For Subgrade Inspection	44,511	CY		$ 3,168,300.00	40%	$ 4,435,620.00
Excavation	*44,511*	*CY*	*$ 2.90*	*$ 129,081.90*	40%	$ 180,714.66
Haul/Dispose (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*57,864*	*CY*	*$ 24.80*	*$ 1,435,034.64*	40%	$ 2,009,048.50
Purchase Fill	*44,511*	*CY*	*$ 12.00*	*$ 534,132.00*	40%	$ 747,784.80
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*57,864*	*CY*	$ 14.80	*$ 856,391.64*	40%	$ 1,198,948.30
Handle, Place & Compact Purchased Fill	*44,511*	*CY*	*$ 4.80*	*$ 213,652.80*	40%	$ 299,113.92
Embankment Fill	65,389	CY		$ 2,356,600.00	40%	$ 3,299,240.00
Embankment Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*65,389*	*CY*	*$ 12.00*	*$ 784,668.00*	40%	$ 1,098,535.20
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*85,006*	*CY*	*$ 14.80*	*$ 1,258,084.36*	40%	$ 1,761,318.10
Handle, Place & Compact Embankment Fill	*65,389*	*CY*	*$ 4.80*	*$ 313,867.20*	40%	$ 439,414.08
Topsoil				$ 708,200.00	40%	$ 991,480.00
Stripping	*7,318*	*CY*	*$ 9.80*	*$ 71,716.40*	40%	$ 100,402.96
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal, 30% Swell, Means cost $14.80)	*9,513*	*CY*	*$ 24.80*	*$ 235,932.32*	40%	$ 330,305.25
Purchase Topsoil	*7,318*	*CY*	*$ 29.40*	*$ 215,149.20*	40%	$ 301,208.88
Haul Purchased topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*9,513*	*CY*	*$ 14.80*	*$ 140,798.32*	40%	$ 197,117.65
Handle/Place Topsoil	*7,318*	*CY*	*$ 6.10*	*$ 44,639.80*	40%	$ 62,495.72
Finish Grading	52,274	SY	*$ 0.90*	$ 47,000.00	35%	$ 63,450.00
Seeding	52,274	SY	*$ 1.80*	$ 94,100.00	35%	$ 127,035.00
Erosion Control Blanket	52,274	SY	*$ 2.40*	$ 125,500.00	35%	$ 169,425.00
Remove 48" and 60" CMP	60	LF	$ 20	$ 1,200.00	35%	$ 1,620.00
Install 60" RCP	20	LF	$ 214	$ 4,300.00	35%	$ 5,805.00
Install 48" Tideflex TF-1 Check Valve at Station 0+50	1	LS	$ 37,800.00	$ 37,800.00	35%	$ 51,030.00
Install 48" Sluice Gate at Station 0+50	1	EA	$ 41,200.00	$ 41,200.00	35%	$ 55,620.00
Construct Sluice Gate Chamber and headwall for 48" Interior Drainage Pipe	1	EA	$ 81,200.00	$ 81,200.00	35%	$ 109,620.00
Install Gate on Interceptor Sewer	1	EA	$ 31,200.00	$ 31,200.00	35%	$ 42,120.00
Construct Chamber on Interceptor Sewer	1	EA	$ 43,000.00	$ 43,000.00	35%	$ 58,050.00
Construct Gravel Access Road (Say 3000 linear feet, 12-foot wide)	4	MSY	$ 18,500.00	$ 74,000.00	35%	$ 99,900.00
Silt Fence (river side of levee & stockpile areas)	11,500	LF	$ 2.70	$ 31,100.00	35%	$ 41,985.00
Remove Gravel Access Road/Existing Road & Parking lots	5,015	SY	$ 5.30	$ 26,600.00	35%	$ 35,910.00
Roadway Demolition and Removal (say 50% of 7700' long x12' wide roadway)	5,133	SY	$ 11.50	$ 59,000.00	35%	$ 79,650.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 4" base)	5,133	SY	$ 34.20	$ 175,500.00	35%	$ 236,925.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 2" surface along entire road)	10,267	SY	$ 11.50	$ 118,100.00	35%	$ 159,435.00
Estimated Earthen Levee Construction Cost				$ 7,472,300.00	39.34%	$ 10,411,700.00

Rocky Ripple Levee Alternative 3 - 100 Year LOP With No Freeboard (Rocky Ripple Stand Alone Alternative)

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Utility Allowance for unknown utility costs	1	Allowance	$ 250,000	$ 250,000.00	35%	$ 337,500.00
Utility Allowance for unknown utility costs						
I-Wall (160 feet along canal for Riviera Club tie-off)	1	EA	$ 391,140	$ 391,140.00		$ 391,140.00
Estimated I-Wall Construction Cost						
T-Wall (310 feet along canal for Riviera Club tie-off & assume 100 LF for downstream tie-off)	1	EA	$ 1,277,650	$ 1,277,650.00		$ 1,277,650.00
Estimated T-Wall Construction Cost						
Canal Gate Structure (Assume Gate is required similar to ACOE gate. Use ACOE cost updated to 2016 dollars)	1	EA	$ 3,219,220	$ 3,219,220.00		$ 3,219,220.00
Canal Gate Structure Cost						
Pump Station	1	EA	$ 1,098,160	$ 1,098,160.00		$ 1,098,160.00
Pump Station Cost						
Stream Bank Protection	1	EA	$ 2,510,080	$ 2,510,080.00		$ 2,510,080.00
Stream Bank Protection Cost						
Gatewell Structure	1	EA	$ 437,780	$ 437,780.00		$ 437,780.00
Gatewell Structure Cost						
Interior Drainage (Assume (1) 24" structure every 400 linear feet)	21	EA	$ 75,000	$ 1,575,000.00	35%	$ 2,126,250.00
Estimated Interior Drainage Construction Cost						
Land, Building Acquisition, Demolition and Relocation Cost						
Building Acquisition (Building and Parcel costs for 34 residential and 1 municipal propertiy)	1	LS	$ 4,228,771.00	$ 4,228,771.00	40%	$ 5,920,279.40
Building Demolition (Assume $25,000 per unit)	35	EA	$ 25,000	$ 875,000.00	35%	$ 1,181,250.00
Survey (Assume $5,000 per lot)	35	EA	$ 5,000	$ 175,000.00	35%	$ 236,250.00
Administration fee (Assume $10,000 per unit)	35	EA	$ 10,000	$ 350,000.00	35%	$ 472,500.00
Land Acquisition (Parcel costs only for 30 properties)	30	EA	$ 13,000	$ 390,000.00	35%	$ 526,500.00
Survey (Assume $5,000 per lot)	30	EA	$ 5,000	$ 150,000.00	35%	$ 202,500.00
Administration fee (Assume $10,000 per unit)	30	EA	$ 10,000	$ 300,000.00	35%	$ 405,000.00
Land Easement for Levee (Assume $2,000 per lot)	39	EA	$ 2,000	$ 78,000.00	35%	$ 105,300.00
Building Relocation/raising *(3 structures, move within property limits & raise 2 feet above the 100-year WSEL)*	1	LS	$ 500,732.00	$ 500,732.00	35%	$ 675,988.20
Survey (Assume $5,000 per lot)	3	EA	$ 5,000	$ 15,000.00	35%	$ 20,250.00
Administration fee (Assume $10,000 per unit)	3	EA	$ 10,000	$ 30,000.00	35%	$ 40,500.00
Estimated Land, Building Acquisition, Demolition and Relocation Cost				$ 7,092,503.00	35%	$ 9,786,317.60
Construction Mobilization/Demobilization (Assume 2.5% of Construction Cost)				$ 596,184.11		$ 596,184.11
Total Estimated Construction Cost (including Land, Building Acquisition, Demolition and Relocation)				$ 27,375,648.91		
Total Estimated Construction Cost with Contingencies						$ 34,229,866.23
Planning, Engineering, and Design (Assume 15% of Cost)				$ 3,666,532.29		$ 3,666,532.29
Construction Management (Assume 7% of Cost)				$ 1,711,048.40		$ 1,711,048.40
Estimated Services Cost				$ 5,377,580.70		$ 5,377,580.70
Estimated Total Project Cost						$ 39,607,446.93

Table A-6. Update of Cost Estimate for Rocky Ripple Rehabilitation/ Replacement (From Christopher Burke, LLP, Rocky Ripple Inspection Report, 2001)

Rocky Ripple Levee Option - Levee Rehabilitation

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Existing Levee Embankment						
Clearing and Grubbing	11.7	AC	$ 23,000.00	$ 269,100.00	40%	$ 376,740.00
Remove Existing Embankment	17,500	CY		$ 615,000.00	40%	$ 861,000.00
Excavation	*17,500*	*CY*	*$ 2.90*	*$ 50,750.00*	40%	$ 71,050.00
Hauling/Disposal Excavated soil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*22,750*	*CY*	*$ 24.80*	*$ 564,200.00*	40%	$ 789,880.00
Remove Existing Leve Embankment Topsoil	6,500	*CY*		$ 273,260.00	40%	$ 382,564.00
Stripping	*6,500*	*CY*	*$ 9.80*	*$ 63,700.00*	40%	$ 89,180.00
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*8,450*	*CY*	*$ 24.80*	*$ 209,560.00*	40%	$ 293,384.00
Estimated Existing Earthen Levee Demolition Cost				$ 1,157,360.00	40%	$ 1,620,304.00
Construct Proposed Levee Embankment						
Clearing and Grubbing	0	AC	$ 23,000.00	$ -	40%	$ -
Excavation For Subgrade Inspection	-	CY		$ -	40%	$ -
Excavation	-	*CY*	*$ 2.90*	*$ -*	40%	$ -
Haul/Dispose (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell, Means cost $14.80)	-	*CY*	*$ 24.80*	*$ -*	40%	$ -
Purchase Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*0*	*CY*	*$ 12.00*	*$ -*	40%	$ -
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell, Means cost $14.80)	*0*	*CY*	$ 14.80	*$ -*	40%	$ -
Handle, Place & Compact Purchased Fill	*0*	*CY*	*$ 4.80*	*$ -*	40%	$ -
Embankment Fill	17,500	CY		$ 403,200.00	40%	$ 564,480.00
Embankment Fill (borrow for Phase 3B2 $550,000 for 45,000 cy or $12.22/cy. use $12/cy)	*17,500*	*CY*	*$ 12.00*	*$ 210,000.00*	40%	$ 294,000.00
Haul Purchased fill (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*22,750*	*CY*	*$ 4.80*	*$ 109,200.00*	40%	$ 152,880.00
Handle, Place & Compact Embankment Fill	*17,500*	*CY*	*$ 4.80*	*$ 84,000.00*	40%	$ 117,600.00
Topsoil				$ 464,400.00	40%	$ 650,160.00
Stripping	*6,500*	*CY*	*$ 9.80*	*$ 63,700.00*	40%	$ 89,180.00
Hauling/Disposal Topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 100% Disposal Means cost $14.80, Assume $10 Disposal, 30% Swell)	*8,450*	*CY*	*$ 24.80*	*$ 209,560.00*	40%	$ 293,384.00
Purchase Topsoil	*6,500*	*CY*	*$ 29.40*	*$ 191,100.00*	40%	$ 267,540.00
Haul Purchased topsoil (16.5 C.Y Truck, 40 Mile Roundtrip, 30% Swell)	*8,450*		*$ 14.80*	*$ 125,060.00*	40%	$ 175,084.00
Handle/Place Topsoil	*6,500*		*$ 6.10*	*$ 39,650.00*	40%	$ 55,510.00
Finish Grading	60,143	SY	*$ 0.90*	$ 54,100.00	40%	$ 75,740.00
Seeding	60,143	SY	*$ 1.80*	$ 108,300.00	35%	$ 146,205.00
Erosion Control Blanket	60,143	SY	*$ 2.40*	$ 144,300.00	35%	$ 194,805.00
Remove 48" and 60" CMP	60	LF	$ 20	$ 1,200.00	35%	$ 1,620.00
Install 60" RCP	20	LF	$ 214	$ 4,300.00	35%	$ 5,805.00
Install 48" Tideflex TF-1 Check Valve at Station 0+50	1	LS	$ 37,800.00	$ 37,800.00	35%	$ 51,030.00
Install 48" Sluice Gate at Station 0+50	1	EA	$ 41,200.00	$ 41,200.00	35%	$ 55,620.00
Construct Sluice Gate Chamber and headwall for 48" Interior Drainage Pipe	1	EA	$ 81,200.00	$ 81,200.00	35%	$ 109,620.00
Install Gate on Interceptor Sewer	1	EA	$ 31,200.00	$ 31,200.00	35%	$ 42,120.00
Construct Chamber on Interceptor Sewer	1	EA	$ 43,000.00	$ 43,000.00	35%	$ 58,050.00
Construct Gravel Access Road (Say 3000 linear feet, 12-foot wide)	4	MSY	$ 18,500.00	$ 74,000.00	35%	$ 99,900.00
Silt Fence (river side of levee & stockpile areas)	11,500	LF	$ 2.70	$ 31,100.00	35%	$ 41,985.00
Remove Gravel Access Road/Existing Road & Parking lots	5,015	SY	$ 5.30	$ 26,600.00	35%	$ 35,910.00
Utility Allowance for unknown utility costs	1	Allowance	$ 100,000	$ 100,000.00	35%	$ 135,000.00
Environmental Mitigation (Say 5% of levee estimate)	1	LS	$ -	$ -	35%	$ -
Roadway Demolition and Removal (say 50% of 7700' long x12' wide roadway)	5,133	SY	$ 11.50	$ 59,000.00	35%	$ 79,650.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 4" base)	5,133	SY	$ 34.20	$ 175,500.00	35%	$ 236,925.00
Pavement Restoration of 52nd St., Riverview Dr., 54th St. (place 2" surface along entire road)	10,267	SY	$ 11.50	$ 118,100.00	35%	$ 159,435.00
Estimated Earthen Levee Construction Cost				$ 1,998,500.00	35%	$ 2,697,975.00

Rocky Ripple Levee Option - Levee Rehabilitation

Description	Estimated Quantities	Units	Unit Cost	Estimated Cost	Contingency	Estimated Cost with Contingency
Interior Drainage (Assume (1) 24" structure every 400 linear feet)	0	EA	$ 75,000	$ -	35%	$ -
Estimated Land/Damage, Acquisition and Replacement Cost						
Construction Mobilization/Demobilization (Assume 2.5% of Construction Cost)				$ 108,000.00		$ 108,000.00
Total Estimated Construction Cost				$ 3,263,860.00		
Total Estimated Construction Cost with Contingencies						$ 4,426,279.00
Planning, Engineering, and Design (Assume 15% of Cost)				$ 667,500.00		$ 667,500.00
Construction Management (Assume 8% of Cost)				$ 356,000.00		$ 356,000.00
Estimated Services Cost				$ 1,023,500.00		$ 1,023,500.00
Estimated Total Project Cost						$ 5,449,779.00

Table A-7. Detailed Feature Comparison of USACE Rocky Ripple Alternative and Alternatives 1-3

Item	**USACE 2013 Plan**	**Alternative 1 (300 yr protection- with 3 - feet of Freeboard USACE plan)**	**Alternative 2 (100-year Standalone with 3 - feet of Freeboard)**	**Alternative 3 (100-year Standalone with 0 - feet of Freeboard)**
Lands and Damages	Land assumed to be acquired for building buyouts: 43 buildings (22 residences)	Land assumed to be acquired: 28 lots with buildings 22 lots without buildings 39 permanent easements 2 relocations	Land assumed to be acquired: 36 lots with buildings 31 lots without buildings 38 permanent easements 2 relocations	Land assumed to be acquired: 35 lots with buildings 30 lots without buildings 39 permanent easements 3 relocations
Borrow & Disposal Site	Assumes 10 acres required at $30k/acre plus $25,000 for borings	Cost Based upon USACE phase 3B2 ($550,000 for 45,000 cy or $12/cy)		
Utility Relocations	5,600 LF of 8" sanitary sewer; Package sewage treatment plant; 600 LF 4" force main to White River; Demolish existing septic tanks and lateral fields	$250,000 allowance for unknown utilities plus 35% contingency		
Earthen Levee	3,200 LF; 12 ft average height above grade; 68,000 cy embankment	8,530 LF; 9.5 ft average height above grade; 118,000 cy embankment	9,000 LF; 9.5 ft average height above grade; 123,500 cy embankment	9,000 LF; 6.5 ft average height above grade; 65,400 cy embankment
I-wall	**Along canal:** 160 LF, 6 ft average height above grade			
	Along White River near Canal Blvd and Ripple Rd: 400 LF 6 ft average height above grade;	Not implemented		
T-wall	**Along canal:** 310 LF, 9.6 ft average height above grade			
	Along White River 5625 LF 12 ft average height above grade;	Not implemented		

Item	USACE 2013 Plan	Alternative 1 (300 yr protection- with 3 - feet of Freeboard USACE plan)	Alternative 2 (100-year Standalone with 3 - feet of Freeboard)	Alternative 3 (100-year Standalone with 0 - feet of Freeboard)
Closure	Closure structures at Riverside Dr and Lester St.		Access ramps included in levee costs	
	In floodwall - At three locations to be determined for local access to the White River shoreline	Not implemented		
Gatewell Structure	1 ea for 72" storm sewer pipe running under the Canal; North of Canal Blvd and Ripple Rd intersection			
	1 ea for 36" sanitary sewer pipe running along east side of the Canal; Near Holcomb Carillion at Butler University			
	Assume 3 ea, 36" storm pipes in Rocky Ripple community	Assume 21 ea, 24" storm pipes in Rocky Ripple community		
Demolition	15,000 cy of existing levee embankment	14,450 cy of existing levee embankment	35,088 cy of existing levee embankment	35,088 cy of existing levee embankment
	43 buildings; 22 residences with out buildings	28 buildings; 22 residences with out buildings	36 buildings; 31 residences with out buildings	35 buildings; 30 residences with out buildings
Canal Gate Structure	64 ft wide; Ties into Levee at Butler University athletic fields levee south of West 51st St		64 ft wide	
Pump Station	3 Total: 2 ea at 150/200 GPM, 1 ea at 300/400 GPM, 2 ea at 400/600 GPM			
Stream Bank Protection	6000 LF along banks of White River;			
	8,000 cy of 18-in rip rap stone; 6 in. aggregate base			
Mobilization and Demobilization	Not specified	Estimated at 2.5% of the construction cost of the project components		
Construction Management	Estimated at 7% of the construction cost of the project components.	Estimated at 7% of the construction cost of the project components, including mobilization and demobilization.		
Planning Engineering & Design	Estimated at 5-15% of construction features of the project components plus 1.9 % for Independent Peer Review	Estimated at 15% of the construction cost of the project components, including mobilization and demobilization.		

Table A-8. Indianapolis North Levee System: Economic Cost of Time Delays

Year	Project Year - Rocky Ripple Implemented Alternative	Project Year - Westfield Alignment Implemented alternative	Westfield Blvd Tieoff Estimated Annual Benefits	Present Worth of Benefits (pre Base yr)	
				Pwf to RR Revised Base Year	Westfield Blvd Tieoff
2016	-6	-2	$ -	1.185384	$ -
2017	-5	-1	$ -	1.152257	$ -
2018	-4	0	$ -	1.120055	$ -
2019	-3	1	$ 4,514,000	1.088753	$ 4,914,633
2020	-2	2	$ 4,514,000	1.058327	$ 4,777,286
2021	-1	3	$ 4,514,000	1.028750	$ 4,643,778
2022	0	4	$ 4,514,000	1.000000	$ 4,514,000
2023	1	5			
				Total Benefit foregone	$ 18,850,000
				Annualized value	$715,000.00

NOTES:

Current Discount Rate	2.875%	
Annual Benefit Westfield Blvd	$4,514,000	Assumed 1.0 BCR at 7% Discount Rate
Annual Benefit Rocky Ripple Alt 1	$1,205,200	
Annual Benefit Rocky Ripple Alt 2	$1,107,200	
Invested Cost	$ 50,000,000	Source email communication
Additional Cost Westfield Closure	$12,300,000	Source Escalated from closure alternatives report

The general approach for the estimate of benefits lost due to delay as shown in Table A-8 is as follows:

Since an official estimate of the project benefits was not available, it was assumed that the benefits would be equal to the construction costs annualized over 50 years at a 7% interest rate. A 7% interest rate was chosen as a conservative assessment of the rate used for project justification since the official interest rate for water resource projects exceeded 7% for the period from 1980 to 1999. Using this approach the annual benefits for the overall project (excluding Rocky Ripple) are estimated to be $4,514,000. Over a 4 year delay period this represents $18,056,000 in potential benefits that would not accrue to the project. Adding interest to these benefits foregone increases the value to $18,850,000. Multiplying by the 50 year capital recovery factor results in an annualized value of $715,000 in benefits foregone.

The loss of benefits associated with a delay reduces the BCR of USACE implementation of the Rocky Ripple closure Alternatives from about 1.06 to approximately 0.4 (See Table 1).

APPENDIX B: LIST OF PREPARERS

Michael Cannon

BS, Hydrology, University of New Hampshire, 1979

Mr. Cannon has 37 years of experience at AECOM (URS until 2014) in completing flood damage reduction feasibility projects. Mr. Cannon's experience includes the plan development and evaluation of flood risk management projects totaling over $2B in USACE construction funding authorizations. Recent or ongoing projects include updates for the levee and floodwall designs and cost estimates for the Union Beach New Jersey (construction estimate $230M), cost, benefits and budget document updates for the ongoing Green Brook Basin Flood Control Project (approximately $1B system of levees, floodwalls, dams, pump stations and channel improvements), and the South Shore of Staten Island Feasibility Study ($560M system of levees, floodwalls, seawalls, drainage outlets, storm water ponding and wetlands creation). Other recent projects include preparation of large portions of the North Atlantic Coast Comprehensive Study and management for Reformulation of Fire Island Inlet to Montauk Point Project. He has authored a wide range of products including General and Limited Re-evaluation Reports, Feasibility Reports, Design Memorandum, and Basis of Design Reports.

John Dromsky-Reed

MS Environmental Engineering, NJ Institute of Technology, 1999
BS Marine Science, US Coast Guard Academy, 1986
Professional Engineer: NJ, 2004
Professional Engineer: NY, 2009

Mr. Dromsky-Reed has 27 years of experience in flood mitigation, hydraulic modeling, and flood mapping. He recently managed the technical development of engineering design and cost estimates for the levee and floodwall systems for the South River, NJ project and the Passaic River Tidal Area Study to protect the communities of Newark, Harrison, and Kearny. He is experienced in hydraulic modelling and recently lead several multi-million dollar task orders for flood data analysis and floodplain mapping for multiple counties in New York and New Jersey. He has also compiled numerous Engineering and Cost Appendices for USACE projects.

Richard Franks

MEng Civil Engineering, Portsmouth Polytechnic, UK, 1990
MSc Water Resources, University of Birmingham, UK, 1994

Chartered Engineer/Member of the Institution of Civil Engineers, UK, 2002-present
Certified Floodplain Manager, 2006-present
Secretary, New Jersey Association for Floodplain Management, 2012-2015

Prior to 1999 Mr. Franks worked in several different civil engineering and related fields including highways design and construction, offshore geotechnics for the oil industry, and construction of rural water supplies in Africa. From 1999 to 2002 Mr. Franks worked as an engineer and project manager for Babtie Group (now part of Jacobs) in London, principally involved with engineering and economic appraisals of the River Thames tidal flood defenses. Since 2003 Mr. Franks has worked for AECOM (URS until 2014) in New Jersey as an engineer and project manager specializing in the plan formulation and analysis for flood risk and coastal storm damage reduction projects for the USACE. This work mostly involves modeling flood and storm damages, benefit-cost analyses of flood risk reduction alternatives, as well as the outline design of alternatives, in particular the community-wide application of nonstructural retrofit treatments. Relevant projects of this nature include Mamaroneck, NY, Long Beach, NY, Sea Bright, NJ, Passaic River Basin, NJ, Delaware River, NJ, Meadowlands, NJ, Fire Island – Montauk Point, NY, Blanchard River, OH, and Galveston, TX. Mr. Franks has also been wholly or partially responsible for the development of numerous FEMA-approved natural hazard mitigation plans for county and municipal government jurisdictions in New Jersey and New York State.

Janusz Jansiewicz

MSCE Environmental Engineering, Cracow Institute of Technology, Cracow, Poland, 1978
Certified Floodplain Manager since 2008

Mr. Janusz Janisiewicz is a Hydrologic and Hydraulic analysis modeler with 32 years of experience specializing in flood mitigation, floodplain mapping, and permitting various commercial, residential projects using computer applications such as HEC-HMS, HEC-RAS, HEC-GeoRAS, HEC-1, HEC-2, Pond Pack, TR-55, ARC-GIS and WISE. He has completed HEC-RAS modelling for the Green Brook Flood Damage Reduction Project, the East Branch Delaware River Watershed Study, The Blanchard River in Ottawa Ohio Flood Risk Management design, the New York City West of Hudson Reservoirs Dam Breach Analyses and Inundation Mapping and the Lake Lenape Dam, NJ repair and scour protection.

Stacy Mulrain

MSc, Infrastructure Planning, New Jersey Institute of Technology, 2011
M.Arch Architecture, New Jersey Institute of Technology, 2010
BSc, Economics, Edinboro University of Pennsylvania, 2001

During her employment with AECOM, Ms. Mulrain has participated in a wide range of architectural and flood related projects, beginning with the Reconstruction, Rehabilitation, Elevation, and Mitigation (RREM) program administered by the State of New Jersey Department of Community Affairs. For RREM, Ms. Mulrain conducted pre-construction technical site visits to establish building structure, scope of work, and design strategy for the rehabilitation of Hurricane Sandy-impacted homes. On an ongoing basis, Ms. Mulrain is involved in field surveys to establish the existing conditions of buildings in project areas, economic analyses, and planning report preparation. Related projects that she is involved with include the Rebuild by Design New Meadowlands Flood Protection Project, the Fire Island to Montauk Point Reformulation Study (FIMP), the Passaic River Tidal Basin Flood Damage Study, the Passaic River Mainstem Structure Inventory, the East Rockaway to Rockaway Inlet Reformulation Study, and the North Atlantic Coast Comprehensive Study. Ms. Mulrain’s experience prior to AECOM includes the design and documentation of renovation projects in New Jersey and New York consisting of residential, commercial, and institutional buildings.

William Slezak

MS Environmental Engineering, New Jersey Institute of Technology, 1984
MS- Ecology, Rutgers University, 1976

Prior to 2013, Mr. Slezak worked for the USACE in various technical and managerial capacities, including Chief of Permits, Regulatory Branch, NY District (1979-1983), Chief, Navigation Branch, Operations

Division, NY District (1985-1989), Technical Manager (water resource projects), Engineering Division, North Atlantic Division, (1989-1991), Project Manager (Green Brook Flood control project, among other water resource projects), NY District (1991-1994), Chief, Civil Works Br. Programs and Project Mgmt. Division, NY District (1995-2004), Chief, NY Harbor Programs Br, Programs and Project Mgmt. Division, NY District (2004-2013. Also served following Temporary: Deputy Chief, North Atlantic Regional Integration Team, HQUSACE (2008-2009), Deputy Commander, Hurricane Sandy Recovery Office, NY District (2012-13).

Since 2013 Mr. Slezak has worked for AECOM (URS until 2014) in New Jersey as a water resource engineer specializing in the plan formulation and analysis for flood risk and coastal storm damage reduction projects for the USACE. Relevant projects of this nature include the North Atlantic Coast Comprehensive Study, Fire Island to Montauk Point, NY South Shore of Staten Island, Green Brook Flood Control Project NJ, Meadowlands.

Robert Ulshafer

BS Civil Engineering Technology, New Jersey Engineering Technology, Newark, NJ, 1984
Engineer Intern Delaware, 1999

Prior to 1990 Mr. Ulshafer worked primarily on the conceptual layout and design of civil features such as roads, storm and sanitary sewer and water lines for residential subdivisions located throughout Central and Southern New Jersey. He also provided oversite for the municipalities of Bricktown, Manalapan and Sayreville New Jersey on several construction projects including roadway modifications and resurfacing, a gabion retaining wall, a park and ride facility, sanitary sewer replacement and waterman installation. From 1990 to 1995 he worked exclusively on the permitting, design and closure of sanitary landfills that were located in New York, New Jersey, Virginia and Florida.

Since 1995 Mr. Ulshafer has worked for AECOM as an engineer specializing in the design of drainage systems for roadways and bridges, landfills, postal facilities and flood damage reduction projects. Pertinent projects include the design of diversion pipes, detention ponds and interior drainage for the Green Brook Flood Damage Reduction Project, detention basin design for 21 miles of highway widening for Route 3 in Massachusetts and evaluation and design of the permanent and temporary drainage system for the New Bay Bridge Deck Replacement. Mr. Ulshafer also has practical experience with the preparation of cost estimates for the Army Corp Engineer with features including levee, floodwall, bridge modifications, roller, swing and stop log closure gates, interior drainage and pump stations and coordination of construction projects.