Stantec

Memo

To:	Steve Wilson, PE, PS Maumee Watershed Conservancy District	From:	David Hayson, PE, SI Stantec Consulting Services Inc.
File:	174316204	Date:	October 31, 2019

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

This technical memorandum summarizes the methods and findings for the evaluation of dam alignments and reservoir capacity for the proposed Eagle Creek Dry-Storage Basin Project (the Project). The Project is part of the Hancock County Flood Risk Reduction (HCFRR) Program led by the Maumee Watershed Conservancy District (MWCD).

The Project would provide storage during flood events to reduce the peak flow rates in Eagle Creek and the Blanchard River, thereby reducing the downstream water surface elevations and associated flood risk. The Project is located in Eagle Township and Liberty Township in Hancock County, Ohio, approximately 4 miles south of the City of Findlay. Figure 1 shows the approximate limits of the study area.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

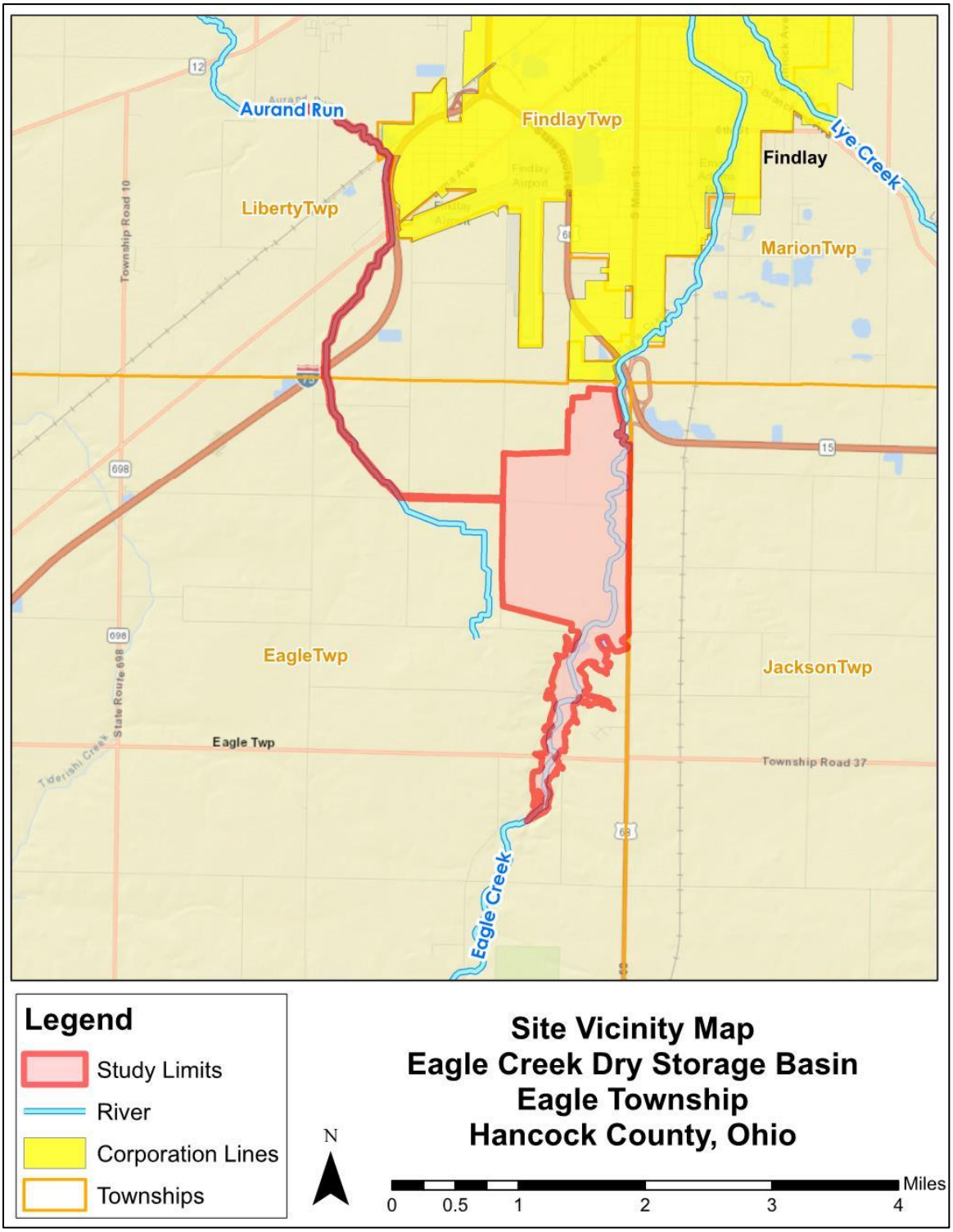

Figure 1 – Study Area for Eagle Creek Dry-Storage Basin

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

BACKGROUND

The HCFRR Program includes multiple flood risk reduction strategies and efforts as described in the "*Hancock County Flood Risk Reduction Program, Final Report: Data Review, Gap Analysis, USACE Plan and Alternatives Review, and Program Recommendation*" report dated April 3, 2017 and the follow-up report, "*Hancock County Flood Risk Reduction Program – Draft Proof of Concept Update*" dated July 9, 2018. Both of these documents can be found at www.HancockCountyFlooding.com. The recommended program included hydraulic improvements along the Blanchard River in the City of Findlay, a dry-storage basin on Eagle Creek upstream of the City, and two (2) dry-storage basins near the Village of Mt. Blanchard on the Blanchard River and Potato Run.

To date, the MWCD has implemented Phase I of the Hydraulic Improvements. The Phase I Hydraulic Improvements include the removal of four (4) inline dam/riffle structures and excavation of a floodplain bench on the Blanchard River near Swale Park (between Broad Avenue and the Norfolk-Southern rail bridge). Phase I of the Hydraulic Improvements project is currently under construction and final completion is anticipated to occur in Spring 2020.

The Eagle Creek dry-storage basin concept was originally developed in the 2017 study. The concept was further refined with the 2018 *Proof of Concept Update* to reduce impacts to residential structures and private property. Figure 2 shows a comparison between the original Proof of Concept footprint and the revised *Proof of Concept Update* "EC-2C" option.

Subsequent to the *Proof of Concept Update*, a local stakeholders group made the following suggestions regarding the Eagle Creek dry-storage basin analysis:

- reduce the footprint of the proposed storage facility;
- reduce the number of parcels potentially impacted by construction;
- reduce the number of structures potentially impacted by construction;
- reduce the acreage of agricultural land impacted by construction;
- reduce the risk of flooding to structures and roadway crossings upstream and downstream of the basins; and
- reduce the opinion of probable construction cost.

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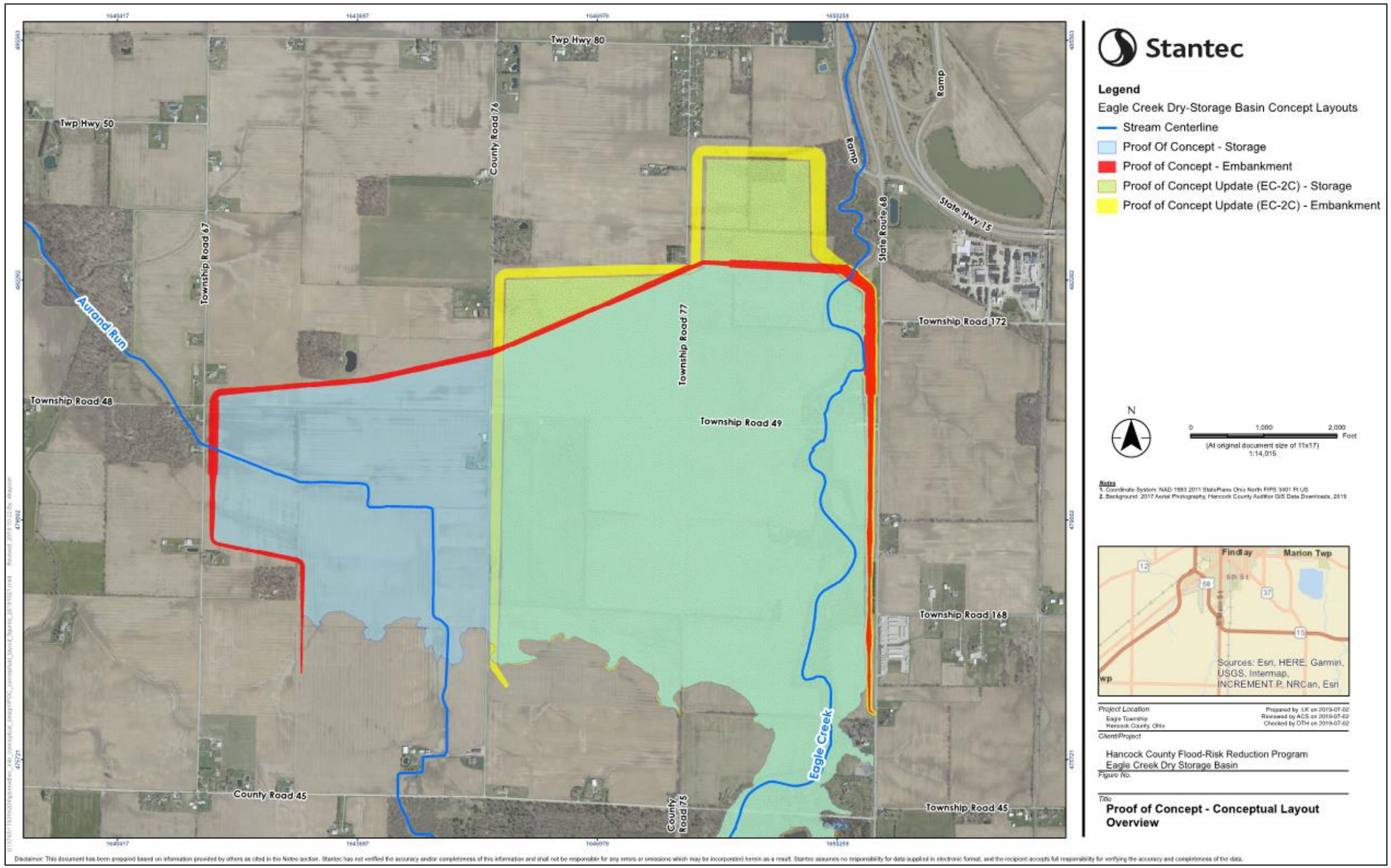

Figure 2 – Eagle Creek Dry-Storage Basin – Original Concept & Proof of Concept Update (EC-2C) Comparison

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

SCOPE

The MWCD contracted Stantec to advance the conceptual design of the Eagle Creek dry-storage basin as a continuation of the Proof of Concept study and the HCFRR Program. The MWCD requested Stantec to collect supplementary field data and perform technical analyses to evaluate additional footprints related to the Project, particularly two (2) variations of the eastern embankment's alignment relative to Eagle Creek. One variation considers the east embankment of the storage basin to be aligned adjacent to and west of Eagle Creek (Western Alignment). This option would create an off-stream, dry reservoir. The second variation considers the east embankment of the storage basin aligned to the east of Eagle Creek (Eastern Alignment), parallel to US 68. This layout would create an in-line reservoir during flood events. MWCD also requested that Stantec refine the Aurand Run secondary spillway concept.

This memorandum provides a summary of Stantec's analysis and conceptual design of the Eagle Creek dry-storage basin, focused on reviewing alternative footprint options relative to the goals listed above. Specifically, this memorandum includes information on:

- Field Studies
  - Geotechnical exploration and laboratory analysis;
  - Mussel reconnaissance surveys;
  - Wetland delineation and waterbody surveys;
  - Threatened and endangered species habitat assessment; and
  - Utility survey
- Eagle Creek Dry-Storage Basin Concept Refinement
  - Concept geometry and components
  - Alternatives
  - Storage capacity
- Aurand Run Secondary Spillway Concept Refinement
- Preliminary Opinion of Probable Construction Costs
- Evaluation of Alternatives
- Conclusions and Recommendations

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

FIELD WORK PERFORMED

Stantec performed certain field activities to collect additional data in order to supplement previous field work. The additional field data was used to support the conceptual design of the Eagle Creek dry-storage basin and inform the opinions of probable construction costs (OPCC). Stantec completed the following field activities as part of this study:

- Geotechnical exploration and laboratory analysis;
- Mussel reconnaissance surveys on Eagle Creek and Aurand Run;
- Wetland and waterbody delineation surveys;
- Threatened and endangered species habitat assessment; and
- Topographic utility and geotechnical boring location survey.

GEOTECHNICAL EXPLORATION AND LABORATORY ANALYSIS

Limited geotechnical information was available for the development of the previous planning and concept studies. Therefore, assumptions were made in previous reports relative to the suitability of existing soils within the Project area for construction of the recommended dam. These assumptions were the basis of basin embankment geometry and estimates related to the opinions of probable construction cost for components related to the dam. Stantec performed additional geotechnical sampling and testing in the vicinity of the proposed dam to gain further information as to whether the materials are suitable for use as embankments, to determine the underlying foundation soils, and to refine the OPCC.

Ten (10) borings were advanced by Stantec to obtain geotechnical data along the proposed embankment alignment west of Eagle Creek (Western Alignment). Figure 3 shows the location of the ten (10) borings. Disturbed and undisturbed soil samples were collected through the soil overburden. Upon encountering bedrock, approximately ten (10) feet of rock coring was performed. Soil and rock samples obtained from the borings were logged in the field by a geotechnical engineer, then returned to the laboratory for testing and storage. A detailed report of the geotechnical exploration and laboratory analysis can be found in Attachment B – *"Report of Preliminary Geotechnical Exploration Hancock County Flood Risk Reduction Program – Eagle Creek Dry Storage Basin Phase 1"* (Stantec, 2019).

Soils encountered along the proposed Western Alignment consisted of alternating layers of fine- and coarse-grained materials. Laboratory testing classified the fine-grained soils as Sandy Lean Clay (CL), Lean Clay (CL), Sandy Silty Clay (CL-ML), Silt with Sand (ML). These soils were described as moist, medium stiff to very stiff, and having varying amounts of sand and gravel. Fine-grained soils were encountered near the ground surface, and again deeper in the profile between two layers of coarse-grained soils. The coarse-grained materials were visually described as poorly graded sand with some gravel or mechanically classified as Silty Sand with Gravel (SM), Silty, Clayey Gravel with Sand (GC-GM), and Clayey Sand (SC). These soils were described as moist and dense to very dense. The layers of coarse-grained materials were found generally near the water table and again above top of bedrock. The depth to bedrock ranged from 12.8 feet (EL. 784.8 feet) in B-1.1 to 21.0 feet (EL. 773.4 feet) in B-2.14a. The bedrock was described as gray dolomite, slightly weathered, fractured to moderately fractured, slightly rough, and thin to medium bedded. Figure 4 shows the soil boring profile along the Western Alignment.

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

Key findings of the geotechnical exploration and laboratory testing program include:

1. Soils within the reservoir footprint are likely adequate to serve as borrow material to construct the embankment dam. Further borrow studies are recommended to confirm these findings as design advances.
2. The presence of granular layers and pervious bed bedrock within the proposed dam foundation will require design consideration including maintaining an upstream impervious blanket layer, seepage cutoffs or embankment and foundation drainaige features.
3. Bedrock ranges from 12 to 21 feet in depth. Deep excavations within the reservoir should anticipate additional measures for rock excavation.
4. The groundwater table is observed within eight to ten feet from top of existing ground. Deep excavations may encounter groundwater and require pumping or other dewatering measures.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

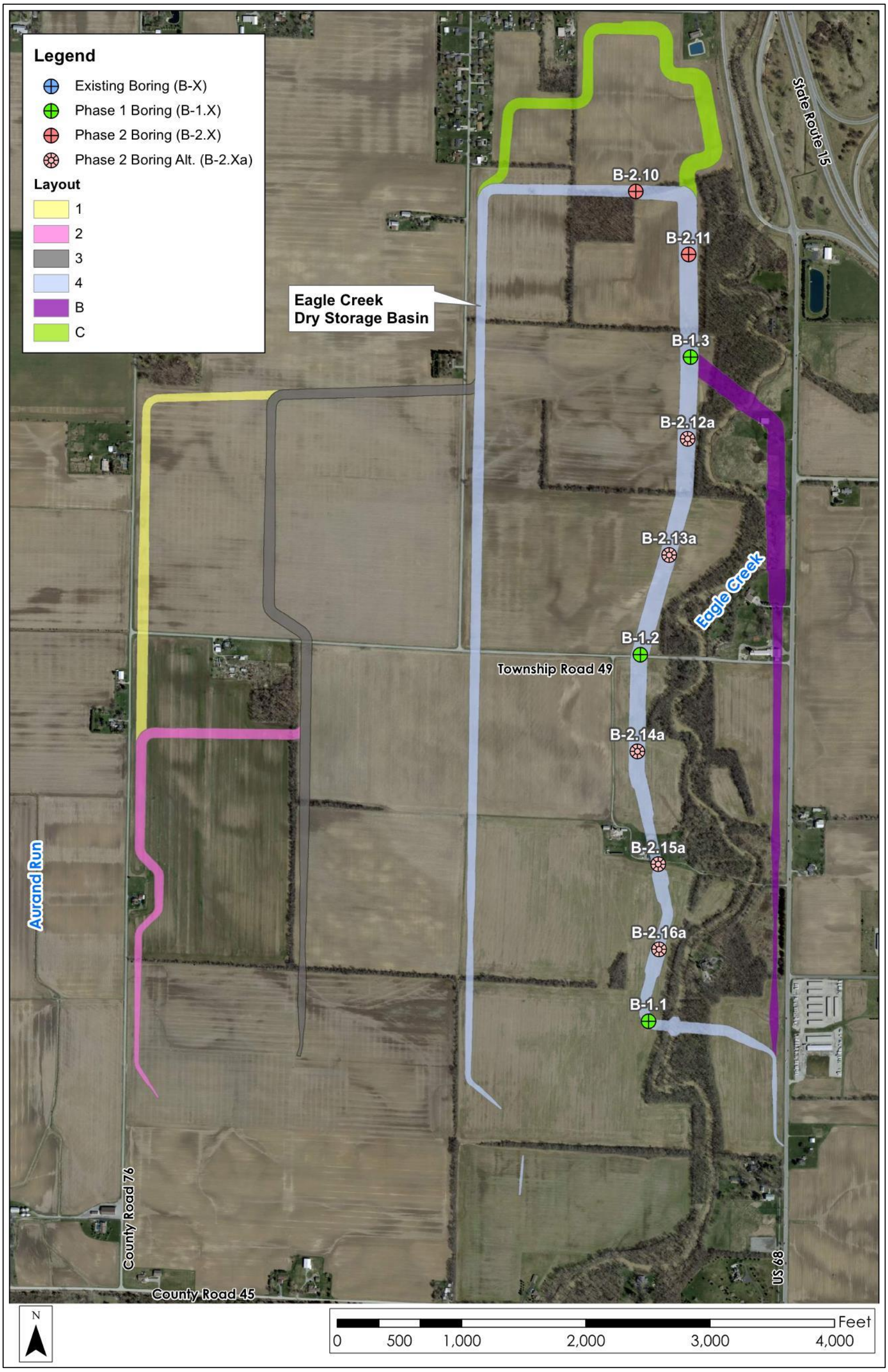

Figure 3 – Eagle Creek Dry-Storage Basin – Geotechnical Boring Layout

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

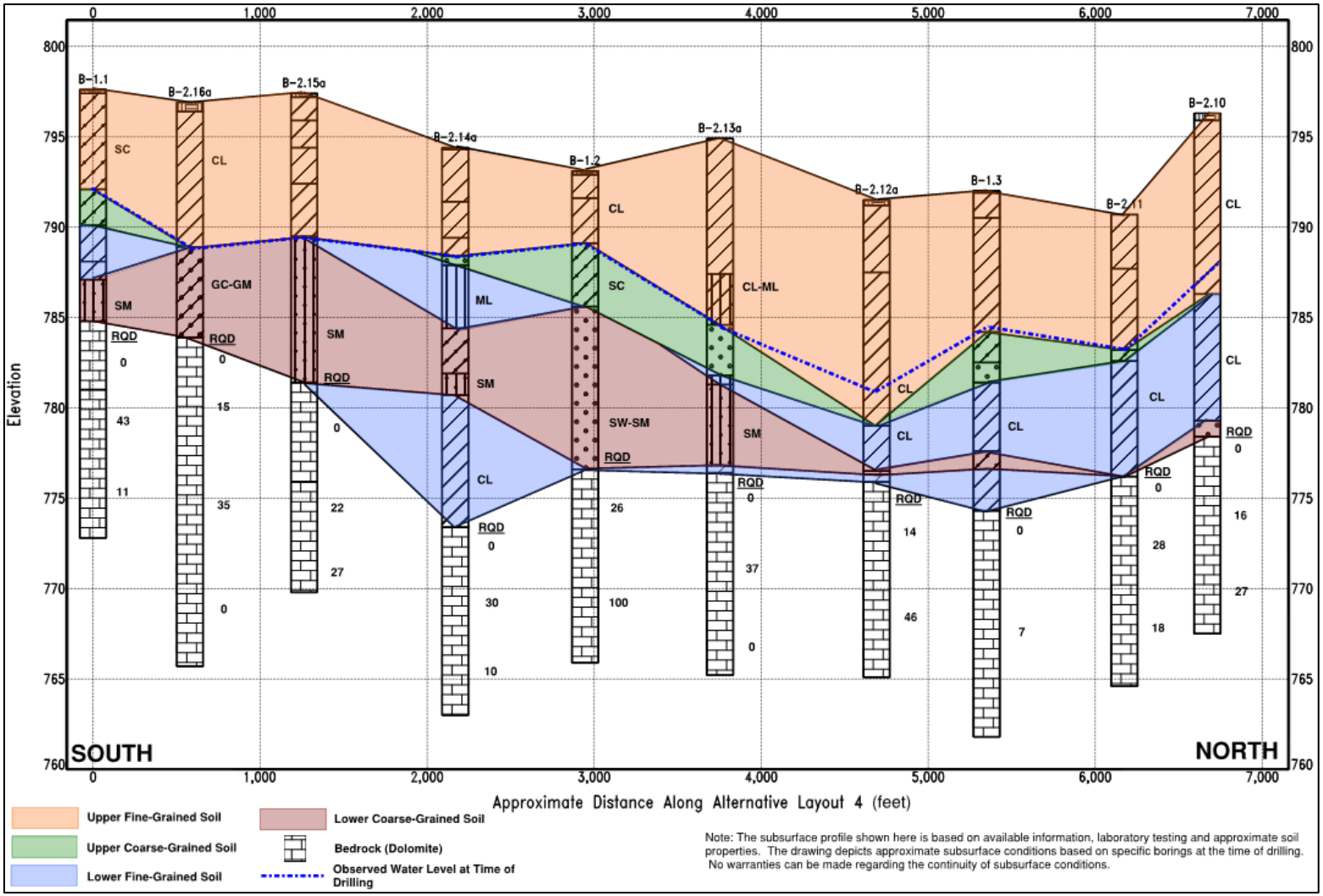

Figure 4 – Eagle Creek Dry-Storage Basin – Soil Boring Profile Along Western Alignment

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

MUSSEL RECONNAISSANCE SURVEYS ON EAGLE CREEK AND AURAND RUN

Stantec conducted freshwater mussel reconnaissance surveys on Eagle Creek and Aurand Run in accordance with the 2018 US Fish and Wildlife Service (USFWS) and Ohio Department of Natural Resources (ODNR) Freshwater Mussel Survey Protocols. Eagle Creek is a Group 1 stream with an approximate drainage area of 52 square miles at the downstream limit of the Project site while Aurand Run is an unlisted stream with an approximate drainage area of 18 square miles at the downstream limit of the Project site. Reconnaissance surveys of Eagle Creek and Aurand Run assessed the potential presence or probable absence of unionid mussels within the Project area for the proposed Eagle Creek flow control structures and potential impacted locations on the waterways. At all locations surveyed on Eagle Creek and the four downstream locations on Aurand Run, mussels were found or presence was determined to be probable due to suitable substrate and presence of shells. No mussels were found and presence is unlikely for the two upstream-most locations in Aurand Run and two locations in an unnamed ditch. No federally or Ohio listed species were found at any location. Additional details of the mussel reconnaissance survey can be found in Attachment C – *"Freshwater Mussel Reconnaissance Survey on Eagle Creek and Aurand Run"* (Stantec, 2019).

Based on the results of the mussel reconnaissance survey, Stantec anticipates that mussel relocation may be required during construction within impacted areas where mussel presence is probable. If impacts are extensive (e.g., channel modification along the entire length of Aurand Run), the magnitude of effort for relocation will also be large. If impacts are discrete and isolated (e.g., dam footprint only), the level of effort will be correspondingly smaller. The selection of the Eagle Creek Dry-Storage Basin layout does not appear to be driven by the findings of mussel reconnaissance survey, but the data collected will be useful for decision making as design progresses on the selected alternative.

WETLAND AND WATERBODY DELINEATION SURVEYS

Stantec delineated potential waters of the United States (WOTUS) and waters of Ohio, including isolated wetlands that may be regulated by the Ohio Environmental Protection Agency (OEPA), within the Eagle Creek Dry-Storage Basin Project (the Project) area. Stantec also assessed streams that demonstrated a continuously defined channel (bed and bank), ordinary high water mark (OHWM), and the disturbance of terrestrial vegetation. These streams were delineated within the Project area.

Stantec prepared a wetland and waterbody delineation report including narrative descriptions of the Project area, wetlands, streams, and other potential regulated waters. The report includes a discussion of the regulatory issues that will need to be considered prior to initiation of Project construction activities. This wetland and waterbody report can be found in Attachment D – "*Eagle Creek Dry-Storage Basin Project Wetland and Waterbody Delineation Report*" (Stantec, 2019).

THREATENED AND ENDANGERED SPECIES HABITAT ASSESSMENT

The USFWS Midwest Region website currently lists the Indiana bat (*Myotis sodalis*; federally endangered), northern long-eared bat (*Myotis septentrionalis*; federally threatened), clubshell (*Pleurobema clava*; federally endangered), rayed bean (*Villosa fabalis*; federally endangered), and bald eagle (*Haliaeetus leucocephalus*; federal species of concern) as occurring in, or having potential to occur in, Hancock County.

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

Stantec coordinated with US Fish and Wildlife and ODNR and then conducted field surveys for potential suitable habitats of federally and state-listed threatened and endangered species within the Project area. Stantec evaluated the habitats within the Project area for their potential suitability as habitat for federally and state-listed threatened, endangered, and rare species that are identified by ODNR as being within the Project area or a one-mile radius of it, and/or that are listed as occurring in Hancock County.

Stantec used the information gathered and plotted critical habitat or potentially suitable habitat areas on a Habitat Assessment Map. Based on the findings of the habitat assessment, impacts to threatened or endangered species habitats are expected to be similar for all Eagle Creek Dry-Storage Basin alternatives. As design of the selected alternative advances, consideration must be given to the location of potential Indiana and northern long eared summer roost trees, and it is likely that seasonal clearing restrictions will be required during construction. Additionally, due to known locations of a bald eagle nest and great blue heron rookery near the Project area, considerations must further be given to the construction window as to prevent the potential take of nesting migratory birds and eagles that are protected by the Migratory Bird Treaty Act of 1918, and the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d, BGEPA). Additional details of the habitat assessment can be found in Attachment E – "*Eagle Creek Dry-Storage Basin Project Threatened and Endangered Species Habitat Assessment Report*" (Stantec, 2019). The report may be submitted to the USFWS for their review and concurrence, in order to initiate Endangered Species Act consultation as part of the Clean Water Act (CWA) Section 404 permitting process.

TOPOGRAPHIC UTILITY AND GEOTECHNICAL BORING LOCATION SURVEY

Stantec contracted with Bockrath & Associates Engineering and Surveying to perform topographic utility survey and geotechnical boring location survey in the Project area. The Aurand Run topographic utility survey included a 100-feet wide corridor along approximately 2,500 linear feet of Aurand Run between County Road 49 and Country Road 9. The Eagle Creek area topographic utility survey included approximately 1,500 acres along Eagle Creek, west of US Route 68, south of Baseline Road, east of County Road 76, and north of County Road 26.

The survey identified several stormwater conduits and drainage tiles. The survey also identified the presence of a buried fiber optic line along Township Road 49 between west of US-68. Relocation of this line, if required, would be similar for all potential configurations of the Eagle Creek Dry-Storage Basin under consideration.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

EAGLE CREEK DRY-STORAGE BASIN – CONCEPT REFINEMENT

EAGLE CREEK DRY-STORAGE BASIN – CONCEPT GEOMETRY AND COMPONENTS

The Eagle Creek dry-storage basin embankment geometry and elevations are similar to those used for the *Proof of Concept Update* report. The critical elevations are listed in Table 1 below. The hydrology for this analysis is consistent with work presented previously by Stantec ("*Hydrologic Evaluation of the Blanchard River*", 2017) as described in the *Proof of Concept Update* (Stantec, 2018).

Table 1 – Design Elevations

Level Description	Event	Elevation (FT, NAVD 88)
Auxiliary Spillway Crest	1% Annual Chance Exceedance (1:100 Year)	807.0
Maximum Water Level	Probable Maximum Flood (PMF)	810.0
Dam Crest	PMF + 2.0 FT	812.0

Each alternative reviewed as part of this study has a principal spillway to Eagle Creek, a secondary spillway to Aurand Run, and an auxiliary spillway to Eagle Creek. Off-stream storage alternatives with a footprint using the Western Alignment (discussed in more detail in the "Concept Footprint" section) also utilize a low-level outlet to Eagle Creek. The Eagle Creek dry-storage basin components are described in the paragraphs below.

Typical Dam Embankment

The proposed dam geometry (height, out slopes and benching) remained unchanged from the *Proof of Concept Update*. Following the most recent geotechnical exploration, additional design elements were added to the concept design and costs to address concerns related to seepage through the granular soil layers and fractured bedrock in the foundation.

A drainage blanket and trench are recommended along portions of the dam based on dam height and where the dam is located adjacent to Eagle Creek and separates Eagle Creek from the storage area (Western Alignment). This feature was added to each concept for cost estimation purposes along the dam alignment where it was applicable. Figure 5 shows the updated dam cross section incorporating the drainage blanket and trench.

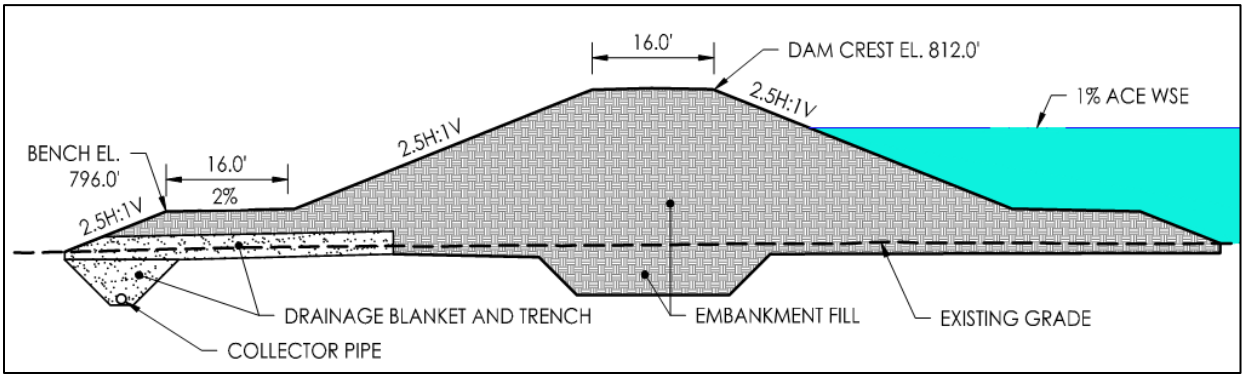

Figure 5 – Typical Dam Embankment with Drainage Blanket and Trench

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

Principal Spillway

The principal spillway to Eagle Creek is in-line with the existing stream channel. The location will vary depending on the selected alignment of the eastern embankment: at the upstream end of the basin for options using the Western Alignment, or at the downstream end of the basin for options using the Eastern Alignment. Figure 6 and Figure 7 identify the location of the principal spillway for the two alignments.

The principal spillway invert elevation is set near the existing channel invert elevation at its designated location. The spillway is a static structure (no gates or valves) which limits the discharge to the designed flowrate when the water surface elevation (WSE) in the basin is at its maximum pool during a 1% ACE event. The proposed concept includes an intake structure with trash racks to reduce the risk of debris blockage, a concrete conduit, and a stilling basin at the outlet.

Secondary Spillway

The proposed secondary spillway to Aurand Run is on the west embankment of the storage basin nearest to Aurand Run. The spillway will discharge when the WSE in the storage basin exceeds the invert elevation of the inlet structure. Similar to the principal spillway, the secondary spillway is a static structure which limits flow to 500 cubic feet per second (cfs) when the WSE in the basin is at its maximum pool during the 1% ACE event. The spillway includes an intake structure with trash racks to reduce the risk of debris blockage, a concrete conduit, and a stilling basin at the outlet. An excavated channel conveys the discharge from the spillway to Aurand Run just north (downstream) of Township Road 48. Additional required modifications to the Aurand Run channel are discussed in the Aurand Run Concept Refinement section. The secondary spillway and discharge channel are shown on Figure 6 and Figure 7.

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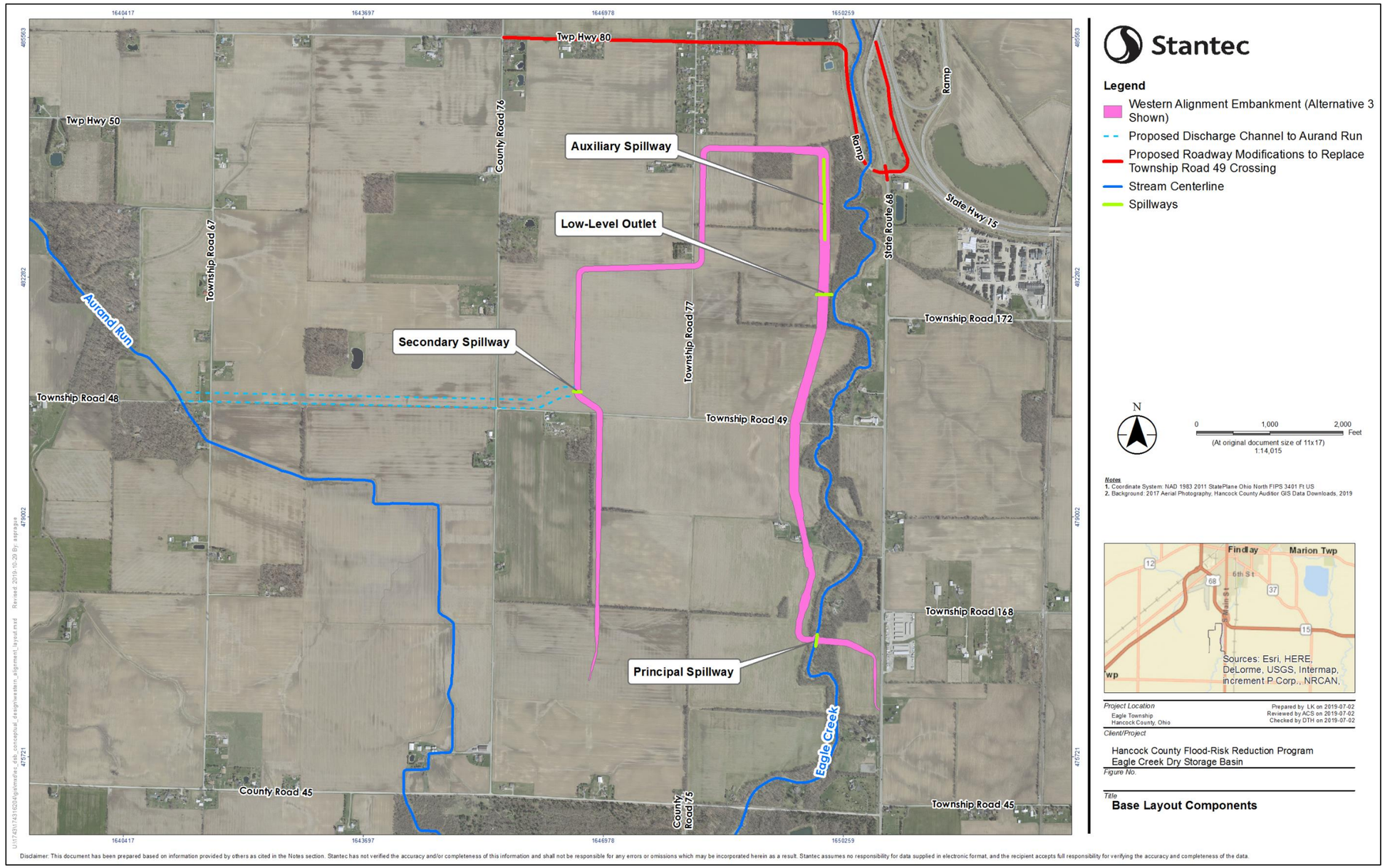

Figure 6 – Eagle Creek Dry-Storage Basin – Western Alignment Components

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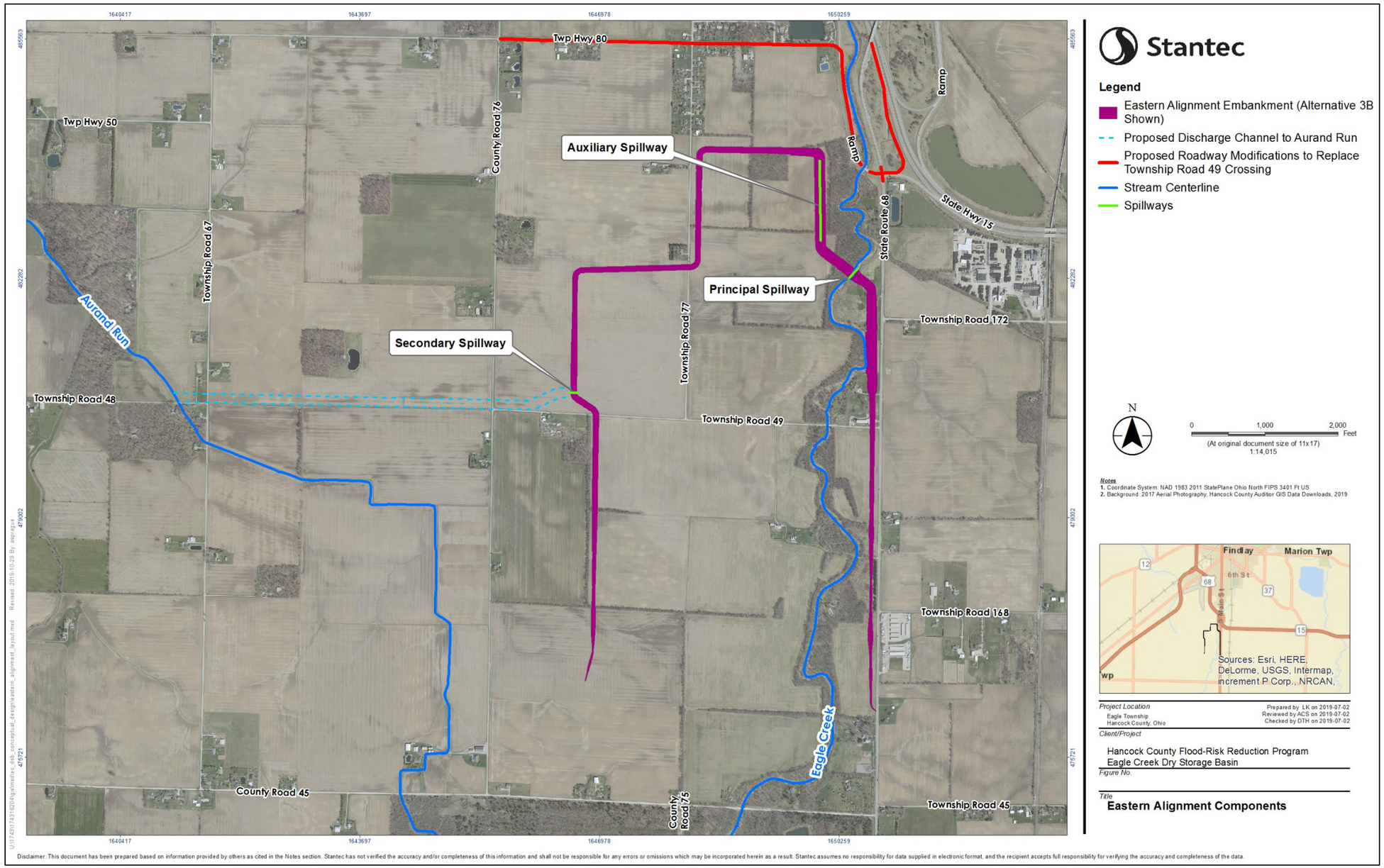

Figure 7 - Eagle Creek Dry-Storage Basin - Eastern Alignment Components

Auxiliary Spillway

The auxiliary spillway concept design provides the discharge capacity to safely pass the PMF as required by the State of Ohio Dam Safety regulations for Class I dams. The auxiliary spillway length varies based on storage volume and required peak discharge capacity. The auxiliary spillway concept may pass the peak discharge from the PMF while maintaining a minimum of two (2) feet of freeboard from the dam crest. The auxiliary spillway concept includes a roller-compacted concrete (RCC) overlay surmounted by an ogee-shaped cast-in-place concrete crest. Figure 8 shows the typical cross section of the auxiliary spillway concept. The proposed location of the auxiliary spillway is shown on Figure 6 and Figure 7.

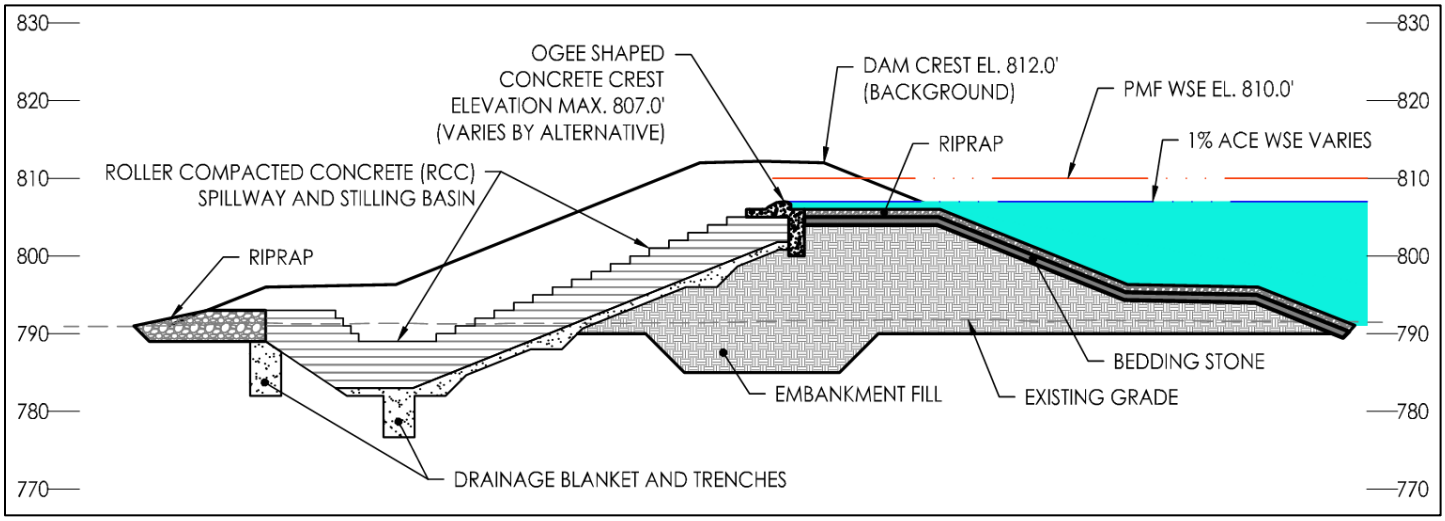

Figure 8 – Eagle Creek Dry-Storage Basin – Auxiliary Spillway Conceptual Section

Low-Level Outlet

The low-level outlet to Eagle Creek for the Western Alignment alternatives is located in the eastern embankment, perpendicular to Eagle Creek and downstream of the principal spillway. The invert of the low-level outlet is set at the lowest elevation in the storage basin to allow the basin to drain to Eagle Creek by gravity. The components of the low-level outlet include a gate and intake structure with trash racks at the inlet, a concrete conduit, and an energy dissipating structure at the outlet. The gate would remain open under typical, non-flood event conditions to allow runoff to be discharged from the basin. The gate would be closed before and during a large storm event. The gate would be opened after the flood event has passed to allow the stored volume of water to be discharged to Eagle Creek. The operation procedures will be further refined during detailed design. The location of the low-level outlet is identified on Figure 6.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

EAGLE CREEK DRY-STORAGE BASIN - ALTERNATIVES

Stantec considered four (4) base layouts for the Eagle Creek dry-storage basin conceptual footprint. Three (3) optional variations ("B", "C", and "B & C") were considered for each of the four (4) base layout footprints, resulting in sixteen (16) unique footprints. In addition, two design discharge criteria were evaluated for each footprint resulting in 32 unique alternatives. Figure 9 shows the configuration of the four (4) base layouts and the potential, additional options. The individual concept layouts are included as Attachment A. Table 2 provides a summary of the footprint acreage and available storage capacity.

Table 2 – Eagle Creek Dry-Storage Basin Alternative Footprints Natural Storage Capacity

Alternative / Option	Footprint (Acres)	Storage Capacity without Additional Excavation (ac-ft)	Average Storage Depth without Excavation (ft)
1	827	5,590	6.8
2	765	5,020	6.6
3	669	4,600	6.9
4	572	3,350	5.9
B	65	1,250	19.2
C	41	430	10.4
BC	106	1,680	15.8

Base Layouts

The four (4) base layouts (Alternatives 1, 2, 3, and 4) have footprints such that the eastern embankment is aligned adjacent to the left descending (west) bank of Eagle Creek. Therefore, the configuration is referred to as the Western Alignment. Figure 9 shows that the basin embankment for each of the base layouts crosses Eagle Creek at the south (upstream) end of the dry-storage basin (near the intersection of Township Road 168 and US-68). This footprint avoids impact to two residential structures and two non-residential structures between US-68 and Eagle Creek to the north (downstream) of the embankment crossing location. The base layouts (Alternatives 1, 2, 3, and 4) vary in impact to property and structures. Of the four base layouts, Alternative 1 has the largest footprint (827 acres) and impacts the most structures (3), while Alternative 4 has the smallest footprint (572 acres) and impacts the fewest number of structures (2).

The configurations using the Western Alignment primarily function as an off-line storage basin, with some in-line storage in the backwater area, upstream of Country Road 45. During low, frequent flows in Eagle Creek, water would pass freely through the principal spillway structure in the Eagle Creek channel. Figure 6 shows the approximate area where the principal spillway would be located for the Western Alignment options. The principal spillway would be designed to back up water in Eagle Creek when flows are elevated during large, less frequent storm events. The water would back up until reaching the elevation of a weir constructed on the left descending (west) bank, upstream of the dam embankment. The weir would be a wide and level excavation in the terrain west of Eagle Creek to divert the flows through a graded channel beyond the weir into the basin to the north. After the storm event has passed, and the WSE has dropped to below the invert of the secondary spillway, the remainder of water stored in the basin would be drained through the low-level outlet to Eagle Creek. The components typical to each of the base layouts are called out on Figure 6.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

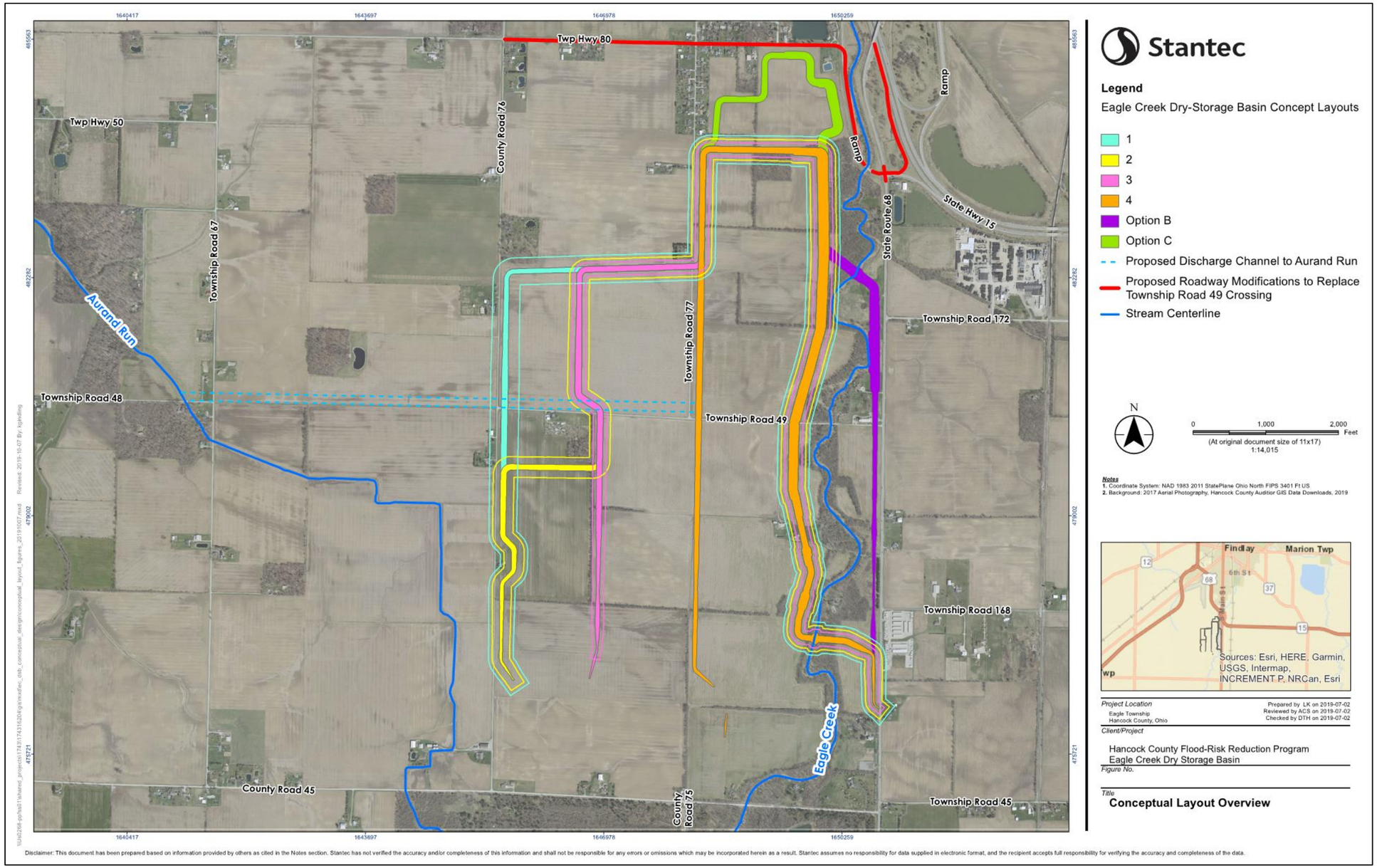

Figure 9 – Eagle Creek Dry-Storage Basin - Conceptual Layout Overview

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

Option B Variation

The Option B alignment is one variation to the base layouts. Rather than crossing Eagle Creek at the upstream end of the basin, the eastern embankment would continue north between Eagle Creek and US-68. The embankment would be aligned adjacent to the right descending (east) bank of Eagle Creek. Therefore, the configuration is referred to as the Eastern Alignment. Figure 9 shows that the Eastern Alignment of Option B crosses Eagle Creek at the northern end (downstream side) of the basin (near the intersection of Township Road 172 and US-68). This configuration is similar to the alignment of the recommended *Proof of Concept Update* alternative "EC-2C". The Option B footprint functions as an in-line storage basin with the principal spillway to Eagle Creek and a secondary spillway to Aurand Run.

Option B increases the storage footprint by approximately 65 acres and increases the storage capacity of the basin by approximately 1,250 acre-feet (22% to 37%).

Option C Variation

The Option C alignment is a second variation to the base layouts. This additional alignment extends the north end of the basin into an open space east of Township Road 77, south of Baseline Road / Township Road 80, and west of the State Route 15 off-ramp. Option C adds approximately 4,300 linear feet of embankment.

Option C increases the storage footprint by approximately 41 acres and increases the storage capacity of the basin by approximately 430 acre-feet (8% to 13%).

Option B & C Variation

The "BC" Option adds both Option B and Option C to the base layout. This variation adds about 106 acres to the basin footprint but provides an increased storage capacity of approximately 1,680 acre-feet (30% to 50%).

Eagle Creek Discharge Variation

Stantec considered two (2) dry-storage basin discharge values to Eagle Creek for each of the sixteen (16) footprints reviewed:

1. 500 cfs: This is the minimum discharge practicable to maintain the upstream project backwater effects and limit the basin footprint.

2. 1,100 cfs: This is the existing downstream channel capacity of Eagle Creek and threshold for overland flooding.

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

EAGLE CREEK DRY-STORAGE BASIN – STORAGE CAPACITY

Stantec used the existing HEC-HMS model developed and revised as part of the HCFRR Program (*Proof of Concept Update* (Stantec, 2018)) to perform analysis of the proposed conditions. Stantec preformed hydraulic modeling and reservoir routing in HEC-HMS to analyze the required storage capacity for the thirty-two (32) conceptual alternatives. The existing HEC-HMS basin model from the *Proof of Concept Update* was modified for each configuration. Initial stage-storage curves developed were input into the HEC-HMS model. The 1% Annual Chance Exceedance (ACE) (100-Year) storm event was then iteratively routed through the basin and spillway structures. The storage was incrementally increased until the design elevations were met. Additional excavation within the basin footprint was required to provide additional storage capacity for twenty-eight (28) of the thirty-two (32) concept alternatives.

Based on the geotechnical investigation and previous analyses, Stantec anticipates that a sufficient quantity of material to construct the dam embankment would be available within the impoundment. Therefore, Stantec assumed that each of the sixteen (16) basin footprints would use borrow material excavated within the footprint of the proposed storage basin to construct the dam embankment. The volume of material to be removed from the footprint for purpose of constructing the dam embankment was added as available storage capacity volume. Furthermore, each of the sixteen (16) alternatives for the 500 cfs discharge option requires additional excavation in order to provide storage for the 1% ACE storm event. Twelve (12) of the sixteen (16) alternative scenarios discharging 1,100 cfs into Eagle Creek also require additional excavation for storage of the 1% ACE storm event.

Stantec assumed a 4-Horizontal to 1-Vertical (4H:1V) excavation from existing grade to the interpolated top of rock surface, or to no deeper than EL. 788.0 feet, whichever was higher. Stantec assumed a 50-foot buffer from the interior toe of the embankment and from within the EL. 807.0 feet contour at the south end of the impoundment. The volume of material excavated was assumed to provide storage capacity at a 1 to 1 ratio. The required excavation quantity to achieve storage capacity for the 1% ACE storm event was attained above EL. 788.0 feet for all but five (5) of the thirty-two (32) basin scenarios. Table 3 provides a summary of the additional excavation volume required to achieve the storage capacity to contain the 1% ACE storm event.

The excavation exercise was continued below EL. 788.0 feet to confirm the possibility of removing the required quantity necessary for storage capacity for the remaining five (5) scenarios. Additional design considerations are needed for the five (5) scenarios where this deeper excavation would likely occur. Draining the Eagle Creek impoundment by gravity becomes difficult if excavation occurs below EL. 788.0 feet, due to the elevation of the Eagle Creek channel invert. Additionally, the geotechnical exploration data (more fully described in Attachment B) typically shows that groundwater was observed near this elevation as shown in Figure 4. For the five (5) configurations where excavation is required below EL. 788.0, a large pumping system would be required to remove the accumulated pool of groundwater within the dry-storage basin in anticipation of a large storm event.

Excavation would be required below the estimated top of bedrock for three (3) of the thirty-two (32) configurations with the smallest footprints and greatest additional storage need. Excavation into bedrock would likely be performed by a combination of ripping and blasting at higher unit costs than conventional excavation.

Finally, if excavation within the impoundment left less than three feet of cohesive soil in place, foundation treatment is recommended. Foundation treatment can be achieved by excavating a key into the bedrock and replacing the granular soils beneath the dam with cohesive soils, or by grout curtain. Due to the large volume of excavation for storage required for smaller footprints, thirteen (13) of the thirty-two (32) alternatives require foundation treatment.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

Table 3 provides a summary of basin features and challenges for each of the thirty-two (32) alternatives.

Table 3 – Eagle Creek Dry-Storage Basin Alternatives Summary

Alternative (Eagle Creek Discharge in cfs)	Features		Challenges			
	Dam Alignment Relative to Eagle Creek	Embankment Length (miles)	Additional Excavation Required for Storage (cy)	Requires Pre-Storm Pump-Down	Required Rock Excavation (cy ripping / blasting)	Requires Bedrock Key or Grout Curtain (full length of embankment)
1 (500)	Western	3.82	3,480,000			
2 (500)	Western	3.90	4,590,000			X
3 (500)	Western	3.63	5,300,000			X
4 (500)	Western	3.41	7,550,000	X	2,040,000	X
1B (500)	Eastern	3.71	1,370,000			
2B (500)	Eastern	3.79	2,490,000			
3B (500)	Eastern	3.52	3,300,000			
4B (500)	Eastern	3.30	5,630,000	X		X
1C (500)	Western	4.30	2,730,000			
2C (500)	Western	4.38	3,820,000			X
3C (500)	Western	4.11	4,540,000			X
4C (500)	Western	3.89	6,790,000	X	630,000	X
1BC (500)	Eastern	4.19	590,000			
2BC (500)	Eastern	4.27	1,700,000			
3BC (500)	Eastern	4.00	2,460,000			
4BC (500)	Eastern	3.78	4,810,000			X
1 (1,100)	Western	3.82	680,000			
2 (1,100)	Western	3.90	1,920,000			
3 (1,100)	Western	3.63	2,760,000			X
4 (1,100)	Western	3.41	5,270,000	X	240,000	X
1B (1,100)	Eastern	3.71				
2B (1,100)	Eastern	3.79	60,000			
3B (1,100)	Eastern	3.52	930,000			
4B (1,100)	Eastern	3.30	3,630,000			X
1C (1,100)	Western	4.30				
2C (1,100)	Western	4.38	1,060,000			
3C (1,100)	Western	4.11	1,980,000			
4C (1,100)	Western	3.89	4,430,000	X		X
1BC (1,100)	Eastern	4.19				
2BC (1,100)	Eastern	4.27				
3BC (1,100)	Eastern	4.00	100,000			
4BC (1,100)	Eastern	3.78	2,730,000			X

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

AURAND RUN CONCEPT REFINEMENT

Previously, Stantec assumed for the draft *Proof of Concept Update* Report that modifications could feasibly be made to Aurand Run to convey an additional 500 cfs of flow from the Eagle Creek dry-storage basin via a secondary spillway. Previous analyses assumed a certain price per linear foot of modification and that the modification would occur for an assumed distance. As part of this study, Stantec refined the concept and confirmed the feasibility of discharging flow from the Eagle Creek Dry-Storage Basin to Aurand Run. Figure 10 shows an overview of the study area. A memorandum to document the full analysis is included as Attachment F. The basic considerations and conclusions are presented below.

Stantec used the existing HEC-HMS and HEC-RAS models developed and revised as part of the HCFRR Program to perform an analysis of existing and proposed conditions within Aurand Run. Three (3) possible scenarios were analyzed for the Aurand Run concept refinement. Each of the three (3) Aurand Run scenarios consider the following:

- Up to 500 cfs is discharged to Aurand Run via the proposed Eagle Creek dry-storage basin secondary spillway assuming a 1% ACE storm event occurs concurrently in the Aurand Run watershed.

- Stantec used the “Typical Storm” developed as described in the *Hydrologic Evaluation of the Blanchard River* (Stantec, 2017) to test for the 1% ACE storm event;

- A discharge channel between the Eagle Creek dry-storage basin’s west embankment and Aurand Run, to a location just north (downstream) of Township Road 48 is sized to accept the 500 cfs; and

- New bridges will be required over this discharge channel where it intersects existing roads. New bridges will be required at Township Road 67 and County Road 76 for base layouts alternatives 1, 2, 3 and 4, and also at Township Road 77 for base layout alternative 4.

The three (3) scenarios considered as part of the Aurand Run concept refinement are:

1. Discharge the additional flow to Aurand Run without incorporating channel or structure modifications to increase capacity;

2. Modify Aurand Run with an increased trapezoidal channel geometry to accept the additional flow; and

3. Modify Aurand Run with a benched channel geometry to accept the additional flow.

All three scenarios presented above are likely feasible options for handling additional flow in Aurand Run from the secondary spillway of the Eagle Creek dry-storage basin; however, the options have varied costs and impacts to consider. The Aurand Run concept could likely be implemented with a combination of modified and unmodified channel sections. The modified sections would likely use the benched channel to reduce impacts to the existing stream habitat. Unmodified channel sections may require flowage easements where the 1% ACE floodplain extents increases compared to existing conditions. The lowest cost option, Scenario 3, Benched Channel, was incorporated into the Preliminary Opinion of Probable Construction Cost.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

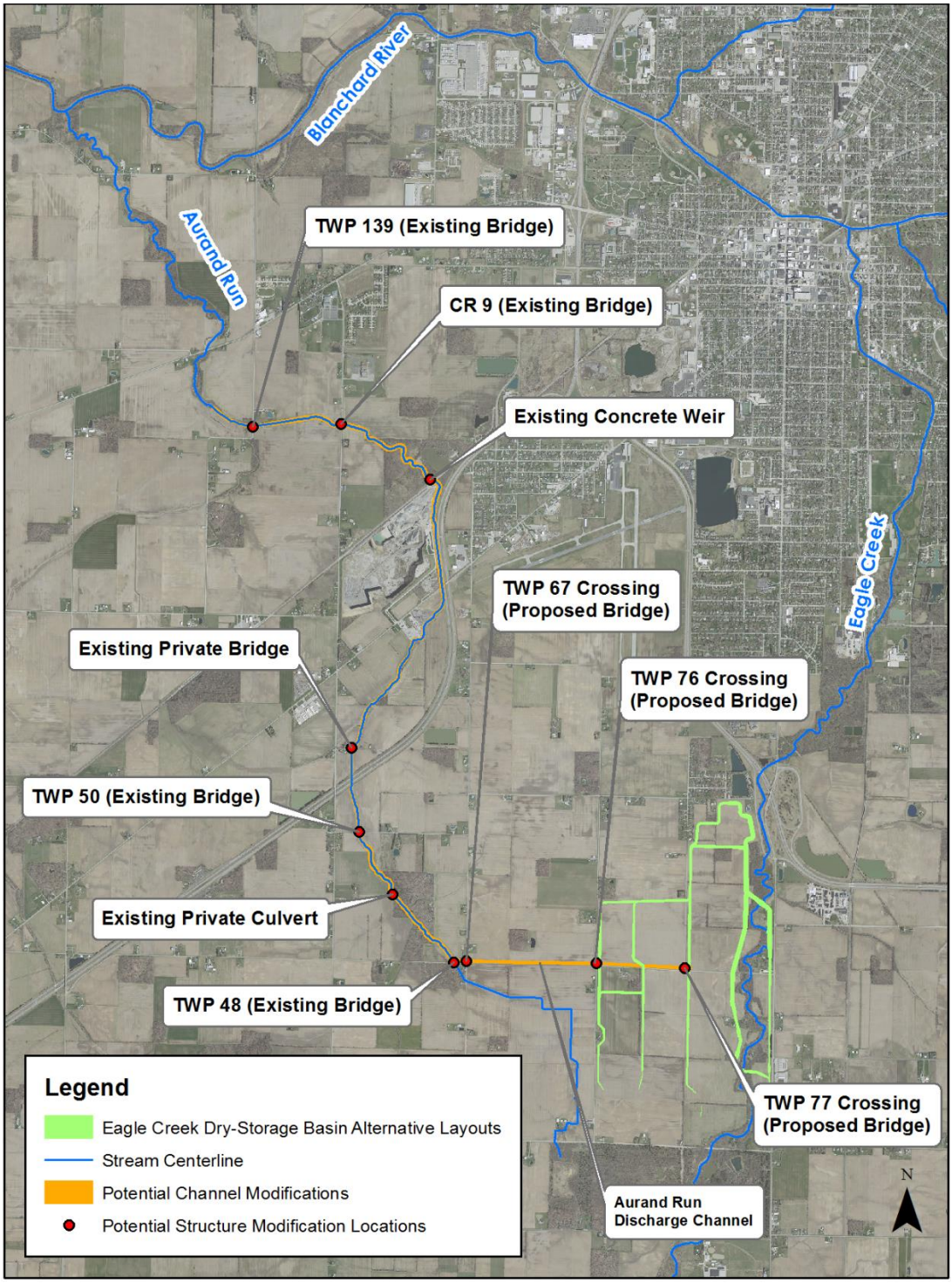

Figure 10 - Aurand Run Concept Refinement Overview

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST

Stantec developed preliminary opinions of probable construction costs (OPCCs) for the thirty-two (32) Eagle Creek dry-storage basin conceptual layout scenarios. These OPCCs were created based on expected quantities measured from the conceptual designs and assumed unit rates for the construction line items. Stantec developed the OPCCs consistent with a 30% planning level conceptual design, per the Association for the Advancement of Cost Engineering (AACE), Estimate Class 3. Unit costs for these items were derived using a combination of bid results from the Phase I Hydraulic Improvements project, RS Means Construction Cost Data, ODOT historical bid data, and Stantec experience.

BASIN EARTHWORK

Basin earthwork includes construction activities related to the mass grading of the dry-storage basin. The activities include dam embankment excavation and placement, stripping, stockpiling and placing topsoil, excavation and export from within the impoundment for storage, excavation into rock, and permanent seeding and mulching of disturbed areas. The cost of a pre-storm pump down system for the five (5) alternatives where it is applicable is also included in this cost category.

SEEPAGE MITIGATION

The seepage mitigation category was not included in previous OPCCs for the Proof of Concept or the Proof of Concept Update. Recent geotechnical exploration revealed the need for additional measures to control the flow of water under the proposed embankment. These recommended measures include a drainage blanket and trench for all alternatives, and foundation treatments for options requiring deeper excavation within the impoundment. The extents and quantities of drainage blanket and trench were determined based on guidance from the geotechnical report (Attachment B). Placement of filter sand in the blanket and trench is included in this cost category. A cutoff key excavated to rock is expected to be the more cost-effective method of foundation treatment when compared with a grout curtain, so the cutoff key was added to the cost where applicable. Excavation for seepage mitigation, in addition to what is already required for the typical embankment section, including some rock excavation, is also included in this cost category.

ROADS AND BRIDGE MODIFICATIONS

The roads and bridges category includes costs for the Township Road 49 relocation Conceptual Alternative 1 as described in the *Proof of Concept Update*. It also includes all structure modifications and new structures as required for the discharge channel to Aurand Run and existing structures along Aurand Run, more fully described in Attachment F. Stantec developed estimated quantities for the major cost drivers of each structure to estimate the costs of new bridges and bridge replacements on Aurand Run. Stantec then used the Ohio Department of Transportation's (ODOT's) Estimator software and history of bid tabulations to develop unit costs for each of the major cost drivers.

SPILLWAYS AND OUTLET STRUCTURES

Costs for the various components of the principal and secondary spillways and the low-level outlet were derived from other Stantec projects which are similar in function and size. The principal spillway at Eagle Creek was sized for both the 500 cfs and the 1,100 cfs options. The principal spillway cost was estimated based on costs for the intake structure, cost per linear foot of conduit, and cost per cubic yard of stilling basin concrete. The secondary spillway to Aurand Run was also sized. A secondary spillway cost was estimated

using similar components as the principal spillway. The low-level outlet components were estimated like the principal and secondary spillways, but with the addition of a gate structure.

Stantec refined the auxiliary spillway conceptual design and costs were updated since the *Proof of Concept Update*. The typical section shown in Figure 8 was used to compute total quantities of the RCC spillway based on the length of auxiliary spillway required for each alternative and the total length of the abutments. Earthwork quantities for embankment placement and seepage mitigation quantities for drainage blanket and trench were adjusted to account for the change from the standard dam section with drainage blanket to the RCC spillway.

AURAND RUN EARTHWORK

As described in the Aurand Run Concept Refinement section of this memorandum, Scenario 3, Benched Channel, was selected for inclusion in the OPCC. Quantities for earthwork and restoration were computed by using the average end area method after comparing existing and proposed channel cross sections.

CONSTRUCTION CONTINGENCY

A 25% contingency was included for the major construction components. The contingency is anticipated to cover unforeseen administrative and legal fees and obstacles or increased quantities that may arise during the detailed design and construction phase, such as minor utility relocations, site drainage, or other design considerations.

MOBILIZATION, DEMOBILIZATION, UTILITY RELOCATIONS, SITE PREPARATION AND DEMOLITION

This category includes mobilization, demobilization, construction staking and layout, site preparation and tree/debris removal, relocation or abandonment of existing utilities in the project footprint, traffic control, erosion and sediment controls, and other temporary construction needs. The assumed cost used for mobilization and demobilization was 5% of the cost of all other construction items. Many of the items covered under this cost category are assumed to be similar for all of the options and are minor in impact to total project cost.

Impacts to utilities for each of the alternatives under consideration are expected to be minor relative to the other project components. The survey of utilities did not identify significant water, electric, gas, or oil main crossings at the Project site. In general, utility relocation and modifications will include disconnection and removal or abandonment of private utilities and wells, modification of stormwater drainage features along the perimeter of the embankment, and relocation of a fiber optic line parallel to Township Road 49. The primary difference between the alternatives for utility relocations is the additional stormwater drainage modifications for Eastern Alignment options. Since utility modifications are anticipated to be minor, a moderate lump sum cost for modifications was added to the OPCC. A specific plan to address utilities will be developed during detailed design.

LANDS AND STRUCTURES

The lands and structures category cover costs associated with land fee-simple purchase, flowage easements, structure purchase, and demolition. Lands permanently impacted by project construction, including those in

the footprint of the storage basin and the benched Aurand Run channel, are assumed to be purchased. Land in the Project area currently under a purchase agreement with MWCD was included in the OPCC.

The backwater on Eagle Creek, generally upstream of Country Road 45, is assumed to be covered under a flowage easement at a lower cost per acre than the purchased land. The flowage easement is assumed to cover up to the peak WSE in the basin during the PMF (EL. 810.0 feet). Most of this backwater area upstream of the storage basin is in the existing floodplain. Quantities of land and structure impacts are listed in Table 2.

STREAM, WETLAND, FISH AND WILDLIFE, AND CULTURAL RESOURCES

Costs associated with cultural resources preservation, stream mitigation for Aurand Run and Eagle Creek, and wetland mitigation are included in this cost category. The wetland and waterbody delineation survey performed in 2019 (Attachment D) indicated that proposed construction activities will likely impact existing wetlands and streams. There may be an opportunity to perform on-site mitigation as part of the Project; however, for the purposes of the OPCC, in-lieu fee mitigation rates were assumed. Stantec estimated quantities of impacted natural features which may require mitigation based on the configurations assumed at this time. Based on previous experience with similar projects, determination of impacts and mitigation methods can be difficult to foresee in early stages of design and prior to coordination with governing agencies. Additional quantities of impact were included to account for these uncertainties.

ENGINEERING, DESIGN, AND PERMITTING

This category includes cost considerations for permitting and other professional services necessary to design the project. The cost for professional services such as design, survey, and other permitting coordination is assumed to be 15% of the total construction cost.

CONSTRUCTION PHASE SERVICES

Engineering and inspection services during construction are assumed to be 7% of the total construction cost. These services include monitoring and inspection, project and construction administration, and reviewing submittals and requests for information.

OPCC SUMMARY

Table 4 presents a summary of the OPCCs for the thirty-two (32) scenarios associated with the four (4) base layouts. As mentioned above, a 25% contingency was included for the major construction components. Additionally, cost accuracy ranges in accordance with the AACE Class 3 cost estimate guidelines are included in the cost summary table. An accuracy range of -20% to +30% was assumed for this project's level of conceptual design.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

Table 4 – Eagle Creek Dry-Storage Basin (500 cfs) - Opinion of Probable Construction Costs

Description	Alternative															
Construction Costs	**1 (500)**	**2 (500)**	**3 (500)**	**4 (500)**	**1B (500)**	**2B (500)**	**3B (500)**	**4B (500)**	**1C (500)**	**2C (500)**	**3C (500)**	**4C (500)**	**1BC (500)**	**2BC (500)**	**3BC (500)**	**4BC (500)**
Basin Earthwork	$40,400,000	$45,600,000	$50,700,000	$218,700,000	$22,200,000	$31,400,000	$37,000,000	$72,600,000	$36,300,000	$40,900,000	$46,000,000	$144,100,000	$17,800,000	$27,000,000	$32,200,000	$46,500,000
Seepage Mitigation	$3,400,000	$20,200,000	$18,700,000	$17,800,000	$2,200,000	$2,600,000	$2,300,000	$16,200,000	$4,300,000	$23,100,000	$21,600,000	$20,700,000	$3,100,000	$3,500,000	$3,200,000	$19,100,000
Road and Bridge Modifications	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000
Spillways and Outlet Structures	$7,900,000	$7,900,000	$7,000,000	$7,900,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000	$7,900,000	$7,900,000	$7,900,000	$7,900,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Aurand Run Earthwork	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000
CONSTRUCTION SUBTOTAL	**$57,600,000**	**$80,100,000**	**$82,800,000**	**$251,200,000**	**$37,300,000**	**$47,400,000**	**$52,700,000**	**$102,600,000**	**$54,400,000**	**$78,300,000**	**$81,900,000**	**$179,500,000**	**$33,800,000**	**$43,900,000**	**$48,800,000**	**$79,400,000**
Construction Contingency (25%)	$14,400,000	$20,025,000	$20,700,000	$62,800,000	$9,325,000	$11,850,000	$13,175,000	$25,650,000	$13,600,000	$19,575,000	$20,475,000	$44,875,000	$8,450,000	$10,975,000	$12,200,000	$19,850,000
Mob/Demobilization, Utilities and Site Prep.	$4,513,000	$5,632,000	$5,771,000	$10,948,000	$3,758,000	$4,263,000	$4,529,000	$5,969,000	$4,352,000	$5,542,000	$5,727,000	$7,903,000	$3,586,000	$4,088,000	$4,331,000	$5,857,000
CONSTRUCTION TOTAL	**$76,513,000**	**$105,757,000**	**$109,271,000**	**$324,948,000**	**$50,383,000**	**$63,513,000**	**$70,404,000**	**$134,219,000**	**$72,352,000**	**$103,417,000**	**$108,102,000**	**$232,278,000**	**$45,836,000**	**$58,963,000**	**$65,331,000**	**$105,107,000**
Other Costs	**1 (500)**	**2 (500)**	**3 (500)**	**4 (500)**	**1B (500)**	**2B (500)**	**3B (500)**	**4B (500)**	**1C (500)**	**2C (500)**	**3C (500)**	**4C (500)**	**1BC (500)**	**2BC (500)**	**3BC (500)**	**4BC (500)**
Lands and Structures	$25,000,000	$23,000,000	$20,400,000	$17,700,000	$27,300,000	$25,400,000	$22,800,000	$20,000,000	$26,100,000	$24,100,000	$21,600,000	$18,900,000	$28,500,000	$26,500,000	$23,900,000	$21,100,000
Stream, Wetland, Fish and Wildlife, and Cultural Resources	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,800,000	$1,800,000	$1,800,000	$1,800,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,800,000	$1,800,000	$1,800,000	$1,800,000
Engineering, Design, and Permitting	$9,600,000	$13,100,000	$13,500,000	$39,600,000	$6,500,000	$8,100,000	$8,900,000	$16,600,000	$9,100,000	$12,800,000	$13,400,000	$28,300,000	$5,900,000	$7,500,000	$8,300,000	$13,100,000
Construction Phase Services	$4,500,000	$6,200,000	$6,400,000	$18,500,000	$3,100,000	$3,800,000	$4,200,000	$7,800,000	$4,300,000	$6,000,000	$6,300,000	$13,300,000	$2,800,000	$3,600,000	$3,900,000	$6,200,000
OTHER SUBTOTAL	**$40,500,000**	**$43,700,000**	**$41,700,000**	**$77,200,000**	**$38,700,000**	**$39,100,000**	**$37,700,000**	**$46,200,000**	**$40,900,000**	**$44,300,000**	**$42,700,000**	**$61,900,000**	**$39,000,000**	**$39,400,000**	**$37,900,000**	**$42,200,000**
TOTAL PROJECT COSTS	**$117,013,000**	**$149,457,000**	**$150,971,000**	**$402,148,000**	**$89,083,000**	**$102,613,000**	**$108,104,000**	**$180,419,000**	**$113,252,000**	**$147,717,000**	**$150,802,000**	**$294,178,000**	**$84,836,000**	**$98,363,000**	**$103,231,000**	**$147,307,000**
Total Cost AACE Class 3 Accuracy Range																
-20%	$93,610,000	$119,570,000	$120,780,000	$321,720,000	$71,270,000	$82,090,000	$86,480,000	$144,340,000	$90,600,000	$118,170,000	$120,640,000	$235,340,000	$67,870,000	$78,690,000	$82,580,000	$117,850,000
+30%	$152,120,000	$194,290,000	$196,260,000	$522,790,000	$115,810,000	$133,400,000	$140,540,000	$234,540,000	$147,230,000	$192,030,000	$196,040,000	$382,430,000	$110,290,000	$127,870,000	$134,200,000	$191,500,000

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

Table 5 – Eagle Creek Dry-Storage Basin (1,100 cfs) - Opinion of Probable Construction Costs

Description	Alternative															
Construction Costs	**1 (1,100)**	**2 (1,100)**	**3 (1,100)**	**4 (1,100)**	**1B (1,100)**	**2B (1,100)**	**3B (1,100)**	**4B (1,100)**	**1C (1,100)**	**2C (1,100)**	**3C (1,100)**	**4C (1,100)**	**1BC (1,100)**	**2BC (1,100)**	**3BC (1,100)**	**4BC (1,100)**
Basin Earthwork	$18,000,000	$28,300,000	$30,400,000	$93,500,000	$11,300,000	$12,000,000	$18,000,000	$35,600,000	$14,500,000	$23,300,000	$29,700,000	$61,500,000	$13,200,000	$13,500,000	$13,300,000	$29,800,000
Seepage Mitigation	$3,500,000	$3,800,000	$18,700,000	$17,800,000	$2,400,000	$2,600,000	$2,300,000	$16,200,000	$4,300,000	$4,700,000	$4,400,000	$20,700,000	$3,300,000	$3,600,000	$3,200,000	$19,100,000
Road and Bridge Modifications	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000	$3,900,000	$4,300,000	$4,300,000	$4,600,000
Spillways and Outlet Structures	$7,900,000	$7,900,000	$7,000,000	$7,900,000	$5,700,000	$7,000,000	$7,000,000	$7,000,000	$7,900,000	$7,900,000	$7,900,000	$7,900,000	$5,300,000	$6,100,000	$7,000,000	$7,000,000
Aurand Run Earthwork	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000	$2,000,000	$2,100,000	$2,100,000	$2,200,000
CONSTRUCTION SUBTOTAL	$35,300,000	$46,400,000	$62,500,000	$126,000,000	$25,300,000	$28,000,000	$33,700,000	$65,600,000	$32,600,000	$42,300,000	$48,400,000	$96,900,000	$27,700,000	$29,600,000	$29,900,000	$62,700,000
Construction Contingency (25%)	$8,825,000	$11,600,000	$15,625,000	$31,500,000	$6,325,000	$7,000,000	$8,425,000	$16,400,000	$8,150,000	$10,575,000	$12,100,000	$24,225,000	$6,925,000	$7,400,000	$7,475,000	$15,675,000
Mob/Demobilization, Utilities and Site Prep.	$3,392,000	$3,949,000	$4,755,000	$6,249,000	$3,155,000	$3,292,000	$3,580,000	$5,167,000	$3,262,000	$3,744,000	$4,050,000	$5,634,000	$3,278,000	$3,369,000	$3,389,000	$5,025,000
CONSTRUCTION TOTAL	$47,517,000	$61,949,000	$82,880,000	$163,749,000	$34,780,000	$38,292,000	$45,705,000	$87,167,000	$44,012,000	$56,619,000	$64,550,000	$126,759,000	$37,903,000	$40,369,000	$40,764,000	$83,400,000
Other Costs	**1 (1,100)**	**2 (1,100)**	**3 (1,100)**	**4 (1,100)**	**1B (1,100)**	**2B (1,100)**	**3B (1,100)**	**4B (1,100)**	**1C (1,100)**	**2C (1,100)**	**3C (1,100)**	**4C (1,100)**	**1BC (1,100)**	**2BC (1,100)**	**3BC (1,100)**	**4BC (1,100)**
Lands and Structures	$25,000,000	$23,000,000	$20,400,000	$17,700,000	$27,300,000	$25,400,000	$22,800,000	$20,000,000	$26,100,000	$24,100,000	$21,600,000	$18,900,000	$28,500,000	$26,500,000	$23,900,000	$21,100,000
Stream, Wetland, Fish and Wildlife, and Cultural Resources	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,800,000	$1,800,000	$1,800,000	$1,800,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,800,000	$1,800,000	$1,800,000	$1,800,000
Engineering, Design, and Permitting	$6,000,000	$7,800,000	$10,300,000	$20,100,000	$4,600,000	$5,000,000	$5,900,000	$10,900,000	$5,600,000	$7,100,000	$8,100,000	$15,600,000	$5,000,000	$5,200,000	$5,300,000	$10,500,000
Construction Phase Services	$2,900,000	$3,700,000	$4,900,000	$9,400,000	$2,200,000	$2,400,000	$2,800,000	$5,100,000	$2,700,000	$3,400,000	$3,800,000	$7,300,000	$2,400,000	$2,500,000	$2,500,000	$4,900,000
OTHER SUBTOTAL	$35,300,000	$35,900,000	$37,000,000	$48,600,000	$35,900,000	$34,600,000	$33,300,000	$37,800,000	$35,800,000	$36,000,000	$34,900,000	$43,200,000	$37,700,000	$36,000,000	$33,500,000	$38,300,000
TOTAL PROJECT COSTS	**$82,817,000**	**$97,849,000**	**$119,880,000**	**$212,349,000**	**$70,680,000**	**$72,892,000**	**$79,005,000**	**$124,967,000**	**$79,812,000**	**$92,619,000**	**$99,450,000**	**$169,959,000**	**$75,603,000**	**$76,369,000**	**$74,264,000**	**$121,700,000**
Total Cost AACE Class 3 Accuracy Range																
-20%	$66,250,000	$78,280,000	$95,900,000	$169,880,000	$56,540,000	$58,310,000	$63,200,000	$99,970,000	$63,850,000	$74,100,000	$79,560,000	$135,970,000	$60,480,000	$61,100,000	$59,410,000	$97,360,000
+30%	$107,660,000	$127,200,000	$155,840,000	$276,050,000	$91,880,000	$94,760,000	$102,710,000	$162,460,000	$103,760,000	$120,400,000	$129,290,000	$220,950,000	$98,280,000	$99,280,000	$96,540,000	$158,210,000

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

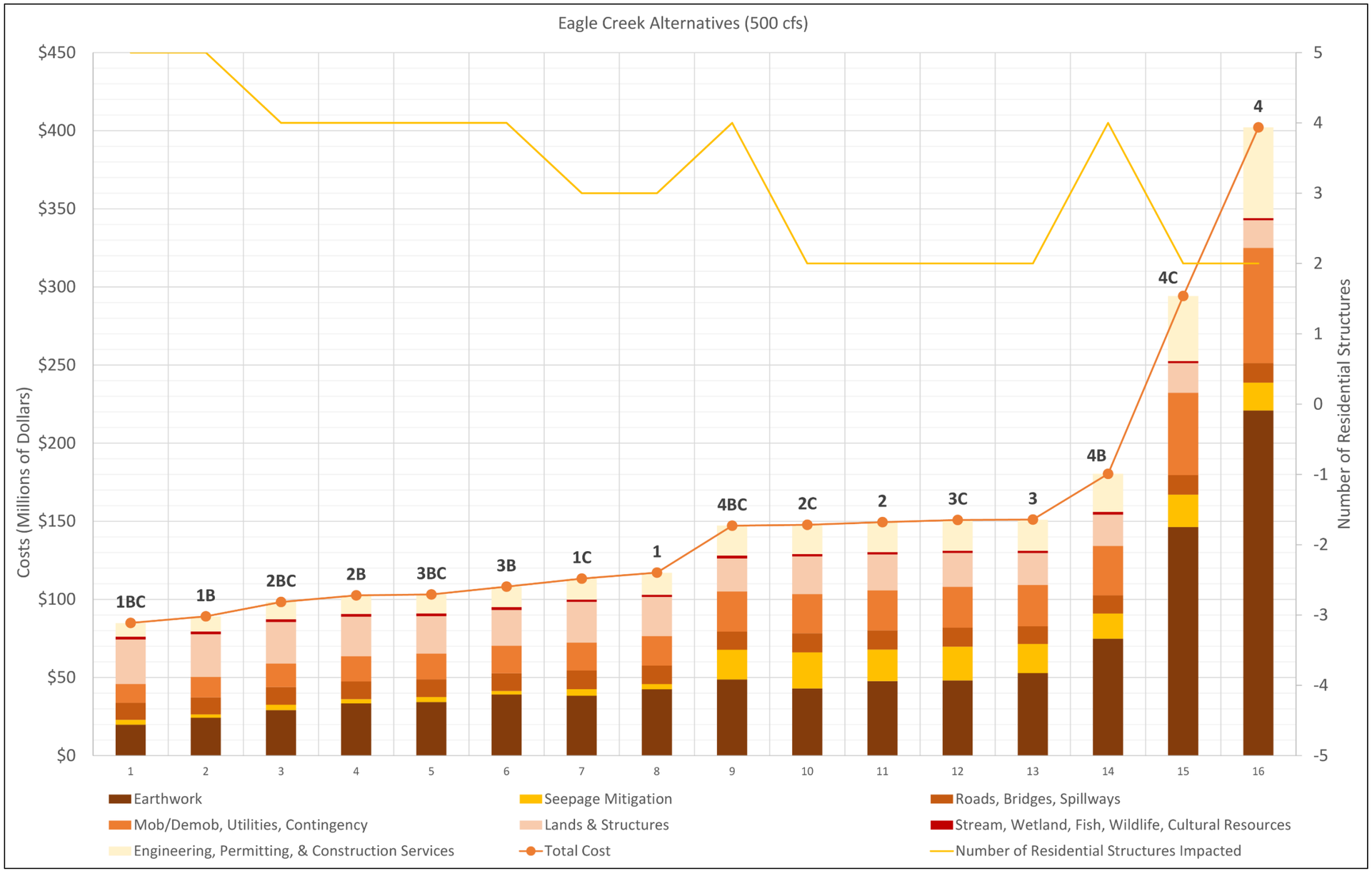

Figure 11 – Cost Curve and Number of Residential Structures Impacted for the 500 cfs Alternatives

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

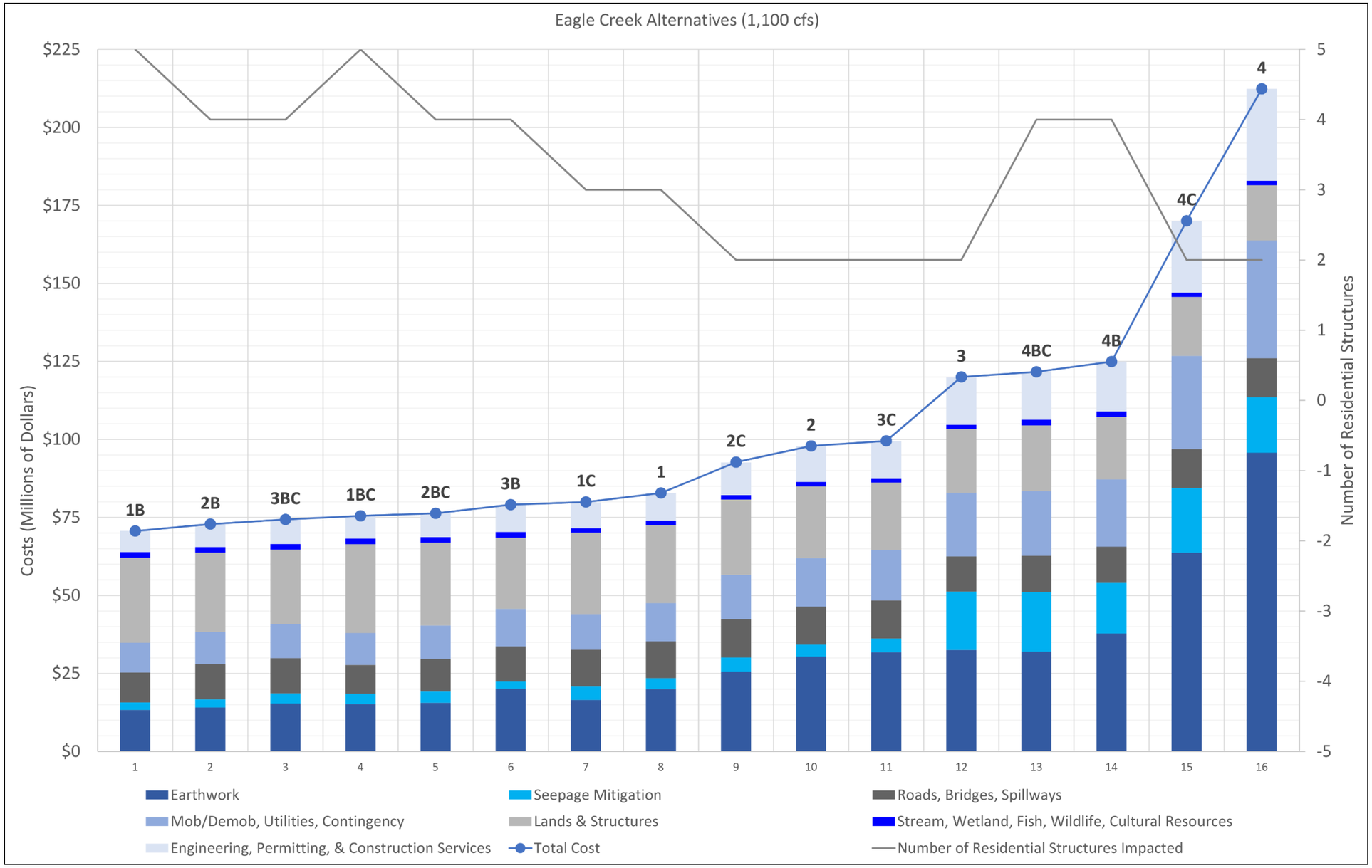

Figure 12 – Cost Curve and Number of Residential Structures Impacted for the 1,100 cfs Alternatives

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

EVALUATION OF ALTERNATIVES

This memorandum provides updated costs and additional information for a range of potential alternatives. Key differentiators are discussed below.

EAGLE CREEK DISCHARGE – 500 CFS VERSUS 1,100 CFS

In general, there is a greater reduction in flood risk for the community when discharging 500 cfs out of the Eagle Creek spillway compared to 1,100 cfs. However, discharging only 500 cfs through the principal spillway requires the footprint of the storage facility to increase and/or the cost to increase due to land impacts and the size of the auxiliary spillway required. The optimal discharge rate to balance flood risk reduction, cost, and impacts is likely between 500 cfs and 1,100 cfs. Further analysis of the outlet flow rate would occur if detailed design is advanced.

Three (3) components of the dry-storage basin vary between the 500 cfs and 1,100 cfs scenarios:

1. The volume of earth that must be excavated for flood storage is higher for the 500 cfs scenario compared to the 1,110 cfs scenario to achieve the same storage capacity;

2. The size and shape of the principal spillway in Eagle Creek increases for the 1,100 cfs scenario; and

3. The length of the auxiliary spillway varies based on available storage capacity.

A comparison of estimated impacts and benefits to land and parcels is presented in Table 6. The costs and impacts vary between each of the 32 options considered, but only one alternative for each rate of discharge (500 cfs and 1,100 cfs) was included for the purpose of comparison. The flood protection benefits for all sixteen (16) 500 cfs alternatives are the same; likewise, flood protection benefits for all sixteen (16) 1,100 cfs alternatives are the same. As shown in the table below, the estimated acres and parcels removed from the floodplain and WSE reduction at Main Street is greater for the 500 cfs alternatives than for the 1,100 cfs alternatives. However, impacts of land impacted by construction, impacts to parcels, and impacts to residential structures is greater for 500 cfs alternatives than for 1,100 cfs alternatives for similar ranges of cost.

Figure 13, Figure 14, and Figure 15 show floodplain results along Eagle Creek and in downtown Findlay based on the two discharge options.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

Table 6 – Alternatives Benefit / Impact Summary

Alternative	Total Acres Directly Impacted by Project Construction[4.]	Residential Structures Impacted	Estimated Acres Impacted Outside of Existing Regulatory Floodplain[4.]	Acres Removed from Floodplain[1.]	Estimated Agricultural Acres Directly Impacted by Project Construction[2., 5.]		Estimated Agricultural Acres Removed from Floodplain[1., 2., 4.]	Estimated Number of Parcels Directly Impacted by Project Construction.	Estimated Number of Parcels Removed from Floodplain	WSE at Main Street (XS 295930) (Feet)	WSE Reduction at Main Street Compared to Existing Conditions (Feet)	Opinion of Probable Construction Cost (for Eagle Creek Dry-Storage only)
					Within Floodplain	Outside of Floodplain						
Existing Conditions										777.2	--	
Phase I Hydraulic Improvements										776.4	0.8	
Hyd. Impr. + Eagle Creek Dry Storage Basin 1BC (500 cfs)	1,160	5	745	2,541	204	633	965	85	2,174	774.7	2.5	$ 84,836,000
Hyd. Impr. + Eagle Creek Dry Storage Basin 3BC (1,100 cfs)	1,002	4	587	2,329	204	481	881	79	2,076	774.9	2.3	$ 74,264,000

1. Existing floodplain acreage within the areas impacted by construction is included.
2. Agricultural acres include cultivated crop and hay/pasture categories within the National Land Cover Dataset
3. Hydraulic Improvements include removal of four inline dam/riffle structures, floodplain bench widening between Broad Avenue and the Norfolk Southern Railroad bridge.
4. Acres impacted by project construction includes acreage of private land purchased and flowage easements at the Hydraulic Improvements site on the Blanchard, at Eagle Creek Dry-Storage Basin including the backwater in Eagle Creek, and along Aurand Run where benching is proposed.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

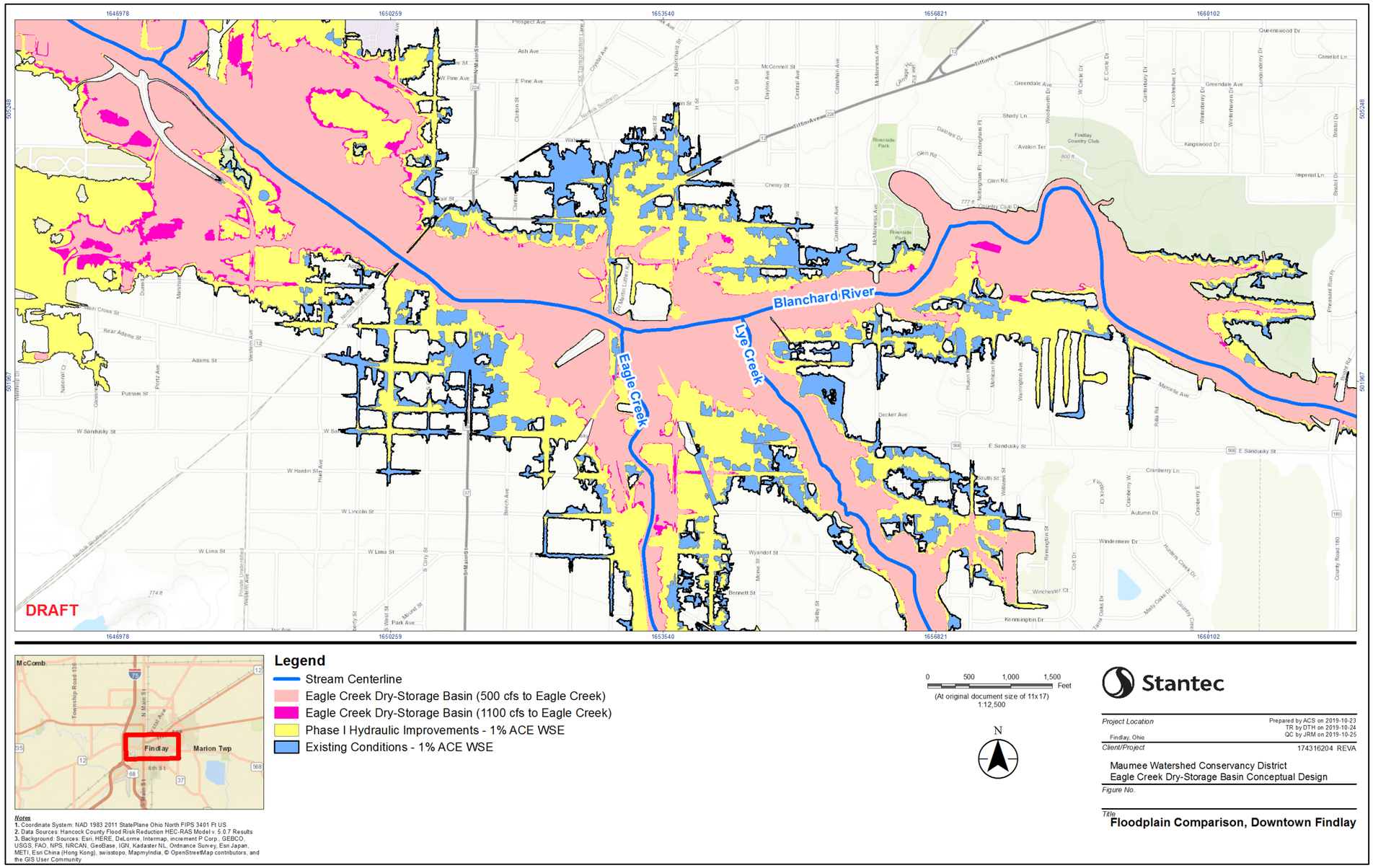

Figure 13 – Floodplain Comparison, Downtown Findlay

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

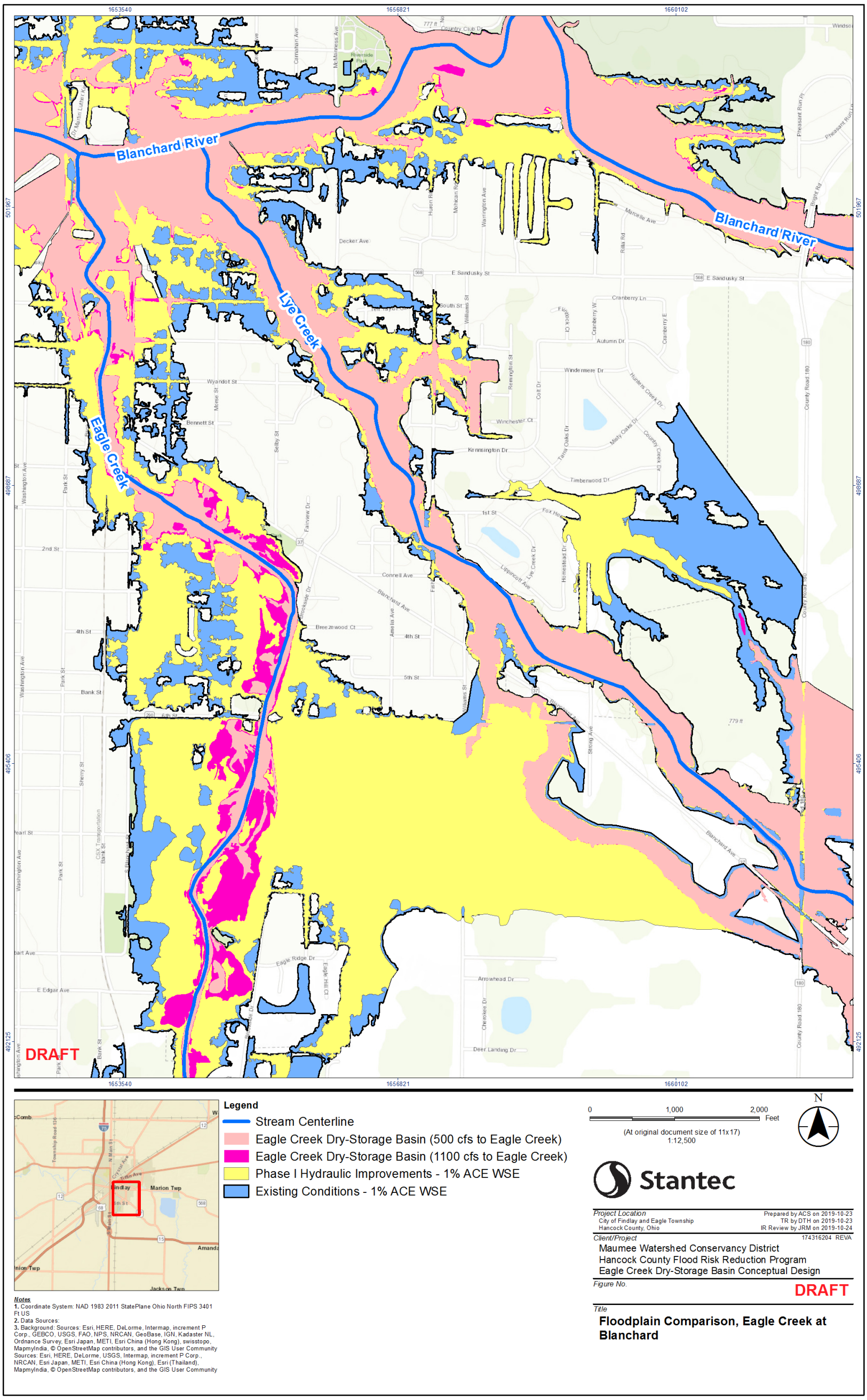

Figure 14 – Floodplain Comparison, Eagle Creek at Blanchard

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

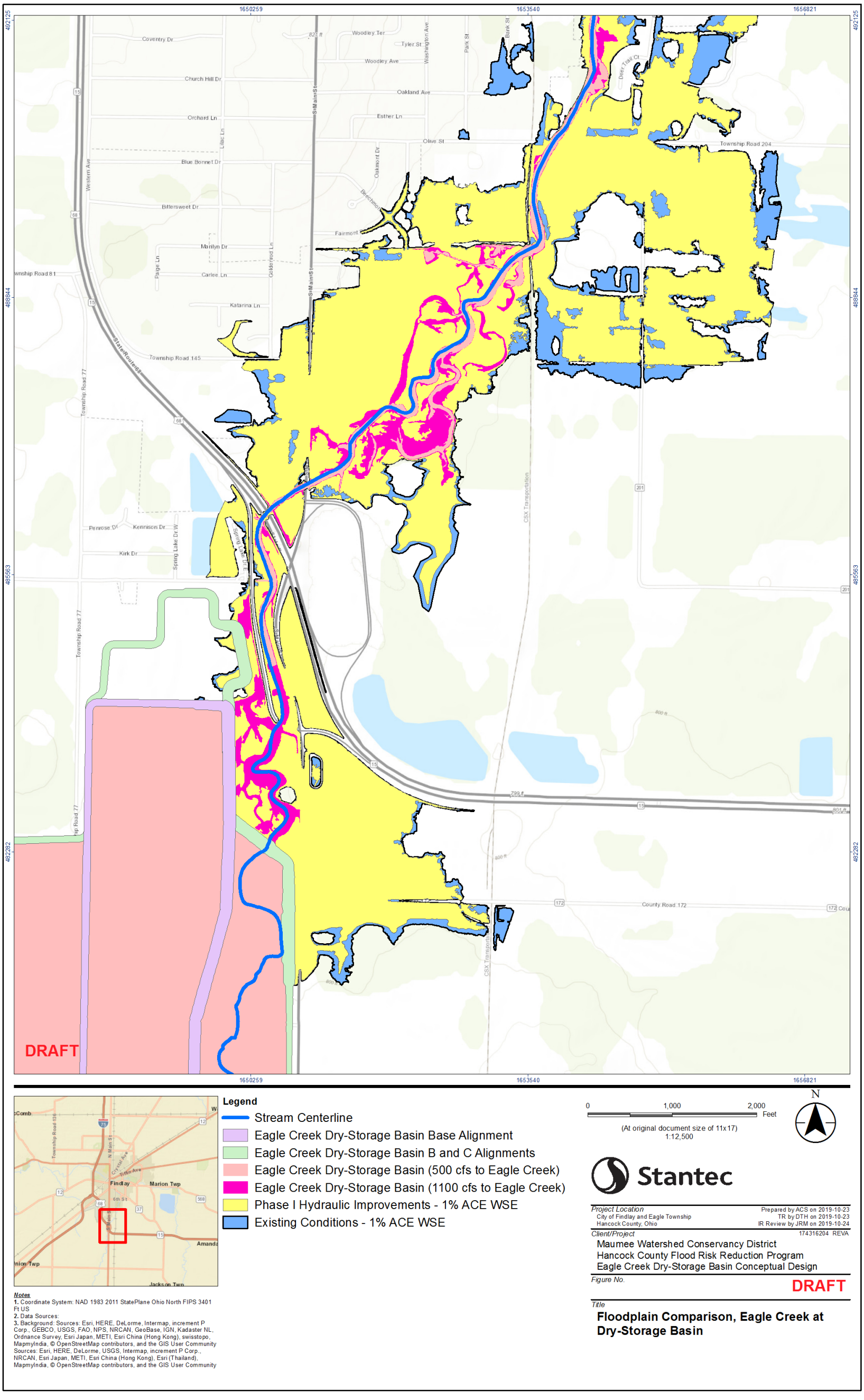

Figure 15 - Floodplain Comparison, Eagle Creek at Dry-Storage Basin

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

EASTERN EMBANKMENT ALIGNMENT

The following paragraphs discuss the differences between the Western Alignment and the Eastern Alignment and their associated risks and benefits.

Cost

Based on the OPCC, alternatives using the Western Alignment are approximately 30% more expensive than their Eastern Alignment counterparts. The major cost drivers of the Western Alignment are the need for excavated storage, seepage mitigation, and the low-level outlet structure. The area added by the Eastern Alignment is low-lying and provides 1,249 acre-feet of efficient (volume per area) water storage. For Western Alignments, this volume of storage must be obtained by expanding the basin laterally or by excavating at significant expense. In some cases, the additional excavation triggers the need for additional seepage mitigation which also raises the cost, as discussed in other sections.

The cost of utility relocations would likely be higher for the Eastern Alignment than for the Western Alignment. Some areas east of US-68 currently drain toward Eagle Creek through culverts under US-68. A drainage ditch will be required between US-68 and the embankment, and other modifications to the existing storm drains and other utilities along US-68 would be necessary.

Lands and Structures

The Eastern Alignment requires purchase of 65 more acres of land and impacts two residential structures and two non-residential structures, as compared to the Western Alignment. However, to make up the difference in storage that the Eastern Alignment would provide, additional land is needed for the Western Alignments to achieve similar costs. For example, the closest alternative to 3B (1,100 cfs) in cost is 1C (1,100 cfs), and 1C requires 134 more acres of land than 3B and impacts only one less residential structure.

Seepage Mitigation

Less foundation improvement, including excavation, treatment, and grouting of underlying bedrock will be required for the larger footprints that do not require excavations from within the reservoir. Typically, the Western Alignment requires more excavation to attain necessary storage capacity than the Eastern Alignment concepts. For Western alignments, 9 of the 16 alternatives require a cutoff key or grout curtain along the length of the embankment, while only 3 of the 16 Eastern alignments alternatives require these foundation treatments.

The geotechnical report also noted that bedrock appeared to be more fractured in the borings to the south and less fractured in those to the north. The Eastern Alignment crosses Eagle Creek in the north end where bedrock was found to be less fractured, so that crossing location would likely require less foundation treatment than the Western Alignment crossing to the south.

Streams and Wetlands

Potential wetlands were delineated near where the Eastern Alignment embankment crosses Eagle Creek. No wetlands were delineated as part of the wetlands and waterbodies reconnaissance within the proposed footprint of the Western Alignment.

The existing Eagle Creek channel is in close proximity to US-68 between TR-49 and TR-172. If the Eastern Alignment is constructed, Eagle Creek would likely need to be realigned to facilitate construction of the embankment. Realignment of the creek is expected to require stream mitigation. Both the Eastern and Western Alignments will impact the Eagle Creek channel at the point of crossing.

Operation

For the Western Alignment, a weir excavation is required at the south end of the basin near the primary spillway. Water would flow over this weir and to the north through an excavated channel to the low point in the basin. While excavation will be required within the basin for every alternative for borrow material and for storage, the best material for dam construction may or may not coincide with the desired channel location, leading to additional unforeseen excavation costs. Consideration should be given to potential scour in the excavated channel. The Eastern Alignment primary spillway functions as an inline structure, and no weir is required to allow the basin to fill in a controlled manner.

For the Western Alignment, a gated low-level outlet structure is required. The low-level outlet would remain open during low-flow, typical conditions so that the basin remains dry. The gate would be closed during operation in order to limit flows to Eagle Creek as designed. When severe weather is forecast, an operator would need to manually close the gate, and then open the gate when flows in Eagle Creek drop to low enough levels. Alternatively, an automatic gate operator could open or close the gate based on water level sensors installed at Eagle Creek. For the Eastern Alignment, the basin would be fully drained through the primary and secondary spillways, and no operation of gates would be necessary.

EAGLE CREEK STORAGE OPTION C VARIATION

The Option C variation expands the basin embankment into the fields north of the base layout. Expanding to the north adds storage capacity to the basin, but also increases the embankment length. For many alternatives, the addition of Option C adds storage to the basin and reduces the amount of excavation required for storage. For two alternatives, 1B (1,100 cfs) and 2B (1,100 cfs), excavation for storage is not required. Adding Option C for these alternatives increases the cost and the amount of land required but is not necessary to meet project criteria.

Option C appears to be a lower cost alternative to excavated storage, but the cost of such a long embankment is also high and limits the cost-effectiveness of this option. If the decision is made to advance an alternative that includes Option C, the alignment of C will likely be shortened and simplified during detailed design to provide storage at a lower embankment cost.

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

CONCLUSIONS AND RECOMMENDATIONS

The study results indicate that the each of the 32 options would provide a level of flood risk reduction for the downstream communities along Eagle Creek, Lye Creek, and the Blanchard River. The degree of WSE reduction is dependent on the rate of discharge released from the Eagle Creek basin. The Eagle Creek dry-storage basin is expected to provide the following benefits:

- Reduced flooding over Main Street at the Blanchard River between Center Street and Sandusky Street;
- Reduced flooding through large stretches of residential areas along the Blanchard River and Eagle Creek;
- Reduced flooding near the Hunter's Creek Subdivision and County Fairgrounds along Lye Creek; and
- Reduced flooding for major intersections and business in downtown Findlay including reduced closure of the Dr. Martin Luther King Parkway.

The costs of Eastern and Western alignments for 500 cfs alternatives and 1,100 cfs alternatives are plotted on Figure 16. Construction costs vary significantly based on the selected embankment alignment and downstream discharge criteria. The following trends are noted:

- Construction costs are generally lower for alternatives that utilize a larger reservoir area. This trend is more pronounced when comparing the Western and Eastern alignments.
- Alternatives that incorporate excavation are more expensive than similar options without excavation.
- The added flood benefits (decreased downstream discharge) derived from storage excavation do not likely warrant the additional costs.
- The cost to increase the reservoir footprint to reduce discharge downstream are likely similar to implementing the Aurand Run secondary spillway.

Stantec understands that the MWCD is currently exploring options for acquisition of property for construction and operation of the Eagle Creek Dry-storage Basin. Based on the studies and analyses performed to date, we recommend the following:

- Construct the eastern embankment to the East of Eagle Creek. This is the most cost-efficient option and is anticipated to present fewer dam safety design and operations concerns.
- Implement the largest reservoir footprint feasible.
- Design the principal spillway and downstream flood discharge protection for the acquired project footprint without excavation for additional storage.
- Evaluate the benefits of the Aurand Run secondary spillway in comparison to the achieved principal spillway discharge and other potential flood protection measures downstream.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

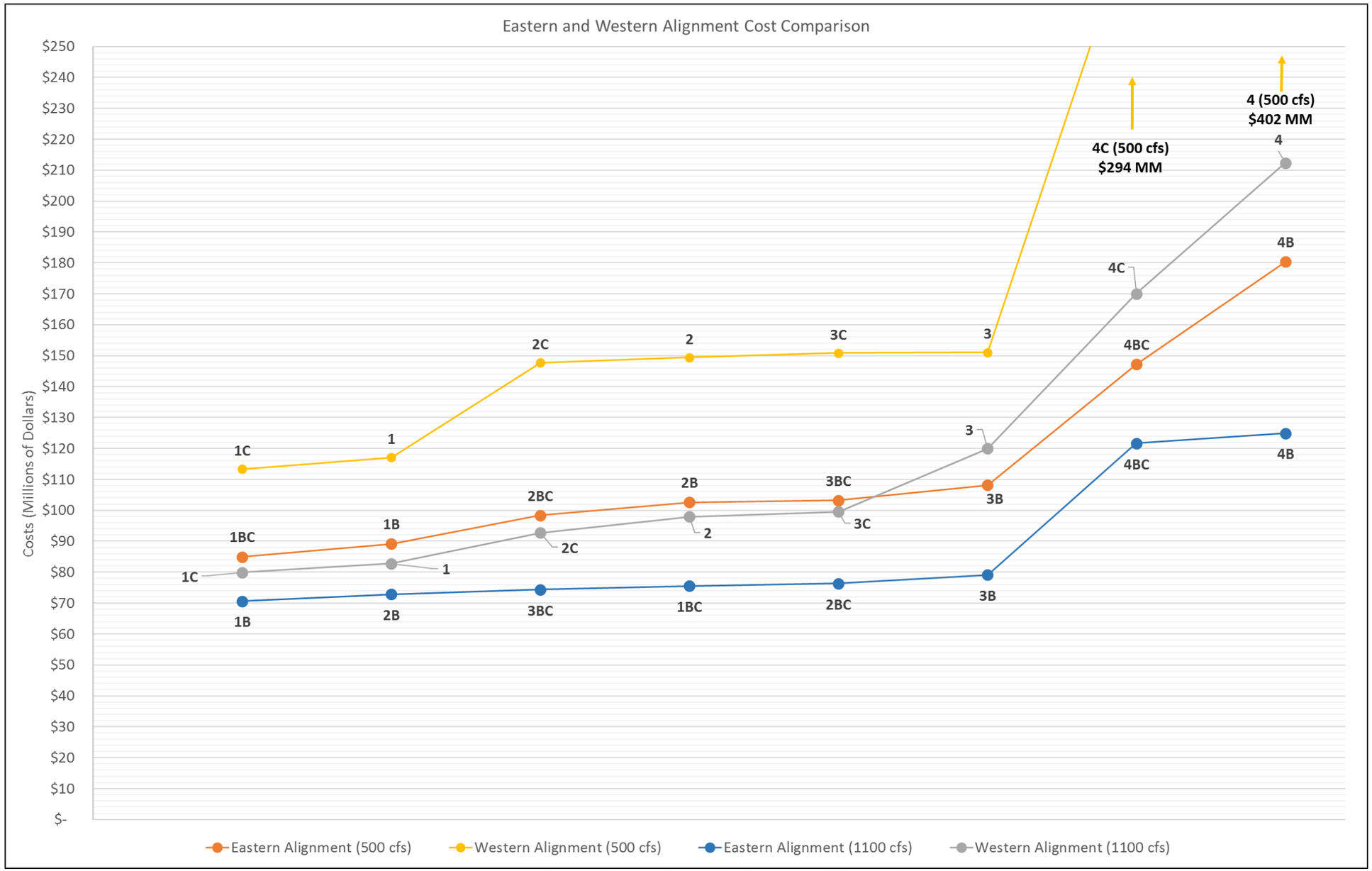

Figure 16 – Cost Curves for Eastern and Western Alignments

Reference: Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review

NEXT STEPS

The Stantec team understands that conversations have taken place with stakeholders in the vicinity of the proposed Eagle Creek Dry-Storage Basin. The analyses described in this memorandum were intended to clarify and advance the conceptual design of the Eagle Creek Dry-Storage Basin to a refined conceptual layout, while taking into consideration feedback from the stakeholders.

The costs and benefits associated with the conceptual designs presented within this memorandum are provided for planning purposes only. The planning level costs presented in this memorandum are provided for comparative purposes and should not be used for capital planning. Additional work in advancing the concept alternatives to Stage 1 plans (30% design) may include additional site survey, geotechnical exploration specific to the selected footprint, and detailed design that could better refine the planning level costs.

Stantec also recommends updating of the benefit-cost ratio of the Hancock County Flood Risk Reduction Program using the 30% design dry-storage basin on Eagle Creek. Other work that should be performed as the 30% design is advanced are cultural resources surveys and consultations, preparation of documents for Clean Water Act permitting through the U.S. Army Corps of Engineers and the Ohio Environmental Protection Agency, and preparation of 30% conceptual design level construction drawings.

Stantec understands there is a balance that must be achieved between benefit to the local community and the potential for adverse impacts associated with the cost and construction of improvements.

Reference: **Hancock County Flood Risk Reduction Program – Eagle Creek Dry-Storage Basin Project Alternatives Review**

Stantec recommends review of this memo by the Maumee Watershed Conservancy District and other key stakeholders like the City of Findlay, Hancock County, local residents, businesses, and the agricultural community among others. After review, stakeholders should select a Project footprint and basin discharge to proceed with design, permitting, and eventually construction.

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Attachment: Attachment A – Individual Conceptual Layout Figures

Attachment B – Report of Preliminary Geotechnical Exploration Hancock County Flood Risk Reduction Program – Eagle Creek Dry Storage Basin Phase 1

Attachment C – Freshwater Mussel Reconnaissance Survey on Eagle Creek and Aurand Run

Attachment D – Eagle Creek Dry-Storage Basin Project Wetland and Waterbody Delineation Report

Attachment E – Eagle Creek Dry-Storage Basin Project Threatened and Endangered Species Habitat Assessment Report

Attachment F – Aurand Run Concept Refinement Memo

c. Derek Dalton, Scott Peyton, Kyle Blakley, Cody Fleece, Dan Godec, Adam Sprague – Stantec