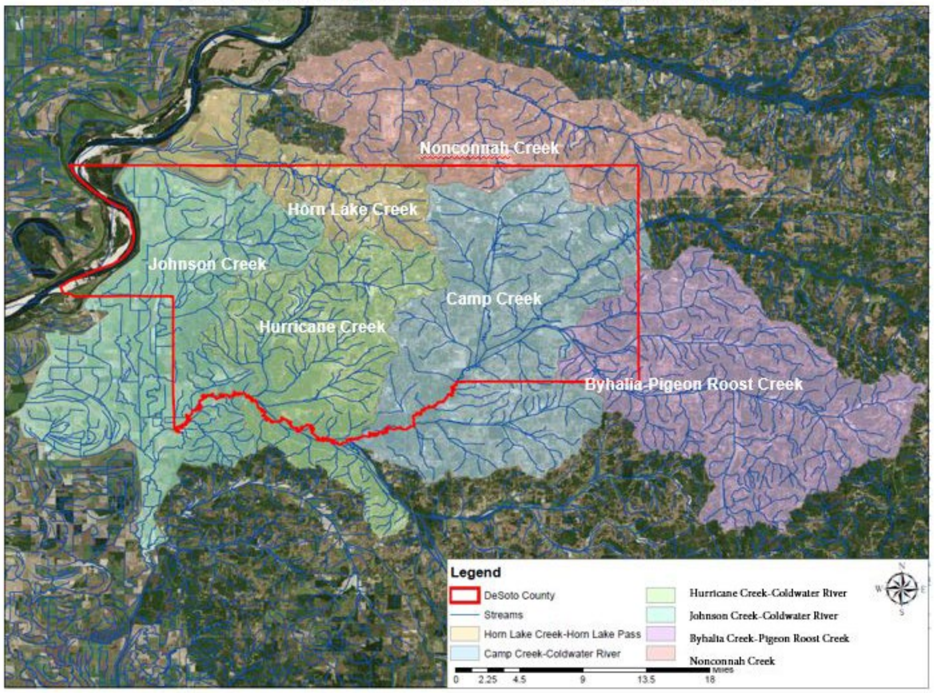
Mississippi Valley Division,
Regional Planning and Environment Division South

Memphis Metropolitan Stormwater – North DeSoto County Feasibility Study, DeSoto County, Mississippi



Revised Draft Feasibility Study with Integrated Supplemental Environmental Impact Statement Appendix I - Design

MAY 2022

Section 1
General Overview

1.1 BASIN DESCRIPTION

The study area includes the watersheds of Horn Lake Creek, Hurricane Creek, Johnson Creek, and Coldwater River in DeSoto County, MS. DeSoto County is in northern Mississippi and is a part of the Memphis, TN, Metropolitan Statistical Area. The most significant flooding impacts occur within Horn Lake and Camp Creek. Horn Lake Creek is a tributary to the Mississippi River. The creek drains 54 square miles and flows generally northwest for 26 miles before joining the Mississippi River at Horn Lake in Memphis.

The terrain consists of gently rolling forested hills, with relief generally less than 50 vertical feet. The area is highly developed – the county is the most populous in the state of Mississippi – with two interstate highways and three rail lines running through the study area.

The study area is densely developed with a mix of suburban-scale residential, commercial, and light industrial development.

1.2 ENGINEERING PROBLEM STATEMENT

Mitigate the impact of short-duration high-volume headwater flooding within DeSoto County.

1.3 HYDRAULIC DESIGN CONSIDERATIONS

Historically, the forested watersheds conveyed runoff through flat alluvial creeks to larger waterways – Johnson and Hurricane creeks to the Coldwater River, and Horn Lake to the Mississippi River. As the region has developed, many tributaries were channelized first to drain land for agriculture, then to dry land for development. Land was developed for residential and commercial uses right up to the edge of the floodplain, and sometimes on fill extending into the floodplain. Changed land use coverages increased runoff, and channelized creeks brought tributary water together faster. This is most noticeable at “Bullfrog Corner” in Horn Lake. As a result, flooding in DeSoto County tends to develop rapidly from headwater events, but durations of flooding tend to only last 12-36 hours.

1.4 CIVIL DESIGN CONSIDERATIONS

The gently sloping streams theoretically offer the opportunity to detain water above areas where damages are occurring. However, the narrow streams and close proximity to development restricts the size of any detention structure.

Existing infrastructure further constrained design. Sewer lines run through the creek valleys and provide additional challenges to siting measures. Initial cost screening determined that large-scale relocations of sewer lines would be unaffordable given the benefits offered by the proposed detention sites. Roadways and the CN railroad bridge restrict flows as well and measures were templated to avoid relocating these items. Electrical and water delivery infrastructure are also widespread but do not impact proposed measures to the same scale.

1.5 DATA SOURCES

The design is based on commercially available topographic maps, aerial imagery, and LiDAR captured in 2015 and 2018-2019.

Section 2

Measures and Alternatives

2.1 OVERVIEW

Several previous studies have generated alternatives. These are discussed in detail in Section 4 of the Main Report. Of note are the two alternatives from the 2005 GRR. The Team reevaluated measures from the 2005 GRR. The 25-year extended channel enlargement performed well enough to carry forward to the 2021 array. However, channel improvement was eliminated after more refined modeling indicated a low BCR. This prompted a reformulation and included a variation on the 2005 berm. The berm was strengthened to a levee and floodwall, shortened, and the diversion weir was dropped.

Table 1. Alternatives from the 2005 General Reevaluation Report.

Alternative No.	Design Plan	Location Channel Reach	Bottom Width (feet)	Side Slope	Type of Improvement
1	10-year Plan	Horn Lake Creek 18.86 - 19.39	30	1:3	Channel Enlargement with Riprap Toe Protection
		19.39 – 19.42			Transition Structure
		19.42 - 19.82	30	Vertical	Concrete U-Frame
		19.82 – 19.84			Transition Structure
		19.84 – 19.93	30	1:3	Channel Enlargement with Riprap Toe Protection
		Rocky Creek	20	1:2 to 1:3	Concrete lined in lower 50’and riprap lined upstream to 120’
		Diversion Ditch east of Hwy 51, and south of Goodman	20	1:2.5	Diversion Channel
		West Bank of Horn Lake Creek SM 18.80 – 19.91	Crown width of 10’	1:4	Berm with a Diversion Weir

		Abandoned lagoon upstream of ICRR	25 acres		Detention Basin and Environmental Enhancement
2	25-year	Horn Lake Creek 18.86 - 19.39	40	1:3	Channel Enlargement with Riprap Toe Protection
		19.39 – 19.42			Transition Structure
		19.42 - 19.82	40	Vertical	Concrete U-Frame
		19.82 – 19.84			Transition Structure
		19.84 – 19.93	40	1:3	Channel Enlargement with Riprap Toe Protection
		Rocky Creek	20	1:2 to 1:3	Concrete lined in lower 50’and riprap lined upstream to 120’
		Diversion Ditch east of Hwy 51, and south of Goodman	20	1:2.5	Diversion Channel
		West Bank of Horn Lake Creek SM 18.80 – 19.91	Crown width of 10’	1:4	Berm with a Diversion Weir
		Abandoned lagoon upstream of ICRR			Detention Basin and Environmental Enhancement

2.2 METHODOLOGY

The technical team first reviewed previous studies prepared for USACE, the sponsor, local jurisdictions, and non-governmental organizations. Measures were reviewed to verify completeness of previous analysis. New measures were developed in a brainstorming session with the project sponsor conducted in 2019, and again during a reformulation in 2021. The focus of new measures was to a) reduce damages at the 0.04 ACE flow by attenuating or diverting flow; or b) localized protection of existing developed land. This approach let to the development of the new arrays described in the Main Report.

Large-scale measures such as dams or levees were considered and eliminated. Dams were eliminated for multiple reasons: 1) there is no one-structure solution for the entire basin due to multiple sources of flood water; 2) the land area required to provide meaningful benefits was larger than what could be reasonably acquired; 3) the expense of large embankment and outlet works was not justified by the anticipated benefits; and 4) the additional risk of raising WSE was not justified by the anticipated benefits. Large-scale levees were similarly eliminated because 1) development up to the top bank means there is little to no space available to place a levee without demolishing structures, and 2) the additional risk of raising the WSE was not justified by the anticipated benefits. A bypass waterway or floodway was also eliminated from consideration because it would require demolition of existing structures, significantly increasing costs.

Smaller measures such as on-site detention appeared effective but would be large in number and provide benefits on a smaller scale. This scale of solution is better implemented by local entities or other federal programs. Thus, the PDT focused efforts on identifying multiple channel improvement and/or detention measures that could be combined to provide a 0.04 ACE level of protection.

Sites were screened and selected for further analysis based on potential to reduce damages. Site design focused on using the existing terrain as much as possible, minimizing impacts to existing infrastructure, and balancing benefits and risks of improvements. For instance, detention basin footprints were laid out to take advantage of existing high ground and avoid the cost and risk of an above-ground embankment. Channel improvements, detention, and NER measures were laid out in a manner that would avoid costly relocations of utilities, impacts to existing development, or adverse effects to existing infrastructure. Detention basins were kept mostly in ground to avoid cost of constructing to levee or dam design standards around the entire perimeter, and additional risk from elevating the water surface elevation above the 0.01 ACE line.

The team considered similar projects in the region. CEMVM maintains a large inventory of drainage ditches and had many examples of enlargement and revetment in similar contexts from which to draw. For detention, smaller dry and wet facilities are found within the metro area. In particular, the Purple Creek detention facility in Ridgeland, MS, was seen as a close proxy to what could reduce flood in the study area. It is similar in its urban context, terrain, and soils.

Environmental features were analyzed separately by ERDC with support from the Team and are included in Appendix B and C.

2.3 LIMITATIONS

Existing development is the most significant limitation to structural measures in the study area. Development crowds the floodplain and limits the ability to store floodwater either inline or offline. It also means there is no physical space to divert floodwater around development in a designated floodway.

The team concluded early in the study that large-scale levee protection was less desirable due to higher maintenance costs, higher risk compared to subgrade measures, and continued flood insurance costs for residents. This focused the Team on exploring opportunities to detain water upstream of damage areas.

2.4 ASSUMPTIONS

Key assumptions made by the technical team for this report include

- Soils will be suitable for detention and berms with minimal improvement. A typical slope of 3H:1V was used pending more detailed geotechnical analysis.
- Disposal of excess fill can be made either within the project footprint, or a haul distance less than 5 miles.
- HEC-RAS model is suitable for screening new alternatives but must be improved prior to feasibility-level analysis.
- LiDAR is acceptable for reconnaissance-level design.
- Existing utilities should be avoided; relocations of sewer and gas lines are prohibitively expensive and shall be minimized or avoided.
- Demolition of existing structures is typically not justified for the anticipated benefits and should be avoided.

2.5 MEASURES CONSIDERED

Brainstorming produced numerous potential measures. These were evaluated based on potential performance, costs, environmental considerations, and suitability to the project sponsor. Many proposals dropped out due to site limitations, poor performance, or utility conflicts. At the end of this exercise, the Team identified seven discrete measures that would be screened for more detailed design and evaluation.

2.6 MEASURES CARRIED FORWARD

2.6.1 Expanded Channel Enlargement (M18.6-19.4)

This measure was adopted from the 2005 GRR. The measure was reevaluated and found to perform well enough to carry forward for further analysis. The channel engagement improved hydraulic efficiency downstream of Goodman Rd. and better conveys floodwater away from development, reducing damages. Extending the channel enlargement to the railroad overpass further improved suitability compared to the 2005 plan. The Horn Lake Creek channel enlargement will increase the bottom width to 40 feet for approximately 4,500 linear feet from Mile 18.6 to Mile 19.4, downstream of Goodman Rd. in Horn Lake, MS. The banks of the improved channel will be flattened to a 3H to 1V slope for stability. The enlargement and slope flattening will require 68,200 cubic yards of excavation, all of which will be disposed off-site. Approximately 21,200 tons of riprap will be placed at sides at the toe to prevent scour damage. The riprap will be placed 2-foot deep at the toe and 5 feet up both banks. This protection will run continuously across the bottom width at the downstream end. The riprap will be placed over approximately 4,300 tons of filter material. The upper banks will be protected with 22,800 square yards of turf reinforcing mat.

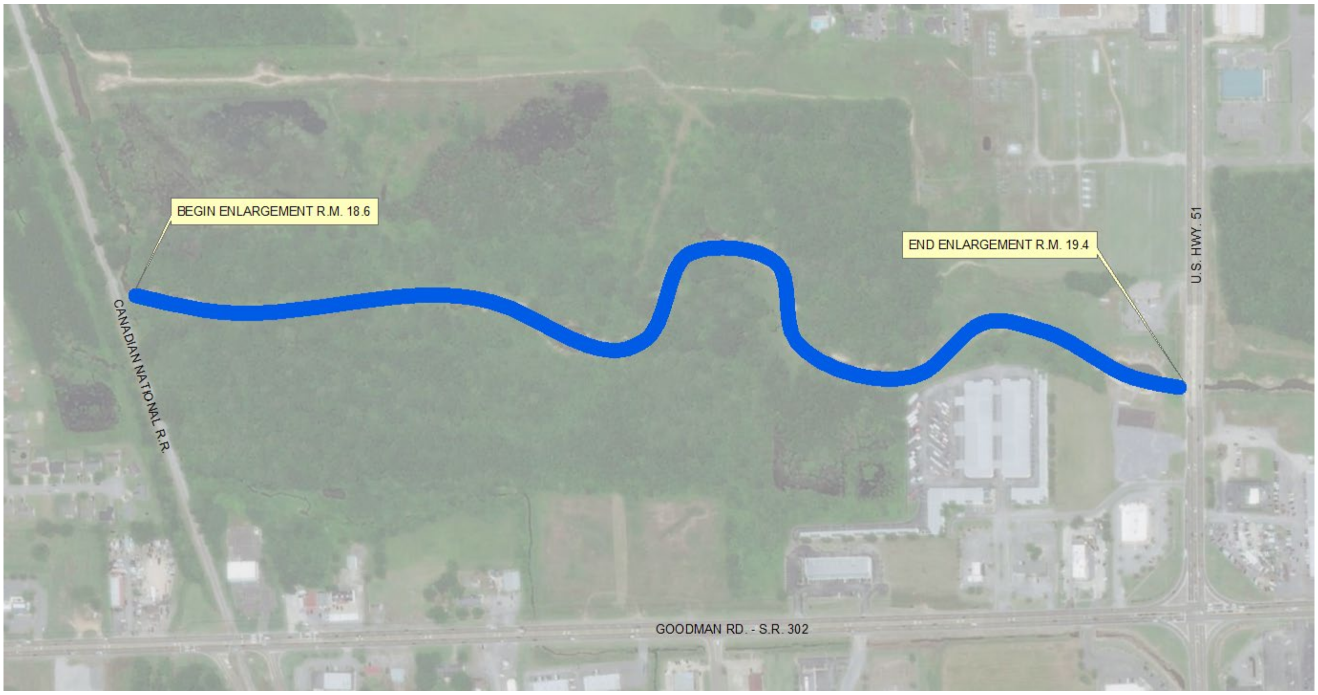


Figure 1. Expanded channel enlargement, R.M. 18.6 to 19.4.

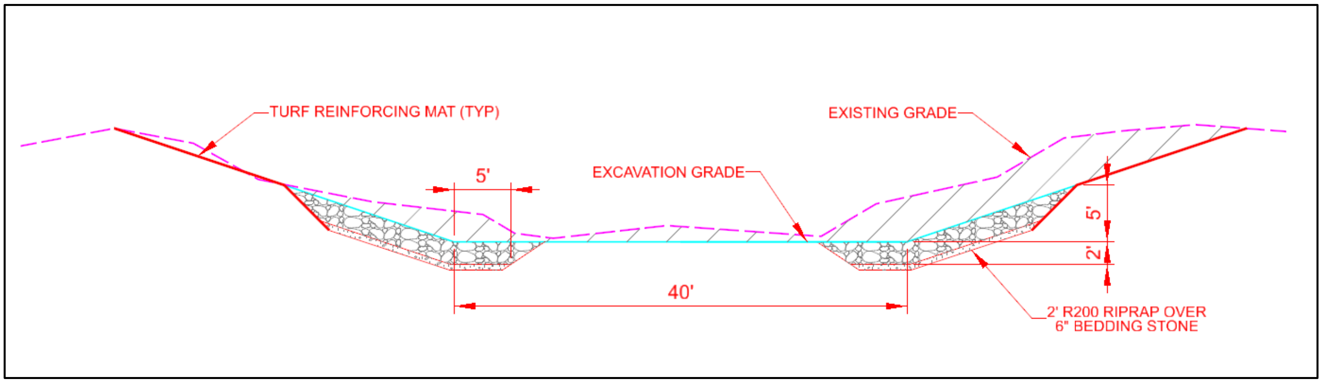


Figure 2. Channel improvement typical section.

2.6.2 Cowpen Cr. Detention - North

Two detention basins were sited within Cowpen Cr. Both basins will operate passively to attenuate the flow by storing floodwater. This will lengthen the crest but reduce the peak flows that cause damages along Cowpen Cr.

The first basin is a 12-acre inline detention basin south of Nail Rd. in Horn Lake, MS. The dry detention basin will have a bottom elevation of 262.0, bottom area of 10 acres, and shall be sloped back up to grade at 3H to 1V. A 500-foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100-foot-wide overflow spillway armored with approx. 2,000 tons of riprap on the downstream side. The riprap will be placed over approximately 500 tons of filter material. A gravel-surfaced access road and security fence will be installed along the perimeter of the basin. The basin will be turfed and may include limited tree and shrub plantings at the edge of a low-flow channel. The 100-foot-wide spillway will operate at elevation 272.0, approx. at the 0.50 ACE event. The maximum storage of 108 acre-feet requires approx. 175,000 cubic yards of excavation.

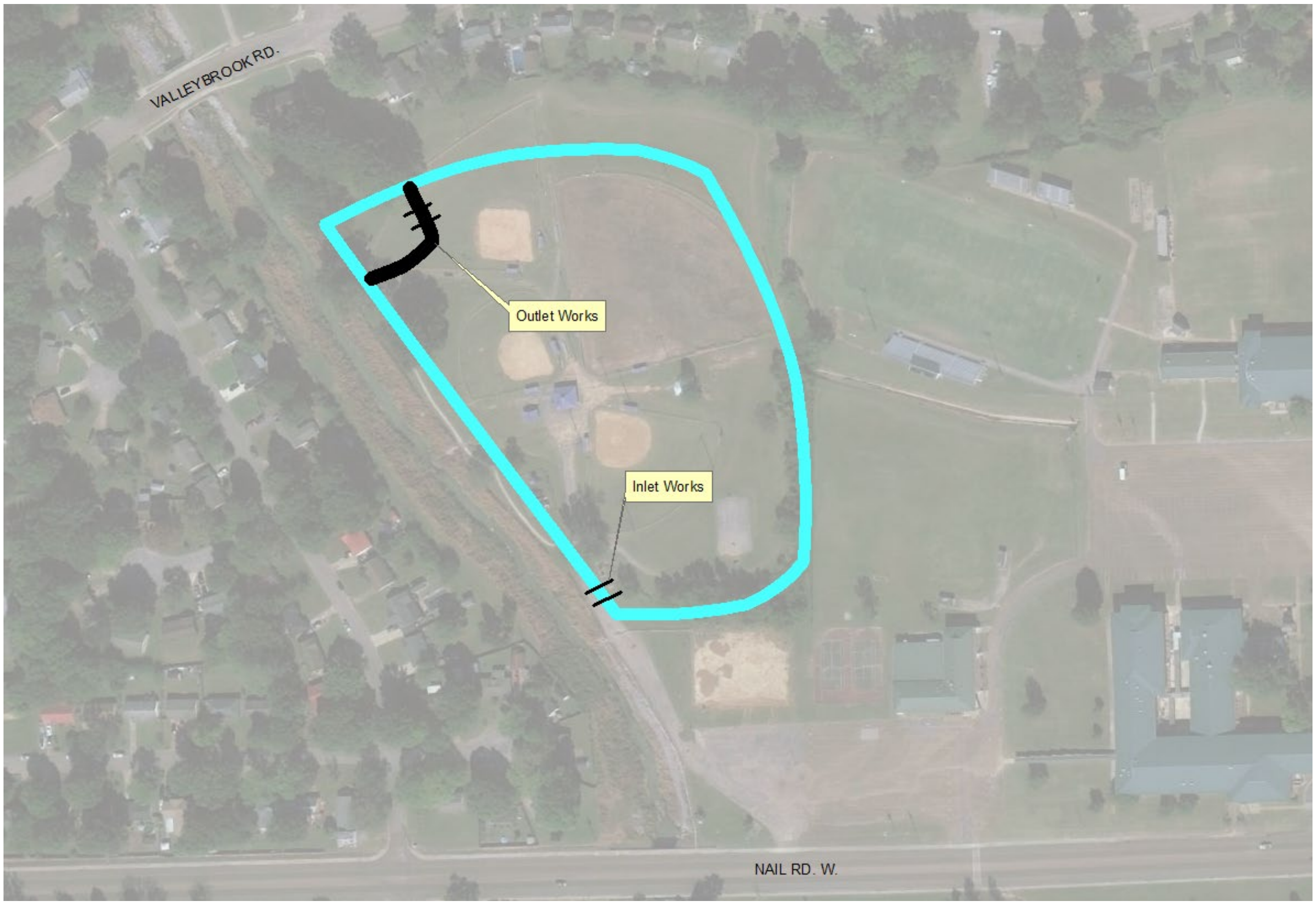


Figure 3. Cowpen Cr. Detention – North

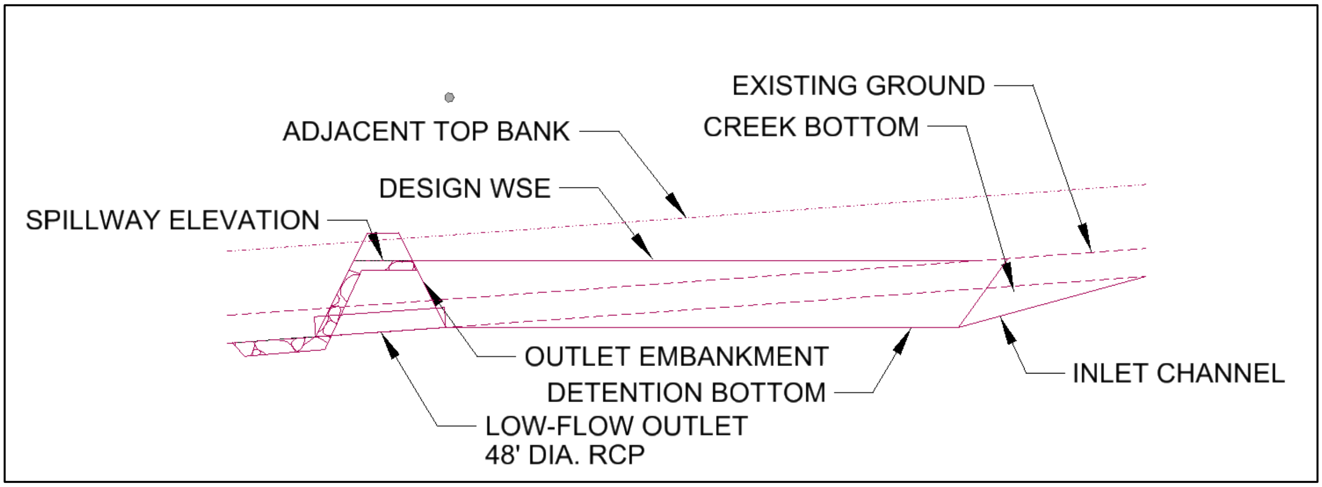


Figure 4. Typical detention profile.

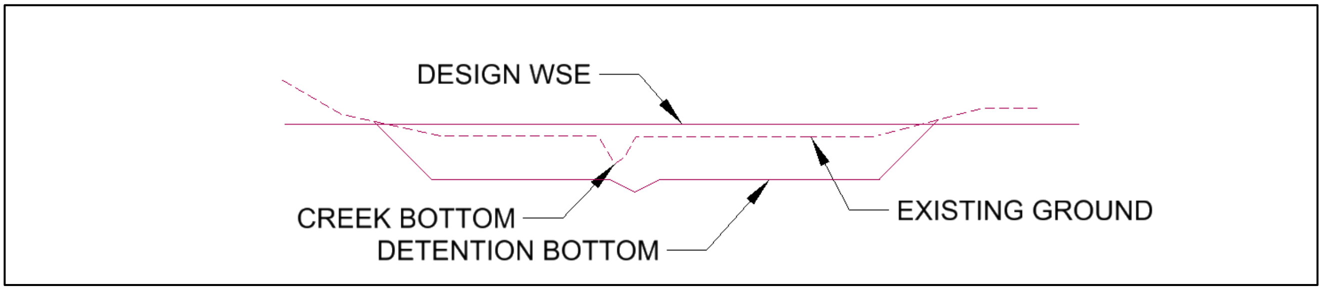


Figure 5. Typical detention cross section.

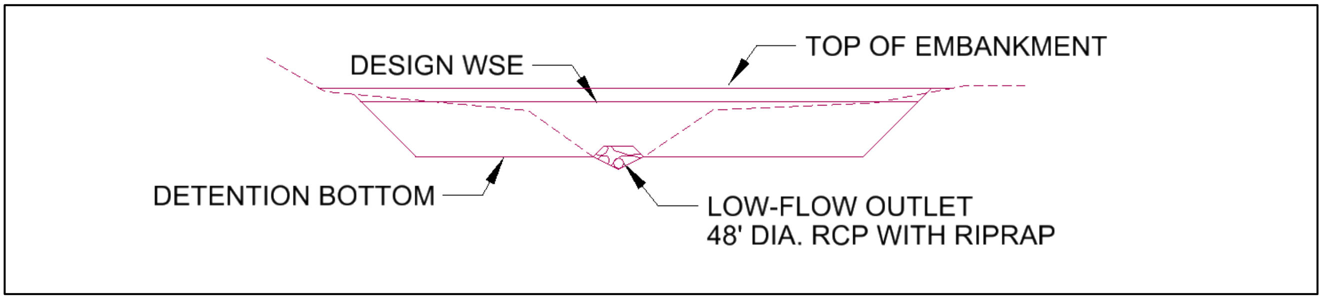


Figure 6. Typical detention outlet.

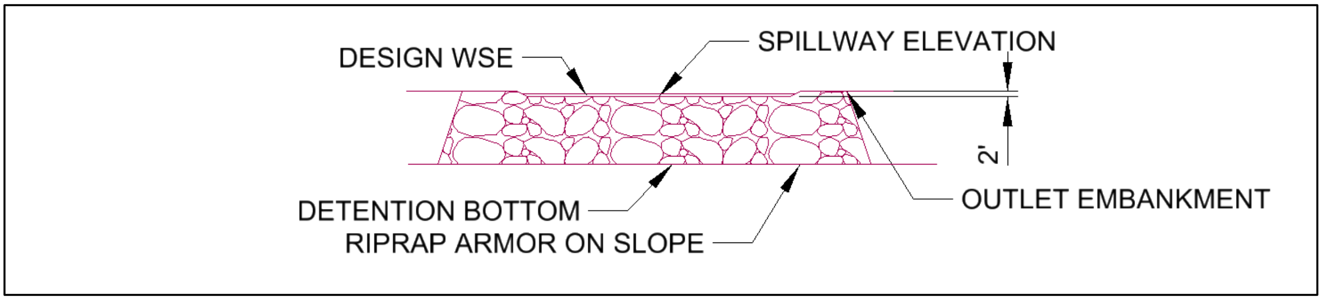


Figure 7. Typical detention spillway.

2.6.3 Cowpen Cr. Detention - South

The second basin in Cowpen Cr. will be located north of Nail Rd. in Horn Lake, MS. The dry detention basin will have a bottom elevation of 258.0, bottom area of 6 acres, and shall be sloped back up to grade at 3H to 1V. A 500-foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100-foot-wide overflow spillway armored with approx. 2,000 tons of riprap on the downstream side. An inlet sill will require an additional 800 tins of riprap. The riprap will be placed over approximately 680 tons of filter material. A gravel-surfaced access road and security fence will be installed along the perimeter of the basin. The basin will be turfed and may include limited tree and shrub plantings at the edge of a low-flow channel. The 100-foot-wide spillway will operate at elevation 268.0, approx. at the 0.50 ACE event. The maximum storage of 68 acre-feet requires approx. 115,000 cubic yards of excavation.

Figure 8. Cowpen Cr. Detention - South

2.6.4 Lateral D Detention

A 22-acre inline detention basin will be located on Lateral D south of Church Rd in Southaven, MS. This dry detention basin will have a bottom elevation of 290.0, bottom area of 16 acres, and shall be sloped back up to grade at 3H to 1V. A 500-foot-long outlet embankment will include a 48 in. Reinforced Concrete Pipe outlet and 100-foot-wide overflow spillway armored with approx. 2,000 tons riprap on the downstream side. The riprap will be placed over approximately 500 tons of filter material. A gravel-surfaced access road and security fence will be installed along the perimeter of the basin. The basin will be turfed and may include limited tree and shrub plantings at the edge of a low-flow channel. The 100-foot-wide spillway will operate at elevation 300.0, at the 0.50 ACE event. The maximum storage of 177 acre-feet requires approx. 350,000 CY of excavation.

Figure 9. Lateral D detention site.

2.6.5 Rocky Creek

A nine-acre inline detention basin will be located on Rocky Creek east of Swinnea Rd. in Southaven, MS. The dry detention basin will have a single pool elevation 302.0. The pool bottom area is six acres. All slopes back up to grade shall be 3H to 1V. Downstream embankment is 500 linear feet and will include a 48 in. Reinforced Concrete Pipe outlet and 100-foot-wide overflow spillway armored with approx. 6,000 tons riprap on the downstream side. The riprap will be placed over approximately 1,500 tons of filter material. A gravel-surfaced access road and security fence will be installed along the perimeter of the basin. The basin will be turfed and may include limited tree and shrub plantings at the edge of a low-flow channel. The 100-foot-wide spillway will operate at elevation 312.0 at the 0.50 ACE event. The maximum storage of 72 acre-feet requires approx. 115,000 cubic yards of excavation.

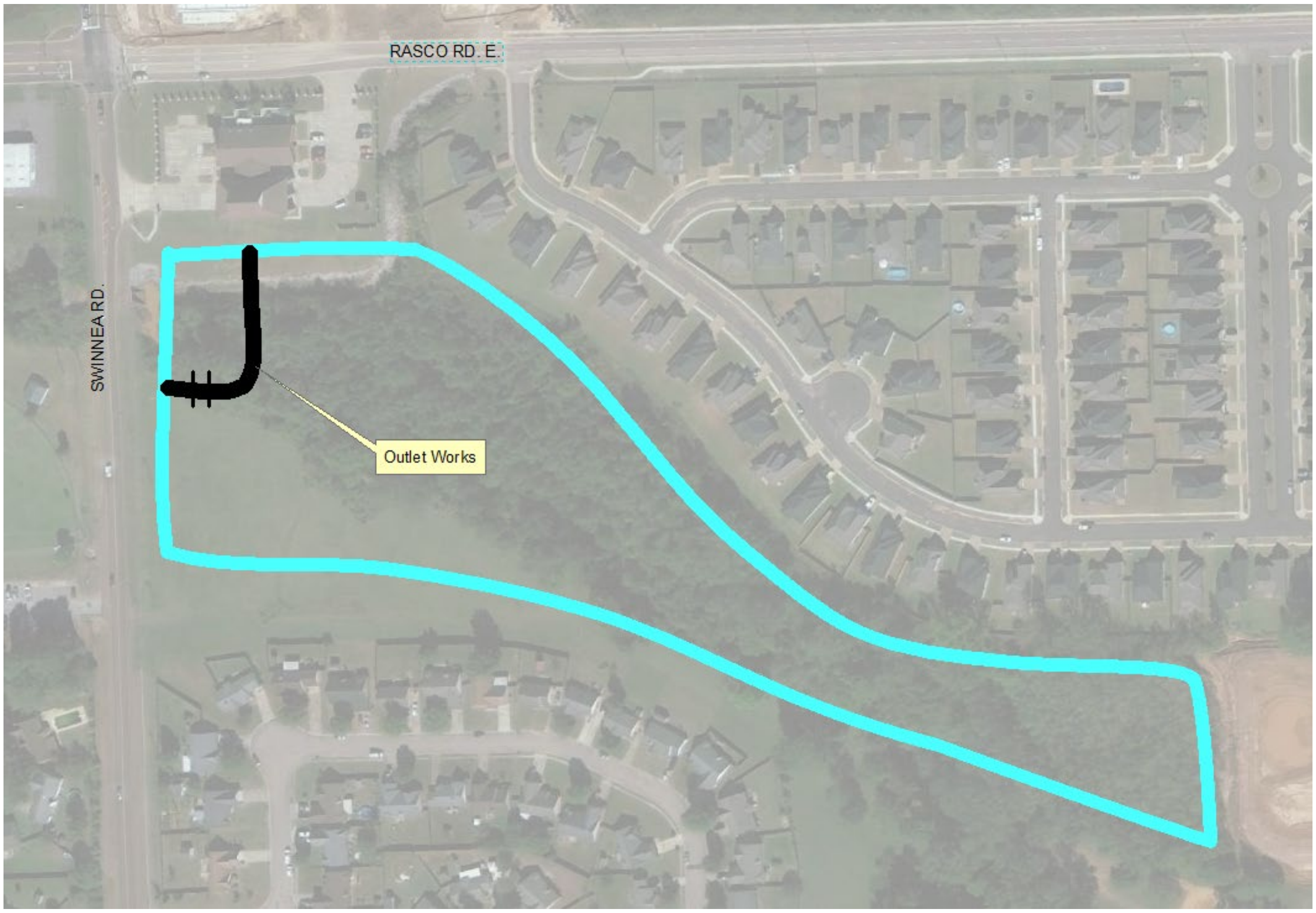


Figure 10. Rocky Cr. detention site.

2.6.6 Horn Lake Creek Levee & Floodwall

A new 3,000 linear foot levee and floodwall system will protect structures on the left-bank of Horn Lake Creek upstream of Goodman Rd. The levee will be constructed with 3-foot horizontal to 1-foot vertical (3H:1V) side slopes and a 12-foot-wide crown. The levee will run approx. 2,475 linear feet adjacent to US Hwy. 51 with an average height between 5-7'. A 600-linear-foot ditch will drain a depression on the riverside of the levee. Where development makes a levee infeasible, protection will transition to a 525 linear foot floodwall. The floodwall be 18" thick with an eight-foot-wide foundation. The wall will be five feet high and protrude 3.5 feet above ground level. The levee will require approx. 14,000 cubic yards of fill, and the floodwall will require 300 cubic yards of reinforced concrete. This alternative will require relocation of several utility poles and signs, removal and replacement of asphalt, and demolition of an existing vacant structure. Removal of the structure and setting back the levee will also support additional environmental habitat described in XX.

The Team initially targeted 0.04 ACE level of protection; however, the small height of the levee allowed greater protection. The height of protection proposed at TSP provides protection exceeding the 0.01 ACE event.

During analysis, it was determined that the increased water surface elevations on the east bank created induced damages due to flooding at more frequent events. These inducements are mitigated through non-structural measured described in XX.

Table 1. Horn Lake Cr. levee and floodwall quantities.

QUANTITIES			
Embankment	14000	CY	From InRoads volume measurement
Reinforced Concrete	300	CY	
Excavation	3000	CY	2000CY inspection trench, 400CY floodwall, 600CY ditch
Backfill	2200	CY	2000CY inspection trench, 200CY floodwall
ROW	8	AC	
Temp. Const. Easement	1.5	AC	For structural demolition
Seeding	7.5	AC	
Asphalt removal	12000	SY	N. parking area: 2000 SY, bldg: 10000 SY
Asphalt replacement	2000	SY	N. Parking Lot only
Structural demolition	1	EA	15000 SF steel frame. Remove utilities.
Sign relocation	1	EA	Behind strip mall
Power Pole relocation	4	EA	Behind strip mall

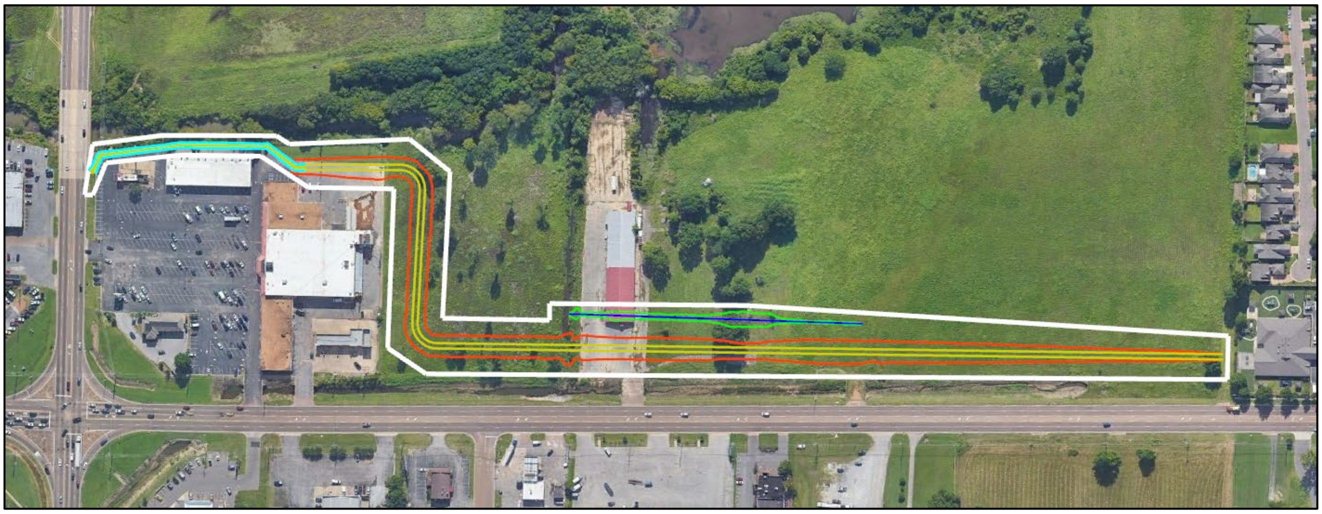


Figure 11. Horn Lake Creek Levee and floodwall, SE of the intersection of US 51 and Goodman Rd.

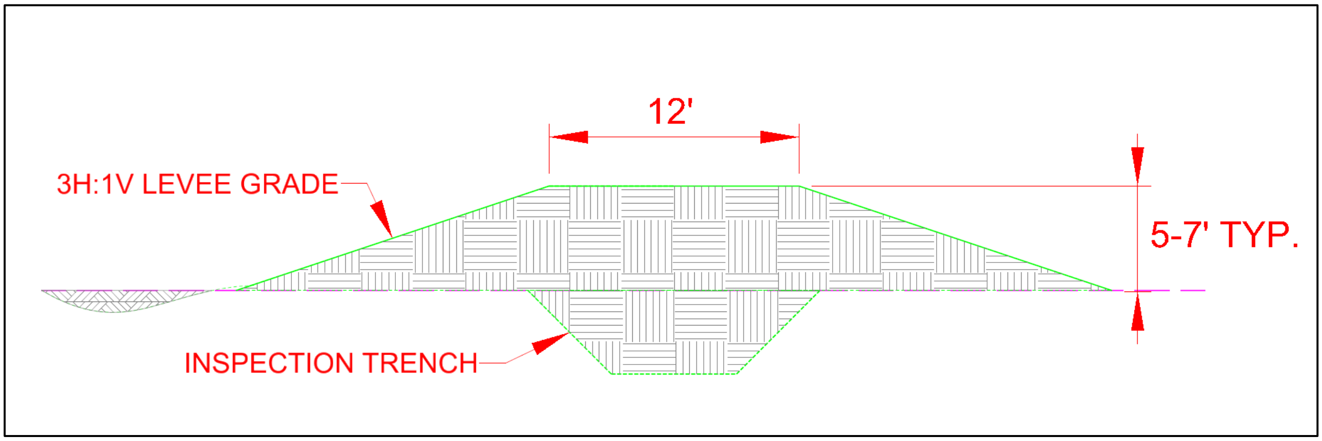


Figure 12. Levee

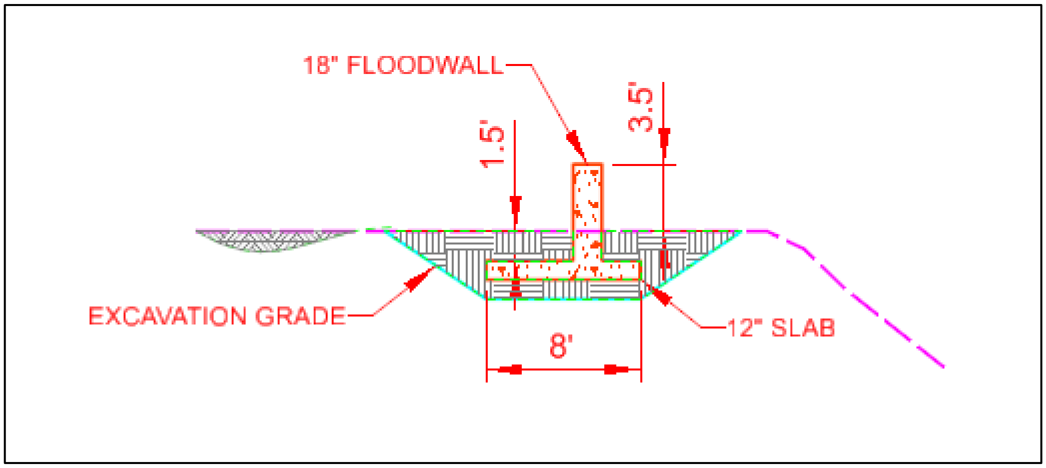


Figure 13. Floodwall.

2.7 NEW MEASURES NOT CARRIED FORWARD

2.7.1 Elmore-Swinnea Detention

The team explored inline detention options on Horn Lake east of Elmore Rd. The site is large but slopes such that a single detention pool would be limited to about a ¼ of the site or require much more extensive embankment and outlet works to hold 20+ feet of water. The high-embankment option was dropped from consideration due to risk and costs. Adding smaller pools in series increased theoretical capacity from 240 ac-ft to 700 ac-ft at much lower risk. However, the volume of detention after adjusting for utilities were only marginally higher than the storage from the current forested bottomland, and the high costs of excavation made this alternative no longer economically justified.

2.7.2 Horn Lake Detention

The team explored offline detention options on Horn Lake upstream (south) of Goodman Rd. Early hydraulic modeling indicated negligible benefits at the 1.0 ACE event, and the site was dropped from further consideration.

2.7.3 Other locations

Other county-owned sites in the Horn Lake basin were investigated for detention but were screened out from lack of benefits. Similarly, potential detention sites in Johnson Cr., Hurricane Cr., and other waterways in the county were investigated but not carried forward for lack of benefits.

2.8 NATIONAL ECOSYSTEM RESTORATION PLAN MEASURES

NER measures were formulated by ERCD with input from the Team. Measures proposed include grade control, bank armoring, riser pipes, and riparian buffers (non-structural). Improvements are proposed for 11 streams and are described in detail in Appx. X (Environmental). These measures provide environmental benefits such as reduced scour and deposition. These measures were not evaluated for flood risk management benefits. During feasibility, modeling will determine impacts of each measure, and any ancillary benefits identified will be noted in the Final Report.

2.8.1 Grade Control

Up to 88 grade control structures (GCS) are proposed in the NER Plan. These GCSs counteract headcutting that was observed in these streambeds. Structural improvements are designed to stabilize the streambed and reduce future headcutting. The structures will typically be 3.5 feet high off of the channel bottom. Larger 600 lb. stone will face upstream, with smaller 200 lb. stone protecting the downstream side. Side slope armoring and keys will reduce the risk of flanking or undercutting the structure. This design was adapted from ERDC loose rock riffle, with additional slope armor and keys to account for the erodibility of local soils.

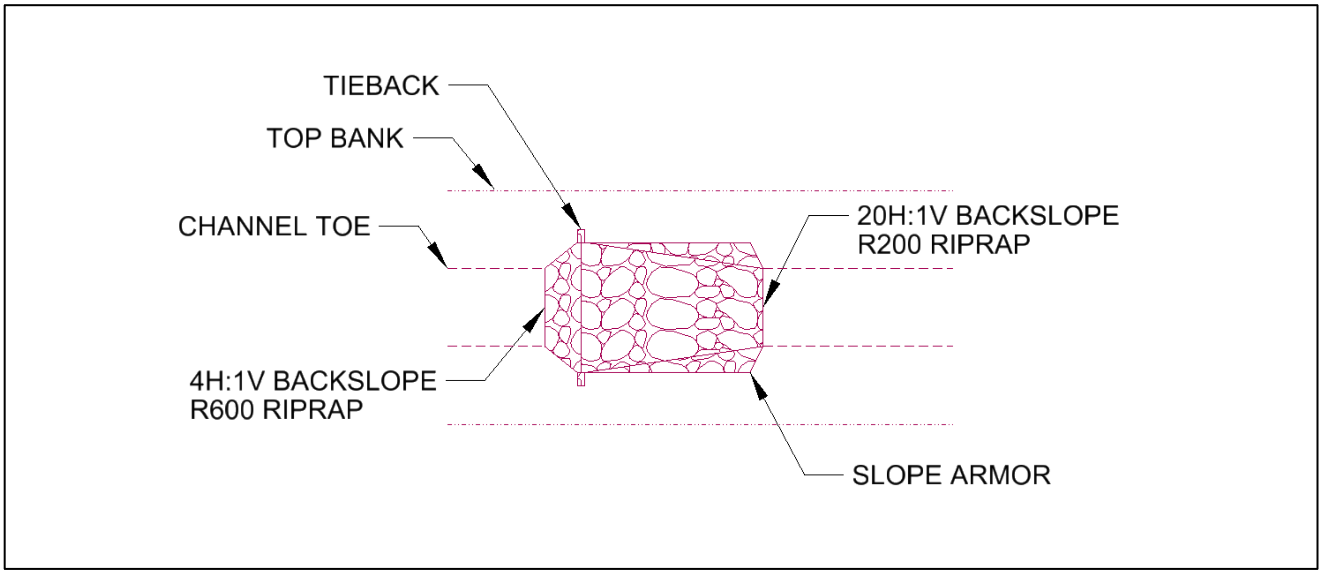


Figure 14. Grade control structure typical plan layout.

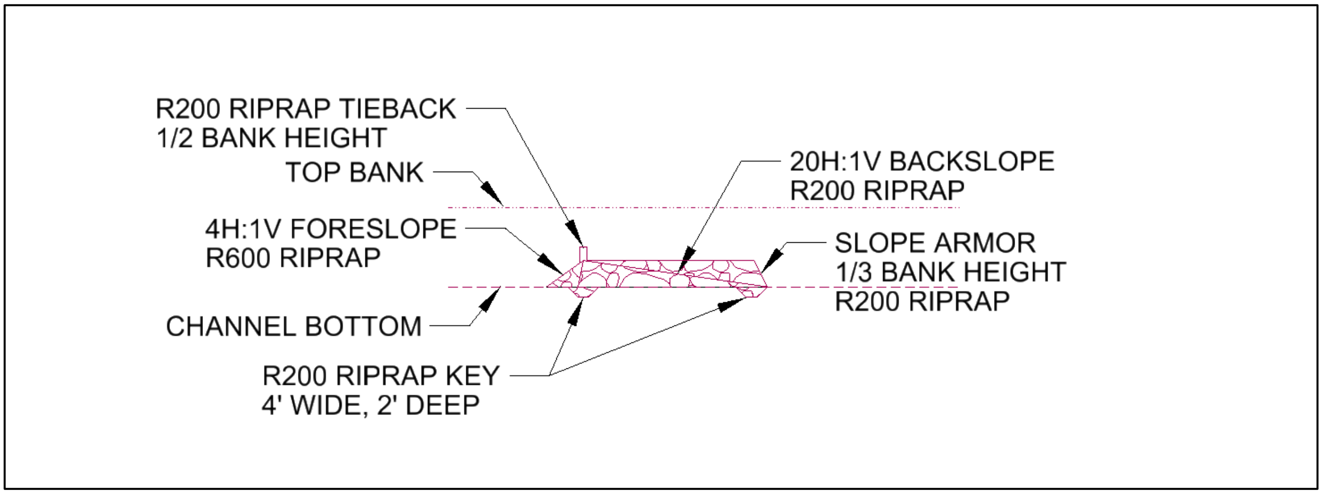


Figure 15. grade control structure typical profile.

2.8.2 Bank Protection

The NER Plan proposes 50,000 LF of Longitudinal Peaked Stone Toe Protection (LPSTP) with tiebacks in the 11 identified streams. These were not located in the field but are to be placed in proximity of identified GCSs. These will reduce damages to banks and protect top bank habitat. It will also reduce the ability of the river to meander and scour into the outside bend of the stream.

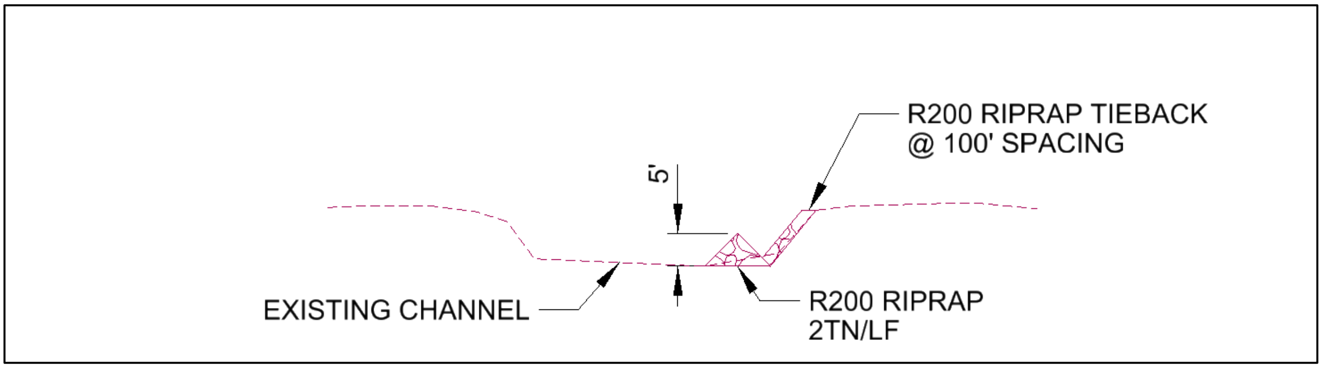


Figure 16. Longitudinal peaked stone toe protection typical section.

2.8.3 Riser Pipes

Concentrated flows can create deep incisions in the bank. Select incisions will be mitigated by installing a pipe to convey handle the grade change without scouring the bank. This will help to retain vegetation and reduce scour at these locations.

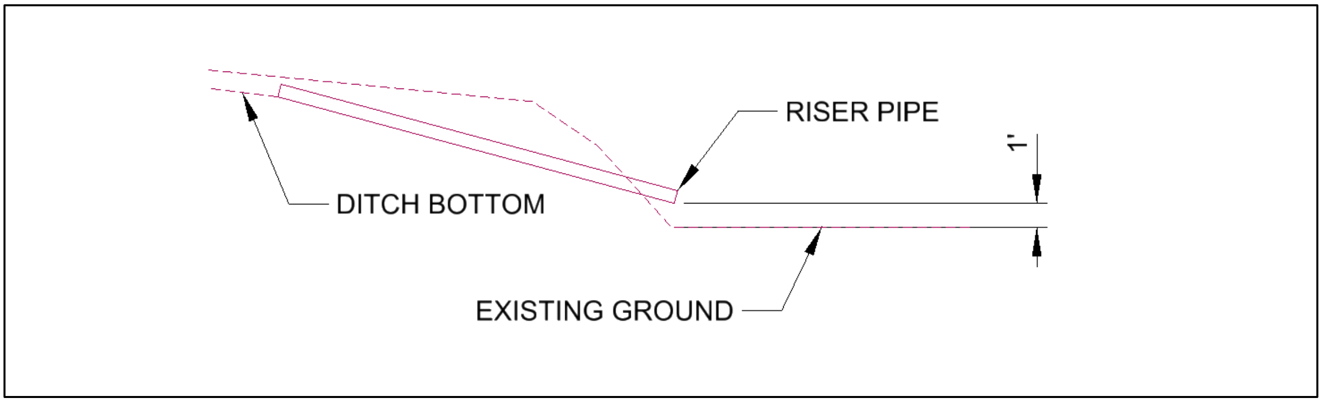


Figure 17. Riser pipe typical section.

2.8.4 Riparian Buffer

Land adjacent to the waterway will be converted to forest to provide a buffer from development and agriculture. There are no structural improvements associated with this measure; however, this could be paired with other measures to mitigate anticipated impacts.

For instance, a parcel prone to flooding may be converted to riparian buffer, reducing the risk of damage to private property.

2.9 RELOCATIONS

The team sought to avoid relocations as best as possible so to minimize relocation costs. Utilities to be removed and/or replaced are noted above. Remaining utilities at the levee and floodwall are as follows:

Water supply pipeline at Goodman Rd. During feasibility, the Team will investigate methods of protection, such as encasement, flowable fill, or other method to prevent damage to the pipeline.

Other utilities were investigated and found to run along corridors outside the proposed levee and floodwall footprint. For instance, gas and water run west of US 51, and sewer runs east of Horn Lake Cr.

2.10 BORROW AND DISPOSAL

Borrow for the levee is available on site (primary source) and at a city-owned site on Nail Rd. adjacent to Cowpen Creek (continency source). Additional borings are needed during PED to confirm the acceptability of material on site. Construction debris and any contaminated soil discovered demolition will be disposed of offsite at a commercial landfill.

Section 3
Feasibility-Level Design

3.1 TESTS AND DATA COLLECTION

In order to properly analyze and reduce risk, additional data must be acquired. A detailed inventory of existing utilities in the project footprint must be obtained in cooperation with the sponsor and utility owners. This is particularly important to subsurface utilities that are not easily located with imagery or site visits. Discussions with owners must determine which conflicting utilities can be relocated, and at what cost. Select topographic surveys are required to locate key existing features (including utilities) and gain more fidelity in elevations. A topographic survey is required to improve the confidence of material quantity estimates, aid in validating hydraulic models, and identify conflicts with existing features. Modeling will also be used to refine the height of the levee and degree of revetment required. Detailed topographic data is not needed for all GCS, but field measurements of the bank and channel are as overhead imagery does not provide the accuracy necessary for Feasibility-level performance modeling and quantity calculations. Some limited shots to validate HEC-RAS modeling may be required as well.

3.2 ANALYSIS/OPTIMIZATION STRATEGY

During feasibility-level design, the PDT will continue to refine the design of the TSP. The team will refine models and test FRM and NER features to validate performance. Grade Control Structures in particular must be modeled to ensure sites selected will not induce unacceptable damages. It may also identify ancillary benefits that will be noted in the Final Report.

Geotechnical analysis will help refine design slopes, riprap requirements, and outlet embankment design.

Improved survey will allow for refined quantity calculations and cost estimates.

Construction sequence and phasing will be addressed during feasibility-level design.

3.3 INTEGRATION WITH OTHER AUTHORIZED PROJECTS

Analysis and coordination will be done to ensure this plan integrates into existing structures owned by municipal interests, private entities, and other government agencies. In particular, the Team will coordinate with the Vicksburg District as several NER measures overlap improvements authorized by the Delta Headwaters Project. This coordination was imitated prior to the TSP and will continue through feasibility-level design and implementation.

3.4 COORDINATION WITH OTHER AGENCIES

The design team will coordinate with other agencies to identify and incorporate regulatory requirements into the feasibility-level design. This includes setback requirements, stormwater permits, and other local, state, and federal requirements. See also Appendix F – Interagency Coordination.

References

U.S. Army Corps of Engineers (USACE), 2005, Horn Lake Creek and Tributaries General Reevaluation Report.

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