Mid-Barataria Sediment Diversion

Value Engineering Report
30% Basis of Design

Coastal Protection and Restoration Authority of Louisiana

July 2014

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Value Engineering Report
30% Basis of Design

Prepared for
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Preliminary Documents
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1 Introduction

This report documents value engineering (VE) ideas generated for the Mid-Barataria Sediment Diversion (MBSD), a proposed project being investigated by the Coastal Protection and Restoration Authority of Louisiana (CPRA).

> **Value engineering**
>
> The value engineering process balances a project's effectiveness with cost considerations—seeking the best performance for the lowest cost.

The engineering team for the proposed MBSD had previously focused on the design and layout of a 75,000 cubic feet per second (cfs) diversion project, as requested by CPRA. Details regarding that effort are contained in two reports: *Mid-Barataria Sediment Diversion Alternative 1, Base Design Report, 30% Basis of Design* and *Mid-Barataria Sediment Diversion, Geotechnical Report, 30% Basis of Design*. The 30% design and site characterization effort revealed extremely challenging soil conditions that greatly increased construction costs using "traditional" design and construction methods, compared with previous CPRA estimates for similarly sized diversions. Based on new direction provided by CPRA, the engineering team developed a revised design process to align design efforts with CPRA's planning and the MBSD environmental impact statement (EIS) process. Figure 1 illustrates the approach that was used to refine and optimize design development to support CPRA's decision making. This approach can also be used to facilitate the development of reasonable alternatives for evaluation in the EIS process during formal scoping.

An adaptive design process was used to test design alternatives against objective criteria and to determine whether the selected criteria were met or exceeded. With each alternative, different design criteria/assumptions were used and design modifications were made to compare cost outcomes. A separate report is being prepared to address the hydraulic and sediment performance of these alternatives.

2 Value Engineering

In general, the VE process systematically seeks to improve the value of a project by evaluating the functions of various project components and determining whether alternative means/methods/systems can be used to achieve the same functions at an overall lower project cost.

CPRA asked HDR to conduct an abbreviated VE evaluation that included consideration of several design alternatives to the base project design. A *design alternative* generally refers to a targeted design flow and inlet configuration, while a *design version* refers to a group of VE concepts applied to that alternative. In total, eight diversion alternatives/versions were evaluated for cost estimating. The eight alternatives/versions are summarized below:

- Alternative 1, Version 1 – base design concept, 75,000 cfs peak flow design, 300-foot bottom width channel, three open-channel inlets with gated structure, seven-bay gated back structure (described in detail in *Mid-Barataria Sediment Diversion Alternative 1, Base Design Report, 30% Basis of Design*)

- Alternative 2, Version 1 – 50,000 cfs peak flow design, 200-foot bottom width channel, two open-channel inlets with gated structure, five-bay gated back structure
- Alternative 3, Version 1 – 35,000 cfs peak flow design, 100-foot bottom width channel, one open-channel inlet with gated structure, three-bay gated back structure

Subsequent VE versions (designated with the "X.2" suffix in the drawing packages) included the following alternatives:

- Alternative 1, Version 2 – open channel inlet, three-gate diversion structure, 300-foot channel bottom width, seven-gate back structure, 75,000 cfs
- Alternative 2, Version 2 – open channel inlet, two-gate diversion structure, 200-foot channel bottom width, five-gate back structure, 50,000 cfs
- Alternative 3, Version 2 – two immersed tunnel inlets, two-gate diversion structure, 100-foot channel bottom width, three-gate back structure, 35,000 cfs
- Alternative 4, Version 2 – three-bay immersed tunnel inlet, three-gate structure, three box structures outlet, 100-foot channel bottom width, three-gate back structure, 35,000 cfs
- Alternative 5, Version 2 – three-bay immersed tunnel inlet, three-gate structure, three bored tunnels outlet, 100-foot channel bottom width, three-gate back structure, 25,000 cfs

3 Discussion of Flow Rate and Size of Alternatives

Alternative 1 is considered the base design alternative. The governing design criterion for Alternative 1 is a nominal peak design discharge of 75,000 cfs with the Mississippi River flowing at or near a peak flow of 1.25 million cfs.

Version 1 of Alternative 1 was based on two primary assumptions that affected the design layout and, subsequently, the cost estimate: (1) design for optimum hydraulic/sediment transport efficiency (hydraulic design) and (2) design for construction in the dry using cast-in-place concrete structures. Alternative 1 consists of a three-opening gated diversion structure and is shown in Figure 2.

Building from Alternative 1, Alternatives 2 and 3 were developed for initial cost comparisons. Keeping the gate size constant, a two-bay and one-bay alternative were evaluated for cost by removing a gate bay and reducing the discharge, gate, channel size, and back structure size accordingly.

Figure 3 shows Alternative 2, the two-bay alternative. Figure 4 shows Alternative 3, the one-bay alternative. No other VE ideas were incorporated into this initial cost and flow analysis. Table 1 summarizes the results of the analysis.

Figure 1. MBSD adaptive approach

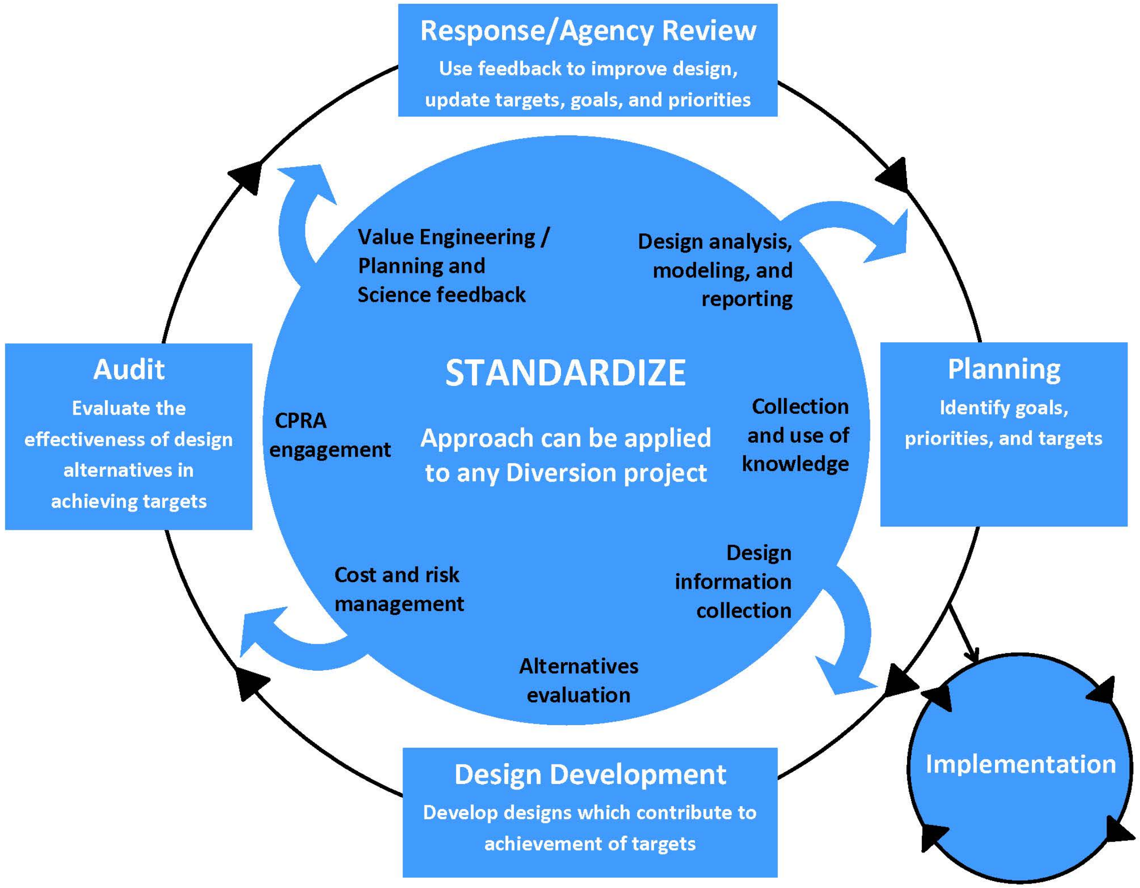


Figure 2. MBSD Alternative 1 (three-bay system)

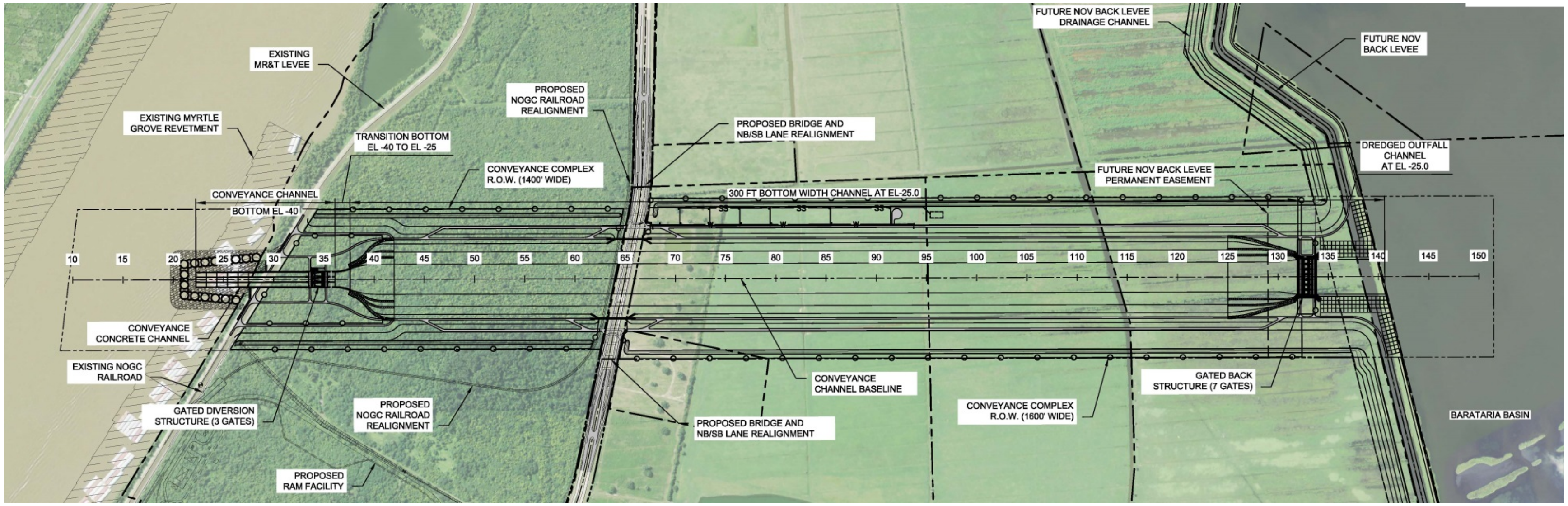


Figure 3. MBSD Alternative 2 (two-bay system)

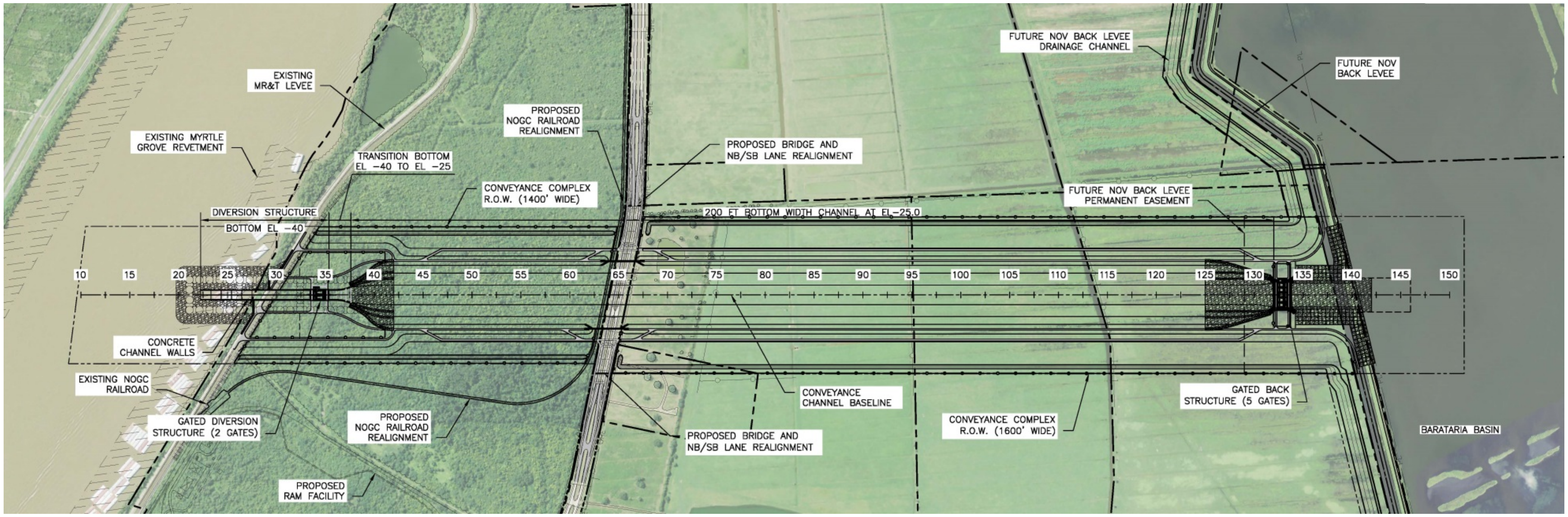


Figure 4. MBSD Alternative 3 (one-bay system)

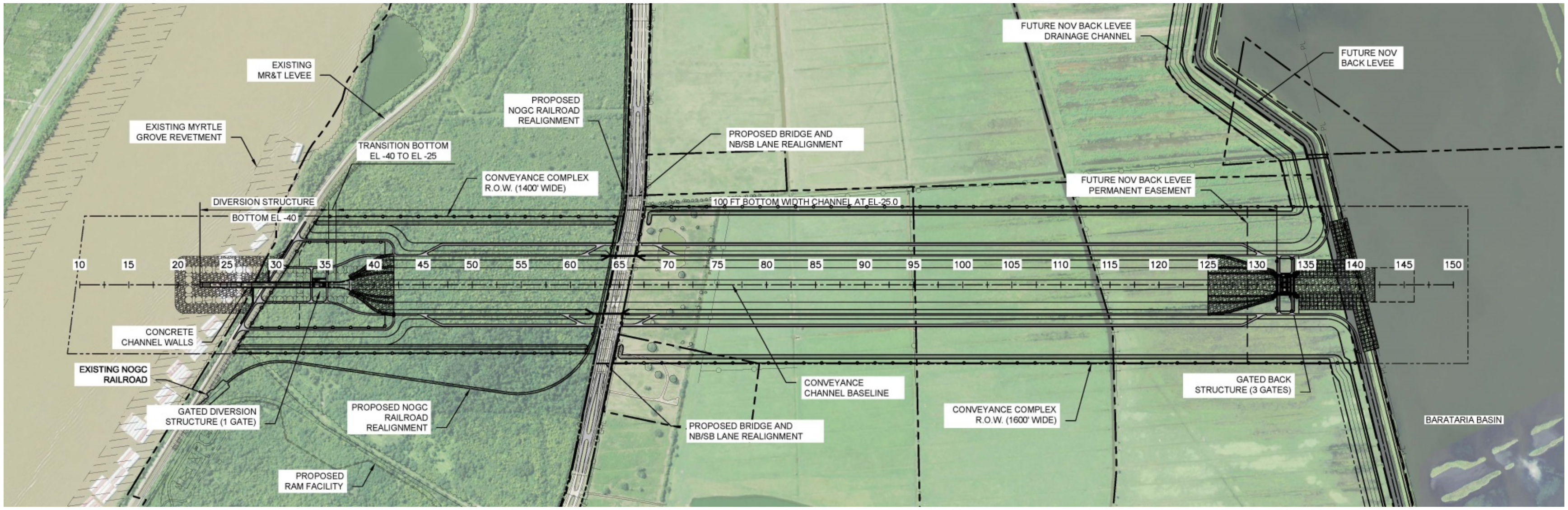


Table 1. MBSD opinion of probable cost

Item	Alternative 1, Version 1 Three-bay system	Alternative 2, Version 1 Two-bay system	Alternative 3, Version 1 One-bay system
Base construction cost	$750,000,000	$672,000,000	$608,000,000

As shown in Table 1, the total construction cost would be approximately $750 million with Alternative 1. Using the two-bay system under Alternative 2, the cost would be reduced to approximately $672 million. The one-bay system under Alternative 3 would cost approximately $608 million. Appendix A provides a more detailed cost analysis with contingency ranges for each alternative.

A more detailed analysis of the cost estimate revealed that the diversion size was not the driving factor with regard to the project's overall cost. The hydraulic, geotechnical, and construction engineering criteria and approaches can be modified to achieve additional cost reductions. Major cost factors in the Version 1 design are summarized in Table 2.

Table 2. MBSD general cost trends and comments

Cost item	Cost trend	Comment
Roadway/bridge	Less steel/materials at bridge given reduction in channel width	Same roadway impact on all alternatives
Rail	No change for all alternatives	Track alignment and route remains constant—keeping rail on existing alignment could save costs
Rail bridge	Less steel/materials at bridge given reduction in channel width	Same rail bridge impact on all alternatives—if flow can be brought into project under pressure flow, rail bridge can be eliminated
Clear and grub	Smaller diversion has less area	—
Haul road	No change for all alternatives	—
Laydown	No change for all alternatives	—
Utilities	No change for all alternatives	—
Site work	No change for all alternatives	—
Earthwork	Reduction in surcharge/sand materials	Surcharging for strength gain and consolidation requires double handling of fill materials—an area for further evaluation

Table 2. MBSD general cost trends and comments

Cost item	Cost trend	Comment
Geostructures	No change for all alternatives	Wall systems primarily a linear system along channel alignment; channel width has little impact. Same length of cellular coffer walls required for work in the dry. Evaluate eliminating and reducing the extensive geostructures.
Diversion channel revetment	Reduction in bottom width reduces armoring materials	Side slopes remain unchanged
Other site work	No change for all alternatives	—
Additional levee fill	No change for all alternatives	Levee prism and height do not change based on flow or channel width. Same hydraulic grade line. Can consider alternative levee configuration or setbacks to reduce levee costs.
Utility relocations	No change for all alternatives	—
Dewatering/other care of water	No change for all alternatives	Version 1 alternatives use cellular coffer cells and construction in the dry, requiring dewatering. Consider more in-the-wet construction alternatives.
Approach channel revetment	Reduction in materials/piling	Version 1 alternatives use cellular coffer cells and construction in the dry. Consider using more in-the-wet construction to eliminate materials.
Control structure	Reduction in materials/piling	Control structure required for all alternatives
Mechanical and electrical building	No change for all alternatives	—
Diversion structure outlet channel	Reduction in materials/piling	—
Transition structure	Reduction in materials/piling	Eliminating curvilinear wall systems would reduce project costs
Back structure	Reduction in materials/piling	Relocation of back structure in line with NOV Levee would reduce wall system costs
Pump station	No change for all alternatives	Same drainage area needs to be managed. An inverted siphon or other project realignment that would preserve use of existing drainage patterns could reduce costs.

Note: NOV = New Orleans to Venice

3.1 Initial Value Engineering Concepts

An initial VE brainstorming session was held with HDR subject matter professionals to consider other major cost saving ideas to incorporate into the design. The initial brainstorming session yielded the results shown in Table 3. The VE ideas that have been carried forward into the alternatives analysis and cost estimating are as indicated. The remaining ideas are still valid, but insufficient information exists to advance them at this stage in the analysis.

Table 3. MBSD VE concepts applicable to alternatives

Concept	Description	Approaches
	VE concepts advanced	
Construct in-the-wet	Build and install functional project elements without dewatering.	• Construct channel in wet with dredge. • Use immersed tube tunnel for inlet. • Use tremie concrete floor elements. • Assemble with precast elements.
Convey flow in pressure conduit under MR&T and past existing rail alignment	Use immersed tube tunnel for rail to remain on or near existing alignment, eliminating rail bridge and reducing right-of-way.	• Use cellular coffer cells to provide excavation support. • Barge precast tunnel elements to site and assemble in wet or construct a steel frame and form system to set in place in wet (concrete tremied in to form tunnel).
Reduce amount of surcharge	The location of the guide levees adjacent to the diversion channel results in diversion channel slope instability. Set levees back or use lighter weight levee section to reduce need to strengthen channel side slopes.	• Set levees farther back from channel. • Use geofoam levee section.
Replace ACB mats on berm and levee slopes	Use ACB mats on berm and levee slopes to prevent erosion (as required by base design velocities).	• Set levees back to reduce amount of surcharge, which results in lower overbank velocities and allows use of soil anchor turf systems in lieu of ACB mats.
Reduce or eliminate transition walls	Transition structure and transition walls result in a more hydraulically efficient system. They must be pile-supported with substantial geostructural improvements for stability.	• Eliminate the transition and curvilinear walls, which would result in larger eddies at exit of diversion structure and entrance to back structure. Cost savings may warrant slightly reduced efficiency.
Optimize inlet efficiency	Reduce discharge and costs while optimizing sediment delivery.	• Lower invert of inlet channel/tunnel. • Use immersed tube or tunnel inlet. • Modify orientation of inlet channel.
Eliminate constructing top 15 feet of channel in the dry	Initial assumption was that initial excavation of pilot channel would be in the dry. Use a large drag line to allow construction in the wet without dewatering.	• Construction in the wet is preferable from a slope stability standpoint. • Use a drag line to excavate and side cast over levee alignment for surcharge. • Initial pilot channel allows use of barge-mounted dredge to excavate remainder of channel.

Table 3. MBSD VE concepts applicable to alternatives

Concept	Description	Approaches
Replace pump station with inverted siphon	Using an inverse siphon to convey flow from north drainage area to the south would eliminate need for pump station.	• A multitube inverse siphon with a presettlement basin could be effective.
Reduce or eliminate interior inlet channel walls	The interior channel walls serve two purposes: to align flow with gates and to serve as a debris barrier. Eliminate the walls to reduce construction costs.	• Use coffer cells for inlet to eliminate interior walls for inlet channel. • Retain interior walls for inlet channel and outlet channel from diversion structure.
Delete back structure	Back structure decision was made to preserve federally approved NOV alignment and to allow modification of road and rail impacts.	• Full risk-based decision process may result in lower risk/cost solution to federal alignment question. • A tunnel approach may allow road and rail to remain at existing grade and allow back structure approach to be revisited.
VE concepts not advanced		
Prefabrication of structural elements	Use a modular design approach to facilitate prefabrication of major structure elements for assembly versus cast-in-place.	• Use modular design elements. • Use barge delivery. • Use steel frame and tremie systems.
Move diversion structure 300 feet closer to Mississippi River	Use immersed tube tunnel and keep rail on or near existing alignment—necessitates relocation in line with MR&T.	• Preferred gate system for immersed tube tunnel would be a lift gate system rather than a radial arm gate. • Gate on "wet" side of MR&T—a short section of precast pressure conduit is needed to keep rail on its alignment.
Road bridge modification	Current bridge is LADOTD standard; evaluate other types to reduce costs.	• Driving factor is clearance over levee and access roads.
Alternative guide levee section	Current design uses clay levee with seepage berms to manage seepage through and beneath levee system.	• Use sand core levee with clay cap. • Use chimney and/or toe drain to manage seepage and use alternative backfill materials for levee.
Reduce road and rail bridge height and length or eliminate need for bridges	FLOW-3D results indicate lower design water surface elevations, which may allow for lowering the low chord of both bridges. However, access issues may ultimately control bridge height.	• Using lower hydraulic grade line would necessitate reevaluation of road access routes. • Tunnel under road/rail would eliminate need for bridge systems.

Notes: ACB = articulated concrete block, LADOTD = Louisiana Department of Transportation and Development, MR&T = Mississippi River and Tributary, VE = value engineering

3.2 Value Engineering Concepts Carried Forward

VE 1: Construct In-the-Wet

The in-the-wet construction VE alternative focuses on the inlet channel from approximately Station 20+50 to Station 28+00. This segment of the project would be located riverside of the Mississippi River batture. Figure 5 illustrates the base design concept, which involves construction in the dry through advancing a series of cellular coffer cells into the Mississippi River, installing the required dewatering systems, and placing a significant quantity of rip-rap to manage scour expected to occur around the coffer cells. Cast-in-place concrete channels that are structurally independent of the cellular coffer cells would be constructed within the coffer cells.

HDR screened the wall systems that could be constructed in the wet. Table 4 summarizes the systems evaluated. Of these, two were considered feasible, and additional design analysis was completed to further size and evaluate their feasibility. The two systems carried forward for additional analysis were an interlocked pipe pile wall system and a cellular sheet pile wall system. Appendix B provides additional details on the wall analysis.

Table 4. Diversion inlet wall systems summary

Wall type	Wall design tool	Pros	Cons	Status
Pipe pile wall	Shoring Suite, PYWALL, LPILE	Interlocks improve alignment during driving; leverage experience from storm surge barrier project; piles can be driven with a follower down to revetment grade	Large diameter limits availability of specialized equipment to install wall system	Evaluate for 30% design screening
Cellular cofferdam	USACE Guidance or USS Sheet Pile Manual	Common technique used for open-water construction	Relatively large cofferdams proposed push up project cost; need to accommodate differential settlement of cofferdams	Evaluate for 30% design screening
Precast concrete pipe/box sections (jack and bore)	Not applicable	Install from dry side of levee using a jacking pit; jacking pit could also be base of diversion structure	Receiving pit is an issue for the in-river segment	Do not consider further
Deep soil mixing to form a channel with 2H:1V sideslopes	Not applicable	Avoids the need for structural elements and floor slab; scour resistant; select strength to provide stability but still be excavatable	Management and control of deep soil mixing in the wet is very challenging and has environmental concerns	Additional data needed under the revetment to fully evaluate applicability

Table 4. Diversion inlet wall systems summary

Wall type	Wall design tool	Pros	Cons	Status
Drilled shaft	Not applicable	—	Temporary casing through water precludes installation of drilled shafts in a secant fashion; soil would scour through gaps between shafts	Do not consider further
Concrete sheet pile	Not applicable	—	Cantilever height is not sufficient	Do not consider further

Note: USACE = U.S. Army Corps of Engineers

HDR conducted structural calculations and conducted informal constructibility reviews with professionals who have direct marine construction experience. The consensus of the reviews was that while the pipe pile wall system was feasible, the potential need for bracing and specialized pile driving equipment rendered the cellular sheet pile wall system the preferred wall system. A caveat to the preference for the cellular sheet pile wall system is the potential availability of the required special equipment to drive the pipe piles at the time the project is advertised for construction. Given the large amount of marine construction in the immediate Gulf Coast area, it is possible that the equipment may be readily available for use on the project, thereby reducing the cost of the pipe pile wall system.

VE 2: Convey Flow in Pressure Conduit under MR&T and Past Existing Rail Alignment

A major cost contributor and environmental factor in the MBSD project involves the relocation of the New Orleans and Gulf Coast Railway (NOGC) alignment and potential construction of a rail bridge over the MBSD channel. Geometric limitations and conflicts with other existing infrastructure render a vertical curve adjustment along the existing alignment impossible. Therefore, the base design concept, which includes open channel inlet systems, requires relocation of the rail alignment and construction of a rail bridge over the MBSD channel near the Belle Chasse Highway (LA 23) right-of-way.

Three pressure conduit concepts were developed as part of the VE analysis. The first was developed as Alternative 3, Version 2, which consisted of an immersed tube tunnel technology. However, an issue was identified with Alternative 3, Version 2, in that the 30-foot-high box installed at an invert of –40 feet would impede navigation. Two additional alternatives were developed.

Alternative 4 would use immersed tube tunnel technology, but the invert would be lowered to elevation –60 feet and the design would use a 15-foot by 200-foot flared inlet section that would transition to a 30-foot by 100-foot box—designed to better approximate the existing revetment slope. Alternative 5 would consist of three 35-foot-diameter tunnels with an invert at –60 feet mean sea level. A cellular coffer dam receiving area would be required, centered around Station 28+50 to receive the tunnel boring machine and to constructed a gated intake tower. The intake would consist of an immersed tube tunnel constructed similar to Alternative 4. A second cellular coffer dam receiving area would be needed at Station 80+00 just west of LA 23 to receive the tunnel boring machine and to construct a gated outlet and transition to the open channel outlet. Alternative 5 would avoid construction of both the rail and roadway bridges and would reduce the number of overall hydraulic structures. Alternative 5 would also eliminate the back structure, given the close proximity of the outfall gate at Station 80+00. Alternatives 4 and 5 are illustrated in Figures 6 and 7.

VE 3: Reduce Amount of Surcharge/Replace Articulated Concrete Block Mats on Berm and Levee Slopes

The base design of the conveyance channel and guide levee system sought to maximize the hydraulic efficiency of the water/sediment conveyance and to minimize the required rights-of-way. To satisfy these design criteria, the geotechnical investigation and analysis determined that wick drains and surcharging would be needed over a large area that encompassed the channel side slopes, stability berms, and levee section, as indicated in Figures 8 to 10. In this configuration, the weight of the levee and depth of the conveyance channel influenced the stability of each other and resulted in an integrated system design that relied on needed strength gains through the surcharging effort. Two VE ideas were developed to reduce the amount of wick drains and surcharge needed for the project. One involved the use of a geofoam core in the levee section to lighten the overall levee load and to reduce its influence on both settlement and the stability of the channel side slope. The use of a geofoam levee section also would have the ancillary benefits of reducing long-term clay borrow needs and perhaps reducing construction schedules.

The other VE idea involved increasing the levee setback from the channel. Setting the guide levee back farther from the channel would remove the guide levee from influencing the stability of the conveyance channel side slope. The channel side slope could be made flatter as long as it was constructed in the wet. The need for wick drains and surcharge would then be limited to just the levee and berm footprint, thereby reducing the total quantity of materials required. Additionally, by setting the guide levee back, velocities along the berm and levee side slope would be reduced such that armoring with articulated concrete block mat would not be required, furthering the cost savings. The modification may increase right-of-way needs and would result in some loss in hydraulic efficiency. However, those issues are offset by the realized cost savings. Typical sections for each of these VE ideas are presented in Figure 11.

VE 4: Reduce or Eliminate Transition Walls

Figure 2 illustrates the base design transition structure and associated transition walls for both the inlet transition and the back structure outlet transition. The governing criterion for these designs was constructing the most hydraulically efficient transition to minimize losses while maximizing discharge and sediment-carrying capacity. However, poor site soils are not capable of supporting traditional gravity wall systems. Geotechnical analysis determined that the walls would need to be built on pile-supported geotechnical platforms with tie backs to overcome the soil conditions. Eliminating these systems significantly reduce costs.

Figure 5. Base design concept (construction in the dry)

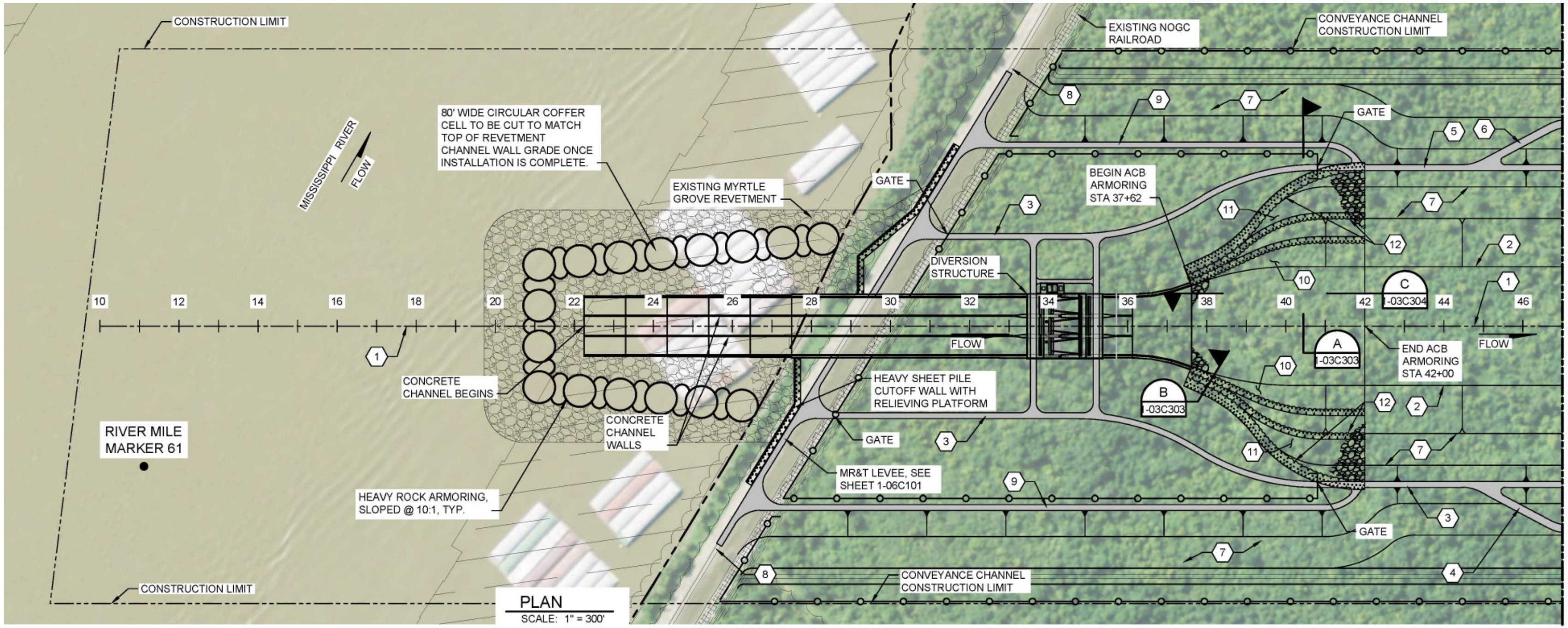


Figure 6. MBSD Alternative 4 (immersed tube tunnel)

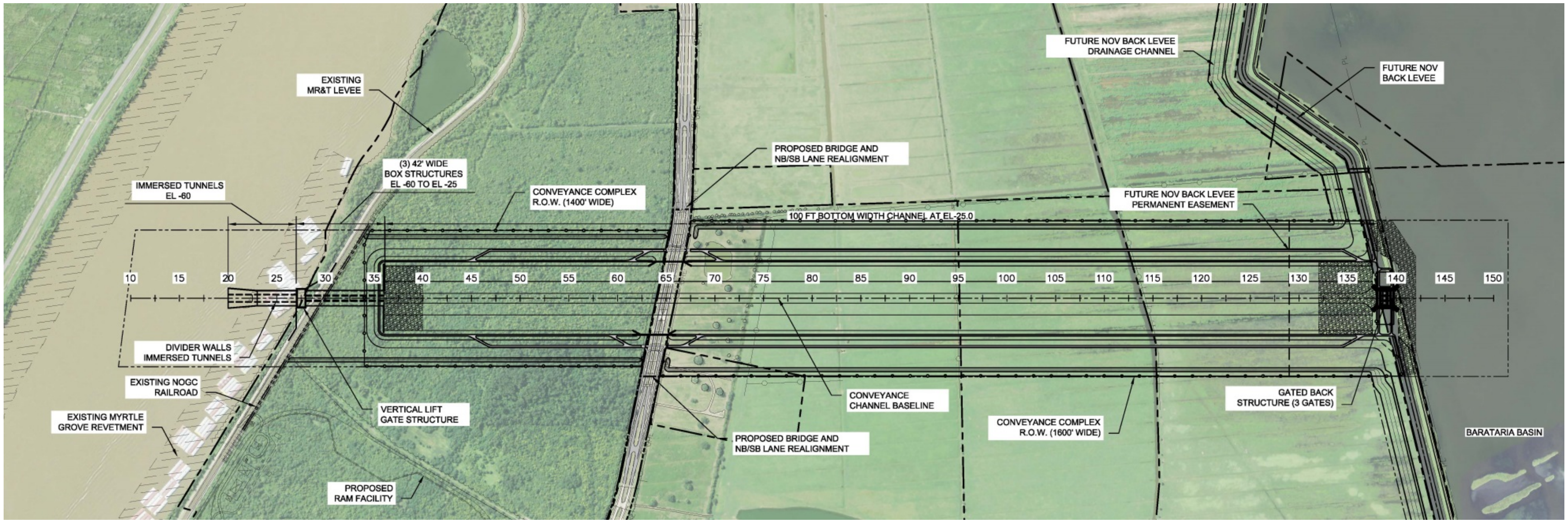


Figure 7. MBSD Alternative 5 (immersed tube tunnel)

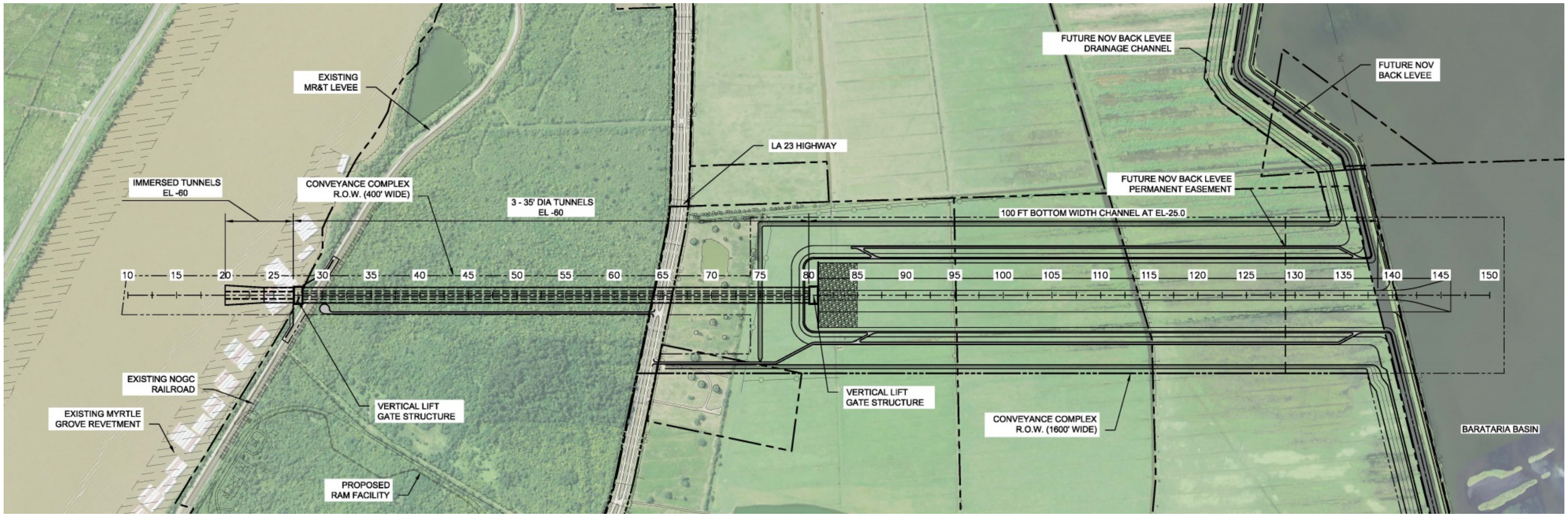


Figure 8. Surcharge area

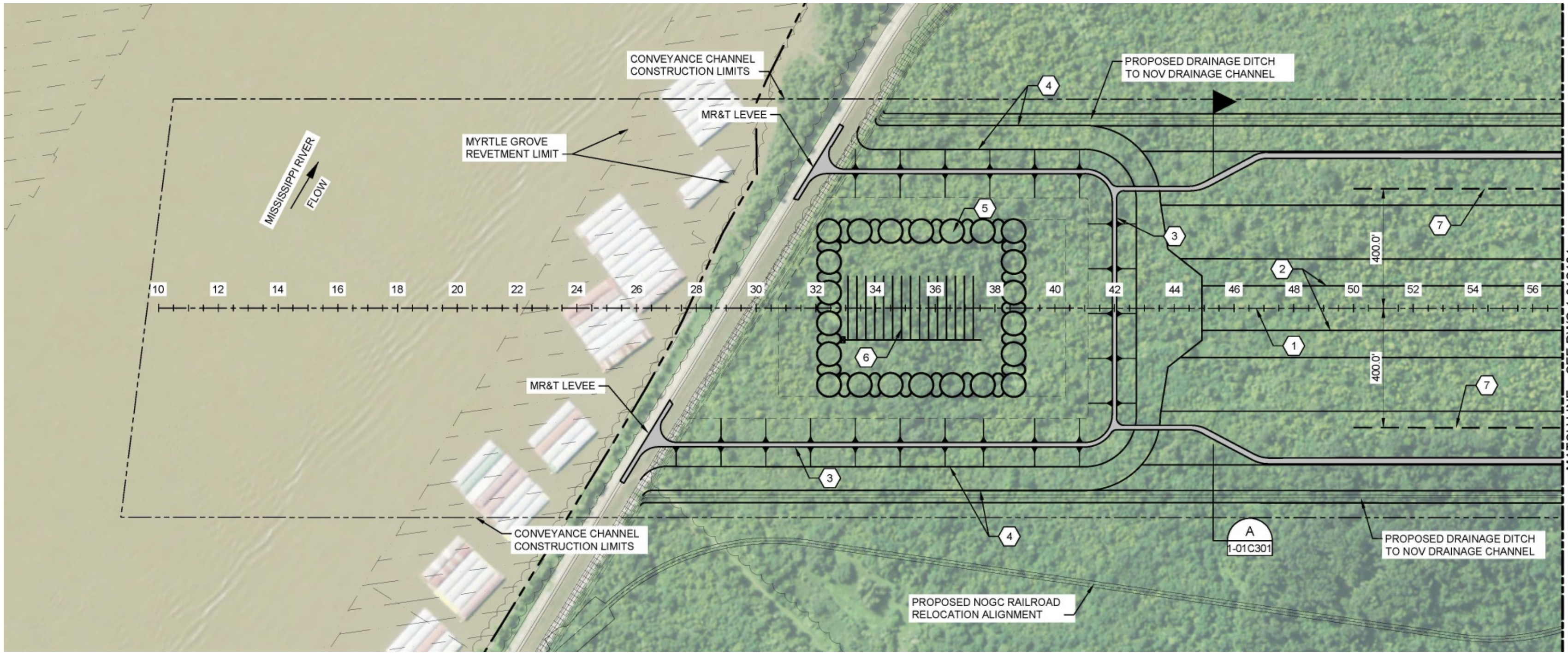


Figure 9. Surcharge area (continued)

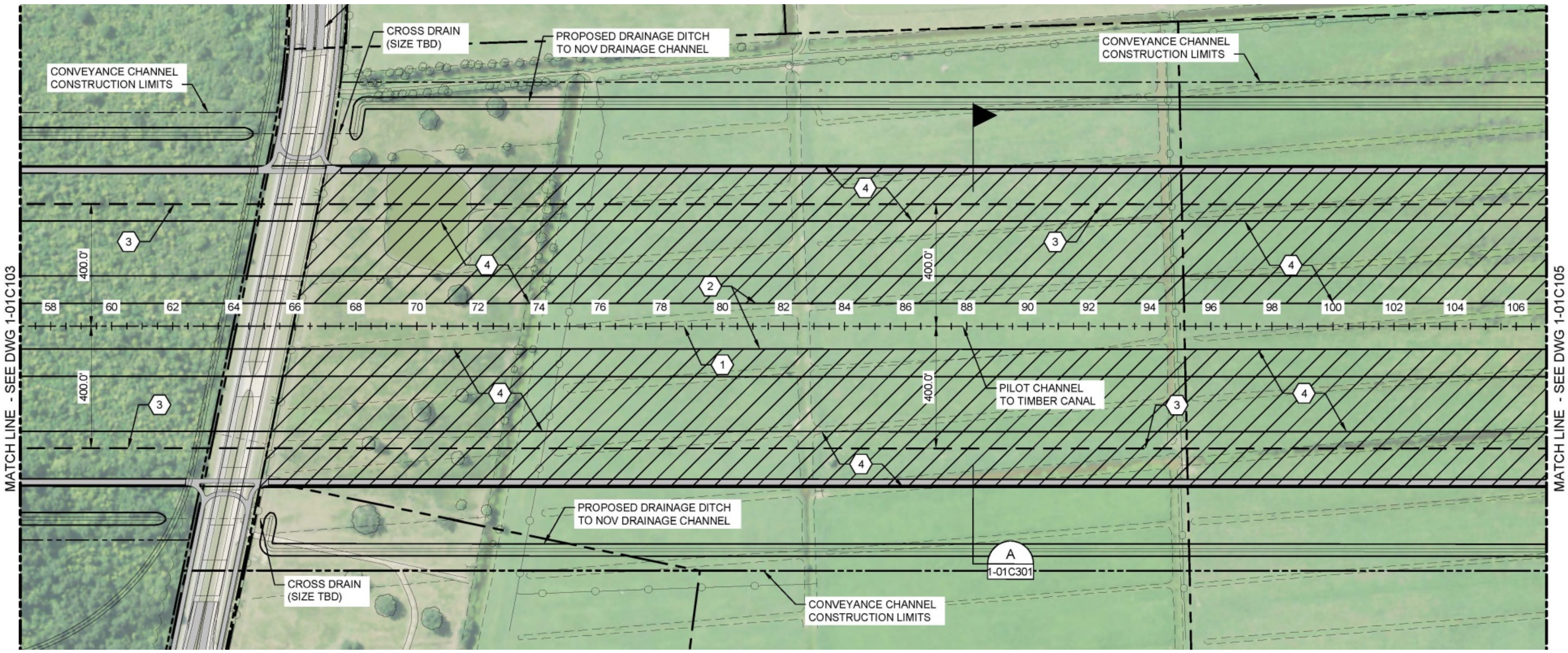


Figure 10. Surcharge area (continued)

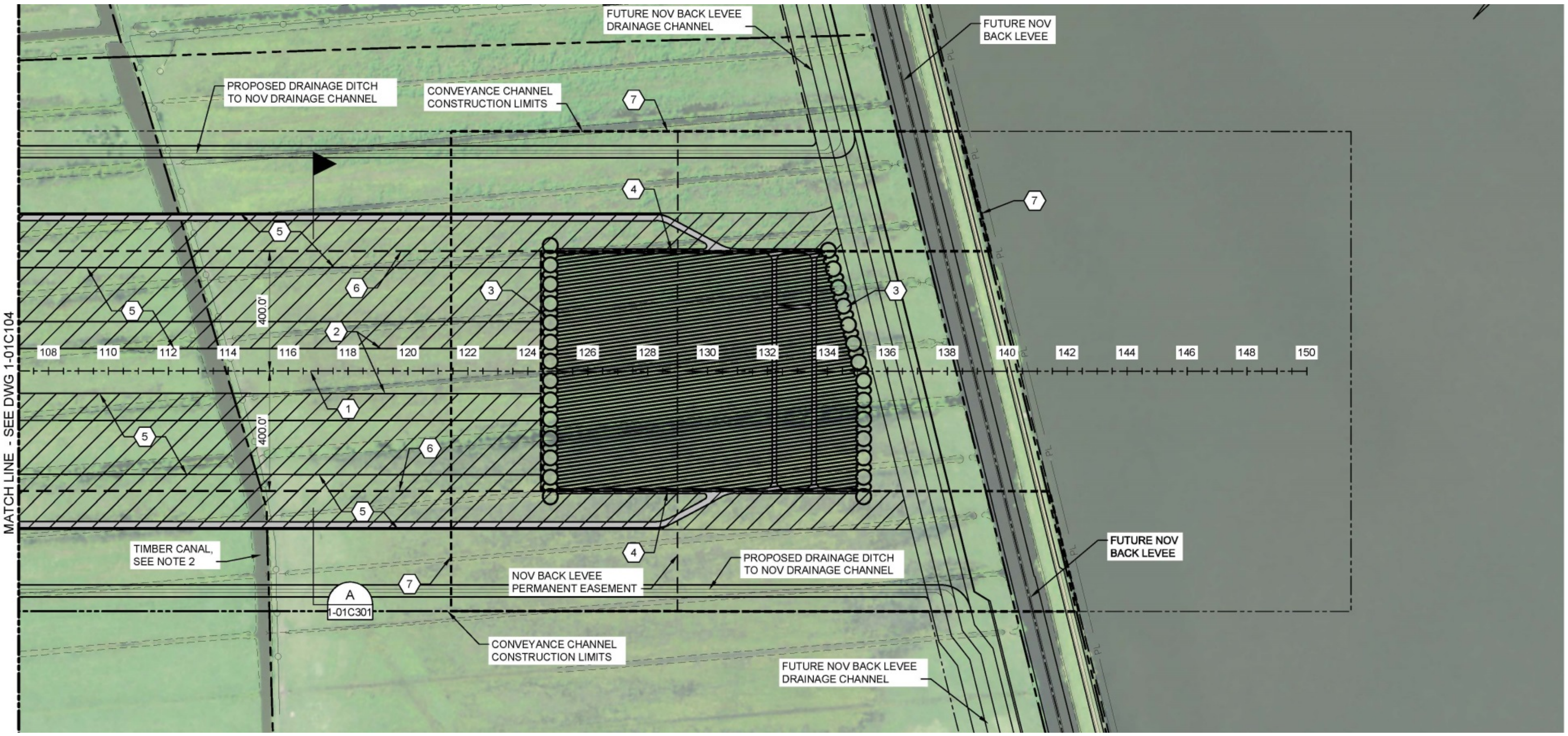
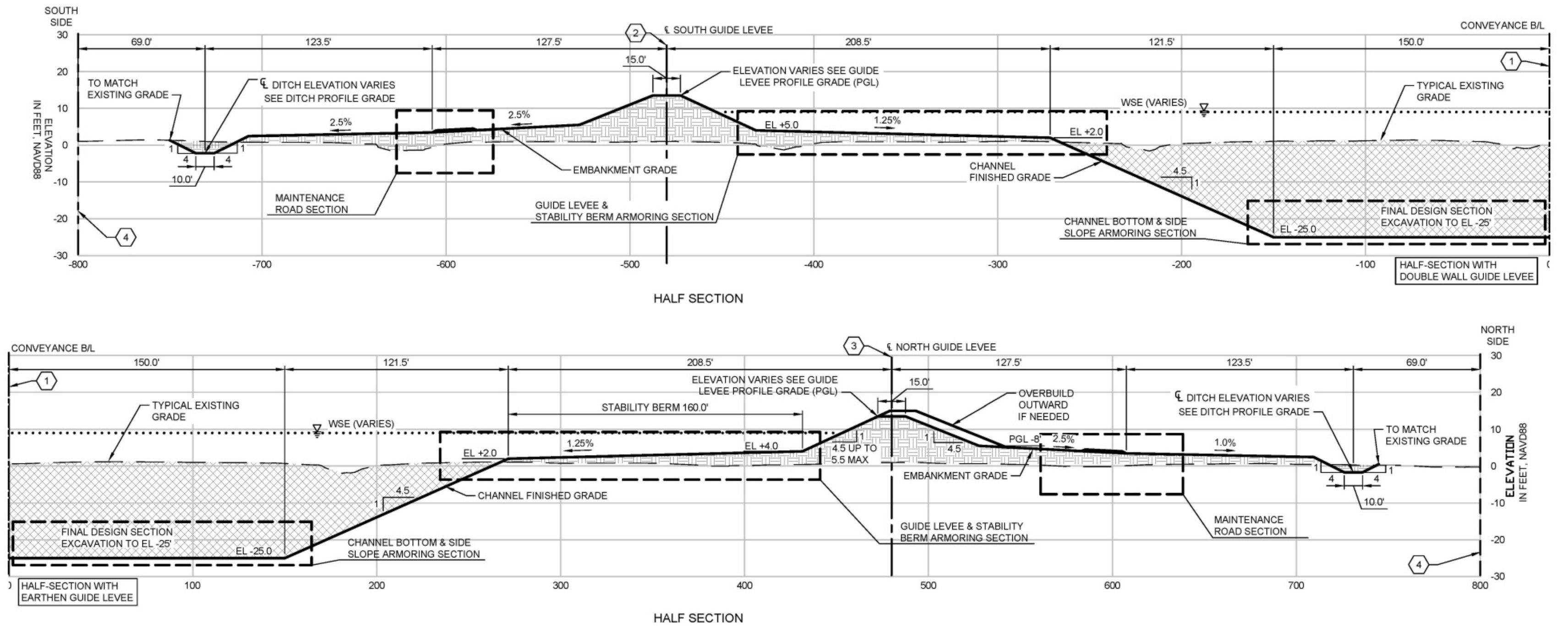


Figure 11. Typical sections (surcharge reduction VE idea)



The design concept was to create a more abrupt transition at the outfall of the diversion structure and the inlet to the back structure, as shown in Figure 12. The drawback is that a larger recirculating eddy would be created by the abrupt transition. It is likely sediment would deposit in the eddy area, which would form a more “natural” transition. There is a minor loss in overall hydraulic efficiency with the change; however, the cost savings warrant consideration of this project modification.

VE 5: Optimize Inlet Efficiency

A fundamental design criterion of the base 75,000 cfs design was modeling results derived from the CPRA/nongovernmental organization efforts to evaluate the optimum location and initial sizing of the MBSD (documented in the Louisiana Coastal Area’s 2011 report, *Myrtle Grove Delta Building Diversion Modeling Effort in Support of the LCA Medium Diversion at Myrtle Grove with Dedicated Dredging Project – Data Collection, Preliminary Design and Modeling Initiative*). The work demonstrated that for an open channel inlet of similar configurations, a 75,000 cfs average discharge would result in a sediment-to-water ratio of greater than 1.0. This result was determined to minimize potential shoaling in the Mississippi River and maximize sediment delivery to the Barataria Basin.

The concept of moving more sediment per unit volume of water is considered a VE idea because it would be possible to reduce discharge below 75,000 cfs while maintaining a sediment-to-water ratio greater than 1.0. Moving less flow while maximizing sediment delivery would allow for downsizing project features and reducing overall project costs while minimizing the potential for shoaling in the river. An extensive analysis of different inlet shapes was not completed in this phase of the project; however, the use of an immersed tube tunnel (and a lower invert of the immersed tube tunnel) is being evaluated under a separate hydraulic modeling effort.

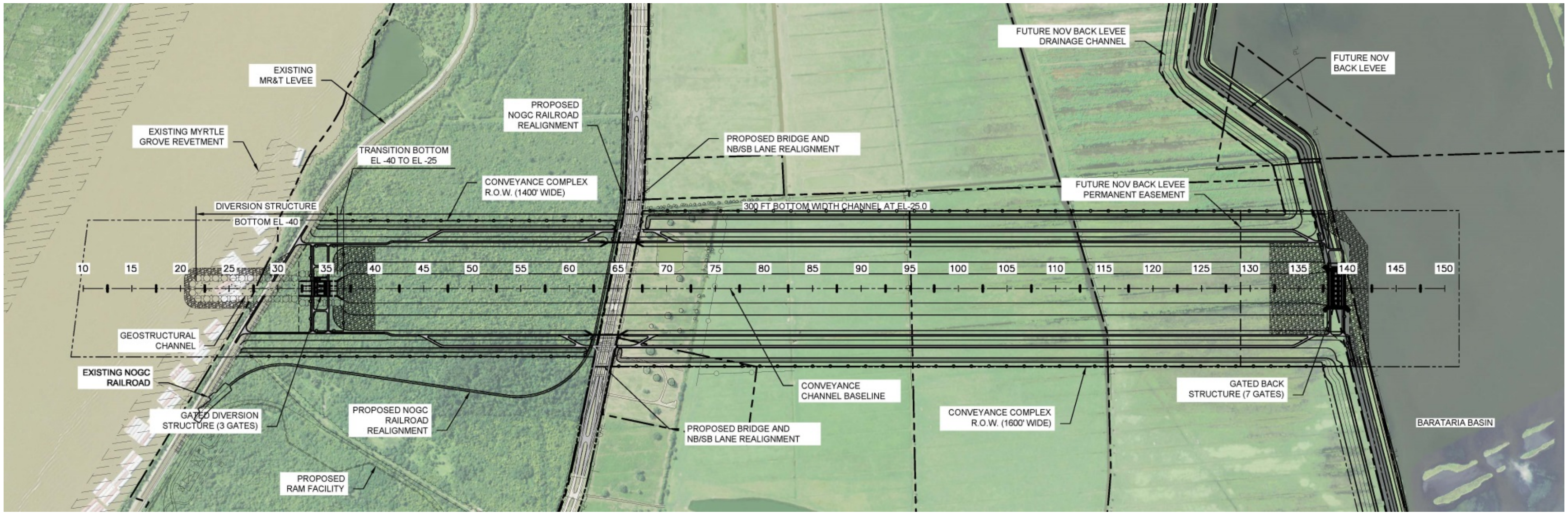
VE 6: Eliminate Top 15 feet of Channel Built in the Dry

The initial cost estimate for the project assumed that the upper 15 feet of the conveyance channel would be constructed in the dry. After reviewing pump test reports conducted as part of the geologic investigation, it was determined that dewatering and drying of the soils would create less stable conditions and would be cost-prohibitive. A drag line would be used to excavate an initial pilot channel in the wet, which would then allow for the use of a barge-mounted hydraulic dredge. Therefore, the dewatering costs were removed from the project estimate.

VE 7: Replace Pump Station with Inverted Siphon

CPRA staff suggested considering eliminating the pump station by using an inverted siphon to convey flows from the north to the south into the Wilkinson Pump Station. Appendix C contains technical information regarding the design considerations for the inverted siphon. The cost savings over the use of a pump station are on the order of $13 million. However, there are maintenance and performance concerns regarding its use. The concept was not carried forward but warrants further consideration in subsequent design phases.

Figure 12. Modified transition



VE 8: Reduce or Eliminate Inlet Channel Interior Walls

Under this VE idea, these walls were eliminated by using the cellular coffer cells to form the inlet wall systems. A tremie concrete flow was included in the design and the majority of the inlet channel system was constructed in the wet.

VE 9: Delete Back Structure

The back structure was removed from Alternative 5. A closure structure would be constructed just west of LA 23 and would be incorporated into the receiving/launching pit required for the tunnel installation.

3.3 Final Value Engineering Concepts Considered

The final VE ideas considered are as follows:

- Alternative 1, Version 2
- Alternative 2, Version 2
- Alternative 4, Version 2
- Alternative 5, Version 2

Alternative 3 was not considered further because the smaller flow, open channel inlet performance was inferior to any of the considered alternatives without significant cost savings. Alternative 3, Version 2 was eliminated from further analysis because the projection of the immersed tube tunnel into the water column was considered a navigation hazard. An analysis of the selected VE ideas is summarized in Table 5.

Table 5. MBSD alternatives and VE ideas

Alternative scenarios	VE 1: Construct in the Wet	VE 2: Convey Flow in Pressure Conduit	VE 3: Reduce Surcharge/ Eliminate ACBM	VE 4: Reduce or Eliminate Transition Walls	VE 5: Optimize Inlet Efficiency	VE 6: Eliminate Top 15 feet of Channel Built in Dry
Alternative 1, Version 2, open channel inlet, –40 feet msl invert (peak Q of 75,000 cfs)	Remove cast-in-place inlet channels; rely on coffer cellular walls with tremie floor for inlet channel	Not applicable	Set levee back farther from channel to reduce wick drains and surcharge volume	Modify diversion structure and back structure transition to eliminate wall systems	Not applicable	Applied
Alternative 2, Version 2, open channel inlet, –40 feet msl invert (peak Q of 50,000 cfs)	Remove cast-in-place inlet channels; rely on coffer cellular walls with tremie floor for inlet channel	Not applicable	Set levee back farther from channel to reduce wick drains and surcharge volume	Modify diversion structure and back structure transition to eliminate wall systems	Not applicable	Applied
Alternative 4, Version 2, immersed tube tunnel, –60 feet msl invert (peak Q of 25,000 to 35,000 cfs)	Cellular coffer system to support excavation; prefab tunnel sections barge-delivered; foundation system built in the wet or use prefab steel frame to sink in place and tremie concrete to form immersed tube tunnel	Eliminate rail bridge by maintaining existing rail right-of-way; use an immersed tube tunnel to transition flow in tunnel from –60 to –25 feet prior to diversion structure	Set levee back to reduce amount of wick drains and surcharge required	Modify diversion structure and back structure transition to eliminate wall systems	Modeling indicates immersed tube tunnel would extract more water from over sandbar and lower elevations in river, increasing sediment capture	Applied

Table 5. MBSD alternatives and VE ideas

Alternative scenarios	VE 1: Construct in the Wet	VE 2: Convey Flow in Pressure Conduit	VE 3: Reduce Surcharge/ Eliminate ACBM	VE 4: Reduce or Eliminate Transition Walls	VE 5: Optimize Inlet Efficiency	VE 6: Eliminate Top 15 feet of Channel Built in Dry
Alternative 5, Version 2, –60 feet msl invert[a] (peak Q of 25,000 cfs)	Cellular coffer system to support excavation; prefab tunnel sections barge-delivered; foundation system built in the wet or use prefab steel frame to sink in place and tremie concrete to form immersed tube tunnel	Receiving pit/lift gate structure constructed in line with MR&T; tunnel used to convey flow under both rail and roadway, eliminating both bridges	Levees set back to reduce amount of surcharge; wick drains and erosion protection required	Tunnel system would use a different inlet/outlet system that would be constructed as part of receiving pits to create transitions	Immersed tube inlet efficiency is improved over open channel inlet	Applied

Notes: ACBM = articulated concrete block mat, cfs = cubic feet per second, MR&T = Mississippi River and Tributary, msl = mean sea level, VE = value engineering

[a] Other VE ideas for Alternative 5 include eliminating the pump station and integrating the back structure into the outlet transition from tunnel to open channel.

Table 6 presents the proposed MBSD's general cost with value engineering ideas enacted for each alternative.

Table 6. MBSD cost summary, with VE ideas enacted

Item	Alternative 1, Version 2, three-bay system, 75,000 cfs	Alternative 2, Version 2, two-bay system, 50,000 cfs	Alternative 4 Version 2, flared immersed tube tunnel	Alternative 5, Version 2, flared immersed tube tunnel inlet with tunnel conveyance
Base construction cost	$570,000,000	$502,000,000	$506,000,000	$546,000,000

As shown in Table 6, the value engineering ideas enacted under Alternatives 1, 2, 4, and 5 would result in a reduced project construction cost—ranging from approximately $502 million to $570 million (compared with the project construction cost range of

$608 million to $750 million under the original Alternatives 1 to 3, as shown in Table 1). Appendix A provides a more detailed cost breakdown with associated contingencies.

It is realistic to consider that a design alternative under $500 million is possible. As previously discussed, Alternative 3, Version 2 was eliminated from further consideration because of navigational concerns. However, the less complex construction of the rectangular immersed tube tunnel resulted in a cost on the order of $460 million. This alternative may be feasible by lowering the invert to avoid navigation impacts and by downsizing the flow rate.

In addition, if a lower flow rate is desirable due to environmental or land rights issues, Alternative 5, the tunneling option, could come in under $500 million by eliminating one of the tunnel runs and simplifying the immersed tube tunnel inlet to match the rectangular inlet of Alternative 3, Version 2.

Also, all project cost estimates include the cost of the rail modifications. Should those costs not materialize, then further cost reductions are warranted.

4 Geotechnical Considerations

From a geotechnical standpoint, HDR reviewed several options for the guide levees that would potentially provide cost savings to the project. Cost savings can be achieved in several forms: materials costs, cost associated with time (either scheduled days or man hours), and costs associated with risk.

In the development of the guide levees and their locations relative the centerline of the conveyance channel, HDR determined that the locations had ramifications on slope stability and, therefore, on construction costs. The guide levees provide a driving force along the conveyance channel excavation slopes and require foundation strengths to resist sliding.

The following are value engineering options that could provide cost reduction opportunities. Memorandums discussing these in detail are presented in Appendix D.

- Relocate the guide levees farther from the conveyance channel centerline. Relocation of the levees far enough away from the conveyance channel centerline would remove their influence on the excavated slopes, thereby reducing the need to surcharge, wick, and strengthen the excavation slopes.
- Use lightweight fills in the core of the guide levees as a means of reducing the driving forces on excavated conveyance channel slopes.
- Install geotechnical fabric reinforcement along the foundation and levee footprint. As a means of transferring and spreading the load across the foundation materials, geotextile fabrics may be used in differing configurations. Currently, the NFL system is incorporating a single layer of 20 kip per foot geotextile along the foundation. Less expensive configurations should be considered in future design efforts.

5 Constructibility Considerations

HDR held a series of informal constructibility discussions with a cross section of construction professionals. Several constructibility issues and cost saving approaches were identified:

- Pouring a sloping tremie floor is difficult under water, conveys additional construction risk, and should be avoided.
- Constructing an enclosed system requires the use of some form of immersed tube tunnel technology. Either a precast concrete system or a prefabricated metal frame system fitted with a bladder is needed to receive tremie concrete under water to form an in-place structure.
- Consider the addition of permitted laydown, river access, and material storage areas. Do not leave it up to the contractor to obtain permits/approvals
- Consider obtaining a temporary construction servitude for a larger area to thin spread clay borrow to promote drying and conditioning of levee material.
- In the design of intakes, channels, and diversion structures, to the extent practicable, consider use of modular design and simple shapes to promote the use of precast sections and ease form work.
- Incorporating an outfall pilot channel would create opportunities to access the project from the basin side and allow for entry of equipment and materials for the back structure and pump station by supply and crane barge.
- The issue of U.S. flagged vessels would need to be addressed if supplies are delivered by waterborne vessels.
- Preference for large modular precast/prefabricated components puts a premium on accurate foundations and connections.
- A multistep design-build approach would make sense for the final design and construction of the inlet and diversion structure systems.
- Sand can be dredged from the river to provide construction road access and surcharge materials for improving foundation conditions.
- A 16- to 30-inch dredge may be used to excavate the conveyance channel.
- A 42-foot-wide radial arm gate bay is too narrow to allow barge access to the channel. Consider making one bay 50 feet wide to ease constructibility.
- Tunneling does appear feasible, but the big questions are availability of equipment and flexibility in the exact diameter of the tunnel. With more flexibility, it is more likely a lower-cost piece of equipment could be located.
- Working crane barge would be on the order of 80 feet wide, with a 30-foot-wide supply barge alongside. Drafts would be on the order of 8 to 12 feet, depending on the equipment.
- If interlocking pipe piles are used, the largest practical diameter for this area without looking for specialized equipment is on the order of 66 to 80 inches.

Initial assessments of the immersed tube tunnel technology considered an on-site casting yard and dry dock. The construction professionals agreed that they would prefer to use one of the several large marine casting yards within the New Orleans/Gulf Coast area. Using an existing casting yard would likely improve cost and quality control management. Therefore, it is likely that the contractors would prefer to use local casting yards for precast elements and delivery by barge, rather than relying on on-site fabrication.

Alternative 5 involves application of a different technology: use of a tunnel boring machine. Alternative 5 would convey a flow of approximately 25,000 cfs and would consist of three 35-foot-diameter tunnels. HDR requested that Gall Zeidler Consultants provide an initial overview of the applicability of tunneling to the MBSD project site. The following summarizes their conclusions:

> The geotechnical conditions along the alignment are not easy, taking into consideration the abrupt changes that might be encountered due to the nature of the fluvio-deltaic sedimentation, the high water content combined with the high plasticity clays particularly on the SW side as well as increased organic content. However, the geotechnical conditions are well within the realm of EPB TBM (Earth Pressure Balanced Shield Tunnel Boring Machine).

The plan view of Alternative 5 is presented in Figure 7. The launching pit would sit on the western side of LA 23, and the receiving pit would be constructed at Station 28+00. The tunnel boring machine would advance, on average, 40 feet per day and would be followed by reinforced concrete rings. Excavated material would be removed either by slurry or by screen conveyor. The receiving and launching pits would then become the gated inlet and outlet systems for the project.

Selection of the appropriate contractor and project delivery method can have a significant impact on the project cost risk profile and overall cost and value. CPRA is provided significant project delivery flexibility under Louisiana R.S. Title 49, Chapter 214.6.2. Authorized project delivery methods include:

- conventional design-bid-build
- design/construction management at risk
- design-build
- design-bid-operate-maintain
- design-build-finance-operate-maintain

HDR conducted an integrated delivery analysis of the MBSD to determine which project elements would most benefit from use of integrated delivery. Major elements include:

- roadway and railway relocation
- new bridges
- pump stations
- inlet and control structures

- conveyance channel and guide levees
- back structure and outfall

The conclusion of the analysis is that the roadway, rail, bridge, and pump station can be considered stand-alone facilities, are low-risk, and can be built using traditional construction methods. HDR recommends design-bid-build as the preferred procurement method for these project components, given their low-risk and stand-alone nature.

In contrast, the inlet and control structures, conveyance channel, levees, back structure, and outfall have a much higher risk profile, would be built using specialized construction means and methods, and would benefit from collaboration and innovation. HDR recommends that progressive design-build be used to deliver these aspects of the project.

Figure 13 presents a flow chart for implementing progressive design-build on the MBSD. Careful consideration and further work are needed regarding navigating the Section 408 review process. The exact timing of starting the procurement process in coordination with the U.S. Army Corps of Engineers will be required to gain its acceptance of the process.

6 Summary of Value Engineering Effort

In addition to the above-described analysis, HDR contracted with GEI Consultants and Bittner-Shen Consultants to review its VE ideas and to generate additional areas of investigation for consideration. There are a number of potential opportunities to further reduce project costs. Table 7 provides an overall summary of all VE ideas generated to date. Additional information and design analysis are needed to fully consider and/or incorporate these VE ideas. Of these, the immersed tube tunnel, levee setback, and transition improvements appear to provide substantial cost reductions.

Given the sheer size of the MBSD project, the three major cost reduction opportunities are (1) minimizing redundant construction (separate temporary and permanent features), such as the inlet channel; (2) modifying the design and construction assumptions of the conveyance channel and guide levees to eliminate double handling of material; and (3) potentially leaving the railroad and perhaps the road along the current alignment if conveyance can occur under pressure in a tunnel.

Detailed cost breakdowns and schematic design plans are provided in Appendix A. These cost breakdowns also include additional contingency information to evaluate an optimistic and a pessimistic estimate of construction costs. Major cost-risk items relative to the overall project remain potential mitigation costs for project impacts or basin-side land rights issues. Insufficient information is available to accurately estimate these costs at this time.

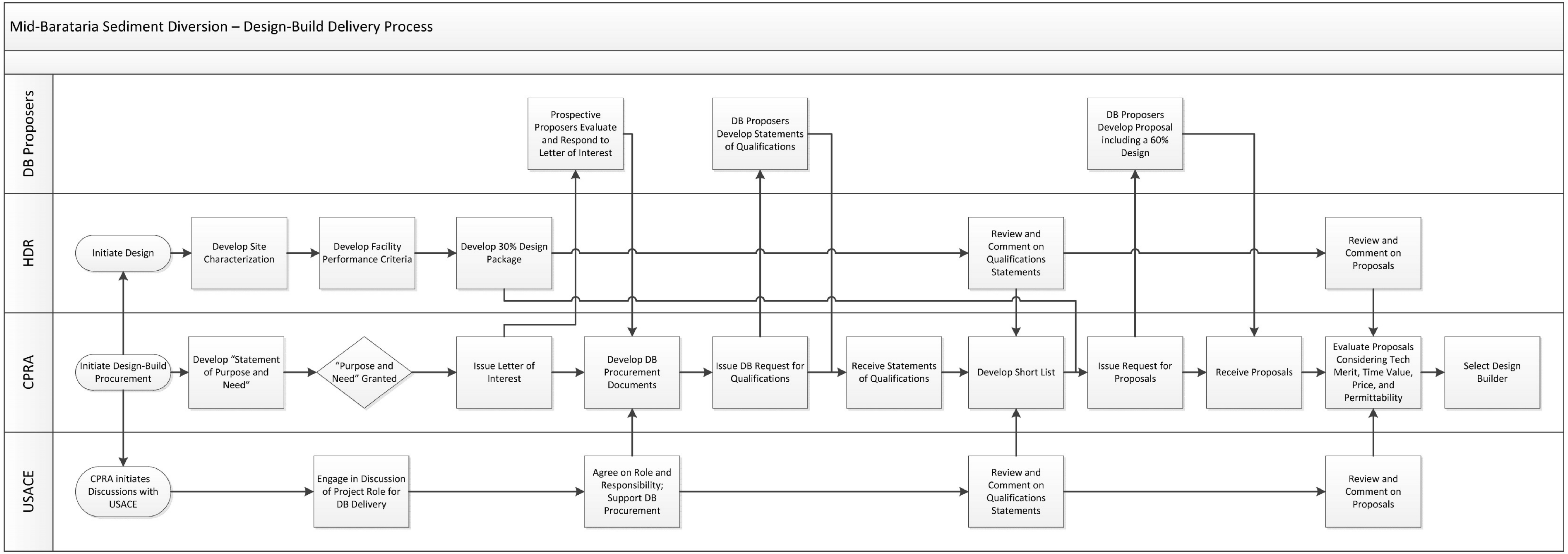
This VE effort focused on identifying design and construction features and methods to reduce construction costs. It did not address operational performance, sediment delivery efficiency, or environmental outcomes or benefits. Subsequent analysis will need to evaluate the overall cost and value of the selected alternative.

7 Future Work Efforts

Assuming the MBSD project proceeds with project scoping, HDR developed Table 8 to summarize, by discipline, suggested work elements to support each phase of the NEPA process and to continue design advancement.

The primary issue facing further design development is determining the desired project outcome, which will then affect the design flow. Once the design flow is determined, then the inlet configuration can be optimized for sediment capture. Once these criteria are established, sufficient information will exist to continue additional design development.

Figure 13. Process flow chart



Notes: CPRA = Coastal Protection and Restoration Authority of Louisiana, DB = Design-Build, USACE = U.S. Army Corp of Engineers

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Inlet channels, approach channel, control structure, transition structure, back structure	• Construct in the wet for selected structures	• Alternative delivery method reduces costs • Allows onshore precast and/or prefabrication • Expedites construction and minimizes risks associated with constructing/maintaining cofferdam • Reduces the number of construction sequences	• Difficult geologic conditions require building two substantial structures if completed in the dry	• Special construction methods increase risks for placement and securing	• Proven construction technology and methods • Chartering and partnering meeting between contractor, owner, and engineer	• Utilize for inlet channel excavation and inlet channel construction
Back structure	• Move back structure 600 feet west to align with NOV levee	• Reduces project costs • Eliminates need for composite wall structure • Eliminates 600 feet of outfall channel armoring • Aligns gate structure with NOV levee • Potentially reduces exit losses at expansion	• Potential storm surge impacts not changed • USACE will prefer alignment • Can consider in-the-wet construction options	• Requires temporary NOV levee setback and relocation of Shell pipeline; structure directly exposed to storm surge and debris along face of levee with no wave attenuation • Construction requires significant soil strengthening measures, regardless of location	• NOV levee tie-ins and bank armoring are most critical design locations	• Incorporate into design
Approach channels	• Cover approach channel with top slab from Station 20+50 to Station 32+50 • Maintain rail at existing grade	• Reduces project costs • Eliminates 10 feet of open channel vertical height for 250-foot section • Allows railroad to be reconstructed along existing alignment • Allows MR&T to be restored on existing alignment with floodwall at elevation 17.5 feet across structure • Capture efficiency of sand potentially improved	• Railroad alignment along existing servitude eliminates right-of-way issues and limits relocation length • Use of covered system braces wall system and improves structural stability • Reduces project environmental footprint; minimizes wetland impacts and rail fuel consumption • Potentially Improves stability of levee/channel tie-in	• USACE would have to approve covered structure under MR&T alignment • Railroad proximity to gate structure when operating increases vibrations in adjoining soils • Issue of debris loading and channel plugging needs to be resolved • Requires relocation of rail to an alternative alignment	• Contractor/fabricator coordination • Design of debris management system • Closure structures	• Do not carry forward because immersed tube technology is recommended approach
Approach channels	• Move control structure beginning station from Station 33+45 to Station 30+45	• Reduces project costs • Deletes 300-foot approach channel deep wall structure • Head loss reduced through diversion structure • Flow and sediment-water ratio from sandbar is potentially increased	• Control structure still located land side of MR&T levee and NOGC existing alignment • Temporary setback levee and cofferdams provide flood risk reduction while MR&T levee degraded	• Proximity to river increases risk due to potential changes in river morphology • Bottom seal, dewatering more critical in the short term • Seepage cutoff and sectional stability critical • Potential instability of point bar deposit	• Location has been relatively stable over past century • Myrtle Grove revetment protects bank stability • Other industrial structures upstream closer to river • River alignment will be maintained by USACE	• Put on hold pending 60% design analysis of point bar stability

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Surcharge fill over wick drain sand layer	• Reduce amount of proposed surcharge by placing minimum surcharge material and monitoring	• Reduces project costs • Additional surcharge material added to targeted areas based on monitoring	• Embankment height after settlement will be nearer to proposed finish grade • Maximizes benefits of surcharge material placement to areas subject to the greatest subsidence	• Increases time required for dewatering	• Surcharge added to select rather than broad areas based on settlement and pore pressure monitoring	• Put on hold pending 60% design analysis of point bar stability
Stability berms, levee foreslopes	• Replace ACB with soil-anchored turf stabilization mat	• Reduces project costs • Velocities along stability berms and levee foreslopes can be stabilized with mat for scour protection	• Sand filter still protected for dispersive clays with soil-anchored turf mat system • Scour protection for velocities along overbank in channel section still provided	• Does not provide geostructural bridging benefits of ACB mats for maintenance equipment • More susceptible to deformation, tearing, and rolling with surface loads	• Lime stabilize subsoils to strengthen and bridge underlying weaker soils • Provide sand layer to contain underlying dispersive clays and allow draining for channel rise/drawdown	• Incorporate as part of increasing levee setback
LA 23 channel crossing	• Replace bridge structure with pier walls and top slab box structure and construct LA 23 on minimal fill over structure if rail can be maintained on existing alignment	• Moving railroad back to original alignment over covered structure allows road grade to be lowered with decreased transition length • Bridge replaced with box structure • Road section on grade with better all-weather access • Utility relocations can be across top of structure	• Floodwalls under bridge eliminated and replaced with headwalls on each end to guide levee height • Box structure will be preferred by LADOTD because of inspection/maintenance requirements • Enclosed section is non-pressure flow • Distributes loads more evenly on subsoils • Provides scour protection with concrete bottom	• Increases head loss through channel reach • Entrance/exit losses and scour potential	• Box structure length would be minimized • Scour protection can be provided at inlet/exit • Box openings can be optimized to minimize energy losses	• Hold for 60% design analysis and further coordination with LADOTD
Transition walls	• Eliminate transition walls by sizing more abrupt transition	• Reduces project costs	• Small amount of hydraulic efficiency loss, but for significant cost savings	• Abrupt flow transition • Larger eddy	• ACB mats will stabilize section for flow transition	• Transition walls were eliminated in VE analysis and applied to alternatives
Inlet channels, approach channel	• Lower interior channel partition walls 10 feet below exterior walls	• Reduces project costs • Reduces turbulence across interior partition	• Potentially improves inflow characteristics	• Requires hydraulic evaluation to assess impacts	• Optimize inlet hydraulics with additional modeling	• Interior walls for inlet channel eliminated • Hold approach channel walls for 60% design
Back structure	• Delete back structure and transition walls • Delete levee tie-ins • Delete armored outfall channel • Install closure gates on LA 23 crossing downstream	• Significantly reduces project costs • Reduces energy losses and increases conveyance • Reduces restrictions on outflow into basin	• Guide levees would be constructed and permitted as part of NOV levee system west of LA 23 • Maintains storm surge gate control within forced drainage area between MR&T and LA 23	• See back structure memorandum	• Gates at LA 23 constrain storm surge and NOV levee line of flood risk reduction system west of highway • Road, railroad, guide levees, and structures between LA 23 and MR&T levee not within USACE system	• Back structure moved in alignment with NOV Levee • Transition walls eliminated

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Geostructural hybrid levee section	• Construct double sheet pile wall section along both sides of guide levees west of LA 23 • Decrease stability berm width because of seepage cutoff sheet pile wall stabilizing channel slope	• Mitigates long-term costs associated with rebuilding earthen levee section as consolidation occurs • Reduces stability berm width, surcharging, wick drains, sand and armoring costs	• Requires two sheet pile walls; one sheet pile wall is already included in cost estimate as seepage cutoff wall along levee centerline • Provides more manageable guide levee and scour protection system as armored levee foreslope settles • Provides double seepage cutoff wall system	• Replaces earthen section with a geostructural system that is subject to long-term corrosion and limited design life	• Provide corrosion protection measures for steel • Deep anchor sheet pile wall to mitigate long-term movement horizontally due to area soil movement • Leave walls projecting for pile downdrag	• Considered, but cost to benefit does not appear attractive • Hold for further analysis
Transition walls, control structure, and back structure	• Replace tiered sheet pile walls with reinforced CB walls supported by relieving platforms constructed by top-down methods; tallest wall to provide earth retention during construction, reducing temporary shoring requirements	• Provides an integral reinforced structural wall • Top-down construction reduces time required for excavation dewatering • Reduces need for temporary shoring deep excavation • Reduced corrosion consideration and sheet pile joint leakage consideration • May be able to replace relieving platform with construction of CB wall cells	• Allows construction to proceed with reduced temporary shoring and dewatering • Reinforcing can be designed to provide a more ridged wall where required with inclusion of steel H-beams and/or vertical rebar mats • Provides a more uniform surface for hydraulic transitions • May be able to replace relieving platforms with cell construction	• Potentially higher cost of CB wall • Connection between CB wall and relieving platform may be more involved than for sheet pile wall • May not perform as intended in weak, soft, compressible soils present at back structure	• Reinforce for elastic behavior • Install relieving platform before wall construction • Design wall for dewatered temporary condition • H-beams can be advanced to provide vertical support to wall in more competent foundation layer	• To be considered should transition walls prove to be required in subsequent project phases
Inlet channel walls	• Replace cast-in-place structure with in-the-wet pipe pile wall system with bracing	• Allows top-down construction, having the walls braced • Piling integral with wall; interior piling driven with follower to specified top elevations for uplift resistance	• Currently proposed in-the-dry construction requires installation of shoring and dewatering prior to structure construction • Top-down method reduces schedule for wall construction • Construction of vertical walls does not limit to dewatering phases	• Installation of bracing system • Bracing may impede hydraulic performance	• Contractor/fabricator partnering • Test pile program to develop site-specific design information	• Evaluated as part of VE • Constructibility concerns • Eliminated from further consideration
Inlet channel conversion to tunnel	• Use tunnel bore machine to tunnel from west of LA 23 to receiving cofferdam in river • Eliminate road, rail, and inlet system impacts	• Does not penetrate existing levee; places culvert system in more competent granular soils • Avoids rail and road raise • Reduces amount of coffer cells and dewatering	• Deep excavation through the MR&T levee and river banks entails considerable risk and cost • Tunneling river reduces those risks	• Risk of plugging need for cleanout • Vertical structure could be navigation hazard • Advancing culvert system in denser materials may be problematic • Excavation technique will drive type of culvert system	• Use inclined intake structure with gate controls • Have stop log closures on land side	• A variation is being evaluated as a tunnel that performs similarly • Immersed tube tunnel of inlet would be preferred approach

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Conveyance channel cross section	• Replace single wide channel with multiple channels to lower the in-channel water surface elevation and reduce the required height of guide levee	• Reduces height of guide levees and guide levee construction-induced sediments • Provides better means of operating at a lower discharge levels • Flattening slope reduces slope instability concerns and may remove/reduce wick drain and surcharging needs • Easier to cross highway with box culvert-like structures • Installation of channel lining not as complicated	• Need for wick drains and application of surcharge fills is driven by both the channel slope inclination and height required for levee • If flows can be contained within excavated channels, then tall guide levees are no longer primary conveyance systems (for example, three 12-foot-deep channels with 10:1 side slopes and 25-foot wide bottom width)	• Conveyance footprint would be wider and excavated volume slightly greater • Transition between inlet and conveyance would be more complex, resulting in three separate smaller back structures • Risk that one channel would receive more flow than other, requiring a meting structure • Lower guide levees increase risk of overtopping during operation • Cost to provide access to center channel for maintenance	• Replace earthen guide levees with sheet pile walls to provide freeboard • Three-bay structures would feed into an individual canal	• Hydraulically not feasible • Not carried forward
Structure backfill	• Use a combination of "marina" ramp structures and geofoam lightweight materials to raise site grades and provide access to the control and back structure top slabs for maintenance • Currently proposed normal weight fill option would induce significant short- and long-term settlements, requiring maintenance and subject tie-in walls to federal levees to significant vertical and lateral loads	• Use of marina-style ramps with a fixed connection on the structure and a free end on the top of fill would allow for smooth access between structure and adjacent ground surface • Even with wick drain and surcharge treatment, long-term settlements would occur, resulting in differential settlements • Geofoam backfill would reduce imposed loads and resulting consolidation of the foundation soils immediately beside the structure • Geofoam can be placed directly behind levee tie-in walls to reduce fill-imposed lateral loads	• Use of normal weight fill to raise grade around structures results in large consolidation settlements and high lateral loads on tie-in walls required to toe federal levees to structures • Use of marina-style ramps that account for tide fluctuations would account for long-term settlements but are difficult to estimate • Use of geofoam would allow raising of site grades immediately behind tie-in walls without inducing significant lateral or vertical loads on the wall and wall foundation system • More than 20 feet (vertical) needs to be placed to create access to top of the structures	• Would require special design of ramps for proposed equipment • Ramps need to be designed to resist uplift forces from hurricane winds • Geofoam fill needs to designed so that it would not become buoyant when adjacent areas/polder are flooded	• Optimize use of geofoam so that overlying soils would restrain buoyant forces • Design ramp to accommodate reasonable settlements • Design measures to extend ramp if reasonable settlement threshold is exceeded	• Feasible – on hold for 60% design effort
Inlet configuration	• Splay and widen inlet, cover to use covered inlet conduit to gate structure to normal elevation minus 10 feet	• Large-scale physical model indicates wider diversions more efficient • Best mimics previous inlet modeling by The Water Institute • Maintains flow but reduces amount of surface water taken into the system • May also reduce amount of steel in gates	• Increasing sediment capture efficiency allows for reduced flow	• Covering conduit increases energy loss • May pose navigation concerns • Wider splay more complicated underwater given geotechnical conditions	—	• Considered as part of VE Alternatives 4 and 5
Intake channel and intake flume	• Remove concrete sections/liner and use steel cofferdam for conveyance	• Reduce cost, ease construction, and potentially eliminate need for dewatering	• System hydraulics may not be as sensitive to channel roughness as first believed • Main concern for this approach was efficiency of inlet hydraulics	• Concern is that steel coffer systems would not have same design life as concrete systems	• Potential treatments and cathodic protection to reduce corrosion	• Feasible, use in VE Alternatives 1 and 2, Version 2

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Transition walls	• Reconfigure transition structure to eliminate need for transition walls	• Potential cost savings • Reduces the amount of geo/structural design, piles, and linear feet of sheet pile • May also reduce the amount of temporary coffer cells required	• Transition walls are expensive and are aligned based on hydraulic sizing principals; however, the expense may not warrant the hydraulic efficiency gained	• Would create additional ineffective flow area and loss of energy in the system • Costs of extending concrete structural may offset costs of geo/structural transition walls	—	• Feasible, incorporate into VE alternatives
Alignment and location concepts (relocate major diversion to north to Naomi Siphon)	• Reorient or relocate alignment to a shorter path (current alignment is about 11,200 feet long—river's edge to basin edge) • Move intake about ½ mile south and keep current discharge location (alignment would be about 10,300 feet long and would cross the MR&T levee at a point set back from the river) • Move entire alignment about ½ mile south (alignment would be about 8,800 feet long and would cross the MR&T levee at a point set back from the river) • Move entire alignment about 12 miles south below West Pointe a La Hache (alignment would be about 1,900 feet long and would discharge into an entirely different basin, but would be significantly shorter)	• CPRA has done extensive analysis of selecting optimum locations for sediment capture • Reducing total length of diversion reduces total project costs	• Cost savings	• May not capture the desired sediment load or have desired environmental outcomes	—	• Not implemented • Site is out of scope
Alignment and location concepts	• Reorient the intake with a gradual upstream curve to reduce entrance losses and facilitate easier movement of sediment from river into the diversion	• Optimizing inlet shape conveys more sediment for reduced costs	• Current inlet configuration may not optimize sediment capture	• May cost more to construct	• Physical model studies coupled with hydrodynamic modeling to confirm concepts	• Hold for 60% design analysis
Intake/ diversion structure concepts	• Prepare a stabilized soil foundation for the diversion structure using deep soil mixing from existing grade, while guide levees around diversion structure work area are being constructed	• Improves soil structure and reduces wall requirements	• Soils are affecting location of structures and wall designs	• Deep soil mixing in an aquatic environment requires specialized expertise • Environmental concerns	• Work out construction sequence with specialized contractor	• Hold for 60% design • Insufficient geotechnical data to fully evaluate

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Intake/ diversion structure concepts	• After construction of temporary MR&T levees around the diversion structure area, excavate for the diversion structure in the wet and prepare the base pad for the structure • Includes removing the existing MR&T levee between the guide levees • Eliminates the cellular cofferdams for the diversion structure and the dewatering associated with construction in the dry	• Potentially reduces costs • Minimizes dewatering	• Cellular cofferdams and dewatering are major project costs	• Ability to conduct quality control on foundation • Foundation preparation integral to MR&T long-term performance	• Early contractor involvement or progressive design-build can reduce CPRA risks	• Hold for 60% design • Informal contractor meetings indicate they prefer to work in dry for approach channel and diversion structure
Intake/ diversion structure concepts	• Construct diversion structure in an off-site dry-dock while site preparation is being performed • Float to the site and sink onto the prepared bed; may save time on construction schedule • Requires bulkheads at ends of structures and methods for controlled flooding and sinking of unit into final position	• Fabrication of structure off site in the dry improves quality control • Minimizes dewatering and weather risks	• Have access to fabrication yards and inland navigation systems	• Needs significant wall systems to support underwater excavations • Need to decide early in project – substantially different design approach	• Early contractor involvement • Progressive design build	• Hold for 60% design • Insufficient contractor involvement to accurately price
Intake/ diversion structure concepts	• Add protective structure at river end of concrete diversion structure intake channel to prevent large river debris from entering channel • Should be sufficiently strong to withstand barge impact • May need to consider safety issues to avoid smaller boats from being pulled into the intake channel	• Operation of large hydraulic structure requires safety considerations • Woody debris aids in land building; too much or too large can become a maintenance and operation concern	• Mississippi River conveys large amounts of woody debris	• Screening system would require maintenance and long-term operations	• Conduct more specific study of size and type of debris in this portion of river • Benchmark against debris management at other structures	• Hold for 60% design • Consider once a viable diversion alternative is selected

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
Intake/ diversion structure concepts	• Eliminate concrete intake channel in the river, ending the intake structure where the existing river bottom is at about elevation –5 feet • Create a riprap or ACB revetment-lined intake channel 150 feet wide at the bottom, at elevation –40 feet, and with sloping sides at between 5H:1V and 10H:1V • Eliminates the cellular cofferdams in the river bottom; note that the concrete intake structure has interior dividing walls to create three parallel channels—consider whether these can be eliminated or shortened	• Reduces the need for large steel/concrete structures • Potentially reduces costs	• Structural inlet systems pose construction challenges and high costs	• Grading of river in the wet requires removing revetment and potential scour • Grading to stabilize slope requires substantial realignment of MR&T and river bank	• Use deep soil mixing to increase allowable side slope	• Evaluated • Grading does not work with given site constraints and soil stability issues
Conveyance channel concepts	• Use deep soil mixing to create stabilizing panels in the conveyance channel transition zones to allow steeper slopes and eliminate the pile-supported relieving platforms	• Reduces pile-supported structures • Reduces excavation	• Deep soil mixing can improve soil/foundation conditions and reduce settlements	• It is over 125 feet to foundation bearing layer; this drives up costs	• Additional geotechnical characterization improves ability to target areas for improvement	• On hold for 60% design effort pending further data
Back structure concepts	• Use deep soil mixing to eliminate pile foundations for the back structure	• Reduces pile-supported structures • Reduces excavation	• Deep soil mixing can improve soil/foundation conditions and reduce settlements	• It is over 125 feet to foundation bearing layer; this drives up costs	• Additional geotechnical characterization improves ability to target areas for improvement	• On hold for 60% design effort pending further data
Geofoam levee section	• Use geofoam core to reduce weight of levee	• Reduces need for surcharge fill and wick drains	• Wick drains and surcharge fill are a major project cost	• Buoyancy • New design concept • Seepage	• Conduct pilot testing and additional analysis	• Hold for further contractor involvement • Time savings need
Back structure concepts	• Use deep soil mixing to stabilize the soils around the back structure excavation to permit excavation in the dry without the cellular cofferdams, using sloped excavations or less expensive conventional excavation support systems	• Reduces sheet pile costs	• Cellular coffer dams and dewatering are expensive	• Long distance to bearing layer • Management of pore pressures	• Conduct additional geotechnical characterization	• To be priced • On hold for 60% design effort pending further data
Back structure concepts	• Use deep soil mixing to stabilize the soil slopes on the sides of the back structure discharge channel instead of the steel sheet pile cells	• Reduces sheet pile costs	• Sheet pile wall systems are expensive	• Differential settlements • Extreme storm loads	• Conduct additional geotechnical characterization	• On hold for 60% design effort pending further data
LA 23 bridge concepts	• Continue external slopes of guide levees for conveyance channel under LA 23 bridge instead of using sheetpile and T-walls	• Reduces structural costs	• Sheet pile and T walls are expensive • Transitions are prone to failure	• Levee maintenance • May require raising bridge profile	• Need to work out bridge/levee/wall cost optimization	• Not carried forward because it would raise bridge profile and add costs

Table 7. Value engineering ideas

Component	Description	Benefits/Advantages	Justification	Liabilities/Disadvantages/Risks	Risk mitigation	Recommendations
LA 23 bridge concepts	• Use soil improvement (controlled modulus columns with load dense graded aggregate load transfer platform or wick drains with preloading) and/or lightweight fill (EPS or geofoam) for approach embankments to LA 23 bridge to reduce length of bridge structure and place abutment near the guide levees	• Reduces number of piles and fill volumes	• Maximum limit of 3 feet of fill before using bridge due to settlement	• Area in polder subject to submergence • Geofoam could float • Geofoam section may not cost out	• Conduct more detailed analysis in final design phase	• Hold for 60% design pending further data collection
Levee set back	• Set levee back from channel to remove channel slope stability failure mode	• Reduces need for surcharge and wick drains • Reduces need to armor berm and levee slope	• Weight of levee causing failure of conveyance channel slope	• Sand deposition in berm area • Lower average velocities in overbank • Uses maximum right-of-way	• More detailed hydraulic, geotechnical, and cost engineering in final design	• Incorporated into Version 2 alternatives
USACE revetment materials	• USACE has large-volume contract to produce concrete revetment at below commercial pricing	• Reduces project costs • USACE has specialized and efficient delivery systems	• Could be considered aid to states • Demonstrates federal cooperation • Reduces costs	• Need to gain USACE acceptance • Local vendors may protest use	• Need 214 agreement	• Hold for 60% design discussions

Notes: ACB = articulated concrete block, CB = cement bentonite, CPRA = Coastal Protection and Restoration Authority of Louisiana, LA 23 = Belle Chasse Highway, LADOTD = Louisiana Department of Transportation and Development, MR&T = Mississippi River and Tributary, NOGC = New Orleans and Gulf Coast Railway, NOV = New Orleans to Venice, USACE = U.S. Army Corps of Engineers, VE = value engineering

Table 8. Engineering support for alternative refinement and environmental process

Discipline	Phase 1 NEPA scoping	Phase 2 Draft EIS	Phase 3 Start Final EIS	Phase 4 Finish Final EIS	Phase 5 Record of Decision/ Permit
Geotechnical	• Site characterization • Design model development • Data report submittal to USACE • Typical design section	• Submit report to USACE on site characterization design criteria and design parameters • Create workplan for preferred alternative investigation • Establish final design section and typicals	• Submit 408 package for preferred alternative	• Respond to 408 comments • Advance design to 90%	• 100% plans and specifications • Final 408 submittal • Response to comments and close out
Civil	• Constructibility • Inlet configuration • Channel/guide levee section • Cost engineering • Contracting alternatives	• Advance preferred alternative • Cost estimates • Specifications • Draft contract documents	• Submit 408 package for preferred alternative	• Respond to 408 comments • Advance design to 90%	• 100% plans and specifications • Final 408 submittal • Response to comments and close out • Final procurement plan
Structural	• Wall system refinement • Precast design analysis • Back structure design	• Final structure models • Prepare 60% plans • Specifications	• Submit 408 package for preferred alternative	• Respond to 408 comments • Advance design to 90%	• 100% plans and specifications • Final 408 submittal • Response to comments and close out
Pump station	• NOV/NFL design coordination	• Advance to 60% design	• Submit 408 package for preferred alternative	• Respond to 408 comments • Advance design to 90%	• 100% plans and specifications • Final 408 submittal • Response to comments and close out
Numerical modeling	• Inlet configuration • Basin hydrodynamics • Boundary conditions	• Refined operating plans based on water levels, salinity, and sediment discharge • Final inlet hydraulics • Final boundary conditions • Final hydraulic design data • biological modeling	• Preferred alternative operational plan modeling • Final basin side modeling • Final river side modeling	• Ongoing scenario modeling	• Final conformed operational model
Operations	• Establish preliminary water level criteria • Draft project descriptions	• Incorporate water levels, salinity, and sediment discharge into operating plan • Final project descriptions • Evaluate weather and seasonal factors	• Establish final adaptive management and operation plan	• Respond to Final EIS comments • Incorporate into final permit application	• Include Record of Decision-specific requirements
Road and rail	• General coordination • Cost engineering	• Advance 60% design for the preferred alternative	• Advance design to 90%	• Address department of transportation and railroad comments	• 100% plans and specifications • Final agency submittal

Notes: EIS = environmental impact statement, NEPA = National Environmental Policy Act, NFL = Non-Federal Levee, NOV = New Orleans to Venice, USACE = U.S. Army Corps of Engineers