Mid-Barataria Sediment Diversion (BA-153) Independent Technical Design Review

REVIEW OF 30% ENGINEERING DESIGN ALTERNATIVE REPORTS, PLANS AND SPECIFICATIONS

FINAL DRAFT REPORT

JANUARY9, 2015

FOR

THE COASTAL PROTECTION AND RESTORATION AUTHORITY OF LOUISIANA

CONFIDENTIAL

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ATKINS Ben C. Gerwick, Inc. COWI

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NOTICES

This document and its contents have been prepared and are intended solely for information and use by the Coastal Protection and Resource Agency of the State of Louisiana in relation to the review of documents describing the work associated with the 30% Basis of Design provided to this team.

DOCUMENT HISTORY

VERSION	PREPARED BY	DATE	REVIEWED BY	DATE	COMMENTS
INTERIM DRAFT	WKJ ATKINS	AUG 17, 2014	DL, DB GERWICK	AUG 18,2014	FOR RELEASE
INTERIM DRAFT		AUG 27, 2014			MINOR CORRECTIONS
FINAL DRAFT INITIATED APPENDIX C	DB GERWICK	SEPT 12 2014	WKJ ATKINS	SEPT 12 2014	MINOR COMMENTS FROM CPRA INCORPORATED
INCLUDED EXEC SUMMARY, MODELING, RECOMMENDATIONS,	WKJ ATKINS	SEPT 18, 2014			FOR FINAL REVIEW BY CPRA, NOT TO BE RELEASED WITHOUT AUTHORIZATION
FINAL DRAFT	WKJ-ATKINS	JAN 9, 2015	LL ATKINS	JAN 2, 2015	INCLUDES FINAL COMMENTS CPRA

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Executive Summary

The Coastal Protection & Restoration Authority (CPRA) commissioned Atkins North America, Inc. (Atkins) to perform an Independent Technical Review (ITR) of the major design deliverables for the BA-153 Mid–Barataria Sediment Diversion (MBSD) project. To support this review, Atkins sub-contracted with Ben C. Gerwick, Inc. (Gerwick). Together, the Atkins/Gerwick team worked with the CPRA staff to evaluate the design deliverables as presented by the primary project designer, HDR, Inc. (HDR).

The MBSD project is one (1) of three (3) major sediment diversion projects currently being evaluated on the Lower Mississippi River and is the first of these major diversion designs initiated by CPRA. The project is located at River Mile 60.7 above Head of Passes and is the northern-most of the three diversions currently being evaluated. The MBSD project and specified criteria as cited in the 2012 Coastal Master Plan has evolved over the last decade in various forms. The work tasked to HDR by CPRA here was based in part on a preliminary study effort for the Myrtle Grove diversion. Generally speaking, the intent of the project is to construct and operate a controlled diversion structure at an appropriate scale to provide an acceptable flow and sediment/water ratio which will allow a prograding deltaic sediment depositional pattern in the lower Barataria Basin. Land building will provide a storm buffer to nearby communities as well support healthy marsh habitat growth. Target restoration criterion is highlighted in numerous documents; however, the specific goal of this project remains undefined. HDR documents in their Alternative 1, Base Design Report that the USACE authorized a "medium diversion" at Myrtle Grove in WRDA 2007 to provide 13,400 acres of new marsh and prevent the loss of 6000 acres. In the CPRA Master Plan estimates range from a minimum of 7000 acres (Project SE-9) to 80,000 acres (Project SE-10). Additional work continues to be conducted to evaluate the validity of these targets and ultimately the assurances that a diversion could work as designed and operated correctly.

HDR was selected to perform engineering and analysis of the proposed project based on the work initiated through the Myrtle Grove feasibility study to a 30% design level. This level of effort is of sufficient detail to provide anticipated project outcomes along with project features and associated costs. CPRA set a schedule for delivering a final project design in eighteen months and the design process has progressed to meet this target. As the project approached the 30% stage, HDR related to CPRA that project capital costs were significantly higher than those in the Master Plan, largely due to changes in scope from the base plan including; a greater maximum flow rate from the one used in the preliminary study effort (75,000 cfs vs 50,000 cfs), addition of the railroad corridor and inclusion of a back structure, major features also not included in the feasibility study. HDR was subsequently redirected by CPRA to provide a limited value engineering (VE) study to determine more effective cost options for selected project features. These included changes in construction techniques from a traditional "in the dry" methodology to "in the wet" technologies as well as reduction in flows. In both cases, VE options by HDR were reviewed by the Atkins/Gerwick team. Based on the work by HDR as expanded by the Atkins/Gerwick team, it is our opinion that modifying construction techniques and/or reduction of flows back to concept levels the total cost of a diversion at this location could be developed for a $600M budget which was stated by CPRA as a potential project limitation. These VE concepts would need further review by the MBSD team.

The VE study created an ambiguity regarding structure size, type and construction. The Atkins/Gerwick team suggests a detailed VE session should be initiated that includes the designers of the lower Mississippi diversions so that each of the teams can add to and benefit from the extensive amount of work that the CPRA and HDR have accomplished to date. It is clear that there have been significant advances by this team and these should be allowed to evolve. Careful consideration of all of the physical constraints that will dictate construction and operation such as the transition of the sand wave on the bar in the Mississippi River should be understood. We recommend continuation of alternative structure evaluations to potentially identify structures that could be effective in transporting flow and sediments. We also recognize that these structures may be nontraditional or not previously conceived, and may not fit into a predetermined study methodology. The cost of building these structures is significant and CPRA should continue to pursue the lowest Capital Expenditure (CAPEX) program while considering the operational expenses (OPEX) for the life of the project. We have noted that OPEX is not addressed anywhere in the studies to date.

Results of the hydraulic, hydrodynamic and sediment transport modeling to date are incomplete, at least as they are defined in the modeling reports provided. We recognize that modeling has been conducted parallel to the design and timing has created coordination problems in describing flows through the structure and into the Barataria Basin. Three independent modeling efforts have been conducted and there appears to be inconsistencies between the work such as operational time frames, boundary conditions and water levels. The modeling tools appear to be nearing completion and suggest that CPRA and the design team will have a robust modeling platform from which they will be able to work.

Recommended Path Forward

1. Re-establish project goals and constraints in response to information that has been developed to date. These could include:

   a. Project cost limitations: for example; is $600M a rational total project budget (less mitigation) Can this budget meet the other project targets?
   b. A land building (marsh creation) target
   c. A flood protection targets
   d. Acceptable water levels in the basin
   e. Environmental constraints (once the above targets are defined).
2. Because the hydraulic models are independent of each other, better documentation is needed that describes how the models are coupled to each other so that the platform can be used to clearly describe the physical impacts to the receiving basin. An understanding of water levels versus flow needs to be methodically reviewed. This is a key parameter in deciding the flow constraints, if any, on the diversion. We recognize the Water Institute is in the process of developing a single model for the system (March 2015). However, much can be accomplished while that effort continues. We also recommend that the modeling reports to date be clarified so that results developed so far are not used out of context. A detailed discussion of this issue is provided in Section 2 (Commentary).
3. Hold a detailed value engineering session between CPRA, HDR and the designers of the lower river diversions to further define construction methodology, risk, costs and efficiencies.
4. Re-engage HDR to take the information developed above and redefine a “base project” that can be critically reviewed as a preferred alternative. HDR should carry the project far enough to verify constructability while the Water Institute can focus on the flow and sediment modeling to predict outcomes for land building and other environmental characteristics.
5. Advance the NEPA process once the preferred alternative is defined and conduct modeling to support flow, sediment transport and other environmental features completed to a point where impacts can be assessed and discussed.
6. Develop a timeline/schedule and budget to conduct the actions described.

Conclusion:

It is our opinion that HDR has generally reached the milestone originally anticipated for this project. The 30% design documents for the various components of the diversion structure, as directed to be designed, meet a level of completion typically seen at this stage. There are a number of deficiencies in the documents; however, the vast majority of these appear to be the result of changes in direction by CPRA due to the realization that the design basis would cost nearly twice the anticipated project cost, if "traditional" design assumptions were to be adopted. As a result of the changed focus to the HDR scope, a “Basis of Design” to allow the project to move to a 60% design document stage does not presently exist. Questions of construction methodology and configuration, flow rates, downstream impacts, sediment transport and cost that were generated as a result of the work to date have resulted in a deliverable that does not define a clear path forward and suggests that a series of project goals be more thoroughly investigated and defined.

The path forward should include a rigorous examination of the land building targets and the flows through the diversion structure necessary to meet these goals by using the modeling tools that have been and continue to be developed by HDR and the Water Institute. Closer coordination of this partnership is required and a clearer set of goals and objectives must be developed to capitalize on the expertise of these two groups. The Atkins/Gerwick team recommends continued refinement of the most likely design alternatives covering the variety of configurations and flow characteristics. Water levels in the Barataria Basin need to be quantified against flows through the structure to establish a maximum acceptable flow. Once this is known, sediment transport along with a variety of other environmental criteria can then be reviewed through a more focused assessment of those sets of flows that do not inappropriately impact water surface elevations. The Water Institute will have to acknowledge a range of potential outcomes of land building from the MBSD so that CPRA can make decisions on funding.

Robust alternative analysis of conceptual MBSD designs must be performed iteratively with the performance of sediment delivery and their associated impacts. The appropriate modeling platform must be applied to the corresponding structure configuration(s) in order to characterize a "best" performance structure and ranked by sediment delivery and cost. A modeling platform must not dictate the type of structure selected. Once the project team has a preferred alternative that meets flow and land building targets without adversely impacting water levels in Barataria Basin the NEPA process initiated under the preliminary information available at this time will be significantly more meaningful.

The MBSD and the other two lower diversions represent a major capital investment by the state and offer an opportunity to reverse the continual degradation of the marsh system in the Barataria Basin. This review recognizes that considerable progress has been made in advancing the knowledge and designs for a successful project. The complex nature of the lower Mississippi River and the Barataria Basin, the project scale and importance for the success of this and other diversions requires systematic and methodical evaluation of the decisions that have been made at each step including design parameters and expectation of the realization of the project targets. Additional work needs to be conducted as outlined in the recommendations section in this report. The Atkins/Gerwick team suggests that the diversion design teams and CPRA continue through the iterative process that has been initiated and to clearly define constraints and reduce uncertainty and risk as the design process moves forward.

Section 1 - Introduction

The Coastal Protection and Restoration Authority (CPRA) authorized HDR Inc. to develop the 30% design documents for the Mid-Barataria Sediment Diversion (MBSD). The CPRA objective is a CAPEX (capital expenditures) efficient, technically acceptable design for the MBSD with a favorable sediment/water ratio that is ready for bid, as expeditiously as practicable. A concept design by BCG Engineering and Consulting Inc. (BCG), previously commissioned by CPRA to develop the conceptual plans for the structure, established general design guidance and a target budget for this project.

To assist CPRA in meeting this stated objective, the CPRA retained Atkins, and Atkins retained Ben C. Gerwick, Inc. (Gerwick hereinafter) as a major sub-consultant, to perform an independent technical review (ITR) of the MBSD 30% design. This review was further extended when CPRA asked HDR to generate value engineering (VE) alternatives to address cost issues and included that deliverable in this review. This document represents a technical summary of the Atkins/Gerwick reviews which, together with our technical comments, mark-ups, and verbal contributions/meetings, represents the Atkins/Gerwick deliverables.

The following documents were received:

- MBSD Alt 1 Base Design Report 30% July 2014
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix A Sediment Budget (TWIG)
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix B Navigation Ship Simulations
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix C Channel Lining
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix D CTB Pump Station Outfall
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix E Bridge Type Foundations
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix F Access to Project
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix G Specifications
- MBSD Alt 1 Base Design Report 30% July 2014 – Appendix H Opinion of Probable Construction Cost
- Civil Drawings CPRA-MBSD Volume 1 – 7-02-2014 (General Civil Site Work)
- Civil Drawings CPRA-MBSD Volume 2 – 7-02-2014 (Diversion Structure)
- Civil Drawings CPRA-MBSD Volume 3 – 7-02-2014 (Cheniere Traverse Bayou Pump Station)
- Civil Drawings CPRA-MBSD Volume 4 – 7-02-2014 (Roadway and Bridge Plans)
- Civil Drawings CPRA-MBSD Volume 5 – 7-02-2014 (Railroad Design)
- MBSD Geotechnical Report 30% July 14 2014
- MBSD Geotechnical Report 30% July 14 2014 - Appendix A Seepage
- MBSD Geotechnical Report 30% July 14 2014 - Appendix B Slope Stability
- MBSD Geotechnical Report 30% July 14 2014 - Appendix C Settlement

- MBSD Geotechnical Report 30% July 14 2014 - Appendix D Recommendations
- MBSD Geotechnical Report 30% July 14 2014 - Appendix E Wall Pressures

A table of the various components for review is provided in Appendix A.

In addition to these documents an abbreviated value engineering (VE) session was held between HDR and CPRA (attended by Atkins/Gerwick) where various options for potentially lowering project costs were considered. CPRA later commissioned HDR to explore some of these comments more thoroughly which HDR accomplished as provided in the following additional documents submitted for review. It is our understanding that modeling of these alternatives has not been fully addressed and could impact some of the concepts.

- MBSD Value Engineering Report 30% July 2014
- MBSD Value Engineering Report 30% July 2014 – Appendix A OPCC
- MBSD Value Engineering Report 30% July 2014 – Appendix B Retaining Wall
- MBSD Value Engineering Report 30% July 2014 – Appendix C Inverted Siphon
- MBSD Value Engineering Report 30% July 2014 – Appendix D Geotechnical

The "Alternative 1, Base Design Report 30% Basis of Design" document begins with a clear narrative of the history of the Alternative 1 design. This narrative provides a general idea of how this "Alt 1, Base Design" evolved from the BCG design concepts as developed in the Myrtle Grove Delta Building Study and Concept Design. This BCG study resulted in recommendations using traditional (in the dry) engineering technologies to address a particularly challenging project site. It is evident from the documentation developed by HDR that the scope of work to be accomplished was to develop the concepts initiated by BCG by advancing this design to efficiently and safely capture sediments from the Mississippi River and transport them to the Barataria basin. This 30% design package is consistent with the stated objectives outlined in the 15% Channel Configuration report previously developed by HDR and presumably approved by CPRA.

Subsequent to the documents described above the Atkins/Gerwick team received the following reports to further describe the hydraulic and hydrodynamic modeling that was conducted in support of the project. The goals of the modeling were to document and validate the diversion capacity and inlet performance and to further confirm the sediment water ratios and the geomorphic response of the basin to the diversion outfall.

- MBSD Draft Executive Summary Report 30% Basis of Design August 2014
- MBSD Final Draft Executive Summary Report 30% Basis of Design October 2014
- MBSD Hydraulic Report 30% Basis of Design and Value Engineering August 2014
- Mid Barataria Sediment Diversion Report (Draft) (E. Meselhe et.al.), July 28, 2014

At the 30% stage of a project, we would expect that a clear design concept had been developed and agreed upon by the designer and owner. Due to the size and location of the proposed sediment diversion, the limitations caused by delayed modeling results and the significant issues related to the soils, the Basis of Design (BOD) appears to be in flux, generally due to costs not anticipated at the concept phase. As the BOD continues to be an evolving document, the 30% design package is more representative of a 15% package, largely because final decisions on the key design metrics related to peak diversion rates (and associated sediment transfer) have not been finalized. Reducing the flows from 75,000 cfs to 50,000 cfs lowers costs. However, there is no guidance regarding the realization of the underlying objectives.

As the evolution of the various designs that make up the project are expanded there will be a need to separate the major design components and provide a BOD document for each of the components of the project This will add clarity to the specifics of the design elements instead of trying to sort through a generalized report.

The design documents and other submittals provided to date convey a base design featuring the construction of a 75,000 cfs diversion (Alt 1) that could be executed as indicated by the 30% submittal documents. The accompanying VE documents provide an opportunity for some cost relief, however significant compromises maybe required. The VE also touches on alternative construction methodologies that have been discussed between the team. Some of these ideas could be expanded for additional savings. This will be further discussed in the VE section below.

To date the modeling work has been performed by independent teams with minor coordination of the goals and objectives of each effort and information needed by each group to successfully reach the modeling goals that each has set. There is no apparent lead in this effort. This may be due to the presumption at the initiation of the project that key features had already been determined and the focus by HDR was to “build” an appropriate structure. Some of these assumptions such as total flow required/needed may be changing, resulting in uncertainty in the design. At the 30% stage of a project these issues should be resolved or at a minimum identified and with a statement defining the probability of success, risks assumed and a clear scope to be completed by the next phase.

Section 2 - Modeling

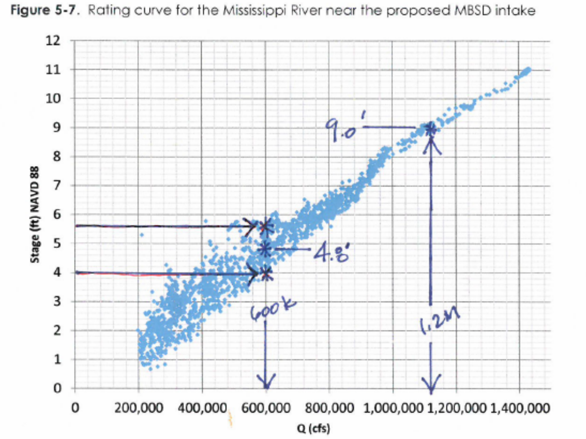
Three major modeling exercises were conducted for this scope of work. The "30% Base Design Report" (dated July 2014) developed by HDR focuses generally on the hydraulics of the structure using FLOW-3D. The Water Institute report ("Mid Barataria Sediment Diversion Report" dated July 28, 2014) uses a depth (2D) integrated version of Delft3D to look at sediment transport characterization and flows from the river through the diversion and into an 8-mile radius zone downstream of the outfall. HDR then examined various VE alternatives, again using their FLOW-3D model and ultimately applied a HEC RAS 5.0 (Beta version) ("Hydraulics Report, 30% Base Design and Value Engineering" dated August 2014) to look at water level impacts throughout the Barataria Basin from various flow regimes through the MBSD.

The development of the modeling platforms by each team has come from the view point of the specific team. HDR is generally looking at how flows, sediments and discharge will impact the design of the structure. From their viewpoint the structure has to work as indicated (i.e. 75,000 cfs peak discharge), must be stable and safe, must be operable and sustainable and must not negatively impact health and safety of the people and property in the area. As such, the majority of the analyses that HDR has performed have been over extreme conditions. HDR is looking at worst case scenarios to make sure the structure will survive over these adverse conditions. The Water Institute on the other hand is looking at the system from a much more "normal" perspective. Their modeling philosophy and resulting models highlight expected conditions, year in and year out. The model simulations cover general expectations of conditions that can be extrapolated over the life of the project. Both view points are required and appropriate. It is important to recognize that the data derived from each of these efforts needs to be used in the context of the modeling philosophies and at this time are not necessarily comparable to each other and potentially cannot support each other's work.

FLOW-3D (HDR)

FLOW-3D is a non-hydrostatic model with structured grid. It has a momentum equation in the vertical which is not neglected. It can provide a more accurate computation at free surfaces and is an appropriate tool for analyzing a complex structure as is the case for the MBSD. In the 30% Base Design report HDR defined geometry for a structure that can convey 75,000 cfs as directed by CPRA. The modeling effort used a 9.0-ft condition

Figure 5-7. Rating curve for the Mississippi River near the proposed MBSD intake



Source: Data provided by The Water Institute to HDR on April 8, 2013
Note: NAVD 88 = North American Vertical Datum 1988

in the Mississippi River and a conservative tailwater condition of 6.0-ft to test the reliability of the structure in producing the design flow for the upper bounds of both the river and the receiving basin. Operational considerations were not taken into account. A 9.0-ft Mississippi River stage corresponds to an approximately 1.2M cfs flow. This assumes a condition where water may be piled up in the upper reaches of the basin for any of a number of reasons such as wind, tides and the outfall itself. Various geometries were reviewed and a structure configuration was developed to meet this flow in this most extreme condition. Under this condition the structure sized in the report can transport the water down the diversion channel and out into the basin with about a one foot head drop from the back of the gates to the outfall. This is a useful exercise, focusing on the upper bounds of the structure and flows. The above hydrograph of river stage demonstrates that the stage can fall between 4.0-ft at 600,000 cfs and 9.0-ft at 1.2M cfs. Nominal water levels in the basin run between 0.5-ft and 2.0-ft.

Delft3D (The Water Institute)

The Water Institute developed the Delft3D model for the purposes of connecting the River to Barataria Basin through the MBSD as a single hydraulic unit. This more accurately describes the continuity of the flows from the river to the basin and helps to eliminate problems associated with boundary conditions that presently exist as the teams have to move from model to model to calculate flows and sediment transport. This report covers modeling efforts on the near-field (an 8 mile by 8 mile) area of the MBSD project with intents to describe (1) calibration, validation of the Delft3D model in investigating the geomorphic response of the near-field basin response to sedimentation as well as sediment/water ratios in the domain covered; and (2) tracking of sediment particles through the first mile downflow from the diversion structure outlet using a FLOW-3D model. The work to date does a good job of characterizing the Mississippi River and begins to identify the components necessary for the Barataria Basin. The document is weak on describing how flows are calculated through the channel and the channel outfall, presumably using the data generated from the HEC-RAS model. This approach is potentially over conservative thus leaving a gap in the information on the transition from the channel to the basin and may not be appropriate for uses other than design of the structure. As a result, flows and water levels at the outfall of the diversion structure may be significantly different under more strict operational guidelines.

The model was integrated in the vertical direction generating a depth average 2D computational domain that was deemed acceptable based on the basin characteristics. The value of the 2D version is significantly reduced computational time. Since velocity and water levels are key drivers for sediment transport and the system is shallow and baroclinic forces are deemed small, especially in the near field, this seems to be a reasonable assumption, however, there is little explanation of this decision.

A key feature of this model is that a moveable bed allows for the quantification of scour and the movement of sediments to occur which changes the downstream geometry and opens channels in the delta to allow for transport of diverted flows. This feature is critical in quantifying the near field geomorphological response and as importantly better defining the impact of the diversion on the near field water surface elevations. Flow characterization of the Mississippi River is derived to account for the variability of the flows over a 5-year period. This is a realistic expectation of the changing elevation of the head pressure in the river. There does not seem to be a discussion on the outflow characteristic of the discharge channel relative to these head conditions.

The report states that parameters from the West Bay Sediment Diversion modeling effort were used due to the absence of data in this basin. Some discussion on differences and similarities of these two systems (i.e., West Bay Sediment Diversion is an open shallow bay without marsh except the periphery, while the MBSD basin does exhibit a substantial subaerial marsh platform) should be included along with potential impacts to the results. There is an expectation that additional data would be collected so that this effort would not need to include these calibration criteria.

The models frame up an order of magnitude spread (0.1 to 1.0 Pa) of the potential critical shear stress values on the existing and deposited marsh and results indicate significant variation in the behavior of sediment deposition when comparing the two model scenarios. Because of this uncertainty, land building capabilities from the diversion scenarios are bracketed between the results of the different runs. The short, 5 year time frame, and limited domain in the receiving basin for looking at deposition as a response to the diversions is promising but needs to be increased to the 50 year life of the project with the computational domain increasing beyond the 8 mile zone to the Gulf of Mexico to fully predict and quantify marsh creation. These comments are noted in the report as required in future studies. At some point the Water Institute will have to acknowledge the range of potential outcomes of land building from the MBSD so that CPRA can make decisions on funding.

Results of the modeling efforts include discussion of erosion/deposition expected in the near field of the basin (the 8 mile limit). The results also obliquely address water surface elevations near the mouth of outfall channel. These appear to be inconsistent with those described in the HDR Hydraulics Report (discussed below) which incorporates a fixed bed. In future versions, a fully developed three dimensional model may need to be run to look at environmental factors further into the bay where salinity may be a greater factor.

Detailed review comments on this report highlight boundary condition concerns and how they impact results in the modeling efforts as well as friction coefficient questions that may be important. Improvement on correlating the datum between the CRMS stations is critical as variations on the order of 0.3-ft to 1-foot have been reported. As we consider surface water level changes on the order of a couple of feet for some of the engineering options these datum errors will probably have a substantial influence on interpreting modeling results.

Open boundary condition for water surface elevation (from the three CRMS stations) was constant along one segment of the open boundary. Tidal variation of the open boundary was filtered. There is no justification other than computational stability that suggests this approximation is appropriate. Tidal variability will influence sediment retention and/or export from the system. This is intuitively more important in the near field of the outfall and the tailwater condition near the outfall. Profiles of the water surface elevation data starting at the MBSD and ending at the open boundary could be presented which could provide useful insight into the water surface elevations across the domain.

Further discussion within the text of the report notes that since the effort focuses only on the near-field no conclusions can be reached yet to infer the overall water surface elevations or the erosion/deposition footprints of the land building efforts in the entire basin. The report notes that a basin-wide model is needed and that a 50 year simulation is necessary to address critical issues of design concepts. The model also neglects flocculation of fine clay matter sediments and drop out of sediments as the system transitions from a freshwater to an estuarine condition. With an increase of the computational domain where calculations can be impacted by saltwater a discussion on how the sediments are expected to react should be included.

HEC RAS 5.0 (Beta version)

Both HEC-RAS 1D and FLOW-3D models have been used on various domains to establish channel hydrodynamic characteristics in the vicinity of the outfall; tailwater analysis, limited sediment transport and scour potential, and inlet performance. HEC RAS 5.0 (Beta), a new version tested in conjunction with the USACE Hydraulics Engineering Center was adapted to better quantify the impacts on water surface elevations in Barataria Basin over the range of flows tested through the MBSD. In addition, the model is intended to further quantify or refine the tailwater condition at the channel outfall. This model includes the shallow water equations to allow tides to be included in a basinwide model. No other model was available to the team that covered the entire Barataria Basin (personal communication). This model maintains a fixed bed condition which does not allow for scour to occur in high flow areas. Unfortunately, this is exactly the area where significant scour is expected to occur in response to high discharge. If changes in the conveyance are not apriori inserted into the downstream bathymetry and scour is significant, the receiving conveyances may not be able to transport flow and may report higher water levels to generate a head pressure necessary to push water out of each grid.

The value of this simpler model (than Delft3D) is that multiple simulations can be developed and tested prior to being run through the more robust and computationally restrictive full 3D version of Delft3D. This allows for the testing of many configurations over longer timeframes and focuses the larger model on only viable alternatives. The model documentation however states that this model is not calibrated or validated and the topography/bathymetry is generalized. At this time results should only be used to examine very general and relative responses to the basin and should not be relied upon on in absolute terms. In its present state, even the addition of new, more accurate bathymetric data would not offset the uncertainty in the results that are caused by the fixed bed condition.

It is noted that “The primary purpose of these modeling efforts was to provide insight into the general Barataria Basin response to MBSD diversions as well as provide near-field Basin water surface elevations for use in modeling” which suggests this work should be combined with the main BOD documents. Care should be taken when using the information defined in this report. Operational considerations were not incorporated. Flows through the MBSD were modeled based on a “worst” year. In the scenarios discussed in the report the structure was operated at maximum discharge, say 80,000 cfs, for over 200 days as compared to a normal year(s) as discussed in the Water Institute report. While the Delft3D model report does not specifically state the outfall characteristics of the MBSD, the water levels provided in the basin infer that flow from the outfall structure was modified by the stage in the river which resulted in significant water level changes over the operational time frames.

The period for testing as defined by HDR is far greater than what would normally have been seen. Water surface elevations are directly correlated to discharge. Statistically speaking, maximum flows would occur on the order only 5 to 10% of the time and over much shorter time frames. We need to recognize that the model scenarios posed by HDR were for design purposes and not operational schemes and these results are not appropriate for discussing specific impacts due to flows. For example, the HEC RAS 5.0 model shows that the water levels near the outfall will be over 4-feet higher than normal conditions while Delft3D infers lower changes. Datum, tailwater,model domain, and bathymetry all have an effect on the calculations from the model. Errors in the bathymetric data are on the order of the changes in water levels themselves; therefore, quantifying water surface impacts specifically is not valid with this model at this time.

Commentary

To date the modeling work has been performed by independent teams with little coordination of the goals and objectives of each effort and information needed by each group to successfully reach the modeling goals that each has set. There is no apparent lead in this effort. This may be due to the presumption at the initiation of the project that key features had been determined and the focus by HDR was to "build" an appropriate structure. Some of these assumptions such as total flow required/needed may be changing, resulting in uncertainty in the design.

It appears that the MBSD 30% Base Design report (dated July 2014) and its appendices were written prior to the MBSD Hydraulics report (dated August 2014). This document also appears to be the only report reviewed that provides information on the modeling of the overall Barataria Basin from the Mississippi River to the Gulf of Mexico and as such seems vitally important to the overall project design yet is dated after the MBSD 30% Basis of Design Reports. It would appear that considerable information included within this report should also be in the MBSD Alternative 1, Base Design Report, especially where tailwater assumptions are involved. Numerous additional technical comments are provided in comment tables in Appendix B. The MBSD 30% report does not discuss the efforts necessary to establish the tailwater elevations assumed at the MBSD diversion structure outlet. There is a serious need to clearly document the procedure, numerical models (with input parameters defined), boundaries of models (via sketches/drawings), real gage data (time periods used and spatial locations of the gages in calibrating and verifying the models). Without such documentation it is not clear that the fundamental hydraulic performance of the project will perform as expected.

In summary, at the 30% stage of design the MBSD project should entail:

1. An expectation that most of the questions that will define the design have been asked, considered, and subsequently answered. If answers are not completed, then there are reasonable approximations and a clear path to finalize any ambiguity by the next stage. The modeling is not yet sufficiently completed or the analysis has not yet been performed to address the questions posed at this time.
2. The expectation that the hydraulic performance of the project will be acceptable. Flow of water and sediment through the MBSD results in appropriate land building without major impacts from water levels in the basin. There should be assurances that no sedimentation problems will occur with the assumed diversion flows. Although considerable modeling effort has gone into the basis of design reports, many of the model domains do not include the entire basin and consequently, results of acceptable project performance are not clear from the reports as written. This is amplified by the lack of conclusions within many of the reports and various caveats concerning the results provided.
3. At this time flood risk and conceptual flood risk reduction and resiliency designs should at least have begun to be addressed. The base design report does state that a set of storm surge models is proposed to be completed in the next phase of design to further quantify project impacts on storm surge. One of the main stakeholder concerns of the

MBSD project is increased water levels. The Risk reduction relies on proper operation and maintenance of all the structural components to perform as designed.

The Atkins/Gerwick team feels that the manner in which the reports were accomplished has detracted from the intent to show the project viability in various areas including (but not inclusive of):

- Accurate tailwater elevations in the receiving water body at the start of the diversion and as a result of flows through the diversion structure,
- Assurance that the diversion structure will convey the entrained sediment in the river through the structure to the Barataria Basin,
- Continuity of flow volumes (i.e. water volume conveyed through the diversion structure is either contained within the Barataria Basin or diverted through the Barataria Basin to the Gulf or elsewhere),
- Continuity of sediment volumes (i.e. sediment conveyed through the diversion structure is dependent on flow and is transported in such a way as to build land)
- Correction of the datum errors so that all of the data correlates to the same datum.

Robust alternative feasibility analysis of conceptual MBSD designs must be performed iteratively with the performance of sediment delivery and their associated impacts (i.e., water levels, etc.). The appropriate modeling platform(s) must be applied to the corresponding structure configuration(s) in order to optimize the best performance structure(s) and ranked by sediment delivery and cost. The modeling platform(s) must not dictate the type of structure selected as the modeling is only intended as a tool in selecting the most efficient and cost effective structure to be considered for construction.

Delft3D provides a solid platform for modeling the flow and sediment transport from the river, through the channel and into the basin. This model, when expanded to the Gulf of Mexico will allow for the appropriate continuous tailwater conditions at the channel outfall. FLOW-3D provides the detail for design purposes and should continue to be used as the hydraulic model for the specifics of the structure. Coordination between the Delft3d team and the FLOW-3D team is critical. HEC RAS 5.0 (Beta) may be a good tool to run multiple, simplified scenarios in order to cull down the runs that will be necessary for the basinwide Delft3D model. Because of the fixed bed conditions a significant number of assumptions regarding the sizes of the conveyance channels scoured out by the diversion will need to be made so that the model more accurately captures water levels in the receiving basin. Without these assumptions there is little value of pursuing this effort.

Various review comments have been provided that would be necessary to clarify this report prior to a complete review of the project. Review comments made concern clarification with regards to Alternatives, Versions, and Value Engineering concepts being considered. In various cases improved sketches and drawings need to be made as well as clarification of models utilized, modeling domains, model boundaries, boundary conditions, and data for the calibration and verification for the models. Also numerous sketches/drawings need to be incorporated to provide information regarding the concepts being tested.

It is recommended that at the present time, this series of MBSD 30% reports should be re-written with the intent to establish the above items for project viability while clearly stating any assumptions required in the analysis. It would be beneficial to provide sensitivity analysis to help assess uncertainty in areas where these assumptions have been made. An expedient suggestion to confirm viability of this approach would be to use a maximum Mississippi River flow and diversion design in the existing modeling efforts and show that the concepts are valid through step-by-step explanation of input and output as well as boundary calibrations for the entire system of models utilized covering the region from the Mississippi River to the Gulf of Mexico. This work could be reported on as a first step in checking various alternative diversion flows.

Ancillary Reports

The MBSD Alternative 1 Base Design Report - Appendix A: This report is a short seven page progress report meant to detail the 50 year suspended sediment loads. Being exceptionally short, numerous details are not covered by the report and must be assumed in concurrence with the Mid-Barataria Sediment Diversion Report (Draft). This report appendix does not clearly state purpose of modeling within context of the general study nor provide any conclusions with regard to the modeling accomplished to date. HEC6-T model appears to have been used for all water flow and sediment flow computations although no details or references are provided in the report concerning model parameters, limitations, boundary considerations. Model domains are not shown. Minor comments and discussion of problems with polynomial modeling are discussed in detailed review comments.

The MBSD Alternative 1; Base Design Report – Appendix B report is a summary of both 3D water flow modeling using FLOW-3D and ship simulation for navigation efforts to detail potential navigation problems that might occur with the MBSD design. The flow model domain and diversion flows utilized for design considerations are provided. Vector current diagrams for diversion scenarios are provided and details for the ship simulations are provided for two size ships with drafts of 47 and 33-ft. Although results of the simulation analysis provided and conclusions drawn with regards to safety seem reasonable for conditions provided, it is not clear that the project would be safe for smaller vessels than those tested. Additionally as wind and waves were not included within the modeling, the project design utilized cannot be reasonably concluded to be safe for all environmental conditions encountered. Minor comments are discussed in detailed review comments.

Section 3 - Opinion of Probable Cost

HDR has provided a cost basis for design as projected in the 30% documents. At the 30% stage there are a number of areas where the detail cannot be fully defined and HDR has taken broad liberties in the lump sum estimates to account for undeveloped portions of the design. This is not uncommon at this point of the design and these areas warrant further study during the next phase. HDR may also have additional data that could have been reviewed, however this information was not provided to the team.

The cost estimate includes a range of costs around the calculated value based on the ability of HDR to determine the reliability (uncertainty) of an estimate of a specific feature. For the design reviewed, the cost of construction was $750M with an optimistic cost of $603M (20% uncertainty) and a more conservative estimate of $932M (24% uncertainty). This provides CPRA with an estimate that can aid the designer and CPRA in determining where work needs to be directed as part of a next phase in the design process to more fully develop a dependable project cost. There remains key features unaccounted for such as the back structure estimated at $165M which the reviewers had no basis for review. It is also our understanding that this feature was not originally part of the scope of work and was added later, thus accounting for this deficiency.

In addition to the construction costs, HDR describes the additional costs that will be required to complete the work. These costs are embedded within their report. Adding these costs provides an accounting of the full project costs. This is provided in Table 1 below.

Table 1 Total Project Costs - Base Design ALT 1

HDR 30% 75,000 cfs	low %	High %	OPCC	Low	High
Construction Costs	20	24	$750,000,000	$603,000,000	$932,000,000
Land Costs	5	30	12,000,000	11,400,000	15,600,000
NEPA, Third party EIS, permitting	5	15	10,000,000	9,500,000	11,500,000
USACE 214	10	25	1,500,000	1,350,000	1,875,000
[1]Owner Costs (2% on OPCC)	10	10	15,000,000	13,500,000	16,500,000
Engineering Costs (5.5%on OPCC)	5	15	41,000,000	38,950,000	47,150,000
Construction Management (5% on OPCC)	5	10	37,500,000	35,625,000	41,250,000
[2]Unforeseen conditions (25% on OPCC)	10	25	187,500,000	168,750,000	234,375,000
Project Totals			**$1,054,500,000**	**$882,075,000**	**$1,300,025,000**

1. CPRA will expend resources to accomplish this project and that funding should be accounted in the costs (Atkins/Gerwick)
2. HDR accounts for risk and variability in their low and high estimates. As such CPRA may want to consider only adding a 10% contingency to the high estimate. This would lower the high cost by $141M.(Atkins/Gerwick)
3. 25% is applied to construction costs only.

The BCG concept study developed two general concepts, a 15,000 and a 45,000 cfs diversion. Project estimates from the Myrtle Grove report[1] are $180M and $330M accordingly. To compare these costs directly to the HDR design, land and other soft costs that were provided in the HDR report need to be added to the BCG estimates. We calculate the following total cost tables accordingly.

Table 2 Total Project Costs BCG Conceptual Design

BCG Myrtle Grove	OPCC – 15,000 cfs	OPCC - 45,000 cfs
Construction Costs (from BCG report)	$180,000,000	$330,000,000
Land Costs	12,000,000	12,000,000
NEPA, Third party EIS, permitting	10,000,000	10,000,000
USACE 214	1,500,000	1,500,000
[1]Owner Costs (2% on OPCC)	3,600,000	6,600,000
Engineering Costs (5.5%on OPCC)	9,900,000	18,150,000
[2]Construction Management (5% on OPCC)	9,000,000	16,500,000
Unforeseen conditions (25% on OPCC)	45,000,000	82,500,000
Project Totals	**$271,000,000**	**$477,225,000**

When comparing the HDR total project to the concept design total project, we need to add in those costs not identified in the BCG concept study. It is unclear whether the BCG costs covered the road and bridge construction however it was mentioned in their report. Additional project expenses developed through the work that HDR performed would include:

Table 3 - Normalized BCG Conceptual Design Project Costs

	Cost not included in BCG concepts ($M)
The rail realignment and associated bridge	$ 44
The Back structure estimate from HDR scaled 30% (75k cfs to 50k cfs structure)	115
Reduced unforeseen conditions (25%) scaled 30%	56
Total variance	215
BCG project cost scaled to 75,000 cfs	$ 477
Total BCG project costs	**$ 692**

Based on this simplified evaluation, the HDR design provides for a 75,000 cfs diversion against a 45,000 cfs BCG concept diversion or a 67% larger structure (by use) for an additional cost of $362M. Relating the two traditionally designed and constructed large diversion structures, we

[1] 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 (CPRA 2011) including Conceptual Designs, Myrtle Grove Diversion Structure (BCG Engineering and Consulting 2009)

see a slight cost reduction "per unit", probably due to size, based on the normalized estimated cost of about $14,000/cfs for the 75,000 cfs structure versus $15,000/cfs for the 45,000 cfs structure. The sediment transport modeling has not been developed fully enough to see if the sediment transport relationships are as linear as the flow characteristics of the various diversions.

Some specific areas to be reviewed in the OPCC are:

1) It is not clear whether an adequate amount of markups have been applied to all cost items. These markups include field supervision and offices, other general conditions, subcontractor markups, overhead and profit;

2) We are not clear if lump sum allowance-type items also accounted for these multipliers. At this point we were only able to confirm the inclusion of mobilization, insurance and bonds in the Appendix H estimate, and the markups in the HCSS backup, which were only applied to $282 million of the project cost.

3.) Earthwork prices can vary greatly based on where the material comes from and how it is handled. As earthwork represents $80 million of the estimated cost, it is recommended that the unit prices be reconsidered once the designer has a better idea of the locations, quantities, and methods for excavation and disposal.

4.) Our greatest concern regarding cost growth is associated with the areas of design and construction of the Mississippi River revetment and entrance channel including the need for a barrier to mitigate ship/barge impacts.

5.) Neither the roadway nor railroad estimates appear to be prepared using current plans. We suggest updating those estimates using the latest design.

6.) The back structure represents $165 million or about 22% of the project cost. There is no way to tell at this point that this is a reasonable cost.

7.) We do not understand the need for the bridge deck to be so much higher than the levee.

8.) The project design does not address life cycle costs. Operational costs and maintenance could have a significant effect on design choices and should have been part of this submittal in order for CPRA to provide guidance.

9.) The project documentation discusses some of the potential areas of impact. However, the cost estimates do not discuss costs for mitigation.

Section 4 - Value Engineering

Based on earlier discussions on the projected CAPEX for Alt 1, Base Design, the CPRA requested HDR to look at value engineering alternatives to see if there were areas of cost saving to lower the overall project cost. In general, the VE process should systematically seek 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. For this analysis, CPRA deemed it acceptable to lower costs by reducing the size of the structure yielding lesser flow through the diversion. This presumably lessens sediments distributed to the MBSD receiving basin. There was no discussion on how to quantify the reduction of sediment transport and the impact to the success criteria of the diversion.

Time constraints and guidance from CPRA only allowed HDR to conduct an abbreviated VE evaluation that included consideration of several design alternatives to the base project design. Their analysis included the use of contractors and discipline experts to vet some of the general ideas that they explored. 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 " (Ref. MBSD Value Engineering Report, 30%, July 2014, page 9)

The VE ideas enacted by HDR under Alternatives 1, 2, 4, and 5 would result in a reduced project construction cost—ranging from a Low to High range as shown in Table 4. Appendix A provides a more detailed cost breakdown with associated contingencies. ALT 1 version 2 provides a $180M savings in construction costs over ALT 1 Version 1 (base design). This is accomplished by reductions as follows in Table 5 (in round numbers). When looking at total project savings, this alternative saves $250M.

Table 4 MBSD Base Construction Cost Summary, with VE ideas enacted[1]

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 35,000 cfs	Alternative 5, Version 2, flared immersed tube tunnel inlet with tunnel conveyance 25,000 cfs
Base Construction Cost	$570,000,000	$502,000,000	$506,000,000	$546,000,000
Low Range Cost	$458,000,000	$403,000,000	$392,000,000	$437,000,000
High Range Cost	$706,000,000	$607,000,000	$605,000,000	$653,000,000
Savings over Base Alt 1	**$180,000,000**	**$248,000,000**	**$244,000,000**	**$204,000,000**

1 Costs do not include soft costs to be consistent with HDR cost estimates.

Table 5 Cost Savings by Component ALT 1 V1 and ALT 1 V2

Item	Cost Savings ($M)
• Significantlly reducing the approach channel	$54
• Reduction in the backstructure transition walls	$41
• Civil Construction efficiencies	$40
• No transition structure	$37
• General Conditions	$ 8
Total Savings	**$180**

If we compare Alternative 2 Version 2 to the initial design by BCG (normalized to similar conditions) which compares equal projects (~50,000 cfs) we see a $25M increase for the HDR design or 5% over the project cost defined in the BCG concept design. Relating these two alternatives at the total cost level the HDR defined project is only $22M more than the BCG concept or an increase of 3% over the conceptual design.

Variations of the VE Opportunities as Identified by the Atkins/Gerwick team:

In the review of the VE report we believe that it is realistic to consider that a design alternative with a construction cost of under $600M may be possible. For example, Alternative 3, Version 2 was eliminated from further consideration because of navigational concerns and low flows. However, a less complex construction of a similar configuration, the rectangular immersed tube tunnel, resulted in a cost on the order of $460M. This alternative may be feasible by lowering the tube 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 $500M by eliminating one of the tunnel runs and simplifying the immersed tube tunnel inlet to match the rectangular inlet of Alternative 3, Version 2.

In reviewing the work generated by HDR, we are able to develop variations on the VE concepts that the CPRA and HDR could consider in order to further reduce CAPEX while likely maintaining the cited objectives of the MBSD. Furthermore, our technical review indicates the potential for additional CAPEX cost savings using variations of the following additional VE concepts, labeled Alternative A (see Table 6). The 30% design documents provided have assumed that the Alt 1 Base Design will be built "in-the-dry" The VE report addresses minor "in-the-wet" construction alternatives. We also suggest that CPRA continue to pursue more advanced "in-the-wet" and "offsite prefabricated" construction methodologies and design concepts as proposed in the following table.

Table 6 VE concept (ALT A)

Concept	Description	Approach
1) In-the-Wet Construction at MR&T revetment inlet with three bay U-Shaped concrete channel in MR and immersed tube Approach to Control Structure Gate.	Dredge MR bank and channel through the Levee back to Control Structure. Float in Control Gate and Immersed Tube. Revetment inlet structure is constructed in the MR using concrete sheet piles, steel vertical and batter piles with rock and tremie base.	Diversion structure from river bed inlet, approach and control is dredged to greater than El -40ft. Setback MR Levees replace existing riverside levee. Backfill will be applied to Outlet, Control Structure, Approach Immersed tube and MR levee opening.
2) Alternative Back Structure with a stop log barrier from El -25 ft to El +20 ft. The stop logs and seven channel support structure close 357 ft width of the conveyance channel.	Conveyance channel cutoff wall is constructed with King Pile combi wall with sill at El -25 ft. Stop Logs (5' high x 44' 6" long) are contained by a four leg structure (10' drill shafts). 51' wide by 50' deep.	The seven channels have eight bents 50' deep, with drilled shaft columns and 9' thick precast pier shear wall with 6' diameter voids from El -25 to El +20.
3) Stop signs on haul roads at LA 23 highway reduce bridge span and pier heights	LA 23 roadbed vertical curve is modified to eliminate grade separated crossings with haul roads.	Road bridge size sufficient to include Utility corridor zone.
4) Railroad crossing over approach diversion immersed tube at removed MR&T levee. Immersed tube covered with Geo-Foam topped with concrete slab support forrail crossing	Rising railroad grade (1%) approach adjacent to MR levee sheet pile closure of wet dredged construction channel crosses over Approach structure.	Grade separated crossing of closed water channel and railroad uses levee type construction in lieu of bridge
5) Inverted Siphon underneath the Conveyance channel takes flows from the northern part of the Forced Drainage Area to the new Wilkinson Pump Station. Siphon eliminates need for pump station on north end of Forced Drainage Area	The ends of the siphon need to be beyond the limits of the guide bank levees. The siphon is 1,200 ft long and is placed 3 ft below bottom of channel (El -25 ft) and El +3 ft above sea level.	The siphon will convey flow between two level polls on each side of the diversion channel. The outlet channel is needed to contain siphon discharge water during periods of low water.
6) Pump House is located on north end of Forced Drainage Area and can be eliminated by selecting the Inverted Siphon.		
7) Replace the driven piles beneath the control structure with a cast-in drill hole (CIDH or drilled shafts) foundation.	Nominally 6-ft dia CIDH shafts are proposed to replace the 2-ft dia driven pipe piles.	CIDH reinforced concrete shafts are proposed to be built using floating equipment with the steel casings recovered.

Construction Cost Estimate, Focused on the VE Concepts:

The VE study contains alternatives with specific options and a pro and con discussion. Specific statements that eliminate features in the VE documents are not complete, hence, challenges are presented by the Atkins/Gerwick team to demonstrate solutions based on the variations of the HDR concepts with cost savings based on comparison values and eliminated and added features.

Table 7 ALT A, B VE Concept Challenges

Alternative 1, Version 2	Alternative A Challenge
In the wet, three bay immersed tunnel inlet	MR levee removed at Diversion Channel after construction of Setback Levee. In the wet open dredged channel glory hole cut to approximately El. -40+ for installation of Control Structure piles and float-in, three channel immersed tube, U shaped three channel revetment inlet constructed with concrete sheet piles, steel vertical and battered piles and tremie base
Three gate control structure	Three gate control structure floated in
Three bored tunnels outlet	
100-foot channel bottom width	150-foot channel bottom width
Seven bay gate back structure	Alternate Back Structure
75,000 cfs	75,000 cfs

Conceptual cost estimates of the 75,000 cfs solution (ALT A) and 50,000 cfs solution (ALT B) cfs structures are provided in Appendix A. The major component of the estimates revolve around the enlargement of the immersed tube as identified by HDR to meet the higher flow criteria cited as opposed to the 35,000 and 25,000 cfs structures in the VE report. This alternative also used extensive "in the wet" flow-in technologies for the U-shaped, 3-channel structure as well as sheet pile. This results in savings as follows (in round numbers).

Table 8 Construction and Total Project savings of ALT A over HDR ALT 1 V2 and ALT A' over HDR ALT 2 V2

	ALT A savings over HDR ALT 1 version 2 75,000 cfs ($M)	ALT B Savings over HDR ALT 2 version 2 50,000 cfs ($M)
Total project costs ALT 1, 2 - Gerwick	**$589**	**$516**
Reductions in construction components		
Approach channel	10	17
Control structure	15	22
Transition structure	35	40
Back structure	65	48
Inverted siphon	14	14
Roadwork	4	6
Rail Bridge	42	39
Total construction savings	**185**	**186**
Total project savings	**218**	**197**

Appendix C provides a more complete description of Alternates A (Alternate B is not described as it is a smaller version of Alternate A) to reinforce the certainty in which we believe the estimated cost savings can be achieved (compared to Alt. 1 V2) by:

a. Building the Approach Channel, Control Structure and Back Structure, using "in-the-wet" methodology;
b. By using concrete in drilled hole, technology for the foundations of both the Control, and Back, Structure;
c. By replacing the tainter gates in the Back Structure, with maintenance bulkheads, or roller-bulkheads, controlled by hoists built into the bulkhead slots;
d. By using inverted siphon drains instead of the construction of a new pump station;
e. By lowering the elevation of the highway bridge so that the bottom cord was within a nominal vertical distance of 3-ft from the crest of the conveyance levees;
f. And by, eliminating the railroad bridge by maintaining the current railway alignment, and by re-grading the local ground elevation so that the trains can pass over the top (at El +13.5 [with a ceiling elevation of El +10]) of the approach channel that is proposed to be re-configured into a concrete immersed tube between the MR&T levee and the Control Structure.

Furthermore, Appendix C also provides a description of an Alternate C conceptual 75,000 cfs configuration that includes an approach channel invert level of El. -60 together with fully submerged concrete box culverts beneath both the MR&T and the NOV, levees. (which, again, would require additional study to verify their acceptability). Alternate C is estimated at a total project cost of less than $500 million. The Atkins/Gerwick team acknowledges that additional hydraulic and construction/cost studies are performed to verify the acceptability of this design. The Water Institute is concerned that the sand bar that forms near this location could bury the intake structure and generate new design challenges to make sure the structure stays open.

Alternate C is estimated to save at least an additional $90 million compared to Alternate A (with both conveying approximately 75,000 cfs), by the following measures:

a. Replacing the immersed tube section (with a top level of El +13.5, and a ceiling elevation of +10.0 to allow for open channel flow) behind the MR&T levee with mined (using deep mixing method) cast-in-place concrete box culverts (with a ceiling elevation of El -15, and an invert at El -60, resulting in closed channel flow); replaced the tainter gate control structure with an operating bulkhead gate structure located on the Mississippi River side of the MR&T levee, and extending the conveyance levees to within 200 to 300-ft of the MR&T levee.
b. Replacing the Back Structure Outlet Channel with mined (using deep mixing method) cast-in-place concrete box culverts (with a ceiling elevation of El -15, and an invert at El -60, resulting in closed channel flow, at the low point) underneath the new drainage canal, NOV levee. This also eliminates the need for the inverted siphons for drainage.
c. It is possible/probable that Alternate C will also improve the Sand to Water ratio for the diversion, thus improving the Benefit/Cost ratio for this option. Note that it is proposed to provide sand-pumps/eductor jets in both the Approach and Outlet Channels/Box Culverts, in order to prevent blockage of these areas by sediment, and it is proposed that these eductor jets could be piped to the drainage pump facilities. Also note that if designed properly, the alignments of wall panels at the entrance to the Approach Channel in Alternate C could be adjustable in order to match future sand/sediment conveyance patterns.

Project Delivery

The 30% Base Design Report contains recommendations that the MBSD project be delivered on a Design-Build basis, especially if “in the wet” alternatives are advanced. Whether Design-Build (DB), or Design-Bid-Build (DBB), contracting methodology is used, if innovative construction methods (such as the "in-the-wet" methodology) are adopted/allowed, it is important that such innovative construction methodologies be thoroughly evaluated in-light of the relatively poor geotechnical conditions and hydrological challenges, existent at this site. Providing this data in both a DB or DBB environment is important.

“In the wet” methodologies can be riskier and will require the designer to spend more time working out the significant number of additional details for successful deployment of the various components. Planning is critical and involves close coordination and cooperation with the contractor. The result can be significant savings over traditional methods.

Section 5 - Recommendations

Objectively, it appears that HDR's 30% submittal generally meets the requirements of their scope of work. However, subjectively, it also appears that this 30% submittal has not met the standard for a Basis of Design document and there is no clear direction as to how to proceed to the final design of the MBSD. Basically, findings developed during this work effort have identified gaps in the scope of work that need to be filled prior to advancing the design to the next phase. HDR's draft Executive Summary Report recommendation to change the design discharge of the diversion from nominally 75,000 cfs to nominally 38,000 cfs is based on qualitative evaluations of hydraulics, and cost; these projections are premature and/or incomplete. Therefore, the following recommendations are provided with regards to:

a. Key Objectives;
b. Key Technical Issues;
c. Diversion Configuration and Construction Methodology;
d. Hydraulic Modeling; and
e. Permit Considerations:

Recommendations Regarding Key Objectives

The 30% submittal correctly points out that for the case of the Future Without Project, the Mid-Barataria Basin will be seriously degraded within a few decades. HDR recommended changing the design discharge of the base design diversion configuration down to 38,000 cfs, with an option for expansion of the discharge in the future. This is based on a notion of an "acceptable" project from the perspective of cost and adverse water surface impacts. While the thought is correct, the work to date has not gone far enough in trying to control costs through innovative technologies or to appropriately quantify water surface impacts in the Barataria Basin. It is too early to use the findings of the modeling reports to define real impacts.

The Atkins/Gerwick team recommends that the original design discharge objective be retained at 75,000 cfs, and that the base design be suitable for a practicable expansion of the project discharge capacity up to 250,000 cfs stated in the Master Plan as originally stated. Additional information needs to be developed before the project should be modified. This includes much more rigorous modeling of the water surface elevation in conjunction with the geomorphologic studies that continue to be advanced. Work needs to be completed that will define, to the extent possible:

a. Project cost limitations: for example; is $600M a rational total project budget (less mitigation) for this project? Can this budget meet the other project targets?

b. A land building (marsh creation) target,
c. A flood protection target,
d. Acceptable water levels in the basin,
e. Environmental constraints (once the above targets are defined).

Furthermore, it is recommended that an initial operations plan be developed for the project and begin development of its OPEX. Work has been conducted to begin understanding the criteria that will regulate the structure. This will allow operators to participate in developing key environmental criteria for monitoring in order to regulate the flow through the diversion. Maintaining acceptable environmental criteria while striving to optimize the Sediment to Water Ratio will increase acceptance and improve performance.

It is further recommended that once the 60% design is initiated, that a next submittal include life cycle costs for the proposed diversion that would consider at least:

a) a 50-year operational life;
b) a 100-year durability life [assuming that the diversion is adapted to extend its operation beyond 50-years];
c) full operational and maintenance costs; and
d) future case considerations for relative sea level rise.

Recommendations Regarding Key Technical Issues

The base design, and all VE alternates, evaluated by HDR adopted the use of some form of cellular cofferdam located on the Mississippi River revetment to facilitate the construction of the inlet / approach channel. However, the 30% submittal does not present any calculations of the stability of such cofferdams against a deep-seated failure plane through the soil in the revetment area. It is strongly recommended that such calculations be developed if such a construction option is retained, as the addition of pinning piles through the sheet-pile cofferdams may be required to stabilize such cofferdams against a deep-seated sliding failure mode. These costs are not included at this point and may continue to reinforce the need to use other construction methodologies.

Recommended Path Forward Regarding Diversion Configuration and Construction Methodology

There is a healthy discussion regarding the invert of the receiving structure on the Mississippi River. The Water Institute has correctly pointed out that the development of sand waves along the bar of the river creates significantly high sand dunes in the vicinity of the inlet structure. These dunes may offer problems with regards to maintaining the hydraulic opening of an immersed tube (anything other than an open channel). There is also some discussion that the lower the invert the better the SWR and improved efficiency of the structure. We recommend that additional study be conducted with regard to such matters as:

a) additional construction evaluations to test viability of concept, these may include inverted siphons, deep soil mixing and modular structural components
b) additional numerical hydraulic models specifically focused on the structure; and
c) investigations of means to prevent sediment blockage from debris of either/both of the inlet and outlet channels;
d) Use of a physical model if deemed necessary to verify numerical models.

Recommended Path Forward Regarding Hydraulic Modeling

Robust alternative feasibility analysis of conceptual MBSD designs must be performed iteratively with the performance of sediment delivery and their associated impacts (i.e., water levels, etc.). The appropriate modeling platform(s) must be applied to the corresponding structure configuration(s) in order to optimize the best performance structure(s) as ranked by sediment delivery and cost. We recommend that tailwater elevations and flows be determined using the planned hydraulic model developed by the Water Institute this methodology will continuously model the water flow from the Mississippi River through the diversion and then through the Barataria Basin. Modeling platform(s) must not dictate the type of structure selected as the modeling is only intended as a tool in selecting the most efficient and cost effective structure to be considered for construction.

HDR's commentary in their Executive Summary states that "Establishing water level criteria in the Basin is directly related to design water surface elevations for the channel. Cost savings from establishing desired tailwater conditions will bring more clarity to the cost estimate." This is one of the most important issues to be resolved, not only for design considerations, but for development of basin hydrologic characterization leading to environmental and human impacts.

Recommended Path Forward Regarding Permits

With regard to the 408 permit, previously, the USACE has expressed concerns about the risks of the formation of a deep-seated failure plane through the soil when working in the Mississippi River revetment and MR&T levee areas. The development of appropriate design details/calculations for Alternate C should demonstrate that this configuration / construction methodology, has reduced risk of the formation of a deep-seated failure plane in this area than does any of the alternates presented in the 30% submittal. The project does not have a preferred alternative nor does it begin to address environmental issues that will dominate the conversation once CPRA has specifically finalized the goals and targets of the diversion. Though the NEPA process for the project has been initiated it is imperative for CPRA to begin discussing the potential impacts of the diversion to all of the stakeholders in the basin. Modelers and designers should both become more acquainted with these issues so that they can continually be addressed as work is being conducted.

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