APPENDIX Q: NAVIGATION/DREDGING ANALYSIS

Q1: Dredging Analysis

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Q1: Dredging Analysis

Mid-Barataria Sediment Diversion Project EIS

Appendix Q1: Dredging Analysis

FINAL

February 8, 2021

US Army Corps of Engineers®
New Orleans District

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Acronym List

AHP	above Head of Passes
BHP	below Head of Passes
cfs	cubic feet per second
CPRA	Coastal Protection and Restoration Authority
cy	cubic yards
EIS	Environmental Impact Statement
ERDC	U.S. Army Engineer Research and Development Center
FWOP	Future without Project
FWP1	Production Run #1
GIWW	Gulf Intracoastal Waterway
HP	Head of Passes
LMR	Lowermost Mississippi River
MBSD	Mid-Barataria Sediment Diversion
mcy	million cubic yards
RM	River Mile
SDE	sediment diversion efficiency
SWP	Southwest Pass
SWR	sediment-to-water ratio
USACE	U.S. Army Corps of Engineers
WOP	without project

APPENDIX Q1: DREDGING

1.0 INTRODUCTION

This Appendix provides a synthesis of the results of available analyses that have been performed to investigate the potential for operation of the Mid-Barataria Sediment Diversion (MBSD) to impact future sedimentation rates and maintenance dredging requirements in the Lowermost Mississippi River (LMR) and the Barataria Basin.

2.0 PRIOR STUDIES

Prior work has evaluated the impacts of Mississippi River water and sediment diversions on channel sedimentation (note this term encompasses: sediment erosion, transport, and deposition) and the resulting maintenance dredging requirements. Letter et al. (2008) summarized several modeling and analysis reports, stating, “The majority of numerical modeling studies show that flow diversions cause a depositional response in the river downstream of the diversion, particularly in the reach immediately downstream of the diversion. The impact on dredging requirements can be an immediate increase or can be a temporary decrease, with increased dredging as the long-term geomorphological response evolves.” Immediately downstream typically refers to a distance within 10 to 20 river widths.

In their report, *A Simplified Analytic Investigation of the Riverside Effects of Sediment Diversions*, Brown et al. (2013) examined sediment diversions analytically in terms of the sediment diversion efficiency (SDE), which is equal to the ratio of equivalent sediment concentration diverted to the sediment transport concentration potential upstream of the diversion. The SDE is identical to the sediment-to-water ratio (SWR) term that is often used in other reports on diversions. On the basis of their simplified analytic investigation, Brown et al. (2013) concluded that in the long term (years to decades):

- If SDE actual is greater than SDE for equilibrium conditions, there is likely to be downstream erosion and significant upstream channel degradation.
- If SDE actual equals SDE for equilibrium conditions, there is likely to be small downstream deposition and moderate upstream channel degradation.
- If SDE actual is less than SDE for equilibrium conditions, there is likely to be moderate downstream deposition and small upstream channel degradation.

In their 2013 report, Brown et al. pointed out that, “Real changes in river morphology are much more complex than this simple analysis. …. However, in spite of these simplifications, the general trends associated with this simple analysis can serve to provide a basic understanding of the types of riverine morphologic responses to be expected from the introduction of a diversion.” They went on to stress that, “The analysis given here is strictly applicable only for the conditions given in the ‘Simplification and Initial Conditions’ section of this report. However, real rivers are subject to many important processes and complicating factors that do not satisfy these conditions." The authors listed some of these other important conditions that affect sediment and morphological responses to new diversions in the Mississippi River as being:

- "erosion resistant substrate and armored bed gradation effects," which can lead to supply-limited sediment transport in the LMR;
- "nonuniform flow effects," which occur due to drawdown and, especially, backwater conditions imposed by sea level in the Gulf;
- "unsteady flow," which is pervasive in the LMR; and
- "multiple flow diversions," of which there are many in the forms of existing crevasses, cuts, and diversions that interact with each other in complex ways. The proposed MBSD is located upstream of several large, uncontrolled diversions with which it would also interact.

Completed in 2003, the West Bay Diversion Project, federally and locally sponsored by U.S. Army Corps of Engineers (USACE) and Coastal Protection and Restoration Authority (CPRA), respectively, diverts Mississippi River water into West Bay, Louisiana at River Mile (RM) 4.7 above Head of Passes (AHP). Sharp et al. (2013) described a combined field and multi-model study of sedimentation effects of the diversion, which had ranged in discharge from 14,000 to 27,000 cubic feet per second (cfs) over the period between construction and their investigation. The focus of their efforts was sedimentation at the Pilottown Anchorage (RM 1.5 to 6.7 AHP) and the adjacent Mississippi River Channel. They concluded that the West Bay Diversion contributed 15 percent to 55 percent of the required Anchorage Area dredging and 10 percent to 30 percent of the adjacent river channel dredging. The applicability of those findings to the MBSD Project is limited, since the West Bay Diversion was essentially adjacent to the dredged area instead of approximately 60 miles upstream.

3.0 PAST, EXISTING, AND FUTURE DREDGING UNDER THE NO ACTION ALTERNATIVE IN THE LMR, BARATARIA BAY WATERWAY, AND THE GULF INTRACOASTAL WATERWAY

For the past several decades, the Mississippi River required at least annual dredging from below Venice, Louisiana (RM 13.4 AHP) to the 48-foot depth contour in the Gulf of Mexico beyond the end of Southwest Pass (SWP) (RM 22 below Head of Passes [BHP]). Maintenance dredging has not been required to maintain authorized depths from below New Orleans Harbor (RM 82.2 AHP) to Venice, Louisiana. On average, over the last several decades, about 20 million cubic yards (mcy) of sediment have been dredged annually from the reach below Venice, Louisiana to the Head of Passes (HP). The same rate of maintenance dredging has also been necessary in SWP. This approximates to a rate of about 3 feet per year, when averaged over the length and width of the navigation channel from Venice to the Gulf (computed from reported dredging volumes for 1998 to 2018 [USACE 2019]).

Year-to-year, annual maintenance dredging quantities vary widely in response to varying river discharge and available maintenance funding. For example, from 1996 to 2019, annual dredging volumes in SWP have varied by more than an order of magnitude, ranging from about 5 to nearly 50 mcy (Figure 1).

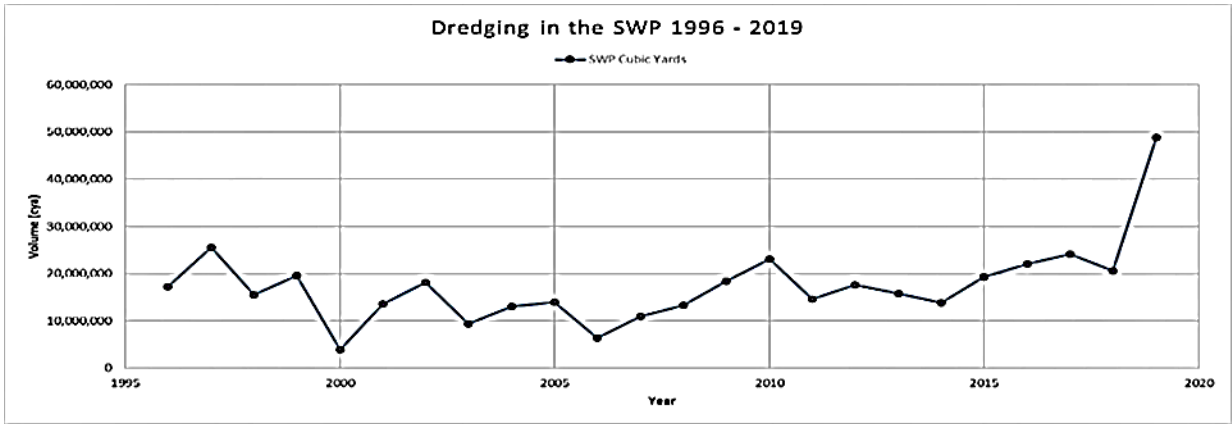


Figure 1. **Variability in annual dredging in Southwest Pass 1996 to 2019** (source: USACE 2019).

Shoaling in the LMR is dependent on many factors, including but not limited to, subsidence, eustatic sea-level rise, river stages, Gulf water levels, river sediment loads, and the interplay between salinity intrusion and the flocculation and deposition of fine sediments, making it a complicated system to precisely quantify future dredging requirements. However, assuming that the navigation channel continues to be maintained at close to authorized design dimensions over the long term, dredging volumes will eventually match sediment deposition volumes, so the cumulative total dredging will tend toward a linear trend. A sound basis for judging long-term diversion impacts is a “Base-to-Plan Comparison”. This is the approach used by Thomas et al. (2018) and Brown et al. (2018 draft, 2019) in the continuous simulations they undertook using HEC-6T and AdH/SEDLIB, respectively. Under the No Action Alternative, it is reasonably foreseeable that the USACE will deepen portions of the LMR from -45 to -50 feet in depth. USACE (2018) provides a useful perspective on assessing the potential impacts of proposed channel deepening of the LMR. Key points in the USACE (2018) supplement relevant to the No Action Alternative of the current study are listed in Table 1. Note that USACE employed the AdH and HEC-6T models (described further in Sections 4.3 and 4.4 below) to evaluate deepening of the channel. USACE (2018) qualified the models’ use for assessing dredging quantities, saying, “The study chose to use the results of the 1D and 2D model but this decision provides a level of uncertainty to the quantities and cost to compare alternatives due to the fact that these models did not account for changes in the fine sediment” (page 5-7).

Table 1 Key Points Relevant to Dredging under the No Action Alternative, USACE (2018)	
Page	**Key points**
4-3	Models used for "Base-to-Plan Comparisons" for shoaling/dredging analyses from Baton Rouge (RM 234 AHP) to the bar channel beyond SWP (RM 22 BHP) were: 1-D HEC-6T and 2-D AdH. A 3-D Delft model was used to model channel deepening impacts on salt-wedge migration upstream of HP, in relation to drinking water supplies.
4-6	Shoaling in the LMR would not be anticipated to increase as a result of deepening the channel. [Note: The model did not address potential increases in the extent or frequency of salinity intrusion due to channel deepening or eustatic sea-level rise, which may influence the rate of fine-sediment deposition in SWP. Also note that this pertains to impacts of deepening the channel, not to impacts of proposed diversions].
4-9	Under the selected 'with deepening' future (Alternative 3), the recent trend in shoaling between RM 13.4 AHP and RM 6 AHP in the vicinity of Venice, Louisiana, is anticipated to increase due to additional channel deepening and eustatic sea-level rise.
4-11	Under the 'without deepening' future (Alternative 1), gradual shoaling upriver of HP (between RM 6 and 13.4 AHP) is anticipated to continue. This is based on observations indicating the migration of dredging requirements upriver of this reach and proportionally fewer demands for dredging downriver. An overall increase in dredging quantities under the No Action Alternative in the lower river is not anticipated.
4-17	The salt water wedge is present throughout the year in SWP and during low flow conditions may intrude upstream of HP.

In summary, USACE (2018) accepts HEC-6T and AdH Base-to-Plan model comparisons as providing the basis for decision making with respect to shoaling and dredging (page 4-3). In a future with navigation channel deepening but no new diversions, USACE (2018) expects the current trend for increased shoaling around Venice to continue (page 4-9). In a future without deepening and without new diversions, USACE (2018) anticipates gradual shoaling around Venice to continue, leading to increased dredging requirements there that are offset by reduced dredging requirements downstream, so that overall future dredging quantities are unchanged (page 4-11).

In the Barataria Bay Waterway during the period 1990 through 2006, mean annual dredging was 244,000 cubic yards (cy), or approximately 0.3 feet (3.6 inches) per year, when averaged over the length and width of the channel. The Barataria Bay Waterway Bar Channel was dredged every 3 to 4 years at an annual average rate of 170,000 cy per year. In the Barataria Basin, segments of the Gulf Intracoastal Waterway (GIWW), maintenance dredging was conducted three times from 1998 through 2018, averaging about 100,000 cy per year. Maintenance dredging was conducted in Bayou Lafourche six times between 2006 and 2015, with an annual average of 214,000 cy over that 10-year period (USACE 2019).

4.0 MODEL STUDIES

Numerical models for hydrodynamics and sedimentation are capable of producing reliable predictions of sedimentation and thus reasonable predictions of potential dredging requirements, provided that the models are validated to reproduce appropriate measures of performance. With regard to sedimentation, parameters such as suspended solids concentration can be used as proxy variables for validation, but by themselves are insufficient to validate model predictions of sediment deposition. For dredging predictions, that means that the models should be validated to reproduce the proper observed (field data) hydrodynamic forcings (water levels and flow velocities) and sediment deposition patterns and rates. Other parameters, such as suspended solids concentration, can be used for validation but by themselves are insufficient to validate modeled sediment deposition.

Three models and four model studies assessing the impacts of diversions on the LMR and Barataria Basin federal navigation channels were examined for this report. These are the Delft3D Basinwide, AdH/SEDLIB, and HEC-6T models of the river and basin. AdH/SEDLIB and HEC-6T models were also used by USACE (2018).

Delft3D, created by Delft Hydraulics in the Netherlands, is a 2- or 3-D hydrodynamic, sediment transport, wave, water quality, and morphological development model for estuarine and coastal environments. It uses a curvilinear boundary-fitted grid with a constant number of layers. This model has been used throughout the world in coastal studies. In this application (Delft3D Basinwide Model) the 3-D model was employed for near-field riverside studies, and the 2-D model was employed for basinside studies. (See Appendix E of the Environmental Impact Statement [EIS] for more information about this model).

AdH/SEDLIB, the Adaptive Hydraulics modeling system and fully generalized, multi-grain class, multi-bed layer, cohesive and cohesionless sediment transport module, developed by the U.S. Army Engineer Research and Development Center (ERDC) (Vicksburg), Coastal and Hydraulics Laboratory, simulates saturated and unsaturated groundwater flow, overland flow, and 2- or 3-D hydrodynamics plus salt and sediment transport over an automatically adapting unstructured model grid. The 2-D version of AdH has been used extensively over the last few years and in its applications, the 2-D hydrodynamics was used with a quasi-3-D sediment transport calculation that assumes logarithmic vertical velocity profile and a Rouse-type nonequilibrium vertical sediment profile. Results of investigations performed for the riverside and basinside impacts of proposed diversions are reported in Brown et al. (2018 draft) and Brown et al. (2019), respectively.

HEC-6T, Sedimentation in Stream Networks, was applied to model the physical processes of 1-D, quasi-unsteady, open-channel flow and sedimentation. This model includes a dredging computation option that removes sediment from the model bed at appropriate intervals. The 1-D calculation scheme provides a semi-2-D result by means of parallel strips which can exchange water and sediment. HEC-6T assumes that long-term sedimentation processes can be modeled by a daily series of steady flow events (quasi-unsteady flow). Previous studies have employed HEC-6T to examine the behavior of long-term sedimentation processes in the LMR, and Thomas et al. (2018) report the results of using HEC-6T “focused on the delivery of water and sediment to proposed projects along the Lower 175 miles of the Mississippi River and potential sedimentation impacts in the river.” The main findings of this study are summarized in a paper published by Heath et al. (2019).

4.1 MODEL LIMITATIONS

4.1.1 General Limitations

Every model has limitations that are dependent on its dimensionality, equations solved, spatial and temporal resolution, and assumptions made. Every model is, at best, an approximation of the real world and requires careful, informed application and interpretation before the results are used to help inform decision making.

The four model studies examined here were performed according to established standards by well-qualified modelers. Each was limited in some respects. In terms of limitations, specifically, and most significantly:

- None of the three models simulated the well-known salt wedge in SWP. The position of the salt wedge in SWP is primarily a function of the Mississippi River discharge, and hence any changes in the discharge, including changes associated with proposed MBSD operations, would alter the position of the salt wedge, which would potentially change the rate of deposition of silts and clay and therefore dredging requirements in SWP. In the models summarized in this appendix, numerical analyses of long-term trends suggest that changes in the rate of deposition associated with changes in the position of the salt wedge may not result in a significant average change in dredging in SWP, but the rate of dredging in a given year could potentially increase or decrease, relative to the No Action Alternative. Sedimentation and dredging impacts in SWP were based on best professional judgement by USACE and the most current knowledge and understanding of the dynamics that occur there. Model results for SWP will probably be smaller than actual deposition based on best professional judgement.

- The Delft3D Basinwide Model was not validated by comparison to observed sediment deposition rates in navigation channels; therefore, its predictions of navigation channel sedimentation are considered qualitative. Additionally, in the Barataria Basin, the Delft3D Basinwide Model data for Bayou Lafourche were too close to the grid boundary to be useful.

- The AdH/SEDLIB Basin-Wide model (Brown et al. 2019) was not validated by comparison to observed sediment deposition rates in navigation channels; therefore, its predictions of navigation channel sedimentation are considered qualitative.

- The AdH/SEDLIB hydrodynamic and sediment transport model of the LMR (Brown et al. 2018 draft) was validated by comparison to observed sand deposition rates. Therefore, its predictions of sedimentation are considered to be quantitative in the LMR AHP, and qualitative within SWP where saline intrusion occurs. AdH/SEDLIB was used to inform decision making in the 2018 channel deepening EIS Supplement (USACE 2018).

- The HEC-6T river model was validated for sand, calibrated for fine sediment and validated for dredging volumes (by comparison with observed dredging volumes in the Mississippi River between about 1991 and 2000); therefore, its predictions of sand deposition are considered quantitative and its predictions of long-term dredging volumes AHP are considered quantitative. However, the fine sediment “validation” is strictly a calibrated result, with no fine sediment or salt-wedge physics included, so the model does not necessarily reproduce changes in fine-sediment deposition in SWP that result from diversions.

- HEC-6T was used to inform decision making in the 2018 channel deepening EIS Supplement (USACE 2018).

- HEC-6T was a single, long-term, continuous simulation that included dredging calculations at intervals. Hence, this model did have the capability to quantitatively simulate sediment deposition and maintenance dredging for 50+ years of diversion operations. The HEC-6T model included prediction of the annual and long-term median dredging requirement in the SWP. HEC-6T long-term results were used to inform decision making with respect to the EIS performed for deepening the navigation channel in the SWP and Mississippi River between the eastern Jetty and Baton Rouge (USACE 2018).

- The Delft3D Basinwide Model and AdH/SEDLIB model applications did not compute dredging events during the model simulations; thus, model channels continued to accumulate sediment as if dredging were not performed. Delft3D Basinwide Model’s decadal deposition predictions may be somewhat low, since allowing sediment to build up in the channel over 10 years would drive morphological changes that affect time rates and spatial distributions of deposition. The AdH/SEDLIB river model simulated just 3 years of sedimentation, so its results are more reliable, but short-term.

- AdH/SEDLIB Basin-Wide modeling included a 35,000 cfs discharge into Breton Sound, so its results in the main stem Mississippi River were significantly different than considering the MBSD Project alone. Only the Barataria Basin results from AdH/SEDLIB Basin-Wide model (Brown et al. 2019) were used here.

- The riverside AdH/SEDLIB model results reported by Brown et al. (2018 draft) simulate operation of not only the MBSD Project (at diversion flows of up to 50,000 and 250,000 cfs), but also four other diversions (upper-Breton Basin at up to 250,000 cfs, mid-Breton Basin at 5,000 cfs, lower-Breton Basin at 50,000 cfs, and lower-Barataria Basin also at 50,000 cfs). The total new diversion flows simulated are therefore either 405,000 or 605,000 cfs, depending on whether the MBSD Project operates at 50,000 or 250,000 cfs. Consequently, in the context of this study, the sedimentation impacts predicted using the AdH/SEDLIB riverside model over-represent those expected if the MBSD Project were operated in isolation. However, consideration of the difference between the simulations is still useful because it illustrates the sensitivity of sedimentation to increasing diversion flows of the MBSD Project by a factor of five, from 50,000 to 250,000 cfs. Note that the Applicant's Preferred Alternative for the MBSD Project is a 75,000 cfs diversion flow.

4.1.2 Limitations Related to the Influence of the Salt Wedge on Fine-Sediment Processes

None of the model simulations fully reproduce estuarine processes in SWP, where river and ocean water mix and flow is stratified. A saline wedge forms and intrudes from the Gulf along the deep navigation channel, with fresh water flowing Gulfward in the upper part of the water column and salty water flowing *upstream* in the lowest portion of the water column. The stratified flow and sediment transport regime in SWP is very well documented (for example, see Simmons 1969, Benson and Boland 1986), though the mechanisms by which the salt wedge influences sedimentation in SWP are complex and incompletely understood (Heltzel et al. 1989, Richards and Bach 1987, Ayres 2018).

From numerous past studies, it is known that when discharge in the Mississippi River falls to about 300,000 cfs, the saline wedge in SWP reaches HP. As discharge measured at Tarbert Landing decreases below 300,000 cfs due to drought conditions, penetration into the river upstream of the HP increases, affecting communities with freshwater intakes along the river (McAnally and Pritchard 1998). The increase in the contact area between fresh and saline water that occurs when the salt wedge advances upstream is also known to influence sediment deposition (see for example Richards and Bach 1987, Mehta and McAnally 2008). However, as noted on page 4-18 of USACE (2018), sediment deposition and dredging impacts are muted because, “such increases are most likely during low flow periods when fine sediment concentrations are relatively low”. Dredging records establish that requirements are highest in ‘wet years’ when river discharges are high, when the tip of the salt wedge is well downstream of HP and closer to the end of the SWP (around RM 18 to RM -22 BHP).

The position of the salt wedge in SWP is primarily a function of the river discharge, and hence any changes in the discharge, including changes associated with a diversion, will alter the position of the wedge. The potential for changes in the rate of deposition of silts and clays associated with changes in the position of the salt wedge in SWP were investigated extensively in physical (scale) models and several numerical models (for example, Benson and Boland 1986, Heltzel et al. 1989, and others).

4.1.3 Advantages of ‘Base-to-Plan’ and Multi-Model Comparisons

Model results are best used by comparing results from one model simulation to another simulation with the same model. This comparative approach, called “Base-to-Plan Comparison,” provides more useful results than absolute model outputs, because model errors and limitations (such as the lack of a simulation of the sedimentation effects of stratification) affect both base and plan results in a similar fashion as long as base and plan conditions do not change the system excessively. The base-to-plan comparison method does not replace model validation, but can reduce model uncertainty to some degree and provide useful results and information.

To the extent that multiple models agree, these results can be considered reliable qualitative indicators of Project effects. However, in this study the models differ on some key points. When interpreting points on which the models differ, it may be considered that the Delft3D Basinwide Model ran as five back-to-back 10-year simulations and the AdH/SEDLIB simulation ran for only 3 years. In contrast, HEC-6T modeling was a continuous, long-term simulation, and also simulated dredging. For these reasons, the HEC-6T model is best suited to a base-to-plan comparison of future long-term deposition, but note that none of these models, including the HEC-6T model, fully incorporate dredging impacts from the proposed MBSD Project in SWP because salt-wedge dynamics related to river discharge variations and fine-sediment deposition are not fully represented in the model.

Application of base-to-plan comparisons allows for a semi-quantitative interpretation of their predictions, but care must be taken not to use the results as precise and accurate predictions. As noted above, similar results among different models can provide increased confidence in those results.

As noted above, because the models used were 1-D or 2-D, they did not properly reproduce stratified flow. Thus, although they may show similar results in SWP (where the salt wedge resides for the great majority of the time), those results may not reproduce actual rates and long-stream distributions of fine-sediment deposition.

To explain why qualitative base-to-plan comparisons are still useful even when the salt wedge is not simulated explicitly, it is necessary to consider two factors: (1) the degree to which the influence of the salt wedge on sedimentation in the SWP would be affected by operation of the MBSD Project, which is unknown, and (2) the way that dredging results for SWP were aggregated over time in base-to-plan comparisons.

The first factor is that the salt wedge will be in the SWP at discharges higher than 450,000 cfs, which is when the MBSD Project would be operating. The position of the salt wedge in SWP is primarily a function of the river discharge, and hence any changes in the discharge, including changes associated with a diversion, will alter the position of the wedge. This potential change is not quantified by these models.

Immediately downstream of the diversion, MBSD Project operation would reduce the discharge in the LMR by a few percentage points. However, far downstream in SWP, the percentage reduction in discharge is likely to be smaller. This is because, as demonstrated by Brown et al. (2018 draft) and explained above, the effect of planned diversions in lowering water surface elevations would reduce spills of sediment-lean river water out of the channel at crevasses and diversions between Pointe à la Hache and HP, such as at Bohemia and Fort St. Philip. Consequently, it is likely that the percent reduction in discharge through SWP attributable to the MBSD Project would be smaller. As noted in USACE (2018), the increase in the contact area between fresh and saline water that occurs when the salt wedge advances upstream would affect sedimentation, and subtle changes in flow can have a significant influence on the salinity intrusion length, so we cannot say that the diversion will have only limited impacts on sedimentation of fine sediments for a given year, even at lower flows.

The second factor is that the models were all run over multi-year periods to compare without and with Project dredging requirements. For example, to compare with and without Project dredging in the SWP, HEC-6T modelers aggregated the results over 50 years of diversion operation. The HEC-6T model is calibrated to a long-term average rate of fine-sediment deposition. This implicitly aggregates the depositional characteristics of fine sediment over a wide range of salt-wedge characteristics. Consequently, the long-term, aggregated annual dredging results from the model are insensitive to short-term changes in the position of the salt wedge.

The following sections provide the modeling results. Numerical values should not be over-interpreted but, where calibrated and validated, results provide reasonable insights as to the effects of the proposed MBSD Project on sedimentation and maintenance dredging in the LMR and SWP.

4.2 DELFT3D BASINWIDE MODEL RESULTS

The Delft3D Basinwide Model of the system was validated to observed (prototype) water levels, flow velocities, and suspended sediment concentrations, but not validated by comparison with observed deposition/erosion or dredging volumes; therefore, its sedimentation (deposition/erosion) results are considered to be primarily qualitative rather than quantitative, except in base-to-plan comparisons, which are semi-quantitative.

EIS Results from the “HYST” simulations at 50,000, 75,000, and 150,000 cfs are used here. The Delft3D Basinwide Model application is described in Appendix E of this EIS.

The base-to-plan comparison technique was employed here by using the No Action Alternative as the base (in other words, without the MBSD Project). Sedimentation volumes have been aggregated over substantial channel lengths to avoid over-interpreting these unvalidated model results.

Output from the Delft3D Basinwide Model decadal-scale morphological runs was analyzed by comparing initial bed elevations with the end results of each decadal cycle on a cell-by-cell basis. Federal channels were examined by reach, with the Barataria Bay Waterway and Barataria Basin segment of the GIWW considered in their entirety, and the Mississippi River divided into four sections:

- model upstream boundary to 1 mile upstream of structure;
- 1 mile upstream of the structure to the structure centerline;
- structure centerline to 1 mile downstream of the structure; and

- 1 mile downstream of the structure to the end of SWP (a distance of 80 river miles).

Model data for the Bayou Lafourche Waterway were too close to the grid boundary to be useful.

Federal navigation channel shapefiles were overlaid onto the Delft3D Basinwide Model grid, and cells that most closely followed the channels were selected. These cells were further checked to confirm a lower bed elevation than the surrounding cells, further verifying the presence of a channel in the model. As the model consists of rectangular cells of varying sizes, the geometry of the navigation channel cross-section is not replicated in the model. By comparing on large spatial scales and normalizing (base-to-plan comparison) to the No Action Alternative, effects from this approximation were reduced. In other words, absolute sediment volume predictions could be either very high or very low, depending on how far the model channel cross-section deviated from the actual channel cross-section. Using the same simplified cross-section for 'base' and 'plan' to calculate a percent change reduces the potential error. Even so, to be considered substantial, the difference between the simplified cross-sections in the No Action and Plan alternatives must be large when considered in the context of how far the model channel cross-section deviated from the actual channel cross-section in the No Action and Plan alternatives. After the channel cells were selected, bed elevations for each Plan Alternative (50,000 cfs, 75,000 cfs, and 150,000 cfs flow diversions) for each decadal cycle (modeled years 10 [2030], 20 [2040], 30 [2050], 40 [2060], and 50 [2070]) were compared to the initial bed elevations, and the product of the cell areas and the bed elevation change were calculated and summed to generate a positive total model channel volume for each alternative. These values were compared to the No Action Alternative volume to determine broad changes in sediment deposition volumes.

The following standard comparative calculations are applied here to the Delft3D Basinwide Model output employing a sedimentation index, I_V, defined as:

$$I_V(t) = \frac{V_{NA}(t) - V_P(t)}{V(0)}$$

In which $I_V(t)$ is the index value at time t after start of the simulation, $V_P(t)$ is channel volume at time t for the plan condition, $V_{NA}(t)$ is channel volume at time t for the No Action Alternative, and $V(0)$ is river channel volume at time zero for both 'Plan' and 'No Action' Alternatives. Values of the index can be interpreted as:

- $I_V(t)$ greater than 0: 'Plan' model channel is shallower at time t than the 'No Action' Alternative at time t. (Deposition in the 'Plan' model run exceeds that in the 'No Action' Alternative).

- $I_V(t)$ equals 0: 'Plan' model channel at time t is the same depth as the 'No Action' Alternative' at time t. (No 'Plan' effect.)

- $I_V(t)$ less than 0: ‘Plan’ model channel is deeper at time *t* than the ‘No Action’ Alternative at time *t*. (Erosion in the ‘Plan’ model run exceeds that in the ‘No Action’ Alternative).

- The ‘No Action’ Alternative has a sedimentation index of zero. Since both ‘No Action’ and the ‘Plan’ Alternative simulations included relative subsidence, the subsidence effect is removed from the index. Time history plots of the sedimentation indices for the designated waterways are plotted in Figures 2 to 7 and tabulated in Table 2. As described above, negative index values indicate that in the ‘Plan’ run, the simplified model channel is deeper at the end of a decade long simulation than the ‘No Action’ Alternative, and positive values indicate the ‘Plan’ model channels being shallower.

- For purposes of this report it is assumed that, in reaches where maintenance dredging is currently required, modeled ‘base-to plan’ changes in deposition rates (the sedimentation index) are approximately equivalent to changes in existing channel maintenance dredging requirements.

- In reaches where maintenance dredging is not currently required (such as between Venice and the proposed location of the MBSD structure at Ironton), modeled ‘base-to-plan’ changes in deposition rates (the sedimentation index) may not be equivalent to changes in existing channel maintenance dredging requirements. This is because additional deposition in areas that are either naturally deep or outside the navigation channel would not trigger the need for maintenance dredging unless sufficient sediment accumulates for bed elevations within the navigation channel to reach the elevation necessary to trigger the requirement for maintenance dredging.

- In the following, calculated sedimentation indices are presented precisely, as if the results were quantitative, so that relative magnitudes can be compared by the reader. As stated above, deposition rates in this model are unvalidated and cross-sections are simplified. Hence, sedimentation indices should be interpreted as qualitative but with some indication of relative magnitude. That is how the results are used in the main report.

Table 2 lists sedimentation index values for the ‘Plan’ scenarios, including adding terraces. As noted, the ‘No Action’ Alternative has a value of zero. To aid interpretation, table cells have been emphasized with blue background for more deposition than ‘No Action’, gray and italics for more erosion than ‘No Action’, and white for little to no difference from ‘No Action’. In the absence of rigorous uncertainty calculations from model sedimentation validation data, uncertainty bands for defining qualitative differences were deduced from the validation data for the proxy variable, total suspended sediment presented in Appendix E. Uncertainty bands were determined to be the following: that variations of less than 1 percent are insignificant and are shown only for clarity of presentation, 1 percent to 5 percent are considered small, 5 percent to 20 percent as substantial, and greater than 20 percent as large relative changes. The calculated changes are for sedimentation rate, not dredging requirement. Increased sedimentation will suggest increased dredging requirements if the location presently requires dredging. If the location does not presently require dredging, a predicted increase in sedimentation does not signify increased dredging unless the positive increase is large.

In general terms, Table 2 and Figures 2 through 7 show that:

- The GIWW results display an increase in deposition rate less than 0.5 percent under the 50,000 cfs and 75,000 cfs ‘Plan’ alternatives after 50 years of operation (2070). If discharge through the proposed MBSD Project (current design discharge is 75,000 cfs) were to be doubled (as in the ‘Plan’ Alternative with a 150,000 cfs diversion), the indicative sediment deposition rate would still only increase over the 50-year life by about 1 percent (see Table 2 and Figure 2). According to this regional model, the Applicant’s Preferred ‘Plan Alternative’ may increase the GIWW deposition rate insubstantially. A 150,000 cfs diversion may further increase deposition, but the amount would still be insignificant.

- The Barataria Bay Waterway results indicate a 10 percent to 25 percent increase in deposition rate proportional to the three MBSD Project flow alternatives (50,000, 75,000, and 150,000 cfs) after 50 years of operations (2070). As this waterway currently requires maintenance dredging, this suggests an increase in maintenance dredging volume of about 14 percent for the 50,000 cfs Alternative, 19 percent for the 75,000 cfs Alternative, and 22 percent for the 150,000 cfs Alternative that could be substantial under the largest ‘Plan Alternative’ discharge (see Table 2 and Figure 3).

- Model results for Reach 1 of the LMR (upstream boundary of model to 1 mile above the proposed structure) exhibited an erosive trend of less than 1 percent that increases with maximum diversion discharge (see Table 2 and Figure 4).

- Model results for Reach 2 of the LMR (from 1 mile above diversion structure to centerline of structure) displayed an insubstantial, increasing trend in deposition rate for the 50,000 cfs and 75,000 cfs maximum diversion discharges during the first few decades of operation, and suggest that the reach might approach an equilibrium condition later. At 150,000 cfs diversion, the results indicate a larger, but still very small, initial depositional trend. This trend declines through time, which may indicate an equilibrium condition after about 50 years of operation (2070) (see Table 2 and Figure 5). The reason for the zero change result in the 150,000 cfs plans at year 40 has not been investigated.

- Model results for Reach 3 of the LMR (from centerline of the diversion structure to 1 mile below the structure) exhibited an increased depositional rate in the first decade that reached a plateau of about 5 percent that remained nearly constant through the remainder of the 50-year simulation.

Depositional rates for the 50,000 cfs (increased deposition of about 4 percent) and the 75,000 cfs (increased deposition of about 5 percent) were nearly the same. The 150,000 cfs depositional rate increase (about 12 percent) was about double that of the Applicant's Preferred Alternative (Figure 6).

- Reach 4 of the LMR extends approximately 80 miles, (from 1 mile below the MBSD structure at RM 60 AHP to RM 22 BHP in the bar channel of SWP.) Model results for the 50,000 and 75,000 cfs alternatives suggest an increasing depositional trend for the first few decades that accelerates from about 1 percent to about 3 percent over the 50 years of model simulations (by 2070, see Table 2 and Figure 7). The 150,000 cfs discharge reaches about a 5 percent depositional rate increase in year 50 (2070) (Figure 7). For the LMR AHP, these results are considered useful, but results in SWP, which constitutes about 25 percent of Reach 4, are more uncertain because the Delft3D Basinwide Model does not incorporate results for fine-sediment deposition influenced by the salt-wedge phenomenon, as discussed above and pointed out in the notes at the foot of Table 2. Experience in SWP and other estuarine systems (see for example Simmons and Rhodes 1965, CTH 1971, Benson and Boland 1986, CTH 1995, Prandle 2009) suggests that under the No Action Alternative, sediment deposition there could potentially increase.

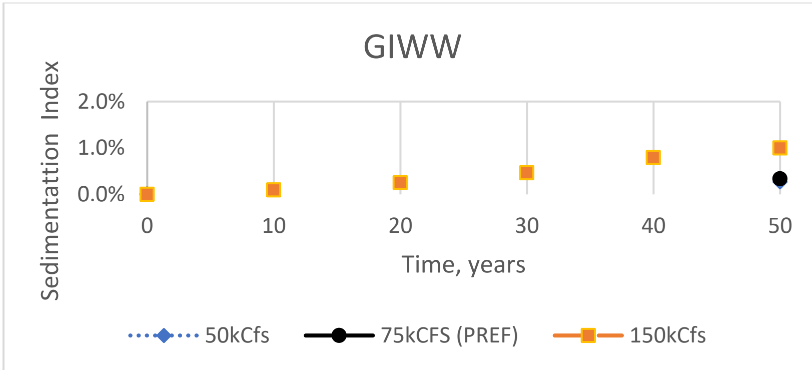
- Adding terraces had no discernable effect on Mississippi River or GIWW sedimentation rates.

- In the Barataria Bay Waterway, adding terraces negligibly increased channel deposition at all diversion discharges.

Table 2
Sedimentation Index for Alternatives (No Action has an index of zero)*

Modeled Decade during Operations	50,000 cfs	50,000 cfs+ Terraces	75,000 cfs (App. Pref. Alt)	75,000 cfs+ Terraces	150,000 cfs	150,000 cfs+ Terraces
Gulf Intracoastal Waterway						
2030	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2040	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
2050	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%
2060	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%
2070	0.1%	0.1%	0.2%	0.2%	0.4%	0.4%
Barataria Bay Waterway						
2030	1.6%	1.7%	2.6%	2.7%	3.4%	3.5%
2040	4.5%	4.8%	6.3%	6.4%	7.2%	7.2%
2050	8.4%	8.6%	10.8%	11.2%	10.3%	10.5%
2060	11.7%	12.2%	15.4%	16.0%	16.7%	17.0%
2070	13.9%	14.3%	19.1%	19.9%	21.9%	22.9%
Mississippi River Reach 1 - Upstream boundary to 1 mi above structure						
2030	*-0.1%*	*-0.1%*	*-0.2%*	*-0.2%*	*-0.3%*	*-0.3%*
2040	*-0.2%*	*-0.2%*	*-0.3%*	*-0.3%*	*-0.6%*	*-0.6%*
2050	*-0.2%*	*-0.2%*	*-0.3%*	*-0.3%*	*-0.7%*	*-0.7%*
2060	*-0.2%*	*-0.2%*	*-0.3%*	*-0.3%*	*-0.7%*	*-0.7%*
2070	*-0.4%*	*-0.4%*	*-0.5%*	*-0.4%*	*-0.7%*	*-0.7%*
Mississippi River Reach 2 - 1 mi above structure to structure midline						
2030	0.1%	0.1%	0.2%	0.2%	0.5%	0.5%
2040	0.1%	0.1%	0.2%	0.2%	0.7%	0.7%
2050	0.0%	0.0%	0.1%	0.1%	0.5%	0.5%
2060	0.0%	0.0%	*-0.1%*	*-0.1%*	0.0%	0.0%
2070	*-0.1%*	*-0.2%*	*-0.2%*	*-0.2%*	0.2%	0.2%
Mississippi River Reach 3 - Structure midline to 1 mi below structure						
2030	1.4%	1.4%	2.5%	2.5%	7.8%	7.8%
2040	1.8%	1.8%	3.2%	3.2%	9.5%	9.5%
2050	2.6%	2.6%	4.4%	4.4%	11.0%	11.0%
2060	3.1%	3.1%	4.9%	4.9%	10.8%	10.7%
2070	3.7%	3.5%	5.4%	5.3%	12.1%	12.1%
Mississippi River Reach 4 - 1 mi below structure to Gulf through SWP						
2030	0.6%	0.6%	0.8%	0.8%	1.5%	1.5%
2040	0.7%	0.7%	1.0%	0.9%	1.9%	1.9%
2050	0.9%	1.0%	1.1%	1.0%	2.4%	2.4%
2060	1.4%	1.5%	1.8%	1.7%	3.6%	3.5%
2070	2.8%	2.8%	3.2%	3.1%	4.7%	4.6%

* NOTE: Positive values indicate increased sedimentation. Negative values indicate decreased sedimentation. Indices are primarily qualitative. However, differences less than 1% are considered negligible (but shown for clarity's sake) and differences greater than 5% are considered indicative of change and may indicate relative magnitude.



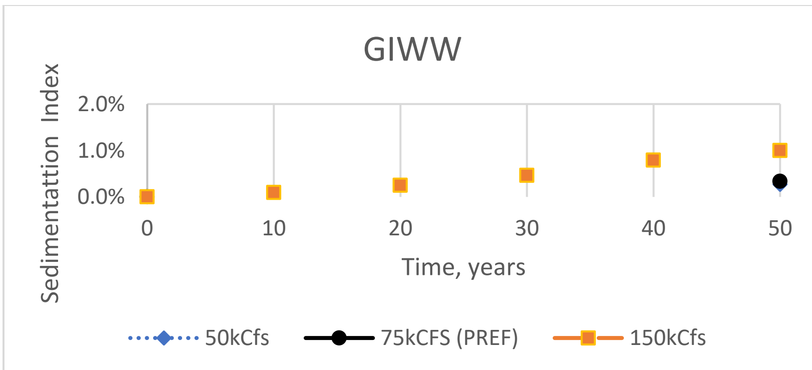


Figure 2. Delft3D Basinwide Model Sedimentation Index for the GIWW under Three Diversion Rates. Note the range of values on the y axis differs between figures.

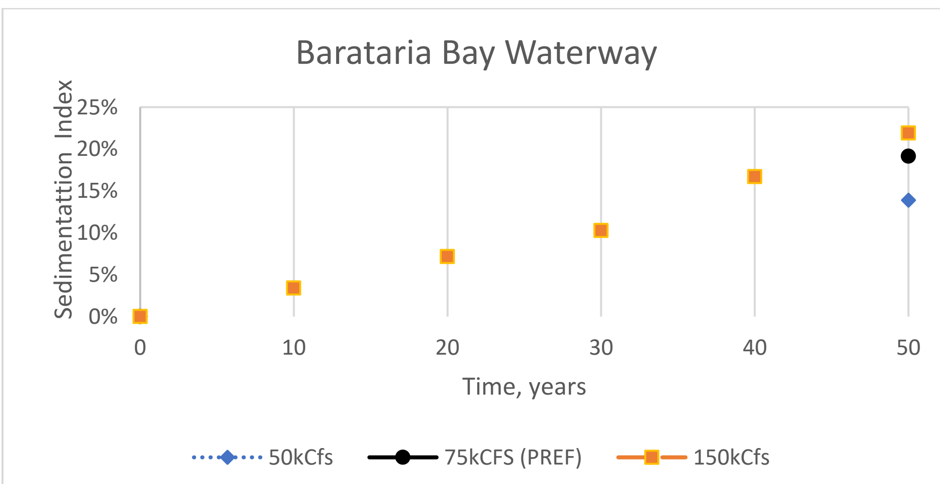


Figure 3. Delft3D Basinwide Model Sedimentation Index for the Barataria Bay Waterway under Three Diversion Rates. Note the range of values on the y axis differs between figures.

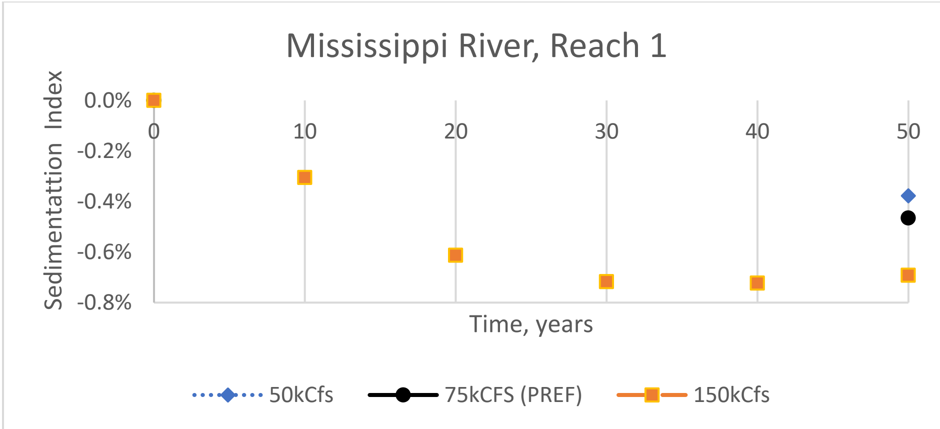


Figure 4. Delft3D Basinwide Model Sedimentation Index for Reach 1 of the Mississippi River (Upstream Boundary to 1 Mile Above Structure) under Three Diversion Rates. Note the range of values on the y axis differs between figures.

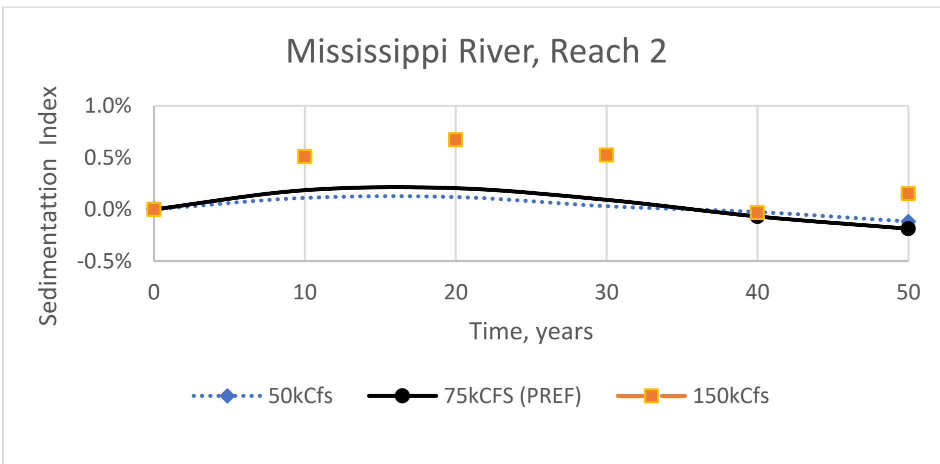


Figure 5. Delft3D Basinwide Model Sedimentation Index for Reach 2 of the Mississippi River (1 Mile Above Structure) under Three Diversion Rates. Note the range of values on the y axis differs between figures.

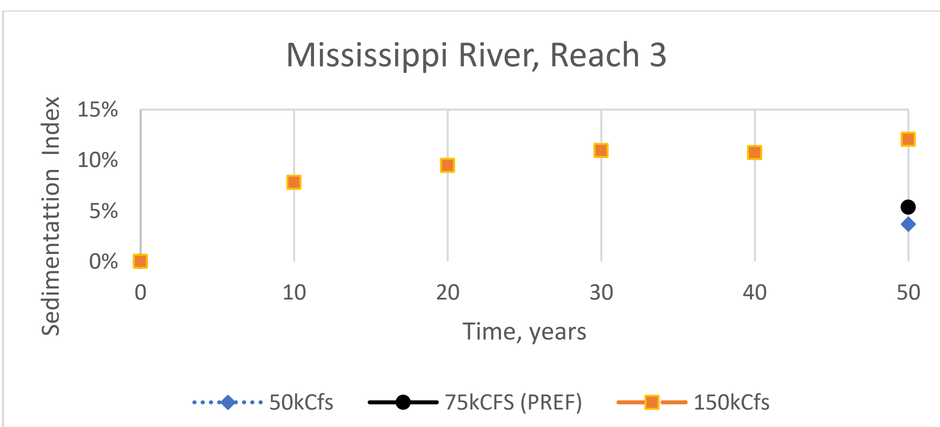


Figure 6. Basinwide Model Sedimentation Index for Reach 3 of the Mississippi River (1 Mile Below Structure) under Three Diversion Rates. Note the range of values on the y axis differs between figures.

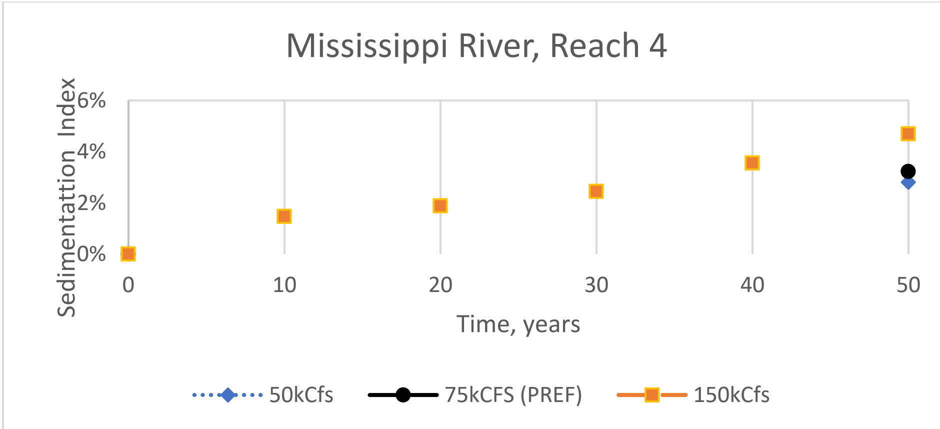


Figure 7. Delft3D Basinwide Model Sedimentation Index for Reach 4 of the Mississippi River (From 1 Mile Below Structure to Gulf) under Three Diversion Rates. Note the range of values on the y axis differs between figures.

4.3 ADH/SEDLIB MULTI-DIMENSIONAL HYDRODYNAMIC, SALINITY, SEDIMENT TRANSPORT, AND COASTAL WETLAND MORPHOLOGY MODEL OF THE LOWER MISSISSIPPI RIVER DELTA (BROWN ET AL. 2018)

The quasi-3-D version of the USACE AdH/SEDLIB numerical model was applied to the Mississippi River from Reserve, Louisiana (RM 139 AHP) to an offshore boundary in the Gulf of Mexico and includes Breton and Barataria Basins on either side of the river. The model and its application are described by Brown et al. (2019). The AdH/SEDLIB model was validated for surface elevation, discharge, and salinity. Comparison of land-building predictions with observed (prototype) conditions in the basins below the Caernarvon and West Bay Diversions showed that the model produced reasonable results under those conditions.

The following conditions were among those tested in the AdH/SEDLIB model:

- Without the proposed MBSD and mid-Breton diversions termed; “No Action Alternative” by Brown et al. (2019)
- With the proposed MBSD and mid-Breton diversions; termed “base operations” by Brown et al. (2019)

Base operations consisted of a 75,000 cfs diversion at the proposed MBSD structure and a 35,000 cfs diversion at the proposed mid-Breton structure. These AdH/SEDLIB model results are qualitatively applicable to navigation channel sedimentation in the Barataria Bay Waterway and to the cumulative effects of the two modeled diversions on the main stem of the Mississippi River, but not the effects of just the MBSD Project operating alone on the main stem of the Mississippi River, which were not presented in the report.

Results of AdH/SEDLIB modeling showed that Barataria Basin channels in the immediate vicinity (within 0.5-mile) of the proposed diversion structures would grow wider and deeper as a consequence of the diversion flow. However, according to this model, channels farther away (toward the Gulf), including Barataria Bay Waterway, would accumulate fine-grained sediment. The model showed net additional sediment accumulations up to about 2 meters (6.6 feet) due to operation of the MBSD Project over 50 years. While 2 meters (6.6 feet) in 50 years, equates to a time-averaged rate of only about 1.5 inches per year, it indicates that the Barataria Bay Waterway's existing maintenance dredging requirements under the 75,000 cfs diversion scenario could increase by about 40 percent over the 3.6 inches per year described in Section 3 above. This suggests a potentially substantial increase in sediment deposition that could lead to increased maintenance dredging volumes.

4.4 ADH MULTI-DIMENSIONAL HYDRODYNAMIC AND SEDIMENT TRANSPORT MODEL OF THE LOWER MISSISSIPPI RIVER (BROWN ET AL. 2018 DRAFT)

Brown et al. (2018 draft) considered the effects of multiple proposed diversions upstream of Venice on sediment deposition, particularly considering how operating these new diversions would affect spill flows at existing, large crevasses and diversions below Point à la Hache (RM 48.7 AHP). They ran future scenarios with no new diversions (which they term 'without Project' – WOP) and with five proposed new diversions at:

- upper-Breton Basin (250,000 cfs);
- mid-Breton Basin (5,000 cfs);
- lower-Breton Basin (50,000 cfs);
- lower-Barataria Basin (50,000 cfs); and
- mid-Barataria Basin (at 50,000 cfs and at 250,000 cfs).

Findings relevant to this report are summarized in the bullet points below.

4.4.1 Effect of Relative Sea-Level Rise

In the future, relative sea-level rise will move the locus of sand deposition upstream. This will happen in either with or without new diversions. It is a consequence of two separate factors:

- The first effect of eustatic sea-level rise is to cause the backwater curve generated by sea level in the Gulf of Mexico to migrate upstream, which means that the energy slope, and hence stream power, of the LMR would fall below the threshold necessary to transport sand farther upstream than is currently the case. However, this effect is relatively minor compared to the second factor.
- The second, more important, effect is that relative sea-level rise would raise water surface elevations, causing more flow and sediment to spill through

existing crevasses and diversions. This is particularly marked at the Bohemia Spillway and Fort St. Philip breach. Increased discharges at existing diversions may scour the diversion channels, further increasing spills. Relative sea-level rise dramatically increases spill discharges in the Bohemia/Fort St. Philip reach, further reducing stream power in the LMR downstream. Sediment response under the WOP future with relative sea-level rise is to heavily increase deposition just downstream of Fort St. Philip and Bohemia because their sediment diversion coefficients are very low – that is the water spilling is sediment lean; resulting in major bar development immediately downstream, a small reduction in the volume of sand deposited further downstream, and a tendency for the center of mass of the deposited sediment to move upstream.

- Proposed diversions remove water and sediment from the river, inducing deposition just downstream due to the loss of stream power associated with the diversions. They also reduce spill discharges at the Bohemia/Fort St. Philip reach. These spills have low efficiency for diverting sand. Both these impacts result in less sand arriving at the lowermost river, leading to reductions in sand deposition below Venice.

- Overall, there is increased deposition upstream of Venice – the reduction in spill flow at Bohemia/Fort St. Philip does not compensate for this. Whether or not this results in more or frequent dredging is a more complex question, because it represents a shift in location from where dredging occurs now.

- Relative sea-level rise, or more specifically subsidence, causes the weir-like diversions (like Fort St. Philip) to capture more and more water. So this, together with the landward migration of the backwater curve associated with eustatic sea-level rise causes the locus of deposition to migrate further upstream.

- Overall, the AdH/SEDLIB model showed some compensatory effect of reduced discharge loss at Fort St. Philip, but the primary effect of the diversions was some upstream migration of deposition. Whether or not this results in more dredging is more difficult to ascertain.

4.4.2 Sensitivity of Sedimentation Impacts to Changing Diverted Flows at the MBSD Structure

To assess the sedimentation impacts of the diversions, the AdH/SEDLIB model was used to calculate net bed elevation changes for 14 control volumes along the LMR (Figure 8, which is Figure 5.9 from the Brown et al. [2018 draft]).

Figure 8. Map of Numbered Control Volumes used for Near- and Far-field Bed Elevation Change Analysis. This is Figure 5.9 from Brown et al. (2018 draft).

Results for all 14 sediment control volumes mapped in Figure 8 are shown in Figure 9, which is Figure 5.10 in Brown et al. (2018 draft).

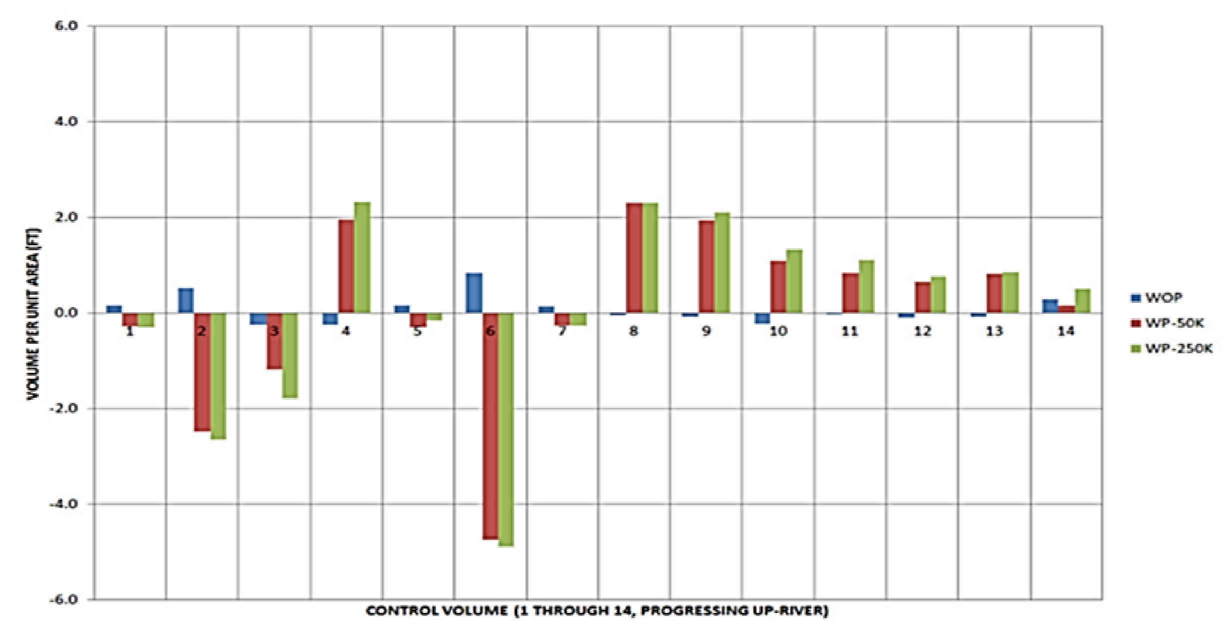


Figure 9. LMR Bed Elevation Change by Control Volume: 2008-2010 Hydrograph, Without Future Relative Sea-level Rise. 'WOP' = without diversions; 'WP-50k' = with upper-Breton (250,000 cfs), mid-Breton (5,000 cfs), lower-Breton (50,000 cfs), lower-Barataria (50,000 cfs) and MBSD at 50,000 cfs; 'WP-250k' = same as 'WP-50k' but with MBSD at 250,000 cfs. This is Figure 5.10 from Brown et al. (2018 draft).

The blue bars ('WOP') in Figure 9 show that according to the AdH/SEDLIB model, if no new diversions were built, future deposition would be focused in control volumes 7, 5, and especially 6 (around Bohemia/Fort St. Philip), and in control volumes

1 and 2 (SWP and just AHP). The brown and green bars in Figure 9 indicate the impacts of diverting totals of either 405,000 or 605,000 cfs at five new diversions, including the MBSD Project operating at either the at 50,000 or 250,000 cfs. Obviously, if the bars were indicating the impacts of operating the MBSD Project alone, they would be much smaller.

The *differences* between the brown and green bars are most directly relevant to this study, because these differences represent the outcome of what is effectively a 'Base-to-Plan' comparison for changes in sedimentation resulting from a five-fold increase in flows diverted at the MBSD structure, with all other conditions (including flows at the other four diversions), held constant.

Brown et al.'s modeling indicates that deposition driven by diverting either 405,000 cfs or even 605,000 cfs would not reach the trigger elevation (approximately −45 feet) for dredging to be required upstream of Venice. However, this analysis only represents 3-years of bed elevation change. Comparison of the WP-50k (brown) and WP-250k (green) simulations in Figure 9 shows that quintupling diversions at the MBSD structure would increase deposition rates in the immediate vicinity (within 0.5-mile) of the diversion (control volume 12). The magnitude of that increase then diminishes with distance downstream, becoming undetectable in control volumes 7 and 8. In control volumes 5 and 6 (around Bohemia and Fort St. Philip) increasing diversion discharge at the MBSD structure results in a slight change in the rate of net erosion. Deposition in control volume 4 (upstream of Venice) is predicted to increase slightly, but in control volumes 2 (upstream of HP) and 3 (downstream of Venice), net erosion is increased. In this 'Base-to-Plan' comparison, quintupling the maximum diversion at the MBSD structure had no discernible impact on the rate of net erosion in the SWP predicted using AdH/SEDLIB for both with diversion futures.

The sedimentation impacts predicted using AdH/SEDLIB result from the combination of a net reduction in the volume of sediment supplied to the lowermost river, and a shift in the locus of deposition upstream to control volume 4 (upstream of Venice). This pattern of change is consistent with current, conceptual understanding of the drivers of deposition in the lowermost reaches of the Mississippi River.

4.4.3 River Cross-section Analysis

AdH/SEDLIB model cross-sections replicate actual cross-sections in the LMR. This is an advantage over the regional Delft3D Basinwide Model described above in Section 4.2, because it supports investigation of how sedimentation is distributed laterally across the river. Selected cross-sections are shown in Figures 10 and 11, which are Figures 5.21 and 5.22 in the AdH/SEDLIB riverside modelling report by Brown et al. (2018 draft).

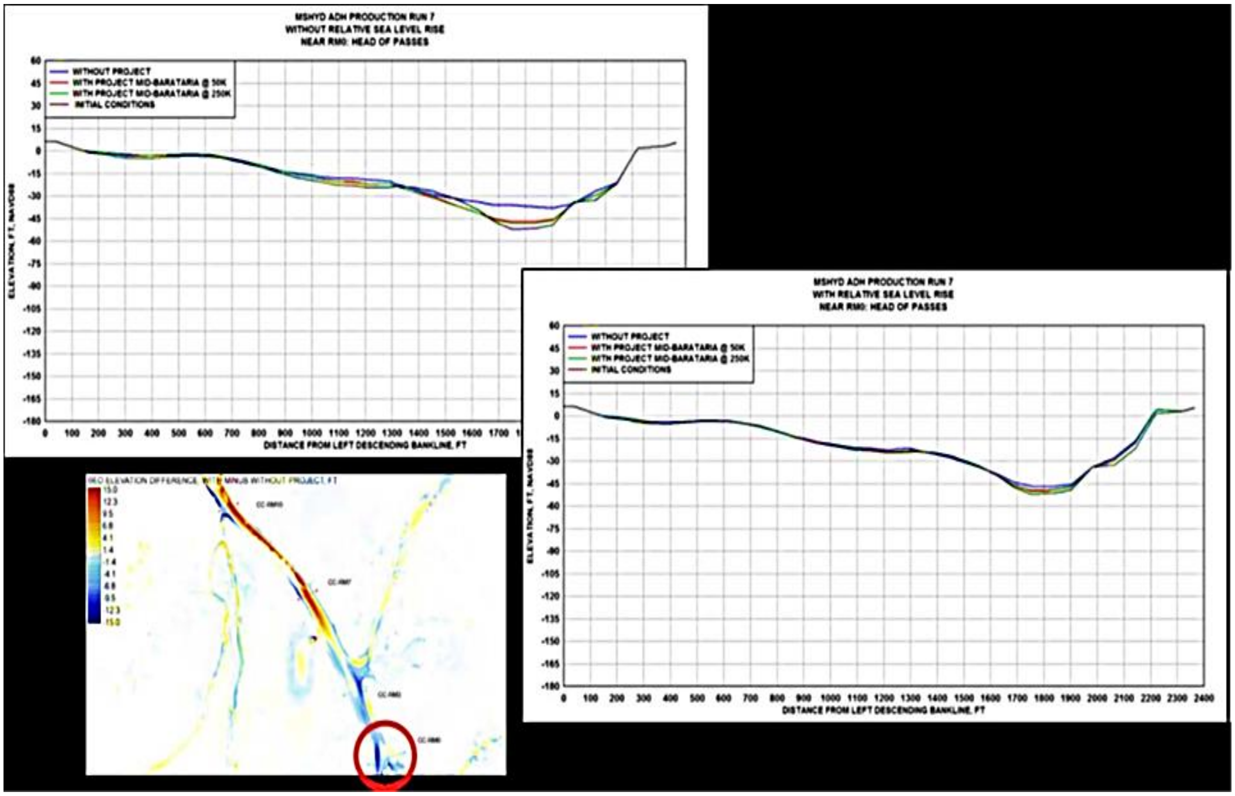


Figure 10. Bed Elevations at Cross Section 10 (HP). This is Figure 5.21 in Brown et al. (2018 draft).

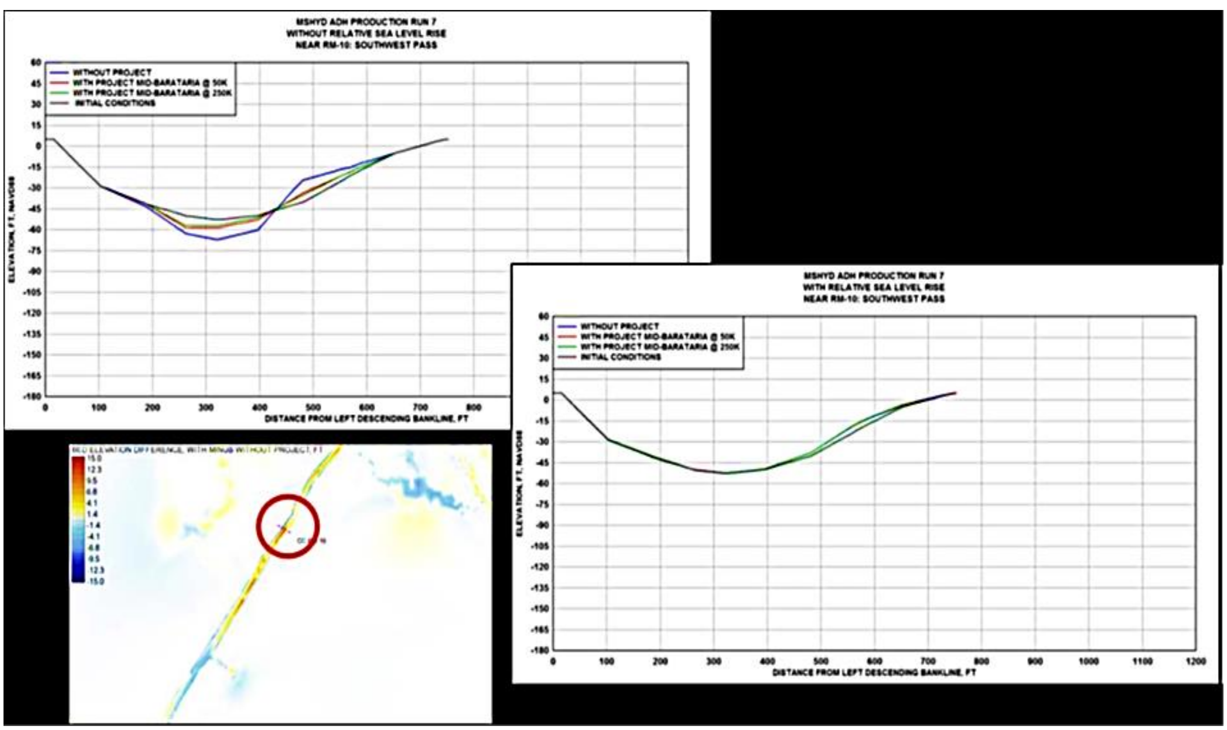


Figure 11. Bed Elevations at Cross Section 11 (SWP). This is Figure 5.22 in Brown et al. (2018 draft).

These cross-sections show a general tendency for increased deposition induced by operation of the five diversions to be stored on existing point and lateral bars outside the navigation channel. Cross-section changes predicted by AdH/SEDLIB modeling are insensitive to quintupling diverted flows at the MBSD structure.

4.5 HEC-6T

The 1-D model HEC-6T was applied to the lower 127 miles of the Mississippi River main stem (including SWP) as reported by Thomas et al. (2018) and summarized by Heath et al. (2019). The model was validated for sand sedimentation and calibrated for fine sediment and validated with dredging observations in the navigation channel. Simulations were performed for a variety of diversion rates (50,000 to 200,000 cfs) at several locations by Thomas et al. (2018). A single diversion of 75,000 cfs out of the LMR and into the Barataria Basin at Ironton was tested in Production Run #1 (FWP1) and those results are used here.

For the diversion simulations, a SDE (aka SWR) of 1.0 was assumed for proposed diversions. CPRA's hydraulic analyses for the Project SWR for the MBSD Project range from 0.8 to 1.3 for sand (mostly bed material load at that diversion) and 1.0 for silts and clays (wash load at that site).

The HEC-6T model diversion report (Thomas et al. 2018) stated these salient conclusions for the Mississippi River:

- The model computed that dredging volumes with each diversion alternative would be less than the FWOP condition[1].
- Proposed diversions, particularly multiple diversions in close proximity to one another, may result in channel pattern changes, that is, the location and size of lateral bars, impacting multiple stakeholders.
- Large scale diversions may increase fine-sediment deposition rates beyond values computed in this study.
- The 80-year test hydrograph was not long enough to form a new equilibrium condition between Alhambra Crossing (RM 192 AHP) and Venice (RM 6 AHP) in this computer model.

Thomas et al.'s (2018) last conclusion about equilibrium of the lower 190+ miles of the main stem Mississippi River means that the process of adapting to major diversions takes longer than the simulated period. The river can be expected to keep changing. That is demonstrated in Figure 12, taken from Thomas et al. (2018) which showed that after an initial reduction in sediment deposition rate AHP, the rate rebounded and became greater than the No Action Alternative at about 40 years (year

[1] FWOP is 'Future without Project', same as the 'No Action Alternative'.

70 in the simulation) after construction. Thus, the HEC-6T conclusion that the diversion would reduce dredging requirements is restricted to the first 40 years for the reach AHP and does not apply to SWP since the model did not reproduce salinity intrusion changes there.

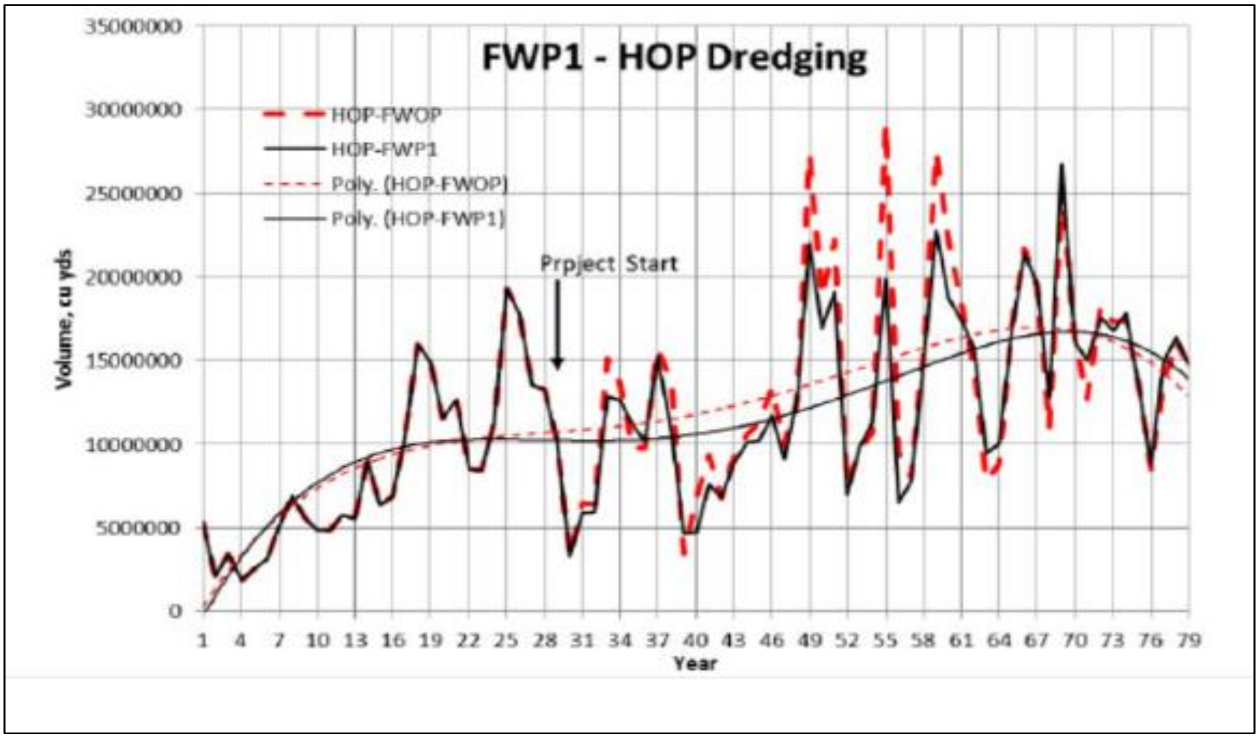


Figure 12. HEC-6T Model Results for Dredging AHP (source: Thomas et al. 2018)

Figure 12 shows that according to modeling performed by Thomas et al. (2018), operation of the proposed diversion (starting in model year 2020) has little impact on dredging volumes AHP for average years: that is the FWOP (red dashed line) and FWP1 (black dashed line) plot almost on top of each other.

During 'wet' years and periods with large dredging requirements (that is, y-axis values >10 mcy), dredging volumes are generally lower in the FWP1 scenario. The magnitudes of the reductions vary, but year 59 is in the middle of the range of variability in differences between FWP1 and FWOP volumes. In that year, the annual dredging volume AHP (where dredging is currently required) was about 27 mcy in the FWOP, but only about 23 mcy with the MBSD Project operating: a reduction of about 15 percent, which may be considered substantial. In year 55, operation of the MBSD Project reduces the dredging requirement from approximately 28.5 mcy to approximately 20 mcy: a 30 percent reduction that may be considered substantial.

In Figure 12, the polynomial line of best fit for FWP1 dredging volumes is identical to that for the FWOP scenario until year 29 (which is the model year when the proposed MBSD Project comes into operation). The FWP1 line then trends below that for FWOP from model years 29 to 73 and above it for years 73 to 79. This period represents the first 44 years of the 50-year period of interest in this study.

The area of the band between the FWOP and FWP1 best fit curves gives a broad indication of overall difference in AHP dredging that could be expected from this 'Base-to-Plan' comparison. By eye, the average width of that band between years 29 and 73 (the period when operation of the MBSD Project is predicted to reduce dredging) appears, conservatively, to be approximately 1 mcy to approximately 1.5 mcy. This indicates a reduction in the dredging requirement in the reach AHP on the order of 44 mcy to 66 mcy, compared to the FWOP. Between years 73 and 79, FWP1 dredging exceeds that for FWOP, resulting in around 6 mcy to 9 mcy of additional dredging. Thus, according to the validated, quantitative results of HEC-6T modeling upstream of HP, the impact of operating the MBSD Project over the 50 years of interest in this study is a net reduction in dredging volume on the order of 35 mcy to 60 mcy. Dredging BHP cannot be estimated from these model results.

5.0 DISCUSSION

5.1 MISSISSIPPI RIVER ABOVE MBSD PROJECT SITE

The Delft3D Basinwide Model indicates that the LMR from the upstream boundary of the model to 1 mile above the proposed MBSD structure exhibited an erosive trend of less than 1 percent that increases with maximum diversion discharge (see Figure 4). HEC-6T results concur with this finding. AdH/SEDLIB simulation results upstream of the MBSD structure are influenced by the upper-Breton diversion, but show that sedimentation in this reach is insensitive to increasing diversion discharge from 50,000 to 250,000 cfs (compare brown and green bars in control volume 13 of Figure 9). Overall, in this reach the models agree that the river above the proposed diversion site may experience negligible net erosion. That is consistent with past studies and known physical processes.

5.2 MISSISSIPPI RIVER, AROUND THE MBSD PROJECT SITE

The Delft3D Basinwide Model results for the LMR from 1 mile above the MBSD structure to the centerline of structure displayed an insubstantial, increasing trend in deposition rates for the 50,000 cfs, 75,000 cfs, and 150,000 cfs alternatives during the first few decades of the simulation (see Table 2 and Figure 5). From the MBSD structure centerline to 1 mile below the structure, and diversions, Delft3D Basinwide Model results exhibited an increased depositional rate for both 50,000 and 75,000 cfs alternatives that peaked at about 4 percent and 5 percent, respectively, by 2070. At 150,000 cfs the depositional rate increased to about 12 percent by 2070 (see Table 2 and Figure 7). AdH/SEDLIB results also indicate deposition, although the impact of increasing the maximum diversion discharge from 50,000 to 250,000 cfs on the deposition rate is not as marked as that predicted by the Delft3D Basinwide Model (compare brown and green bars for control volumes 11 and 12 in Figure 9).

5.3 MISSISSIPPI RIVER, MBSD TO VENICE, LOUISIANA

The Delft3D Basinwide and HEC-6T river models' results indicate that sediment deposition will increase but probably not by enough to require federal navigation channel dredging. That is the most probable outcome unless point bar growth intrudes into the navigation channel. River facilities that have required maintenance dredging in the past may see small increases in dredging requirements. Those findings are consistent with past studies and known physical processes.

The AdH/SEDLIB riverside model simulated the river between the MBSD structure and the Gulf using multiple control volumes (see control volumes 4 to 11, in Figure 9) and actual LMR cross-sections (see Figures 10 and 11 for examples). AdH/SEDLIB results concur with the Delft3D Basinwide Model that additional deposition is expected upstream of Venice, Louisiana and that this is unlikely to trigger the need for dredging unless point bar growth intrudes into the navigation channel.

5.4 MISSISSIPPI RIVER, VENICE, LOUISIANA TO GULF OF MEXICO

Venice to HP. The Delft3D Basinwide Model indicates small but rising sediment deposition rates over time. AdH/SEDLIB indicates that increasing the maximum diversion at the MBSD structure from 50,000 to 250,000 cfs would generate a small erosional trend (see control volumes 2 and 3 in Figure 9). HEC-6T is the only model that simulates dredging. This model indicates an initial decrease in dredging followed by a small increase in dredging after 44 years of MBSD Project operation (Figure 12). HEC-6T has been validated for sand deposition, calibrated for silt and clay, and validated to observed channel dredging, and is known to reproduce fluvial processes reasonably well. Note that even small increases or decreases in deposition rates may constitute large changes in dredging requirements in areas already requiring dredging. For example, an increase or decrease of only 3 percent in the river channel AHP equates to 600,000 cy. These results are generally applicable to the several outlets between Venice and HP which are intermittently dredged for navigation – Tiger Pass, Baptiste Collette, and South Pass.

Southwest Pass. None of the three model studies presented here reproduced the saline wedge phenomenon in SWP; therefore, their localized results in SWP are not considered. From well-known physical processes and past modeling, it is known that the saline wedge will move farther upstream if flow is diminished, as it would be by a diversion. It is further known that sedimentation in SWP increases as the saline wedge moves. For these reasons and the extensive literature (cited above) on SWP sedimentation processes, it is probable that sediment deposition and dredging there would potentially increase under diversion conditions.

Venice to Gulf. The above considerations suggest that dredging from Venice to the Gulf, including the several federally maintained channels, will experience either a decline or an increase in maintenance dredging requirements. Changes may be relatively small but volumetrically large. According to the AdH/SEDLIB and HEC-6T models, the effect of new diversions (including the MBSD Project) is to somewhat offset upstream migration of the locus of deposition, though it does not eliminate it.

5.5 BARATARIA BAY WATERWAY

The Delft3D Basinwide Model and AdH/SEDLIB Basin-Wide models both showed potentially substantial increases in sediment deposition rates in the lower course of this waterway over 50 years – about 20 percent according to the Delft3D Basinwide Model and 40 percent by AdH/SEDLIB. While those values cannot be considered as absolute, such an increase in sediment deposition is consistent with known physical processes in the basin and the intended delivery of new sediment supplies to the basin. Those sediments can be used beneficially in the nearby marshes, albeit at the cost of additional dredging and placement.

5.6 BAYOU LAFOURCHE

Model results were unavailable; however, inspection of AdH/SEDLIB sediment deposition distributions supports the probability that some diverted sediments would be transported to the west side of the basin and become available for deposition. Those amounts are expected to be small.

5.7 GULF INTRACOASTAL WATERWAY

The Delft3D Basinwide Model showed negligible increases in sediment deposition resulting from the diversion, which is consistent with the waterway’s position near the top of the basin.

5.8 EFFECT OF DIVERSION DISCHARGE RATE

The Delft3D Basinwide Model tested 50,000, 75,000, and 150,000 cfs diversion alternatives and the relative magnitude of results among the simulations is reasonable, with sediment deposition roughly proportional to discharge to some power. Comparison of AdH/SEDLIB model results for quintupling the maximum discharge diverted by the MBSD Project (see Figure 9) suggest that the sensitivity of sedimentation impacts to changing the maximum discharge at the MBSD Project decreases with distance downstream of the structure.

5.9 EFFECT OF TERRACES

The Delft3D Basinwide Model indicated negligible to no changes to sedimentation as a result of terraces. That outcome is expected.

5.10 NON-FEDERAL FACILITIES

Sedimentation results were not sufficiently resolved by the models to justify conclusions for non-Federal channels and facilities (ports, marinas, anchorages). This point is stressed by Brown et al. (2018 draft). As a first approximation and pending more focused studies, the above qualitative predictions for Federal channels are likely similarly applicable to adjacent non-Federal channels and related facilities.

5.11 GENERAL

All model results suggest that the Mississippi River and Barataria Basin would not reach equilibrium conditions during their various simulation periods. In other words, sedimentation rates in the river and the basin would continue to change after the 50-year period of analysis for this study. That prediction is consistent with previous geomorphological studies on the systems (for example Russell and Russell 1955, Roberts 1997, Little and Biedenharn 2014, Thomas 2018).

6.0 CONCLUSIONS

From the above analyses of model results, the following conclusions are drawn concerning potential changes to required maintenance dredging volumes in the MBSD Project-area Federal channels:

- No Action Alternative – volumes would continue historical trends with the possible exceptions that dredging requirements may either decrease as channels deepen by relative subsidence or increase as channels are exposed to increased sediment supply by flooding, overwash, and bankline erosion related to relative sea-level rise, coupled with decreasing stream power due to subsidence and increased spills of sediment-lean water at existing diversions and crevasses in the birdfoot delta. All models show landward migration of locus of deposition due to landward migration of backwater curve associated with relative sea-level rise (Brown et al. 2018), though an overall increase in dredging quantities in the lower river is not anticipated (USACE 2018).

- 50,000 cfs MBSD Project Alternative (with and without terraces) – dredging volumes would be essentially unchanged in the Mississippi River AHP and GIWW, and would moderately increase in the Barataria Bay Waterway. The Mississippi River from below Venice to the Gulf would remain what it is now: a net depositional reach, but with the locus of deposition moving somewhat upstream. The requirement for dredging is also likely to move upstream, but whether this leads to an increase in dredging volumes is more difficult to say. Small changes in deposition rates can result in significant changes in dredging requirements. Adding terraces to the plan would not have a noticeable effect on dredging volumes.

- 75,000 cfs MBSD Project Alternative (with and without terraces) – deposition rates would be essentially unchanged in the GIWW, increase substantially in the Barataria Bay Waterway, and increase moderately in the Mississippi River from Venice to the Gulf. Mississippi River sedimentation areas, and possibly dredging requirements, may shift in location. Adding terraces to the plan would not have a substantial effect on navigation channel dredging volumes.

- 150,000 cfs MBSD Project Alternative (with and without terraces) – impacts would be similar to, but more pronounced than for the 75,000 cfs Plan

Alternative. Sedimentation would be essentially unchanged in the GIWW, increase moderately in the Barataria Bay Waterway, and increase moderately in the Mississippi River from Venice to the Gulf. Adding terraces to the plan would not have a substantial effect on dredging volumes.

- The above conclusions for the Mississippi River, Venice to the Gulf, are generally applicable to the several outlets between Venice and HP, which are intermittently dredged for navigation – Tiger Pass, Baptiste Collette, and South Pass.

- Federal and non-Federal navigation facilities (ports, anchorages, terminals) – as a first approximation would probably experience sedimentation impacts similar to those of the nearby Federal channels that have been specifically mentioned.

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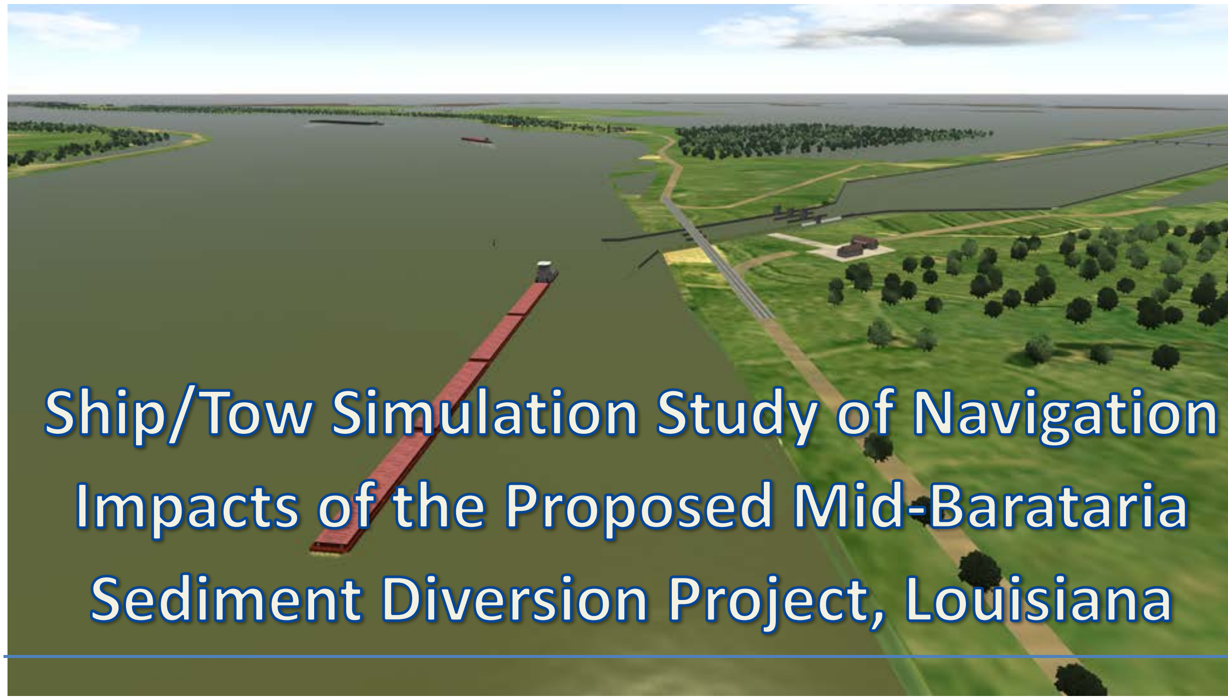
Q2: Navigation Study Reports

2018 Ship Simulations Report



Ship/Tow Simulation Study of Navigation Impacts of the Proposed Mid-Barataria Sediment Diversion Project, Louisiana

Study Performed for

Coastal Protection and Restoration Authority

State of Louisiana

by

Waterway Simulation Technology, Inc.

and

Maritime Institute of Technology and Graduate Studies

November 21, 2018

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Introduction

Project Purpose

A proposal to divert flow from the Lower Mississippi River near River Mile +61 (RM61) into the wetlands and waterways in the Barataria Basin on the west side of the confining levees has been proposed and is being designed (see Figure 1 & Figure 2). The purpose of this project is to introduce sediment into the Basin. Flows of approximately 30,000 cfs up to 75,000 cfs are proposed for diversion from the river to the basin. The navigation simulations used diversion operation flows of 48,000 and 75,000 cfs when the river would be flowing at a discharge of 600,000 and 1,000,000 cfs, respectively. Large amounts of water withdrawn locally on the western side of the channel could potentially have impacts on the safe operations of ship and tow traffic transiting past this project, when in operation. For the purposes of this report, ships are considered deep draft vessels (drafts deeper than 14ft) and tows refer to shallow draft barges, with a pusher boat, which comprise line-haul tows (through traffic coming from outside the study reach typically made up of 30 barges) or fleeting tows (operating between terminals and/or fleeting areas typically 4 barges or less).

In addition, during construction a cofferdam and temporary protective cells will be placed in the river to facilitate construction of the intake structure. Barges will likely be placed around the protective cells, and work boat(s) could be moving around these barges to assist in the construction. These will all cause constriction of the navigable portion of the Mississippi River at the location of the project, which could affect vessel traffic. The cofferdam will also affect local flow patterns along that side of the bank.

Figure 1: Mississippi River at Myrtle Grove

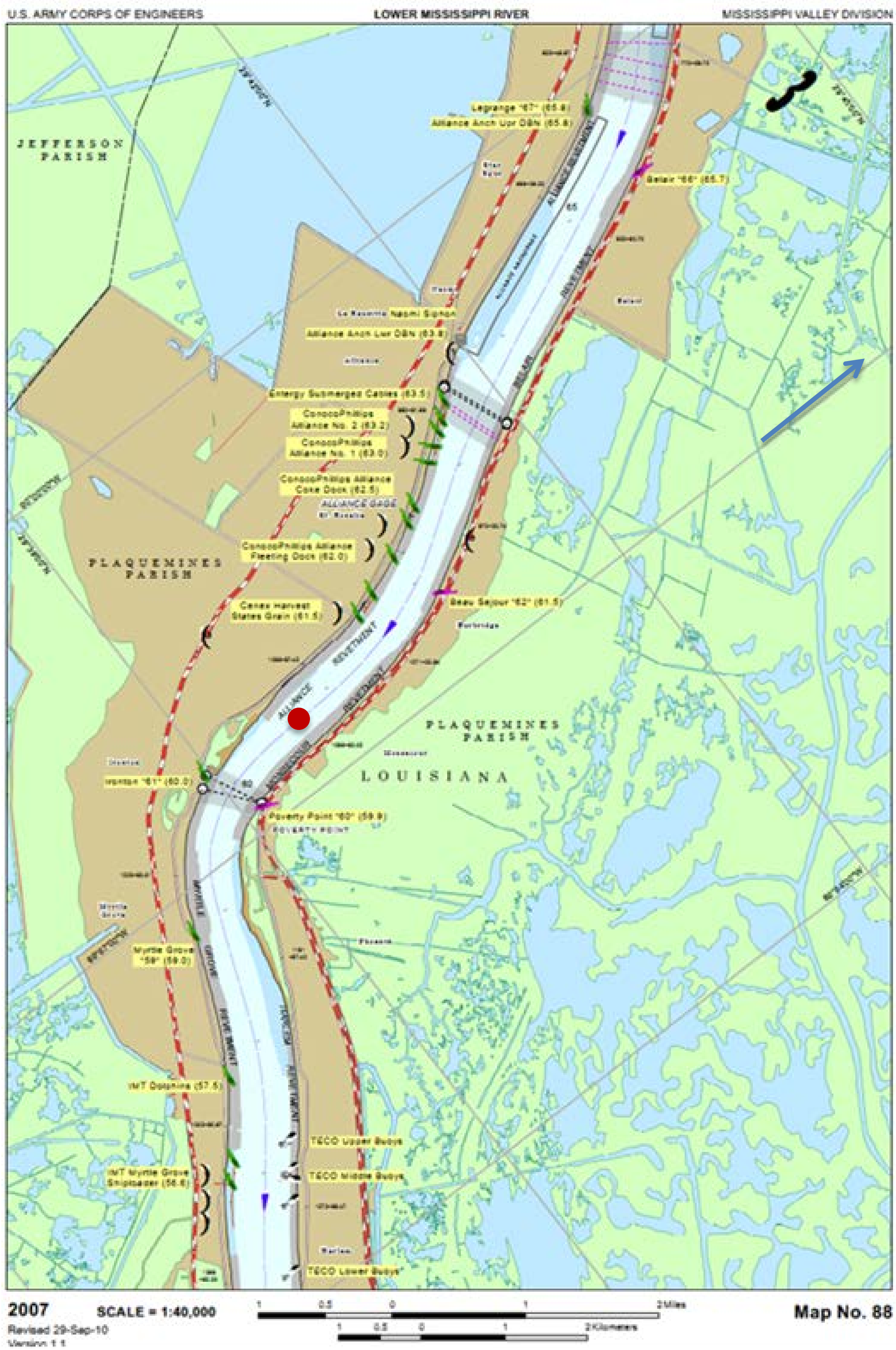

Figure 2: Corps of Engineer's Navigation Chart at Myrtle Grove – Proposed Project Site (Red dot marks RM 61 and arrow indicates North)

Navigation in the Project Reach

Navigation in the project reach of the Mississippi River is conducted in a Federal Navigation Channel for which the U.S. Army Corps of Engineers, New Orleans District (USACE), is responsible. Information about the channel, including hydrographic survey data, navigation markers, revetment locations, dock facilities, etc. as well as levee data was provided by the USACE. A meeting of navigation interests was held in New Orleans on August 16, 2013 and again on August 2, 2018, to gather information about navigation on this reach of the river, understand the industry's thoughts about this proposed project and what should be included in a navigation study of the impacts of this project on ship and tow operations[1][2]. During the 2018 meeting it was learned that this reach of the Mississippi River has one of the nation's most dense volumes of ship and tow traffic. There are major terminals and marine facilities that receive and ship products, storing and transferring cargo between ships and tows in addition to the through traffic of ships and tows. All of the New Orleans to Baton Rouge ship traffic passes through this reach, which has an authorized 50-ft deep navigation channel and a wide maneuvering area within the river. Ships passing through this reach include Suezmax tankers, Capesize bulk carriers, and large cruise passenger ships. Tow traffic is also heavy, bringing grains, petroleum products and chemicals to terminals for export. With large fleets in the area, fleeting activity is busy. As a result, determination of the impact on navigation operations in this reach by the intermittent operation of this proposed project was required. This ship/tow maneuvering simulation study was conducted to address the impacts on this navigation traffic with a special focus on the tow traffic.

Proposed Project Design

The proposed Mid-Barataria Sediment Diversion Project design details are shown in Figure 3 & Figure 4. This is the 15% design; therefore, the simulation study timing was relatively early in the design process. If future project design changes create significant changes in the currents at the project intake, consideration should be given to repeating the simulation study.

This design includes the intake structure with three U-frame channels coming through the Mississippi River Levee with training walls upstream and downstream. The bottom of the intake will be armored and slopes from the intake walls to a bottom depth of -40ft below the North American Vertical Datum of 1988 (NAVD88). The training wall structures are stepped down to follow the slope of the shoal on the west side of the river. The intake structure does not extend beyond the existing alliance revetment at -50ft NAVD88.

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[1] Waterway Simulation Technology, Inc. Memo For Record dated August 27, 2013, **Subject: Meeting with Maritime Interests in New Orleans, LA, to Discuss the Ship and Tow Simulation Impacts of the Proposed Mid-Barataria Sediment Diversion Project**

[2] Waterway Simulation Technology, Inc. and CPRA, Meeting Summary, **CPRA Mississippi River Mid-Basin Sediment Diversion Program: Study of the Potential Impacts of the Proposed Mid-Barataria Sediment Diversion Project on Tow Traffic on the Mississippi River,** Meeting date: August 2, 2018.

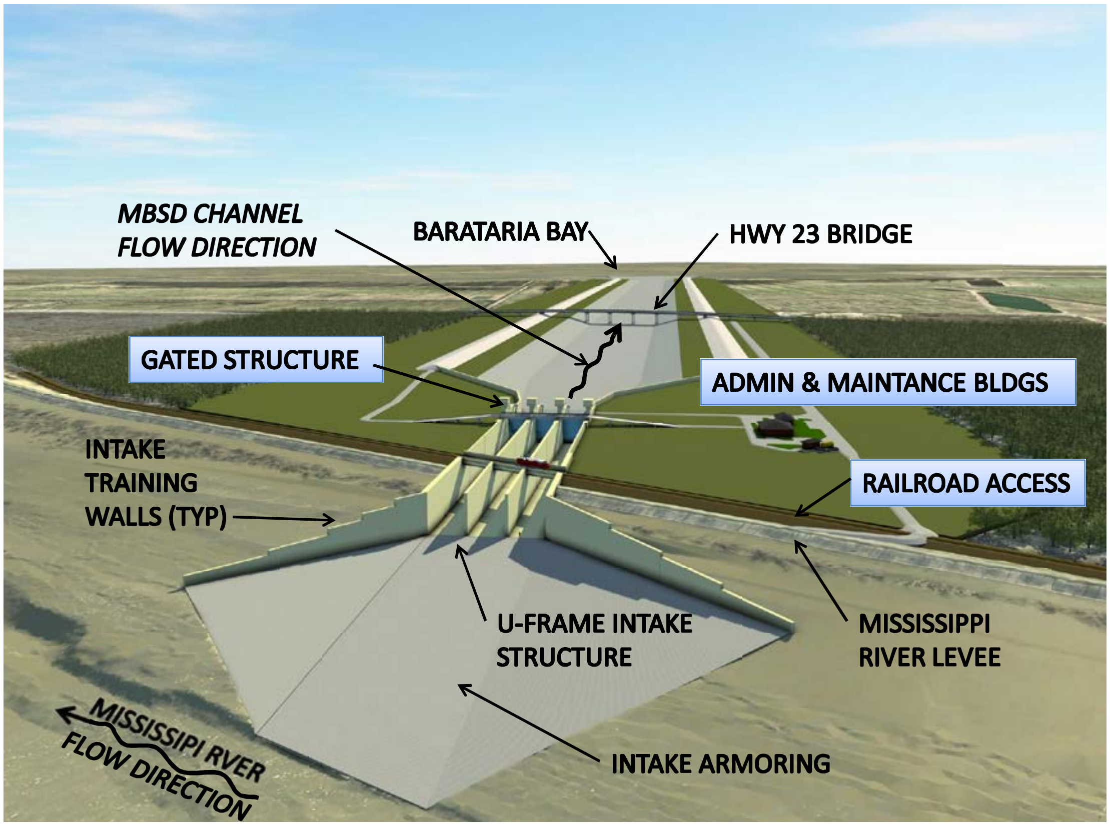

Figure 3. Mid-Barataria Sediment Diversion Project Proposed Design

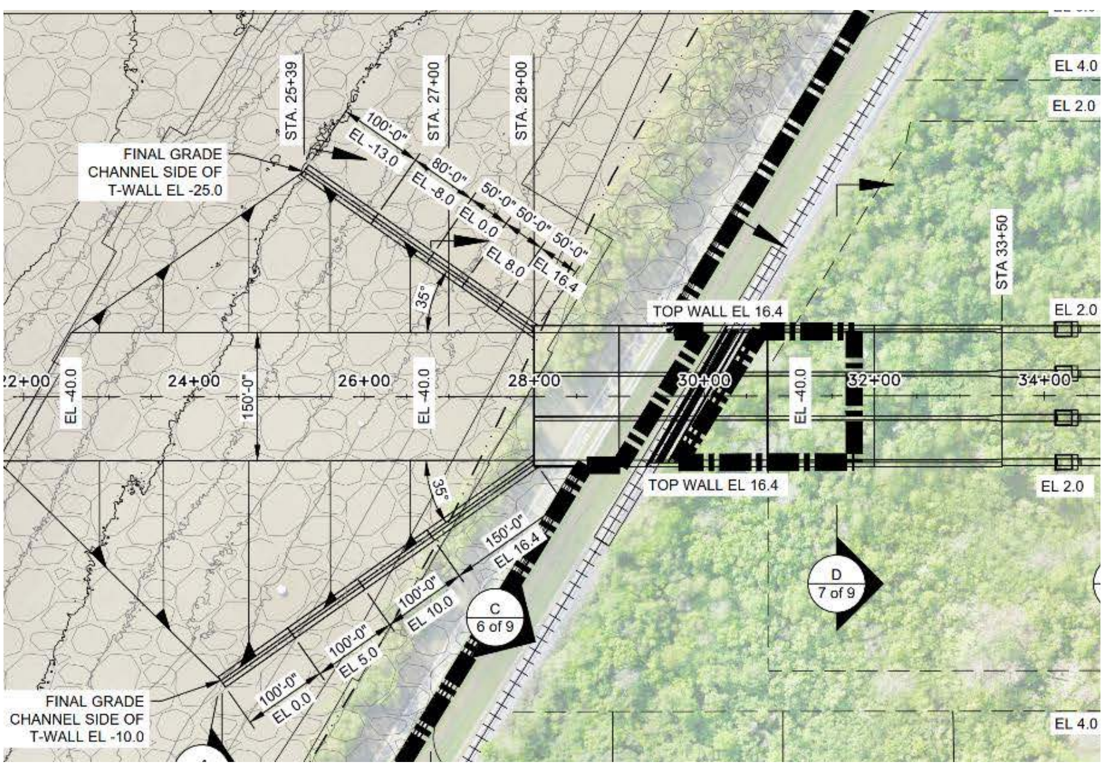

Figure 4. Mid-Barataria Sediment Diversion Project Design Details

The proposed construction layout is shown in Figure 5. The construction is anticipated to be completed in the dry and, therefore, a cofferdam will be built around the construction site. In addition, temporary protective cells or dolphins (shown as black dots in Figure 5) will be constructed on the riverside of the cofferdam to protect the cofferdam from being damaged by possible impact. A protective mat will be laid around these cells extending from the cofferdam to beyond the protective cells and will be at a depth ranging from -21ft to -48ft NAVD88. Small wing walls will be constructed from the cofferdam to the levee. The top elevation of the cofferdam and the protective cells will be +18ft NAVD88.

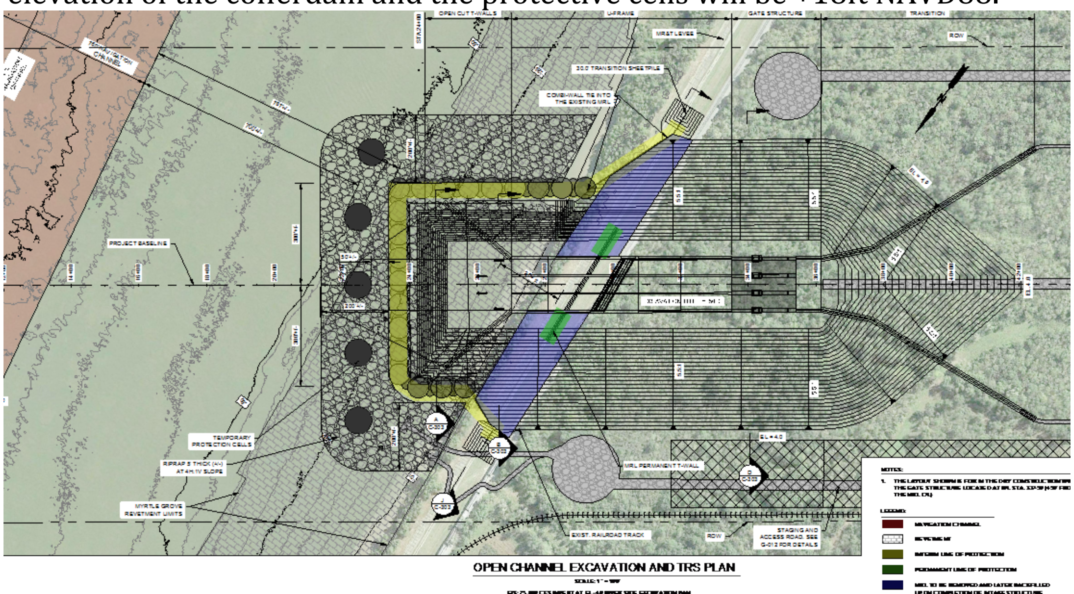

Figure 5. Proposed Construction Layout for the Mid-Barataria Sediment Diversion

Previous Ship Simulation Study

Simulations of ship operations in the vicinity of the project have been completed and documented.[3] This study was conducted in 2013 for a preliminary design being considered at that time. The previous study was conducted at the same location on the river and had similar diversion flow rates for approximately the same river discharges. The project design was for a slightly narrower intake channel that extended into the river farther and with a bottom elevation of -40ft, rather than -50ft and decreased the depth past the gates to -25ft but also widened the conveyance channel. It also had a radius flare intake. Figure 6 shows the difference between the two project intake layouts. The changes in this design would be expected to have little effect on the previous ship simulations results since the ships did not approach the intake close enough to be affected by the change in design.

Purpose

The purpose of this study is to determine if the proposed diversion project could have negative impacts for the safe maneuvering of line-haul tows or tow fleeting

[3] Waterway Simultion Technology, Inc., *Mid-Barataria Sediment Diversion Project – Impact on the Navigation of Ships in the Mississippi River*, February 2, 2014.

operations within the influence of the project while water is being diverted. Identified diversion discharge quantities associated with negative navigation impacts were to be addressed. In addition, if such negative impacts are found, what vessel types and load conditions will be impacted the most were to be identified.

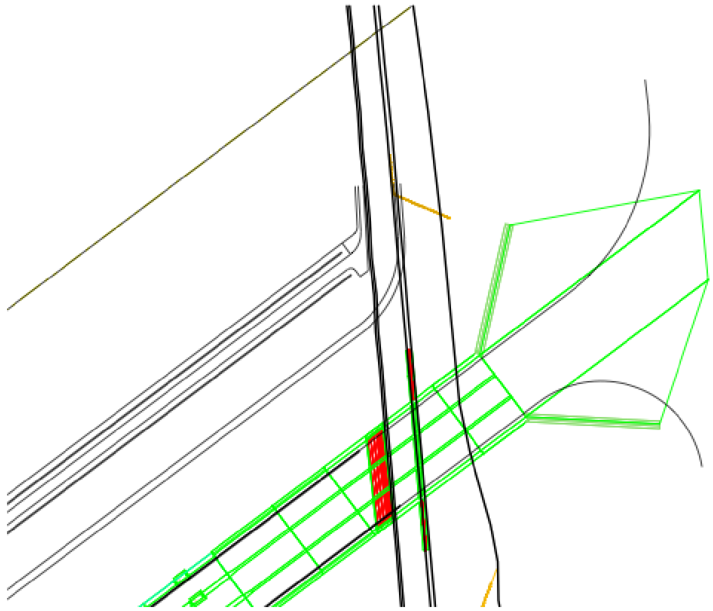

Figure 6. Comparison between Previous Intake Design (black line) and the Current Intake Design (green line)

Additionally, proposed construction conditions that have been defined by the CRPA will be programmed and simulated to evaluate the safety of navigation operational conditions during project construction.

Approach

A real-time piloted tow maneuvering simulation study was performed in which a model of the proposed project was developed, during construction and at operational completion, with a selected set of river and diversion discharges. Based on discussions with navigation stakeholders on August 2, 2018, it was agreed that one primary concern was the potential impact of the ship and tow traffic in the area and the possible restricted waterway that could exist during both the construction (expected to last two years) and the completed operation of the project. Also, a concern was the navigation impact of the downstream wing wall of the intake structure and the intake flow.

Traffic conditions were set up with upbound and downbound ships following transit lines provided by the participating pilots. During construction test runs, the downbound ship was conned by a local pilot. A line-haul tow was maneuvered as part of the traffic past the diversion project under each of these conditions to determine if safe control of the tow could be maintained. The simulations involved a towboat master operating in a tow-simulator and using the available controls in order to transit the project area as a downbound and upbound tow. Typical fleeting operations with towboats handling two to four barges were tested working between the CHS terminal and fleeting area and fleeting areas downstream near the IMT and Myrtle Grove Fleeting. These tows were conned by pilots from the principal fleeting tow company in the area. The tests with completed and construction project phases provided a measure of the impact on expected navigation conditions. These tests were conducted at the Maritime Institute of Technology and Advanced Graduate Studies (MITAGS) in Linthicum Heights, Maryland using three tow simulators and one ship simulated bridge; all interacting together.

Simulation Databases

Visual, ECDIS, Radar, and Bathymetry

The databases from the earlier simulation study were modified to reflect the changes in the design of the project structure as shown in Figure 4 and the construction condition as shown in Figure 5. Three-dimensional graphic images of the river, terminals, aids to navigation, trees and vegetation lining the banks of the river, towns and various buildings, and the diversion project were constructed in the geographically correct locations. These images are textured and change as the objects are approached. To add even more realism to the simulation, 30-barge tows were positioned in the locations where fleets of barges are normally secured. Since models of individual barges were not available on the simulator, tows were used which included the towboats; however, the pilots participating in the simulation approved the realism of this approach. Also, ships models were placed on the major ship docks. One view of the simulated image of the project with traffic is shown in Figure 7. Figure 8 shows traffic during the construction phase.

The project area modeled with the current model extended from approximately River Mile 58.5 (RM 58.5) to RM 62.5. This limited the modeling area over which the ship/tow maneuvering could be conducted and is shown in Figure 9. This figure shows the extent of the modeled river reach, the locations of the fleeting areas and ships at berth, and the simulator bathymetry, which was taken from the current model bathymetry. A close-up of the bathymetry at the project site is shown in Figure 10 and of the project under construction is presented in Figure 11.

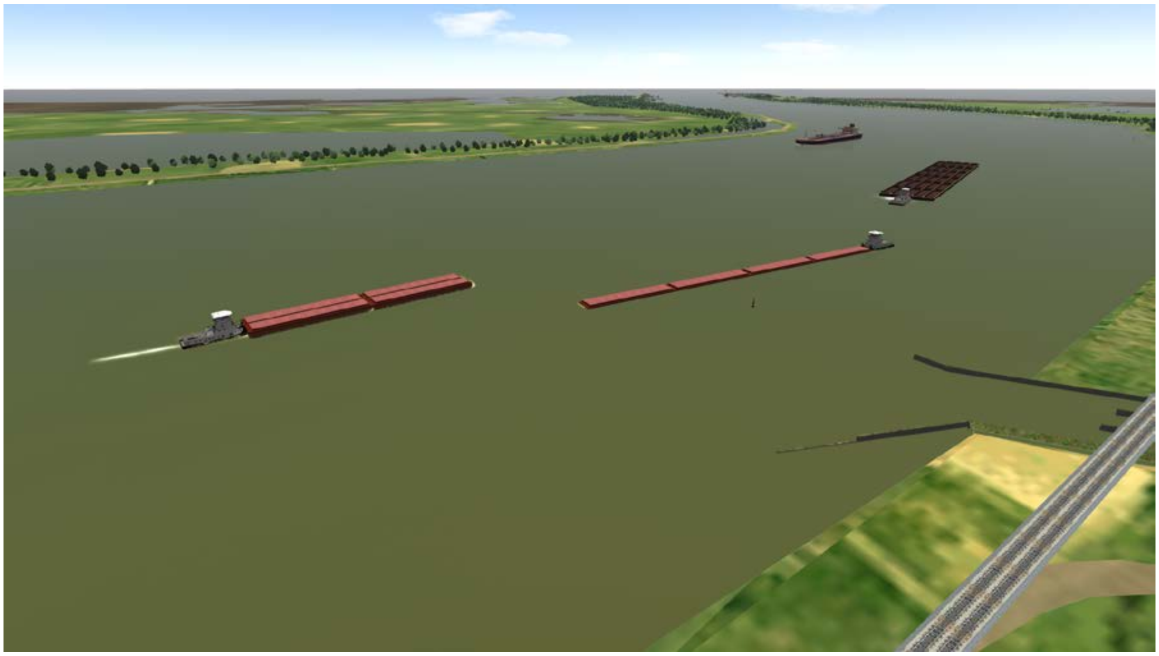

Figure 7. Mid-Barataria Sediment Diversion with Tow and Ship Traffic

Figure 8. Mid-Barataria Sediment Diversion Under Construction with Ship and Tow Traffic, Work Barges and Workboat on the Perimeter of the Construction

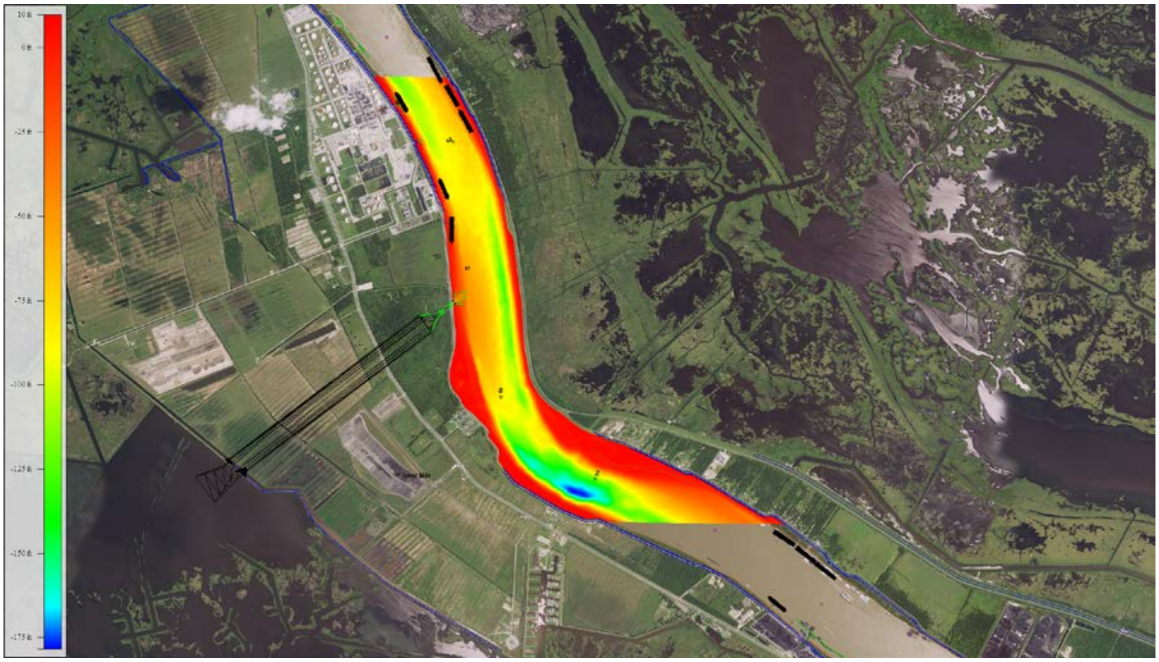

Figure 9. Modeled Reach of the Mississippi River Showing the Bathymetry and the Modeled Location of Tow Fleets and Ships at Berth

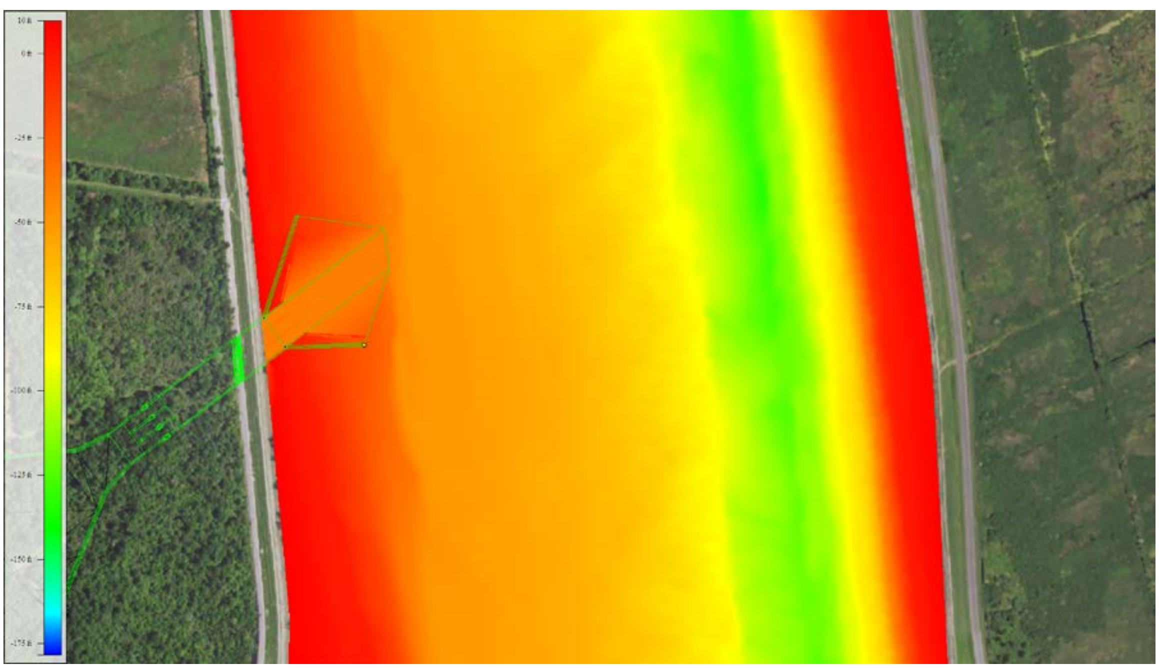

Figure 10. Local Bathymetry at the Mid-Barataria Sediment Diversion. The intake structure extends to the limit of the existing Alliance revetment (-50ft)

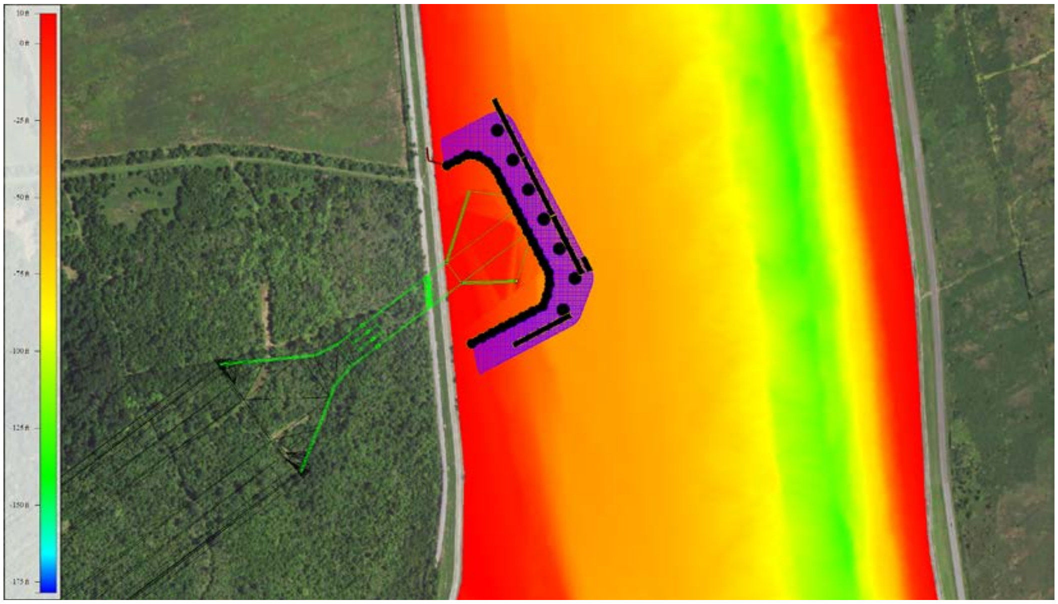

Figure 11. Bathymetry at the Mid-Barataria Sediment Diversion Construction Site Showing the Construction Barges and Work Boat in Place

Radar and the Electronic Chart Display Information System (ECDIS) displays were generated from the navigation charts. The Automated Information System (AIS) signals emanating from each modeled vessel during the simulation runs were visible to each pilot on his own ECDIS. A typical image on the simulator radar is shown in Figure 12.

ECDIS displays and a simulator view from the Suezmax tanker while approaching traffic at the Mid-Barataria Sediment Diversion are shown in the following figures, Figure 13 & Figure 14. Figure 15 is a view from a fleeting tow as it passes the construction site.

Figure 12. Radar image with Traffic Passing the Mid-Barataria Sediment Diversion

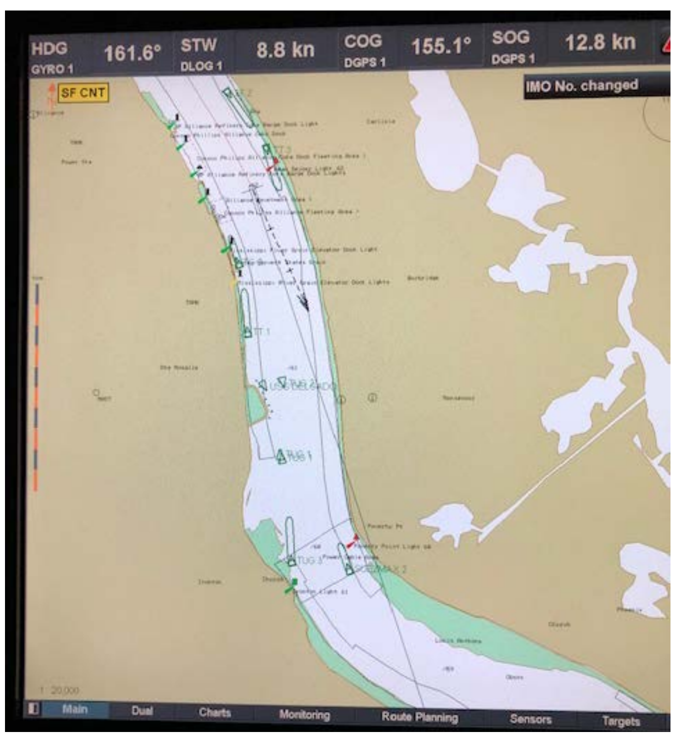

Figure 13. ECDIS Image on Suezmax Tanker Approaching the Mid-Barataria Sediment Diversion Under Construction with Tow and Ship Traffic

Figure 14. View of the Traffic from Suezmax Tanker Approaching Mid-Barataria Sediment Diversion Under Construction with Upbound Suezmax Tanker, Downbound 4-Barge Tow, and Upbound 30-Barge and 4-Barge Tow

Figure 15. View from 4-Barge Upbound Tow Passing Mid-Barataria Sediment Diversion Under Construction

Tow and Ship Models

Four ship models were included in these simulation tests, a loaded and a ballast Suezmax Tanker and a loaded and a ballast Panamax Bulk Carrier. These ship models were used in the 2013 simulation tests. Their pilot cards are included in Appendix C.

A loaded and empty (MT) 30-barge tow was used to represent line-haul towing operations. Normal operation of line-haul tows includes both upbound and downbound loaded and empty tows; however, the primary operation is for the line-haul tows to be loaded downbound and empty upbound. In the simulations both directions of operation were included; however, the primary operation mode was used most of the time. The 30-barge tow model was constructed as a unit and was 5 barges wide and six barges long. A 12-barge tow was also available as a unit tow model, both empty and loaded, but was not used during the simulations. The 30-barge tow was the primary model used because it used the most space in the river traffic situations and, therefore, was the most critical. Pilot cards for these models are included in Appendix C.

The smaller fleeting tows were constructed by attaching models of loaded or empty barges to a selected towboat. These models use a technique developed by Transas that allows the barges to be lashed together with other barges and/or towboats and then simulated forces and moments computed for these lashed tows during the simulated runs. Two towboats were used in building these tows – a 17-ton bollard pull (bp) model used for the 2-barge tow configurations and a 20-ton model used for the 4-barge tow. Loaded or empty barge models of standard jumbo barges were used for the flotilla. 2-barge tows were constructed with two barges side-by-side and two barges end-to-end. 4-barge tows were constructed with the barges 2-wide by 2-long and 4-barges long and 1-barge wide. These tows were tested extensively three days prior to beginning the simulation tests to assure realistic performance by an experienced mariner. Pilot cards for these towboats are included in Appendix C.

Hydrodynamic Model Data

FTN Associates has developed a three-dimensional (3D) model of the Mississippi River reach and the project to study the hydrodynamics and transport characteristics of the proposed concept of the project. The hydrodynamic model used was Flow3D, developed by Flow Science, Inc. A brief description from the official Flow-3D internet site is provided:

FLOW-3D *is a powerful and highly-accurate CFD software that gives engineers valuable insight into many physical flow processes. With special capabilities for accurately predicting free-surface flows,* ***FLOW-3D*** *is the ideal CFD software to use in your design phase as well as in improving production processes.* ***FLOW-3D*** *is an all-inclusive package. No special additional modules for meshing or post-processing are* *needed. An integrated graphical user interface ties everything together, from problem setup to post-processing[4].*

The current model data for the ship simulation study was provided by FTN Associates by averaging the 3-D data over the upper 12ft of river flow. This is the current that would affect the shallow-draft tow traffic. These currents would be somewhat higher than the ships would experience when the currents are integrated over 30-50 ft of depth. However, the focus in this study was-- on the tow traffic and only one set of current data can be loaded at a time in the simulator.

It should be noted that the bathymetry and current data modeled by FTN was provided for this study prior to receiving the final project plan and construction layout. As noted above, the design had been progressing and the plan used in this study for the physical layout - viewed in the simulator - had a bigger footprint than the physical plan used for the river current modeling. Therefore, the currents that would be produced by using the final project design in the hydrodynamic model could be expected to be lower in magnitude due to the enlarged area for the same flow to pass through the project intake. Consequently, the simulation results would be expected to indicate less impact. Also, the currents used in the simulation had higher magnitudes in the area outside the temporary protective cells since the design used in producing the currents for the construction phase was smaller and did not project out into the river as far as did the final design, which would make the test results be conservative.

The currents provided for the project operation were developed for two river flows and one flow during construction. The project modeled by FTN covered the area from River Mile 58.5 (RM58.5) to RM62.5 as shown in Figure 9. The river and project flows modeled are presented in Table 1. The velocities used in the simulations of low flow are shown in Figure 16 with a close-up at the project area in Figure 17 – the magnitude of the current for this case near the project was between 3 and 5 feet per second. High flow velocities are shown in Figure 18 with a close – up of the project shown in Figure 19. High flow current magnitudes in the river near the project were generally between 5 and 7 feet per second. Velocities under the construction phase are presented in Figure 20 with a close-up of velocities in Figure 21.

Table 1. Modeled Flow Conditions for Mid-Barataria Sediment Diversion Simulation Study

Condition	River Discharge (cfs)	Project Diversion (cfs)
Low Flow	600,000	48,000
High Flow	1,000,000	75,000
Construction	1,000,000	0

[4] http://www.flow3d.com/flow3d/flow3d-overview.html?gclid=CMf2vZnw77oCFRFo7AodbAwAPg

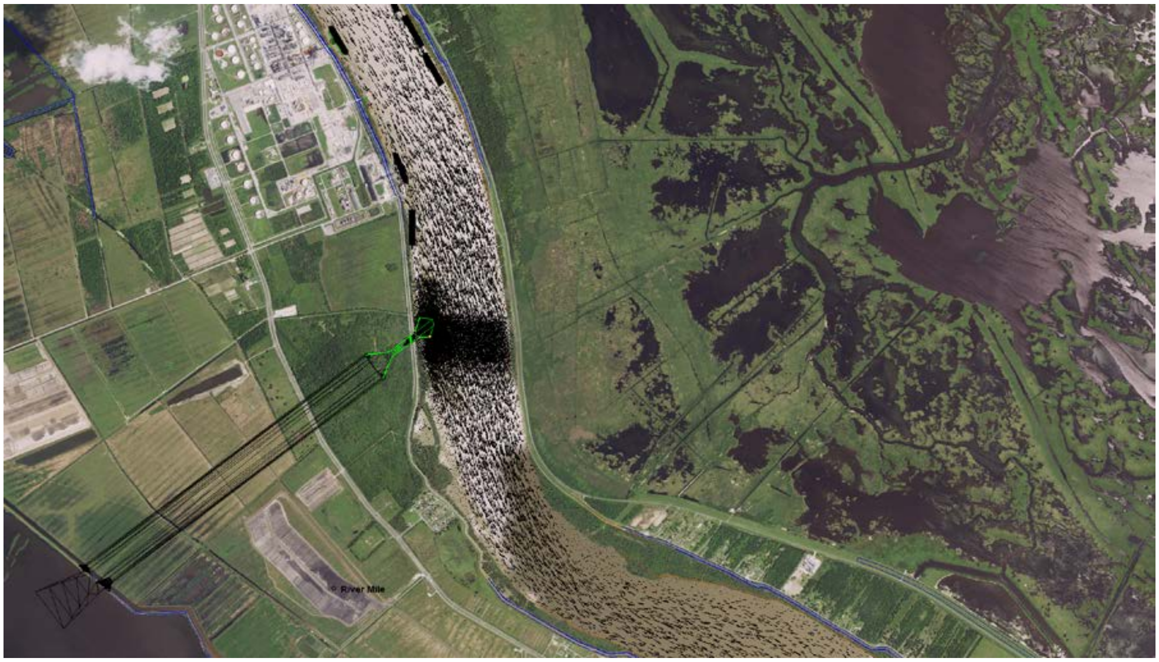

Figure 16. Low Flow Currents for Mid-Barataria Sediment Diversion at a River Flow of 600,000 cfs/Project Diversion of 48,000 cfs

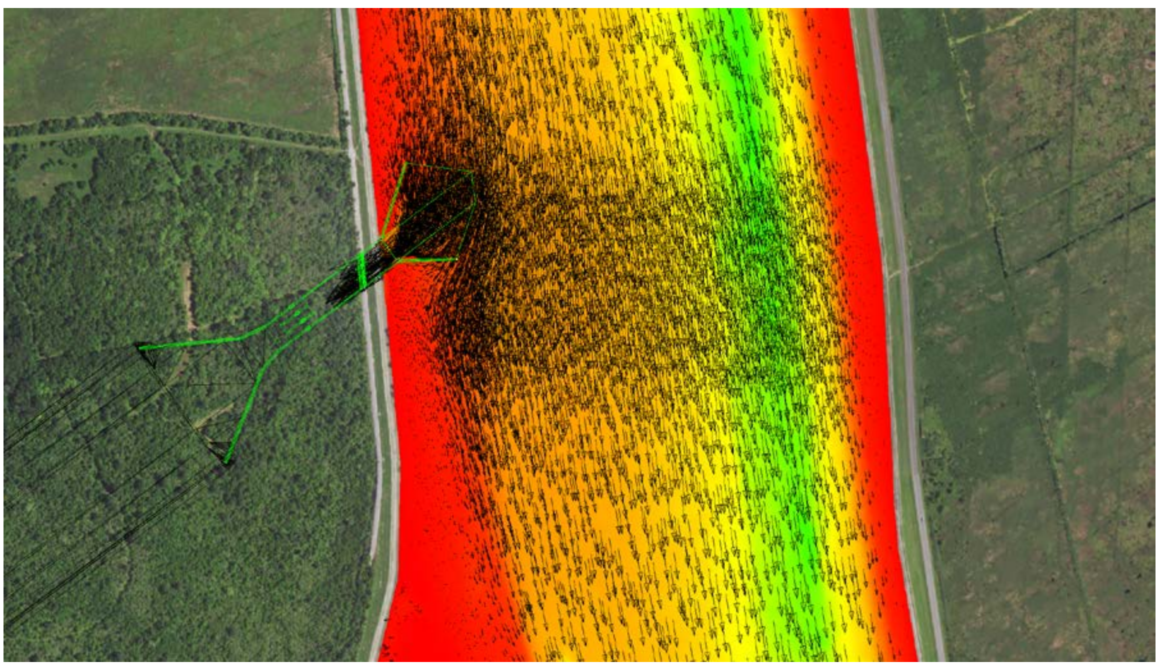

Figure 17. Close-up of Low Flow Currents for Mid-Barataria Sediment Diversion at a River Flow of 600,000 cfs/Project Diversion of 48,000 cfs at the Project Intake.

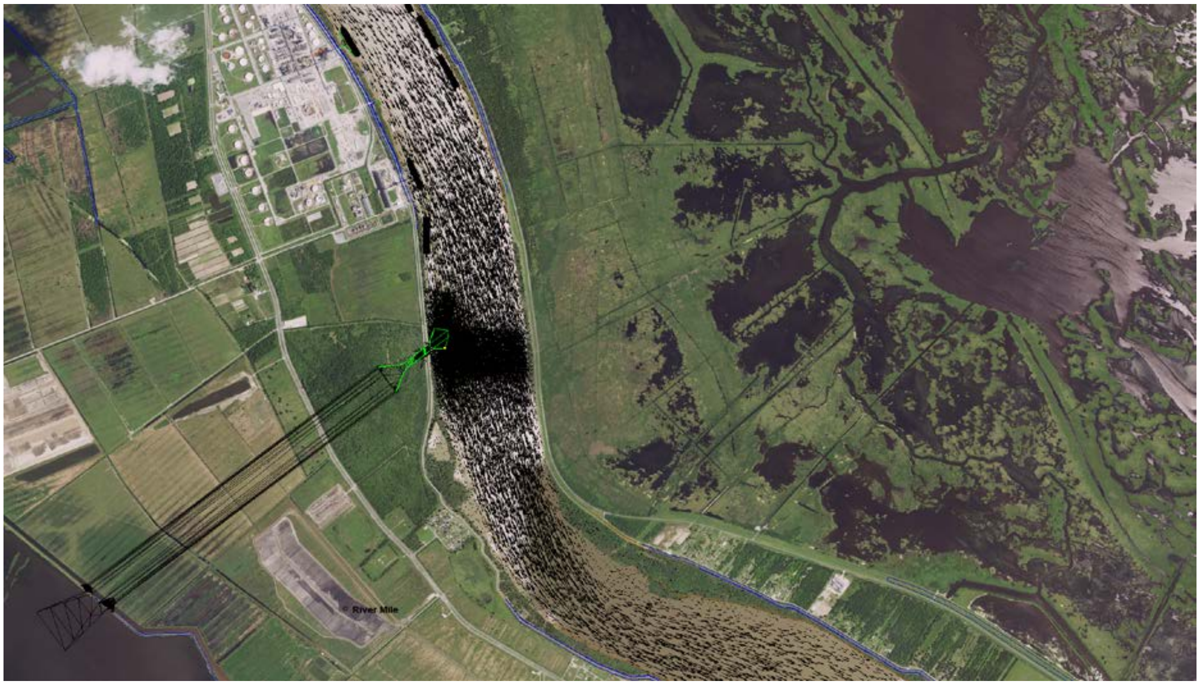

Figure 18. High Flow Currents for Mid-Barataria Sediment Diversion at a River Flow of 1,000,000 cfs/Project Diversion of 75,000 cfs

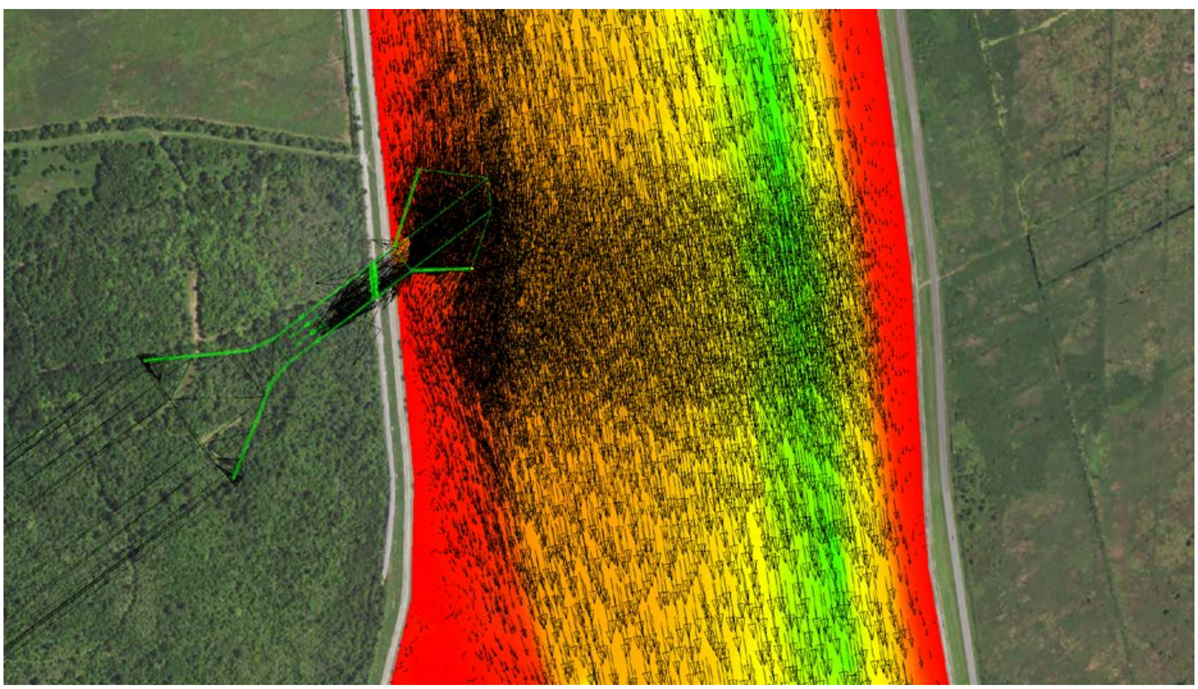

Figure 19. Close-up of High Flow Currents for Mid-Barataria Sediment Diversion at a River Flow of 1,000,000 cfs/Project Diversion of 75,000 cfs at the Project Intake.

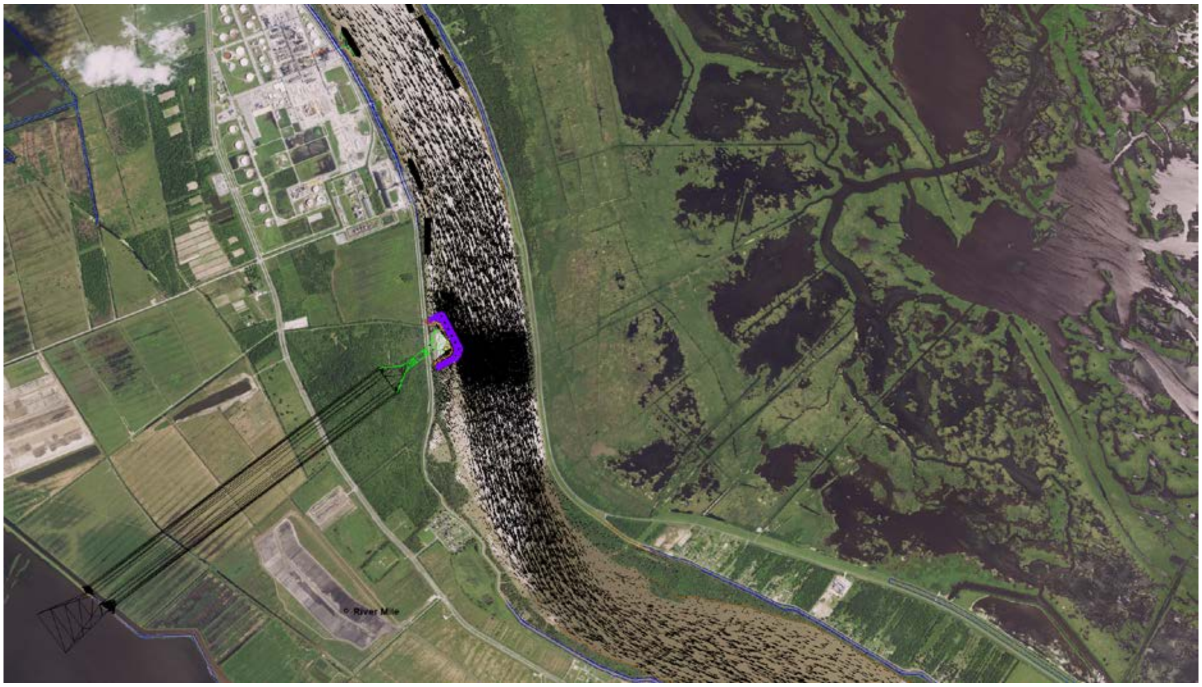

Figure 20. High Flow Currents for the Construction Phase of the Mid-Barataria Sediment Diversion Project at a River Flow of 1,000,000 cfs.

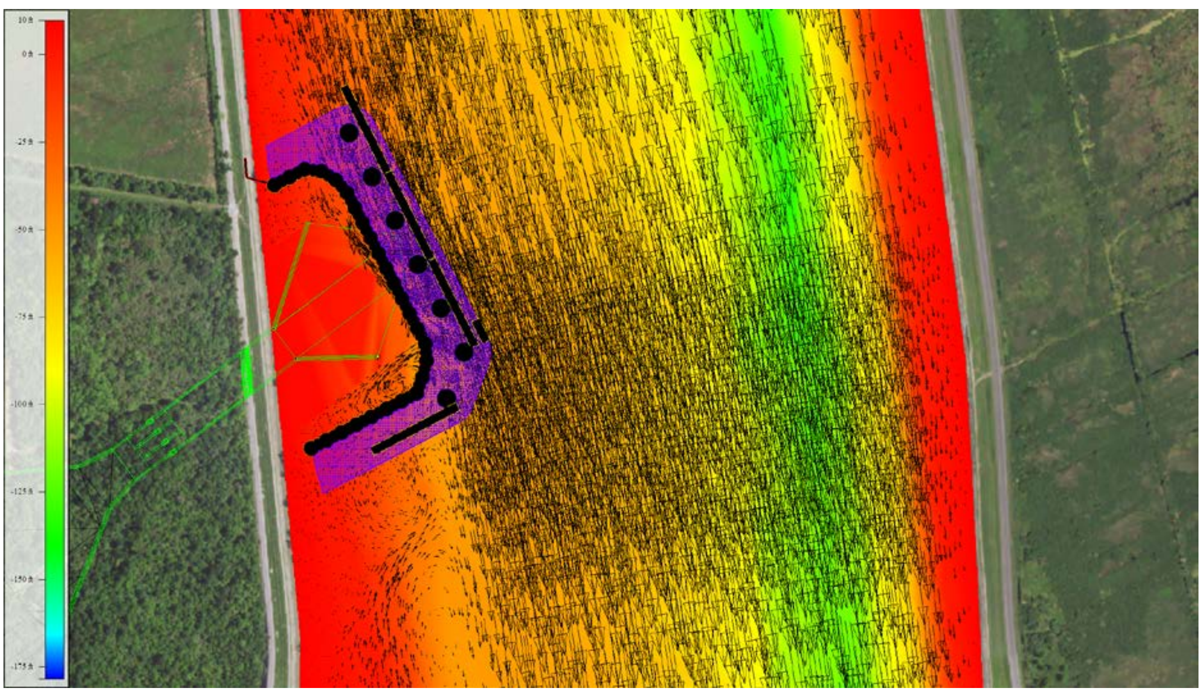

Figure 21. Close-up of High Flow Currents for the Construction Phase of the Mid-Barataria Sediment Diversion Project at a River Flow of 1,000,000 cfs.

Wind

Wind data were obtained for one year from NOAA'S PORTS Station at the Pilot Station, LA from October 1, 2017, to September 9, 2018. This station has a limited set of data. A wind rose is presented in Figure 22 and a distribution of wind speed is presented in Figure 23. These data show that most of the wind comes from the south to south-east and from the north-northeast to the east-northeast. A relatively significant percentage of the wind is in the range from 17 knots to above 21 knots. Thus, wind from the southeast and east-northeast at 20 knots was used during the simulations.

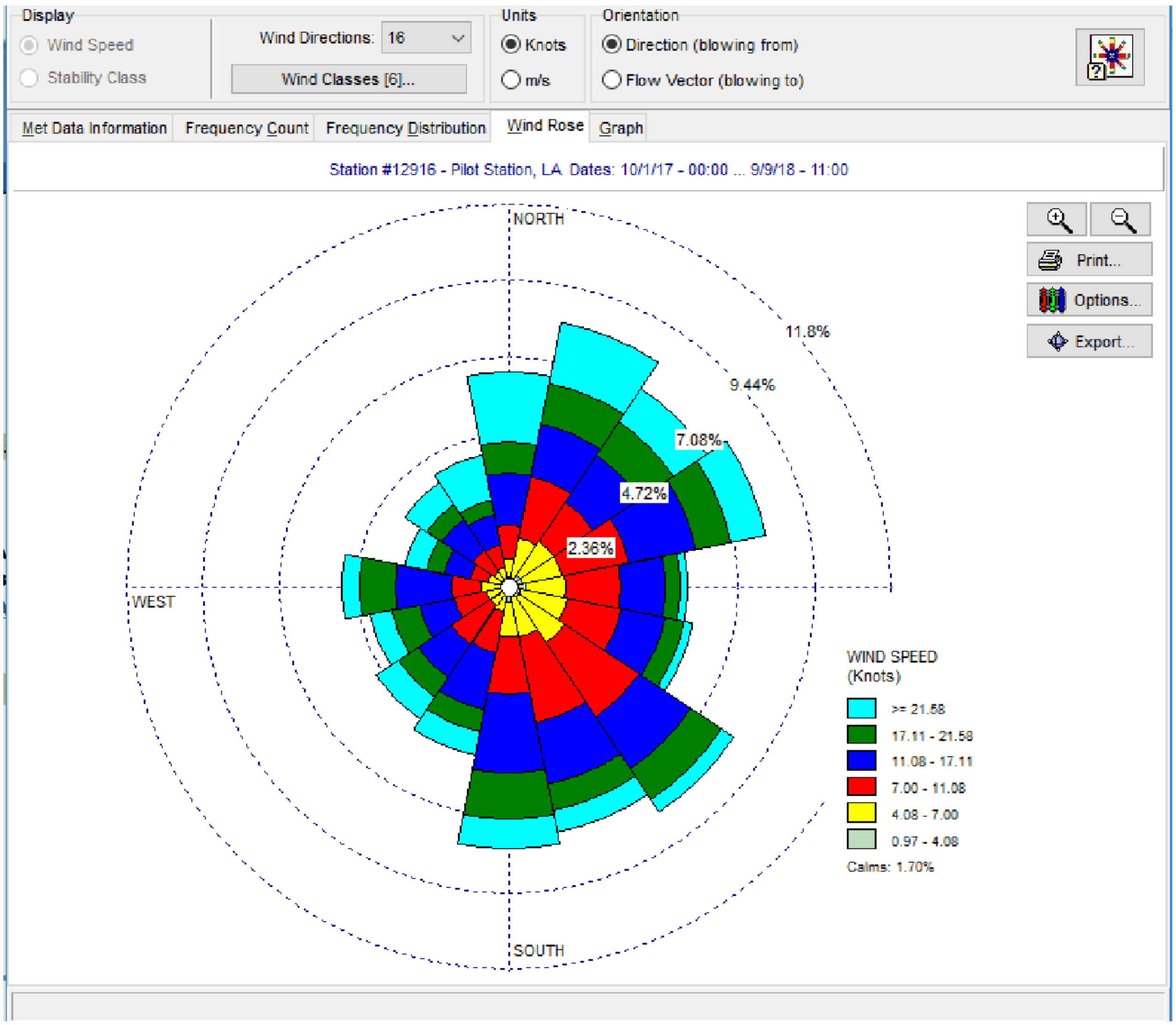

Figure 22. Wind Rose from Pilot Station, LA for the period 10-1-2018 to 9-9-2018

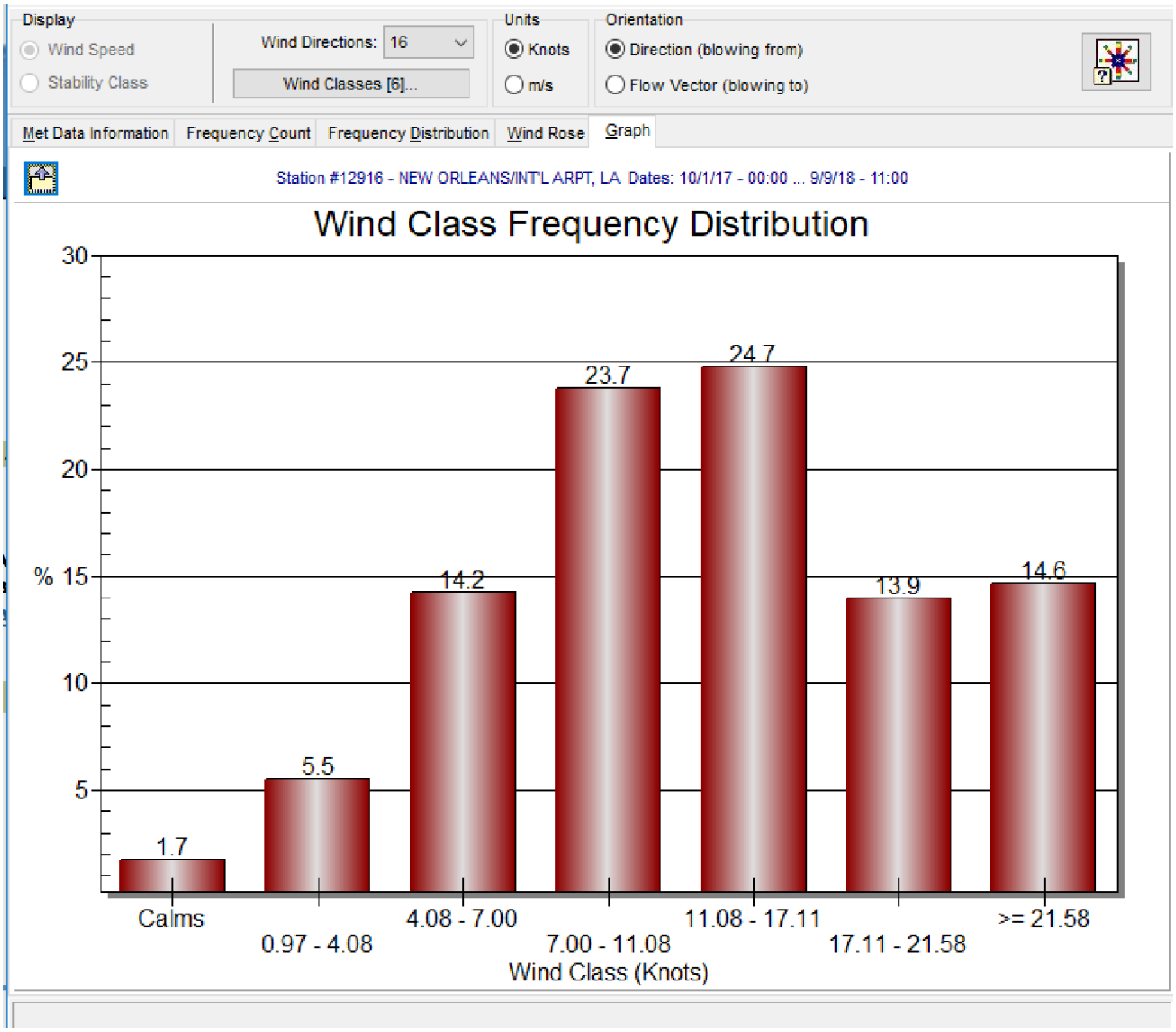

Figure 23. Wind Speed Frequency Distribution at Pilot Station, LA from 10-1-2017 to 9-9-2018

Participating Pilots

Three tow pilots participated in the complete set of simulated runs from September 10 to 14, 2018. Two of the pilots were from Turn Services, the principle fleeting operation service in the area. One of the pilots was a line-haul tow pilot from ACBL. During the last two days of testing, which focused on the construction phase, a local Federal Pilot operated the downbound loaded Suezmax tanker.

Simulation Tests Performed

Test Matrix

The ship maneuvering tests that were conducted during the period September 10-14, 2018, are presented in Table 2.

Table 2. Ship Maneuvering Simulation Runs of the Mississippi River; River Miles 59-62; with the Mid-Barataria Sediment Diversion Project - During Construction and In-Operation

Run	River flow (kcfs/ft)	Proj. Flow (kcfs)	Wind (knts)	Tow 1 (Fleeting Tow)						Tow 2 (Fleeting Tow)						Tow 3 (Line-Haul Tow)						Ship 1						Ship 2					
				Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot
Finished Project in Operation																																	
1	0/0	0	0/0	2-LD	IMT-RM59	Up	0mph	CHS Fleet	B	2-LD	Carlisle	Down	7mph	IMT-RM59	A	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD						Panamax-LD	RM62	Down	12knts	RM59	Auto
2	600/3.6	48	SE/20	2-LD	IMT-RM59	Up	3mph	CHS Fleet	B	2-LD	Carlisle	Down	7mph	IMT-RM59	A	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD						Panamax-LD	RM62	Down	11knts	RM59	Auto
3	600/3.6	48	SE/20	2LD	MG-RM59	Up	3mph	CHS	A	2-MT	CHS	Down	6mph	MG-RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD						Panamax-LD	RM62	Down	12knts	RM59	Auto
4	600/3.6	48	ENE/20	2-LD	IMT-RM59	UP	3mph	CHS	A	2-MT	IMT-RM59	Down	6mph	CHS	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD						Panamax-LD	RM59	Up	8knts	RM62	Auto
5	600/3.6	48	ENE/20	2-LD	IMT-RM59	UP	3mph	CHS	B	2-MT	IMT-RM59	Down	6mph	CHS	A	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
6	600/3.6	48	SE/20	2-LD	IMT-RM59	Up	3mph	CHS	A	2-MT	CHS	Down	5mph	IMT-RM59	B	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
7	600/3.6	48	SE/20	2-LD	MG-RM59	Up	3mph	IMT RM59	B	2-MT	iMT 59	Down	6mph	CHS	B	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
8	600/3.6	48	SE/20	4-LD	IMT-RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Panamax-LD	RM59	Up	10knts	RM62	Auto
9	600/3.6	48	SE/20	4-LD	IMT-RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Panamax-LD	RM59	Up	10knts	RM62	Auto
10	600/3.6	48	ENE/20	4-LD	MG-RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-LD	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
11	600/3.6	48	ENE/20	4-LD	IMT-RM59	Up	3mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
11a	600/3.6	48	ENE/20	4-LD	IMT-RM59	Up	3mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Panamax-LD	RM62	Down	12knts	RM59	Auto
12	600/3.6	48	SE/20	4-LD	MG-RM59	Up	3mph	CHS	A	4-LD	IMT-RM59	Up	3mph	CHS	B	30-MT	RM62	Down	6mph	RM59	C	Suezmax-BL	RM62	Down	12knts	RM59	Auto	Panamax-BL	RM59	Up	10knts	RM62	Auto
13	600/3.6	48	SE/20	4-LD	IMT-RM60	Up	3mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM62	Down	6mph	RM59	C	Suezmax-BL	RM62	Down	12knts	RM59	Auto	Panamax-BL	RM59	Up	10knts	RM62	Auto
14	600/3.6	48	ENE/20	4-LD	CHS	Up	3mph	MG RM59	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-BL	RM59	Up	10knts	RM62	Auto	Panamax-BL	RM62	Down	12knts	RM59	Auto
15	600/3.6	48	ENE/20	4-LD	MG-RM59	Up	3mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM59	Up	4mph	RM62	C	Suezmax-BL	RM59	Up	10knts	RM62	Auto	Panamax-BL	RM62	Down	12knts	RM59	Auto
16	1,000/8.9	75	ENE/20	2-LD	IMT RM59	Up	3mph	CHS	A	2-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Panamax-LD	RM59	Up	10knts	RM62	Auto
17	1,000/8.9	75	SE/20	2-LD	MG-RM59	Up	3mph	CHS	B	2-MT	Carlisle	Down	6mph	IMT-RM59	A	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Panamax-LD	RM59	Up	10knts	RM62	Auto
18	1,000/8.9	75	SE/20	2-LD	IMT RM59	Up	3mph	CHS	A	2-MT	Carlisle	Down	6mph	IMT-RM59	B	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
19	1,000/8.9	75	SE/20	2-LD	MG-RM59	Up	3mph	CHS	B	2-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM62	Down	7mph	RM59	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
20	1,000/8.9	75	ENE/20	2-LD	MG-RM59	Up	3mph	CHS	A	2-MT	CHS	Down	6mph	MG-RM59	B	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
21	1,000/8.9	75	ENE/20	2-LD	IMT-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	IMT-RM59	A	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
22	1,000/8.9	75	SE/20	4-LD	IMT-RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-LD	RM62	Down	5mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
22a	1,000/8.9	75	SE/20	4-LD	IMT-RM59	Up	1.5mph	CHS	B	4-MT	CHS	Down	6mph	IMT-RM59	A	30-LD	RM62	Down	7mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto

Run	River flow (kcfs/ft)	Proj. Flow (kcfs)	Wind (knts)	Tow 1 (Fleeting Tow)						Tow 2 (Fleeting Tow)						Tow 3 (Line-Haul Tow)						Ship 1						Ship 2					
				Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot
23	1,000/8.9	75	SE/20	4-LD	MG-RM59	Up	1.5mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
24	1,000/8.9	75	ENE/20	4-LD	IMT-RM59	Up	1.5mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-LD	RM59	Up	1.3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
25	1,000/8.9	75	ENE/20	4-LD	MG-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
26	1,000/8.9	75	SE/20	4-LD	MG-RM59	Up	3mph	CHS	B	4-MT	CHS	Down	6mph	IMT-RM59	A	30-MT	RM62	Down	7mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
27	1,000/8.9	75	SE/20	4-LD	IMT-RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-MT	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
28	1,000/8.9	75	ENE/20	4-LD	MG-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
29	1,000/8.9	75	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-MT	RM59	Up	3mph	RM62	C	Suezmax-LD	RM59	Up	10knts	RM62	Auto	Suezmax-LD	RM62	Down	12knts	RM59	Auto
Project Construction With Cofferdam, Work Barges and Work Boat																																	
30	1,000/8.9	0	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-MT	RM59	Up	3mph	RM62	C	Suezmax-BL	RM59	Up	10knts	RM62	Auto	Suezmax-BL	RM62	Down	12knts	RM59	Auto
30a	1,000/8.9	0	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM59	Up	3mph	RM62	C	Suezmax-BL	RM59	Up	10knts	RM62	Auto	Suezmax-BL	RM62	Down	12knts	RM59	Auto
31	1,000/8.9	0	ENE/20	2-LD	IMT-RM59	Up	2mph	CHS	A	2-MT	CHS	Down	6mph	IMT RM59	B	30-LD	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
32	1,000/8.9	0	SE/20	2-LD	MG-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
33	1,000/8.9	0	SE/20	2-LD	IMT-RM59	Up	2mph	CHS	A	2-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
34	1,000/8.9	0	SE/20	2-LD	MG-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM62	Down	6mph	RM59	C	Suezmax-LD	RM62	Down	12knts	RM59	Auto	Suezmax-LD	RM59	Up	10knts	RM62	Auto
35	1,000/8.9	0	ENE/20	2-LD	MG-RM59	Up	2mph	CHS	A	2-MT	CHS	Down	6mph	MG-RM59	B	30-LD	RM62	Down	5mph	RM59	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
36	1,000/8.9	0	ENE/20	2-LD	IMT-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	IMT-RM59	A	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
37	1,000/8.9	0	ENE/20	2-LD	IMT-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	IMT-RM59	A	30-MT	RM59	Up	5mph	RM62	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
38	1,000/8.9	0	ENE/20	2-LD	IMT-RM59	Up	2mph	CHS	B	2-MT	CHS	Down	6mph	MG-RM59	A	30-MT	RM59	Up	6mph	RM62	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
39	1,000/8.9	0	SE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
40	1,000/8.9	0	SE/20	4-LD	IMT-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
41	1,000/8.9	0	SE/20	4-LD	MG-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	IMT-RM59	A	30-LD	RM62	Down	6mph	RM59	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
42	1,000/8.9	0	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-LD	RM59	Up	4mph	RM62	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
43	1,000/8.9	0	ENE/20	4-LD	MG-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	MG-RM59	A	30-LD	RM59	Up	4mph	RM62	C	Suezmax-LD	RM63	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
44	1,000/8.9	0	SE/20	4-LD	MG-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	MG-RM59	B	30-MT	RM62	Down	5mph	RM59	C	Suezmax-BL	RM63	Down	10knts	RM59	D	Suezmax-BL	RM59	Up	10knts	RM62	Auto
45	1,000/8.9	0	SE/20	4-LD	IMT-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	IMT-RM59	A	30-MT	RM62	Down	5mph	RM59	C	Suezmax-BL	RM63	Down	10knts	RM59	D	Suezmax-BL	RM59	Up	10knts	RM62	Auto
46	1,000/8.9	0	ENE/20	4-LD	MG-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-BL	RM63	Down	10knts	RM59	D	Suezmax-BL	RM59	Up	10knts	RM62	Auto

Run	River flow (kcfs/ft)	Proj. Flow (kcfs)	Wind (knts)	Tow 1 (Fleeting Tow)						Tow 2 (Fleeting Tow)						Tow 3 (Line-Haul Tow)						Ship 1						Ship 2					
				Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Size/ Cond	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot	Type/Cond.	Origin	Dir.	Speed	Dest.	Pilot
47	1,000/8.9	0	ENE/20	4-LD	IMT RM59	Up	3mph	CHS	A	4-MT	CHS	Down	6mph	MG RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-BL	RM63	Down	10knts	RM59	D	Suezmax-BL	RM59	Up	10knts	RM62	Auto
Finished Project in Operation with Ship Piloted																																	
48	1,000/8.9	75	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	B	4-MT	CHS	Down	6mph	IMT-RM59	A	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto
49	1,000/8.9	75	ENE/20	4-LD	IMT-RM59	Up	2mph	CHS	A	4-MT	CHS	Down	6mph	IMT-RM59	B	30-MT	RM59	Up	4mph	RM62	C	Suezmax-LD	RM62	Down	10knts	RM59	D	Suezmax-LD	RM59	Up	10knts	RM62	Auto

Simulation Test Results

Traffic Patterns Modeled and Results

During the stakeholders meeting on August 2, 2018, concern was expressed about the effects of the Mid-Barataria Sediment Diversion project design and construction on traffic passing through the project reach of the Mississippi River. In order to address this issue, the simulation tests were modified to include a number of traffic vessels representative of the area. The available pilots that could participate in the simulations limited this approach. Two fleeting pilots from Turn Services were able to model the fleeting operation in this reach. One large tow (line-haul) pilot from ACBL was available to conn the through tow traffic. Finally, one Federal Pilot was available to conn a large deep-draft ship through the project reach but was only available for the last two days of the five days of simulation. To increase the traffic when ship pilots were not available, two ship models were programmed to pass through the reach using autopilot controls to follow a path defined by the tow pilots as representative of the way ships typically transit this reach. When the ship pilot was available, that pilot conned the downbound ship and the upbound ship was set on autopilot.

The traffic was made up of two ships, two fleeting tows, and one line-haul tow, in all but the first four runs. The first four runs only had a Panamax ship down bound in the first three runs with an upbound in the fourth run. These runs were primarily initialization runs to get familiar with the integration of auto-piloted ships and the tow traffic. The first two runs had a loaded fleeting tow going between the Carlisle Fleet and the CHS terminal (see Table 3). This was quickly identified as not producing any critical traffic pattern or any test of the project intake flow; therefore, no further runs were included to or from the Carlisle Fleet. All other simulations were conducted with tows going between the CHS terminal and either the IMT terminal or fleet on the western bank below CHS or the Myrtle Grove Fleet on the eastern bank below the CHS terminal. The latter situation required the tow to cross the river and therefore, work between the traffic.

Table 3. Facility Location on the Mississippi River

Facility	Location on the River	Bank
Carlisle Fleet	62.2	East
CHS Terminal	61.5	West
IMT Terminal	56.9	West
Myrtle Grove Fleet	56.0	East

It was during these runs that the tow pilots all agreed that the ship traffic would favor the east bank and that the predominate pattern of tow operations involved fleeting tows operating downbound empty and upbound loaded while the line-haul tows would be predominately loaded downbound and empty upbound. This then became the dominant modes for the tow operations. The Suezmax tanker was then included in the ship traffic and the ships were alternated between loaded and in ballast for the next 13 transits. The ships were also alternated between upbound and downbound. The line-haul tow was alternated between upbound and downbound; loaded and empty.

The first run was conducted with no river currents and no wind as a familiarization run so that the pilots could orient themselves to the bridge equipment and the visual and other aids to navigation. Runs 2-15 were run with the river flow of 600,000 cfs and diversion flow of 48,000 cfs. Runs 16 through 29 and runs 48 and 49 were all conducted with 1,000,000 cfs river flow and 75,000 cfs diversion flow. Runs with each flow condition were conducted with 2-barge fleeting tows for the first six runs and the rest were conducted with 4-barge tows. Beginning with Run 18 throughout the remaining simulated transits, the two ships were both Suezmax tankers with the predominant condition being loaded and in some runs the ships were in ballast.

Runs 30 through 47 simulated the construction condition in the river with the river flow at 1,000,000 cfs and no flow in the diversion canal as the cofferdam blocked the construction area from the river. Eight of these simulated transits were conducted with 2-barge tows and eleven were conducted with 4-barge tows. Beginning with Run 35 the downbound Suezmax tanker was piloted with the Federal Pilot. Beginning with this run, the tows and the pilot-conned ship were able to establish meeting and overtaking situations as soon as the simulations began. While the tow pilots had been doing this between the tows, this coordination was not possible with the ships, which were being operated on autopilot. All the pilots noted that they would normally have established these situations long before entering this reach; however, with the limited test area available, they had to do it while entering the reach. While this was somewhat unrealistic for them, they were able to accomplish the meeting/overtaking arrangements effectively and, therefore, manage the traffic safely. This means that there was less time for them to react to the situation and, therefore, resulted in more conservative results.

As the simulations progressed, the starting setup of vessels was adjusted by moving the starting locations of the vessels so that traffic was heavy (four vessels wide) in the critical reach. With the addition of the piloted ship, these situations were relieved somewhat with the ship slowing down to avoid the congestion.

During Construction

Figure 24 shows a composite trackplot of the closest approaches during all the runs with the cofferdam in place during the construction phase of diversion project. Normally, the closest approach was with the upbound tow; however, on a few runs the downbound tow was closest. The individual trackplots for the cofferdam cases are shown in Appendix A with timing marked to show the location of all the vessels at the time of the closest approach.

During the simulations work barges and a workboat were present outside of the protective cells. These are not shown in the trackplot figures because they were within the surrounding mat extending beyond the protective cells. Figure 24 indicates that all the closest approaches were outside of the surrounding mat. Since during the construction phase there will be no diverted water, the prime navigation factor will be the restriction of the channel for passing vessels. The simulations conducted show that given good communication and planning between vessels, the construction phase of the project will not cause degradation of navigation conditions.

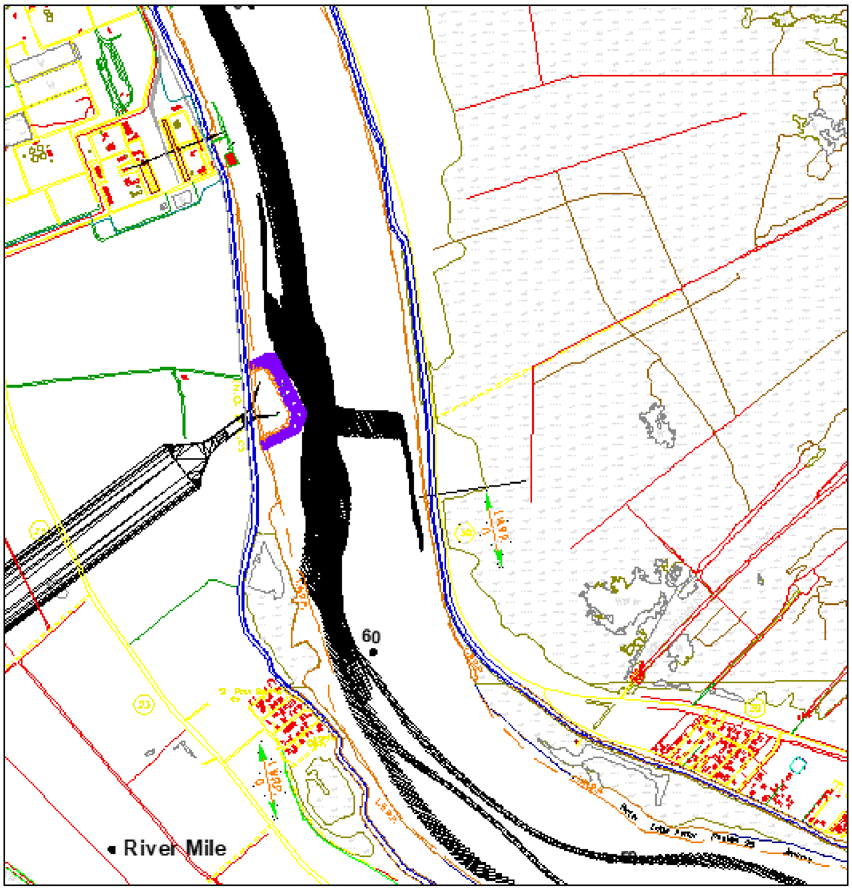

Figure 24: Composite Trackplot of Closest Approaches for Cofferdam Simulations; Runs 30 - 47

During Project Operations

Figure 25 and Figure 26 show a composite trackplot of all the runs during project operation in which the pilot commented that he felt an influence of the diversion. During several of these runs the pilot purposely steered close to the diversion in order to gauge for himself how much the operating project would affect tow navigation. In all the runs shown for the low-flow case, the pilot was able to maneuver and pull away from the area without incident. The western edge of the tow for these runs had to be within 200 ft of the *simulated navigation marker at the river end of the southern diversion wing wall*[5] for the pilot to notice a "pull" into the diversion. For the high-flow case this measure was 300 ft; however, the pilot in all but one of these runs (Run 29) was able to drive out of the influence. In the one failed run the 4x1 tow was driven toward the wing wall and into the diversion opening by an overtaking line-haul tow and an ENE wind; consequently, the pilot was unable to keep the tow from entering the project intake. The pilots generally thought that, with a slow upbound tow, the east bank of the river should be favored. One pilot in his final comments stated that a slow upbound tow should not come within 500 ft of the diversion during high-flow operation.

Table 4 shows a summary of the runs whose trackplots appear in the figures. The distances between the western most edge of the transiting tow and the navigation marker at the diversion at the river end of the downstream wall are presented in this table as well as the pilot's ratings of difficulty handling the vessel and the safety of the passage. In addition, the run timing of the closest approach is tabulated, which is used in the individual trackplots of the high-flow runs in Appendix A. This timing gives the reader an idea of the closeness of the other traffic at the critical point.

In some cases, the pilot's evaluation of safety seemed unclear and may have been rated safer than expected. These cases are indicated with a yellow highlight. Because incomplete data were recorded for the low-flow simulations it was not possible to provide the timing for these runs. This only affected the analysis of how close the other traffic was to the vessel with the closest approach to the project intake.

[5] It should be noted that for all references to distance from the diversion Project intake, the measurements are made from the marker at the downstream eastern end of the Project wing wall visible in the simulation as a reference point for navigation.

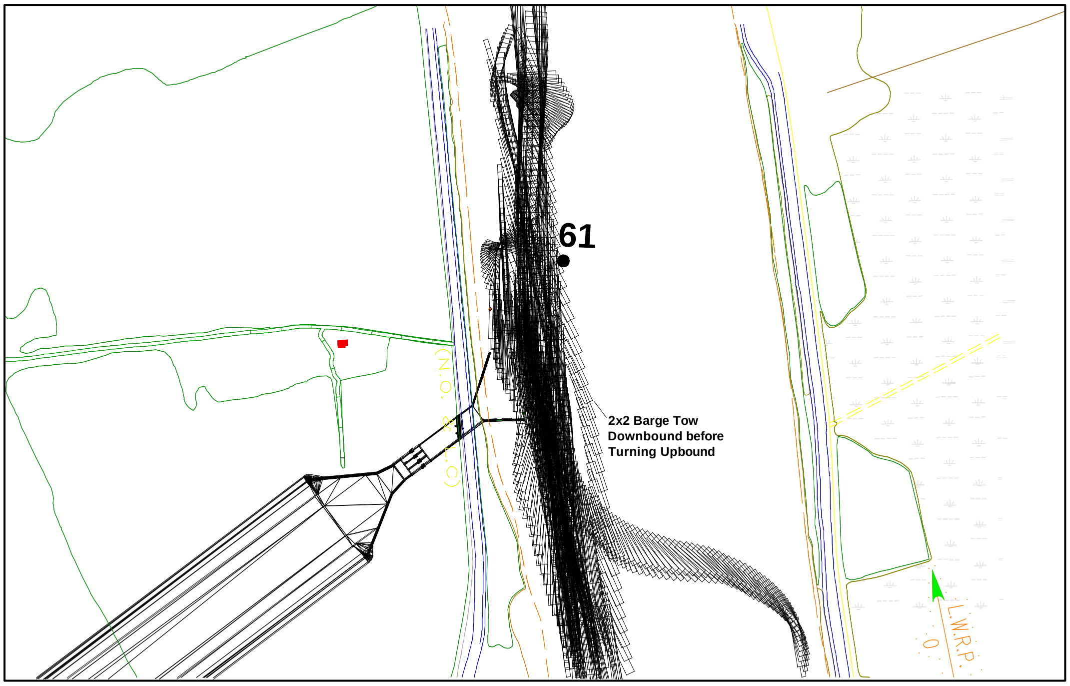

Figure 25: Composite Trackline of Tows Passing Close to Operating Diversion Pilots Noting Effect on Tow of Operating Diversion, Closest Approach <200 ft 600,000 cfs River Flow, SE or ENE 20-knot Wind

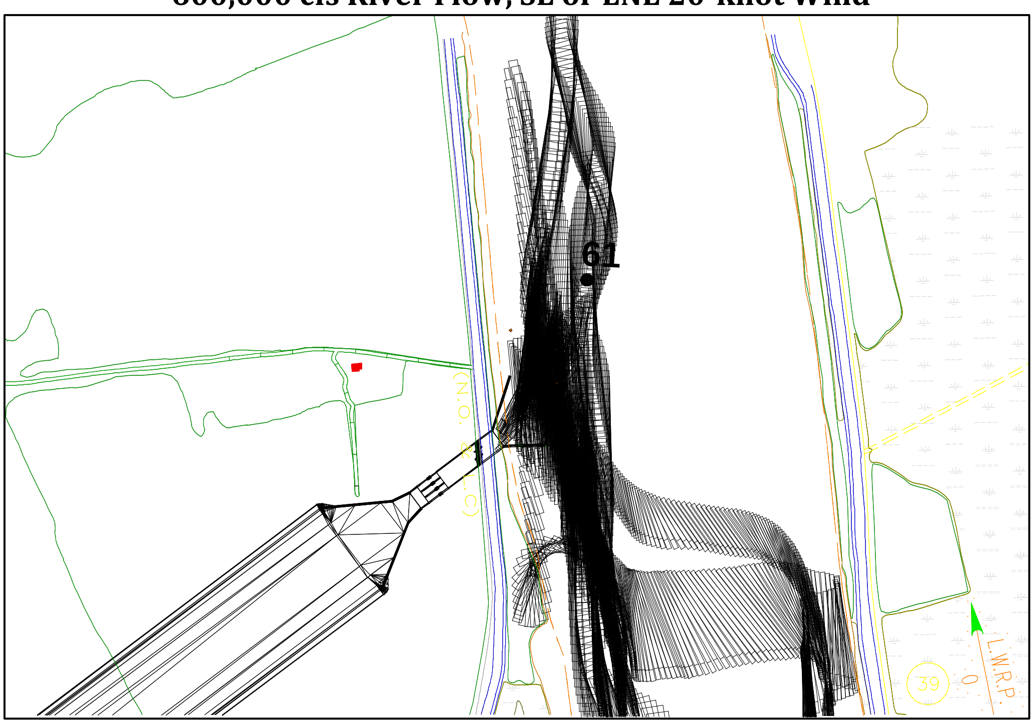

Figure 26: Composite Trackline of Tows Passing Close to Operating Diversion Pilots Noting Effect on Tow of Operating Diversion, Closest Approach <300 ft 1,000,000 cfs River Flow, SE or ENE 20-knot Wind

Table 4. Closest Approach to Diversion Intake (River End of Downstream Wall)

Run #	River Flow Wind	Closest Tow Approach & Travel Direction	Distance to Diversion Wing Wall Marker / Run Time	Notes	Pilot Ratings Difficulty/Safety
1	0/0	N/A	N/A	Familiarization	
2	0.6M cfs SE 20	2x1 Barge Down	154 ft / 441 sec	Tow unaffected by diversion	7.5 / 5
3	0.6M cfs SE 20	2x1 Barge Up	0 ft / 1651 sec	Set into diversion	5 / 5
4	0.6M cfs ENE 20	2x1 Barge Up	173 ft / 1701 sec	Small set into diversion	6 / 7
5	0.6M cfs ENE 20	2x1 Barge Up	28 ft / 1621 sec	Small set into diversion	5 / 5
		2x1 Barge Down	38 ft / 321 ft	Wind set into diversion	7 / 6
6	0.6M cfs SE 20	2x1 Barge Up	277 ft / 721 sec	Tow unaffected by diversion	5 / 9
7	0.6M cfs SE 20	2x1 Barge Up	102 ft / 831 sec	Tow unaffected by diversion	5 / 5
8	0.6M cfs SE 20	2x2 Barge Down	183 ft / 341 sec	Tow unaffected by diversion	5 / 8
9	0.6M cfs SE 20	2x2 Barge Up	232 ft / 1001 sec	Tow unaffected by diversion	5 / 9
10	0.6M cfs ENE 20	2x2 Barge Up	119 ft / 1361 sec	Slight pull into diversion	5 / 5
11	0.6M cfs ENE 20	2x2 Barge Up	74 ft / 1431 sec	Small set into diversion	6 / (8)
12	0.6M cfs SE 20	2x2 Barge Up	199 ft / 1951 sec	Small set into diversion	5 / 5
13	0.6M cfs SE 20	2x2 Barge Up	70 ft / 1151 sec	Tow unaffected by diversion	5 / 8
14	0.6M cfs ENE 20	2x2 Barge Up	135 ft / 1131 sec	Small set into diversion	6 / 6
		30 Barge Up	94 ft / 481 sec	Small set into diversion	5 / 6
5	0.6M cfs ENE 20	2x2 Barge Down/Up	0 ft (up) / 1361 sec	Tow pulled into diversion	8 / 5
		30 Barge Up	45 ft / 501 sec	Small set into diversion	5 / 6
16	1M cfs ENE 20	2x1 Barge Up	0 ft / 1306 sec	Significant set into diversion	8 / (8)
17	1M cfs SE 20	2x1 Barge Down/Up	747 ft / 120 ft	Tow unaffected by diversion	5 / 5
		2x1 Barge Up	146 ft / 1470 sec	Heavy set into diversion	7 / (7)
18	1M cfs SE 20	2x1 Barge Up	155 ft / 1171 sec	Tow unaffected by diversion	5 / 5
19	1M cfs SE 20	2x1 Barge Up	106 ft / 1431 sec	Some set into diversion	7 / (7)
20	1M cfs ENE 20	2x1 Barge Up	379 ft / 1581 sec	Tow unaffected by diversion	5 / 5
21	1M cfs ENE 20	2x1 Barge Up	45 ft / 881 sec	Set into diversion	7 / 5
22	1M cfs SE 20	2x2 Barge Down	145 ft / 451 sec	Tow unaffected by diversion	5 / 5
22A	1M cfs SE 20	2x2 Barge Up	19 ft / 801 sec	Rudder required at diversion	5 / 8
23	1M cfs SE 20	2x2 Barge Down/Up	Inside / 31 ft	Set into diversion/[no assessment]	5 / 5
		2x2 Barge Up	184 ft / 1601 sec	Tow unaffected by diversion	5 / 9
24	1M cfs ENE 20	30 Barge Up	288 ft / 181 sec	Moderate drift to diversion	5 / 6

25	1M cfs ENE 20	2x2 Barge Up	67 ft / 541 sec	Some set into diversion	5 / (8)
26	1M cfs SE 20	4x1 Barge Up	0 ft / 651 sec	Set into diversion	7 / (7)
27	1M cfs SE 20	4x1 Barge Up	64 ft / 1621 sec	Set into diversion	5 / 5
28	1M cfs ENE 20	4x1 Barge Up	0 ft / 1921 sec	Set into diversion	8 / 5
		30 Barge Up	95 ft / 731 sec	Moderate set into diversion	5 / 4
29	1M cfs ENE 20	4x1 Barge Up	Inside / 431 sec	Caught in diversion flow	8 / 3

Pilot Questionnaires

Following each simulation run, the pilots filled out a questionnaire to record their reaction to that simulation transit. The results of those records are presented in this section of the report.

Construction

Simulation runs 30-47 involved testing the proposed project construction layout. It was during these runs that the ship pilot joined the simulations to conn the downbound Suezmax tanker starting with run 35. The fleeting pilots alternated between handling the downbound and upbound tows with each run. The line-haul tow of 30 barges was conned by the river tow pilot.

The rating given by the pilots for difficulty of each run was primarily 5, which was defined as an average situation (see Figure 27). Two of Pilot A's runs elicited a 7 for difficulty indicating that the run was more difficult than usual and Pilot A rated run 38 as an 8. Both of these runs were with empty 2-barge tows headed downstream with strong winds from the ENE at 20 knots. Winds from this direction had a significant effect on the empty tows. The ship pilot rated most of the runs with a difficulty of 2.5, indicating that he felt that these were relatively easy runs after gaining some experience with the simulator and obtaining communications to arrange meetings and overtakings quickly at the beginning of each run.

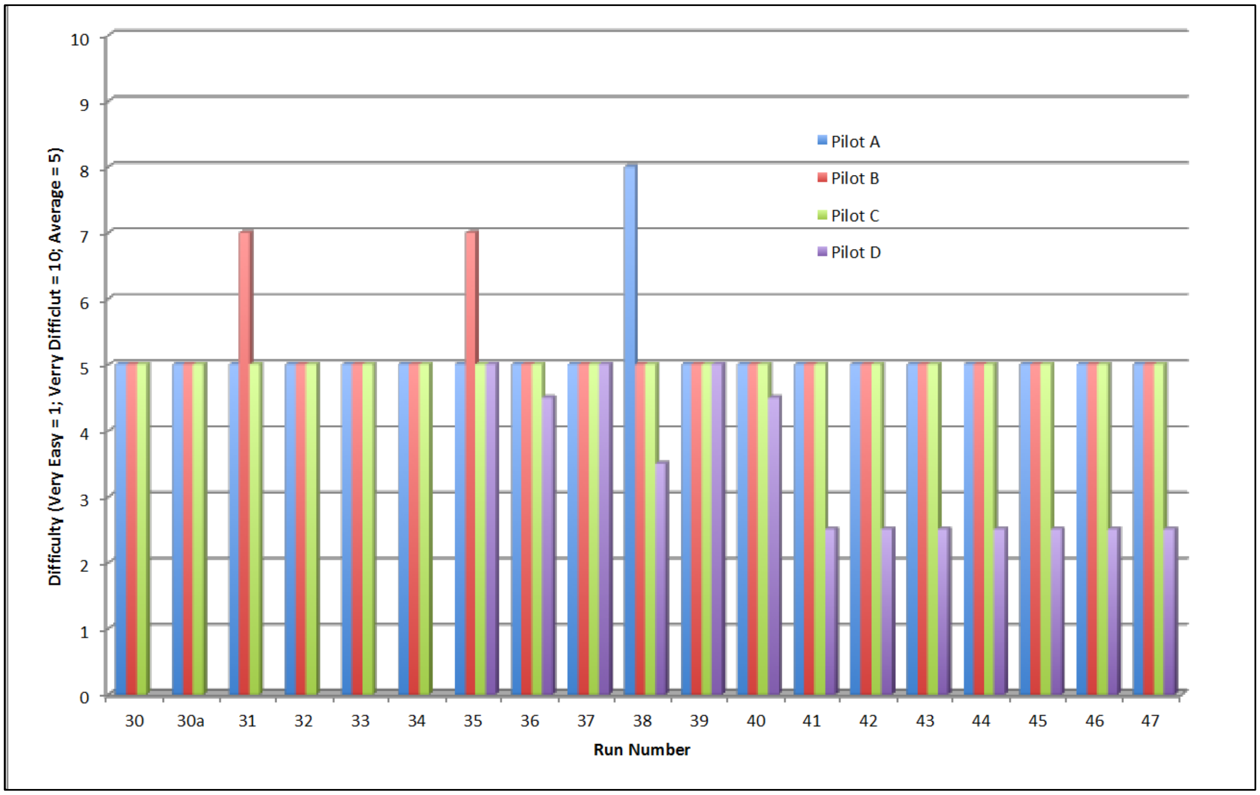

Figure 27. Pilot Rating of Difficulty During Construction Phase

The ratings for safety of the simulated transits was generally 5 or higher with Pilot B giving relatively high ratings for safety of 9 and 8 but dropping to 6 when the 4-barge tows began operation. Pilot C, operating the line-haul tow, consistently gave ratings of 6 for the safety of navigation; although he was concerned about Run 38 using a rating of 4 (see Figure 28). The ship pilot, Pilot D, started out with a 4.5, then jumped to 8.5, dropping to 5.5, and finally ending up with consistent ratings of 7.5.

It should be noted that while Pilot A gave a difficulty rating of 8 for Run 38, he also gave an 8 rating for safety. Similarly, Pilot B gave a safety rating of 6 for Run 35 while he used a rating of 7 (more difficult) for that same run.

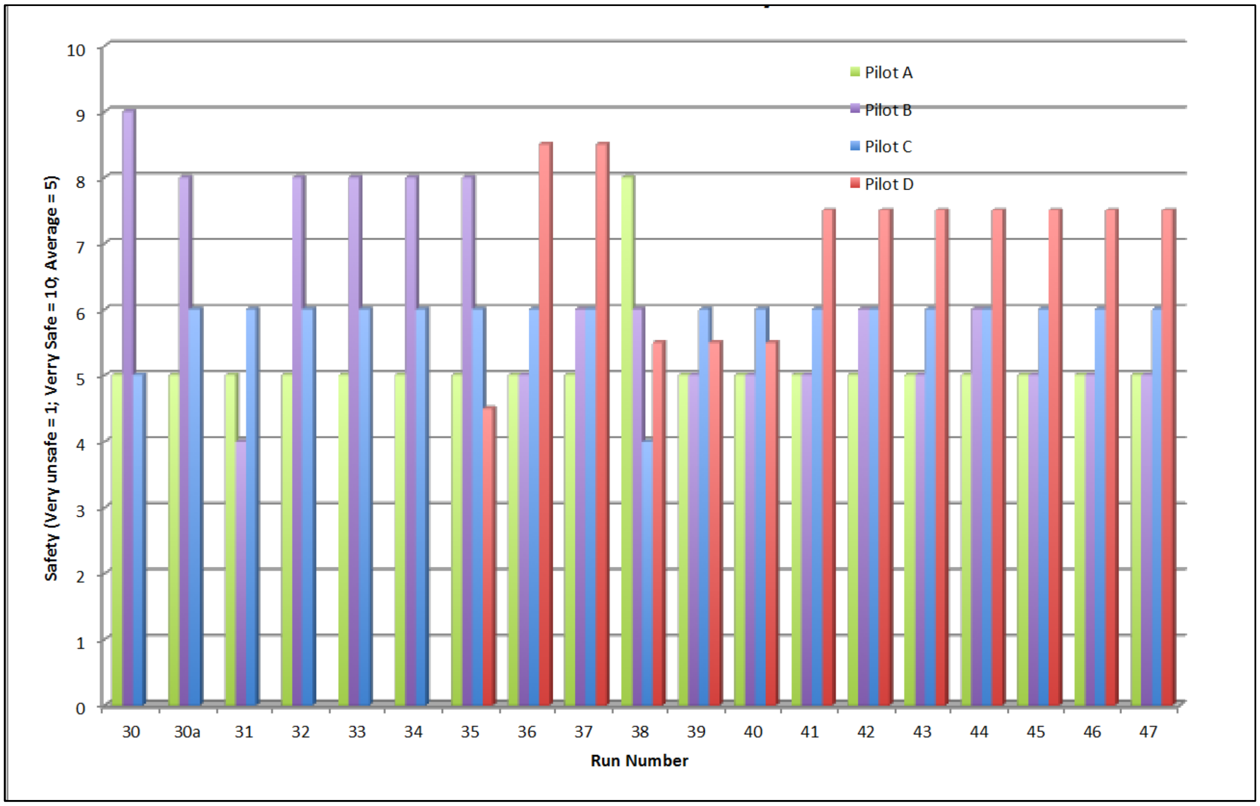

Figure 28. Pilot's Rating of Safety During Construction Phase

Following each simulation, the pilots were asked to comment about:

- Whether they were able to maintain the plan that they had established for making the simulated run,
- What the impact of the project was on their ability to maintain the plan,
- Whether the meetings and overtakings that took place during the runs were safe and controllable,
- Any comments that they wanted to make about the safety of the run,
- Whether they would perform the run in real life (i.e., was this transferable to the real world), and
- Any conclusions or recommendations that they wanted to make based on this run.

Generally, the answers were yes for maintaining their plan, meeting and overtaking, and performing in real life; with no or none for the impact of the plan on their transit and for concerns about safety (see Table 5). The exceptions were Run 31 for Pilot B and Run 38 for Pilot A. Run 30 had a problem with modeling the interaction between the 30-barge tow and the Suezmax with the overtaking forces and moments being too strong. The interaction forces were reduced, and the run was redone as 30a.

Table 5. Pilot Ratings of the Simulated Construction Phase

Run	Pilot A						Pilot B						Pilot C						Pilot D					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
30	Yes	None	Yes	No	Yes	N/A	Yes	None	Yes		Yes		No. Had a hard push off of ship.	None	Yes	The amount of push off the ship gave was too much.	Yes	Reset ship amount of push.						
30a	Yes	None	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None						
31	Yes	None	Yes	No	Yes	No	Had to keep hard rudder in that wind condition and the heavy traffic around diversion.	Clutter and congested with heavy traffic.	Close calls, real life maybe; wouldn't meet in that area.		Highly unlikely		Yes. Some push off of cofferdam.	None	Yes	Ship to ship interaction was a lot.	Yes	None						
32	Yes	None	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	A little set off	Yes	None	Yes	None						
33	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	Very little	Yes	None	Yes	None						
34	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None						
35	Yes	None	Yes	No	Yes	None	Yes	None	Yes	Windy		Yes	Yes	None	Yes	None	Yes	None	Yes	None	Yes, but northbound ship track needs to be adjusted.	No	Yes	It doesn't seem to be a hazard to navigation.
36	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	Little set off	Yes	None	Yes	None	Yes	None	Yes	No	Yes	
37	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None; 22 knt wind on Starboard side	Yes	None	Yes	None	Yes	Caused me to run reduced for approximately 5 minutes to allow Tow 3 to clear diversion.	Yes	No	Yes	
38	No, wind set was really bad.	None	Yes	Wind speed & direction was hard to deal with.	No. Would have to stop if wind set tow that bad.		Yes	None	Yes		Yes		No. Had to pull engine back to let tow shove out front of tow to collect data; normally would have backed it down and	No	No	None	No	No	Yes	Had to run at reduced speed for traffic; approximately 5 minutes.	Yes	No	Yes	

Run	Pilot A						Pilot B						Pilot C						Pilot D					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
													stuck it on bank.											
39	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	A little	Yes	None	Yes	None	Yes	Ran slow for traffic; approximately 5 minutes.	Yes	No	Yes	
40	Yes	None	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	Yes	
41	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Tow 2 was not able to pass.	None	Yes	None	Yes	None	Yes	No	Yes	
42	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes. Had to run slow for awhile.	A little	Yes	Waited for traffic to clean up.	Yes	None	Yes	None	Yes	No	Yes	
43	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	yes	
44	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	Yes	
45	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	Yes	
46	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	Yes	
47	Yes	None	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None	Yes	None	Yes	No	Yes	

600,000 cfs River Flow – 48,000 cfs Diversion Flow Rate

The simulations with river flow discharge at 600,000 cfs and the diversion flow at 48,000 cfs started with Run 1 as a familiarization run to acquaint the pilots with the simulator equipment and modeling of the visual scene, river, currents, ECSDIS, and radar and went until Run 15. The ratings for difficulty from the pilots were generally average with ratings of 5 (see Figure 29). Pilot B gave low ratings for difficulty for the first 2 runs with difficulty going to 6 and 7 for Runs 4, 10 and 11a. Run 11 was rerun due to a problem with interaction between the line-haul and fleeting tow; no ratings were given for Run 11. Pilot A indicated that Runs 2, 14 and 15 were considered to be more difficult than most. In Run 2 he made an overtaking on a side of the slower tow which he preferred not to use. In Run 15 the pilot turned the downbound tow around and tried to pass the project intake; when he did the tow clipped the marker at the intake and was pulled into the intake area. With Run 14 he noted that the project intake pulled the tow in slightly, but he maintained control.

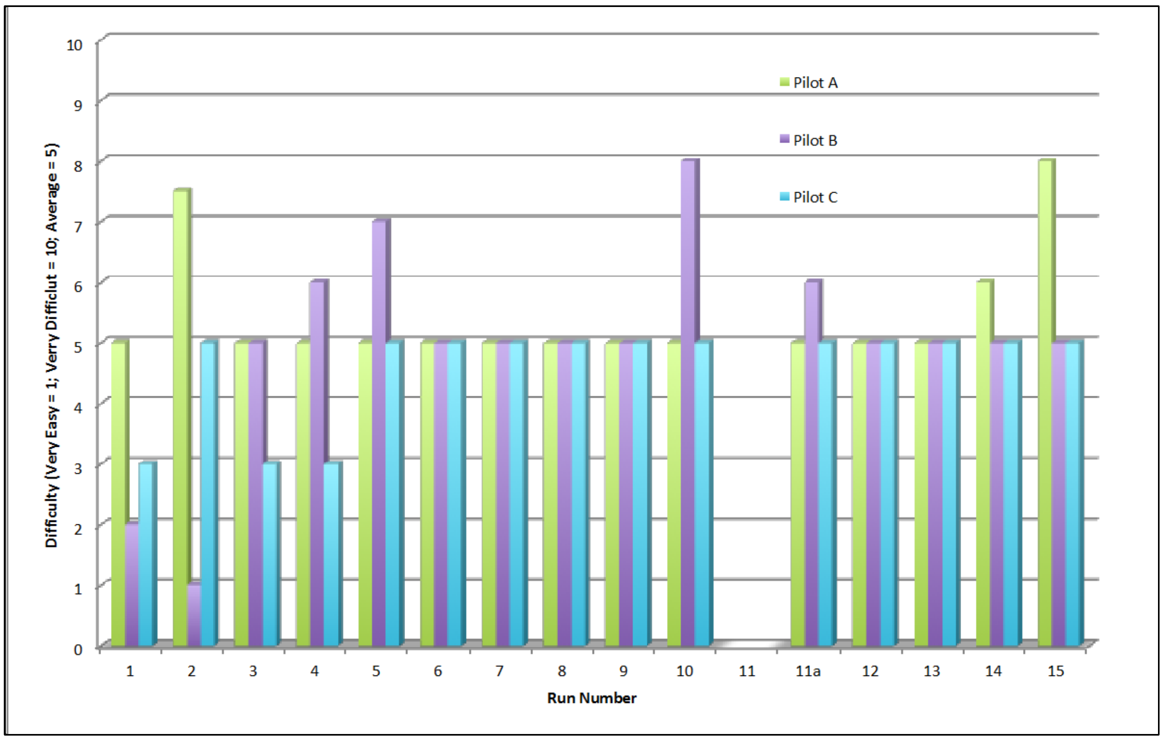

Figure 29. Pilot's Rating of Difficulty with Diversion Flow = 600,000 cfs

For the pilots' ratings of safety, all but one of the runs were rated average (5) or better with many rated 6, 7, 8 and 9 (see Figure 30). The only run rated below 5 was Run 10 by Pilot B. He noted that the wind and the upbound traffic caused him to miss the bend and he grounded below the bend. This run also had winds of 20 knots out of the ENE.

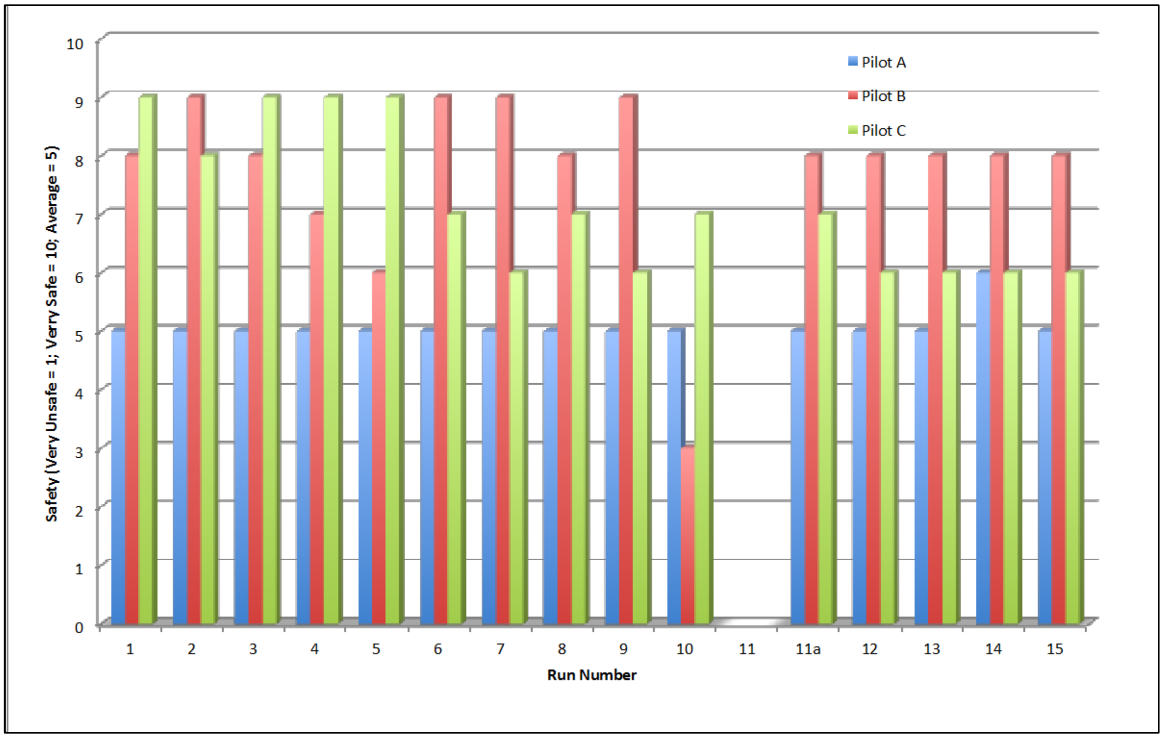

Figure 30. Pilot's Rating of Safety with Diversion Flow = 600,000 cfs

The pilot's comments and statements about the runs for the 600,000 cfs river flow condition are given in Table 6. Generally, the evaluations of maintaining transit plan, meetings and overtakings, and whether they would perform in real life conditions were positive and project impact was considered to be relatively low or none. Pilot A encountered a control concern when he brought the tow very close to the project intake and got pulled into the intake area during Run 3 as he tested the effects of the intake flow. He also had an encounter with the line-haul two when that tow was pushed hard by the downbound loaded Panamax. Then with Run 15, Pilot A's tow was forced by the wind (an ENE 20 knot wind) into the project intake. During Run 5, Pilot B noted some difficulties handling a southbound empty tow when passing the project intake and was pushed towards and into the intake flow. Then in Run 10 as noted above, Pilot B had difficulty making the bend due to the wind and traffic.

Table 6. Pilot's Ratings and Comments for Simulated 600,000cfs River Flow and 48,000cfs Diversion Flow

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
1	Yes	No	Yes	No	Yes	Would have usually overtook tug on 2 whistle instead of 1 whistle	Yes, Diversion did not affect my decision to allow traffic to clear before crossing N/B	Not any. I notced N/B mybe a little set toward diversion which I had to steer out a little.	Very		Yes	Didn't think it would be that shallow that far off poverty.	Yes	None	Yes	None	Yes	None
2	Yes, but wind was a definite factor	No	Yes	No	Yes	No	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
3	No, diversion pulled tow in due to passing very close to the marker buoy.	Yes	Yes	No	No, would stay wider next time.	Stay off buoy marker at least 100 ft.	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
4	Yes	None	Yes	No	Yes	None	Yes. Had to steer away from diversion when abreast because of small set in.	Small set toward diversion when N/B running close to west bank.	Yes		Yes		Yes	None	Yes	None	Yes	None
5	Yes	Pulled tow in slightly	Yes	No	Yes	Stay at least 100 ft off diversion buoy.	SB with empties, running close to diversion with a S/SE wind; had to steer hard to clear diversion buoy.	Wind set to diversion.	Yes		Yes		Yes	None	Yes	None	Yes	None
6	Yes	No	Yes	No	Yes	None	Yes	None this time	Yes		Yes		Yes	No	Yes	None	Yes	None
7	No, Tow 3 slide into me by intake	No	No	No	Yes	Tow 3 needed to hold his course S/B	Yes	None	Yes		Yes		Yes	None	Yes; hard run away from ship	None	Yes	None
8	Yes	None	Yes	No	Yes	No	Yes	N/A	Yes		Yes		Yes	None	Yes	None	Yes	None
9	Yes	None	Yes	No	Yes	None	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
10	Yes	Slight pull into diversion	Yes	No	Yes	None	No, wind and upbound traffic caused me to clear diversion but not make bend; ran aground.		No, would not have started at that spot with wind blowing that way.		No	If real life situation would Try Not to be as tight on west bank in those wind conditions. Would get with traffic earlier than simulated and avoid that cluster in the wind around Poverty and the Diversion.	Yes	A little draft to diversion channel	Yes	None	Yes	None
11a	Yes	None	Yes	No	Yes	None	Yes	Small set in toward diversion when N/B with loads.	Yes		Yes		Yes	None	Yes	None	Yes	None
12	Yes	Slight pull in	Yes	No	Yes	Give wide berth with slow N/B tow around diversion.	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
13	Yes	No	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
14	Yes	Slight pull into diversion	Yes	No	Yes	Stay at least 100 ft off buoy	Yes	None	Yes		Yes		Yes	Small draft to diversion channel	Yes	Ran close to diversion channel to check it out.	Yes	None

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**	**Maintain Plan**	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**	**Maintain Plan**	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**
15	No. Back N/B got in diversion by wind.	Pulled tow in after hitting marker buoy.	Yes	Watch wind set closer.	Yes	Keep better point on tow in wind.	Yes	None	Yes		Yes		Yes	Small draft to diversion channel.	Yes	In there closer than normal to avoid hitting S/B boat.	Yes	None

1,000,000 cfs River Flow – 75,000 cfs Diversion Flow Rate

Runs 16 through 28 and Runs 38 and 49 were conducted with the river flow at 1,000,000 cfs and the diversion flow at 75,000 cfs. The Pilot's ratings of the run difficulty are shown in Figure 31 and Figure 33. More of the runs involve a rating higher than average (5) than in the other simulations. Pilots A and B conning the fleeting tows were the ones making these high ratings of 6, 7, and 8. Pilot A was handling a 2-barge loaded upbound and considered that simulated transit to have a difficulty of 8. He also rated Run 19 at a difficulty of 8 again while conning a 4-barge loaded upbound tow. Pilot B Rated Runs 17, 18, 19, 21, 26 and 28 with difficulty ratings of 6, 7 and 8. In Runs 17, 19, 21, 26 and 28, Pilot B was conning 2- and 4-barge loaded tows upbound past the project intake. This indicates that upbound loaded slow-moving tows were vulnerable to the effects of the project intake flow.

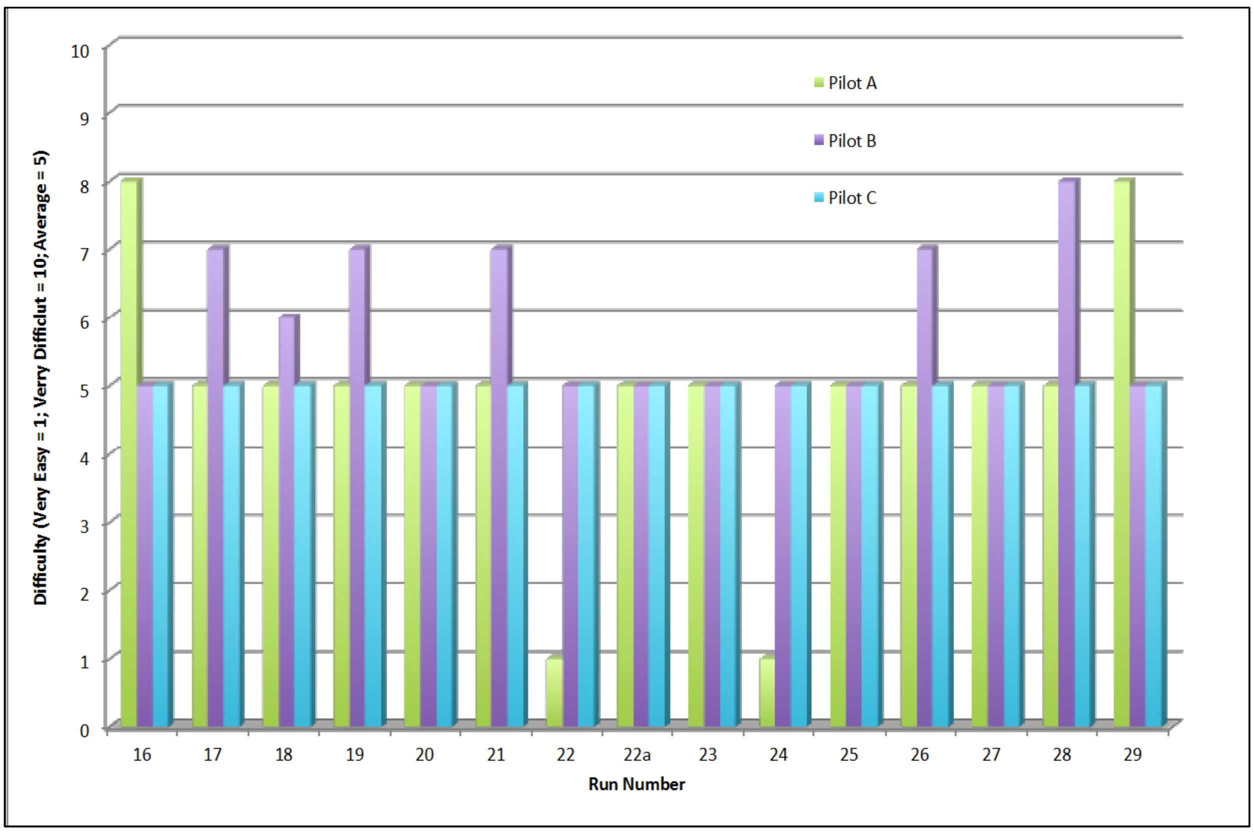

Figure 31. Pilot's Rating of Difficulty with Diversion Flow = 1,000,000 cfs

Figure 32 presents a rating of the safety of transit with the high flow condition and, even with the relatively high rating of difficulty of operating slow-moving upbound loaded tows, that the pilots considered the conditions to be relatively safe with ratings of 6-9. Pilot A rated Run 16 with a high safety rating of 8 while rating the difficulty at 8 while Pilot B also gave a safety rating of 8 but a rating of difficulty of 5. Otherwise, Pilot A considered most of the remaining runs to be average (5) except for Runs 22, 24, and 29, which he rated as relatively unsafe at 1s and a 3. These runs were the ones he conned the slow-moving upbound loaded tow past the project intakes, which are noted as being the most sensitive to the project diversion flows. Pilot B rated safety of the runs for all but Runs 21, 22 and 28 at relatively high values of 7 to 9 with the exceptions rated at average (5). Pilot C, conning the line-haul tow, gave all the runs except Runs 16 and 28 a safety rating of 6. Run 16 had to line-haul tow operating upbound empty in ENE winds of 20 knots; while Run 28 had the line-haul tow also operating with the same condition.

The runs with a ship pilot conning the downbound loaded Suezmax, Runs 48 and 49, have Pilots A and C rating the difficulty average with the safety rated at 5 and 6, respectively. Pilot B rated the difficulty at 7 and 6, respectively, with ratings of safety at 6 and 5, respectively. Pilot D, the ship pilot, rated both runs with a difficulty of 2.5 (very easy) and 9.5 (very safe). These ratings were achieved through communicating and setting up meetings and overtakings and adjusting them to minimize the traffic congestion at the project.

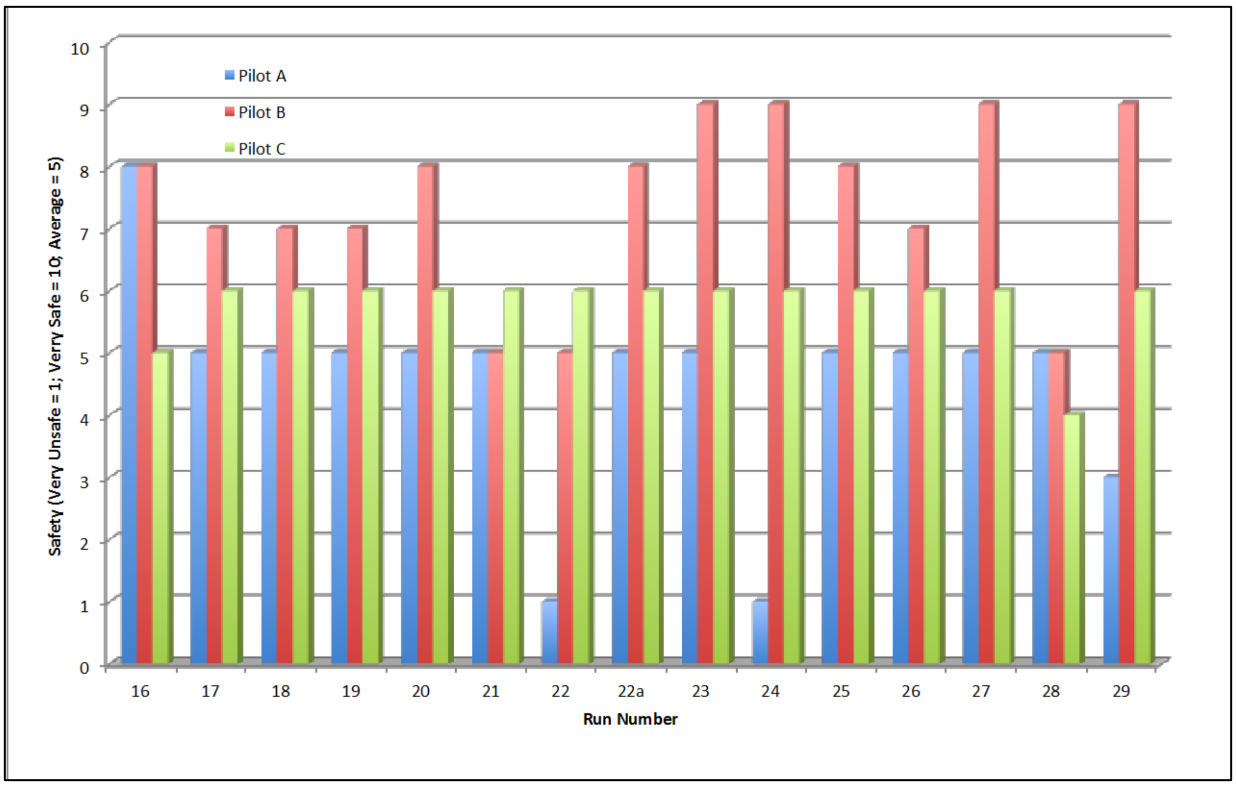

Figure 32. Pilot's Rating of Safety with Diversion Flow = 75,000 cfs

Table 7 presents the pilot's comments and recommendations of the navigation conditions for the high flow situation. Pilot D rated both runs with the same evaluation with Yes being the answer to being able to maintain his transit according to his plan, meetings and overtakings being OK, and to be willing to do these maneuvers in real life. He also stated that there were no impacts on the ship's transit from the project intake and no safety issues to report.

The other pilots generally gave similar evaluations for the runs with a few exceptions. Pilot A noted that Runs 16, 23, 29, and 49 all gave him concern that the tow was being pulled or sucked into the project intake as the tow passed by and expressed a need to "give a wider berth" to the intake. Pilot B also noted concern about the project intake flow for Runs 26, 28, and 48, all with upbound-loaded tows. He also noted some impacts from the project intake flow for Runs 17, 19, 21, 22a, and 25.

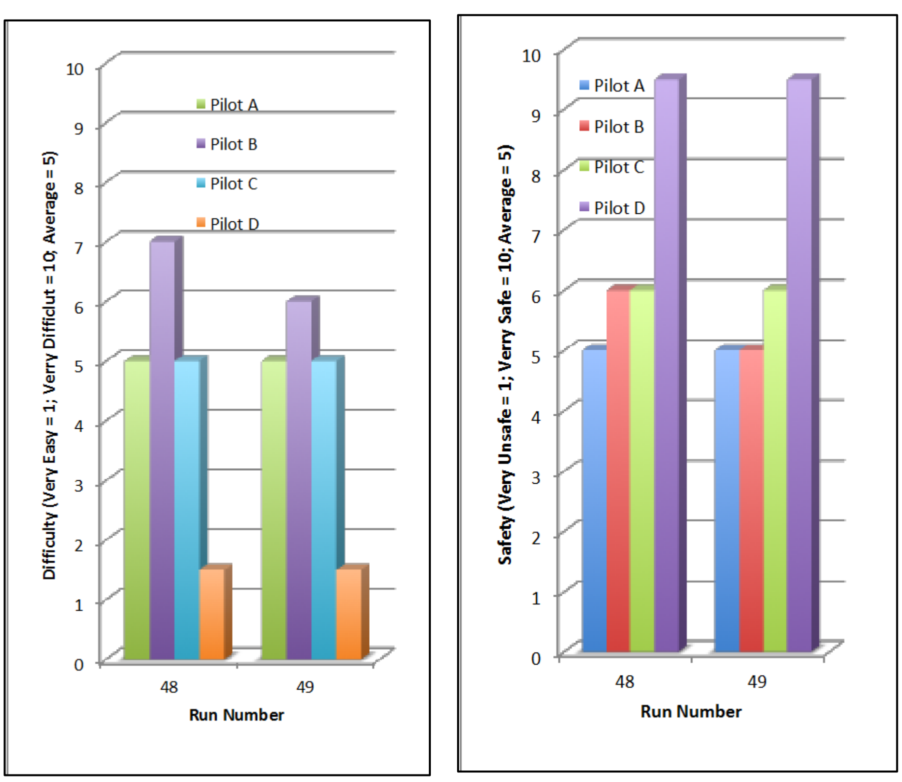

Figure 33. Pilot's Rating of Difficulty and Safety with Diversion Rate = 75,000 cfs and Ship Pilot

Line-haul tow Pilot C also expressed impacts from the project intake flow. Runs 17, 24, and 28 were noted to have a significant enough impact on the tow transit that he had to make some correction; although he defined these as moderate draws toward the intake. When making Runs 17 and 24, Pilot C was attempting to measure the impact of the intake flow in the passing tow. During run 17 the line-haul tow was pushing an empty 30-barge tow upbound and in Run 24 the tow was loaded traveling upbound. Run 17 was with a SE wind of 20 knots and Run 24 was with a wind out of the ENE at 20 knots

Table 7. Pilot's Comments and Evaluations of Simulated Transits with a River Flow of 1,000,000 cfs and Diversion Flow of 75,000 cfs

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
16	No. Was sucked into diversion pretty good.	Felt greatly.	Yes	Pay attention to set.	Yes, but would have probably gave wider berth.	Pass very wide at 1 million cfs.	Yes	None	Yes		Yes		No. Too much reaction from overtaking ship	None	Yes	Reaction from overtaking ship set to high.	Yes	None
17	Yes	None	Yes	No	Yes	N/A	Yes	N/B high water close to diversion with loads and slow moving diversion does have a heavy "set in".	Yes		Yes		Yes	Draw was 0.30 to the diversion channel running on straight rudder with 30 MT and 6 long.	Yes	None	Yes	None
18	Yes	No	Yes	No	Yes	Give diversion wide berth @ 1 million cfs.	Yes	None	Yes		Yes		Yes	No	Yes	None	Yes	None
19	Yes	None	Yes	No	Yes	N/A	Yes	Little set in.	Yes		Yes		Yes	None	Yes	None	Yes	None
20	Yes	Very little pull	Yes	No	Yes	Passed 450 ft off marker buoy little set was seen.	Yes	No	Yes		Yes		Yes	None	Yes	None	Yes	None
21	Yes	No	Yes	No	Yes	N/A	Yes	Set into diversion	Yes		Yes		Yes	None	Yes	None	Yes	None

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation	Maintain Plan	Project Impact	Meeting/ Overtaking OK	Safety Comments	Perform in Real Life	Conclusion / Recommendation
22	Yes	No	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
22a	Yes	None	Yes	No	Yes	None	Yes	None; use a little rudder @ diversion.	Yes		Yes		Yes	None	Yes	None	Yes	None
23	No. Was pulled into diversion.	Sucked the tow in.	Yes	No	No. Would have not gotten in that close.	Stay wider from diversion.	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
24	Yes	None	Yes	No	Yes	N/A	Yes	None	Yes		Yes		Yes	Moderate draft to diversion channel	Yes	None	Yes	None
25	Yes	None	Yes	No	Yes	N/A	Yes	Little set in toward diversion	Yes		Yes		Yes	None, too far away from diversion flow	Yes	None	Yes	None
26	Yes	None	Yes	No	Yes	N/A	Had to steer out of diversion	Set in toward diversion rather close.	Yes		YES		Yes	None	Yes	None	Yes	None
27	Yes	It pulled tow in towards diversion	Yes	No	Yes		Yes	None	Yes		Yes		Yes	None	Yes	Nobne	Yes	None
28	Yes	None	Yes	No	Yes	N/A	Hard set into diversion	Hard steering away from diversion	Yes		Yes		Draft to diversion channel and 22 knts wind	Moderate	Yes	Ran it as close as possible without getting in	No; for test purpose only	Be out wider.

Run	Pilot A						Pilot B						Pilot C					
	Maintain Plan	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**	**Maintain Plan**	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**	**Maintain Plan**	**Project Impact**	**Meeting/ Overtaking OK**	**Safety Comments**	**Perform in Real Life**	**Conclusion / Recommendation**
													at 45 degrees pulled me off			trouble.		
29	No. Sucked in to diversion	Strong pull into diversion	Yes	Stay wide off buoy	No, would be farther out.	Don't get close to buoy marker.	Yes	None	Yes		Yes		Yes	None	Yes	None	Yes	None
48	Yes	Nonew	Yes	No	Yes		Around diversion, had to correct for heavy set into diversion.	Heavy set in.	Yes		Yes		Ran slow to clear up traffic to start with.	A little bit	Yes	None	Yes	None
49	No. Diversion pulled tow in.	Water pulled tow into diversion.	Yes	Stay wide off full flow intake.	No. Would probably run other side of river but it is possible to run westside.		Yes	None	Yes		Yes		Ran slow to start with to clear up traffic.	None	Yes	None	Yes	None

Final Pilot Evaluations/Questionnaires

After the final simulation runs were completed, a debriefing was held and the pilots were asked to respond with their evaluation of the overall simulations and project impacts. The final questionnaire is presented in Appendix B. The results are presented in Table 8 and Table 9.

The ratings had a range of 1 to 10 with 5 being average, 1 being not realistic or unsafe and 10 being very realistic and safe. The tow pilots (A, B, and C) gave a rating for the ships even though they did not conn the ship but observed the behavior of the modeling which was primarily with an autopilot. The ship pilot observing the tow operation made the same type of ratings. Generally, the pilots rated the realism of the simulated vessels realistic to very realistic. Pilot A who believed the ship operations were just below average gave the only observation below 7.

The fleeting tow pilots did not believe that the wind modeling, especially acting on the empty tows, was realistic (rating of 2) because it was stronger than they thought was realistic (especially the ENE wind). The other pilots gave a high rating for the realism of the wind modeling. All pilots gave a good rating for the current modeling. Again, three of the pilots rated the realism of the visual scene and channel modeling high; but Pilot A rated the channel modeling below average and the visual scene average.

While not many of the maneuvers that occurred near the bank, two of the pilots rated the realism of the ship to bank interaction very realistic while Pilot A rated this modeling less than average. Pilot B did not rate this modeling because he did not feel he experienced these forces and moments.

Three of the pilots rated the safety of the sediment diversion very realistic (8) while Pilot A rated safety as average or normally expected safety. Pilot A tended to use the rating of 5 for many of the ratings with extreme situations rated above or below depending on the situation.

Most important were the comments provided by the pilots. The majority of pilots stated they believed that the diversion project would have minimal impact on traffic with one stating that this would be similar to other diversion projects tows have to deal with. One pilot stated that northbound tows should stay 500 ft away from the diversion. There were several suggestions that slower northbound tows should use the east bank if possible. There was general agreement that by making meeting and overtaking arrangements well in advance, allow a concentration of traffic in the diversion area to be avoided, which would make for safer operations with a possible slowing of downbound traffic to avoid meeting near the diversion. Several negative experiences with overtaking of tows by ships moving at higher speeds and close distances separating the vessels during the simulations indicated that ships running at slow bell would reduce some of the ship/tow interactions experienced and make operations in the reach safer.

Table 8, Pilot's Final Questionnaire - Evaluation of Simulations

Pilot	Ship/Tow Model Realism						Environmental Conditions		Database Realism		Hydrodynamic Realism	Overall Safety
	1x2 Fleeting Tow	2x1 Fleeting Tow	2x2 Fleeting Tow	6x5 Line-Haul Tow	Suezmax	Panamax	Wind	River Currents	Visual Scene	Channel	Ship to Bank Interaction	Channel Adjacent to Proposed Diversion
A	7	7	7	7	4	4	2	7	5	4	4	5
B	8	8	10	9	9	10	3	9	9	9		8
C	9	9	9	9	9	9	9	9	9	9	9	8
D	8	8	8	8	8	8	10	7	8	8	8	8

Realism(1=not real; 10=like real life);Environmental Condition(1=not real; 10=like real life);Safety(1=not safe; 10=very safe)

Table 9. Pilot's Final Questionnaire - Evaluation of Impacts on Navigation and Recommendations

Pilot	Project Impacts on Navigation	Safety Recommendations/Efficiency	Additional Comments
A	Full flow impact will have an effect on northbound tows if they get within 500ft outside of marker buoy; most traffic will favor east bank.	River traffic running northbound on the east bank will be the safest route to take.	Vessel impact will be miminal. Mariners will establish passing arrangement well in advance of meeting at diversion and pass well off the diversion.
B	I believe that during construction phase and high flow open diversion it will have minor impact considering the traffic and meeting/overtaking simulation in that area.	Experienced captains will more than likely make arrangements with targets so the area doesn't get jammed with traffic. Avoiding a close pass to it would benefit. Give diversions wide berth would be the safest way to navigate.	The only recommendation I would say would be to request slow bells from fast moving heavy draft vessels navigating the area.
C	It will not be a problem just like all the rest of the out flow.	Safe as long as everone knows its there. If you have a slow moving tow, run east bank.	Run east bank if have a slow moving tow. We would work out meeting farther away from diversion project.
D	I believe the project will cause occasional minimal traffic delays for northbound traffic. Some delays to southbound traffic may occur but very minimal.	Northbound traffic following the east bank side will decrease risk	New Orleans VTS is very good about keeping all mariners updated with restrictions to navigation. I believe this combined with due dilligence will negate any safety issues caused by the project.

Conclusions

This study has led to the following conclusions:

Overall Conclusions

- The simulation study included marine traffic (deep- and shallow-draft vessels) in the project area, which allowed an evaluation of the effect of the Mid-Barataria Sediment Diversion Project, both during construction and during operation, on that traffic when passing the Project.
- Navigation traffic in the area can affect the safety of navigation in the project reach of the Mississippi River.
- The pilots of ships and tows will manage the traffic approaching the project reach and establish meeting and overtaking locations in advance of arriving in the reach so as to minimize traffic in that reach when the Project is operating with discharge being delivered into the project and, also, during construction of the Project.
- Most of the time when tow tracklines came close to the Project intake it was because the tow pilots were attempting to test the current field's effect on controlling the tow; otherwise the pass could have been made with more clearance and less effect on the tow.

Construction of the Project

- Model setup of the river currents around the construction cofferdam was done with a smaller project design. As a result, the currents around the cofferdam in the simulation were higher than would be expected if the existing design were modeled.
- Modeling of the cofferdam with temporary protective cells and with working vessels surrounding the construction site provided an evaluation of the impact of the construction phase on marine traffic.
- Seventeen simulated transits were made with the construction phase of the Project.
- The placement of the cofferdam and the work vessels outside the temporary protective cells extended the blockage of the river navigation area for tow traffic between 400-450 ft beyond the edge of the fleeting barges when the fleeting area below the CHS terminal was in use.
- Almost all of the simulated runs were given good safety and average difficulty ratings by the pilots.
- A few negative comments and low ratings were from the pilot of the light downbound fleeting tow, which was strongly affected by the ENE wind.
- The pilots began to coordinate the meetings and overtakings more aggressively to avoid congestion near the Project intake.
- The loaded upbound fleeting tow coming from the Myrtle Grove Fleeting Area would move to the west side of the channel near the Project site or above the Project site, depending on the traffic situation. When moving from the east to the west side of the channel at or below the Project site, there were no safety issues noted by the pilots.
- Generally, the Project construction phase did not elicit any strong negative opinions of the impact of the location of the Project cofferdam, the temporary protection cells, and work vessels.

Project Operation

- The structure portion of the project does not extend into the Mississippi River further than the prior fleeting area barges did (see Figure 34).

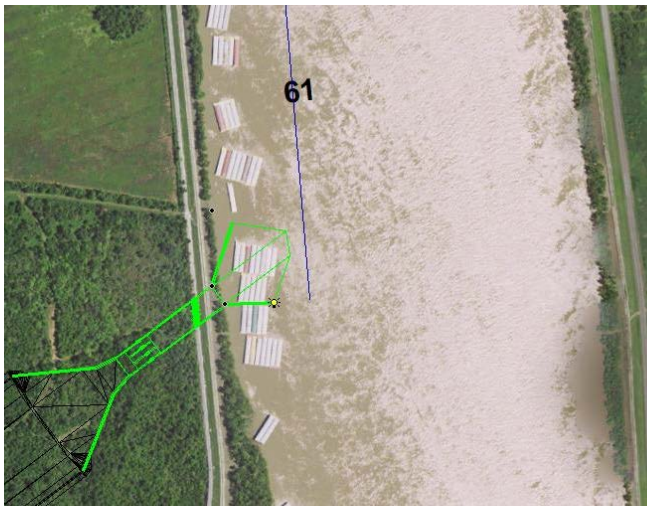

Figure 34. Previous Fleeting in the Mid-Barataria Sediment Diversion Project Location

- The structure portion of the proposed Project does not extend into the Mississippi River as far as the previously permitted (11/7/20124; Permit Number MVN-2012-0123-EPP) RAM Coal Export Facility would, and that facility did not receive negative comments from the navigation community (see Figure 35).

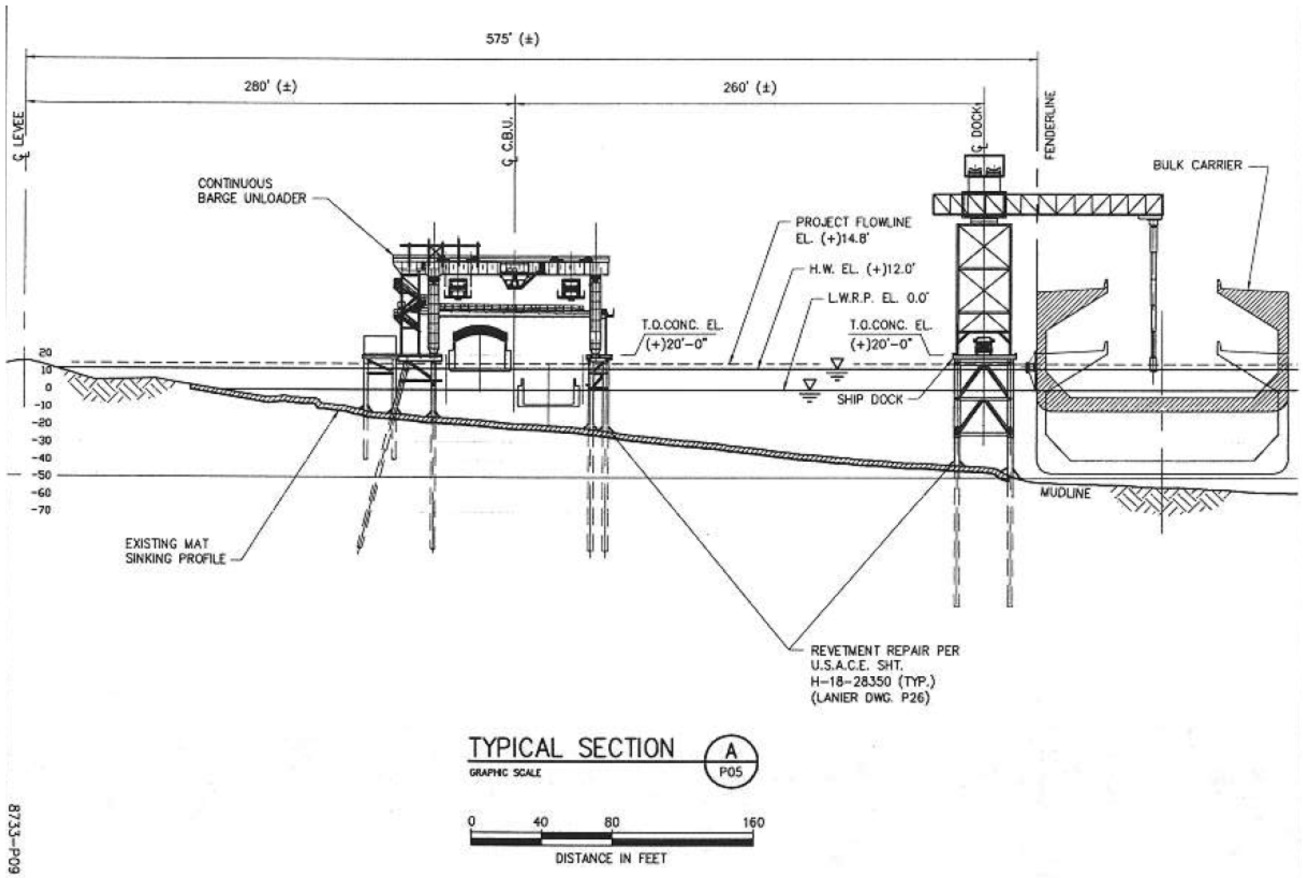

Figure 35. Riverward Extent of the Previously Permitted Ram Coal Export Facility to the Proposed Mid-Barataria Sediment Diversion Project. Based on the estimated distance from the low water reference plane into the river, the fenderline of the dock would extend 425 ft into the river and an additional 140 ft bulk carrier beam width would result in a total of 565 ft of occupied river space.

- The US Coast Guard VTS could assist in notifying the navigation traffic in and approaching the project reach when the Project is withdrawing water and sediment from the river.
- Deep-draft vessels will typically not pass near the Project intake but typically transit on the east side of the channel past the Project intake.
- Deep-draft vessels can have an effect on shallow-draft tows, particularly when overtaking the tows if they pass too close to each other. The tow will be slowed and possibly reverse course and can lose control.
- Line-haul tows can have a similar effect on fleeting tows, particularly when upbound and should avoid overtaking a smaller slow fleeting tow in front of the project intake when it is diverting flow.
- Navigation of tows in close proximity to the Project intake with river flows of 600,000 cfs with project intake flows of 48,000 cfs are affected by the project intake currents less than when the river flow is 1,000,000 cfs with project intake flows of 75,000 cfs.

- Downbound tows are not as affected as upbound tows due to the higher speeds and direction of the flow; however, their swept path is wider and they are more difficult to control in the wind since they are empty.
- Downbound empty tows were significantly affected by the ENE wind; this has nothing to do with the Project.
- Generally, even though the intake currents affect the tows when tows approach close to the Project intake, they were controllable.
- Often when upbound tows are affected by the Project intake currents, the effect is for the tow's bow to begin to be pulled towards the project intake; as the tow was steered away from the intake, the stern swings toward the intake and continues as the towboat passes the intake so that the boat moves inside the intake beyond the intake marker.
- The Project intake currents affected even the line-haul tow but at a much lower force; the line-haul tow was driven close to the intake with a stable steady course and neutral rudder to see what the effect on the tow would be.
- Generally, it was agreed that if tows are kept more than 100 -200 ft away from the Project intake, operations would be safe.

Recommendations

The following recommendations are submitted:

- It will be important for the U.S. Coast Guard to notify the navigation industry when the Project construction activity will take place.
- The present design of the cofferdam and temporary protective cells will not have a significant impact on navigation.
- In order to minimize the impact of the Project construction on the marine traffic, placement of the work barges between the cofferdam and the temporary protective cells should be considered or utilize the downstream side of the cofferdam between the protection cells and the Mississippi River bank.
- When the Project is in operation, it will be important for the U.S. Coast Guard to notify the navigation industry when diversions flows will be started and stopped.
- The present Project design can proceed with the design tested with little effect on the navigation traffic through the project reach.
- The marine operations through the reach will require coordination to minimize meeting and overtaking in the Project reach.
- The east end of the south wall of the river intake structure should be marked with a lighted channel marker (preferred) or a buoy.
- As the Project design progresses, it may be necessary to conduct additional simulations depending on the changes in the design, if any. Practically it is recommended that if the Project design changes increase the magnitude of the currents near the Project intake by more than 50% or if the extent of the currents extends into the river more than 200 ft, then new simulations should be considered.

Appendix A – Simulation Run Trackplots

Low Flow Simulations–6Kcfs Mississippi River Flow; 48Kcfs Diversion Flow

Run 2 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

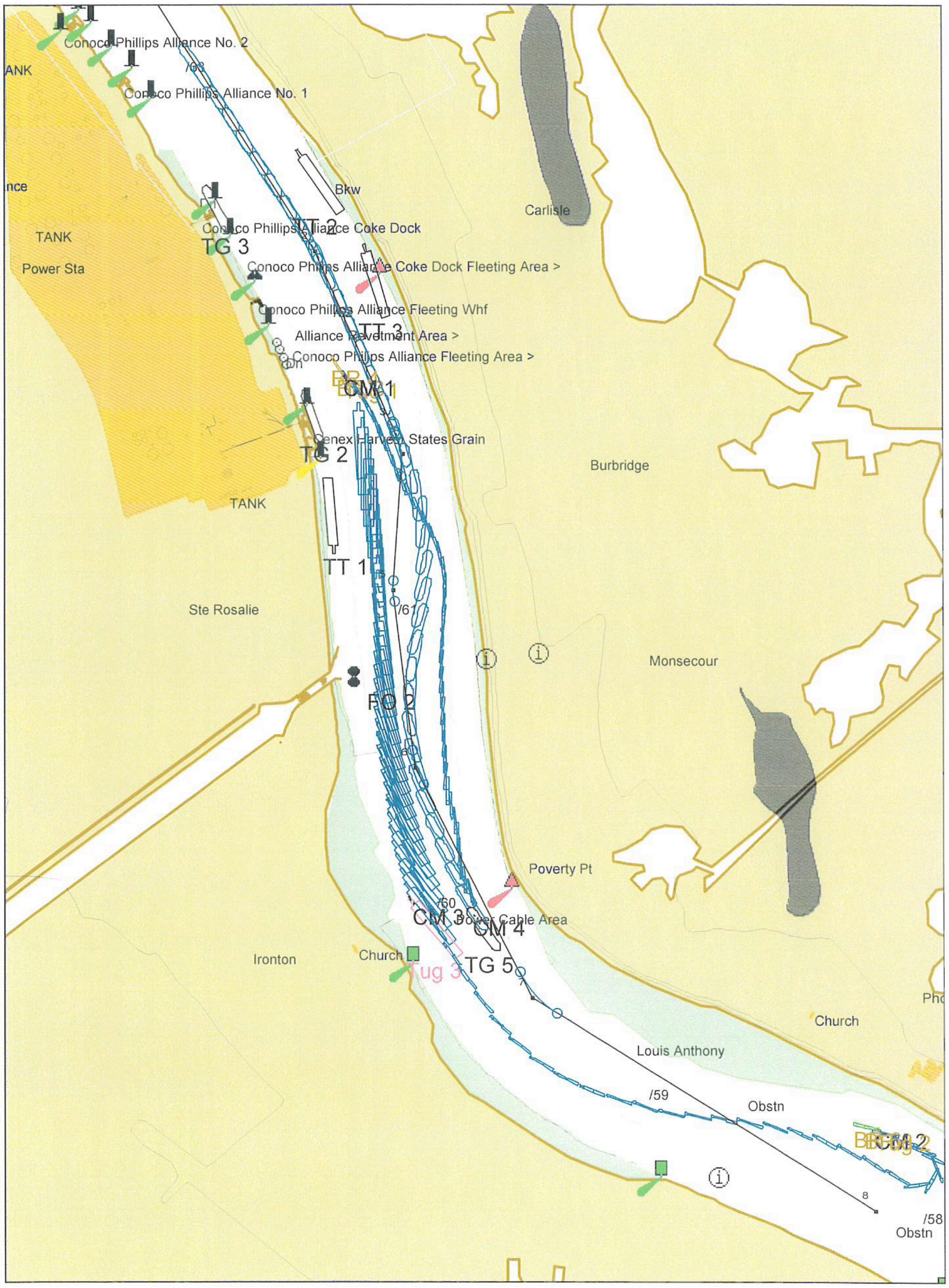

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Figure A - 1: Run 2, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 3 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

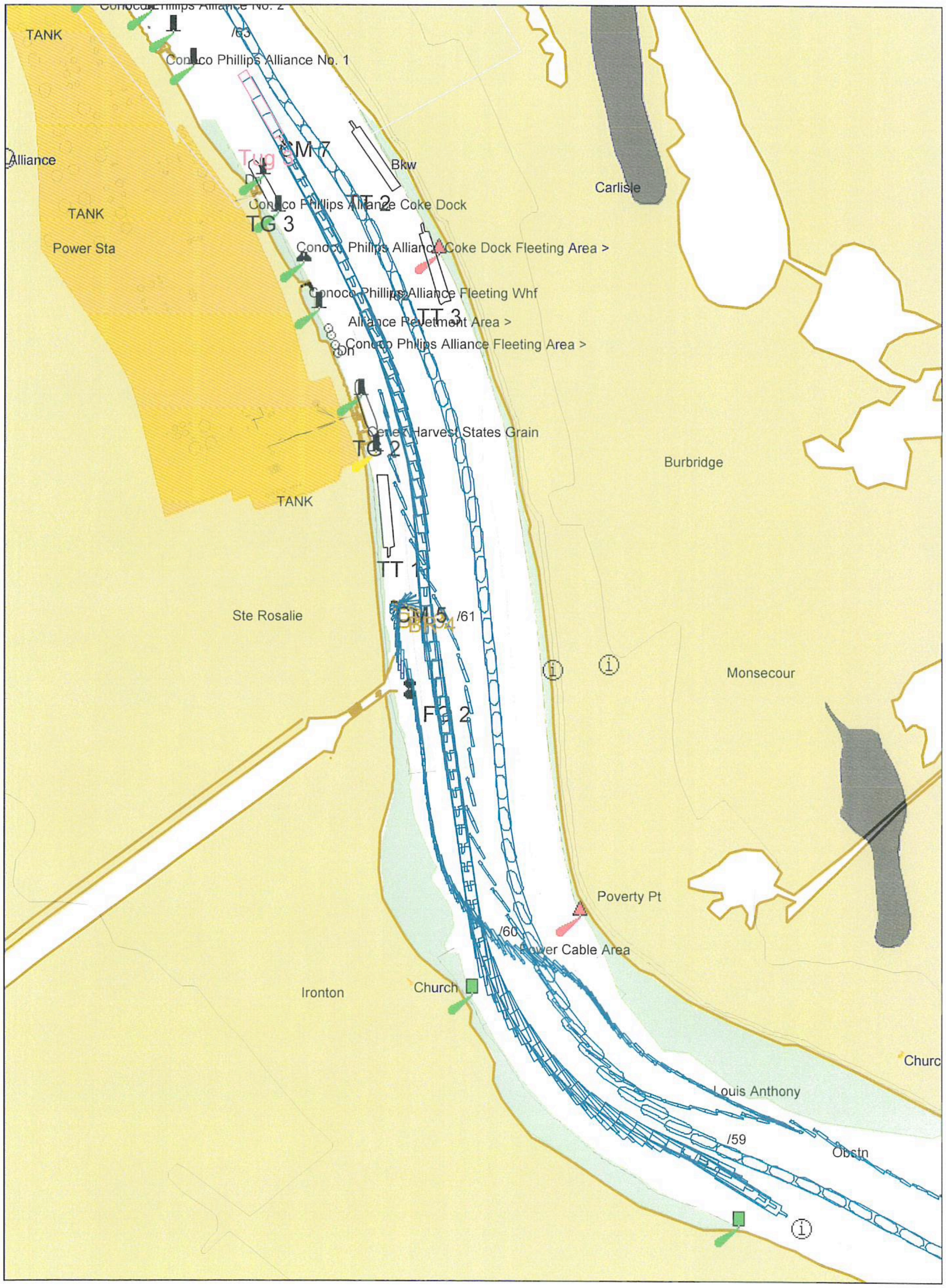

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Figure A - 2, Run 3, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 4 - LowFlowENE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

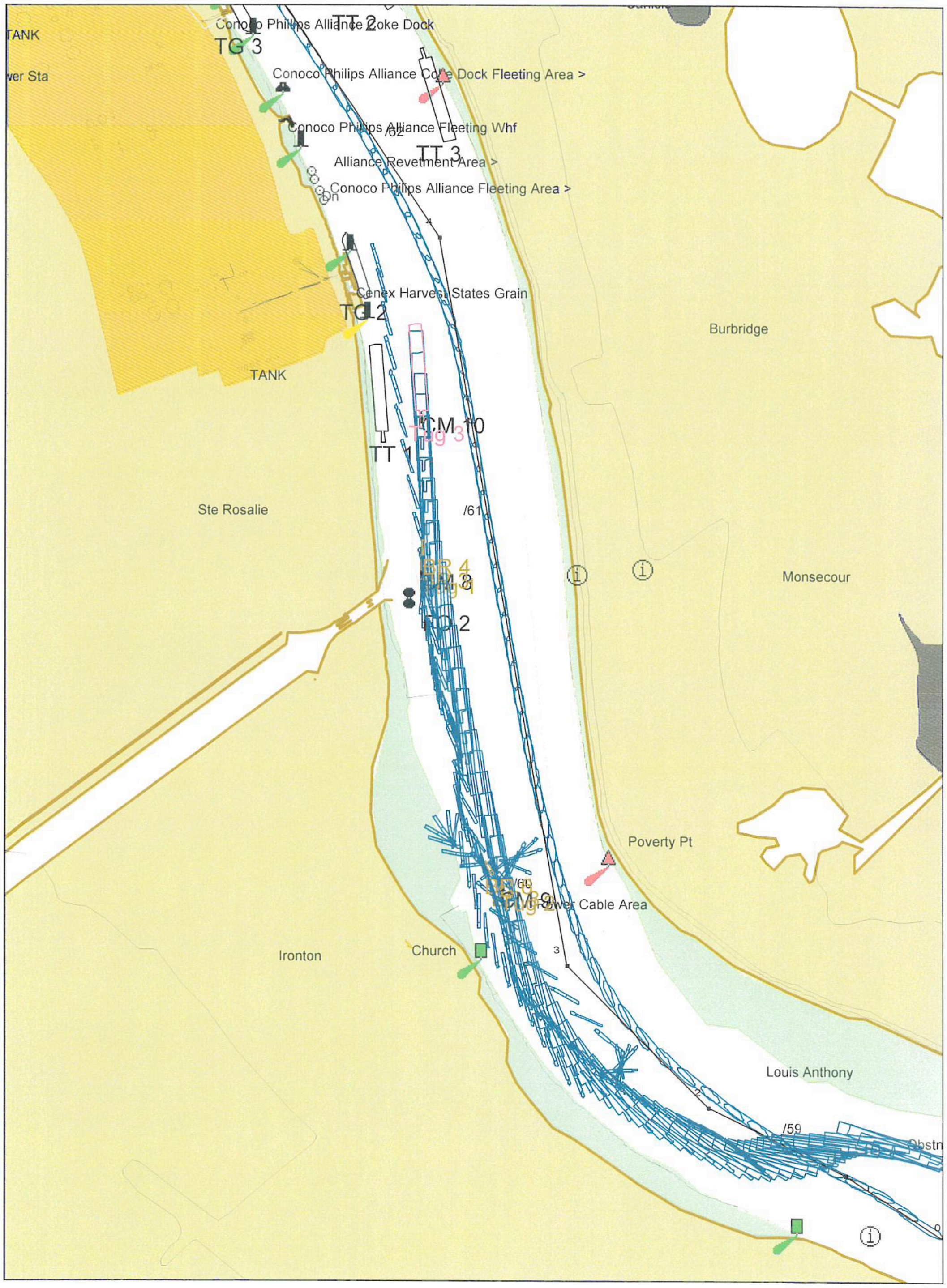

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Figure A - 3: Run 4, Diversion, 0.6M CFS, Wind ENE 20 Knots

Run 5 - LowFlowENE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

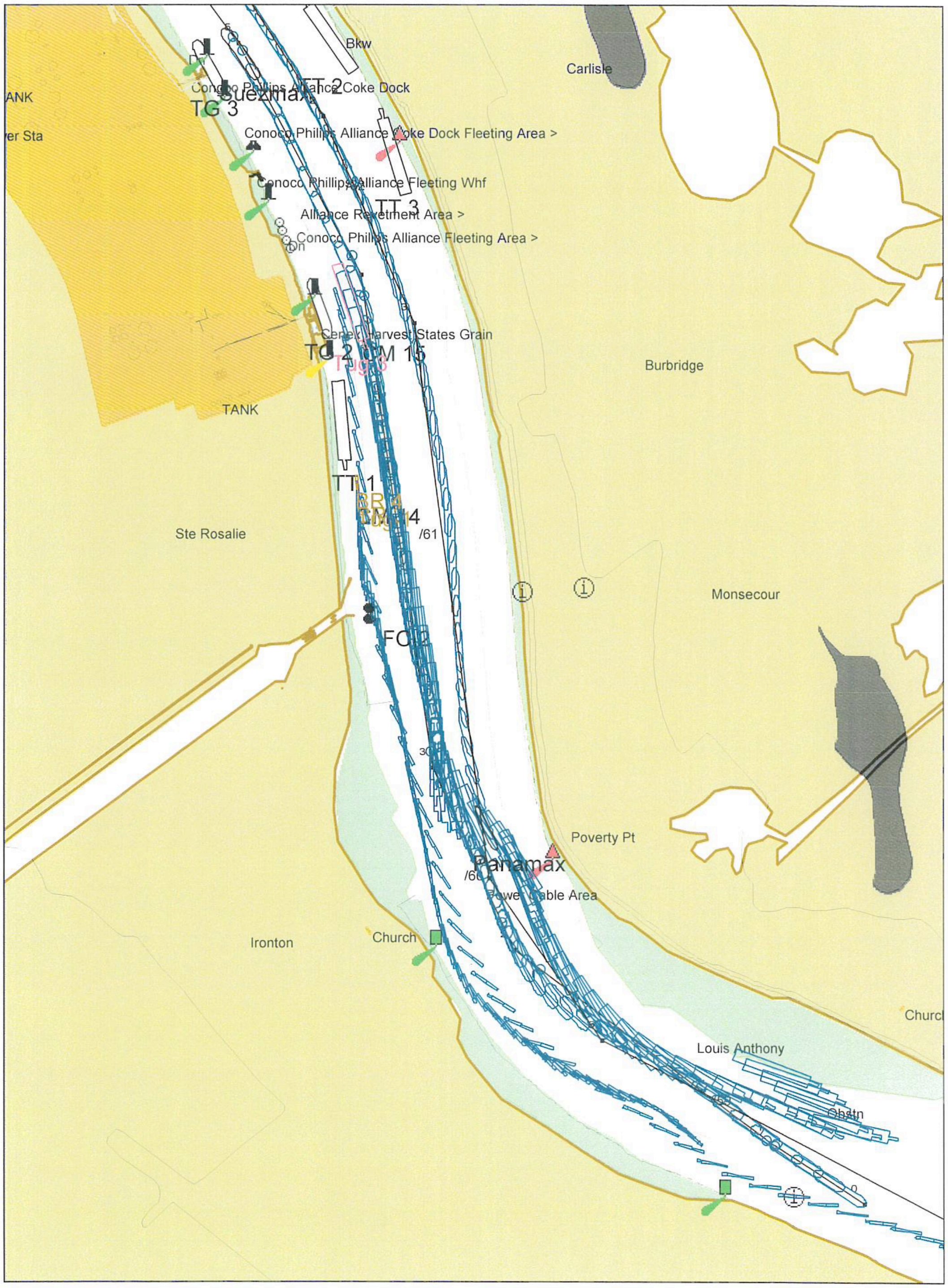

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Figure A - 4: Run 5, Diversion, 0.6M CFS, Wind ENE 20 Knots

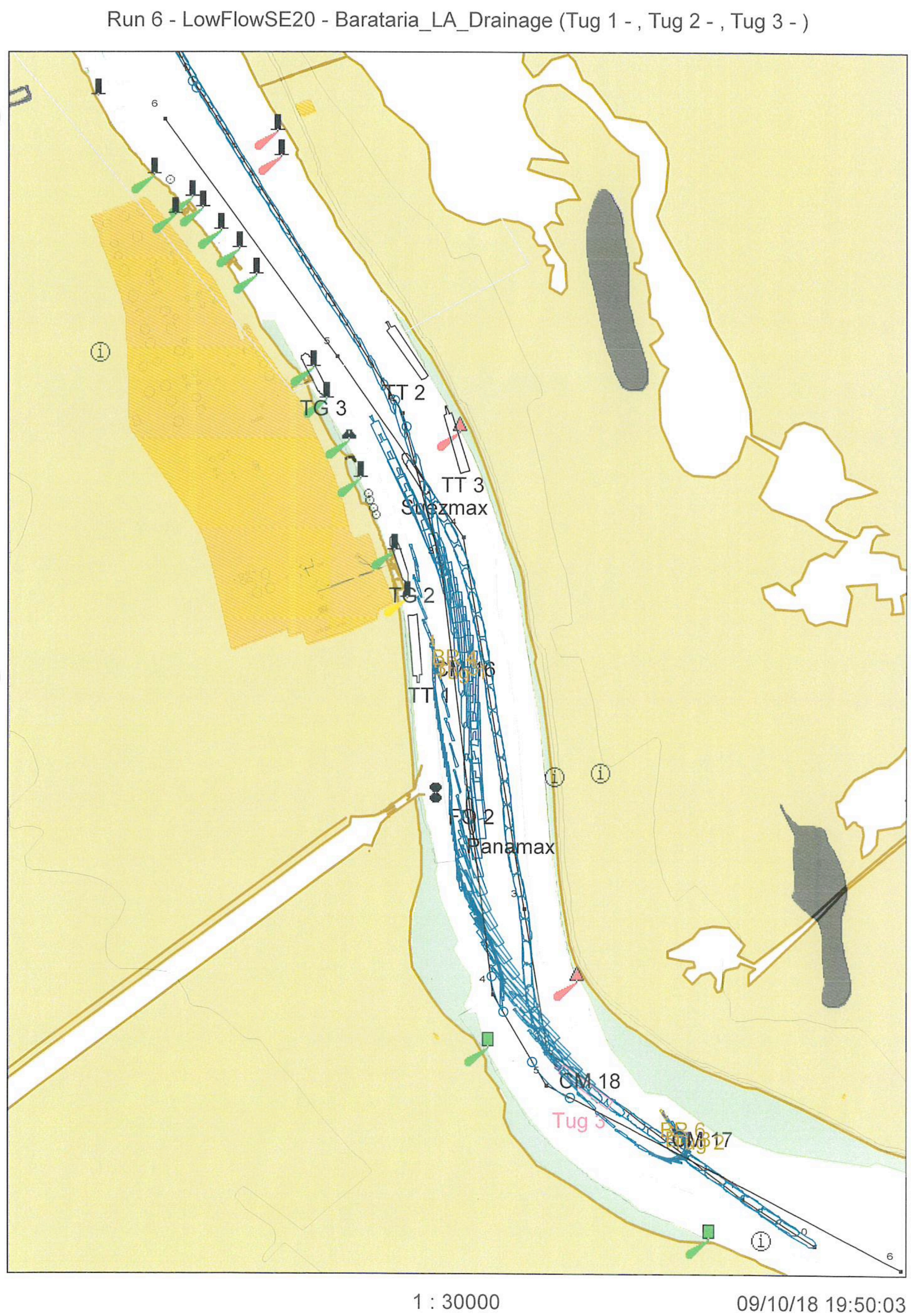
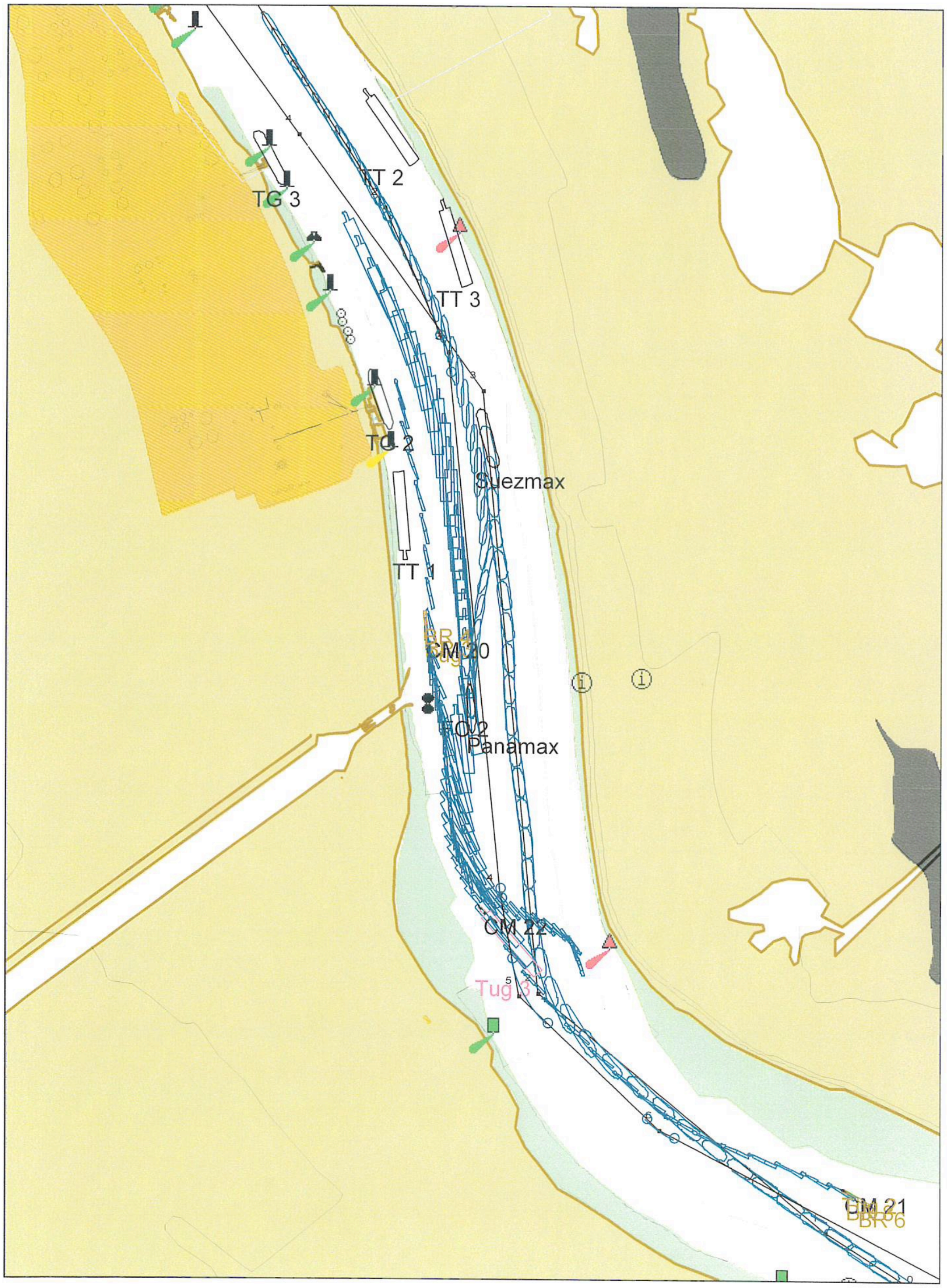


Figure A - 5: Run 6, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 7 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

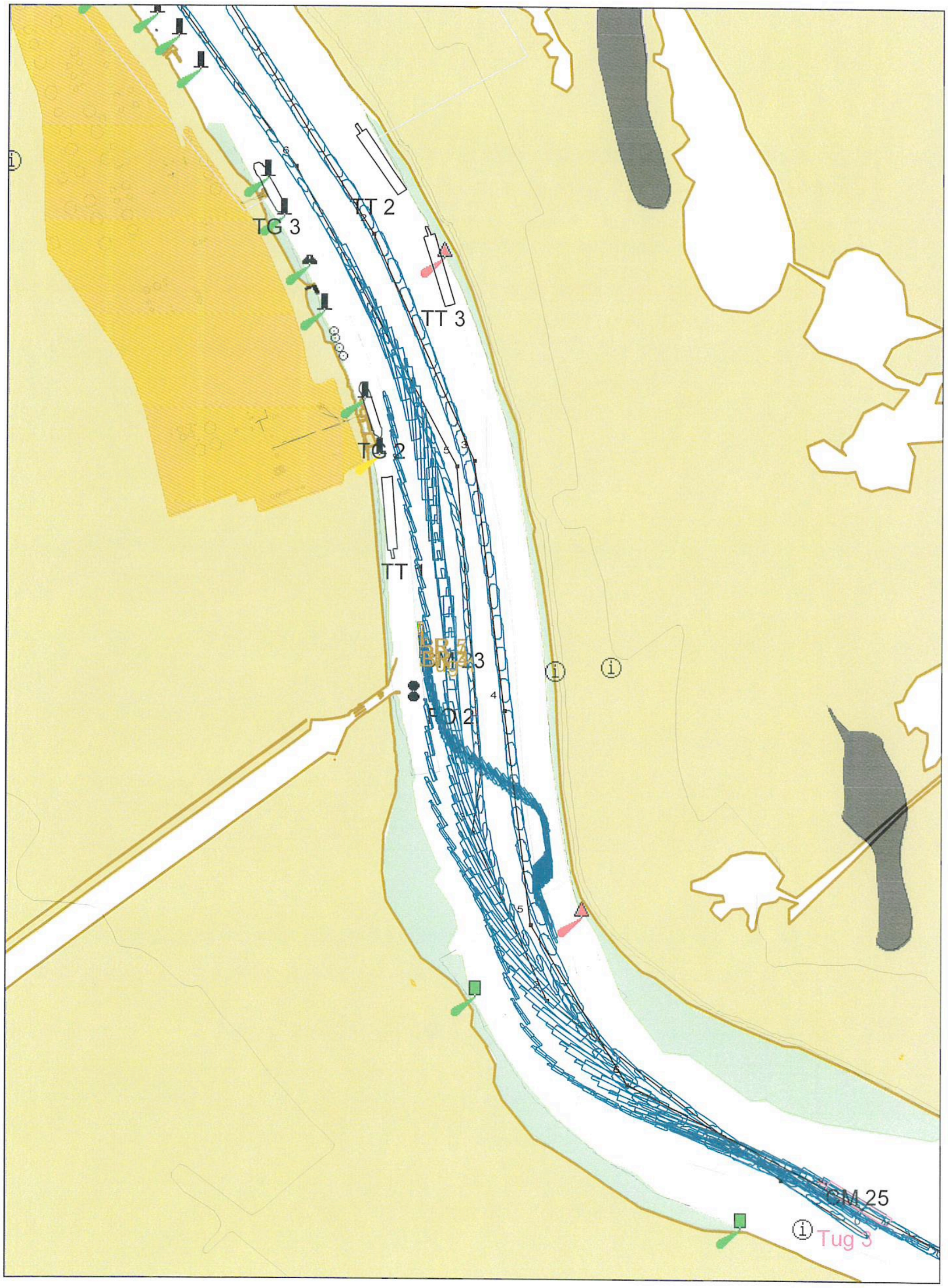


1 : 24000

09/10/18 20:13:01

Figure A - 6: Run 7, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 8 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

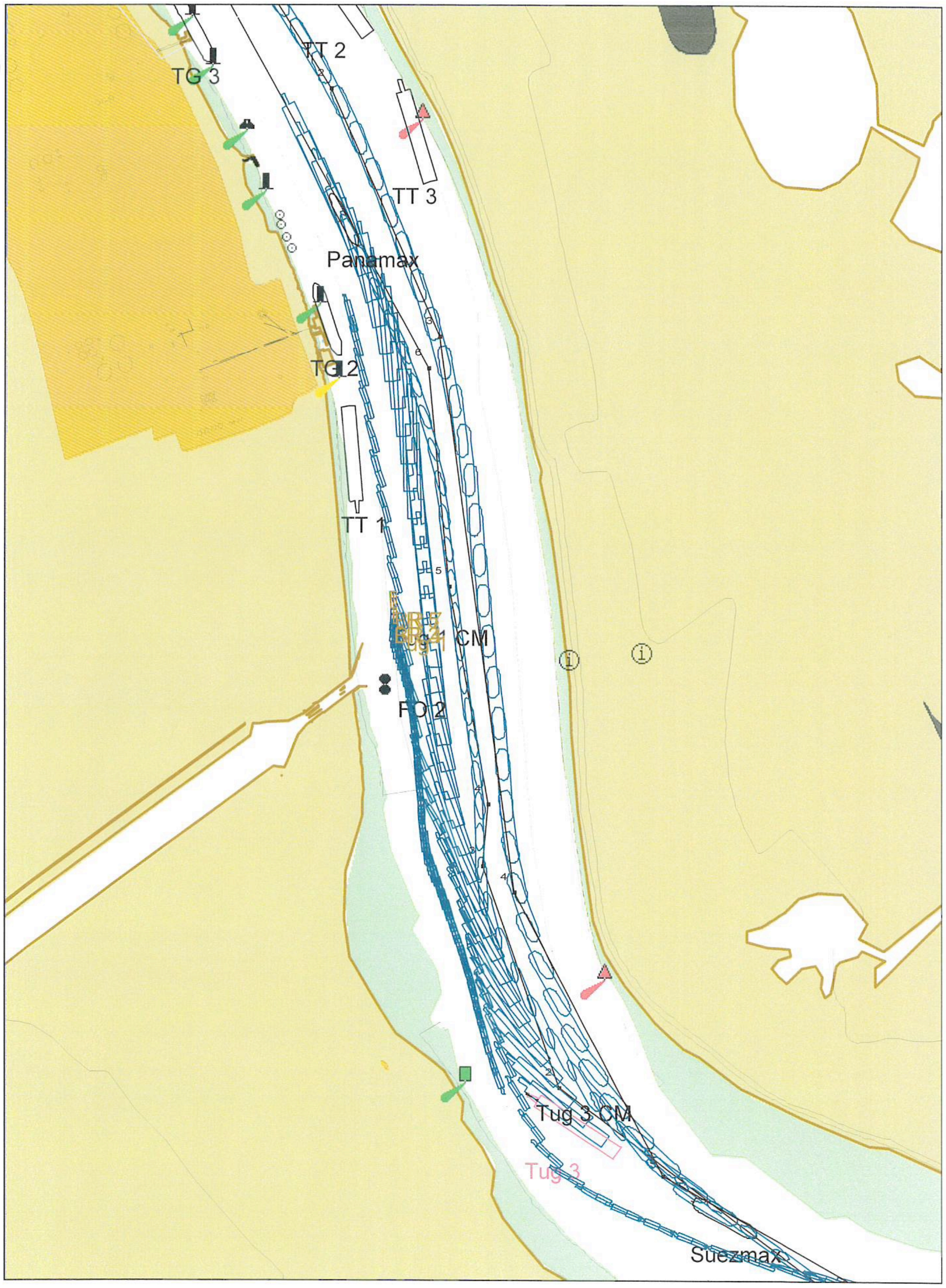


1 : 26000

09/10/18 21:04:33

Figure A - 7: Run 8, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 9 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)



1 : 20000

09/10/18 21:31:18

Figure A - 8: Run 9, Diversion, 0.6M CFS, Wind SE 20 Knots

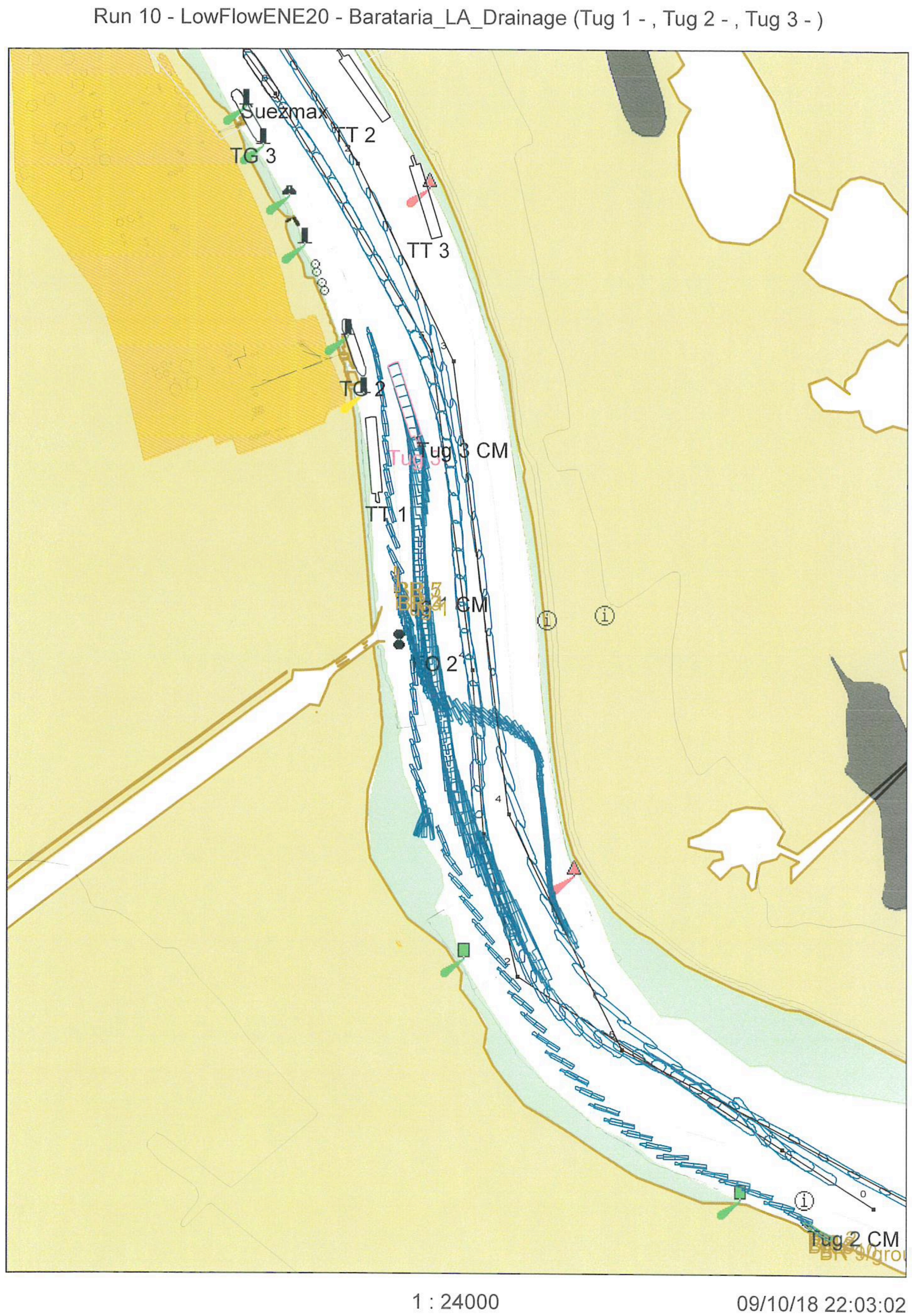


Figure A - 9: Run 10, Diversion, 0.6M CFS, Wind ENE 20 Knots

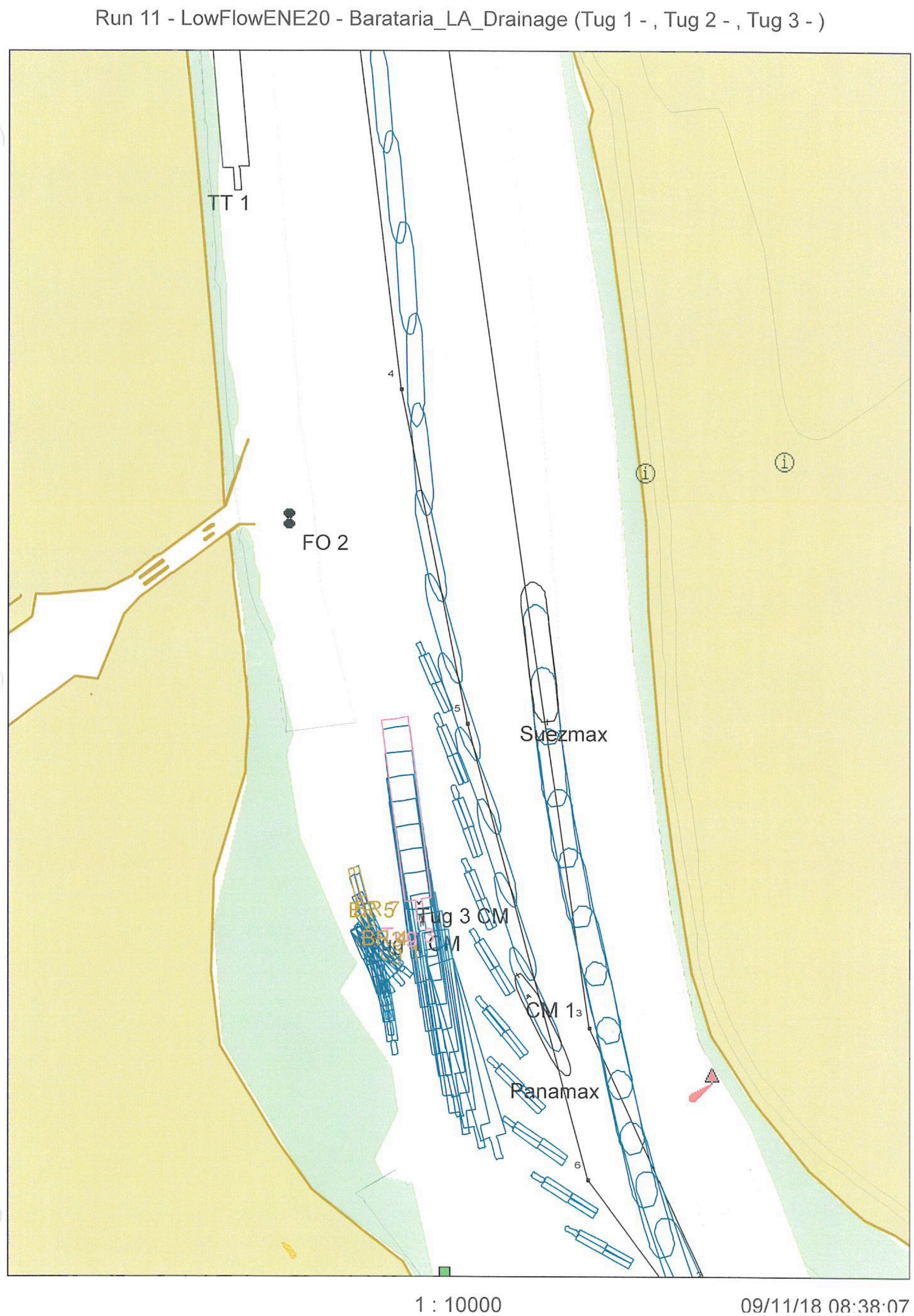


Figure A - 10: Run 11, Diversion, 0.6M CFS, Wind ENE 20 Knots
Incomplete Simulation Data Record

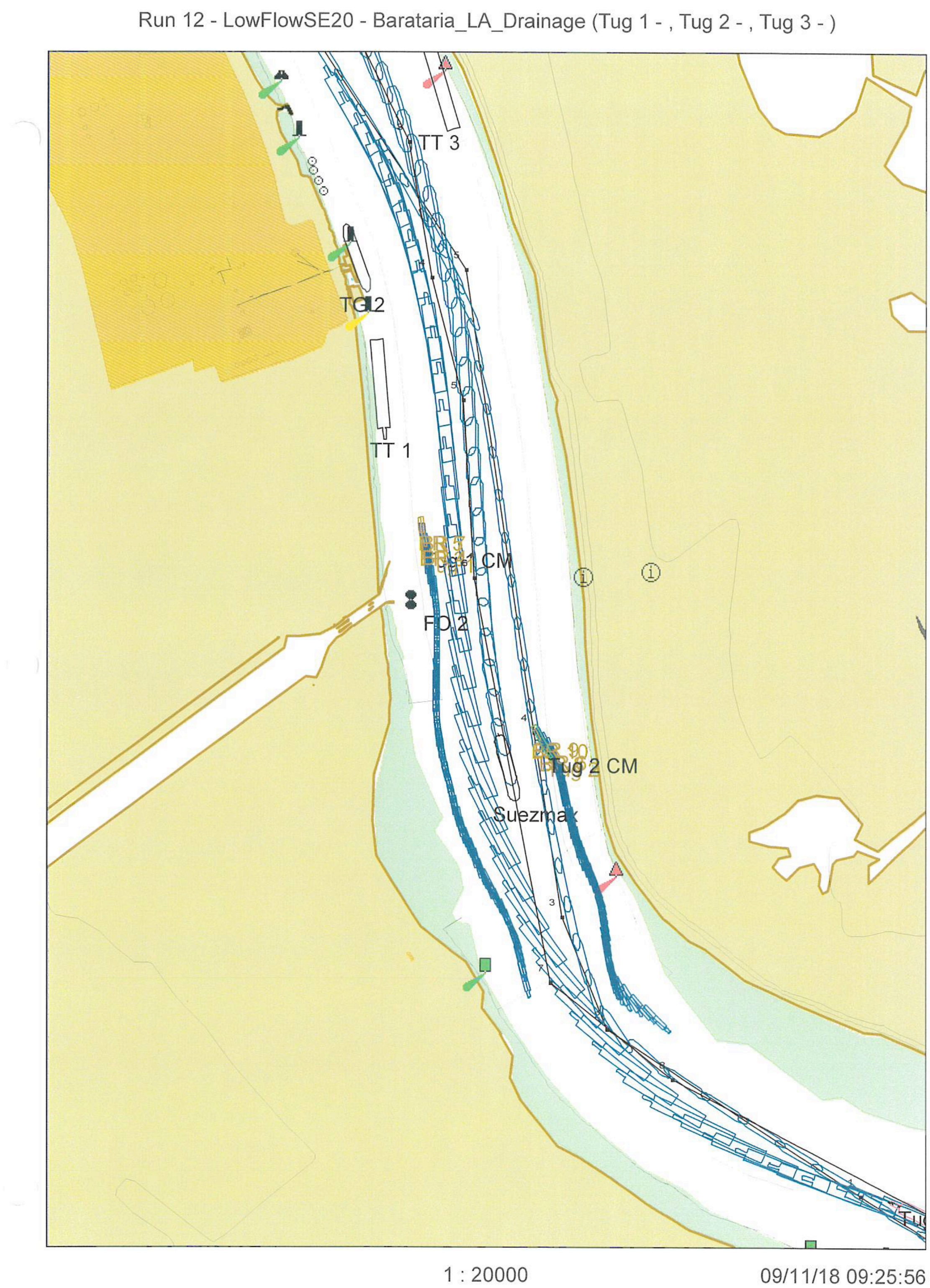
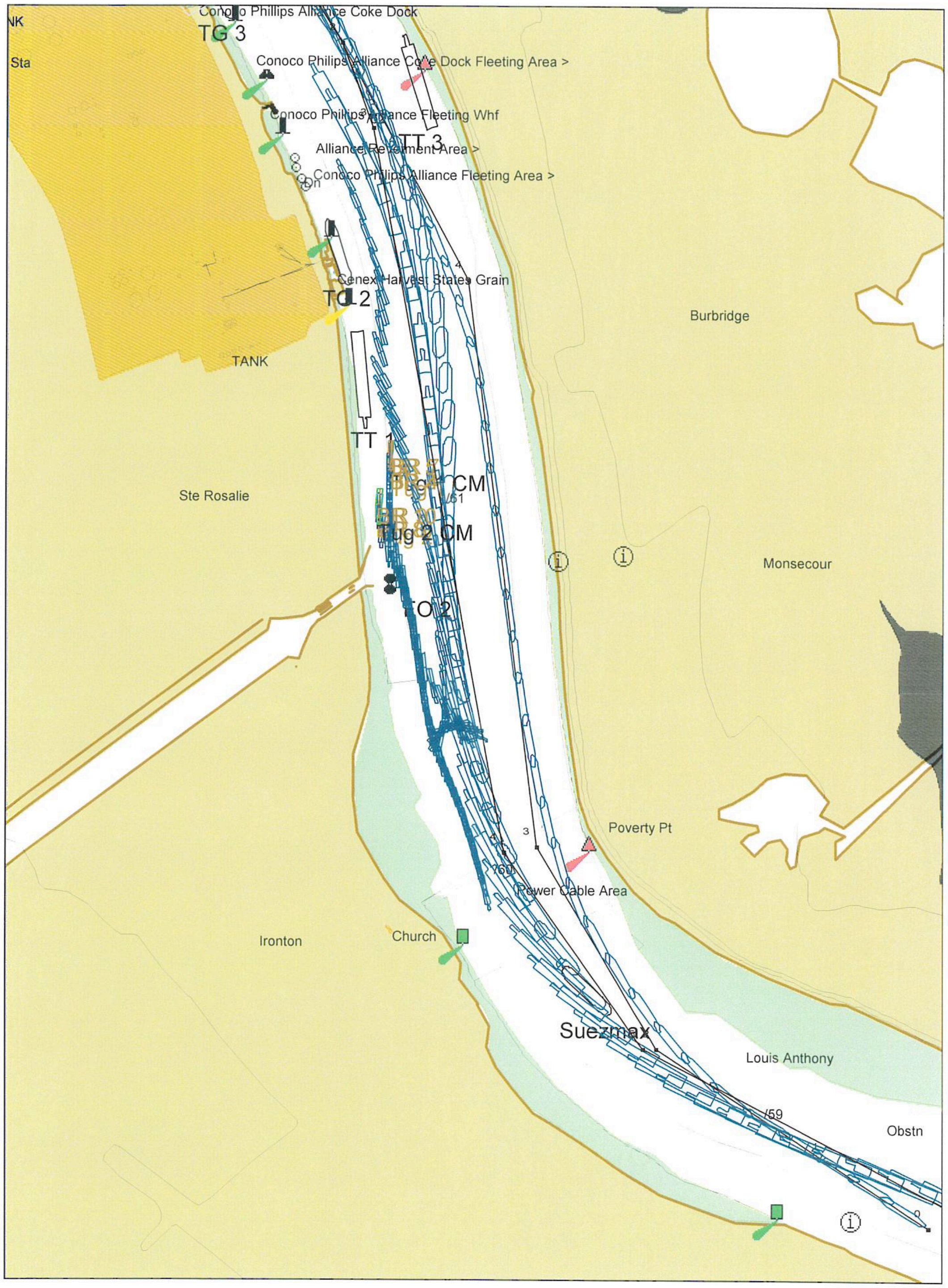


Figure A - 11: Run 12, Diversion, 0.6M CFS, Wind SE 20 Knots
Incomplete Simulation Data Record

Run 13 - LowFlowSE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

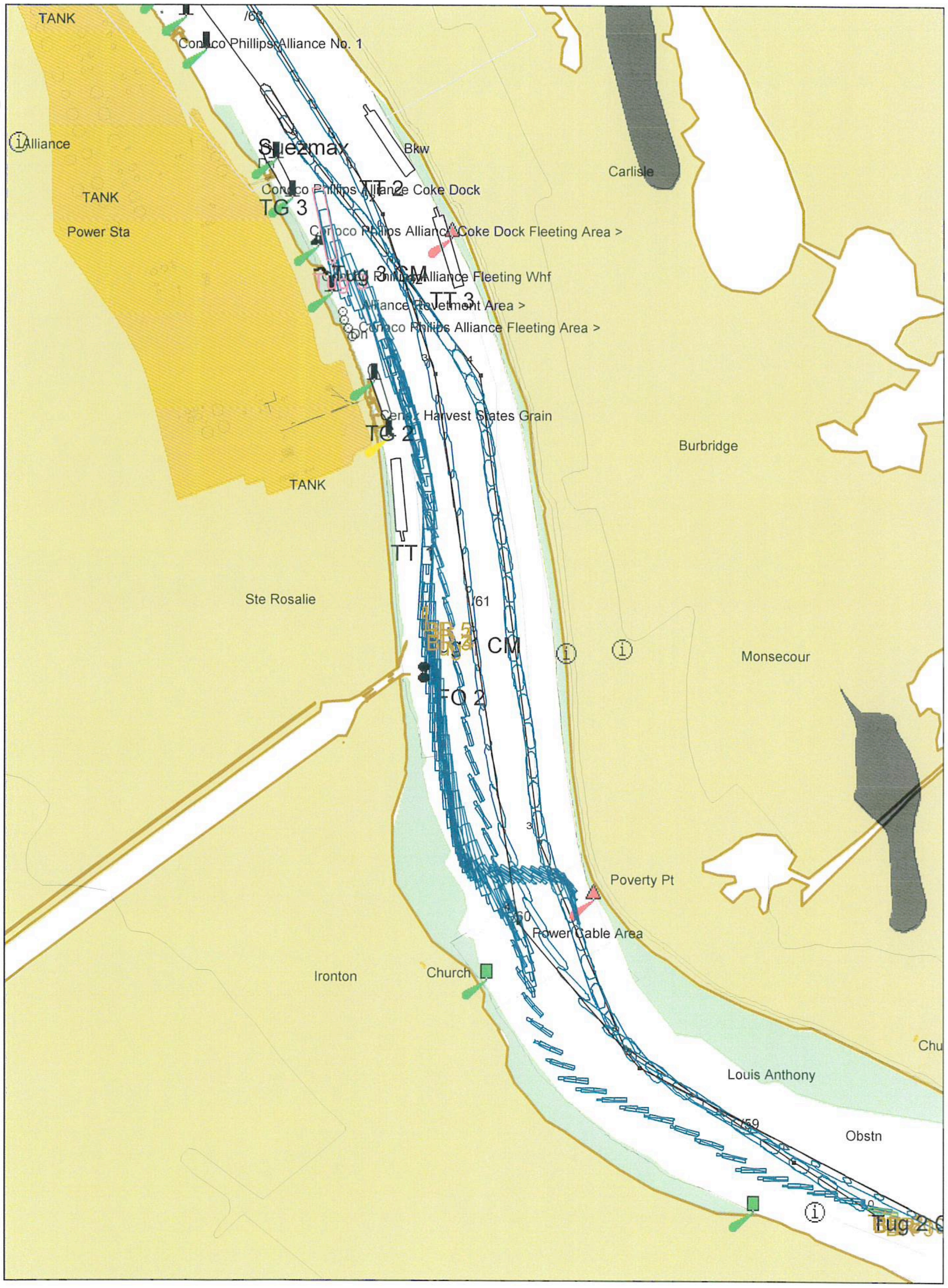


1 : 22000

09/11/18 10:07:38

Figure A - 12: Run 13, Diversion, 0.6M CFS, Wind SE 20 Knots

Run 14 - LowFlowENE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)

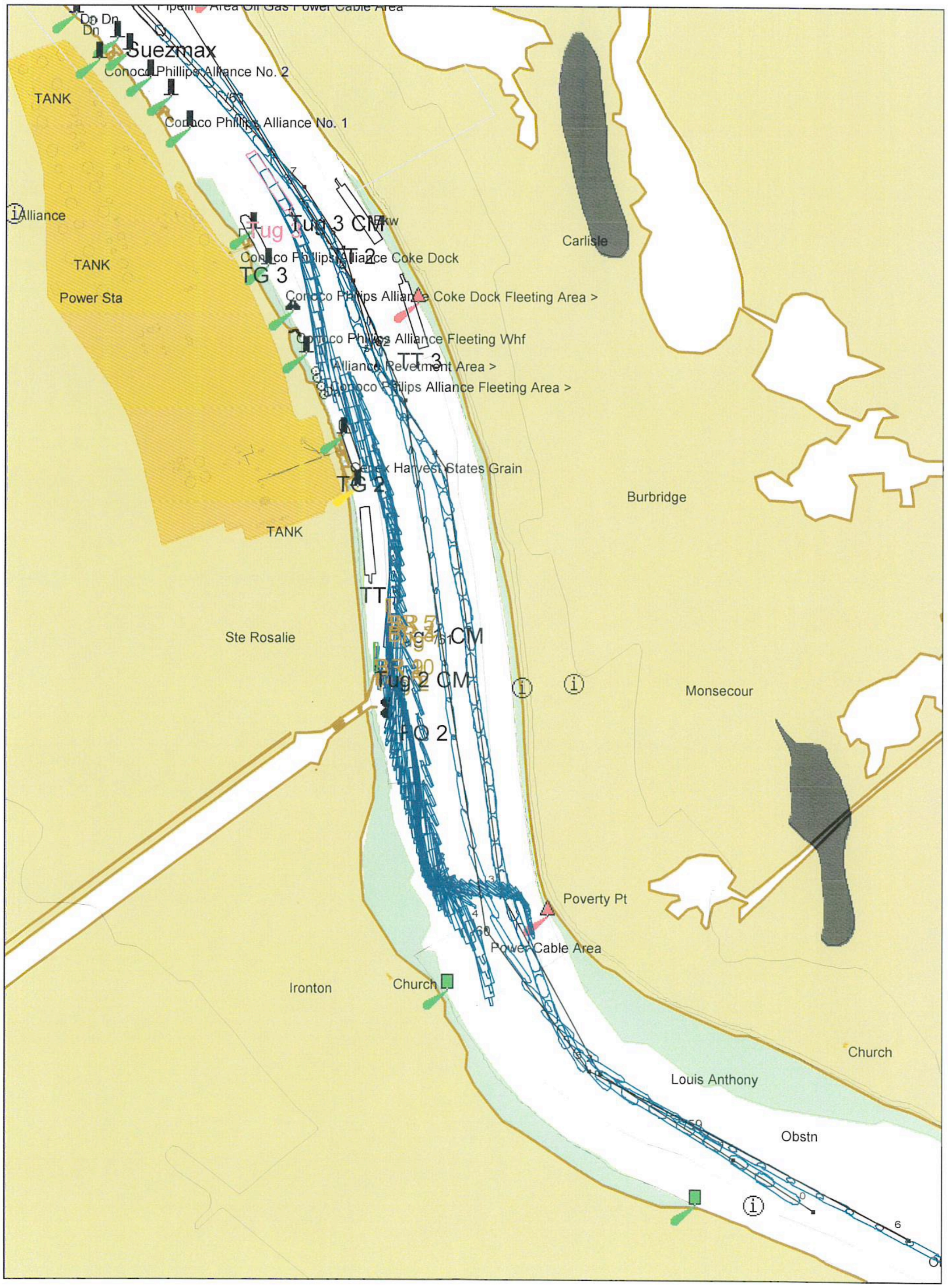


1 : 26000

09/11/18 10:53:36

Figure A - 13: Run 14, Diversion, 0.6M CFS, Wind ENE 20 Knots

Run 15 - LowFlowENE20 - Barataria_LA_Drainage (Tug 1 - , Tug 2 - , Tug 3 -)



1 : 28000

09/11/18 11:22:44

Figure A - 14: Run 15, Diversion, 0.6M CFS, Wind ENE 20 Knots

High Flow Simulation –1Mcfs Mississippi River Flow; 75Kcfs Diversion Flow

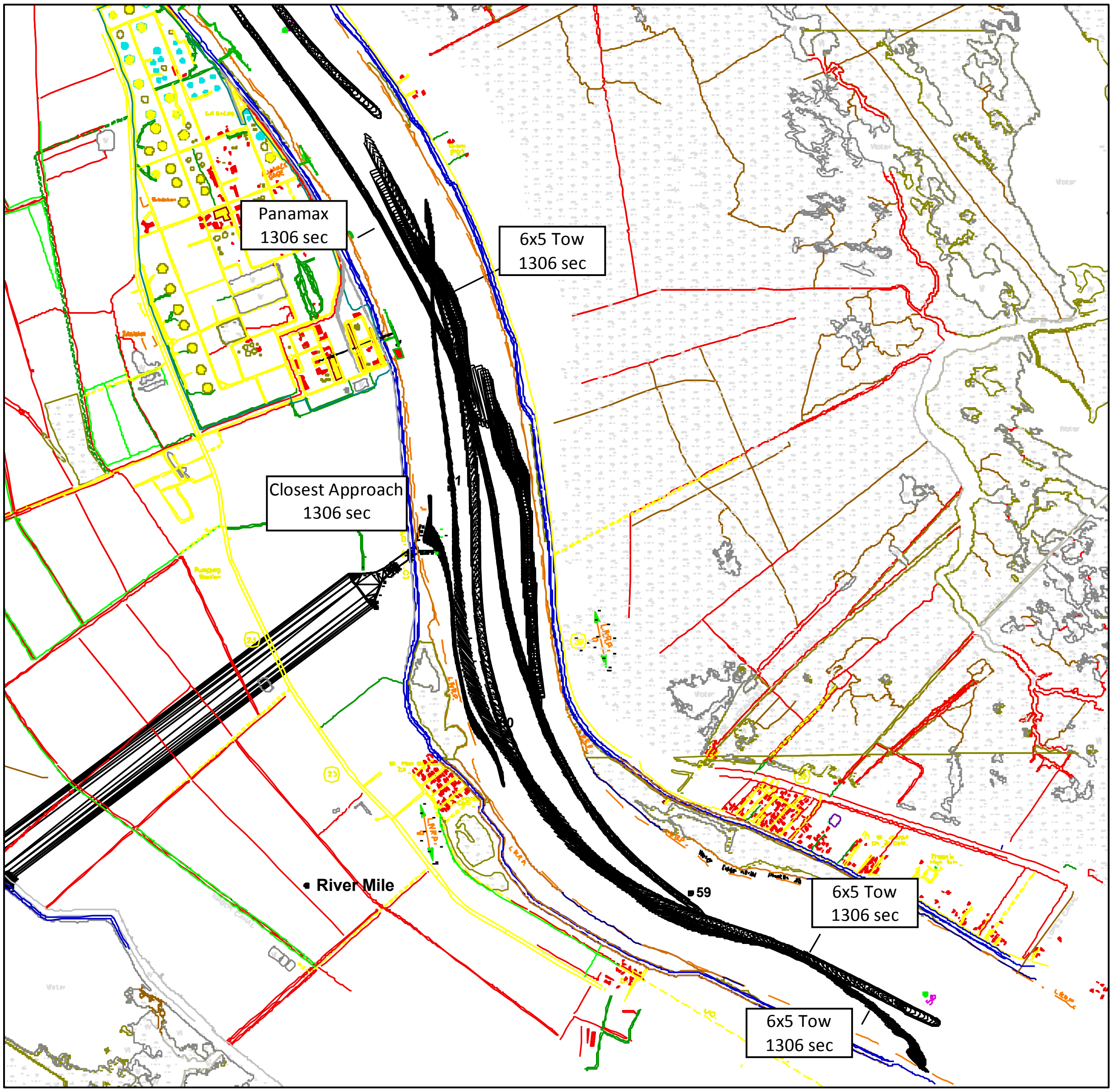


Figure A – 15: Run 16, Diversion, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

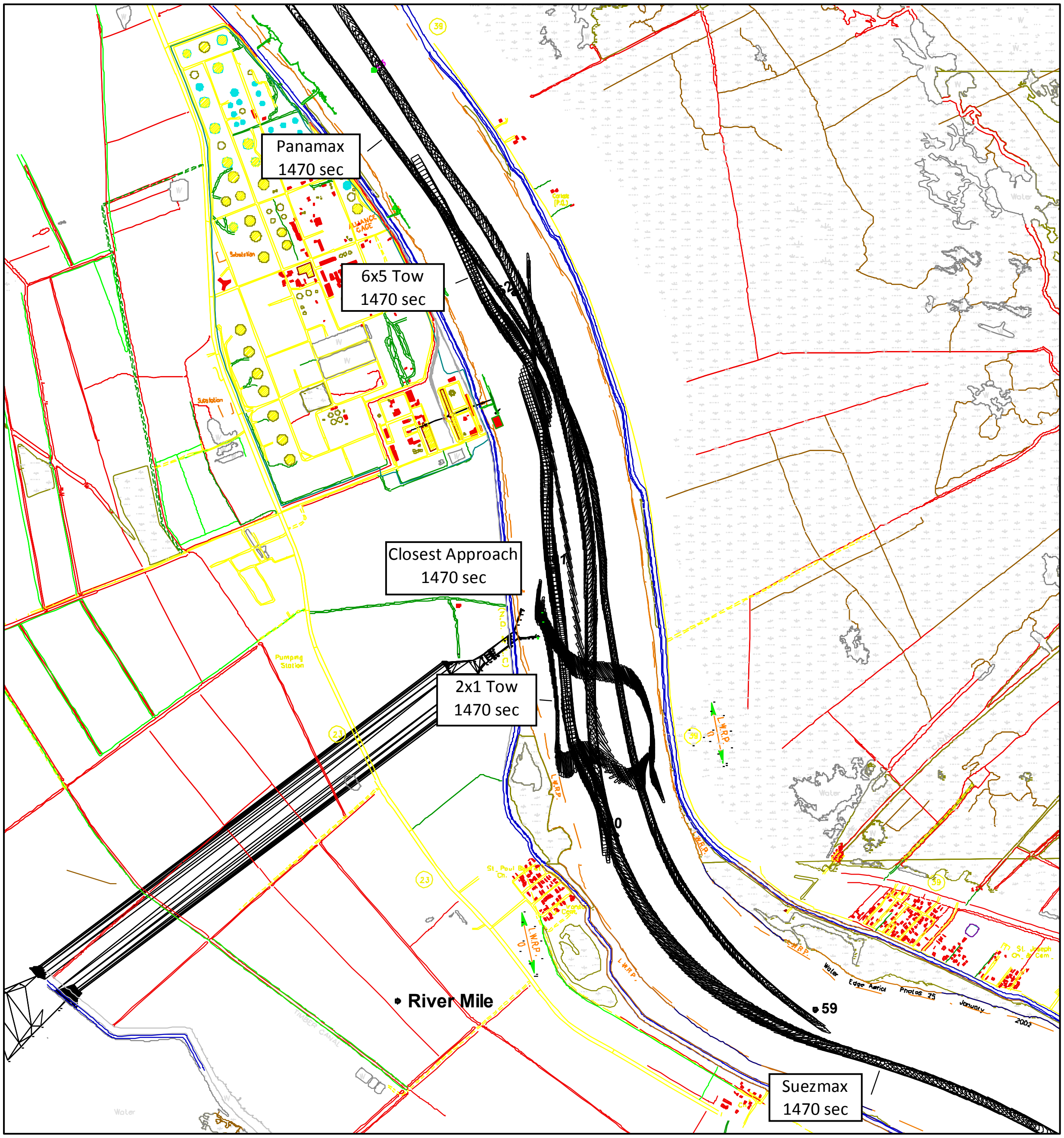


Figure A - 16: Run 17, Diversion, 1M CFS, Wind SE 20 Knots, 2x1 Tow Closest Approach

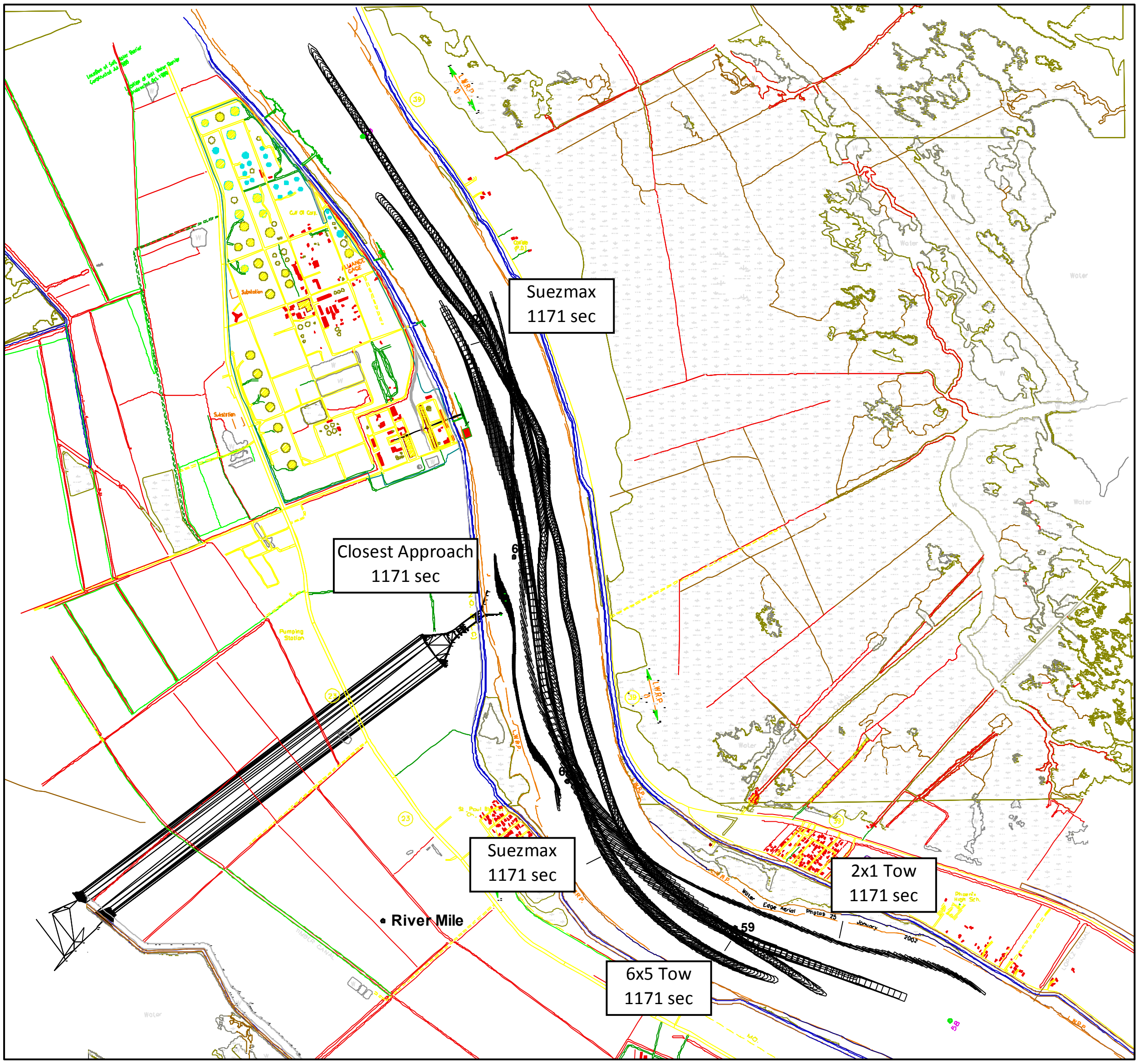


Figure A - 17: Run 18, Diversion, 1M CFS, Wind SE 20 Knots, 2x1 Tow Closest Approach

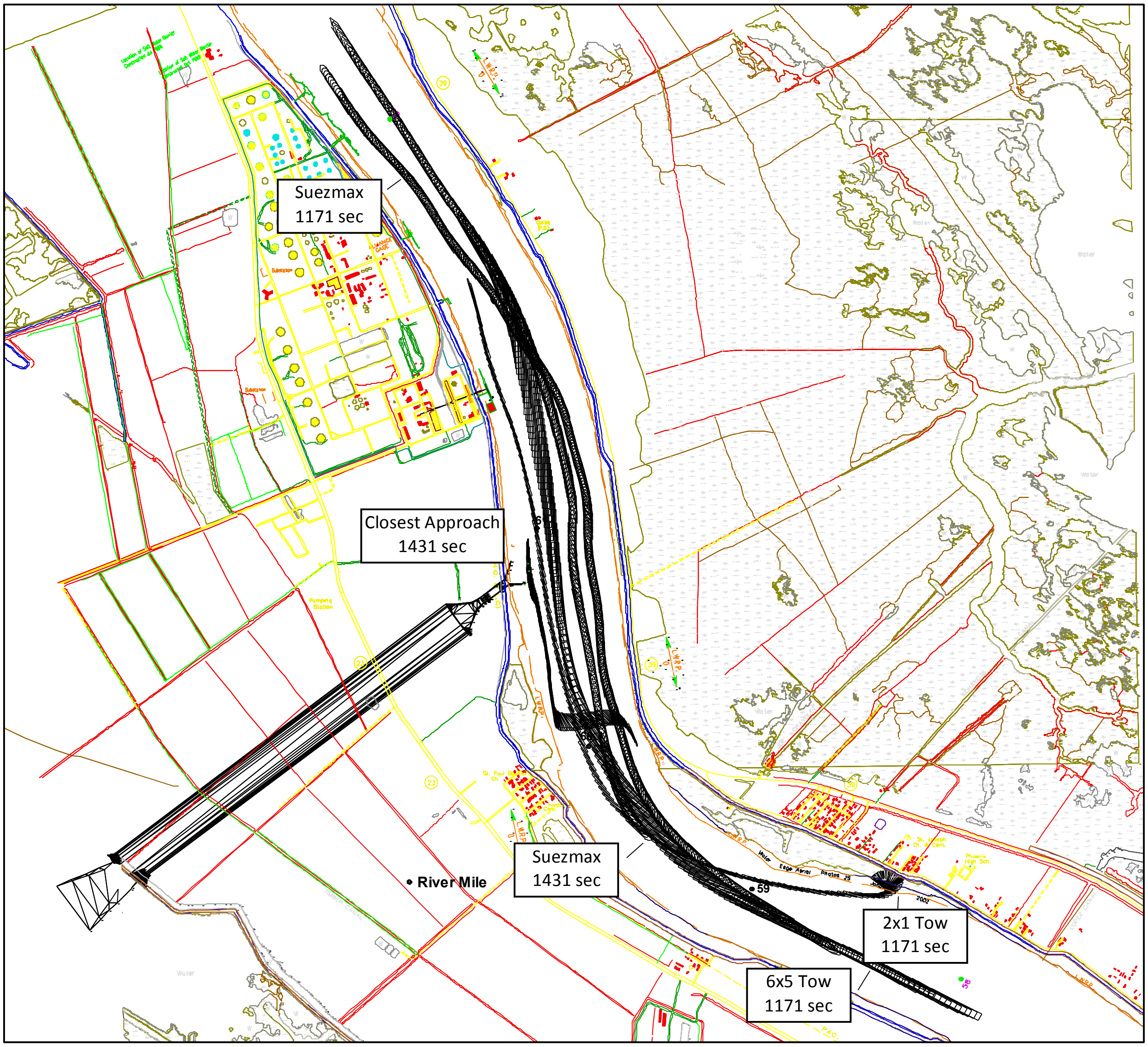


Figure A - 18: Run 19, Diversion, 1M CFS, Wind SE 20 Knots, 2x1 Tow Closest Approach

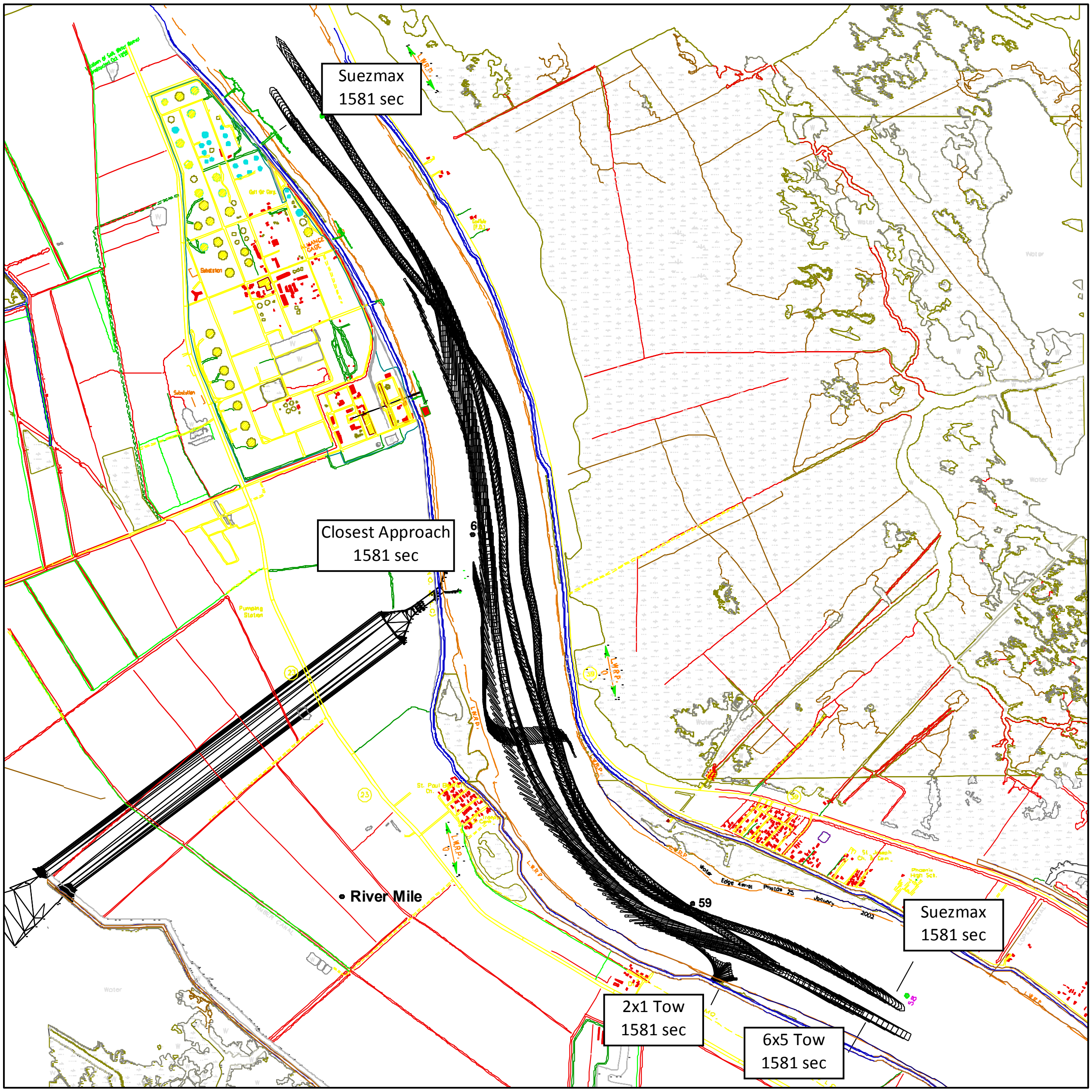


Figure A - 19: Run 20, Diversion, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

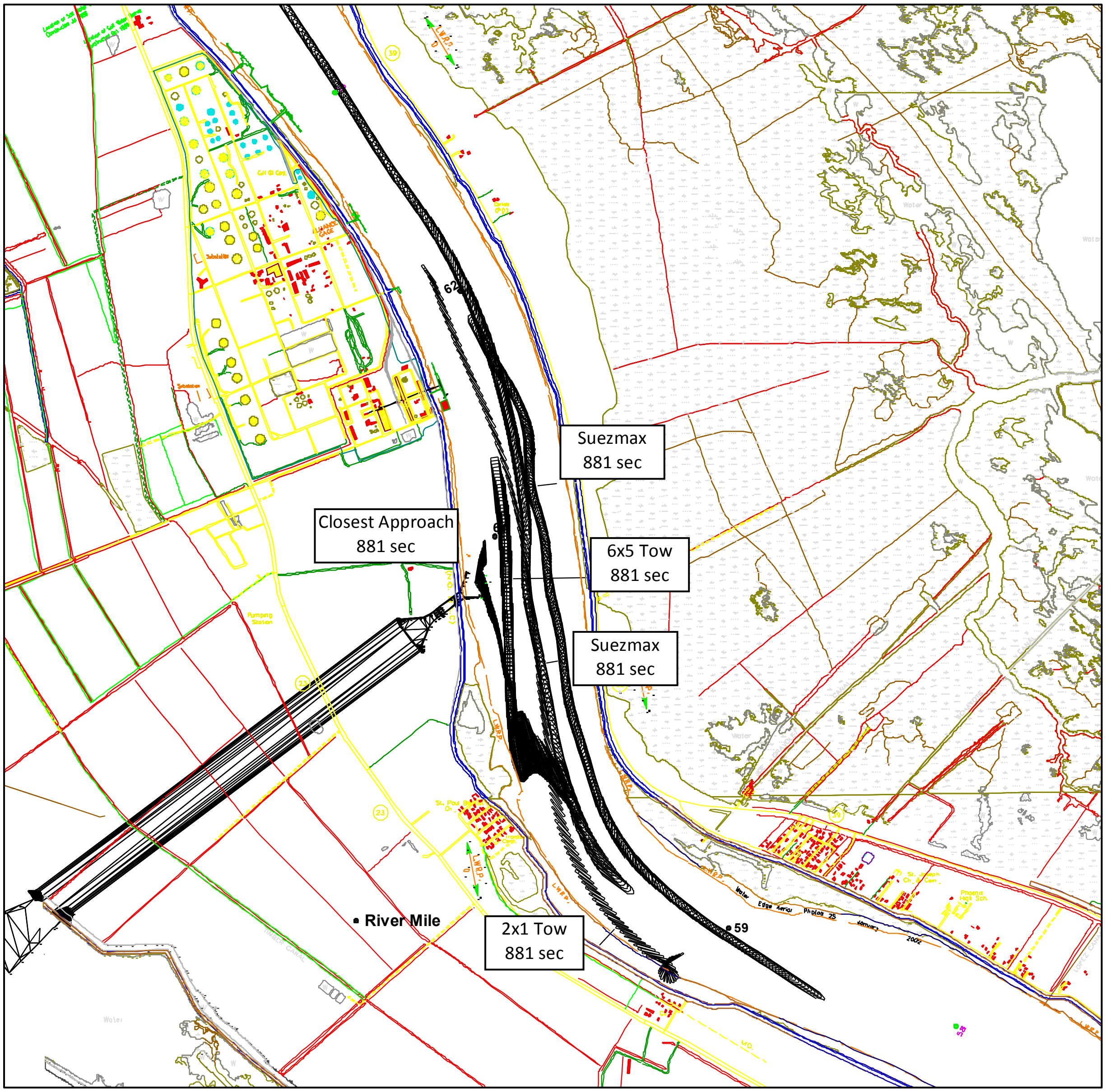


Figure A - 20: Run 21, Diversion, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

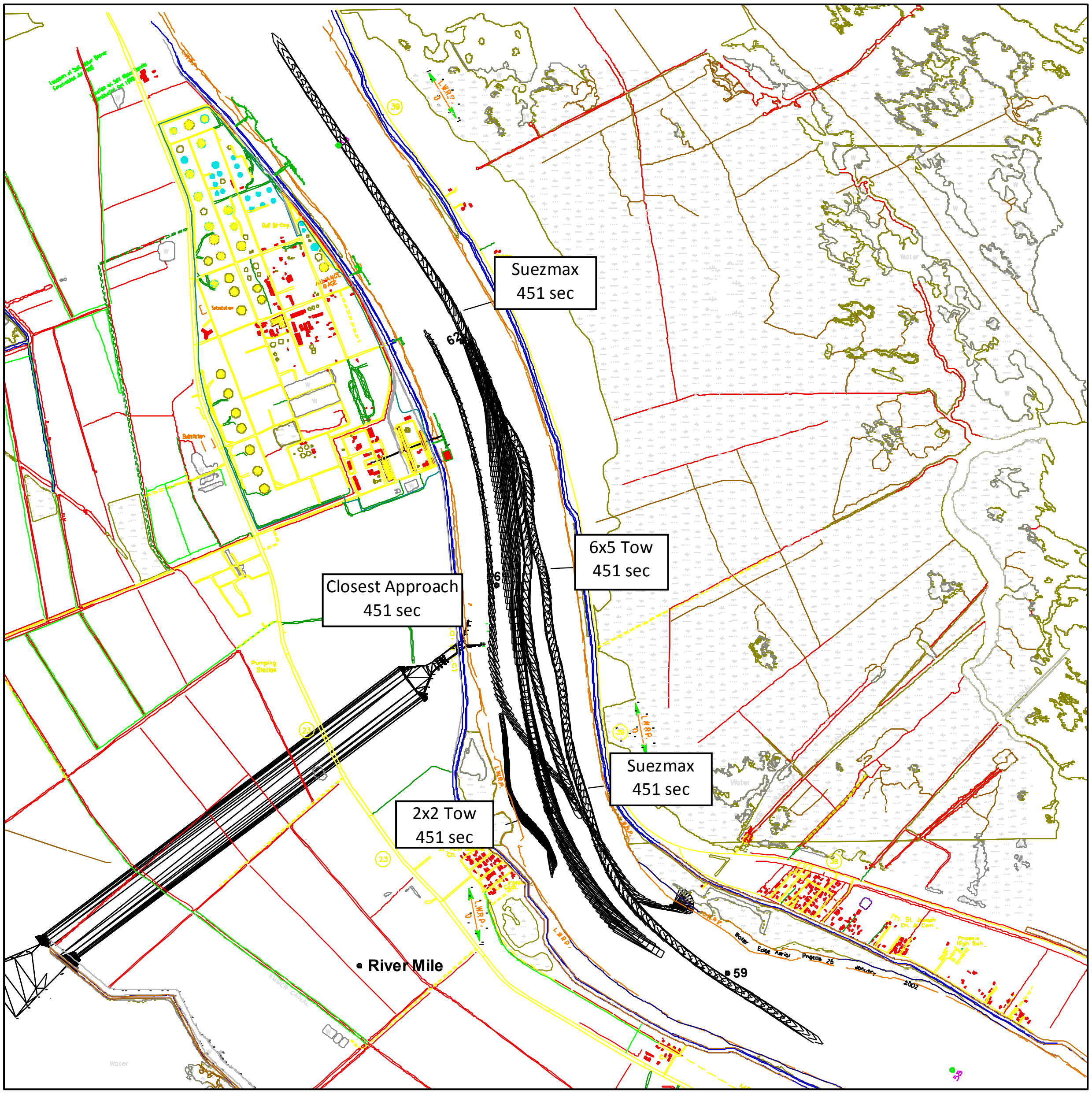


Figure A - 21: Run 22, Diversion, 1M CFS, Wind SE 20 Knots, 2x2 Tow Closest Approach

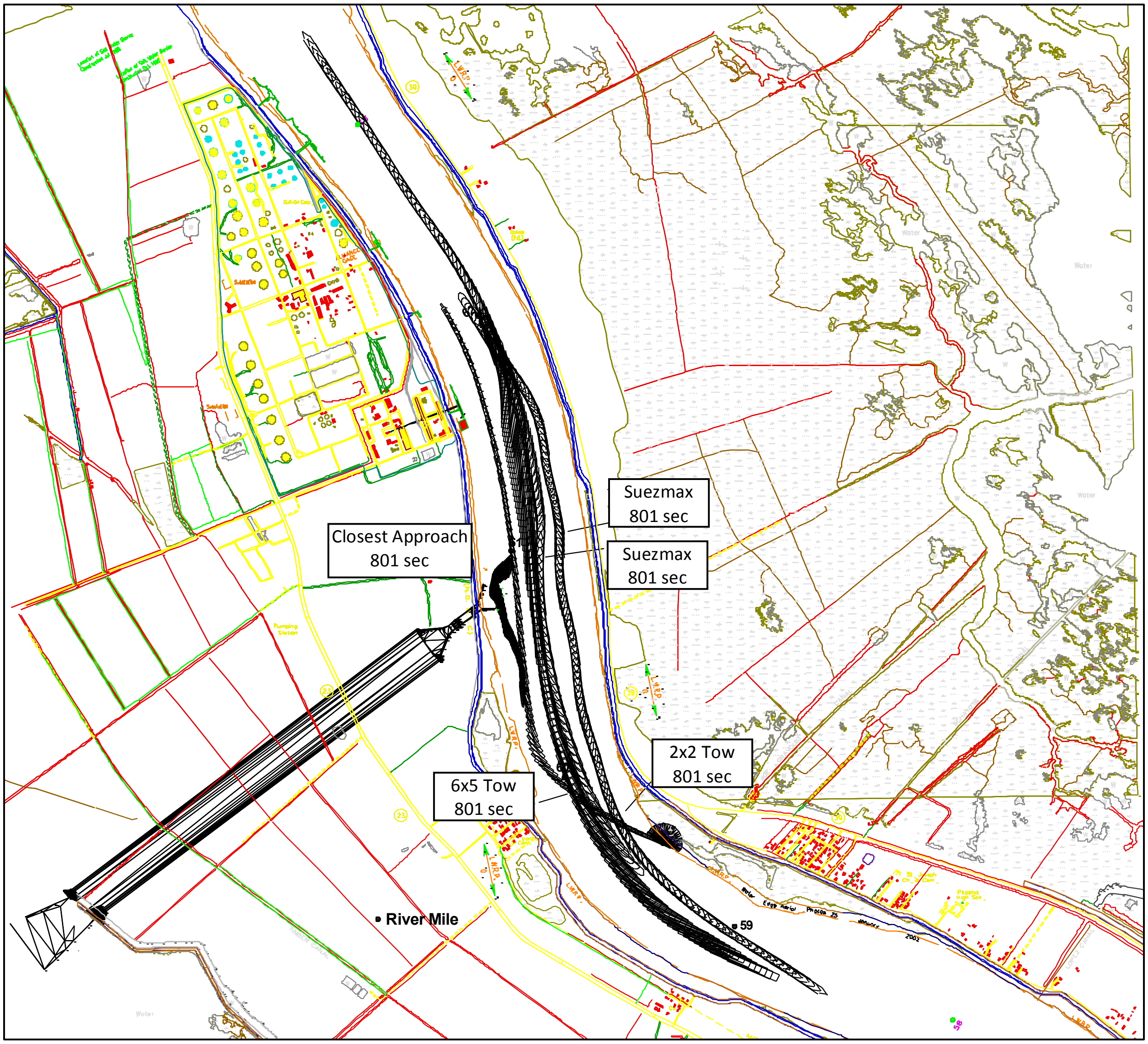


Figure A - 22: Run 22A, Diversion, 1M CFS, Wind SE 20 Knots, 2x2 Tow Closest Approach

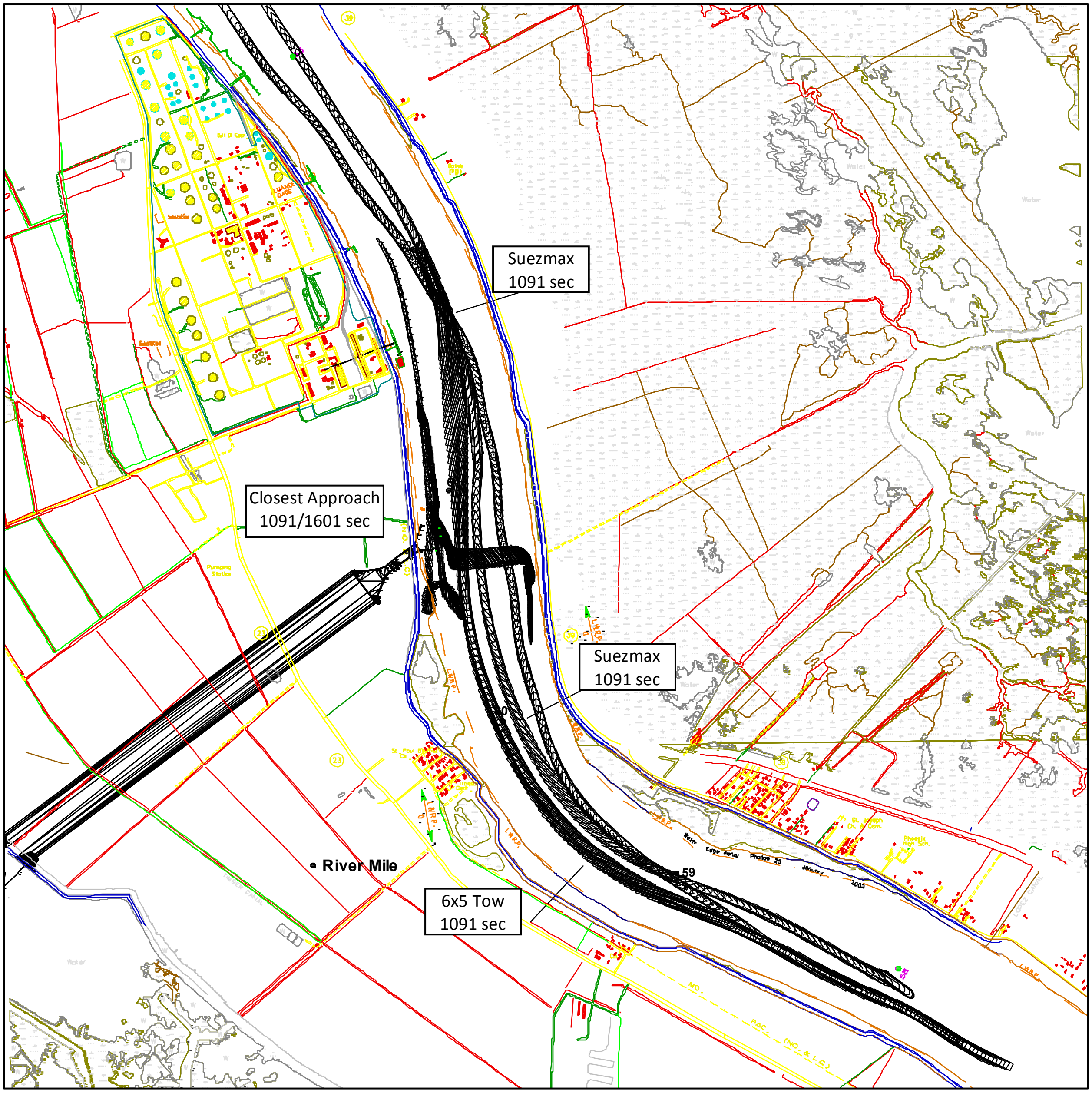


Figure A - 23: Run 23, Diversion, 1M CFS, Wind SE 20 Knots, 2x2 Tow Closest Approach

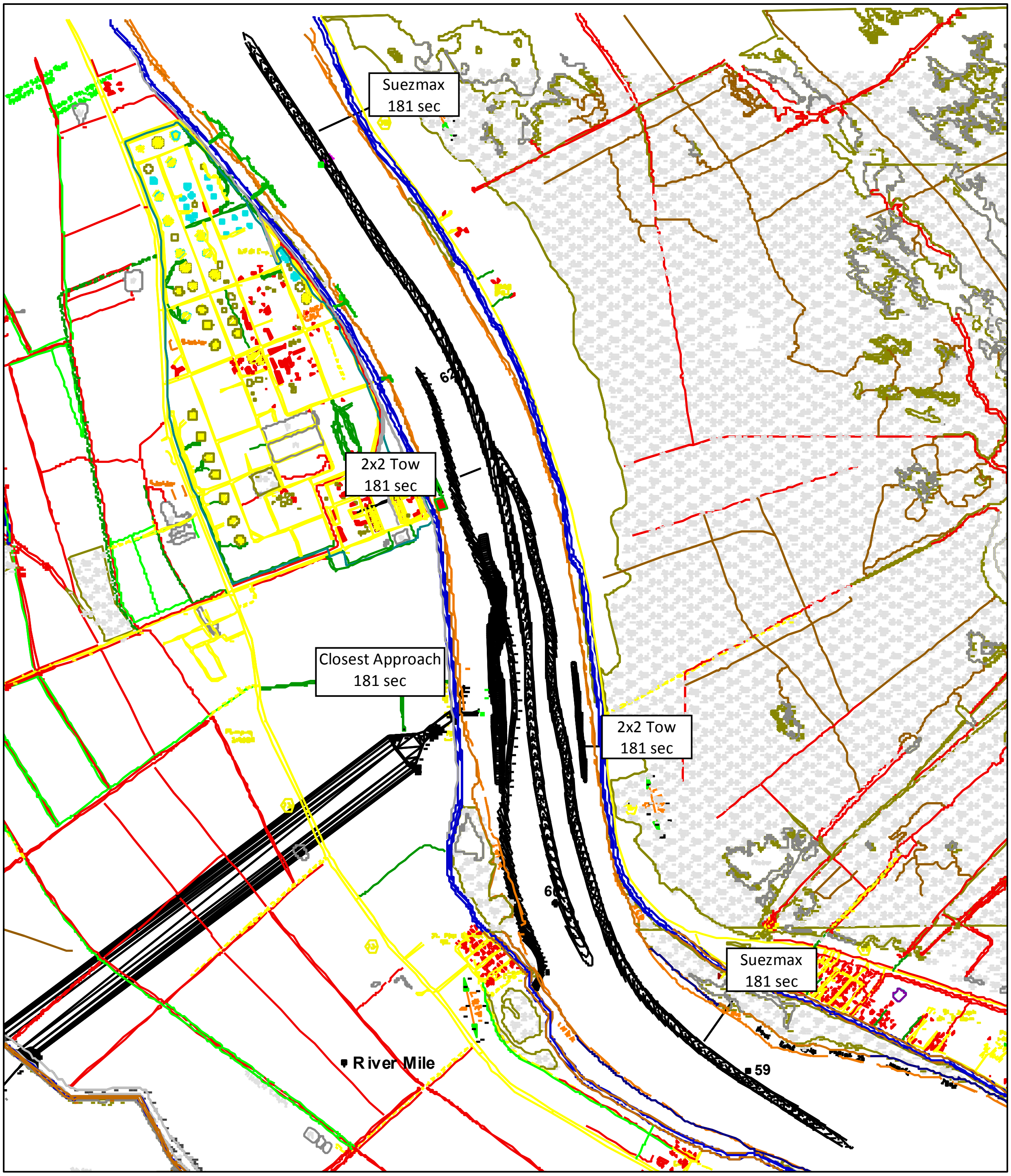


Figure A - 24: Run 24, Diversion, 1M CFS, Wind ENE 20 Knots, 6x5 Tow Closest Approach

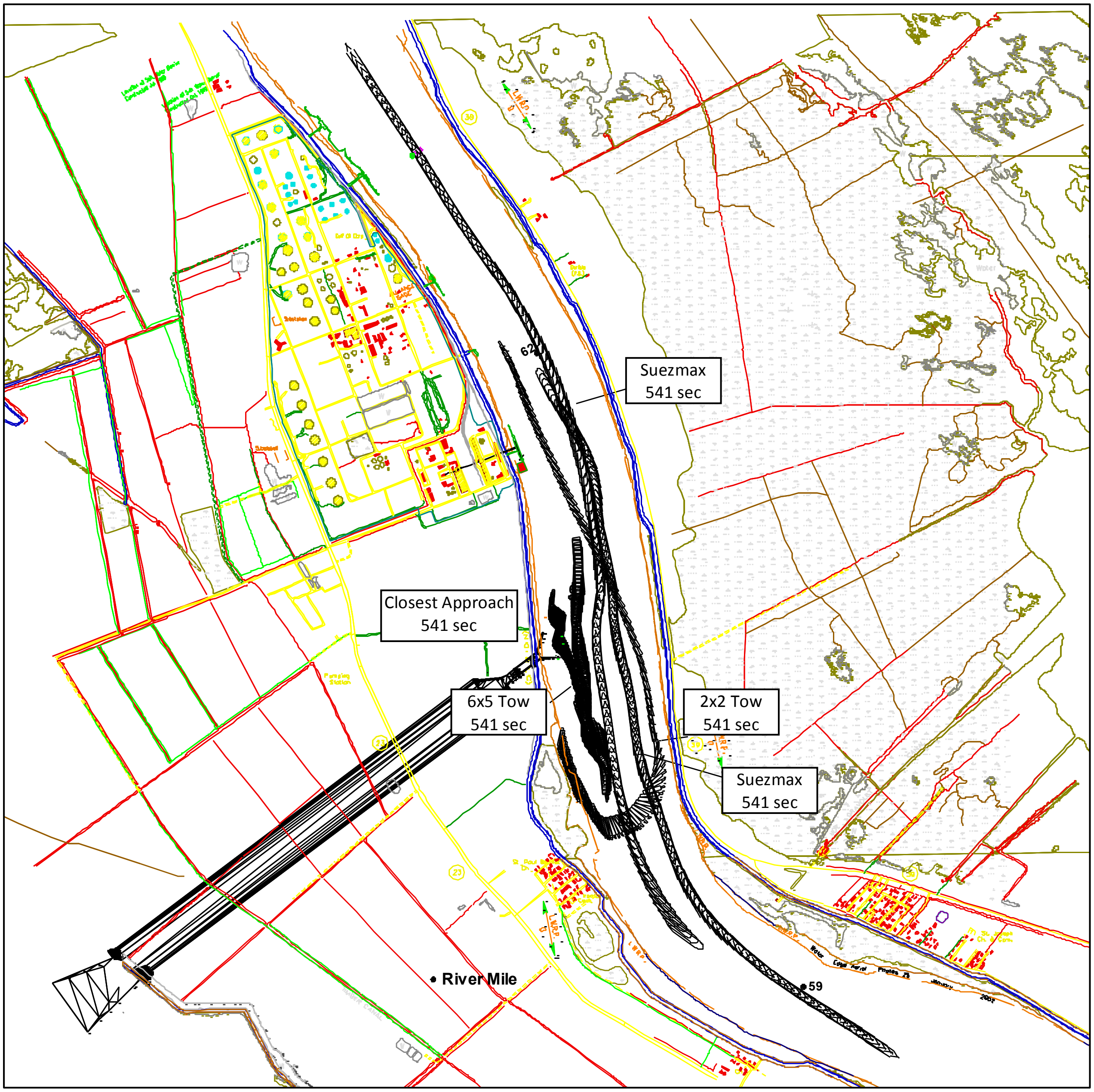


Figure A -25: Run 25, Diversion, 1M CFS, Wind ENE 20 Knots, 2x2 Tow Closest Approach

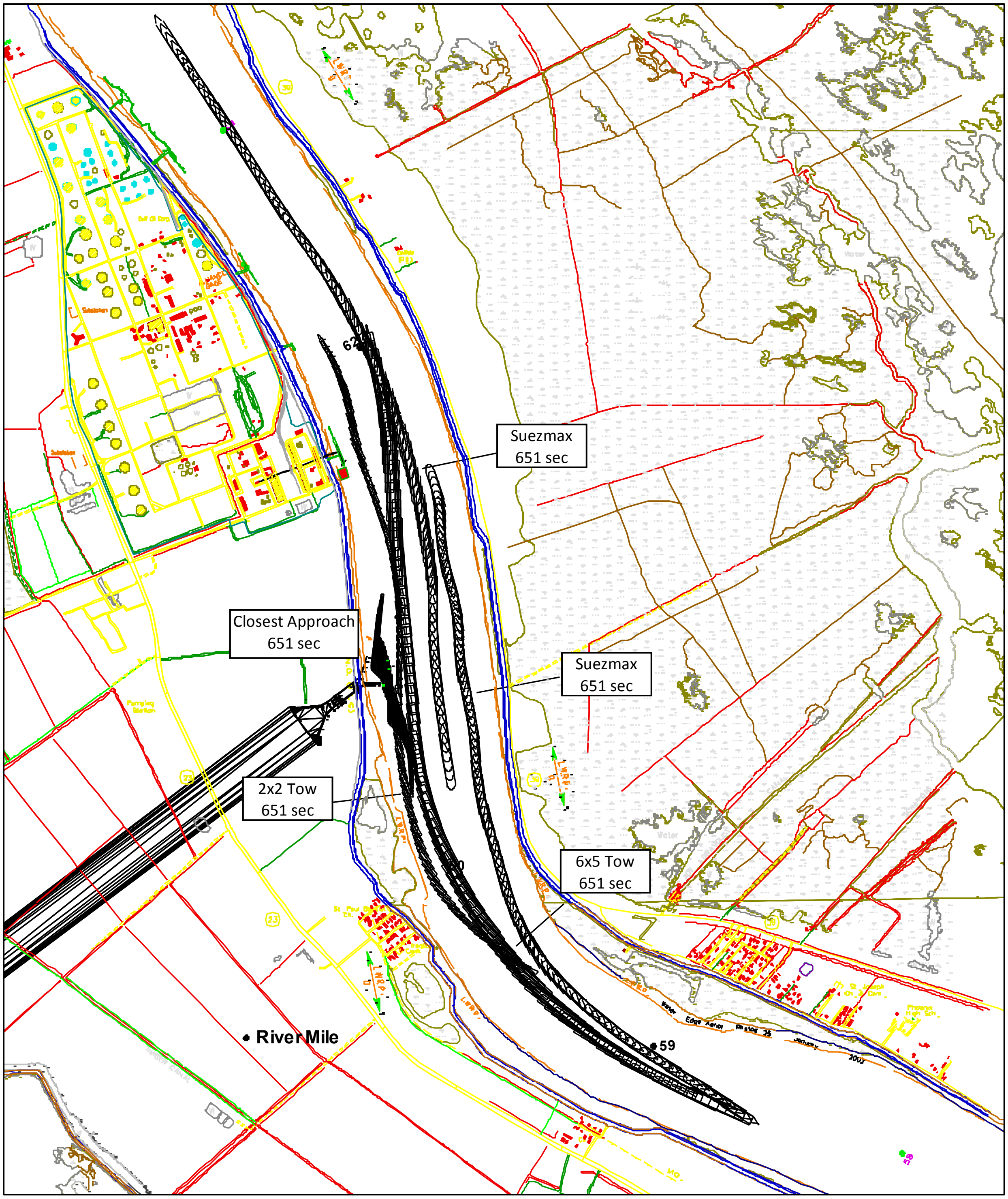


Figure A - 26: Run 26, Diversion, 1M CFS, Wind SE 20 Knots, 4x1 Tow Closest Approach

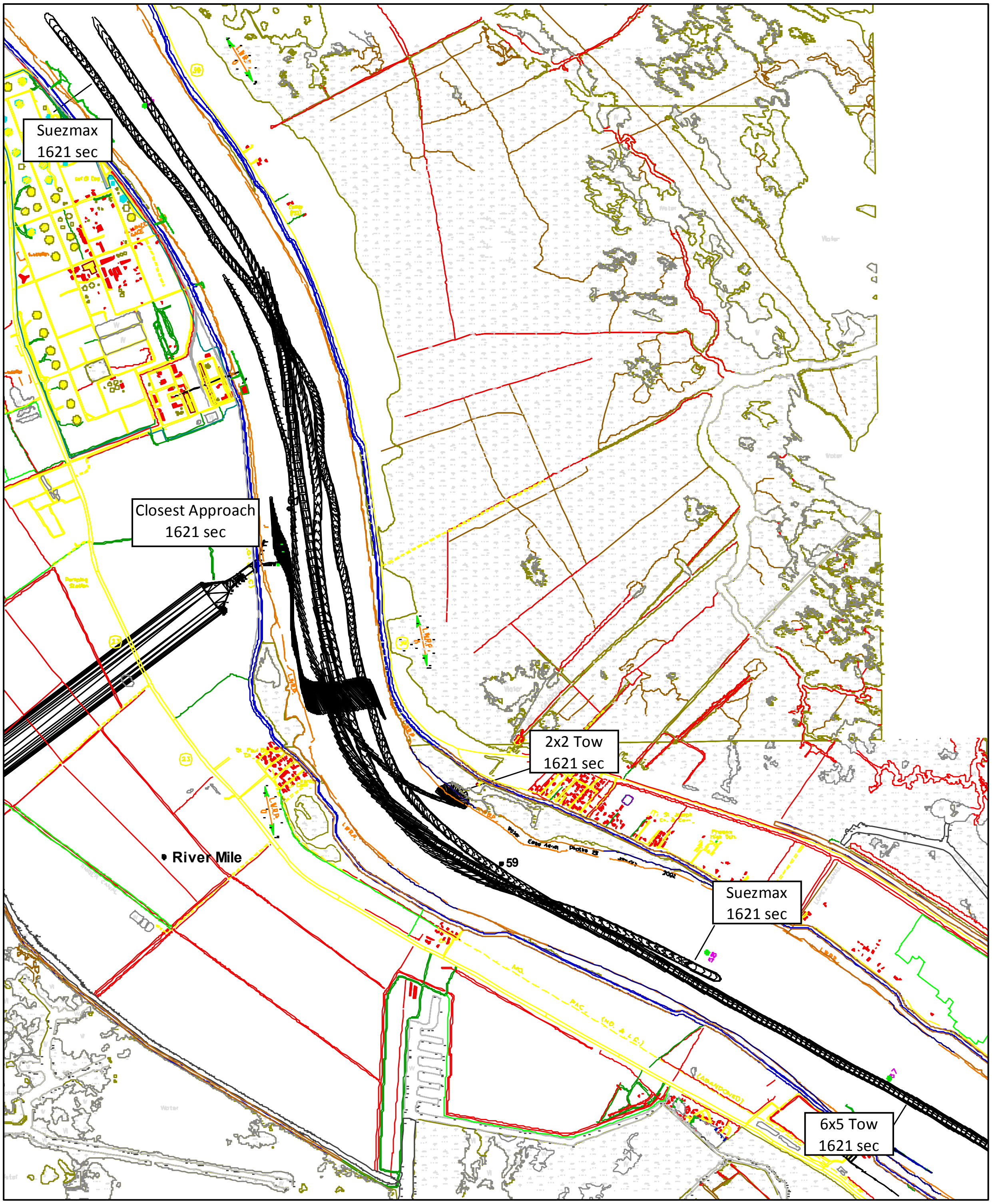


Figure A - 27: Run 27, Diversion, 1M CFS, Wind SE 20 Knots, 4x1 Tow Closest Approach

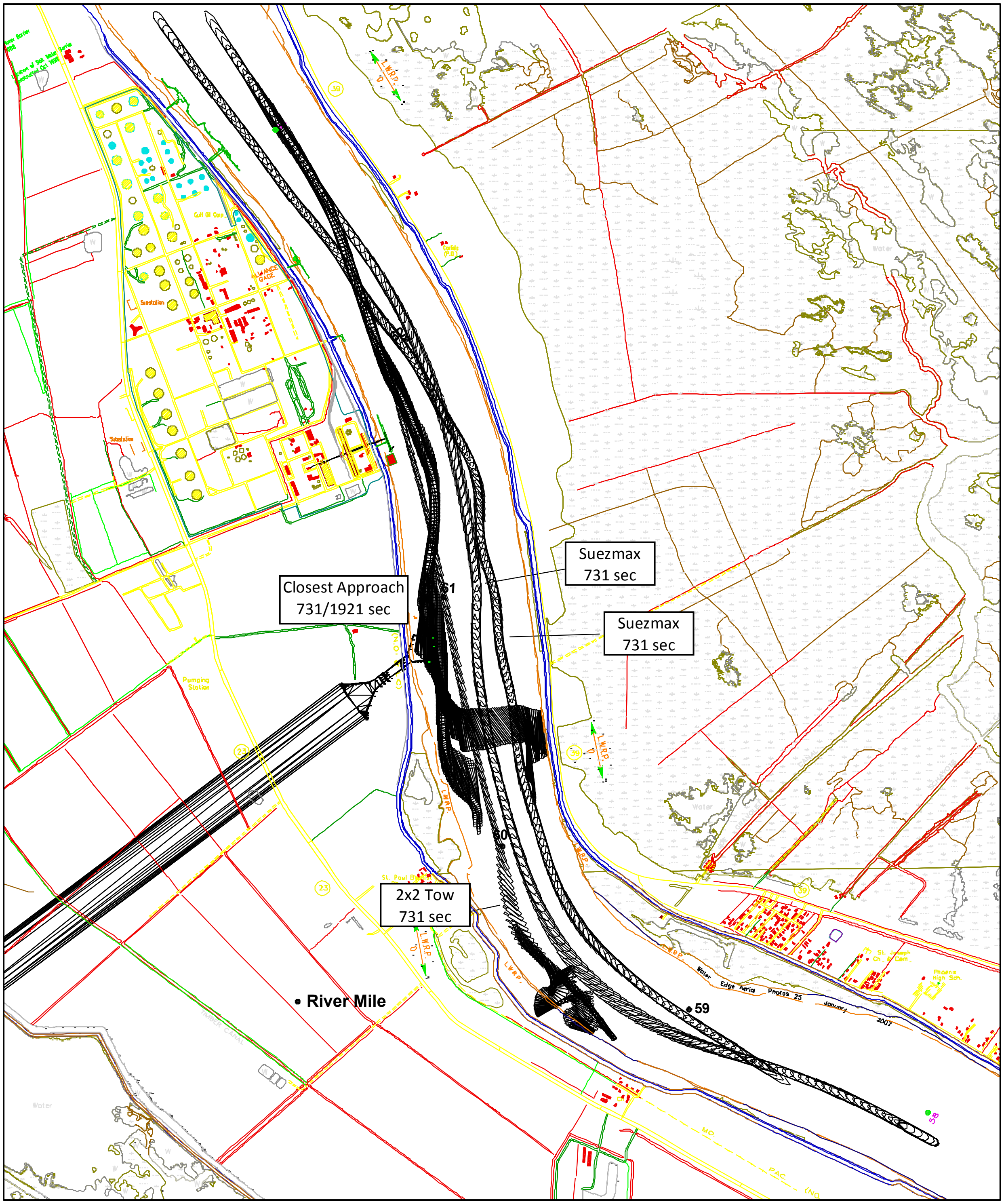


Figure A -28: Run 28, Diversion, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

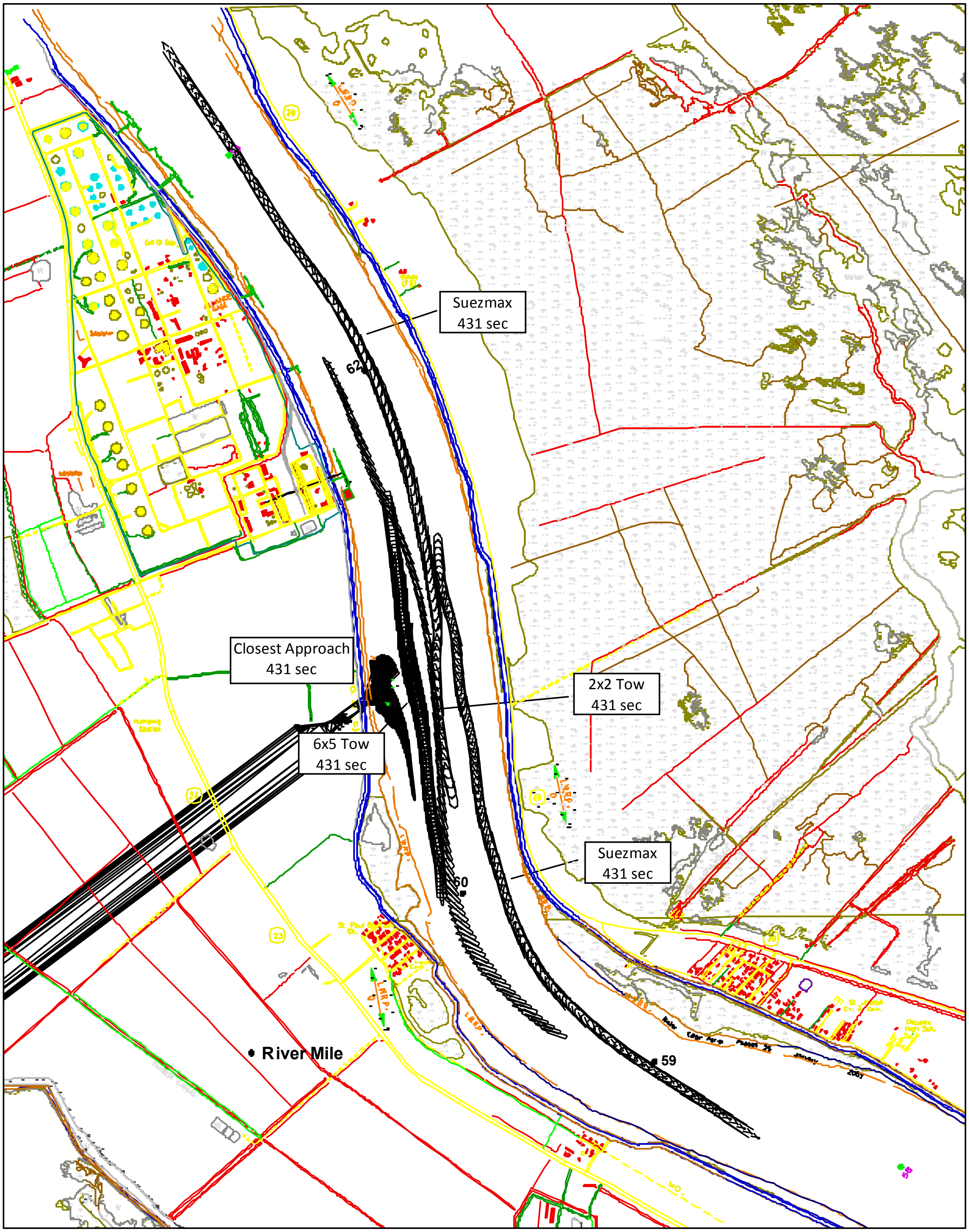


Figure A - 29: Run 29, Diversion, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

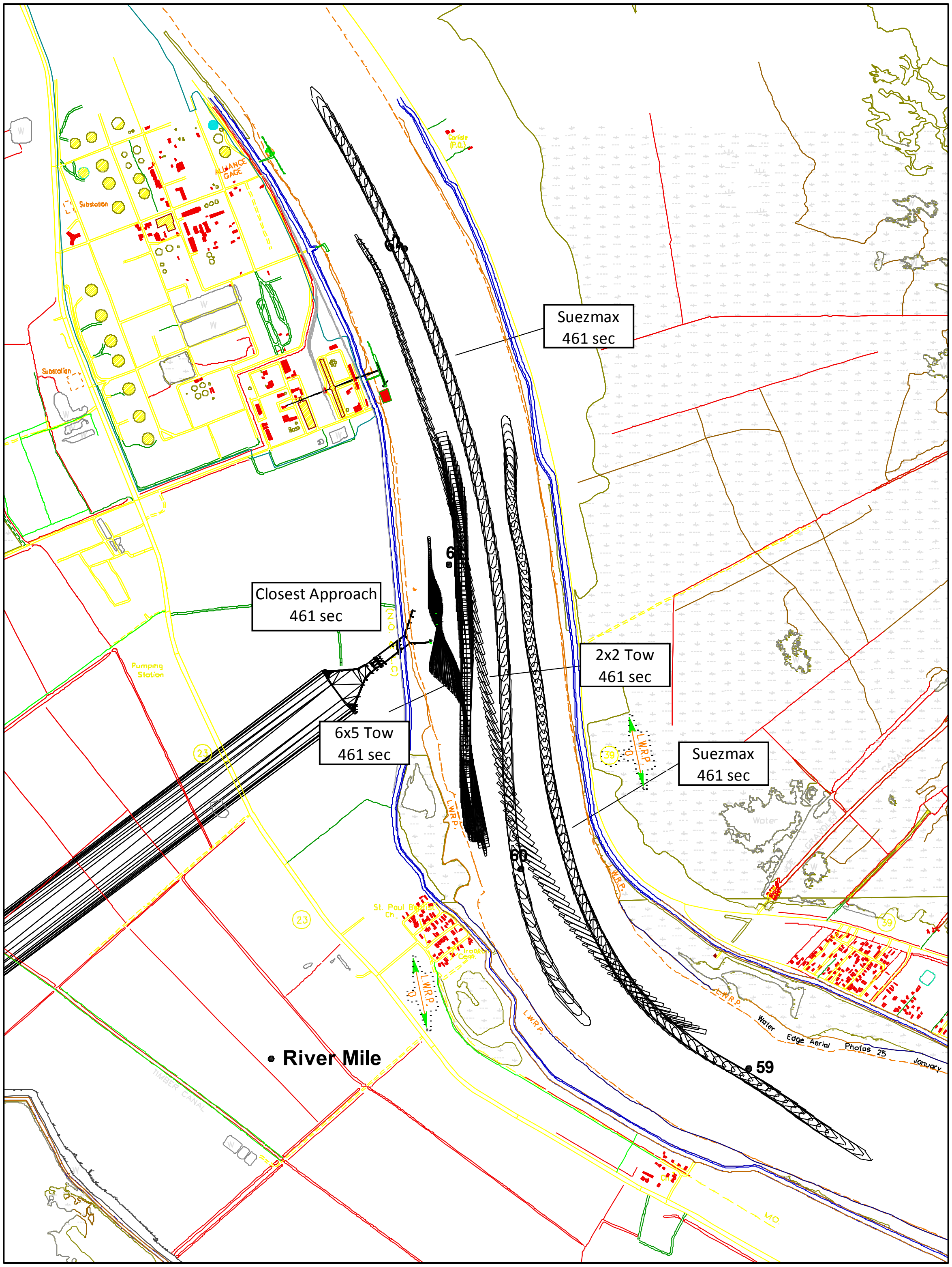


Figure A - 30: Run 48, Diversion, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

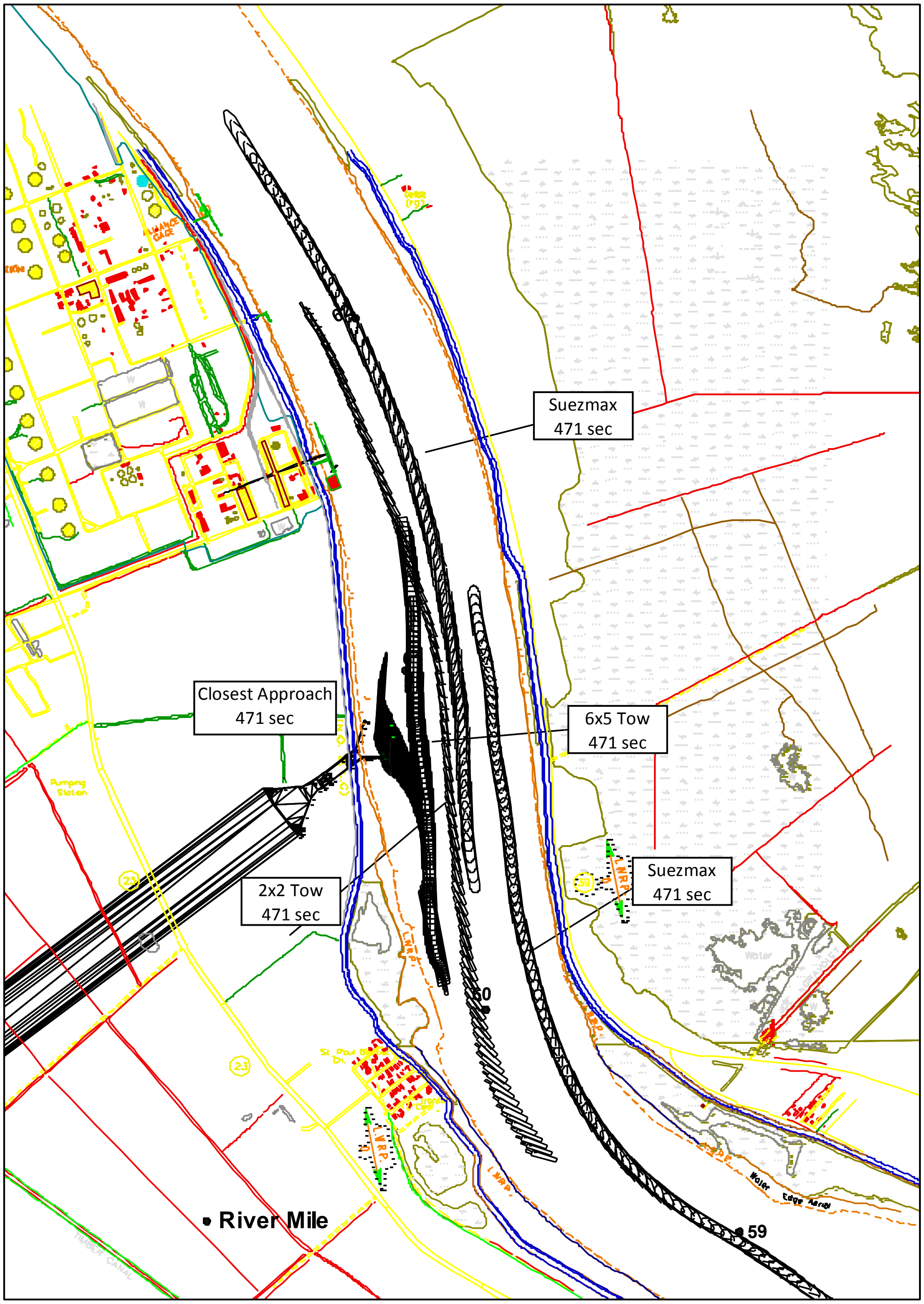


Figure A - 31: Run 49, Diversion, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

Construction Phase-1Mcfs Mississippi River Flow; 75Kcfs Diversion Flow

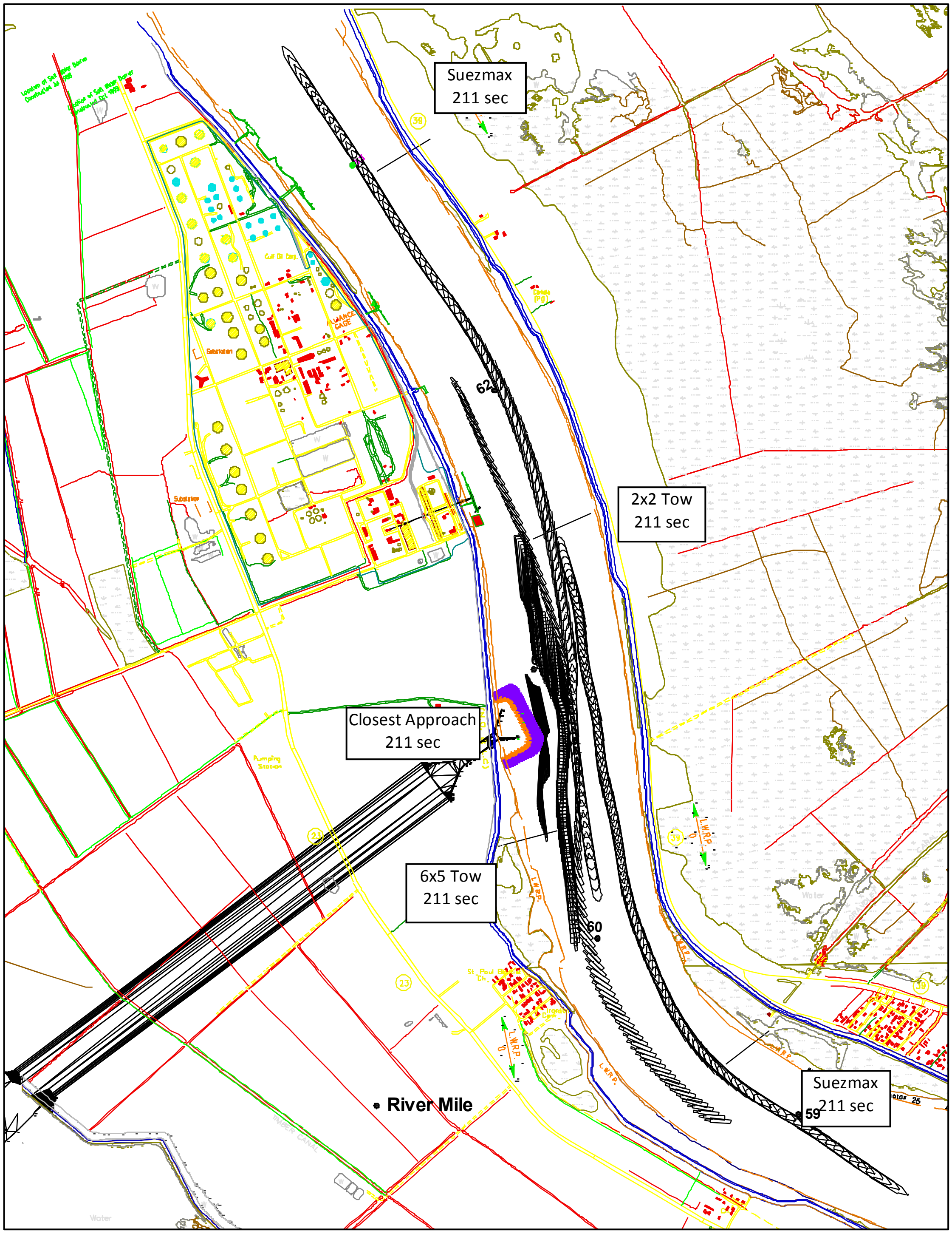


Figure A-32: Run 30, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

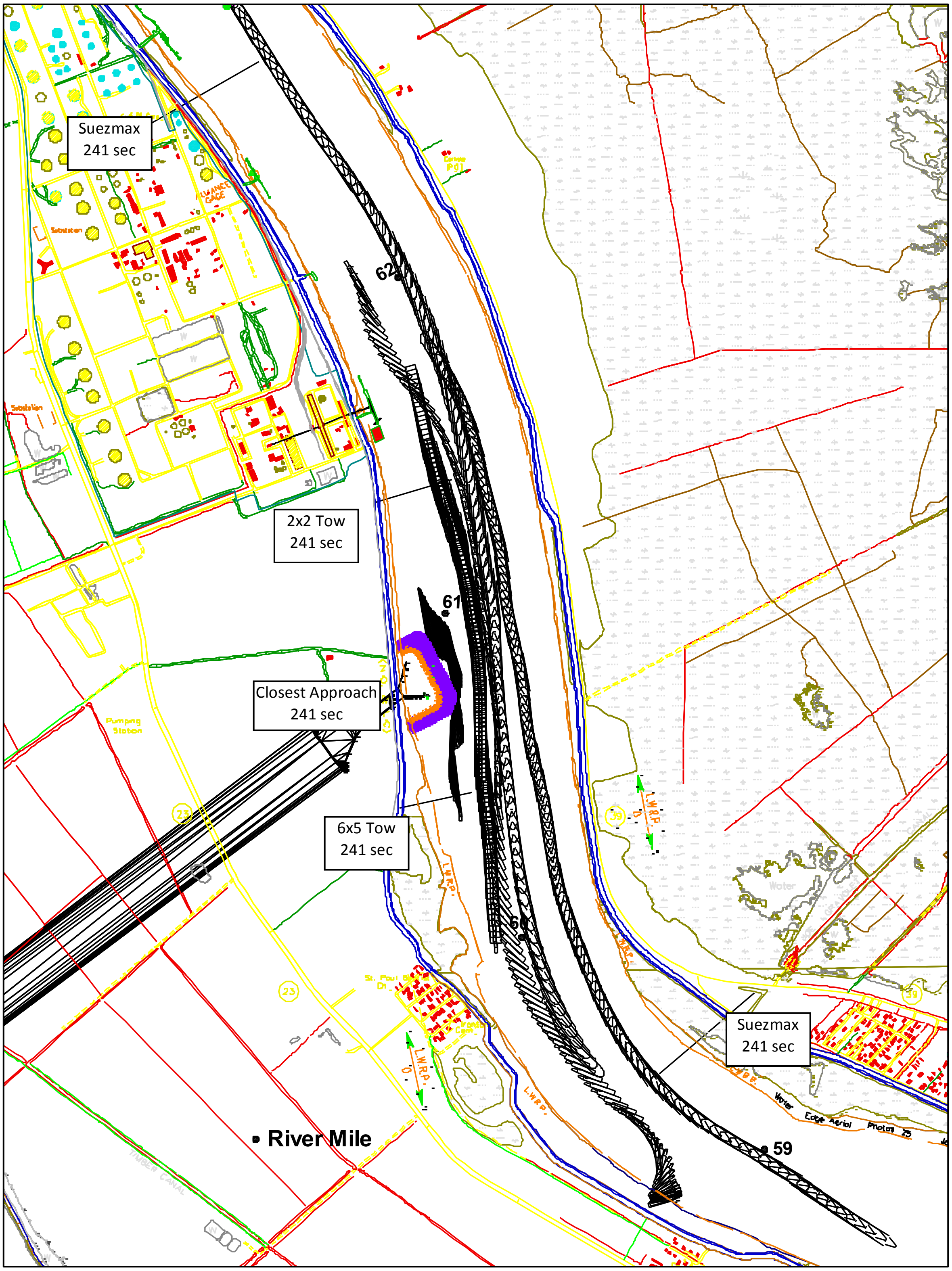


Figure A-33: Run 30A, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

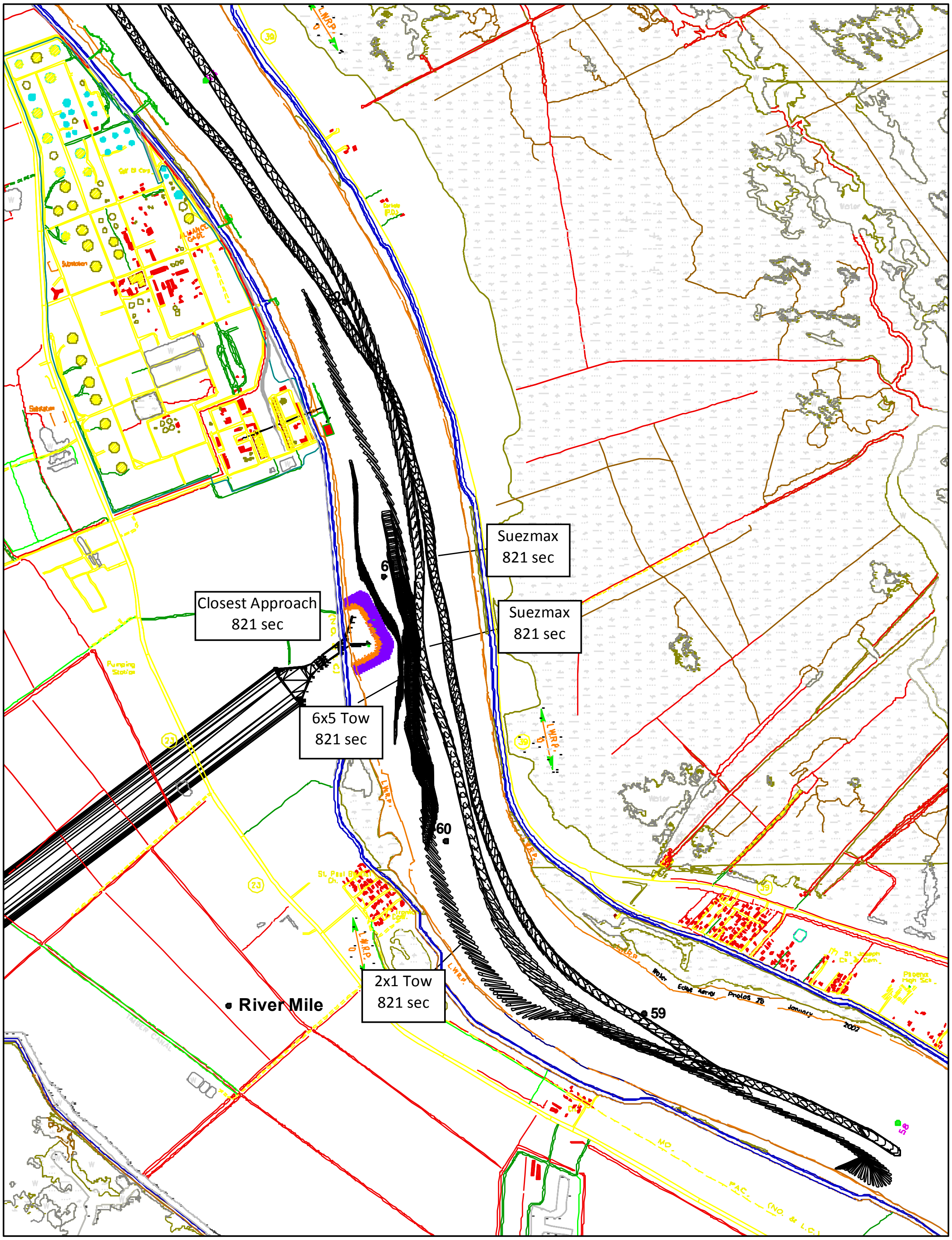


Figure A-34: Run 31, Cofferdam, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

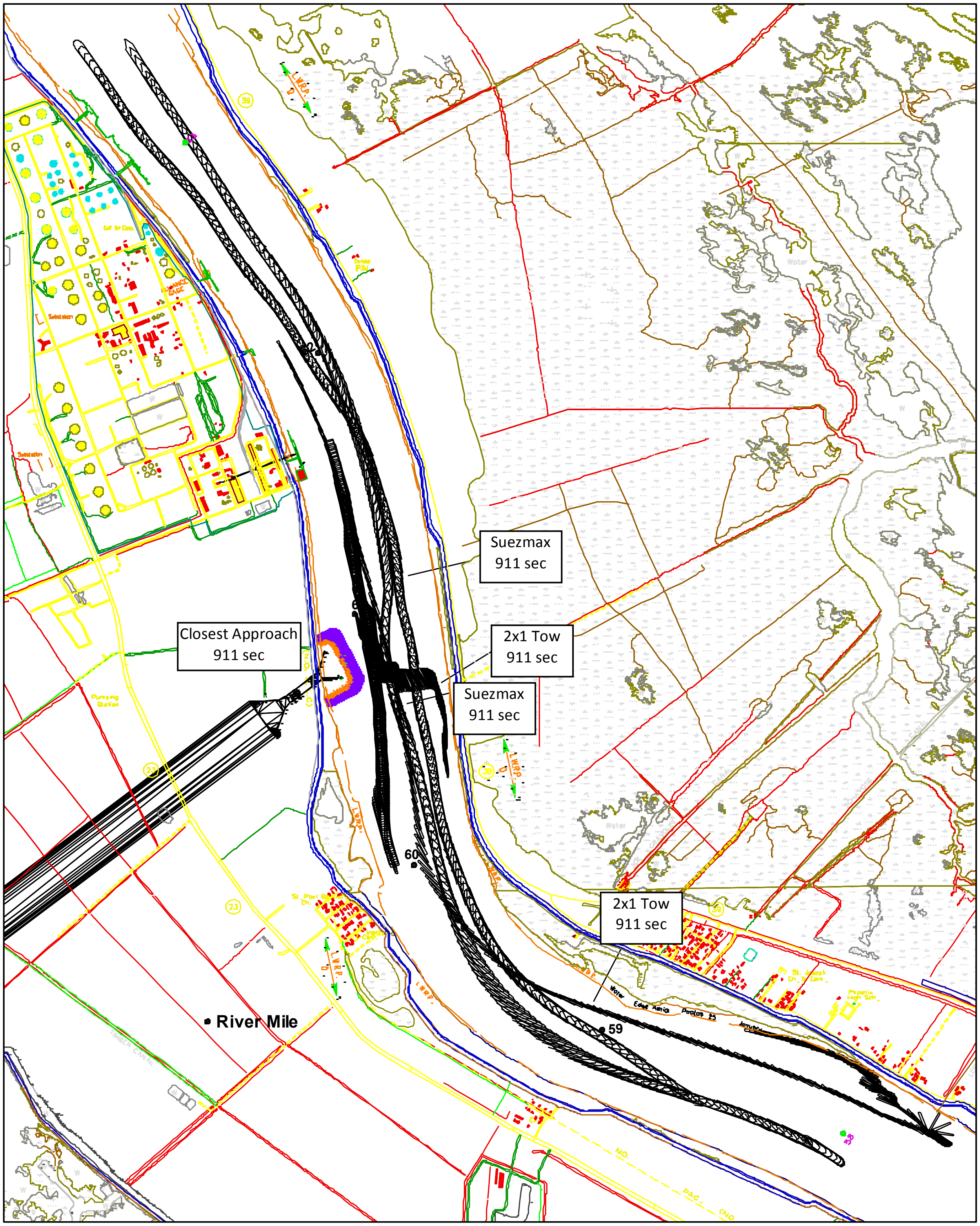


Figure A-35: Run 32, Cofferdam, 1M CFS, Wind SE 20 Knots, 6x5 Tow Closest Approach

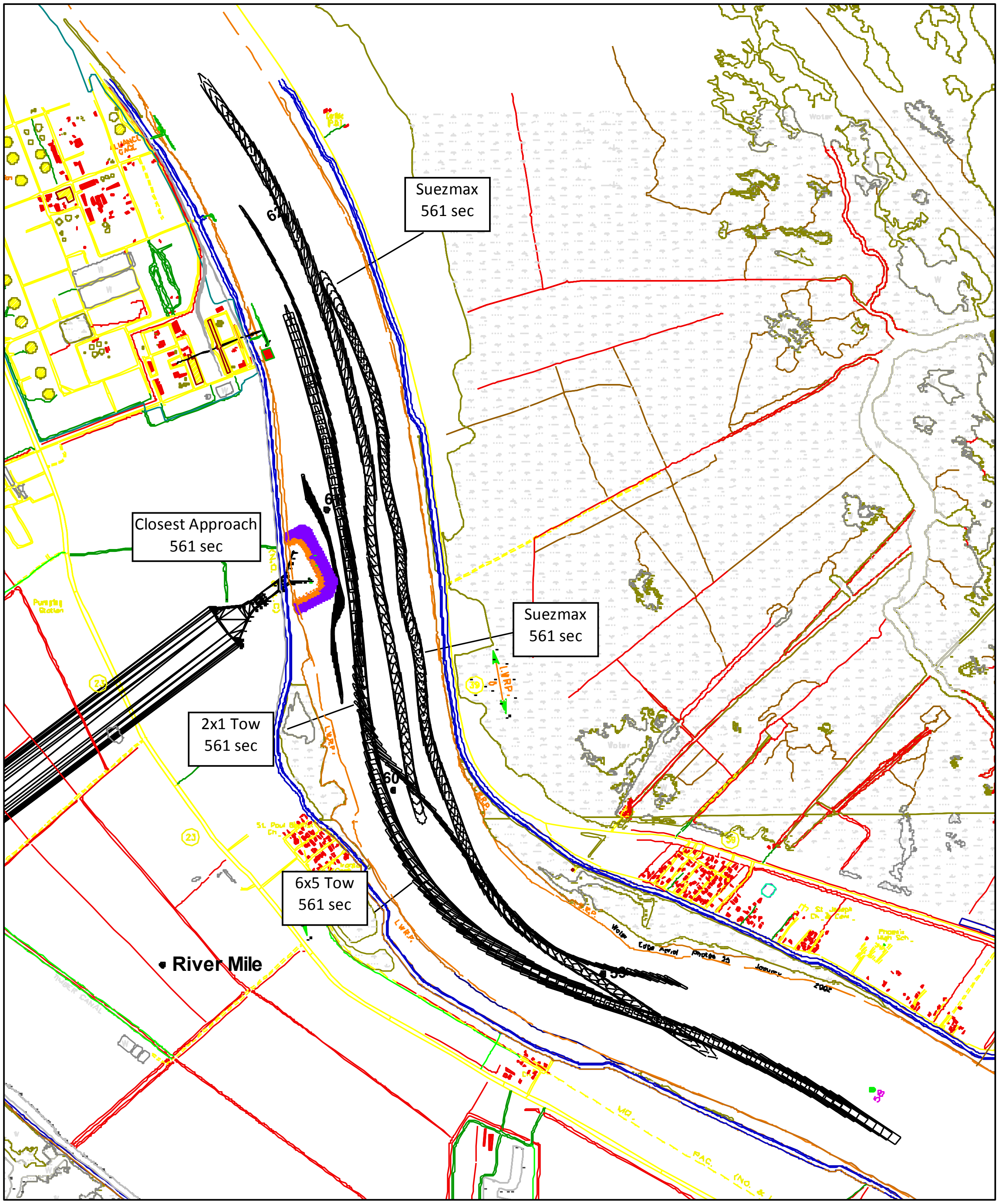


Figure A-36: Run 33, Cofferdam, 1M CFS, Wind SE 20 Knots, 2x1 Tow Closest Approach

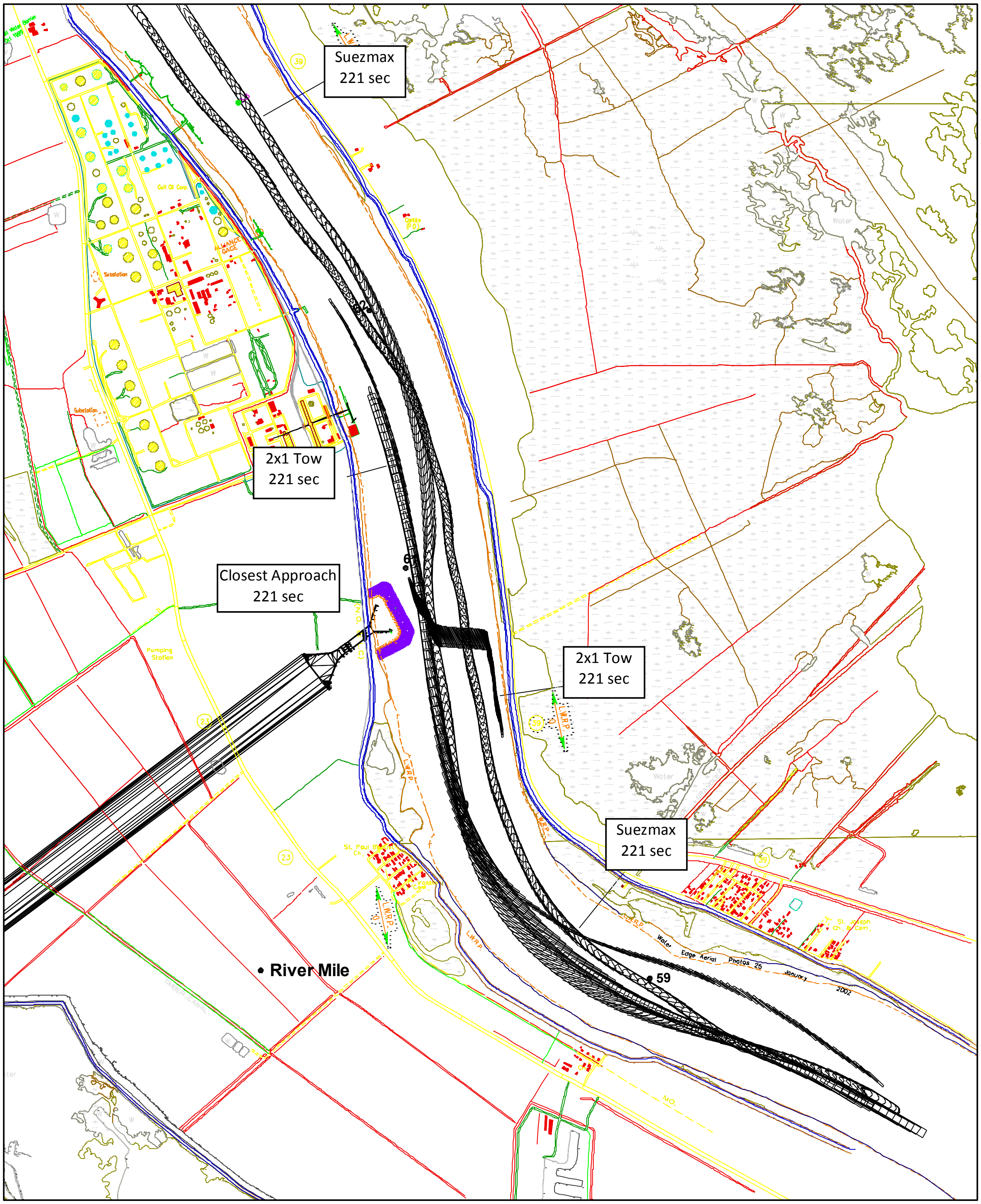


Figure A-37: Run 34, Cofferdam, 1M CFS, Wind SE 20 Knots, 6x5 Tow Closest Approach

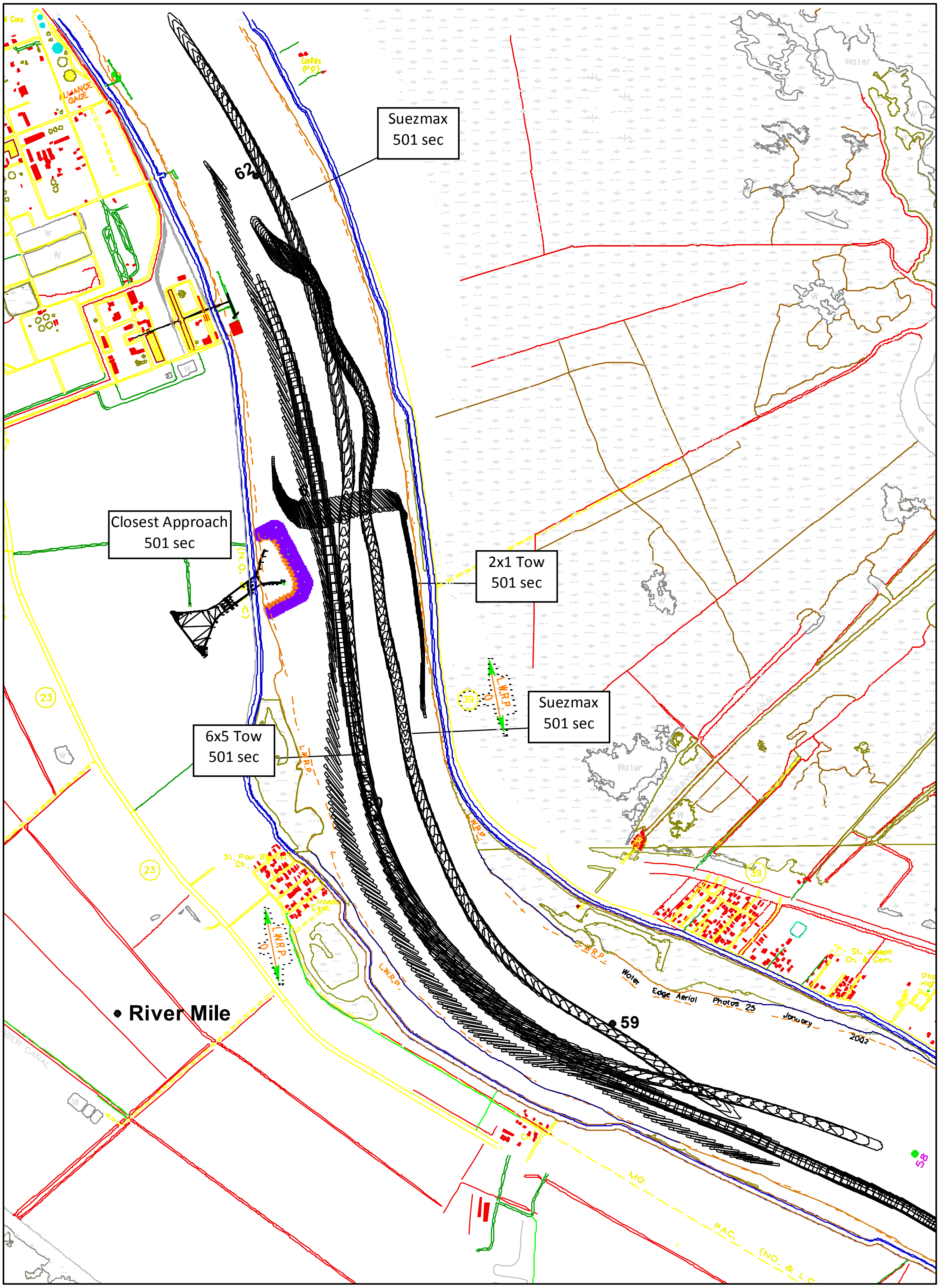


Figure A-38: Run 35, Cofferdam, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

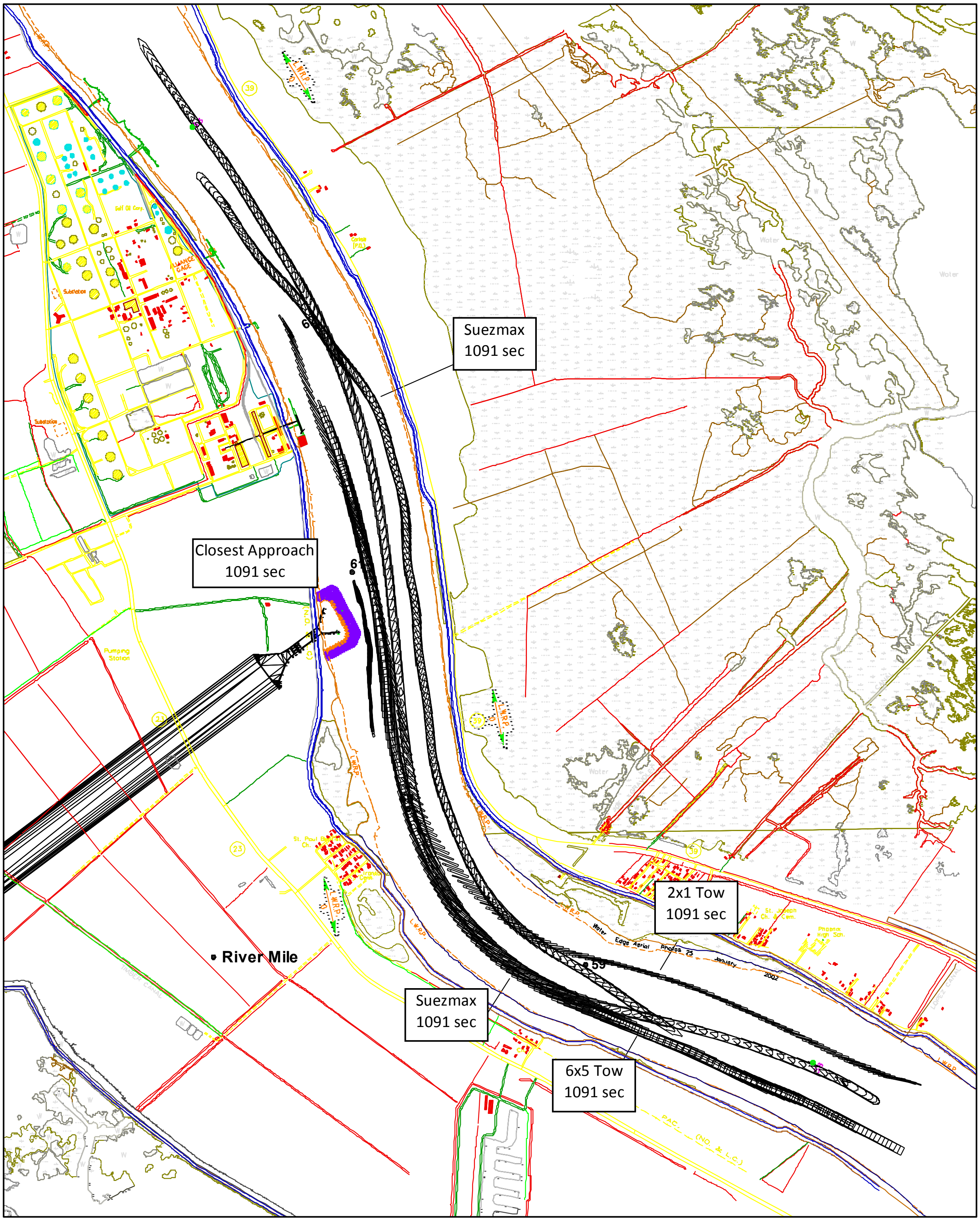


Figure A-39: Run 36, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

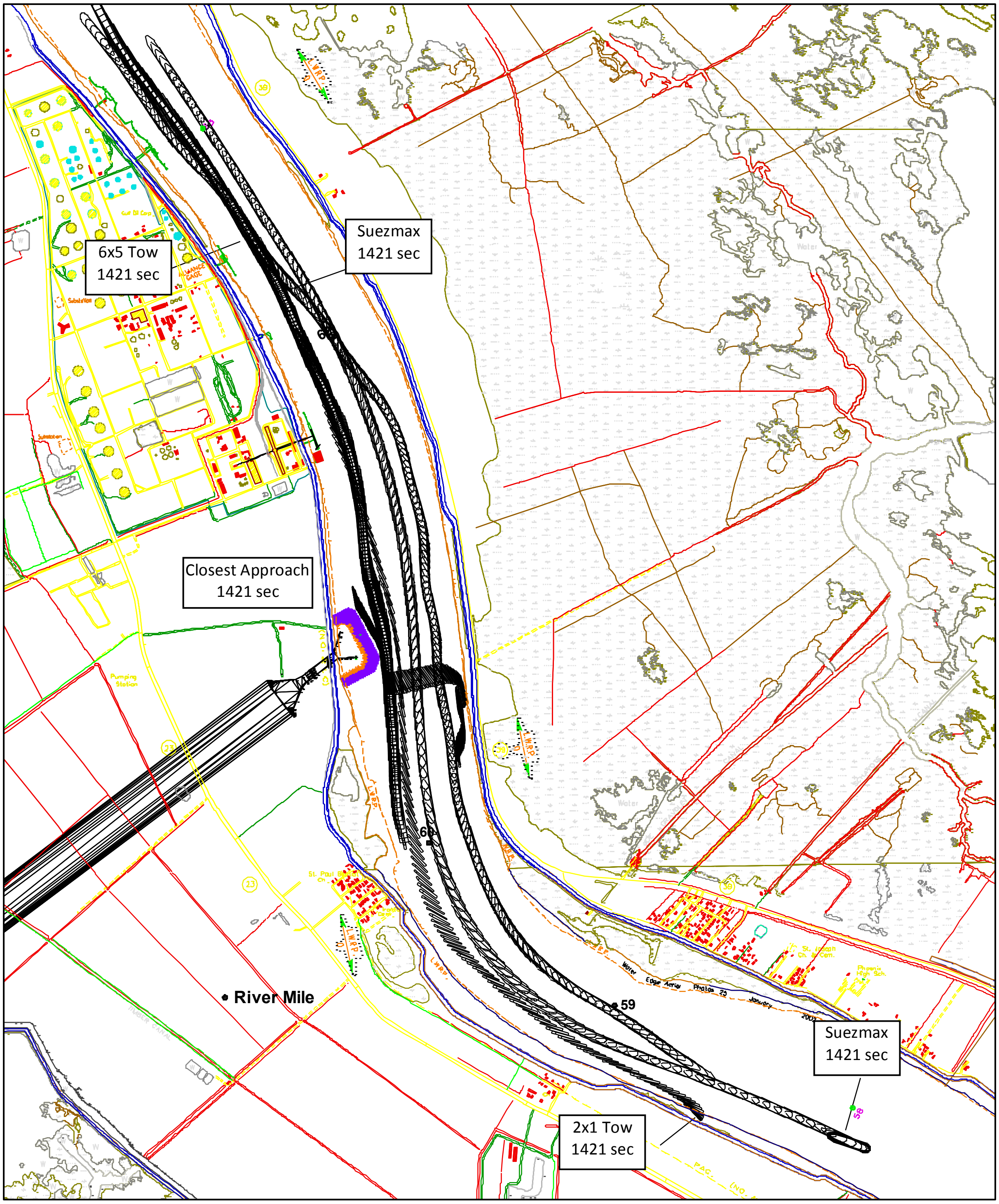


Figure A-40: Run 37, Cofferdam, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

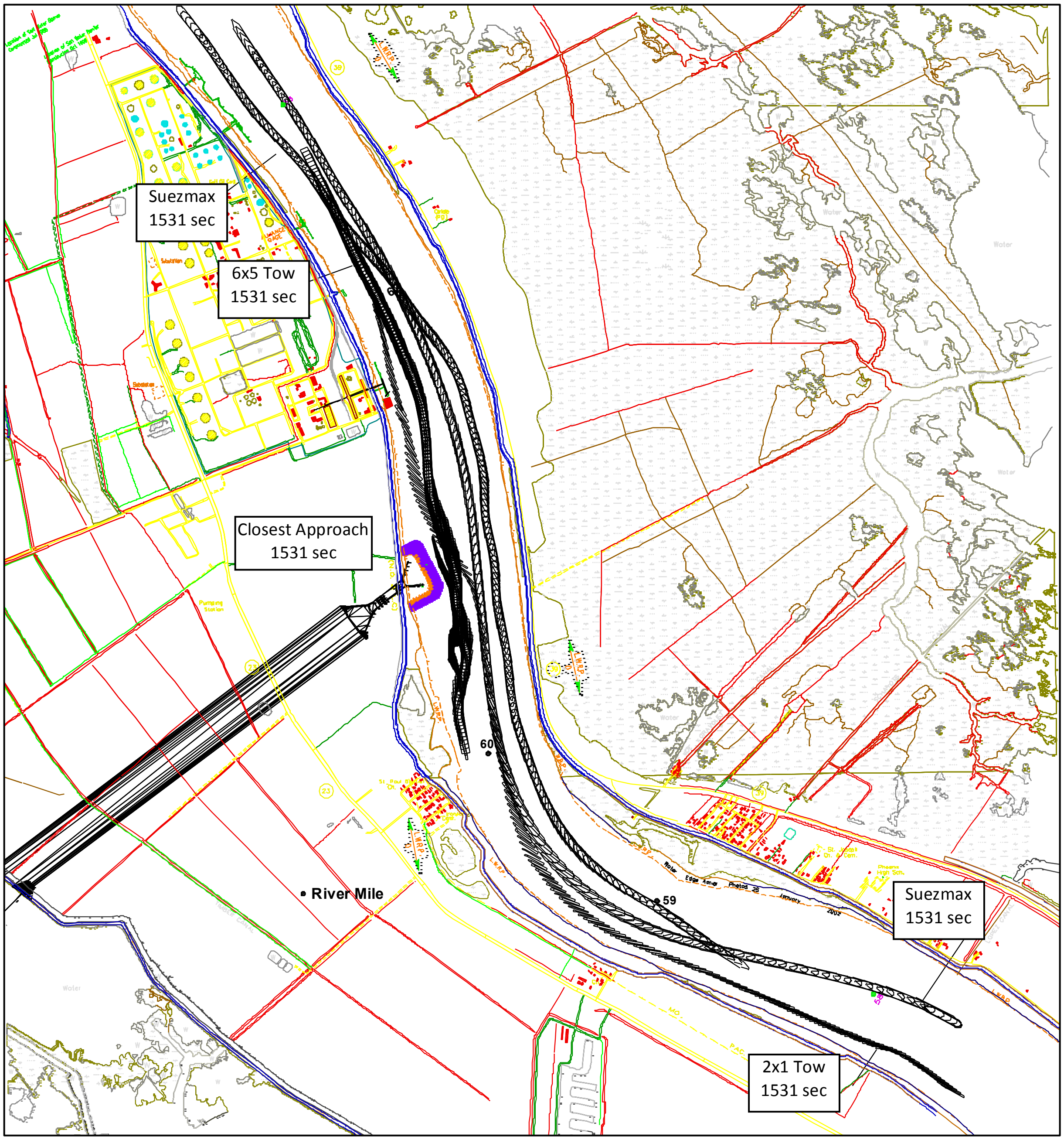


Figure A-41: Run 38, Cofferdam, 1M CFS, Wind ENE 20 Knots, 2x1 Tow Closest Approach

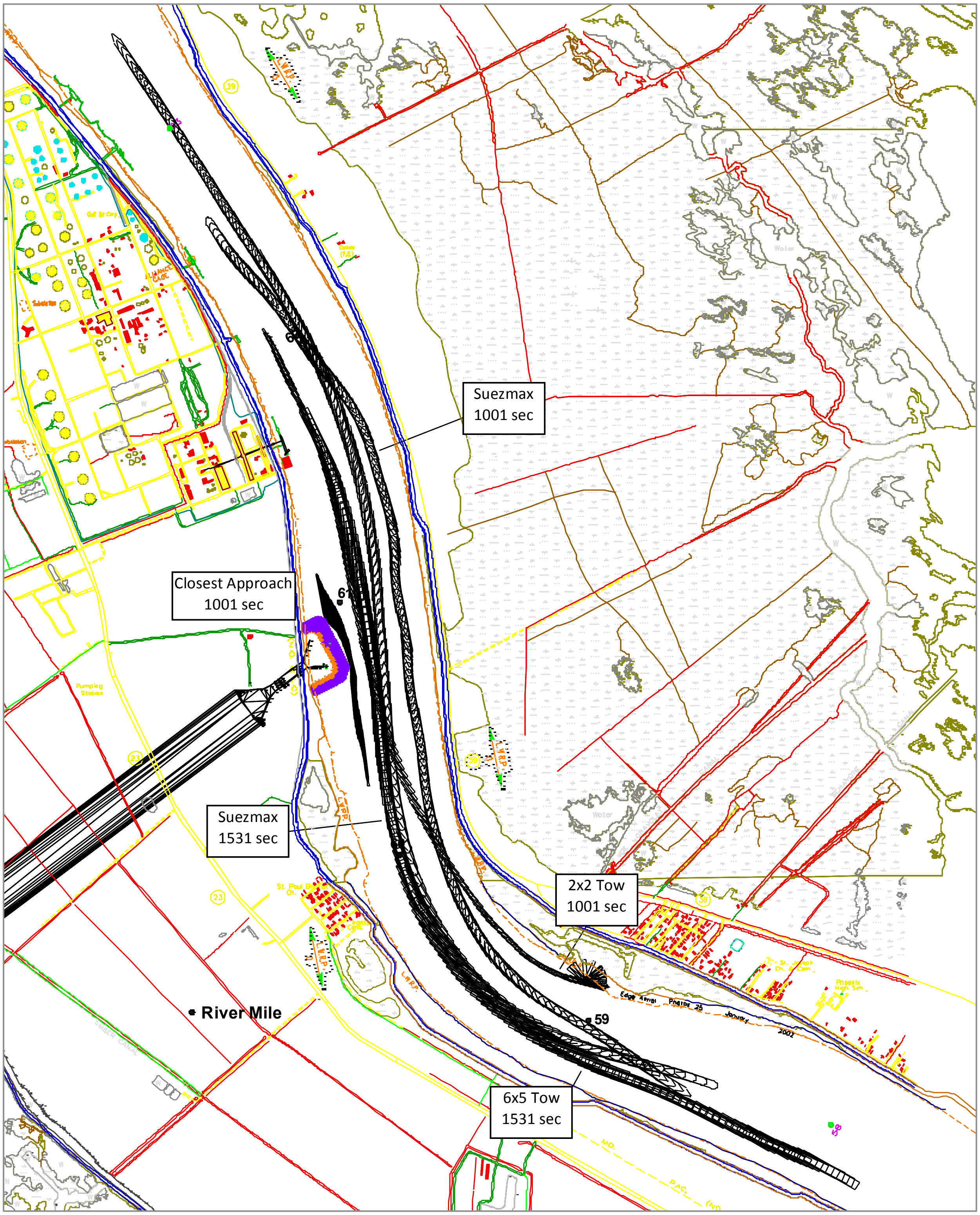


Figure A-42: Run 39, Cofferdam, 1M CFS, Wind SE 20 Knots, 4x1 Tow Closest Approach

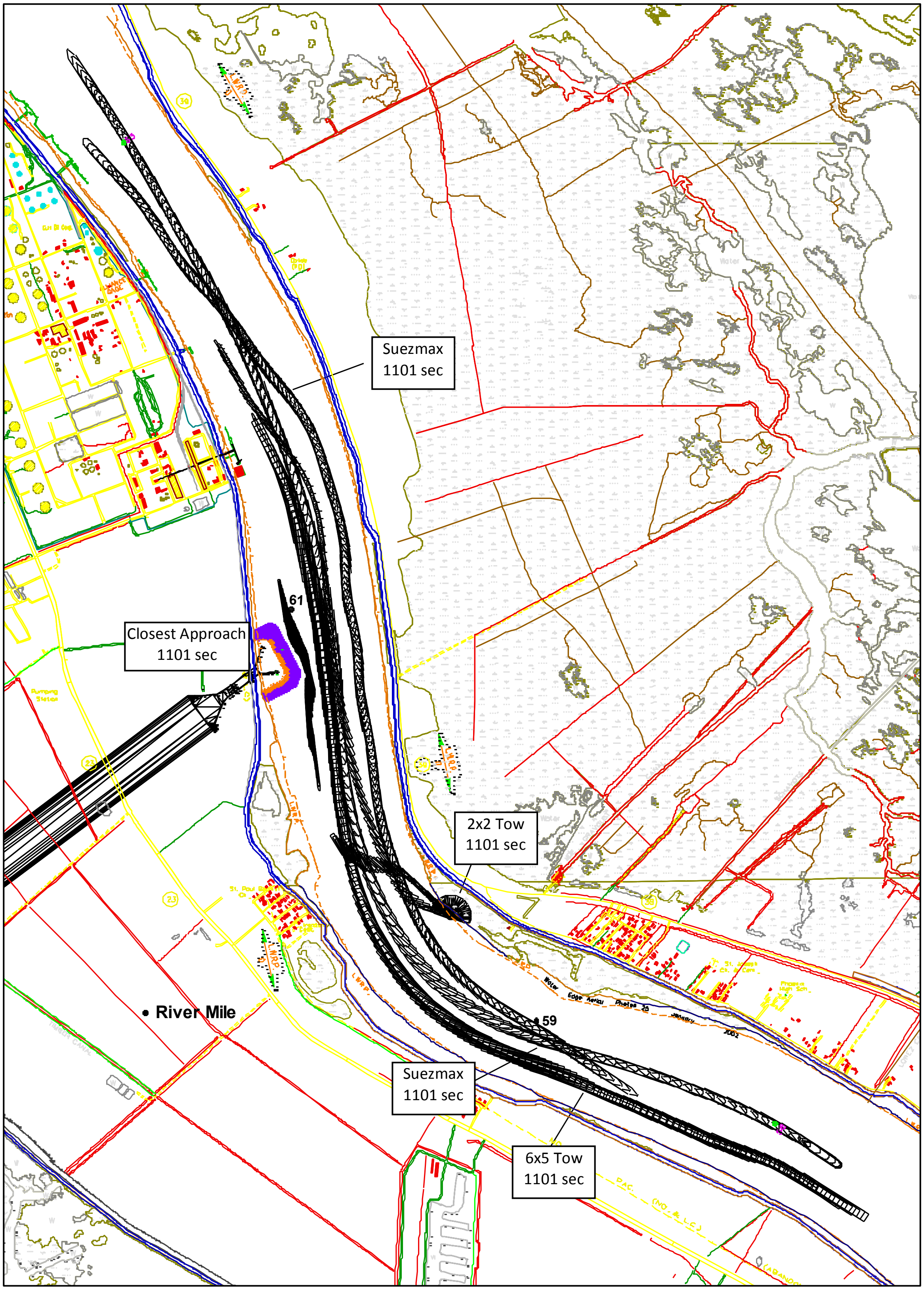


Figure A-43: Run 40, Cofferdam, 1M CFS, Wind SE 20 Knots, 4x1 Tow Closest Approach

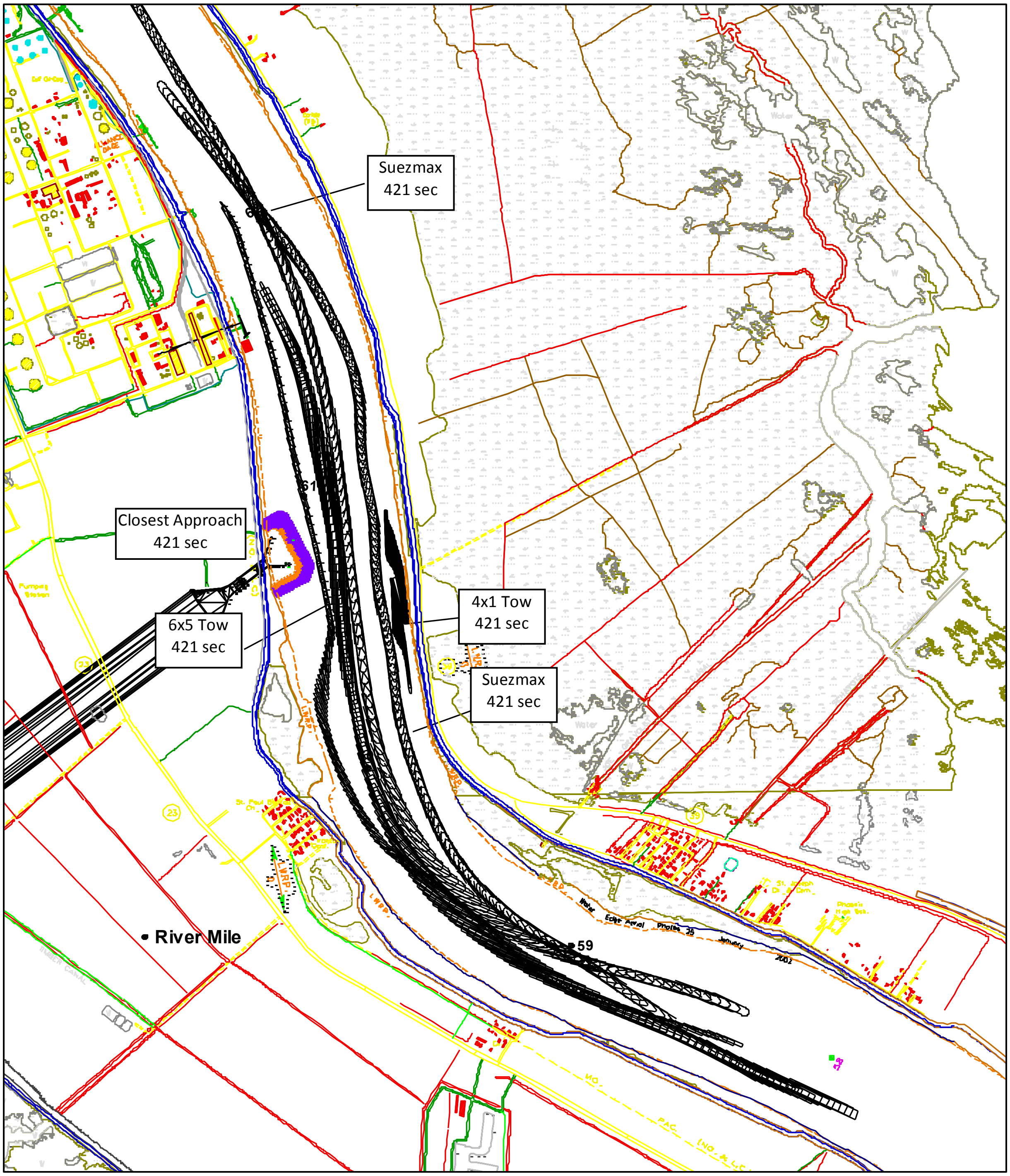


Figure A-44: Run 41, Cofferdam, 1M CFS, Wind SE 20 Knots, 2x2 Tow Closest Approach

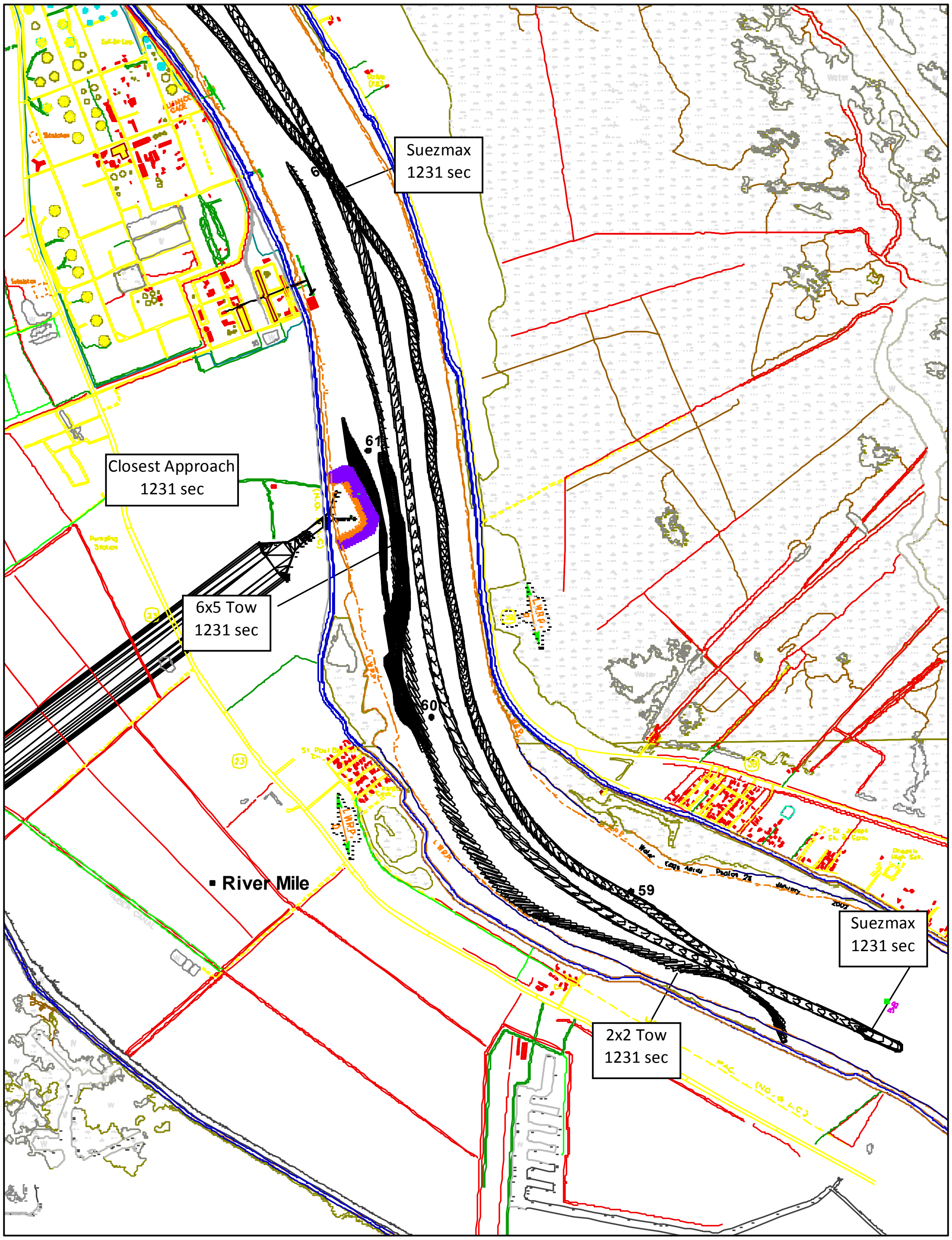


Figure A-45: Run 42, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

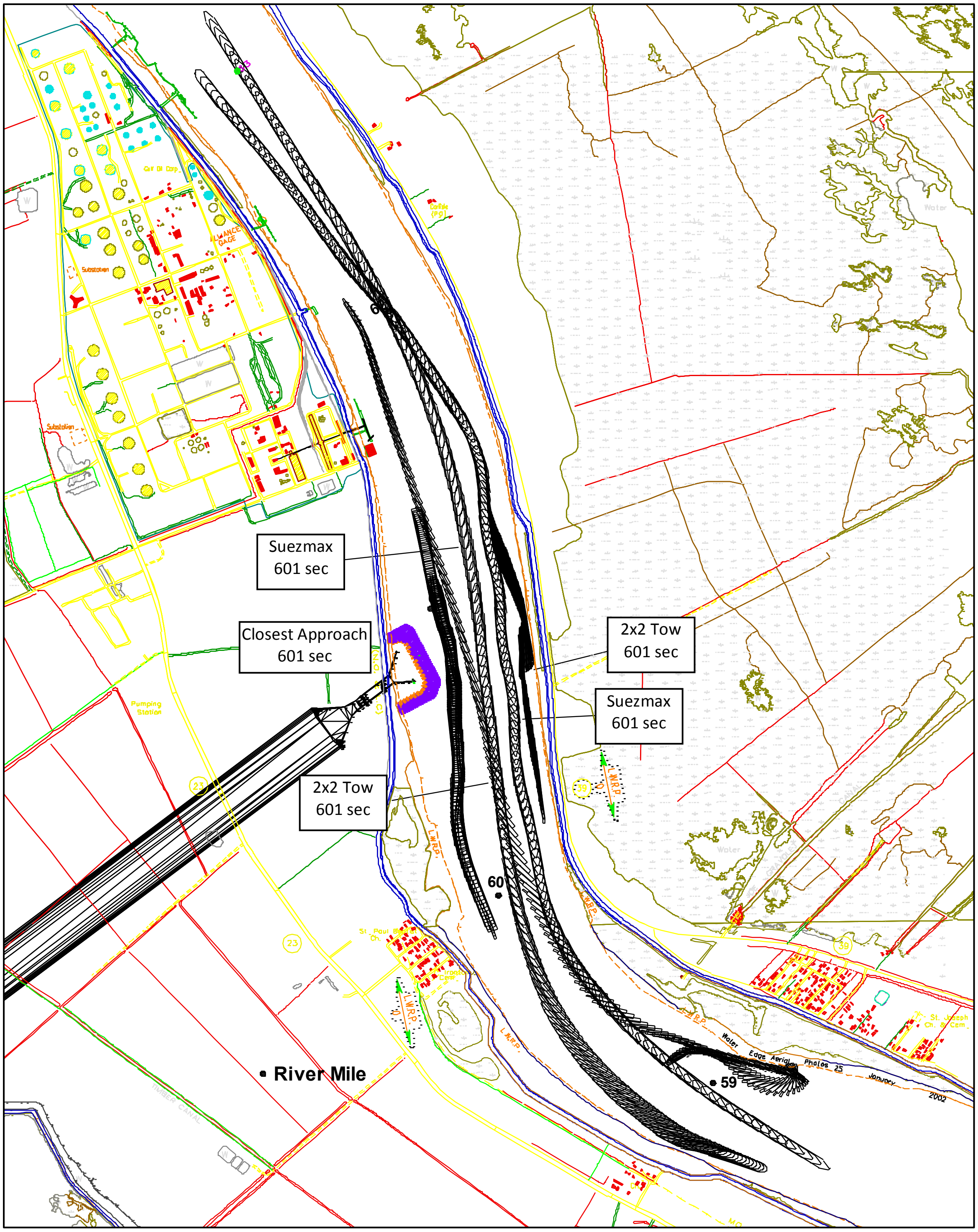


Figure A-46: Run 43, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

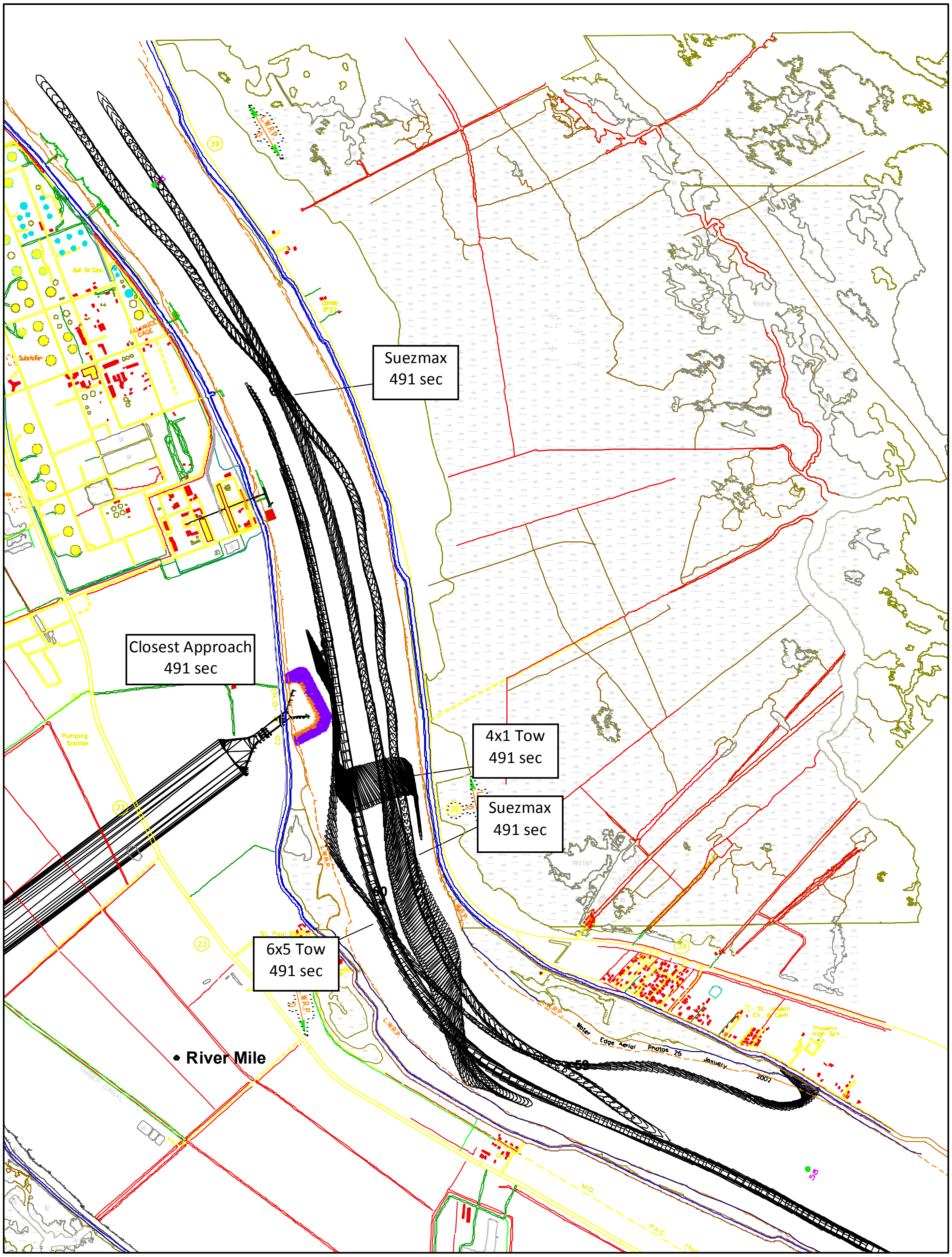


Figure A-47: Run 44, Cofferdam, 1M CFS, Wind SE 20 Knots, 2x2 Tow Closest Approach

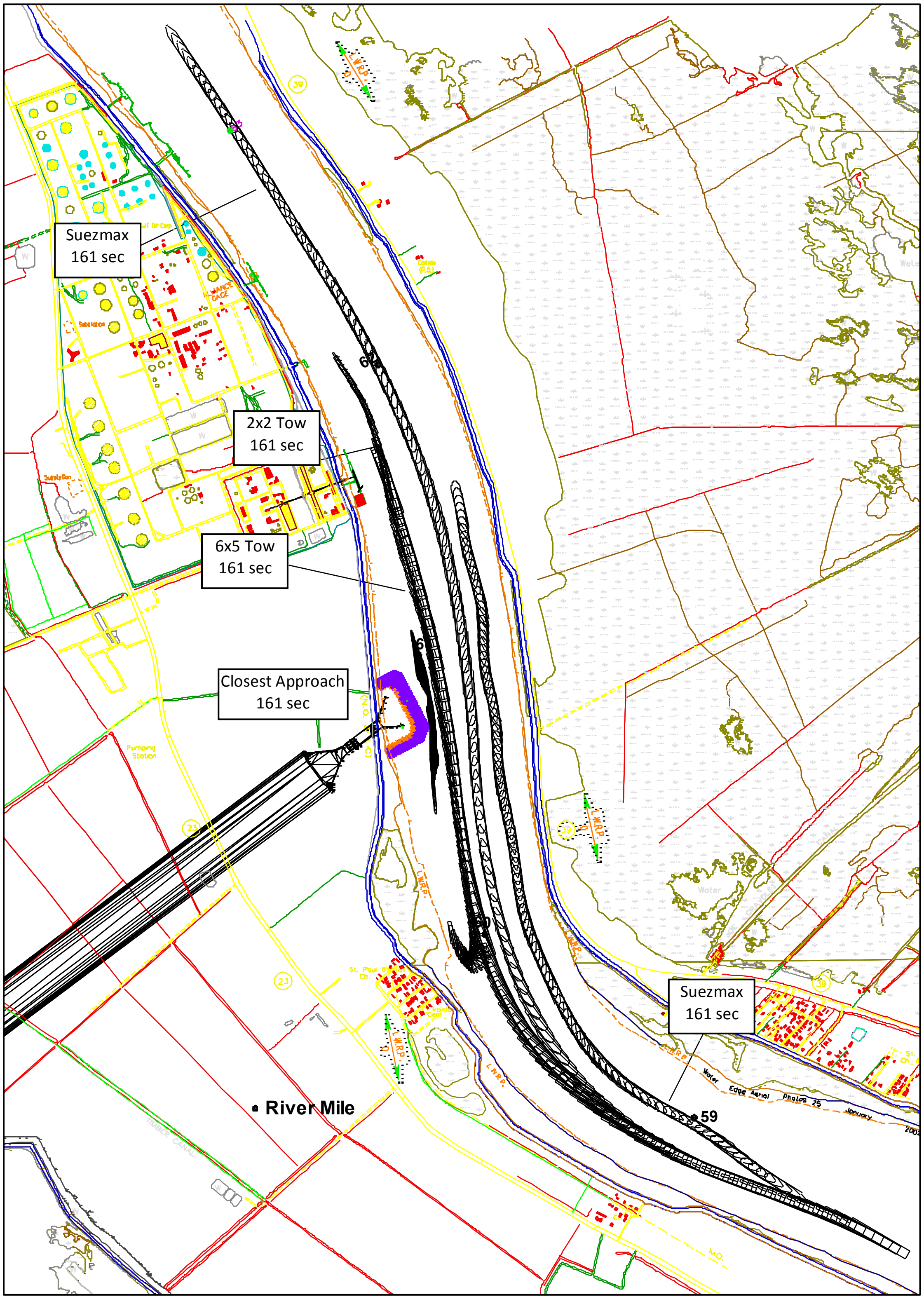


Figure A-48: Run 45, Cofferdam, 1M CFS, Wind SE 20 Knots, 4x1 Tow Closest Approach

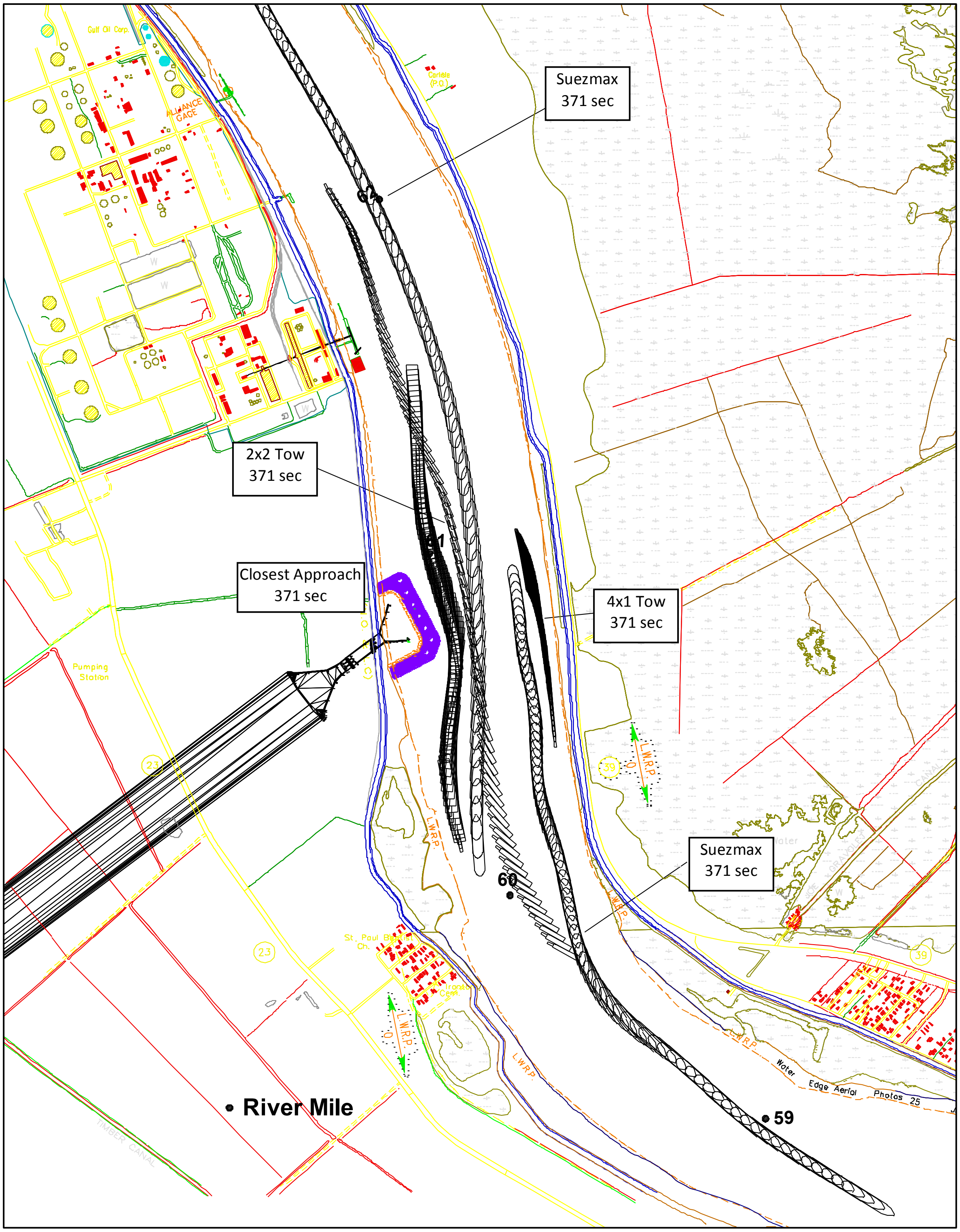


Figure A-49: Run 46, Cofferdam, 1M CFS, Wind ENE 20 Knots, 6x5 Tow Closest Approach

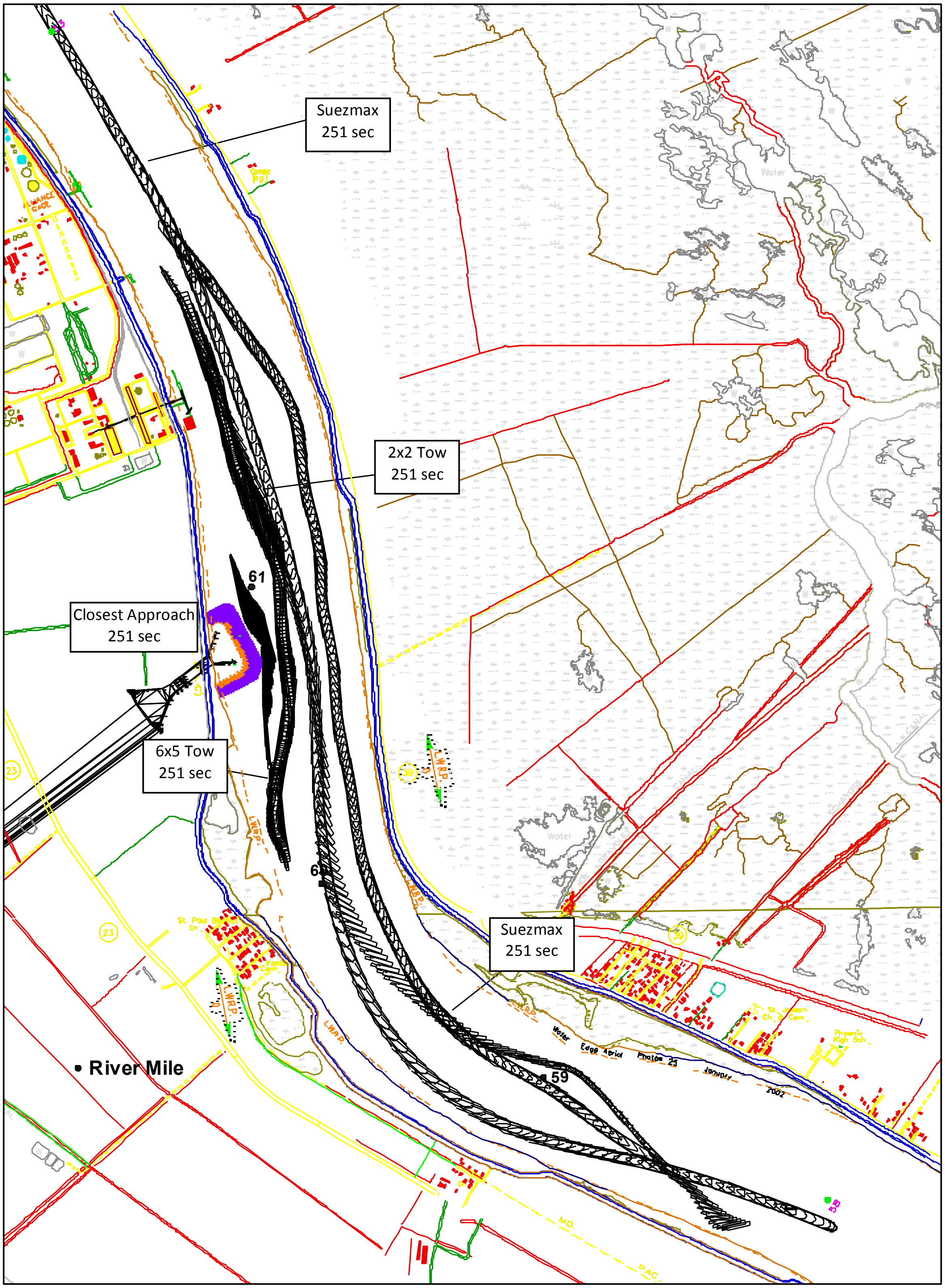


Figure A-50: Run 47, Cofferdam, 1M CFS, Wind ENE 20 Knots, 4x1 Tow Closest Approach

Appendix B: Pilot Questionnaires – Run and Final

Mid-Barataria Simulations
Pilot Evaluation of Tow Simulation Run
Monday, September 10 to Friday, September 14, 2018

Run #: **Date:** **Data Base:**

Vessel/ Tug	Bridge	Pilot	Start/End Loc.	Travel Dir.	Initial Speed	Initial Head.	Load Cond.	Vessels Met
FT_2x2								
FT_2x1								
FT_1x2								
LH_6x5								
LH_4x3								
Panamax								
Suezmax								

Environmental Conditions	River/Diversion Flow (kcfs)	Wind Dir. (from)	Wind Speed (knots)

Run Start Time:	Run End Time:

Notes:

Mid-Barataria Simulations
Pilot Evaluation of Tow Simulation Run
Monday, September 10 to Friday, September 14, 2018

1 **Were you able to maintain the intended track line and voyage plan on this exercise? (If not, why?)**

2 **What was the navigation impact of the proposed diversion channel flow.**

3 **Were the meeting/passing situations with other vessels acceptable?**

4 **Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.**

Increasing Difficulty →

1 2 3 4 5 6 7 8 9 10

5 **Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.**

Increasing Safety →

1 2 3 4 5 6 7 8 9 10

Do you have any "qualifiers" to the above safety rating (senior pilot only, restricted to daylight transits, wind direction/speed limitations, current, etc.)?

6 **Would you perform a similar transit / maneuver in a real-world situation? If not, why?**

7 If applicable, what additional conclusion or recommendations do you have regarding the vessel, channel, under keel clearance, current, etc.?

Mid-Barataria Simulations
Final Pilot Evaluation of Tow Simulation Tests
Monday, September 10 to Friday, September 14, 2018

Date:		Pilot/Captain:	

SECTION A = REALISM	"REALISM" Rating Scale	1	Unrealistic	5	Average	10	Excellent

	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
1.	1x2 Fleeting Tow	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
2.	2x1 Fleeting Tow	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
3.	2x2 Fleeting Tow	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
4.	3x4 Line-Haul Tow	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
5.	6x5 Line-Haul Tow	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
6.	Suezmax	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
7.	Panamax	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
8.		1	2	3	4	5	6	7	8	9	10

	Environmental Conditions Realism	(Circle Choice)				Increasing Realism→→→					
9.	Wind	1	2	3	4	5	6	7	8	9	10
	Environmental Conditions Realism	(Circle Choice)				Increasing Realism→→→					
10.	River Currents	1	2	3	4	5	6	7	8	9	10
	Database Realism	(Circle Choice)				Increasing Realism→→→					
11.	Visual Scene	1	2	3	4	5	6	7	8	9	10
	Database Realism	(Circle Choice)				Increasing Realism→→→					
12.	Channel	1	2	3	4	5	6	7	8	9	10
	Hydrodynamic Simulation Realism	(Circle Choice)				Increasing Realism→→→					
13.	Ship to Bank Interaction	1	2	3	4	5	6	7	8	9	10

Section B = Safety	Overall "SAFETY" Rating Scale	1	Unsafe	5	Average	10	Very Safe

	Overall Safety	(Circle Choice)				Increasing Safety→→→					
1.	Channel Adjacent to Proposed Diversion	1	2	3	4	5	6	7	8	9	10

Mid-Barataria Simulations
Final Pilot Evaluation of Tow Simulation Tests
Monday, September 10 to Friday, September 14, 2018

Section C = Recommendations and Comments

2. Please describe the impacts (if, any) that you believe the Mid-Barataria Sediment Diversion Project will have on navigation through the project reach based on your experience in these simulations.

3. Please describe any recommendations you have for increasing the safety and/or efficiency of the passage past the proposed diversion canal.

4. Please write additional comments you would like to make concerning this project.

Appendix C: Pilot Cards

Note: The "Ship Name" on the following Pilot Cards is an internal file name of the ship simulation computer and does not necessarily correspond to the vessel nomenclature used in the descriptive text. In all cases, the main body text description of vessel characteristics is correct.

PILOT CARD

Ship name	Bulk Panamax_MMX 3.0.16.0 *			Date	12.12.2013
IMO Number	N/A	Call Sign	N/A	Year built	1995
Load Condition	Full Load				
Displacement	81960 tons		Draft forward	13 m / 42 ft 9 in	
Deadweight	70000 tons		Draft forward extreme	13 m / 42 ft 9 in	
Capacity			Draft after	13 m / 42 ft 9 in	
Air draft	45 m / 148 ft 0 in		Draft after extreme	13 m / 42 ft 9 in	

Ship's Particulars

Length overall	242 m	Type of bow	Bulbous
Breadth	32 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9 / 9		

Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.03 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	24 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	623.6 s	8.45 cbls
HAH to HAS	763.6 s	8.27 cbls
SAH to SAS	959.6 s	7.98 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees	
Advance	4.3 cbls
Transfer	1.93 cbls
Tactical diameter	4.99 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 11671 kW	Propeller type	FPP
Astern power	77.6 % ahead	Min. RPM	20
Time limit astern	N/A	Emergency FAH to FAS	16.2 seconds

Engine Telegraph Table

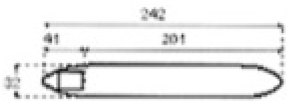
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	14	10292	85	1.05
"80%"	11.7	6008	71	1.05
"60%"	9.4	3115	57	1.05
"40%"	7.1	1345	43	1.05
"20%"	4.8	417	29	1.05
"-20%"	-2.4	479	-28	1.05
"-40%"	-3.5	1384	-40	1.05
"-60%"	-4.4	2858	-51	1.05
"-80%"	-5.5	5375	-63	1.05
"-100%"	-6.5	9057	-75	1.05

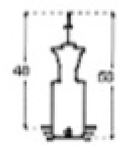
PILOT CARD

Ship name	Bulk Panamax_MMX 3.0.16.0 *			Date	12.12.2013
IMO Number	N/A	Call Sign	N/A	Year built	1995
Load Condition	Partial Loaded 2				
Displacement	55200 tons		Draft forward	10 m / 32 ft 10 in	
Deadweight	46092 tons		Draft forward extreme	10 m / 32 ft 10 in	
Capacity			Draft after	10 m / 32 ft 10 in	
Air draft	48 m / 157 ft 10 in		Draft after extreme	10 m / 32 ft 10 in	

Ship's Particulars

Length overall	242 m	Type of bow	Bulbous
Breadth	32 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9 / 9		





Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.02 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	24 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	577,6 s	7,62 cbls
HAH to HAS	644,6 s	7,42 cbls
SAH to SAS	807,6 s	7,1 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder 35 degrees

Advance	3.97 cbls
Transfer	1.9 cbls
Tactical diameter	4.84 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 11671 kW	Propeller type	FPP
Astern power	77,6 % ahead	Min. RPM	20
Time limit astern	N/A	Emergency FAH to FAS	16,2 seconds

Engine Telegraph Table

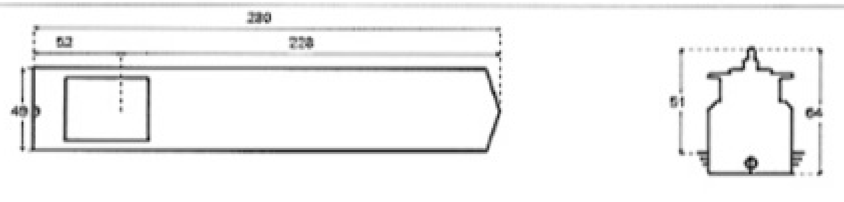
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	14,3	9793	85	1,05
"80%"	11,9	5718	71	1,05
"60%"	9,6	2958	57	1,05
"40%"	7,2	1281	43	1,05
"20%"	4,9	296	29	1,05
"-20%"	-2,4	479	-28	1,05
"-40%"	-3,5	1384	-40	1,05
"-60%"	-4,4	2858	-51	1,05
"-80%"	-5,5	5375	-63	1,05
"-100%"	-6,5	9057	-75	1,05

PILOT CARD

Ship name	VLCC 4_Suez_Statoil 3.0.26.0 *			Date	10.09.2018
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Partial Loaded 3				
Displacement	143571.12 tons		Draft forward	13 m / 42 ft 9 in	
Deadweight	159880 tons		Draft forward extreme	13 m / 42 ft 9 in	
Capacity			Draft after	13 m / 42 ft 9 in	
Air draft	51 m / 167 ft 9 in		Draft after extreme	13 m / 42 ft 9 in	

Ship's Particulars

Length overall	280 m	Type of bow	Bulbous
Breadth	49.9 m	Type of stern	V-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle = 25 m / 13.7 fathoms)
Max. rate of heaving, m/min	18 / 18		



Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	-0.01 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	29 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	1037.9 s	12.82 cbls
HAH to HAS	1261.2 s	12.17 cbls
SAH to SAS	1678.1 s	11.7 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	5.09 cbls
Transfer	2.63 cbls
Tactical diameter	6.19 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 26120 kW	Propeller type	FPP
Astern power	75 % ahead	Min. RPM	11.98
Time limit astern	N/A	Emergency FAH to FAS	35.2 seconds

Engine Telegraph Table

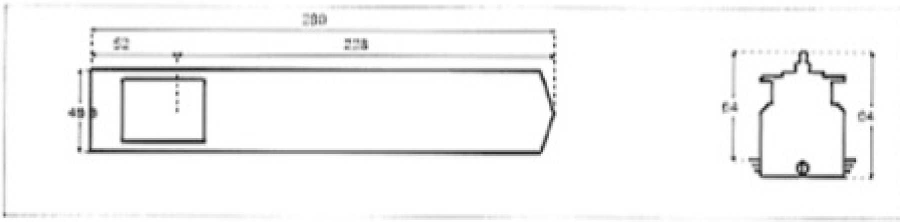
Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	16	20896	85	0.8
"FAH"	13.2	12076	70	0.8
"HAH"	10.3	6209	55	0.8
"SAH"	7.5	2663	40	0.8
"DSAH"	4.5	760	24	0.8
"DSAS"	-2.4	922	-24	0.8
"SAS"	-3.7	2773	-37	0.8
"HAS"	-5	6260	-50	0.8
"FAS"	-6.2	11409	-62	0.8
"FSAS"	-7.5	19590	-75	0.8

PILOT CARD

Ship name	VLCC 4_Suez_Statoil 3.0.34.0 *			Date	15.05.2014
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Partial Loaded 4				
Displacement	110400.86 tons		Draft forward	10 m / 32 ft 10 in	
Deadweight	199880 tons		Draft forward extreme	10 m / 32 ft 10 in	
Capacity			Draft after	10 m / 32 ft 10 in	
Air draft	54 m / 177 ft 7 in		Draft after extreme	10 m / 32 ft 10 in	

Ship's Particulars

Length overall	280 m	Type of bow	Bulbous
Breadth	49.9 m	Type of stern	V-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	13 / 13		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	18 / 18		



Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.01 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	28 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	934.6 s	11.83 cbls
HAH to HAS	1132.5 s	11.18 cbls
SAH to SAS	1506.5 s	10.7 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	5.07 cbls
Transfer	2.55 cbls
Tactical diameter	6.03 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 26120 kW	Propeller type	FPP
Astern power	75 % ahead	Min. RPM	11.98
Time limit astern	N/A	Emergency FAH to FAS	35.2 seconds

Engine Telegraph Table

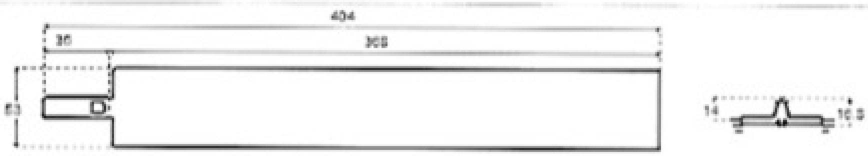
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	16	20896	85	0.8
"FAH"	13.1	12076	70	0.8
"HAH"	10.3	6209	55	0.8
"SAH"	7.5	2663	40	0.8
"DSAH"	4.5	760	24	0.8
"DSAS"	-2.4	922	-24	0.8
"SAS"	-3.6	2773	-37	0.8
"HAS"	-4.9	6260	-50	0.8
"FAS"	-6.1	11409	-62	0.8
"FSAS"	-7.4	19590	-75	0.8

PILOT CARD

Ship name	Composite tow 6x5 FL (Dis.51675t) 3.0.16.1 *			Date	17.02.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Full Load				
Displacement	51675 tons	Draft forward		2.74 m / 9 ft 0 in	
Deadweight	N/A tons	Draft forward extreme		2.74 m / 9 ft 0 in	
Capacity		Draft after		2.74 m / 9 ft 0 in	
Air draft	14.06 m / 46 ft 3 in	Draft after extreme		2.74 m / 9 ft 0 in	

Ship's Particulars

Length overall	404 m	Type of bow	Spoon
Breadth	53 m	Type of stern	U-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15		(1 shackle = 25 m / 13.7 fathoms)
Max. rate of heaving, m/min	9 / 9		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max.Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	291.6 s	1.97 cbls
HAH to HAS	366.6 s	1.89 cbls
SAH to SAS	502.6 s	1.81 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	5.44 cbls
Transfer	2.89 cbls
Tactical diameter	7.53 cbls

Main Engine(s)

Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Right/Left
Maximum power per shaft	2 x 2100 kW	Propeller type	FPP
Astern power	85 % ahead	Min. RPM	500
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	5.9	3948	285	1.1
"80%"	5	2546	244.3	1.1
"60%"	3.9	1264	190	1.1
"40%"	2.8	516	115.7	1.1
"20%"	1.7	151	81.4	1.1
"-20%"	-1.3	142	-81.4	1.1
"-40%"	-2.2	475	-135 7	1.1
"-60%"	-3.1	1152	-190	1.1
"-80%"	-3.9	2308	-244.3	1.1
"-100%"	-4.6	3570	-285	1.1

PILOT CARD

Ship name	Composite tow 6x5 BL (Dis.8562t) 3.0.18.1 *			Date	17.02.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Ballast				
Displacement	8562 tons	Draft forward		0.45 m / 1 ft 5 in	
Deadweight	N/A tons	Draft forward extreme		0.45 m / 1 ft 5 in	
Capacity		Draft after		0.45 m / 1 ft 5 in	
Air draft	16.35 m / 53 ft 9 in	Draft after extreme		2.74 m / 9 ft 0 in	

Ship's Particulars

Length overall	404 m	Type of bow	Spoon
Breadth	53 m	Type of stern	U-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15		(1 shackle =25 m / 13.7 fathoms)
Max. rate of heaving, m/min	9 / 9		

Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max.Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	89.5 s	0.97 cbls
HAH to HAS	103.8 s	0.84 cbls
SAH to SAS	133.5 s	0.73 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	5.41 cbls
Transfer	3.56 cbls
Tactical diameter	8.87 cbls

Main Engine(s)

Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Right Left
Maximum power per shaft	2 x 2100 kW	Propeller type	FPP
Astern power	83 % ahead	Min. RPM	500
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

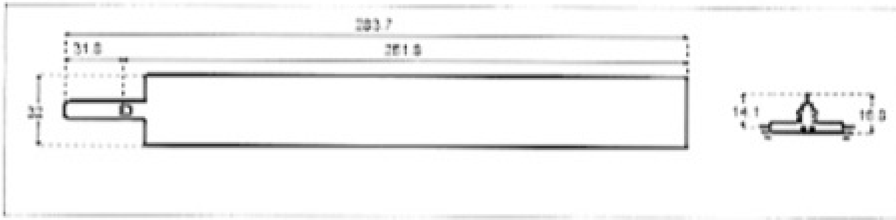
Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	8.1	3612	285	1.1
"80%"	6.9	2329	244.3	1.1
"60%"	5.4	1156	190	1.1
"40%"	3.8	472	135.7	1.1
"20%"	2.3	138	81.4	1.1
"-20%"	-1.8	135	-81.4	1.1
"-40%"	-3	458	-135.7	1.1
"-60%"	-4.2	1119	-190	1.1
"-80%"	-5.4	2250	-244.3	1.1
"-100%"	-6.3	3486	-285	1.1

PILOT CARD

Ship name	Composite tow 3x4 FL (Dis.20000t) 3.0.70.1 *			Date	16.02.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Full Load				
Displacement	20000 tons	Draft forward		2.74 m / 9 ft 0 in	
Deadweight	18000 tons	Draft forward extreme		2.74 m / 9 ft 0 in	
Capacity		Draft after		2.74 m / 9 ft 0 in	
Air draft	14.1 m / 46 ft 4 in	Draft after extreme		2.74 m / 9 ft 0 in	

Ship's Particulars

Length overall	283.7 m	Type of bow	Sloping
Breadth	32 m	Type of stern	U-shaped
Anchor(s) (No. types)	2 (PortBow / StbdBow)		
No. of shackles	10 / 10		(1 shackle = 27.5 m / 15 fathoms)
Max. rate of heaving, m/min	30 / 30		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max.Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	173.1 s	1.71 cbls
HAH to HAS	212.7 s	1.6 cbls
SAH to SAS	286.6 s	1.48 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	3.88 cbls
Transfer	2.08 cbls
Tactical diameter	5.37 cbls

Main Engine(s)

Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Right/Left
Maximum power per shaft	2 x 2100 kW	Propeller type	FPP
Astern power	84 % ahead	Min. RPM	500
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

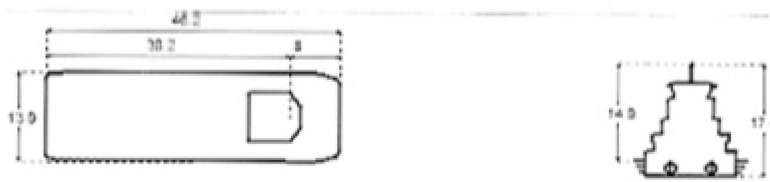
Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	8.1	3738	285	1.1
"80%"	6.9	2410	244.3	1.1
"60%"	5.4	1197	190	1.1
"40%"	3.8	488	135.7	1.1
"20%"	2.3	143	81.4	1.1
"-20%"	-1.7	138	-81.4	1.1
"-40%"	-2.8	466	-135.7	1.1
"-60%"	-3.9	1135	-190	1.1
"-80%"	-5	2278	-244.3	1.1
"-100%"	-5.9	3528	-285	1.1

PILOT CARD

Ship name	Twin screw push boat 5 (bp 60t) 1.0.1.0 *			Date	31.03.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Full Load				
Displacement	817 tons		Draft forward	2.5 m / 8 ft 2 in	
Deadweight	N/A tons		Draft forward extreme	2.5 m / 8 ft 2 in	
Capacity			Draft after	2.5 m / 8 ft 2 in	
Air draft	14.9 m / 49 ft 0 in		Draft after extreme	2.5 m / 8 ft 2 in	

Ship's Particulars

Length overall	46.2 m	Type of bow	Spoon
Breadth	13.9 m	Type of stern	U-shaped
Anchor(s) (No. types)	2 (PortBow / StbdBow)		
No. of shackles	11 / 11		(1 shackle = 25 m / 13.7 fathoms)
Max. rate of heaving, m/min	18 / 18		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max.Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	36.7 s	0.7 cbls
HAH to HAS	36.2 s	0.56 cbls
SAH to SAS	42.2 s	0.46 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	0.54 cbls
Transfer	0.26 cbls
Tactical diameter	0.62 cbls

Main Engine(s)

Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Left/Right
Maximum power per shaft	2 x 2239 kW	Propeller type	FPP
Astern power	54 % ahead	Min. RPM	500
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	13.5	3358	300	1.1
"80%"	11.4	1718	241.4	1.1
"60%"	9.2	873	191.4	1.1
"40%"	7.3	450	151.4	1.1
"20%"	5	163	104.3	1.1
"-20%"	-3.5	121	-91.4	1.1
"-40%"	-5	321	-131.4	1.1
"-60%"	-6.9	756	-178.6	1.1
"-80%"	-8.4	1349	-218.6	1.1
"-100%"	-10.2	2418	-267.2	1.1

PILOT CARD

Ship name	Twin screw push boat 4 (bp 20t) 3.0.1.0 *			Date	30.03.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Full Load				
Displacement	487 tons	Draft forward		2.5 m / 8 ft 2 in	
Deadweight	N/A tons	Draft forward extreme		2.5 m / 8 ft 2 in	
Capacity		Draft after		2.5 m / 8 ft 2 in	
Air draft	15 m / 49 ft 4 in	Draft after extreme		2.5 m / 8 ft 2 in	

Ship's Particulars

Length overall	27.43 m	Type of bow	Spoon
Breadth	10.36 m	Type of stern	U-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	11 / 11	(1 shackle = 25 m / 13.7 fathoms)	
Max. rate of heaving, m/min	18 / 18		

Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	30.2 s	0.49 cbls
HAH to HAS	33.2 s	0.4 cbls
SAH to SAS	41.2 s	0.35 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	0.31 cbls
Transfer	0.13 cbls
Tactical diameter	0.34 cbls

Main Engine(s)

Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Left Right
Maximum power per shaft	2 x 782 kW	Propeller type	FPP
Astern power	58 % ahead	Min. RPM	200
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"80%"	10	938	232.6	0.8
"60%"	7.8	382	174.4	0.8
"40%"	5.9	167	130.8	0.8
"20%"	3.9	55	87.2	0.8
"-20%"	-3.1	56	-87.2	0.8
"-40%"	-4.7	172	-130.8	0.8
"-60%"	-6.2	391	-174.4	0.8
"-80%"	-8.2	907	-232.6	0.8

PILOT CARD

Ship name	Twin screw push boat 3 (bp 17t) 3.0.1.0 *			Date	29.03.2016
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Full Load				
Displacement	412 tons	Draft forward		2.59 m / 8 ft 6 in	
Deadweight	N/A tons	Draft forward extreme		2.59 m / 8 ft 6 in	
Capacity		Draft after		2.59 m / 8 ft 6 in	
Air draft	16.91 m / 55 ft 7 in	Draft after extreme		2.59 m / 8 ft 6 in	

Ship's Particulars

Length overall	23.17 m	Type of bow	Spoon
Breadth	10.67 m	Type of stern	U-shaped
Anchor(s) (No. types)	2 (PortBow / StbdBow)		
No. of shackles	10 / 10		(1 shackle = 25 m / 13.7 fathoms)
Max. rate of heaving, m/min	18 / 18		

Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 2	Number of bow thrusters	N/A
Maximum angle	45	Power	N/A
Rudder angle for neutral effect	0 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	8 seconds	Power	N/A
Flanking Rudder(s)	2 (Max. Angle = 45)	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder 35 degrees	
FAH to FAS	31.2 s	0.53 cbls	Advance	0.3 cbls
HAH to HAS	34.2 s	0.42 cbls	Transfer	0.11 cbls
SAH to SAS	41.2 s	0.36 cbls	Tactical diameter	0.29 cbls

Main Engine(s)

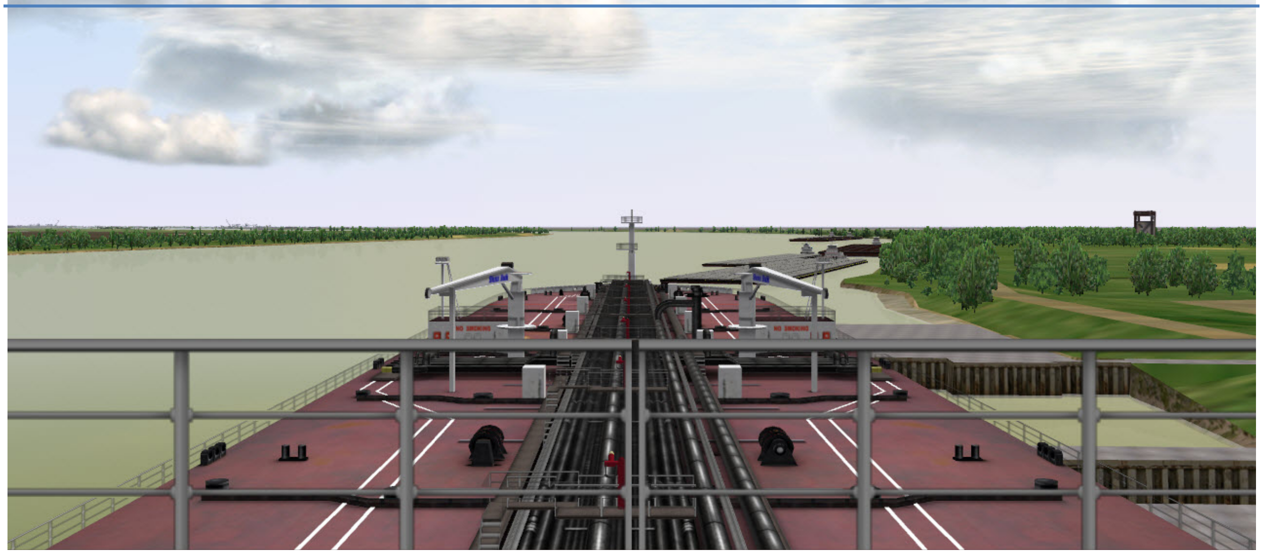
Type of Main Engine	High speed diesel	Number of propellers	2
Number of Main Engine(s)	2	Propeller rotation	Left Right
Maximum power per shaft	2 x 672 kW	Propeller type	FPP
Astern power	56 % ahead	Min. RPM	200
Time limit astern	N/A	Emergency FAH to FAS	2.1 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"80%"	10	757	232.1	0.8
"60%"	7.9	293	174.4	0.8
"40%"	6	127	130.7	0.8
"20%"	4	41	86.8	0.8
"-20%"	-3.2	44	-86.6	0.8
"-40%"	-4.9	139	-130.3	0.8
"-60%"	-6.5	311	-174.1	0.8
"-80%"	-8.5	734	-232.1	0.8

2014 Ship Simulations Report

Mid-Barataria Sediment Diversion Project – Impact on the Navigation of Ships in the Mississippi River



Study Performed for

Coastal Protection and Restoration Authority

State of Louisiana

and

HDR

by

Waterway Simulation Technology, Inc.

and

Maritime Institute of Technology and Graduate Studies

February 2,2014

1 Introduction and Background

1.1 Project Description

Land loss in the Mississippi River Delta has been a growing concern for many years. Reversal of this has become high priority matter following a series of catastrophic hurricanes for which wetlands in the delta are considered to be significant factors in reducing the strength of these hurricanes. Therefore, Increasing wetlands in the delta is a priority in an effort to reduce property damage and loss of life. Since the Mississippi River flood levees have been constructed to control flooding, the overflow of sediment bearing floodwaters into the wetlands of the delta has been constrained and replenishment of sediment in the wetlands reduced or eliminated. Therefore, in an effort to restore wetlands in the delta, a series of sediment diversion projects are being designed to allow sediment-bearing water to be diverted from the Mississippi River through control structures and into a distribution system that will carry these sediments and nutrients into wetlands where restoration is desired.

Figure 1: Location of the Mid-Barataria Sediment Diversion Project on the Lower Mississippi River.

The Mid-Barataria Sediment Diversion Project was authorized in the 2007 Water Resources Development Act. It is a medium size diversion intended to mimic natural land-building processes by reintroducing sediment into the basin from the Mississippi River. The receiving basin of this diversion, Barataria Bay, has experienced some of the highest rates of land loss in coastal Louisiana. The location of this project is shown in Figure 1 and is near Myrtle Grove, LA, along the western side of the Mississippi River (shown in the red box in Figure 1).

A partial project layout is shown in Figure 2 with the focus on the diversion canal location, size and orientation. The project involves cutting into and relocating the main levee on the western side of the Mississippi River, digging a diversion canal with levees along the canal, control structures at the river end of the canal and at the distribution end of the canal along with other features not pertinent to this study and report. This design is a preliminary conceptual design and the main focus for this study is the intake structure as it extends into the Mississippi River and the channel to the eastern control gate, shown in Figure 3. This drawing shows that the conveyance channel will be dredged to -40 ft Mean Lower Low Water Reference Plane (MLLW) to a gate structure that will be closed when the project is not in operation and will control the flow into the project behind the levee when the project is in operation.

Figure 2: Conceptual Mid-Barataria Sediment Diversion Canal with Control Structures

To predict the potential of this project's capability to build land, research was carried out to understand the river's bottom, water flow and sediment content at various discharges. It was found that the potential for carrying high levels of soil and sand was during periods of high river discharge, particularly at rates of 700,000 cfs or greater. It was also found that the location chosen for the intake channel had the highest levels of sediment during these flows on the western side of the river and would, therefore, produce the highest potential for capture of sediment bearing water.

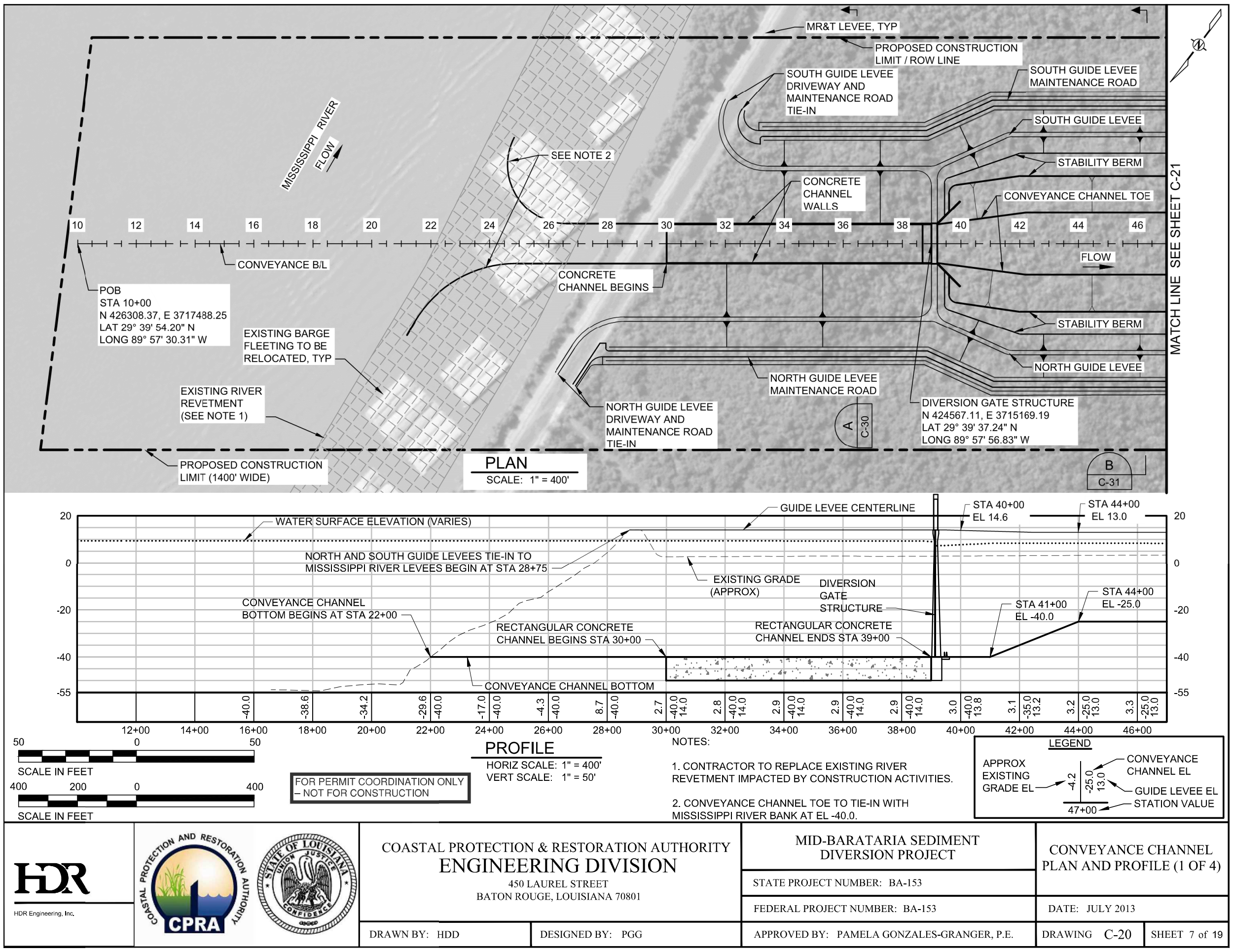


Figure 3: Preliminary Mid-Barataria Sediment Diversion Conveyance Channel Plan and Profile

The significance of this project has brought together governmental agencies and universities in a data collection and modeling effort. The Water Institute of the Gulf has developed a three-dimensional (3D) model of the Mississippi River reach and the project to study the hydrodynamics and transport characteristics of the proposed and initial concept of the project. The hydrodynamic model used is Flow3D, developed by Flow Science, Inc. A brief description from the official Flow-3D internet site is provided:

FLOW-3D *is a powerful and highly-accurate CFD software that gives engineers valuable insight into many physical flow processes. With special capabilities for accurately predicting free-surface flows,* ***FLOW-3D*** *is the ideal CFD software to use in your design phase as well as in improving production processes.* ***FLOW-3D*** *is an all-inclusive package. No special additional* *modules for meshing or post-processing are needed. An integrated graphical user interface ties everything together, from problem setup to post-processing*[1].

The current model data for the ship simulation study was provided by The Water Institute of the Gulf.

1.2 Navigation in the Project Reach

Navigation in the project reach of the Mississippi River is performed in a Federal Navigation Channel for which the U.S. Army Corps of Engineers, New Orleans District (USACE), is responsible. Information about the channel, including hydrographic survey data, navigation markers, revetment locations, dock facilities, etc. as well as levee data was provided by the USACE. A meeting of navigation interests was held in New Orleans on August 16, 2013, to gather information about navigation on this reach of the river, understand the industry's thoughts about this proposed project, and how navigation functioned, and what should be included in a navigation study of the impacts of this project on ship and tow operations[2]. During this meeting it was learned that this reach of the Mississippi River has one of the nation's most dense volumes of ship and tow traffic. There are major terminals and marine facilities that receive and ship products, storing and transferring cargo between ships and tows in addition to the through traffic of ships and tows. All of the New Orleans to Baton Rouge ship traffic must pass through this reach and with an authorized 50-ft deep navigation channel and a wide maneuvering area within the river, ships of all sizes, including some of the largest, transit through this reach. This includes Suezmax tankers, Capesize bulk carriers, and large cruise passenger ships. Tow traffic is also heavy, bringing grains, petroleum products and chemicals to terminals for export. With large fleets in the area, fleeting activity is intense. As a result, determination of the impact on navigation operations in this reach by the intermittent operation of this proposed project is required. This ship maneuvering simulation study has been conducted to address the deep-draft shipping impacts.

2 Study Purpose

Therefore, the purpose of this ship maneuvering simulation study was to:

- Determine if the operation of the proposed diversion project will impact navigation adversely.
- These tests focus on deep-draft navigation.
- The study depends on the participating pilots evaluation of whether or not the diversion flows will affect the control of a ship as it passes the project during diversions.

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[1] http://www.flow3d.com/flow3d/flow3d-overview.html?gclid=CMf2vZnw77oCFRFo7AodbAwAPg

[2] Waterway Simulation Technology, Inc. Memo For Record dated August 27, 2013, **Subject: Meeting with Maritime Interests in New Orleans, LA, to Discuss the Ship and Tow Simulation Impacts of the Proposed Mid-Barataria Sediment Diversion Project**

3 Study Approach

The study approach was to perform a ship maneuvering study on a full bridge simulator using ships representative of the deep-draft traffic operating in this reach of the Mississippi River . The selected design ships would operate in a simulated channel with currents computed with the proposed diversion project in operation at the presently proposed withdrawal rates. These operational withdrawals will be taken at three different river discharge levels. Licensed, experienced, local pilots will conn the ships through simulated transits past the diversion project.

4 Simulation Study

4.1 Simulation Database

The ship simulation database consisted of several different parts which interact together with the ship bridge and controls and present visual, electronic display, and radar images of the ship model moving through the simulated navigation channel and reacting to the conning pilot's commands that are carried out by the helmsman and simulator operator working a the simulation instructor's console. The key databases making up the simulation are described below.

4.1.1 Visuals

Three-dimensional graphic images of the river, terminals, aids to navigation, trees and vegetation lining the banks of the river, towns and various buildings, and the diversion project were constructed in the geographically correct locations. These images are textured and change as the objects are approached. To add even more realism to the simulation, tows of various sizes were positioned in the locations where fleets of barges are normally secured. Since models of individual barges were not available on the simulator, tows were used which included the towboats; however, the pilots participating in the simulation approved the realism of this approach. One view of the simulated image is shown in Figure 4 and on the cover is a view from the grain terminal dock looking downstream towards the control gate structure.

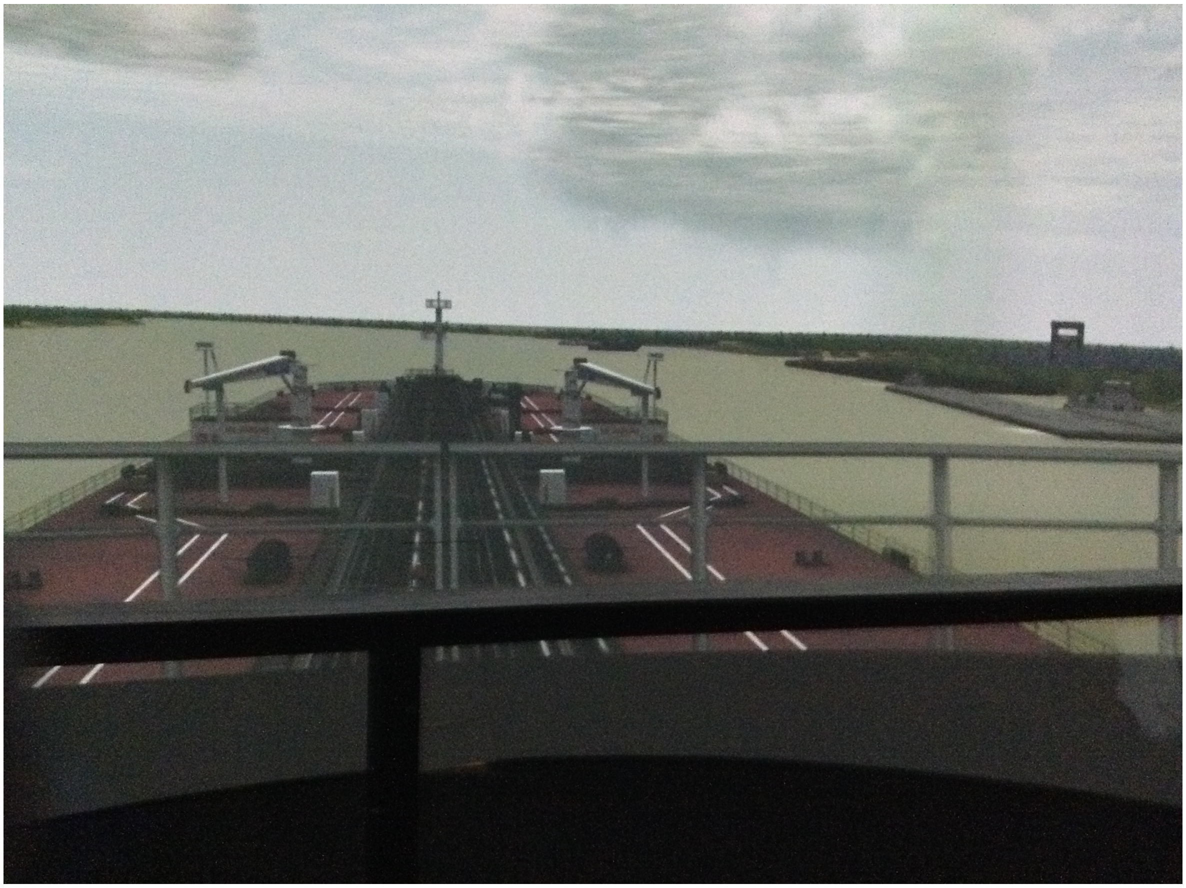


Figure 4: View from the Suezmax Ship's Bridge Downstream from the Grain Elevator Showing the Fleeting Area and the Project Control Gate Structure.

4.1.2 Channel

The simulated navigation channel was constructed from the 3D current model depth data provided by The Water Institute of the Gulf. The existing channel is shown in Figure 5 which shows that the deep part of the river is on the western side of the river near the refineries, crosses over to the eastern side of the river opposite the project site location and then comes back to the western side of the river just below the project on the outside of the bend near River Mile 59 and is very deep in this location. A relatively shallow shelf to about 50 ft is located at the project location and this is where the conveyance channel is to be dredged. The dredged channel is shown in Figure 6 and is from the 3D hydrodynamic model. These are the depths that defined the navigation channel in the simulator.

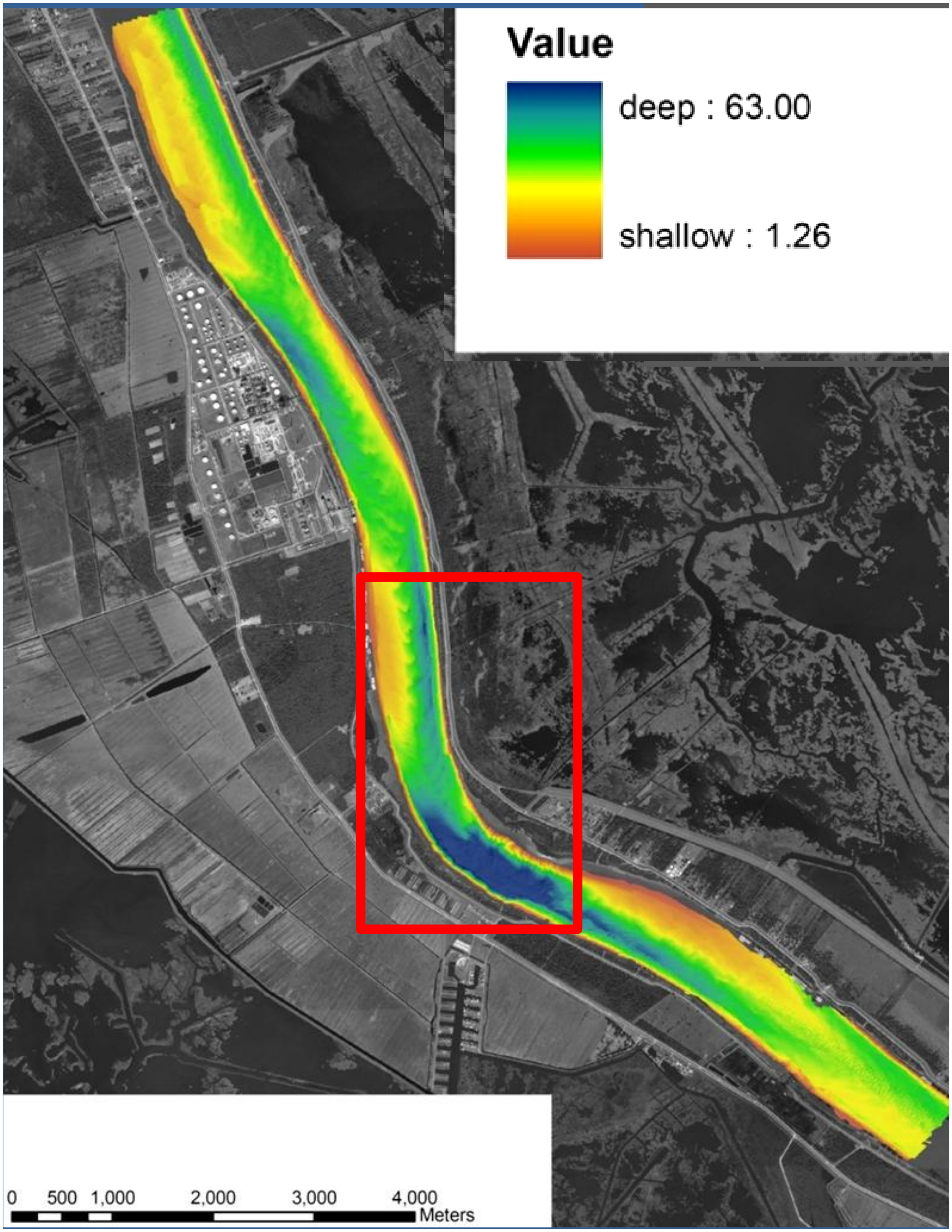


Figure 5: Measured Bottom Depths in Meters in the Proposed Diversion Project Reach

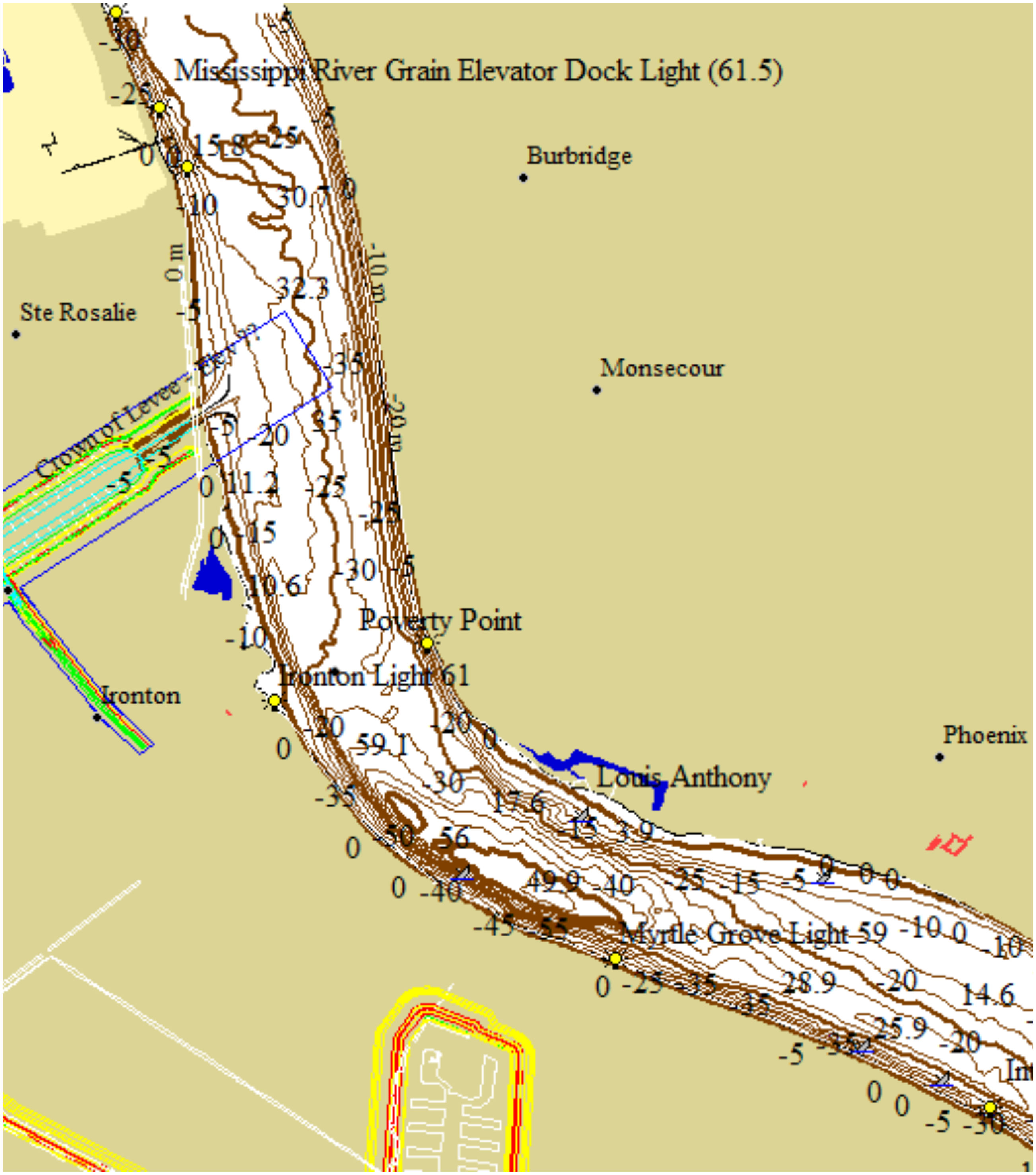


Figure 6: Depth Contours in Meters from The Water Institute of the Gulf 3D Model Including the Diversion Project Conveyance Channel

4.1.3 Currents

River current data for inclusion into the MITAGS simulator were generated using the three-dimensional cartesian-grid numerical model Flow3D[3]. Figure 7 shows an overview of the modeled area covered by the 3D model. The immediate river reach adjacent to the Mid-Barataria Sediment Diversion Canal was modeled in a significantly higher grid density in order to allow the numerics to accurately define the effect on the current caused by the portion of the flow diverted by the canal. The model was run for three flow rates: 600-, 700- and 975-kcfs. The project design identified this flow range as the bracket for future operation of the gate structure in the canal.

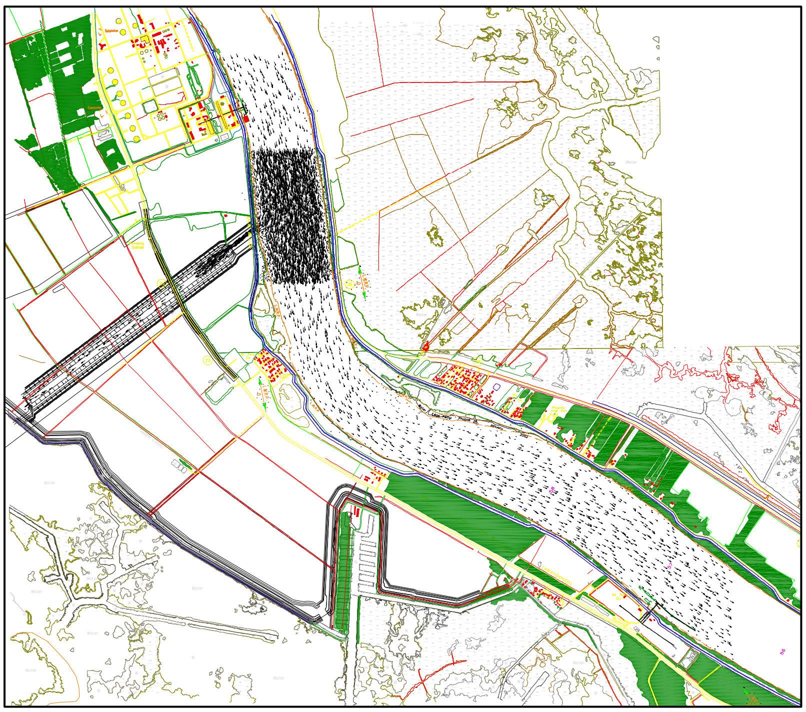


Figure 7: Extent of 3D Model Cartesian Grid – Mississippi River Miles 56.0 – 62.5

Table 1 shows the six different current conditions for the simulation tests of deep-draft vessels in the Mid-Barataria canal vicinity. The numeric values in the table represent nominal comparative measures of the strength of the current in the middle of the Mississippi River adjacent to the future diversion canal. Since the simulation design ships were both ballasted draft and loaded, the three-dimensional structure of the numerical model was exploited for the purpose of using only the portion of the currents in the vertical water column impinging on the hull of the ship for each of their respective drafts. Therefore, for example, the 50ft depth-averaged current was obtained by calculating the mean of the current vector components from the numerical model layers only down to the 50-ft depth. Similarly for the 30ft depth-average current. Figures 8 - 11 show vector plots of the low (600kcfs) and high (975kcfs) simulation-

[3] Department of Natural Systems: Modeling and Monitoring, The Water Institute of the Gulf, One American Plaza, 301 N. Main St., Suite 2000, Baton Rouge, Louisiana, 70825; Attn: Dr. Ehab Meselhe

study design river flows. The figures show the vectors in the entire test reach and higher detail of the inset grid in the canal vicinity. A vector plot of the medium flow of 700kcfs is not depicted; however, the current magnitude for this case can be considered intermediate to that for the high and low flows shown (see Table 1). Also, only the 30-ft depth-averaged case is shown. The vector direction of the various current flows showed little variation – not only in the vicinity of the canal but throughout the entire test reach. The reader should be able to note that the diverted flow into the canal, as predicted by the current model, penetrated only a small distance into the main part of the river.

Table 1: Nominal River Current Speeds at Mid-Barataria Sediment Diversion Canal

Flow Rate	Diverted Flow Rage	30ft Depth Averaged	50ft Depth Averaged
600,000cfs	50,967cfs	4.4 fps	4.3 fps
700,000cfs	60,918cfs	4.8 fps	4.8 fps
975,000cfs	74,190cfs	6.8 fps	6.5 fps

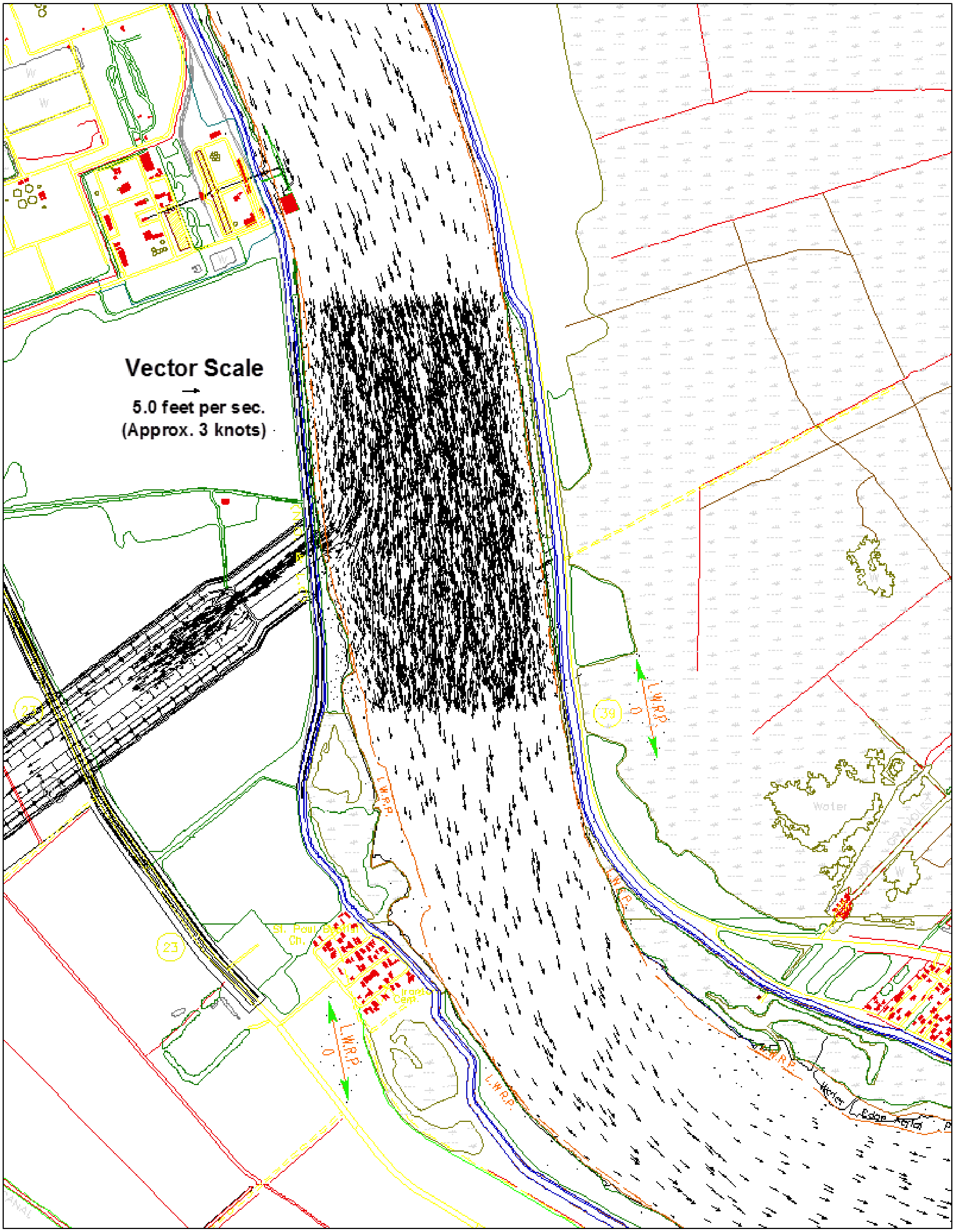


Figure 8: River Current at 600kcfs Flow Rate (30ft depth-averaged)

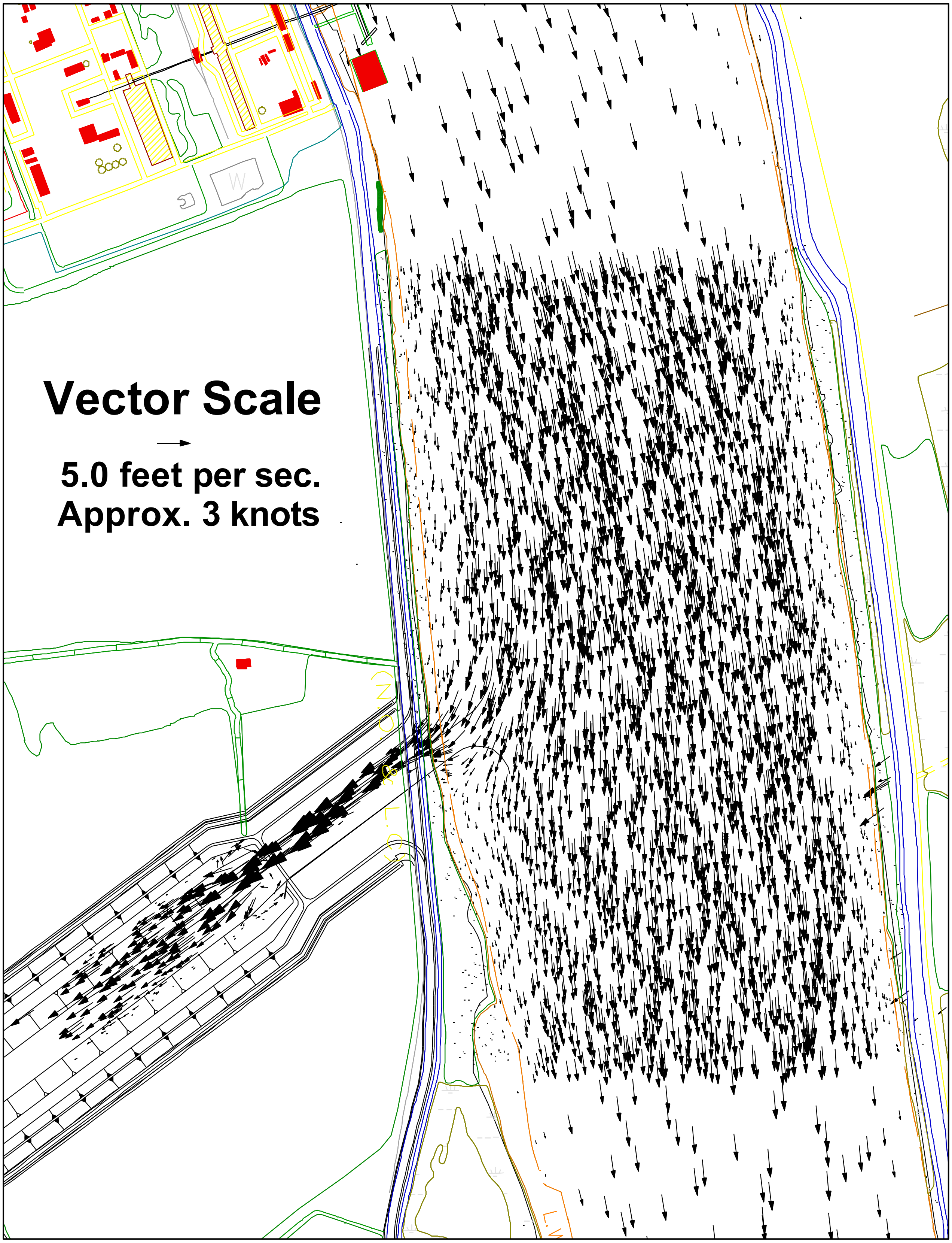


Figure 9: River Current at 600kcfs Flow Rate (30ft depth-averaged) (Inset)

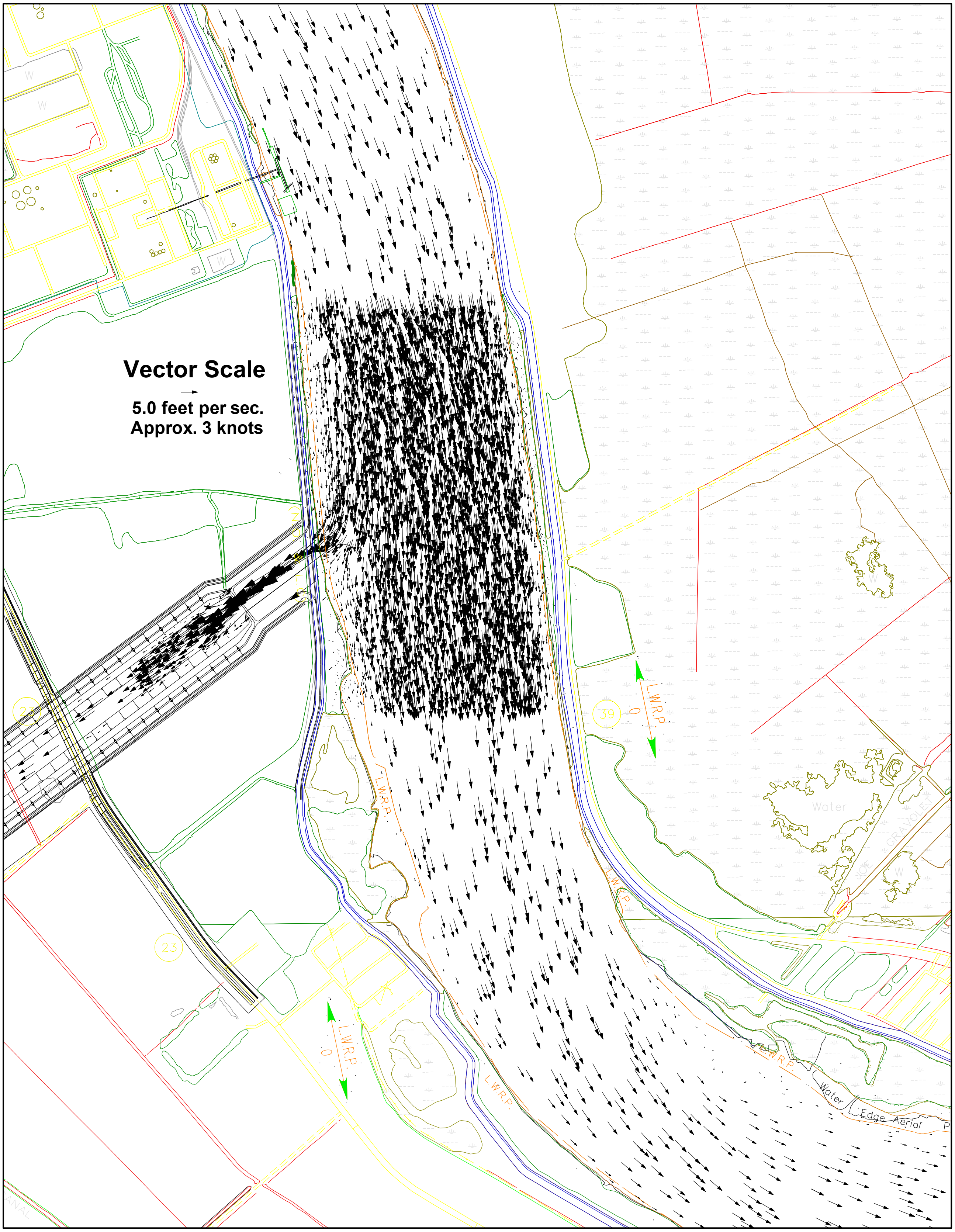


Figure 10: River Current at 975kcfs Flow Rate (30ft depth-averaged)

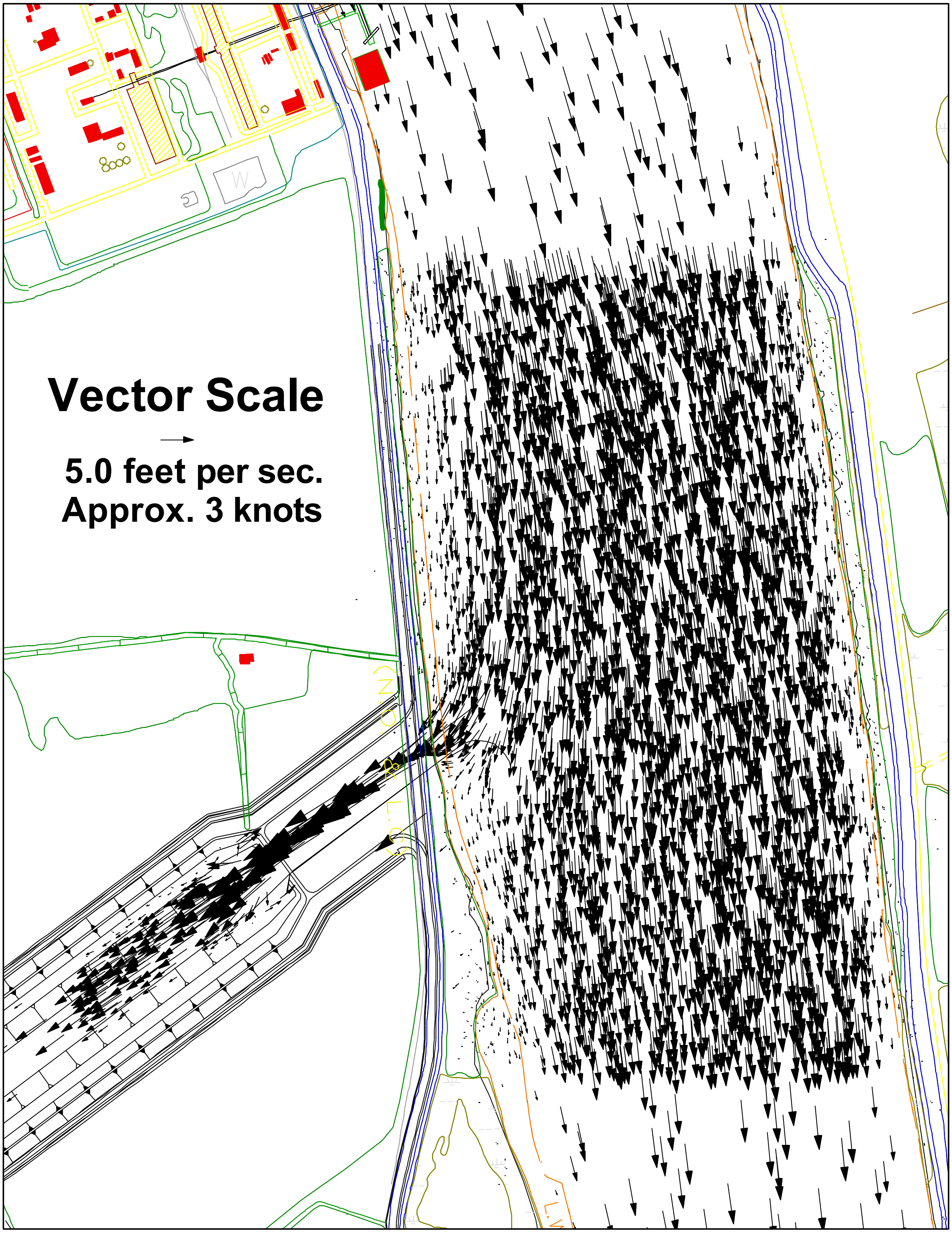


Figure 11: River Current at 975kcfs Flow Rate (30ft depth-averaged) (Inset)

4.1.4 Ships

Two ships were used to represent the shipping traffic through the project reach. A loaded and ballasted Suezmax tanker (47ft and 33ft draft, respectively) was used to represent the large class of ships and a loaded and ballasted Panamax bulk carrier (43ft and 33ft draft, respectively) represented a smaller class of vessels. These ships represented a wide variation in ship hull exposure to the currents as well as displacement. The pilot cards for these ships are presented in Appendix A.

4.1.5 Environment

Because the focus of this study was to determine if the currents generated by the diverted water from the Mississippi River would impact marine navigation through this reach, it was concluded that no other environmental conditions would be included in the testing program. Therefore, no wind or waves were included in the testing program.

4.2 Simulation Results

4.2.1 Ship Tracklines

During the simulations for deep-draft vessels in the Mid-Barataria simulation database twenty-six runs were completed. Table 1 lists these runs associated with critical tests conditions. Two Crescent City pilots conducted the simulations and they alternated between the helm and the con during the tests. The river flow conditions consisted of three discharge levels and two averaging depth values. The average currents for the averaging depths (30ft and 50ft) were obtained from the 3d numerical current model output provided by HDR and were calculated over these specific depths so as to most accurately account for the drafts of the ballasted and loaded ships tested.

Table 2: Mid-Barataria Deep-draft Vessel Simulations

Run	Trackplot	Ship	Load Cond.	Travel Dir.	River Discharge	Current Averaging Depth	Pilot
R01	Figure 12	Panamax	Ballast	Down	600kcfs	30ft	B
R02	Figure 12	Panamax	Ballast	Down	700kcfs	30ft	A
R03	Figure 12	Panamax	Ballast	Down	975kcfs	30ft	B
R04	Figure 12	Panamax	Loaded	Down	600kcfs	50ft	A
R05	Figure 12	Panamax	Loaded	Down	700kcfs	50ft	B
R06	Figure 12	Panamax	Loaded	Down	975kcfs	50ft	A
R07	Figure 13	Suezmax	Ballast	Down	600kcfs	30ft	B
R08	Figure 13	Suezmax	Ballast	Down	700kcfs	30ft	A
R09	Figure 13	Suezmax	Ballast	Down	975kcfs	30ft	B
R09A	Figure 13	Suezmax	Ballast	Down	975kcfs	30ft	A

R10	Figure 13	Suezmax	Loaded	Down	600kcfs	50ft	A
R11	Figure 13	Suezmax	Loaded	Down	700kcfs	50ft	B
R12	Figure 13	Suezmax	Loaded	Down	700kcfs	50ft	A
R13	Figure 13	Suezmax	Loaded	Down	975kcfs	50ft	B
R14	Figure 14	Panamax	Ballast	Up	600kcfs	30ft	A
R15	Figure 14	Panamax	Ballast	Up	700kcfs	30ft	B
R16	Figure 14	Panamax	Ballast	Up	975kcfs	30ft	A
R17	Figure 14	Panamax	Loaded	Up	600kcfs	50ft	B
R18	Figure 14	Panamax	Loaded	Up	700kcfs	50ft	A
R19	Figure 14	Panamax	Loaded	Up	975kcfs	50ft	B
R20	Figure 15	Suezmax	Ballast	Up	600kcfs	30ft	A
R21	Figure 15	Suezmax	Ballast	Up	700kcfs	30ft	B
R22	Figure 15	Suezmax	Ballast	Up	975kcfs	30ft	A
R23	Figure 15	Suezmax	Loaded	Up	600kcfs	50ft	B
R24	Figure 15	Suezmax	Loaded	Up	700kcfs	50ft	A
R25	Figure 15	Suezmax	Loaded	Up	975kcfs	50ft	B

Figures 12-15 show composite trackplots for the runs shown in Table 1. The first composite trackplot in Figure 12 shows loaded and ballasted Panamax bulk carriers passing the Mid-Barataria diversion canal downbound. After an initial simulation the starting position of the ship was shifted upstream based on pilot request. This placed the ship above the upper boundary of the hydrodynamic model and currents were approximated in accordance to the computed velocity distribution at the upper boundary, the river bathymetry and the experience of the pilots. The trackplot includes runs for all three river flows (600kcfs, 700kcfs, 975 kcfs). The applied river current for the ballasted vessel was obtained by averaging the x and y magnitude components from the top 30 ft of the layered 3d numerical model solution output. This averaging process was extended down to 50 ft for the loaded ship simulations. The pilots made note of no difficulties during the downbound transit past the diversion.

Figure 13 shows the loaded and ballasted Suezmax tanker transiting downstream through the study reach in the three river flows. The ship's starting position was shifted closer to the normal position in the channel after the first few simulations, per pilot request. The reader is referred to the depictions of the current vectors presented earlier for better understanding of the current magnitude and direction that the pilot was experiencing during the transits. The pilots made serveral runs specifically going close to the diversion conveyance channel to evaluate the effect of these currents on the handling of the ship. The pilots made note of no difficulties during the downstream pass.

Figure 14 shows the upbound loaded and ballasted Panamax bulk carrier passing the proposed Mid-Barataria diversion canal. The upstream runs were initiated at Poverty Point and the pilots followed their normal practice of staying closer to the east bank of the Mississippi River where deeper water existed. The runs were conducted in all three flows as before and the pilots stated that the ship had no reaction to the diverted flow of the canal on the other side of the river.

Figure 15 shows the composite trackplot of the loaded and ballasted Suezmax tanker upbound from Poverty Point past the proposed diversion canal. The swept path of the tanker was somewhat broader than that for the Panamax bulker shown previously. This was due to the physical characteristics of the ship and not due to influence of the canal outflow.

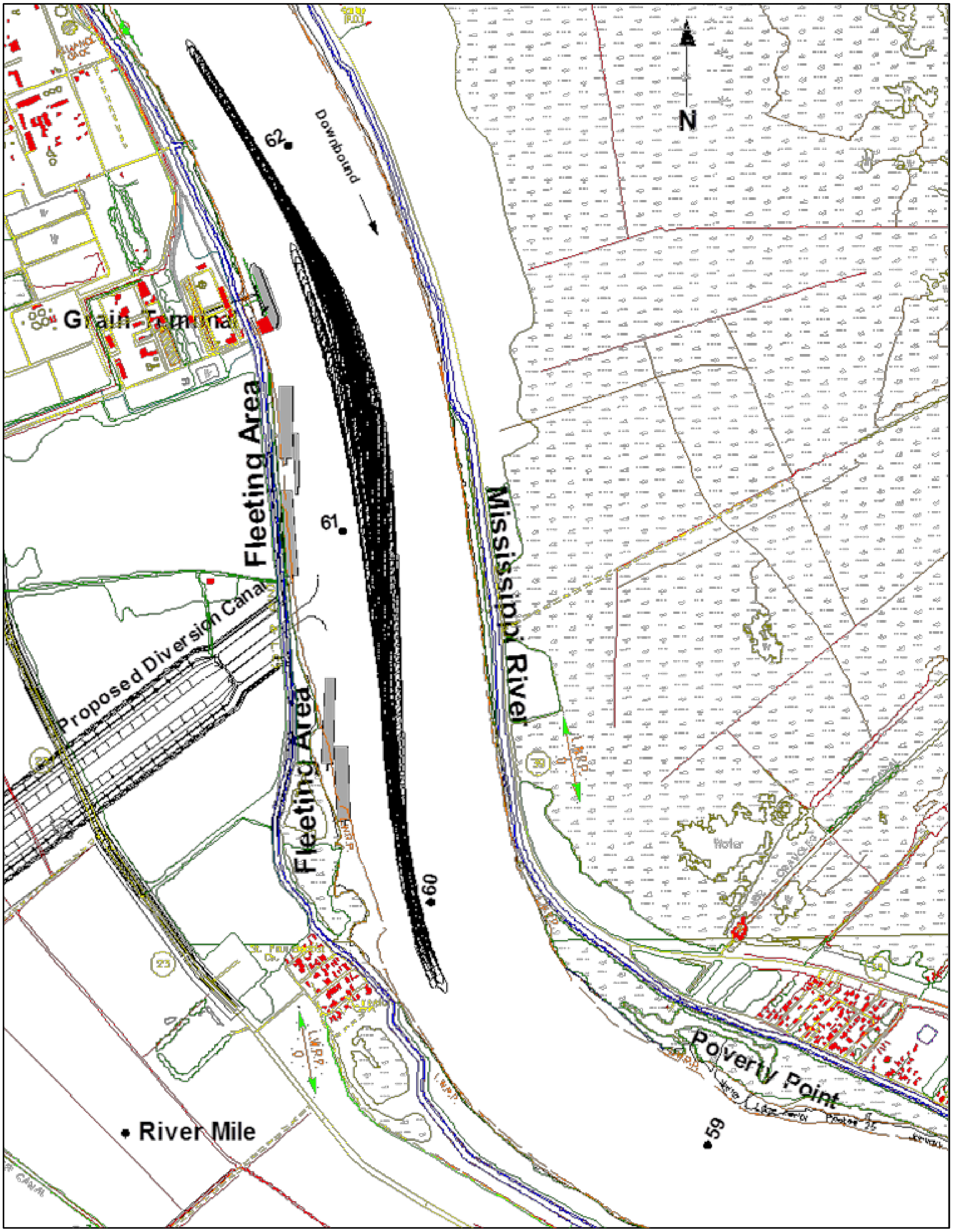


Figure 12: Downbound Ballasted and Loaded Panamax Bulker (794ft x 106ft x 33ft/43ft) 600/700/975-kcfs River Flows, Pilots A&B

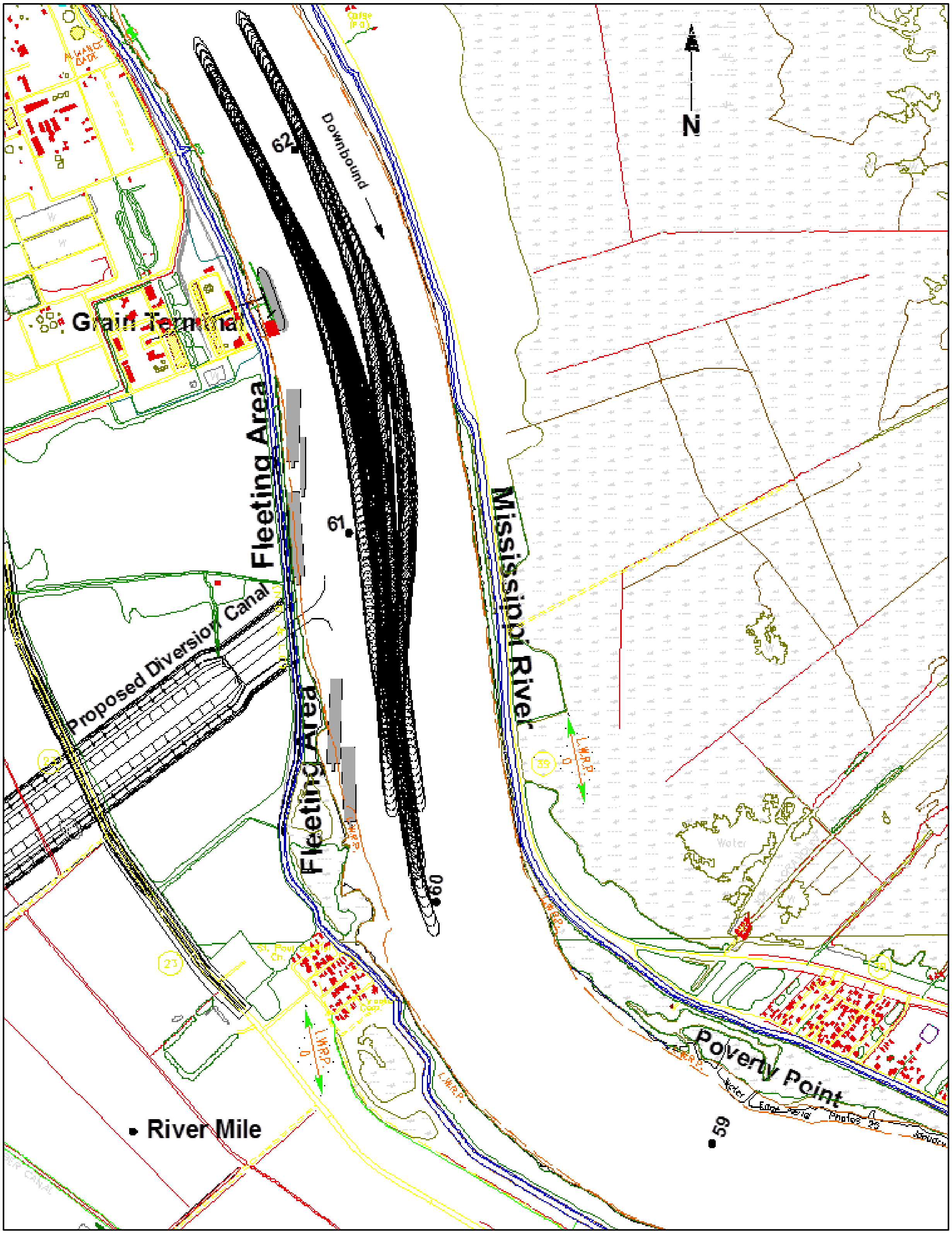


Figure 13: Downbound Ballasted and Loaded Suezmax Tanker (919ft x 164ft x 33ft/47ft) 600/700/975-kcfs River Flows, Pilots A&B

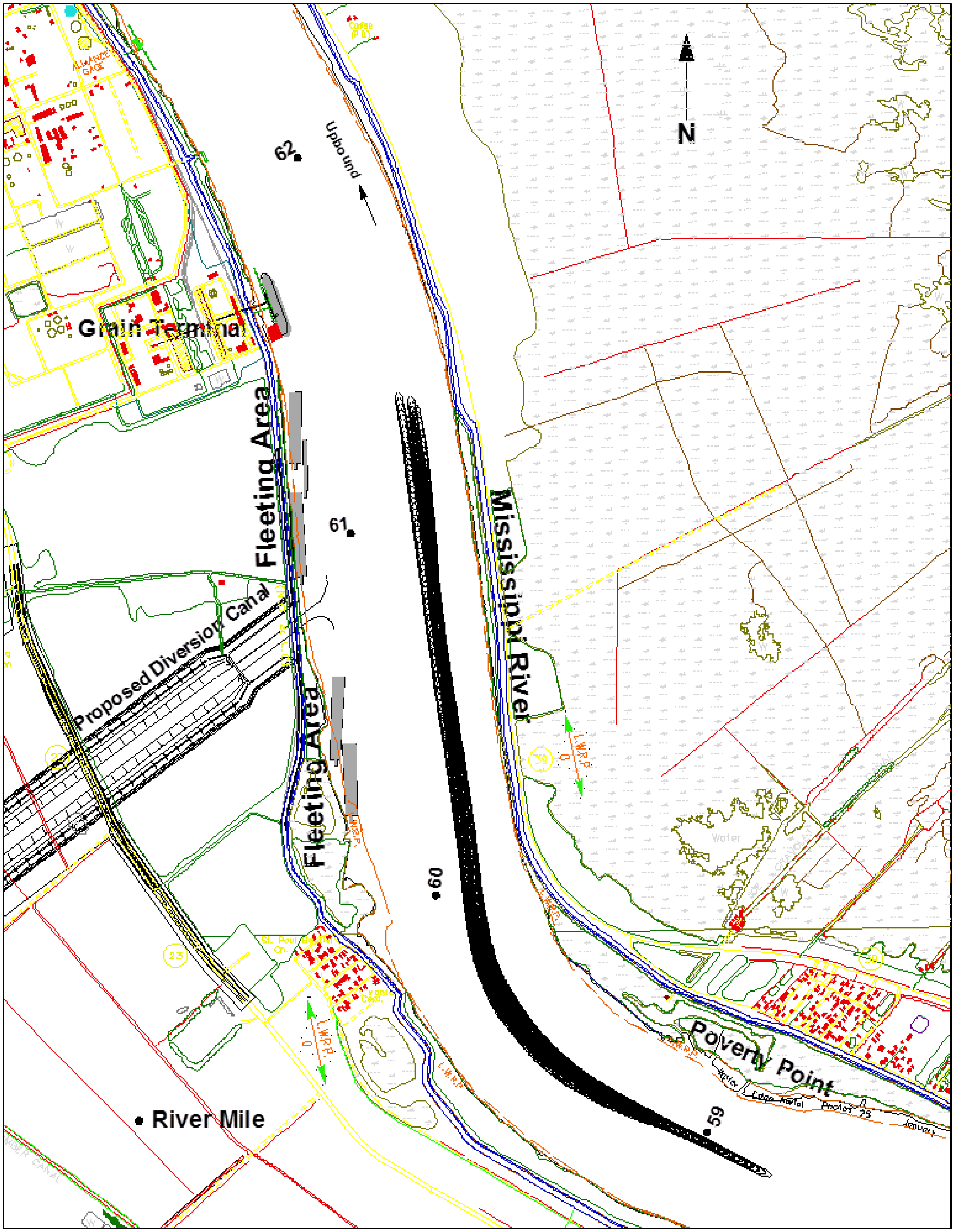


Figure 14: Upbound Ballasted and Loaded Panamax Bulker (794ft x 106ft x 33ft/43ft) 600/700/975-kcfs River Flows, Pilots A&B

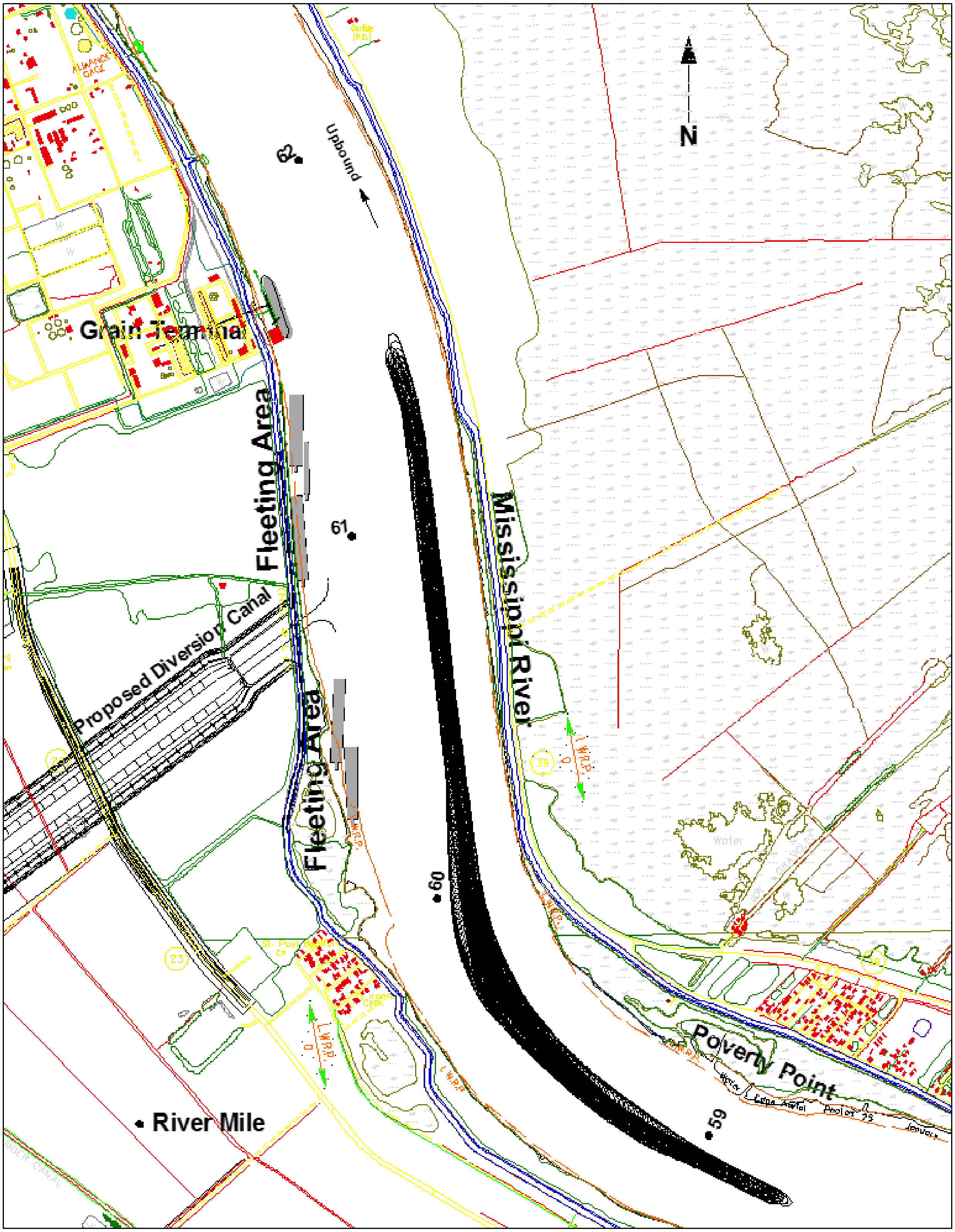


Figure 15: Upbound Ballasted and Loaded Suezmax Tanker (919ft x 164ft x 33ft/47ft) 600/700/975-kcfs River Flows, Pilots A&B

4.2.2 Pilot Questionnaires

4.2.2.1 Run Questionnaires

Following each simulated transit, the pilots were requested to complete a questionnaire designed to obtain the conning pilot's evaluation of the difficulty and safety of the transit and any specific thoughts that they had concerning the impacts of the diversion project on their ability to maintain control of the ship (see Appendix B for an example of the questionnaire). The results of these questionnaires are presented in Table 3. The pilots were advised to rate the difficulty and safety of the run with a value between 1 and 10; with 1 being very easy or safe, 5 indicating normal control and safety, and 10 being very difficult or unsafe. The pilot's response was that navigation conditions are average difficulty and safety according to their experience with existing conditions.

Table 3: Pilot's Response to Run Questionnaires

Run	Maintain Track	Impact of Diversion Flow	Difficulty	Safety	Safety Qualifiers	Perform in Real Life	Additional Comments/Recommendations
R01	I was able to maintain until I got near upriver side of opening and had to correct course once I got below opening; ship handled well	None	5	3	None	Yes	Really have no recommendations to change anything.
R02	Yes	Had to hold a small amount of port rudder to stay on track	5	5		Yes	No recommendations
R03	I was able to maintain my track	None	5	5	None	Yes, I would run same transit as normal	No recommendations
R04	Yes	None	5	5		Yes	None
R05	Yes, I was able to run maintain track line	No	5	5	No	Yes, I would	None
R06	Yes	No impact	5	5		Yes	None
R07	I was able to maintain course	None	5	5	None	Yes; would maneuver the same	None
R08	Yes	None	5	5		Yes	None
R09	Yes, until after opening bow went to starb when all other ships went to port. Think reason was due to ship.	None	5	5	No	Yes	None
R10	Yes	None	5	5		Yes	None
R11	Yes	None	5	5	None	Yes	None
R12	Yes	None	5	5		Yes	None
R13	Yes	None	5	5	None	Yes	No recommendations
R14	Yes	None	5	5	No	Yes	None
R15	Yes	None	5	5		Yes	None
R16	Yes	None	5	5	None	Yes	None
R17	Yes	None	5	5		Yes	None
R18	Yes, I was able to maintain track line	None	5	5	None	Yes	None
R19	Yes	None	5	5		Yes	None
R20	Yes	None	5	5		Yes	None
R21	Yes	None	5	5	None	Yes	None
R22	Yes	None	5	5		Yes	None
R23	Yes	None	5	5	None	Yes	None
R24	Yes	None	5	5		Yes	None
R25	Yes	None	5	5	None	Yes	None

4.2.2.2 Final Questionnaire

Following all simulations the pilots were requested to complete a final questionnaire to obtain their evaluation of the simulation experience and the project impacts on navigating through the project reach (see Appendix B for the final questionnaire). The results of this questionnaire are present in Table 4. The pilots were instructed to rate the items with numbers between 1 to 10 with 1 being very unrealistic or unsafe, 5 being average, and 10 being very realistic or safe.

Table 4: Pilot's Responses to the Final Questionnaires

	Pilot A	**Pilot B**
Realism of Ship Modleing		
Suezmax LD	8	9
Suezmax BL	8	9
Panamax LD	8	9
Panamax BL	8	9
Realism of Environmental Modeling		
Wind	--	9
River Currents	7	9
Visual Scene	8	8
Channel	9	9
Ship to Bank Interaction	7	8
Overall Safety		
Channel Adjacent to Proposed Diversion	8	9

In addition the pilots were asked to make statement about the project

Recommendations to increase safety and/or efficiency of the passage past the proposed diversion channel.

Pilot A None. From the simulations we ran I did not find any safety problems

Pilot B I don't see any problems with passing through the proposed diversion canal.

Additional Comments about this project

Piilot A None

Pilot B -----

5 Conclusions and Recommendations

5.1 Conclusions

- Downbound deep-draft ships transit through the western half of the river channel - fairly close to the diversion canal; however, the study pilots reported no navigation influence during the simulations due to the canal outflow.
- Upbound deep-draft ships transit close to the east bank of the river opposite the diversion canal at a distance which precludes all navigation influence of the canal outflow.
- In general, deep-draft vessel navigation passing the proposed Mid-Barataria Sediment Diversion Canal is safe when diversion canal gates are open in the river flow range of 600- to 975kcfs.

5.2 Recommendations

- Continue normal deep-draft vessel navigation following construction of diversion canal.

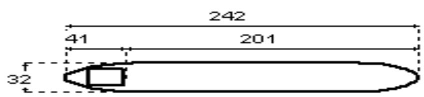
6 Appendix A: Ship Model Pilot Cards

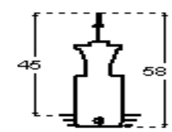
PILOT CARD

Ship name	Bulk Panamax_MMX 3.0.17.1 *			Date	21.08.2013
IMO Number	N/A	Call Sign	N/A	Year built	1995
Load Condition	Full Load				
Displacement	81960 tons	Draft forward	13 m / 42 ft 9 in		
Deadweight	70000 tons	Draft forward extreme	13 m / 42 ft 9 in		
Capacity		Draft after	13 m / 42 ft 9 in		
Air draft	45 m / 148 ft 0 in	Draft after extreme	13 m / 42 ft 9 in		

Ship's Particulars

Length overall	242 m	Type of bow	Bulbous
Breadth	32 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15	(1 shackle =27.5 m / 15 fathoms)	
Max. rate of heaving, m/min	9 / 9		





Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.14 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	24 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	669.6 s	9.25 cbls
HAH to HAS	820.6 s	9.07 cbls
SAH to SAS	1029.1 s	8.7 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees	
Advance	4.31 cbls
Transfer	1.96 cbls
Tactical diameter	5.01 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 11671 kW	Propeller type	FPP
Astern power	77.6 % ahead	Min. RPM	20
Time limit astern	N/A	Emergency FAH to FAS	16.2 seconds

Engine Telegraph Table

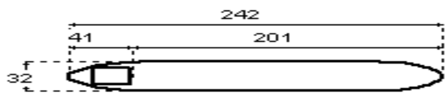
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	14	10292	85	1.05
"80%"	11.7	6008	71	1.05
"60%"	9.4	3115	57	1.05
"40%"	7.1	1345	43	1.05
"20%"	4.8	417	29	1.05
"-20%"	-2.4	479	-28	1.05
"-40%"	-3.5	1384	-40	1.05
"-60%"	-4.4	2858	-51	1.05
"-80%"	-5.5	5375	-63	1.05
"-100%"	-6.5	9057	-75	1.05

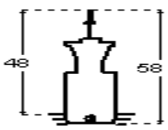
PILOT CARD

Ship name	Bulk Panamax_MMX 3.0.18.0 *			Date	21.08.2013
IMO Number	N/A	Call Sign	N/A	Year built	1995
Load Condition	Partial Loaded 1				
Displacement	55200 tons		Draft forward	10 m / 32 ft 10 in	
Deadweight	45820 tons		Draft forward extreme	10 m / 32 ft 10 in	
Capacity			Draft after	10 m / 32 ft 10 in	
Air draft	48 m / 157 ft 10 in		Draft after extreme	10 m / 32 ft 10 in	

Ship's Particulars

Length overall	242 m	Type of bow	Bulbous
Breadth	32 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	15 / 15		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9 / 9		





Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.13 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	24 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	543.6 s	7.85 cbls
HAH to HAS	664.6 s	7.66 cbls
SAH to SAS	829.6 s	7.28 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	3.99 cbls
Transfer	1.91 cbls
Tactical diameter	4.87 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 11671 kW	Propeller type	FPP
Astern power	77.6 % ahead	Min. RPM	20
Time limit astern	N/A	Emergency FAH to FAS	16.2 seconds

Engine Telegraph Table

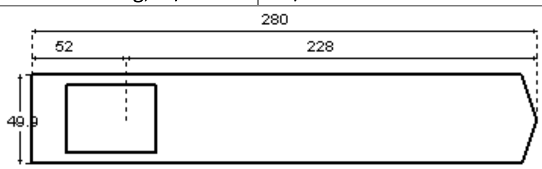
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	14	10050	85	1.05
"80%"	11.7	5862	71	1.05
"60%"	9.4	3044	57	1.05
"40%"	7.1	1313	43	1.05
"20%"	4.8	410	29	1.05
"-20%"	-2.4	479	-28	1.05
"-40%"	-3.5	1384	-40	1.05
"-60%"	-4.4	2858	-51	1.05
"-80%"	-5.5	5375	-63	1.05
"-100%"	-6.5	9057	-75	1.05

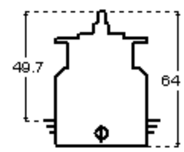
PILOT CARD

Ship name	VLCC 4_Suez_Statoil 3.0.22.0 *			Date	14.10.2013
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Partial Loaded 1				
Displacement	157873.23 tons		Draft forward	14.3 m / 47 ft 0 in	
Deadweight	135770 tons		Draft forward extreme	14.3 m / 47 ft 0 in	
Capacity			Draft after	14.3 m / 47 ft 0 in	
Air draft	49.7 m / 163 ft 5 in		Draft after extreme	14.3 m / 47 ft 0 in	

Ship's Particulars

Length overall	280 m	Type of bow	Bulbous
Breadth	49.9 m	Type of stern	V-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	13 / 13		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	18 / 18		





Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.01 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	28 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	1045.6 s	13.13 cbls	Advance	5.33 cbls
HAH to HAS	1270 s	12.46 cbls	Transfer	2.77 cbls
SAH to SAS	1691.3 s	11.97 cbls	Tactical diameter	6.53 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 26120 kW	Propeller type	FPP
Astern power	75 % ahead	Min. RPM	11.98
Time limit astern	N/A	Emergency FAH to FAS	35.2 seconds

Engine Telegraph Table

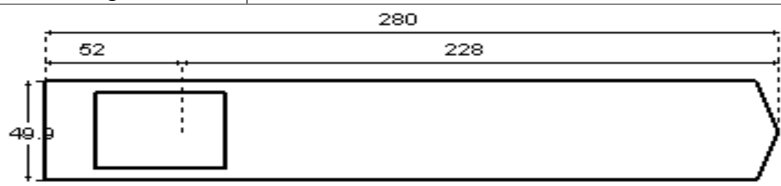
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	16	20896	85	0.8
"FAH"	13.2	12076	70	0.8
"HAH"	10.4	6209	55	0.8
"SAH"	7.5	2663	40	0.8
"DSAH"	4.5	760	24	0.8
"DSAS"	-2.4	922	-24	0.8
"SAS"	-3.7	2773	-37	0.8
"HAS"	-5	6260	-50	0.8
"FAS"	-6.2	11409	-62	0.8
"FSAS"	-7.5	19590	-75	0.8

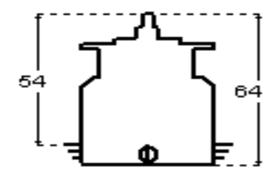
PILOT CARD

Ship name	VLCC 4_Suez_Statoil 3.0.22.0 *			Date	14.10.2013
IMO Number	N/A	Call Sign	N/A	Year built	N/A
Load Condition	Partial Loaded 3				
Displacement	110400.86 tons		Draft forward	10 m / 32 ft 10 in	
Deadweight	96050 tons		Draft forward extreme	10 m / 32 ft 10 in	
Capacity			Draft after	10 m / 32 ft 10 in	
Air draft	54 m / 177 ft 7 in		Draft after extreme	10 m / 32 ft 10 in	

Ship's Particulars

Length overall	280 m	Type of bow	Bulbous
Breadth	49.9 m	Type of stern	V-shaped
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	13 / 13	(1 shackle =27.5 m / 15 fathoms)	
Max. rate of heaving, m/min	18 / 18		





Steering characteristics

Steering device(s) (type/No.)	Semisuspended / 1	Number of bow thrusters	N/A
Maximum angle	35	Power	N/A
Rudder angle for neutral effect	0.01 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	28 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	934.6 s	11.83 cbls
HAH to HAS	1132.5 s	11.18 cbls
SAH to SAS	1506.5 s	10.7 cbls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees	
Advance	5.02 cbls
Transfer	2.55 cbls
Tactical diameter	6.03 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 26120 kW	Propeller type	FPP
Astern power	75 % ahead	Min. RPM	11.98
Time limit astern	N/A	Emergency FAH to FAS	35.2 seconds

Engine Telegraph Table

Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	16	20896	85	0.8
"FAH"	13.1	12076	70	0.8
"HAH"	10.3	6209	55	0.8
"SAH"	7.5	2663	40	0.8
"DSAH"	4.5	760	24	0.8
"DSAS"	-2.4	922	-24	0.8
"SAS"	-3.6	2773	-37	0.8
"HAS"	-4.9	6260	-50	0.8
"FAS"	-6.1	11409	-62	0.8
"FSAS"	-7.4	19590	-75	0.8

7 Appendix B: Pilot Questionnaires

<table>
<tr><td colspan="3">**Run #:**</td><td colspan="3">**Date:**</td><td colspan="2">**Bridge:**</td><td>**Pilot:**</td></tr>
<tr><td>**Circle Ship Used**</td><td>**Suez LD**</td><td>**Suez Empty**</td><td>**Pan LD**</td><td>**Pan Empty**</td><td></td><td></td><td>**Ship's Initial Speed:**</td><td>**Ship's Initial Heading:**</td></tr>
<tr><td rowspan="2">**Environmental Conditions**</td><td colspan="3">**River Flow (kcfs)**</td><td colspan="2">**Current Averaging Depth (ft)**</td><td colspan="2">**Wind Dir. (from)**</td><td>**Wind Speed (knots)**</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="4">**Run Start Time:**</td><td colspan="5">**Run End Time:**</td></tr>
<tr><td colspan="4">**Start Location:**</td><td colspan="5">**End Location:**</td></tr>
<tr><td colspan="2">**Notes:**</td><td colspan="7"></td></tr>
</table>

1 Were you able to maintain the intended track line and voyage plan on this exercise? (If not, why?)

2 What was the navigation impact of the proposed diversion channel flow.

3 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Increasing Difficulty →

1 2 3 4 5 6 7 8 9 10

4 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Increasing Safety →

1 2 3 4 5 6 7 8 9 10

Do you have any “qualifiers” to the above safety rating (senior pilot only, restricted to daylight transits, wind direction/speed limitations, current, etc.)?

5 Would you perform a similar transit / maneuver in a real-world situation? If not, why?

6 If applicable, what additional conclusion or recommendations do you have regarding the vessel, channel, under keel clearance, current, etc.?

Mid-Barataria Simulations
Final Pilot Evaluation of Deep-draft Simulation Tests
Thursday, October 24 to Friday, October 25, 2013

Date:		Pilot/Captain:	

Section A = Realism	"REALISM" Rating Scale	1	Unrealistic	5	Average	10	Excellent

	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
1.	**Suezmax Loaded**	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
2.	**Suezmax Ballast**	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
3.	**Panamax Loaded**	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
4.	**Panamax Ballast**	1	2	3	4	5	6	7	8	9	10
	Ship Model Realism	(Circle Choice)				Increasing Realism→→→					
5.		1	2	3	4	5	6	7	8	9	10

	Environmental Conditions Realism	(Circle Choice)				Increasing Realism→→→					
6.	**Wind**	1	2	3	4	5	6	7	8	9	10
	Environmental Conditions Realism	(Circle Choice)				Increasing Realism→→→					
7.	**River Currents**	1	2	3	4	5	6	7	8	9	10
	Database Realism	(Circle Choice)				Increasing Realism→→→					
8.	**Visual Scene**	1	2	3	4	5	6	7	8	9	10
	Database Realism	(Circle Choice)				Increasing Realism→→→					
9.	**Channel**	1	2	3	4	5	6	7	8	9	10
	Database Channel Designs Realism	(Circle Choice)				Increasing Realism→→→					
10.	**Ship to Bank Interaction**	1	2	3	4	5	6	7	8	9	10

Section B = Safety	Overall "SAFETY" Rating Scale	1	Unsafe	5	Average	10	Very Safe

	Overall Safety	(Circle Choice)				Increasing Safety→→→					
1.	Channel Adjacent to Proposed Diversion	1	2	3	4	5	6	7	8	9	10

Section C = Recommendations and Comments

2. Please describe any recommendations you have for increasing the safety and/or efficiency of the passage past the proposed diversion canal.

3. Please write additional comments you would like to make concerning this project.