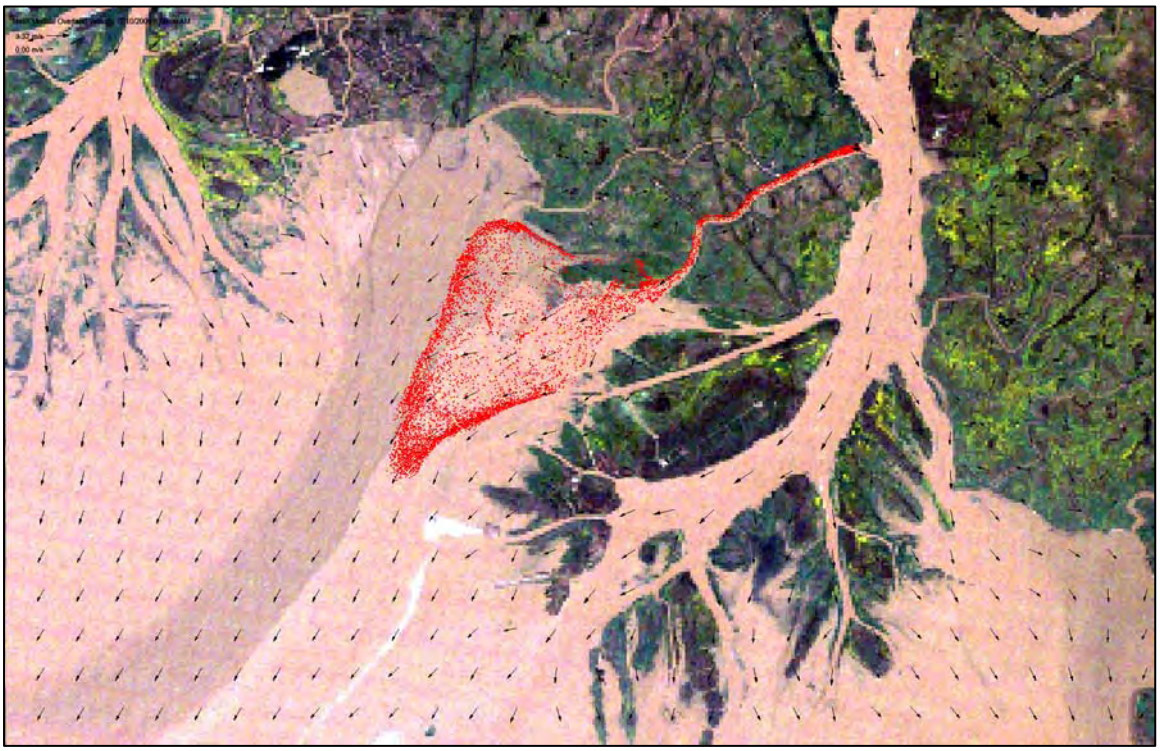
Particle Transport Analysis
Shell Island Pass
Atchafalaya River, LA

Part 1: Particle Tracking Model (PTM) Simulation of Dredge Material Releases in Shell Island Pass



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1. Introduction

Shell Island Pass is a 3 mile long distributary subchannel of the Atchafalaya River delta (Figure 1). The inlet to Shell Island Pass is located about 2 miles below the Horseshoe Bend on the Atchafalaya River. Studies cited by Teeter and Johnson[1] report up to 88 million tons of sediment per year are discharged by the Lower Atchafalaya River (LAR) and Wax Lake Outlet. Atchafalaya Bay traps about 25 percent of the total sediment input and it is estimated that 76 percent of silts and 95 percent of clays are dispersed beyond the bay. Approximately 1 million cubic yards of sediment are dredged each year from the Horseshoe Bend reach of the Atchafalaya River[2,3]. Records indicate that the dredge material consists of approximately 66% fine sand and 33% very fine sand[3]. Bed surface sediment samples from Horseshoe Bend in 2007 had high silt and clay content[4].

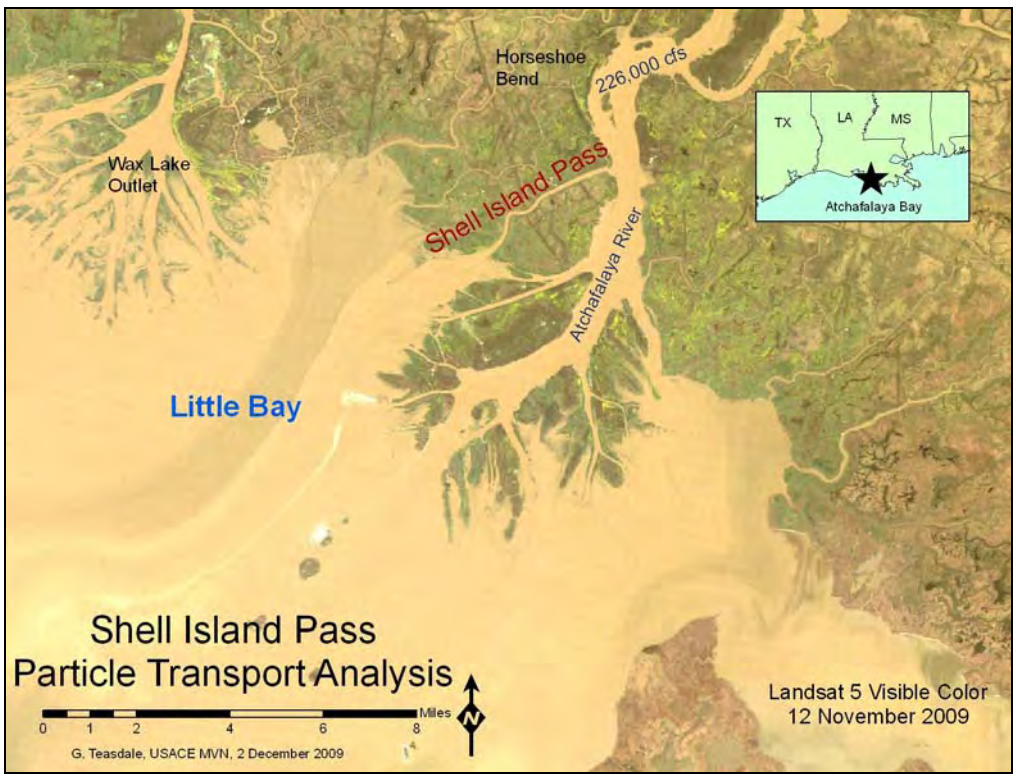

Figure 1. Atchafalaya River - Shell Island Pass.

[1] Teeter, A. M. and Johnson, B. H. (2005). "Atchafalaya Bar Channel Numerical Hydrodynamic and Fluid / Settled Mud Modeling," Computational Hydraulics and Transport LLC, Edwards, Mississippi.
[2] Ayres, S. (2009). *Shell Island Pass Interim Study Report*. Hydraulics and Hydrology Section, New Orleans District, U.S. Army Corps of Engineers.
[3] USACE (2002). *Shell Island Pass Briefing Note*. Hydraulics and Hydrology Section, New Orleans District, U.S. Army Corps of Engineers.
[4] Smith, J. (2009). Sedflume Analysis of Cohesive Sediment Erosion, Horseshoe Bend of Atchafalaya River, Louisiana, Engineering Research and Development Center, Coastal and Hydraulics Lab, U.S. Army Corps of Engineers,

The color of the surface water in Landsat 5 image in Figure 1 indicates a high suspended sediment concentration in the Atchafalaya River and Shell Island Pass when the image was acquired on 12 November 2009. The mean daily discharge of the Atchafalaya River on 12 November was 226,000 cubic feet per second (cfs). A flow-duration analysis shows that the Atchafalaya River discharge equaled or exceeded 226,000 cfs only 6.9 percent of the time in the period 1999 to 2009, so high sediment loads would be expected when the Landsat image was acquired. The discharge in Shell Island Pass is estimated to be about 22,600 cfs based on the results of the hydrodynamic simulation discussed below. Flow patterns are made visible in Figure 1 by the fine sediment entrained in the Atchafalaya River and Wax Lake Outlet discharges. This and other Landsat images provide independent validation of the flow paths predicted by the sediment transport analysis.

1.1. Beneficial Use of Dredge Material

The extent and quality of marshland in Little Bay, near the outlet of Shell Island Pass, has diminished because of storm surge, sea level rise and subsidence[5]. As part of coastal restoration work, it is proposed to replenish the marshland with material dredged from Horseshoe Bend. One alternative being considered is to dispose dredge material at the inlet of Shell Island Pass where it may be transported by ambient flows to the near shore tidal flats of Little Bay. This method of dispersal would be more cost effective than barging the sediment to deeper water or directly pumping the sediment to Little Bay through a slurry line.

1.2. Sediment Transport Analysis Objectives

The technical feasibility of the flow dispersal method depends on the characteristics of the dredge material and the sediment transport dynamics of Shell Island Pass and Little Bay. Sediment transport characteristics of the flow dispersal method were evaluated with several approaches. A two-dimensional Adaptive Hydraulics (ADH) hydrodynamic and sediment transport model has been developed for the lower Atchafalaya River, Shell Island Pass and the affected area of Atchafalaya Bay. The hydrodynamic modeling study is described in a separate report[2] and suggests that a Lagrangian particle model be developed from the hydrodynamic output of the ADH simulations to track the distribution of released dredge material. The Shell Island Pass Project Delivery Team (PDT) subsequently authorized development of a Particle Tracking Model (PTM) and set initial objectives for the PTM simulation. This current work describes the PTM model development and summarizes the primary simulation

[5] PDT (2009). *Shell Island Pass Project Objectives (unpublished)*, Project Delivery Team, New Orleans District, U.S. Army Corps of Engineers.

results. It also examines additional aspects of channel morphology and sand-bed sediment transport to provide context for PTM results.

2. Particle Transport Analysis

A particle transport analysis, also known at particle tracking or tracing, is a mathematical modeling technique that evaluates the movement of individual particles suspended or saltating in a flowing fluid. In the science of fluid mechanics, particle transport methods often adopt the Lagrangian frame of reference which moves with the flow to simplify the mathematical description of the movement of individual particles through space and time. The alternative Eulerian frame of reference describes the bulk motion of fluid and particles as they passes fixed points in the model domain. The Eulerian approach is utilized in complex hydrodynamic models such as ADH, ADCIRC, CMS, and many others.

Lagrangian models are computationally efficient when the main interest is the fate of representative particles that do not significantly affect the motion of the flow. An Eulerian hydrodynamic simulation is a necessary prerequisite to a Lagrangian particle transport analysis. A single Eulerian hydrodynamic simulation can drive many Lagrangian simulations in which the properties of individual particles or particle clusters may be changed to study various aspects of particle fate and transport.

2.1. Particle Tracking Model (PTM)

This study utilized the Particle Tracking Model (PTM)[6] incorporated into the Surface-Water Model System (SMS)[7]. The PTM was developed jointly by the U.S. Army Corps of Engineers, Coastal Inlets Research Program (CIRP) and the Dredging Operations and Environmental Research program. Processes simulated by PTM include particle advection, diffusion, settling, deposition, and resuspension. Particle motion may be computed in two-dimensional (2D), quasi three-dimensional (q3D) flow and full three-dimensional (3D) modes which invoke different levels of physical process complexity. Only the 2D and q3D modes are currently implemented in SMS.

In 2D mode, sediment particles do not interact with each other or the sediment of the bed. Erosion and deposition are controlled by critical shear stress; obtained by default from the Shields function or a manually input user specified value. Particles are entrained when bed shear stress exceeds critical shear stress. Particle settling and vertical trajectories are not simulated. The 2-D

[6] MacDonald, N. J., M. H. Davies, A. K. Zundel, J. D. Howlett, T. C. Lackey, Z. Demirbilek, and J. Z. Gailani. (2006). PTM: Particle tracking Model; Report 1: Model theory, implementation, and example applications. ERDC/CHL TR-06-20. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

[7] http://www.aquaveo.com/.

simulations are generally faster than the other modes and show maximum particle excursions.

Particle settling and vertical trajectories are simulated in the q3D mode. Horizontal movements of particles are influenced by their positions in the water column and vertical velocity components. Particle and bed interactions include a stochastic component. Advection velocity calculations in the 2-D and Q3-D modes require computation of the suspended and bed load sediment concentration profiles which are computed with an adaptation of the Rouse concentration profile. Total sediment load is computed with either the Soulsby-van Rijn transport function (1997) or the van Rijn (1993) method.

Main inputs provided by the user include the time-varying water surface elevation and velocity vector fields (grids) from the hydrodynamic model, sediment mass inflows, and characteristic grain sizes of the sediment inflows and the bed. Users select primary control parameters include the simulation time increment, computation mode (2D, q3D), bed interaction parameters, and diffusion parameters. The user may also chose between alternative Eulerian-like processes that affect the computation of near-bed flow, bed shear, bed forms, and sediment particle mobility. Numerous model outputs may be selected including grain size, mobility parameter, velocity components, and fall velocity. Particle motions and properties are visualized and recorded in the SMS interface. Data files of particle trajectories and characteristics are output for further analysis.

2.2. Shell Island Pass Dredge Material Release Scenario

The overall objective of the particle transport analysis set by the PDT was to semi-quantitatively describe the dispersal limits and retention of a hypothetical mass of dredge material deposited at the head of Shell Island Pass. A PTM model was implemented in SMS with the ADH bathymetry and hydrodynamic simulation developed for the Lower Atchafalaya[2]. The domain of the model extended from the Gulf Intercoastal Water Way (GIWW) to outer limits of Atchafalaya bay.

The ADH hydrodynamic simulation was executed for a 13 day sequence of hourly discharges during which the hydrograph (Figure 2) that varied from 132,100 cfs to 213,100 cfs and averaged 185,400 cfs. Also plotted in Figure 2 is the simulated tide stage at the outlet of Shell Island Pass which varied from -0.74 ft to 2.36 ft. Shell Island Pass discharges computed by the ADH simulation varied from 14,400 cfs to 30,400 cfs and averaged 26,400 cfs, about 14 percent of the Atchafalaya River discharge above Shell Island Pass.

The flow duration curve for the Atchafalaya River for the 13-day simulation period is plotted in Figure 3 with the 10 year flow duration curve (1999 – 2009) for discharges recorded at the USGS stream gage on the Atchafalaya River at Morgan City. The annual maximum discharge frequency curve for the Morgan City gage is also plotted in Figure 3. The flow duration plots show that the discharges of the ADH simulation correspond to about the 10 percent flow

duration discharge for the lower Atchafalaya River. The peak of the simulated discharges corresponds to about the 80 percent chance exceedance discharge, equivalent to a return period of 1.25 years. The flow duration and discharge frequency statistics indicate that the discharges in the ADH simulation were moderate, but not excessive and provide a reasonable scenario for the particle transport analysis of released dredged material.

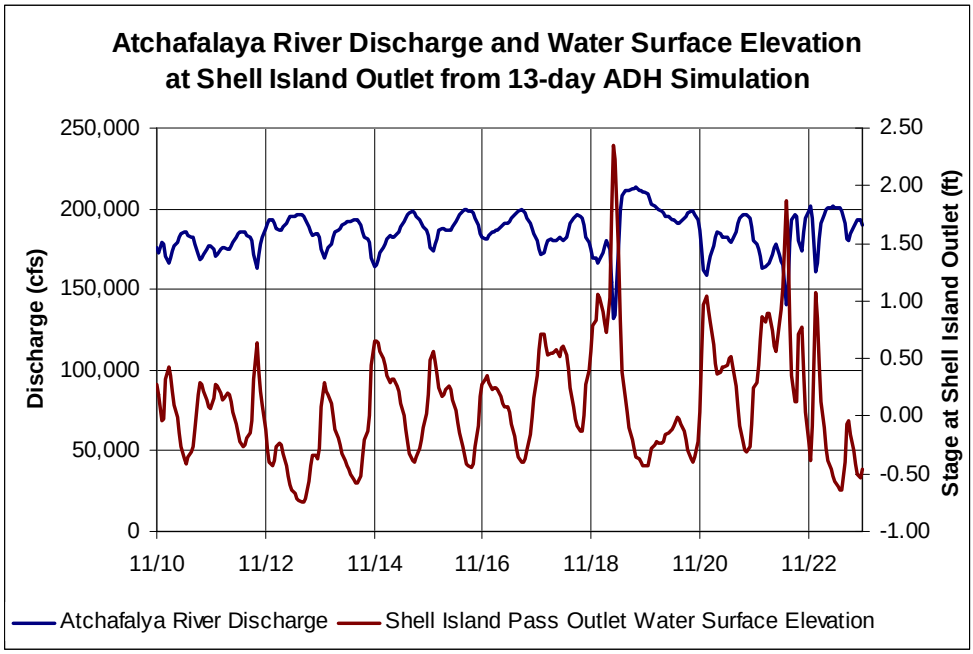

Figure 2. Atchafalaya River discharge and water surface elevation at outlet of Shell Island Pass.

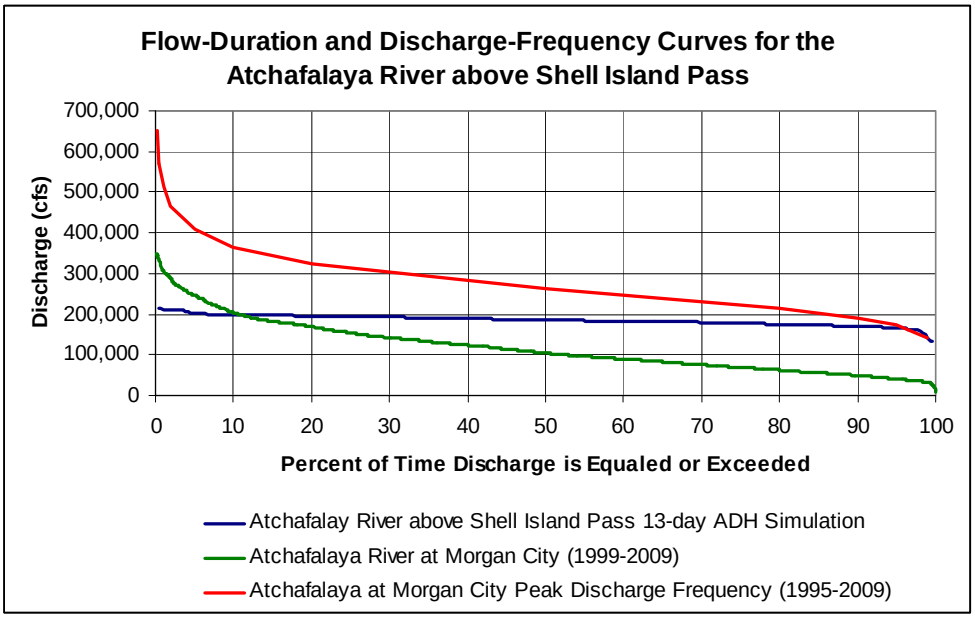

Figure 3. Flow-Duration and Flood-Frequency Curves for the Atchafalaya River

In the first scenario, a release of dredge material into the head of Shell Island Pass was simulated and its dispersal tracked through the full domain of the Lower Atchafalaya River ADH model. The release of both mixed grain and uniform fine-grained sediment was simulated. Since the objective of the analysis was to track the dredge material release, the bed was defined as fine sand to minimize direct bed entrainment. The median grain size of the bed was 0.2 mm and the 90th percentile size (D_{90}) was set a 0.3 mm.

A second scenario was developed with an ADH hydrodynamic model of the Shell Island Pass channel and the adjacent channel of the Atchafalaya River (Figure 4). The bathymetry for this model was extracted from the primary ADH model. Discharge and tide stage boundary conditions were developed from the discharges recorded at the Morgan City stream gage and the Lawma, Amerada Pass tide station. This model was developed to examine various aspects of Eulerian sediment transport and Lagrangian particle transport within the Shell Island Pass channel over a range of ambient discharges and simulated dredge releases. Initial results of this model and simulation are introduced below. A more detailed particle and sediment transport investigation is discussed in Part 2.

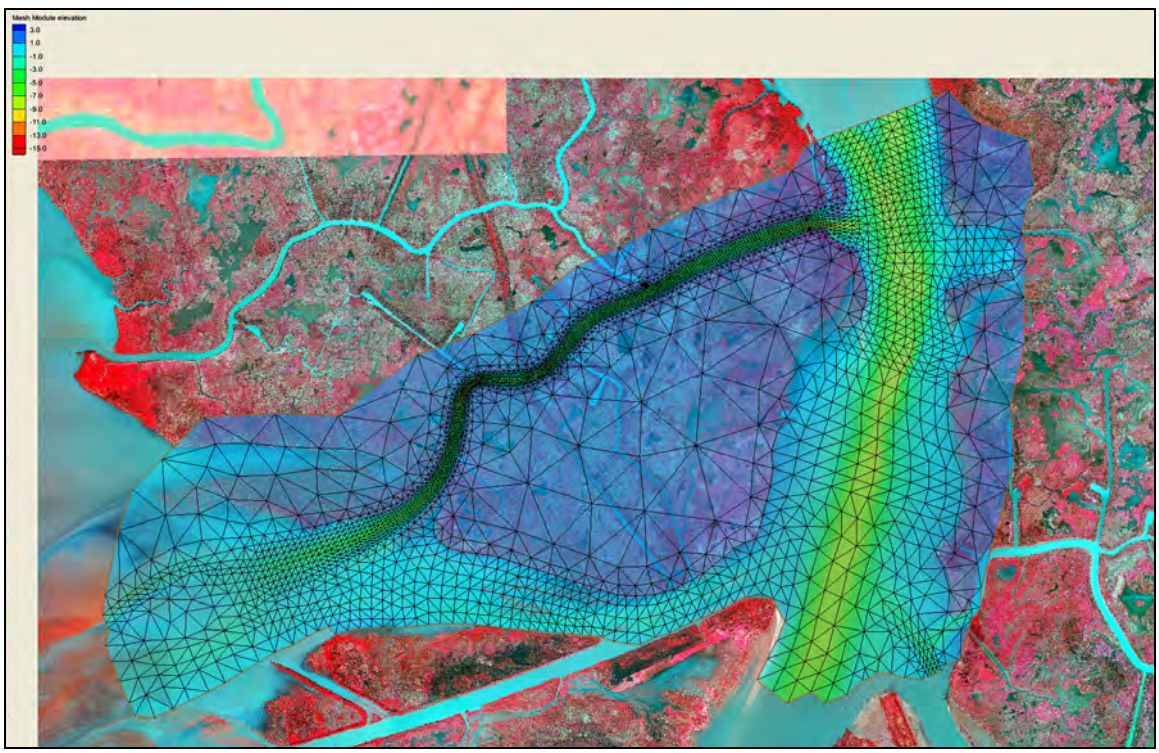

Figure 4. Shell Island Pass ADH model.

2.3. PTM Model Parameters

Particle tracking simulations were performed in both the two-dimensional and quasi three-dimensional modes. The Rouse concentration profile and 2D logarithmic velocity profile were selected for all simulations and the Eulerian

potential total load transport algorithm was set to the Soulsby-van Rijn ("PTM") method. The numerical scheme level was set to 2 for the 2D mode and level 4 was selected for the q3D mode. The horizontal and vertical diffusion scalar parameters were set to 0.25 and 0.0086 on guidance from the PTM user's manual[6]. The minimum diffusion coefficients were set at the suggested defaults of 0.02 m^2 s^{-1}. The diffusion parameters are in the range employed in estuary modeling[8]. For the 2D simulation, all model computation options were invoked except the algorithm that computes neutrally buoyant particles, morphology and mass wave transport. The computation options were the same for the first q3D simulation as for the 2D simulation except the computation level was set to 4. The morphology and mass wave transport were set for the second q3D simulation. After some experimentation, the computation time increment was set to 30 seconds for all final 2D and q3D simulations. Bed forms were updated every 5 minutes and particle positions were output every 30 minutes.

2.4. Particle Transport Simulations

Several simulations were developed to characterize the transport of dredge material through the full Lower Atchafalaya River ADH model domain. Both mixed grain and uniform sediments were simulated. The model parameters were varied to investigate the sensitivity of PTM results to model settings.

2.4.1. Simulation 1: 2D Simulation of the Release of Mixed Grain Dredge Material

In the first simulation, a total mass of 18.7 tons (17.0 metric tonnes) of mixed grain dredge material was released over a period of 1.0 hour in the simulation. The dredge material mass simulated as 8,479 particle clusters each representing a composite mass of 2 kg (4.4 lb). The source sediment had a median (D_{50}) grain size of 0.01 mm (fine silt) and a standard deviation of 2.2 phi units. The relatively large standard deviation assured that a significant quantity of clay and sand size particles would be present in the source material. Numerous PTM simulations were executed with the 13 day hydrodynamic output from the full domain Lower Atchafalaya River ADH model and with the smaller domain Shell Island Pass ADH model. The initial PTM simulations were performed in 2D mode to demonstrate the maximum potential dispersion of the dredge material.

Figure 5 through Figure 8 show the dispersal of the dredge material simulated by PTM for the first 24 hours of the 13 day ADH time series. The particles are superimposed on the 12 November 2009 Landsat 5 image to show the particle dispersal in relation to the observed sediment flow paths. Figure 6

[8] George L. Bowie, et al. (1985), *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling* (Second Edition) (EPA/600/3-85/040), Athens, GA.

also shows the boundary of the near-shore Little Bay Deposition Area (LBDA) used in the quantitative analysis of particle transport discussed below.

The dredge material particles are transported through Shell Island Pass and enter Little Bay within 2 hours of the initial release. Most of the material is dispersed within the Little Bay deposition area by the end of 8 hours. At the end of 12 hours, dredged material has merged with the discharge from the Wax Lake Outlet and is being transported to outer Atchafalaya Bay. The maximum extent of the dispersal in Little Bay occurs within 24 hours of the initial release. Particles begin to exit the model boundary in outer Atchafalaya Bay with 30 hours of release. The trajectories of the particles in the PTM simulation agree very well with the sediment streams observed in the 12 November 2009 Landsat image. Animated image sequences (AVI format) generated from the PTM time series provide additional insight to the transport of the dredge material particles through the ADH model domain.

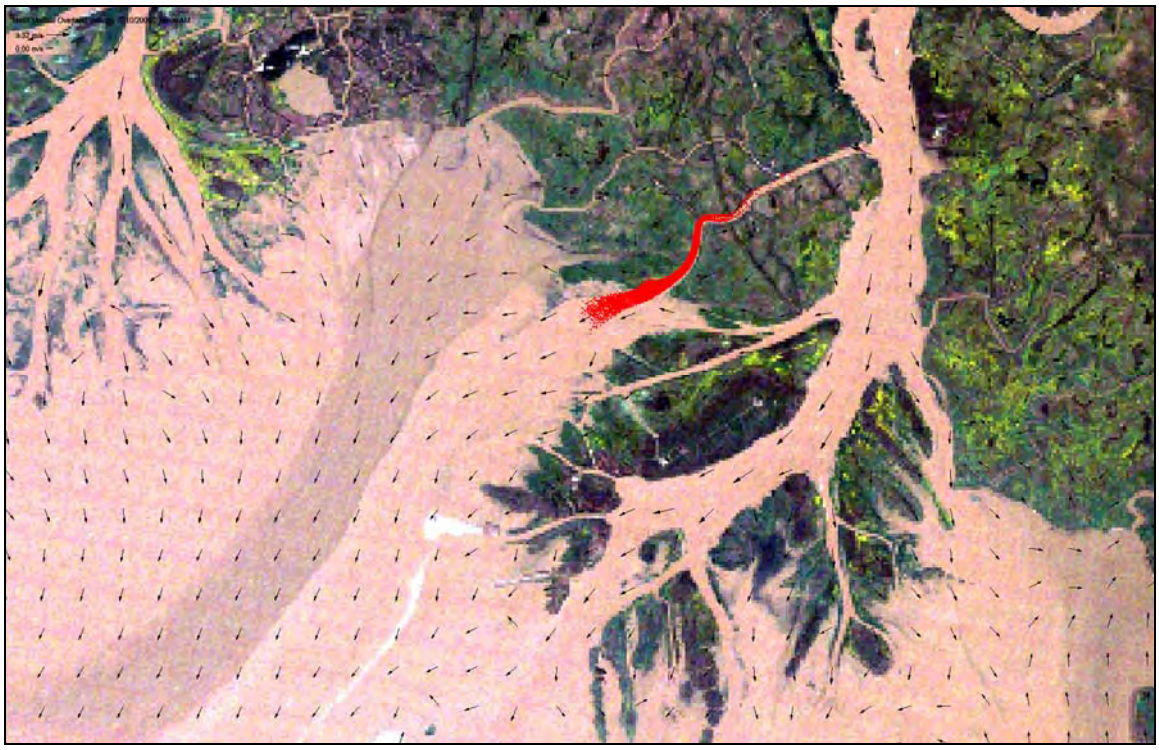

Figure 5. Initial 2D PTM simulation – time 2:00 hrs.

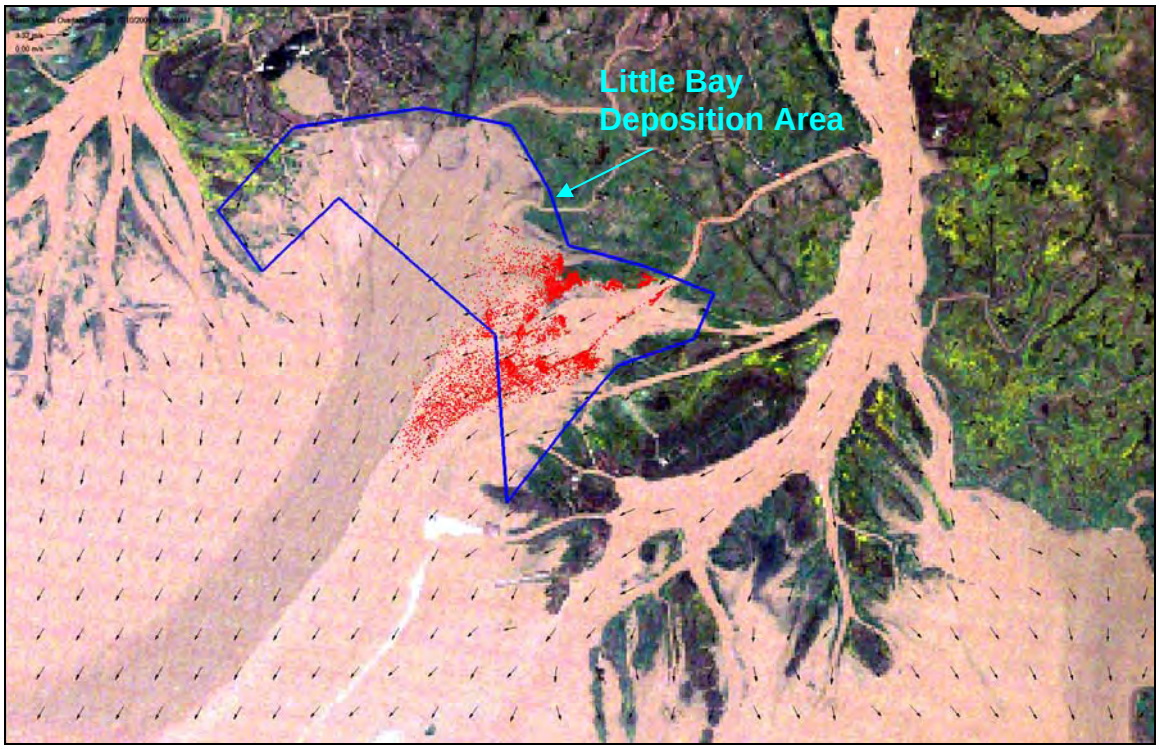

Figure 6. Initial 2D PTM simulation – time 8:00 hrs.

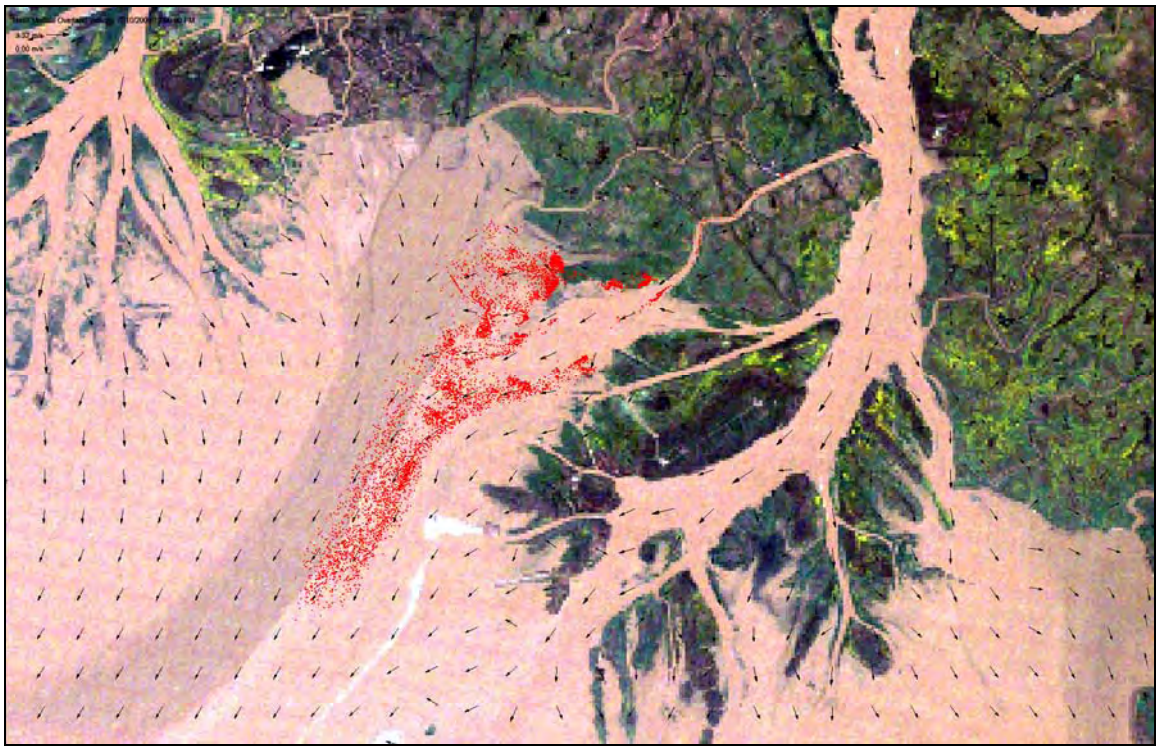

Figure 7. Initial 2D PTM simulation – time 12:00 hrs.

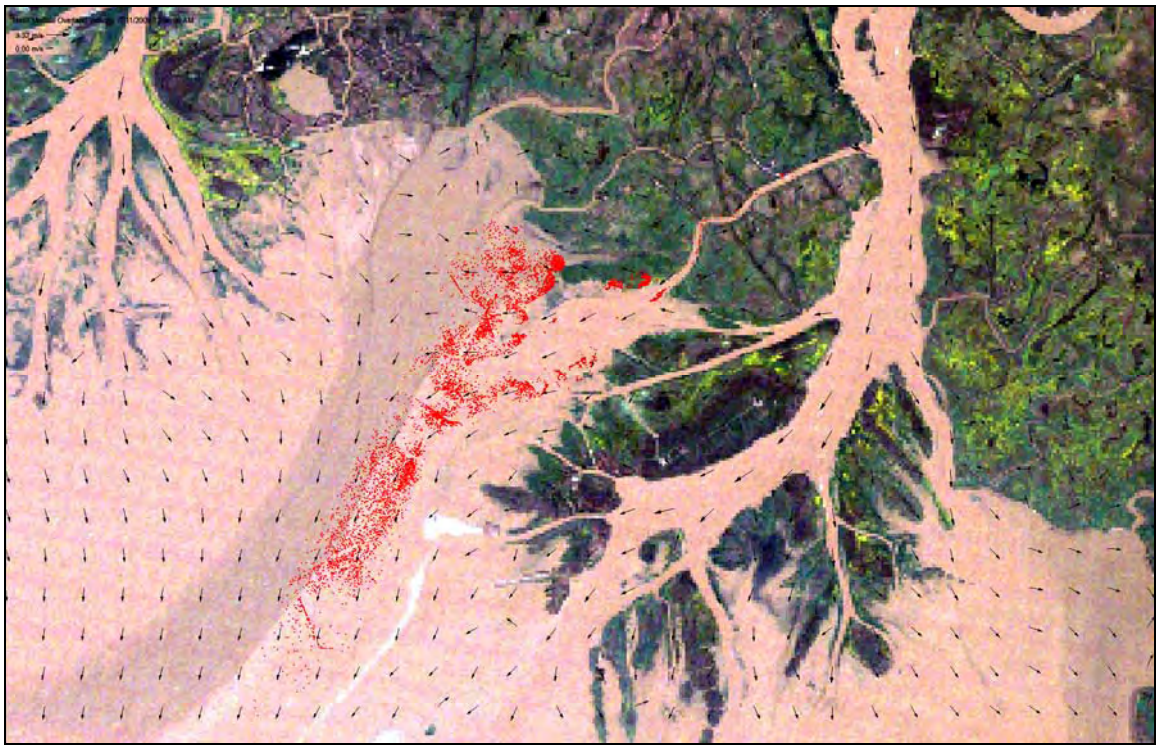

Figure 8. Initial 2D PTM simulation – time 24:00 hrs.

Quantitative particle transport data can be derived from the time series of PTM particle trajectories with the SMS interface. Summary statistics were developed for the full model domain and the LBDA. Table 1 summarizes the PTM 2D particle transport data for 13 day ADH time series. For the full model domain, statistics include the number of particles retained and percent retained. For the LBDA, the statistics include the particles retained, percent retained, mass retained, and average diameter of the retained particles.

	Full Model Domain Grid		Little Bay Deposition Area			
Date and Time	Particle Count	Percent Retained	Particle Count	Mass kg	Percent Retained	Avg. Diameter mm
11/10/09 0:00	8,473	99.9%	0			
11/10/09 3:00	8,473	99.9%	6,002	12,004	70.8%	0.022
11/10/09 6:00	8,473	99.9%	4,907	9,814	57.9%	0.034
11/10/09 12:00	8,472	99.9%	2,261	4,522	26.7%	0.135
11/11/09 0:00	8,472	99.9%	2,261	4,522	26.7%	0.168
11/12/09 0:00	4,958	58.5%	2,021	4,042	23.8%	0.180
11/13/09 0:00	4,205	49.6%	1,635	3,270	19.3%	0.185
11/14/09 0:00	4,061	47.9%	1,588	3,176	18.7%	0.194
11/15/09 0:00	4,029	47.5%	1,615	3,230	19.0%	0.195
11/16/09 0:00	4,029	47.5%	1,600	3,200	18.9%	0.197
11/17/09 0:00	3,982	47.0%	1,592	3,184	18.8%	0.199
11/18/09 0:00	3,967	46.8%	1,600	3,200	18.9%	0.205
11/19/09 0:00	3,801	44.8%	997	1,994	11.8%	0.296
11/20/09 0:00	3,233	38.1%	989	1,978	11.7%	0.299
11/21/09 0:00	3,233	38.1%	989	1,978	11.7%	0.299
11/22/09 0:00	3,100	36.6%	978	1,956	11.5%	0.303
11/23/09 0:00	2,695	31.8%	863	1,726	10.2%	0.337

Table 1. Particle transport statistics for the Little Bay Deposition Area – Simulation 2D-1.

About 32 percent of the particles are retained within the full model domain after 13 days (essentially 2 weeks). The percent particles retained declines rapidly as silt and clay sediment are dispersed beyond the model domain. Only 10 percent of the total initial mass is retained within the LBDA. The particles retained in the LBDA have an average size of 0.34 mm which is in the medium to fine sand size class. The time variation of percent retention and average particle size for the LBDA is plotted in Figure 9.

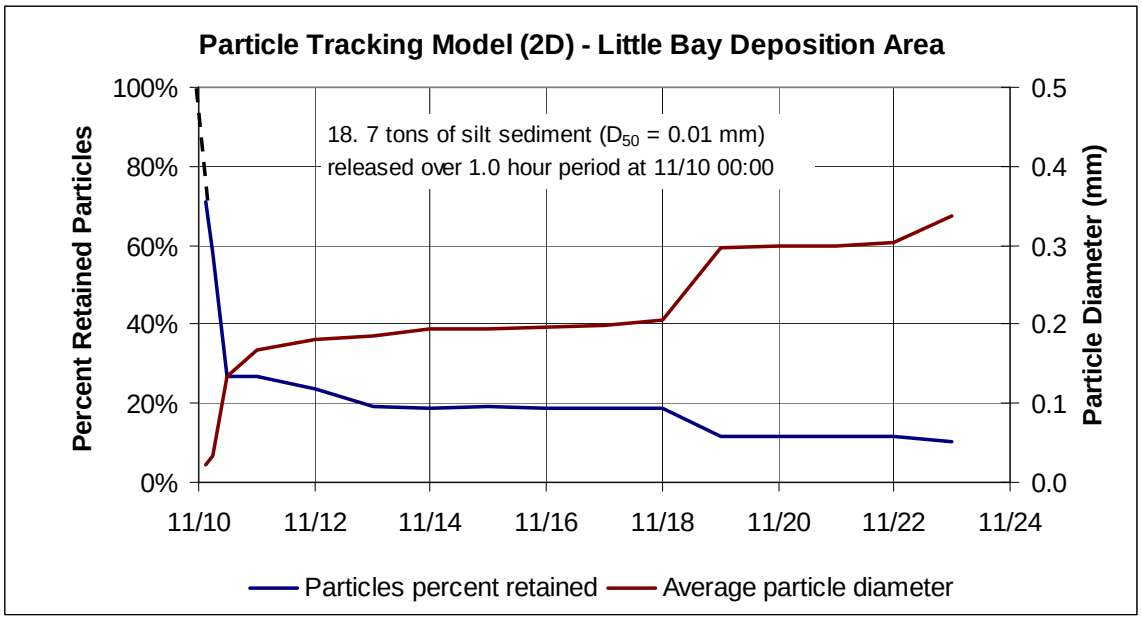

Figure 9. PTM (2D) dredge material particle retention and particle diameter for Little Bay.

2.4.2. Simulation 2: Quasi-3D simulation of the Release of Mixed Grain Dredge Material

Visual inspection of particle trajectory data indicated that the dispersal pattern produced by the PTM 2D simulation lacked the bedform organization expected when fine sand is transported in a shallow estuary[9,10]. In the second series of simulations, the PTM model was set to run in q3D mode at numerical scheme level 4. The results of the q3D simulation are shown in Figure 10 through Figure 16 and the particle transport data are summarized in Table 2.

The initial rate and pattern of particle dispersal in the q3D simulation is similar to the 2D simulation. This is expected because the ADH hydrodynamic time series of water surface elevations and velocity vectors are the same in both simulation sets. However, the particles within the transport zone become

[9] van Rijn, L.C. (2007). "Unified View of Sediment Transport by Currents and Waves.I: Initiation of Motion, Bed Roughness, and Bed-Load Transport", *Journal of Hydraulic Engineering*, 133(6).
[10] Garcia, M.H. (2008). "Chapter 2: Sediment Transport and Morphodynamics", *Sedimentation Engineering, Processes, Measurements, and Practice, ASCE Manuals and Reports on Engineering Practice No. 110*, American Society of Civil Engineers, Reston, VA.

noticeably more organized as the simulation progresses, particularly at the leading and lateral edges of the transport zone. Inclusion of the vertical velocity components in the trajectory computations influences the horizontal motion of the particles, slightly the rate of dispersal in the middle and latter phase of the simulation. The effect of the 3D simulation is clearly evident in the animated image series generated from the particle trajectory data.

The decrease in percent retention for the q3D particle transport data in Table 2 is about the same as in the 2D simulation, but the average particle size is reduced is reduced by about 30 percent. The smaller average size of the retained sediment is likely due to the effect of the particle hiding function that increases the critical (Shields) stress.

	Full Model Domain Grid		Little Bay Deposition Area					
	Particle	Percent	Particle	Mass	Percent	Particle Size, mm		
Date and Time	Count	Retained	Count	kg	Retained	Minimum	Maximum	Average
11/10/09 0:00	8,477	100.0%	0					
11/10/09 3:00	8,477	100.0%	5,834	5,829	34.4%	0.000	0.171	0.019
11/10/09 6:00	8,477	100.0%	4,607	9,214	54.3%	0.000	0.234	0.033
11/10/09 12:00	8,477	100.0%	2,165	4,330	25.5%	0.000	0.330	0.073
11/11/09 0:00	8,476	100.0%	1,903	3,806	22.4%	0.000	0.418	0.100
11/12/09 0:00	4,473	52.8%	1,618	3,236	19.1%	0.000	0.511	0.125
11/13/09 0:00	3,859	45.5%	1,442	2,884	17.0%	0.000	0.556	0.138
11/14/09 0:00	3,671	43.3%	1,440	2,880	17.0%	0.000	0.631	0.141
11/15/09 0:00	3,634	42.9%	1,433	2,866	16.9%	0.000	0.661	0.146
11/16/09 0:00	3,605	42.5%	1,440	2,880	17.0%	0.000	0.685	0.148
11/17/09 0:00	3,586	42.3%	1,425	2,850	16.8%	0.000	0.747	0.150
11/18/09 0:00	3,577	42.2%	1,405	2,810	16.6%	0.000	0.819	0.151
11/19/09 0:00	3,522	41.5%	1,003	2,006	11.8%	0.000	0.956	0.193
11/20/09 0:00	2,951	34.8%	972	1,944	11.5%	0.000	0.956	0.194
11/21/09 0:00	2,841	33.5%	954	1,908	11.3%	0.000	0.956	0.199
11/22/09 0:00	2,723	32.1%	804	1,608	9.5%	0.000	0.956	0.228
11/23/09 0:00	2,616	30.9%	778	1,556	9.2%	0.071	0.956	0.230

Table 2. Particle transport statistics for the Little Bay Deposition Area – Simulation q3D-1.

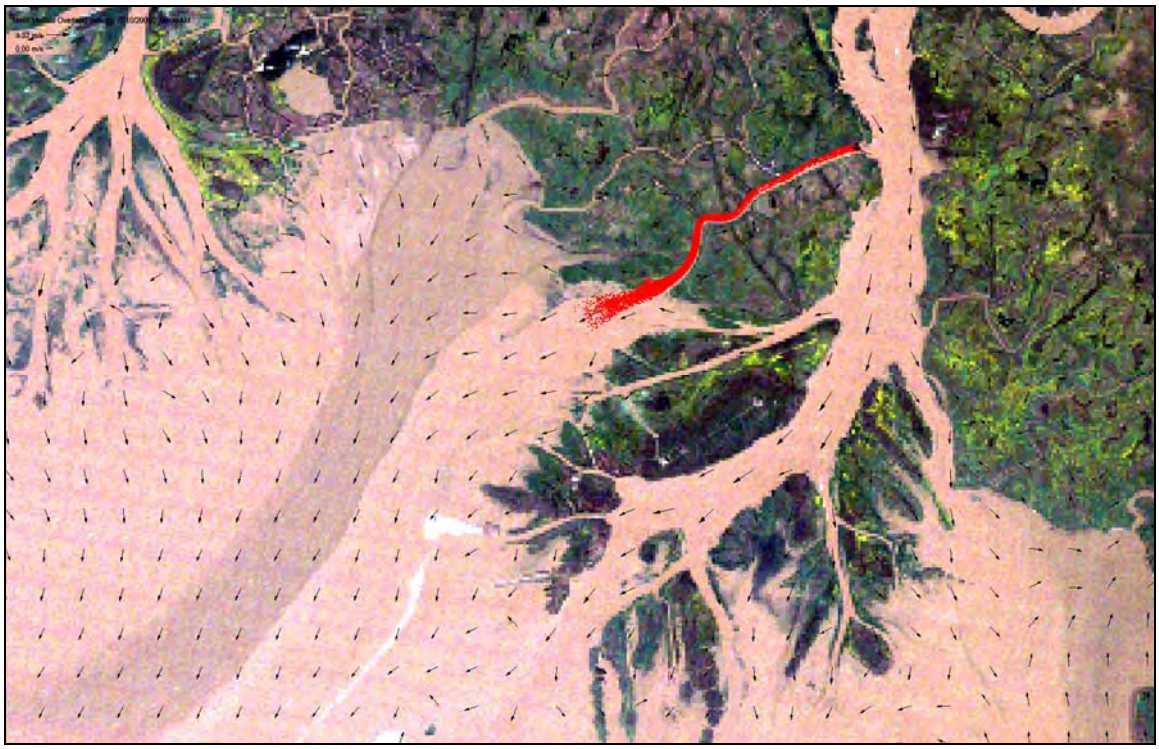

Figure 10. First q3D PTM simulation – time 2:00 hrs.

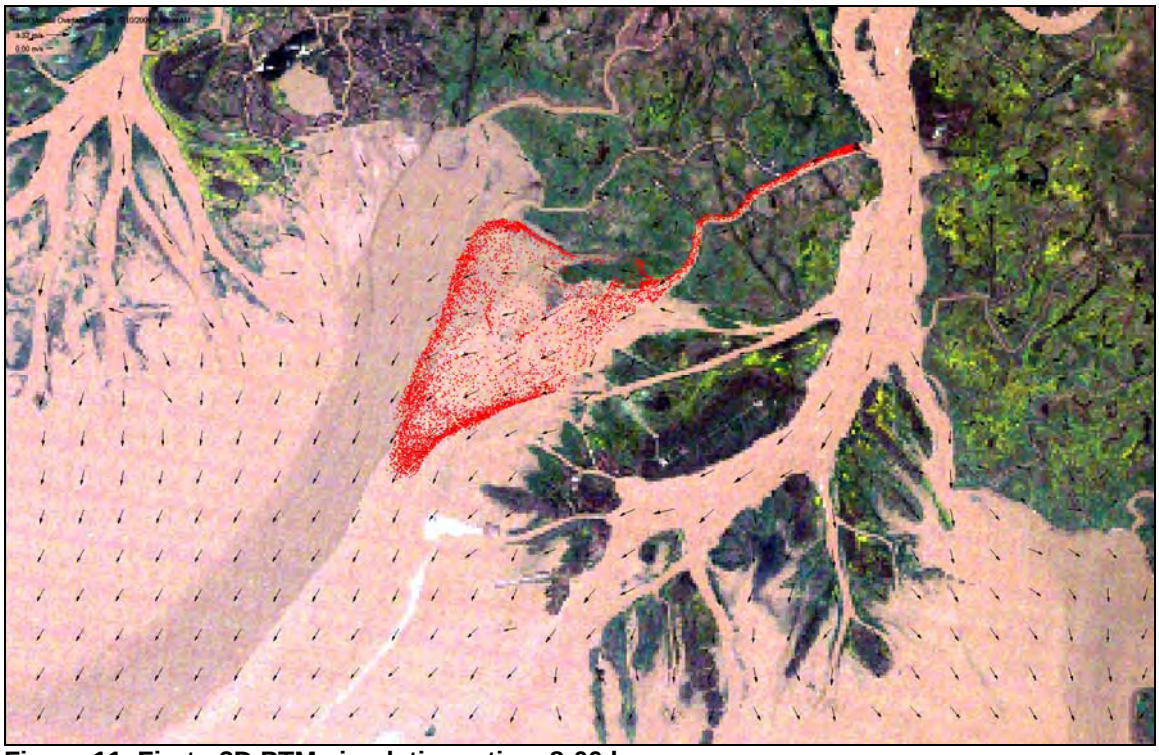

Figure 11. First q3D PTM simulation – time 8:00 hrs.

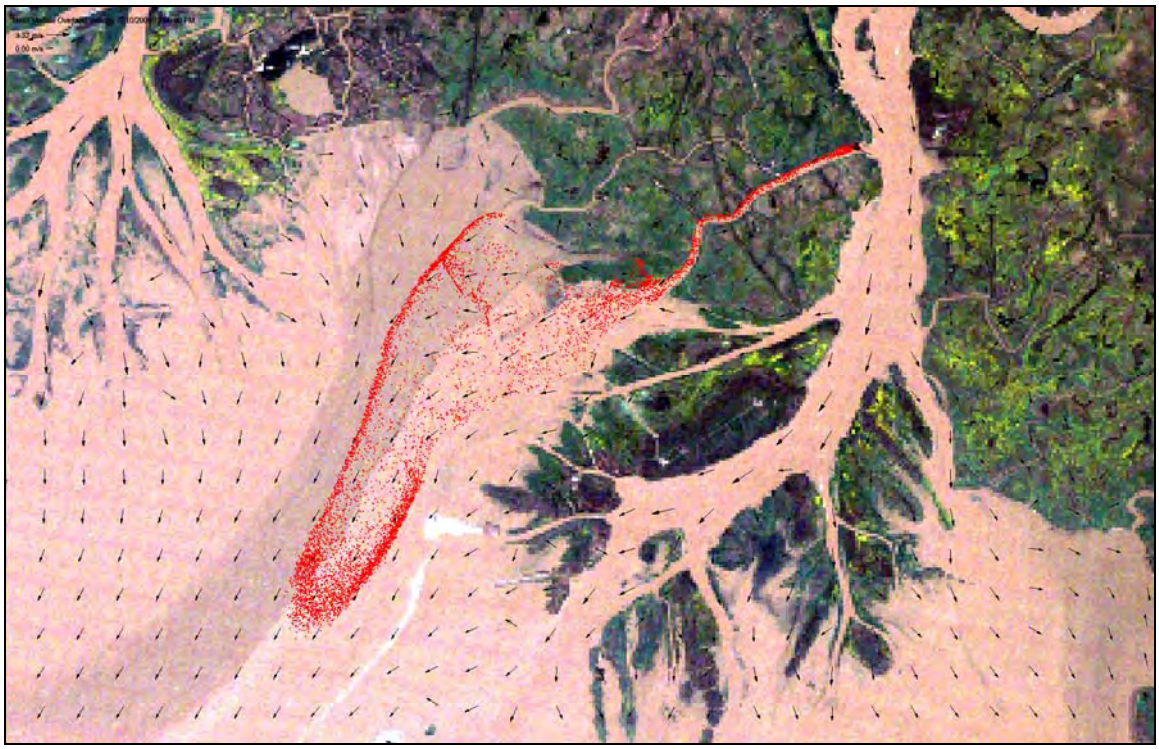

Figure 12. First q3D PTM simulation – time 12:00 hrs.

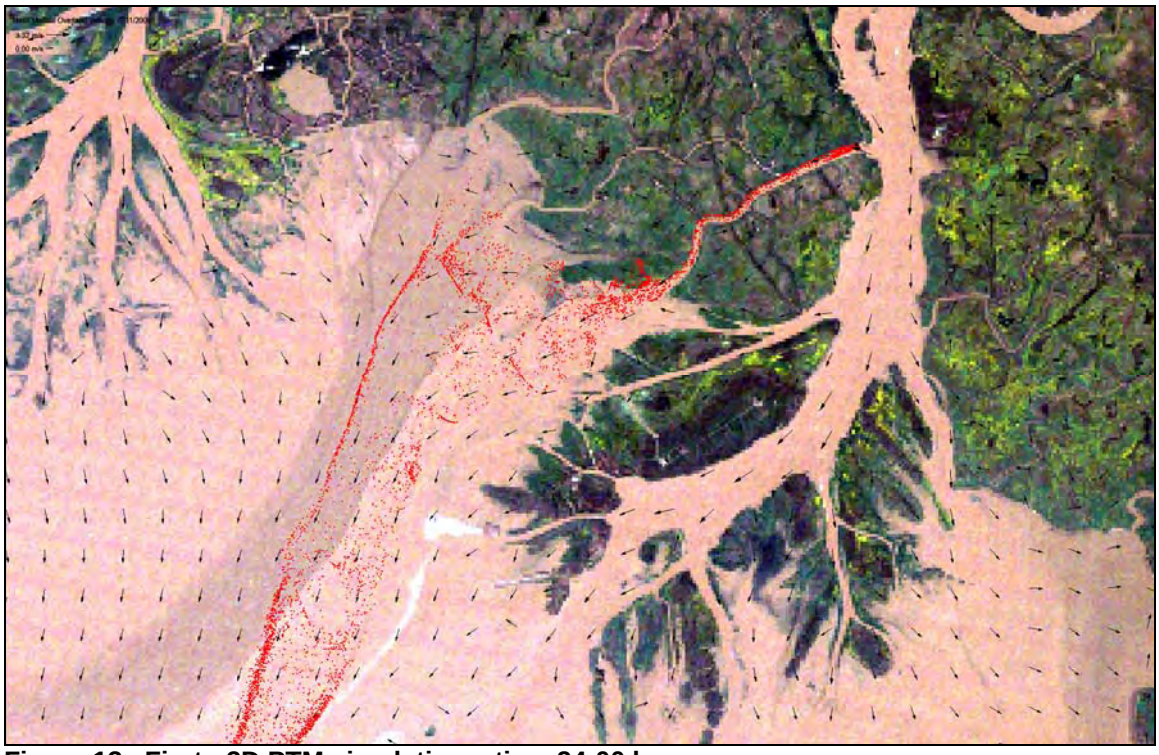

Figure 13. First q3D PTM simulation – time 24:00 hrs.

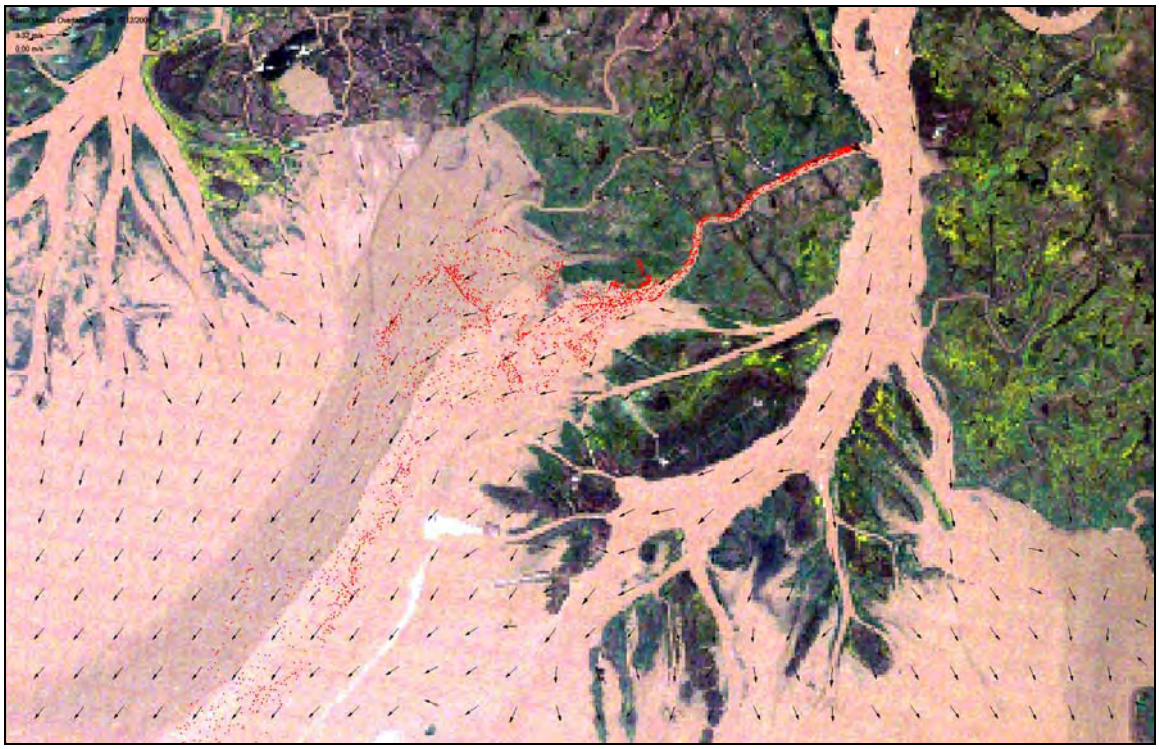

Figure 14. First q3D PTM simulation – time 48:00 hrs.

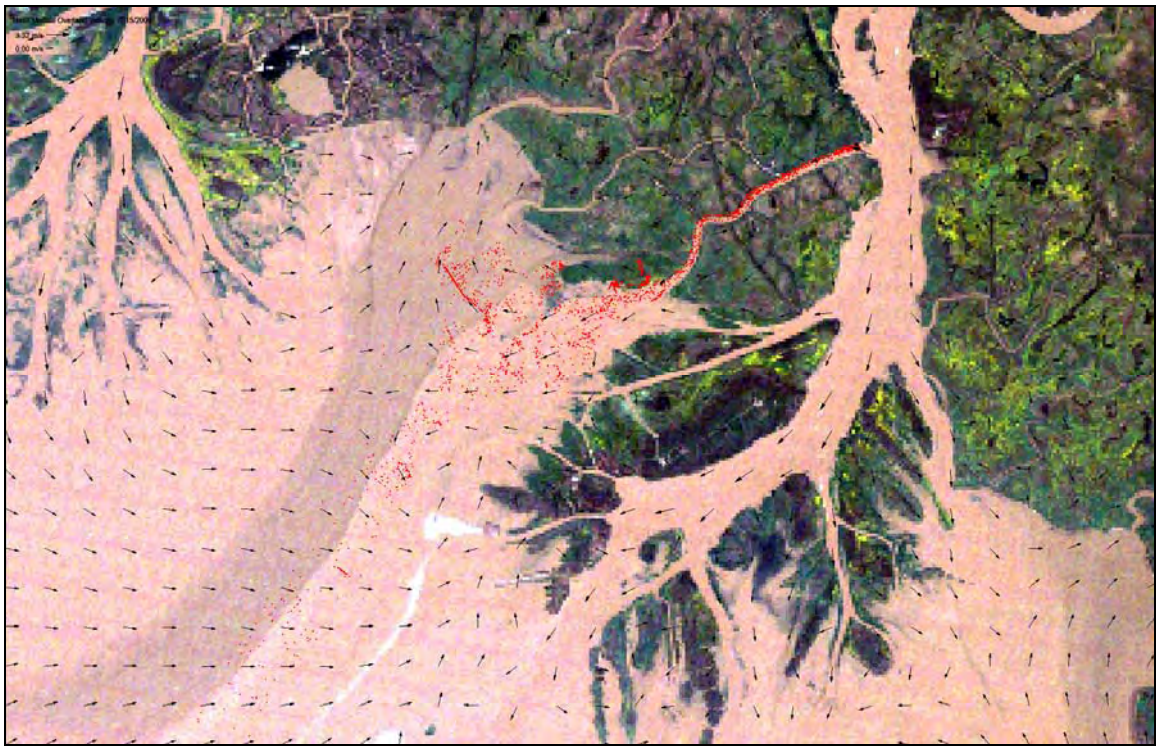

Figure 15. First q3D PTM simulation – 5 days.

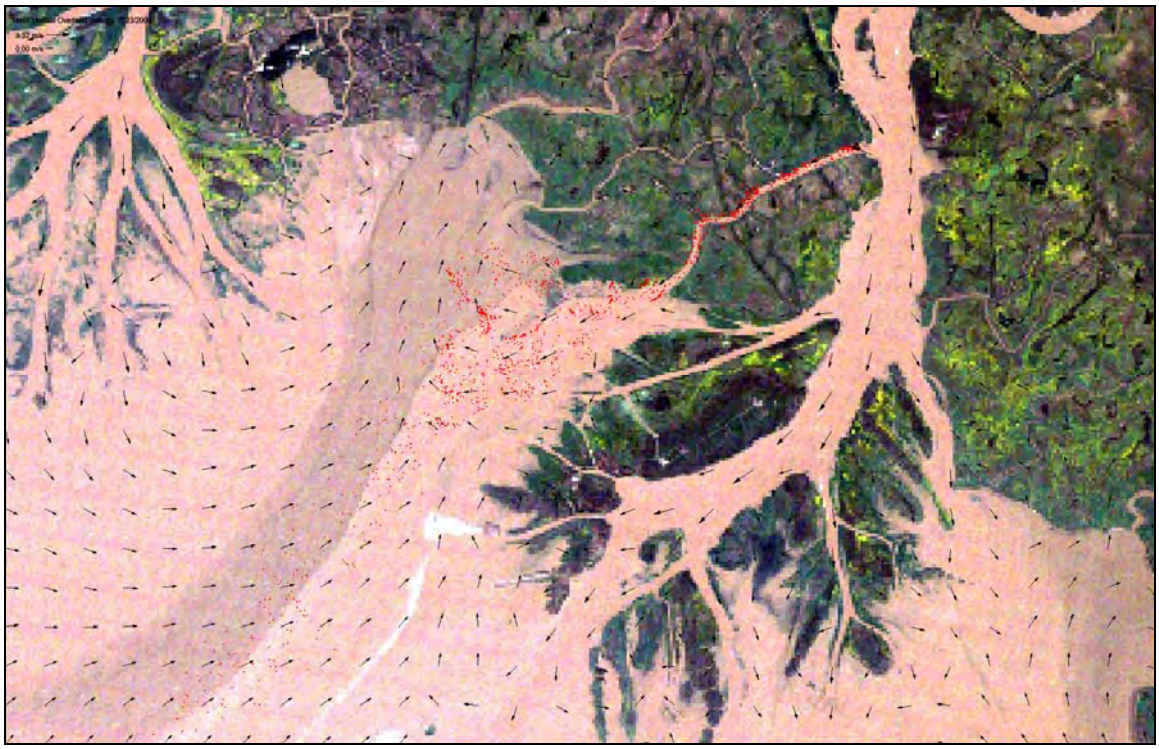

Figure 16. First q3D PTM simulation – time 13 days.

2.4.3. Simulation 3: Quasi-3D simulation of the Release of Mixed Grain Dredge Material with Bedform Development and Wave Mass Transport

A second q3D simulation was performed with the morphology and wave mass transport options in PTM set. Figure 17 exhibits a more prominent bedform organization in the particle dispersal pattern for hour 24:00 in the simulation. More developed bedform structures persist through the early to middle phase of the simulation, but did not significantly change the rate of decrease in the percentage of retained particles. However, the morphology and mass wave transport computations did significantly coarsened the particles retained within the LBDA. Average particle sizes in the particle transport summary for the second q3D simulation in Table 3 are over twice the average sizes in Table 2. The reason for this effect is likely due to the increased transport of fine sediment due to the simulation of wave mass transport.

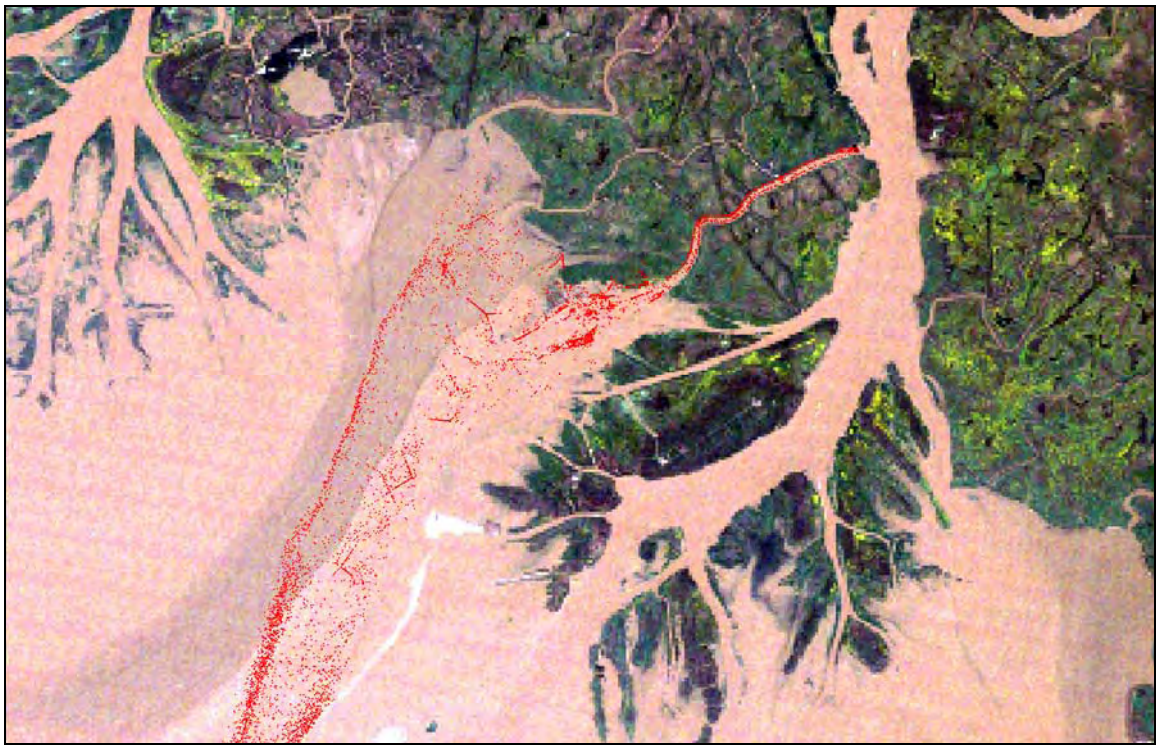

Figure 17. Second q3D PTM simulation – time 24:00 hrs.

	Full Model Domain Grid		Little Bay Deposition Area					
	Particle	Percent	Particle	Mass	Percent	Particle Size, mm		
Date and Time	Count	Retained	Count	kg	Retained	Minimum	Maximum	Average
11/10/09 0:00	8,477	100.0%	0					
11/10/09 3:00	8,471	99.9%	5,103	5,829	34.4%	0.000	0.157	0.021
11/10/09 6:00	8,470	99.9%	5,837	11,674	68.8%	0.000	0.190	0.023
11/10/09 12:00	8,470	99.9%	2,481	4,962	29.3%	0.000	1.270	0.204
11/11/09 0:00	8,470	99.9%	2,307	4,614	27.2%	0.000	0.224	0.108
11/12/09 0:00	4,503	53.1%	2,046	4,092	24.1%	0.000	1.736	0.324
11/13/09 0:00	3,849	45.4%	1,596	3,192	18.8%	0.000	1.866	0.387
11/14/09 0:00	3,656	43.1%	1,715	3,430	20.2%	0.000	1.932	0.385
11/15/09 0:00	3,616	42.6%	1,710	3,420	20.2%	0.000	1.317	0.131
11/16/09 0:00	3,577	42.2%	1,702	3,404	20.1%	0.000	2.000	0.393
11/17/09 0:00	3,547	41.8%	1,698	3,396	20.0%	0.000	2.000	0.395
11/18/09 0:00	3,536	41.7%	1,723	3,446	20.3%	0.000	2.000	0.394
11/19/09 0:00	3,449	40.7%	1,345	2,690	15.9%	0.000	2.060	0.517
11/20/09 0:00	3,207	37.8%	1,370	2,740	16.2%	0.000	2.140	0.524
11/21/09 0:00	3,063	36.1%	1,393	2,786	16.4%	0.000	2.141	0.520
11/22/09 0:00	2,931	34.6%	1,325	2,650	15.6%	0.000	2.141	0.544
11/23/09 0:00	2,847	33.6%	1,249	2,498	14.7%	0.000	2.141	0.562

Table 3. Particle transport statistics for the Little Bay Deposition Area – Simulation q3D-2.

2.4.4. Simulation 4: Quasi-3D Simulation of the Release of Uniform Silt Dredge Material

A third q3D simulation for the full model domain was developed for a dredge material release of nearly uniform medium silt size sediment having a small standard deviation of 0.2 phi units. Figure 18 and Figure 19 show the particle dispersal for hours 24:00 and 72:00 of the simulation. The uniform silt material is rapidly transported to outer Atchafalaya bay and almost no particles are retained with the LBDA. The result of this simulation indicates a low probability that silt and clay dredge material would contribute significantly to replenishment of sediment within the near-shore marshland of Little Bay in a flow dispersal method of disposal.

Figure 18. Third q3D PTM simulation for fine silt – time 24:00 hours.

Figure 19. Third q3D PTM simulation for fine silt – time 72:00 hours.

2.5. Potential Retention of Particles in the Shell Island Pass Channel

The second PTM modeling scenario investigated the potential of released dredge material to deposit within the Shell Island Pass channel. Significant retention of dredge material particles would indicate that the flow dispersal method of dredge material disposal could have adverse impacts on navigational use and environmental characteristics of Shell Island Pass. The potential to deposit dredge material in the Shell Island Pass channel can be evaluated by ascertaining the number of particles retained in the channel in the PTM simulations. This evaluation was performed with the simulations from PTM model of the full ADH domain discussed above and for a simulation of the release of a large dredge disposal load with the smaller Shell Island Pass Channel ADH model (Figure 4).

2.5.1. Particle Retention – Full Domain PTM Simulations

The dispersal images in Figure 20 through Figure 22 show that few particles retained in the bend near the middle of Shell Island Pass for both the mixed grain and uniform silt dredge material. This bend is the deepest section in the pass. The average size of the retained particles in the middle of the bend is

0.35 mm for the q3D simulation in which the morphology and wave mass transport options were not set (Figure 20). The average size of the retained particles was 1.04 mm when the morphology and wave mass transport options were set in q3D simulation (Figure 21). Essentially no particles were retained in the 3qD simulation of the uniform silt dredge material (Figure 22).

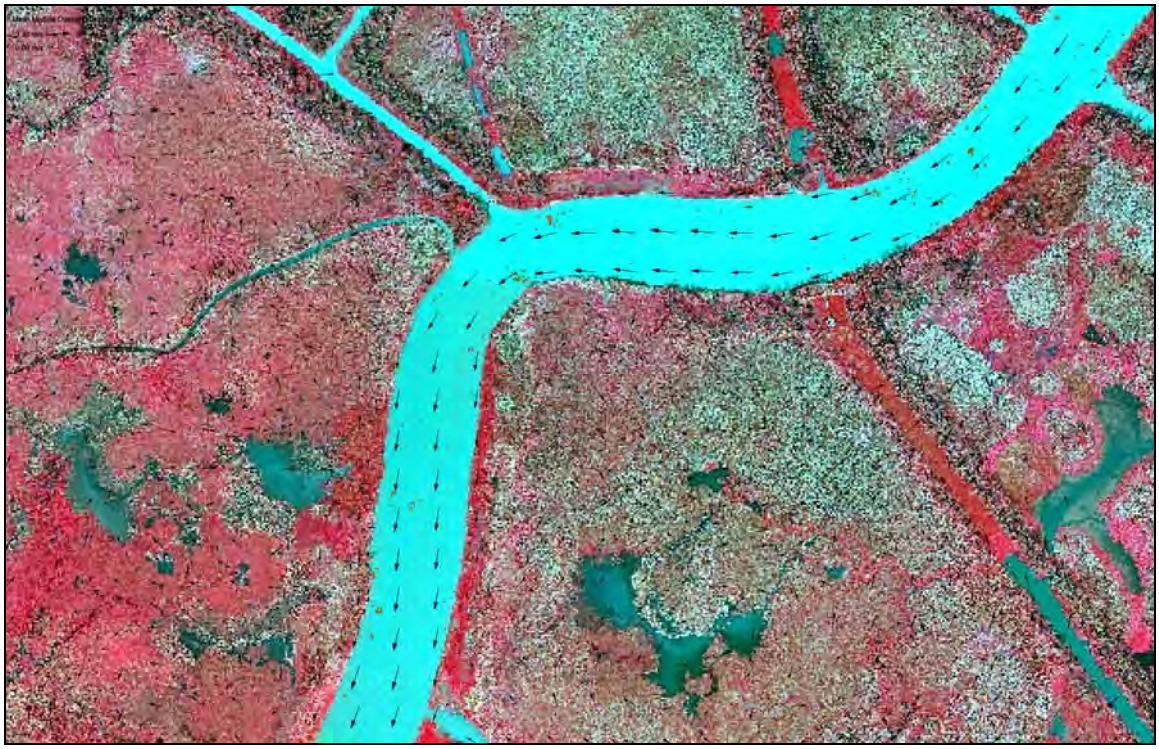

Figure 20. Particle retention in the bend of Shell Island Pass – day 13, q3D-1 simulation.

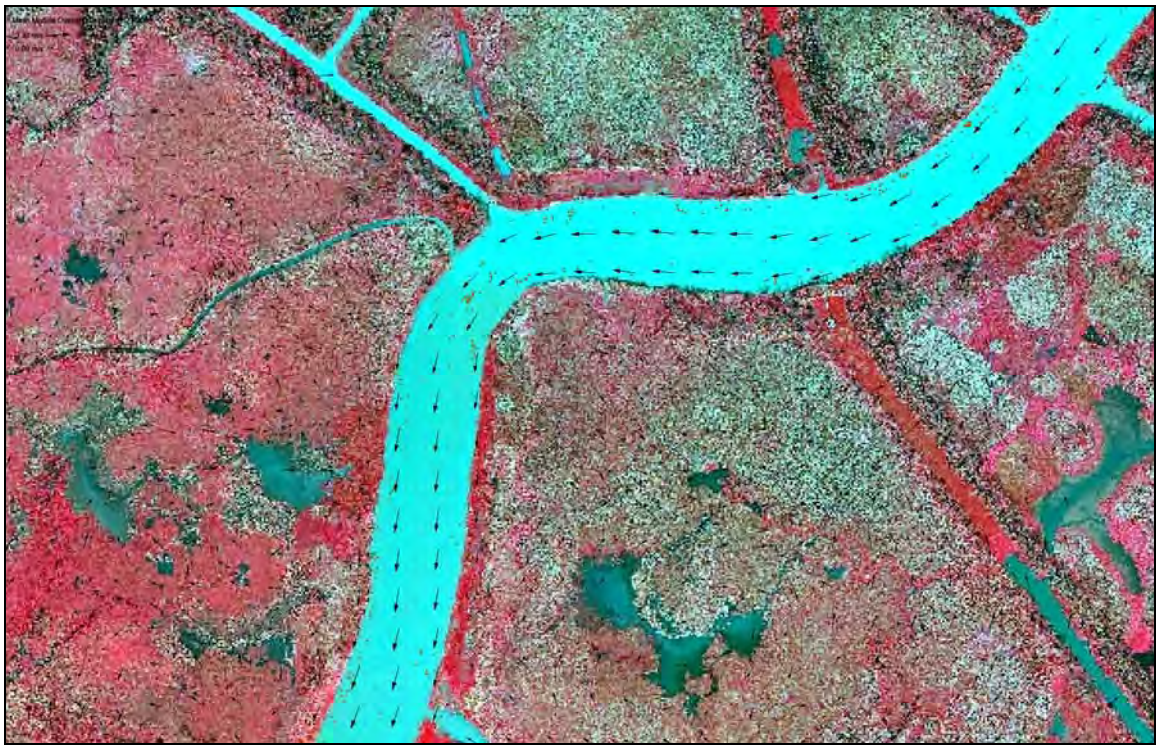

Figure 21. Particle retention in the bend of Shell Island Pass – day 13, q3D-2 simulation.

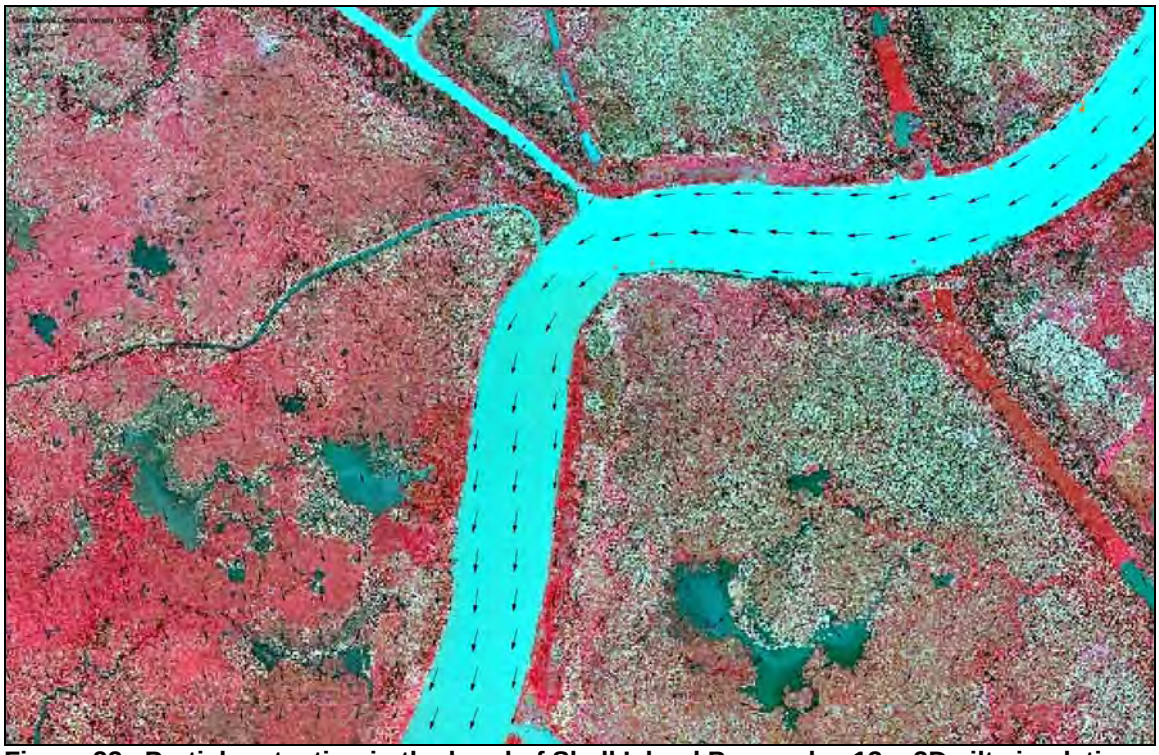

Figure 22. Particle retention in the bend of Shell Island Pass – day 13, q3D silt simulation.

2.5.2. Dredge Disposal Load Particle Retention

The second PTM modeling scenario investigated the potential of released dredge material to deposit within the Shell Island Pass channel. In this simulation, a total mass of 3,720 tons (3,374 metric tonnes) of mixed grain dredge material was released over a period of 1.0 hour. This is an amount that a hopper dredge (e.g. Wheeler) might release in a single disposal event. The dredge material was simulated as 337,400 particle clusters each representing a composite mass of 10 kg (22 lb). The sediment was assumed to be dispersed evenly across a 400 foot line set at an elevation of -1.0 m (3.3 ft). Mounding of sediment on the bottom of the channel was not simulated. The source sediment had the same particle distribution as the mixed grain sediment employed in the PTM simulation above (D_{50} grain size of 0.01 mm (fine silt) and standard deviation 2.2 phi units).

The 12 November 2009 15-minute inflow hydrograph recorded by the Morgan City stream gage was used in the ADH simulation that produced the hydrodynamic files for the PTM model. The estuary water surface elevation time series was obtained from the Lawma, Amerada Pass tide station.

The particle dispersal images in Figure 23 shows that the large dredge material load was mostly transported through Shell Island Pass into Little Bay at the end of 24 hours. About 54 percent of the material released (2,021 tons) remains in the reduced model domain. The particles retained in the Shell Island Pass are from the relatively coarse fraction of the dredge material load.

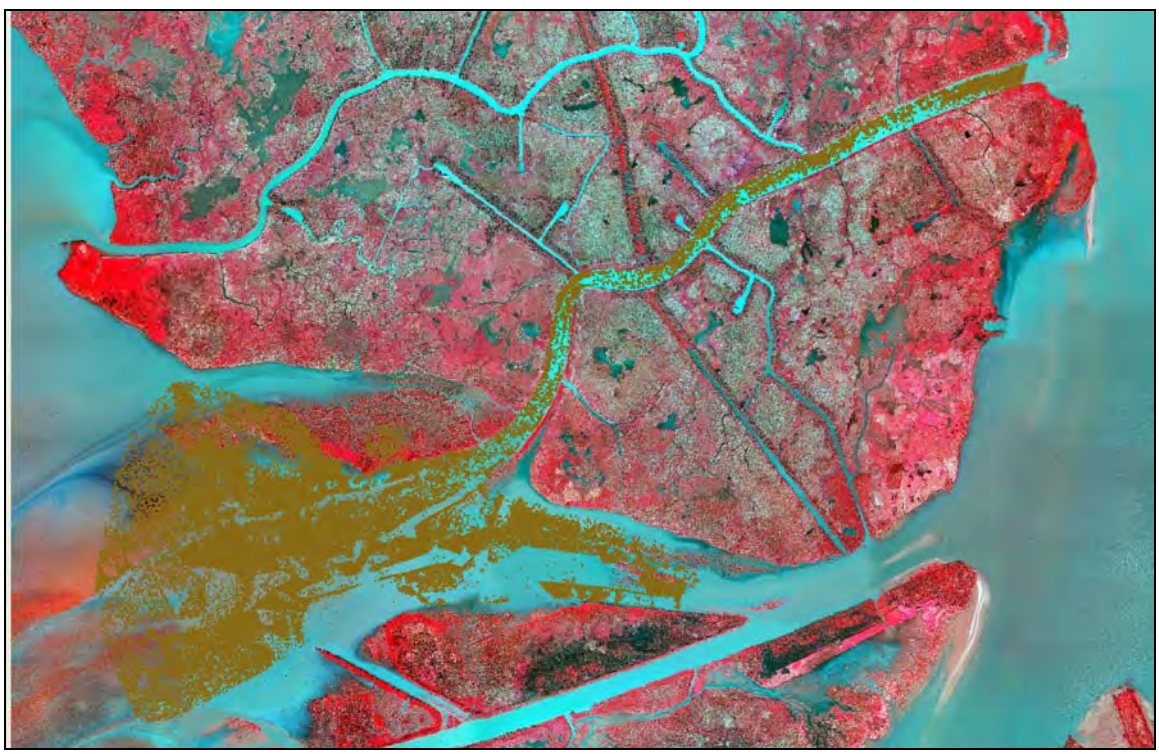

Figure 23. Dredge material disposal release – hour 24:00.

Figure 24 show that particles from the coarse fraction of the dredge material load are retained in the bend in Shell Island Pass. A total of 5791 particles (63 tons) or 2 percent of the total load are retained through the bend. The average size of the retained particles size is 0.31 mm which is medium to fine sand. Most of the sediment is concentrated in bedforms, so most of the retained particles would be expected to be transported out of the reach in an extended simulation of realistic discharges.

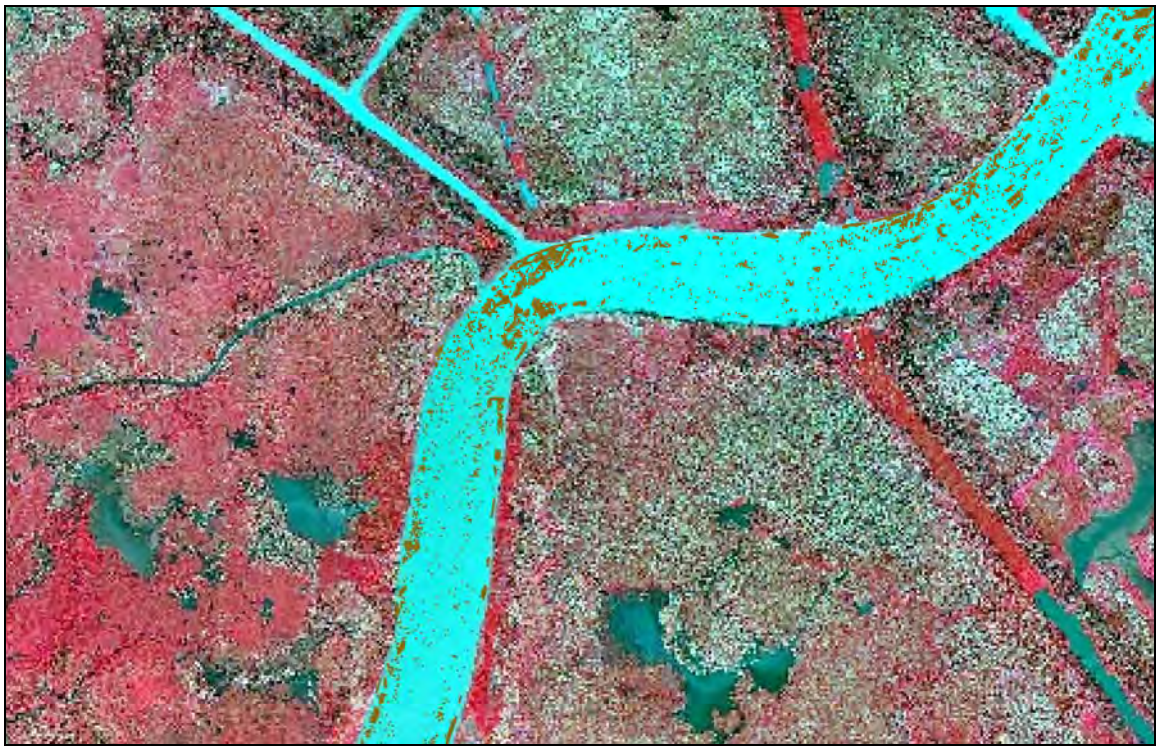

Figure 24. Dredge material retained in the bend in Shell Island Pass – hour 24:00.

2.6. Summary and Conclusions

Part 1 of this report described a state-of-the-art Lagrangian particle transport analysis of the fate and transport of dredge material released at the head of Shell Island Pass. The PTM model analysis showed that fine grained dredge materials are readily transported through Shell Island Pass and out to Little Bay and outer Atchafalaya Bay. Much of the fine sediment is dispersed beyond Little Bay, calling into question the effectiveness of the flow dispersal alternative for replenishing sediments of the near shore marshland in Little Bay. The PTM analysis suggests there is a low potential for fine grained dredge material to accumulate in the bend and other reaches of Shell Island Pass if disposed under moderate flow conditions.

Other methods besides Lagrangian particle transport can be used to evaluate the potential (capacity) of Shell Island Pass to transport sediment. In

part two of this report sediment transport capacity is evaluated with several sediment transport modeling and stream morphology methods. These evaluations generally support the conclusions of the PTM model, but they also show that sediment transport capacity of Shell Island Pass is very dependent on the grain size distribution of the released dredge material.