45th GSA South-Central Meeting

3-D Modeling of Diversions from the Lower Mississippi River

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Presentation Outline

1) Introduction

2) The Numerical Model ECOMSED

3) 3-D Mississippi River Model Scenarios

4) Results

5) Conclusions

1 - Introduction

3-D modeling is needed for studying

- Water & Sediment Diversions
- Effect of Diversions on river currents
- Effect of Dredging on river currents

ECOMSED

- State-of-the-art model
- It has a sediment transport module
- Free and open source

2 – Numerical Model ECOMSED

Description

- 3-D Hydrodynamics and Sediment Transport
- Estuarine Model
- Finite-Volume Model
- Developed by HydroQual (2002)
- Unsteady Flow
- Structured Curvilinear Grid
- Serial Code

2 – Numerical Model ECOMSED (Cont.)

Limitations

- Estuarine Model
- Has not been extensively applied to coarse sediment transport
- Friction constant in time and space
- Hydrostatic pressure

2 – Numerical Model ECOMSED (Cont.)

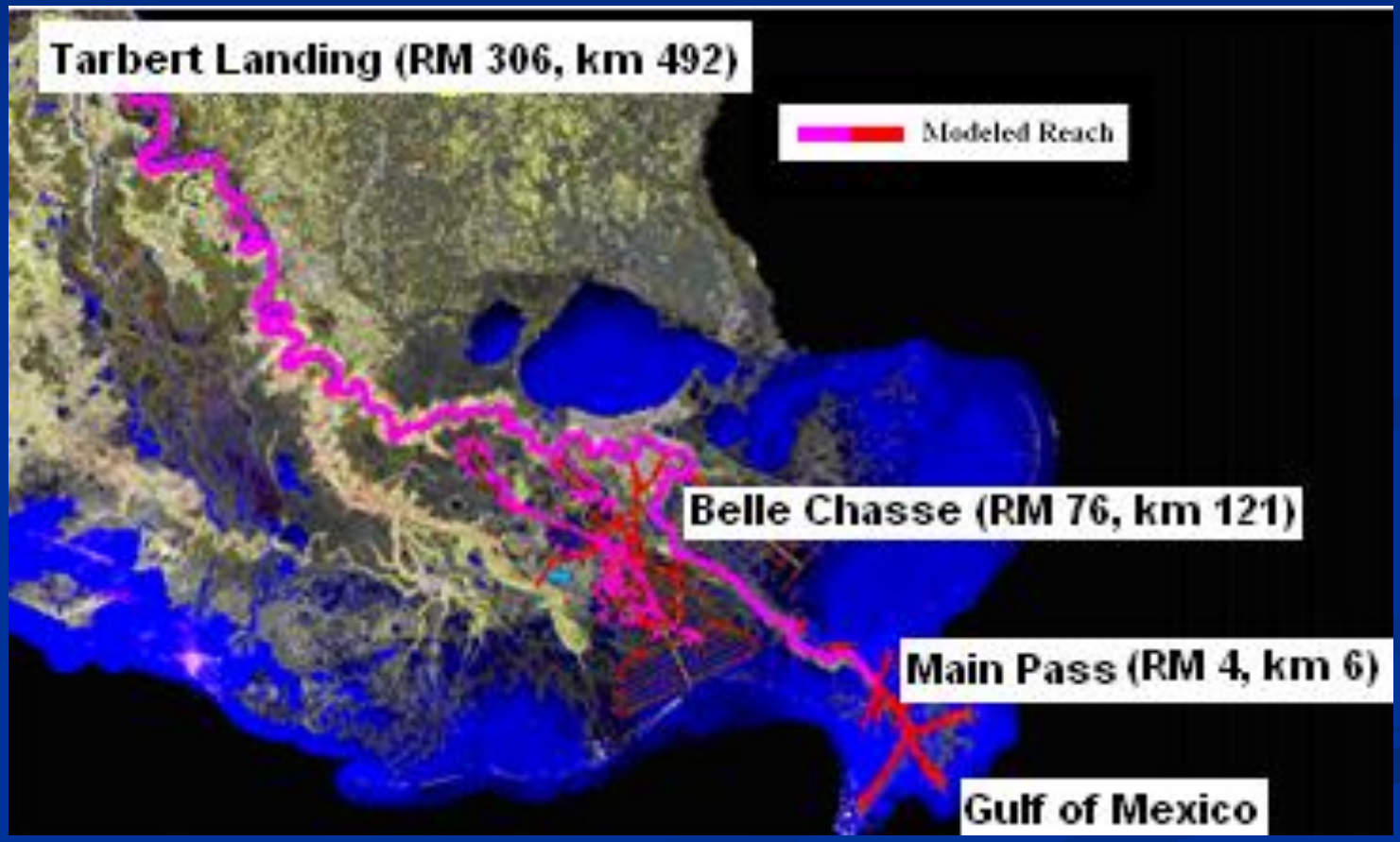
Upgrades we have made

- Manning's Formulation
- Spatially Variable Friction
- Upper limit on the maximum near bed sand concentration and change in Einstein's bed-layer height estimate

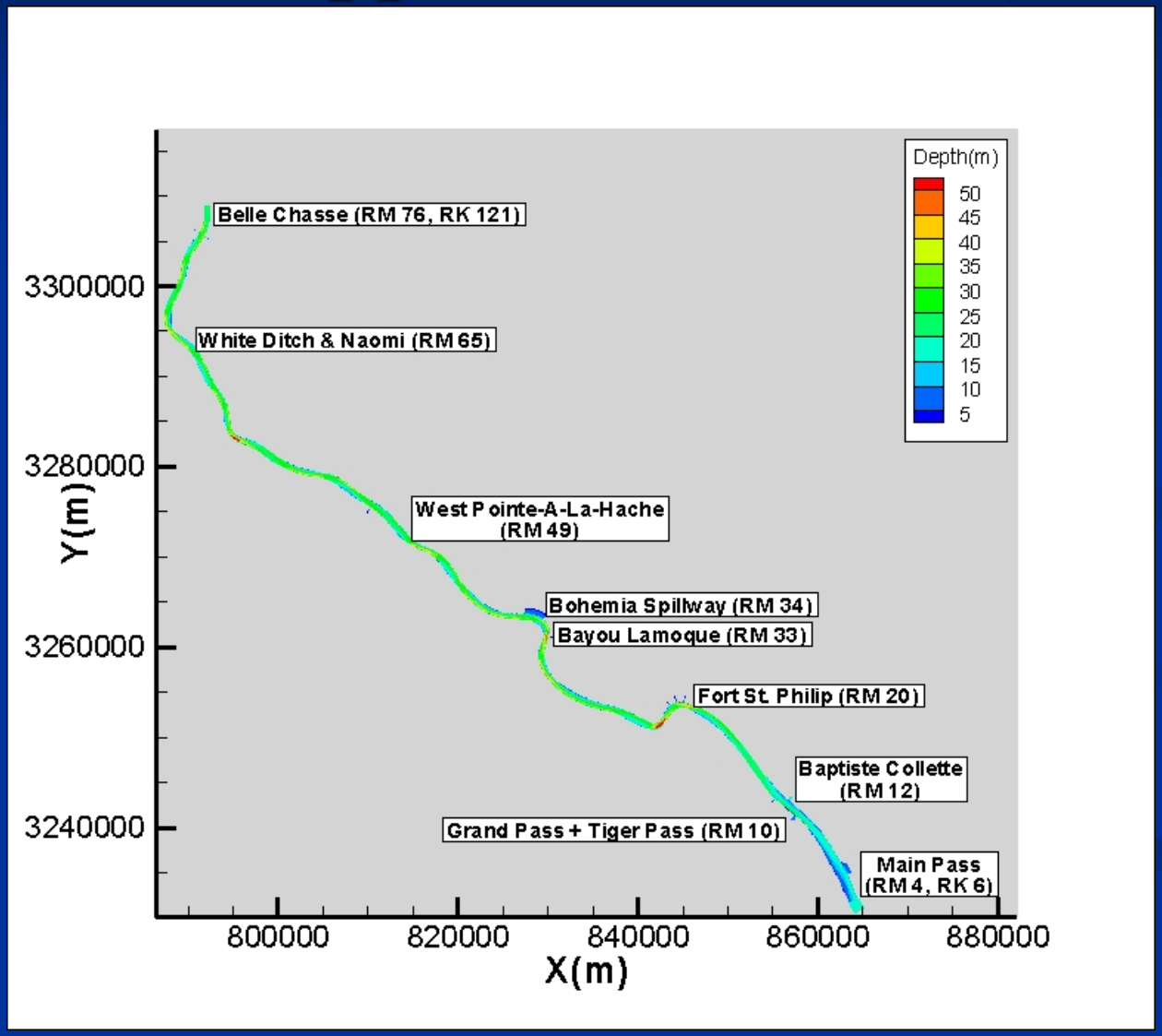
3 – Mississippi River Model

- Belle Chasse (RM 76) to Main Pass (RM 4)
- 100mx50m grid of 50,000 quadrilateral cells
- Bathymetry from 2003

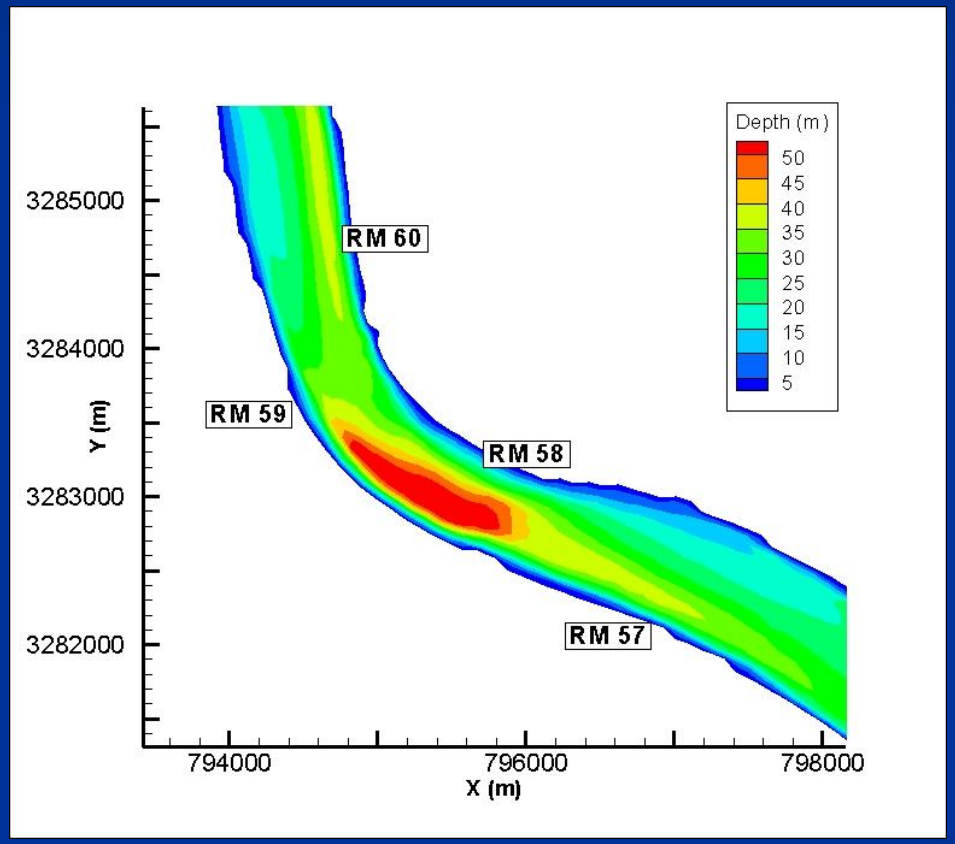
3 – Mississippi River Model (Cont.)

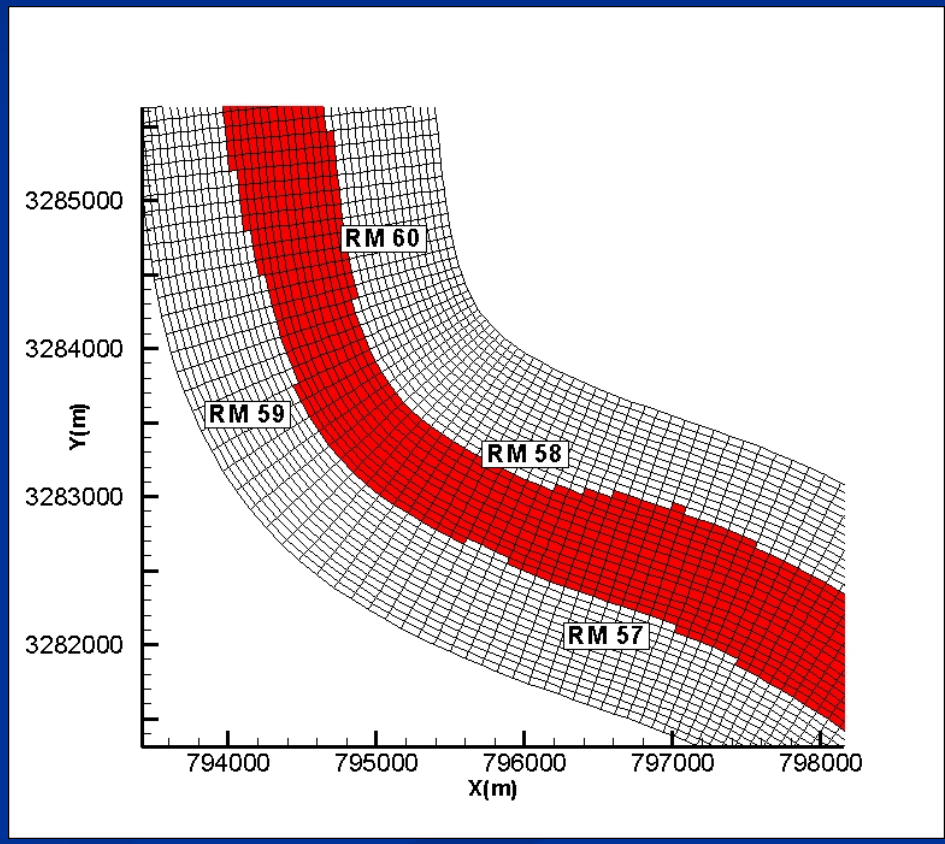


3 – Mississippi River Model (Cont.)

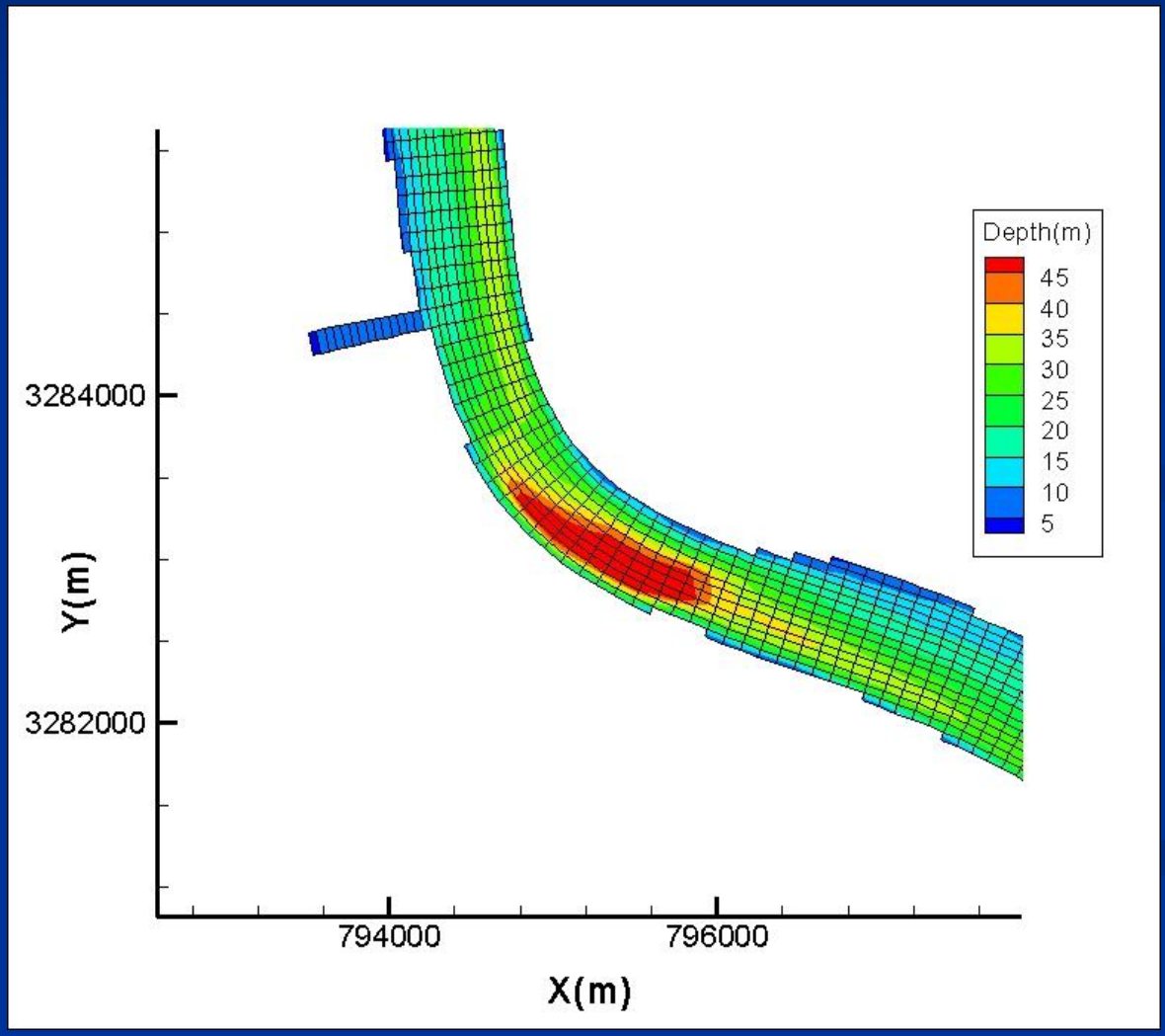


3 – Mississippi River Model (Cont.)





3 – Mississippi River Model (Cont.)



3 – Mississippi River Model (Cont.)

Scenarios

1) Existing Outflows

2) Myrtle Grove (RM 59) Diversion + Existing
   Peak 30,000 cfs (2.5% of 1.2 Million cfs Main Stem)

3) Belair (RM 65) Diversion + Existing
   Peak 200,000 cfs (17% of 1.2 Million cfs Main Stem)

4) Proposed Diversions + Existing
   Involves Closing South and SW Passes and Dredging Pass a Loutré
   Jesuit Bend (RM 68), Belair (RM 65), Myrtle (RM 59), Deer Range (RM 54), Buras (RM 25)
   Total Peak 365,000 cfs (30% of 1.2 Million cfs Main Stem)

3 – Mississippi River Model (Cont.)

External Boundary Conditions

- U/S Boundary: Q and C_s at Belle Chasse
- D/S Boundary: Stage and C_s at Main Pass

Intermediate Boundary Conditions

- Outflows: Q and C_s

3 – Mississippi River Model (Cont.)

Q at Belle Chasse and Diversions

- From HEC-RAS Model Tarbert Landing (RM 306) to the Gulf of Mexico by Davis (2010)

C_s at Belle Chasse

- From 2008 Field Measurements by Nittrouer *et al.* (2008) and Allison (2010)

Stage upstream of Head of Passes

- From HEC-RAS Model Tarbert Landing (RM 306) to the Gulf of Mexico by Davis (2010)

4 – Results (Cont.)

Mobile-Bed Calibration and Validation

Suspended Sand Concentrations

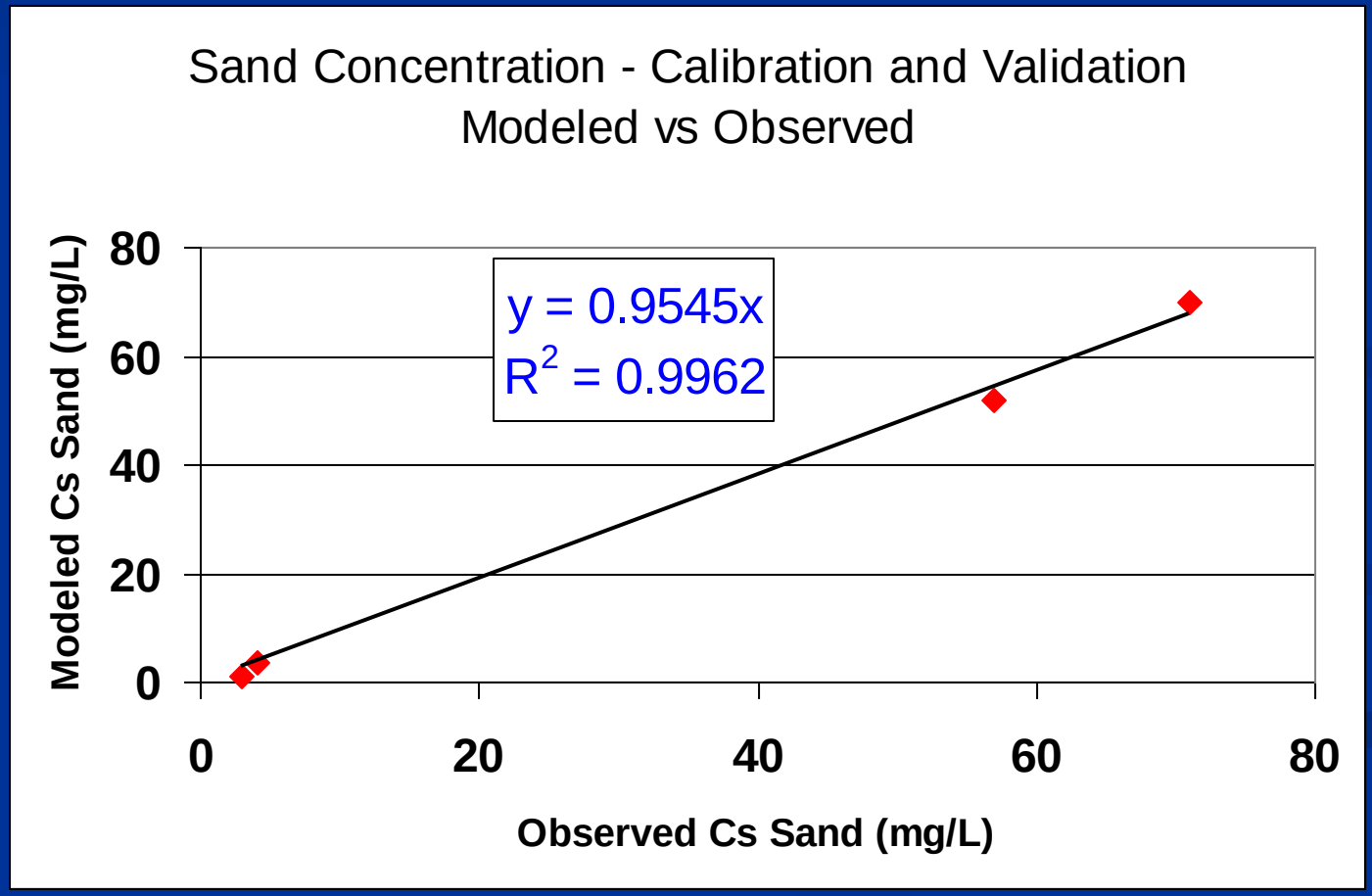
Date/Station	Sand Concentration (mg/L)					
	Belle Chasse (RM 76)		Myrtle Grove (RM 57)		Scofield (RM 16-24)	
	Observed	*Simulated*	*Observed*	*Simulated*	*Observed*	*Simulated*
1/10/08 (Validation)	**1.0**	**3.0**	-	-	**4.1**	**3.5**
3/3/08 (Validation)	**70.0**	**68.0**	**57.0***	**52.0**	-	-
4/15/08 (Calibration)	**90.0**	**92.0**	-	-	**71.0**	**69.8**

**All field data for these flows were collected by Dr. Mead Allison, UT (College Station)*

4 – Results (Cont.)

Mobile-Bed Calibration and Validation

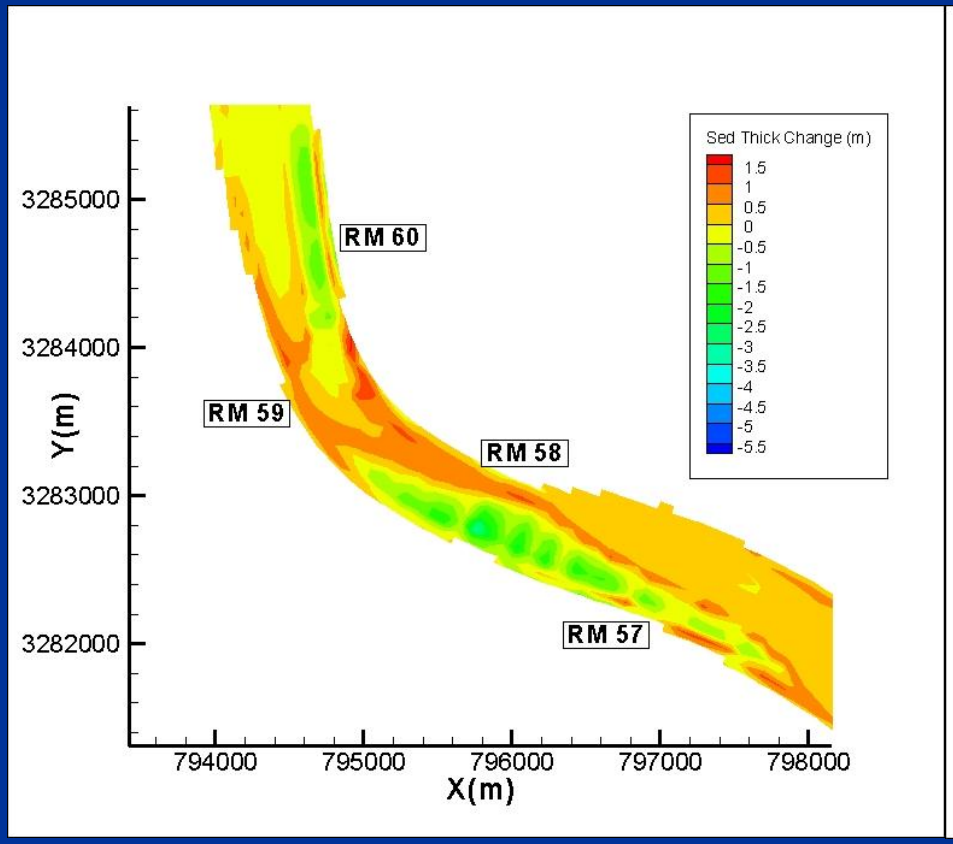
Suspended Sand Concentrations

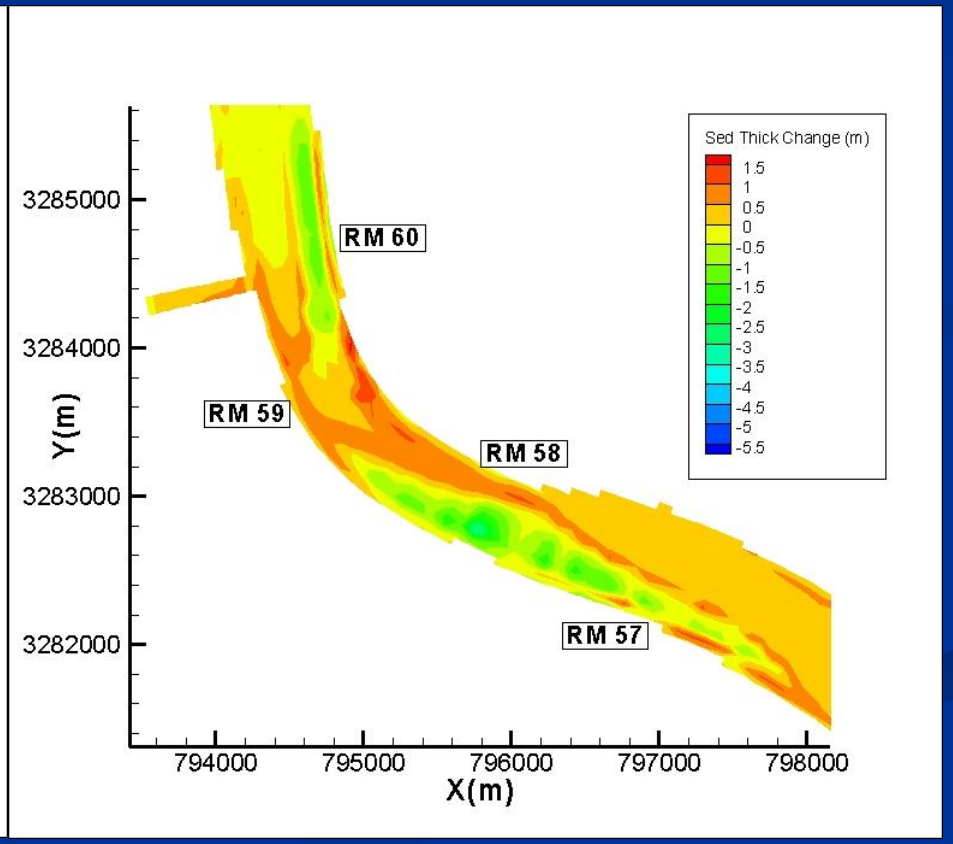


4 – Results (Cont.)

BED CHANGE AT MYRTLE GROVE

MYRTLE GROVE TEST

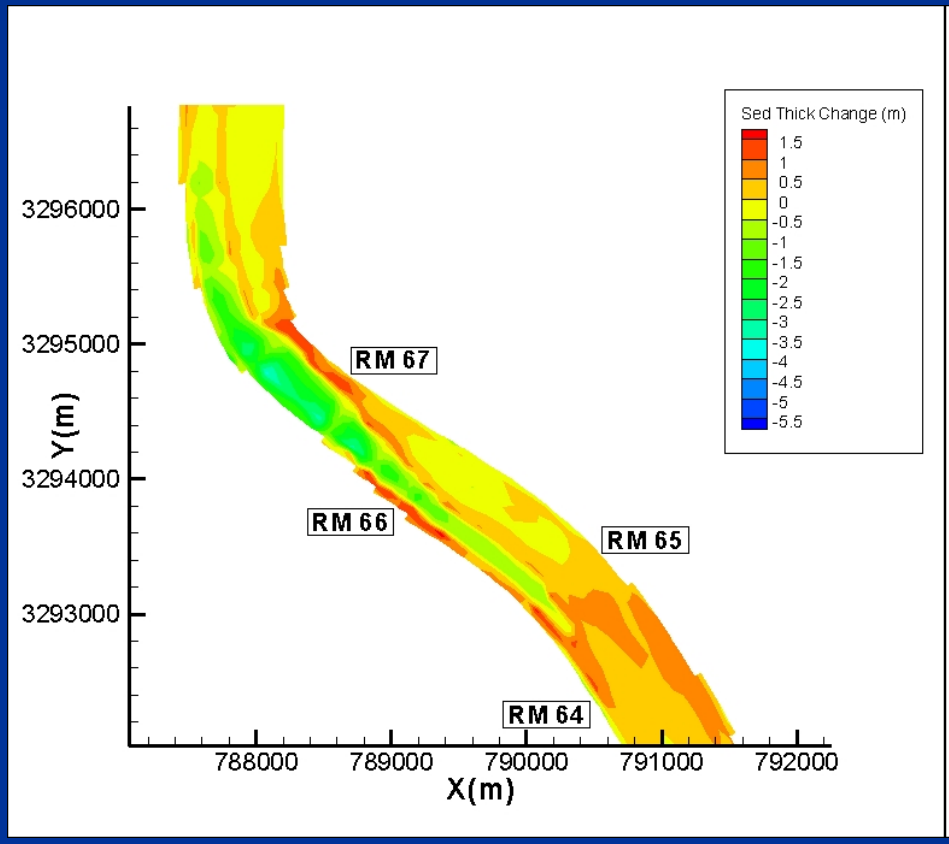


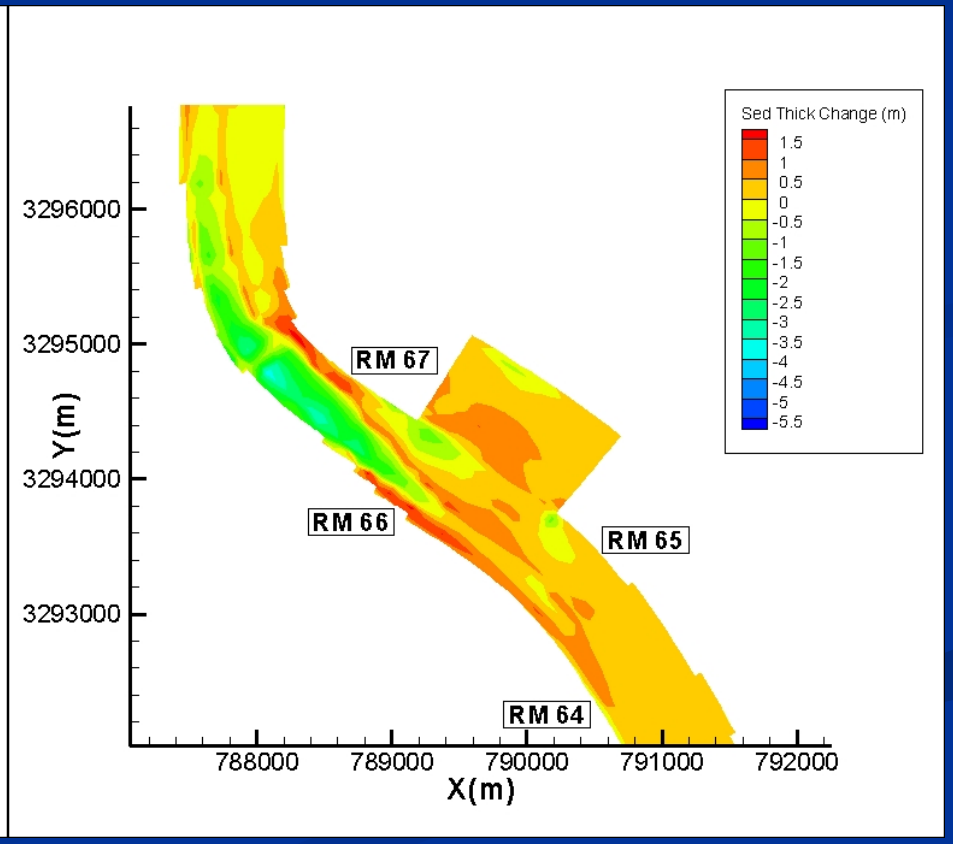


4 – Results (Cont.)

BED CHANGE AT BELAIR

BELAIR TEST

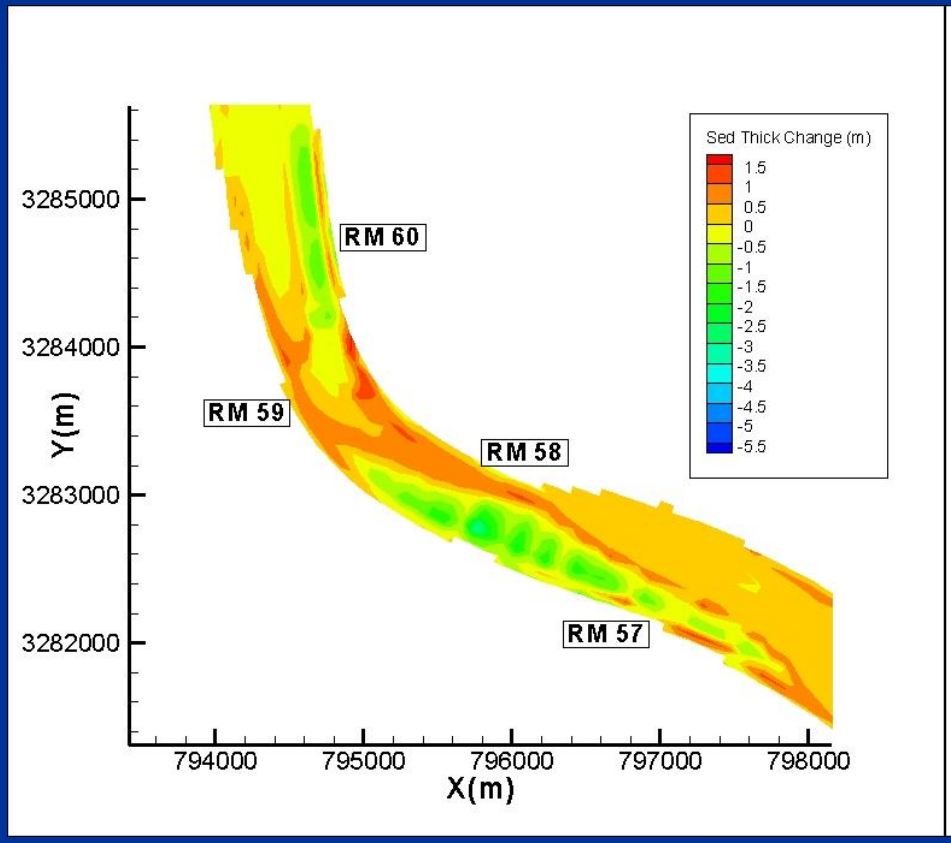


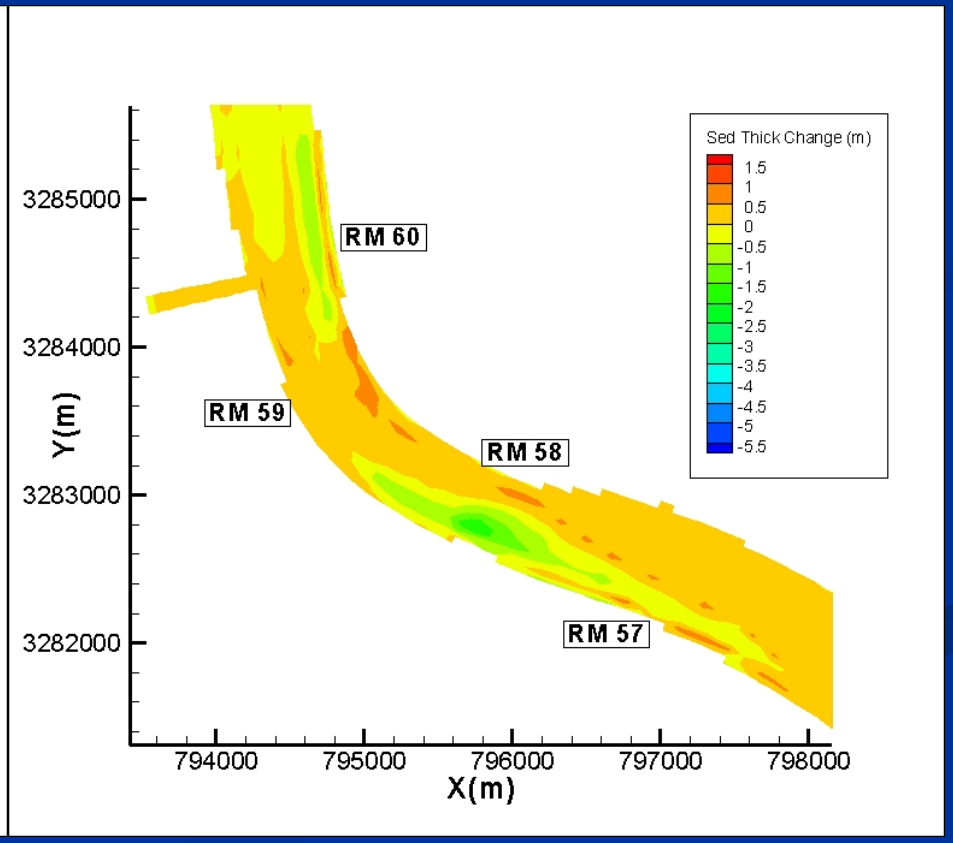


4 – Results (Cont.)

BED CHANGE AT MYRTLE GROVE

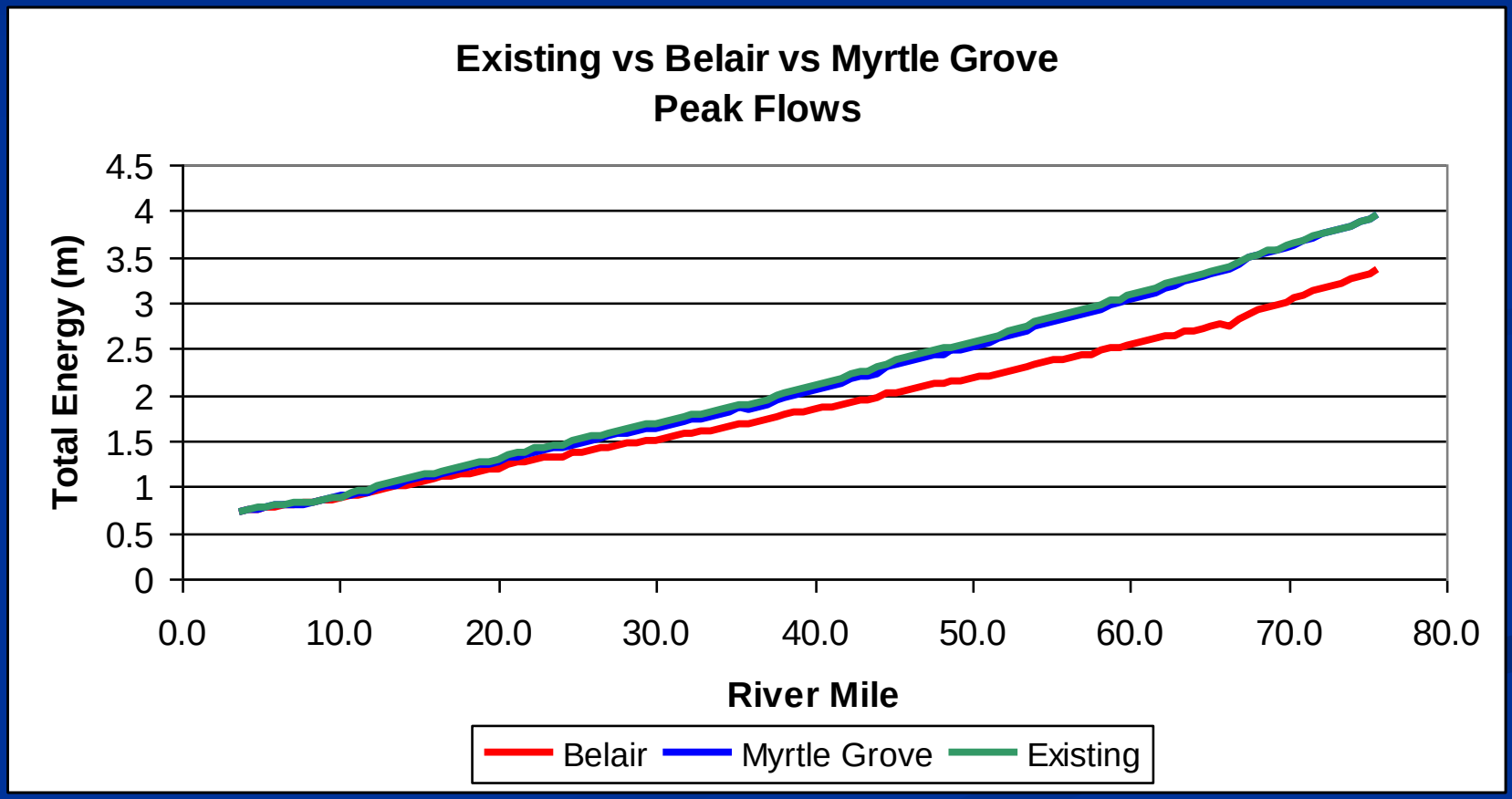
PROPOSED MULTIPLE DIVERSIONS TEST





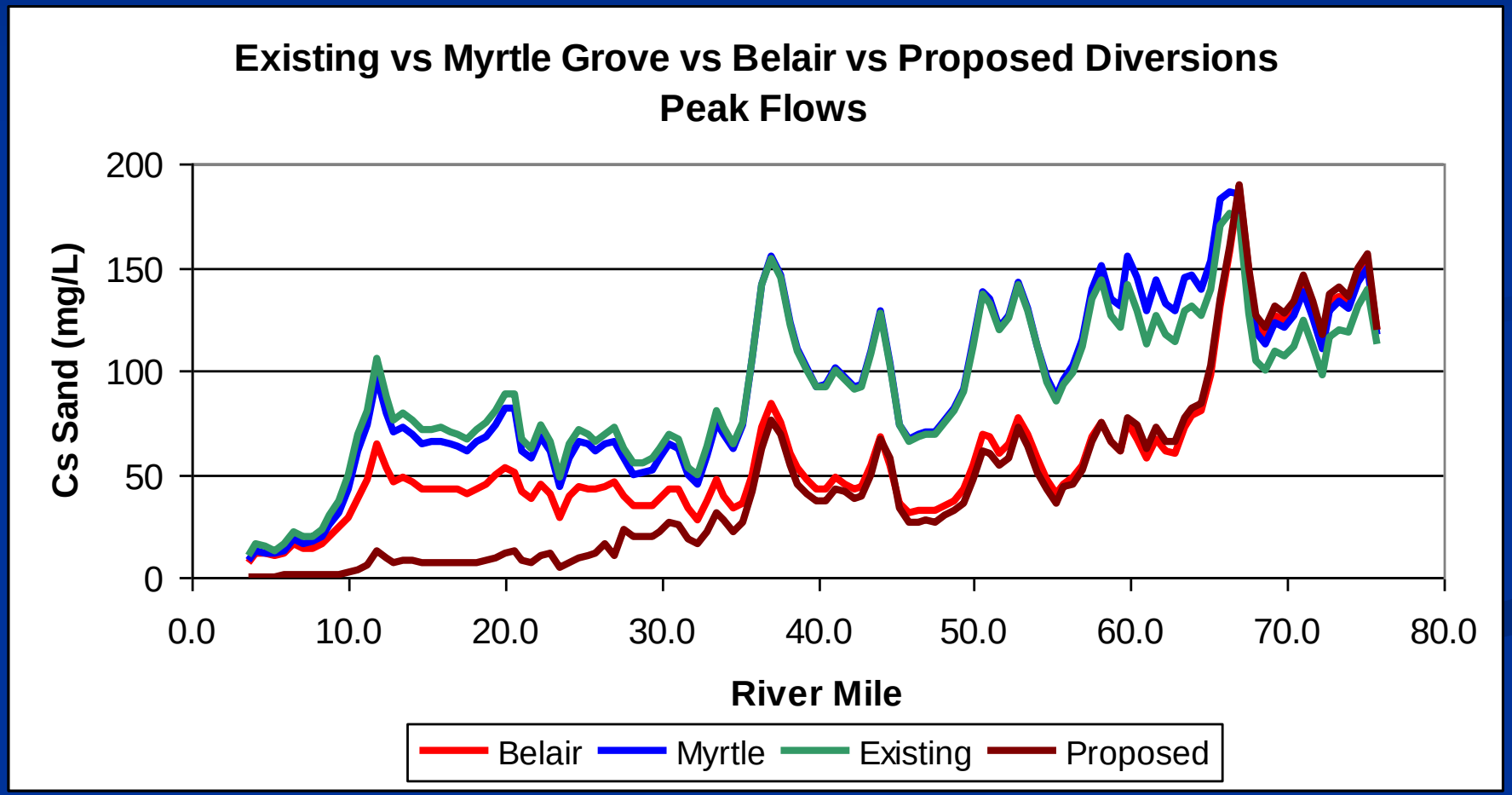
4 – Results (Cont.)

Total Energy



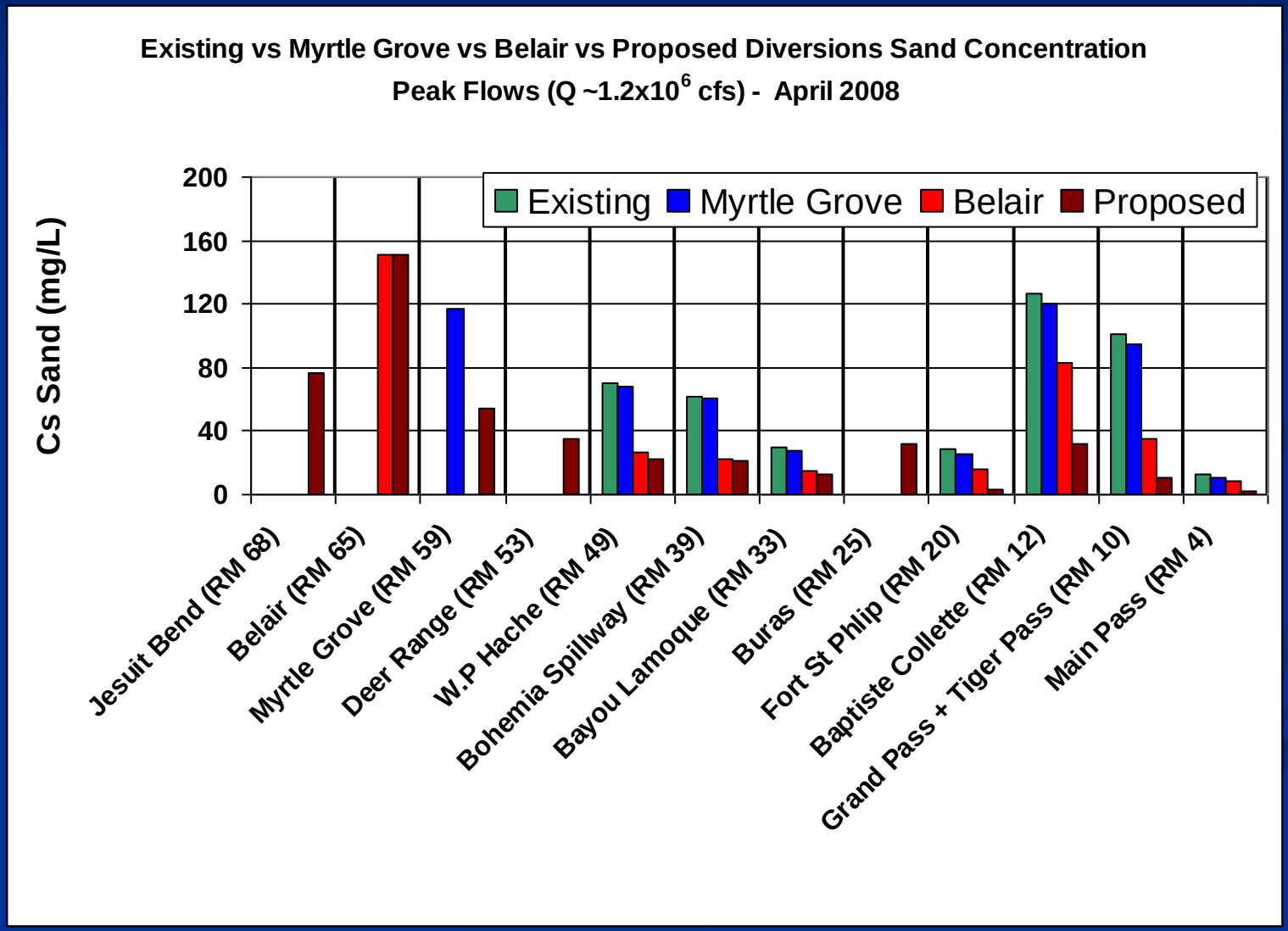
4 – Results (Cont.)

Main Channel Cs Suspended Sand



4 – Results (Cont.)

Outflows Cs Suspended Sand



5 – Conclusions

- The Myrtle Grove diversion (30,000 cfs or 2.5% of the peak flow) showed mild impacts
  - Diversion captures sand at close to the main stem concentrations
  - Sand Concentrations at the existing diversions and distributaries were not dramatically changed

5 – Conclusions

- The Belair diversion (200,000 cfs or 17% of the peak flow) showed strong impacts:
  - Drop in River stage throughout the domain;
  - Increase in Energy gradient upstream and decrease downstream of the diversion;
  - Increase in bed erosion at and upstream of the diversion with possible head-cutting;
  - Increase in depositional areas downstream of the diversion leading to shoaling;
  - Significant flow reduction in existing outflows
  - Significant decrease in sand diversion loads downstream of the diversion

5 - Conclusions (Cont.)

- The Proposed Multiple Diversions Tests showed the strongest impacts:
  - The large Belair diversion dominates the River response, and
  - Due to reduced sand transport capacities downstream of Belair, sand captured by diversions downstream of Belair was greatly reduced;
  - The large Buras diversion (RM 25; 140,000 cfs) did not have as much of an effect on the hydraulic grade line compared to the Belair diversion but contributed for a significant reduction in the downstream sediment transport.

5 - Conclusions (Cont.)

- The Results support the concept that there are three inter-related resources that must be considered in optimizing the beneficial use of the Mississippi River:
  - Discharge
  - Energy
  - Sediment transport

THANK YOU