# Desktop Study for Sediment-Related Problems at Sabine Neches Project

**VOLUME 1**

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**VOLUME 1**

Part 1: Project Information and Background Study

Part 2: Effect of Channel Modifications

Part 3: Pleasure Island Erosion

Part 4: Sabine Lake Eastern Shore Erosion

# Contents

# Appendices

**Appendix A**: Particle size distribution curves for surface bed samples along SNWW Navigation Channel

**Appendix B**: Superposed velocity plots for flood and ebb for Base (existing) Conditions at SNWW Navigation Channel Locations

**Appendix C**: Superposed velocity plots for base and plan for Flood at locations Along SNWW Navigation Channel

**Appendix D**: Superposed velocity plots for base and plan for Ebb at locations Along SNWW Navigation Channel

**Appendix E**: Superposed velocity plots for base and plan for Flood at locations Along Pleasure Island west shoreline

**Appendix F**: Superposed velocity plots for base and plan for Ebb at locations Along Pleasure Island west shoreline

**Appendix G**: Particle size distribution curves for pleasure Island locations

**Appendix H**: Photographs

- H_A: Propagation of transverse stern waves generated by passage of ship
- H_B: Vessel-generated waves attacking the shore
- H_C: Bank Erosion at Various Locations In Sabine Neches Project Area
- H_D: Bank protection measures adopted at Sabine
- H_E: Bank sediment at various locations
- H_F: Eastern shoreline of Sabine Lake near Willow Bayou

**Appendix I**: Particle size distribution curves for Willow Bayou locations

**Appendix J**: Particle size distribution curves for Sabine Lake East shoreline locations

**Appendix K**: Superposed velocity plots for base and plan for Flood at locations along Willow Bayou shoreline

**Appendix L**: Superposed velocity plots for base and plan for Ebb at locations along Willow Bayou shoreline

# List of Figures

# Preface

The US Army Engineer District Galveston proposed increasing the length, width and depth of the navigation channel at Sabine Neches Project, TX. The proposed modifications were varying in different segments of the navigation channel. The impact of these channel modifications on the following needed to be assessed.

Study 1: Estimation of siltation in the navigation channel
Study 2: Pleasure Island Erosion
Study 3: Sabine Lake shoreline erosion

A desktop study was conducted at the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, during 2001-2002 for the above three topics. The U.S. Army Engineer District, Galveston, provided funding for this study. Dr. Trimbak M. Parchure, research hydraulic engineer, was the principal investigator for the project. Dr. Parchure prepared this report jointly with Ms. Soraya Sarruff of CHL. Dr. Vemulakonda Rao provided the results of numerical hydrodynamic model. The CHL team consisting of Tim Fagerburg, Mr. Howard Benson and Mr. Chris Callegan collected new field data. Mr. Doug Brister of CHL conducted laboratory analysis of bed samples and water samples under the guidance of Dr. Allen Teeter and Dr. Parchure. Ms. Mary Lynn Bagshaw and Ms. Dorothy King provided assistance in analyzing the large number of sediment and water samples collected at the project. Mr. Corey Foster assisted in data analysis, plotting of results and report compilation. Mr. Ed Reindl and Ms. Nancy Young of Galveston District supplied the data available at the District.

The work was conducted under general supervision of Dr. Robert T. McAdory, Chief, Estuarine Engineering Branch, and Mr. Thomas Richardson, Director, CHL.

The report was published by CHL. CHL was formed in October 1996 with the merger of the Coastal Engineering Research Center and the Hydraulics Laboratory. The Waterways Experiment Station (WES) has now become part of ERDC.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

Desktop Study for
Sediment-Related Problems at
Sabine Neches Project

# Part 1
# Project Information and Background Study

# Chapter 1.1: Report Information

## Introduction

The U.S. Army Engineer District, Galveston (SWG) and the local sponsor the Jefferson County Navigation District (JCND) have proposed to widen and deepen the Sabine-Neches Waterway (SNWW), Texas from its entrance in the Gulf of Mexico to Beaumont, Texas. The proposed modification of the navigation channel in the Sabine Neches River requires several studies, which include hydrodynamic modeling and sedimentation studies. The Coastal and Hydraulics Laboratory (CHL) of the U. S. Army Engineer Research and Development Center (ERDC), is conducting some of the studies for the Sabine Neches project. This report describes studies conducted to evaluate the impact of the proposed development on sediment-related problems.

In view of the complexity of the project and involvement of two states, namely Texas and Louisiana, a committee represented by members of several National organizations was set up. This group called the Interagency Coordination Team (ICT) included National Ocean and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), Texas Water Development Board (TWDB), U. S. Army Corps of Engineer (USACE), etc. Members of the ICT recommended that the sedimentation study for the Sabine Neches Project should be focused only on the impact of the proposed project over the existing conditions. Hence the scope of work for this desktop study was prepared accordingly.

This report deals with two sediment-related problems. The first is the effect of navigation channel modifications on the future dredging quantities. The second is the impact of channel modifications on the erosion of Pleasure Island shoreline. The problem of erosion of the eastern shoreline of Sabine Lake will be covered in a separate report.

## Scope of Desktop Study

Study 1: Effect of navigation channel modifications

Problem: Channel widening / deepening may increase tidal range and tidal currents. What impact will these changes have on the current sedimentation pattern in the navigation channel?

The scope of Study 1 was defined as follows:

Dredging data will be analyzed to establish the current siltation pattern. Field sediment samples will be analyzed in CHL laboratory. Laboratory results will be plotted and studied. Properties of sediment at site will be evaluated. Transportation characteristics of sediment will be determined. Velocity data at selected stations will be extracted from the numerical solution files for the existing and plan conditions. Velocity data will be plotted for comparison. Change in the current pattern caused by navigation improvement will be assessed. Effect of velocity change on channel siltation and erosion will be assessed. A letter report will be submitted.

Study 2: Pleasure Island Erosion

Problem: The shoreline of Pleasure Island has been eroding over the past several years. Determine whether this erosion process would be accelerated by implementation of the proposed improvements to the ship channel.
(Part 1B) Recommend measures to alleviate the adverse impact of the proposed project, if considered necessary.

Scope (Part 1A) was defined as follows:
Sediment data available with the Galveston District will be examined and used in the study. The Measurement and Analysis Group of the CHL will collect additional sediment data, which will be analyzed in CHL laboratory. Necessary provision for the collection and analysis has been included in a separate estimate for field data collection. Laboratory results will be plotted and reviewed. Properties of sediment at site and their transportation characteristics will be evaluated for their use in the study. The cause of erosion will be assessed. Velocity data at selected stations will be extracted from the numerical solution files for the existing and plan conditions. Velocity data will be plotted for comparison. Change in the current pattern caused by navigation improvement will be assessed. Effect of velocity change on sediment erosion will be assessed. A letter report will be submitted.

Scope (Part 1B): Assess whether the sediment impact will be marginal and if so, recommend deferment for taking mitigation measures. If the impact is adverse and severe, then recommend that taking mitigation measures is essential. Recommend mitigation measures to alleviate the adverse impact of the proposed project.

## Report Organization

The report is organized in the following three parts.

Part 1: Project Information and Background Study
This provides information about the report, the description of project and proposed developments, site conditions and background data for the present study.

Part 2: Effect of Channel Modifications
This describes the existing shoaling conditions, dredging data, sediment characteristics, numerical model results and conclusions of study on the expected sediment deposition in the navigation channel as a result of channel modifications.

Part 3: Pleasure Island Erosion
This describes the present shoreline erosion at Pleasure Island, site conditions, general technical considerations, numerical model results and conclusions.

Part 4: Sabine Lake Erosion

This describes the erosion problem noticed near Willow Bayou located at the eastern shoreline of Sabine Lake, site conditions, and a general assessment of the problem.

All the respective figures are given at the end of the text for each chapter followed by all the Tables.

# Chapter 1.2: Project Information

## Sabine Neches Project Description

Sabine River and Neches River are among the large rivers in the southeastern part of the State of Texas. The two rivers have a confluence near the north-western part of Sabine Lake, which is a large lake situated close to the shoreline of the Gulf of Mexico. Beaumont Port is situated on the Neches River, whereas Orange Port is on the Sabine River. Port Arthur is located south of the confluence on the combined part of the two rivers. The deep channel waterway that runs along the Neches River, connecting the Port Arthur and Beaumont Port is denoted as the Sabine Neches Waterway (SNWW). Orange Port, which is situated on the Sabine River, is not considered as a part of SNWW. After the confluence, the combined Sabine-Neches river runs along the western boundary of Sabine Lake and meets the ocean about 75 miles northeast of Galveston. The boundary between the two states divides the Sabine Lake into two parts. The western shoreline of Sabine Lake is in Texas, whereas the eastern shoreline is in Louisiana. Sabine Pass connects Sabine Lake with the Gulf of Mexico. Location map of the project is shown in Figure 1.2.1, and an index map is shown in Figure 1.2.2.

A coordinate system that has evolved historically is used for measuring distances along the SNWW. It is also used for identifying locations and for conducting dredging operations. The SNWW is arbitrarily divided into seven reaches and each segment is identified by a different name. Figure 1.2.3 shows these seven reaches. Detailed geographic features of each reach are shown in Figures 1.2.4 through 1.2.8. Table 1.2.1 gives the extent of each reach using the site coordinates.

Reach 1: Neches River Channel

This reach covers the uppermost part of the Neches River. It extends from the confluence of the two rivers towards north (0+00 to 1037+59.40). The total length of about 20 miles for this reach is subdivided into six sub-sections designated by 1A, 1B, 1C, 1D, 2 and 3.

Reach 2: Sabine Neches Canal

This reach covers the length from the confluence of rivers southwards from station 593+68.50 to 0+00.

Reach 3: Port Arthur Canal

This reach covers the length from station 0+00 to 326+24.4

Reach 4: Sabine Pass Channel

This reach covers the channel segment south of reach 3 up to the natural ocean shoreline. (station 0+00 to 296+24.6)

Reach 5: The Sabine Pass Jetty Channel

This segment is confined between the two jetties provided at the mouth of the Sabine Neches Waterway. (station - 214+88.30 to 0+00)

Reach 6: Sabine Pass Outer Bar Channel
This segment extends from the end of jetties to a distance of about 3.5 miles into the ocean. (18+00 to 0+00)

Reach 7: Sabine Bank Channel
This is the last segment of the navigation channel, extending into the Gulf of Mexico beyond reach 6 for a distance of about 15 miles.

The Port Arthur Canal and Sabine-Neches Canal are dredged channels separated by a narrow strip of land from the western shore of Sabine Lake.

In November 1975 the U. S. Army Engineer District, Galveston, Texas prepared the Final Environmental Statement Report on Maintenance Dredging for Sabine Neches Waterway. The project dimensions given in that report are reproduced in Table 1.2.2. The bottom widths, channel depths and side slopes for each of the seven reaches listed earlier are given in Table 1.2.3. All the depths and elevations given in this report are referenced to Mean Low Tide Datum (MLT), which is 0.81 feet below Mean Sea Level Datum in the Sabine Pass Area as determined by the National Geodetic Survey. The navigation channel may also be sub-divided into deep water and shallow water (less than 25 feet deep) channels. The areas included under these two types are listed in Table 1.2.4.

The Gulf Intracoastal Waterway (GIWW), which extends from Apalachee Bay, Florida, to Brownsville, Texas, connects with the Sabine-Neches Waterway at a point about 3 miles below Orange. The GIWW then follows the Sabine River and Sabine-Neches Canal to the head of the Port Arthur Canal. The GIWW section to the east provides a connection with the Calcasieu River through the Lake Charles Deep Water Channel and Choupique cutoff. The GIWW also provides shallow-draft access westward to Galveston Bay.

Several small streams join the Sabine and Neches Rivers. Also there are extensive marshlands that are indirectly connected to the river system. This makes a very complex interconnected hydrodynamic system for propagation of tides, salt water and fresh water flows.

## Port Facilities

The port has more than 160 piers, wharves, turning basins and docks serviced by the project waterway. The types of facilities include general cargo handling, bulk petroleum and grain handling, shipbuilding, commercial fish handling, and others. A detailed description of the port facilities serviced by the Sabine-Neches Waterway is available in the Corps of Engineers Port Series No. 22, revised in 2001.

## Proposed Development

The existing project depth in the navigation channel is 44 feet with 2 feet over-depth in the outer channel. The project depth is 42 feet with a 1-foot over-depth for the inner channel. Based on several considerations, the team members at Galveston District selected the project depth of 50-foot for the navigation channel and connected areas such as turning circles and harbor basins. It is customary to dredge navigation channels at a depth greater than the project depth. This excess dredging, referred to as over-depth, covers various allowances for safe navigation and also minimizes the need for emergency dredging for small loss of depths due to shoaling. For the SNWW project the depths would be as follows:

a) For navigation channel outside the jetties:

| | |
|---|---|
| Project depth | 52 feet |
| Advance maintenance dredging | 2 feet |
| (Allowable over-depth | 2 feet) |
| (Wave effect allowance | 2 feet) |
| Total depth of dredged channel | 54 feet |

b) For the interior navigation channel inside the jetties:

| | |
|---|---|
| Project depth | 50 feet |
| Total depth of dredged channel | 52 feet |

## Table 1.2.1: Reaches of Sabine Neches Navigation Channel

| ZONE | REACH (EXISTING STATIONS) | FROM STATION | TO STATION | LENGTH FEET | LENGTH MILES |
|---|---|---|---|---|---|
| | | | | | |
| 7 | SABINE BANK CHANNEL | 95+734 | 18+000 | 77,734 | 14.72 |
| | | | | | |
| 6 | SABINE PASS OUTER BAR | 18+000 | 0+000 | 18,000 | 3.41 |
| | | | | | |
| 5 | SABINE PASS JETTY CHANNEL | -214+88.30 | 0+00.00 | 21,488 | 4.07 |
| | | | | | |
| 4 | SABINE PASS CHANNEL | 0+00.00 | 296+24.6 | 29,625 | 5.61 |
| | | | | | |
| 3 | PORT ARTHUR CANAL | 0+00.00 | 326+24.4 | 32,624 | 6.18 |
| | | | | | |
| 2 | SABINE-NECHES CANAL | 0+00.00 | 593+68.50 | 59,368 | 11.24 |
| | | | | | |
| 1 | NECHES RIVER CHANNEL | 0+00.00 | 1037+59.40 | 103,759 | 19.65 |
| | | | | | |
| | | | TOTAL | | 64.88 |
| | | | | | |
| | NECHES RIVER CHANNEL (1A) | 0+00 | 10+00 | | |
| | NECHES RIVER CHANNEL (1B) | 10+00 | 34+00 | | |
| | NECHES RIVER CHANNEL (1C) | 34+00 | 75+00 | | |
| | NECHES RIVER CHANNEL (1D) | 75+00.00 | 978+59.76 | | |
| | NECHES RIVER CHANNEL 2 | 978+59.76 | 998+63.42 | | |
| | NECHES RIVER CHANNEL 3 | 998+63.42 | 1037+59.40 | | |

## Table 1.2.2: Project dimensions

| Section of Waterway | Authorized Project Dimensions (Feet) Depth (MLT) | Bottom Width | Length of Section |
|---|---|---|---|
| Sabine Bank Channel ………… | 42 | 800 | 77,800 |
| Sabine Pass Outer Bar Channel. | 42 | 800 | 18,000 |
| Sabine Pass Jetty Channel……. | 40 | 800-500 | 21,488 |
| Sabine Pass Anchorage Basin… | 40 | 1500 | 3,000 |
| Sabine Pass Channel………….. | 40 | 500 | 29,624 |
| Port Arthur Canal……………… | 40 | 500 | 32,625 |
| Entrance to Port Arthur Turning basins………………………… | 40 | 275-678 | 1,500 |
| Port Arthur East Turning Basin.. | 40 | 420 | 1,765 |
| Port Arthur West Turning Basin. | 40 | 620 | 1,610 |
| Channel connecting Port Arthur West Turning Basin and Taylors Bayou Turning Basin. | 40 | 200-250 | 3,020 |
| Taylors Bayou Turning Basin.. | 40 | 150-1,000 | 3,470 |
| Sabine-Neches Canal, Port Arthur Canal to Neches River | 40 | 400 | 59,369 |
| Neches River, mouth to maneuvering area at Beaumont Turning Basin………………… | 40 | 400 | 96,500 |
| Neches River, turning point vicinity mile 31.1………….. | 40 | 1,000 dia, | 700 |
| Neches River, turning point vicinity mile 36.6………… | 40 | 1,000 dia. | - |
| Neches River, turning point vicinity mile 40.3………. | 40 | 1,000 dia. | - |
| Neches River, channel extension, vicinity mile 40.3…… | 36 | 350 | 1,256 |
| Maneuvering Area at Beaumont Turning Basin……………….. | 40 | Irregular | 1,300 |
| Beaumont Turning Basin……. | 34 | 500 | 1,500 |
| Beaumont Turning Basin extension…………………………. | 34 | 350 | 2,096 |
| Beaumont Turning Basin extension to end of project channel, vicinity Bethlehem Steel Co… | 30 | 200 | 3,864 |
| Sabine-Neches Canal, Neches River to Sabine River………. | 30 | 200 | 23,000 |
| Sabine River, mouth to foot of Green Avenue………………. | 30 | 200 | 49,938 |

Table 1.2.2 (Cont'd)

| Section of Waterway | Authorized Project Dimensions (Feet) Depth (MLT) | Bottom Width | Length of Section |
|---|---|---|---|
| Orange Turning Basin………. | 30 | Irregular | 1,550 |
| Orange Municipal Slip………. | 30 | 200 | 2,435 |
| Old Channel around Harbor Island………………………. | 25 | 150-200 | 12,634 |
| Channel to Echo……………. | 12 | 125 | 24,578** |
| Adams Bayou……………….. | 12 | 100 | 8,900 |
| Cow Bayou………………….. | 13 | 100 | 37,000* |
| Orangefield Turning Basin….. | 13 | 300 | 500 |

*Upper 0.7 mile is in inactive category.
**4.6 miles are in inactive category (not constructed).
Figures 1-4 are drawings of the Sabine-Neches Waterway.

Reference: Table 1 from the Final Environmental Statement Report on Maintenance Dredging Sabine Neches Waterway, Texas, dated 4 November 1975 prepared by the U. S. Army Engineer District, Galveston, Texas.

## Table 1.2.3: Details of Sabine Neches Navigation Channel Reaches

| ZONE | REACH (EXISTING STATIONS) | EXISTING BOTTOM WIDTH (FT) | EXISTING CHANNEL DEPTH (FT, MLT) | ALLOWABLE OVERDEPTH (FT) | SIDE SLOPE |
|---|---|---|---|---|---|
| | | | | | |
| 7 | SABINE BANK CHANNEL | 800 | 44 | 2 | 1V/10H |
| 6 | SABINE PASS OUTER BAR | 800 | 44 | 2 | 1V/10H |
| 5 | SABINE PASS JETTY CHANNEL | 800-500 | 42 | 2 | 1V/2H |
| 4 | SABINE PASS CHANNEL | 500 | 42 | 2 | 1V/2H |
| 3 | PORT ARTHUR CANAL | 500 | 42 | 1 | 1V/2H |
| 2 | SABINE-NECHES CANAL | 400 | 42 | 1 | 1V/2H |
| 1 | NECHES RIVER CHANNEL (See details given below) | | | | |
| | | | | | |
| | | | | | |
| 1 | NECHES RIVER CHANNEL (1A) | 400 | 42 | 2 | 1V/2H |
| 1 | NECHES RIVER CHANNEL (1B) | 400 | 42 | 2 | 1V/2H & 1V/5H RS |
| 1 | NECHES RIVER CHANNEL (1C) | 400 | 42 | 2 | 1V/2H |
| 1 | NECHES RIVER CHANNEL (1D) | 400 | 42 | 1 | 1V/2H |
| 1 | NECHES RIVER CHANNEL 2 | 1000-300 | 36 | 1 | 1V/2H |
| 1 | NECHES RIVER CHANNEL 3 | 300-200 | 32 | 1 | 1V/2H |

Reference: Table

## Table 1.2.4: Deep Draft and Shallow Draft Channels

| Deep Draft Channels (>25' Depth) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Channel** | **Area #** | **Location** | **Mile Length** | | **Station** | **to** | **Station** |
| **SP** | **SABINE PASS** | | | | | | |
| | 1 | Sabine Bank Channel | | | 18+000 | **to** | 93+734 |
| | 2 | Outer Bar Channel | | | 0+000 | **to** | 18+000 |
| | 3 | Jetty Channel | | | 0+000 | **to** | 214+88.3 |
| | 4 | Pass Channel | | | 0+000 | **to** | 296+24.3 |
| | 5 | Anchorage Basin | | | 100+00 | **to** | 182+00 |
| **PA** | **PORT ARTHUR CANAL** | | | | | | |
| | 1 | Junction-Port Arthur & Sabine-Neches Canals | | | 290+00 | **to** | 40+00 |
| | 2 | Entrance to Port Arthur Turning Basins | | | 0+00 | **to** | 22+10.2 |
| | 3 | Port Arthur East Turning Basins | | | 0+00 | **to** | 17+65 |
| | 4 | Port Arthur West Turning Basins | | | 17+97 | **to** | 31+09.8 |
| | 5 | Port Arthur West Turn Basns. To Taylors Bayou Turn Bsns | | | 31+09.8 | **to** | 61+30 |
| | 6 | Taylors Bayou Turning Basins | | | 61+30 | **to** | 96+00 |
| | 7 | P.A. Canal | | | 0+00 | **to** | 290+00 |
| **SN** | **SABINE NECHES CANAL** | | | | | | |
| | 1 | Junction with Port Arthur Canal to Neches River | | | 40+00 | **to** | 593+68.5 |
| | 2 | Neches River to Sabine River (Section B) | | | 0+00 | **to** | 230+00 |
| **NR** | **NECHES RIVER CHANNEL** | | | | | | |
| | 1 | Mouth to Smith Bluff Cut-Off | | | 0+00 | **to** | 505+00 |
| | 2 | Turning Basin at Deer Bayou | | | 197+50 | **to** | 213+60 |
| | 3 | Turning Basin at Smiths Bluff | | | 492+50 | **to** | 505+00 |
| | 4 | Smith Bluff Cut-Off to Beaumont Turning Basin | | | 505+00 | **to** | 978+00 |
| | 5 | Turning Basin @ Mile 40.3 | | | 690+00 | **to** | 705+00 |
| | 6 | Channel Extension "C" | | | 714+20 | **to** | 725+74 |
| | 7 | Maneuvering Area @ Beaumont Turning Basin | | | 950+15.97 | **to** | 978+00 |
| | 8 | Beaumont Turning Basin | | | 0+00 | **to** | 15+00 |
| | 9 | Beaumont Turning Basin Extension | | | 978+00 | **to** | 998+00 |
| | 10 | Beaumont Turn Bsns. Ext. to Vic. Bethlehem Shipyards | | | 978+00 | **to** | 1037+59.4 |
| **SR** | **SABINE RIVER** | | | | | | |
| | 1 | Mouth to Orange Municipal Slip | | | 0+00 | **to** | 590+00 |
| | 2 | Orange Turning Basin | | | 590+13.3 | **to** | 630+31.3 |
| | 3 | Orange Municipal Slip | | | -4+00 | **to** | 26+35 |
| | 4 | Orange Municipal Slip to Old U.S. Hwy 90 Bridge Site | | | 620+00 | **to** | 729+37.8 |
| | 5 | Channel Around Orange Harbor Island | | | 0+00 | **to** | 115+00 |
| | | | | | | | |

| SHALLOW DRAFT CHANNELS (>25' Depth) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Channel** | **Area #** | **Location** | **Mile Length** | | **Station** | **to** | **Station** |
| **GI** | **GULF INTRACOASTAL WATERWAY, TEXAS** | | | | | | |
| | 1 | Port Arthur to High Island | | | 0+00 | **to** | 1613.97.5 |
| **AB** | **ADAMS BAYOU CHANNEL** | | | | | | |
| | 1 | Channel | | | 0+00 | **to** | 82+00 |
| **CW** | **COW BAYOU CHANNEL** | | | | | | |
| | 1 | Channel | | | -4+00 | **to** | 368+00 |
| | 2 | Orangefield Turning Basin | | | 368+00 | **to** | 375+00 |

# Chapter 1.3: Site Conditions

Field data collected by different agencies and reported in literature are included in this chapter. Field data collected by ERDC and their analysis are reported subsequently.

## Tides

A tide gage on Pleasure Island (PI) is situated at station 524 of the Texas Coastal Ocean Observation Network (TCOON). This station is located at latitude 29 degrees 52.0'N and longitude 93 degrees 55.9' W, which is at the U.S. Army Corps of Engineers (USACE) facility located on the northwest side of PI on the Sabine-Neches Canal shoreline. Another tide gage close to the area is the National Oceanic and Atmospheric Administration's (NOAA) Station 8770570, which is located at latitude 29 degrees 43.8'N and longitude 93 degrees 52.2' W, at the U.S. Coast Guard compound located on South First Avenue.

PBS&J Consulting Engineers obtained tidal datums from the TCOON and NOAA web sites http://dnr.cbi.tamucc.edu/datum/524 and http://cops.nos.noaa.gov/benchmarks/8770570.html, respectively. After converting to English units and relating the datums to Mean Lower Low Water (MLLW), the tidal datums are listed in Table 1.3.1. The Mean Low Tide (MLT) datum used by the USACE is also listed in the Table for comparison. Tidal data indicated a semi-diurnal pattern with a tidal range of about 1.0 to 1.5 feet, which is typical of Texas shoreline.

Depths and elevations given in this report are with reference to the Mean Low Tide Datum (MLT), which is 0.81 feet below Mean Sea Level Datum in the Sabine Pass Area as determined by the National Geodetic Survey.

## Salinity

Salinity data provides indication on the amount of fresh water flow in an estuarine situation. A monitoring station with water quality data has been installed along the Sabine-Neches Canal. The station is 10683, Sabine-Neches Canal, which is close to the north end of Pleasure Island adjacent to TOPCO Docks. PBS&J have reported salinity data at this location. Salinity was measured at 0.3 m and 1 m below water surface. The results are shown in Figure 1.3.1. Salinity at this station fluctuated from 1 ppt to 18 ppt. It was noted that the sampling location was too close to the mouth of the Neches River and hence the results may not be representative of the Sabine-Neches Canal.

## Table 1.3.1: Tidal Datums

| Tidal Datums | TCOON (Feet) | NOAA (Feet) | USACE (Feet) |
|---|---|---|---|
| Highest Observed Water Level (08.01/1989) | --- | 4.32 | --- |
| Mean Higher High Water (MHHW | 1.02 | 1.62 | --- |
| Mean High Water (MHW) | 0.97 | 1.50 | --- |
| Mean Tide Level (MTL) | 0.55 | 0.98 | --- |
| Mean Sea Level (MSL) | 0.62 | 0.98 | 0.81 |
| Mean Low Water (MLW) | 0.13 | 0.47 | --- |
| Mean Low Tide (MLT) | --- | --- | 0.00 |
| Mean Lower Low Water (MLLW) | 0.00 | 0.00 | --- |
| Lowest Observed Water Lower (01/19/1996) | --- | -3.74 | --- |

Reference: Table 2-2 from PBS&J (Consulting Engineers), 2000, Document No. 000377, Engineering Report for Task 1: Project Review of the Pleasure Island Shoreline Protection Project. Report prepared for Texas General Land Office at Austin, TX.

# Chapter1.4: Numerical Modeling

## Background

In connection with the proposed widening and deepening of the SNWW navigation channel, a hydrodynamic and salinity (H&S) numerical model study is being conducted simultaneous with the sediment study. Results of tides and velocities obtained from this model, which is verified for the hydrodynamics, have been used for the sediment study.

## Hydrodynamic Model

The three-dimensional (3-D), finite-element code TABS-MD available with CHL was used to develop the model and obtain results. The TABS-MD code has been used successfully at CHL for several navigation studies. Because the model used a finite-element mesh, it represented the complex geometries of ship channels, turning basins, etc. realistically and with sufficient resolution. The model extended from the Gulf of Mexico to inland past Beaumont and Orange, and included Sabine Lake and portions of the Gulf Intracoastal Waterway (GIWW) going east and west past the SNWW. The offshore boundary was located well beyond the maximum contemplated plan channel depth of 56-ft including over-dredging. The model grid and its boundaries are shown in Figure 1.4.1. The model was forced with water levels, and the interior boundaries were forced with freshwater inflows from Neches and Sabine Rivers. Pine Island Bayou inflows were neglected for the simulations used for the sediment study since they are relatively small. Wind forcing was applied to the study area as appropriate.

## The Mesh

The existing conditions as well as one selected plan were tested. For the existing conditions, the geometry and bathymetry were developed using National Oceanic and Atmospheric Administration (NOAA) charts, US Geological Survey (USGS) Quad Sheets, aerial orthographic photos, and latest surveys supplied by the Galveston District. Sufficient resolution was provided in the navigation channels to represent the velocity distribution across the deeper channel section as well as side banks, and any cross currents. The mesh and bathymetry for existing conditions were modified appropriately for the plan conditions. The mesh for the existing conditions is shown in Figure 1.4.1.

The area included in the model as well as the model grids are shown in Figure 1.4.1. Attempt has been made to accurately simulate the real geographic boundaries as far as possible while formulating the model grid. Higher resolution is provided in the study areas by adopting smaller size elements and larger size elements are provided in the areas of less interest in order to keep smaller number of grid elements. Such schematization is inevitable for most numerical models involving large geographic areas. The schematization used for each reach is shown in Figures 1.4.2 through 1.4.6.

## Test Conditions

The following test conditions were used for running the model.

1. A spring tide with southeasterly winds of magnitude 15 mph and zero freshwater inflows to represent high flood currents. This boundary condition is referred to as "Flood". The time series is shown in Figure 1.4.7.

2. A spring tide with northwesterly winds of magnitude 20 mph and high freshwater inflows to represent high ebb currents. Freshwater inflows of 16,200 and 18,600 cfs were applied respectively at the Neches and Sabine River boundaries, as they represent the 90 percentile flow values for the two rivers, based on long-term statistics collected by the USGS. This boundary condition is referred to as "Ebb". The time series is shown in Figure 1.4.8.

The two test conditions are referred to as "Flood" and "Ebb" only for the convenience of reference, although the total duration of their respective runs extends over a time of about 120 hours and includes cycles of the rising and falling tidal water levels, which are conventionally called the flood and ebb respectively.

The water level time series used at the offshore boundary were obtained from observed water levels at Sabine Pass, following a procedure developed during tidal validation. In this procedure, the observed water levels at Sabine Pass were shifted ahead in time by 1-hour to account for the time of travel of tides. Because winds influence water levels at the model's boundary, the historic data on water levels and corresponding winds were examined, and water levels used in the model were selected from actual data that approximately corresponded to winds of the desired magnitude and direction for the two test conditions.

Computed maximum flood and ebb currents for the two test conditions corresponding to the existing and plan conditions were provided for use in the ship simulator study.

## Results of Hydrodynamic Model

The "base condition" in the model consisted of year 2000 bathymetry with the navigation channel at 45 feet depth. Results on flow pattern and currents were obtained by running the model for an adequate duration, allowing for initial "spin-up time". The model was then run for the "plan condition" by widening and deepening the navigation channel as suggested by the Galveston District. The boundary conditions described earlier were used for running both the existing and plan conditions. The flood currents solution (for both existing and plan) is 173.5 hours long and the ebb currents solution is 192.0 hr long. 124 Nodes were selected from the model grid for extracting model results. Locations of nodes were selected adjacent to the locations of bed sample collection in each of the seven reaches. The actual numerical model node numbers of these selected nodes were assigned new numbers for convenience of reference. The relationships between the actual node numbers, their respective new node numbers, and the nearest bed sample numbers are given in Table 1.4.1. The results of hydrodynamic model were used for estimation of shoaling for plan conditions so as to determine impacts of channel modification.

## Sediment Modeling

Under many situations a full-fledged numerical sediment modeling is recommended for important projects and Sabine Neches is not an exception. However, every sediment modeling effort requires results of a satisfactorily verified hydrodynamic model as the first step. Since fine sediment dynamics is significantly influenced by salinity, a three-dimensional model including salinity simulation becomes essential. This first step requires field data on several parameters such as bathymetry, tides, currents, and salinity. The task of verification of numerical sediment model requires additional data on suspended sediment, bed sediment, and historical data on capital and maintenance dredging quantities. Collection of field data for a project covering reaches extending over several miles and conducting their laboratory analysis is quite expensive and time consuming. Hence the Galveston District proposed conducting a desktop study on the sediment-related problems for the SNWW project.

## Desktop Study

A desktop study is an alternative method of obtaining preliminary answers without conducting a full-fledged numerical sediment modeling study. It requires field data on sediments and dredging quantities and results of a hydrodynamic model. Estimation of anticipated shoaling involves an unavoidable subjective element and hence the results need to be considered as a preliminary estimate, which is sometimes adequate for a feasibility study.

Desktop studies conducted earlier by ERDC include the following two reports by Parchure et al. 1. Desktop Study for La Quinta Project, and 2. Desktop study for shoaling prediction in Corpus Christi navigation channel.

# Desktop Study for
# Sediment-Related Problems at
# Sabine Neches Project

# Part 2
# Effect of Navigation Channel Modifications

# Chapter 2.1: Navigation Channel Shoaling

## Introduction

Shoaling of navigation channels is a universal problem. Since most navigation channels are deeper than the surrounding natural bed elevation, they function as efficient sediment traps. Sediment may deposit due to bed load transport, as in the case of along shore littoral drift accumulating in a navigation channel running normal to the shore. Shoaling is also caused by deposition of suspended sediment Increasing the dimensions of a navigation channel results in increased quantity of sediment deposition.

## General Considerations

It is necessary to determine the important factors at play while evaluating shoaling of navigation channel and harbor areas under the present conditions and for estimating future shoaling caused by channel modifications. These factors are listed below (Parchure and Teeter, 2002c).

1. Type of sediment
   - Cohesive
   - Non-cohesive
   - Mixture
   - Fluid mud
   - Calcareous
   - Biogenic
   - Loam
   - Peat
2. Identification of sediment source
   - Suspended sediment
   - Bed erosion
   - Bank sloughing
   - Adjacent land areas
   - Sediment recirculation
   - Aolian sediment transport
   - Littoral drift
   - Flood/ebb shoal
   - Porous land reclamation
   - Porous other structures
3. Critical natural parameter involved
   - Tidal current
   - Ocean influx
   - River discharge
   - Tributary inflow
   - Density current
   - Waves
   - Vessel-induced waves and currents
   - Eddies
   - Flow stagnation

Meandering river
Geomorphology
Land runoff
Sea level rise
Land upheaval
Over-bank flow
Existing structures
Episodic events such as earthquake and storm

4. Time scale of shoaling occurrence
   - Perennial
   - Periodically recurring
   - Sporadic
5. Total volume of sediment
   - For selecting suitable dredging equipment
   - For working out benefit / cost ratio for proposed measures
6. Importance of the location
   - National defense
   - Recreational
   - Environmental
   - Archeological
   - Commercial
7. Location of major problem
   - Specific channel reach
   - Berths
   - Estuary mouth
8. Best approach to investigate the problem
   - Physical modeling
   - Tracer study
   - Numerical modeling
   - Field data analysis
   - Desktop study
9. Success or failure of measures taken at other sites under similar site conditions and natural parameters.

## Field Data Collection

The Galveston District supplied survey data, dredging history data and project layout maps, which have been used for the present study.

CHL collected field data on tides, currents and salinity. These were used for validation of a numerical hydrodynamic model.

CHL collected surface bed sediment samples along the SNWW ship channel and along the shoreline of Pleasure Island for use in the sedimentation studies. These were analyzed at the CHL Sedimentation Laboratory to determine particle size distribution and organic contents. CHL also collected mid-depth water samples, which were analyzed to determine the concentration of total suspended matter (TSM) and salinity.

Results of analysis of all the field data are reported at relevant places in this report.

# Chapter 2.2: Field Data on Sediment, Water and Velocity

## Bed Sediment New Data

In all, 92 surface bed samples were collected in April 2002 by CHL along the SNWW navigation channel. The number of samples collected from each reach was as follows: Reach 1 (18), Reach 2 (23), Reach 3 (12), Reach 4 (12), Reach 5 (8), Reach 6 (3), and Reach 7 (16). All these samples were collected approximately at the center of the navigation channel. Locations of all the bed samples are shown in Figure 2.2.1 through Figure 2.2.9. The sample numbers are written at the center of the navigation channel. They do not appear in serial numbers. They start with 1900 at the upstream reach of Neches River and end with zero at the end of the jetties. Then they start with OS52 to represent the offshore samples and end with the number OS1003 beyond the existing offshore navigation channel. All the bed samples were analyzed to determine the percent fraction finer than silt (smaller than 64 micron in size), particle size distribution of the fraction coarser than silt, and the percentage of total organic matter. The particle size distribution curves of bed samples are given in Appendix A. The results of silt-sand split and percent organic matter are given in Table 2.2.1. The average values are given in Table 2.2.2.

It is seen that the sediment consists of a mixture of sand, silt and clay. The contents vary from 4 percent sand and 96 percent silt plus clay to 38 percent sand and 62 percent silt plus clay. The average percentage of organic matter varied from 3.74 to 8.73.

## Bed Sediment Old Data

The Galveston District had supplied bed sediment data collected in the past at several locations along the navigation channel. These data were collected over a period of several years from 1984 to 1996. The data included results of laboratory analysis, which included percentages of sand, silt and clay as well as the median diameter of sediment sample. The original data supplied by the District were rearranged in groups representing the seven reaches of the SNWW navigation channel and are presented in Table 2.2.3. Since the data were not synoptic, they could not be used for the present study, however they are included here only for the purpose of reporting.

## Suspended Sediment

CHL-ERDC collected water samples at mid-depth on April 16 and 18 for the inner part of SNWW at the same locations where bed samples were collected. Water samples were again collected on August 22 in the outer channel. These were analyzed in the ERDC laboratory to determine the percentage concentration of suspended matter. The results are given in Table 2.2.4.

The Total Suspended Matter (TSM) showed considerable variation along the navigation channel. It varied from 14 mg/l to 242 mg/l in the inner channel, and from 4 mg/l to 33 mg/l in the outer channel.

Water samples were also collected at two locations, labeled as 2 and 5, at 30-minute intervals on April 17 th. The locations are shown in Figure 2.2.10. The samples were collected at three depths, namely near surface, mid-depth and near bed. These were analyzed to determine suspended sediment concentration. The results are given in Tables 2.2.5 for location 2, and in Table 2.2.6 for location 5.

It may be noted that field data were collected during calm weather conditions. Suspended sediment concentration could be much higher during adverse conditions such as high wind and wave conditions.

## Salinity

Water samples collected at mid-depth at the same locations as bed samples were analyzed to determine salinity. The samples were collected on April 16 and 18 for the inner channel and on August 22 for the offshore channel. The results of salinity measurements are given in Table 2.2.4 simultaneous with the results of suspended sediment concentration.

The salinity varied from near zero in the riverine part to 28 ppt in the ocean. It is necessary to note that both the suspended sediment concentration and salinity depend upon the river discharge and tidal conditions at the time of data collection. The combined discharge of Neches and Sabine River was 25,900 cfs on April 16 and 45,300 on April 18. In view of the significant variation on the two days, the data presented here cannot be considered close to simultaneous at all the locations of data collection.

The second set consisted of water samples collected at every 30-minute interval at two locations, named as 2 and 5, which are shown in Figure 2.2.10. Both the locations were close to the center of navigation channel. Station 5 was located close to the natural shoreline. Station 2 was located at Port Arthur. Salinity at stations 2 and 5 is reported in Table 2.2.7.

Salinity measured at surface, mid-depth and near-bottom at Station 2 near Port Arthur showed that the surface and mid-depth salinity stayed close to zero but the near-bottom salinity rose to as high as 9.2 ppt at some stages of tide. Rapid flocculation of certain clay minerals occurs in the range of salinity between 1 and 5 ppt. Hence the observed high level of salinity is expected to be responsible for shoaling in the reach downstream of Port Arthur.

Salinity measured at surface, mid-depth and near-bottom at Station 5 near the inlet showed a large variation in salinity over the vertical. The surface salinity varied from 3 to 7 ppt whereas the near-bottom salinity remained close to about 28 ppt. The mid-depth salinity showed a large variation with tide between these two values.

Salinity data were collected over a 25-hour period at transects shown on Figure 2.2.11. The data were collected at three depths, namely near surface, mid-depth and near bottom. All the locations were in the navigation channel, which may be approximately described as follows:

R1: South of the anchorage area in the Sabine Pass Channel

R3: South of Intracoastal Waterway junction with navigation channel
R4: In the Intracoastal waterway
R5: Near East Basin of Port Arthur
R6: In Neches River
R7: At the outfall of Neches River in the Sabine Lake

The results are presented in Figures 2.2.12 through 2.2.17. The following conclusions are drawn:

1. There was substantial variation in salinity over the water depth, indicating stratification.
2. Salinity at all depths showed variation with time, however it was not consistently correlated to tidal stage variation.
3. The bottom salinity at transects R1, the location closest to the ocean, varied from about 24 to 31 ppt and the surface salinity varied form 14 to 28 ppt.
4. The bottom salinity at R6, the location farthest from the ocean varied from 16 to 20 ppt and the surface salinity varied form 9 to 10 ppt.

## River Discharge

Salinity is a function of tidal prism and fresh water discharge in an estuary. Fresh water flows in the Sabine and Neches rivers around the water sample collection dates are given in Table 2.2.8.

## Additional Field Data

In addition to the field data reported above, CHL-ERDC also collected long-term field data on tides, salinity and velocity. The locations of collection are shown in Figure 2.2.18. The locations relevant to the navigation channel study are

7: Sabine Pass
6: Port Arthur
3: Rainbow Bridge on Neches River
2: Beaumont on Neches River

Data on water level elevations are given in Figures 2.2.19 through 2.2.23.
Data on salinity are given in Figures 2.2.24 through 2.2.27
Data on velocity are given in Figures 2.2.28 through 2.2.31.

# Table 2.2.1: Bed Sample Analysis for Sabine Neches Project

**Reach 1**

| S. No. | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| 1 | 1900 | 92.72 | 7.28 | 2.06 |
| 2 | 1874 | 82.36 | 17.64 | 3.15 |
| 3 | 1848 | 96.6 | 3.4 | 1.95 |
| 4 | 1821 | 95.02 | 4.98 | 0.97 |
| 5 | 1795 | 20.83 | 79.17 | 7.34 |
| 6 | 1768 | 3.2 | 96.8 | 9.61 |
| 7 | 1742 | 4.6 | 95.4 | 11.24 |
| 8 | 1716 | 26.02 | 73.98 | 8.56 |
| 9 | 1689 | 9.39 | 90.61 | 7.82 |
| 10 | 1663 | 88.22 | 11.78 | 0.61 |
| 11 | 1636 | 25.64 | 74.36 | 8.38 |
| 12 | 1610 | 9.03 | 90.97 | 8.74 |
| 13 | 1584 | 21.75 | 78.25 | 7.16 |
| 14 | 1557 | 49.57 | 50.43 | 7.80 |
| 15 | 1531 | 3.62 | 96.38 | 7.98 |
| 16 | 1504 | 10.74 | 89.26 | 7.96 |
| 17 | 1478 | 29.48 | 70.52 | 7.17 |
| 18 | 1452 | 20.59 | 79.41 | 7.05 |
| Avg. = | | 38.30 | 61.70 | 6.42 |

Table 2.2.1 (contd.): Bed Sample Analysis for Sabine Neches Project

**Reach 2**

| **S. No.** | **Sample #** | **% Sand** | **% Silt + Clay** | **% Organic Matter** |
|---|---|---|---|---|
| 19 | 1425 | 16.38 | 83.62 | 6.81 |
| 20 | 1399 | 66.21 | 33.79 | 3.63 |
| 21 | 1372 | 29.05 | 70.95 | 5.30 |
| 22 | 1346 | 23.44 | 76.56 | 4.87 |
| 23 | 1320 | 17.14 | 82.86 | 4.50 |
| 24 | 1293 | 13.69 | 86.31 | 4.96 |
| 25 | 1267 | 45.16 | 54.84 | 5.06 |
| 26 | 1240 | 28.74 | 71.26 | 5.44 |
| 27 | 1214 | 12.58 | 87.42 | 6.80 |
| 28 | 1188 | 31.72 | 68.28 | 5.41 |
| 29 | 1161 | 20.02 | 79.98 | 7.46 |
| 30 | 1135 | 40.51 | 59.49 | 8.09 |
| 31 | 1108 | 8.32 | 91.68 | 7.53 |
| 32 | 1082 | 21.64 | 78.36 | 7.68 |
| 33 | 1056 | 13.15 | 86.85 | 5.46 |
| 34 | 1029 | 16.9 | 83.1 | 8.48 |
| 35 | 1003 | 13.13 | 86.87 | 7.80 |
| 36 | 976 | 11.65 | 88.35 | 14.64 |
| 37 | 950 | 16.78 | 83.22 | 7.54 |
| 38 | 924 | 8.85 | 91.15 | 9.49 |
| 39 | 897 | 37.53 | 62.47 | 5.37 |
| 40 | 871 | 7.51 | 92.49 | 7.71 |
| 41 | 844 | 9.42 | 90.58 | 8.66 |
| Avg. = | | 22.15 | 77.85 | 6.90 |

Table 2.2.1 (contd.): Bed Sample Analysis for Sabine Neches Project

**Reach 3**

| S. No. | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| 42 | 818 | 7.29 | 92.71 | 9.23 |
| 43 | 792 | 7.57 | 92.43 | 8.99 |
| 44 | 765 | 7.9 | 92.1 | 6.91 |
| 45 | 739 | 22.26 | 77.74 | 6.27 |
| 46 | 712 | 33.86 | 66.14 | 6.07 |
| 47 | 686 | 13.83 | 86.17 | 7.82 |
| 48 | 660 | 4.1 | 95.9 | 8.25 |
| 49 | 633 | 16.82 | 83.18 | 8.63 |
| 50 | 607 | 25.15 | 74.85 | 6.08 |
| 51 | 580 | 8.68 | 91.32 | 7.26 |
| 52 | 554 | 26.3 | 73.7 | 4.19 |
| 53 | 528 | 20.53 | 79.47 | 5.93 |
| Avg. = | | 16.19 | 83.81 | 7.13 |

**Reach 4**

| S. No. | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| 54 | 501 | 16.94 | 83.06 | 7.05 |
| 55 | 475 | 36.72 | 63.28 | 7.08 |
| 56 | 448 | 83.5 | 16.5 | 9.04 |
| 57 | 422 | 86.85 | 13.15 | 9.48 |
| 58 | 396 | 3.79 | 96.21 | 8.22 |
| 59 | 369 | 1.84 | 98.16 | 9.78 |
| 60 | 343 | 1.52 | 98.48 | 7.55 |
| 61 | 316 | 14.42 | 85.58 | 12.45 |
| 62 | 290 | 3.67 | 96.33 | 7.69 |
| 63 | 264 | 22.66 | 77.34 | 7.12 |
| 64 | 237 | 69.89 | 30.11 | 12.75 |
| 65 | 211 | 19.45 | 80.55 | 6.60 |
| Avg. = | | 30.10 | 69.90 | 8.73 |

Table 2.2.1 (contd.): Bed Sample Analysis for Sabine Neches Project

## Reach 5

| S. No | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| 66 | 184 | 4.02 | 95.98 | 11.12 |
| 67 | 158 | 10.79 | 89.21 | 7.27 |
| 68 | 132 | Shells | Shells | Shells |
| 69 | 105 | 12.13 | 87.87 | 3.28 |
| 70 | 79 | Shells | Shells | Shells |
| 71 | 52 | Shells | Shells | Shells |
| 72 | 26 | Shells | Shells | Shells |
| 73 | 0 | 16.81 | 83.19 | 2.30 |
| Avg. = | | 10.94 | 89.06 | 6.00 |

## Reach 6

| S. No | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| | | | | |
| 74 | OS52 | 5.62 | 94.38 | 1.81 |
| 75 | OS105 | 3.52 | 96.48 | 7.16 |
| 76 | OS158 | 3.88 | 96.12 | 2.26 |
| Avg. = | | 4.34 | 95.66 | 3.74 |

Table 2.2.1 (contd.): Bed Sample Analysis for Sabine Neches Project

Reach 7

| S. No. | Sample # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|---|
| 77 | OS211 | 1.89 | 98.11 | 5.02 |
| 78 | OS264 | 5.97 | 94.03 | 3.15 |
| 79 | OS316 | 32.88 | 67.12 | 2.65 |
| 80 | OS369 | 32.99 | 67.01 | 3.93 |
| 81 | OS422 | 20.66 | 79.34 | 4.14 |
| 82 | OS475 | 47 | 53 | 2.89 |
| 83 | OS528 | 8.06 | 91.94 | 4.28 |
| 84 | OS580 | 9.39 | 90.61 | 5.38 |
| 85 | OS633 | 20.28 | 79.72 | 9.58 |
| 86 | OS686 | 21.9 | 78.1 | 4.51 |
| 87 | OS739 | 3.45 | 96.55 | 7.16 |
| 88 | OS792 | 29.65 | 70.35 | 3.5499 |
| 89 | OS844 | 65.26 | 34.74 | 2.1731 |
| 90 | OS897 | 8.73 | 91.27 | |
| 91 | OS950 | 34.46 | 65.54 | 3.60 |
| 92 | OS1003 | 46.15 | 53.85 | 4.083 |
| Avg. = | | 24.29 | 75.71 | 4.13 |

**Table 2.2.2: Average percentages of sand, silt plus clay and percent organic matter in bed sediment**

| Reach # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|
| 1 | 38.30 | 61.70 | 6.42 |
| 2 | 22.15 | 77.85 | 6.90 |
| 3 | 16.19 | 83.81 | 7.13 |
| 4 | 30.10 | 69.90 | 8.73 |
| 5 | 10.94 | 89.06 | 6.00 |
| 6 | 4.34 | 95.66 | 3.74 |
| 7 | 24.29 | 75.71 | 4.13 |

# Table 2.2.3: SNWW Sediment Data (1984 to 1996) Supplied by Project

| New<br>Sample # | Original<br>Number | % Sand | %<br>Silt | %<br>Clay | D50 mm | Location<br>Zone | Channel | Station |
|---|---|---|---|---|---|---|---|---|
| 8 | S-NR-88-01 | 17.8 | 42.20 | 40.00 | 0.022 | 1 | Neches River Channel | 0+00 |
| 9 | S-NR-88-03 | 1.4 | 28.40 | 70.20 | | 1 | Neches River Channel | 100+00 |
| 10 | S-NR-88-05 | 4.6 | 29.10 | 66.30 | 0.002 | 1 | Neches River Channel | 200+00 |
| 11 | S-NR-88-07 | 3.2 | 29.30 | 67.50 | 0.002 | 1 | Neches River Channel | 300+00 |
| 12 | S-NR-88-19 | 19.8 | 39.10 | 41.10 | 0.01 | 1 | Neches River Channel | 900+00 |
| 13 | S-NR-88-21 | 23.8 | 30.20 | 46.00 | 0.006 | 1 | Neches River Channel | 1000+00 |
| 23 | S-NR-90-01 | 6.9 | 50.00 | 43.10 | 0.0012 | 1 | Neches River Channel | 0+00 |
| 52 | S-NR-94-08 | 16.9 | 69.30 | 13.80 | 0.04 | 1 | Neches River Channel | 350+00 |
| 53 | S-NR-94-09 | 9.1 | 79.80 | 11.10 | 0.058 | 1 | Neches River Channel | 400+00 |
| 54 | S-NR-94-10 | 11.8 | 55.50 | 32.70 | 0.026 | 1 | Neches River Channel | 450+00 |
| 55 | S-NR-94-11 | 40.8 | 50.00 | 9.20 | 0.065 | 1 | Neches River Channel | 500+00 |
| 56 | S-NR-94-12 | 15.7 | 72.40 | 11.90 | 0.036 | 1 | Neches River Channel | 550+00 |
| 57 | S-NR-94-13 | 11.9 | 69.30 | 18.80 | 0.036 | 1 | Neches River Channel | 600+00 |
| 58 | S-NR-94-15 | 25.5 | 58.00 | 16.50 | 0.043 | 1 | Neches River Channel | 700+00 |
| 59 | S-NR-94-16 | 43.7 | 44.90 | 11.40 | 0.069 | 1 | Neches River Channel | 750+00 |
| 60 | S-NR-94-17 | 34.8 | 44.60 | 20.60 | 0.043 | 1 | Neches River Channel | 800+00 |
| 61 | S-NR-94-18 | 62 | 26.60 | 11.40 | 0.204 | 1 | Neches River Channel | 850+00 |
| 62 | S-NR-94-01 | 32 | 47.40 | 20.60 | 0.061 | 1 | Neches River Channel | 0+00 |
| 63 | S-NR-94-02 | 7.7 | 69.20 | 23.10 | 0.055 | 1 | Neches River Channel | 50+00 |
| 64 | S-NR-94-03 | 13.2 | 55.50 | 31.30 | 0.032 | 1 | Neches River Channel | 100+00 |
| 65 | S-NR-94-04 | 20.8 | 63.90 | 15.30 | 0.051 | 1 | Neches River Channel | 150+00 |
| 66 | S-NR-94-05 | 9.6 | 65.20 | 25.20 | 0.042 | 1 | Neches River Channel | 200+00 |
| 67 | S-NR-94-06 | 61.1 | 13.70 | 25.20 | 0.138 | 1 | Neches River Channel | 250+00 |
| 68 | S-NR-95-18 | 69.6 | 25.10 | 5.30 | 0.279 | 1 | Neches River Channel | 850+00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 69 | S-NR-95-19 | 43.1 | 41.20 | 15.70 | 0.064 | 1 | Neches River Channel | 900+00 |
| 70 | S-NR-95-20 | 55 | 35.10 | 9.90 | 0.099 | 1 | Neches River Channel | 950+00 |
| 71 | S-NR-95-21 | 98.5 | 0.90 | 0.60 | 0.318 | 1 | Neches River Channel | 1000+00 |
| 76 | S-NR-95-18 | 25.6 | 31.60 | 42.80 | 0.009 | 1 | Neches River Channel | 850+00 |
| 77 | S-NR-95-19 | 51.8 | 29.10 | 19.10 | 0.083 | 1 | Neches River Channel | 900+00 |
| 78 | S-NR-95-20 | 72.5 | 10.70 | 16.80 | 0.161 | 1 | Neches River Channel | 950+00 |
| 79 | S-NR-95-21 | 85.7 | 6.50 | 7.80 | 0.456 | 1 | Neches River Channel | 1000+00 |
| 114 | S-NR-97-01 | 53.6 | 1.70 | 44.70 | 0.119 | 1 | Neches River Channel | 0+00 |
| 1 | S-SN-84-01 | 0.14 | 77.27 | 22.59 | 0.0097 | 2 | Sabine-Neches Canal | 0+00 |
| 4 | S-SN-87-01 | 0.77 | 73.32 | 25.91 | 0.0071 | 2 | Sabine-Neches Canal | 0+00 |
| 22 | S-SN-90-17 | 52.2 | 34.20 | 13.60 | 0.143 | 2 | Sabine-Neches Canal | 200+00 |
| 24 | S-SN-90-01 | 3.3 | 46.60 | 50.10 | 0.005 | 2 | Sabine-Neches Canal | 0+00 |
| 25 | S-SN-90-03 | 13.3 | 53.90 | 32.80 | 0.025 | 2 | Sabine-Neches Canal | 100+00 |
| 26 | S-SN-90-05 | 23.8 | 46.70 | 29.50 | 0.022 | 2 | Sabine-Neches Canal | 200+00 |
| 27 | S-SN-90-07 | 18.5 | 61.70 | 18.50 | 0.05 | 2 | Sabine-Neches Canal | 300+00 |
| 28 | S-SN-90-09 | 13 | 45.90 | 41.10 | 0.01 | 2 | Sabine-Neches Canal | 400+00 |
| 29 | S-SN-90-11 | 9.4 | 59.20 | 31.40 | 0.011 | 2 | Sabine-Neches Canal | 500+00 |
| 51 | S-SN-93-01 | 14.4 | 44.40 | 41.20 | 0.011 | 2 | Sabine-Neches Canal | 0+00 |
| 72 | S-SN-95-13 | 10.6 | 51.00 | 38.40 | 0.013 | 2 | Sabine-Neches Canal | 0+00 |
| 73 | S-SN-95-15 | 6 | 56.60 | 37.40 | 0.015 | 2 | Sabine-Neches Canal | 100+00 |
| 74 | S-SN-95-17 | 26.7 | 52.10 | 21.20 | 0.055 | 2 | Sabine-Neches Canal | 200+00 |
| 100 | S-SN-96-01 | 52.2 | 33.40 | 14.40 | | 2 | Sabine-Neches Canal | 0+00 |
| 108 | S-SN-96-06 | 75.1 | 18.10 | 6.80 | 0.095 | 2 | Sabine-Neches Canal | 250+00 |
| 109 | S-SN-96-07 | 12.6 | 45.70 | 41.70 | 0.008 | 2 | Sabine-Neches Canal | 300+00 |
| 110 | S-SN-96-08 | 76.5 | 17.10 | 6.40 | 0.16 | 2 | Sabine-Neches Canal | 350+00 |
| 111 | S-SN-96-09 | 72.2 | 8.20 | 19.60 | 0.165 | 2 | Sabine-Neches Canal | 400+00 |
| 112 | S-SN-96-10 | 19.4 | 45.50 | 35.10 | 0.019 | 2 | Sabine-Neches Canal | 450+00 |
| 113 | S-SN-96-11 | 49 | 34.50 | 16.50 | 0.073 | 2 | Sabine-Neches Canal | 500+00 |
| 115 | S-SN-97-02 | 31.5 | 30.60 | 37.90 | 0.014 | 2 | Sabine-Neches Canal | 50+00 |
| 116 | S-SN-97-03 | 15.5 | 43.00 | 41.50 | 0.009 | 2 | Sabine-Neches Canal | 100+00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 117 | S-SN-97-04 | 24.1 | 27.90 | 48.00 | 0.006 | 2 | Sabine-Neches Canal | 150+00 |
| 118 | S-SN-97-05 | 60.1 | 10.90 | 29.00 | 0.088 | 2 | Sabine-Neches Canal | 200+00 |
| 119 | S-SN-97-06 | 36.5 | 34.20 | 29.30 | 0.046 | 2 | Sabine-Neches Canal | 250+00 |
| 120 | S-SN-97-07 | 46.4 | 29.20 | 24.40 | 0.069 | 2 | Sabine-Neches Canal | 300+00 |
| 121 | S-SN-97-08 | 54.7 | 30.20 | 15.10 | 0.078 | 2 | Sabine-Neches Canal | 350+00 |
| 122 | S-SN-97-09 | 46.8 | 34.70 | 18.50 | 0.07 | 2 | Sabine-Neches Canal | 400+00 |
| 123 | S-SN-97-10 | 52.7 | 20.00 | 27.30 | 0.078 | 2 | Sabine-Neches Canal | 450+00 |
| 124 | S-SN-97-11 | 42.4 | 29.30 | 28.30 | 0.05 | 2 | Sabine-Neches Canal | 500+00 |
| 125 | S-SN-97-12 | 29.7 | 22.30 | 48.00 | 0.006 | 2 | Sabine-Neches Canal | 550+00 |
| 147 | S-SN-98-01 | 30.7 | 44.70 | 24.60 | 0.044 | 2 | Sabine-Neches Canal | 0+00 |
| 163 | S-SN-98-01 | 30.7 | 44.70 | 24.60 | 0.044 | 2 | Sabine-Neches Canal | 0+00 |
| 2 | S-PA-87-07 | 1.55 | 72.52 | 25.94 | 0.00677 | 3 | Port Arthur Canal | 300+00 |
| 3 | S-PATB-87-09 | 0.98 | 78.00 | 21.02 | 0.007 | 3 | Port Arthur Turning Basins | 15+00 |
| 5 | S-PA-87-01 | 18.25 | 64.88 | 16.88 | | 3 | Port Arthur Canal | 296+00 |
| 14 | S-PA-89-07 | 1.7 | 41.20 | 57.10 | 0.004 | 3 | Port Arthur Canal | 300+00 |
| 15 | S-PATB-89-09 | 0.7 | 33.50 | 65.80 | 0.003 | 3 | Port Arthur Turning Basins | 15+00 |
| 16 | S-PATB-89-10 | 3 | 28.10 | 68.90 | 0.003 | 3 | Port Arthur Turning Basins | 25+00 |
| 17 | S-PATB-89-12 | 3.3 | 74.70 | 22.00 | 0.009 | 3 | Taylors Bayou Turning Basin | 75+00 |
| 18 | S-PA-90-02 | 61.2 | 29.70 | 9.10 | 0.12 | 3 | Port Arthur Canal | 50+00 |
| 19 | S-PA-90-04 | 55.9 | 32.20 | 11.90 | 0.134 | 3 | Port Arthur Canal | 150+00 |
| 20 | S-PA-90-06 | 50.9 | 33.90 | 15.20 | 0.076 | 3 | Port Arthur Canal | 200+00 |
| 21 | S-SP-90-06 | 46 | 34.60 | 19.40 | 0.069 | 3 | Port Arthur Canal | 250+00 |
| 30 | S-PA-92-01 | 29.9 | 38.40 | 31.70 | 0.019 | 3 | Port Arthur Canal | 0+00 |
| 31 | S-PATB-92-08 | 12.7 | 29.90 | 57.40 | 0.003 | 3 | Port Arthur Turning Basins | 0+00 |
| 32 | S-PATB-92-09 | 18.4 | 19.50 | 62.10 | 0.004 | 3 | Port Arthur Turning Basins | 15+00 |
| 33 | S-PATB-92-10 | 24.6 | 39.00 | 36.40 | 0.012 | 3 | Port Arthur Turning Basins | 25+00 |
| 46 | S-PA-93-07 | 11.2 | 58.40 | 30.40 | 0.032 | 3 | Port Arthur Canal | 300+00 |
| 47 | S-PATB-93-08 | 0.7 | 63.90 | 35.40 | 0.016 | 3 | Port Arthur Turning Basins | 0+00 |
| 48 | S-PATB-93-08A | 2 | 59.60 | 38.40 | 0.013 | 3 | Port Arthur Turning Basins | 5+00 |
| 49 | S-PATB-93-10 | 2 | 44.40 | 53.60 | 0.004 | 3 | Port Arthur Turning Basins | 25+00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 50 | S-PATB-93-11 | 4.1 | 60.80 | 35.10 | 0.012 | 3 | Taylors Bayou Turning Basin | 50+00 |
| 94 | S-PA-96-07 | 5.5 | 67.50 | 27.00 | 0.02 | 3 | Port Arthur Canal | 300+00 |
| 95 | S-PATB-96-08 | 5.1 | 36.40 | 58.50 | 0.001 | 3 | Port Arthur Turning Basins | 0+00 |
| 96 | S-PATB-96-09 | 1.3 | 50.70 | 48.00 | 0.01 | 3 | Port Arthur Turning Basins | 15+00 |
| 97 | S-PATB-96-10 | 2.7 | 51.20 | 46.10 | 0.01 | 3 | Port Arthur Turning Basins | 25+00 |
| 98 | S-PATB-96-11 | 8.1 | 26.20 | 65.70 | | 3 | Taylors Bayou Turning Basin | 50+00 |
| 99 | S-PATB-96-12 | 5.6 | 61.00 | 33.40 | 0.02 | 3 | Taylors Bayou Turning Basin | 75+00 |
| 135 | S-PA-98-01 | 52.9 | 19.50 | 27.60 | 0.083 | 3 | Port Arthur Canal | 0+00 |
| 136 | S-PA-98-02 | 33.35 | 26.75 | 39.90 | 0.023 | 3 | Port Arthur Canal | 50+00 |
| 137 | S-PA-98-03 | 36.1 | 25.90 | 38.00 | 0.016 | 3 | Port Arthur Canal | 100+00 |
| 138 | S-PA-98-04 | 11.5 | 29.50 | 59.00 | 0.003 | 3 | Port Arthur Canal | 150+00 |
| 139 | S-PA-98-05 | 51.3 | 29.80 | 18.90 | 0.077 | 3 | Port Arthur Canal | 200+00 |
| 140 | S-PA-98-06 | 6.95 | 25.00 | 68.05 | 0.002 | 3 | Port Arthur Canal | 250+00 |
| 141 | S-PA-98-07 | 7.4 | 18.70 | 73.90 | 0.002 | 3 | Port Arthur Canal | 300+00 |
| 142 | S-PATB-98-08 | 5 | 56.90 | 38.10 | 0.022 | 3 | Port Arthur Turning Basins | 0+00 |
| 143 | S-PATB-98-09 | 0.8 | 26.80 | 72.40 | 0.002 | 3 | Port Arthur Turning Basins | 15+00 |
| 144 | S-PATB-98-10 | 1.4 | 31.20 | 67.40 | 0.002 | 3 | Port Arthur Turning Basins | 25+00 |
| 145 | S-PATB-98-11 | 7.1 | 46.80 | 46.10 | 0.007 | 3 | Taylors Bayou Turning Basin | 50+00 |
| 146 | S-PATB-98-12 | 3.8 | 36.80 | 59.40 | 0.003 | 3 | Taylors Bayou Turning Basin | 75+00 |
| 151 | S-PA-98-01 | 52.9 | 19.50 | 27.60 | 0.083 | 3 | Port Arthur Canal | 0+00 |
| 152 | S-PA-98-02 | 33.35 | 26.75 | 39.90 | 0.023 | 3 | Port Arthur Canal | 50+00 |
| 153 | S-PA-98-03 | 36.1 | 25.90 | 38.00 | 0.016 | 3 | Port Arthur Canal | 100+00 |
| 154 | S-PA-98-04 | 11.5 | 29.50 | 59.00 | 0.003 | 3 | Port Arthur Canal | 150+00 |
| 155 | S-PA-98-05 | 51.3 | 29.80 | 18.90 | 0.077 | 3 | Port Arthur Canal | 200+00 |
| 156 | S-PA-98-06 | 6.95 | 25.00 | 68.05 | 0.002 | 3 | Port Arthur Canal | 250+00 |
| 157 | S-PA-98-07 | 7.4 | 18.70 | 73.90 | 0.002 | 3 | Port Arthur Canal | 300+00 |
| 158 | S-PATB-98-08 | 5 | 56.90 | 38.10 | 0.022 | 3 | Port Arthur Turning Basins | 0+00 |
| 159 | S-PATB-98-09 | 0.8 | 26.80 | 72.40 | 0.002 | 3 | Port Arthur Turning Basins | 15+00 |
| 160 | S-PATB-98-10 | 1.4 | 31.20 | 67.40 | 0.002 | 3 | Port Arthur Turning Basins | 25+00 |
| 161 | S-PATB-98-11 | 7.1 | 46.80 | 46.10 | 0.007 | 3 | Taylors Bayou Turning Basin | 50+00 |
| 162 | S-PATB-98-12 | 3.8 | 36.80 | 59.40 | 0.003 | 3 | Taylors Bayou Turning Basin | 75+00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | S-SP-87-03 | 10.29 | 75.12 | 14.59 | | 4 | Sabine Pass Channel | 100+00 |
| 34 | S-SP-92-03 | 21.9 | 48.10 | 30.00 | 0.023 | 4 | Sabine Pass Channel | 100+00 |
| 35 | S-SP-92-04 | 37.7 | 34.20 | 28.10 | 0.018 | 4 | Sabine Pass Channel | 150+00 |
| 36 | S-SP-92-06 | 24 | 37.50 | 38.50 | 0.012 | 4 | Sabine Pass Channel | 250+00 |
| 148 | S-SP-98-03 | 35.6 | 18.30 | 46.10 | 0.008 | 4 | Sabine Pass Channel | 100+00 |
| 149 | S-SP-98-04 | 7.6 | 32.10 | 60.30 | 0.003 | 4 | Sabine Pass Channel | 150+00 |
| 150 | S-SP-98-06 | 23.1 | 37.80 | 39.10 | 0.031 | 4 | Sabine Pass Channel | 250+00 |
| 164 | S-SP-98-03 | 35.6 | 18.30 | 46.10 | 0.008 | 4 | Sabine Pass Channel | 100+00 |
| 165 | S-SP-98-04 | 7.6 | 32.10 | 60.30 | 0.003 | 4 | Sabine Pass Channel | 150+00 |
| 166 | S-SP-98-06 | 23.1 | 37.80 | 39.10 | 0.031 | 4 | Sabine Pass Channel | 250+00 |
| 101 | S-J-96-01 | 19 | 42.20 | 38.80 | 0.042 | 5 | Entrance Channel | -200+00 |
| 102 | S-J-96-02 | 33.5 | 33.50 | 33.00 | 0.053 | 5 | Entrance Channel | -150+00 |
| 103 | S-J-96-03 | 12.8 | 45.10 | 42.10 | 0.015 | 5 | Entrance Channel | -100+00 |
| 104 | S-J-96-04 | 72.9 | 21.10 | 6.00 | 0.101 | 5 | Entrance Channel | -50+00 |
| 105 | S-J-96-05 | 32 | 34.00 | 34.00 | 0.057 | 5 | Entrance Channel | 0+00 |
| 126 | S-J-98-01 | 16.8 | 56.90 | 26.30 | 0.006 | 5 | Entrance Channel | -200+00 |
| 127 | S-J-98-02 | 16.6 | 55.20 | 28.20 | 0.013 | 5 | Entrance Channel | -150+00 |
| 128 | S-J-98-03 | 15 | 64.00 | 19.70 | 0.014 | 5 | Entrance Channel | -100+00 |
| 129 | S-J-98-04 | 3.9 | 23.50 | 72.60 | 0.002 | 5 | Entrance Channel | -50+00 |
| 130 | S-J-98-05 | 22.5 | 55.30 | 17.00 | 0.009 | 5 | Entrance Channel | 0+00 |
| 37 | S-SB-93-01 | 3 | 61.20 | 35.80 | 0.026 | 6 | Entrance Channel | 7+000 |
| 38 | S-SB-93-02 | 10.2 | 56.90 | 32.90 | 0.018 | 6 | Entrance Channel | 18+000 |
| 43 | S-SB-93-DA4 | 8.3 | 69.90 | 21.80 | 0.029 | 6 | Entrance Channel | 7+000 |
| 80 | S-SB-95-01 | 5.6 | 19.20 | 75.20 | | 6 | Entrance Channel | 7+000 |
| 81 | S-SB-95-02 | 2.2 | 41.90 | 55.90 | 0.002 | 6 | Entrance Channel | 18+000 |
| 91 | S-SB-95-DA4 | 8 | 31.00 | 61.00 | 0.002 | 6 | Entrance Channel | 12+000 |
| 93 | S-SB-95-REF3&4 | 52.3 | 29.40 | 18.30 | 0.079 | 6 | Entrance Channel | See Notes |
| 106 | S-J-96-DA4 | 1.9 | 41.20 | 56.90 | 0.003 | 6 | Entrance Channel | 12+000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 107 | S-J-96-REF3&4 | 43.3 | 40.50 | 16.20 | 0.068 | 6 | Entrance Channel | Note 6 |
| 131 | S-SB-98-01 | 1 | 13.00 | 86.00 | 0.004 | 6 | Entrance Channel | 7+000 |
| 132 | S-SB-98-02 | 1.1 | 20.70 | 78.20 | 0.004 | 6 | Entrance Channel | 18+000 |
| 133 | S-SB-98-DA4 | 2.4 | 26.90 | 70.70 | 0.003 | 6 | Entrance Channel | 12+000 |
| 134 | S-SB-98-REF3+4 | 44.4 | 30.20 | 22.00 | 0.067 | 6 | Entrance Channel | Note 6 |
| 39 | S-SB-93-05 | 7.7 | 68.40 | 23.90 | 0.033 | 7 | Entrance Channel | 54+900 |
| 40 | S-SB-93-06 | 30.7 | 41.30 | 28.00 | 0.015 | 7 | Entrance Channel | 66+700 |
| 41 | S-SB-93-DA2 | 63.7 | 22.30 | 14.00 | 0.206 | 7 | Entrance Channel | 62+000 |
| 42 | S-SB-93-DA3 | 64.7 | 23.40 | 11.90 | 0.183 | 7 | Entrance Channel | 31+350 |
| 44 | S-SB-93-REF1&2 | 61 | 28.70 | 10.30 | 0.135 | 7 | Entrance Channel | See Notes |
| 45 | S-SB-93-REF3&4 | 45.2 | 41.60 | 13.20 | 0.065 | 7 | Entrance Channel | See Notes |
| 82 | S-SB-95-03 | 3.4 | 49.70 | 46.90 | 0.006 | 7 | Entrance Channel | 30+000 |
| 83 | S-SB-95-04 | 5.8 | 59.60 | 34.60 | 0.026 | 7 | Entrance Channel | 42+500 |
| 84 | S-SB-95-05 | 5.2 | 46.90 | 47.90 | 0.007 | 7 | Entrance Channel | 54+900 |
| 85 | S-SB-95-06 | 19 | 47.20 | 33.80 | 0.022 | 7 | Entrance Channel | 66+700 |
| 86 | S-SB-95-07 | 6.5 | 42.70 | 50.80 | 0.004 | 7 | Entrance Channel | 78+500 |
| 87 | S-SB-95-08 | 6.3 | 42.60 | 51.10 | 0.004 | 7 | Entrance Channel | 87+000 |
| 88 | S-SB-95-DA1 | 94 | 1.20 | 4.80 | 0.188 | 7 | Entrance Channel | 98+870 |
| 89 | S-SB-95-DA2 | 55.1 | 27.10 | 17.80 | 0.154 | 7 | Entrance Channel | 60+000 |
| 90 | S-SB-95-DA3 | 18.5 | 36.50 | 45.00 | 0.01 | 7 | Entrance Channel | 30+000 |
| 92 | S-SB-95-REF1&2 | 54 | 26.30 | 19.70 | 0.081 | 7 | Entrance Channel | See Notes |
| 75 | S-SR-95-09 | 11 | 70.00 | 19.00 | 0.22 | ? | Orange Municipal Slip | 25+00 |

## Table 2.2.4: Analysis of water samples collected at Sabine-Neches Project

| S. No. | Channel Reach # | Sample # | Suspended Sediment Concentration (mg/l) | Salinity (ppt) |
|---|---|---|---|---|
| Collection Date: April 16, 2002 | | | | |
| 1 | 1 | 1900 | 42 | 0.01 |
| 2 | | 1874 | 90 | 0.01 |
| 3 | | 1848 | 45 | 0.01 |
| 4 | | 1821 | 49 | 0.01 |
| 5 | | 1795 | 37 | 0.01 |
| 6 | | 1768 | 49 | 0.01 |
| 7 | | 1742 | 20 | 0.01 |
| 8 | | 1716 | 78 | 0.01 |
| 9 | | 1689 | 76 | 0.01 |
| 10 | | 1663 | 64 | 0.01 |
| 11 | 2 | 1636 | 53 | 0.01 |
| 12 | | 1610 | 65 | 0.01 |
| 13 | | 1584 | 27 | 0.01 |
| 14 | | 1557 | 73 | 0.01 |
| 15 | | 1531 | 88 | 0.01 |
| 16 | | 1504 | 60 | 0.01 |
| 17 | | 1478 | 24 | 0.01 |
| 18 | | 1452 | 38 | 0.01 |
| 19 | | 1425 | 14 | 0.01 |
| 20 | | 1399 | 30 | 0.01 |
| 21 | 3 | 1372 | 58 | 0.01 |
| 22 | | 1346 | 54 | 0.01 |
| 23 | | 1320 | 56 | 0.01 |
| 24 | | 1293 | 35 | 0.01 |
| 25 | | 1267 | 15 | 0.01 |
| 26 | | 1240 | 90 | 0.01 |
| 27 | | 1214 | 66 | 0.01 |
| 28 | | 1188 | 68 | 0.02 |
| 29 | | 1161 | 58 | 0.02 |
| 30 | | 1135 | 70 | 0.04 |

Table 2.2.4 (continued): Analysis of water samples collected at Sabine-Neches Project

| S. No. | Channel Reach # | Sample # | Suspended Sediment Concentration (mg/l) | Salinity (ppt) |
|---|---|---|---|---|
| 31 | 4 | 1108 | 24 | 0.04 |
| 32 | | 1082 | 67 | 0.05 |
| 33 | | 1056 | 33 | 0.04 |
| 34 | | 1029 | 53 | 2.02 |
| 35 | | 1003 | 40 | 3.20 |
| 36 | | 976 | 47 | 2.87 |
| 37 | | 950 | 54 | 2.75 |
| 38 | | 924 | 46 | 4.17 |
| 39 | | 897 | 40 | 6.78 |
| 40 | | 871 | 31 | 6.09 |
| 41 | 5 | 844 | 34 | 5.32 |
| 42 | | 818 | 24 | 2.74 |
| 43 | | 792 | 37 | 6.88 |
| 44 | | 765 | 30 | 8.57 |
| 45 | | 739 | 124 | 5.77 |
| 46 | | 712 | 242 | 9.90 |
| 47 | | 686 | 126 | 8.77 |
| 48 | | 660 | 47 | 6.81 |
| April18,2002 | | | | |
| 49 | | 633 | 27 | 0.04 |
| 50 | | 607 | 76 | 0.04 |
| 51 | 6 | 580 | 76 | 0.04 |
| 52 | | 554 | 76 | 0.05 |
| 53 | | 528 | 82 | 2.79 |
| 54 | | 501 | 48 | 6.00 |
| 55 | | 475 | 54 | 10.74 |
| 56 | | 448 | 31 | 13.42 |
| 57 | | 422 | 43 | 15.77 |
| 58 | | 396 | 56 | 16.65 |
| 59 | | 369 | 40 | 15.74 |
| 60 | | 343 | 29 | 12.97 |

Table 2.2.4 (continued): Analysis of water samples collected at Sabine-Neches Project

| S. No. | Channel Reach # | Sample # | Suspended Sediment Concentration (mg/l) | Salinity (ppt) |
|---|---|---|---|---|
| April18,2002 | | | | |
| 61 | 7 | 316 | 36 | 20.03 |
| 62 | | 290 | 34 | 16.8 |
| 63 | | 264 | 44 | 19.57 |
| 64 | | 237 | 22 | 15.87 |
| 65 | | 211 | 51 | 20.04 |
| 66 | | 184 | 30 | 21.26 |
| 67 | | 158 | 24 | 18.54 |
| 68 | | 132 | 24.24 | 26.84 |
| 69 | | 105 | 17.34 | 26.70 |
| 70 | | 79 | 32 | 27.24 |
| 71 | | 52 | 22.22 | 27.81 |
| 72 | | 26 | 20.40 | 27.97 |
| 73 | | 0 | 19.19 | 28.19 |
| 74 | | OS52 | 18.36 | 28.25 |
| 75 | | OS105 | 12 | 28.17 |
| 76 | | OS158 | 33.33 | 28.01 |
| 77 | | OS211 | 14 | 28.09 |
| 78 | | OS264 | 18 | 28.28 |
| 79 | | OS316 | 12.37 | 28.38 |
| 80 | | OS369 | 10.30 | 28.42 |
| 81 | | OS422 | 9.183 | 28.40 |
| 82 | | OS475 | 11.22 | 28.22 |
| 83 | | OS528 | 12.12 | 27.90 |
| 84 | | OS580 | 9 | 25.98 |
| 85 | | OS633 | 11 | 27.31 |
| 86 | | OS686 | 15 | 26.48 |
| 87 | | OS739 | 25 | 25.72 |
| 88 | | OS792 | 9.090 | 26.85 |
| 89 | | OS844 | 14.14 | 26.98 |
| 90 | | OS897 | 4 | 26.44 |
| 91 | | OS950 | 26.53 | 27.20 |
| 92 | | OS1003 | 7.071 | 28.30 |

**Table 2.2.5: Suspended Sediment Concentration measured at Station 2 on April 17, 2002**

| Near Bed | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| | | ft. | mg/l |
| 68 | 0600 | 46.0 | 125 |
| 71 | 0631 | 48.0 | 90 |
| 74 | 0701 | 48.0 | 36 |
| 77 | 0731 | 48 | 24 |
| 80 | 0801 | 48 | 290 |
| 83 | 0831 | 46.0 | 702 |
| 86 | 0901 | 48.0 | 180 |
| 88 | 0931 | 45.5 | 20 |
| 91 | 1001 | 48.0 | 24 |
| 94 | 1031 | 48.0 | 94 |
| 97 | 1101 | 45.0 | 66 |
| 100 | 1131 | 49 | 30 |
| 103 | 1201 | 46.0 | 22 |
| 106 | 1231 | 49.0 | 71 |
| 109 | 1301 | 46.0 | 26 |
| 112 | 1331 | 49.0 | 71 |
| 116 | 1401 | 46.0 | 125 |
| 118 | 1431 | 44.0 | 382 |
| 121 | 1501 | 44.0 | 120 |
| 124 | 1534 | 46.0 | 76 |
| 127 | 1601 | 48.0 | 408 |
| 130 | 1631 | 50.0 | 544 |
| 133 | 1701 | 49.0 | 302 |
| 136 | 1731 | 48.0 | 1424 |
| 139 | 1801 | 49.0 | 5 |
| 142 | 1831 | 48.0 | 285 |

| Mid-Depth | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| 69 | 0602 | 24.0 | 48 |
| 72 | 0632 | 25.0 | 74 |
| 75 | 0702 | 25.0 | 78 |
| 78 | 0732 | 25.0 | 78 |
| 81 | 0802 | 25.0 | 134 |
| 84 | 0832 | 24.0 | 104 |
| 89 | 0932 | 24.0 | 140 |
| 92 | 1002 | 25.0 | 426 |
| 95 | 1032 | 25.0 | 300 |
| 98 | 1102 | 23.5 | 228 |
| 101 | 1132 | 25.5 | 250 |
| 104 | 1202 | 24.0 | 184 |
| 107 | 1232 | 25.5 | 175 |
| 110 | 1302 | 24.0 | 150 |
| 113 | 1332 | 25.5 | 802 |
| 117 | 1402 | 24.0 | 262 |
| 119 | 1432 | 23.0 | 179 |
| 122 | 1502 | 23.0 | 51 |
| 125 | 1536 | 24.0 | 219 |
| 128 | 1602 | 25.0 | 104 |
| 131 | 1632 | 26.0 | 212 |
| 134 | 1702 | 25.5 | 86 |
| 137 | 1732 | 25.0 | 130 |
| 140 | 1802 | 25.5 | 322 |
| 143 | 1832 | 25.0 | 4 |

| Near Surface | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| 70 | 0603 | 2.0 | 57 |
| 73 | 0630 | 2.0 | 14 |
| 76 | 0700 | 2.0 | 64 |
| 79 | 0730 | 2.0 | 60 |
| 82 | 0800 | 2.0 | 84 |
| 85 | 0830 | 2.0 | 26 |
| 87 | 0900 | 2.0 | 106 |
| 90 | 0930 | 2.0 | 80 |
| 93 | 1000 | 2.0 | 98 |
| 96 | 1030 | 2.0 | 24 |
| 99 | 1100 | 2.0 | 79 |
| 102 | 1130 | 2.0 | 19 |
| 105 | 1200 | 2.0 | 56 |
| 108 | 1230 | 2.0 | 114 |
| 111 | 1300 | 2.0 | 49 |
| 114 | 1330 | 2.0 | 38 |
| 115 | 1400 | 2.0 | 19 |
| 120 | 1430 | 2.0 | 102 |
| 123 | 1500 | 2.0 | 72 |
| 126 | 1533 | 2.0 | 138 |
| 129 | 1600 | 2.0 | 102 |
| 132 | 1630 | 2.0 | 102 |
| 135 | 1700 | 2.0 | 33 |
| 138 | 1730 | 2.0 | 61 |
| 141 | 1800 | 2.0 | 96 |
| 144 | 1830 | 2.0 | 90 |

**Table 2.2.6: Suspended Sediment Concentration measured at Station 5 on April 17, 2002**

| Near Bed | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| | | ft. | mg/l |
| 145 | 0604 | 51.0 | 400 |
| 148 | 0630 | 53.8 | 570 |
| 151 | 0700 | 53.2 | 40 |
| 154 | 0730 | 53.0 | 422 |
| 157 | 0800 | 54.2 | 456 |
| 160 | 0830 | 52.4 | 1156 |
| 163 | 0900 | 52.6 | 432 |
| 166 | 0930 | 52.8 | 510 |
| 169 | 1000 | 52.4 | 476 |
| 172 | 1030 | 53.0 | 578 |
| 175 | 1100 | 52.8 | 180 |
| 178 | 1135 | 52.6 | 828 |
| 181 | 1200 | 53.2 | 44 |
| 184 | 1230 | 52.6 | 150 |
| 187 | 1303 | 51.8 | 74 |
| 190 | 1338 | 53.0 | 45 |
| 193 | 1400 | 52.8 | 88 |
| 196 | 1430 | 52.4 | 41 |
| 199 | 1500 | 53.4 | 46 |
| 202 | 1530 | 52.8 | 35 |
| 205 | 1600 | 52.2 | 37 |
| 208 | 1630 | 53.0 | 44 |
| 211 | 1700 | 52.8 | 30 |
| 214 | 1730 | 52.6 | 53 |
| 217 | 1800 | 51.8 | 27 |
| 220 | 1830 | 51.8 | 21 |

| Mid-Depth | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| | | ft. | mg/l |
| 146 | 0605 | 26.5 | 35 |
| 149 | 0631 | 27.9 | 44 |
| 152 | 0701 | 27.6 | 38 |
| 155 | 0731 | 27.5 | 60 |
| 158 | 0801 | 28.1 | 220 |
| 161 | 0831 | 27.2 | 72 |
| 164 | 0901 | 27.3 | 30 |
| 167 | 0931 | 27.4 | 31 |
| 170 | 1001 | 27.2 | 16 |
| 173 | 1031 | 27.5 | 55 |
| 176 | 1101 | 27.4 | 24 |
| 179 | 1136 | 27.3 | 102 |
| 182 | 1201 | 27.6 | 317 |
| 185 | 1231 | 27.3 | 137 |
| 188 | 1304 | 26.9 | 88 |
| 191 | 1339 | 27.5 | 784 |
| 194 | 1401 | 27.4 | 44 |
| 197 | 1431 | 27.2 | 42 |
| 200 | 1502 | 27.7 | 36 |
| 203 | 1531 | 27.4 | 26 |
| 206 | 1601 | 27.1 | 34 |
| 209 | 1631 | 27.5 | 31 |
| 212 | 1701 | 27.4 | 26 |
| 215 | 1731 | 27.3 | 32 |
| 218 | 1801 | 26.9 | 28 |
| 221 | 1831 | 26.9 | 25 |

| Near Surface | | | |
|---|---|---|---|
| Sample # | Time | Depth | Conc |
| | | ft. | mg/l |
| 147 | 0606 | 2.0 | 30 |
| 150 | 0632 | 2.0 | 37 |
| 153 | 0702 | 2.0 | 36 |
| 156 | 0732 | 2.0 | 32 |
| 159 | 0802 | 2.0 | 36 |
| 162 | 0832 | 2.0 | 34 |
| 165 | 0902 | 2.0 | 32 |
| 168 | 0932 | 2.0 | 34 |
| 171 | 1002 | 2.0 | 28 |
| 174 | 1032 | 2.0 | 46 |
| 177 | 1102 | 2.0 | 33 |
| 180 | 1137 | 2.0 | 24 |
| 183 | 1202 | 2.0 | 31 |
| 186 | 1232 | 2.0 | 31 |
| 189 | 1305 | 2.0 | 20 |
| 192 | 1340 | 2.0 | 36 |
| 195 | 1402 | 2.0 | 33 |
| 198 | 1432 | 2.0 | 31 |
| 201 | 1503 | 2.0 | 26 |
| 204 | 1532 | 2.0 | 27 |
| 207 | 1602 | 2.0 | 26 |
| 210 | 1632 | 2.0 | 27 |
| 213 | 1702 | 2.0 | 8 |
| 216 | 1732 | 2.0 | 28 |
| 219 | 1802 | 2.0 | 29 |
| 222 | 1832 | 2.0 | 27 |

**Table 2.2.7: Salinity at Stations 2 and 5**

| | Date | Station | Time | Depth | Sal. (ppt) | $^oC$ |
|---|---|---|---|---|---|---|
| 68 | 4/17/2002 | 2 | 6:00 | 46 | 0.02 | 22.1 |
| 69 | 4/17/2002 | | 6:02 | 24 | 0.02 | 22.1 |
| 70 | 4/17/2002 | | 6:03 | 2 | 0.02 | 22.1 |
| 71 | 4/17/2002 | 2 | 6:31 | 48 | 0.02 | 22.1 |
| 72 | 4/17/2002 | | 6:32 | 25 | 0.02 | 22.1 |
| 73 | 4/17/2002 | | 6:30 | 2 | 0.02 | 22.2 |
| 74 | 4/17/2002 | 2 | 7:01 | 48 | 0.02 | 22.2 |
| 75 | 4/17/2002 | | 7:02 | 25 | 0.02 | 22.2 |
| 76 | 4/17/2002 | | 7:00 | 2 | 0.02 | 22.2 |
| 77 | 4/17/2002 | 2 | 7:31 | 48 | 0.02 | 22.2 |
| 78 | 4/17/2002 | | 7:32 | 25 | 0.02 | 22.2 |
| 79 | 4/17/2002 | | 7:30 | 2 | 0.02 | 22.2 |
| 80 | 4/17/2002 | 2 | 8:01 | 48 | 0.02 | 22.2 |
| 81 | 4/17/2002 | | 8:02 | 25 | 0.02 | 22.2 |
| 82 | 4/17/2002 | | 8:00 | 2 | 0.02 | 22.2 |
| 83 | 4/17/2002 | 2 | 8:31 | 46 | 0.02 | 22.3 |
| 84 | 4/17/2002 | | 8:32 | 24 | 0.02 | 22.3 |
| 85 | 4/17/2002 | | 8:30 | 2 | 0.02 | 22.3 |
| 86 | 4/17/2002 | 2 | 9:01 | 48 | 0.02 | 22.3 |
| 87 | 4/17/2002 | | 9:02 | 25 | 0.02 | 22.3 |
| 88 | 4/17/2002 | | 9:00 | 2 | 0.02 | 22.3 |
| 89 | 4/17/2002 | 2 | 9:31 | 46 | 0.02 | 22.3 |
| 90 | 4/17/2002 | | 9:32 | 24 | 0.02 | 22.3 |
| 91 | 4/17/2002 | | 9:30 | 2 | 0.02 | 22.3 |
| 92 | 4/17/2002 | 2 | 10:01 | 48 | 0.02 | 22.3 |
| 93 | 4/17/2002 | | 10:02 | 25 | 0.02 | 22.3 |
| 94 | 4/17/2002 | | 10:00 | 2 | 0.02 | 22.3 |
| 95 | 4/17/2002 | 2 | 10:31 | 48 | 0.02 | 22.4 |
| 96 | 4/17/2002 | | 10:32 | 25 | 0.02 | 22.4 |
| 97 | 4/17/2002 | | 10:30 | 2 | 0.02 | 22.4 |
| 98 | 4/17/2002 | 2 | 11:01 | 45 | 0.02 | 22.4 |
| 99 | 4/17/2002 | | 11:02 | 24 | 0.02 | 22.4 |
| 100 | 4/17/2002 | | 11:00 | 2 | 0.02 | 22.4 |
| 101 | 4/17/2002 | 2 | 11:31 | 49 | 2.000 | 22.4 |
| 102 | 4/17/2002 | | 11:32 | 26 | 0.02 | 22.5 |
| 103 | 4/17/2002 | | 11:30 | 2 | 0.02 | 22.5 |
| 104 | 4/17/2002 | 2 | 12:01 | 46 | 2.120 | 22.5 |
| 105 | 4/17/2002 | | 12:02 | 24 | 0.02 | 22.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 106 | 4/17/2002 | | 12:00 | 2 | 0.02 | 22.5 |
| 107 | 4/17/2002 | 2 | 12:31 | 49 | 2.200 | 22.5 |
| 108 | 4/17/2002 | | 12:32 | 26 | 0.02 | 22.5 |
| 109 | 4/17/2002 | | 12:30 | 2 | 0.02 | 22.5 |
| 110 | 4/17/2002 | 2 | 13:01 | 46 | 2.720 | 22.5 |
| 111 | 4/17/2002 | | 13:02 | 24 | 0.01 | 22.5 |
| 112 | 4/17/2002 | | 13:00 | 2 | 0.02 | 22.5 |
| 113 | 4/17/2002 | 2 | 13:31 | 49 | 2.230 | 22.5 |
| 114 | 4/17/2002 | | 13:32 | 26 | 0.02 | 22.6 |
| 115 | 4/17/2002 | | 13:30 | 2 | 0.01 | 22.6 |
| 116 | 4/17/2002 | 2 | 14:01 | 46 | 2.090 | 22.6 |
| 117 | 4/17/2002 | | 14:02 | 24 | 0.04 | 24.6 |
| 118 | 4/17/2002 | | 14:03 | 2 | 0.02 | 24.6 |
| 119 | 4/17/2002 | 2 | 14:31 | 44 | 2.180 | 24.6 |
| 120 | 4/17/2002 | | 14:32 | 23 | 0.05 | 24.6 |
| 121 | 4/17/2002 | | 14:30 | 2 | 0.02 | 24.6 |
| 122 | 4/17/2002 | 2 | 15:01 | 44 | 2.400 | 24.6 |
| 123 | 4/17/2002 | | 15:02 | 23 | 0.04 | 24.7 |
| 124 | 4/17/2002 | | 15:00 | 2 | 0.02 | 24.7 |
| 125 | 4/17/2002 | 2 | 15:34 | 46 | 2.010 | 24.7 |
| 126 | 4/17/2002 | | 15:36 | 24 | 0.04 | 24.7 |
| 127 | 4/17/2002 | | 15:33 | 2 | 0.03 | 24.7 |
| 128 | 4/17/2002 | 2 | 16:01 | 48 | 2.380 | 24.7 |
| 129 | 4/17/2002 | | 16:02 | 25 | 0.03 | 24.7 |
| 130 | 4/17/2002 | | 16:00 | 2 | 0.02 | 24.7 |
| 131 | 4/17/2002 | 2 | 16:31 | 50 | 2.460 | 24.7 |
| 132 | 4/17/2002 | | 16:32 | 26 | 0.03 | 24.7 |
| 133 | 4/17/2002 | | 16:30 | 2 | 0.02 | 24.7 |
| 134 | 4/17/2002 | 2 | 17:01 | 49 | 2.500 | 24.7 |
| 135 | 4/17/2002 | | 17:02 | 26 | 0.02 | 24.7 |
| 136 | 4/17/2002 | | 17:00 | 2 | 0.02 | 24.7 |
| 137 | 4/17/2002 | 2 | 17:31 | 48 | 6.740 | 24.7 |
| 138 | 4/17/2002 | | 17:32 | 25 | 0.02 | 24.7 |
| 139 | 4/17/2002 | | 17:30 | 2 | 0.02 | 24.7 |
| 140 | 4/17/2002 | 2 | 18:01 | 49 | 6.760 | 24.7 |
| 141 | 4/17/2002 | | 18:02 | 26 | 0.02 | 24.7 |
| 142 | 4/17/2002 | | 18:00 | 2 | 0.02 | 24.7 |
| 143 | 4/17/2002 | 2 | 18:31 | 48 | 9.230 | 24.7 |
| 144 | 4/17/2002 | | 18:32 | 25 | 0.02 | 24.7 |
| 145 | 4/17/2002 | | 18:30 | 2 | 0.02 | 24.7 |
| 146 | 4/17/2002 | 5 | 6:04 | 51 | 27.920 | |
| 147 | 4/17/2002 | | 6:05 | 27 | 5.770 | |
| 148 | 4/17/2002 | | 6:06 | 2 | 3.230 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 149 | 4/17/2002 | 5 | 6:30 | 54 | 28.340 | |
| 150 | 4/17/2002 | | 6:31 | 28 | 7.600 | |
| 151 | 4/17/2002 | | 6:32 | 2 | 3.290 | |
| 152 | 4/17/2002 | 5 | 7:00 | 53 | 28.180 | |
| 153 | 4/17/2002 | | 7:01 | 28 | 8.760 | |
| 154 | 4/17/2002 | | 7:02 | 2 | 3.380 | |
| 155 | 4/17/2002 | 5 | 7:30 | 53 | 28.240 | |
| 156 | 4/17/2002 | | 7:31 | 28 | 18.510 | |
| 157 | 4/17/2002 | | 7:32 | 53 | 3.410 | |
| 158 | 4/17/2002 | 5 | 8:00 | 54 | 28.160 | |
| 159 | 4/17/2002 | | 8:01 | 28 | 27.710 | |
| 160 | 4/17/2002 | | 8:02 | 2 | 3.590 | |
| 161 | 4/17/2002 | 5 | 8:30 | 52 | 27.750 | |
| 162 | 4/17/2002 | | 8:31 | 27 | 13.630 | |
| 163 | 4/17/2002 | | 8:32 | 2 | 3.760 | |
| 164 | 4/17/2002 | 5 | 9:00 | 53 | 27.830 | |
| 165 | 4/17/2002 | | 9:01 | 27 | 13.140 | |
| 166 | 4/17/2002 | | 9:02 | 2 | 4.080 | |
| 167 | 4/17/2002 | 5 | 9:30 | 53 | 27.810 | |
| 168 | 4/17/2002 | | 9:31 | 27 | 14.610 | |
| 169 | 4/17/2002 | | 9:32 | 2 | 4.660 | |
| 170 | 4/17/2002 | 5 | 10:00 | 52 | 27.450 | |
| 171 | 4/17/2002 | | 10:01 | 27 | 13.750 | |
| 172 | 4/17/2002 | | 10:02 | 2 | 5.140 | |
| 173 | 4/17/2002 | 5 | 10:30 | 53 | 27.570 | |
| 174 | 4/17/2002 | | 10:31 | 28 | 16.310 | |
| 175 | 4/17/2002 | | 10:32 | 2 | 5.630 | |
| 176 | 4/17/2002 | 5 | 11:00 | 53 | 27.580 | |
| 177 | 4/17/2002 | | 11:01 | 27 | 17.840 | |
| 178 | 4/17/2002 | | 11:02 | 2 | 5.940 | |
| 179 | 4/17/2002 | 5 | 11:35 | 53 | 27.430 | |
| 180 | 4/17/2002 | | 11:36 | 27 | 27.470 | |
| 181 | 4/17/2002 | | 11:37 | 2 | 7.830 | |
| 182 | 4/17/2002 | 5 | 12:00 | 53 | 20.310 | |
| 183 | 4/17/2002 | | 12:01 | 28 | 27.450 | |
| 184 | 4/17/2002 | | 12:02 | 2 | 7.280 | |
| 185 | 4/17/2002 | 5 | 12:30 | 53 | 27.530 | |
| 186 | 4/17/2002 | | 12:31 | 27 | 27.590 | |
| 187 | 4/17/2002 | | 12:32 | 2 | 6.700 | |
| 188 | 4/17/2002 | 5 | 13:03 | 52 | 27.640 | |
| 189 | 4/17/2002 | | 13:04 | 27 | 27.690 | |
| 190 | 4/17/2002 | | 13:05 | 2 | 5.430 | |
| 191 | 4/17/2002 | 5 | 13:38 | 53 | 27.640 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 192 | 4/17/2002 | | 13:39 | 28 | 27.720 | |
| 193 | 4/17/2002 | | 13:40 | 2 | 4.410 | |
| 194 | 4/17/2002 | 5 | 14:00 | 53 | 27.660 | |
| 195 | 4/17/2002 | | 14:01 | 27 | 27.330 | |
| 196 | 4/17/2002 | | 14:02 | 2 | 4.630 | |
| 197 | 4/17/2002 | 5 | 14:30 | 52 | 27.730 | |
| 198 | 4/17/2002 | | 14:31 | 27 | 27.270 | |
| 199 | 4/17/2002 | | 14:32 | 2 | 5.250 | |
| 200 | 4/17/2002 | 5 | 15:00 | 53 | 27.530 | |
| 201 | 4/17/2002 | | 15:01 | 28 | 27.410 | |
| 202 | 4/17/2002 | | 15:02 | 2 | 4.820 | |
| 203 | 4/17/2002 | 5 | 15:30 | 53 | 27.480 | |
| 204 | 4/17/2002 | | 15:31 | 27 | 26.340 | |
| 205 | 4/17/2002 | | 15:32 | 2 | 5.160 | |
| 206 | 4/17/2002 | 5 | 16:00 | 52 | 27.530 | |
| 207 | 4/17/2002 | | 16:01 | 27 | 27.400 | |
| 208 | 4/17/2002 | | 16:02 | 2 | 4.800 | |
| 209 | 4/17/2002 | 5 | 16:30 | 53 | 27.610 | |
| 210 | 4/17/2002 | | 16:31 | 28 | 27.560 | |
| 211 | 4/17/2002 | | 16:32 | 2 | 4.250 | |
| 212 | 4/17/2002 | 5 | 17:00 | 53 | 27.580 | |
| 213 | 4/17/2002 | | 17:01 | 27 | 27.630 | |
| 214 | 4/17/2002 | | 17:02 | 2 | 4.590 | |
| 215 | 4/17/2002 | 5 | 17:30 | 53 | 27.590 | |
| 216 | 4/17/2002 | | 17:31 | 27 | 27.570 | |
| 217 | 4/17/2002 | | 17:32 | 2 | 4.570 | |
| 218 | 4/17/2002 | 5 | 18:00 | 52 | 27.510 | |
| 219 | 4/17/2002 | | 18:01 | 27 | 27.380 | |
| 220 | 4/17/2002 | | 18:02 | 2 | 4.140 | |
| 221 | 4/17/2002 | 5 | 18:30 | 52 | 27.490 | |
| 222 | 4/17/2002 | | 18:31 | 27 | 27.130 | |
| 223 | 4/17/2002 | | 18:32 | 2 | 4.050 | |

**Table 2.2.8: River discharges at the time of water sample collection**

| | April 11 | April 13 | April 15 | April 16 | April 17 | April 18 | Aug 22 |
|---|---|---|---|---|---|---|---|
| Sabine | 19,000 | 22,000 | 2,500 | 2,900 | 21,600 | 21,900 | 6,700 |
| Neches | 15,800 | 19,300 | 22,400 | 23,000 | 23,300 | 23,300 | 2,950 |
| | | | | | | | |
| Total | 34,800 | 41,300 | 24,900 | 25,900 | 44,900 | 45,300 | 9,650 |

# Chapter 2.3: Channel Dredging

## Project Description

The Sabine-Neches Waterway affords deepwater navigation to the ports of Port Arthur, Beaumont, and Orange in the southeastern part of the State of Texas. The deepwater portion of the waterway extends from deep water in the Gulf of Mexico northward through an entrance channel with two jetties extending from the shoreline to the ocean. Sabine Pass connects Sabine Lake with the Gulf of Mexico. The Port Arthur and Sabine-Neches Canals are dredged channels separated by a narrow strip of land from the western shore of Sabine Lake. The Sabine Pass, Lake, and River together form part of the boundary between the States of Texas and Louisiana.

The Gulf Intracoastal Waterway (GIWW), which extends from Apalachee Bay, Florida, to Brownsville, Texas, connects with the Sabine-Neches Waterway at a point about 3 miles below Orange. The GIWW then follows the Sabine River and Sabine-Neches Canal to the head of the Port Arthur Canal. The GIWW section to the east provides a connection with the Calcasieu River through the Lake Charles Deep Water Channel and Choupique cutoff. The GIWW also provides shallow-draft access westward to Galveston Bay.

A total of 70,549 vessel passages were made over the project waterway in 1974. Of these 35,275 were inbound and 35,274 were outbound. Shallow-draft commercial vessels made up over 90 percent of the total passages but these accounted for less than 50 percent of the total tonnage handled. About 25 percent of the deep-draft vessels using the waterway had drafts of 34 feet or greater. The trend during recent years has been toward larger and deeper draft vessels.

## Dredging

The Galveston District made dredging data available to ERDC over the years 1949 to 2001. These were analyzed to work out the quantities of new work dredging and maintenance dredging. The maintenance dredging quantities were grouped serially under each of the seven reaches adopted by the project for convenience of reference. These are described under Chapter 1.2. The names are given below again for easy reference.

Reach 1: Neches River Channel
Reach 2: Sabine Neches Canal
Reach 3: Port Arthur Canal
Reach 4: Sabine Pass Channel
Reach 5: The Sabine Pass Jetty Channel
Reach 6: Sabine Pass Outer Bar Channel
Reach 7: Sabine Bank Channel

## New Dredging Works

New dredging works have been undertaken at the project from time to time. Details are given in Table 2.3.1 over the years from 1950 to 11967. Before 1962 the project depth was 36 feet. Between 1962 and 1967 a total of 40 million cubic yards of material was removed from navigable areas to increase the project depth from 36 feet to 40 feet. The break-up of quantities is given in Table 2.3.2. No new dredging was done after 1967 and the project channel depth continues to be 40 feet as of now.

## Maintenance Dredging

Maintenance dredging of project channels is a continuing operation because of the shoaling process. Most shoaling is the result of littoral transport, tidal action in the Gulf of Mexico, and alluvial deposition occurring during high water periods in the Sabine and Neches Rivers. Maintenance dredging data provided by the Galveston District were analyzed to calculate quantity of dredging in each reach of the navigation channel. The results are given in Table 2.3.3.

The Final Environmental Statement produced by the Galveston District in 1975 states as follows: “The annual shoaling rates of the various project channels range from about 1,500 to 5,400,000 cubic yards per year. With the present rate of shoaling, the frequency of dredging in the project area ranges from once a year in the outer bar and jetty channels, to about once every ten years in the Sabine River Channel and Turning Basin. Table 10 lists the frequency of dredging and the estimated annual shoaling rate for each reach of the project.”

Table 10 cited above is reproduced as Table 2.3.4, which is based on data prior to 1975. Results of the present analysis, which cover the years 1967 to 2001, are given in Table 2.3.5. A summary of average annual dredging quantity per year in each reach is given in Table 2.3.6. It is noted that the difference between the findings reported in Tables 2.3.4 and 2.3.6 is significant. Since the new results are based on the latest available data, these are used for shoaling prediction in this report.

## Table 2.3.1: New Work Dredging Quantities at Sabine Neches Project

| Sabine New Work Dredging Data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Reach | Section Number | DownStrm Section | UpStrm Section | Start Date | End Date | Actual Dredged Quantity | Actual OverDepth | Total Actual Dredged Quantity (cubic yards) |
| Neches River Channel | 1 | 0+00 | 710+00 | 10-Jul-49 | 15-Feb-50 | 3.115,507 | 0 | 3.115,507 |
| Neches River Channel | 1 | 710+00 | 982+54.2 | 21-Apr-50 | 21-Oct-50 | 2,610,560 | 0 | 2,610,560 |
| Sabine Neches Canal | 2 | 137+00 | 610+84.4 | 5-Feb-51 | 5-Aug-51 | 4,358,141 | 0 | 4,358,141 |
| Sabine Neches Canal | 2 | 163+41 | 195+43 | 23-Dec-52 | 29-Apr-53 | 781,252 | 0 | 781,252 |
| Neches River Channel | 1 | 0+00 | 330+00 | 27-Mar-57 | 9-Mar-58 | 6,160,476 | 0 | 6,160,476 |
| Sabine Neches Canal | 2 | 290+00 | 593+69 | 1-Jul-58 | 29-May-59 | 11,333,567 | 0 | 11,333,567 |
| Sabine Pass Channel | 4 | 0+00 | 296+09 | 4-Dec-59 | 25-Jul-60 | 8,720,800 | 0 | 8,720,800 |
| Neches River Channel | 1 | 20+00 | 1055+00 | 26-Oct-61 | 25-Jan-63 | 11,306,622 | 864,242 | 12,170,864 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sabine Pass Channel | 4 | 210+00 | 270+00 | 4-May-62 | 22-Sep-62 | 1,554,802 | 174,121 | 1,728,923 |
| | | | | | | | | |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 290+00 | 530+00 | 4-May-62 | 22-Sep-62 | 1,980,032 | 337,906 | 2,317,938 |
| | | | | | | | | |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 167+00 | 210+00 | 31-Aug-63 | 5-Jun-64 | 7,698,746 | 475,224 | 8,173,970 |
| | | | | | | | | |
| | | | | | | | | |
| Port Arthur Canal | 3 | | | 21-Jul-64 | 15-Jan-65 | 512,185 | 73,164 | 585,349 |
| | | | | | | | | |
| | | | | | | | | |
| Sabine Pass Channel | 3 | | | 1-Apr-65 | 22-Mar-66 | 6275750 | 1463051 | 7,738,801 |
| | | | | | | | | |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 290+00 | 4-Jun-65 | 5-Sep-66 | 2797659 | 246288 | 3,043,927 |
| | | | | | | | | |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 240+00 | 10-May-67 | 26-Aug-67 | 3484883 | 415534 | 3,900,417 |
| | | | | | | | | |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 52+79.5 | 10-May-67 | 26-Aug-67 | 236180 | 119423 | 355,603 |

## Table 2.3.2: New dredging conducted during 1962 and 1967

| Reach | Reach # | From | To | Dredging (Cu. Yd) |
|---|---|---|---|---|
| | | | | |
| Neches River Channel | 1 | 26-Oct-61 | 25-Jan-63 | 12,170,864 |
| | | | | |
| Sabine Pass Channel | 4 | 4-May-62 | 22-Sep-62 | 1,728,923 |
| | | | | |
| Sabine Neches Canal | 2 | 4-May-62 | 22-Sep-62 | 2,317,938 |
| | | | | |
| Sabine Pass Channel | 4 | 31-Aug-63 | 5-Jun-64 | 8,173,970 |
| | | | | |
| Port Arthur Canal | 3 | 21-Jul-64 | 15-Jan-65 | 585,349 |
| | | | | |
| Sabine Pass Channel | 3 | 1-Apr-65 | 22-Mar-66 | 7,738,801 |
| | | | | |
| Port Arthur Canal | 3 | 4-Jun-65 | 5-Sep-66 | 3,043,927 |
| | | | | |
| Neches River Channel | 1 | 10-May-67 | 26-Aug-67 | 3,900,417 |
| | | | | |
| Sabine Neches Canal | 2 | 10-May-67 | 26-Aug-67 | 355,603 |

# Table 2.3.3: Maintenance Dredging Quantities at Sabine Neches Project

| Sabine Maintenance Dredging Data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Reach | Section | DownStrm | UpStrm | Start | End | Actual | Actual | Total Actual |
| | Number | Section | Section | Date | Date | Dredged | OverDepth | Dredged Quantity |
| | | | | | | Quantity | | (cubic yards) |
| | | | | | | | | |
| REACH 1 | | | | | | | | |
| | | | | | | | | |
| Sabine River Channel | 1 | 245+00 | 670+00 | 1-Oct-48 | 19-Jan-49 | 400051 | 0 | 400051 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 440+00 | 11-Oct-64 | 11-Feb-66 | 2250504 | 359487 | 2609991 |
| | | | | | | | | |
| Sabine River Channel | 1 | 350+00 | 470+00 | 15-Mar-68 | 13-Aug-68 | 318110 | 82992 | 401102 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 487+14.4 | 15-Mar-70 | 28-Aug-70 | 2343221 | 601972 | 2945193 |
| | | | | | | | | |
| Neches River Channel | 1 | 240+00 | 623+33 | 17-Feb-71 | 8-Jun-71 | 5211232 | 557459 | 5768691 |
| | | | | | | | | |
| Neches River Channel | 1 | 623+33 | 1037+59 | 27-Jul-71 | 3-Apr-72 | 4993008 | 559277 | 5552285 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 213+50 | 7-Jul-73 | 8-Mar-74 | 1195533 | 252336 | 1447869 |
| | | | | | | | | |
| Sabine River Channel | 1 | 230+00 | 370+00 | 7-Jul-73 | 8-Mar-74 | 245118 | 72865 | 317983 |
| | | | | | | | | |
| Neches River Channel | 1 | 213+50 | 505+00 | 11-Mar-74 | 23-Dec-74 | 1059563 | 306772 | 1366335 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 213+50 | 27-Oct-76 | 8-Dec-76 | 1000719 | 289095 | 1289814 |
| | | | | | | | | |
| Sabine River Channel | 1 | 170+00 | 650+00 | 5-Oct-77 | 17-Feb-78 | 1029837 | 404569 | 1434406 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 530+00 | 21-Jun-79 | 26-Nov-79 | 2528617 | 483183 | 3011800 |
| | | | | | | | | |
| Neches River Channel | 1 | 530+00 | 1037+59.4 | 29-Oct-80 | 8-Apr-81 | 2100558 | 461501 | 2562059 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 120+00 | 11-Jun-82 | 15-Jan-83 | 915406 | 159734 | 1075140 |
| | | | | | | | | |
| Neches River Channel | 1 | 120+00 | 440+85 | 17-Feb-84 | 24-Mar-84 | 1170981 | 262411 | 1433392 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 120+00 | 28-Jan-86 | 12-Jun-86 | 719171 | 143158 | 862329 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 1037+59.4 | 27-Apr-90 | 21-Aug-90 | 2287095 | 333496 | 2620591 |
| | | | | | | | | |
| Sabine River Channel | 1 | 234+00 | 655+00 | 22-Aug-91 | 19-Oct-91 | 377392 | 129774 | 507166 |
| | | | | | | | | |
| Neches River Channel | 1 | 320+00 | 1037+59.4 | 20-May-94 | 18-Aug-94 | 1764210 | 0 | 1764210 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 320+00 | 28-Oct-95 | 22-Jan-96 | 1303023 | 0 | 1303023 |
| | | | | | | | | |
| Neches River Channel | 1 | 250+00 | 978+40 | 26-Apr-96 | 23-May-96 | 830418 | 201823 | 1032241 |
| | | | | | | | | |
| Neches River Channel | 1 | 0+00 | 445+00 | 11-Nov-99 | 28-Apr-00 | 1535128 | 275184 | 1810312 |
| | | | | | | | | |
| **REACH 2** | | | | | | | | |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 26+56.5 | 137+00 | 8-Feb-48 | 20-Apr-49 | 1815508 | 0 | 1815508 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 137+00 | 30-Jan-51 | 12-May-51 | 1562449 | 0 | 1562449 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 163+41 | 17-Feb-53 | 3-Nov-53 | 1425008 | 0 | 1425008 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 175+00 | 4-Jan-55 | 7-Jul-55 | 1349896 | 0 | 1349896 |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sabine Neches Canal | 2 | 0+00 | 178+00 | 7-Mar-57 | 9-Mar-58 | 1131239 | 0 | 1131239 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 70+00 | 230+00 | 10-Mar-58 | 14-May-58 | 781896 | 0 | 781896 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 30+00 | 178+00 | 21-Aug-60 | 19-May-61 | 2108155 | 0 | 2108155 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 30+00 | 178+00 | 30-Dec-62 | 3-Oct-63 | 1161326 | 83732 | 1337445 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 290+00 | 565+00 | 11-Oct-64 | 11-Feb-66 | 3093369 | 335746 | 3429115 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 30+00 | 178+00 | 31-Oct-65 | 18-Apr-66 | 776592 | 112218 | 888810 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 52+80 | 593+69 | 15-Mar-68 | 13-Aug-68 | 1650008 | 554713 | 2204721 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 26+57 | 178+00 | 9-May-68 | 9-Nov-68 | 563103 | 154297 | 717400 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 40+00 | 593+68 | 3-Dec-70 | 26-Nov-71 | 5396339 | 724895 | 6121234 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 230+00 | 7-Jul-73 | 8-Mar-74 | 683353 | 256107 | 939460 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 40+00 | 593+68 | 1-Apr-75 | 29-Jul-75 | 1934631 | 416836 | 2351467 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 0+00 | 52+79.5 | 27-Oct-76 | 8-Dec-76 | 150233 | 105166 | 255399 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 52+79.5 | 170+00 | 5-Oct-77 | 17-Feb-78 | 224850 | 172264 | 397114 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 40+00 | 570+00 | 21-Nov-77 | 26-Apr-78 | 2171627 | 657008 | 2828635 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 40+00 | 593+68 | 11-Jun-82 | 15-Jan-83 | 2717744 | 447139 | 3164883 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 10+00 | 260+00 | 17-Feb-84 | 24-Mar-84 | 1101767 | 323807 | 1425574 |
| | | | | | | | | |
| Sabine Neches Canal | 2 | 40+00 | 593+68 | 28-Jan-86 | 12-Jun-86 | 1670092 | 352058 | 2022150 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sabine Neches Canal | 2 | 0+00 | 593+68.5 | 7-Mar-91 | 10-Jun-91 | 1855541 | 487515 | 2343056 |
| Sabine Neches Canal | 2 | 9+08.1 | 234+00 | 22-Aug-91 | 19-Oct-91 | 682962 | 276621 | 959583 |
| Sabine Neches Canal | 2 | 30+00 | 318+75 | 6-Nov-92 | 9-Jan-93 | 458407 | 94944 | 553351 |
| Sabine Neches Canal | 2 | 0+00 | 40+00 | 14-Jul-94 | 27-Sep-94 | 337143 | 0 | 337143 |
| Sabine Neches Canal | 2 | 10+00 | 250+00 | 18-Mar-96 | 1-Jul-96 | 417713 | 378958 | 796671 |
| Sabine Neches Canal | 2 | 0+00 | 40+00 | 27-Jul-96 | 27-Apr-97 | 394179 | 0 | 394179 |
| Sabine Neches Canal | 2 | 40+00 | 593+68.5 | 1-Apr-98 | 26-Aug-98 | 1698019 | 367557 | 2065576 |
| Sabine Neches Canal | 2 | 0+00 | 40+00 | 3-Apr-99 | 21-Dec-99 | 350869 | 44638 | 395507 |
| Sabine Neches Canal | 2 | 10+00 | 330+00 | ??-??-00 | ??-??-00 | 653520 | 271771 | 925291 |
| **REACH 3** | | | | | | | | |
| Port Arthur Canal | 3 | 60+00 | 294+33.3 | 8-Feb-48 | 20-Apr-49 | 4618302 | 0 | 4618302 |
| Port Arthur TB, Ent Ch | 3 | 0+00 | 94+12.2 | 8-Feb-48 | 20-Apr-49 | 1782599 | 0 | 1782599 |
| Port Arthur Canal | 3 | 50+00 | 329+25.5 | 30-Jan-51 | 12-May-51 | 2088273 | 0 | 2088273 |
| Port Arthur TB, Ent Ch | 3 | 0+00 | 94+12.2 | 29-Dec-51 | 9-Mar-52 | 624041 | 0 | 624041 |
| Port Arthur Canal | 3 | 50+00 | 329+25 | 17-Feb-53 | 3-Nov-53 | 1577817 | 0 | 1577817 |
| Port Arthur B, Ent Ch | 3 | 0+00 | 94+12 | 17-Feb-53 | 3-Nov-53 | 1186092 | 0 | 1186092 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Port Arthur Canal | 3 | 50+00 | 329+25 | 4-Jan-55 | 7-Jul-55 | 1304684 | 0 | 1304684 |
| | | | | | | | | |
| Port Arthur TB West | 3 | 0+00 | 36+00 | 4-Jan-55 | 7-Jul-55 | 529624 | 0 | 529624 |
| | | | | | | | | |
| Port Arthur TB, Ent Ch | 3 | 0+00 | 329+26 | 7-Mar-57 | 9-Mar-58 | 2724400 | 0 | 2724400 |
| | | | | | | | | |
| Port Arthur TB, Ent Ch | 3 | 0+00 | 310+00 | 21-Jan-59 | 3-May-59 | 1625755 | 0 | 1625755 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 294+33 | 21-Aug-60 | 19-May-61 | 3205412 | 0 | 3205412 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 294+33 | 30-Dec-62 | 3-Oct-63 | 1764162 | 58974 | 2119186 |
| | | | | | | | | |
| PA Canal, TB, EC | 3 | 0+00 | 96+00 | 31-Oct-65 | 18-Apr-66 | 1650833 | 275647 | 1926480 |
| | | | | | | | | |
| PA Canal & SNC Junct | 3 | 290+00 | 26+57 | 15-Nov-67 | 8-Mar-68 | 997192 | 138818 | 1136010 |
| | | | | | | | | |
| PA TB, Entrance Ch | 3 | 0+00 | 96+00 | 15-Nov-67 | 8-Mar-68 | 634719 | 123999 | 758718 |
| | | | | | | | | |
| PA Canal, TB, EC | 3 | 0+00 | 15+00 | 31-Aug-69 | 6-Dec-69 | 3003839 | 567890 | 3571729 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 290+00 | 326+25 | 13-Oct-70 | 7-Sep-71 | 1754926 | 185148 | 1940074 |
| | | | | | | | | |
| Port Arthur West TB | 3 | 0+00 | 290+00 | 20-Aug-71 | 10-Apr-72 | 4527994 | 765515 | 5293509 |
| | | | | | | | | |
| PA Canal, TB, Ent Ch | 3 | 290+00 | 326+25 | 7-Jan-74 | 21-Mar-74 | 2405240 | 340522 | 2745762 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 290+00 | 4-Feb-74 | 2-Aug-74 | 1634004 | 381822 | 2015826 |
| | | | | | | | | |
| PA TB, Entr Ch | 3 | 0+00 | 325+24 | 5-Apr-76 | 10-Aug-76 | 2359345 | 211084 | 2570429 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 20+00 | 290+00 | 10-Jul-77 | 10-Nov-77 | 2214836 | 372205 | 2587041 |
| | | | | | | | | |
| PA Canal, TB, | 3 | 0+00 | 320+00 | 24-Oct-78 | 20-Apr-79 | 2220751 | 197875 | 2418626 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PA Canal, TB, Ent Ch | 3 | 0+00 | 326+25.4 | 20-Feb-81 | 19-Jul-81 | 2307550 | 143538 | 2451088 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 290+00 | 3-Sep-81 | 13-Dec-81 | 2178878 | 414038 | 2592916 |
| | | | | | | | | |
| PA Canal, TB, En Ch | 3 | 0+00 | 16+00 | 18-Apr-83 | 3-Jul-83 | 1840618 | 192105 | 2032723 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 290+00 | 30-Apr-84 | 9-Nov-84 | 2224644 | 311020 | 2535664 |
| | | | | | | | | |
| PA Canal, TB | 3 | 0+00 | 326+24 | 4-Sep-85 | 6-Nov-85 | 1971591 | 233290 | 2204881 |
| | | | | | | | | |
| PA Canal, TB | 3 | 0+00 | 319+60 | 4-Sep-87 | 13-Nov-87 | 3311848 | 512048 | 3823896 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 290+00 | 326+24.47 | 7-Mar-91 | 10-Jun-91 | 601127 | 100257 | 701384 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 290+00 | 318+75 | 6-Nov-92 | 9-Jan-93 | 438802 | 82674 | 521476 |
| | | | | | | | | |
| PA En Ch TB | 3 | 0+00 | 36+00 | 6-Nov-92 | 9-Jan-93 | 531173 | 85184 | 616357 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 290+00 | 29-Oct-93 | 2-Dec-93 | 1263910 | 350592 | 1614502 |
| | | | | | | | | |
| PA Canal, TB , Ent Ch | 3 | 0+00 | 10+00 | 14-Jul-94 | 27-Sep-94 | 1113358 | 0 | 1113358 |
| | | | | | | | | |
| Port Arthur Canal | 3 | 0+00 | 326+24.5 | 27-Jul-96 | 27-Apr-97 | 2936698 | 192719 | 3129417 |
| | | | | | | | | |
| PA TB, Ent Ch | 3 | 0+00 | 31+09.8 | 27-Jul-96 | 27-Apr-97 | 625215 | 7664 | 632879 |
| | | | | | | | | |
| PA Canal, TB, Ent Ch | 3 | 0+00 | 326+24.5 | 3-Apr-99 | 21-Dec-99 | 3048099 | 464787 | 3512886 |
| | | | | | | | | |
| **REACH 4** | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 60+00 | 257+91.4 | 8-Feb-48 | 20-Apr-49 | 1305411 | 0 | 1305411 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sabine Pass Channel | 4 | 50+00 | 250+00 | 30-Jan-51 | 12-May-51 | 585918 | 0 | 585918 |
| Sabine Pass Channel | 4 | 100+00 | 155+00 | 29-Dec-51 | 9-Mar-52 | 888341 | 0 | 888341 |
| Sabine Pass Channel | 4 | 50+00 | 265+00 | 17-Feb-53 | 3-Nov-53 | 456003 | 0 | 456003 |
| Sabine Pass Channel | 4 | 50+00 | 265+00 | 4-Jan-55 | 7-Jul-55 | 342318 | 0 | 342318 |
| Sabine Pass Channel | 4 | 50+00 | 265+00 | 7-Mar-57 | 9-Mar-58 | 1329206 | 0 | 1329206 |
| Sabine Pass Channel | 4 | 167+00 | 210+00 | 31-Aug-63 | 5-Jun-64 | 7698746 | 475224 | 8173970 |
| Sabine Pass Channel | 4 | 230+00 | 296+24 | 28-Aug-67 | 18-Sep-67 | 677065 | 194549 | 871614 |
| Sabine Pass Channel | 4 | 230+00 | 296+24 | 15-Mar-70 | 28-Aug-70 | 682775 | 154609 | 837384 |
| Sabine Pass Channel | 4 | 100+00 | 190+00 | 20-Aug-71 | 10-Apr-72 | 1019800 | 315252 | 1335052 |
| Sabine Pass Channel | 4 | 227+11 | 296+24 | 4-Feb-74 | 2-Aug-74 | 613639 | 101266 | 714905 |
| Sabine Pass Channel | 4 | 110+00 | 182+00 | 29-Apr-76 | 21-Jun-76 | 1376001 | 335317 | 1711318 |
| Sabine Pass Channel | 4 | 227+11.4 | 296+24.3 | 10-Jul-77 | 10-Nov-77 | 1076769 | 195877 | 1272646 |
| Sabine Pass Channel | 4 | 105+00 | 182+00 | 13-Feb-79 | 4-Jun-79 | 1076940 | 292320 | 1369260 |
| Sabine Pass Channel | 4 | 105+00 | 296+24 | 2-May-82 | 4-Aug-82 | 2055686 | 481409 | 2537095 |
| Sabine Pass Channel | 4 | 227+11.4 | 296+24.3 | 30-Apr-84 | 9-Nov-84 | 757864 | 149263 | 907127 |
| Sabine Pass Channel | 4 | | 185+00 | 28-Feb-85 | 29-Mar-85 | 607219 | 229619 | 836838 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sabine Pass Channel | 4 | 100+00 | 296+24.3 | 21-Mar-88 | 14-Jul-88 | 1150280 | 358643 | 1508923 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 227+11 | 296+24 | 7-Nov-90 | 16-Nov-91 | 3011197 | 0 | 3011197 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 165+00 | 263+92.44 | 6-Nov-92 | 9-Jan-93 | 578439 | 124798 | 703237 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 105+00 | 296+24.3 | 27-Jul-96 | 27-Apr-97 | 2171369 | 0 | 2171369 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 105+00 | 296+24 | 21-Jun-99 | 31-Jul-99 | 1614295 | 488282 | 2102577 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 0+000 | 18+000 | 6-Dec-00 | ??-??-00 | 1705420 | 738404 | 2443824 |
| | | | | | | | | |
| Sabine Pass Channel | 4 | 118+00 | 296+24.3 | 20-Aug-01 | 14-Dec-01 | 1356253 | 439358 | 1795611 |
| | | | | | | | | |
| **REACH 5** | | | | | | | | |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | n/a | n/a | 10-Feb-71 | 25-Feb-71 | 953500 | 0 | 953500 |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | n/a | n/a | 27-Jun-71 | 30-Jun-71 | 277000 | 0 | 277000 |
| | | | | | | | | |
| Entr Ch - Jetty Channel | 5 | -214+88 | -55+00 | 1-Jun-77 | 9-Sep-77 | 3000000 | 0 | 3000000 |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | -100+00 | -46+00 | 13-Aug-98 | 7-Oct-98 | 612928 | 4441159 | 1057087 |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | 214+88.3 | 180+00 | 6-Dec-00 | ??-??-00 | 93436 | 84676 | 178112 |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | 180+00 | 110+00 | ??-??-00 | ??-??-00 | 262281 | 212554 | 474835 |
| | | | | | | | | |
| Entr Ch, Jetty Channel | 5 | 110+00 | 50+00 | ??-??-00 | ??-??-00 | 233023 | 306337 | 539360 |
| | | | | | | | | |
| **REACH 6** | | | | | | | | |
| | | | | | | | | |
| Entr Ch, Outer Bar Ch | 6 | n/a | n/a | 23-Jul-73 | 7-Sep-73 | 1105274 | 0 | 1105274 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Entr Chl, Outer Bar Ch | 6 | n/a | n/a | 7-Nov-73 | 30-Jan-74 | 6496347 | 0 | 6496347 |
| | | | | | | | | |
| Entr Ch, Outer Bar Ch | 6 | n/a | n/a | 25-Sep-74 | 20-Nov-74 | 2520638 | 0 | 2520638 |
| | | | | | | | | |
| Entr Ch, Outer Bar Ch | 6 | n/a | n/a | 4-Mar-76 | 30-Jun-76 | 4676665 | 0 | 4676665 |
| | | | | | | | | |
| Entr Ch, Outer Bar Ch | 6 | 18+000 | 0+000 | 18-Jul-78 | 22-Aug-78 | 1100000 | 0 | 1100000 |
| | | | | | | | | |
| Entr Chl-Outer Bar ch | 6 | n/a | n/a | 4-Oct-78 | 16-Feb-79 | 3376521 | 0 | 3376521 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | n/a | n/a | 1-Oct-79 | 4-Oct-79 | 58080 | 0 | 58080 |
| | | | | | | | | |
| Entr Ch-Outer Bar Ch | 6 | 18+000 | 0+000 | 19-Mar-81 | 30-May-81 | 3589486 | 0 | 3589486 |
| | | | | | | | | |
| Entr Ch-Outer Bar Ch | 6 | 18+000 | 0+000 | 27-Apr-82 | 20-May-82 | 1693264 | 0 | 1693264 |
| | | | | | | | | |
| Entr Chl-Outer Bar Ch | 6 | 20+000 | 0+000 | 12-Jul-83 | 20-Oct-83 | 378000 | 0 | 378000 |
| | | | | | | | | |
| Entr Chl-Outer Bar Ch | 6 | 5+000 | 0+000 | 22-Jul-84 | 22-Sep-84 | 5601112 | 0 | 5601112 |
| | | | | | | | | |
| EntrCh-Outer Bar Ch | 6 | 12+000 | 2+000 | 12-May-86 | 13-Jul-86 | 2264038 | 641681 | 2905719 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | 18+000 | 0+000 | 16-Jul-87 | 15-Sep-87 | 4572109 | 0 | 4572109 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | 18+000 | 2+000 | 4-Sep-88 | 16-Oct-88 | 1992245 | 1010073 | 3002318 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | 20+000 | 0+000 | 8-Apr-91 | 20-Jul-91 | 4738542 | 0 | 4738542 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | 5+000 | 0+000 | 11-Sep-92 | 7-Nov-92 | 1950614 | 413367 | 2363981 |
| | | | | | | | | |
| Entr Ch- Outer Bar Ch | 6 | 5+000 | 0+000 | 1-Sep-94 | 30-Oct-94 | 2301212 | 0 | 2301212 |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Entr Ch, Outer Bar Ch | 6 | 20+000 | 0+000 | 23-Jan-96 | 6-May-96 | 2006744 | 582154 | 2588898 |
| | | | | | | | | |
| Entr Ch, Outer Bar Ch | 6 | 25+000 | 0+000 | 12-May-01 | 17-Jun-01 | 626994 | 764483 | 1391477 |
| | | | | | | | | |
| **REACH 7** | | | | | | | | |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | n/a | n/a | 6-Feb-72 | 18-Apr-72 | 7676244 | 0 | 7676244 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | n/a | n/a | 10-Apr-72 | 31-May-72 | 1943370 | 0 | 1943370 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | n/a | n/a | 21-Jan-73 | 6-Mar-73 | 3479450 | 0 | 3479450 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | n/a | n/a | 1-Nov-74 | 12-Feb-75 | 4667000 | 0 | 4667000 |
| | | | | | | | | |
| Ent Ch, Bank Ch | 7 | 76+000 | 48+000 | 13-Jul-85 | 7-Sep-85 | 5353000 | 0 | 5353000 |
| | | | | | | | | |
| Entrance Channel, | 7 | 28+000 | 12+000 | 12-May-86 | 13-Jul-86 | 2050336 | 670782 | 2721118 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | 25+000 | 20+000 | 8-Apr-91 | 20-Jul-91 | 512935 | 0 | 512935 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | 25+000 | 15+000 | 1-Sep-94 | 30-Oct-94 | 597991 | 0 | 597991 |
| | | | | | | | | |
| Entr Ch, Bank Channel, | 7 | 25+000 | 20+000 | 23-Jan-96 | 6-May-96 | 576570 | 558367 | 1134937 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | 90+000 | 0+000 | 12-Mar-97 | 25-Sep-97 | 4742465 | 0 | 4742465 |
| | | | | | | | | |
| Entr Ch, Bank Channel | 7 | 55+000 | 50+000 | 6-Dec-00 | ??-??-00 | 1057889 | 1102877 | 2160766 |
| | | | | | | | | |

## Table 2.3.4: Maintenance dredging frequencies and shoaling rates for Sabine Neches Waterway

| Project Reach | Frequency (Months) | Estimated Annual Shoaling (C.Y.) |
|---|---|---|
| Sabine Bank Channel | 12 | 5,400,000 |
| Sabine Pass Jetty & Outer Bar Channels | 12 | 3,000,000 |
| Sabine Pass Channel (a) | 24 | 500,000 |
| Port Arthur Canal | 24 | 1,000,000 |
| Port Arthur Turning Basins (a) | 18 | 500,000 |
| Sabine-Neches Canal (Upper and Lower Reaches) (a) | 24 | 1,000,000 |
| Neches River Channel (Lower Reach) (a) | 24 | 1,000,000 |
| Neches River Channel (Middle Reach) (a) | 36 | 500,000 |
| Neches River Channel (Upper Reach) | 60-72 | 200,000 |
| Sabine-Neches Canal (Sec. "B") N.R. to S.R. (a) | 24-48 | 400,000 |
| Sabine River Channel (a) | 36 | 200,000 |

(a) Usually combined with work in other selected reaches of the project
(b) Adams and Cow Bayou Channels have not been maintained since construction. Available depths in the channels currently support the using traffic, however, maintenance will be scheduled in the future should available depths prove inadequate.

<u>Reference</u>: Table 10 from the Final Environmental Statement Report on Maintenance Dredging Sabine Neches Waterway, Texas, dated 4 November 1975 prepared by the U. S. Army Engineer District, Galveston, Texas.

## Table 2.3.5: SNWW Maintenance Dredging Data

## Reach Number 1: Sabine River Channel

| Start Date | End Date | Total Actual Dredged Quantity (Cubic Yards) |
|---|---|---|
| | | |
| **36 Ft. Channel** | | |
| | | |
| 1-Oct-48 | 19-Jan-49 | 400051 |
| 11-Oct-64 | 11-Feb-66 | 2609991 |
| | | |
| **40-Ft. Channel** | | |
| | | |
| 15-Mar-68 | 13-Aug-68 | 401102 |
| 15-Mar-70 | 28-Aug-70 | 2945193 |
| 17-Feb-71 | 8-Jun-71 | 5768691 |
| 27-Jul-71 | 3-Apr-72 | 5552285 |
| 7-Jul-73 | 8-Mar-74 | 1447869 |
| 7-Jul-73 | 8-Mar-74 | 317983 |
| 11-Mar-74 | 23-Dec-74 | 1366335 |
| 27-Oct-76 | 8-Dec-76 | 1289814 |
| 5-Oct-77 | 17-Feb-78 | 1434406 |
| 21-Jun-79 | 26-Nov-79 | 3011800 |
| 29-Oct-80 | 8-Apr-81 | 2562059 |
| 11-Jun-82 | 15-Jan-83 | 1075140 |
| 17-Feb-84 | 24-Mar-84 | 1433392 |
| 28-Jan-86 | 12-Jun-86 | 862329 |
| 27-Apr-90 | 21-Aug-90 | 2620591 |
| 22-Aug-91 | 19-Oct-91 | 507166 |
| 20-May-94 | 18-Aug-94 | 1764210 |
| 28-Oct-95 | 22-Jan-96 | 1303023 |
| 26-Apr-96 | 23-May-96 | 1032241 |
| 11-Nov-99 | 28-Apr-00 | 1810312 |
| | | |
| **Total** | | 38,505,941 |
| **Average / Year** | | 1,203,310 |

## Reach Number 2: Sabine Neches Canal

| Start Date | End Date | Total Actual Dredged Quantity |
|---|---|---|
| | | |
| **36-Ft. Channel** | | |
| 8-Feb-48 | 20-Apr-49 | 1815508 |
| 30-Jan-51 | 12-May-51 | 1562449 |
| 17-Feb-53 | 3-Nov-53 | 1425008 |
| 4-Jan-55 | 7-Jul-55 | 1349896 |
| 7-Mar-57 | 9-Mar-58 | 1131239 |
| 10-Mar-58 | 14-May-58 | 781896 |
| 21-Aug-60 | 19-May-61 | 2108155 |
| 30-Dec-62 | 3-Oct-63 | 1337445 |
| 11-Oct-64 | 11-Feb-66 | 3429115 |
| 31-Oct-65 | 18-Apr-66 | 888810 |
| | | |
| **40-Ft. Channel** | | |
| | | |
| 15-Mar-68 | 13-Aug-68 | 2204721 |
| 9-May-68 | 9-Nov-68 | 717400 |
| 3-Dec-70 | 26-Nov-71 | 6121234 |
| 7-Jul-73 | 8-Mar-74 | 939460 |
| 1-Apr-75 | 29-Jul-75 | 2351467 |
| 27-Oct-76 | 8-Dec-76 | 255399 |
| 5-Oct-77 | 17-Feb-78 | 397114 |
| 21-Nov-77 | 26-Apr-78 | 2828635 |
| 11-Jun-82 | 15-Jan-83 | 3164883 |
| 17-Feb-84 | 24-Mar-84 | 1425574 |
| 28-Jan-86 | 12-Jun-86 | 2022150 |
| 7-Mar-91 | 10-Jun-91 | 2343056 |
| 22-Aug-91 | 19-Oct-91 | 959583 |
| 6-Nov-92 | 9-Jan-93 | 553351 |
| 14-Jul-94 | 27-Sep-94 | 337143 |
| 18-Mar-96 | 1-Jul-96 | 796671 |
| 27-Jul-96 | 27-Apr-97 | 394179 |
| 1-Apr-98 | 26-Aug-98 | 2065576 |
| 3-Apr-99 | 21-Dec-99 | 395507 |
| | | |
| **Total** | | 30273103 |
| **Average / Year** | | 976,551 |

## Reach Number 3: Port Arthur Canal

| Start Date | End Date | Total Actual Dredged Quantity |
|---|---|---|
| | | |
| **36-Ft. Channel** | | |
| | | |
| 8-Feb-48 | 20-Apr-49 | 4618302 |
| 8-Feb-48 | 20-Apr-49 | 1782599 |
| 30-Jan-51 | 12-May-51 | 2088273 |
| 29-Dec-51 | 9-Mar-52 | 624041 |
| 17-Feb-53 | 3-Nov-53 | 1577817 |
| 17-Feb-53 | 3-Nov-53 | 1186092 |
| 4-Jan-55 | 7-Jul-55 | 1304684 |
| 4-Jan-55 | 7-Jul-55 | 529624 |
| 7-Mar-57 | 9-Mar-58 | 2724400 |
| 21-Jan-59 | 3-May-59 | 1625755 |
| 21-Aug-60 | 19-May-61 | 3205412 |
| 30-Dec-62 | 3-Oct-63 | 2119186 |
| 31-Oct-65 | 18-Apr-66 | 1926480 |
| | | |
| **40-Ft. Channel** | | |
| 15-Nov-67 | 8-Mar-68 | 1136010 |
| 15-Nov-67 | 8-Mar-68 | 758718 |
| 31-Aug-69 | 6-Dec-69 | 3571729 |
| 13-Oct-70 | 7-Sep-71 | 1940074 |
| 20-Aug-71 | 10-Apr-72 | 5293509 |
| 7-Jan-74 | 21-Mar-74 | 2745762 |
| 4-Feb-74 | 2-Aug-74 | 2015826 |
| 5-Apr-76 | 10-Aug-76 | 2570429 |
| 10-Jul-77 | 10-Nov-77 | 2587041 |
| 24-Oct-78 | 20-Apr-79 | 2418626 |
| 20-Feb-81 | 19-Jul-81 | 2451088 |
| 3-Sep-81 | 13-Dec-81 | 2592916 |
| 18-Apr-83 | 3-Jul-83 | 2032723 |
| 30-Apr-84 | 9-Nov-84 | 2535664 |
| 4-Sep-85 | 6-Nov-85 | 2204881 |
| 4-Sep-87 | 13-Nov-87 | 3823896 |
| 7-Mar-91 | 10-Jun-91 | 701384 |
| 6-Nov-92 | 9-Jan-93 | 521476 |
| 6-Nov-92 | 9-Jan-93 | 616357 |
| 29-Oct-93 | 2-Dec-93 | 1614502 |

| | | |
|---|---|---|
| 14-Jul-94 | 27-Sep-94 | 1113358 |
| 27-Jul-96 | 27-Apr-97 | 3129417 |
| 27-Jul-96 | 27-Apr-97 | 632879 |
| 3-Apr-99 | 21-Dec-99 | 3512886 |
| | | |
| **Total** | | 52521151 |
| **Average / Year** | | 1,694,231 |

# Reach Number 4: Sabine Pass Channel

| Start Date | End Date | Total Actual Dredged Quantity |
|---|---|---|
| | | |
| **36-Ft. Channel** | | |
| 8-Feb-48 | 20-Apr-49 | 1305411 |
| 30-Jan-51 | 12-May-51 | 585918 |
| 29-Dec-51 | 9-Mar-52 | 888341 |
| 17-Feb-53 | 3-Nov-53 | 456003 |
| 4-Jan-55 | 7-Jul-55 | 342318 |
| 7-Mar-57 | 9-Mar-58 | 1329206 |
| 31-Aug-63 | 5-Jun-64 | 8173970 |
| | | |
| **40-Ft. Channel** | | |
| 28-Aug-67 | 18-Sep-67 | 871614 |
| 15-Mar-70 | 28-Aug-70 | 837384 |
| 20-Aug-71 | 10-Apr-72 | 1335052 |
| 4-Feb-74 | 2-Aug-74 | 714905 |
| 29-Apr-76 | 21-Jun-76 | 1711318 |
| 10-Jul-77 | 10-Nov-77 | 1272646 |
| 13-Feb-79 | 4-Jun-79 | 1369260 |
| 2-May-82 | 4-Aug-82 | 2537095 |
| 30-Apr-84 | 9-Nov-84 | 907127 |
| 28-Feb-85 | 29-Mar-85 | 836838 |
| 21-Mar-88 | 14-Jul-88 | 1508923 |
| 7-Nov-90 | 16-Nov-91 | 3011197 |
| 6-Nov-92 | 9-Jan-93 | 703237 |
| 27-Jul-96 | 27-Apr-97 | 2171369 |
| 21-Jun-99 | 31-Jul-99 | 2102577 |
| 6-Dec-00 | ??-??-00 | 2443824 |
| 20-Aug-01 | 14-Dec-01 | 1795611 |
| | | |
| **Total** | | 26,129,977 |
| **Average / Year** | | 768,528 |

## Reach Number 5: Entrance Channel and Jetty Channel

| Start | End | Total Actual |
|---|---|---|
| **Date** | **Date** | **Dredged Quantity** |
| | | |
| **40-Ft. Channel** | | |
| | | |
| 10-Feb-71 | 25-Feb-71 | 953500 |
| 27-Jun-71 | 30-Jun-71 | 277000 |
| 1-Jun-77 | 9-Sep-77 | 3000000 |
| 13-Aug-98 | 7-Oct-98 | 1057087 |
| 6-Dec-00 | ??-??-00 | 178112 |
| ??-??-00 | ??-??-00 | 474835 |
| ??-??-00 | ??-??-00 | 539360 |
| | | |
| **Total** | | 6,479,894 |
| **Average /Year** | | 223,444 |

# Reach Number 6: Entrance Channel and Outer Bar Channel

| Start Date | End Date | Total Actual Dredged Quantity |
|---|---|---|
| **40-Ft. Channel** | | |
| | | |
| 23-Jul-73 | 7-Sep-73 | 1105274 |
| 7-Nov-73 | 30-Jan-74 | 6496347 |
| 25-Sep-74 | 20-Nov-74 | 2520638 |
| 4-Mar-76 | 30-Jun-76 | 4676665 |
| 18-Jul-78 | 22-Aug-78 | 1100000 |
| 4-Oct-78 | 16-Feb-79 | 3376521 |
| 1-Oct-79 | 4-Oct-79 | 58080 |
| 19-Mar-81 | 30-May-81 | 3589486 |
| 27-Apr-82 | 20-May-82 | 1693264 |
| 12-Jul-83 | 20-Oct-83 | 378000 |
| 22-Jul-84 | 22-Sep-84 | 5601112 |
| 12-May-86 | 13-Jul-86 | 2905719 |
| 16-Jul-87 | 15-Sep-87 | 4572109 |
| 4-Sep-88 | 16-Oct-88 | 3002318 |
| 8-Apr-91 | 20-Jul-91 | 4738542 |
| 11-Sep-92 | 7-Nov-92 | 2363981 |
| 1-Sep-94 | 30-Oct-94 | 2301212 |
| 23-Jan-96 | 6-May-96 | 2588898 |
| 12-May-01 | 17-Jun-01 | 1391477 |
| | | |
| **Total** | | 54459643 |
| **Average / Year** | | 1,944,987 |

## Reach Number 7: Entrance Channel and Bank Channel

| Start Date | End Date | Total Actual Dredged Quantity |
|---|---|---|
| | | |
| **40-Ft. Channel** | | |
| | | |
| 6-Feb-72 | 18-Apr-72 | 7676244 |
| 10-Apr-72 | 31-May-72 | 1943370 |
| 21-Jan-73 | 6-Mar-73 | 3479450 |
| 1-Nov-74 | 12-Feb-75 | 4667000 |
| 13-Jul-85 | 7-Sep-85 | 5353000 |
| 12-May-86 | 13-Jul-86 | 2721118 |
| 8-Apr-91 | 20-Jul-91 | 512935 |
| 1-Sep-94 | 30-Oct-94 | 597991 |
| 23-Jan-96 | 6-May-96 | 1134937 |
| 12-Mar-97 | 25-Sep-97 | 4742465 |
| 6-Dec-00 | ??-??-00 | 2160766 |
| | | |
| **Total** | | 34989276 |
| **Average / Year** | | 1,249,617 |

**Table 2.3.6: Average Annual Dredging Quantities along SNWW Navigation Channel**

| Reach Number | Average Annual Dredging Quantity (cubic yards) |
|---|---|
| 1 | 1,203,310 |
| | |
| 2 | 976,551 |
| | |
| 3 | 1,694,231 |
| | |
| 4 | 768,528 |
| | |
| 5 | 223,444 |
| | |
| 6 | 1,944,987 |
| | |
| 7 | 1,249,617 |
| | |
| Total | 8,060,670 |

# Chapter 2.4: Shoaling Estimation Methods

## Discussion of Parameters

Relative change in length, depth and width

An increase in channel length and width increases its plan area. Since the dredged navigation channels are typically below the surrounding bed, they act as sediment traps. Hence, an increase in plan area (length and width) increases the quantity of sediment deposition quantity. A change in channel depth almost invariably results in increased sediment deposition, because a deeper channel acts as a more efficient sediment trap. If the channel is very shallow compared to the surrounding area, the trapping efficiency is small and considerable quantity of sediment may bypass over the channel. Sediment in suspension requires a certain amount of time to fall through the water column to reach the natural or dredged bed elevation. During this process, it is also being carried in the direction of flow. Hence, a sediment particle at water surface takes a trajectory path during its travel from surface to bed. If the channel is wide enough, the particle will deposit within the channel, otherwise it will bypass.

Properties of bed material

Non-cohesive and cohesive sediments have widely varying properties governing their erosion, transport, and deposition. Hence, the equations and methods used for determining these characteristics are also different. Mixtures of these two types of sediment prevail at most sites. Appropriate selection needs to be made depending upon the sediment present at site.

Geometry of navigation channel

Alignment of a channel relative to currents is important. Currents crossing the channel width cause more sediment deposition than the currents flowing along a channel. The sedimentation pattern is also different for the open channels versus channels with natural protection.

Properties of suspended material

Non-cohesive sediment such as sand has a larger particle size (on the order of millimeters) and higher weight. When these particles are suspended they tend to deposit quickly as soon as the fluid-induced force that keeps them in suspension drops down below the critical value for deposition. This time may be on the order of a few minutes to hours. On the other hand, fine sediments have a small size (on the order of microns), which keeps them in suspension for a much longer time, on the order of weeks or months. Organic substances in suspension have low specific weight and an open structure. Hence, they remain in suspension for longer duration, on the order of several days, unless they flocculate with other inorganic substances.

Magnitude of suspended sediment concentration

The non-cohesive sediment particles settle independently through the water column. Their fall velocity is a function of parameters such as shape factor, density, and size of particle. The fine sediment particles flocculate and settle as flocs. The fall velocity of flocs is a complex function of suspended sediment concentration, which varies over water depth.

Change in the magnitude and direction of current conditions

Modification to channel geometry or channel dimensions may result in change in the magnitude and direction of currents. These have profound influence on sediment deposition. Currents across the width of channel will deposit more sediment than the currents along the channel.

Wind and wave climate at site

Wind and waves induce shear on the water surface, which may extend through the water column all the way to the bed and influence sediment transport or resuspension.

Nature and location of sediment source

Local bed may be a source for sediment convection or the sediment may be reaching the area of interest form an outside source. An assessment of sediment source helps in predictions.

## Shoaling Estimate: Analytical Methods

A general approach for an analytical method consists of using carefully selected formulas for calculating the quantities of erosion and deposition. The criteria for selection of formulas are based upon their applicability at the given site and the problem. The formulas may contain several fluid-related and sediment-related parameters. The value of each parameter may be determined by means of field or laboratory studies or from literature and provided as input in the formulas for getting the answer. Several sediment formulas and methods are available for computing erosion, transport and deposition for a variety of parameters such as a) cohesive and non-cohesive sediments, b) bed load, suspended load, and total load, c) currents and waves, d) bank erosion, bed erosion and cliff erosion, e) incipient motion and turbulent convection and so on. They are available from simple formula given by DuBoys (1879) to the complex Bed Load Function given by Einstein (1950). The relationship between flow velocity and sediment discharge may be quite complex. The sediment discharge rate may be proportional to the flow velocity to the power of anywhere from 2 to 6. Hence the answer will vary by several orders of magnitude depending upon the power used. If selected carefully and applied properly, these methods sometimes provide an order of magnitude estimates of sediment erosion / deposition / transport.

Such formulas or methods that may be universally applicable are not available in books or published literature for estimating change in siltation rates in navigation channels as a result of extension, widening or deepening.

## Shoaling Estimate: Empirical Methods

Empirical methods are not based upon any established theory. Laboratory or field data are collected on certain pre-selected parameters and empirical relationships are established using statistical / curve-fitting techniques. These methods are often too simplistic and less reliable and are not always approved by the technical communities. However, they sometimes serve the site-specific purpose very well. An example of such methods in the field of sediment transport is the century-old regime theory formulas developed for design of irrigation canals, some of which are still applicable. Such empirical methods are not available for application to sediment problems of navigation channels.

## Shoaling Estimates: Dredging Data Method

An increase in length, width or depth of a navigation channel often results in an increased quantity of siltation and hence an increased cost and frequency of dredging. Data on dredging quantities before and after deepening and / or widening are very useful in prediction of future quantities. For instance, if a navigation channel was deepened from 35 feet to 40 feet and dredging records are available for the pre-deepening and post-deepening conditions, they could be analyzed and used for predicting the effect of further deepening from 40 feet to say 45 feet.

Although dredging records are available for the SNWW project, they are not complete and often times break-up of dredging quantities is not available for individual reaches. Hence available dredging data could be used to a limited extent.

## Shoaling Estimate: Desktop Study

A desktop study is done when application of none of the methods described above is possible for one reason or another. An accepted practice consists of applying a multiplication factor, greater than 1.0 to the dredging quantities for the pre-deepening and pre-widening conditions. Several parameters are taken into account while selecting this factor, which is very much site-specific and may vary for different locations of the same project. Such desktop study has severe limitations for want of adequate data, tools or methods available for making prediction of anticipated future dredging quantities. The estimates are made based on experience, field data, and understanding of site conditions. The study provides an order of magnitude estimates, which may be used for budgeting purposes, for determining feasibility of a project, or for working out an approximate benefit to cost ratio, etc.

# Chapter 2.5: Numerical Model Results

## Introduction

The numerical model was run for the boundary conditions described earlier under Chapter 1.4. Out of the large number of nodes contained in the numerical model, data were obtained for 124 nodes, which were selected over all the seven reaches of the navigation channel. The node selection was also based on the locations of bed samples collected at site. This facilitated getting velocity information close to the sediment information. For the sake of convenience of easy reference, the actual node numbers of the numerical model were renamed in simple serial order. The actual node numbers, the new numbers and the location numbers of the closest bed sample are listed in Table 2.5.1.

Out of 124 nodes, 23 nodes were selected, which were spatially distributed along the total length of the navigation channel covering all the seven reaches of study. The locations of these 23 nodes are shown in Figures 2.5.1 and 2.5.2.

The three-dimensional layered model gave velocity results at several water depths at each node. Data on surface and bottom velocities were extracted from the solution files at the selected 23 nodes. A comparison of surface and bottom velocities showed that while the bottom velocities are a little lower than the surface velocities as expected, the difference was not significant in the context of the sediment study. Hence the results only on bottom velocities have been processed and used in the sediment study.

Numerical model results at these nodes have been presented in Appendices C and D and they have been used for prediction of shoaling in navigation channel after channel modifications.

## Comparison of flood and ebb velocities

Velocity results of numerical model for the flood and ebb at 23 nodes for the base (existing) conditions are presented in Appendix B. The following conclusions are drawn:

1. At nodes 1, 9, and 18, which are located in Neches River, the maximum ebb velocity is about 0.8 feet per second, whereas the maximum flood velocity is about 0.3 to 0.4 feet per second. Higher ebb velocity indicates influence of river discharge over tidal influx.

2. At locations 23, 30 and 38, which are in Sabine Neches Canal, the maximum ebb velocity is about 2 to 2.5 feet per second and the maximum flood velocity is about 1.5 to 2 feet per second. These higher velocities are probably due to the restricted cross section of the navigation channel.

3. At locations 46, 54, and 62, located in the Port Arthur channel, conclusions are the same as for the Sabine Neches Canal reach.

4. At locations 67, 75 and 85, located in the Sabine Pass Channel, the difference between the flood and ebb velocities reduces to only about 0.5 feet per second.

5. In the Sabine Pass Jetty Channel, the peak ebb velocity is high, about 3.5 feet per second and the flood velocity is about 3.0 feet per second. These high velocities are due to the smaller cross section restricted by the two jetties.

6. The peak ebb velocity reduces rapidly over the outer bar. It decreases to 2.5 fps at 103, 2.3 fps at 105 and 1.2 fps at 107. The corresponding flood velocities also decrease to 2.1, 1.5 and 0.4 fps respectively.

7. At locations in the ocean channel the velocity pattern is erratic.

8. A phase shift in the time of occurrence of peak velocities of flood and ebb is noticed at all locations.

## Base and plan velocities for Flood

Superposed velocity plots for the base and plan for the flood test condition are given in Appendix C. It is generally seen that there was no significant difference between the base and plan values of velocity magnitudes.

## Base and plan velocities for Ebb

Superposed velocity plots for the base and plan for the ebb test condition are given in Appendix D. It is generally seen that there was no significant difference between the base and plan values of velocity magnitudes.

## Tidal Elevations and Velocities

Three nodes were selected at the center of navigation channel to examine relationship between tidal elevations and velocity magnitudes. These nodes were: N24, in the Port Arthur area; N50, close to Round Lake; and N102, at the end of jetties. The locations are shown in Figure 2.5.3. Superposed water levels at these three locations for the flood and ebb are shown in Figures 2.5.4 for flood and in Figure 2.5.5 for ebb. Superposed velocities at the three locations are given for flood and ebb in Figures 2.5.6 and 2.5.7 respectively. Superposition of water level and bottom velocity for the base flood are given in Figures 2.5.8, 2.5.9, and 2.5.10. Superposition of water level and bottom velocity for the base ebb are given in Figures 2.5.11, 2.5.12, and 2.5.13. Study of data at more nodes is necessary for drawing any specific conclusions from these plots.

## Flow Pattern

Flow pattern for the flood and ebb for the three nodes are shown in Figures 2.5.14 through 2.5.19.

**Table 2.5.1: Actual Node Numbers, New Node Numbers, and locations of nearest Bed Sample Numbers, selected for study**

| New Node Number | Nearest Bed Sample Number | Actual Node Number |
|---|---|---|
| | | |
| **Reach 1** | | |
| 1 | 1900 | 17787 |
| 2 | 1874 | 17736 |
| 3 | 1848 | 17540 |
| 4 | 1821 | 17297 |
| 5 | 1795 | 17263 |
| 6 | 1768 | 17212 |
| 7 | 1742 | 17178 |
| 8 | 1716 | 17140 |
| 9 | 1689 | 17113 |
| 10 | 1663 | 17080 |
| 11 | 1636 | 16951 |
| 12 | 1610 | 16910 |
| 13 | 1584 | 16876 |
| 14 | 1557 | 16859 |
| 15 | 1531 | 16825 |
| 16 | 1504 | 16787 |
| 17 | 1478 | 16679 |
| 18 | 1452 | 14910 |
| | | |
| **Reach 2** | | |
| 19 | 1425 | 14699 |
| 20 | 1399 | 14693 |
| 21 | 1372 | 14687 |
| 22 | 1346 | 14678 |
| 23 | 1320 | 14629 |
| 24 | 1293 | 14506 |
| 25 | 1267 | 14446 |
| 26 | 1240 | 14329 |
| 27 | 1214 | 14266 |
| 28 | 1188 | 14182 |
| 29 | 1161 | 14098 |
| 30 | 1135 | 14014 |
| 31 | 1108 | 13092 |
| 32 | 1082 | 12703 |
| 33 | 1056 | 12280 |
| 34 | 1029 | 12180 |

| | | |
|---|---|---|
| 35 | 1003 | 11508 |
| 36 | 976 | 11080 |
| 37 | 950 | 11044 |
| 38 | 924 | 10911 |
| 39 | 897 | 10614 |
| 40 | 871 | 10377 |
| 41 | 844 | 10300 |
| | | |
| **Reach 3** | | |
| 42 | 818 | 10189 |
| 43 | | 10118 |
| 44 | 792 | 9808 |
| 45 | | 9734 |
| 46 | 765 | 9679 |
| 47 | | 9639 |
| 48 | 739 | 9599 |
| 49 | | 9559 |
| 50 | 712 | 9518 |
| 51 | | 9494 |
| 52 | 686 | 9402 |
| 53 | | 9356 |
| 54 | 660 | 9179 |
| 55 | | 9125 |
| 56 | 633 | 8964 |
| 57 | | 8872 |
| 58 | 607 | 8805 |
| 59 | | 8634 |
| 60 | 580 | 8579 |
| 61 | | 8500 |
| 62 | 554 | 8425 |
| 63 | | 8373 |
| 64 | 528 | 8176 |
| | | |
| **Reach 4** | | |
| 65 | 501 | 8170 |
| 66 | | 8167 |
| 67 | 475 | 8161 |
| 68 | | 8152 |
| 69 | 448 | 7970 |
| 70 | | 7911 |
| 71 | 422 | 7883 |
| 72 | | 7855 |
| 73 | 396 | 7749 |
| 74 | | 7727 |

| | | |
|---|---|---|
| 75 | 369 | 7691 |
| 76 | | 7662 |
| 77 | 343 | 7631 |
| 78 | | 7533 |
| 79 | 316 | 7274 |
| 80 | | 6858 |
| 81 | 290 | 5973 |
| 82 | | 5891 |
| 83 | 264 | 5788 |
| 84 | | 5724 |
| 85 | 237 | 5692 |
| 86 | 211 | 5624 |
| 87 | | 5592 |
| | | |
| **Reach 5** | | |
| 88 | 184 | 5560 |
| 89 | | 5464 |
| 90 | 158 | 5368 |
| 91 | | 5304 |
| 92 | 132 | 5240 |
| 93 | | 5176 |
| 94 | 105 | 5144 |
| 95 | | 5080 |
| 96 | 79 | 5048 |
| 97 | | 5016 |
| 98 | 52 | 4677 |
| 99 | | 4671 |
| 100 | 26 | 4659 |
| 101 | | 4605 |
| 102 | 0 | 4356 |
| | | |
| **Reach 6** | | |
| 103 | OS52 | 3940 |
| 104 | | 4136 |
| 105 | OS105 | 3889 |
| 106 | | 3919 |
| 107 | OS158 | 3757 |
| 108 | | 3808 |
| | | |
| **Reach 7** | | |
| 109 | OS211 | 3429 |
| 110 | OS264 | 3727 |
| 111 | OS316 | 3058 |
| 112 | OS369 | 2872 |

| | | |
|---|---|---|
| 113 | OS422 | 2759 |
| 114 | OS475 | 2584 |
| 115 | OS528 | 2447 |
| 116 | OS580 | 2302 |
| 117 | OS633 | 2131 |
| 118 | OS686 | 1931 |
| 119 | OS739 | 1773 |
| 120 | OS792 | 1721 |
| 121 | OS844 | 1617 |
| 122 | OS897 | 1494 |
| 123 | OS950 | 1444 |
| 124 | OS1003 | 1348 |

**Table 2.5.2: List of nodes selected for presentation of numerical model results**

| Reach # | Node # |
|---|---|
| 1 | N01 |
| | N09 |
| | N18 |
| | |
| 2 | N23 |
| | N30 |
| | N38 |
| | |
| 3 | N46 |
| | N54 |
| | N62 |
| | |
| 4 | N67 |
| | N75 |
| | N85 |
| | |
| 5 | N90 |
| | N96 |
| | N100 |
| | |
| 6 | N103 |
| | N105 |
| | N107 |
| | |
| 7 | N110 |
| | N114 |
| | N118 |
| | N122 |
| | N124 |

# Chapter 2.6: Shoaling Prediction

## Discussion of Shoaling Parameters

As mentioned under Chapter 2.4, several parameters must be considered in the context of navigation channel shoaling. From the data supplied by the Galveston District and analysis of field data collected at SNWW, the following conclusions are drawn.

Nature and location of sediment source

The following are major sources of sediment supply for shoaling of the navigation channel at Sabine Neches Project:

1. River inflows
2. Tidal influx from ocean
3. Open water disposal areas located close to the navigation channel
4. Bank and bed erosion

Taking into account the large quantity of sediment accumulating in the navigation channel, it appears that abundant supply of sediment enters the system from all of these sources. The natural parameters participating in the sedimentary processes are tidal currents, wind, waves, and vessel-induced currents. All of these are present at the project.

Properties of bed material

Current velocity and magnitude are continuously changing in an estuarine situation. Erosion of bed and banks occurs when the currents are sufficiently high, and sediment deposition occurs when the current velocity decreases. Thus, substantial shoaling occurs at high and low water slack times. Sediments are also transported over large distances by the tidal currents. While sediment remains in suspension due to turbulence, sediment deposition of larger particles and heavier flocs also occurs under flow. This is known as flow-deposition of sediment. The processes of erosion, transport and deposition take place in a cyclic manner in an estuarine situation. Since a substantial quantity of bed sediment participates in these processes, knowledge of their characteristics is essential.

Analysis of 92 surface bed material samples collected at the project indicated that the bed material contains a large percent of particles finer than 64 microns. This fraction is termed as fine sediments that include silt and clay. Average values of the percentage of sand and silt plus clay are shown in Table 2.6.1. The silt plus clay component varies from 61 to 95 percent, which is substantial.

Bed samples from each reach also show a significant quantity of organic matter. It varies from 4 to 9 percent by weight. This amount is sufficient to induce flocculation of fine sediments and accelerate their settling.

Properties of suspended material

Total suspended matter in a natural water column contains inorganic component (sediment of varying particle sizes) and organic component (detritus, diatoms, algae etc). Information on distribution of suspended particle sizes and identification of contents of suspended sediment particulates was not obtained during the present study. It is assumed that the fine sediments prevailing in the bed are represented in the suspended sediments.

Magnitude of suspended sediment concentration

Two sets of water samples were collected for determining suspended sediment concentration and salinity. The first set consisted of mid-depth samples collected along the centerline of navigation channel.

Suspended sediment concentrations at mid depth along the centerline of the navigation channel are plotted in Figure 2.6.1. Neglecting three samples with very high concentration, the average magnitude appears to vary between 20 and 90 mg/l. The average is around 50 mg/l. This high concentration will induce deposition of suspended sediment to the bottom due to flocculation.

Salinity

Salinity measured at mid-depth along the centerline of navigation channel on April 16 and 18 is plotted in Figure 2.6.2. Salinity at the ocean end of the channel was 28 ppt. It decreased gradually towards the upper end of the estuary until about the middle of Pleasure Island or Port Arthur area (Station 1056). Beyond this area the salinity was close to zero.

A common effect of channel deepening is greater penetration of salinity towards upstream reaches. Although results of salinity are not yet available from the hydrodynamic numerical model, increasing the project channel depth from 40 feet to 50 feet may have a profound impact on penetration of salinity wedge. The effect of this parameter will have to be re-examined after results of the numerical salinity model are available.

Change in the magnitude and direction of current

The current magnitude changes continually in an estuarine situation such as at SNWW, and the flow direction reverses with each flood and ebb phase of tide. This results in cyclic occurrence of sedimentary processes involving erosion, transport, and deposition.

Wind and wave climate at site

Both wind and waves are powerful forces at Sabine Neches Project. Ocean waves are strong enough to bring the bed sediment in suspension. Tidal currents carry this suspended sediment to the inner channel through the inlet. When the tidal current strength is reduced, the suspended sediment deposits.

Geometry of navigation channel

The SNWW navigation channel has a complex geometry with several turns and alignment changes on its course. Natural widths and depths also vary to a great extent. Every curvature and depth change results in non-uniform flow in the channel.

Hydrodynamics

The SNWW is a very complex hydrodynamic system. The following are the major features of the system.

1. Confluence of two large rivers, Sabine River and Neches River.
2. Large length of the navigation channel, which is on the order of 65 miles. This results in substantial phase lags in tidal propagation from downstream to upstream end of the estuary.
3. Presence of channel through reaches of diverse physical properties from high saline water to fresh water.
4. Sabine Lake, which is a very large shallow water body of water, is connected to the navigation channel at the southern and northern end. Hence tidal propagation takes place through the channel as well as through the Sabine Lake.
5. Many shallow water marshlands and some lakes are connected to the hydraulic system of the two rivers.

Velocity change

Local cross-sectional area increases as a result of deepening a navigation channel. Hence for the same amounts of fresh water discharge and tidal influx, the current velocity decreases. As a result, greater sediment deposition may be induced. However, other effects of channel deepening include a change in density current pattern and a change in the volume of tidal influx. Increased tidal volume increases velocity. The combined effect can be evaluated only through a numerical model. Velocities at selected locations along the SNWW navigation channel were obtained for the base and plan conditions from the numerical model. It is necessary to compare plan velocities against base velocities in order to evaluate the impact of channel modification on current velocities. Appendix C shows superposed velocity plots for base and plan for Flood. Appendix D shows superposed velocity plots for base and plan for Ebb test condition.

Due to a very complex hydrodynamic system prevailing at Sabine Neches, there is no consistent increase or decrease at various cross sections. An increase in flow velocity at some locations may be an indication of increased tidal volume. The resulting higher velocity may increase local bank erosion and hence channel shoaling.

Dredging History

Dredging data analysis is given in Chapter 2.3. Average annual dredging carried out in various reaches based on data over the years 1967 to 2001 are given in Table 2.6.2.

Relative change in length, depth and width

Proposed channel modifications include changes in length, bottom width and authorized depth in all the reaches. Dimensions of existing channel are given in Table 2.6.3. Dimensions of the proposed project are given in Table 2.6.4.

The authorized project depth of existing channel is 40 feet. The existing as well as proposed channel width may vary locally to facilitate navigation. The existing channel extends 18.1 miles past the jetties. Due to increase in project channel depth from 40 feet to 50 feet, the present navigation channel will be extended into the ocean to meet the natural depth of 56 feet. Hence in addition to the existing seven reaches, new reach #8 is added to represent the extended channel beyond the present end of channel. The lengths of extended navigation channel given by the Galveston District for different project depths are given in Table 2.6.5

The width of navigable area varies locally at several places to accommodate turning basins. Ignoring local widening and considering predominant average width has been used for purposes of the present sediment study. The dimensions adopted for each reach given in Table 2.6.6.

## Shoaling Quantity Estimation

A trapezoidal cross-section of the navigation channel is assumed with side slope of 1 vertical to 2 horizontal for all reaches except reach 6, which has a slope of 1 vertical to 10 horizontal. The plan area of channel at the natural bed elevation is an important parameter related to the volume of shoaling. Widening and deepening a channel increases this area, which results in trapping more sediment and hence in higher shoaling. Increase in area was determined for each reach. The ratio of new area to existing area gives the Area Factor for shoaling computations.

Reach 8 does not have dredging history. Hence data for reach 7 have been used. The change in depth relative to the surrounding natural water depth is also a consideration. For Reach 8, which is the extended outer channel, the change in depth is from 10 feet at the beginning of new channel to zero feet at the end where the natural depth is 54 feet. This change in depth is smaller than for the relative change in depth near the end of the jetties where the natural depth is 20 feet. The new channel depth of 54 feet below water gives a change of depth of 34 feet with respect to prevailing natural bed elevation.

Increase in shoaling quantities resulting from channel deepening may be attributed to four major factors:

1. Increase in channel plan area due to increased bottom width,
2. Decrease in flow velocity due to increased cross-section,
3. Modified salinity regime due to greater salt water penetration, and
4. Other factors, which include increased vessel traffic resulting in greater bank and bed erosion due to vessel-induced waves, channel bank failure, bank sloughing, sediment brought down by rivers, increased trap efficiency resulting from greater size and depth, and wave effect in case of the outer channel.

A factor greater than 1.0 is applied under each of the four types and the existing quantity of dredging is multiplied by the combined factor to get the estimated quantity of dredging. The first three factors can be computed. The fourth factor is based on judgment and experience based on other projects. Several unknown parameters in the ocean channel include direction and magnitudes of ocean currents, varying wave climate, and bed sediment properties in the area where channel is extended beyond the end of the existing navigation channel.

Table 2.6. 7 gives the estimates based on this approach. It is concluded that the average annual quantity of dredging in the SNWW navigation channel will increase form the present average quantity of 8.0 million cubic yards to 16.7 million cubic yards.

## Limitations of Study

The desktop study presented in this report has some limitations. A desktop study is done when application of analytical methods is not possible for one reason or another. Such a desktop study includes study of available data on sediment, past dredging records, prevailing site conditions and experience gained at other projects. The results are based jointly on analysis of field data, results of numerical hydrodynamic model and to some extent on subjective judgment. Complex fine sediment phenomena such as fluid mud and impact of salinity on flocculation are not taken into account. It is assumed that unlimited supply of sediment is available in the system at site. The study provides order of magnitude estimates, which may be used for preliminary budgeting purposes, for determining feasibility of a project, or for working out an approximate benefit to cost ratio, etc.

## Table 2.6.1: Average Percentages of Sand, Silt Plus Clay, and Organic Matter in Bed Samples at Sabine Neches Project

| Reach # | % Sand | % Silt + Clay | % Organic Matter |
|---|---|---|---|
| 1 | 38.30 | 61.70 | 6.42 |
| 2 | 22.15 | 77.85 | 6.90 |
| 3 | 16.19 | 83.81 | 7.13 |
| 4 | 30.10 | 69.90 | 8.73 |
| 5 | 10.94 | 89.06 | 6.00 |
| 6 | 4.34 | 95.66 | 3.74 |
| 7 | 24.29 | 75.71 | 4.13 |

## Table 2.6.2: Average Annual Dredging Quantities in Different Reaches of SNWW Navigation Channel

| Reach Number | Average Annual Dredging Quantity (cubic yards) |
|---|---|
| 1 | 1,203,310 |
| 2 | 976,551 |
| 3 | 1,694,231 |
| 4 | 768,528 |
| 5 | 223,444 |
| 6 | 1,944,987 |
| 7 | 1,249,617 |
| 8 | ------ |
| Total | 8,060,668 |

## Table 2.6.3: Existing project dimensions

| REACH (EXISTING STATIONS) | STATION | TO | STATION | EXISTING BOTTOM WIDTH (FT) | AUTH. DEPTH (' MLT) | EXISTING CHANNEL DEPTH (' MLT) | ADV. MAINT. ADDED (FT) | A.O. (FT) | SIDE SLOPE |
|---|---|---|---|---|---|---|---|---|---|
| SABINE BANK CHANNEL | 95+734 | | 18+000 | 800 | 42 | 44 | 2 | 2 | 1V/2H |
| SABINE PASS OUTER BAR | 18+000 | | 0+000 | 800 | 42 | 44 | 2 | 2 | 1V/10H |
| SABINE PASS JETTY CHANNEL | -214+88.30 | | 0+00.00 | 800-500 | 40 | 42 | 2 | 2 | 1V/2H |
| SABINE PASS CHANNEL | 0+00.00 | | 296+24.6 | 500-1133 | 40 | 42 | 2 | 2 | 1V/2H |
| PORT ARTHUR CANAL | 0+00.00 | | 326+24.4 | 500-1788 | 40 | 42 | 2 | 1 | 1V/2H |
| SABINE-NECHES CANAL | 0+00.00 | | 593+68.50 | 400-1060 | 40 | 42 | 2 | 1 | 1V/2H |
| NECHES RIVER CHANNEL | 0+00 | | 10+00 | 400 | 40 | 42 | 2 | 2 | 1V/2H |
| NECHES RIVER CHANNEL | 10+00 | | 34+00 | 400 | 40 | 42 | 2 | 2 | 1V/2H & 1V/5H RS |
| NECHES RIVER CHANNEL | 34+00 | | 75+00 | 400 | 40 | 42 | 2 | 2 | 1V/2H |
| NECHES RIVER CHANNEL | 75+00.00 | | 978+59.76 | 400 | 40 | 42 | 2 | 1 | 1V/2H |
| | | | | | | | | | |
| NECHES RIVER CHANNEL 2 | 978+59.76 | | 998+63.42 | 1000-300 | 34 | 36 | 2 | 1 | 1V/2H |
| NECHES RIVER CHANNEL 3 | 998+63.42 | | 1037+59.40 | 300-200 | 30 | 32 | 2 | 1 | 1V/2H |

The Neches River Channels 2 & 3 are just past the Beaumont Turning Basin, and have not been included in quantity take-offs.
AO = allowable overdepth.
Existing channel depth is the depth the channel is dredged.
MLT = mean low tide

## Table 2.6.4: SNWW navigation channel dimensions proposed for 50' project

| NOTES | REACH (EXISTING STATIONS) | STATION | TO | STATION | BOTTOM WIDTH (FT) | Project DEPTH (' MLT) | ADV. MAINT. ADDED (FT) | A.O. (FT) | SIDE SLOPE |
|---|---|---|---|---|---|---|---|---|---|
| 1,2,3,4 | EXTENSION CHANNEL | 160+736 | | 95+734 | 700 | 52 | 2 | 2 | 1V/2H |
| 1,2,3,4 | SABINE BANK CHANNEL | 95+734 | | 18+000 | 800 | 52 | 2 | 2 | 1V/2H |
| 1,2,3,4 | SABINE PASS OUTER BAR | 18+000 | | 0+000 | 800 | 52 | 2 | 2 | 1V/10H |
| 2,3,4,6 | SABINE PASS JETTY CHANNEL | -214+88.30 | | 0+00.00 | 800-700 | 50 | 2 | 2 | 1V/2H |
| 2,3,4,6 | SABINE PASS CHANNEL | 0+00.00 | | 296+24.6 | 700 | 50 | 2 | 2 | 1V/2H |
| 2,3,4,5 | PORT ARTHUR CANAL | 0+00.00 | | 326+24.4 | 700 | 50 | 2 | 1 | 1V/2H |
| 2,3,4,6 | SABINE-NECHES CANAL | 0+00.00 | | 593+68.50 | 400 | 50 | 2 | 1 | 1V/2H |
| 1,2,3,4,5,6 | NECHES RIVER CHANNEL | 0+00 | | 10+00 | 400 | 50 | 2 | 2 | 1V/2H |
| 1,2,3,4,5,6 | NECHES RIVER CHANNEL | 10+00 | | 34+00 | 400 | 50 | 2 | 2 | 1V/2H & 1V/5H RS |
| 1,2,3,4,5,6 | NECHES RIVER CHANNEL | 34+00 | | 75+00 | 400 | 50 | 2 | 2 | 1V/2H |
| 1,2,3,4,5,6 | NECHES RIVER CHANNEL | 75+00.00 | | 978+59.76 | 400 | 50 | 2 | 1 | 1V/2H |

ASSUMPTIONS AND NOTES:

1. Assume bottom width remains the same.
2. Assume the Advanced maintenance remains the same.
3. Assume the allowable overdepth remains the same.
4. Assume the side slopes remains the same.
5. Stationing will be adjusted to remove existing equations and errors.
6. New alignment & stationing will be generated with widening.

**Table 2.6.5: Proposed navigation channel extension for different project depths**

| | | | | BOTTOM | CHANNEL | ADV | Add Wave | | | ADD. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | WIDTH | DEPTH | MAINT | Action | A.O. | SIDE | LENGTH |
| STATION | TO | STATON | MILE | (FT) | (' MLT) | (FT) | (FT) | (FT) | SLOPE | MILES |
| | | | | | | | | | | |
| 95+734 | | 161+000 | 30.49 | 700 | 45 | 2 | 2 | 2 | 1V/2H | 12.39 |
| 95+734 | | 165+000 | 31.25 | 700 | 48 | 2 | 2 | 2 | 1V/2H | 13.15 |
| 95+734 | | 169+000 | 32.01 | 700 | 50 | 2 | 2 | 2 | 1V/2H | 13.91 |

**Table 2.6.6: Dimensions of present and future channel adopted for shoaling estimate computations.**

| Reach | Area | Present Width | Present Depth | | Future Width | Future Depth |
|---|---|---|---|---|---|---|
| | | Feet | Feet | | Feet | Feet |
| | | | | | | |
| 8 | EXTENDED OUTER CHANNEL | --------- | --------- | | 700 | 54 |
| | | | | | | |
| 7 | SABINE BANK CHANNEL | 800 | 44 | | 800 | 54 |
| | | | | | | |
| 6 | SABINE PASS OUTER BAR | 800 | 44 | | 800 | 52 |
| | | | | | | |
| 5 | SABINE PASS JETTY CHANNEL | 650 | 42 | | 750 | 52 |
| | | | | | | |
| 4 | SABINE PASS CHANNEL | 500 | 42 | | 700 | 52 |
| | | | | | | |
| 3 | PORT ARTHUR CANAL | 500 | 42 | | 700 | 52 |
| | | | | | | |
| 2 | SABINE-NECHES CANAL | 400 | 42 | | 400 | 52 |
| | | | | | | |
| 1 | NECHES RIVER CHANNEL | 400 | 42 | | 400 | 52 |

## Table 2.6.7: Estimated average annual shoaling quantities after channel modifications

| Reach | Area | Present Dredging (cu yd) | Area Factor | Velocity Factor | Salinity Factor | Other Factors | Combined Factor | Estimated Dredging (cu yd) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 8 | EXTENDED OUTER CHANNEL | (1,249,617) | 0.82 | 1.00 | 1.00 | 1.20 | 1.02 | 1,274,609 |
| | | | | | | | | |
| 7 | SABINE BANK CHANNEL | 1,249,617 | 1.05 | 2.30 | 1.00 | 1.20 | 2.55 | 3,186,523 |
| | | | | | | | | |
| 6 | SABINE PASS OUTER BAR | 1,944,987 | 1.21 | 1.93 | 1.00 | 1.20 | 2.34 | 4,551,269 |
| | | | | | | | | |
| 5 | SABINE PASS JETTY CHANNEL | 223,444 | 1.19 | 1.05 | 1.00 | 1.20 | 1.44 | 321,759 |
| | | | | | | | | |
| 4 | SABINE PASS CHANNEL | 768,528 | 1.41 | 1.05 | 1.15 | 1.15 | 1.76 | 1,352,609 |
| | | | | | | | | |
| 3 | PORT ARTHUR CANAL | 1,694,231 | 1.41 | 1.05 | 1.15 | 1.15 | 1.76 | 2,981,846 |
| | | | | | | | | |
| 2 | SABINE-NECHES CANAL | 976,551 | 1.08 | 1.05 | 1.10 | 1.15 | 1.38 | 1,347,640 |
| | | | | | | | | |
| 1 | NECHES RIVER CHANNEL | 1,203,310 | 1.08 | 1.05 | 1.05 | 1.20 | 1.38 | 1,660,567 |
| | | | | | | | | |
| | TOTAL | 8,060,670 | | | | | | 16,676,825 |

# Chapter 2.7: Conclusions and Remarks

1. It is estimated that the quantity of dredging in the SNWW navigation channel will increase from the present average of 8.0 million cubic yards to 16.7 million cubic yards per year after modifications are made to the navigation channel consisting of increased length, width and depth in order to turn the present 42-foot project into a 50-foot project.

2. It is assumed that unlimited supply of sediment is available in the system at site. If for some reasons, the system becomes deficient in sediment supply, or measures are taken to reduce the sediment supply, the amount of shoaling in navigation channel would reduce.

3. The silt plus clay component in bed samples collected at several locations along the navigation channel varied from 61 to 95 percent, which is substantial. This fine sediment will travel in suspension over long distances even under low flow velocities, flocculate under salt water and eventually deposit in navigation channel and other dredged areas. Since navigation channels are dredged below the natural bed elevation, current velocities over the channel are lower than the velocity in the surrounding natural areas because of the increased cross section. Hence the navigation channel functions as a sediment trap.

4. Bed samples from every reach of the channel also show a significant quantity of organic matter. It varies from 4 to 9 percent by weight. This amount is sufficient to induce flocculation of fine sediments and accelerate their settling.

5. The following are major sources of sediment supply for shoaling of navigation channel at Sabine Neches Project. Abundant quantity of sediment may be entering the system from all of these sources.

   a. River inflows
   b. Tidal influx from ocean
   c. Open water sediment disposal areas located close to the navigation channel
   d. Bank and bed erosion

6. The average magnitudes of suspended sediment concentrations at mid depth along the centerline of navigation channel varied between 20 and 90 mg/l. The average is around 50 mg/l. This is considered as substantial. Flocculation of suspended sediment will result in deposition to the bottom.

7. Salinity measured at mid-depth along the centerline of navigation channel on April 16 and 18 showed that it was 28 ppt at the ocean end of channel. It decreased gradually towards the upper end of estuary until about the middle of Pleasure Island or Port Arthur area. Beyond this the salinity was close to zero for one data set, however another data set showed bottom salinity as high as 20 ppt extending all the way up to the Neches River. When the salinity regime changes from near zero to anywhere up to 5 ppt, flocculation occurs, which induces deposition of suspended sediment.

8. Increase in shoaling quantities resulting from deepening of an existing channel may be attributed to four major factors:

1. Increase in channel plan area due to increased bottom width,
2. Decrease in flow velocity due to increased cross-section,
3. Modified salinity regime due to greater salt water penetration, and
4. Other factors, which include increased vessel traffic resulting in greater bank and bed erosion due to vessel-induced waves, channel bank failure, bank sloughing, sediment brought down by rivers, increased trap efficiency resulting from greater size and depth, and wave effect in case of the outer channel.

9. This desktop study provides an <u>approximate</u> estimate of the anticipated shoaling in the navigation channel resulting from its modification. It may be used for preliminary budgeting purposes, determining feasibility of a project, and for working out an approximate benefit to cost ratio, etc.

# Desktop Study for
# Sediment-Related Problems at
# Sabine Neches Project

# Part 3 (Revised)
# Pleasure Island Erosion

**October 2003**

# Chapter 3.1: Erosion Problem

## Problem Description

Pleasure Island (PI) is located between Port Arthur and Sabine Lake in Jefferson County, Texas (Figure 3.1.1). The island was created from dredged materials and the soil is very weakly consolidated, consisting primarily of silty clay with some sand. Due to significant vessel traffic in the Sabine-Neches Canal, about 6 miles of the western shoreline of the Pleasure Island have been eroding significantly. The 6-mile shoreline extends from 1 mile south of the Martin Luther King (MLK) Bridge to 5 miles north of the bridge. It is feared that unless protective measures are taken, continued erosion would eventually threaten the T.B. Ellison Parkway, the sole access road to PI. The two critical areas are from station 198+86 to 268+60 for the Sabine Neches Canal and from station 130+00 to 230+00 for the Port Arthur Canal. The first area is west of the bulkhead and the second area is between the Round Island and Keith Lake. The erosion concern in Sabine Neches Canal reach is mainly along the bank of Pleasure Island whereas the erosion concern is along both the banks in the Port Arthur Canal reach.

Although various types of shoreline protection efforts have been implemented on several sections of the shoreline, erosion continues and some protection measures have failed. For the purpose of protecting the existing shoreline from further erosion, as authorized by the Texas Coastal Erosion Planning and Response Act (CEPRA), the Texas General Land Office (GLO) and Jefferson County have co-sponsored the Pleasure Island Shoreline Protection Project. PBS&J Consultants were appointed to develop a set of conceptual designs that would meet the project goals. The consultants have submitted a comprehensive report dated 16 January 2001. A lot of information related to description of site conditions from the consultant's report is reproduced in the present since it is relevant and unchanged.

Controlling erosion along this reach of Pleasure Island is important for many reasons. The first is that the eroding land provides useful public functions as parks, public facilities, and road rights-of way. A second reason is that eroded land is a contributor to the material that has to be removed from the navigation channel at public expense in maintenance dredging. A third reason is aesthetic, in that failed shoreline protection measures are unsightly and potentially dangerous.

## Scope of Study

The scope of work for the present report is given under Chapter 1.1. The contents related to Pleasure Island are again given below for ease of reference.

Scope (Part 1A): Sediment data available with the Galveston District will be examined and used in the study. The Measurement and Analysis Group of the CHL will collect additional sediment data, which will be analyzed in CHL laboratory. Laboratory results will be plotted and reviewed. Properties of sediment at site and their transportation characteristics will be evaluated for their use in the study. The cause of erosion will be assessed. Velocity data at selected stations will be extracted from the numerical solution files for the existing and plan conditions. Velocity data will be plotted for comparison. Change in the current pattern caused by navigation improvement will be assessed. Effect of velocity change on sediment erosion will be assessed. A letter report will be submitted.

Scope (Part 1B): Assess whether the sediment impact will be marginal and if so, recommend deferment for taking mitigation measures. If the impact is adverse and severe, then recommend that taking mitigation measures is essential. Recommend mitigation measures to alleviate the adverse impact of the proposed project.

## Previous Study

The PBS&J Consultants have taken into account the following factors in their report. This is a comprehensive list, which includes all the relevant parameters.

1. Characteristics of local soil
2. Shoreline and wave conditions
3. Available shoreline protection measures in the vicinity of the project area
4. Feasibility for phase construction
5. Beneficial use of existing structures
6. Costs and time associated with the alternatives
7. Considerations of the future plans for channel modification
8. Aesthetic considerations for various shoreline uses
9. Environmental aspects
10. Evaluation of the need for additional survey, studies and/or data collection efforts is also evaluated.

## Historical Information

Dredging of a privately financed channel 25 feet deep and 75 feet wide from Sabine Pass to the mouth of Taylor Bayou was completed in March 1899. By this time the jetties had been built sufficiently to obtain a 25 –foot draft channel up to the Sabine Pass area. The Sabine-Neches Canal was constructed to the same dimensions as the Port Arthur Canal and completed in 1916. By 1922 it was deepened to 30 feet, and by 1935 the depth had been increased to 34 feet as far as Beaumont. By 1946 the depth was 36 feet, and by the early 1960's the dimensions had reached their present levels of 40 feet and 400 feet wide through the study area.

Both the Port Arthur Canal and the Sabine-Neches Canal were excavated through low elevation land near the Sabine Lake shore, effectively creating a strip of land that is now an island. A review of a 1917 navigation chart suggests that the approximate location of the existing PI shoreline is where the Sabine Lake shoreline was when the original excavation was made. At that time the island appeared to be about 300 to 500 feet wide. Over time, material taken from the canals for both enlargement and maintenance was placed on PI, building up the land elevation. At the same time the canal increased from 75 feet wide at the toe and 200 feet at the surface to its present width of

400 feet at the toe and 700 to 1,000 feet at the surface. Essentially, all of the width increase occurred on the eastern side of the canal. With each channel width increase (and progressive erosion) the original virgin island with overlying hydraulic fill was removed and placed further to the east.

## Hydrologic Conditions

PI is located at the west side of Sabine Lake, south of the mouth of the Neches River. While most of the water in the Neches River flows directly into the Sabine Lake, a portion of the flow will go through Sabine-Neches Canal toward the Gulf of Mexico, especially during flooding events. This fresh water flow through the canal has some impact on salinity and current in the canal.

The sum of the flows in the three stations is the total Neches River flow entering Sabine Lake. The annual mean flows are 5,824, 894, and 490 cubic feet per second (cfs), respectively, totaling 7,208 cfs. The highest annual mean flow of 13,480, 2,248, and 1,167 cfs, respectively, totaling 16,895 cfs, is also reported for the three stations. However, there is no information indicating what portion of this flow is distributed through Sabine-Neches Canal.

## Geotechnical Conditions

Given that dredging the Sabine-Neches Canal created PI, soil on the surface of the island is dredged material. On the west side of the island where the original Sabine Lake shoreline was, the soil composition underneath the dredged material is most likely Beaumont Clay. Based on the Soil Survey by the Soil Conservation Service (1965), which has been renamed to Natural Resources Conservation Service (NRCS), typical Beaumont Clay has fine particles, with 55 to 75 percent less than 0.074 mm. The clay is considered to have poor shear strength, high compressibility, high plasticity, poor drainage, and very high shrink-swell potential. A more recent publication (National Cooperative Soil Survey, 1997) describes Beaumont Clay as a poorly drained, very slowly permeable soil formed in clayey sediments of the Pleistocene Age. Its taxonomic class is fine, smectitic, hyperthemic Chromic Dystraquerts. As for the dredged material, the NRCS (1965) classified the soil as Ma (Made Land) and described it as a mixture of clay loam, sand, and shells. No additional information is provided in the Soil Survey on Ma Soil due to its variability.

# Chapter 3.2: Vessel Effects

## Ship Effects at Bank line

The following ship effects are noticed at bank line.

- Long Period
  - –Draw down
  - –Surge
  - –Transverse Stern Wave
  - –Return Velocity

- Short Period
  - –Secondary Waves at Bow and Stern
  - –Surge Waves
  - –Propeller Jet (small at bank line)

## Vessel Traffic and Vessel Generated Surges

Bow and stern waves are generated when a vessel moves through water. The wave characteristics, such as height, period, and crest orientation, depend on the vessel speed and direction, water depth, vessel hull form and draft, and distance from the sailing line. The vessel speed is more important than vessel dimensions in determining the wave heights generated. In addition, when the vessel is traveling in a constricted waterway, water is displaced from bow to stern. This displacement of water is referred to as a return flow and is associated with a water-level depression as a vessel approaches a point in a channel commonly known as a drawdown. The drawdown creates a flow away from the shore as a vessel approaches. Subsequently water moves back up resulting in a surge toward the shore.

A large volume of literature is available on vessel-generated surges and waves. Correlation among vessel speeds, draft and channel bathymetry is also available. Field measurements at a location just upstream of the confluence with Taylor Bayou have indicated that vessel-generated surge of about 6 feet high can possibly occur. A study (Herbich, et al, 1982) near the southern end of the project shoreline has indicated that surge heights of 6 feet are possible in the canal.

Literature review provided the following observations.

1. Displacement effects causing drawdown, surge, transverse stern wave, return velocity.
2. Surge waves are the dominant bank loading in the channels
3. Surge waves result from drawdown effects in channels with shallow (3 to 6 feet-deep) berm.
4. Surge waves increase with shallow water depth over berm, increased ship speed, and increased drawdown

5. Ship speed for largest ships in Sabine navigation channel is generally less than 12 knots.
6. Secondary waves at bow and stern are not the dominant bank loading at these speeds.

## Vessel-Generated Waves

Maynord and Martin (1996) have reported numerous examples and references on field studies and model studies conducted in Europe and the USA related to vessel-generated waves. The following parameters are involved in erosion prediction: a) Vessel-Related: size of vessel (draft, length, beam width, and tonnage), speed of the vessel, hull shape. b) Channel-Related: size of channel (width, depth, and cross-sectional area), bank height, and shape of channel. c) Sediment-Related: type of sediment, erodibility. d) Wave-Related: wave height and period, time series of occurrence, time after passage of vessel, distance from the vessel. Hwang and Wang (1982) have reported work on wave kinematics and sediment suspension at the wave breaking point. Maa (1986) conducted a laboratory study on the erosion of soft mud by waves. Li (1996) has provided information on wave-mud interaction. All these studies take into account several parameters and are very complex in nature.

Bank erosion caused by vessel-generated waves can be estimated analytically, if field data on several parameters are available. Parchure et al, 2001a and 2001b have described the procedure.

Magnitudes of vessel-generated bed shear stresses are shown in Figure 3.2.1. It is seen that a 30-cm wave would generate bed shear stress of 0.35, 0.8 and 2.4 Pa in water depths of 1.5 m, 1.0 m, and 0.5 m respectively. A wave height of 30 cm is selected only as an illustration for reporting values of bed shear stresses for this wave height in different water depths. A 30-cm wave is not the highest potential wave height that would occur at Sabine Neches. The magnitude of vessel-induced wave height depends mainly upon three factors. a) Size of vessel (draft, length, beam width and tonnage, b) Vessel speed, and c) Hull shape. In the estuarine waterways ship speed is restricted by water depth, channel width, and channel configuration. Steve Maynord concluded that speed of largest ship in Sabine would be generally less than 12 knots. At this speed, vessel-induced wave heights could be 5 feet or more in height. Such waves break as they travel into shallow water near the bank and reduce the height but they could cause severe erosion of unprotected banks.

## Erosion Potential

The width and depth of the existing navigation channel, the Sabine Neches Waterway (SNWW), would likely be increased for converting the present 40-foot project to 50-foot project. The increase in width and depth is expected to change the tidal conditions along the entire length of the navigation channel, including the Pleasure Island reach. Hence it was considered necessary to study the impact of the proposed modifications on the erosion of Pleasure Island shoreline.

Erosion of riverbanks is a matter of concern for engineering and environmental reasons. Currents, waves, and wind are the natural factors that cause erosion. Waves may be either wind-generated or vessel-generated. Among several dominant mechanisms of riverbank erosion identified in the literature (Maynord and Martin, 1996), navigation effects caused by the passage of vessels are quite important. The components of navigation effects causing sediment resuspension are a) vessel-induced waves, b) drawdown, c) vessel-generated currents, and d) propeller wash. An illustration of vessel-induced wave train is shown in Figure 3.2.2. These waves have a short wave period of 2 to 4 seconds and the total event may last over about 5 minutes or less. Vessels may be large in size, such as ships and barges or they may be small in size such as recreation vessels. Large vessels travel at low speed in deep water away from bank whereas small crafts travel at high speed in shallow water close to the bank. A comparison of field data on maximum wave height, drawdown, and suspended sediment concentration shows that large vessels generally create large drawdown and small wave heights, whereas small vessels may generate small drawdown and large wave heights. Both types of vessels may cause bank erosion and an increase in suspended-sediment concentration.

Camfield et al. (1979) reviewed literature on the possible impact of vessel wakes on bank erosion. Maynord and Martin (1996) have described navigation-related processes and provided numerous examples of bank erosion studies conducted in the world over the past several years. They found that modeling effort relating boating activity to bank erosion has not been adequately reported in published literature. The combined effect of both waves and current, which is more complex than their individual effect, needs to be taken into account in estimating sediment resuspension. Wikramanayake and Madsen (1994) have suggested a method of calculating suspended-sediment transport by combined wave-current flows, however it is applicable only for non-cohesive sediments.

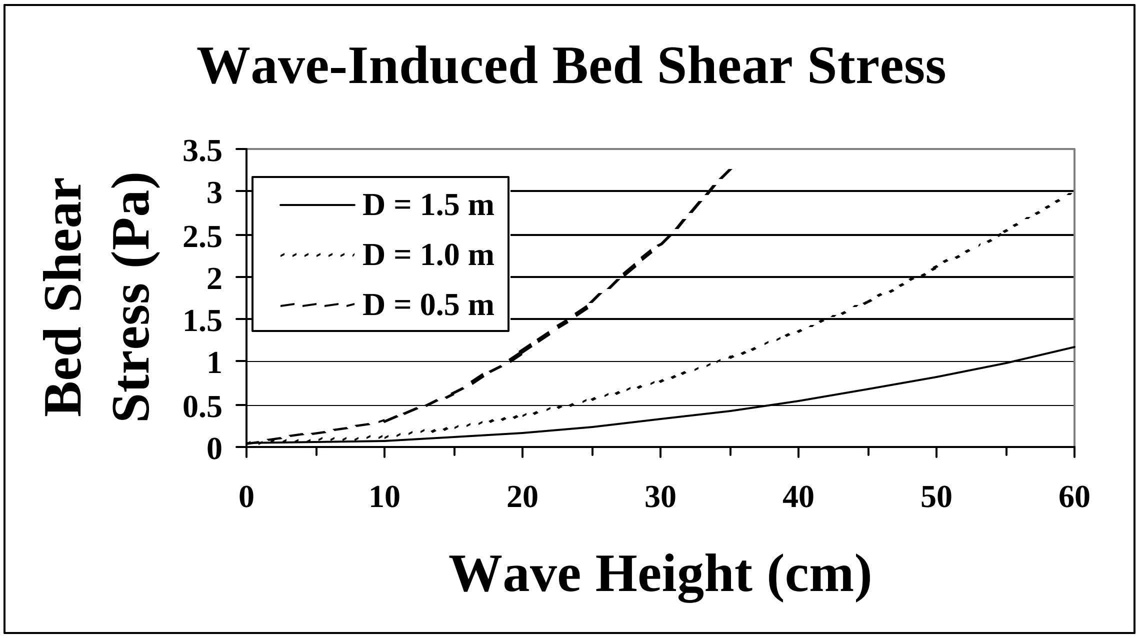


Figure 3.2.1: Wave-induced bed shear stresses under varying wave heights at 0.5, 1.0, and 1.5 meter water depth. (1 Pa is equal to 0.0209 pounds per square foot.)

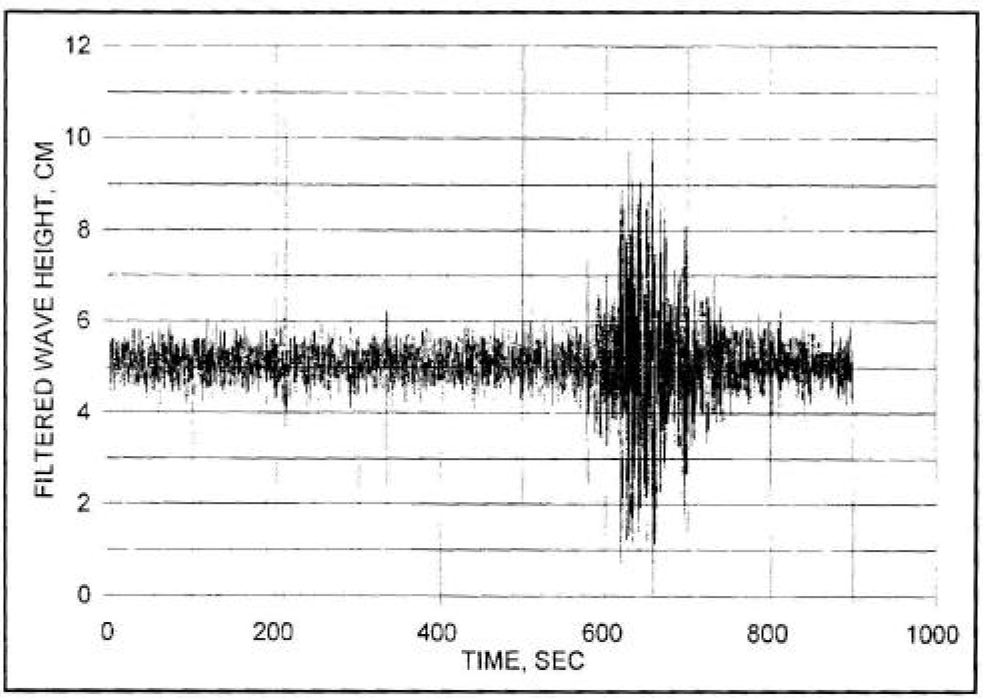


Figure 3.2.2: Illustration of vessel-induced waves

# Chapter 3.3: Numerical Model Results

## Velocity Data

Velocity magnitudes were extracted at 30 selected nodes of the numerical model. First of all, Nodes at all of the 19 bed sample locations were selected. Then more nodes were selected in the areas where the spacing between consecutive nodes was large. The actual node numbers were assigned new numbers for convenience of reference as shown in Table 3.3.1. Al the nodes are located close to the water line along the eroding bank. Superposed velocity magnitudes for base and plan condition for the Flood Test are given in Appendix E. Superposed velocity magnitudes for base and plan condition for the Ebb Test are given in Appendix E.

The peak velocities at different locations for the Flood Test vary from about 1 ft/s to about 2 ft/s for the existing conditions. After channel modifications, the peak velocities remain about the same at some locations. However, they generally show an increase in magnitude, the variation in the peak values often exceeding 1.5 feet. The incremental rise in peak values of velocity is on the order of 0.5 ft/s.

The peak velocities at different locations for the Ebb Test are generally higher than the corresponding Flood values. They vary from about 2 ft/s to about 3 ft/s for the existing conditions. After channel modifications, the peak velocities remain about the same at some locations. However, they generally show an increase in magnitude on the order of 0.5 ft/s.

## Effect of Currents

Numerical model study was conducted using two tidal patterns named as the flood and ebb test conditions. The velocities obtained on the model show patterns with alternate short and tall peaks in velocity magnitudes. Several locations were selected along the Pleasure Island shoreline for extracting velocity data from the numerical model. These are given in Tables 3.3.2 and 3.3.3 respectively for the “flood” and “ebb” test conditions. The magnitudes for base condition have been compared to the values for plan condition. Magnitudes for short peaks showed an increase of 5 to 50 percent from base to plan but they had magnitudes ranging mostly from 1 to 2 feet per second. Magnitudes for tall peaks showed both increase and decrease with magnitudes ranging from 2 to 3 feet per second. Erosion would occur at sustained as well as peak velocities if the flow-induced bed shear stress is greater than the bed shear strength.

Current induces bed shear stress causing erosion. The magnitude of current-induced bed shear stress is a function of water depth and current magnitude. It is estimated that current strength of 1, 2 and 3 feet per second would induce bed shear stress of 0.04, 0.18 and 0.4 Pa in water depth of 0.5 m. The magnitudes in 1 m depth will be 0.036, 0.14 and 0.32 Pa. The magnitudes in 1.5 m depth will be 0.032, 0.126 and 0.28 Pa. It is seen that the magnitudes of current-induced bed shear stress are significantly smaller than those induced by vessel-generated waves. Hence vessel-induced waves are more significant in the context of erosion of Pleasure Island shoreline.

**Table 3.3.1: Actual Node Numbers and Assigned Node Numbers for Pleasure Island**

| Assigned Node # | Actual Node # |
|---|---|
| P1 | 8229 |
| P2 | 8379 |
| P3 | 8431 |
| P4 | 8869 |
| P5 | 9322 |
| | |
| ***P51*** | ***9460*** |
| ***P52*** | ***9527*** |
| ***P53*** | ***9608*** |
| ***P54*** | ***9688*** |
| | |
| P6 | 9731 |
| P7 | 9805 |
| P8 | 10309 |
| | |
| ***P81*** | ***10475*** |
| | |
| P9 | 10902 |
| P10 | 11014 |
| | |
| P101 | 11071 |
| P102 | 11505 |
| P103 | 11633 |
| P104 | 12204 |
| P105 | 12642 |
| P106 | 12697 |
| | |
| P11 | 12924 |
| P12 | 13770 |
| P13 | 14068 |
| P14 | 14152 |
| P15 | 14278 |
| P16 | 14362 |
| P17 | 14440 |
| P18 | 14557 |
| P19 | 14620 |
| | |

**Table 3.3.2: "Flood" Velocities along Pleasure Island Shoreline**
**Comparison of Peak Velocities**

| | Base Flood | Plan Flood | % Change | B Flood | Plan Flood | % Change |
|---|---|---|---|---|---|---|
| | Short | Short | | Tall | Tall | |
| P 1 | 1.16 | 1.22 | 5.2 | 2.36 | 2.14 | -9.3 |
| | | | | | | |
| P 2 | 1.16 | 1.28 | 10.3 | 1.96 | 1.75 | -10.7 |
| | | | | | | |
| P 3 | 1.19 | 1.20 | 0.8 | 2.31 | 2.07 | -10.4 |
| | | | | | | |
| P 4 | 1.19 | 1.40 | 17.6 | 2.13 | 2.08 | -2.3 |
| | | | | | | |
| P 5 | 1.10 | 1.38 | 25.4 | 1.83 | 1.86 | 1.6 |
| | | | | | | |
| P 51 | 1.03 | 1.27 | 23.3 | 1.82 | 2.19 | 20.3 |
| | | | | | | |
| P 52 | 1.10 | 1.46 | 32.7 | 2.05 | 2.38 | 16.1 |
| | | | | | | |
| P 53 | 1.11 | 1.24 | 11.7 | 2.00 | 2.10 | 5.0 |
| | | | | | | |
| P 54 | 1.11 | 1.24 | 11.7 | 1.85 | 1.99 | 7.5 |
| | | | | | | |
| P 56 | 1.33 | 1.43 | 7.5 | 2.51 | 2.33 | -7.1 |
| | | | | | | |
| P 7 | 1.22 | 1.64 | 34.4 | 2.06 | 2.27 | 10.2 |
| | | | | | | |
| P 8 | 0.93 | 1.40 | 50.5 | 1.68 | 1.90 | 13.1 |
| | | | | | | |
| P 81 | 1.28 | 1.99 | 55.5 | 1.86 | 2.59 | 39.2 |
| | | | | | | |
| P 9 | 1.19 | 1.88 | 58.0 | 2.15 | 2.96 | 37.7 |
| | | | | | | |
| P 10 | 1.05 | 1.42 | 35.2 | 2.03 | 1.97 | -2.9 |
| | | | | | | |
| P 101 | 1.55 | 2.25 | 45.1 | 2.80 | 3.10 | 10.7 |
| | | | | | | |
| P 102 | 1.21 | 1.86 | 53.7 | 2.13 | 2.45 | 15.0 |
| | | | | | | |
| P 103 | 0.71 | 1.65 | ------ | 1.08 | 1.93 | 78.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| P 104 | 1.46 | 2.27 | 55.5 | 2.20 | 3.00 | 36.4 |
| | | | | | | |
| P 105 | 1.37 | 2.08 | 51.2 | 2.07 | 2.69 | 30.0 |
| | | | | | | |
| P 106 | 1.19 | 1.81 | 52.1 | 1.94 | 2.62 | 35.0 |
| | | | | | | |
| P 11 | 1.29 | 1.98 | 53.5 | 1.88 | 2.47 | 31.4 |
| | | | | | | |
| P 12 | 1.06 | 1.37 | 1.29 | 1.52 | 1.81 | 19.0 |
| | | | | | | |
| P 13 | 0.93 | 1.24 | 33.3 | 1.48 | 1.73 | 16.9 |
| | | | | | | |
| P 14 | 0.84 | 1.13 | 34.5 | 1.38 | 1.65 | 19.5 |
| | | | | | | |
| P 15 | 1.11 | 1.54 | 38.7 | 1.97 | 2.37 | 20.3 |
| | | | | | | |
| P 16 | 1.33 | 1.68 | 26.3 | 2.19 | 2.28 | 4.1 |
| | | | | | | |
| P 17 | 1.30 | 1.73 | 33.0 | 1.97 | 2.19 | 11.1 |
| | | | | | | |
| P 18 | 1.14 | 1.61 | 41.2 | 1.92 | 2.41 | 25.5 |
| | | | | | | |
| P 19 | 0.80 | 1.10 | 37.5 | 1.49 | 1.88 | 26.1 |
| | | | | | | |

**Table 3.3.3: "Ebb" Velocities along Pleasure Island Sho reline**
**Comparison of Peak Velocities**

| | Base Ebb | Plan Ebb | % Change | Base Ebb | Plan Ebb | % Change |
|---|---|---|---|---|---|---|
| | Short | Short | | Tall | Tall | |
| P 1 | 1.29 | 1.37 | 6.2 | 3.03 | 2.73 | -10.0 |
| | | | | | | |
| P 2 | 1.24 | 1.41 | 13.7 | 2.47 | 2.21 | -10.5 |
| | | | | | | |
| P 3 | 1.32 | 1.37 | 3.8 | 2.95 | 2.64 | -10.5 |
| | | | | | | |
| P 4 | 1.26 | 1.52 | 20.6 | 2.69 | 2.64 | -1.8 |
| | | | | | | |
| P 5 | 1.08 | 1.48 | 37.0 | 2.43 | 2.39 | -1.6 |
| | | | | | | |
| P 51 | 1.06 | 1.39 | 31.1 | 2.40 | 2.85 | 18.7 |
| | | | | | | |
| P 52 | 1.12 | 1.60 | 42.8 | 2.72 | 3.08 | 13.2 |
| | | | | | | |
| P 53 | 1.16 | 1.37 | 18.1 | 2.66 | 2.71 | 1.9 |
| | | | | | | |
| P 54 | 0.96 | 1.36 | 41.7 | 2.54 | 2.56 | 0.8 |
| | | | | | | |
| P 56 | 1.44 | 1.58 | 9.7 | 3.30 | 3.03 | -8.1 |
| | | | | | | |
| P 7 | 1.27 | 1.76 | 38.5 | 2.68 | 2.94 | 9.7 |
| | | | | | | |
| P 8 | 0.98 | 1.51 | 54.0 | 2.18 | 2.45 | 12.4 |
| | | | | | | |
| P 81 | 1.32 | 2.14 | 62.1 | 2.44 | 3.41 | 39.7 |
| | | | | | | |
| P 9 | 1.23 | 2.05 | 66.7 | 2.83 | 3.90 | 37.8 |
| | | | | | | |
| P 10 | 1.12 | 1.53 | 36.6 | 2.70 | 2.59 | -4.0 |
| | | | | | | |
| P 101 | 1.58 | 2.38 | 50.6 | 3.70 | 4.12 | 11.3 |
| | | | | | | |
| P 102 | 1.27 | 1.99 | 56.7 | 2.77 | 3.19 | 15.1 |
| | | | | | | |
| P 103 | 0.73 | 1.76 | 41.0 | 1.41 | 2.54 | 80.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| P 104 | 1.50 | 2.44 | 62.7 | 2.87 | 3.94 | 37.3 |
| P 105 | 1.40 | 2.24 | 60.0 | 2.72 | 3.53 | 29.8 |
| P 106 | 1.24 | 1.98 | 59.7 | 2.55 | 3.44 | 34.9 |
| P 11 | 1.31 | 2.12 | 61.8 | 2.45 | 3.22 | 31.4 |
| P 12 | 1.10 | 1.50 | 36.4 | 2.00 | 2.36 | 18.0 |
| P 13 | 0.99 | 1.35 | 36.4 | 1.95 | 2.25 | 15.4 |
| P 14 | 0.89 | 1.24 | 39.3 | 1.82 | 2.15 | 18.1 |
| P 15 | 1.16 | 1.68 | 44.8 | 2.60 | 3.11 | 19.6 |
| P 16 | 1.38 | 1.82 | 31.9 | 2.87 | 3.01 | 4.9 |
| P 17 | 1.34 | 1.86 | 38.8 | 2.57 | 2.87 | 11.7 |
| P 18 | 1.20 | 1.77 | 47.5 | 2.53 | 3.15 | 24.5 |
| P 19 | 0.85 | 1.22 | 43.5 | 1.95 | 2.45 | 25.6 |

# Chapter 3.4: Sediment Data and Photographs

## Sediment Data

Bed samples were collected along the west shoreline of Pleasure Island at 19 locations. The locations are shown in Figures 3.4.1 through 3.4.4. Their locations corresponding to the node numbers of numerical model are listed in Table 3.4.1. Two samples were collected at each location. One was just above the water line (T) and the other was below the water line (B) in about 3 feet depth. The bed samples were analyzed in laboratory for the sand and silt split, particle size distribution for the fraction coarser than 64 microns and for the total organic contents. The results are given in Table 3.4.2. The particle size distribution curves are given in Appendix G.

It is noticed that the sediment contained a substantial fraction with less than 64-micron size particles. This sediment is easily erodible under the current and wave climate prevailing along the west shoreline of Pleasure Island.

## Beach Profiles

Cross-sections of navigation channel were examined for the beach slopes in the vicinity of Pleasure Island. Figure 3.4.5 provides an illustration of cross sections of navigation channel in Port Arthur canal. Figure 3.4.6 provides an illustration of cross sections of navigation channel in Sabine Neches canal. The right bank of these sections represents the shoreline of Pleasure Island. Bank slopes were measured for three zones of each section, namely above water level (0 to +10 feet elevation), and below water level (0 to –10 feet and –10 to –20 feet elevation). Tables 3.4.3 and 3.4.4 provide slopes for these three zones at various locations in the Port Arthur Canal and Sabine Neches Canal respectively. It is seen that the slopes in the Port Arthur Canal area in zones above and below water level are mild varying from 1 in 7 to 1 in 56. Corresponding slopes in the Sabine Neches Canal are mostly steeper in many locations varying from 1 in 2 to 1 in 10. Slopes in deeper water from –10 to –20 feet are relatively steeper than the slopes in the other two slope areas for both the canals.

## Photographs

Photographs of the SNWW project shorelines are given in Appendix H. All of them are not taken at the Pleasure Island, however they offer a graphic description of the general bank erosion problem. The photographs are presented in the following groups:

Appendix H-A: Sequence of Photographs showing propagation of transverse stern waves generated by passage of ship

Appendix H-B: Photographs showing vessel-generated waves attacking the shore

Appendix H-C: Photographs showing bank protection measures adopted at Sabine

**Table 3.4.1: Bed sample locations along Pleasure Island and corresponding Node Numbers**

| Bed Sample # | Node # |
|---|---|
| P1 | 8229 |
| P2 | 8379 |
| P3 | 8431 |
| P4 | 8869 |
| P5 | 9322 |
| P6 | 9731 |
| P7 | 9805 |
| P8 | 10309 |
| P9 | 10902 |
| P10 | 11014 |
| P11 | 12924 |
| P12 | 13770 |
| P13 | 14068 |
| P14 | 14152 |
| P15 | 14278 |
| P16 | 14362 |
| P17 | 14440 |
| P18 | 14557 |
| P19 | 14620 |

## Table 3.4.2: Results of bed sediment samples along Pleasure Island

| Original Sample # | New Sample # | % Sand | % Silt/Clay | % Moisture Content | % Organic Content |
|---|---|---|---|---|---|
| P36T | P1T | 29.23 | 70.77 | 0.37 | 3.03 |
| P37B | P1B | 76.64 | 23.36 | 0.35 | 1.79 |
| P38T | P2T | 7.66 | 92.34 | 0.44 | 3.8 |
| P39B | P2B | 3.82 | 96.18 | 0.64 | 4.2 |
| P40T | P3T | 2.79 | 97.21 | 0.45 | 3.61 |
| P41B | P3B | 4.04 | 95.96 | 0.60 | 5.18 |
| P42T | P4T | 0.45 | 99.55 | 0.57 | 6.7 |
| P43B | P4B | 6.21 | 93.79 | 0.40 | 4.92 |
| P44T | P5T | 12.78 | 87.22 | 0.62 | 6.1 |
| P45B | P5B | 28.17 | 71.83 | 0.47 | 5.8 |
| P46T | P6T | 7.32 | 92.68 | 0.47 | 4.82 |
| P47B | P6B | 21.82 | 78.18 | 0.55 | 4.24 |
| P48B | P7B | 25.79 | 74.21 | 0.46 | 3.77 |
| P49T | P7T | 4.37 | 95.63 | 0.55 | 5.6 |
| P60T | P8T | 4.55 | 95.45 | 0.46 | 21.92 |
| P61B | P8B | 0.66 | 99.34 | 0.65 | 5.75 |
| P62B | P9B | 52.28 | 47.72 | 0.43 | 3.19 |
| P63T | P9T | 0 | 100.00 | 0.60 | 6.44 |
| P64T | P10T | 0.06 | 99.94 | 0.55 | 5.65 |
| P65B | P10B | 18.89 | 81.11 | 0.44 | 4.13 |
| P66T | P11T | 12.58 | 87.42 | 0.37 | 3.46 |
| P67B | P11B | 0.44 | 99.56 | 0.36 | 2.45 |
| P68T | P12T | 13.79 | 86.21 | 0.25 | 2.2 |
| P69B | P12B | 49.07 | 50.93 | 0.34 | 1.64 |
| P70T | P13T | 60.68 | 39.32 | 0.42 | 5.27 |
| P71B | P13B | 60.07 | 39.93 | 0.38 | 2.07 |
| P72B | P14B | 5.17 | 94.83 | 0.32 | 1.89 |
| P73T | P14T | 5.24 | 94.76 | 0.34 | 3.80 |
| P74B | P15B | 38.70 | 61.30 | 0.37 | 3.46 |
| P75T | P15T | 4.07 | 95.93 | 0.39 | 4.55 |
| P76B | P16B | 80.29 | 19.71 | 0.29 | 1.29 |
| P77T | P16T | 1.56 | 98.44 | 0.46 | 5.00 |
| P78T | P17T | 32.82 | 67.18 | 0.39 | 3.66 |
| P79B | P17B | 24.31 | 75.69 | 0.57 | 4.00 |
| P80B | P18B | 15.72 | 84.28 | 0.43 | 3.50 |
| P81T | P18T | 25.11 | 74.89 | 0.43 | 4.02 |
| P82B | P19B | 5.91 | 94.09 | 0.37 | 2.23 |
| P83T | P19T | 3.05 | 96.95 | 0.41 | 5.63 |

### Table 3.4.3: Port Arthur Canal Right Bank Slopes (Pleasure Island)

| Section at | Bank Slope 0 to +10’ | Bank Slope 0 to –10’ | Bank Slope -10’ to - 40’ |
|---|---|---|---|
| 10 + 00 | 1 : 40 | 1 : 07 | 1 : 2.5 |
| 30 + 00 | 1 : 15 | 1 : 12 | 1 : 4.0 |
| 70 + 00 | 1 : 08 | 1 : 50 | 1 : 3.3 |
| 90 + 00 | 1 : 20 | 1 : 33 | 1 : 3.3 |
| 110 + 00 | 1 : 25 | ----- | 1 : 4.0 |
| 130 + 00 | 1 : 12 | 1 : 20 | 1 : 3.0 |
| 140 + 00 | 1 : 05 | 1 : 40 | 1 : 3.0 |
| 150 + 00 | 1 : 14 | 1 : 56 | 1 : 3.0 |
| 180 + 00 | 1 : 10 | 1 : 25 | 1 : 4.0 |
| 210 + 00 | 1 : 10 | 1 : 30 | 1 : 2.3 |
| 230 + 00 | 1 : 08 | 1 : 25 | 1 : 3.0 |
| 250 + 00 | 1 : 10 | 1 : 25 | 1 : 3.3 |
| 270 + 00 | 1 : 40 | ------ | 1 : 3.0 |
| 284 +44 | 1 : 20 | ------ | 1 : 2.5 |
| 299 + 60 | 1 : 15 | ------ | 1 : 3.3 |
| 308 + 84 | ------ | ------- | ------ |
| 325 + 41 | ------ | ------- | ------ |

### Table 3.4.4: Sabine Neches Canal Right Bank Slopes (Pleasure Island)

| Section at | Bank Slope 0 to +10’ | Bank Slope 0 to –10’ | Bank Slope -10’ to - 40’ |
|---|---|---|---|
| 18 + 93 | 1 : 10 | 1 : 13 | 1 : 6.0 |
| 38 + 69 | 1 : 3.5 | 1 : 40 | 1 : 7.0 |
| 58 + 58 | 1 : 8 | 1 : 48 | 1 : 6.0 |
| 78 + 73 | 1 : 5 | 1 : 37 | 1 : 7.0 |
| 104 + 64 | 1 : 2 | 1 : 15 | 1 : 5.0 |
| 118 + 96 | 1 : 15 | ---- | 1 : 2.8 |
| 138 + 72 | 1 : 3 | 1 : 5 | 1 : 4.3 |
| 158 + 55 | 1 :10 | 1 : 2 | 1 : 2.0 |
| 172 + 89 | 1 : 3 | 1 : 8 | 1 : 7.0 |
| 189 + 44 | 1 : 4 | 1 : 4 | 1 : 4.0 |
| 198 + 86 | 1 : 6 | 1 : 5 | 1 : 3.0 |
| 213 + 72 | 1 : 32 | 1 : 3 | 1 : 3.0 |

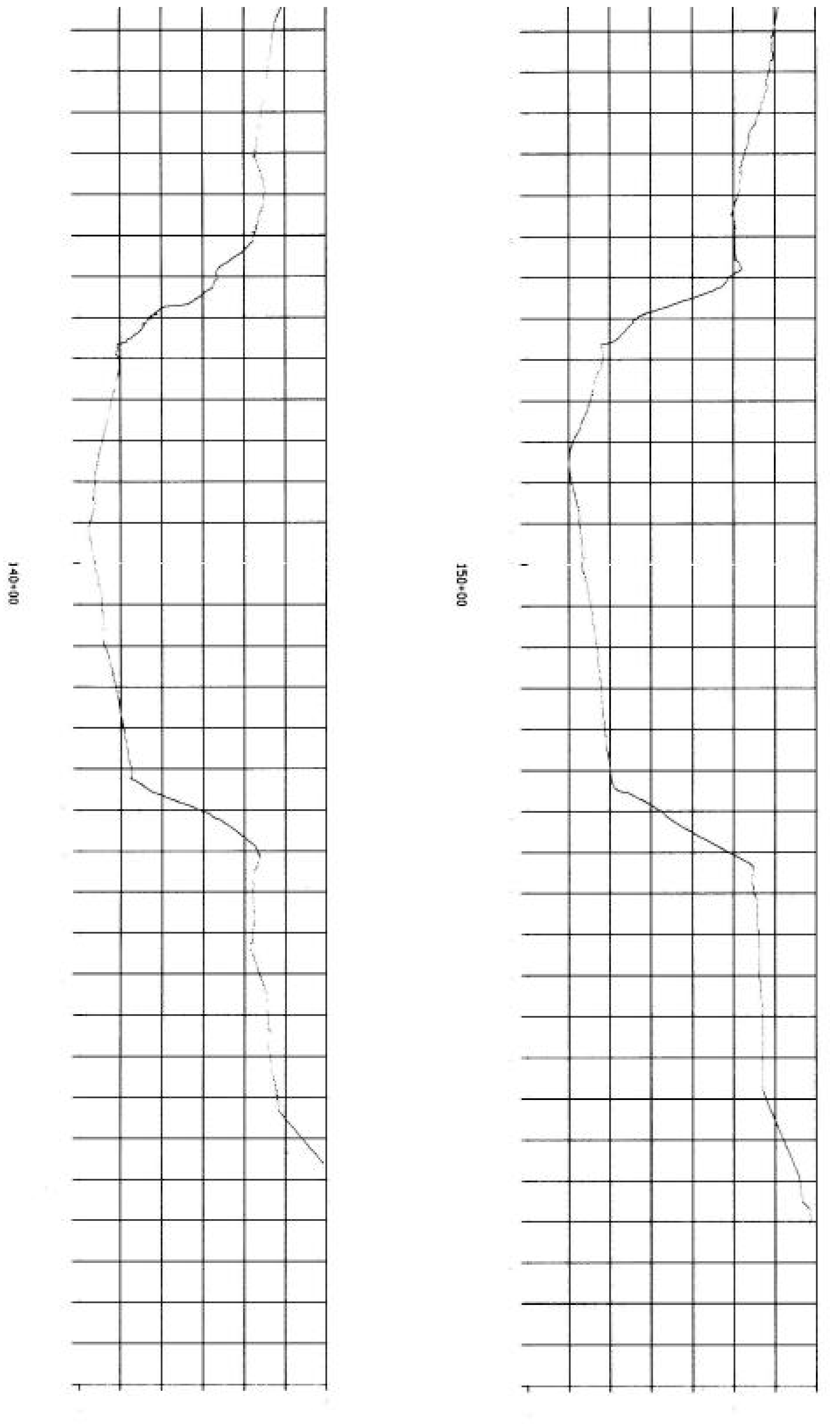


Figure 3.4.5: Port Arthur Canal Cross-Sections

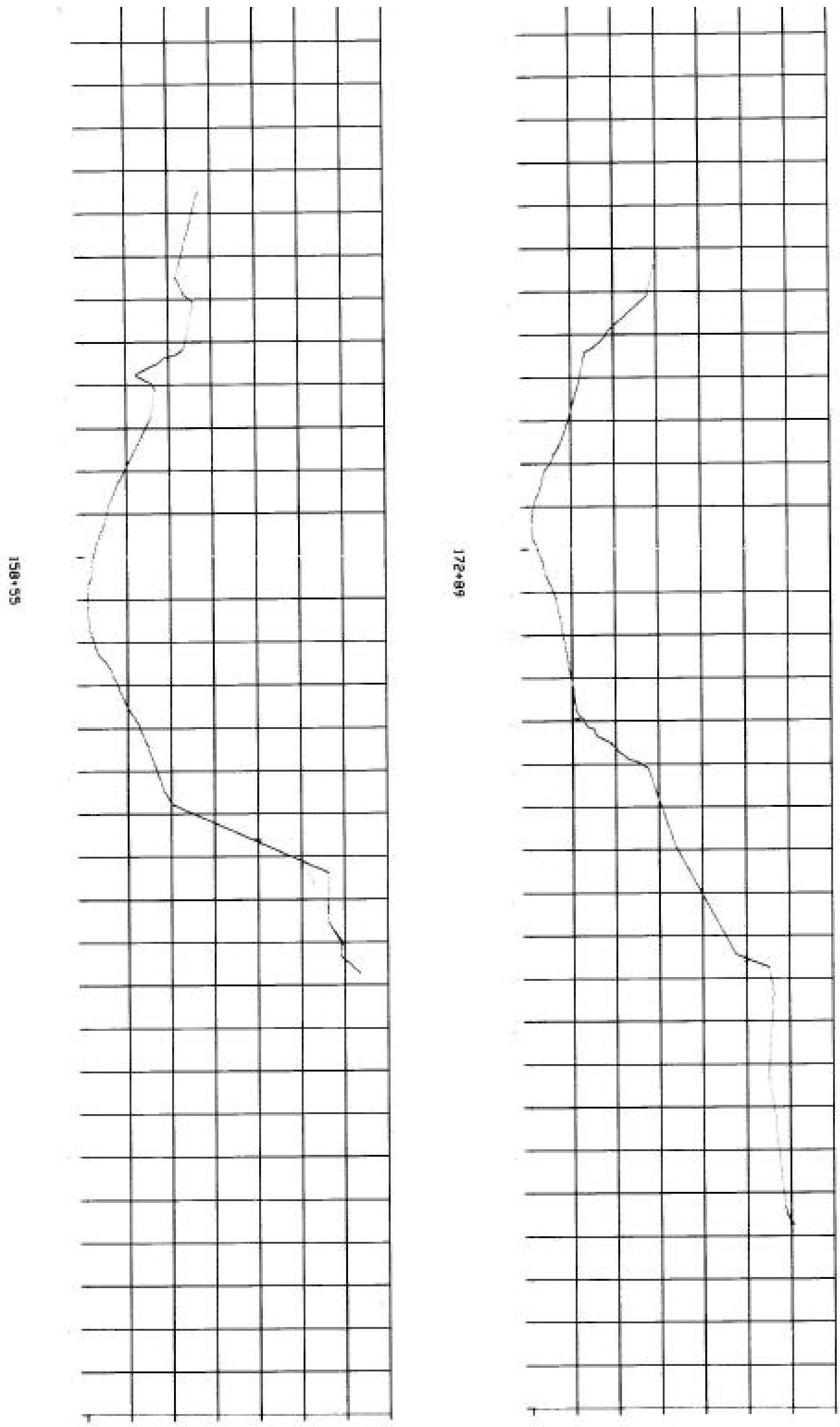


Figure 3.4.6: Sabine Neches Canal Cross-Sections

# Chapter 3.5: Erosion Evaluation

## Present Erosion Condition

The primary reasons for sever erosion along portions of the Pleasure Island shoreline are a) land composed of highly erodible unconsolidated silts and clays and b) vessel wakes and surges. This is a purely man-made environment with neither the soils nor the waves of natural origin. Controlling the erosion will require a similar degree of human intervention.

The island consists of easily erodible hydraulic fill placed on native stiff clay soils that exist at approximate sea level. As water moves in and out of the fill material in response to waves, fine particles are suspended and carried out if not constrained in some fashion. The water movement includes the normal astronomical, wind waves, waves from all types of passing vessels, and surges from larger passing vessels. In view of the highly erodible nature of the soil on the island, the shoreline would continue to erode from tidal currents and wind wave action alone. Vessel-generated waves and surges would accelerate the process.

## Existing Shoreline Protection

It appears that clay soils exist near sea level on Pleasure Island and that all the soils above sea level are hydraulic fill from excavation of the Sabine-Neches Canal. Most of the lower soil layers appear to contain clay balls. These are chunks of relatively stiff clay removed in dredging that are typically 1 to 2 inches in diameter. When discharged from a dredge pipe, these settle and become compacted to some degree, forming a soil that can serve many functions. Most of the structures on the island are built on such materials. However, when exposed to moving water the unconsolidated fine silts and clays surrounding the clay balls can be washed out easily. Where there is no protection, water attacks the base of the shoreline and the overlying material falls into the canal, forming an erosion scarf or cut bank that is typical of much of the present shoreline.

In 1994 and 1995, the City of Port Arthur and the PI Commission installed erosion controls using concrete slabs cut out of the MLK Bridge. These were placed over filter fabric along the shoreline. In the process of removing the slabs from the bridge, holes were cut in the concrete sections to allow lifting. In portions of the shoreline work, these slab sections were installed in a double layer, with the top layer offset from the bottom so the holes would be covered. In other places, a single layer of slab was placed.

Where concrete slabs have protected the filter fabric, the erosion has somewhat slowed. However, in places, the filter fabric has developed gaps where water pipes in and out strongly when vessels produce large drawdown and surge. Over time many of these slabs have been undermined and left in the water as the shoreline has migrated to the east.

There are some examples of effective erosion protection in the project area. One is the granite blocks placed along the shore at the Corps and USCG office locations. These close-fitting granite blocks are placed over smaller stones that are in turn placed over fine sand after the shore was shaped. The bottom course of these granite blocks is placed on the natural stiff clay, and the toe of the slope is protected from scour by additional riprap. These were installed following a standard Corps design in the 1970's and have held up very well.

Another example of effective protection is the sheet piling placed as part of the same location. These have served for almost 40 years, and except for some degree of corrosion, they are still serving their intended purpose today.

A third example of effective erosion protection is some of the concrete slabs placed over filter fabric in 1994-95.

Sections that appear to have functioned reasonably well include several key elements such as 1. Filter fabric was installed all the way down to the virgin clay, 2. A double layer of concrete slab was overlapped at the joints, 3. The slabs were extended up the slope to a sufficient height, and 4. Stones were used to protect the toe of the slopes.

Many shore protection measures have been provided over short lengths along the shoreline of SNWW. They include rubble and woven mattresses of concrete bricks. These were placed on filter fabric, however their failures are seen at many places for various reasons. Photographs of shore erosion are given in Appendix H.

## Current-induced Bank Erosion

The numerical model showed that the current velocities in the vicinity of the Pleasure Island shore line for both flood and ebb conditions are high. The peak magnitudes are on the order of 1.5 to 2 ft/s. These velocities increase by about 0.5 ft/s after navigation channel modifications. The sediment prevailing along the west shoreline of Pleasure Island is easily erodible under these current strengths.

Critical shear stress for erosion of non-cohesive sediments decreases with particle size. Critical shear stress values are given below.

| Particle size | | Shear Stress | Shear Stress |
|---|---|---|---|
| (micron) | (mm) | ($lb/ft^2$) | (Pa) |
| 2000 | 2.0 | 0.03 | 1.43 |
| 1000 | 1.0 | 0.012 | 0.57 |
| 100 | 0.1 | 0.004 | 0.19 |

Silt consists of particles smaller than 64 microns. Clays and organic substances provide binding of particles, which increases the shear strength of sediment mixtures. Laboratory tests showed that the nearshore sediment consisting of 90 percent particles with clays and silt, and 4 percent organic matter had critical shear strength of about 0.4

Pa, and the rate of erosion was low.

## Vessel-induced Bank Erosion

After navigation channel modification, the size of vessels and their frequency will increase. This will lead to greater bank erosion.

# Chapter 3.6: Concluding Remarks

1. In view of the highly erodible and weakly compacted soil on the Pleasure Island, the shoreline would likely continue to erode from tidal currents and wind waves. Vessel-generated waves and surges would continue to accelerate the process.

2. It is estimated that a 30-cm vessel-induced wave would generate bed shear stress of 0.35, 0.8 and 2.4 Pa in water depths of 1.5 m, 1.0 m, and 0.5 m respectively. The magnitudes of current-induced bed shear stress are significantly smaller than those induced by vessel-generated waves. Hence vessel-induced waves are more significant in the context of erosion of Pleasure Island shoreline.

3. The magnitude of tidal current varies continually with time. The present peak values near the shore are on the order of 1 to 2 ft/s. It may be noted that 1.This is only the peak value, 2. It is not observed at all the locations, 3) It is obtained for the select combination of tides, wind and river discharge conditions used for running the numerical model. The average sustained value of tidal current would be about around 1 ft/s. Intermittent bank erosion is expected to occur near the peak values of flow velocities.

4. Tidal pattern used for running numerical model under flood and ebb test conditions gave velocities with alternate short and tall peaks. The magnitudes for base condition have been compared to the values for plan condition. Magnitudes for short peaks showed an increase of 5 to 50 percent from base to plan but they had magnitudes ranging from 1 to 2 feet per second. Magnitudes for tall peaks showed both increase and decrease with magnitudes ranging from 2 to 3 feet per second.

5. As a result of navigation channel modifications, the peak current velocity is expected to be higher by about 0.5 ft/s. Again the three factors mentioned in the above paragraph apply. The average sustained increase in magnitude in the tidal currents under plan over the base condition would be about 0.2 ft/s, which would probably result in less than 10 percent increase in the present bank erosion rate.

6. Since the fetch is limited for the constricted waterway, wind waves are relatively small in magnitude and may not be of concern related to bank erosion.

7. The erosion appears to be caused predominantly by surges, waves, and rapid drawdown resulting from vessel traffic within the constricted Sabine Neches waterway.

8. The characteristics of vessel-induced waves and surges and their effect on the bank depend on several factors, such as waterway geometry, bank slope, shoreline bathymetry, flow conditions, vessel characteristics (draft, tonnage, bow), vessel operating conditions (speed), and the volume of vessel traffic.

9. Beach slopes above and below water line are relatively mild and hence would be mostly stable. However, there are regions where the wave attack has caused caving, leaving unstable, close to vertical profile cliffs.

10. Several types of bank protection measures have been adopted along the navigation channel shoreline. While a few measures have been successful, many others appear to have failed. At several locations that do not have structural protection, a bluff has formed due to erosion and severe setbacks of land have occurred. The main cause of failure appears to be inability of the measure to retain the unconsolidated soil underneath the revetments.

11. The following conceptual shoreline protection alternatives have been considered by the PBS&J Consultants. 1. Two-layer concrete slabs, 2. New revetments using either articulated concrete blocks or revetment mattress, and 3. Use of Gabions or geotubes to serve as a wave barrier. Detailed studies are needed for comparison of merits of these and other options.

12. Use of a filter layer (geotextile) under the armoring structures is often very effective. However, it is seen at site that such fabric has not been always effective, probably due to defective construction practices, tearing of fabric at places, lack of adequate anchoring to the bed to prevent uplifting of the mattress, toe failure and so on. Hence adequate care is needed in selecting, designing and using filter fabrics.

13. Data on historical and current aerial photographs, bathymetric and shoreline survey and values of geotechnical parameters for the shoreline sediment are needed for better evaluation of the present bank erosion, estimated future erosion and design of bank protection alternatives.

14. After navigation channel modification, the size of vessels and their frequency will increase. The factors on which data are needed for providing a quantitative estimate of the impact of vessel traffic under plan condition are listed under paragraphs 6 and 10 above. It is noted that 1) All these data are not currently available; 2) Predictions on future characteristics of vessel traffic are also not available. However, taking into account the site conditions, present vessel traffic and the available sediment data, it is estimated that the proposed plan is likely to result in about 10 percent increase in the present bank erosion rate.

## References

Camfield F., R. E. L. Ray, and J. W. Eckert, (1979), The possible impact of vessel wakes on bank erosion, Report CG-W-1-80, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hwang P. A., and H. Wang, (1982), Wave kinematics and sediment suspension at wave breaking point, Tech Report No. 13, Dept. of Civil Eng., University of Delaware, Newark, DL.

Li Yigong, (1996), "Sediment-associated constituent release at the mud-water interface due to monochromatic waves", Ph. D. Dissertation, Coastal and Oceanographic Engineering Department, University of Florida, Gainesville, FL.

Maa P. Y., (1986), Erosion of soft mud by waves, Ph. D. Dissertation, Coastal and Oceanographic Engineering Department, University of Florida, Gainesville, FL.

Maynord S. T. and S. Martin, (1996), Upper Mississippi river system navigation / sedimentation study, Report 1: Bank erosion literature study, Technical Report HL-96-10, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Parchure T. M., W. H. McAnally, Jr., A. M. Teeter, (2001a), Wave-induced sediment resuspension near the shorelines of Upper Mississippi River, Technical Report, prepared by U.S. Army Engineer Research and Development Center for U.S. Army Engineer Districts, Rock Island, St. Louis, and St. Paul. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Parchure T. M., W. H. McAnally, Jr., A. M. Teeter, (2001b), Desktop method for estimating vessel-induced sediment suspension, Journal of Hydraulic Engineering, ASCE, Vol. 127, No. 7, 577-587.

Wikramanayake P. N., and O. S. Madsen, (1994), "Calculation of suspended sediment transport by combined wave-current flows", Contract Report DRP-94-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

# Desktop Study for
# Sediment-Related Problems at
# Sabine Neches Project

# Part 4
# Sabine Lake Eastern Shore Erosion

# Chapter 4.1: Erosion Problem

## Problem Description

The Sabine Lake has an extensive shoreline on the east side, measuring about 21 miles (Figure 4.1.1). Since the centerline of Lake is the boundary between the Louisiana State and Texas State, the eastern shoreline of Lake belongs to Louisiana whereas the western shoreline belongs to Texas State. The Sabine River joins the Sabine Lake on the northeast side and discharges its entire water into the Sabine lake first. A part of this discharge may be entering the navigation channel after it flows past the mouth of Neches River. The Neches River joins on the northwest side of the Sabine Lake. A part of the fresh water from Neches River is discharged into the lake and the remaining flows through the deeper navigation channel. Freshwater inflows of 16,200 cfs and 18,600 cfs respectively at the Neches and Sabine River mouths represent the 90 percentile flow values for the two rivers, based on long-term statistics collected by the USGS. The distributions of discharges from both the rivers into the lake and into the navigation channel are not reliably known.

No historical information could be found in published literature on the natural processes taking place along the eastern shoreline of Sabine Lake. It is also not known whether the entire eastern shoreline is eroding or whether the bank erosion is restricted to several local places. It is however known through observations that the shoreline near the Willow Bayou mouth has been severely eroding. As a result of erosion, the original shoreline has probably shifted towards the Willow Bayou. It was noticed during field inspection conducted in April 2002 that a narrow strip of land, which may be on the order of only 30 to 50 feet wide separated the Willow Bayou and the Sabine Lake. Tall natural grass grown on this strip of land has not been able to arrest the erosion. Photographs of the area are given in Appendix H_F.

## Scope of Work

The Galveston District restricted the erosion problem investigation to be done at ERDC only to the area adjacent to the Willow Bayou mouth. The scope of work consisted of determining the impact of navigation channel modifications on the erosion of the eastern shoreline of Sabine Lake in the vicinity of Willow Bayou.

## Field Data

ERDC had pointed out that field data would be very useful for examining the problem, however since certain data were not readily and economically available, the need was fulfilled through other means as described below.

1. Historical data such as surveys and cross sections on bank erosion. These were not available. Available surveys were used.
2. Recent hydrographic survey in the vicinity of the study area. This was not available. The latest available survey was used.

3. Surface sediment samples.  No sediment data were collected earlier.  Bed samples were collected by ERDC in the study area and analyzed in laboratory.
4. Magnitudes and directions of currents in the vicinity of study area.  Field data were not available.  Hence these were obtained from the numerical model for the existing conditions and for the modified navigation channel conditions.
5. Details (size, speed, type, draft, etc.) and frequency of recreational and other vessels traveling in the vicinity.  These were not available, however it was learned that the vessel traffic in the vicinity of shoreline was negligible.

# Chapter 4.2: Field Data

## Bed Sediment Data

Surface bed sediment samples and water samples were collected at seven locations inside Willow Bayou and at ten locations outside the Bayou along Sabine Lake shorelines. Two samples were collected at each location; one above the local water line (denoted as top) and the other below the water line (denoted as bottom). The locations for the two sets of samples (denoted by W for Willow Bayou and S for Sabine Lake) are shown in Figures 4.2.1.

The bed samples were analyzed in CHL laboratory to determine particle size distribution. The plots of laboratory analysis results are given in Appendix I for the Willow Bayou samples. The percentage of sand, silt plus clay, and organic matter are given in Table 4.2.1. It is seen that there is no significant difference in the size gradation of samples below and above water at any of the locations. All the samples are finer than 200-micron size with 50 or more percent of sediment finer than 64 microns, indicating a high percent of silt and clay in all the samples.

Appendix J gives plots of laboratory analysis results for the Sabine Lake shoreline samples. The percentage of sand, silt plus clay, and organic matter are given in Table 4.2.2. It is seen that the bed samples collected above water are significantly coarser than the bed samples below water. All the bottom samples are finer than 200-micron size with 90 or more percent of sediment finer than 64 microns indicating predominance of silt and clay in all the samples. Bed samples above water were generally coarser than the samples below water.

The general conclusion of the bed sample analysis is that the shoreline in the vicinity of Willow Bayou contains predominantly silt and clay and it is easily erodible under low bed shear stresses, which may be induced by small-magnitude wind-generated currents or waves. If the erosion continues, the small strip of land separating the mouth of Willow Bayou and the Sabine Lake is likely to disappear, thus shifting the location of the Bayou mouth.

**Table 4.2.1: Results of sediment analysis for Willow Bayou samples**

| Sample # | % Sand | % Silt/Clay | % Organics |
|---|---|---|---|
| W1T | 46.33 | 53.67 | 11.78 |
| W1B | 58.36 | 41.64 | 2.66 |
| | | | |
| W2T | 2.56 | 97.44 | 19.21 |
| W2B | 0.00 | 100.00 | 8.25 |
| | | | |
| W3T | 26.94 | 73.06 | 9.29 |
| W3B | 4.46 | 95.54 | 5.94 |
| | | | |
| W4T | 22.52 | 77.48 | 14.92 |
| W4B | 0.43 | 99.57 | 7.46 |
| | | | |
| W5T | 1.92 | 98.08 | 21.15 |
| W5B | 0.00 | 100.00 | 20.96 |
| | | | |
| W6T | 43.03 | 56.97 | 9.47 |
| W6B | 47.36 | 52.64 | 9.47 |
| | | | |
| W7T | 2.37 | 97.63 | 16 |
| W7B | 22.79 | 77.21 | 10.58 |

Note: T and B denote bed sample collected above and below water line respectively at each location.

**Table 4.2.2: Results of sediment analysis for Sabine Lake samples**

| Sample # | % Sand | % Silt/Clay | % Organics |
|---|---|---|---|
| S1T | 42.57 | 57.43 | 4.25 |
| S1B | 14.29 | 85.71 | 15.65 |
| | | | |
| S2T | 67.74 | 32.26 | 3.72 |
| S2B | 1.02 | 98.98 | 15.83 |
| | | | |
| S3T | 56.58 | 43.42 | 4.75 |
| S3B | 10.05 | 89.95 | 9.62 |
| | | | |
| S4T | 54.98 | 45.02 | 5.18 |
| S4B | 0.37 | 99.63 | 9.49 |
| | | | |
| S5T | 30.26 | 69.74 | 7.31 |
| S5B | | | 12.92 |
| | | | |
| S6T | 4.19 | 95.81 | 27.96 |
| S6B | 0.00 | 100.00 | 17.33 |
| | | | |
| S7T | 7.93 | 92.07 | 19.24 |
| S7B | 0.48 | 99.52 | 27.07 |
| | | | |
| S8T | 41.87 | 58.13 | 10.95 |
| S8B | 0.00 | 100.00 | 10.9 |
| | | | |
| S9T | 67.36 | 32.64 | 8.93 |
| S9B | 3.69 | 96.31 | 4.25 |
| | | | |
| S10T | 61.95 | 38.05 | 9.48 |
| S10B | 3.35 | 96.65 | 9.28 |

Note: T and B denote bed sample collected above and below water line respectively at each location.

# Chapter 4.3: Numerical Model Results

## The Numerical Model

The entire Sabine Lake including its eastern shoreline was included in the numerical model developed at ERDC (Figure 4.3.1). Results of this model were used for examining the erosion problem. Details of the model are given in Chapter 1.4 of this report. Out of the large number of numerical model nodes, nine nodes relevant to the study area near Willow Bayou (WB3 through WB11) were selected for extracting velocity data from solution files of numerical model. List of these nodes is given in Table 4.3.1 and their locations are shown in Figure 4.3.2. In addition to these nine locations, three locations far away from the study area were selected. Locations WB1 and WB2 are at the southern part of the Sabine Lake whereas WB12 is at the northern part of the Lake near the mouth of Sabine River. WB1 is in the navigation channel near Mesquite Point and WB2 is at the center of the Mesquite Point Causeway.

## Numerical Model Results

Velocity data at the above selected nodes were extracted from the numerical model solution files for the existing (base) and for the improved navigation channel (plan) conditions. Velocity data at these nodes were plotted and superposed for comparison. Such superposed plots for the flood and ebb test condition (described under Chapter 1.4 of this report) are given in Appendix K and Appendix L respectively.

Change in the current pattern caused by navigation improvement can be assessed from the superposed velocity plots. At locations WB1 and WB2, near the Mesquite Point Causeway, a small increase in peak velocities for both flood and ebb test condition is noticed. At location WB12 near the mouth of Sabine River Mouth change in peak velocity magnitudes is negligible. At all the remaining locations, which are relevant to the Willow Bayou area, there is no significant or consistent change in velocities. Bank erosion magnitude is a direct function of bed shear and soil properties. Greater erosion occurs for increased velocities for the same soil conditions. Since there is no increase in velocity under plan condition over the base condition, it is concluded that proposed modifications in the navigation channel will not cause any increased erosion of Sabine Lake shoreline in the vicinity of Willow Bayou reach.

**Table 4.3.1: List of numerical model nodes used for Willow Bayou study**

| Original Number | New Number |
|---|---|
| 008080 | WB 1 |
| 008523 | WB 2 |
| 009846 | WB 3 |
| 010001 | WB 4 |
| 010005 | WB 5 |
| 010008 | WB 6 |
| 010011 | WB 7 |
| 010017 | WB 8 |
| 010020 | WB 9 |
| 010023 | WB 10 |
| 010150 | WB 11 |
| 015083 | WB 12 |

# Chapter 4.4: Erosion Evaluation

## Present Erosion Condition

Periodical hydrographic surveys and bank profiles measured normal to the shoreline provide the most reliable information on bank erosion. Such surveys were not available for the area along the eastern shoreline of Sabine. No historical information could be found in published literature on the natural processes taking place along the reach under study. It is not known whether the entire eastern shoreline is eroding or whether the bank erosion is restricted to several local places. It is however known through visual observations that the shoreline near the Willow Bayou mouth has been severely eroding. As a result of erosion, the original shoreline has probably shifted towards the Willow Bayou leaving a narrow strip of land, which may be on the order of only 30 to 50 feet wide separating the Willow Bayou and the Sabine Lake. Tall natural grass grown on this strip of land has not been able to arrest the erosion because the grass roots are not able to hold the soil firmly attached to them.

## Existing Shoreline Protection

As mentioned earlier in the report, historical information on the reach of shoreline in the vicinity of Willow Bayou area could not be obtained. However, site inspection did not indicate any signs of shore protection measures taken for the eroding shoreline. The shoreline itself is extremely poorly defined due to shallow water depths and changing lake levels.

## Bank Erosion Causes

In the simplistic terms, shore erosion results when the bed shear exceeds the erosion resistance of bank soil. Bed shear may result from various factors. The main factors exerting bed shear are currents, vessel-induced waves and wind-induced waves. The peak current magnitudes in the study area vary between 0.04 and 0.20 feet per second. The magnitude of sustained average current may be on the order of 0.06 feet per second, which is very small for causing severe erosion. Recreational boat traffic in this area is understood to be negligible. Hence the only cause for erosion appears to be wind-induced waves. Winds are known to be strong and consistent in this area. Sabine lake offers a large water surface area, which provides sufficient “fetch” length for wave generation. Due to shallow water depths, the waves will induce adequate shear stress to cause erosion. Waves breaking on the shore have greater energy to cause erosion. It is therefore believed that the shoreline erosion of the reach under study is caused by wind-induced local waves generated in the Sabine Lake.

## Chapter 4.5: Concluding Remarks

1. It is believed that the erosion of the shoreline in the vicinity of Willow Bayou reach is caused by wind-induced local waves generated in the Sabine Lake.

2. In the absence of any bank protection measures, erosion of the shoreline in the vicinity of Willow Bayou is expected to continue because no change in the natural forces causing erosion of this reach is foreseen.

3. The proposed modifications in the Sabine Neches navigation channel will not increase the existing rate of erosion of the Sabine Lake shoreline in the vicinity of Willow Bayou mouth.

4. Due to very ill-defined shoreline, it is difficult to take any economical measures to prevent further erosion.

# Desktop Study for Sediment-Related Problems at Sabine Neches Project

**VOLUME 2**
**APPENDICES**

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***October 2003***

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# Appendices

**Appendix A**: Particle size distribution curves for surface bed samples along SNWW Navigation Channel

**Appendix B**: Superposed velocity plots for flood and ebb for Base (existing) Conditions at SNWW Navigation Channel Locations

**Appendix C**: Superposed velocity plots for base and plan for Flood at locations Along SNWW Navigation Channel

**Appendix D**: Superposed velocity plots for base and plan for Ebb at locations Along SNWW Navigation Channel

**Appendix E**: Superposed velocity plots for base and plan for Flood at locations Along Pleasure Island west shoreline

**Appendix F**: Superposed velocity plots for base and plan for Ebb at locations Along Pleasure Island west shoreline

**Appendix G**: Particle size distribution curves for pleasure Island locations

**Appendix H**: Photographs

H_A: Propagation of transverse stern waves generated by passage of ship
H_B: Vessel-generated waves attacking the shore
H_C: Bank Erosion at Various Locations In Sabine Neches Project Area
H_D: Bank protection measures adopted at Sabine
H_E: Bank sediment at various locations
H_F: Eastern shoreline of Sabine Lake near Willow Bayou

**Appendix I**: Particle size distribution curves for Willow Bayou locations

**Appendix J**: Particle size distribution curves for Sabine Lake East shoreline locations

**Appendix K**: Superposed velocity plots for base and plan for Flood at locations along Willow Bayou shoreline

**Appendix L**: Superposed velocity plots for base and plan for Ebb at locations along Willow Bayou shoreline

# Appendix A

## Particle Size Distribution Curves for Surface Bed Samples at SNWW Navigation Channel Locations

List of Figures in Appendix A

## **Reach 1:** **Neches River Channel**



## **Reach 2:** **Sabine Neches Canal**

## Reach 3: Port Arthur Canal


## Reach 4: Sabine Pass Channel


## Reach 5: The Sabine Pass Jetty Channel


## Reach 6: Sabine Pass Outer Bar Channel


## Reach 7: Sabine Bank Channel

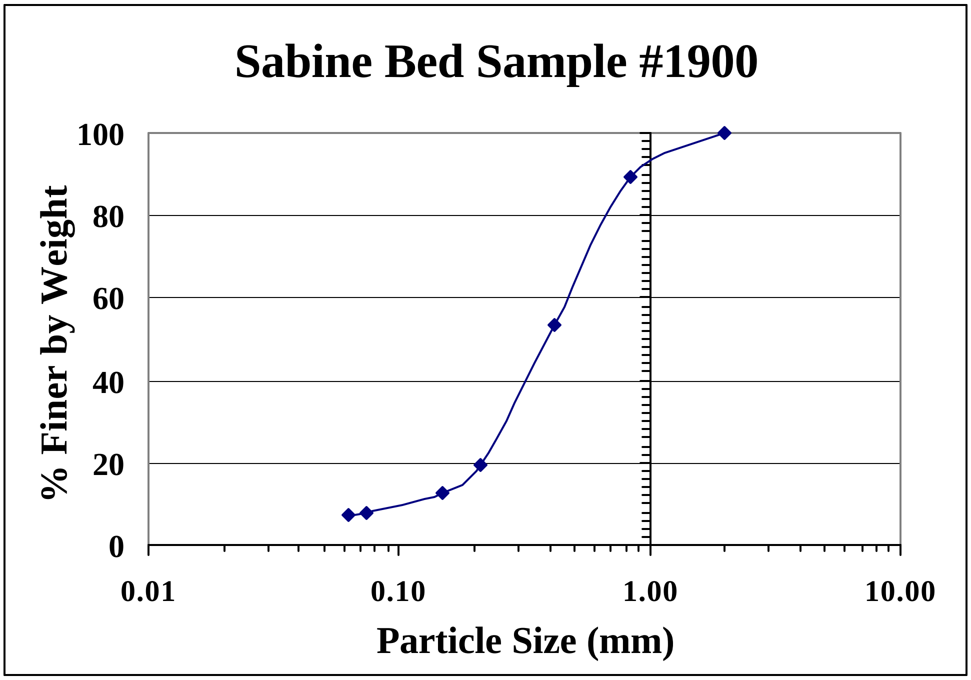



Figure A.1: Particle Size Distribution Curve for Bed Sample #1900

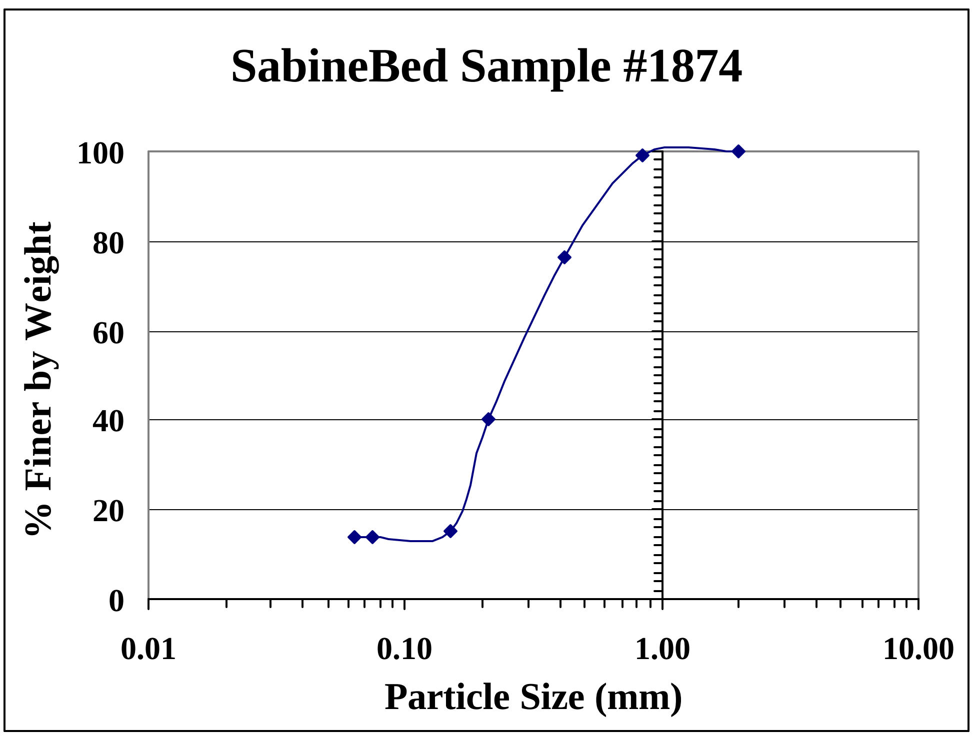



Figure A.2: Particle Size Distribution Curve for Bed Sample #1874

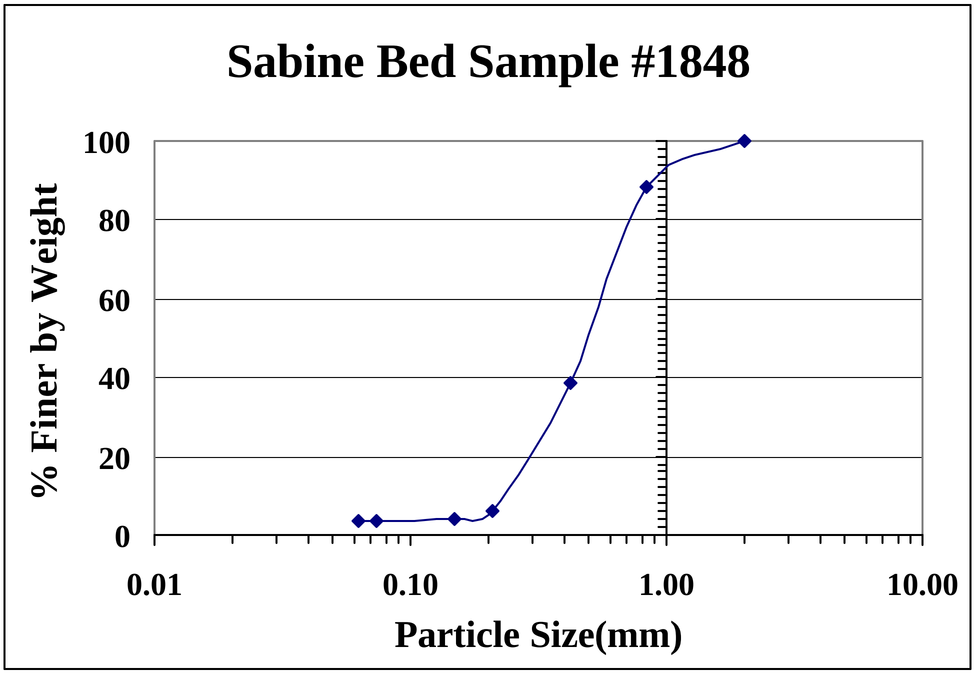



Figure A.3: Particle Size Distribution Curve for Bed Sample #1848

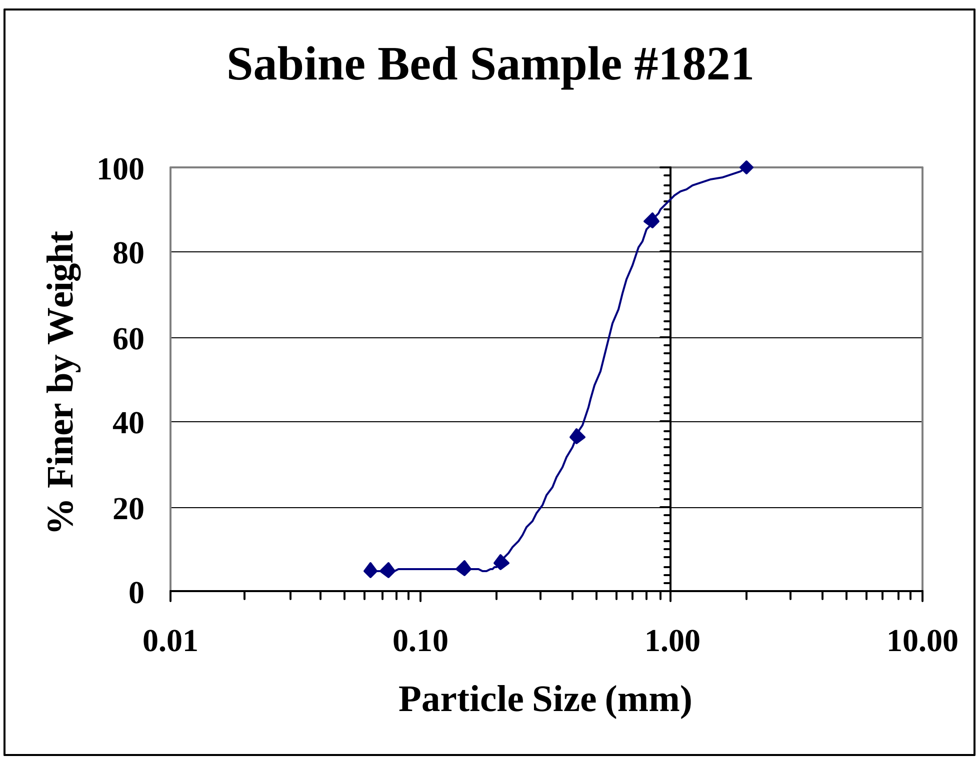



Figure A.4: Particle Size Distribution Curve for Bed Sample #1821

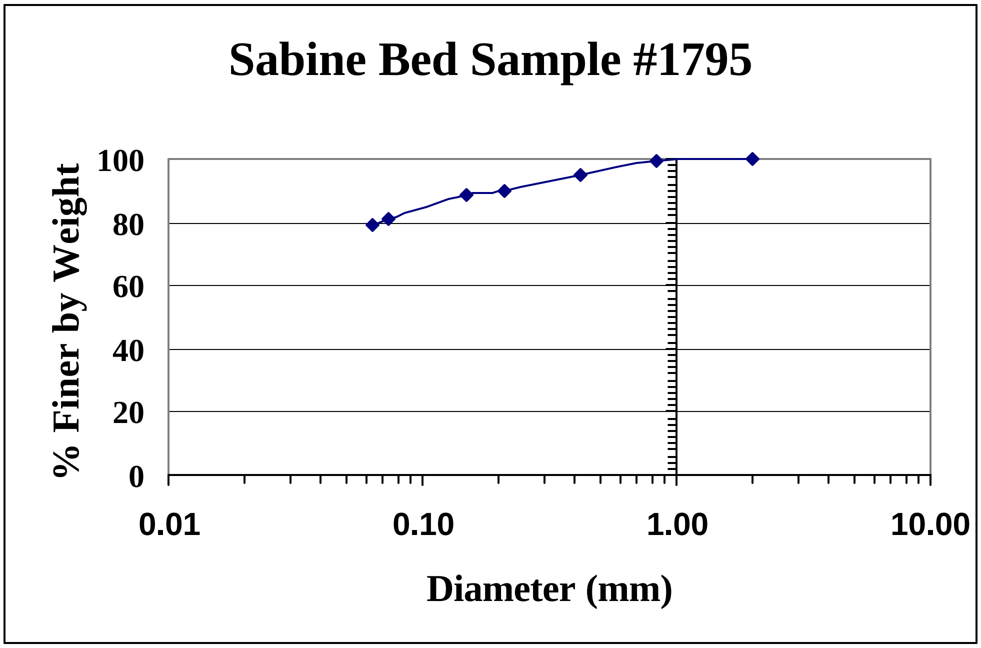



Figure A.5: Particle Size Distribution Curve for Bed Sample #1795

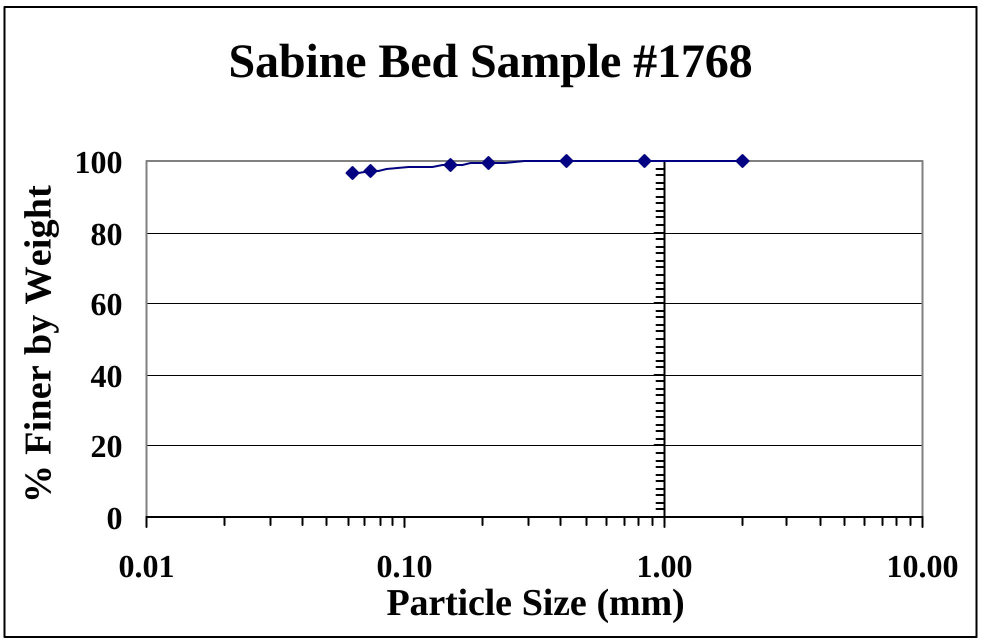



Figure A.6: Particle Size Distribution Curve for Bed Sample #1768

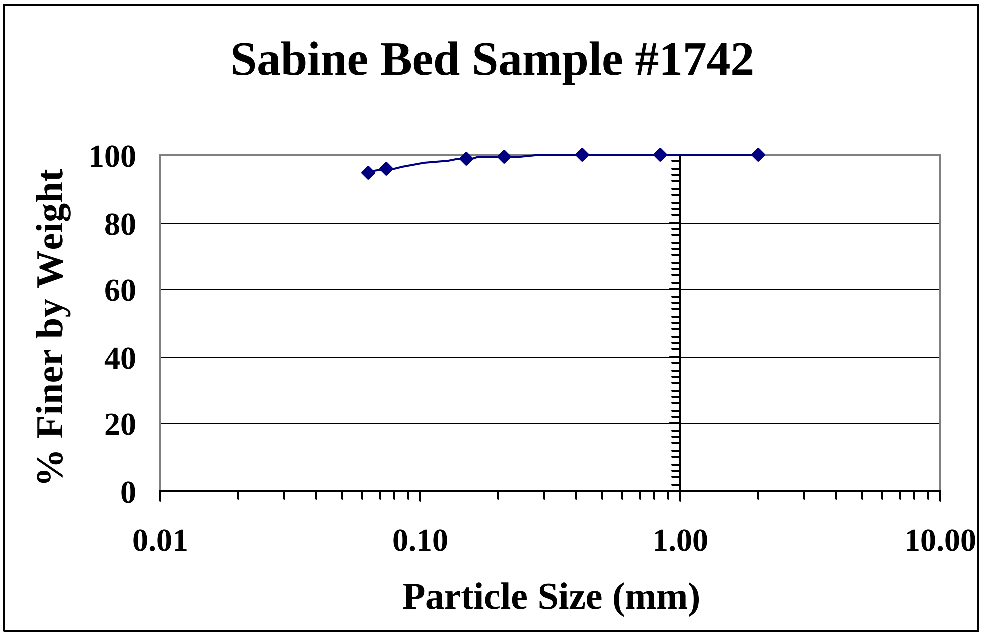



Figure A.7: Particle Size Distribution Curve for Bed Sample #1742

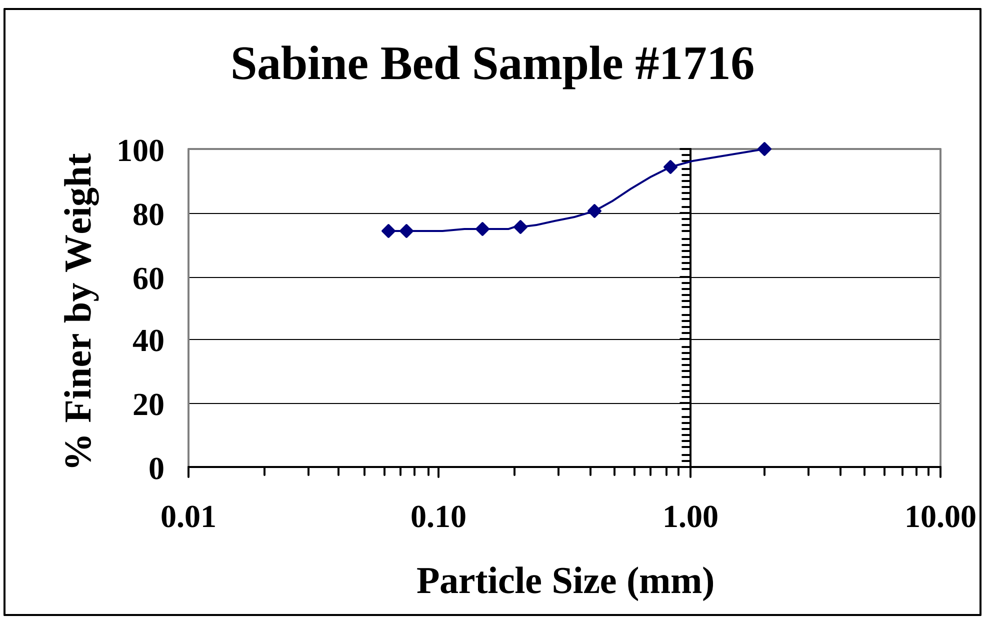



Figure A.8: Particle Size Distribution Curve for Bed Sample #1716

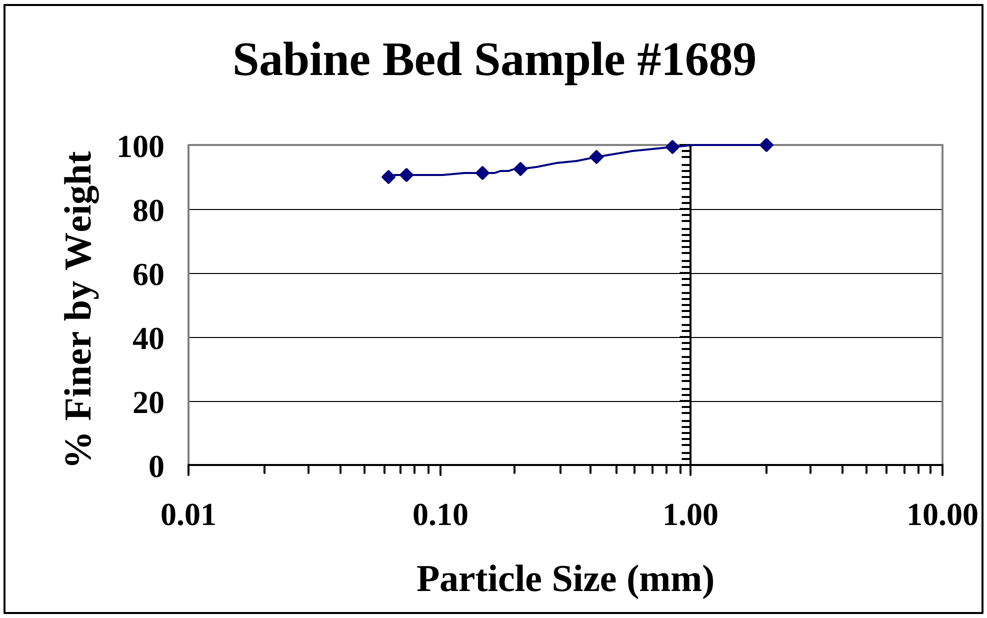



Figure A.9: Particle Size Distribution Curve for Bed Sample #1689

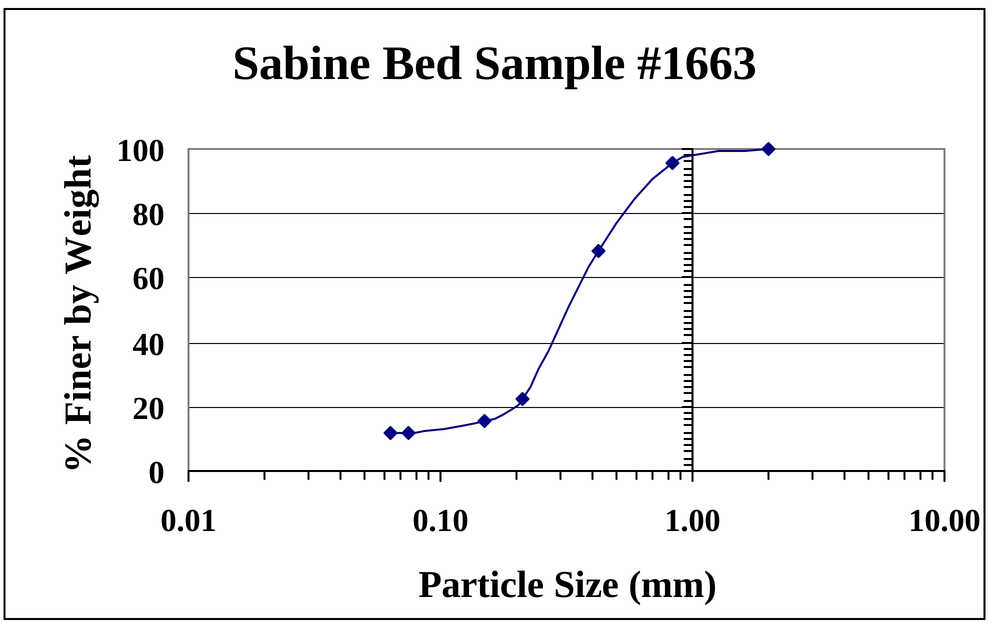



Figure A.10: Particle Size Distribution Curve for Bed Sample #1663

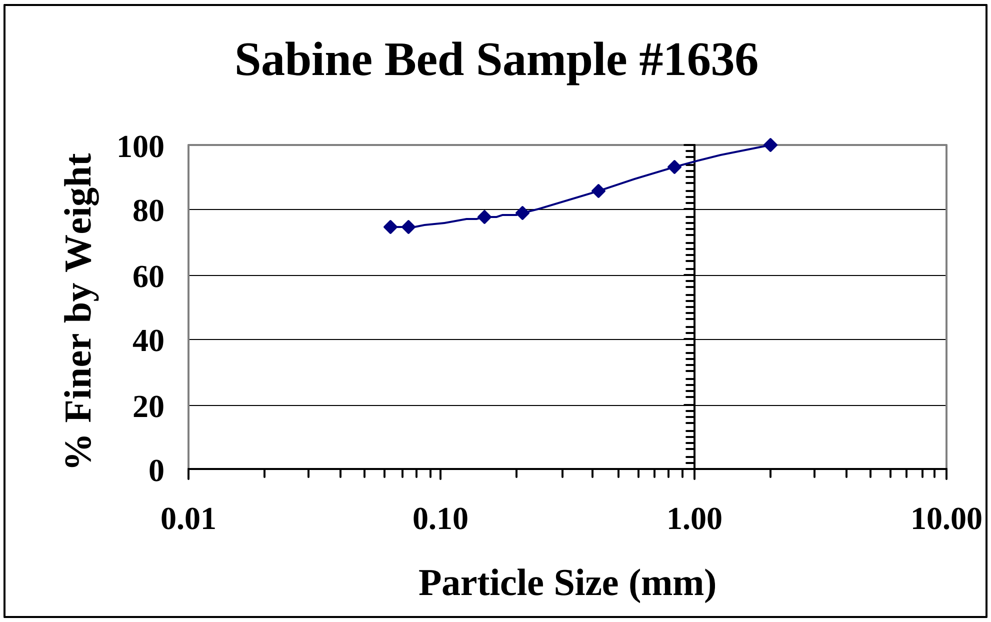



Figure A.11: Particle Size Distribution Curve for Bed Sample #1636

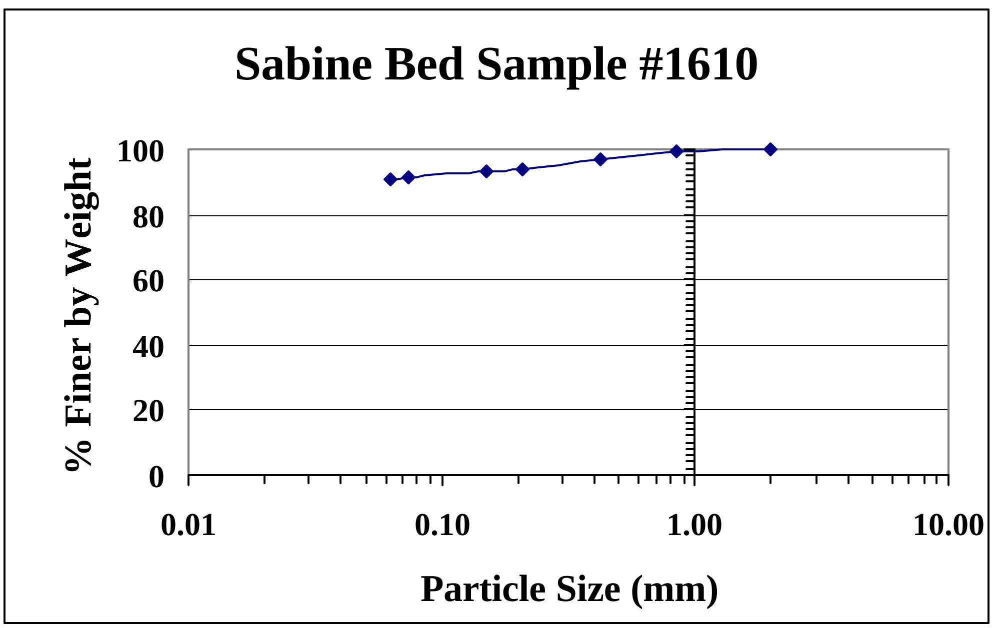



Figure A.12: Particle Size Distribution Curve for Bed Sample #1610

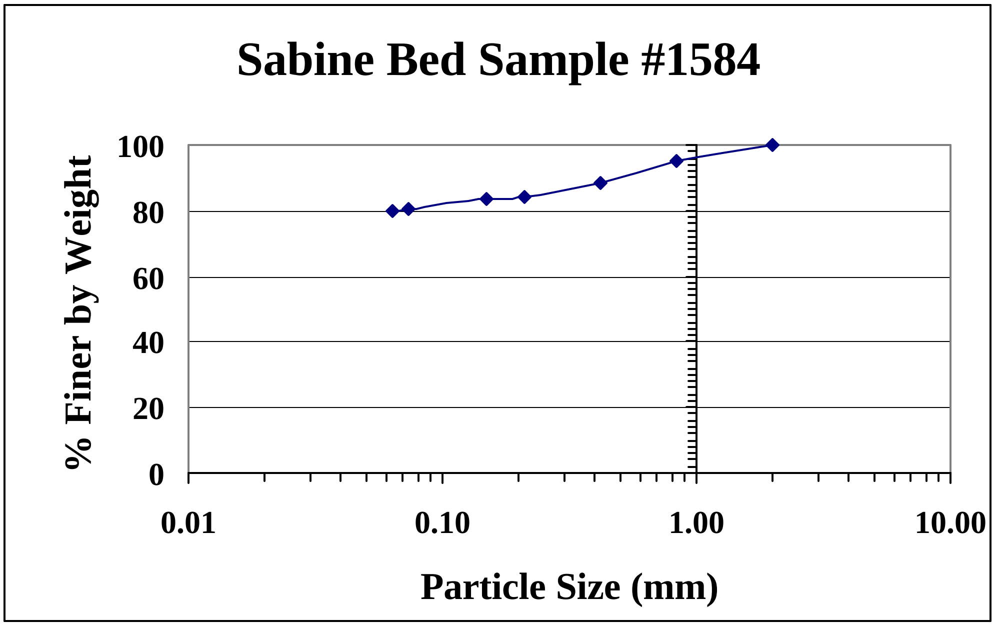



Figure A.13: Particle Size Distribution Curve for Bed Sample #1584

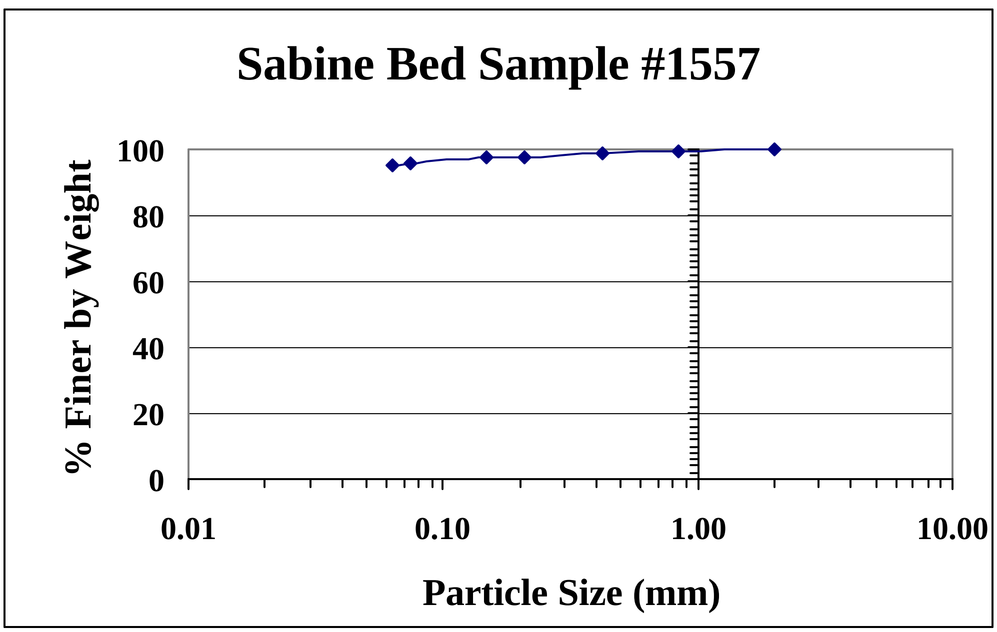



Figure A.14: Particle Size Distribution Curve for Bed Sample #1557

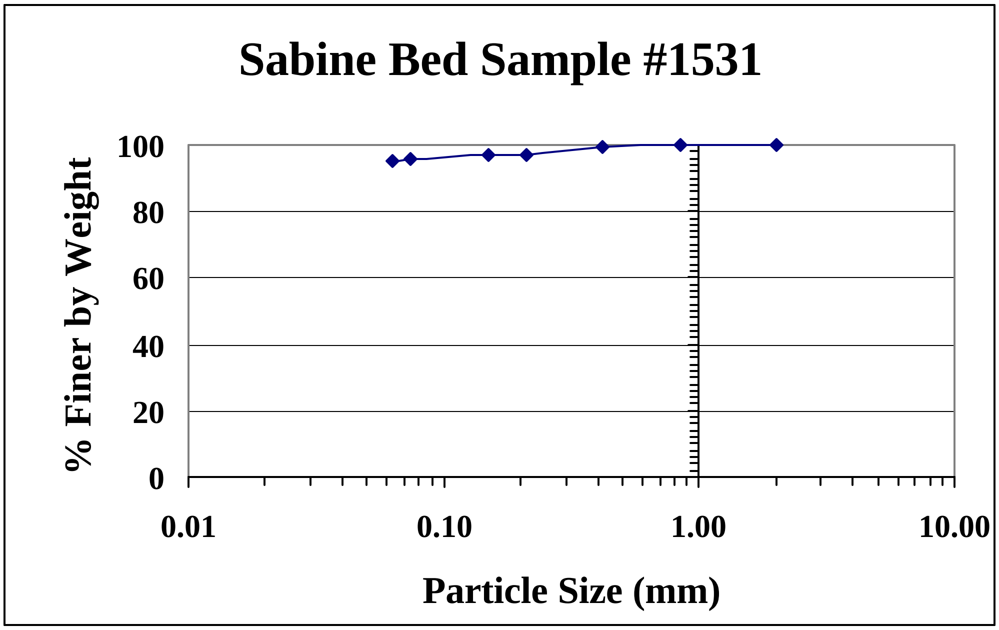



Figure A.15: Particle Size Distribution Curve for Bed Sample #1531

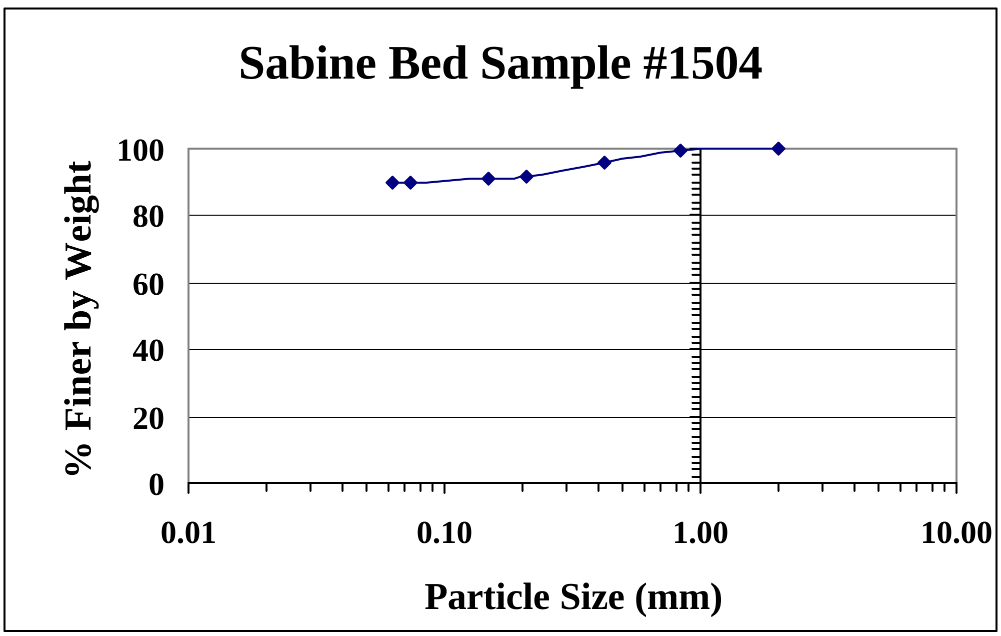



Figure A.16: Particle Size Distribution Curve for Bed Sample #1504

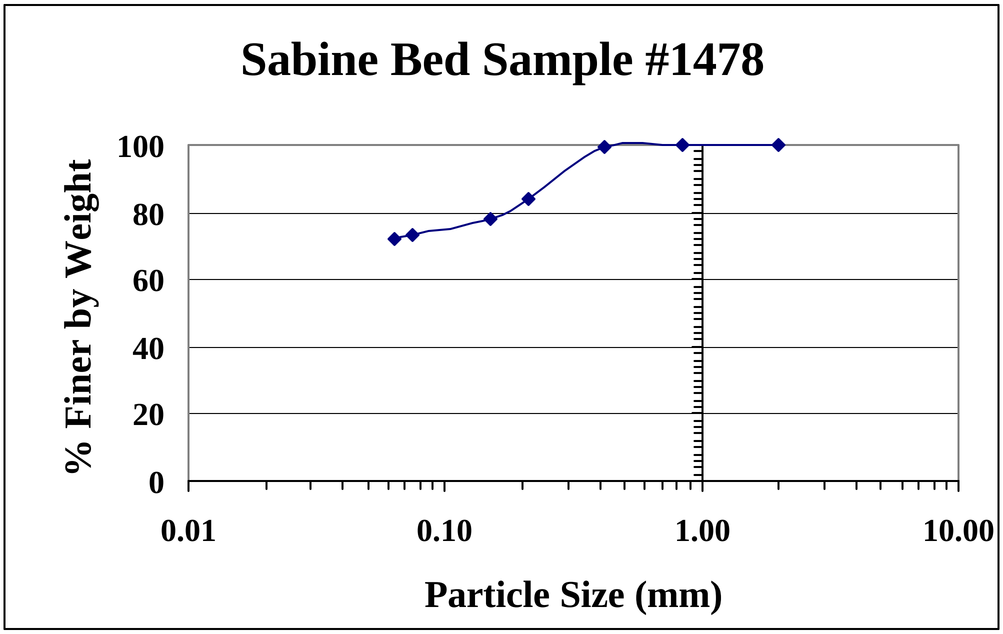



Figure A.17: Particle Size Distribution Curve for Bed Sample #1478

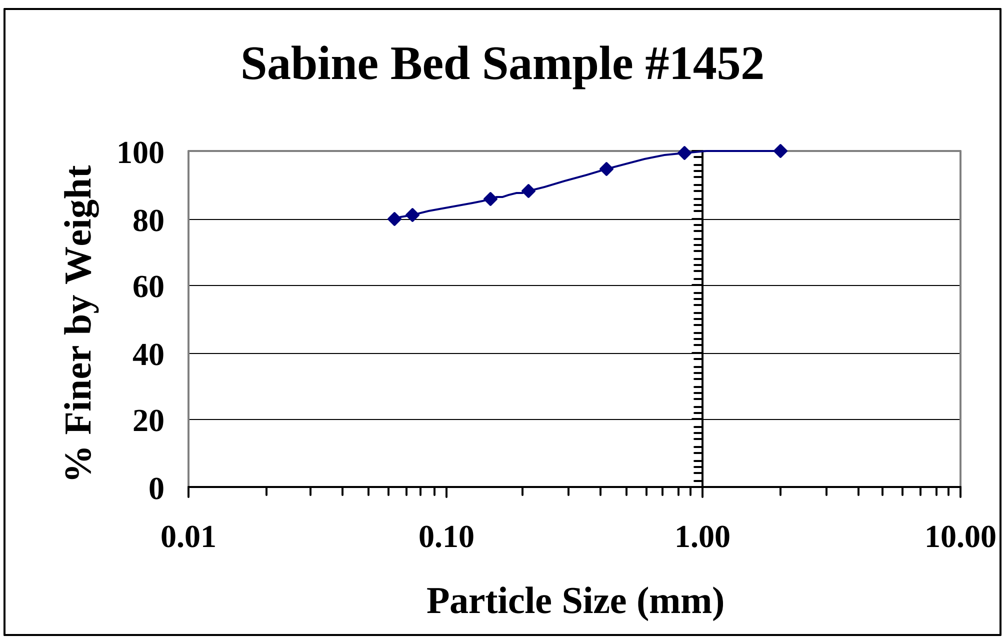



Figure A.18: Particle Size Distribution Curve for Bed Sample #1452

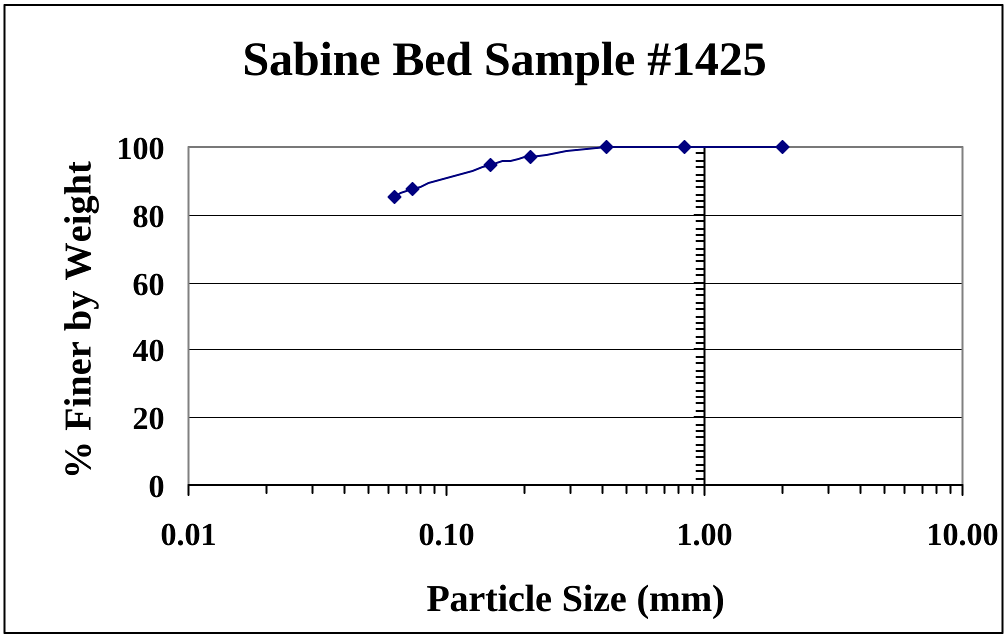



Figure A.19: Particle Size Distribution Curve for Bed Sample #1425

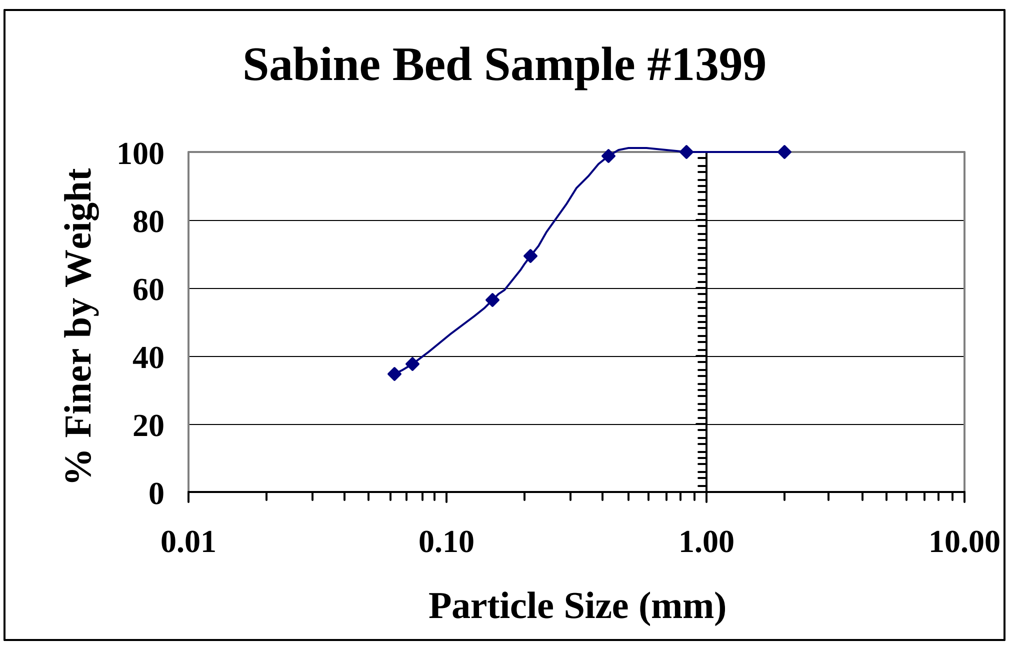



Figure A.20: Particle Size Distribution Curve for Bed Sample #1399

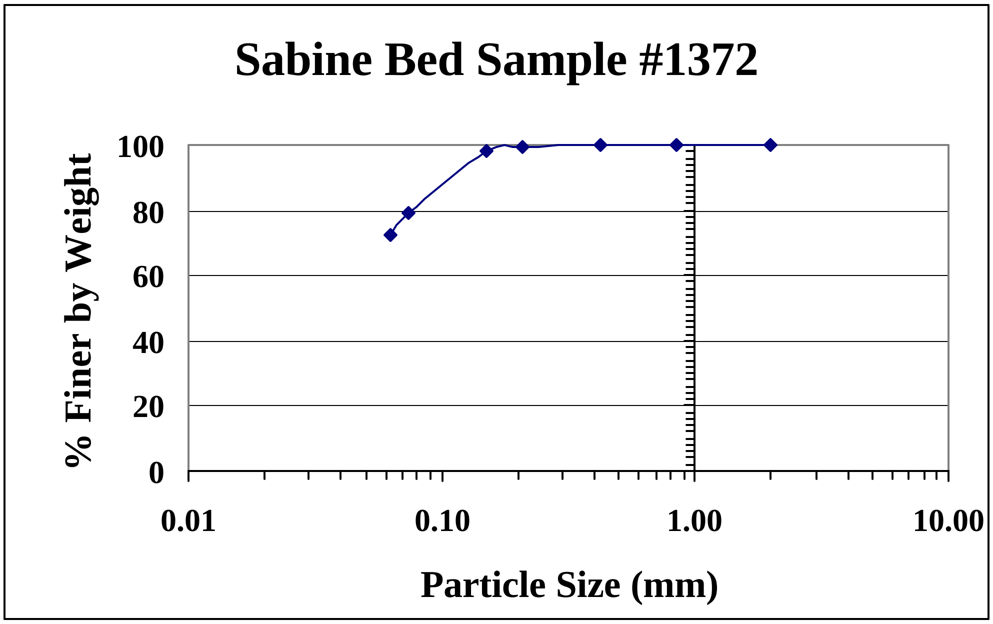



Figure A.21: Particle Size Distribution Curve for Bed Sample #1372

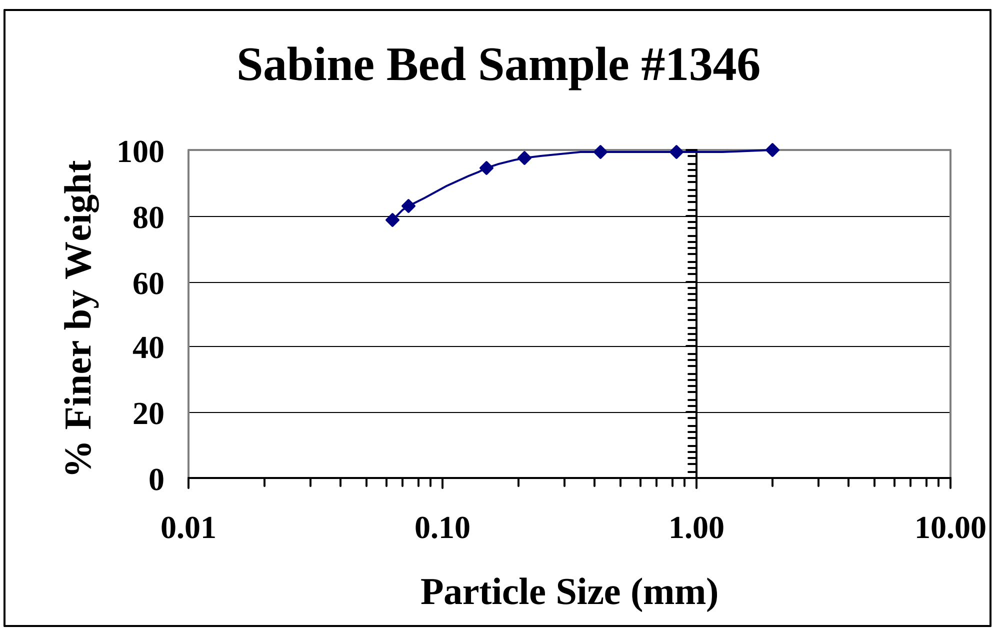



Figure A.22: Particle Size Distribution Curve for Bed Sample #1346

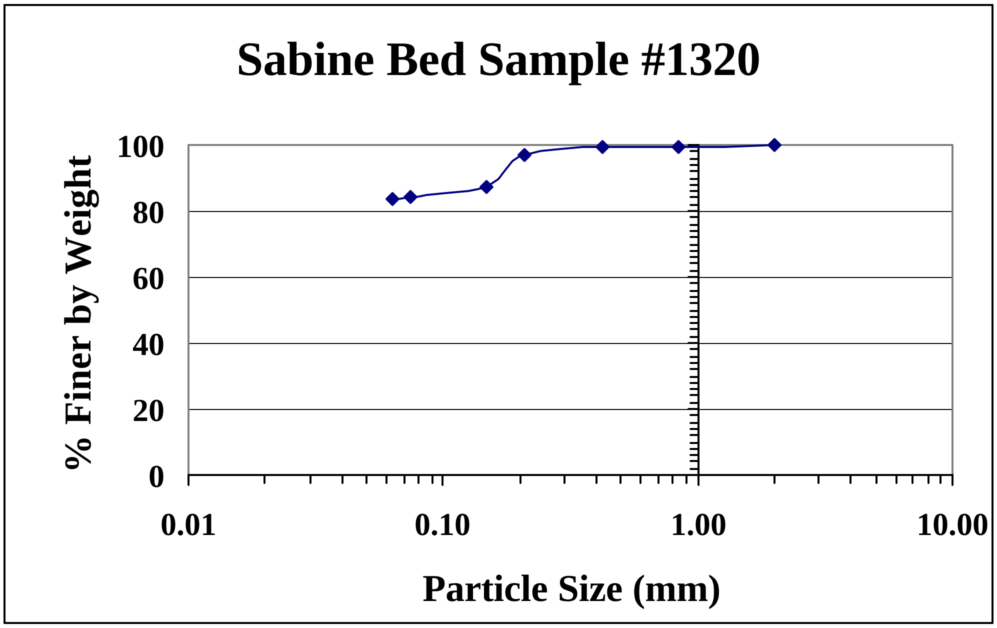



Figure A.23: Particle Size Distribution Curve for Bed Sample #1320

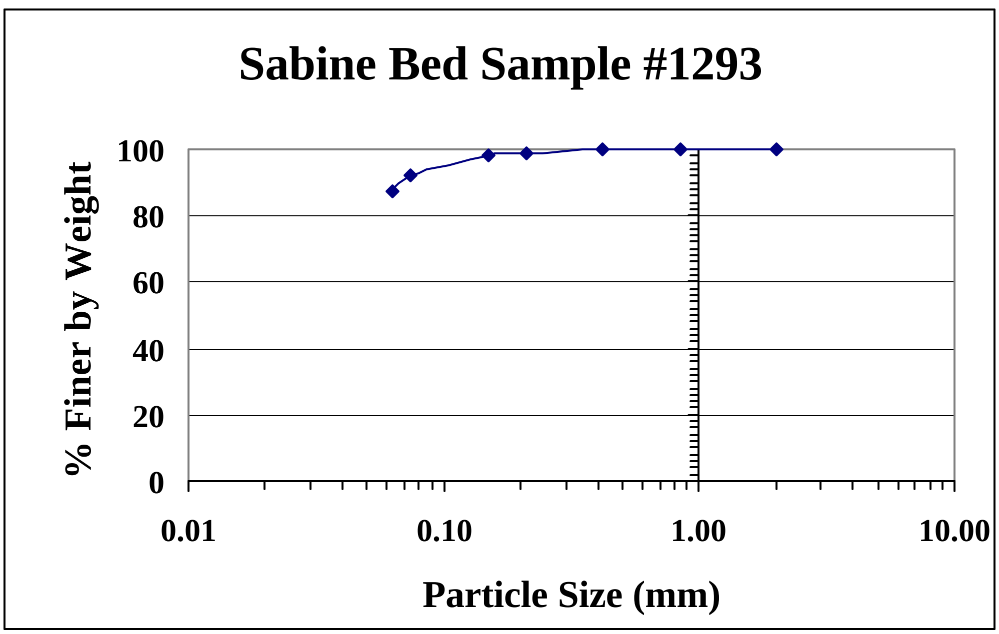



Figure A.24: Particle Size Distribution Curve for Bed Sample #1293

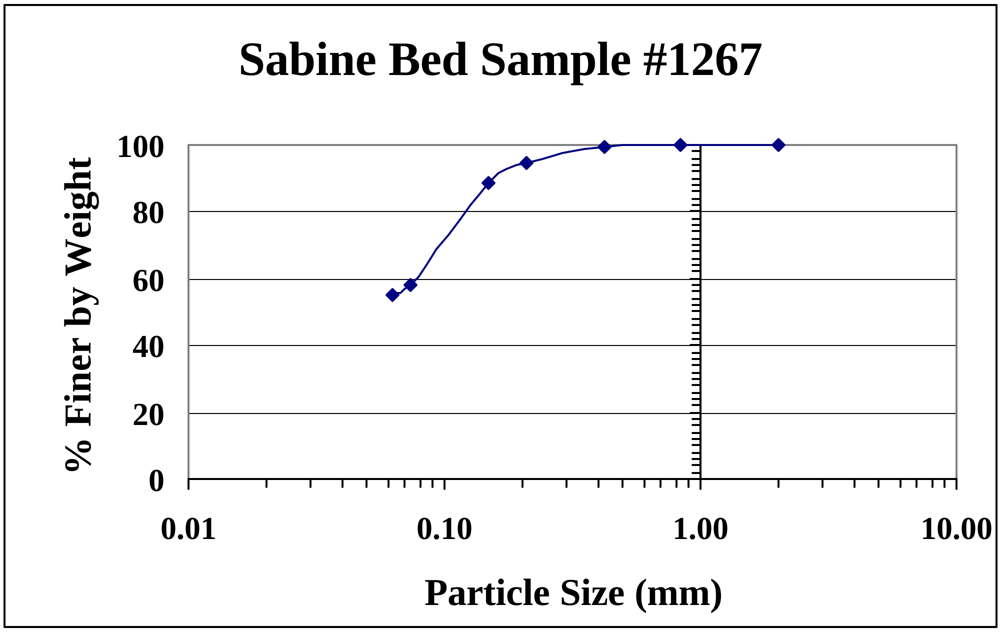



Figure A.25: Particle Size Distribution Curve for Bed Sample #1267

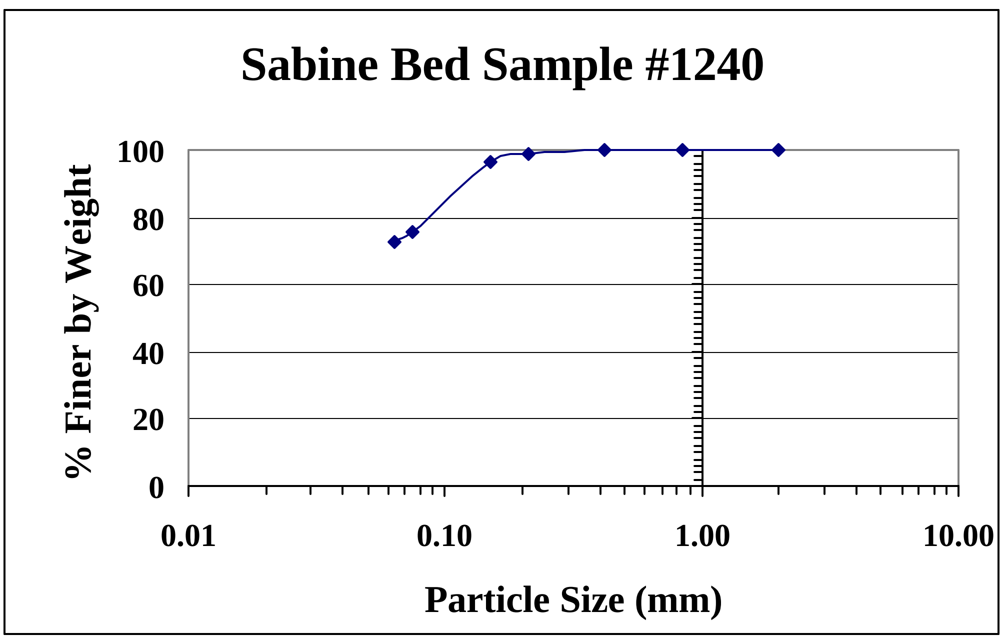



Figure A.26: Particle Size Distribution Curve for Bed Sample #1240

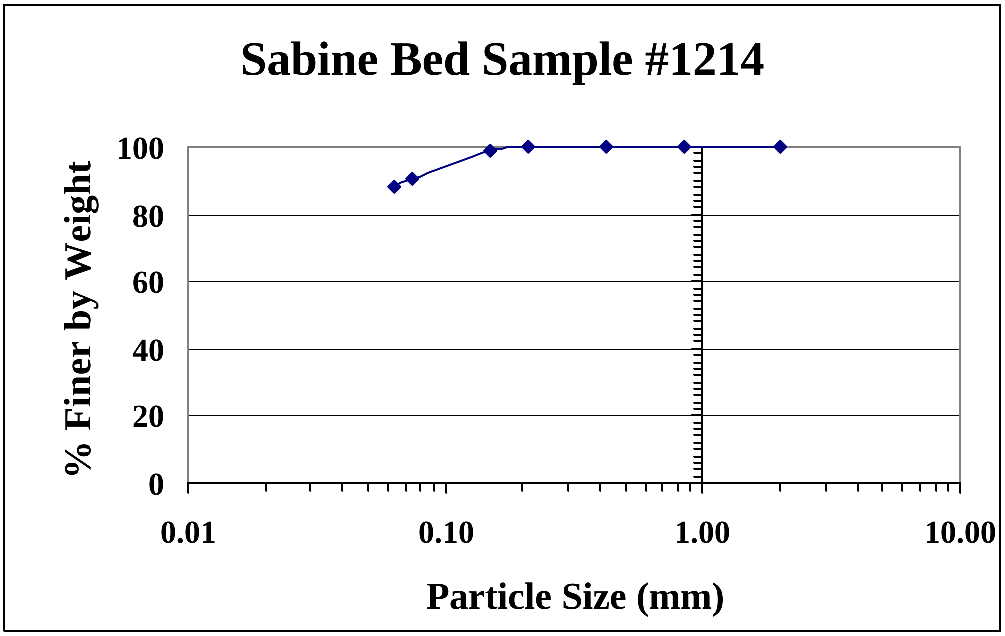



Figure A.27: Particle Size Distribution Curve for Bed Sample #1214

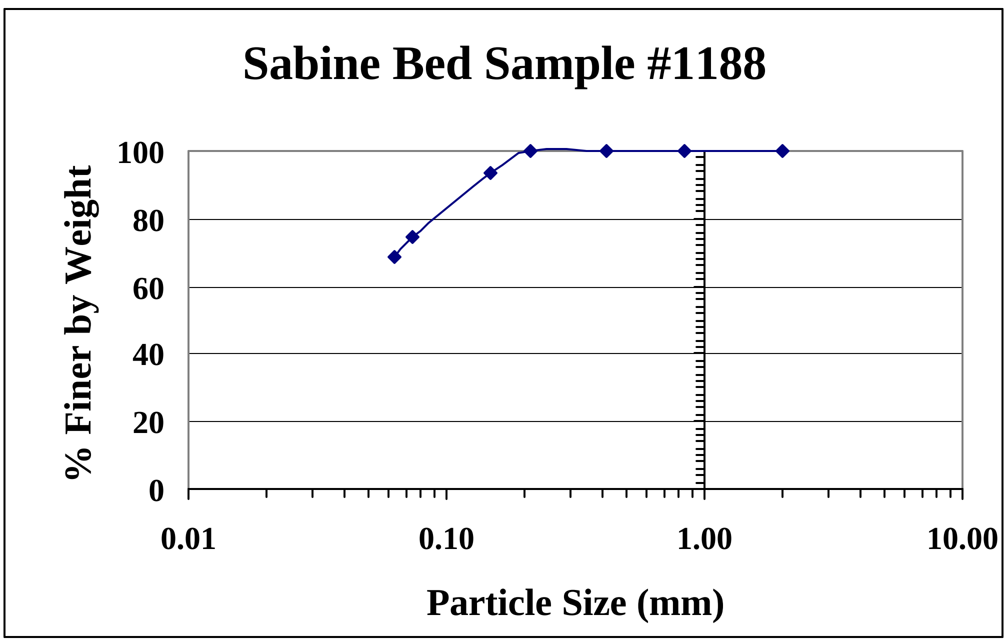



Figure A.28: Particle Size Distribution Curve for Bed Sample #1188

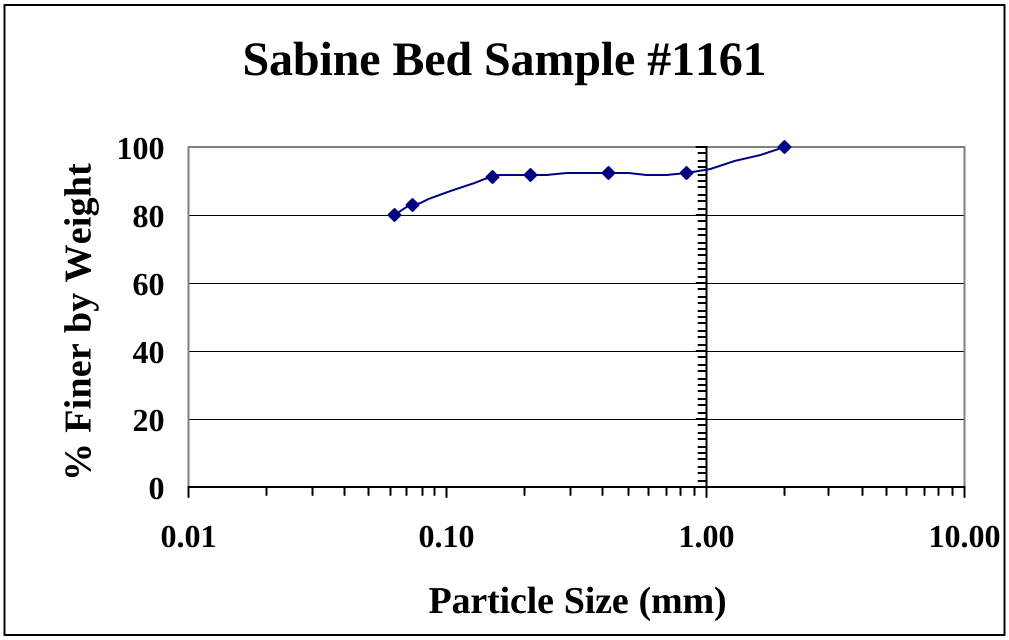



Figure A.29: Particle Size Distribution Curve for Bed Sample #1161

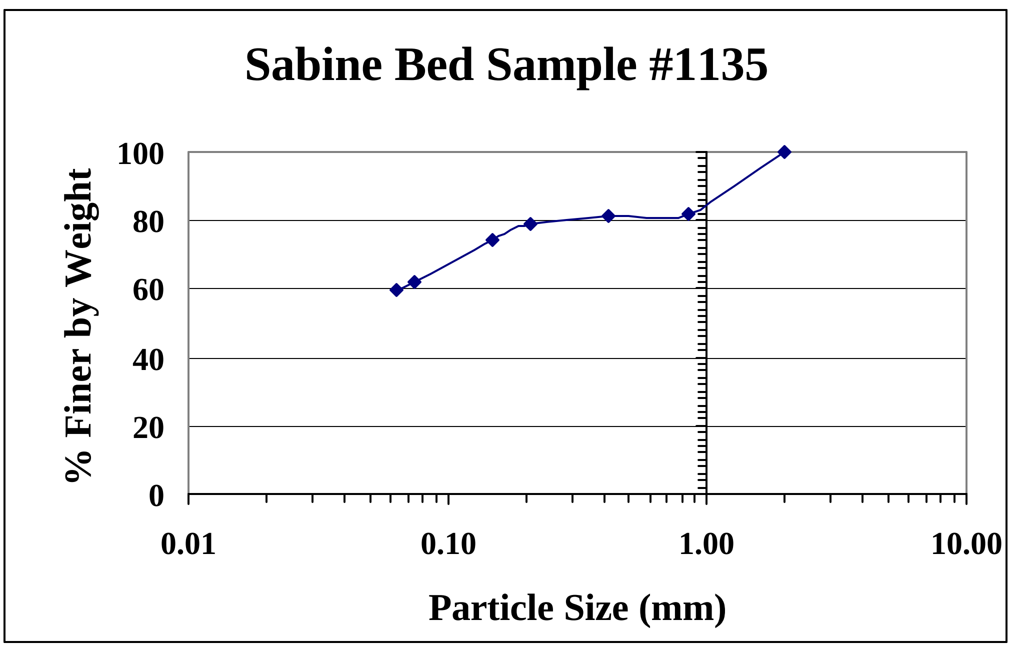



Figure A.30: Particle Size Distribution Curve for Bed Sample #1135

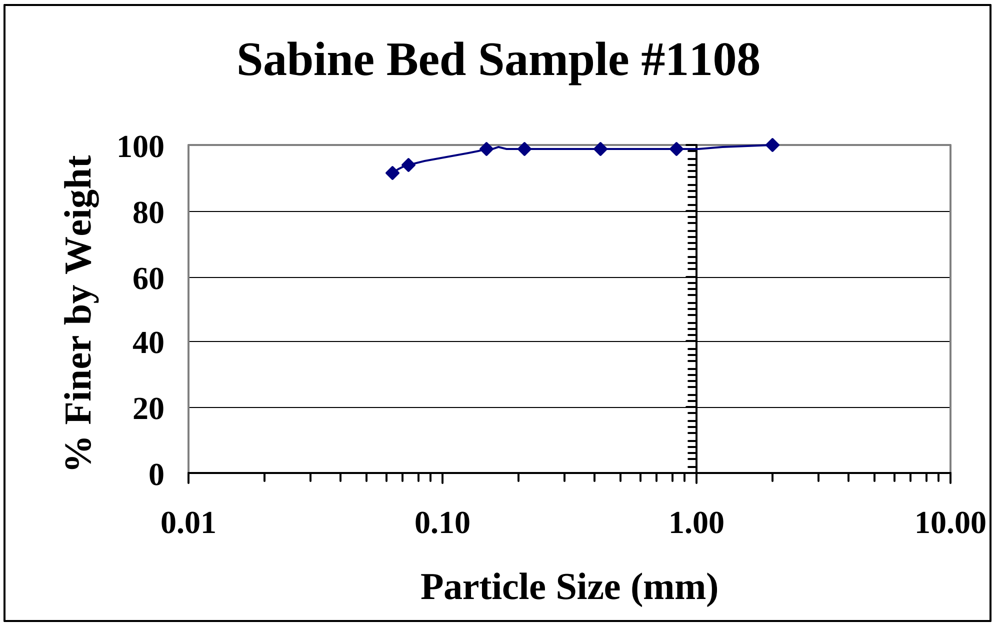



Figure A.31: Particle Size Distribution Curve for Bed Sample #1108

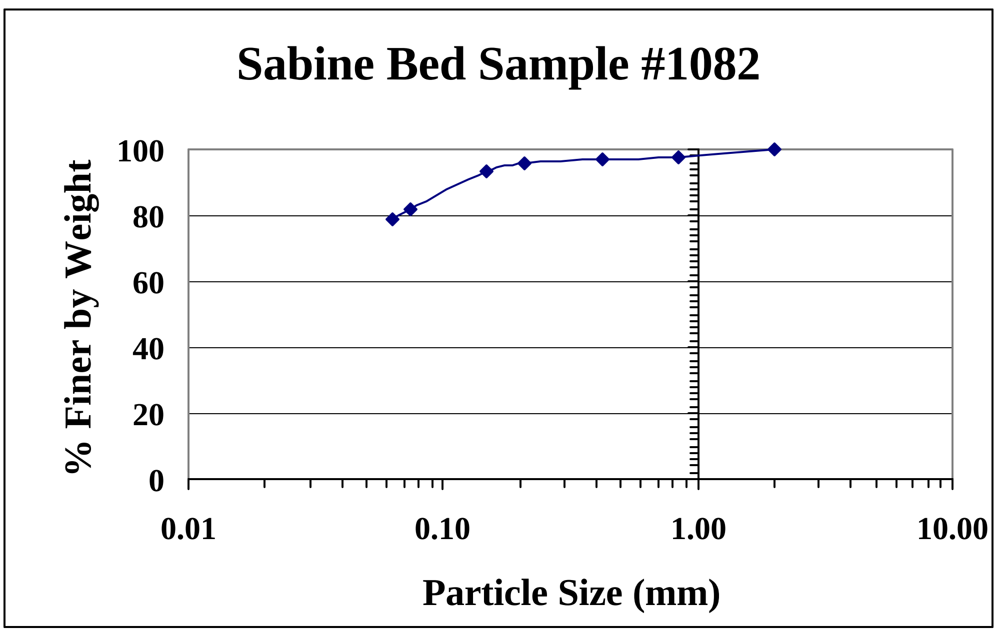



Figure A.32: Particle Size Distribution Curve for Bed Sample #1082

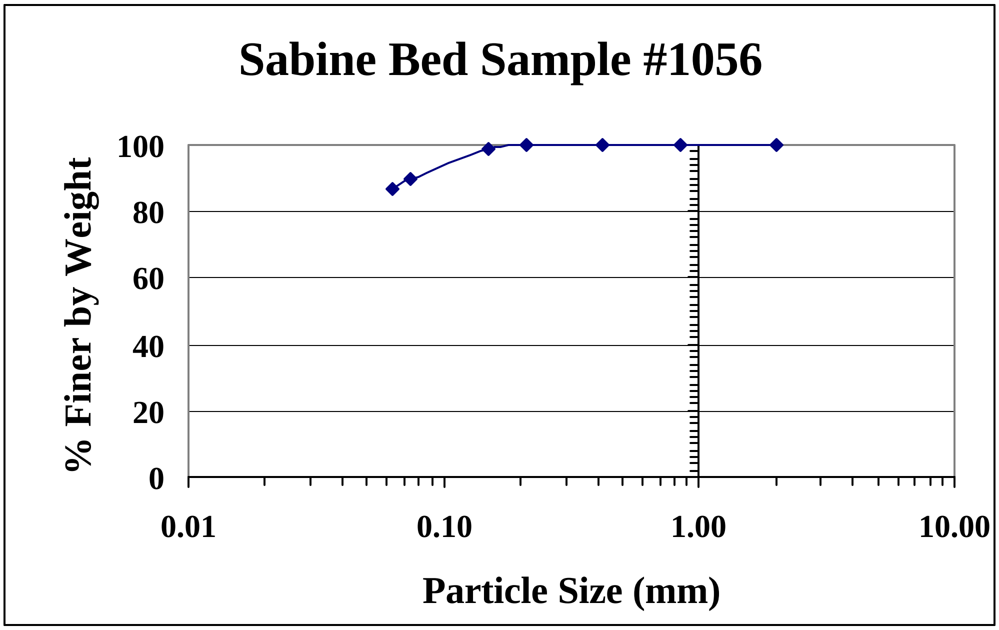



Figure A.33: Particle Size Distribution Curve for Bed Sample #1056

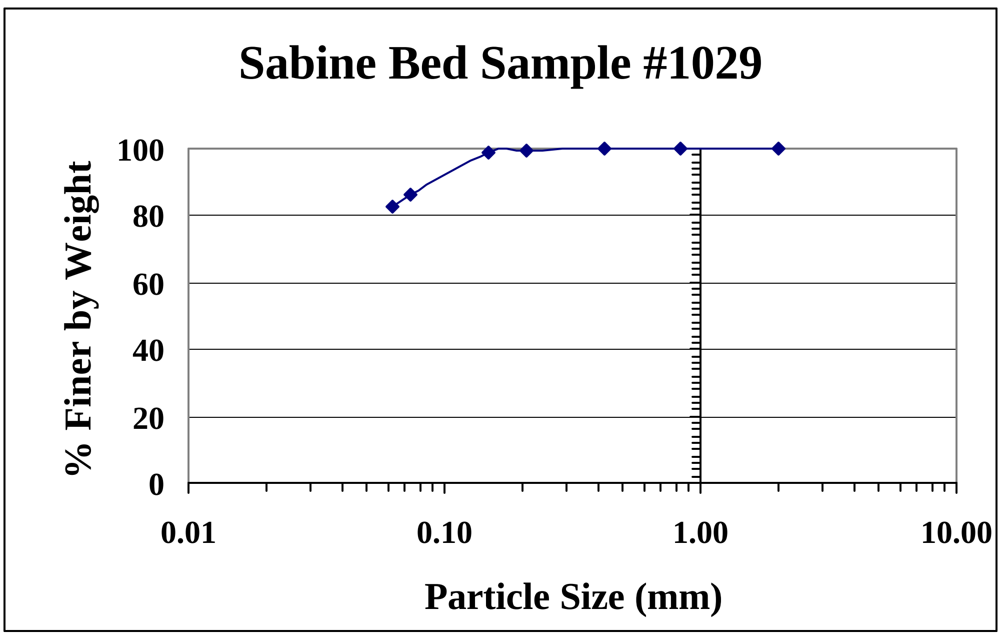



Figure A.34: Particle Size Distribution Curve for Bed Sample #1029

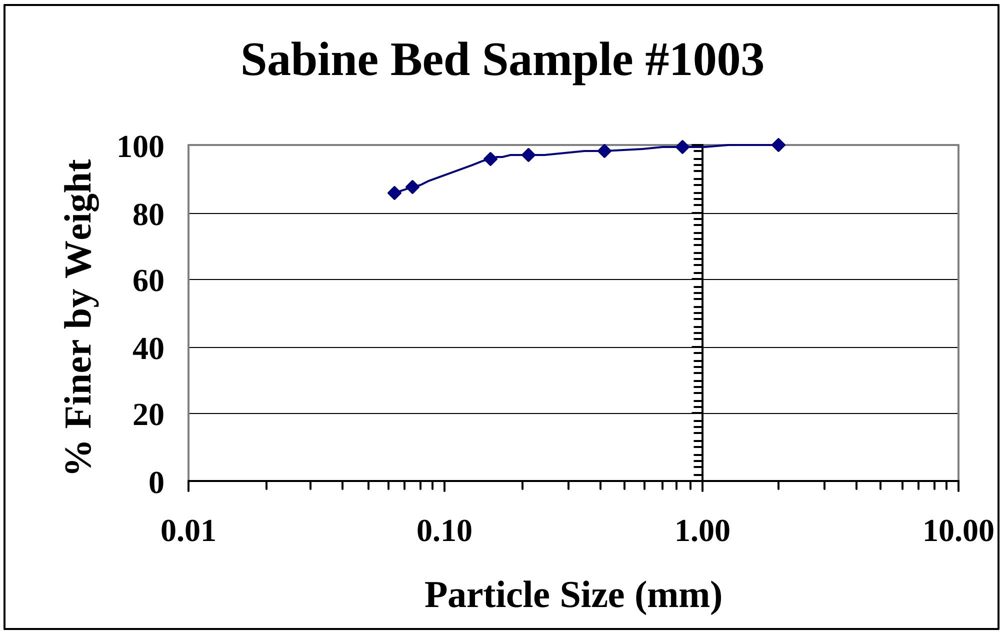



Figure A.35: Particle Size Distribution Curve for Bed Sample #1003

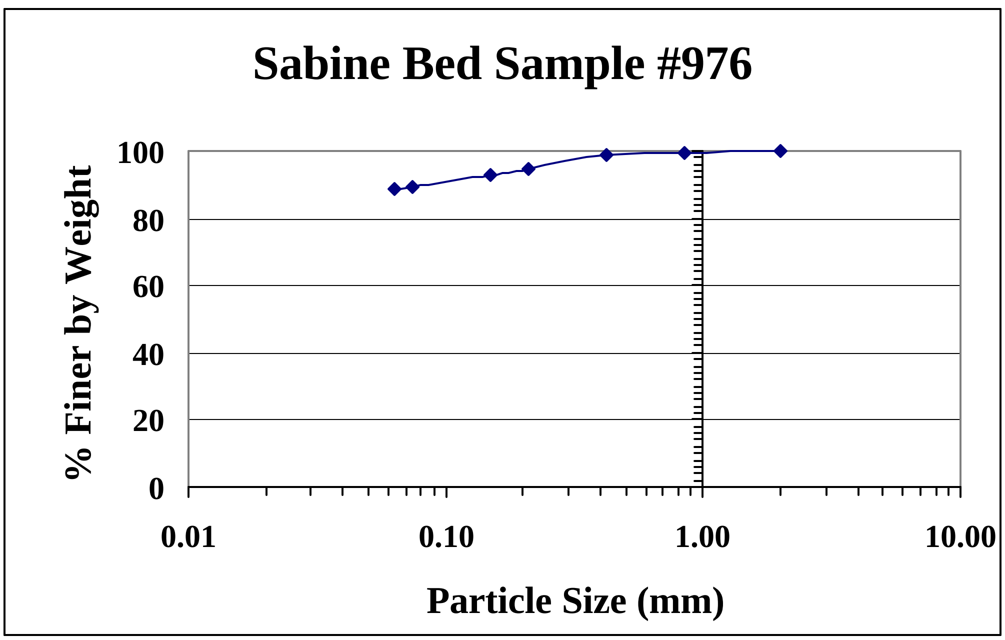



Figure A.36: Particle Size Distribution Curve for Bed Sample #976

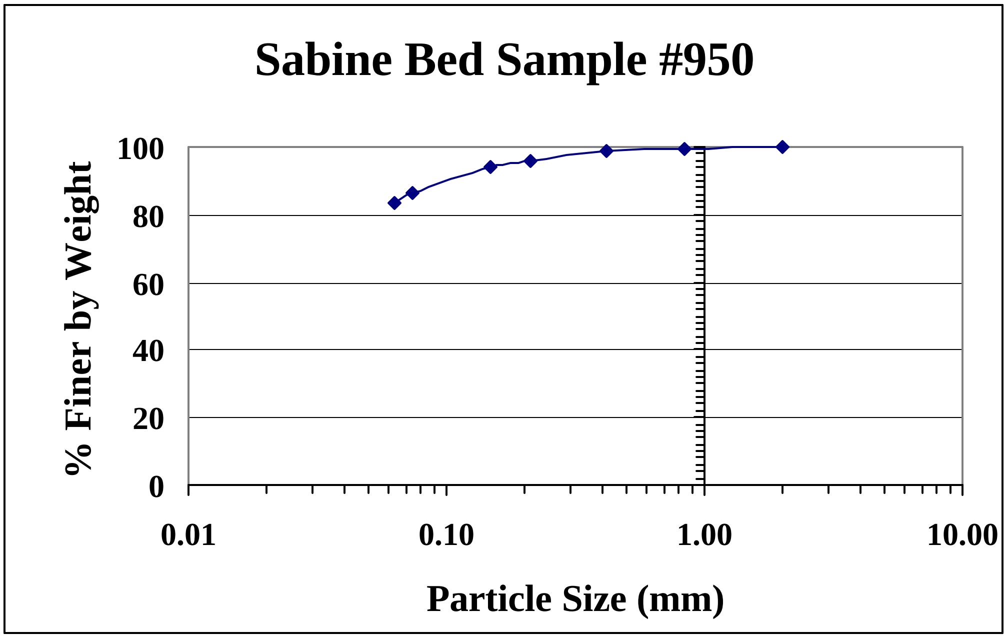



Figure A.37: Particle Size Distribution Curve for Bed Sample #950

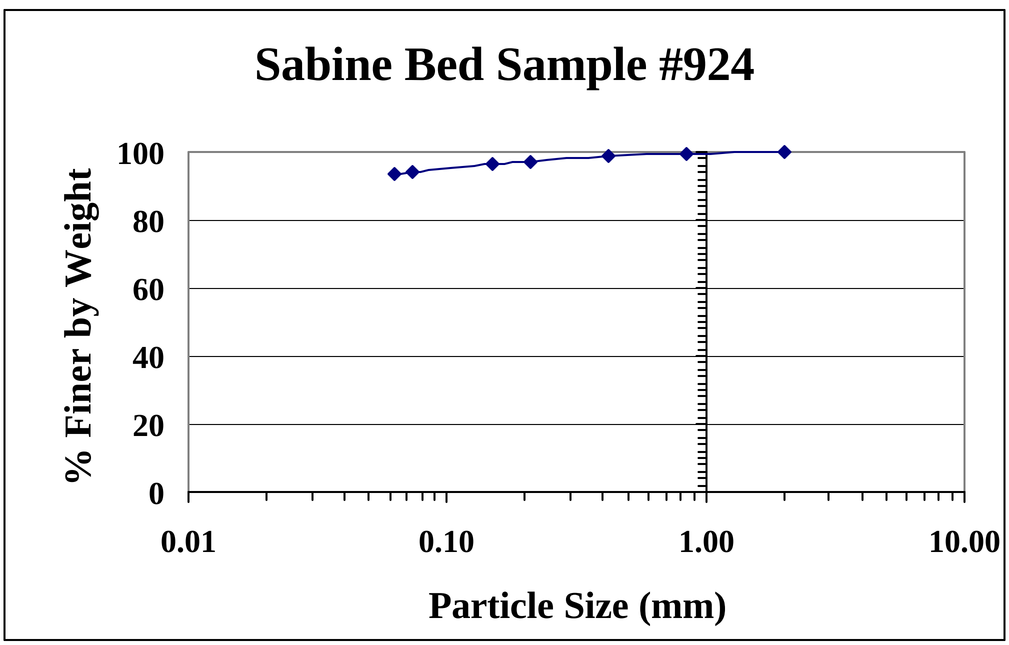



Figure A.38: Particle Size Distribution Curve for Bed Sample #924

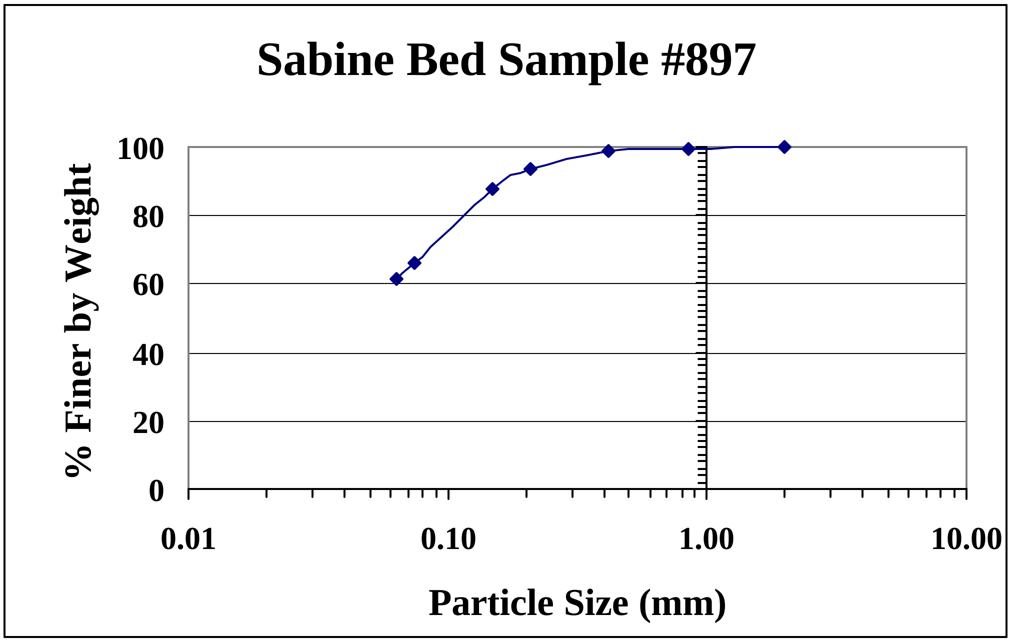



Figure A.39: Particle Size Distribution Curve for Bed Sample #897

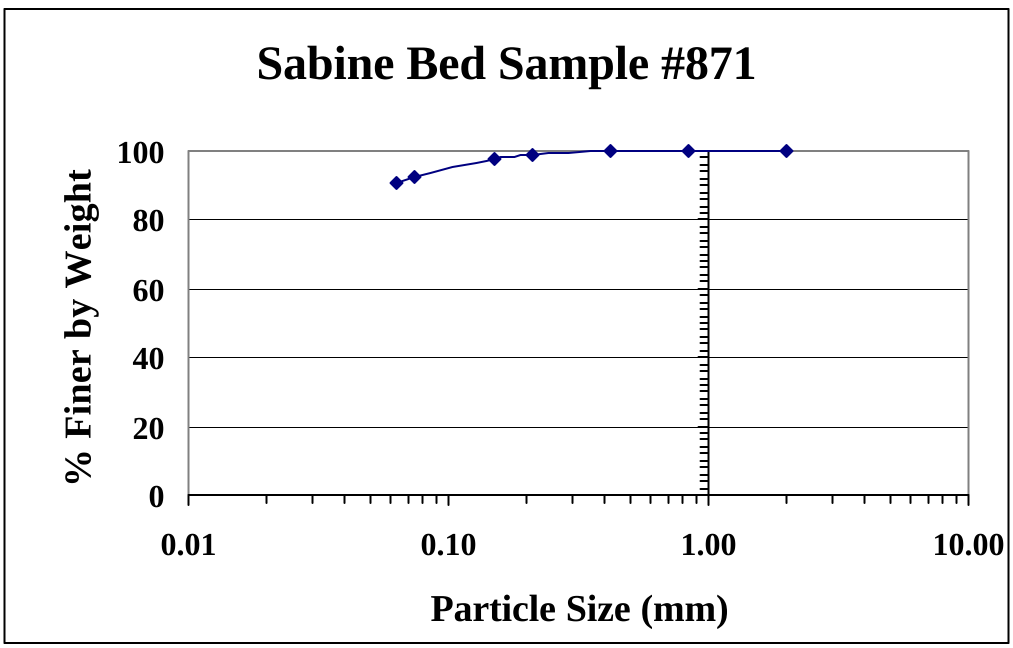



Figure A.40: Particle Size Distribution Curve for Bed Sample #871

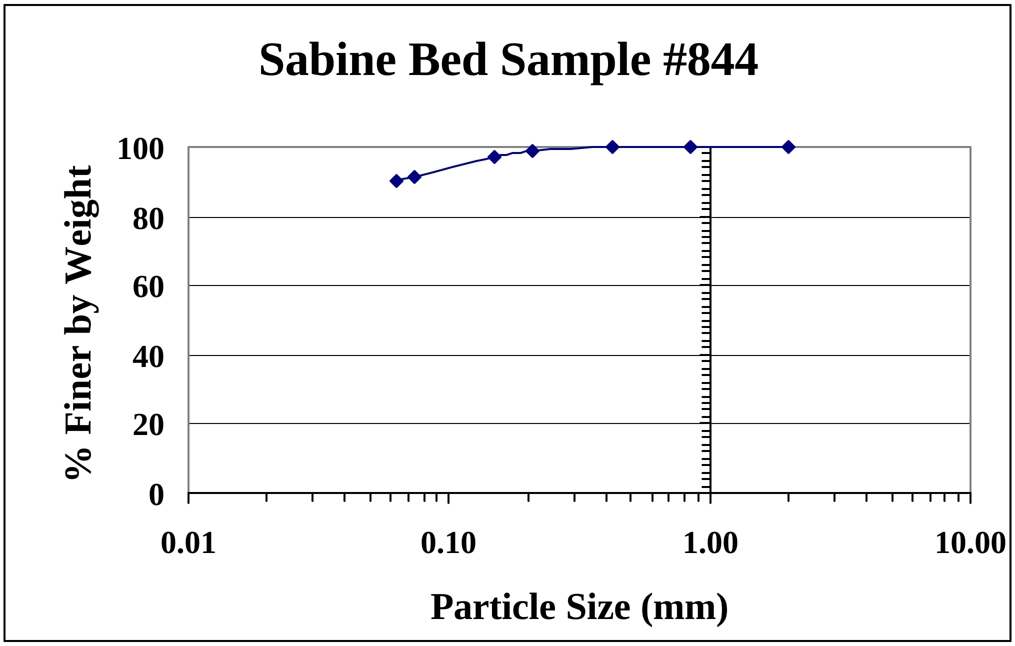



Figure A.41: Particle Size Distribution Curve for Bed Sample #844

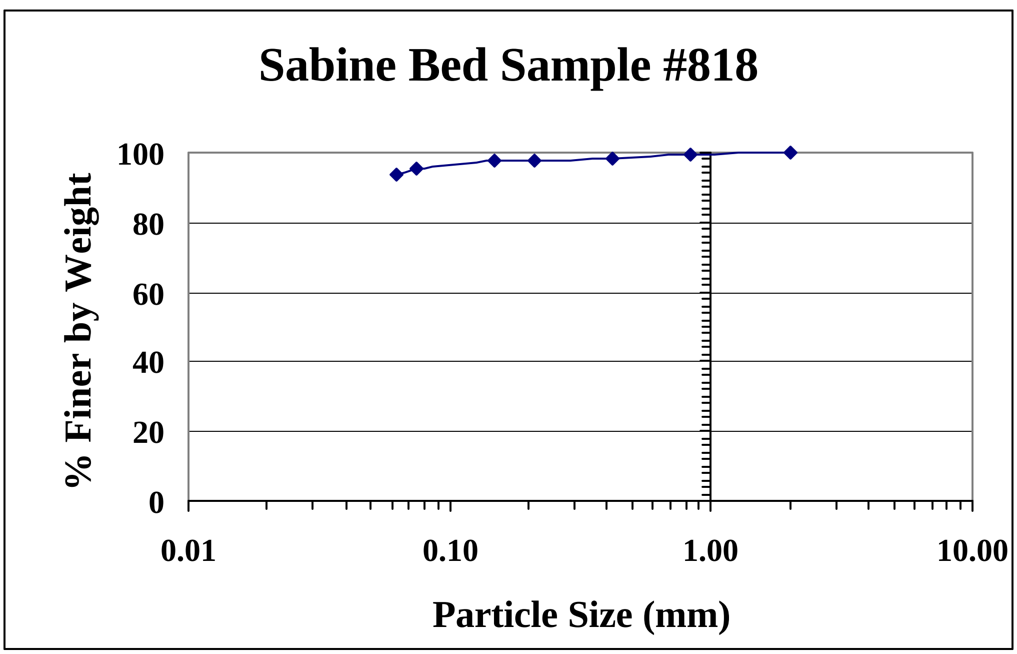



Figure A.42: Particle Size Distribution Curve for Bed Sample #818

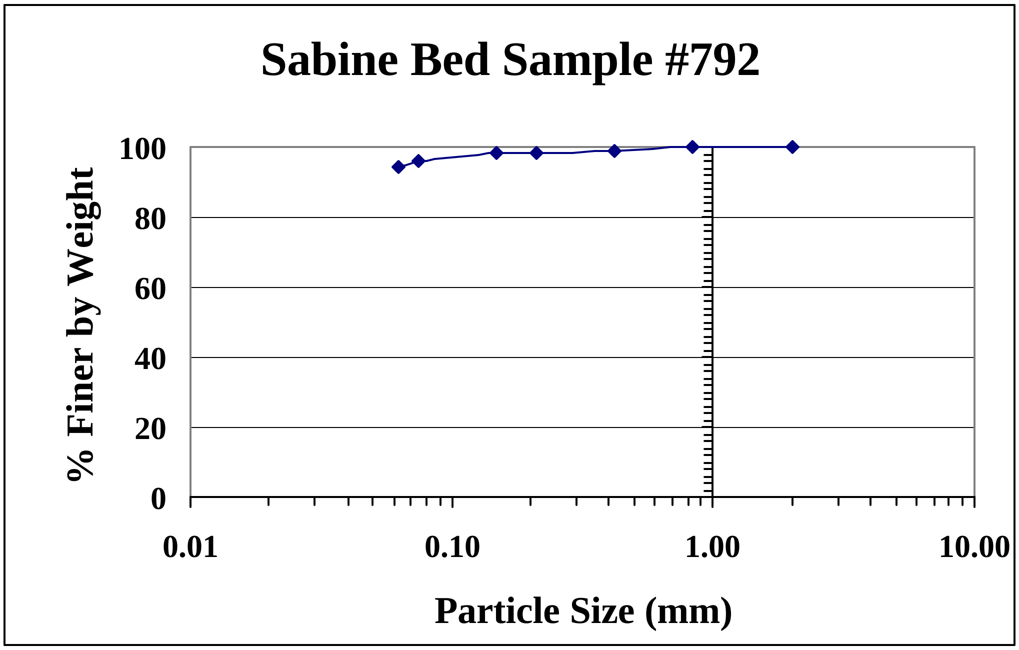



Figure A.43: Particle Size Distribution Curve for Bed Sample #792

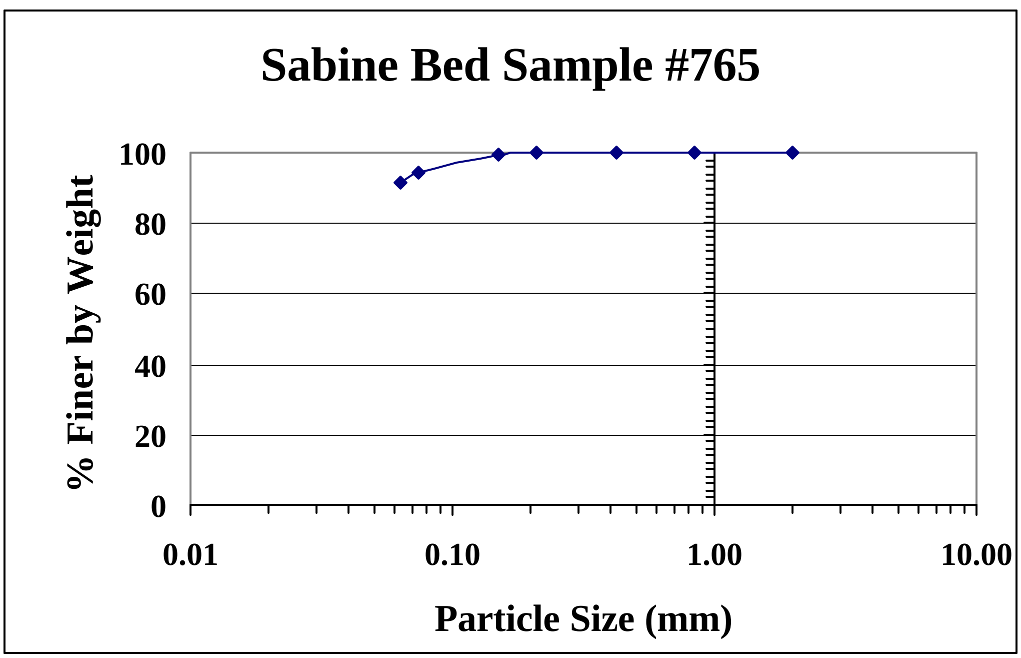



Figure A.44: Particle Size Distribution Curve for Bed Sample #765

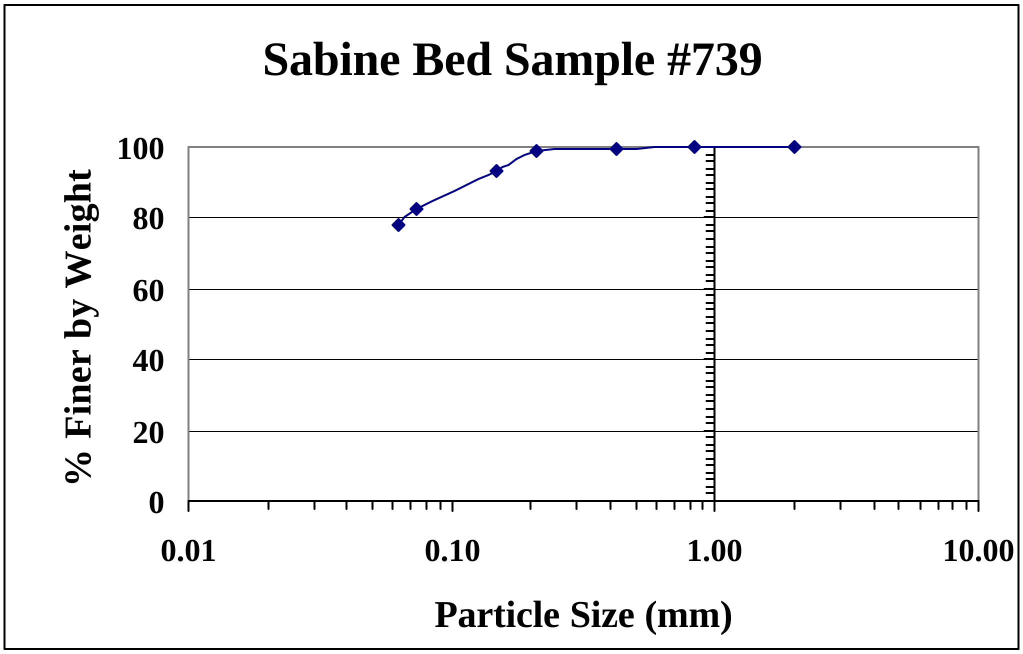



Figure A.45: Particle Size Distribution Curve for Bed Sample #739

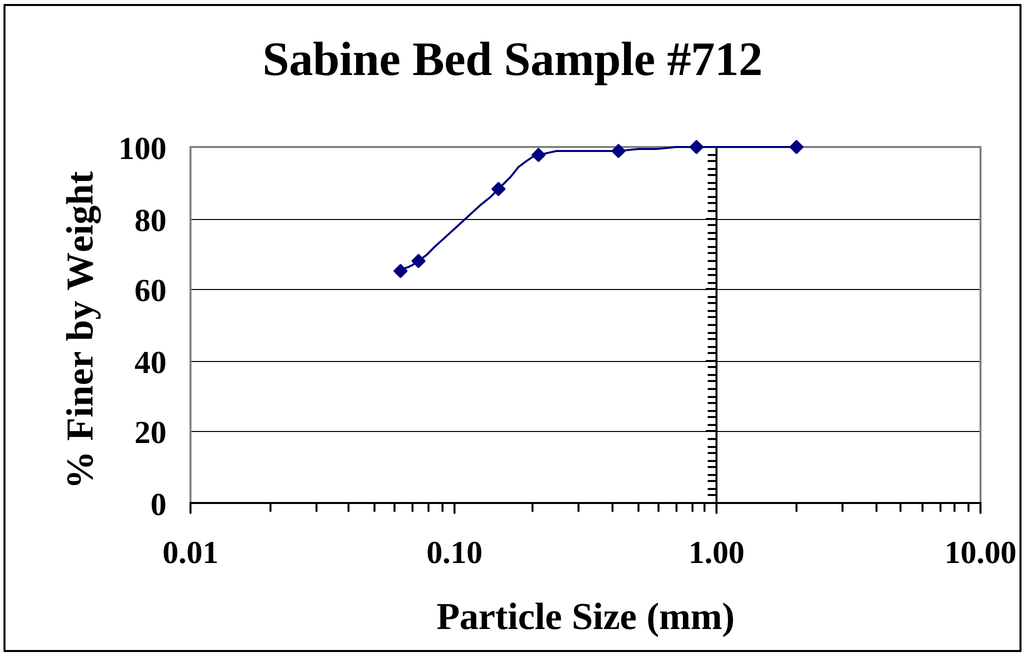



Figure A.46: Particle Size Distribution Curve for Bed Sample #712

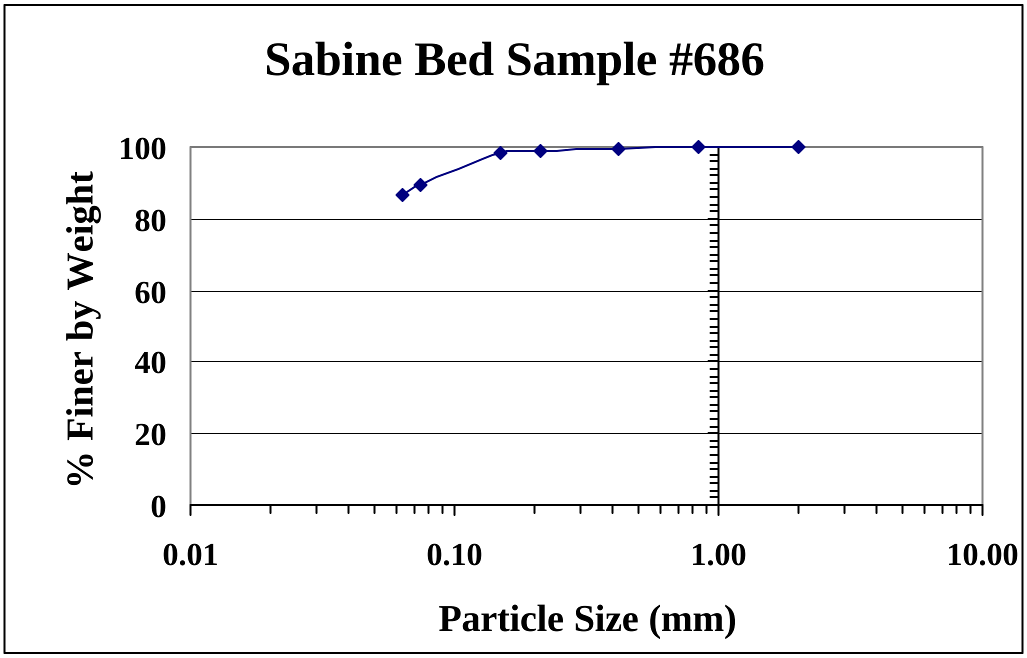



Figure A.47: Particle Size Distribution Curve for Bed Sample #686

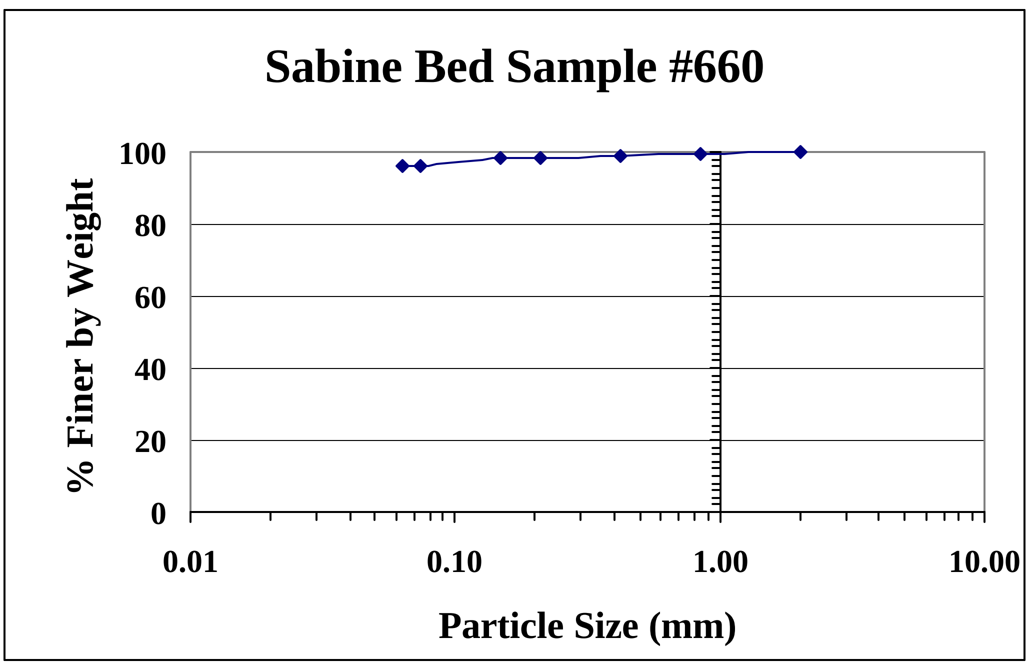



Figure A.48: Particle Size Distribution Curve for Bed Sample #660

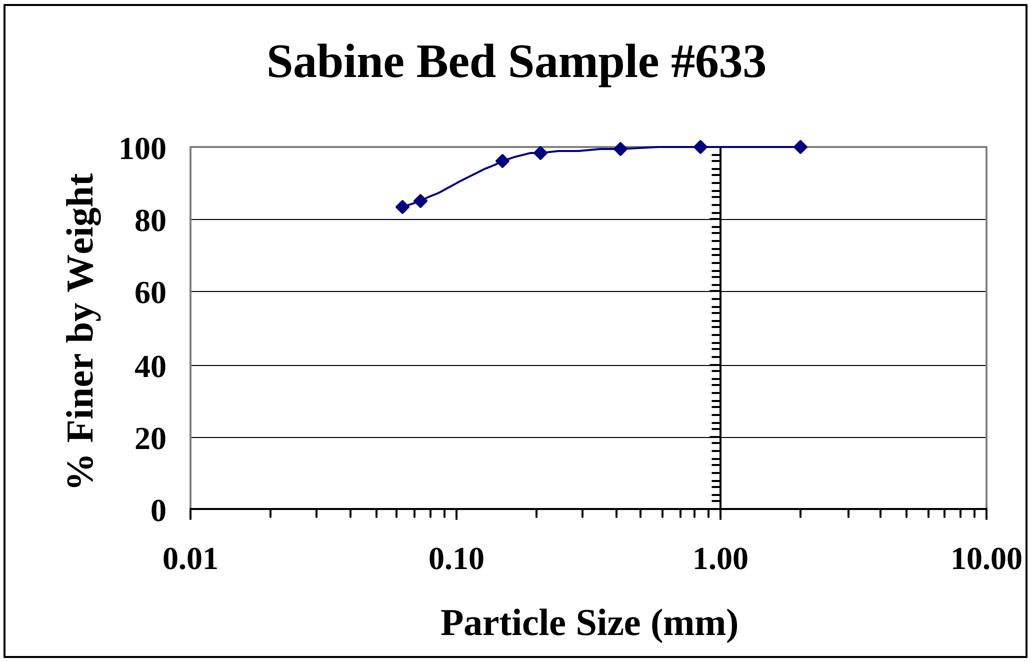



Figure A.49: Particle Size Distribution Curve for Bed Sample #633

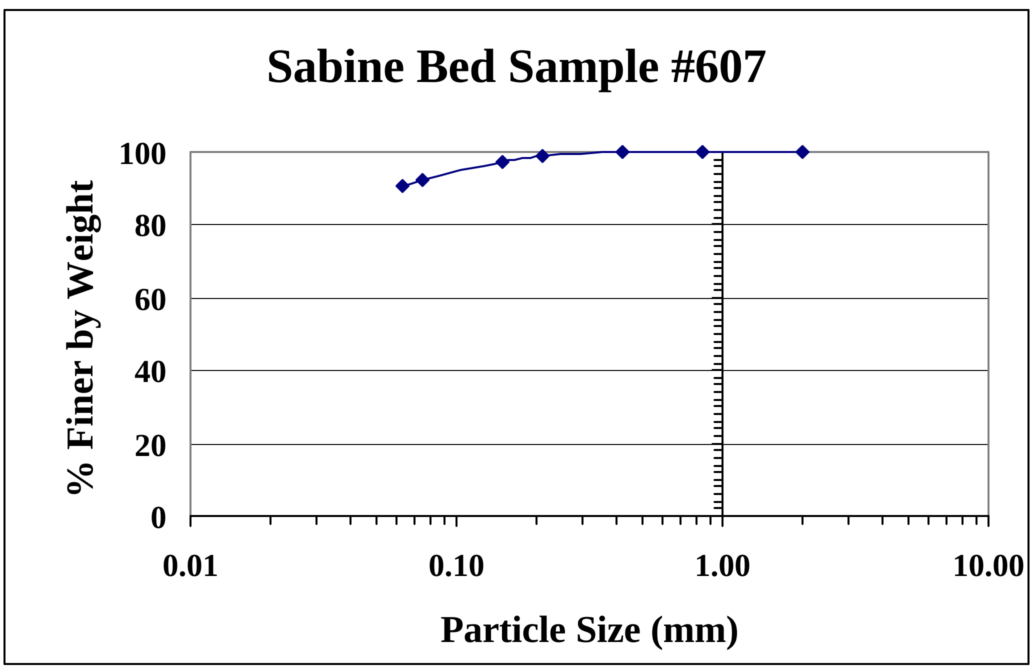



Figure A.50: Particle Size Distribution Curve for Bed Sample #607

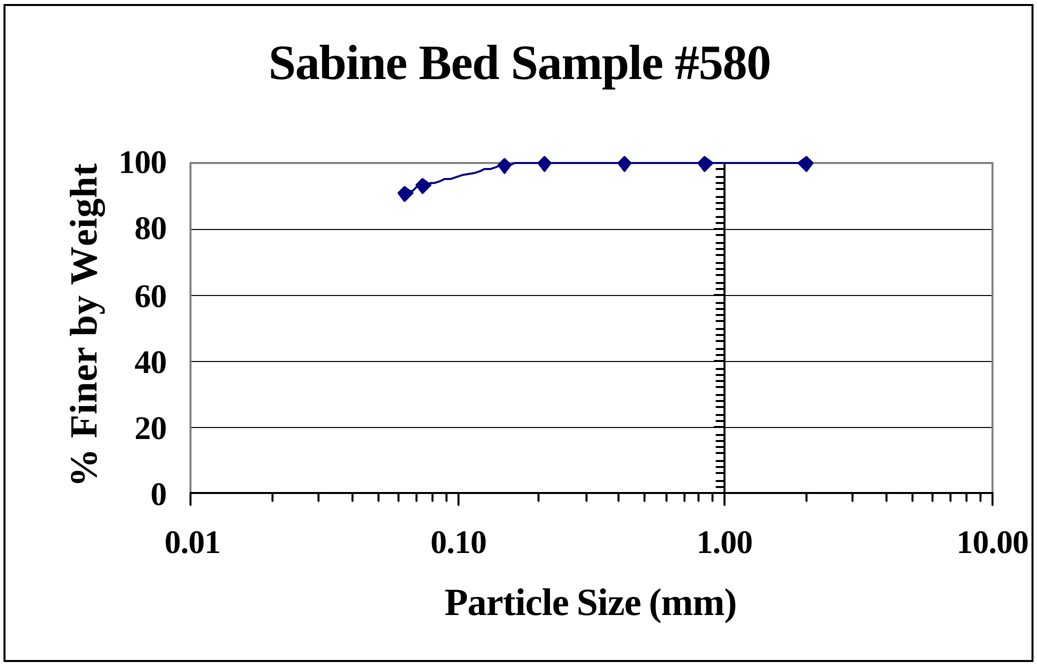



Figure A.51: Particle Size Distribution Curve for Bed Sample #580

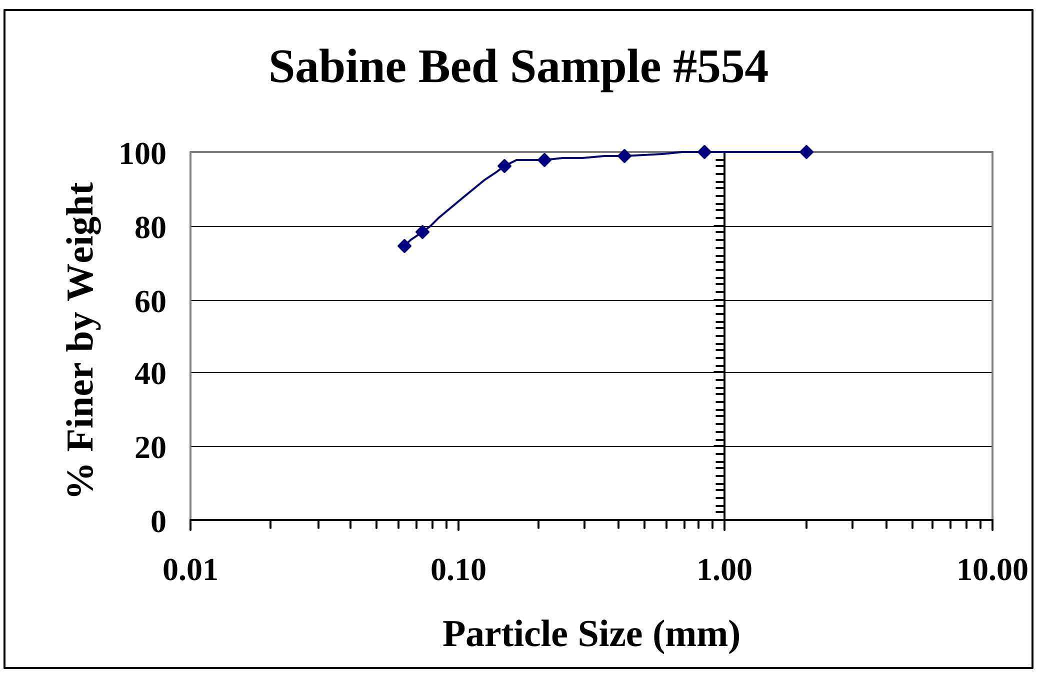



Figure A.52: Particle Size Distribution Curve for Bed Sample #554

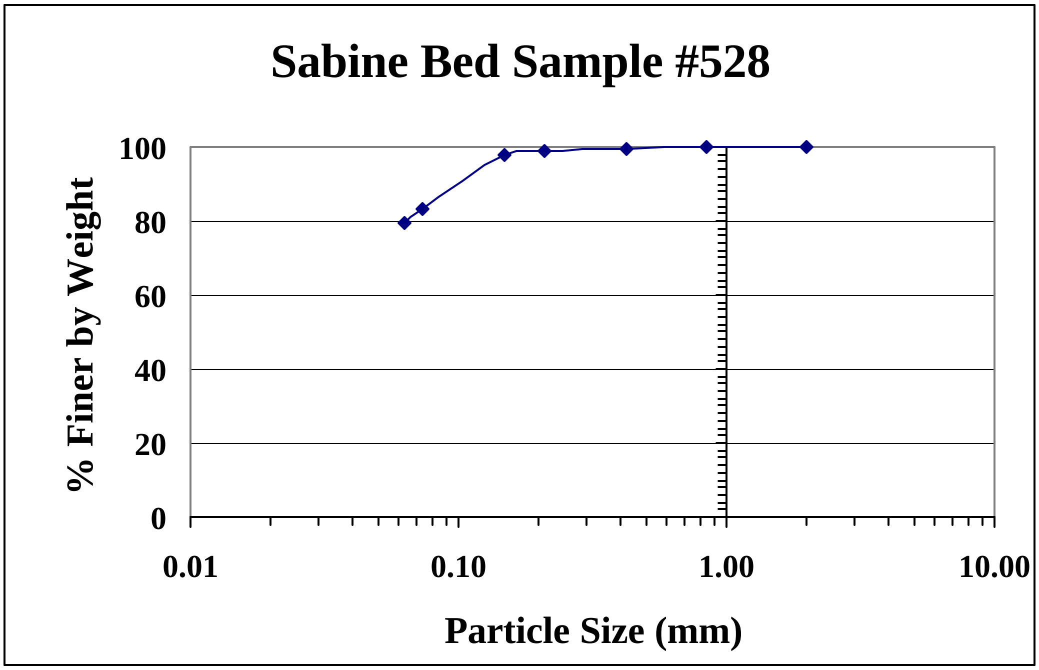



Figure A.53: Particle Size Distribution Curve for Bed Sample #528

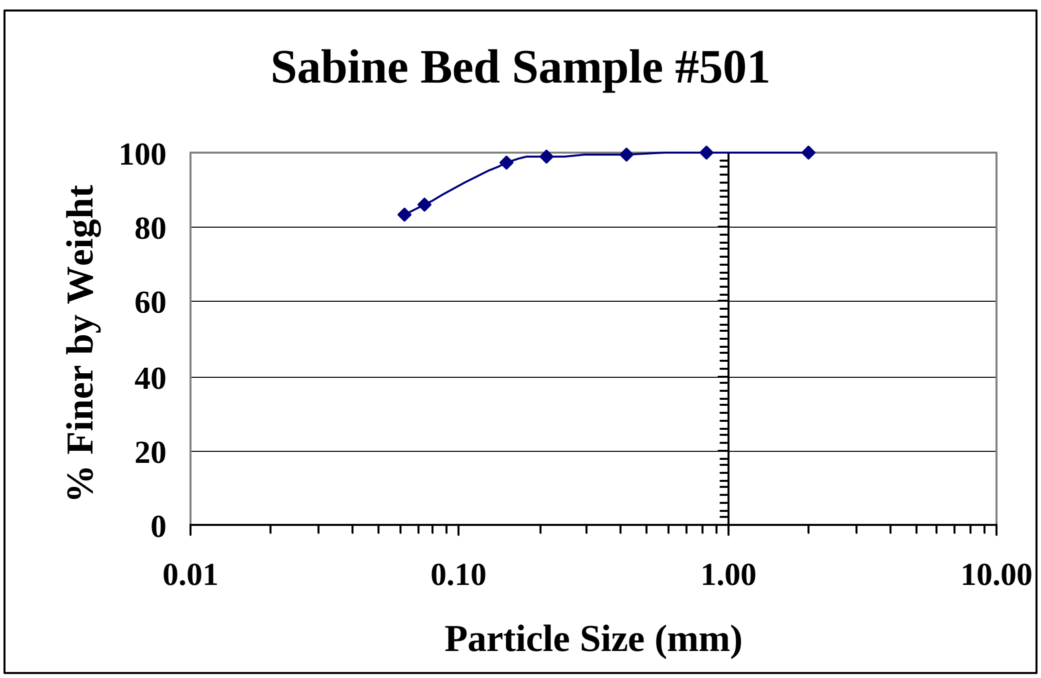



Figure A.54: Particle Size Distribution Curve for Bed Sample #501

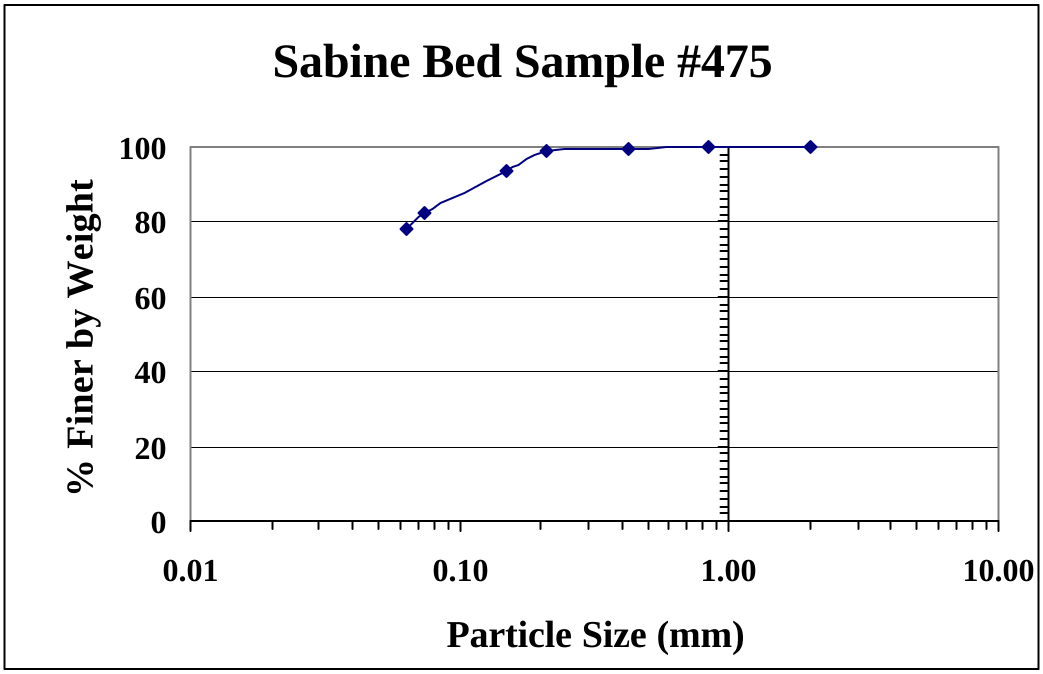



Figure A.55: Particle Size Distribution Curve for Bed Sample #475

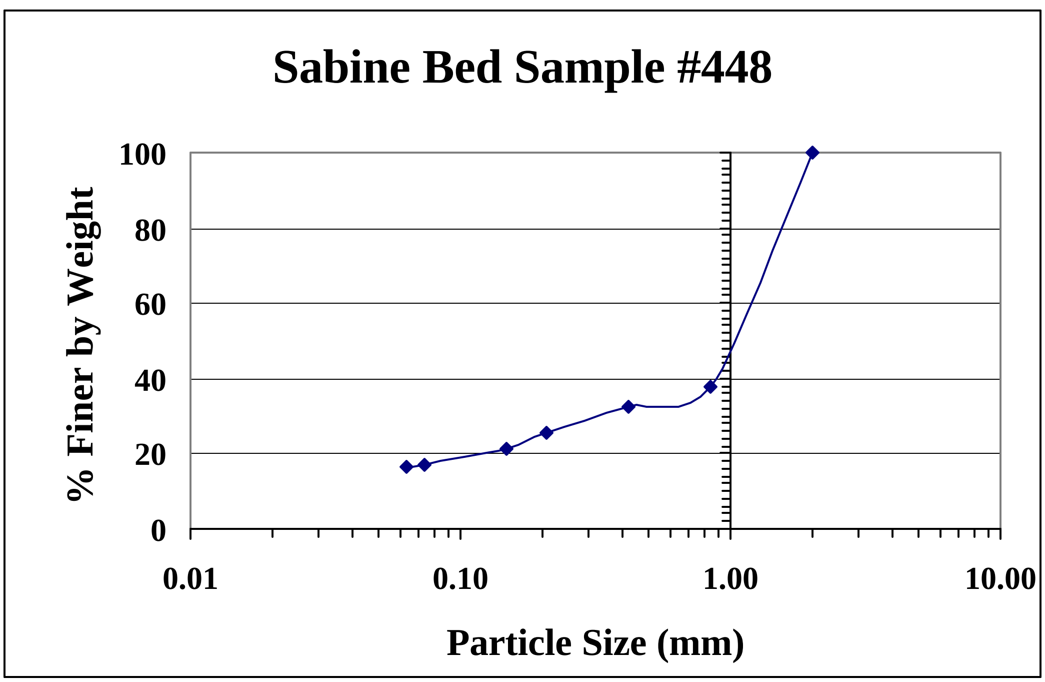



Figure A.56: Particle Size Distribution Curve for Bed Sample #448

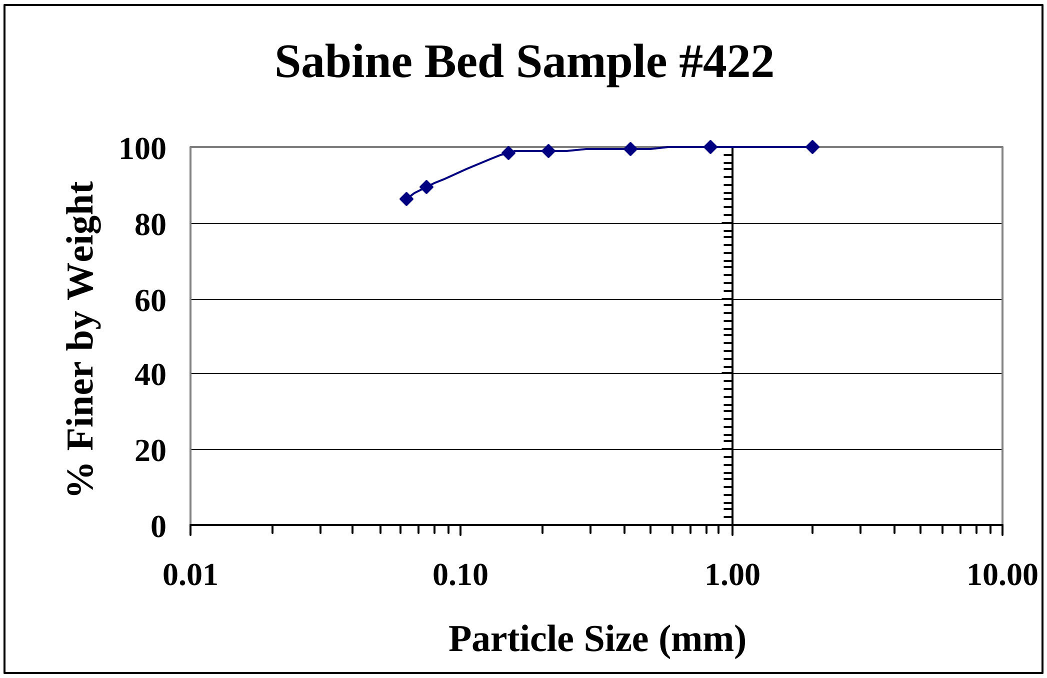



Figure A.57: Particle Size Distribution Curve for Bed Sample #422

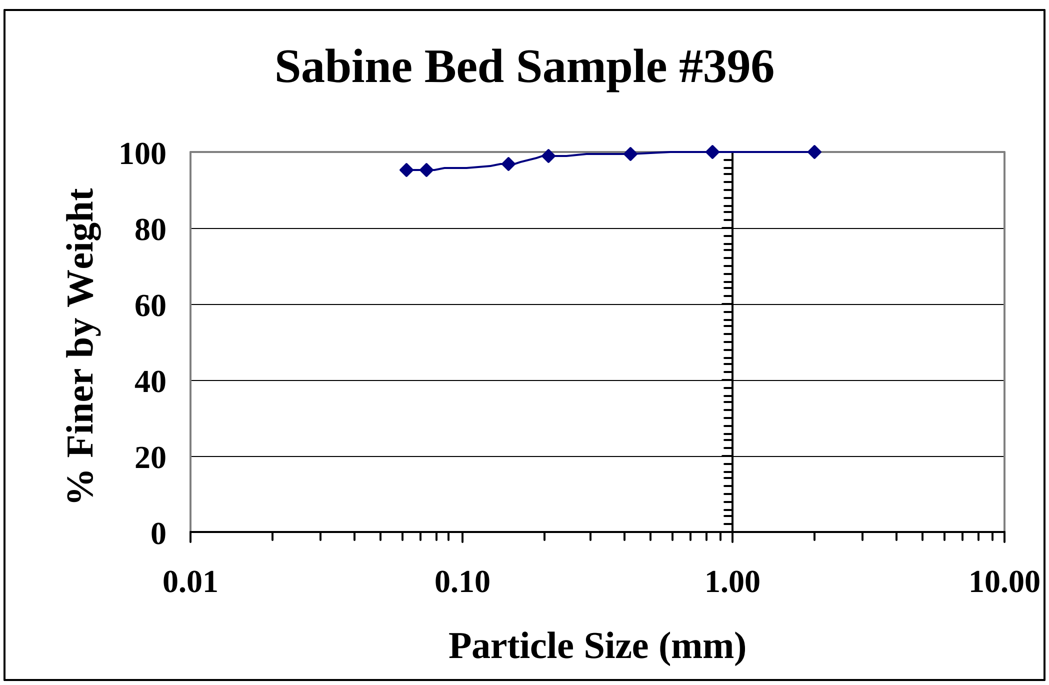



Figure A.58: Particle Size Distribution Curve for Bed Sample #396

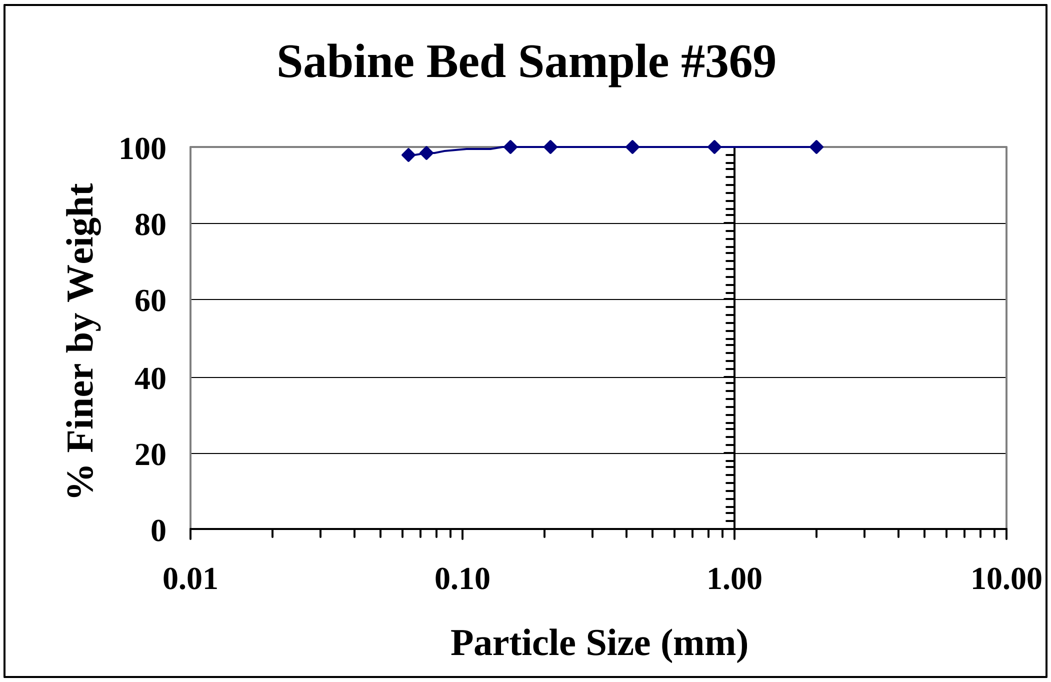



Figure A.59: Particle Size Distribution Curve for Bed Sample #369

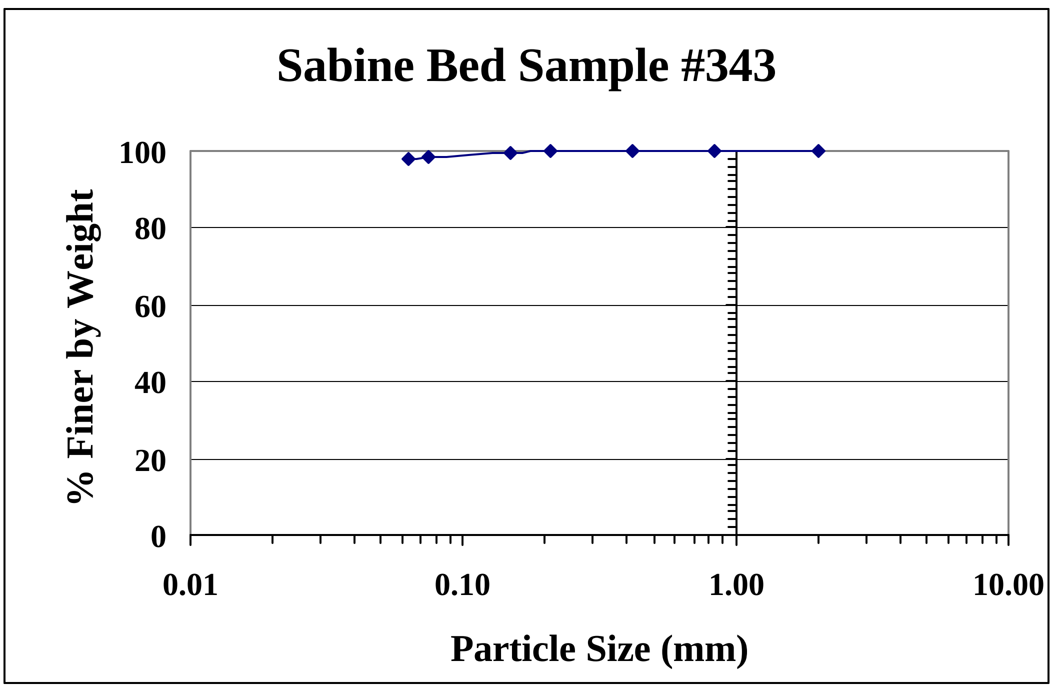



Figure A.60: Particle Size Distribution Curve for Bed Sample #343

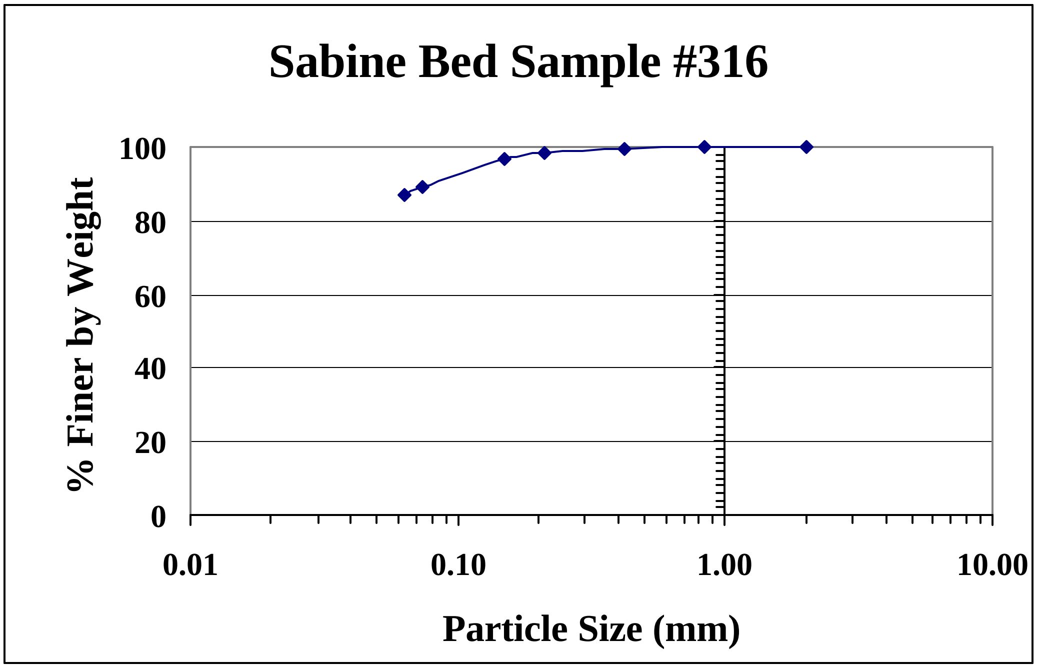



Figure A.61: Particle Size Distribution Curve for Bed Sample #316

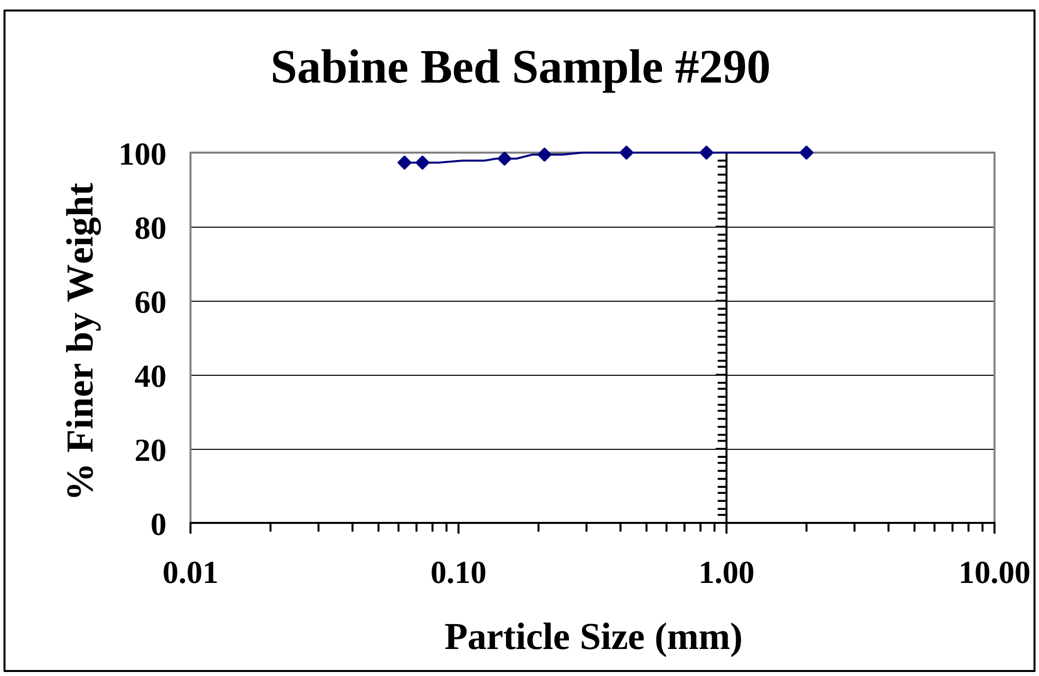



Figure A.62: Particle Size Distribution Curve for Bed Sample #290

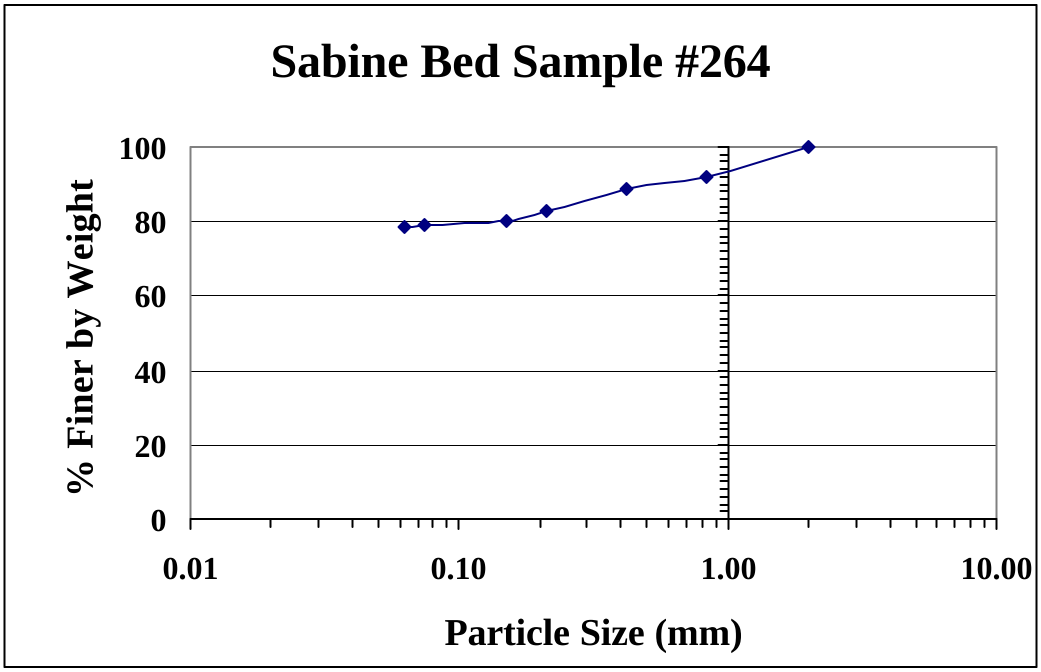



Figure A.63: Particle Size Distribution Curve for Bed Sample #264

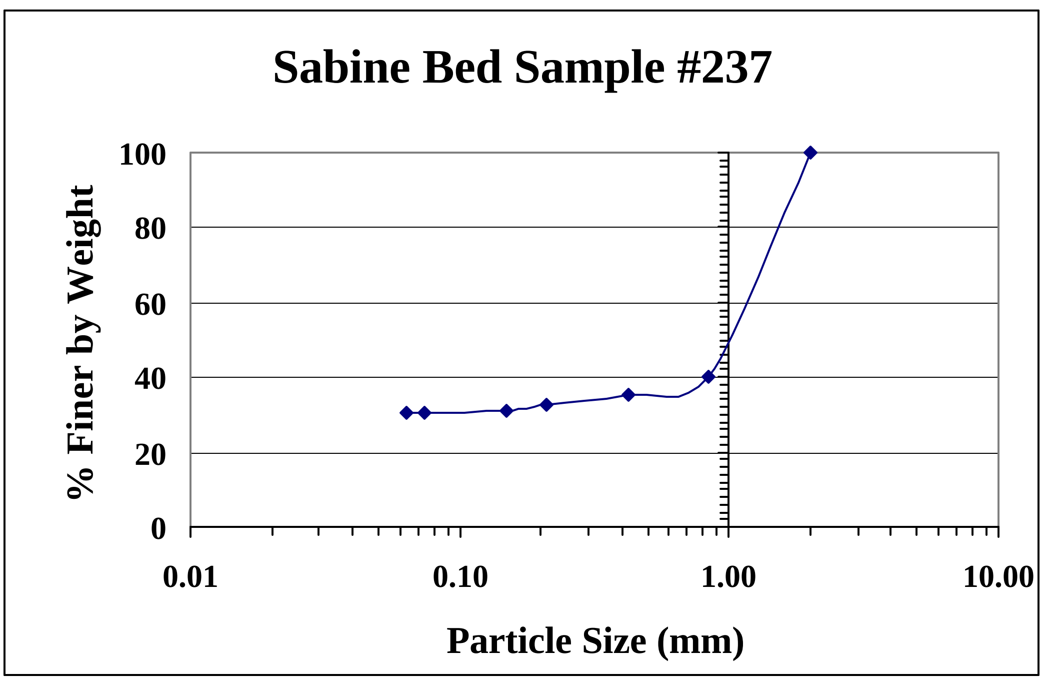



Figure A.64: Particle Size Distribution Curve for Bed Sample #237

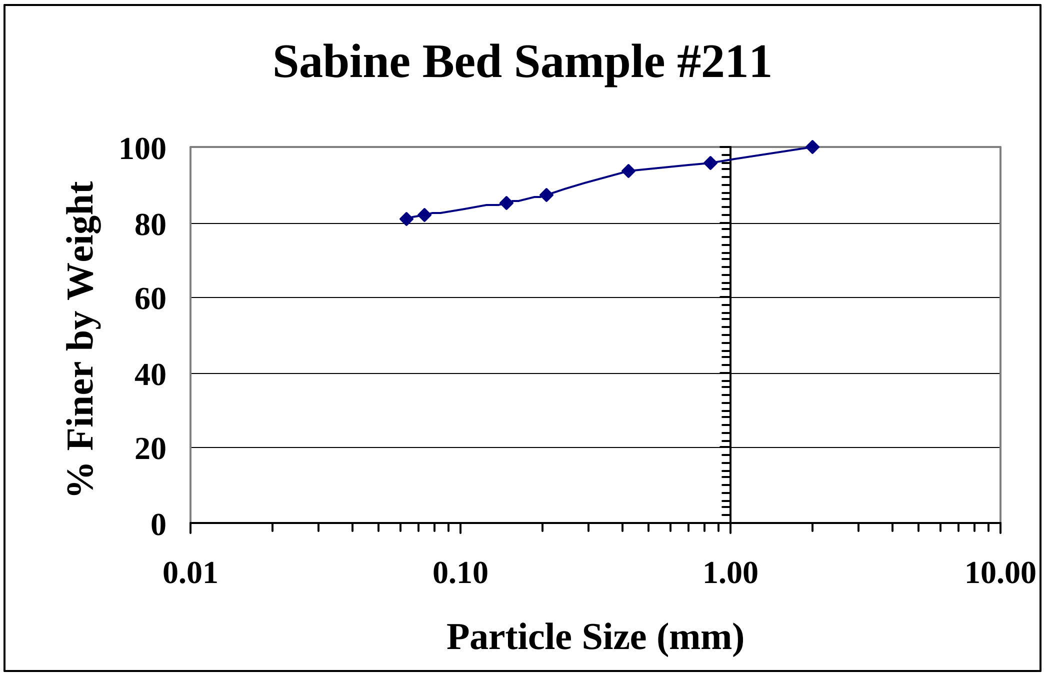



Figure A.65: Particle Size Distribution Curve for Bed Sample #211

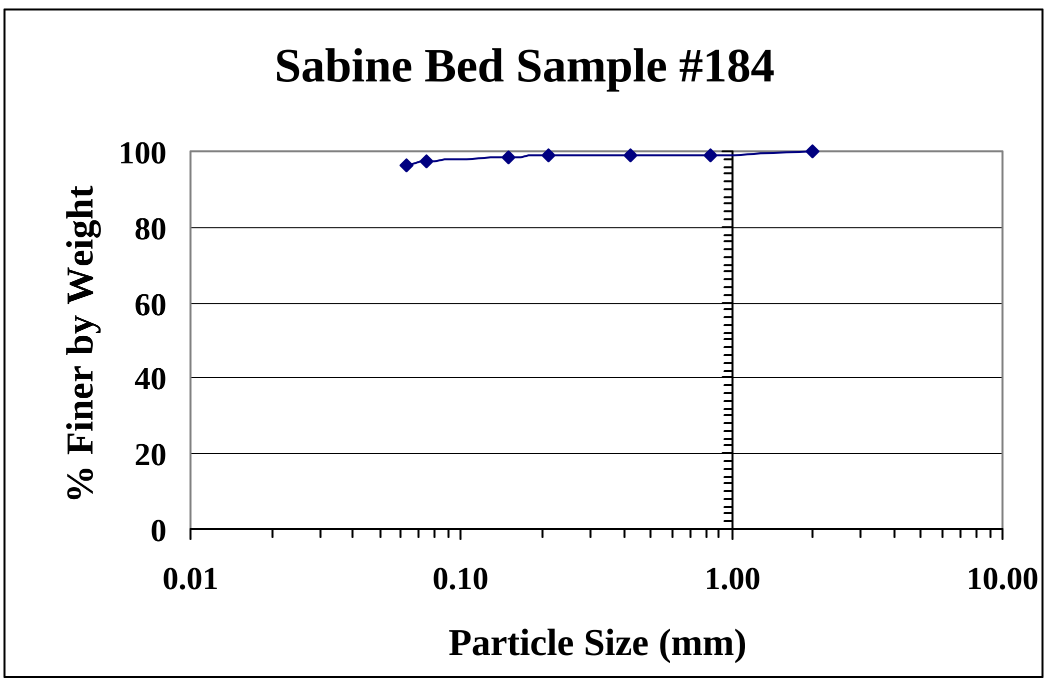



Figure A.66: Particle Size Distribution Curve for Bed Sample #184

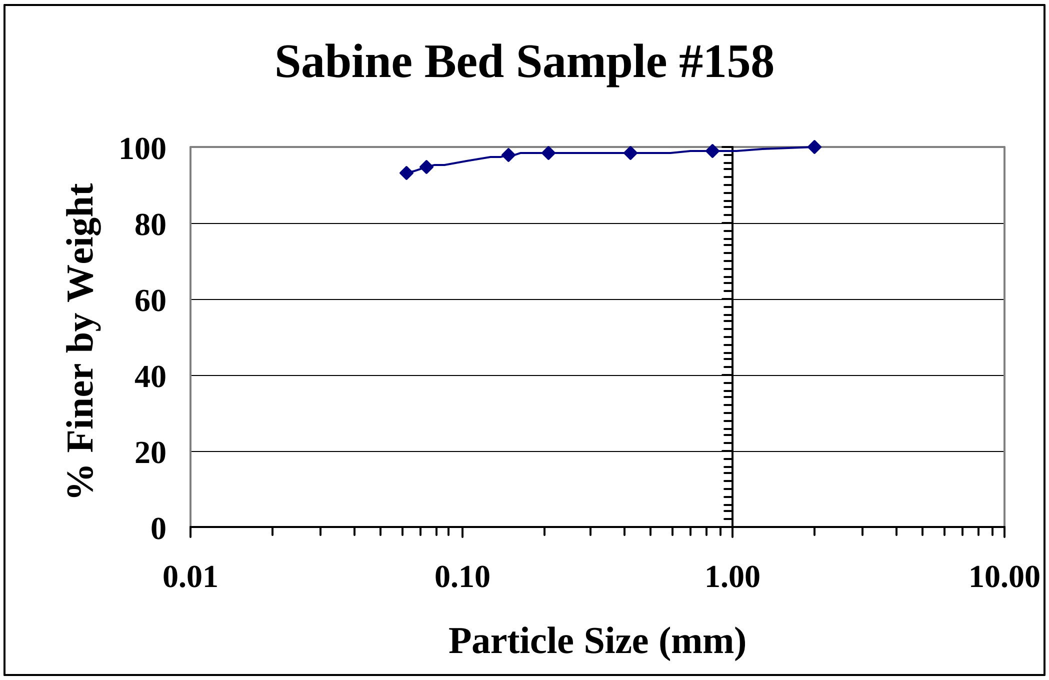



Figure A.67: Particle Size Distribution Curve for Bed Sample #158

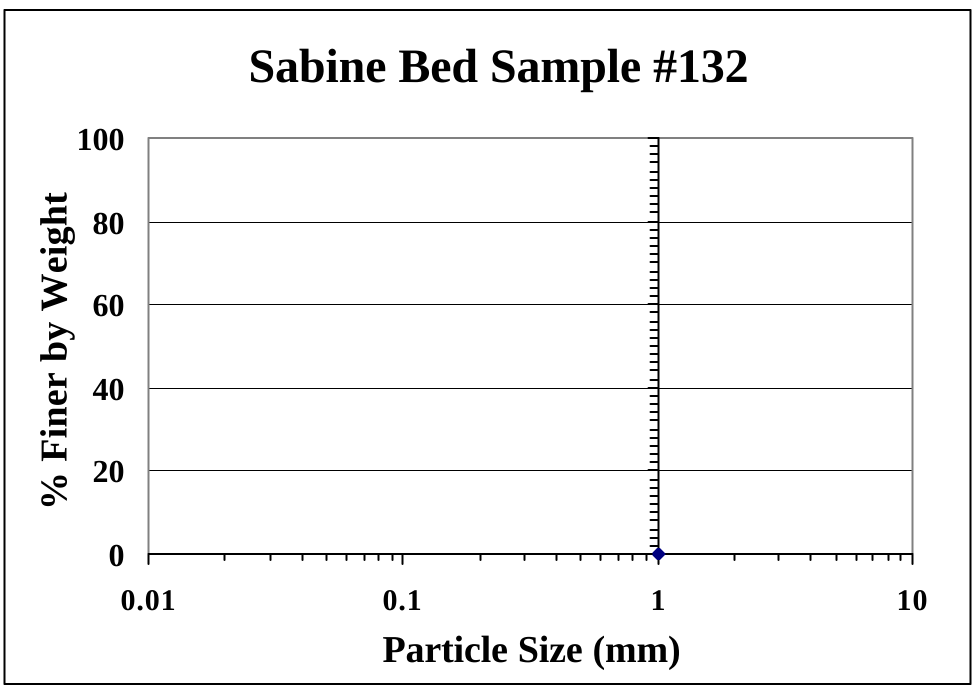



Figure A.68: Particle Size Distribution Curve for Bed Sample #132

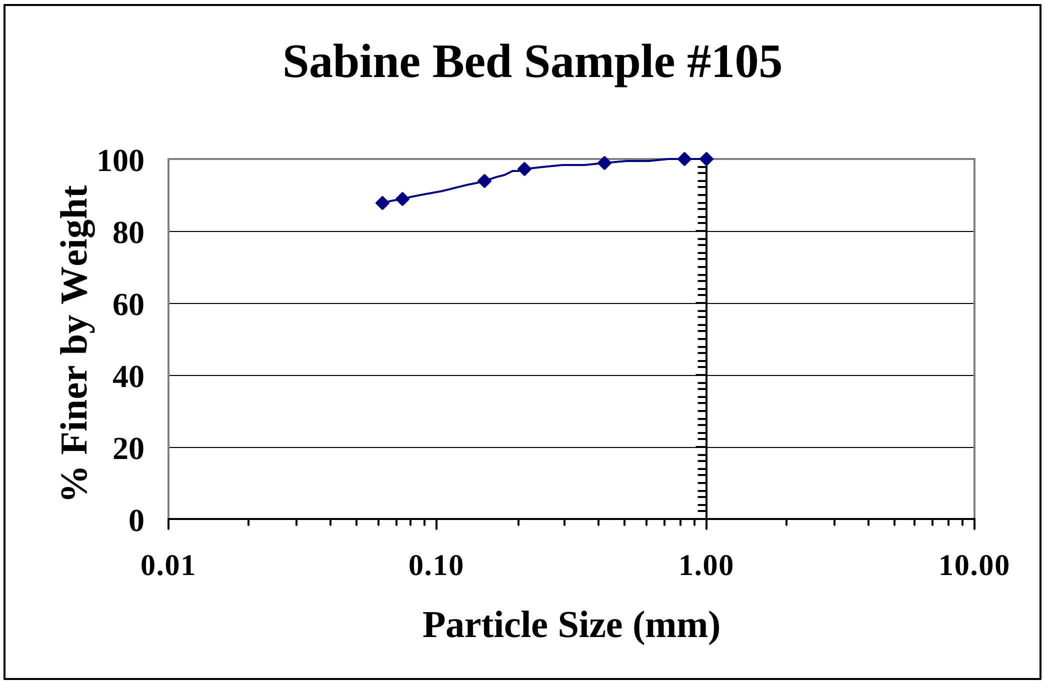



Figure A.69: Particle Size Distribution Curve for Bed Sample #105

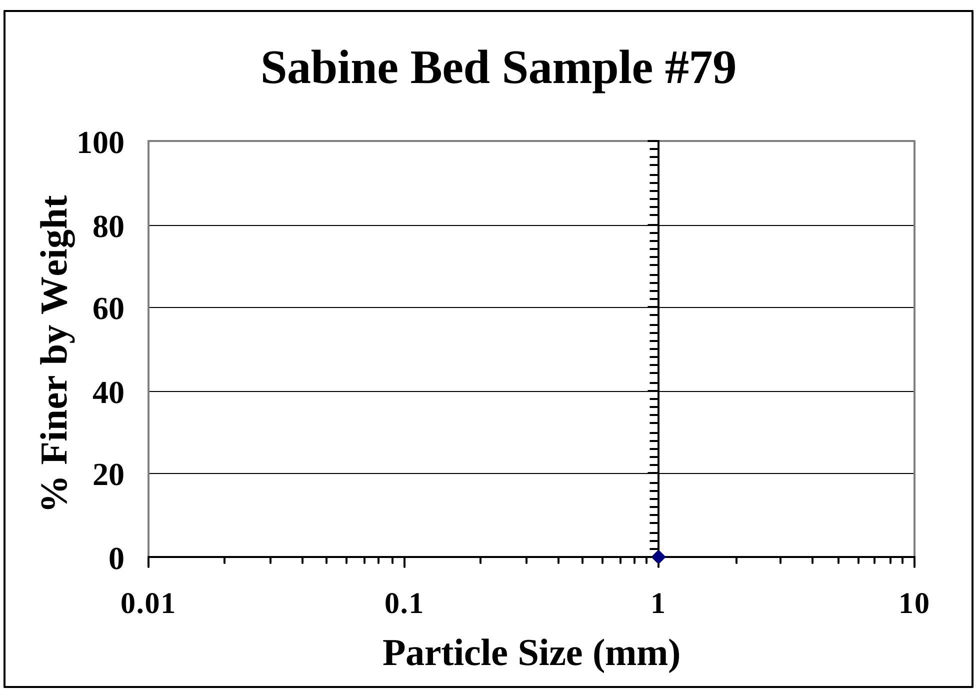



Figure A.70: Particle Size Distribution Curve for Bed Sample #79

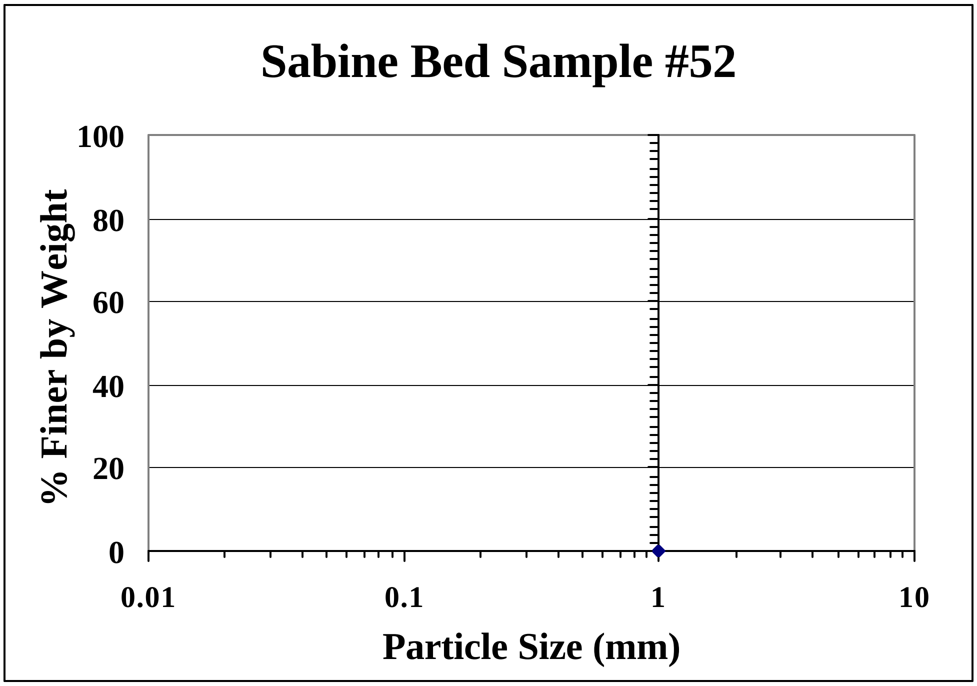



Figure A.71: Particle Size Distribution Curve for Bed Sample #52

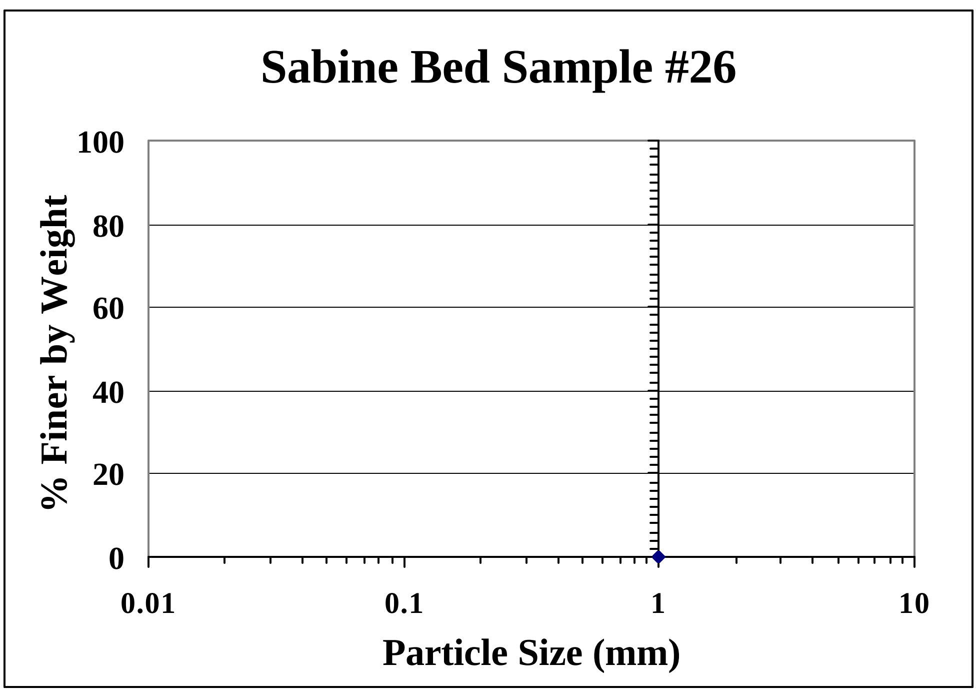



Figure A.72: Particle Size Distribution Curve for Bed Sample #26

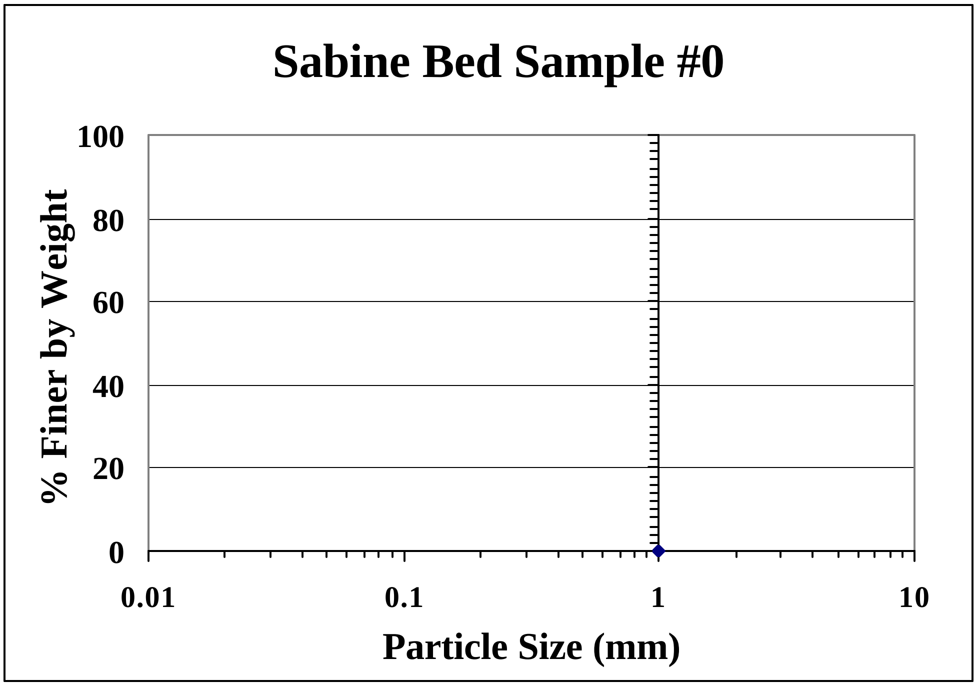



Figure A.73: Particle Size Distribution Curve for Bed Sample #0

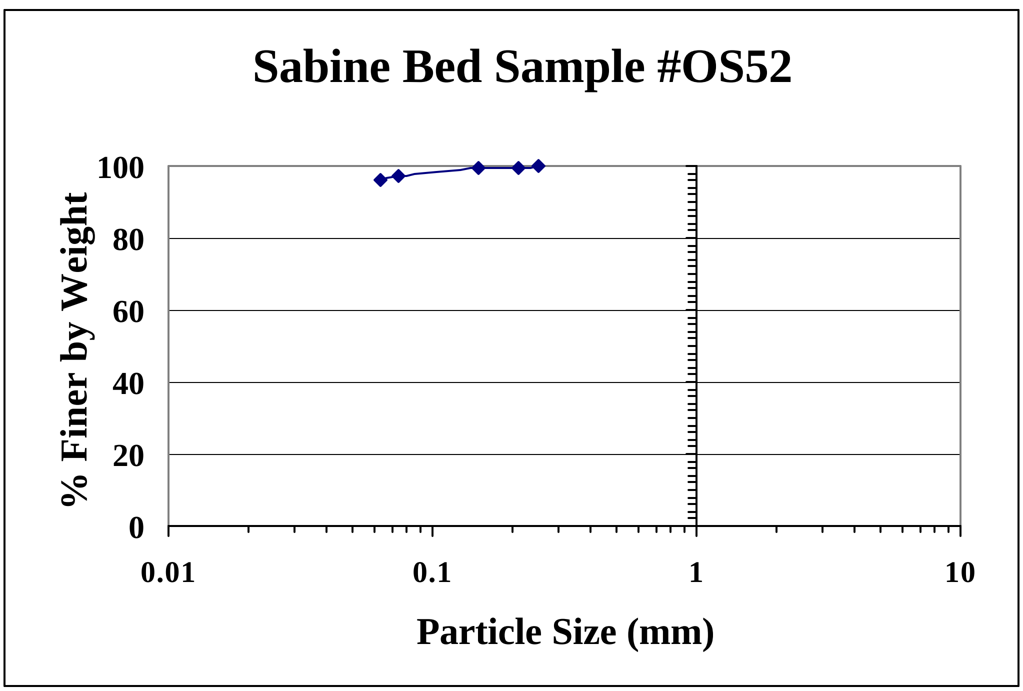



Figure A.74: Particle Size Distribution Curve for Bed Sample #OS52

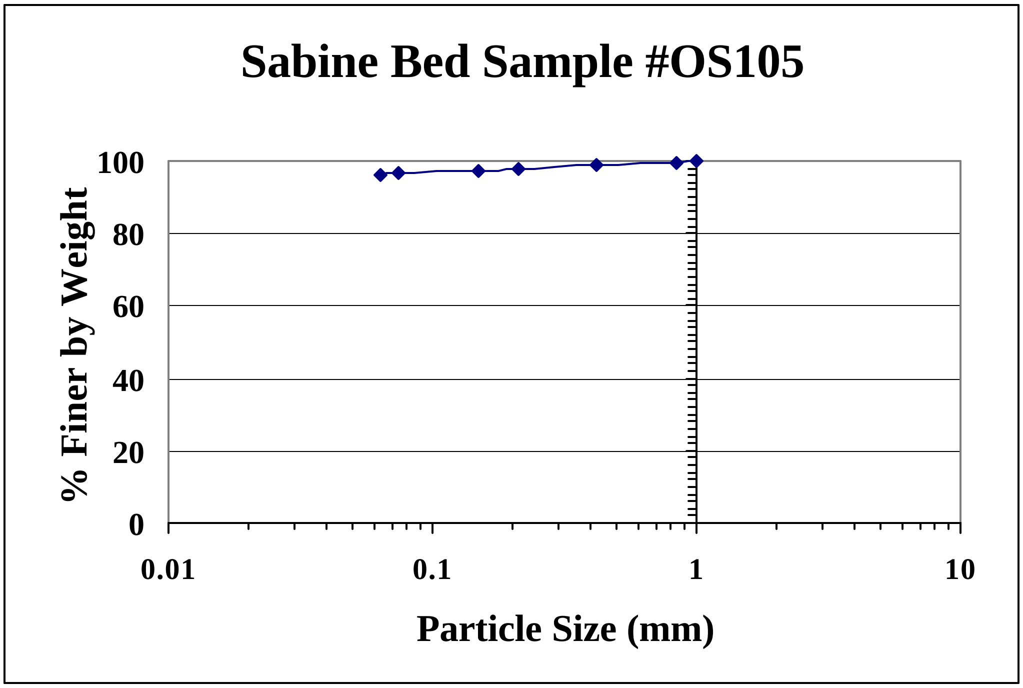



Figure A.75: Particle Size Distribution Curve for Bed Sample #OS105

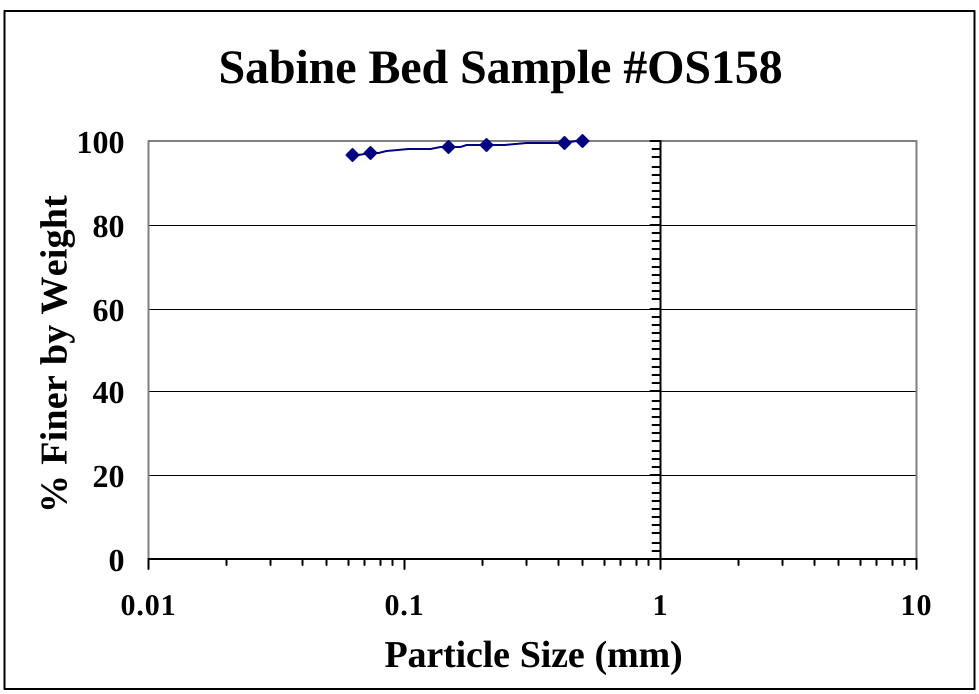



Figure A.76: Particle Size Distribution Curve for Bed Sample #OS158

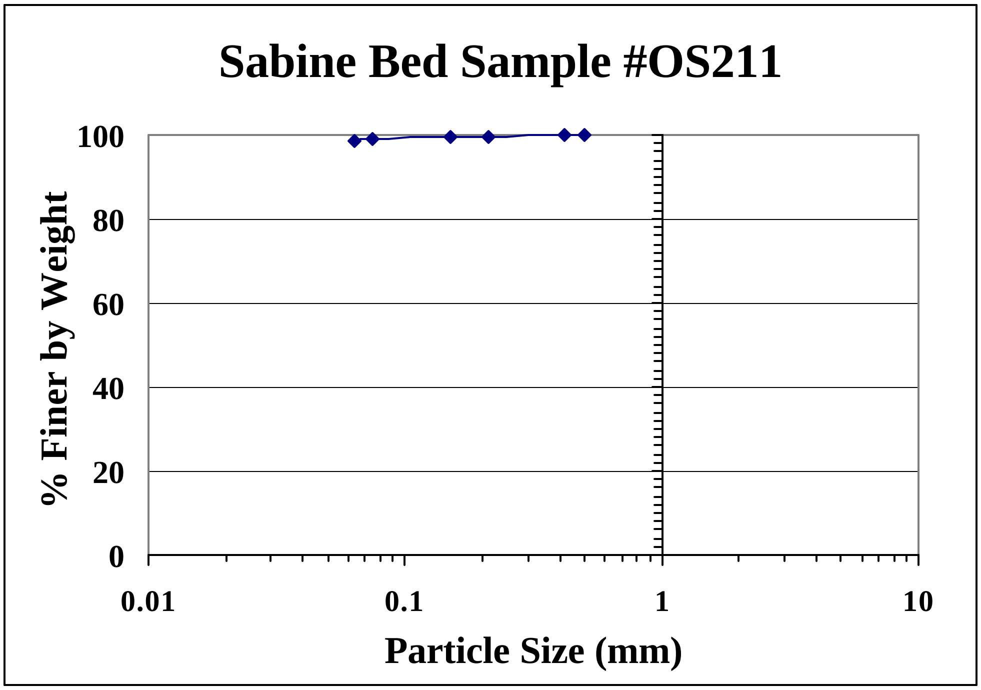



Figure A.77: Particle Size Distribution Curve for Bed Sample #OS211

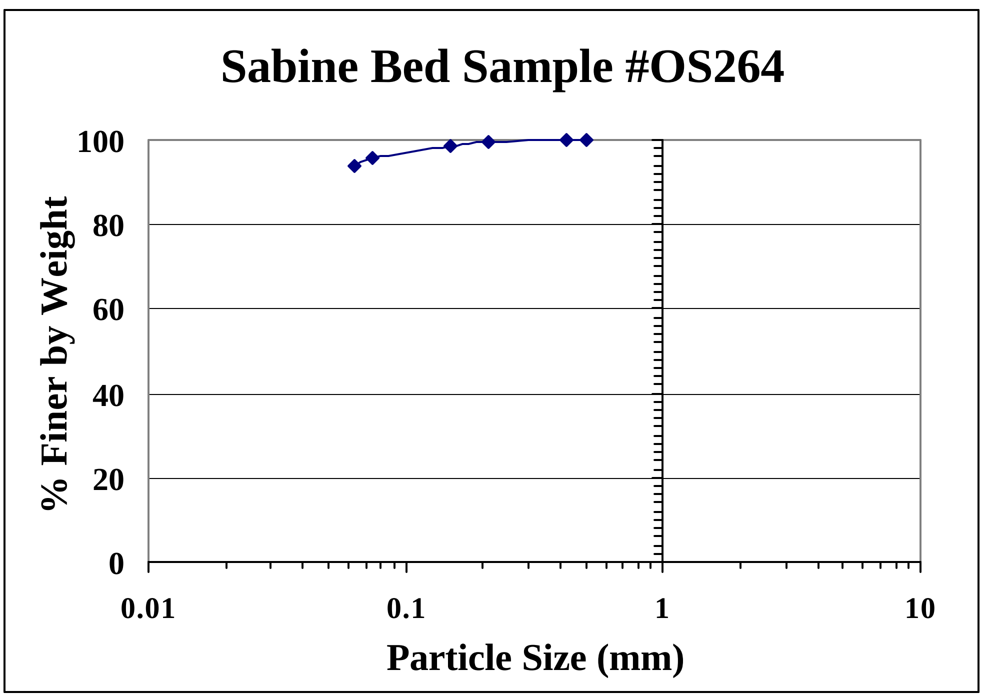



Figure A.78: Particle Size Distribution Curve for Bed Sample #OS264

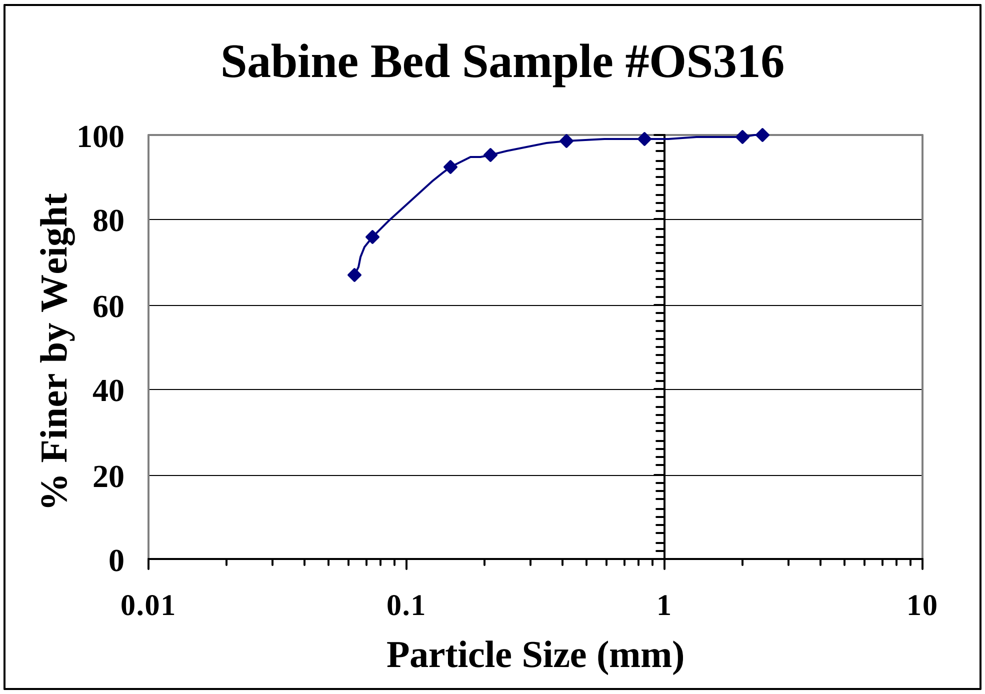



Figure A.79: Particle Size Distribution Curve for Bed Sample #OS316

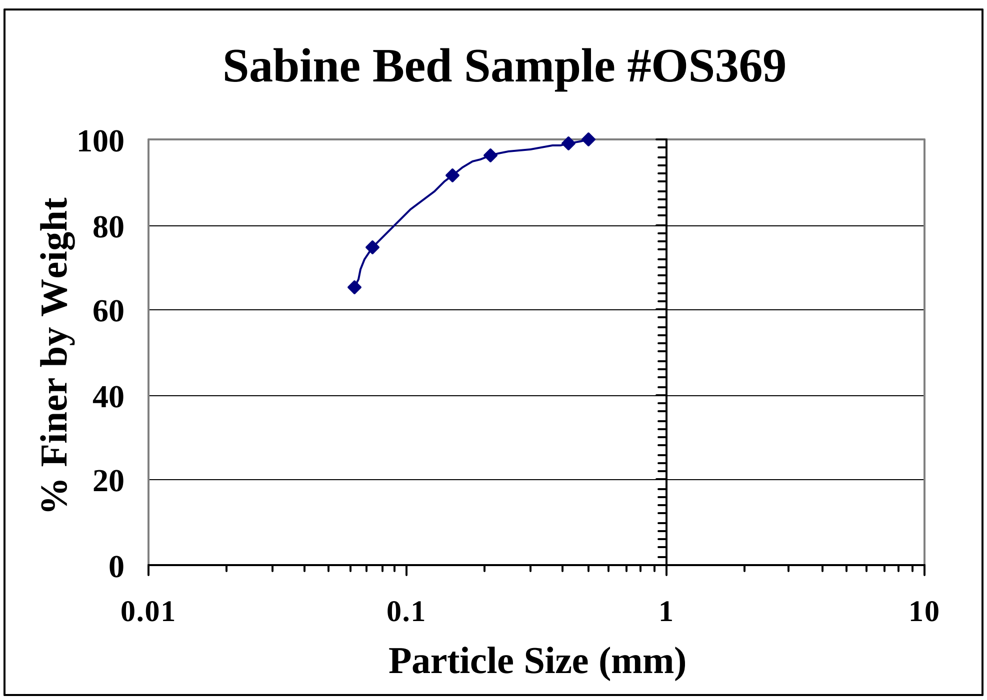



Figure A.80: Particle Size Distribution Curve for Bed Sample #OS369

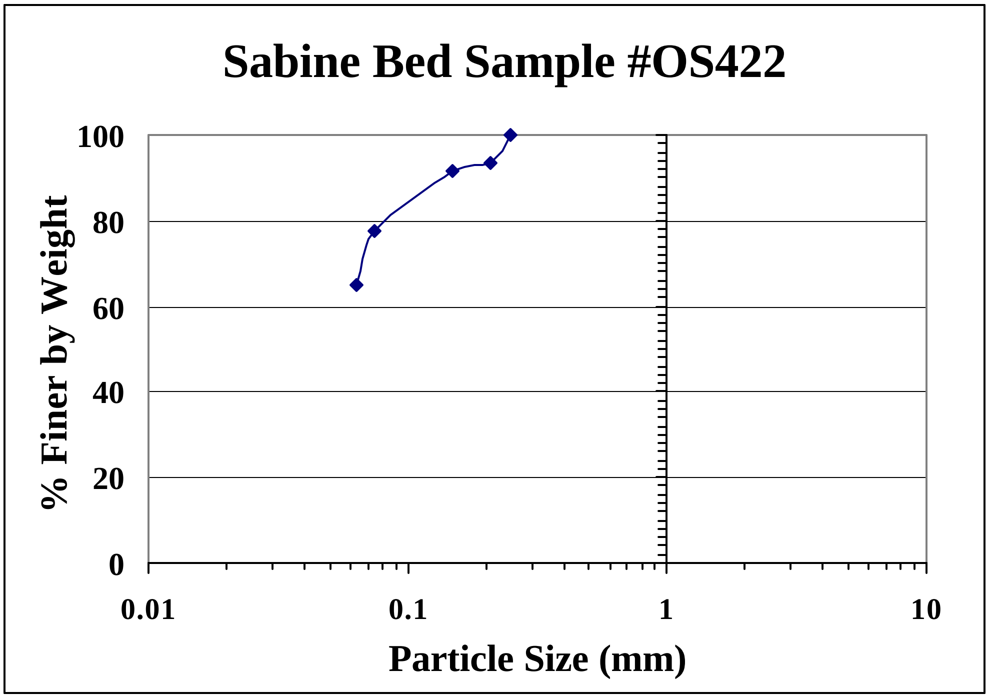



Figure A.81: Particle Size Distribution Curve for Bed Sample #OS422

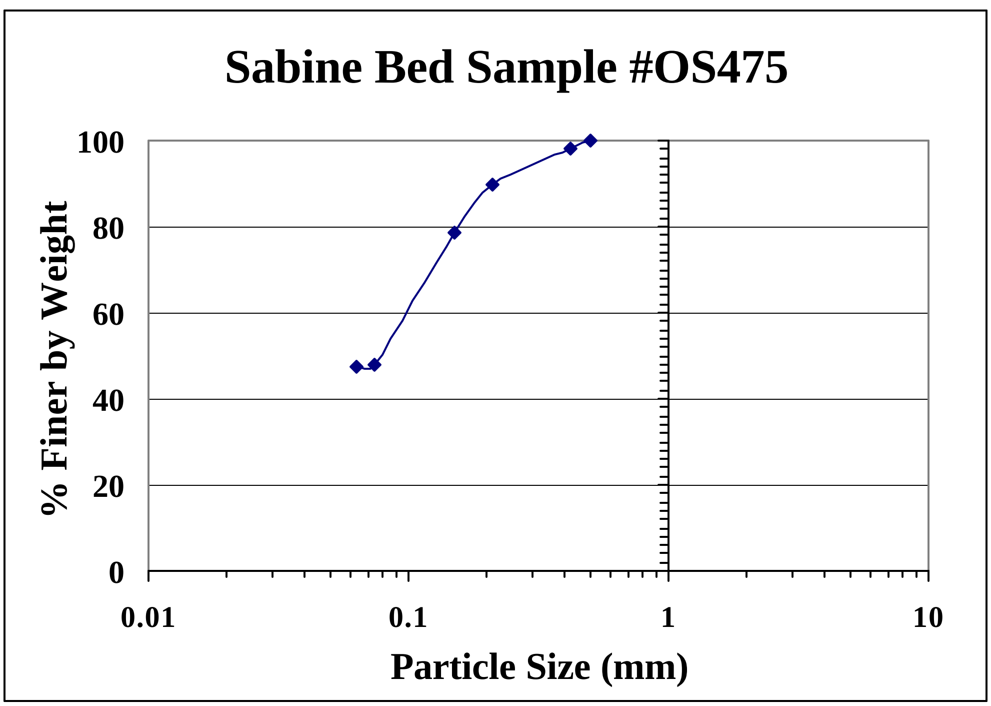



Figure A.82: Particle Size Distribution Curve for Bed Sample #OS475

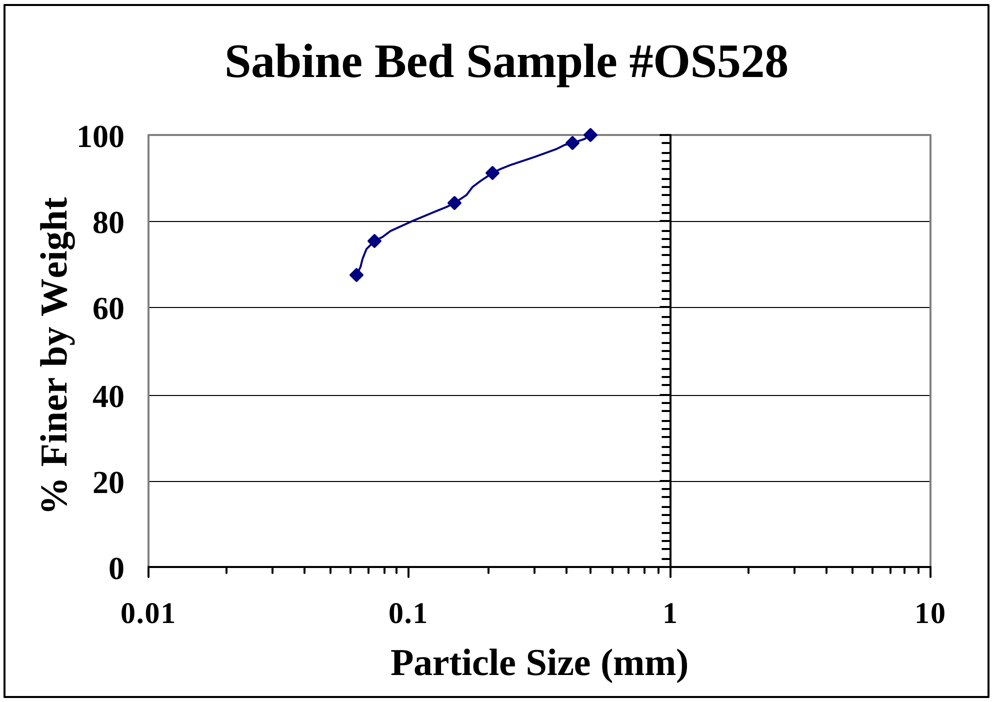



Figure A.82: Particle Size Distribution Curve for Bed Sample #OS475

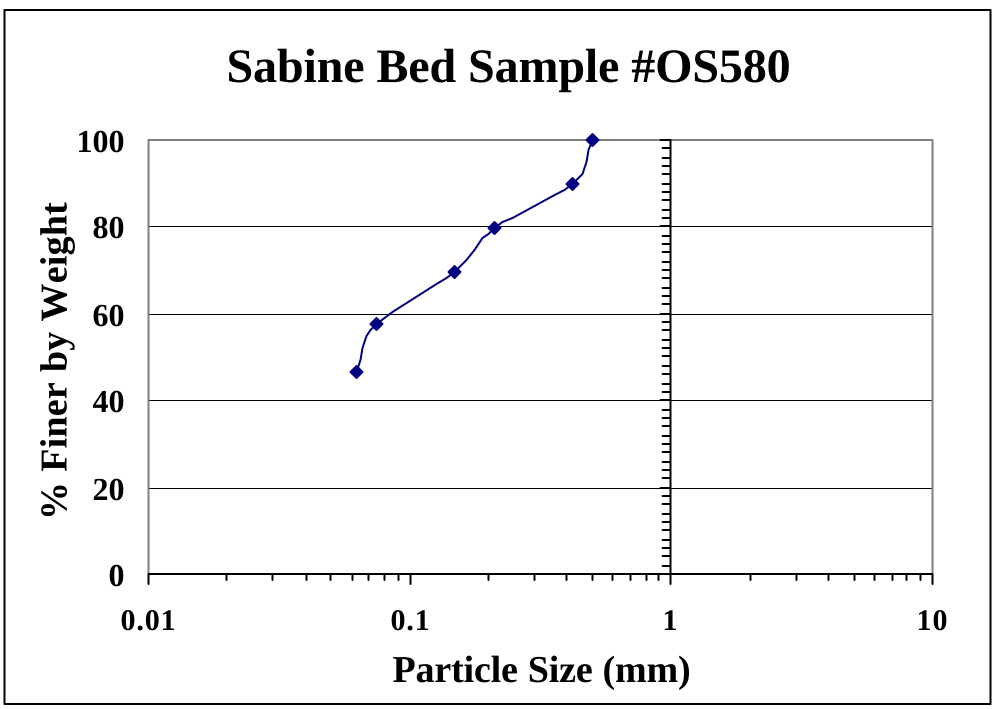



Figure A.84: Particle Size Distribution Curve for Bed Sample #OS580

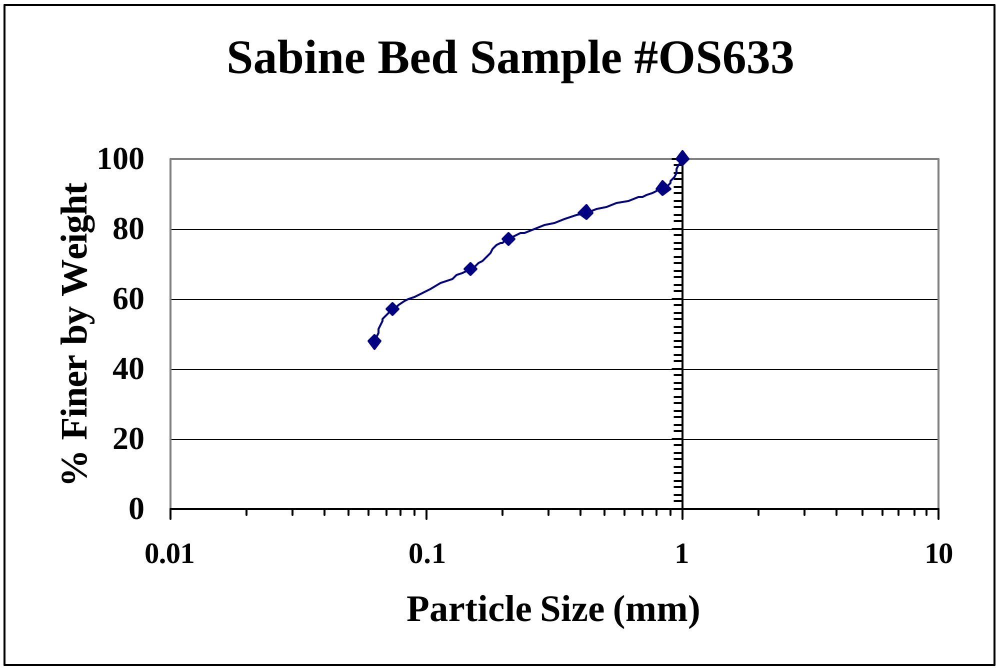



Figure A.85: Particle Size Distribution Curve for Bed Sample #OS633

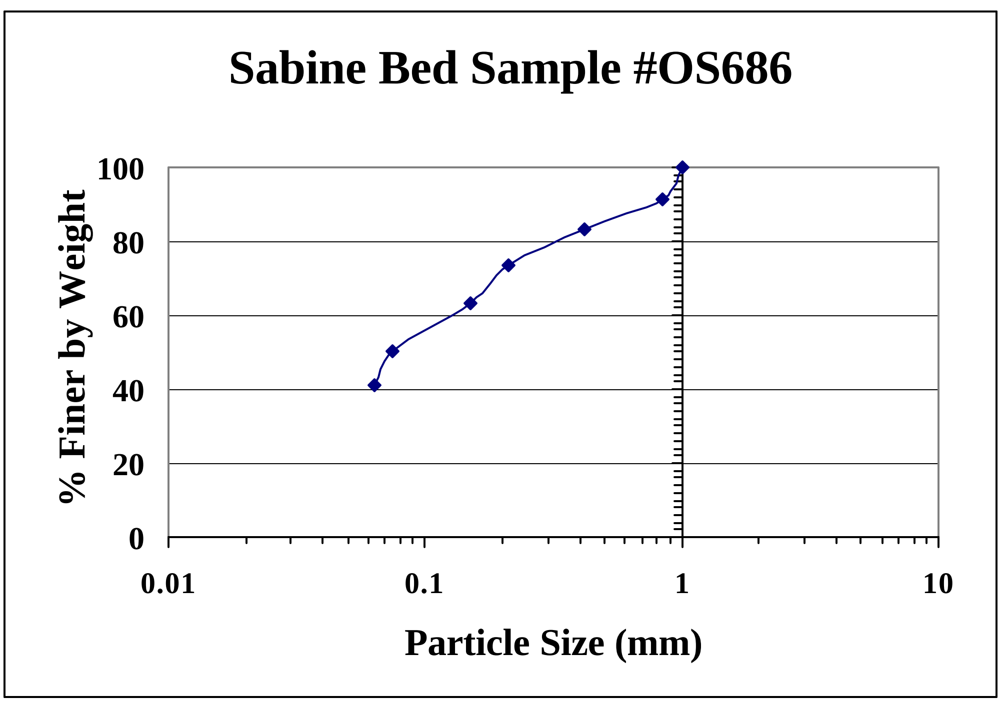



Figure A.86: Particle Size Distribution Curve for Bed Sample #OS686

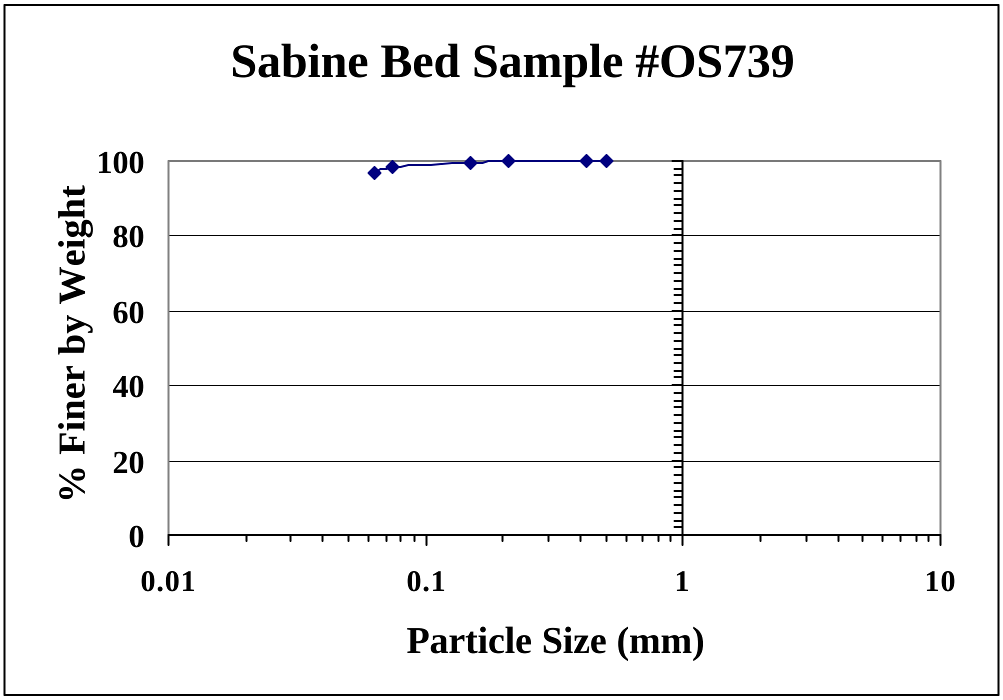



Figure A.87: Particle Size Distribution Curve for Bed Sample #OS739

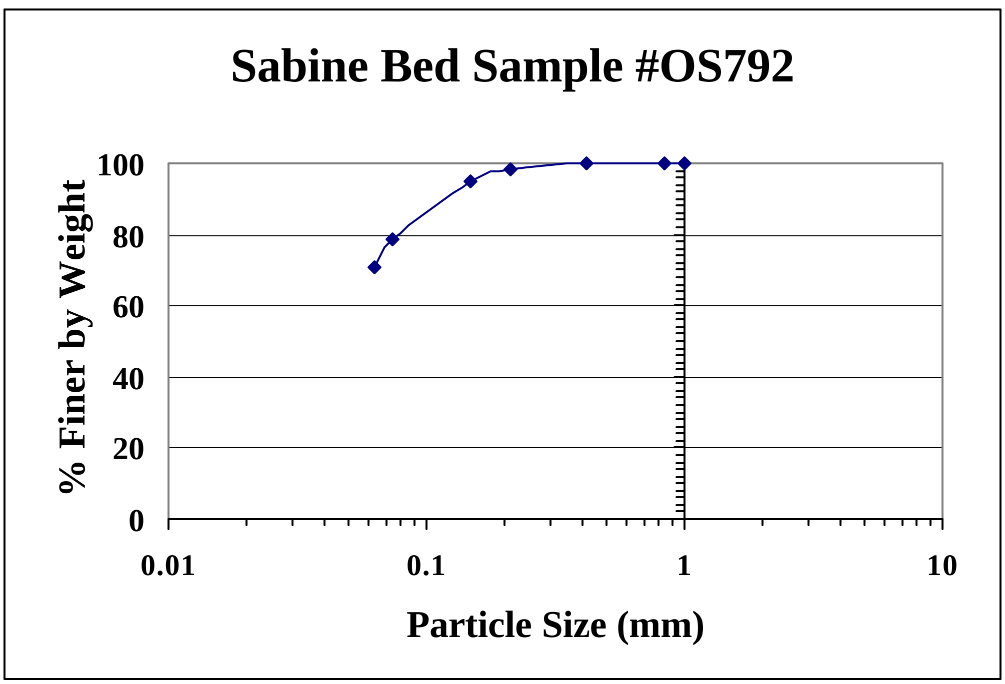



Figure A.88: Particle Size Distribution Curve for Bed Sample #OS792

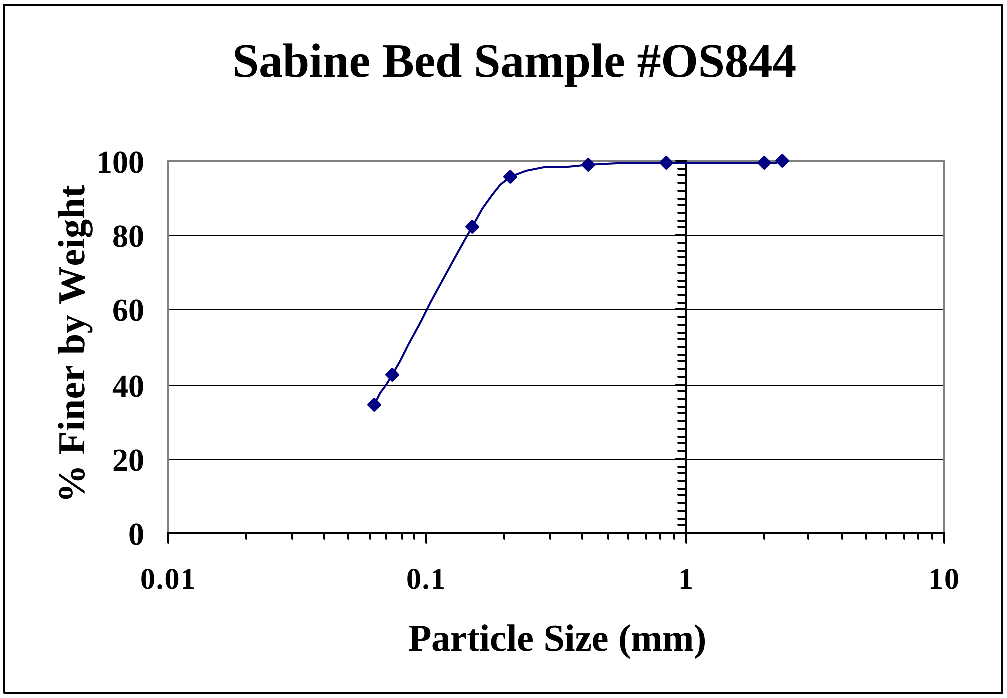



Figure A.89: Particle Size Distribution Curve for Bed Sample #OS844

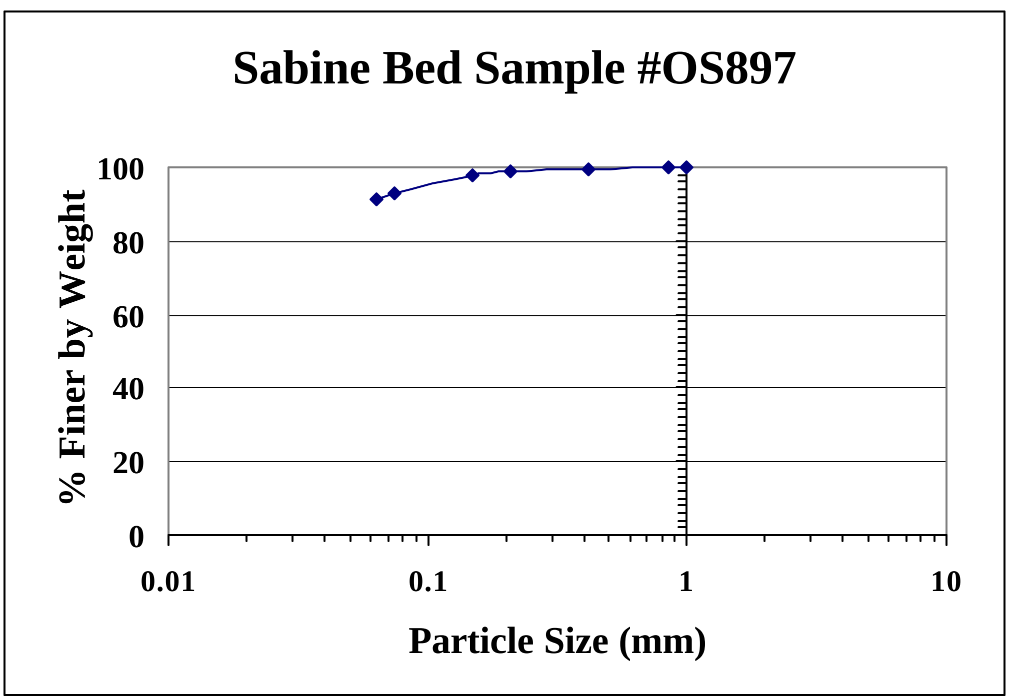



Figure A.90: Particle Size Distribution Curve for Bed Sample #OS897

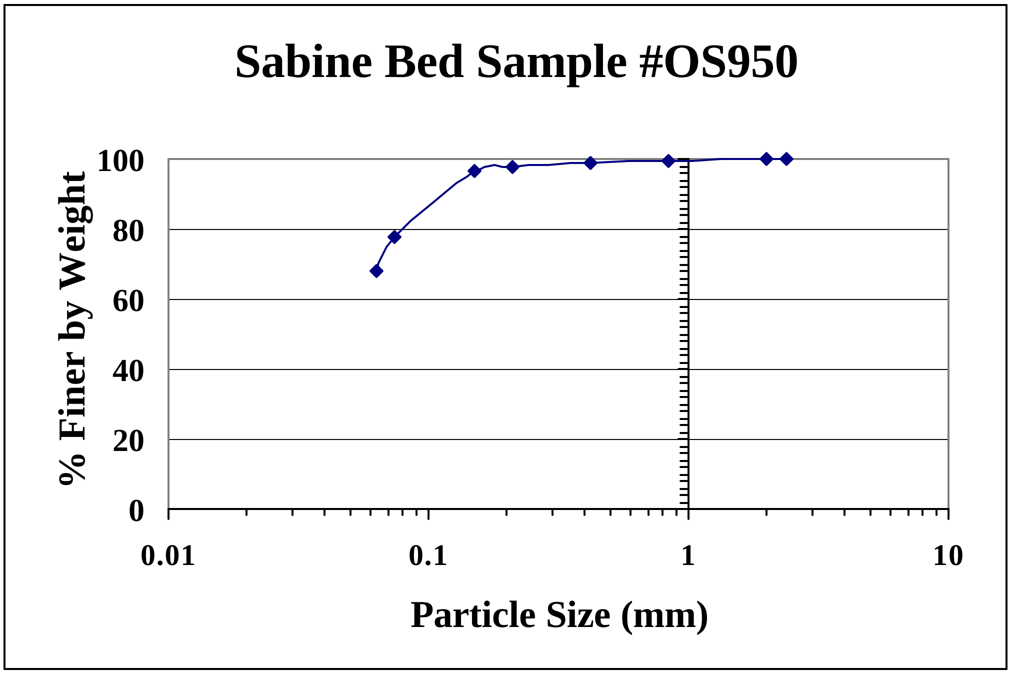



Figure A.91: Particle Size Distribution Curve for Bed Sample #OS950

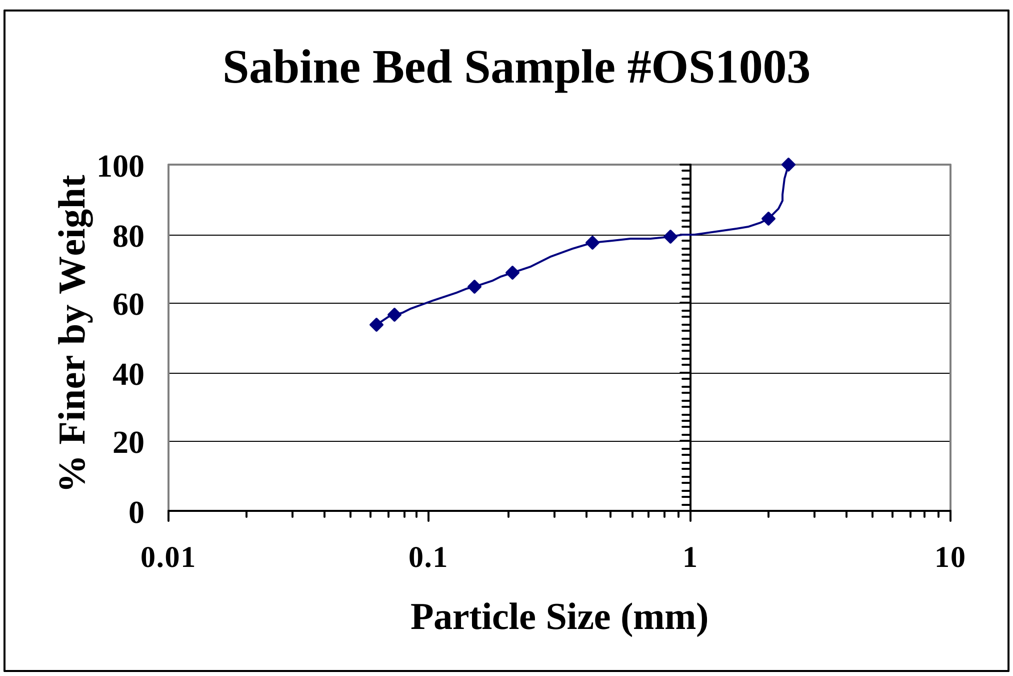
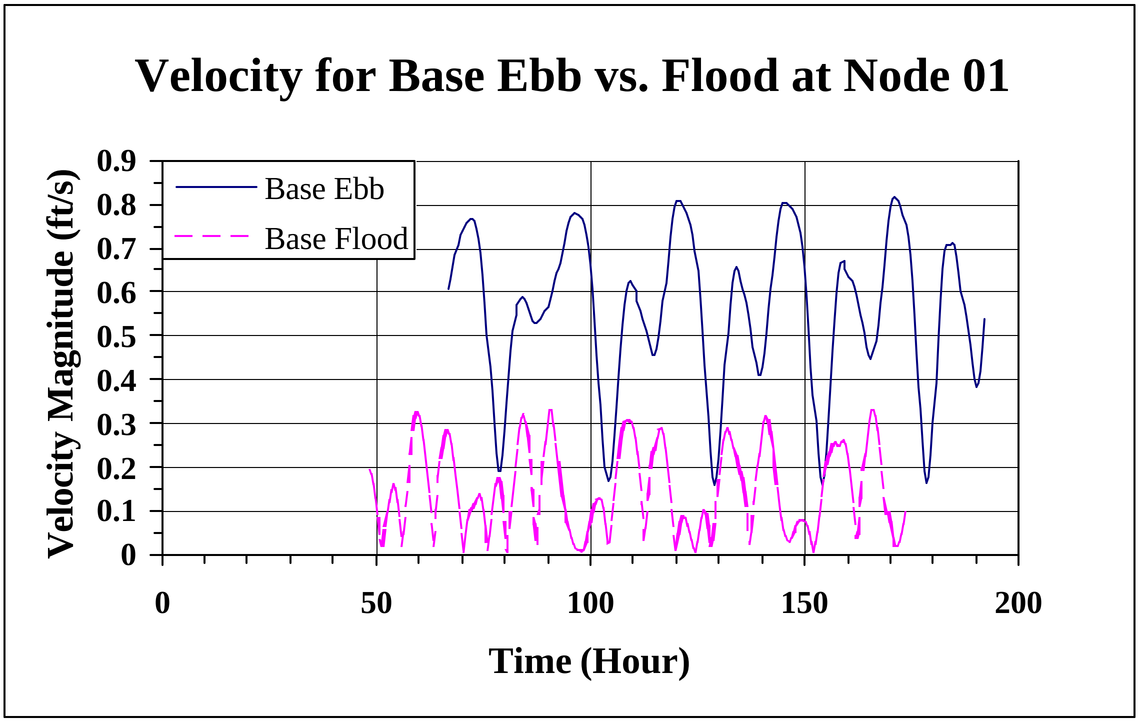
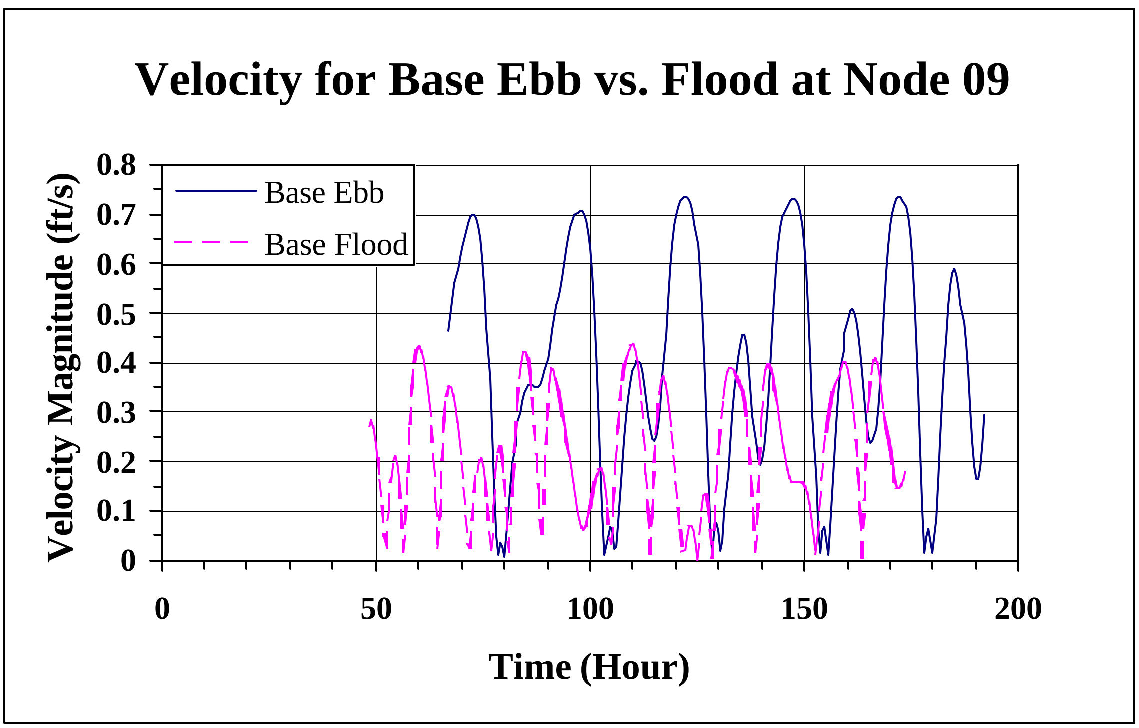


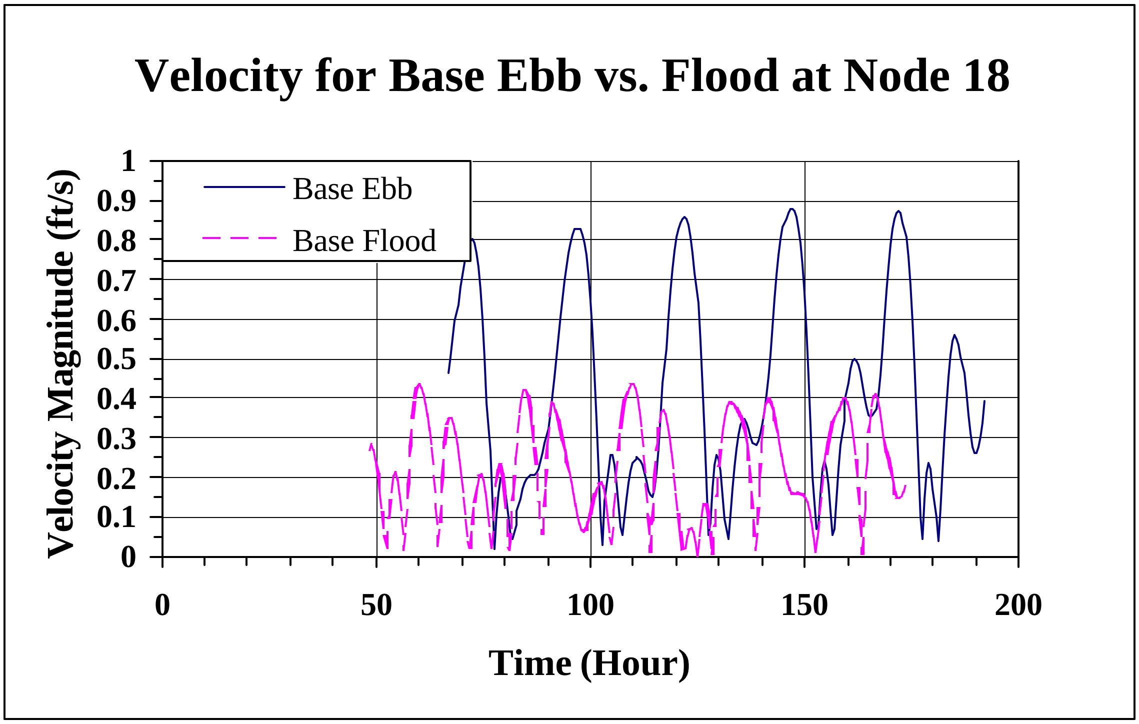

Figure A.92: Particle Size Distribution Curve for Bed Sample #OS1003

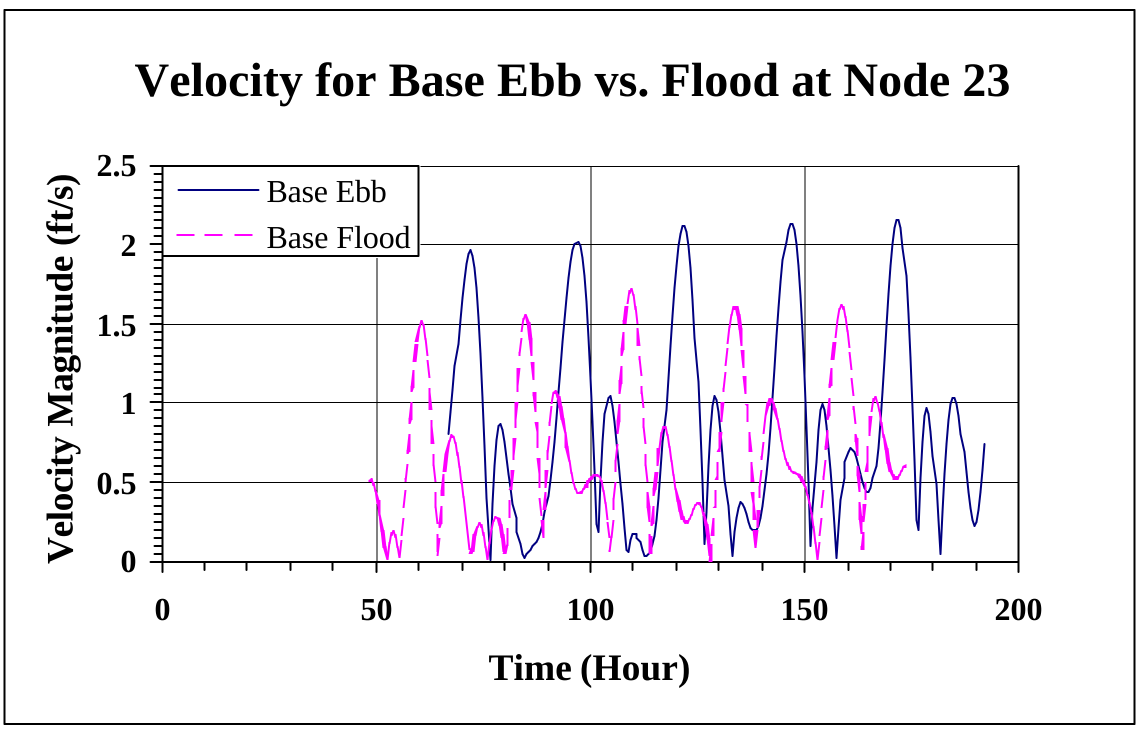
# Appendix B

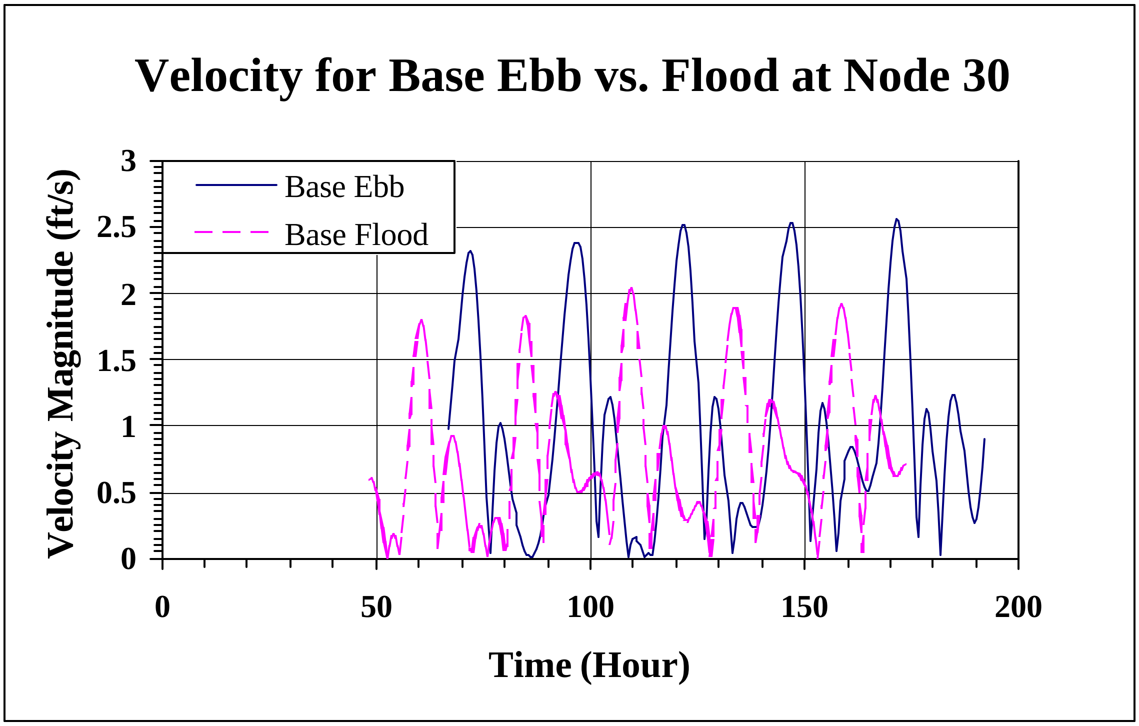
## Superposed Velocity Plots for
## Flood and Ebb for Base (existing) Conditions at
## SNWW Navigation Channel Locations

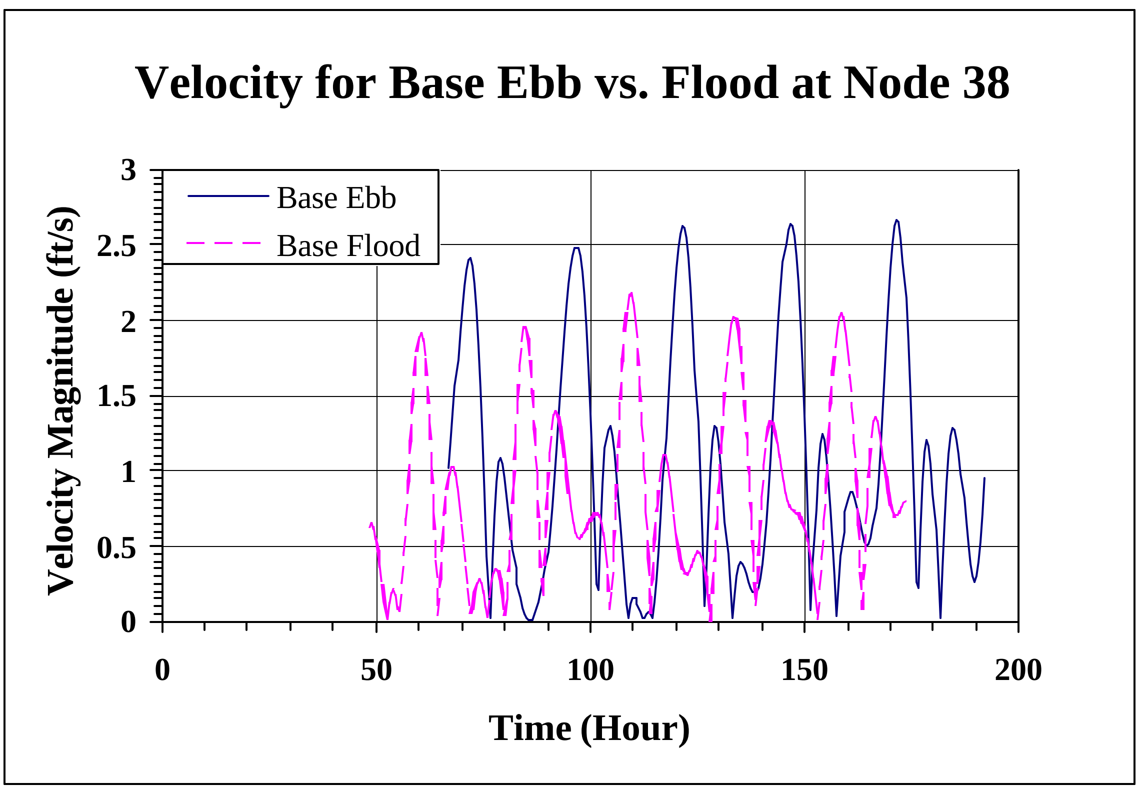

Velocity for Base Ebb vs. Flood at Node 01
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Base Flood
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200

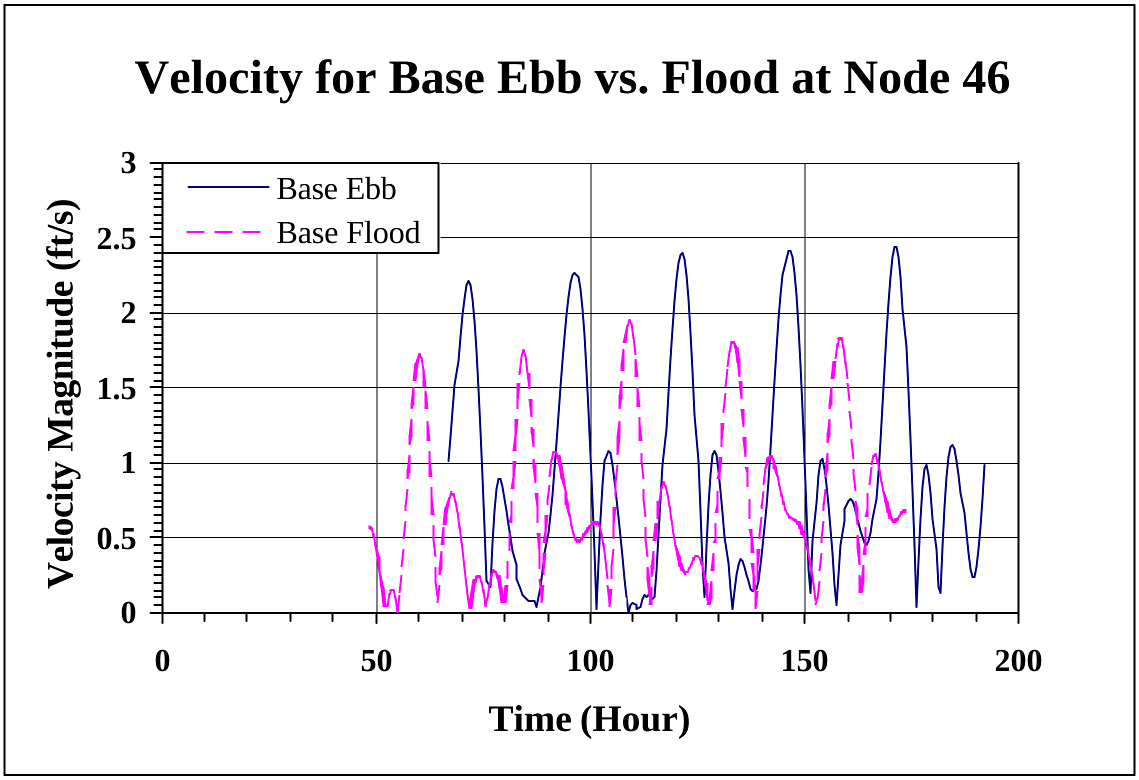

Velocity for Base Ebb vs. Flood at Node 09
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Base Flood
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200

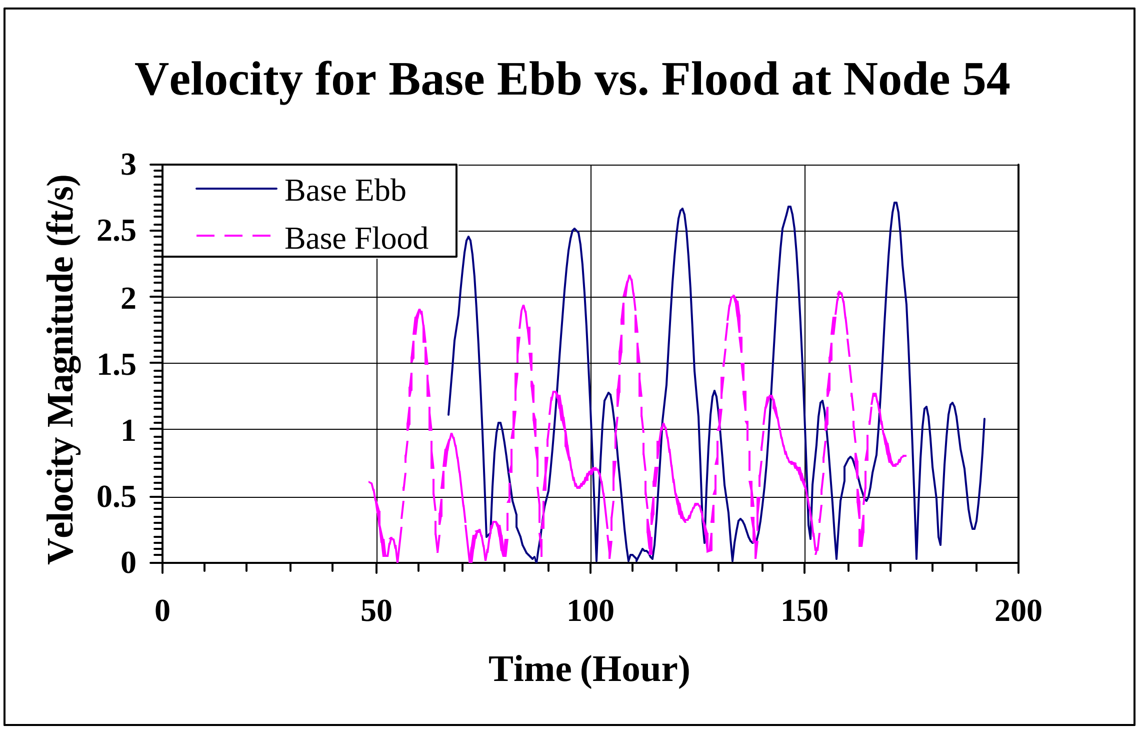

Velocity for Base Ebb vs. Flood at Node 18
Velocity Magnitude (ft/s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Base Ebb
Base Flood
0
50
100
150
200
Time (Hour)

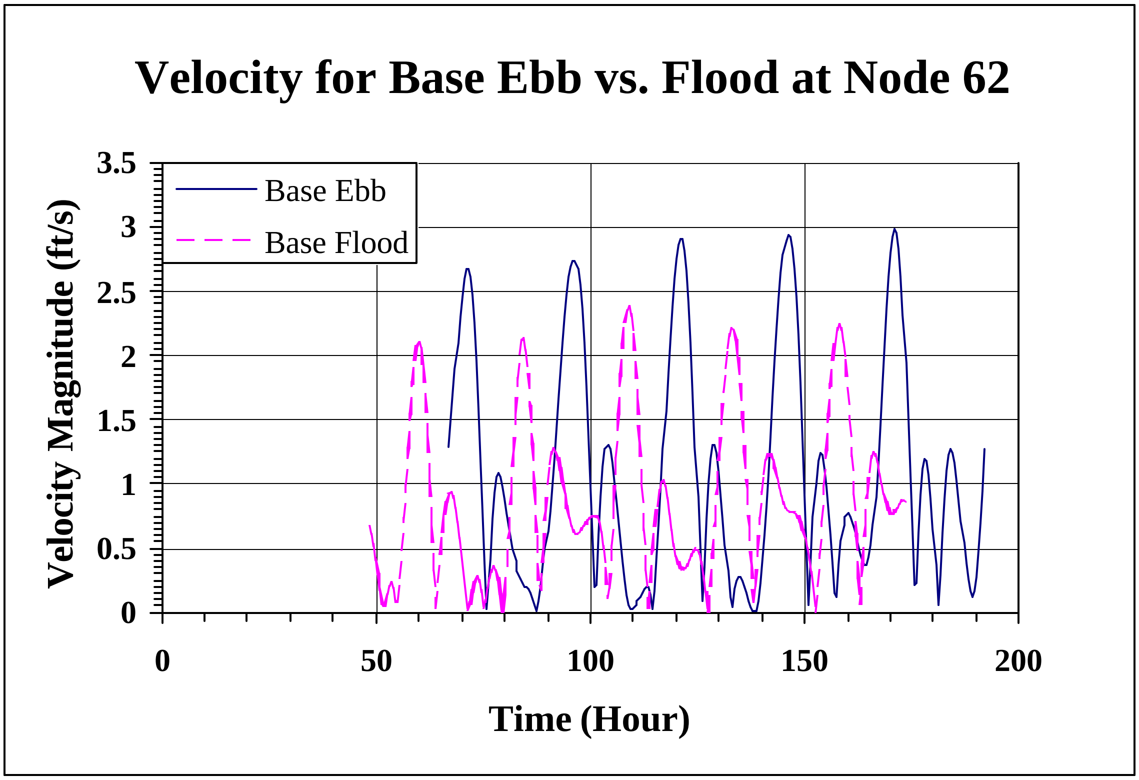

Velocity for Base Ebb vs. Flood at Node 23
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
Base Ebb
Base Flood
0
50
100
150
200
Time (Hour)

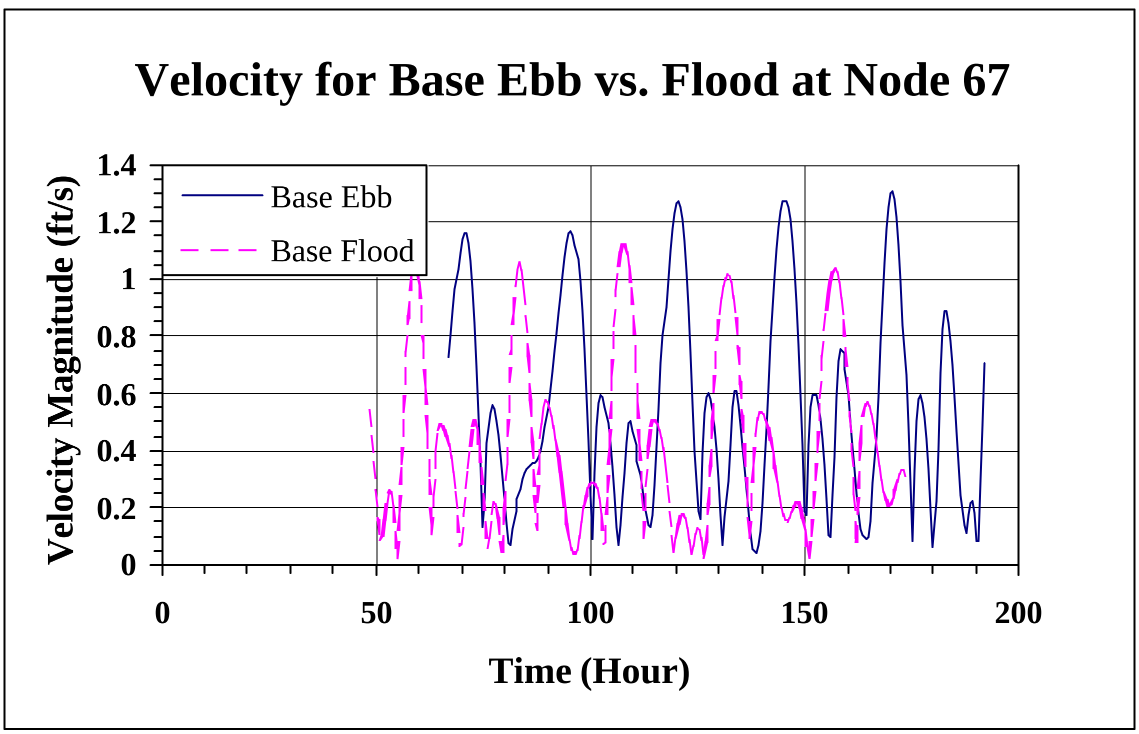

Velocity for Base Ebb vs. Flood at Node 30
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

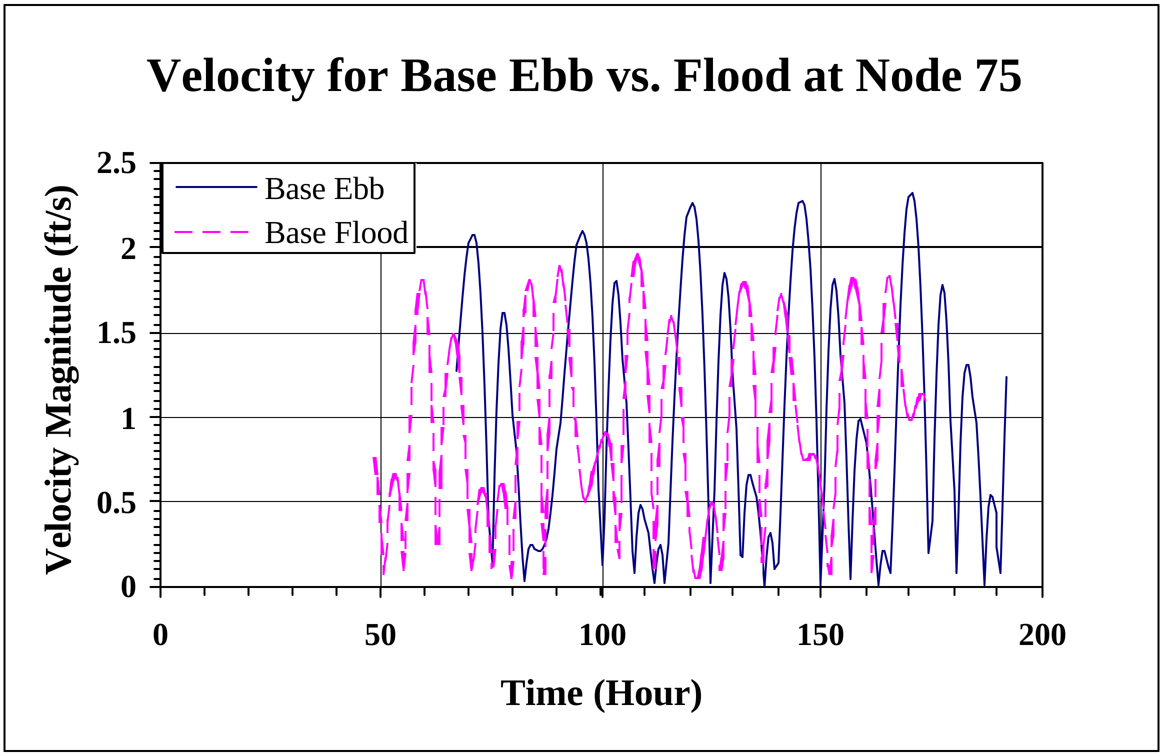

Velocity for Base Ebb vs. Flood at Node 38
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

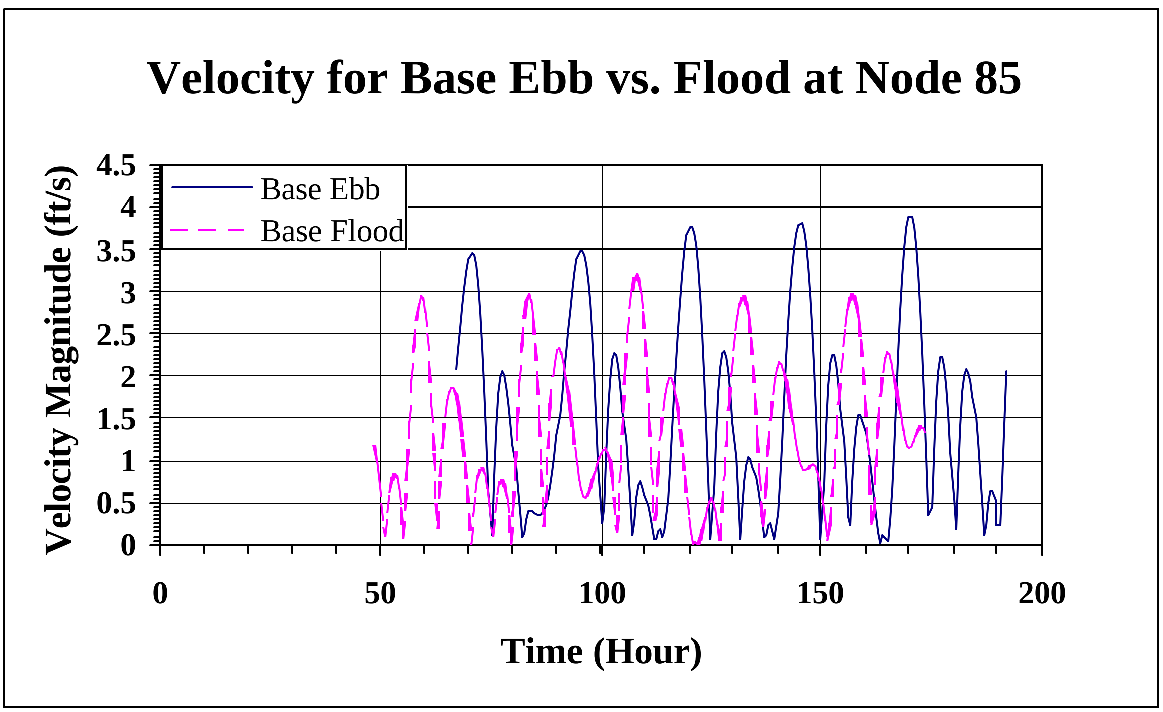

Velocity for Base Ebb vs. Flood at Node 46
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Base Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

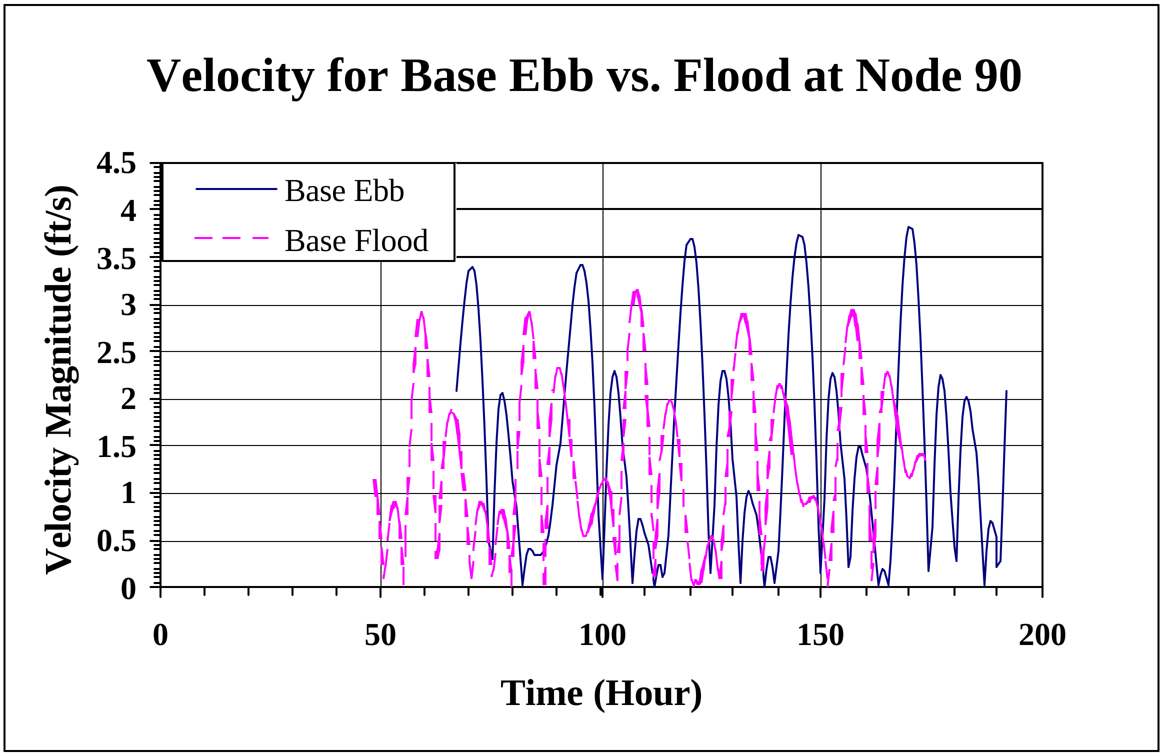

Velocity for Base Ebb vs. Flood at Node 54
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Base Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200


Velocity for Base Ebb vs. Flood at Node 62
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Base Flood

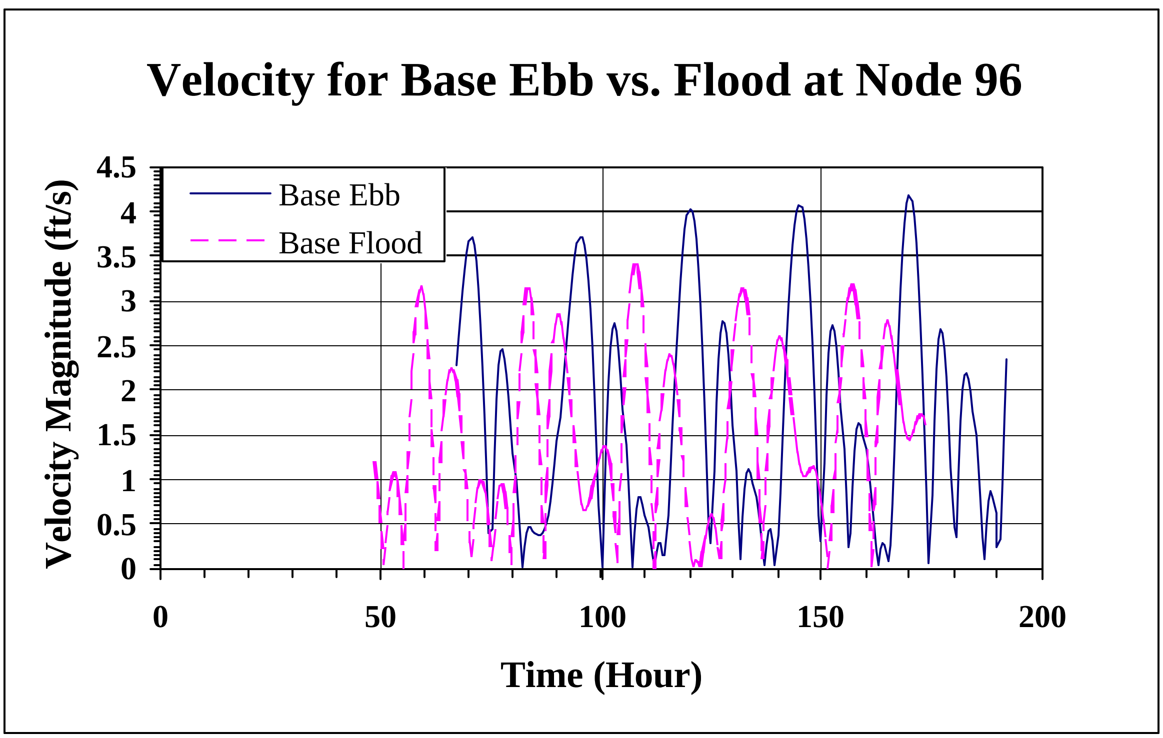

Velocity for Base Ebb vs. Flood at Node 67
Velocity Magnitude (ft/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)
Base Ebb
Base Flood


Velocity for Base Ebb vs. Flood at Node 75
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

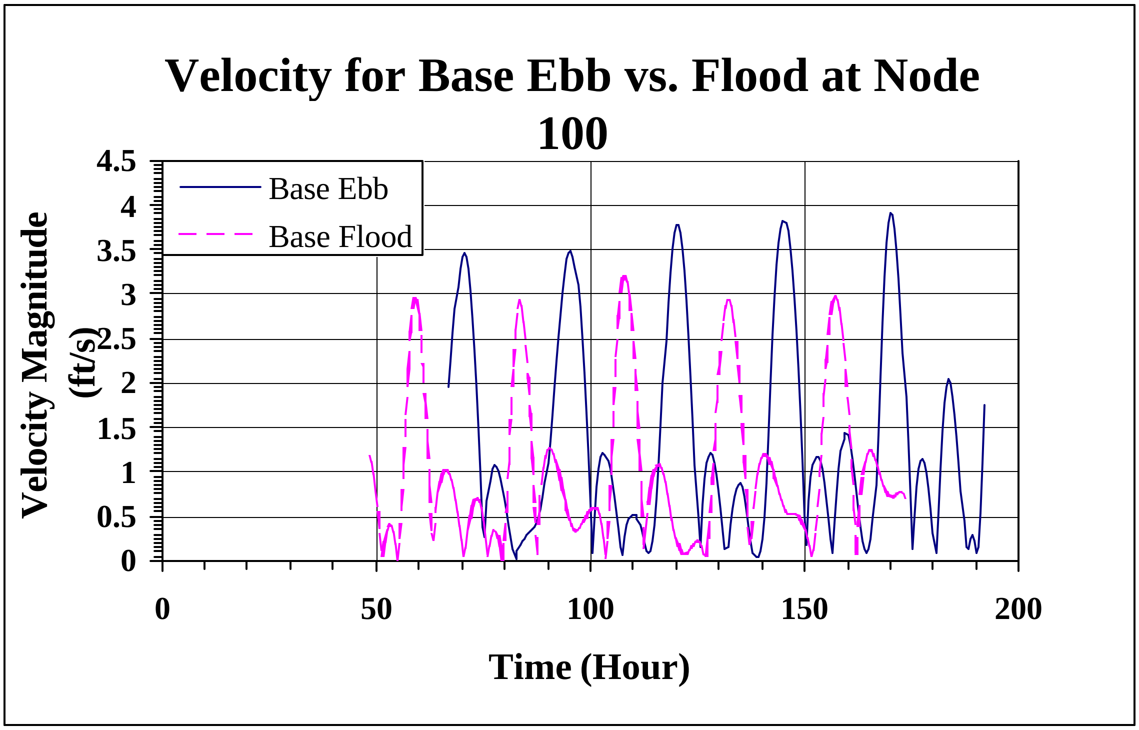

Velocity for Base Ebb vs. Flood at Node 85
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)



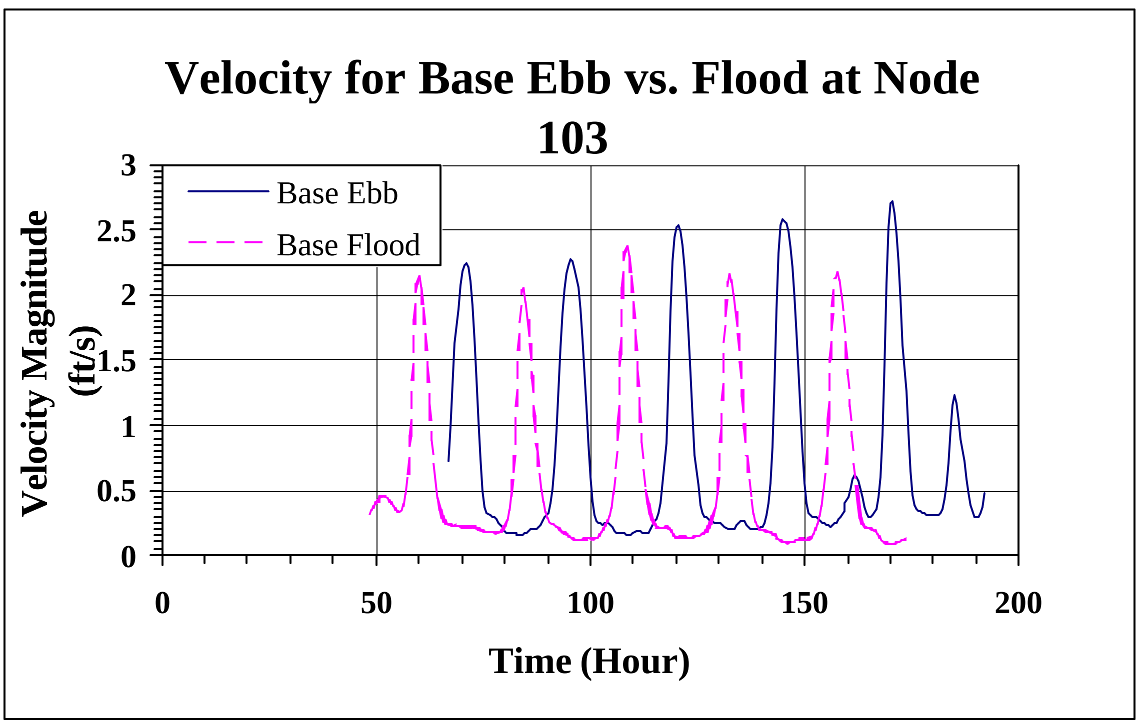
Velocity for Base Ebb vs. Flood at Node 90
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

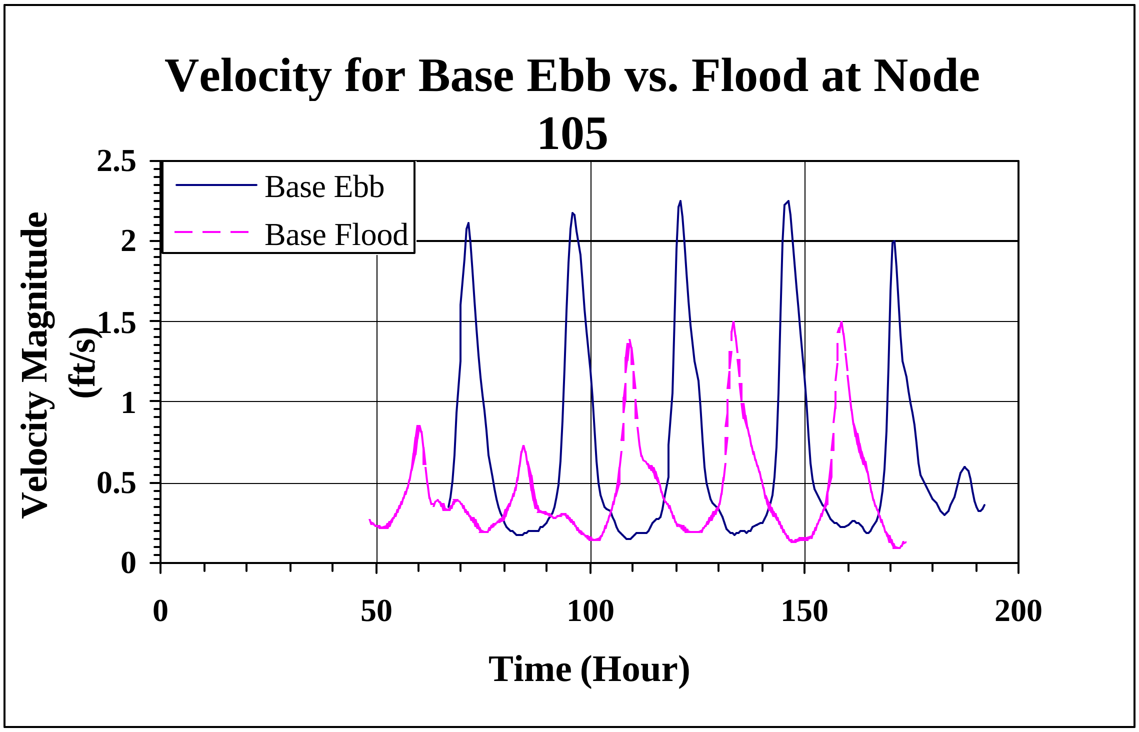
Velocity for Base Ebb vs. Flood at Node 96
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

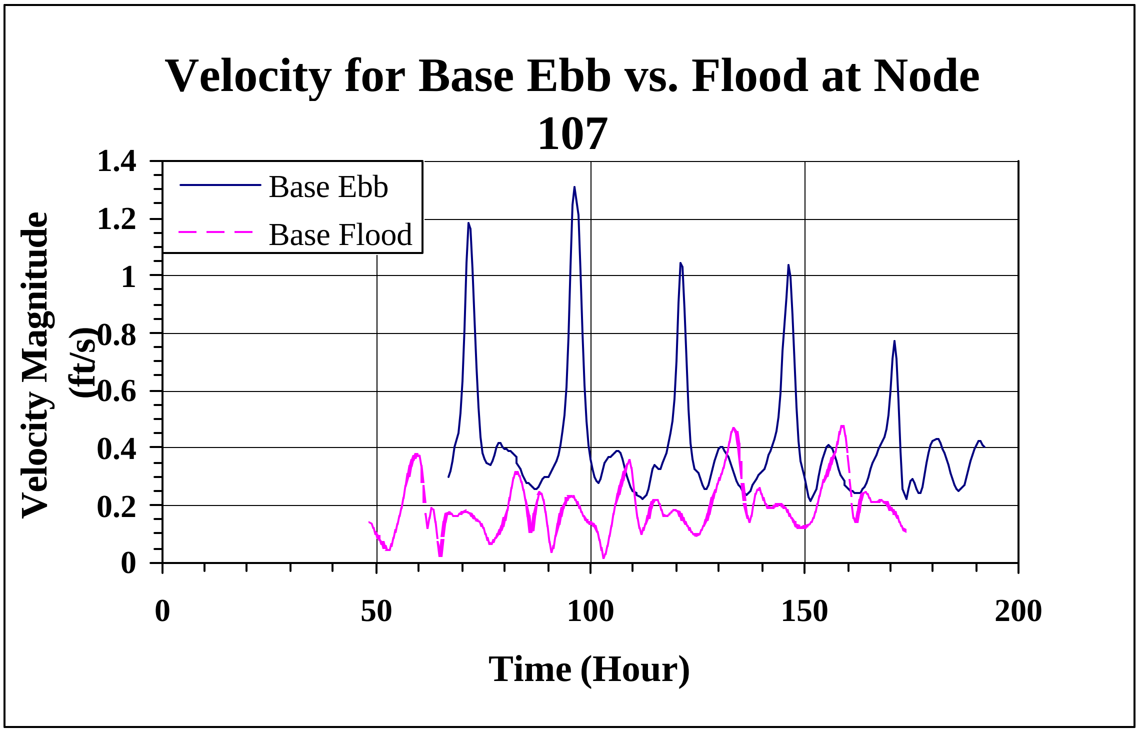


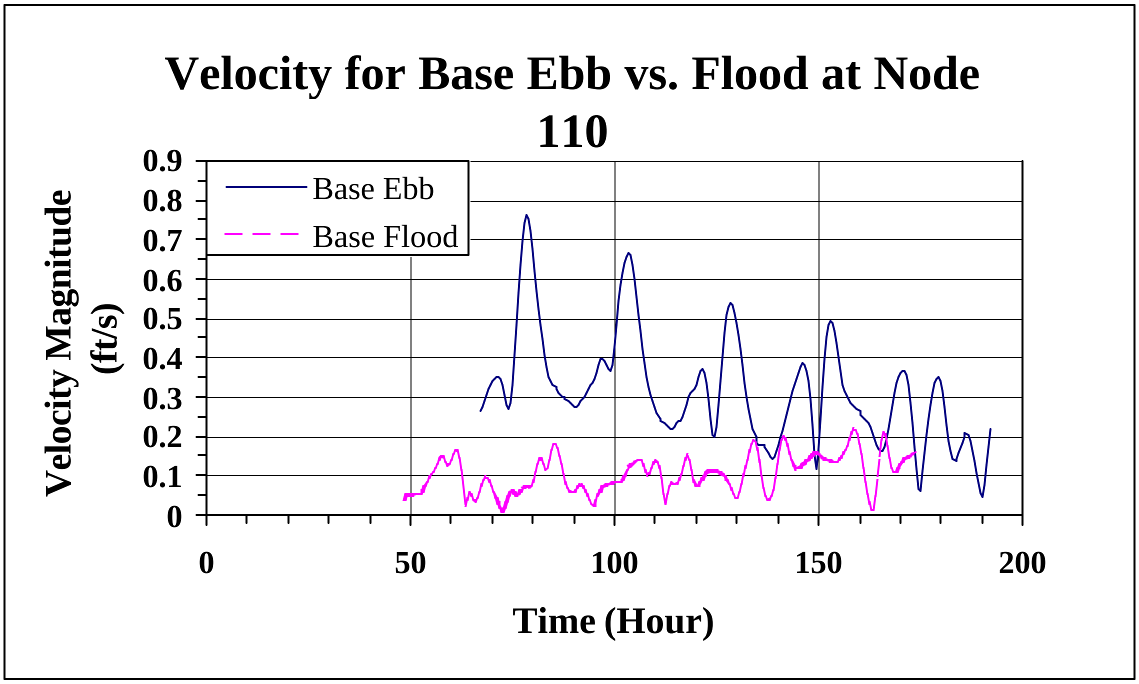
Velocity for Base Ebb vs. Flood at Node 100
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

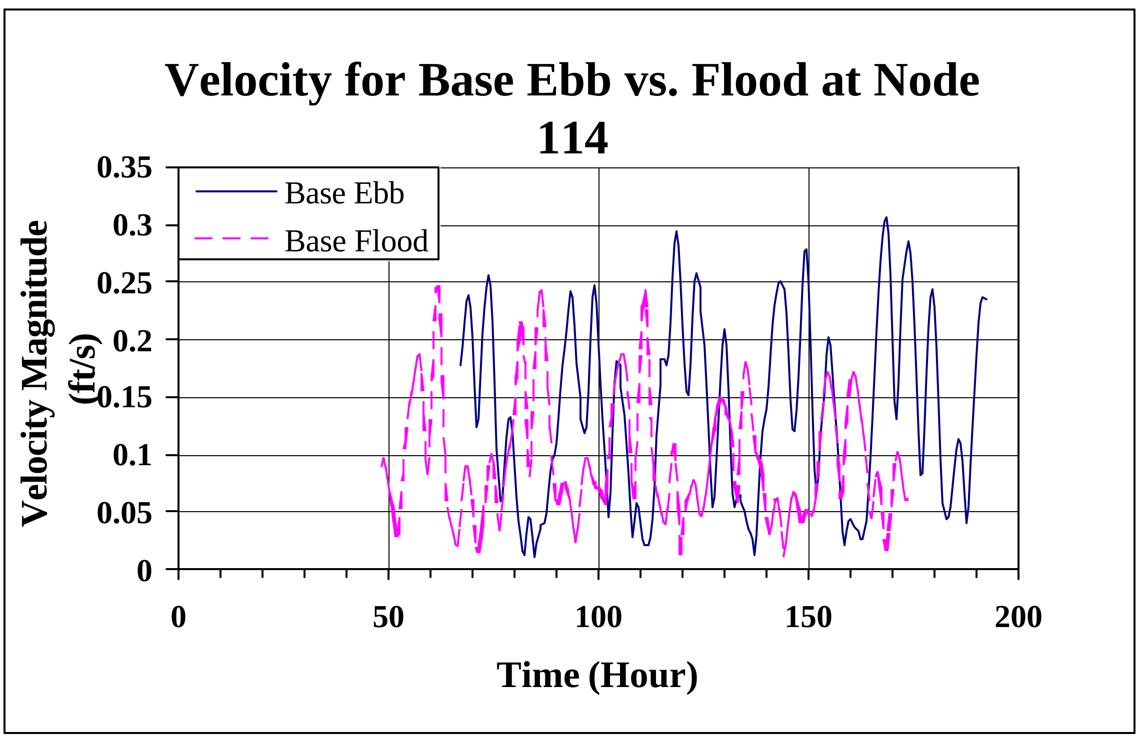



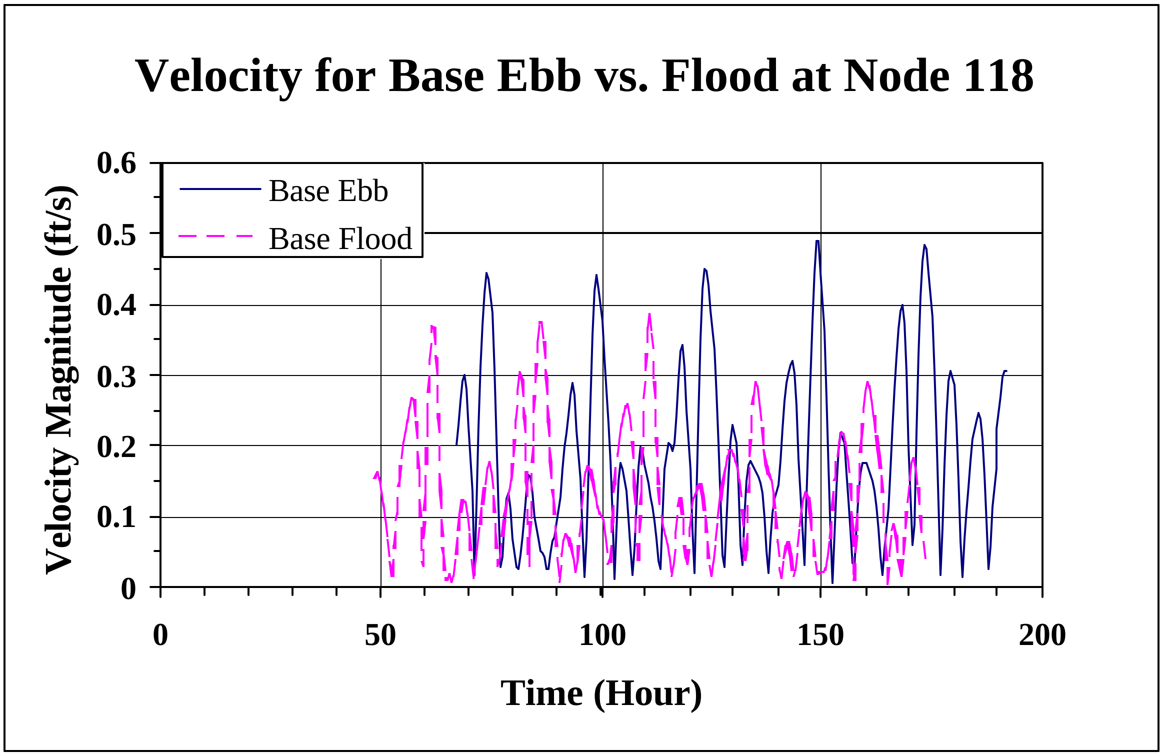
Velocity for Base Ebb vs. Flood at Node 103
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

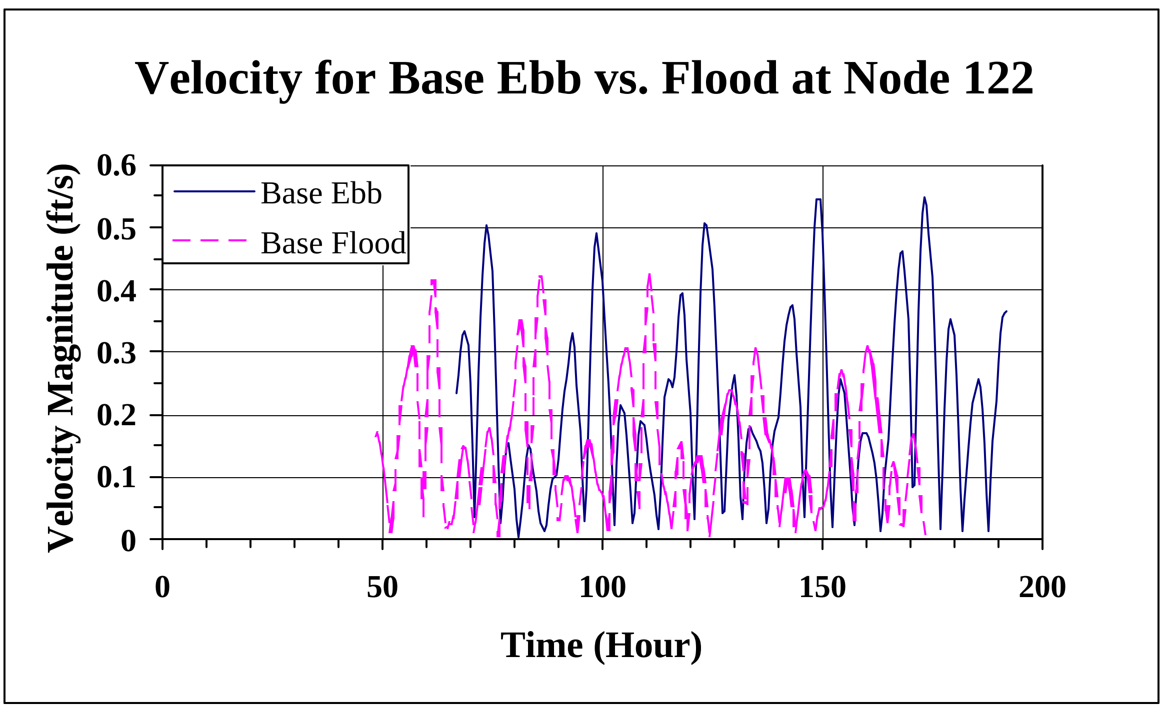

Velocity for Base Ebb vs. Flood at Node 105
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

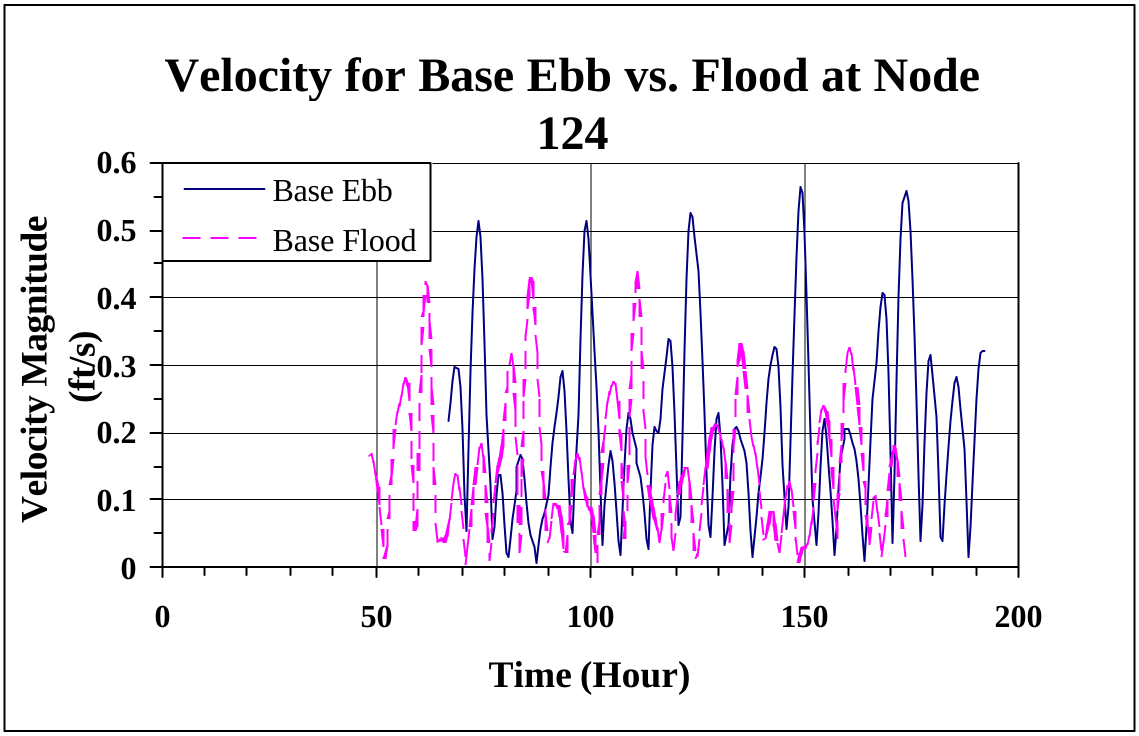

Velocity for Base Ebb vs. Flood at Node 107
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)


Velocity for Base Ebb vs. Flood at Node 110
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
Time (Hour)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200


Velocity for Base Ebb vs. Flood at Node 114
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
Time (Hour)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200


Velocity for Base Ebb vs. Flood at Node 118
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

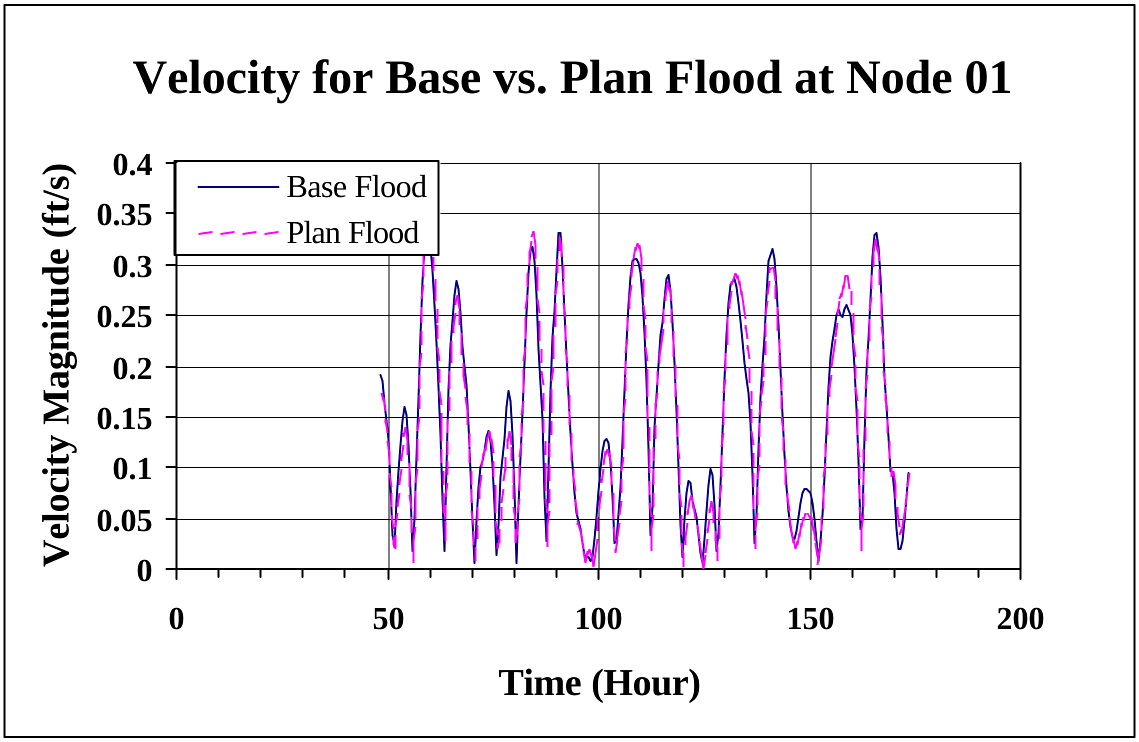

Velocity for Base Ebb vs. Flood at Node 122
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

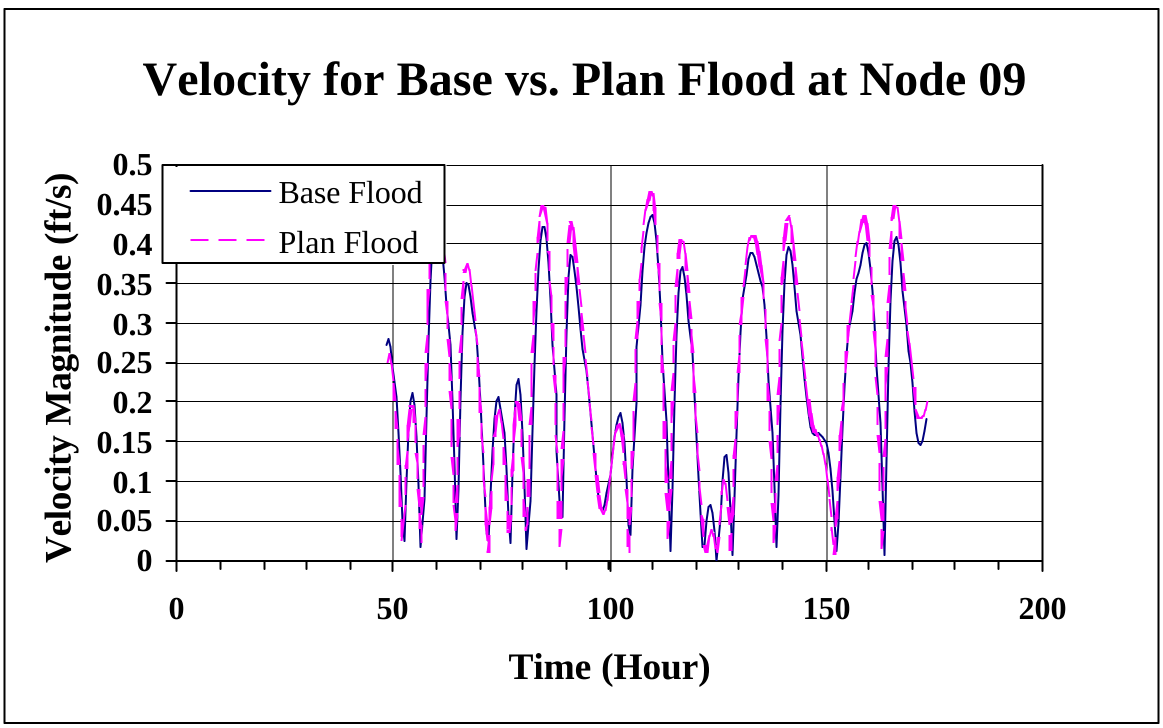


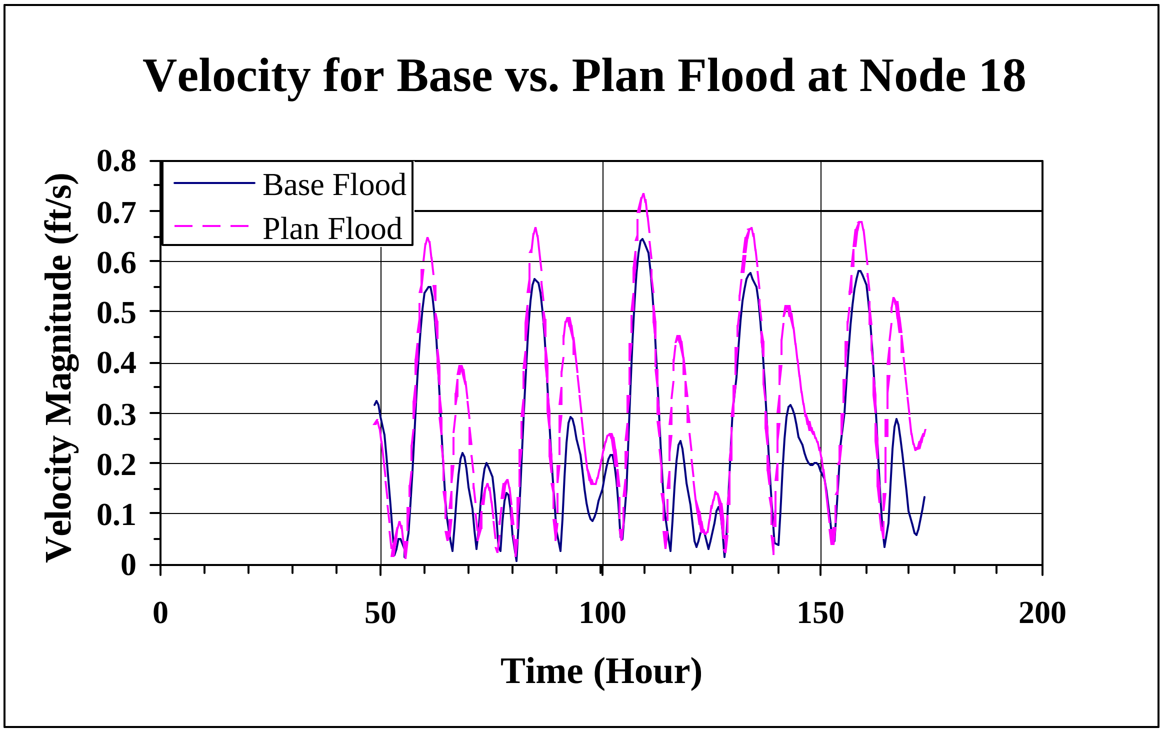
Velocity for Base Ebb vs. Flood at Node 124
Base Ebb
Base Flood
Velocity Magnitude (ft/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

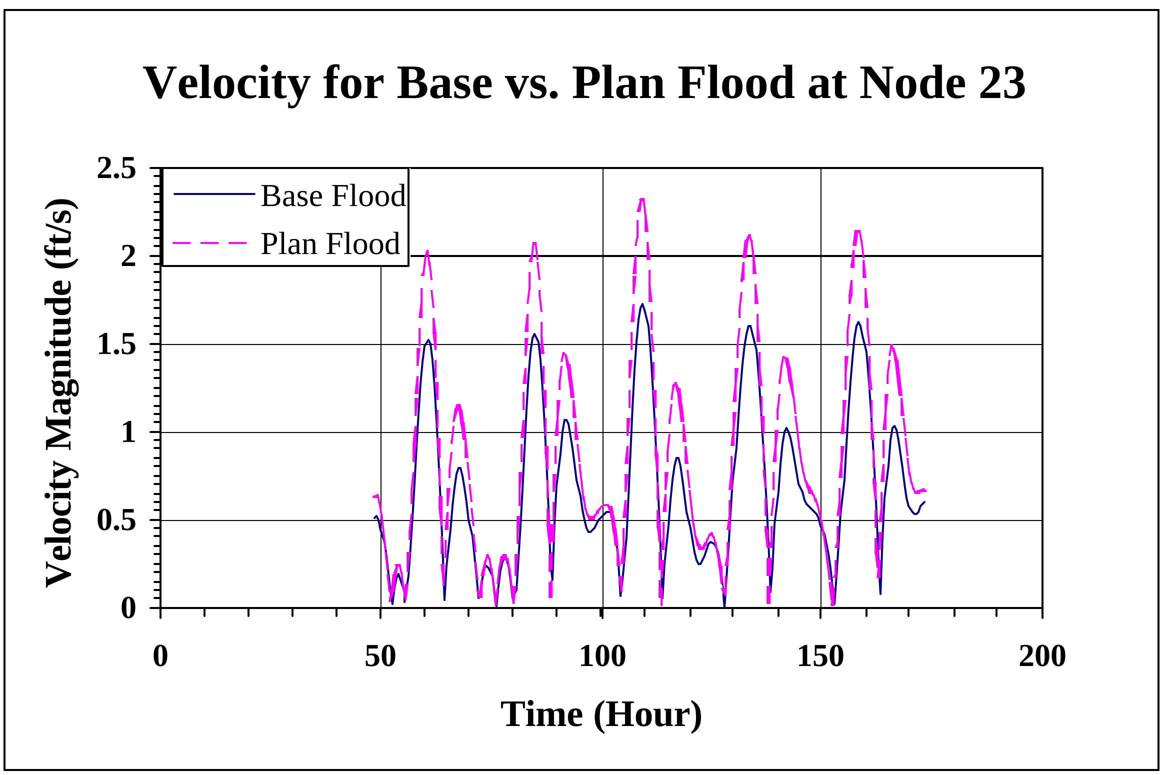
# Appendix C

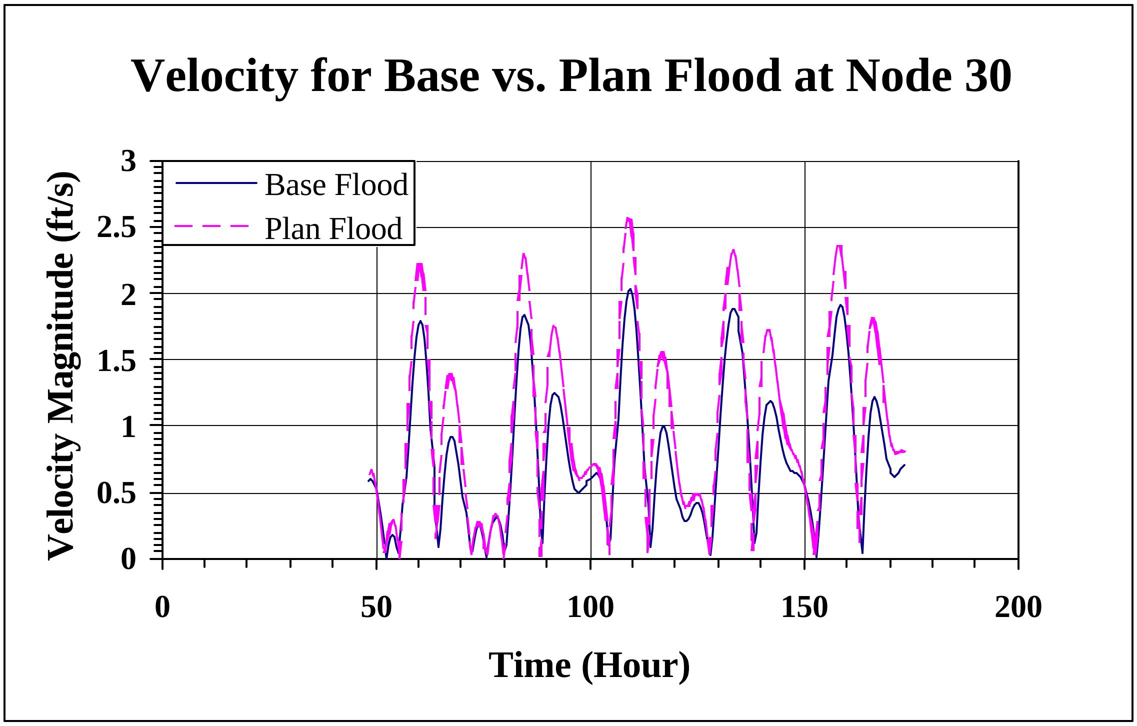
## Superposed Velocity Plots for Base and Plan for Flood at Locations Along SNWW Navigation Channel

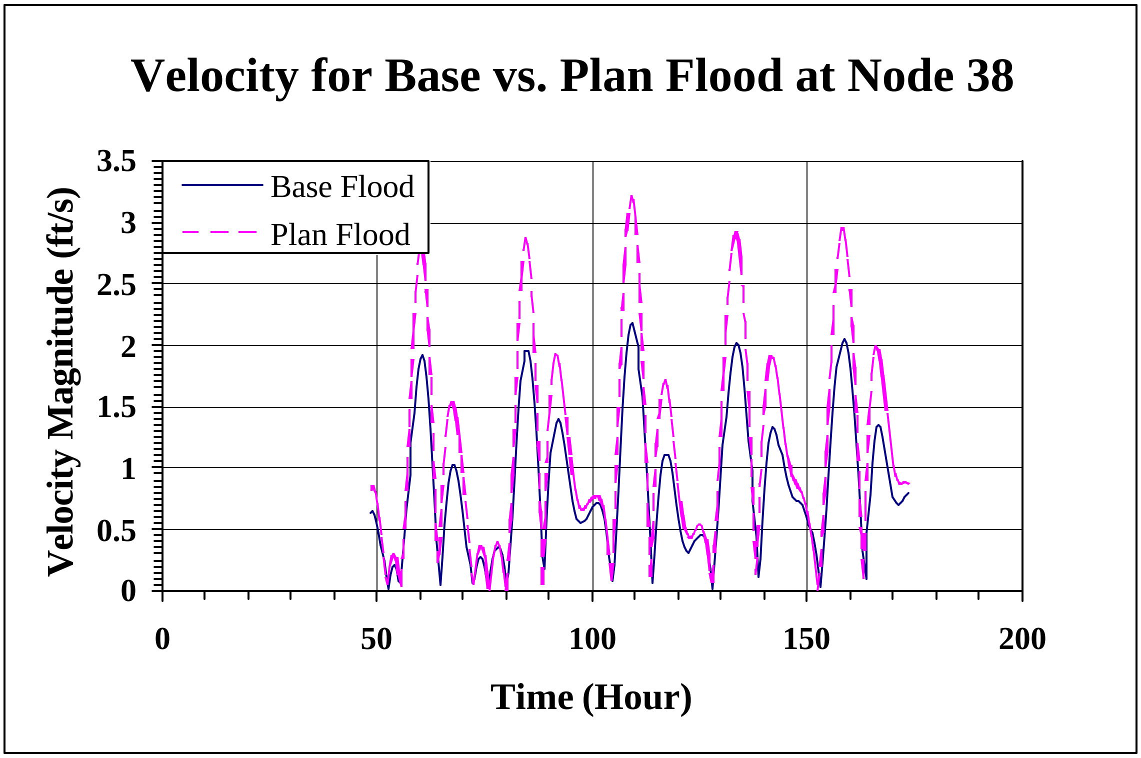

Velocity for Base vs. Plan Flood at Node 01
Velocity Magnitude (ft/s)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

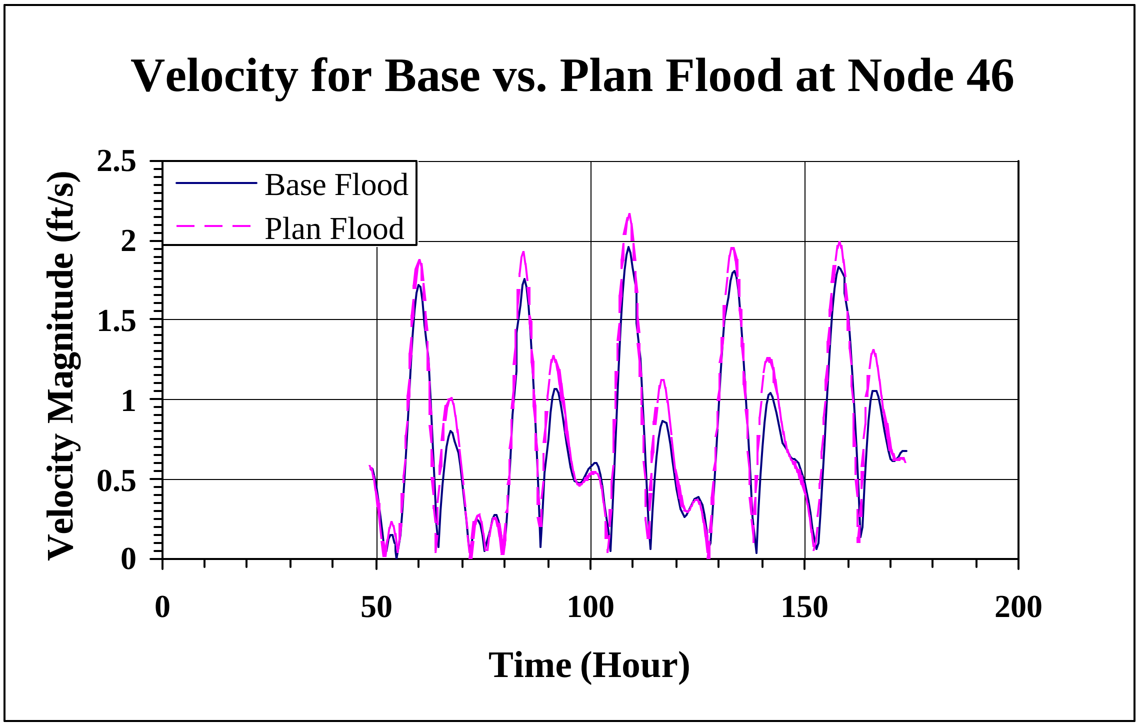

Velocity for Base vs. Plan Flood at Node 09
Velocity Magnitude (ft/s)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

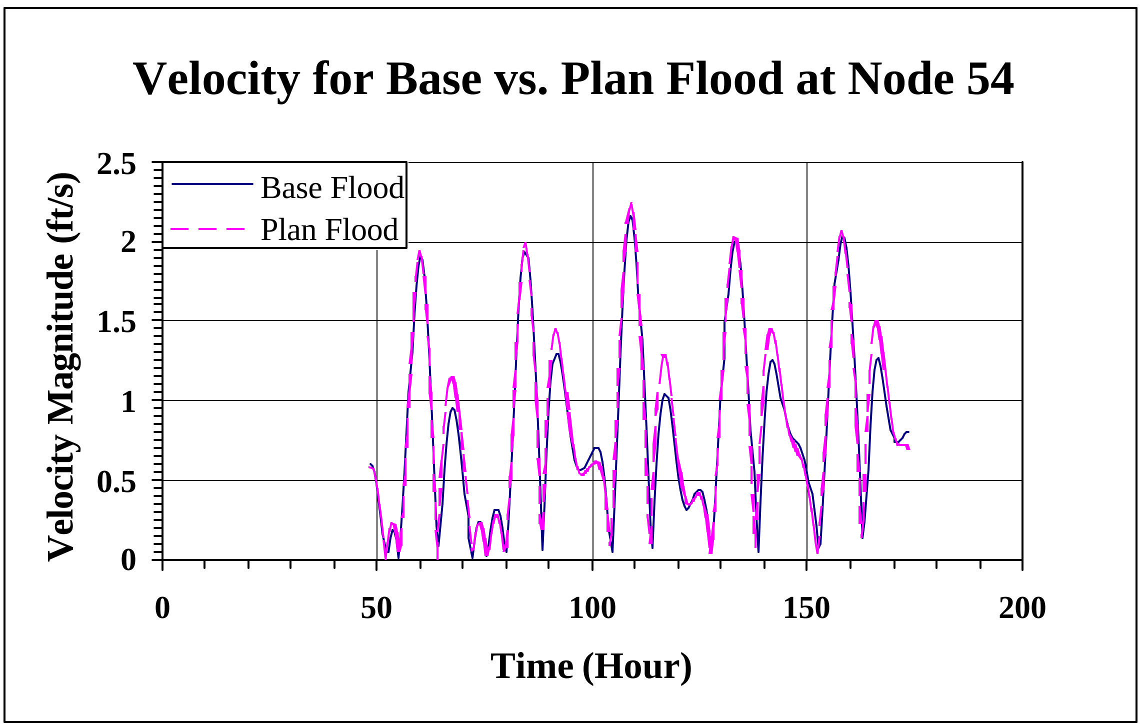

Velocity for Base vs. Plan Flood at Node 18
Velocity Magnitude (ft/s)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

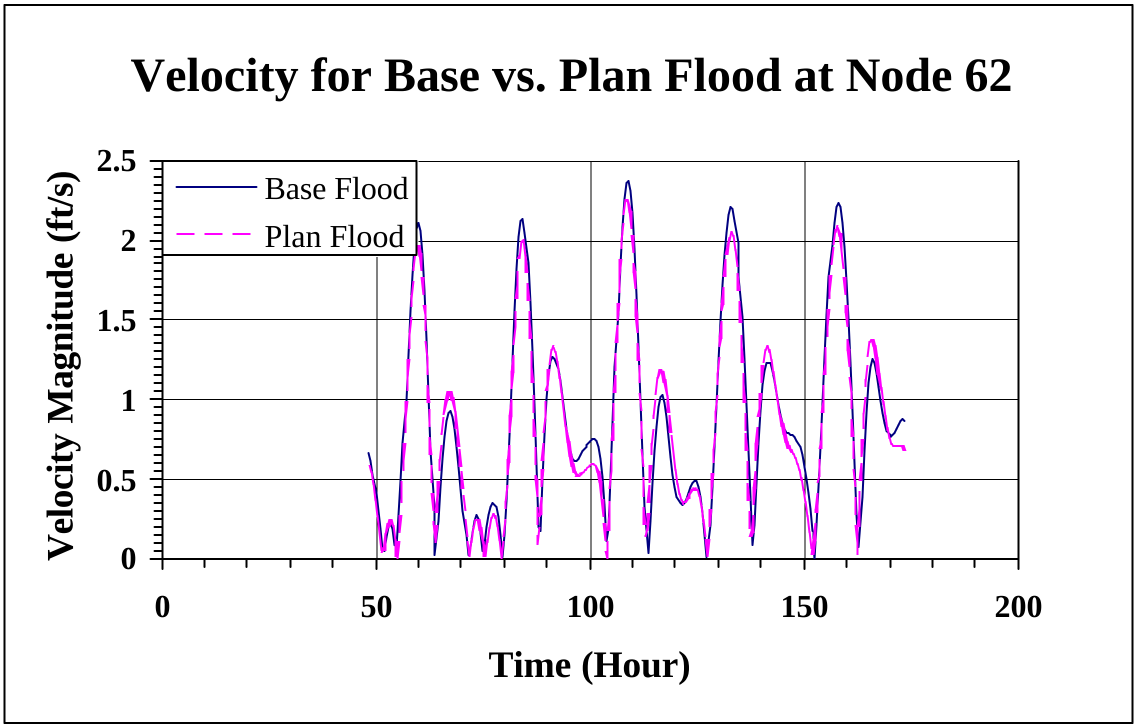

Velocity for Base vs. Plan Flood at Node 23
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node 30
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

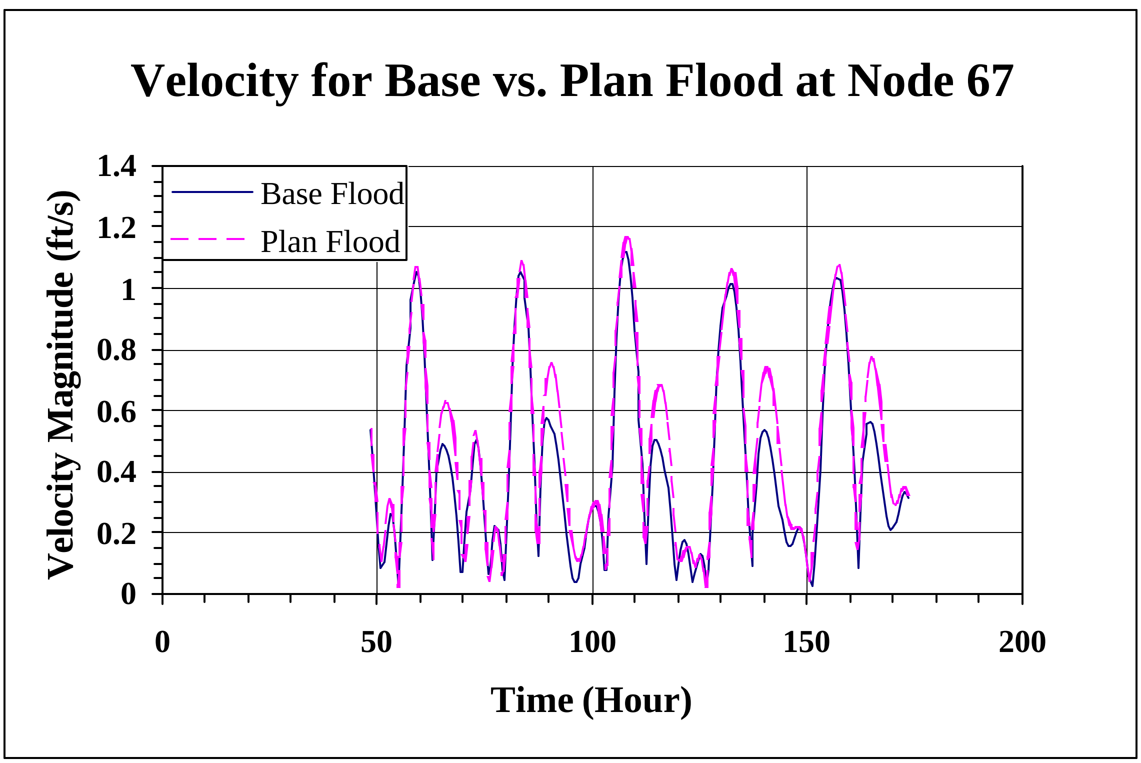

Velocity for Base vs. Plan Flood at Node 38
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200


Velocity for Base vs. Plan Flood at Node 46
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

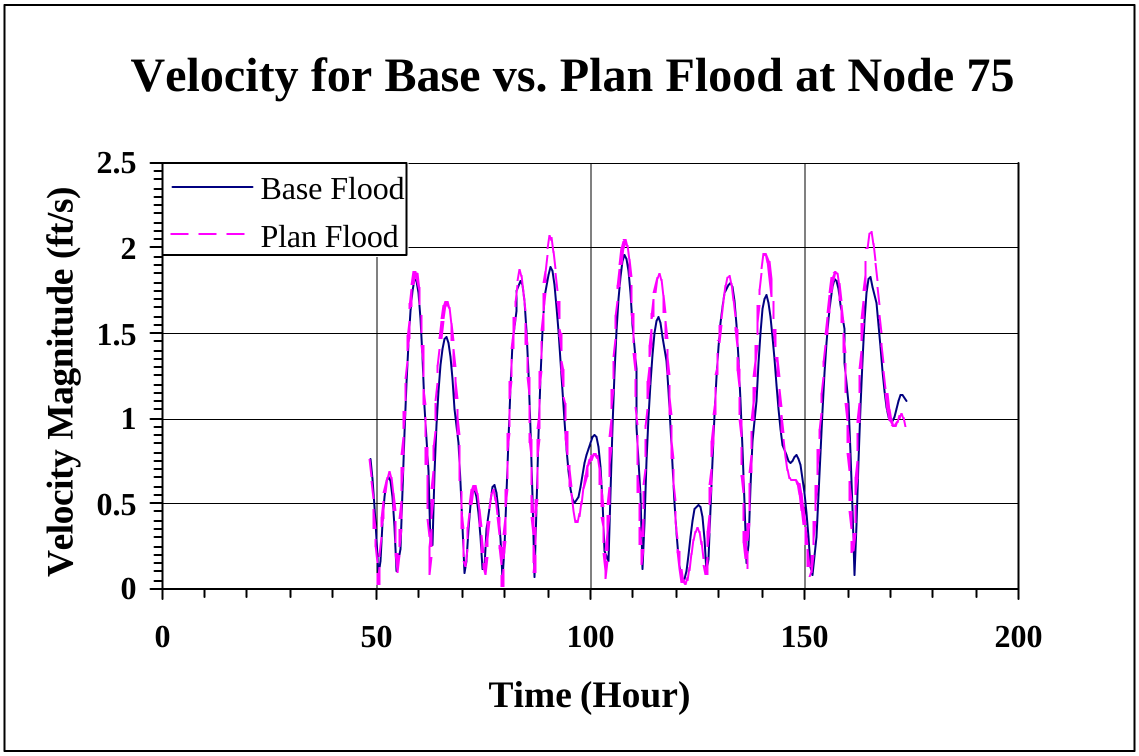

Velocity for Base vs. Plan Flood at Node 54
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood



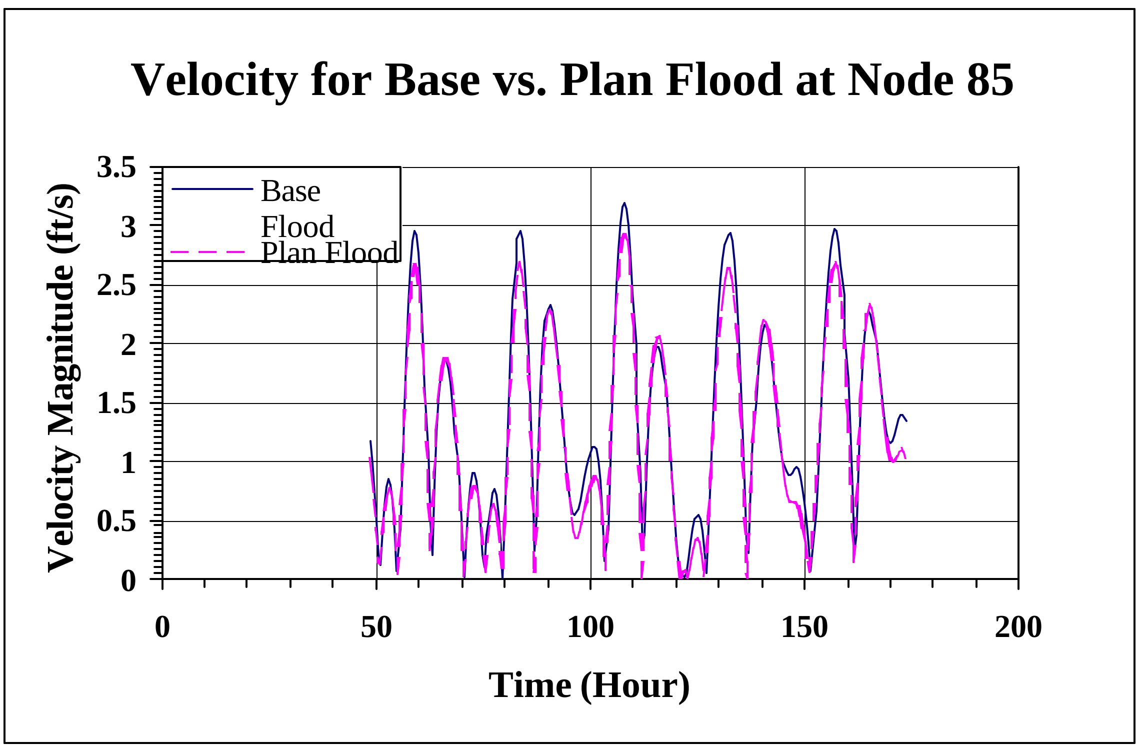
Velocity for Base vs. Plan Flood at Node 62
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

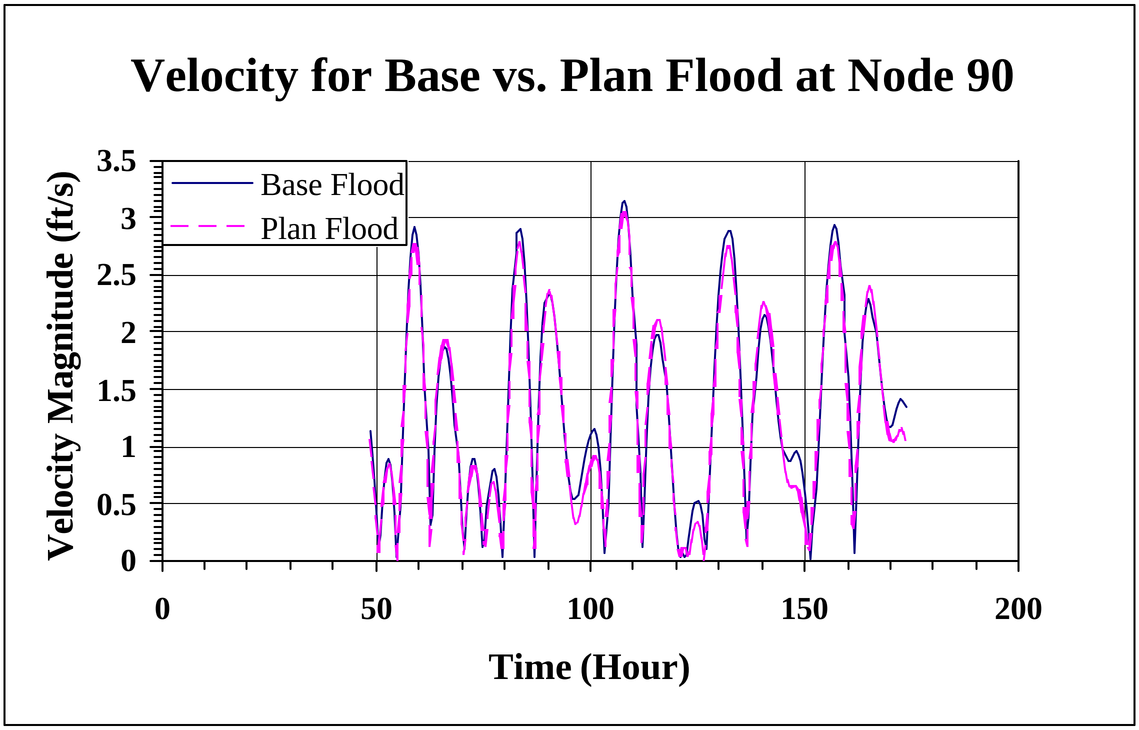
Velocity for Base vs. Plan Flood at Node 67
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)

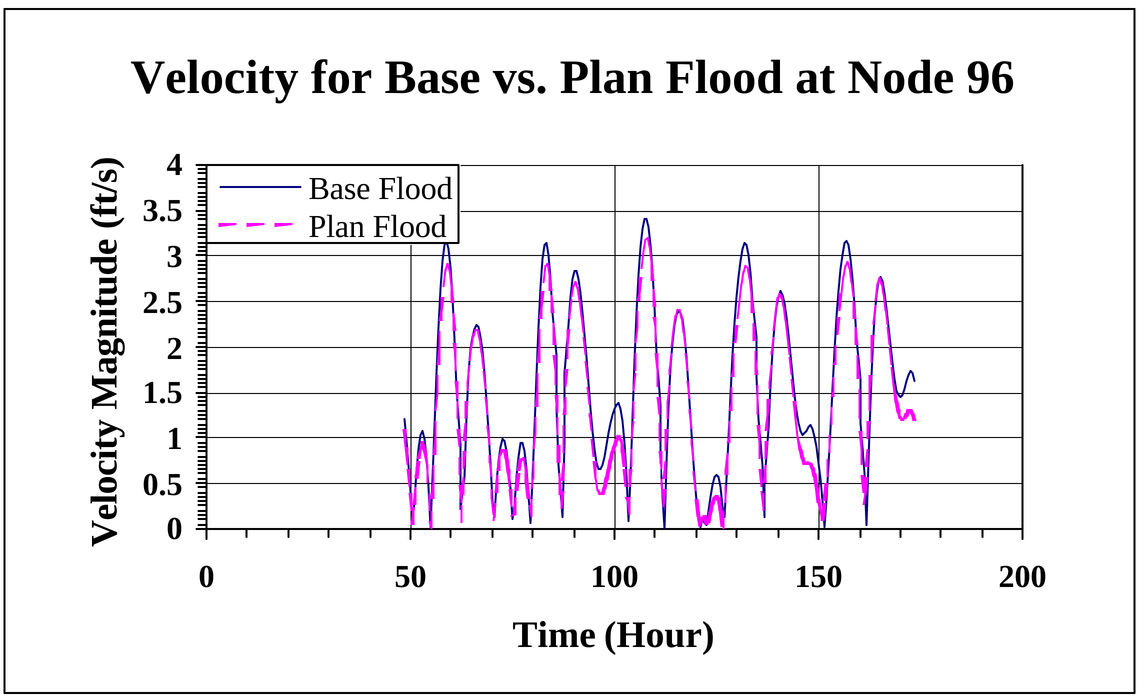


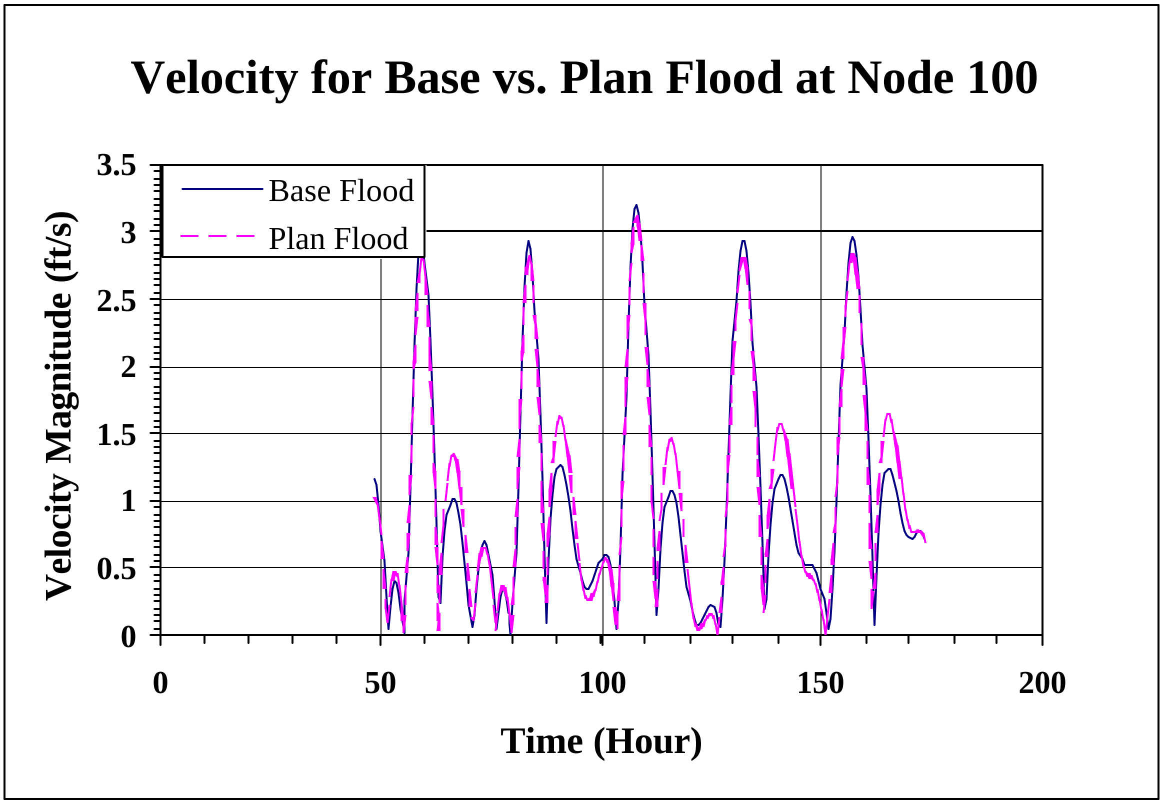
Velocity for Base vs. Plan Flood at Node 75
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
0
50
100
150
200

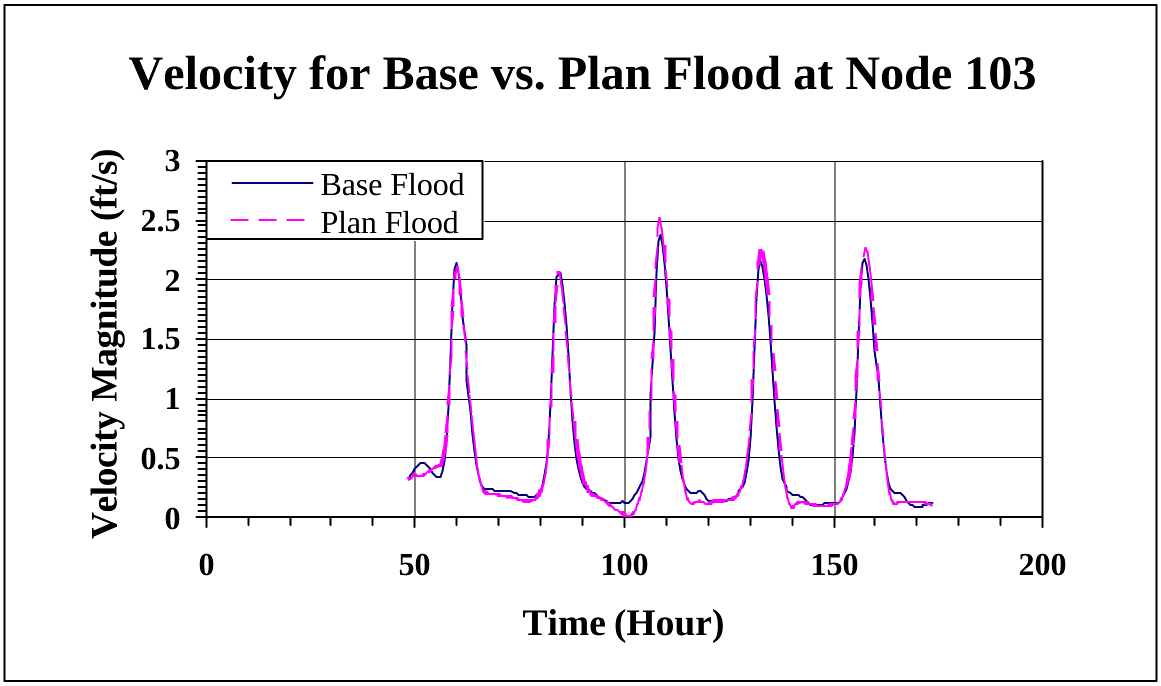
Velocity for Base vs. Plan Flood at Node 85
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

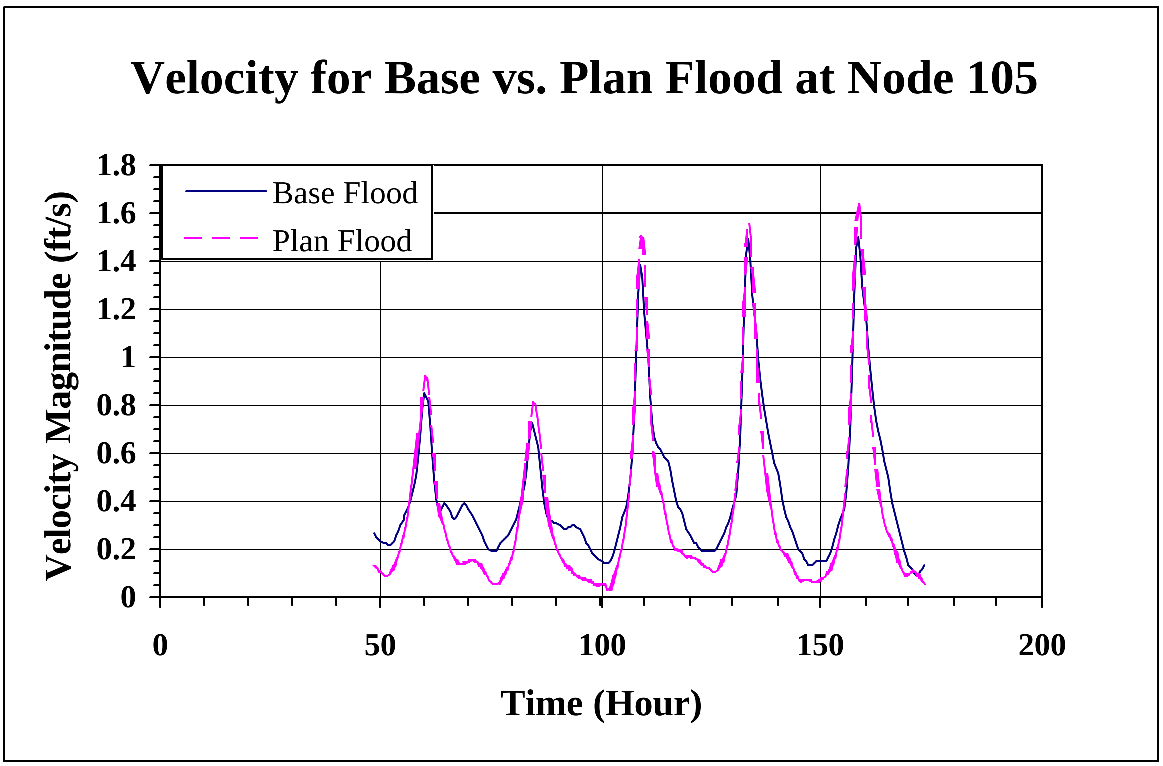

Velocity for Base vs. Plan Flood at Node 90
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

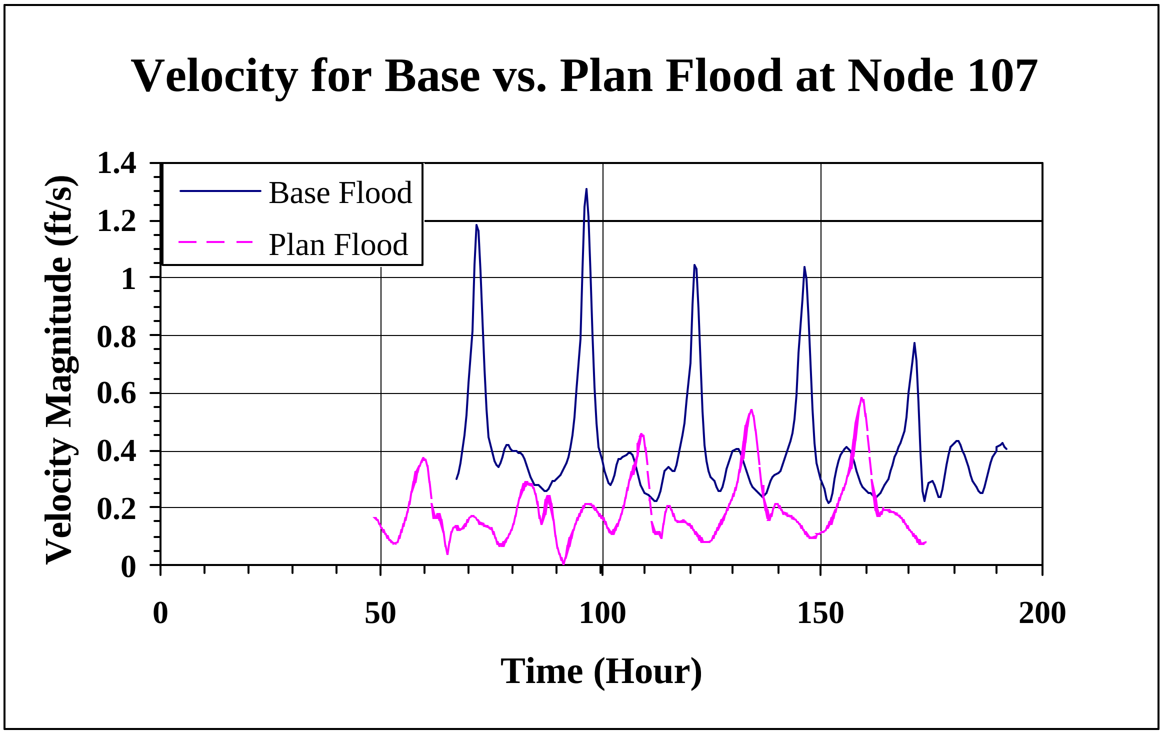

Velocity for Base vs. Plan Flood at Node 96
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

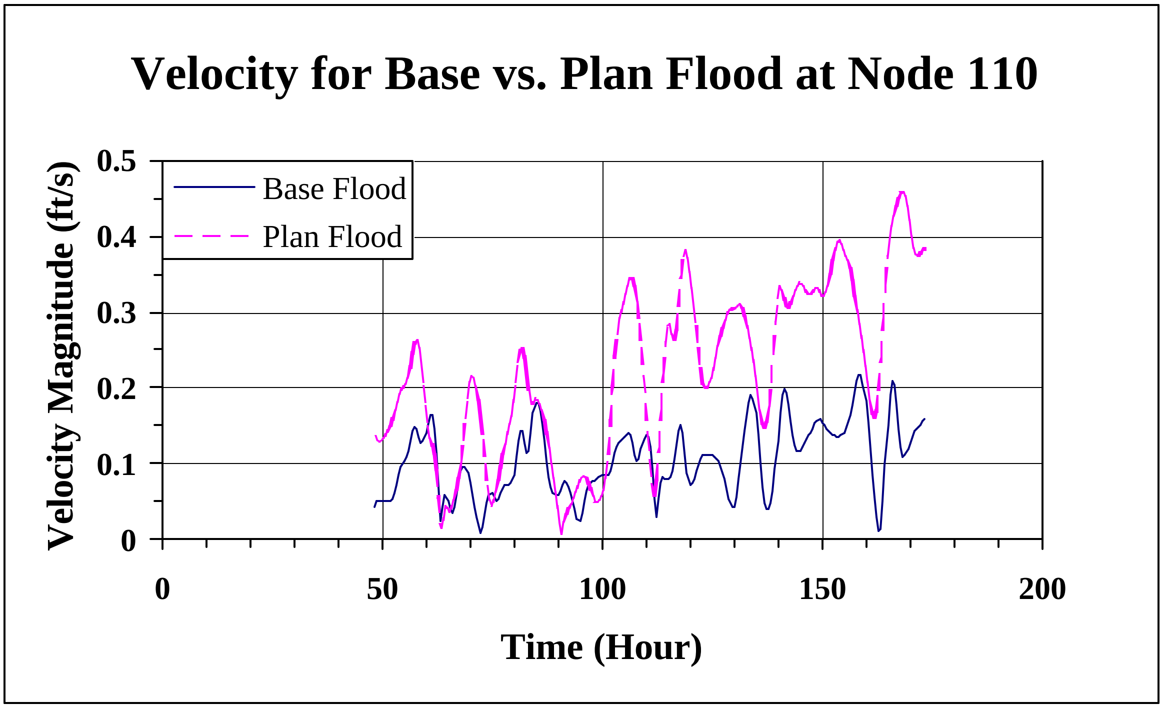


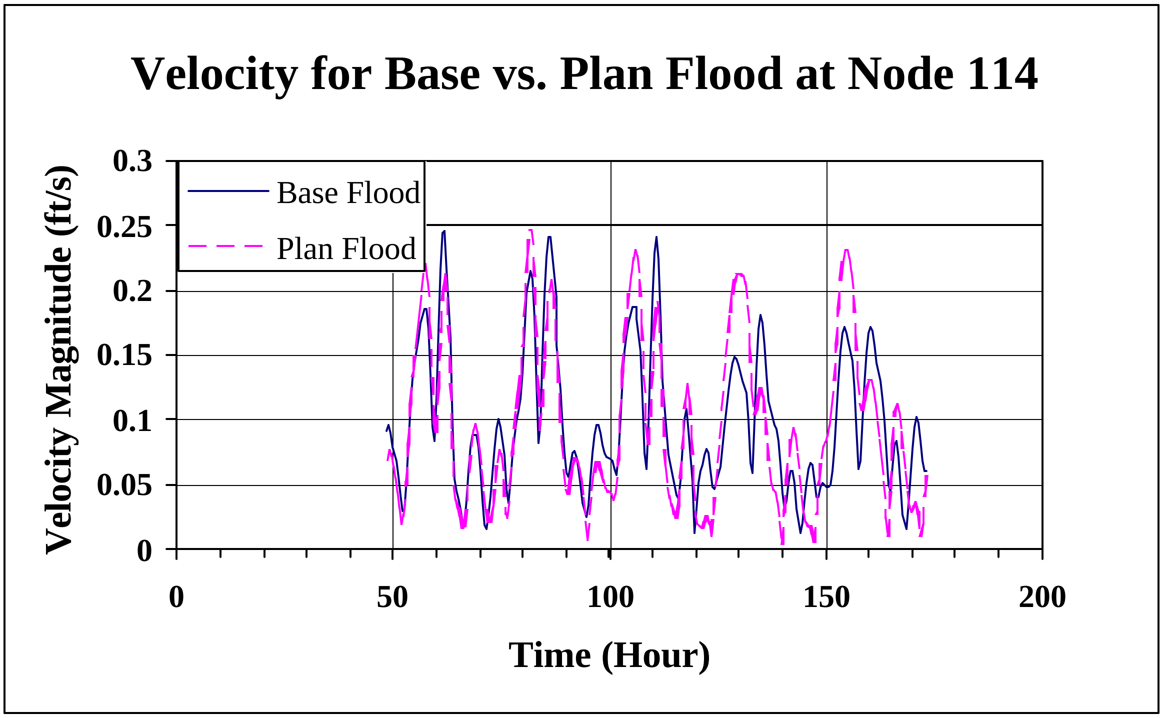
Velocity for Base vs. Plan Flood at Node 100
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

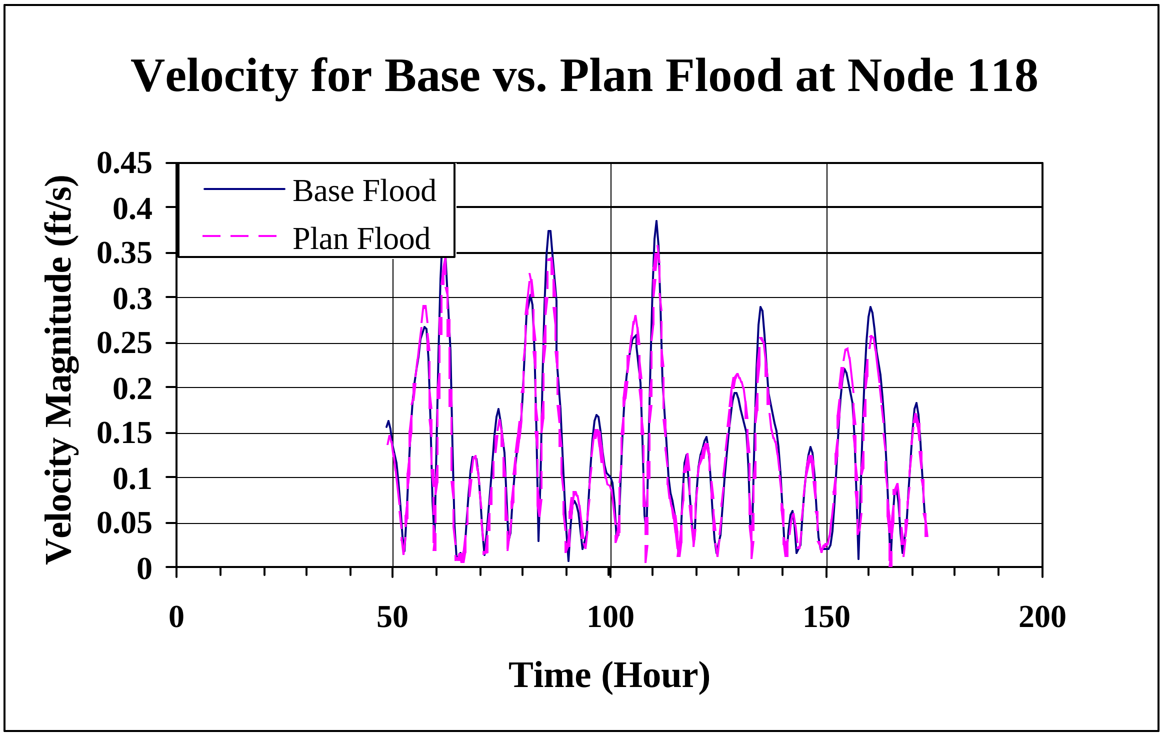

Velocity for Base vs. Plan Flood at Node 103
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

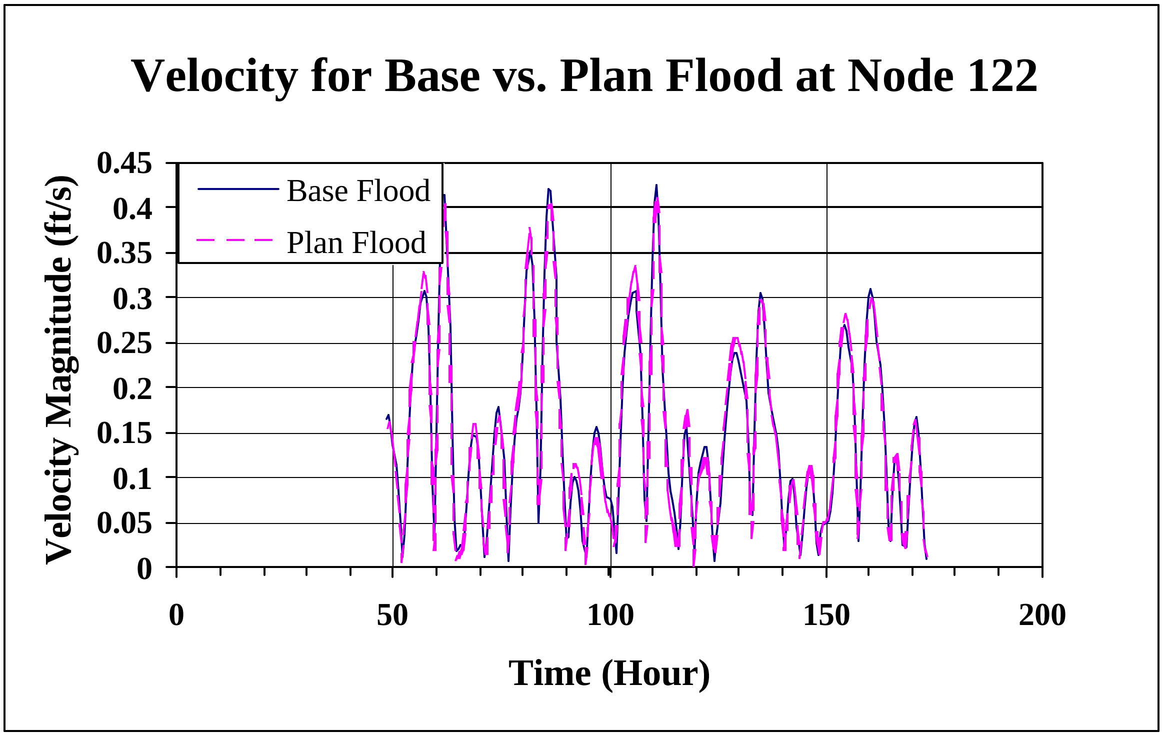

Velocity for Base vs. Plan Flood at Node 105
Velocity Magnitude (ft/s)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

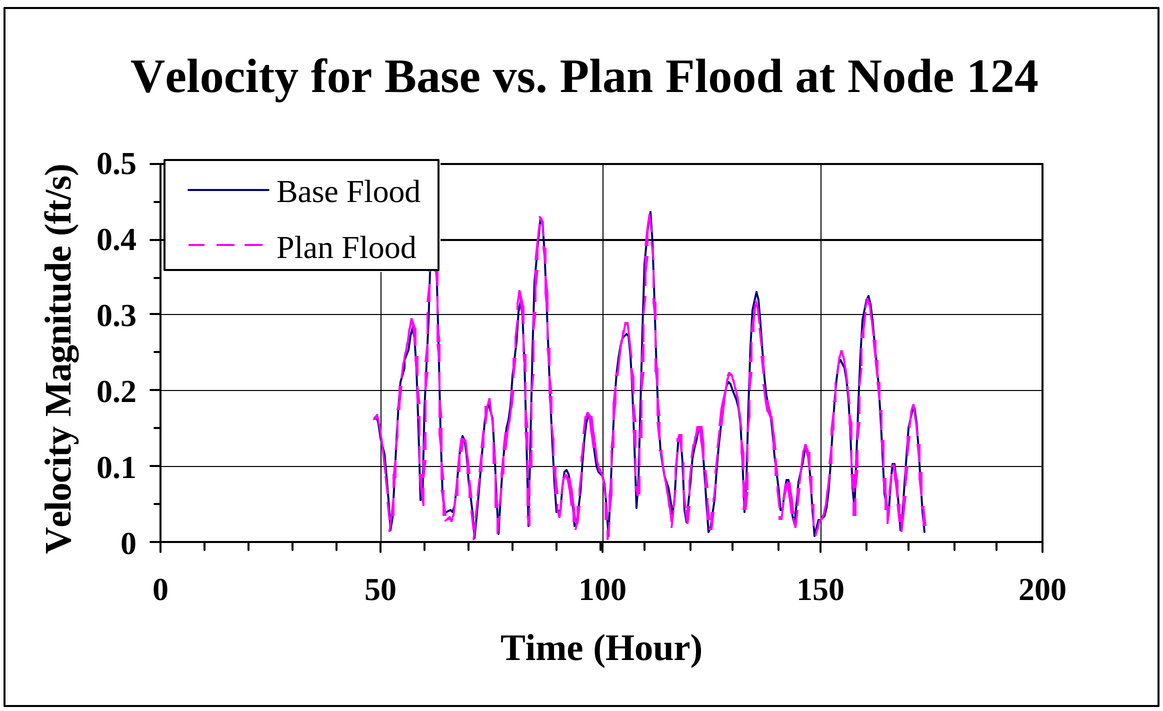

Velocity for Base vs. Plan Flood at Node 107
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node 110
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node 114
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.05
0.1
0.15
0.2
0.25
0.3
0
50
100
150
200

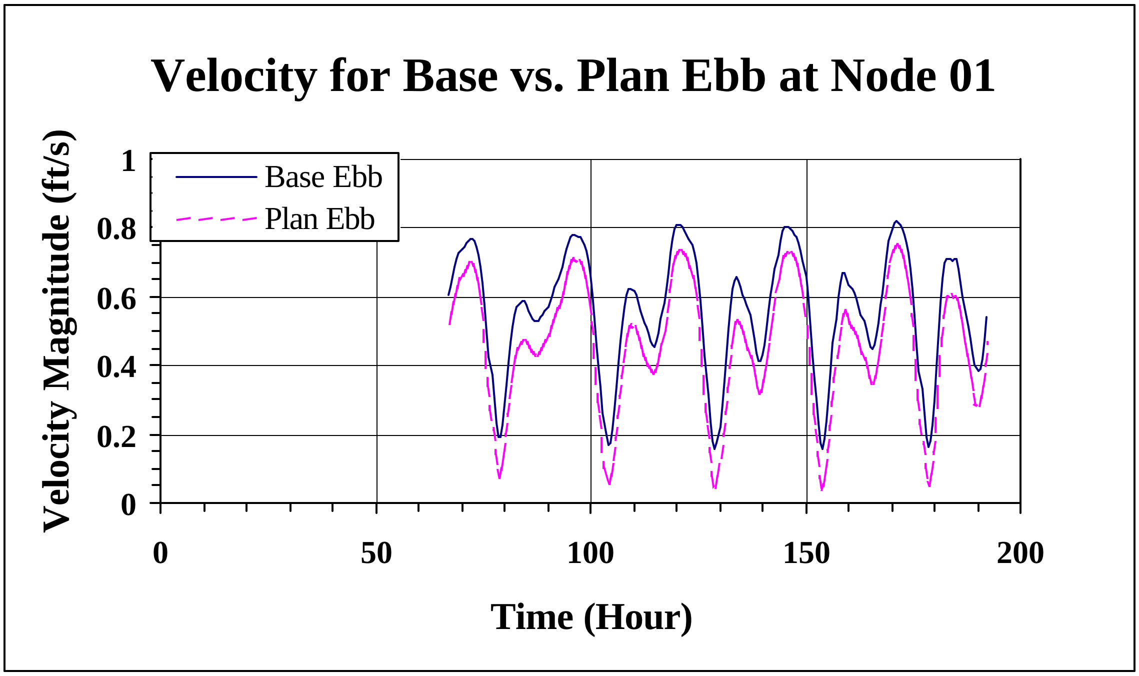

Velocity for Base vs. Plan Flood at Node 118
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0
50
100
150
200

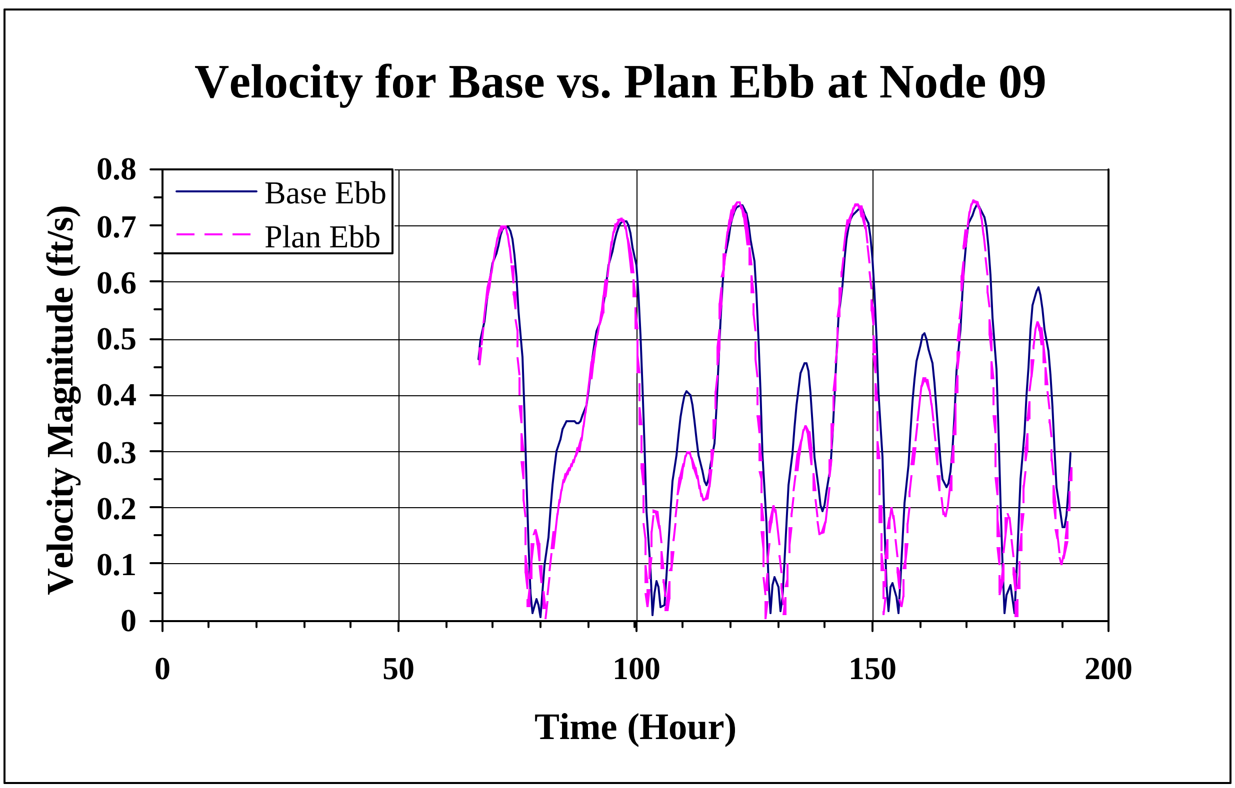

Velocity for Base vs. Plan Flood at Node 122
Velocity Magnitude (ft/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

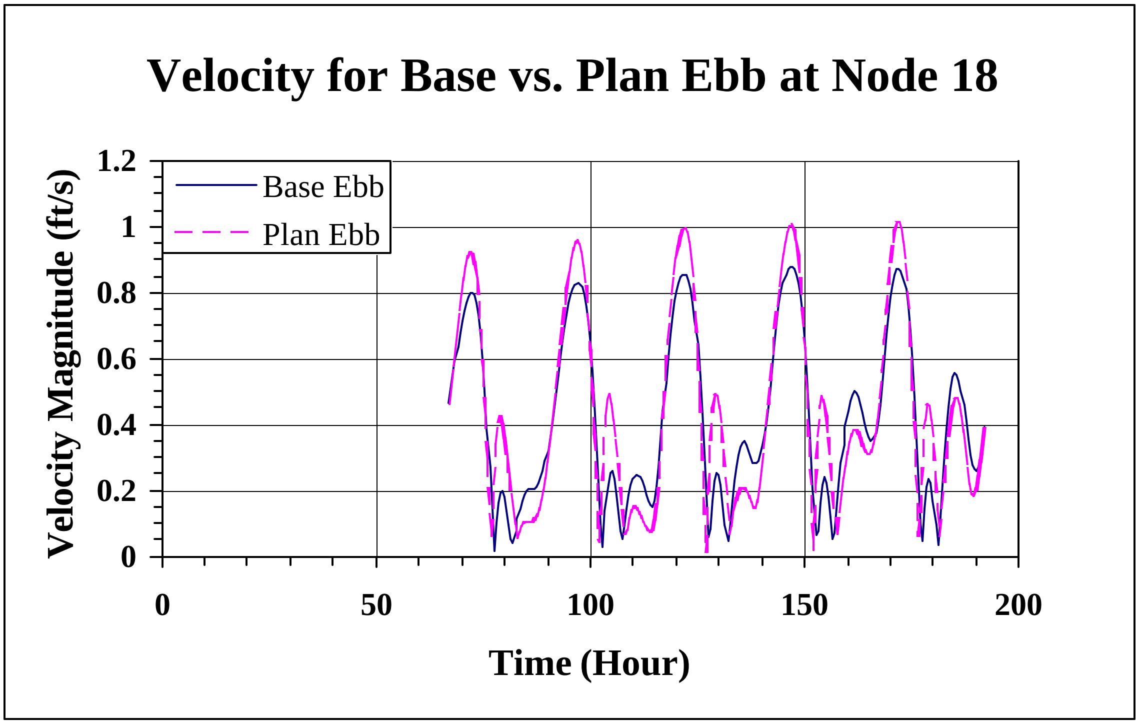

Velocity for Base vs. Plan Flood at Node 124
Velocity Magnitude (ft/s)
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

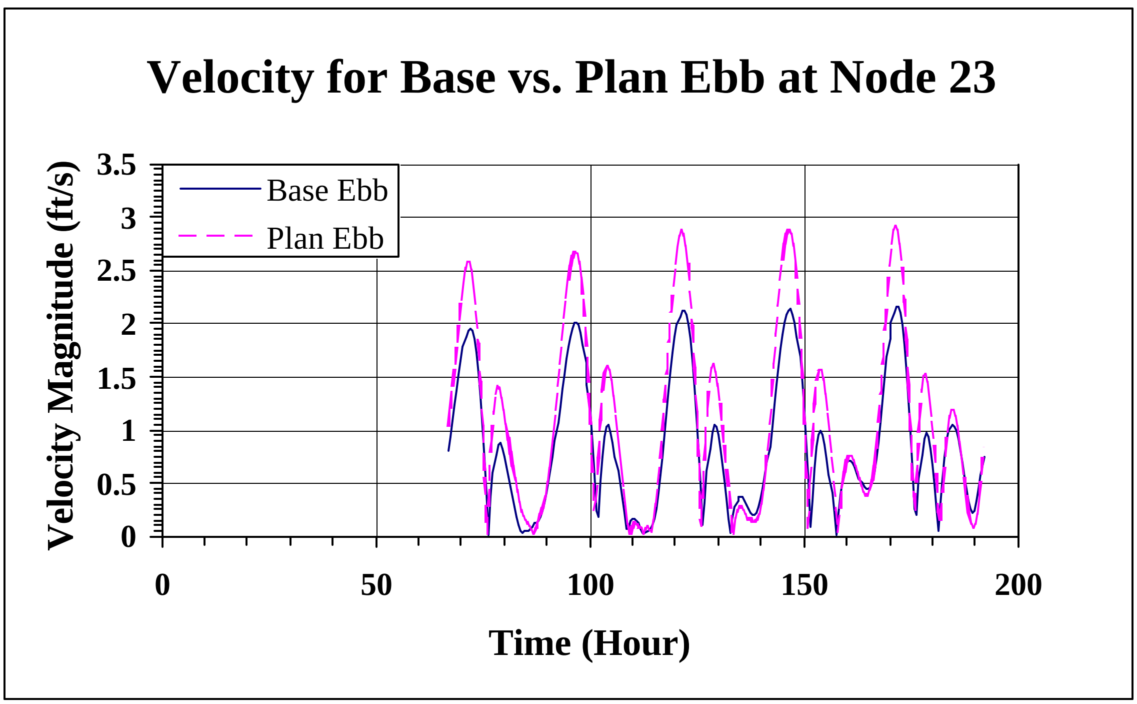
# Appendix D

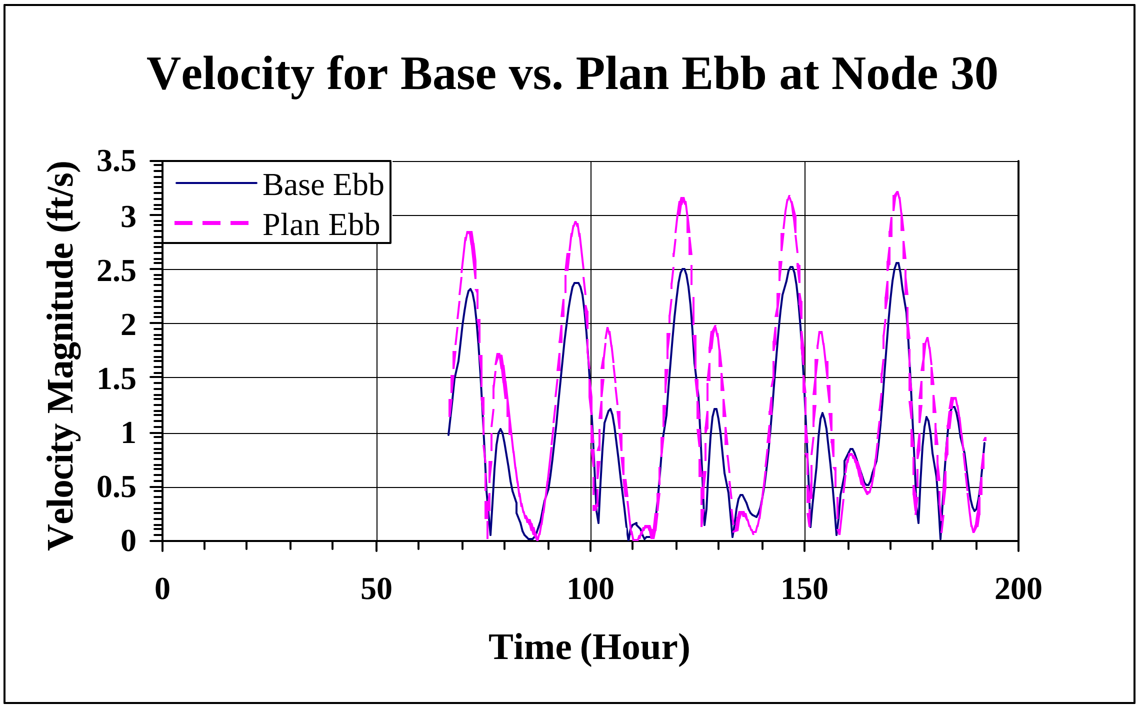
## Superposed Velocity Plots for
## Base and Plan for Ebb at Locations Along
## SNWW Navigation Channel

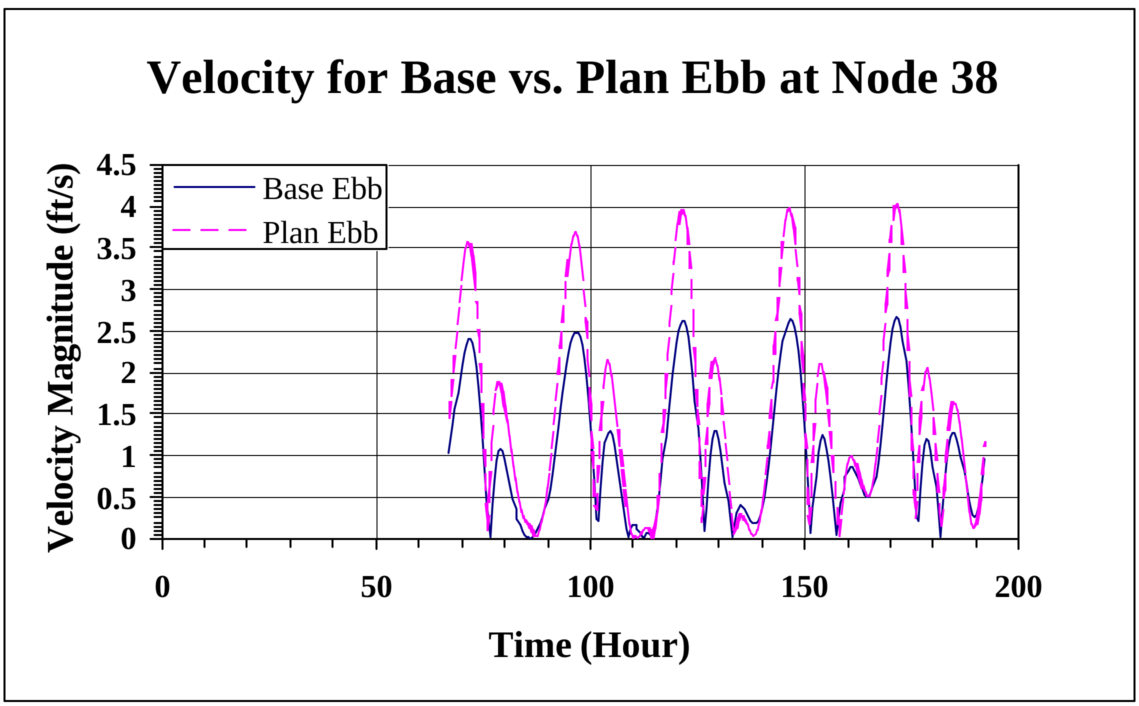

Velocity for Base vs. Plan Ebb at Node 01
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)

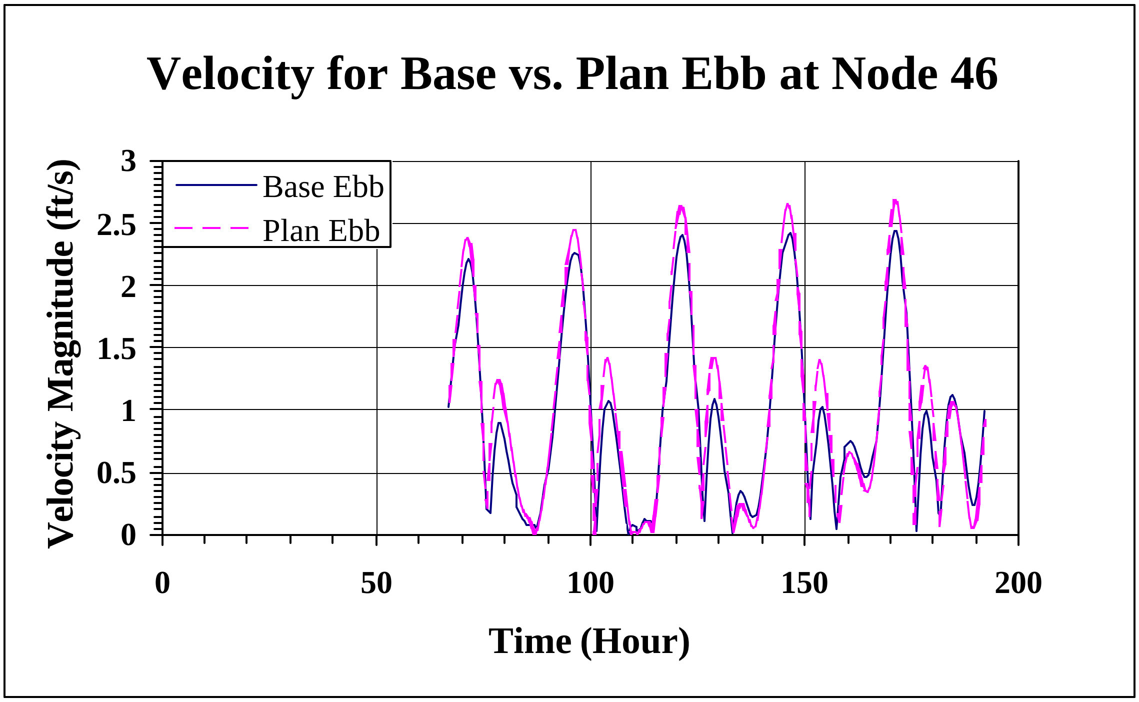

Velocity for Base vs. Plan Ebb at Node 09
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

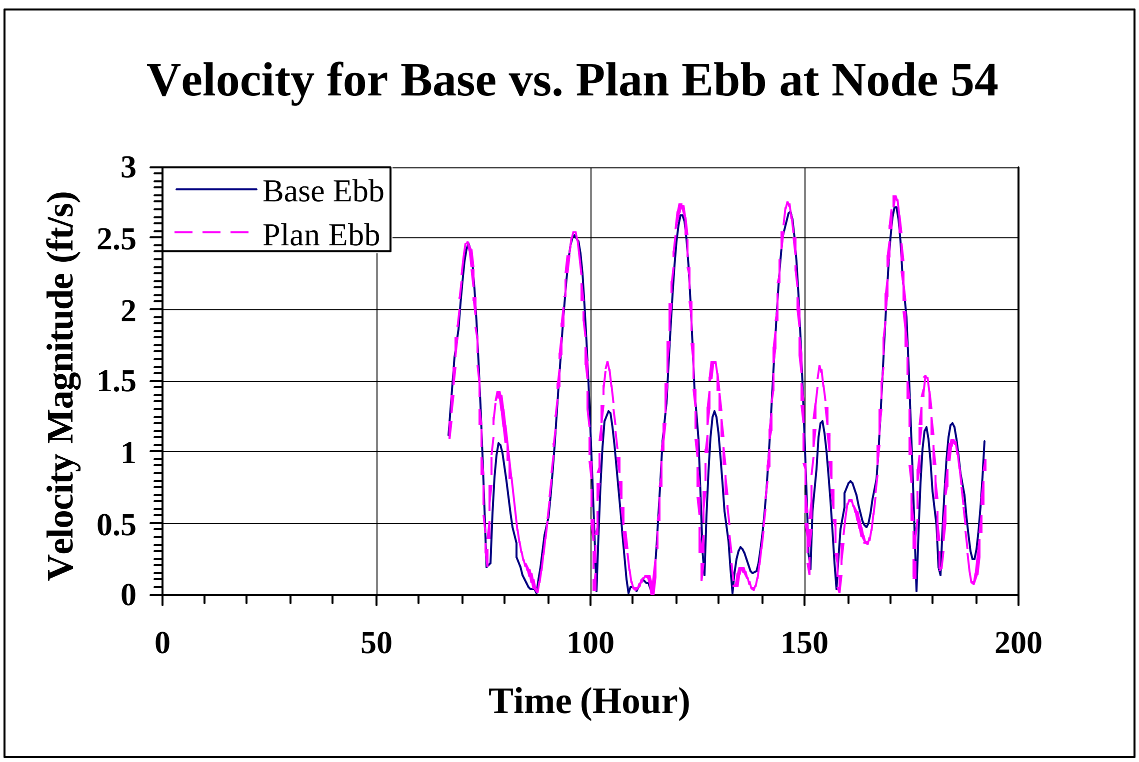

Velocity for Base vs. Plan Ebb at Node 18
Velocity Magnitude (ft/s)
1.2
1
0.8
0.6
0.4
0.2
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)

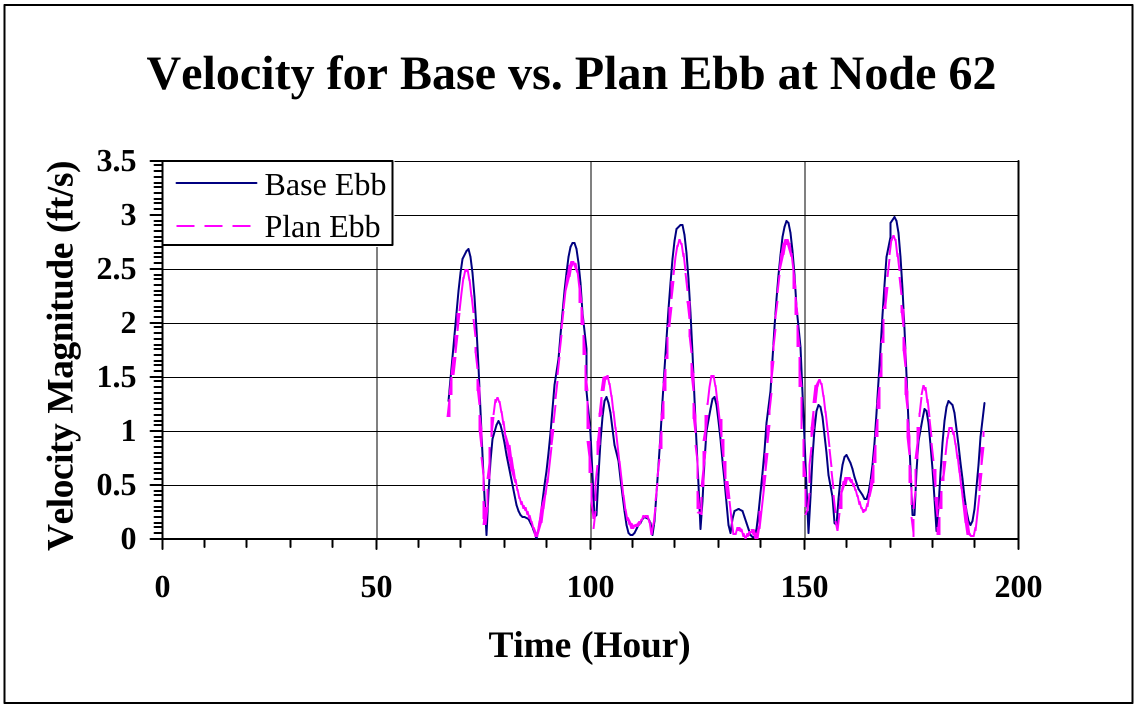

Velocity for Base vs. Plan Ebb at Node 23
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)

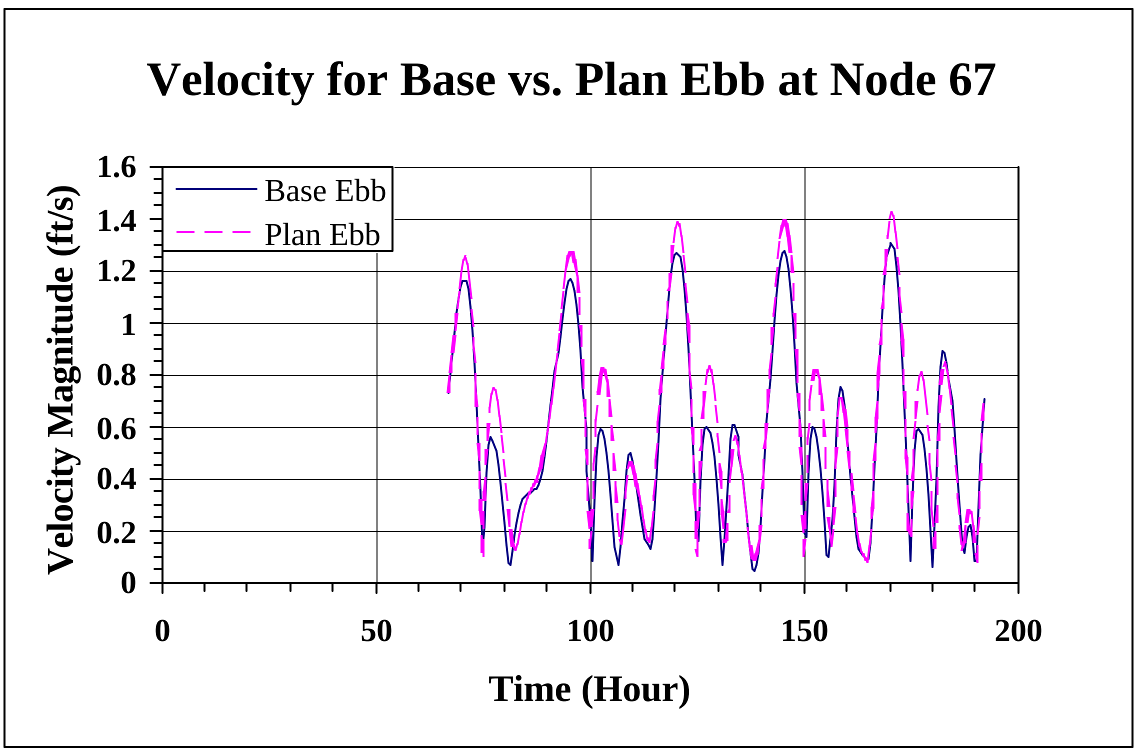

Velocity for Base vs. Plan Ebb at Node 30
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

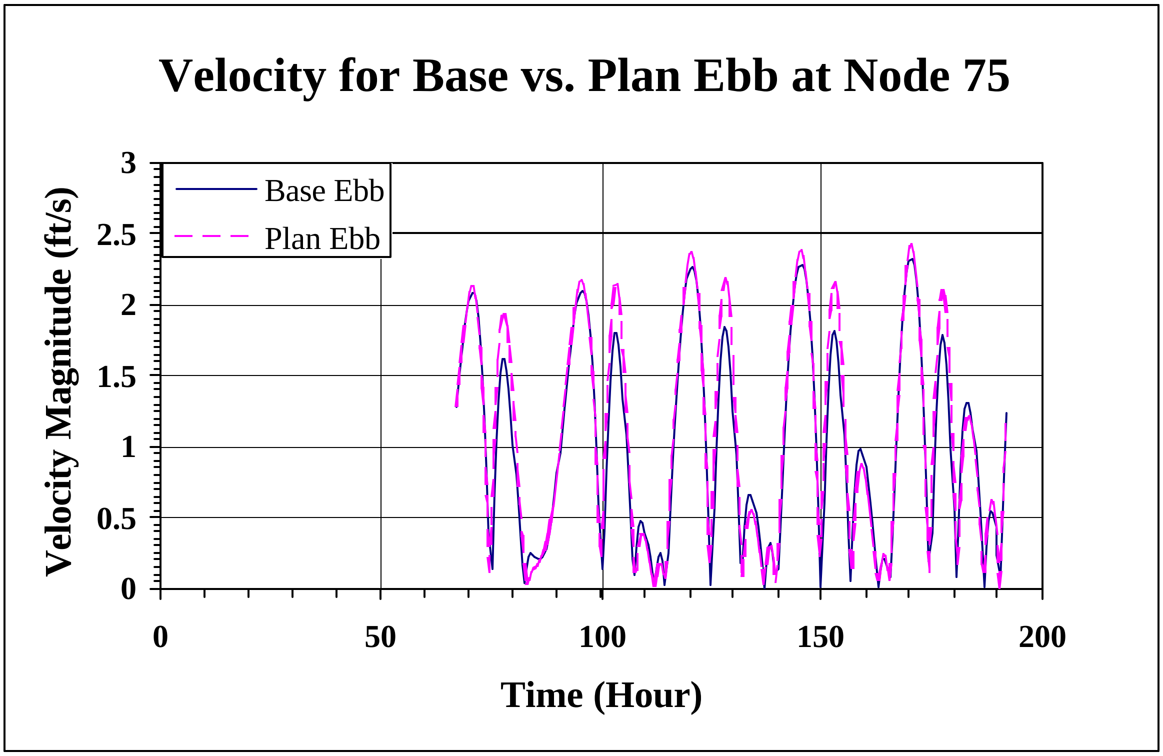

Velocity for Base vs. Plan Ebb at Node 38
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
50
100
150
200

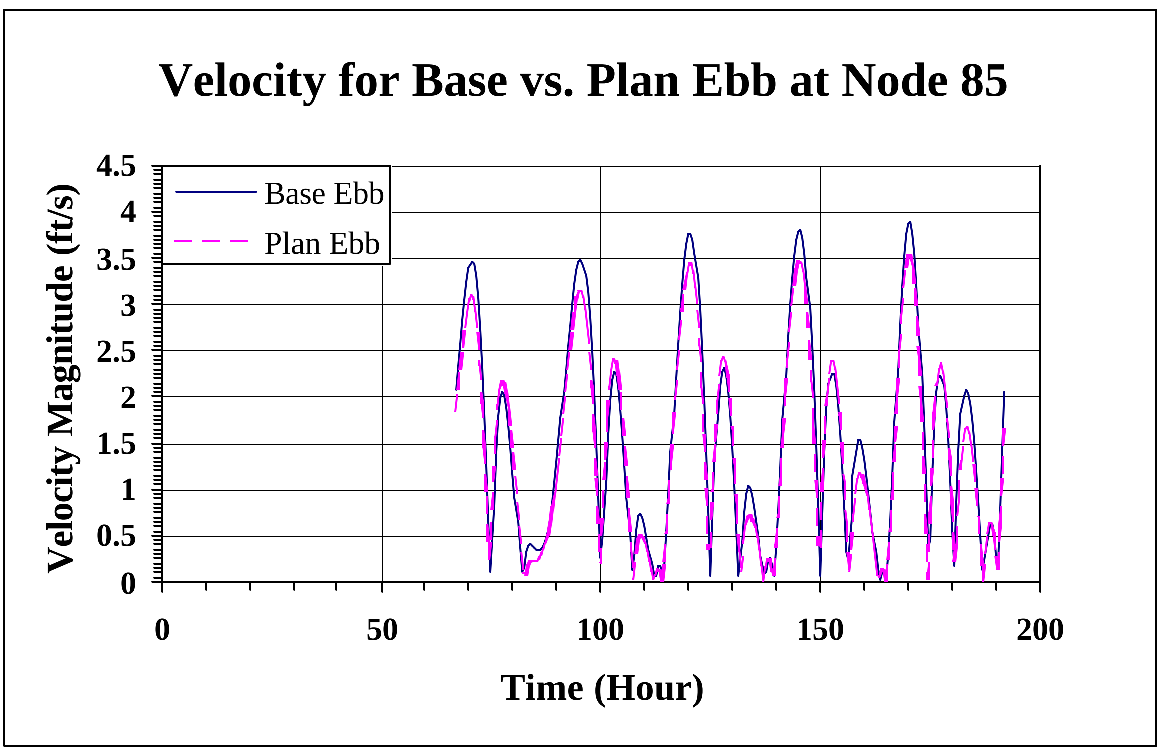

Velocity for Base vs. Plan Ebb at Node 46
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

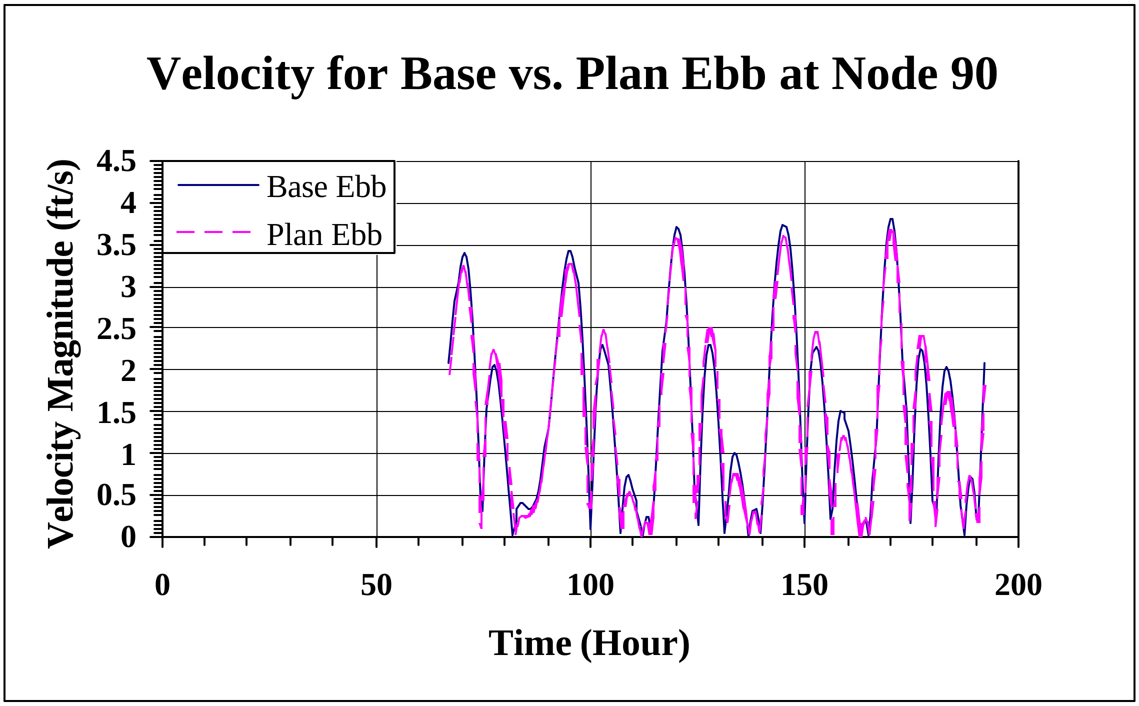

Velocity for Base vs. Plan Ebb at Node 54
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

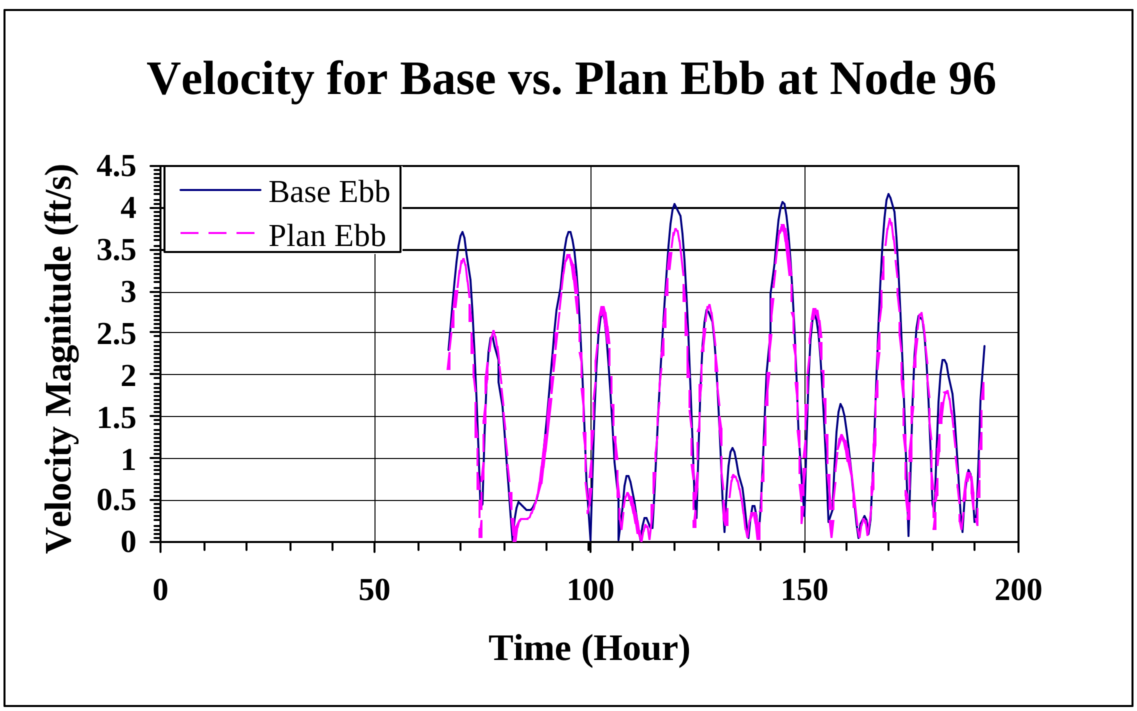

Velocity for Base vs. Plan Ebb at Node 62
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

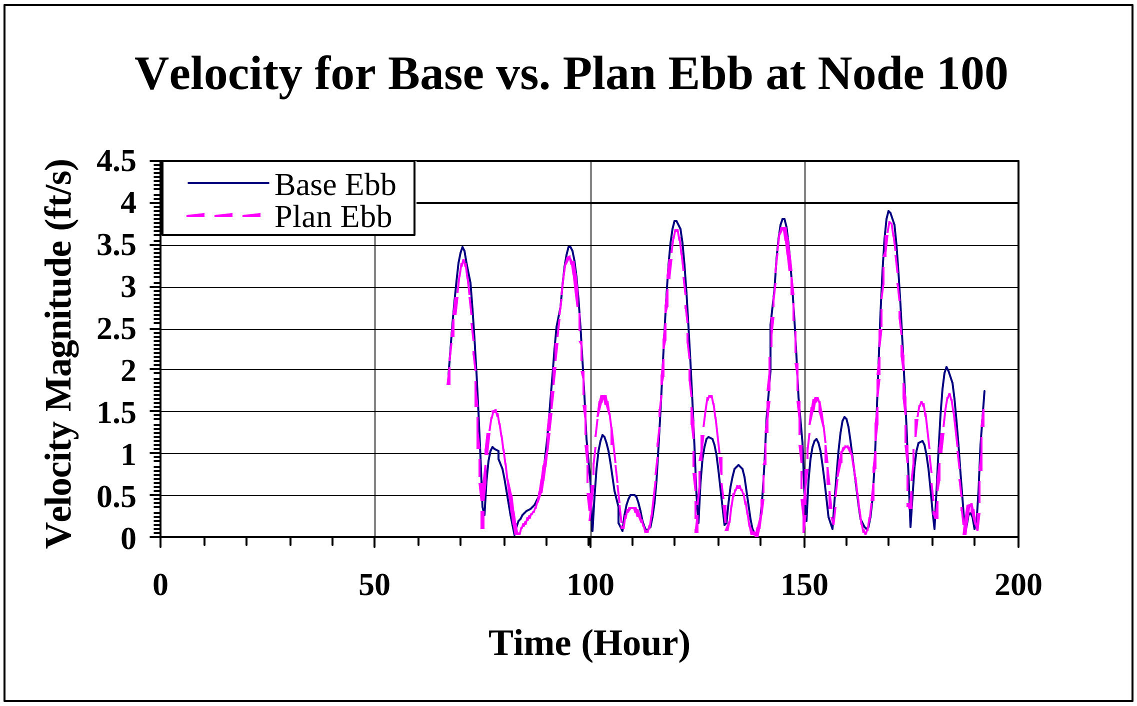

Velocity for Base vs. Plan Ebb at Node 67
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)

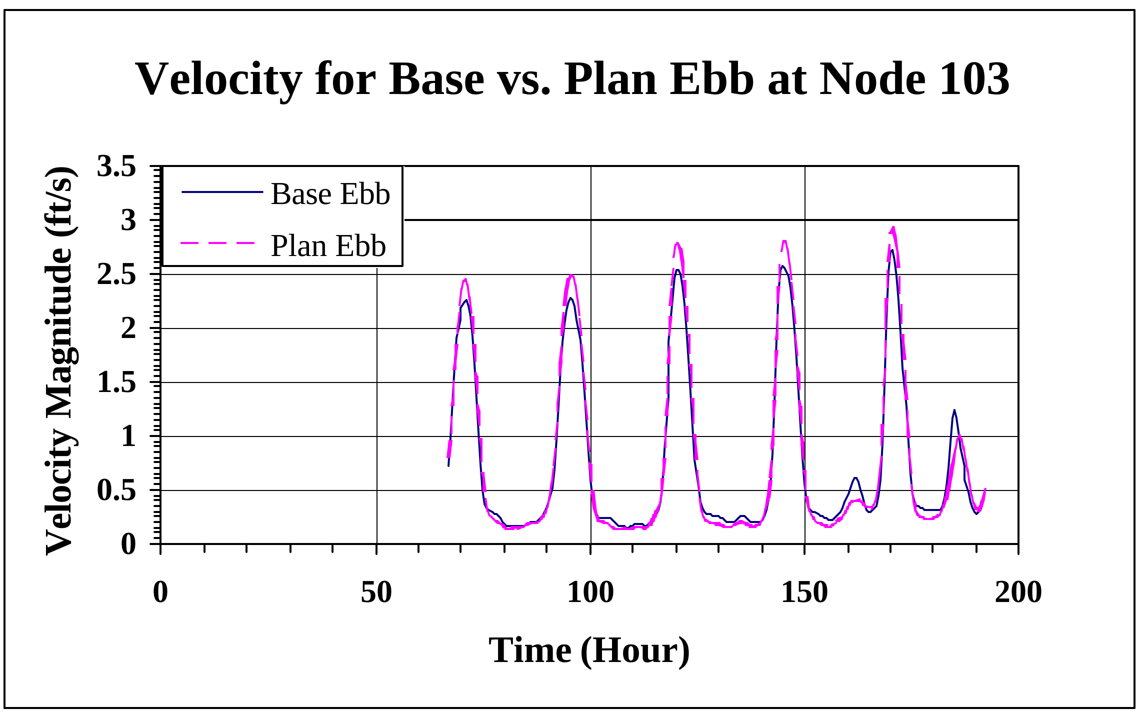

Velocity for Base vs. Plan Ebb at Node 75
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

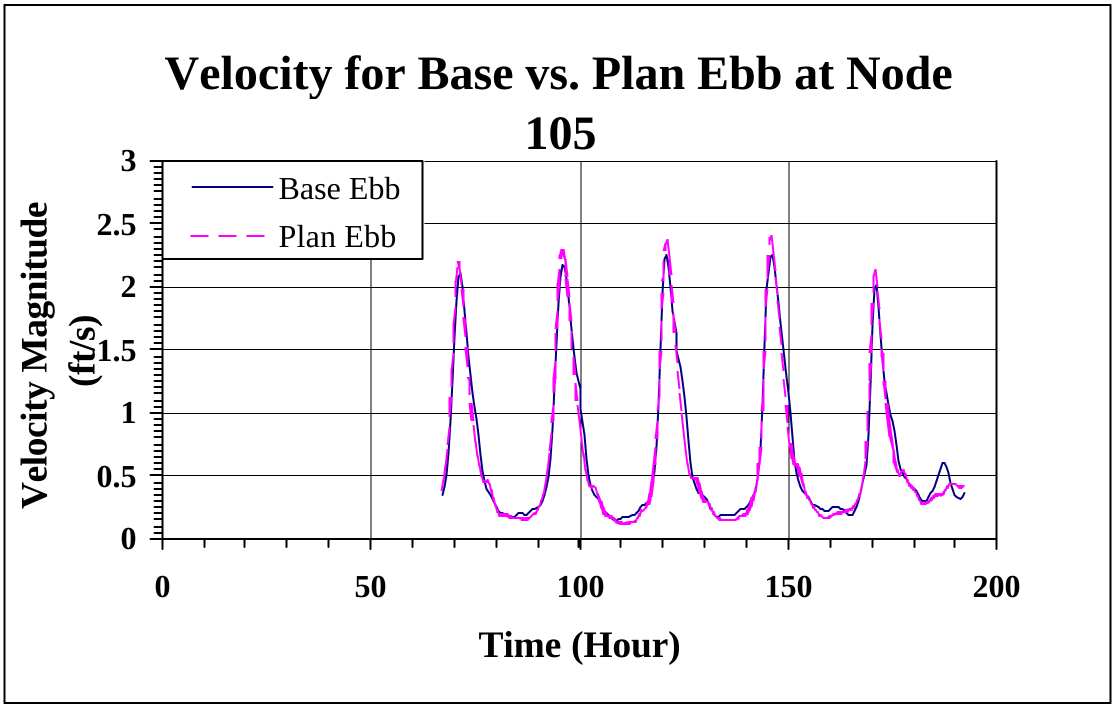

Velocity for Base vs. Plan Ebb at Node 85
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

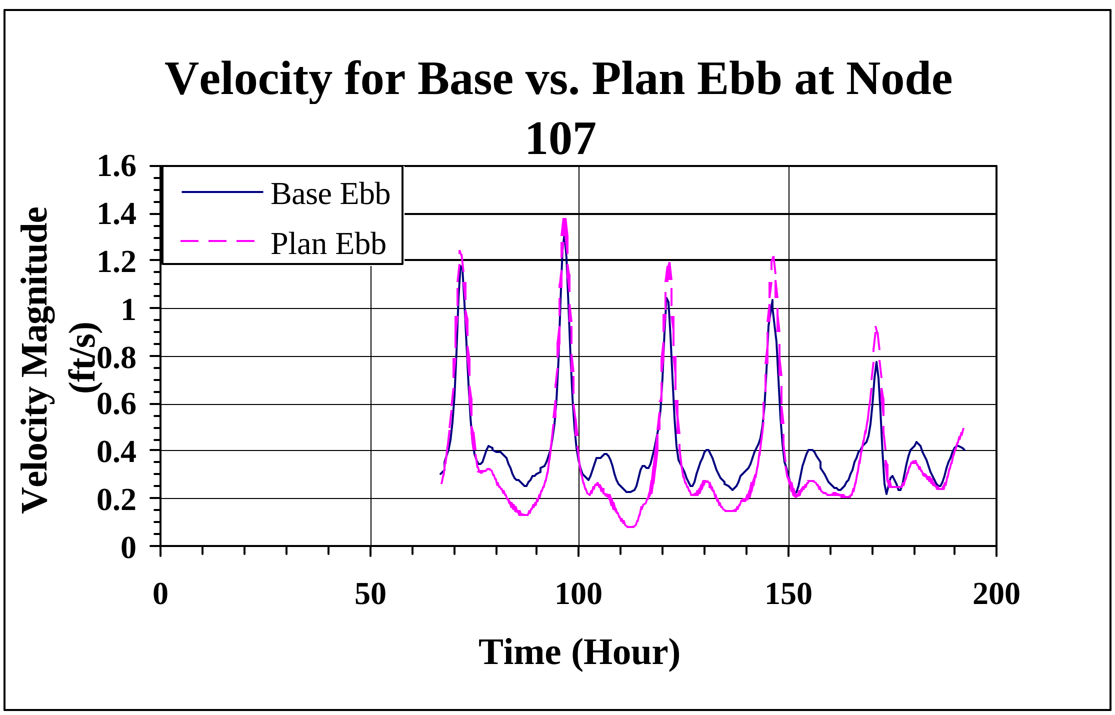

Velocity for Base vs. Plan Ebb at Node 90
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

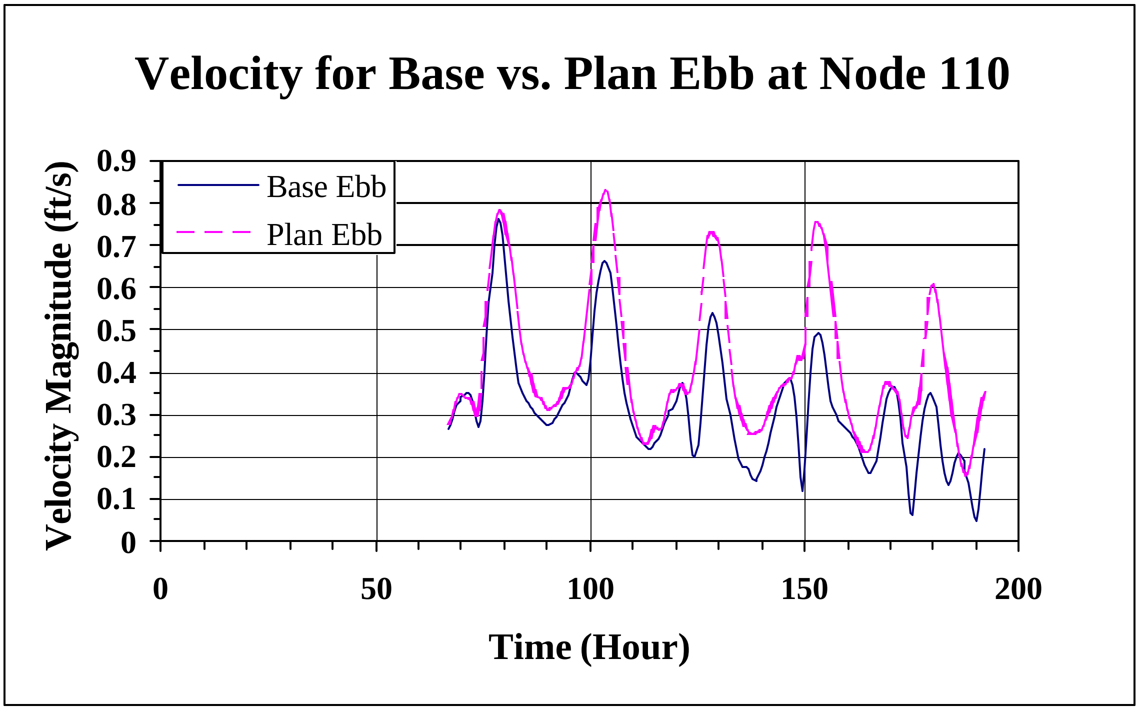

Velocity for Base vs. Plan Ebb at Node 96
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

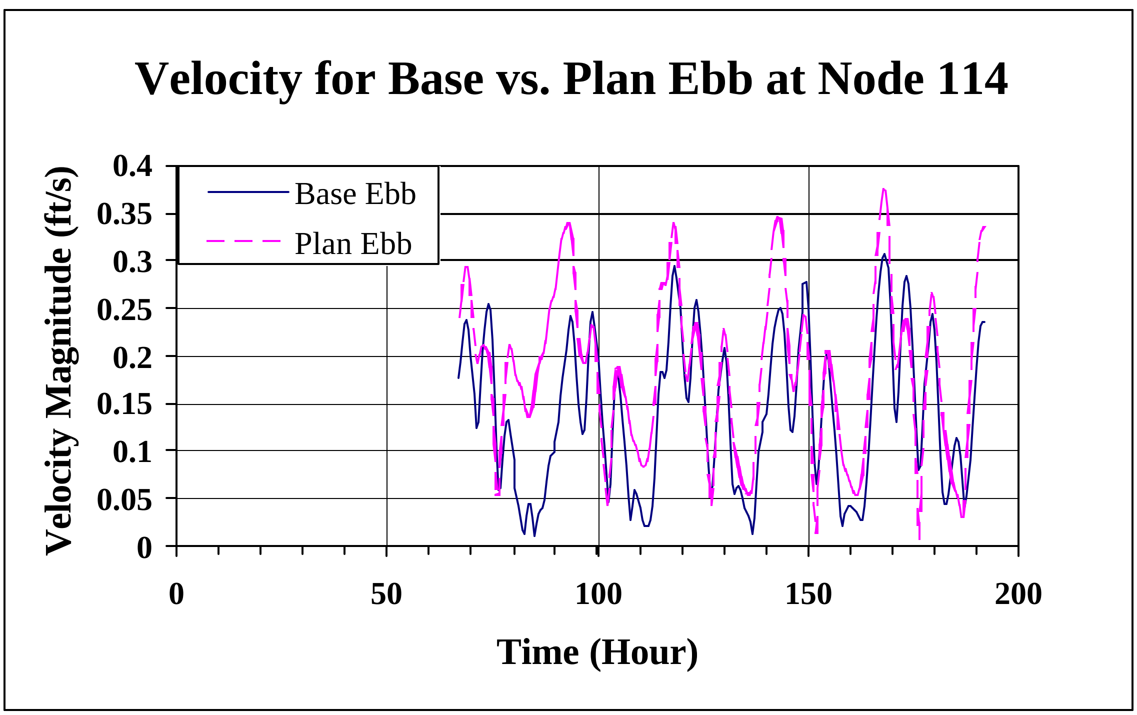

Velocity for Base vs. Plan Ebb at Node 100
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

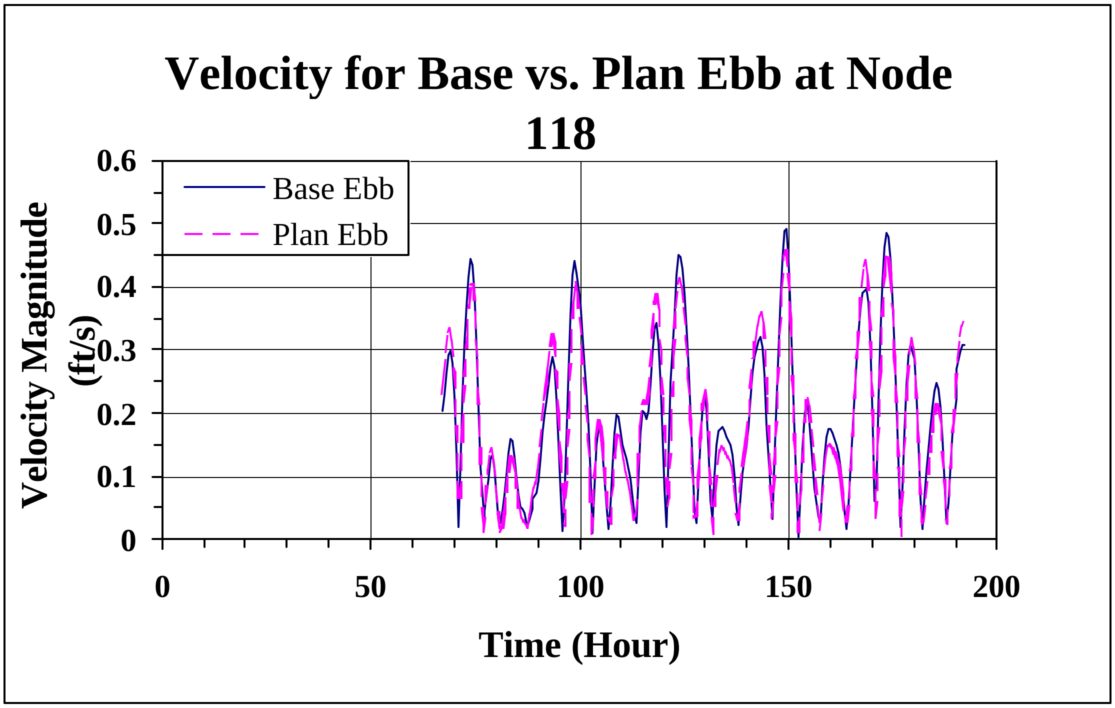

Velocity for Base vs. Plan Ebb at Node 103
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

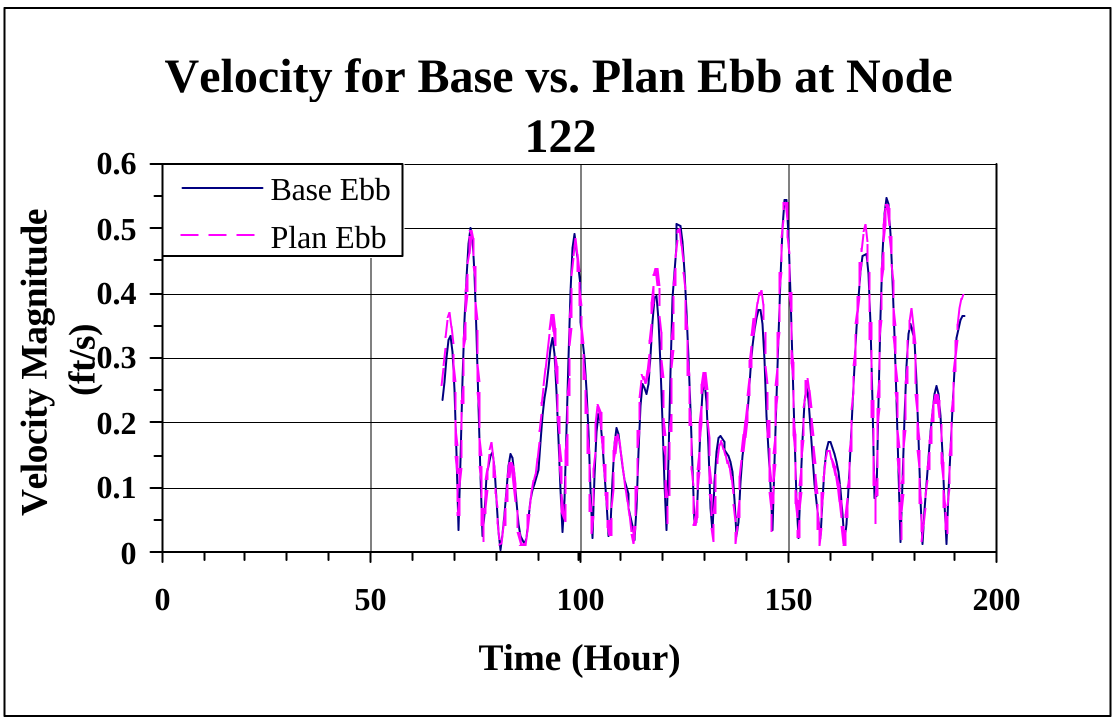

Velocity for Base vs. Plan Ebb at Node 105
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

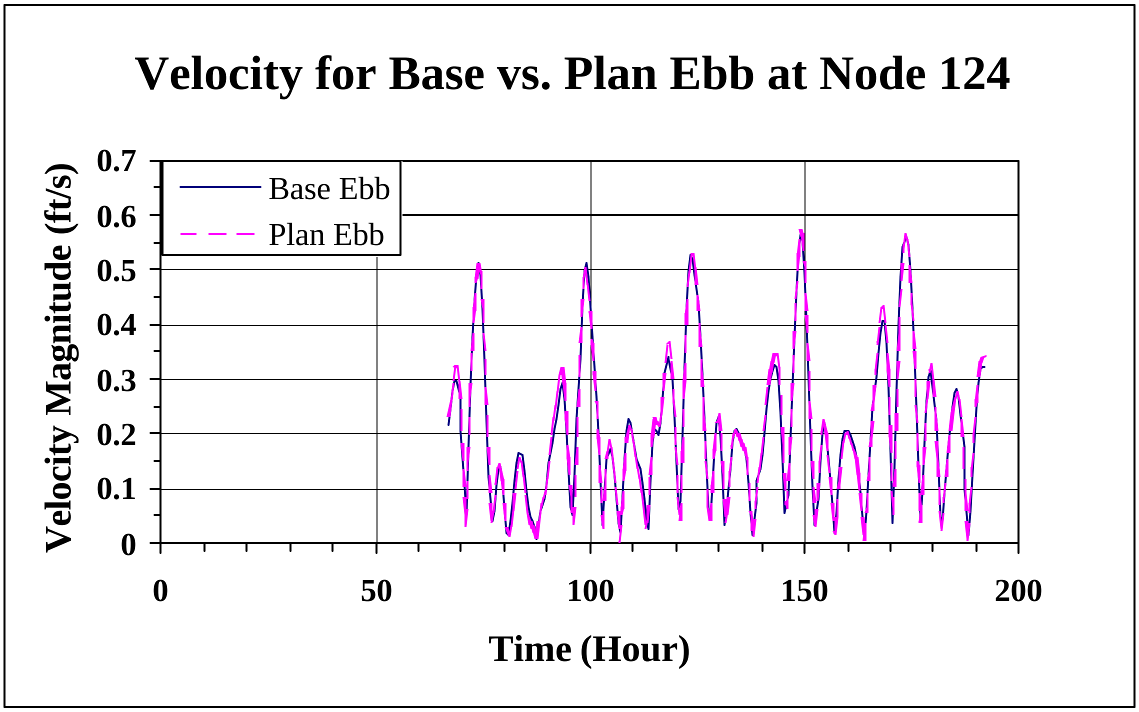

Velocity for Base vs. Plan Ebb at Node 107
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node 110
Velocity Magnitude (ft/s)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb


Velocity for Base vs. Plan Ebb at Node 114
Velocity Magnitude (ft/s)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb


Velocity for Base vs. Plan Ebb at Node 118
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

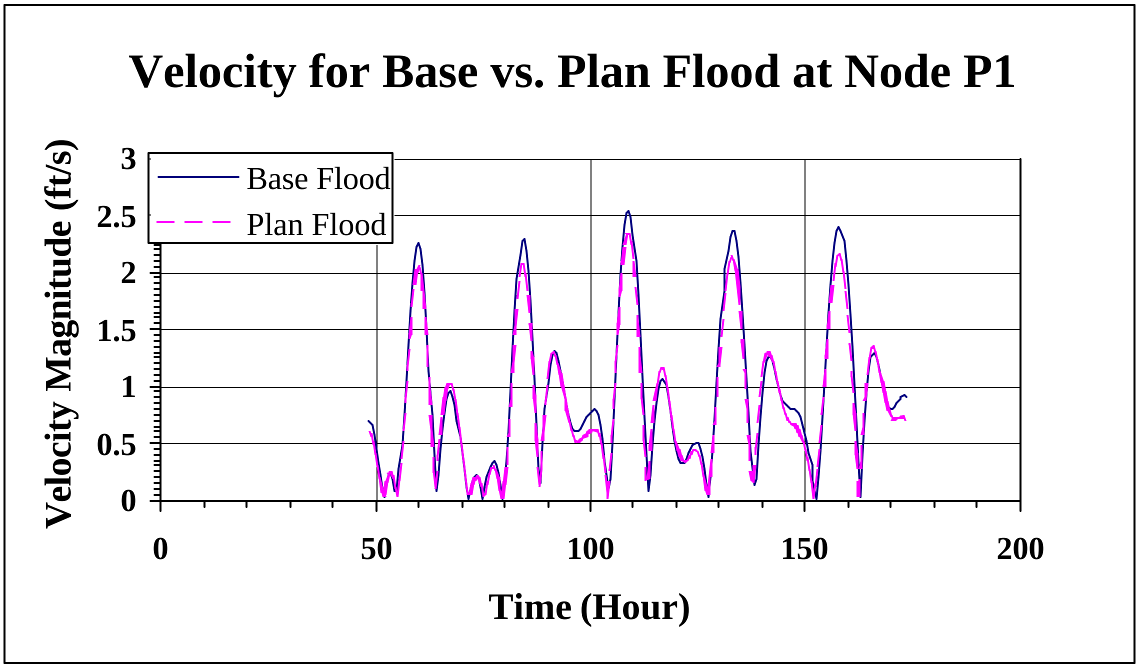

Velocity for Base vs. Plan Ebb at Node 122
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

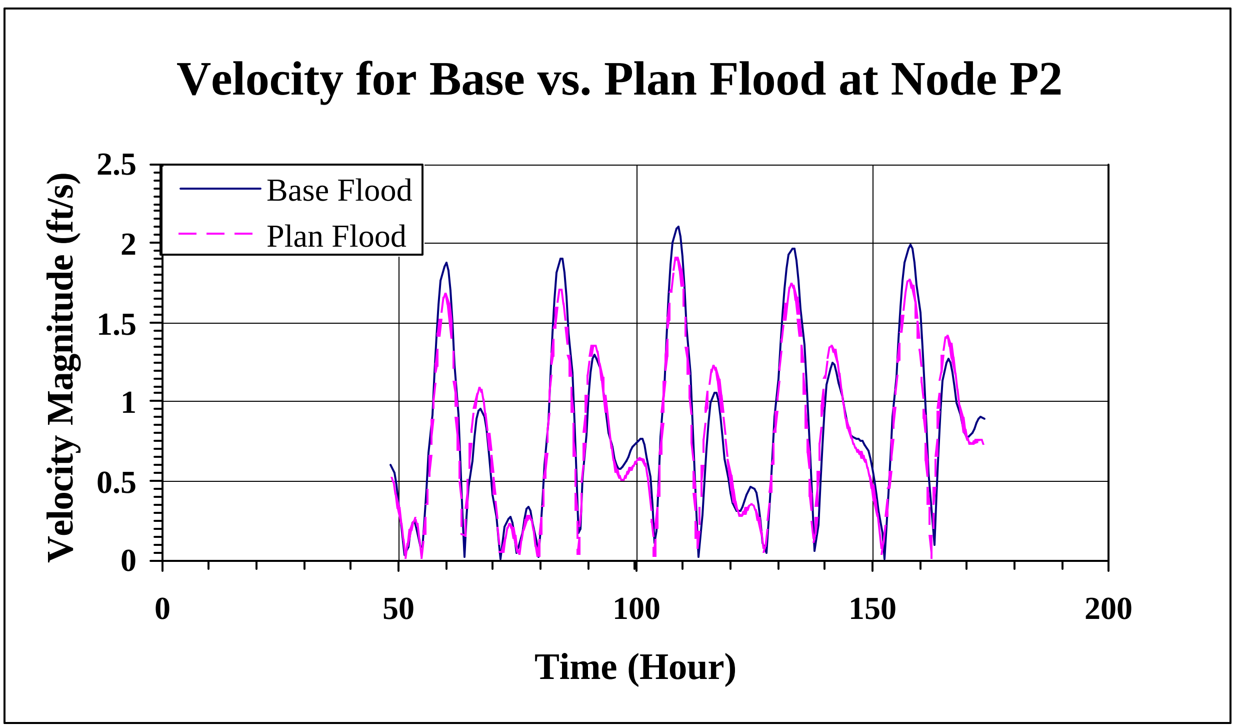


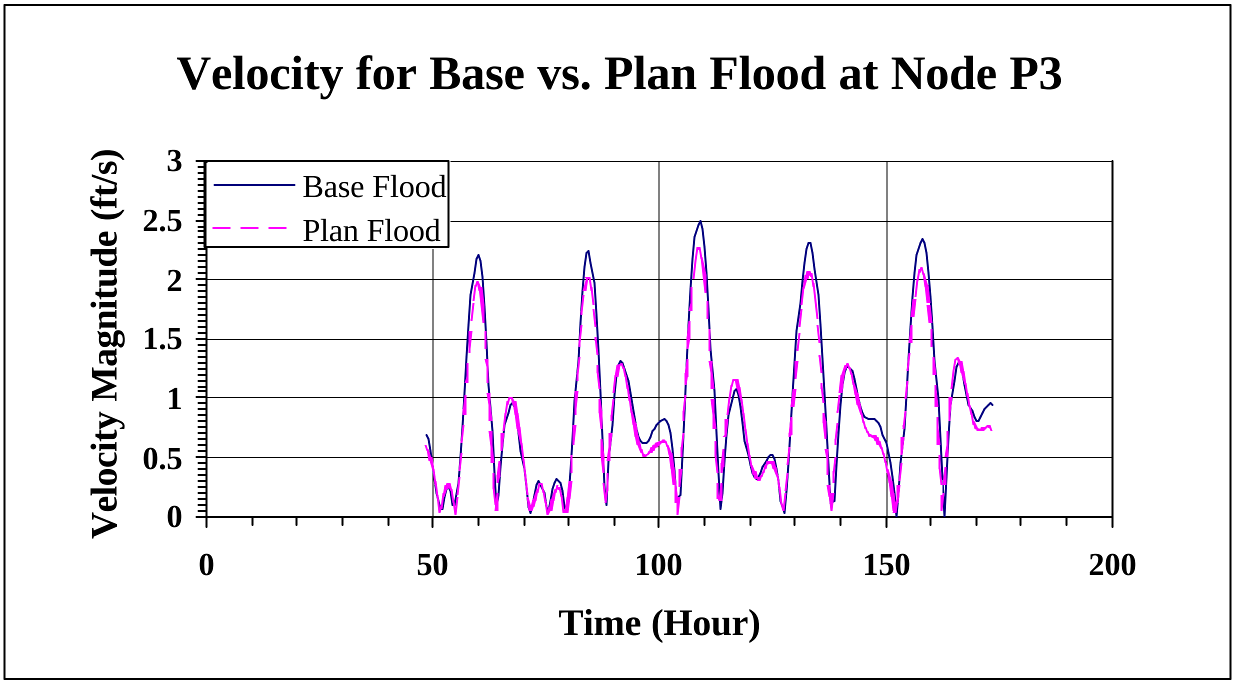
Velocity for Base vs. Plan Ebb at Node 124
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

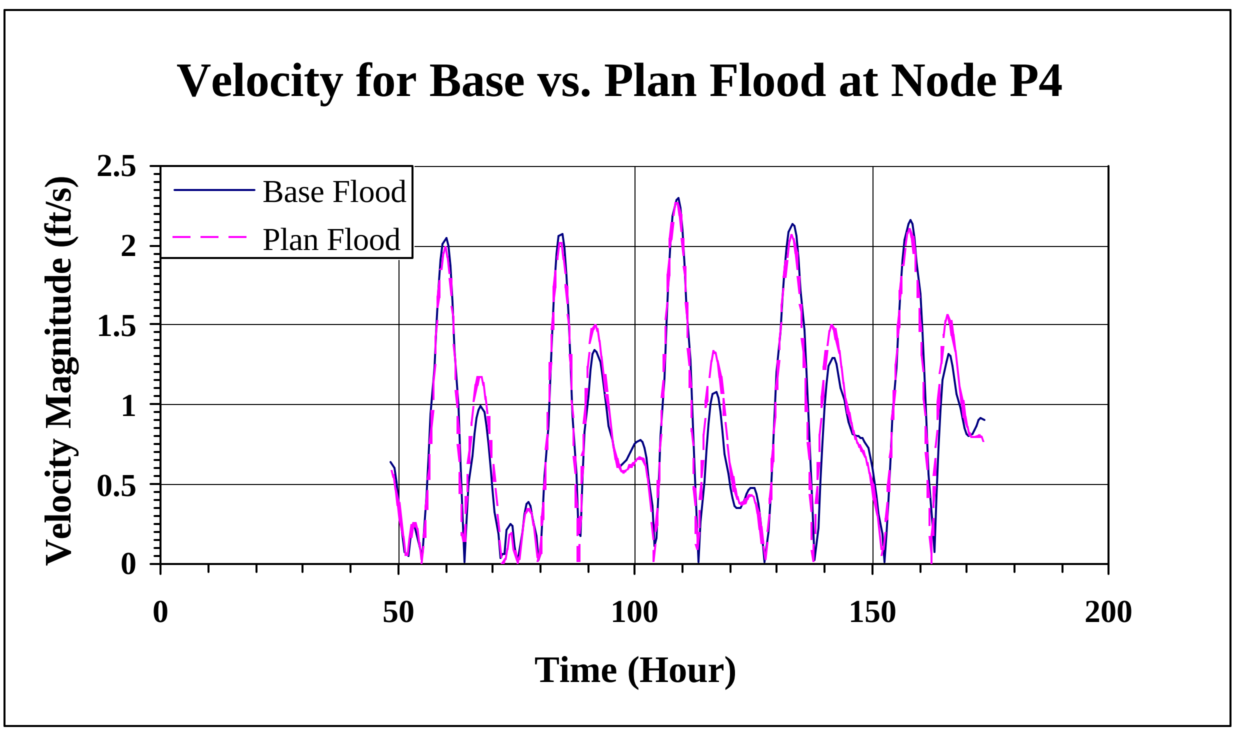
# Appendix E

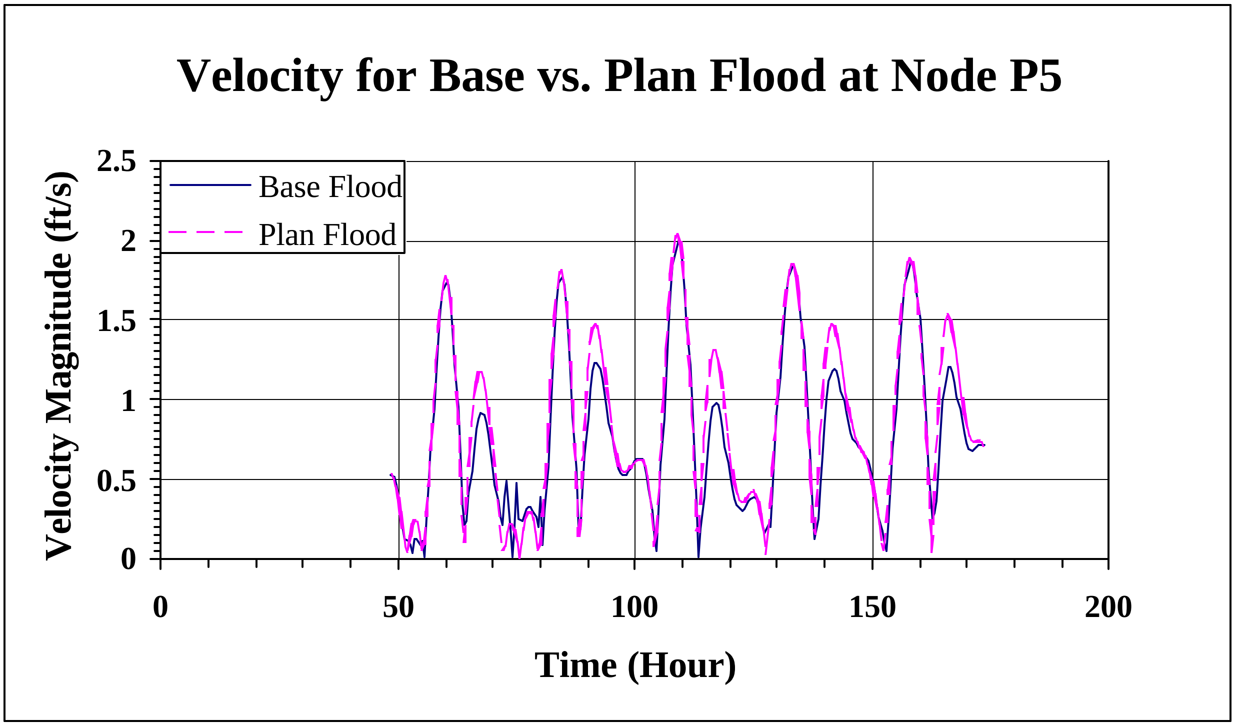
## Superposed Velocity Plots for Base and Plan for Flood at Locations Along Pleasure Island West Shoreline

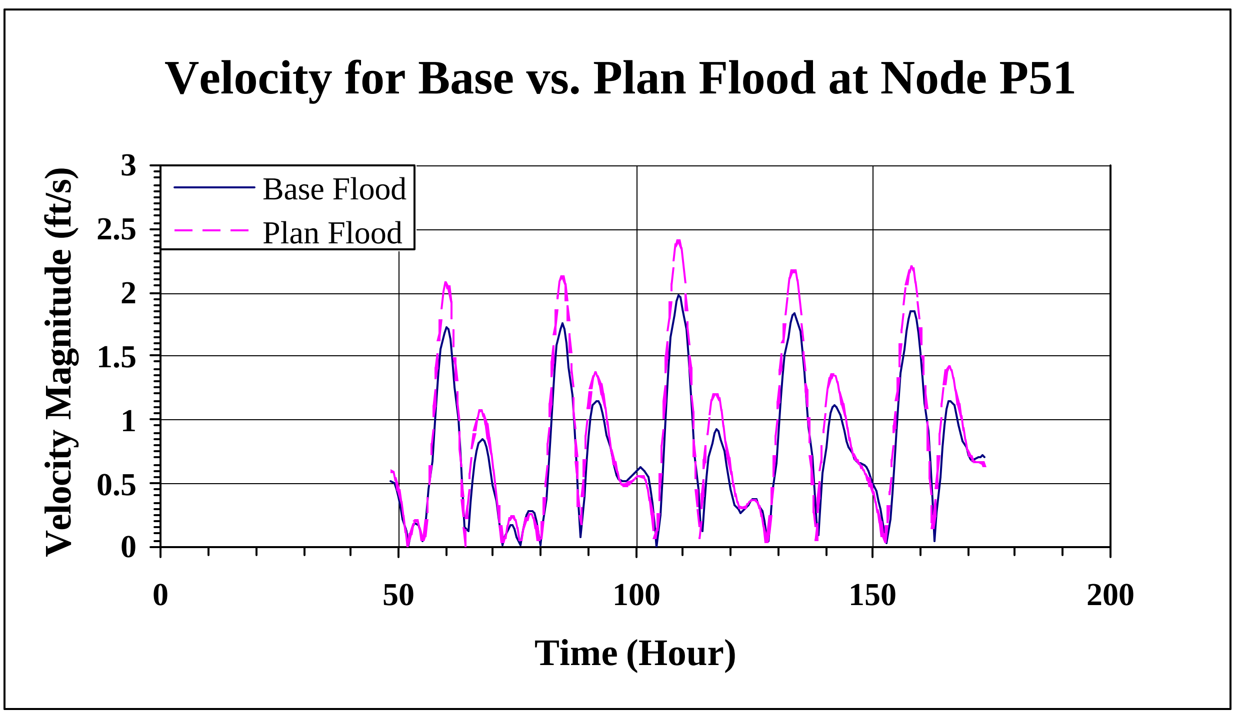

Velocity for Base vs. Plan Flood at Node P1
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

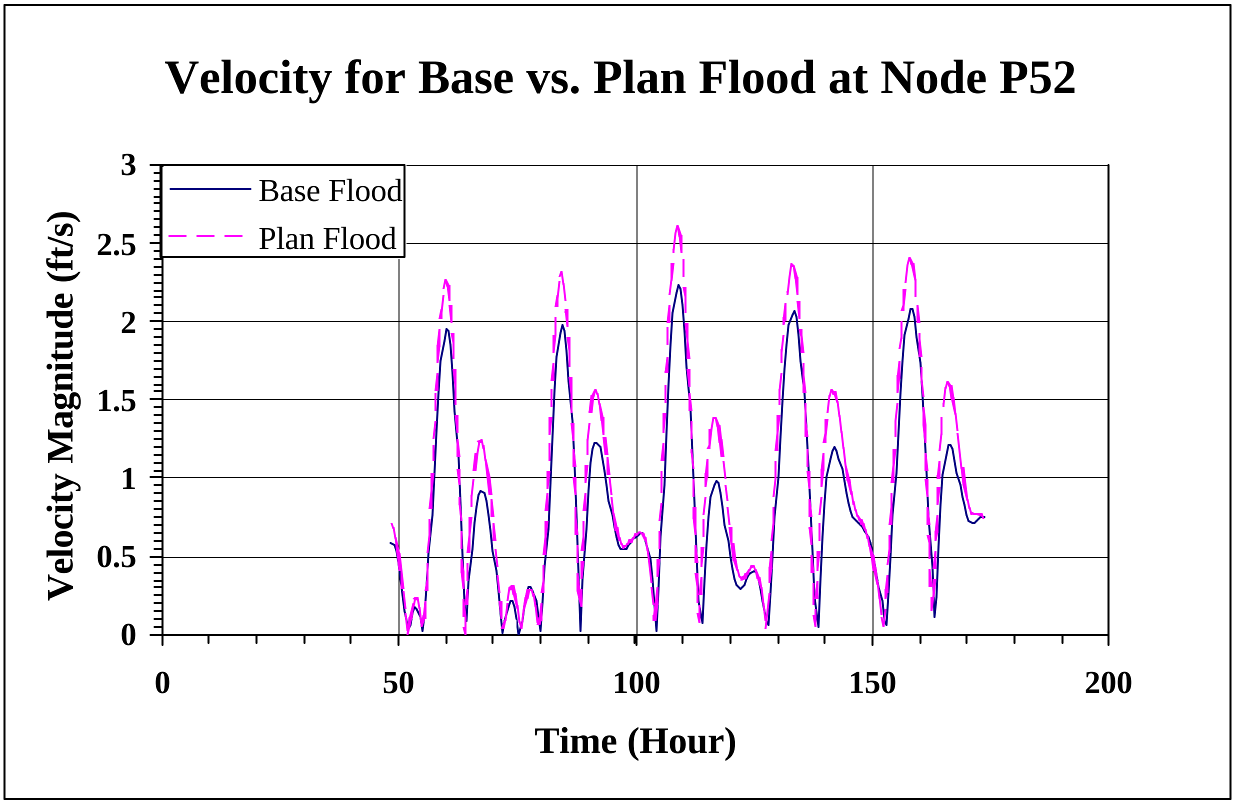

Velocity for Base vs. Plan Flood at Node P2
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
0
50
100
150
200


Velocity for Base vs. Plan Flood at Node P3
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

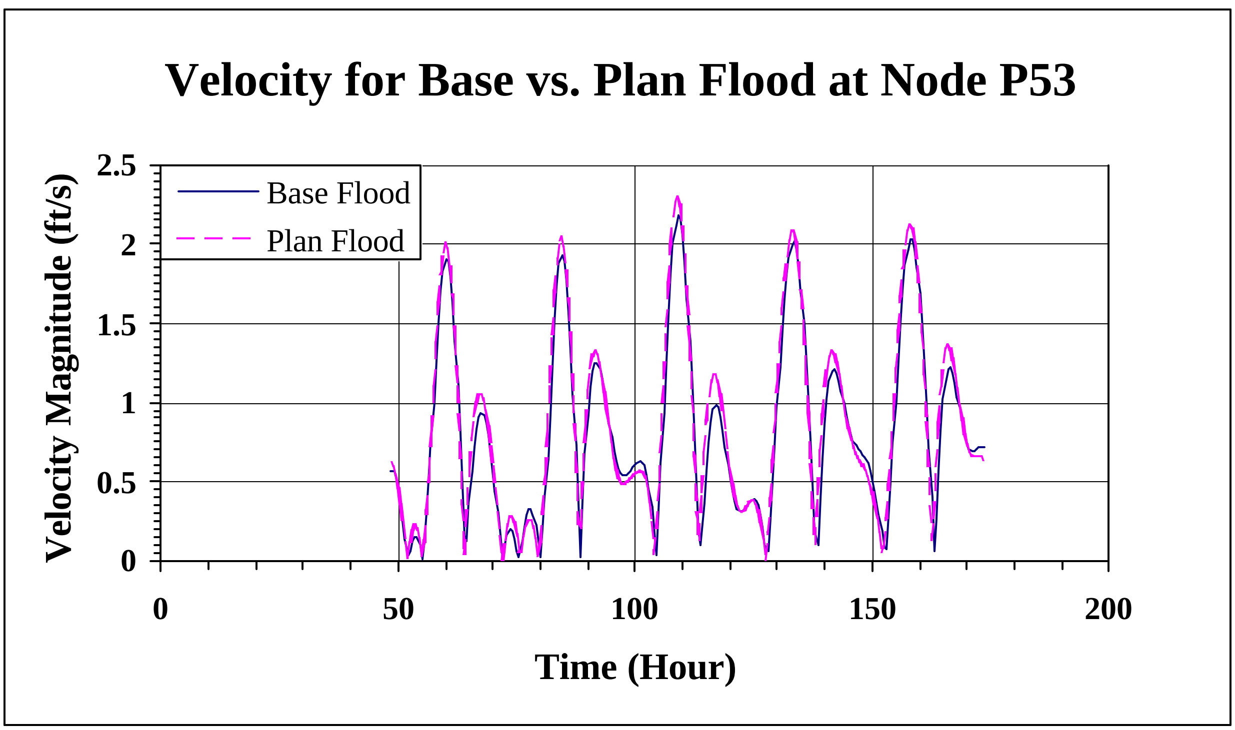

Velocity for Base vs. Plan Flood at Node P4
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node P5
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
0
50
100
150
200

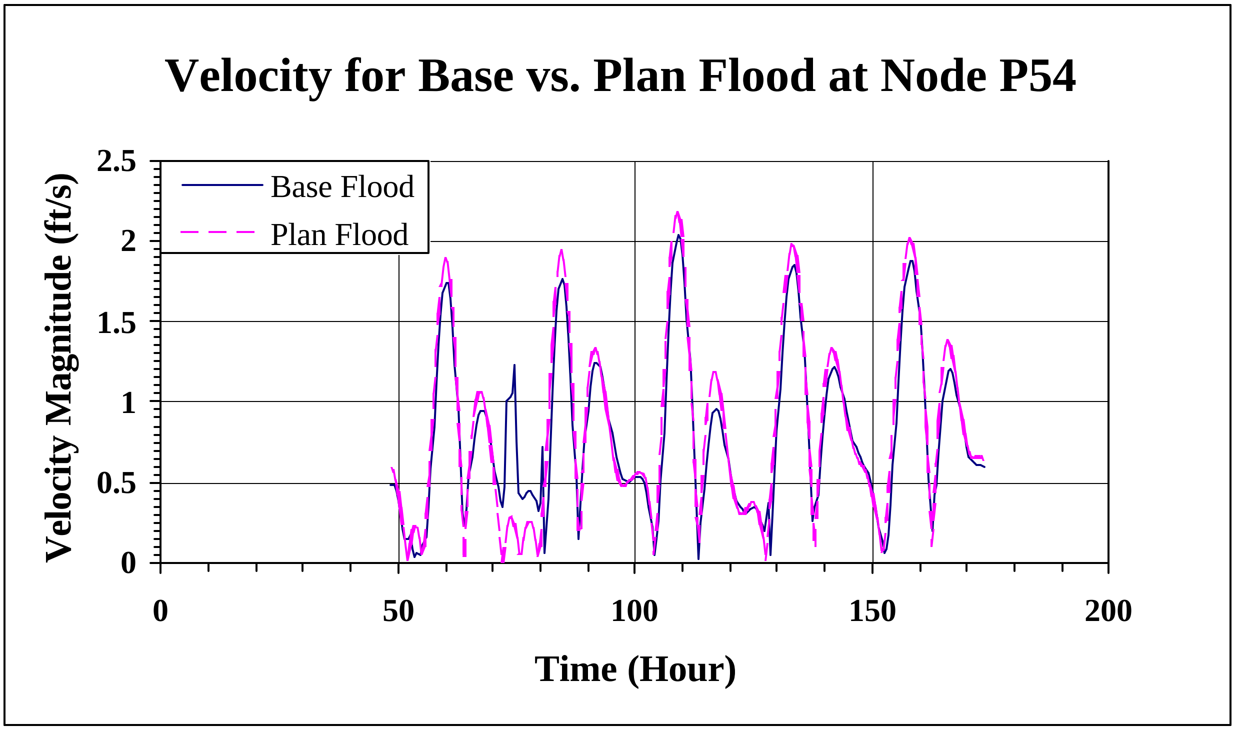

Velocity for Base vs. Plan Flood at Node P51
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

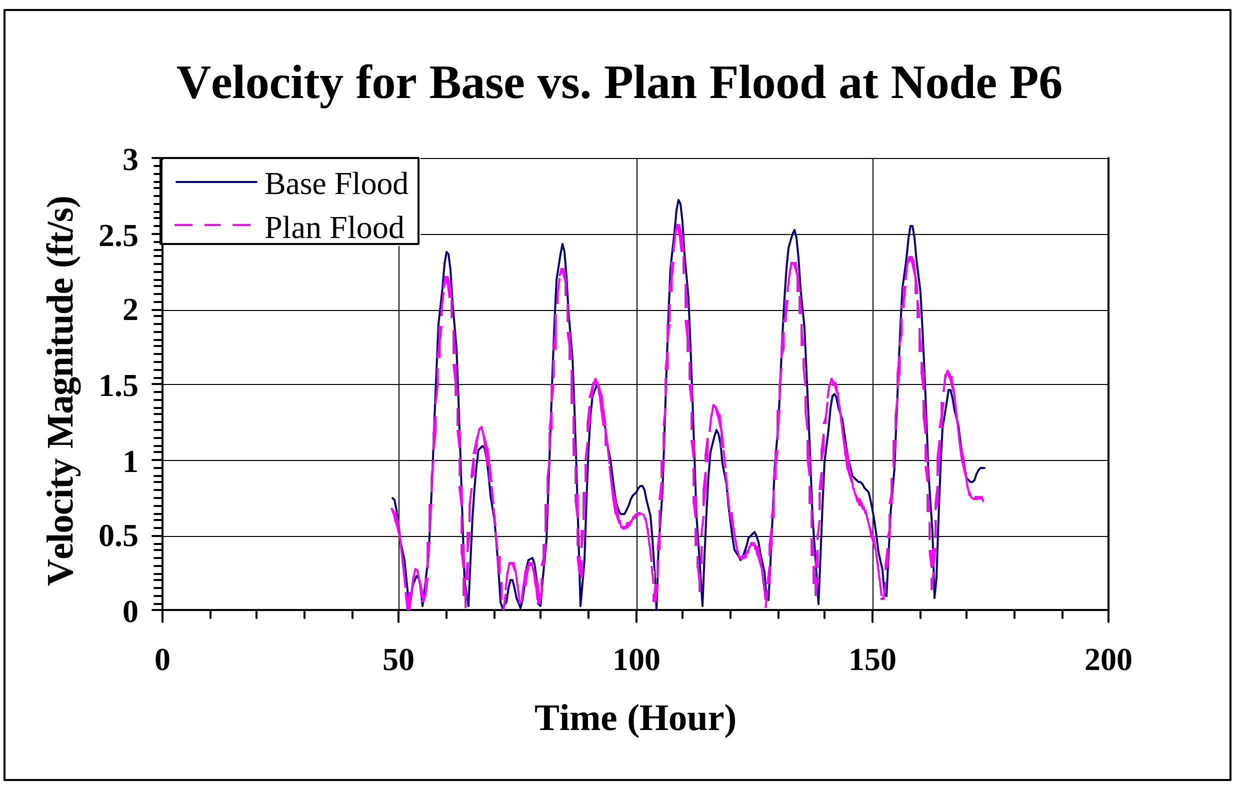


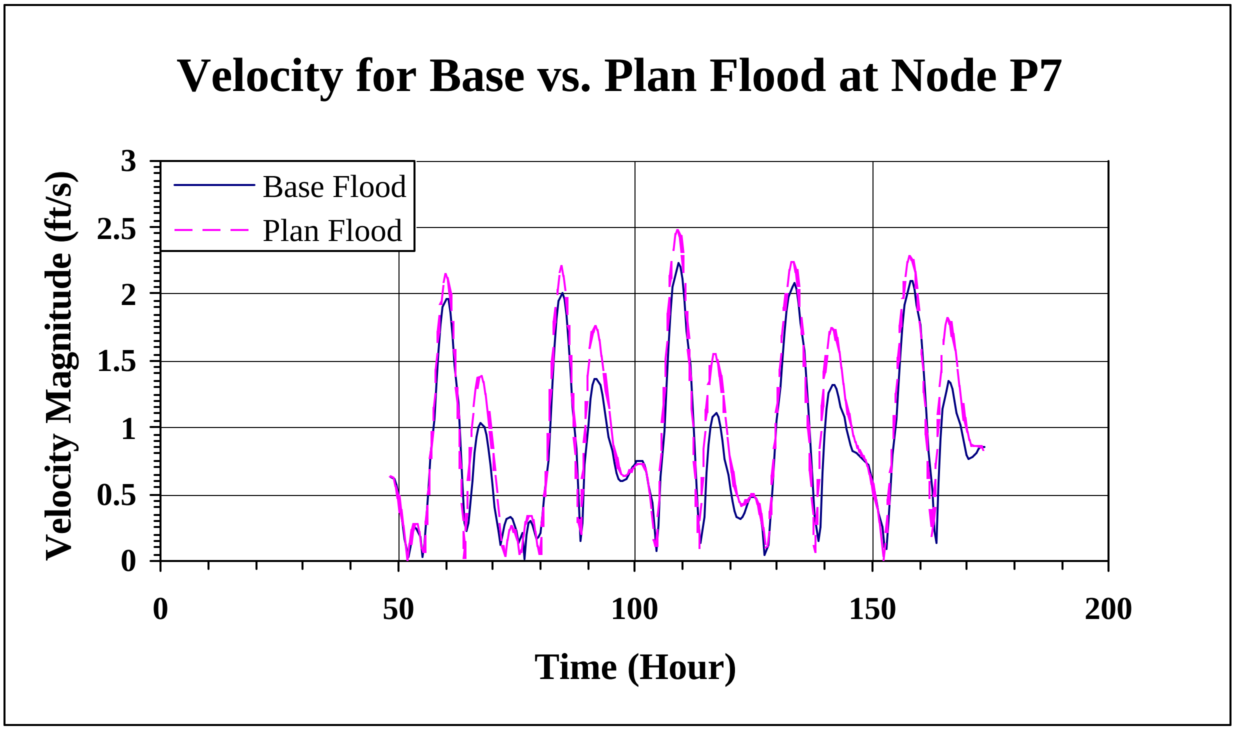
Velocity for Base vs. Plan Flood at Node P52
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

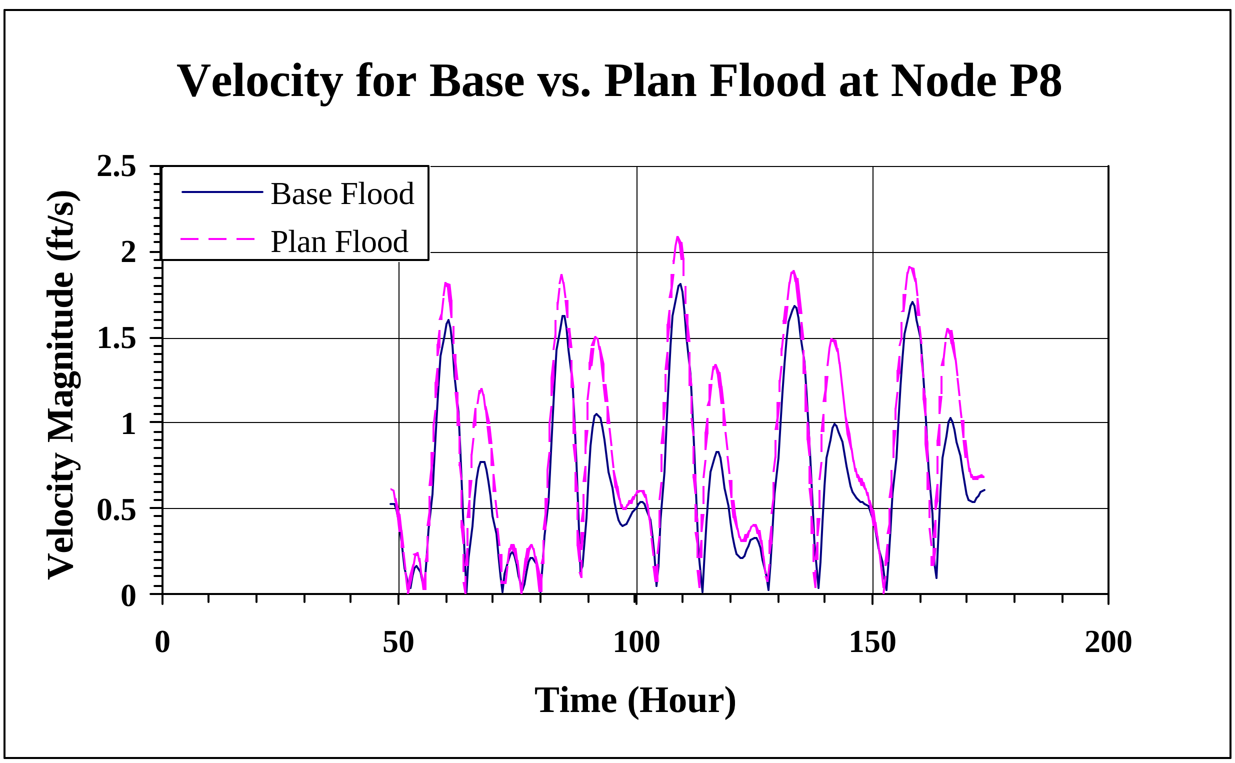



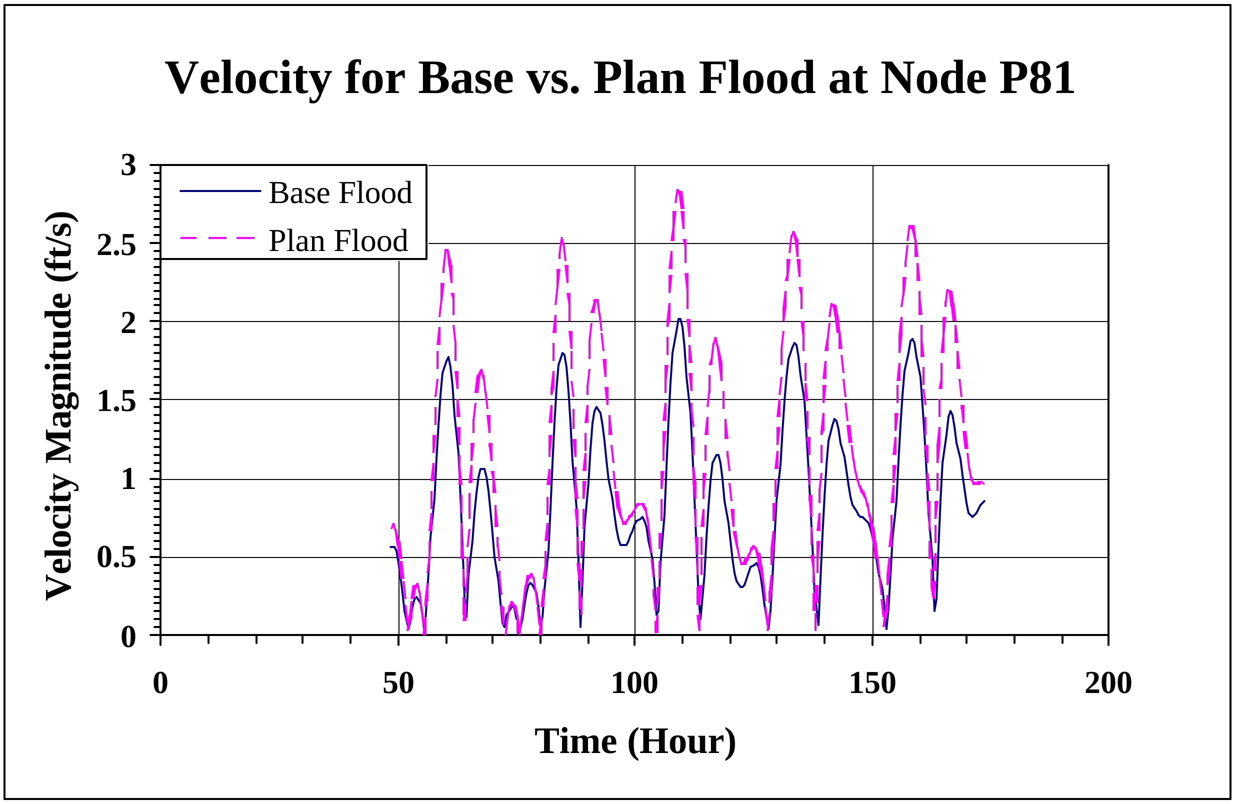
Velocity for Base vs. Plan Flood at Node P53
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
0
50
100
150
200

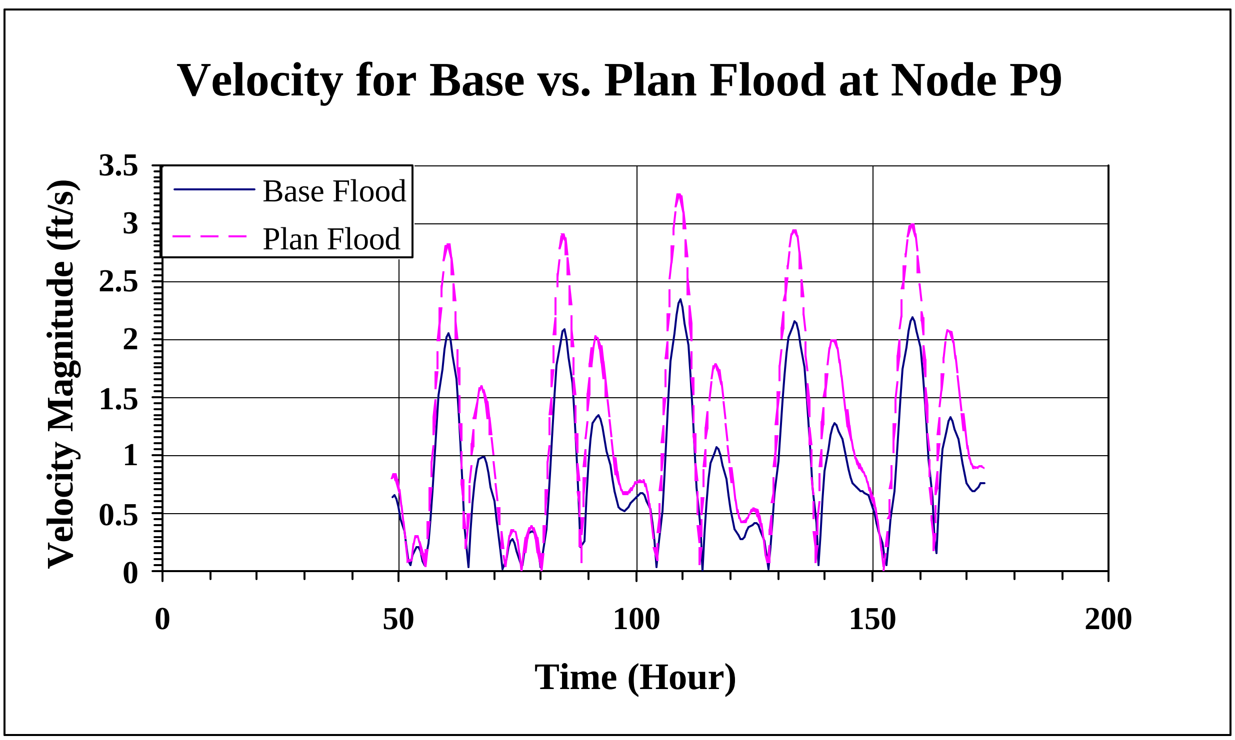

Velocity for Base vs. Plan Flood at Node P54
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
0
50
100
150
200

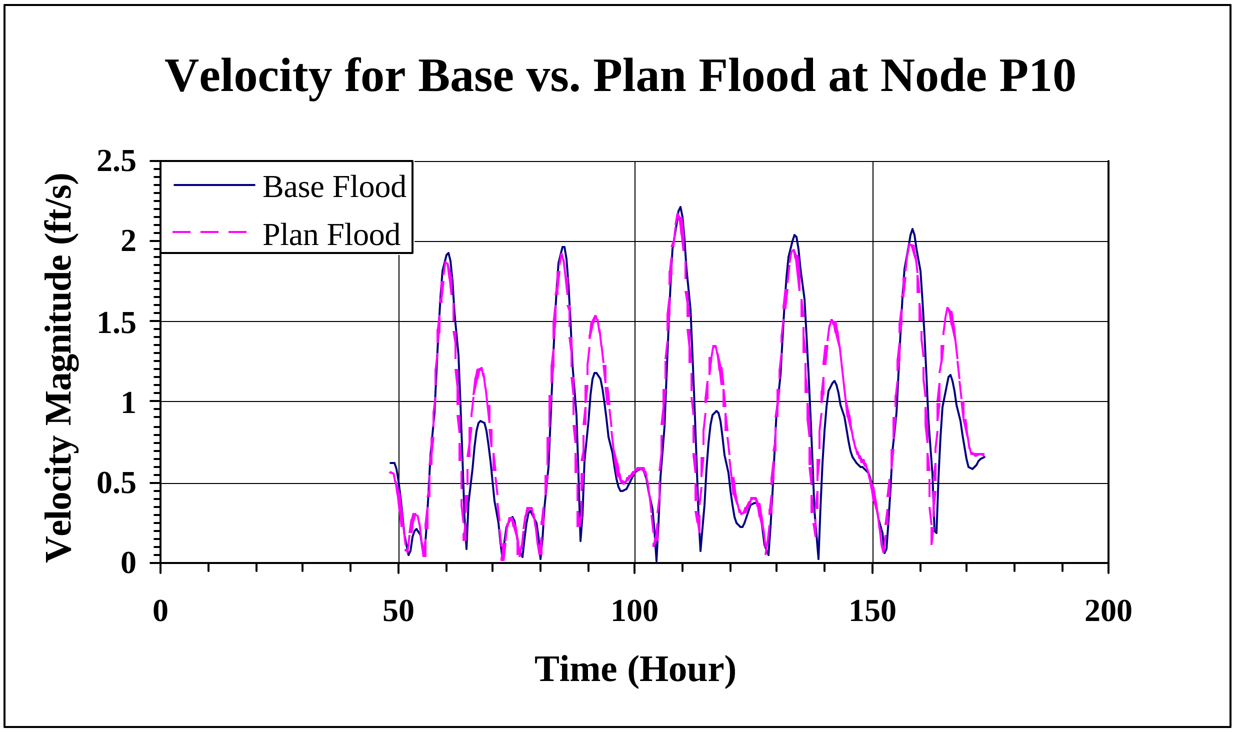

Velocity for Base vs. Plan Flood at Node P6
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

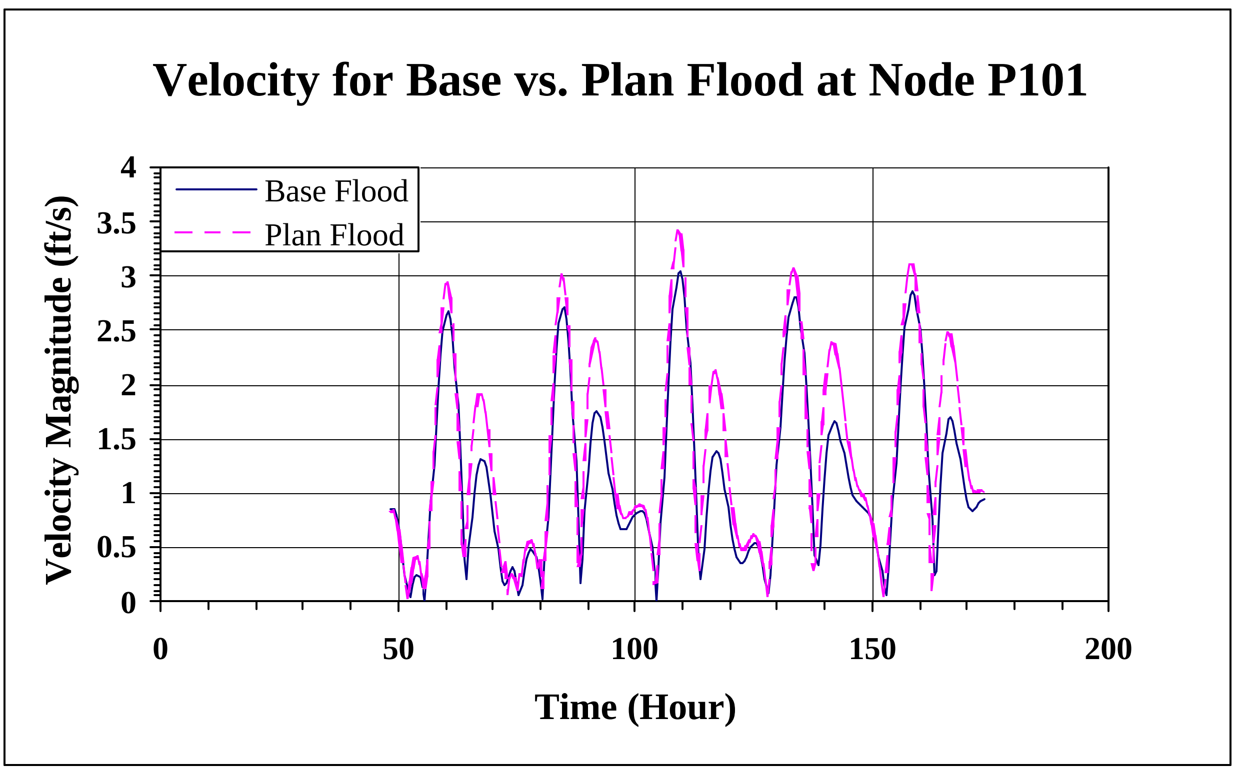

Velocity for Base vs. Plan Flood at Node P7
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200
Time (Hour)

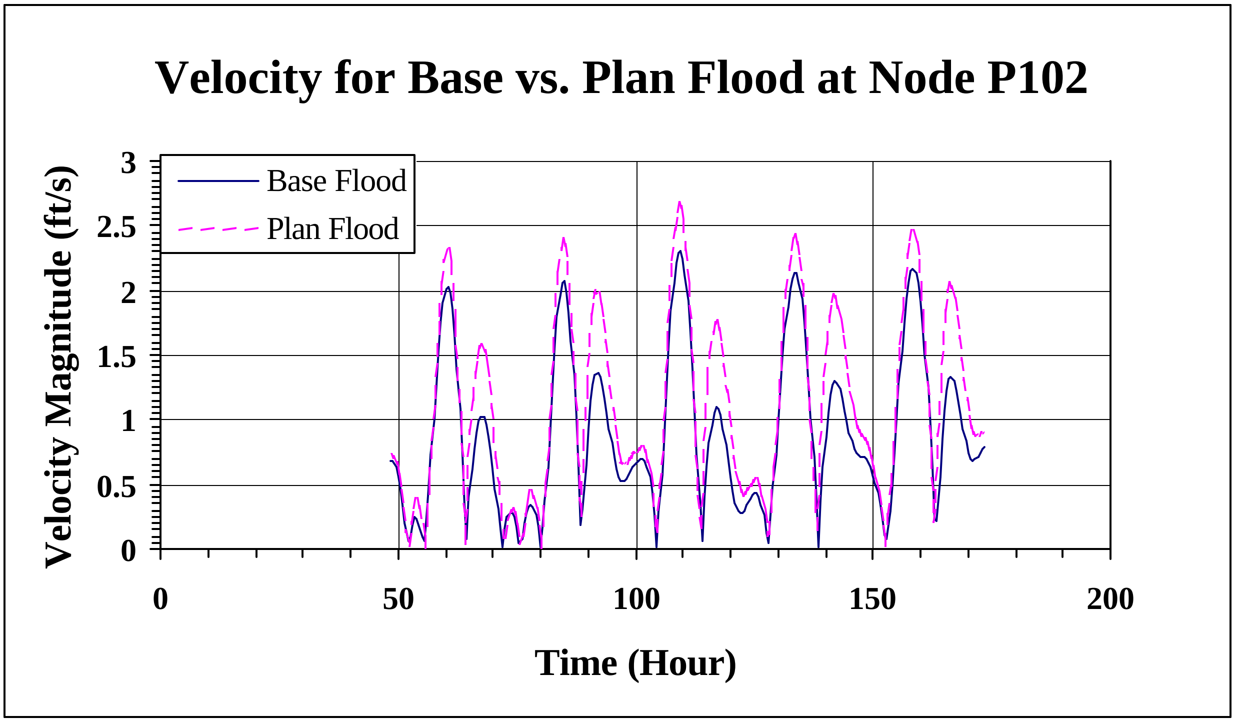

Velocity for Base vs. Plan Flood at Node P8
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0
0.5
1
1.5
2
2.5
0
50
100
150
200
Time (Hour)

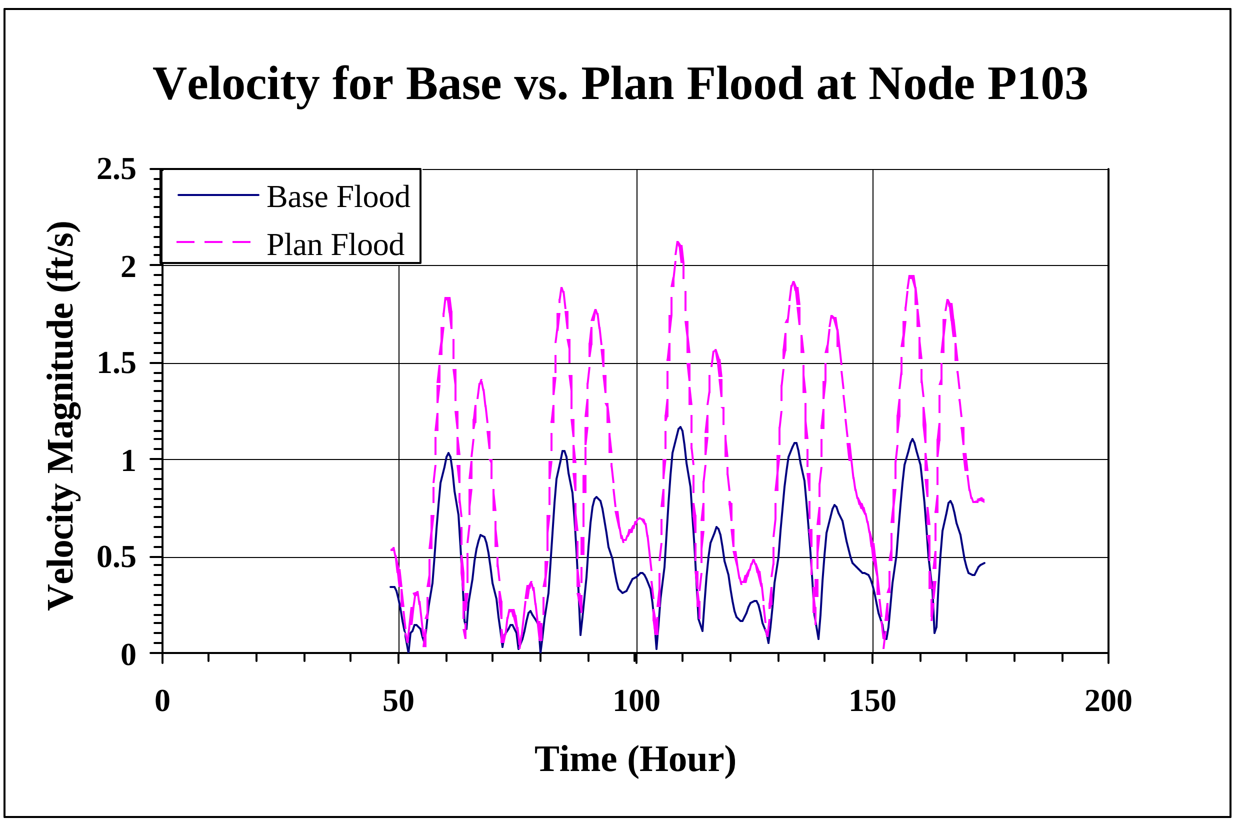

Velocity for Base vs. Plan Flood at Node P81
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

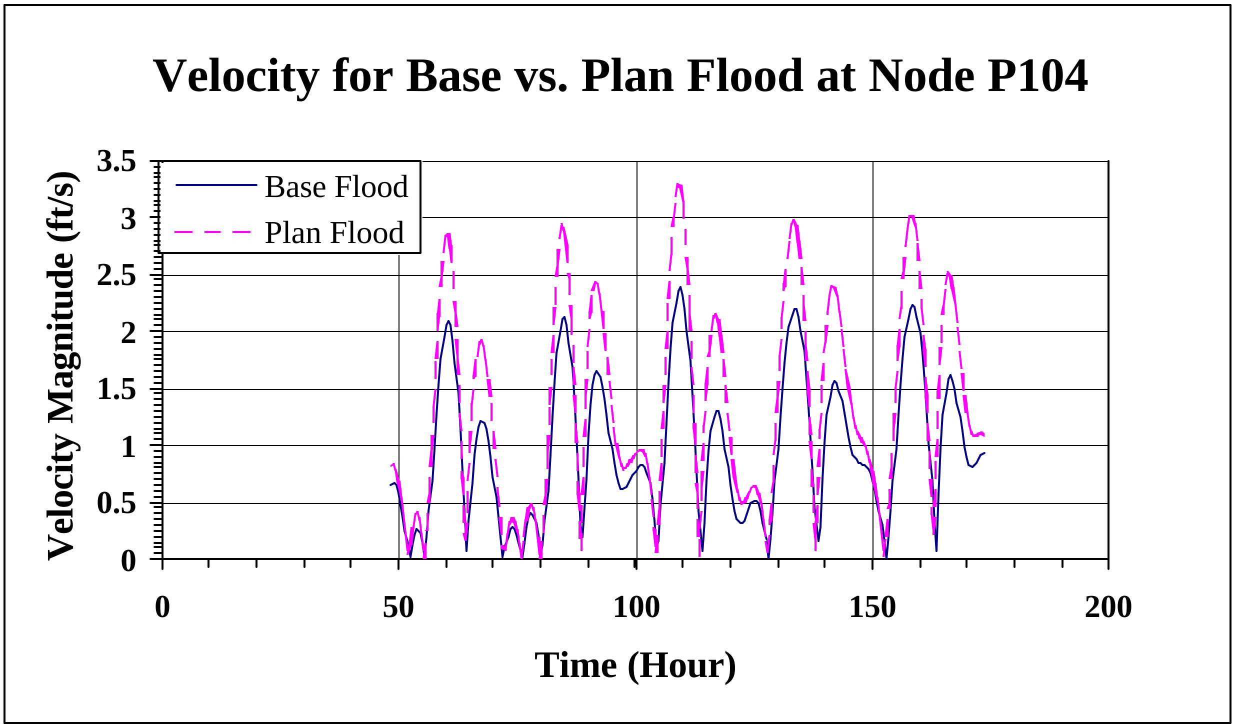

Velocity for Base vs. Plan Flood at Node P9
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

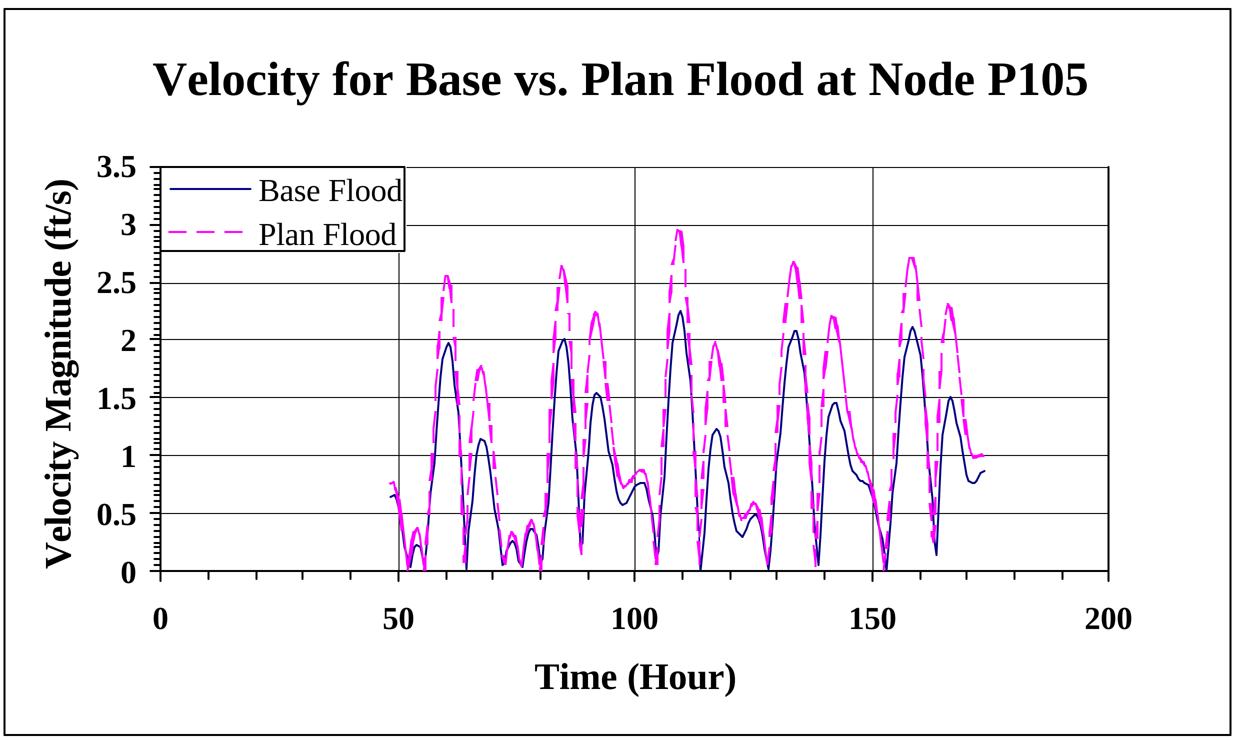

Velocity for Base vs. Plan Flood at Node P10
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

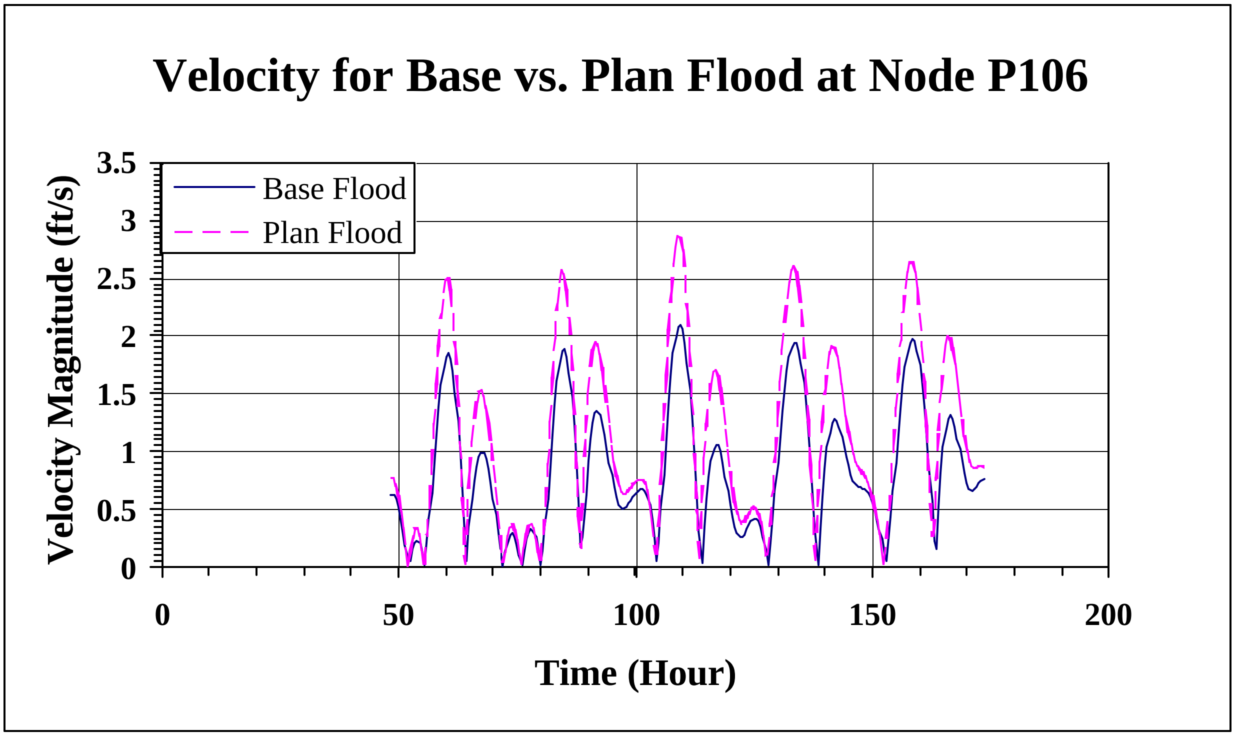

Velocity for Base vs. Plan Flood at Node P101
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

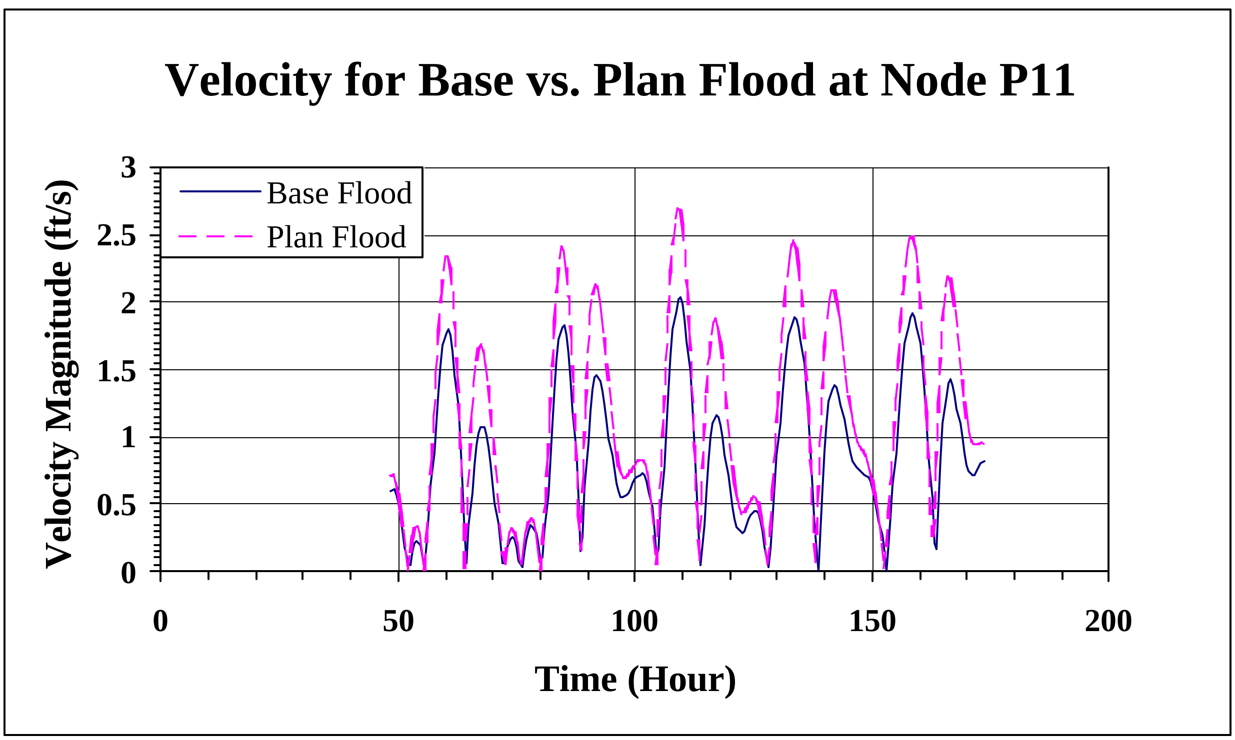

Velocity for Base vs. Plan Flood at Node P102
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

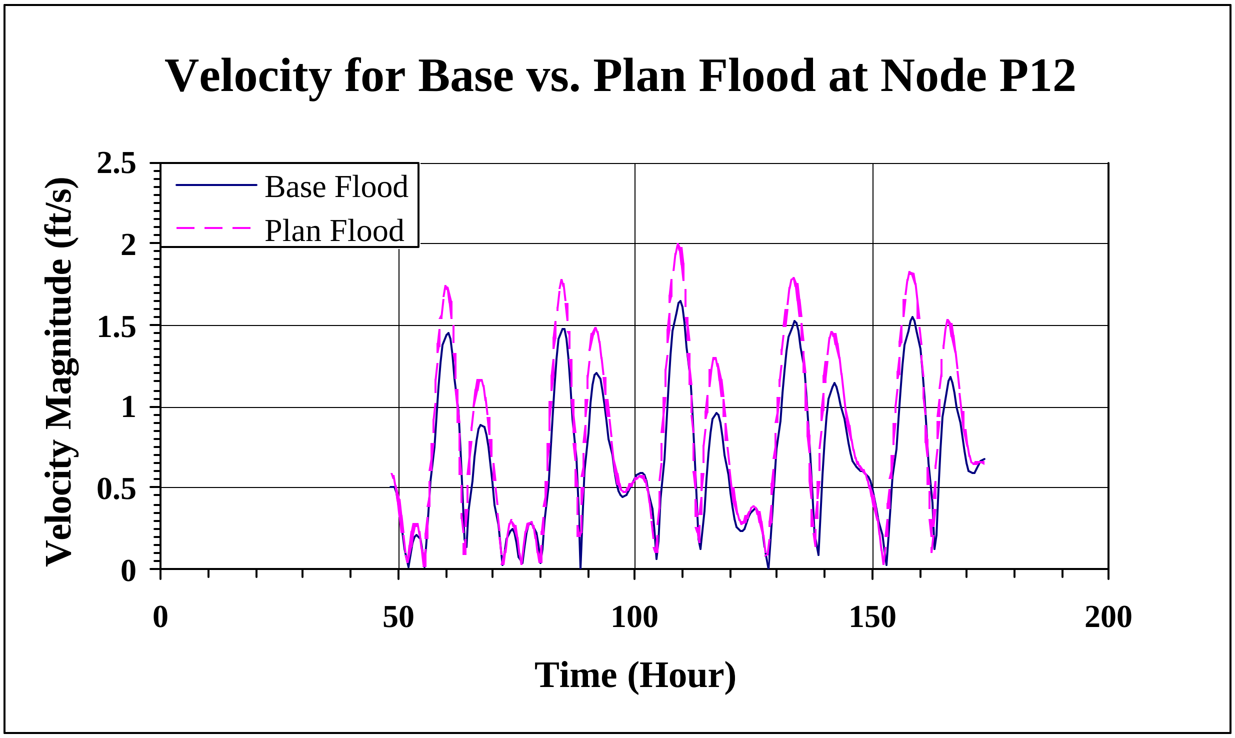

Velocity for Base vs. Plan Flood at Node P103
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

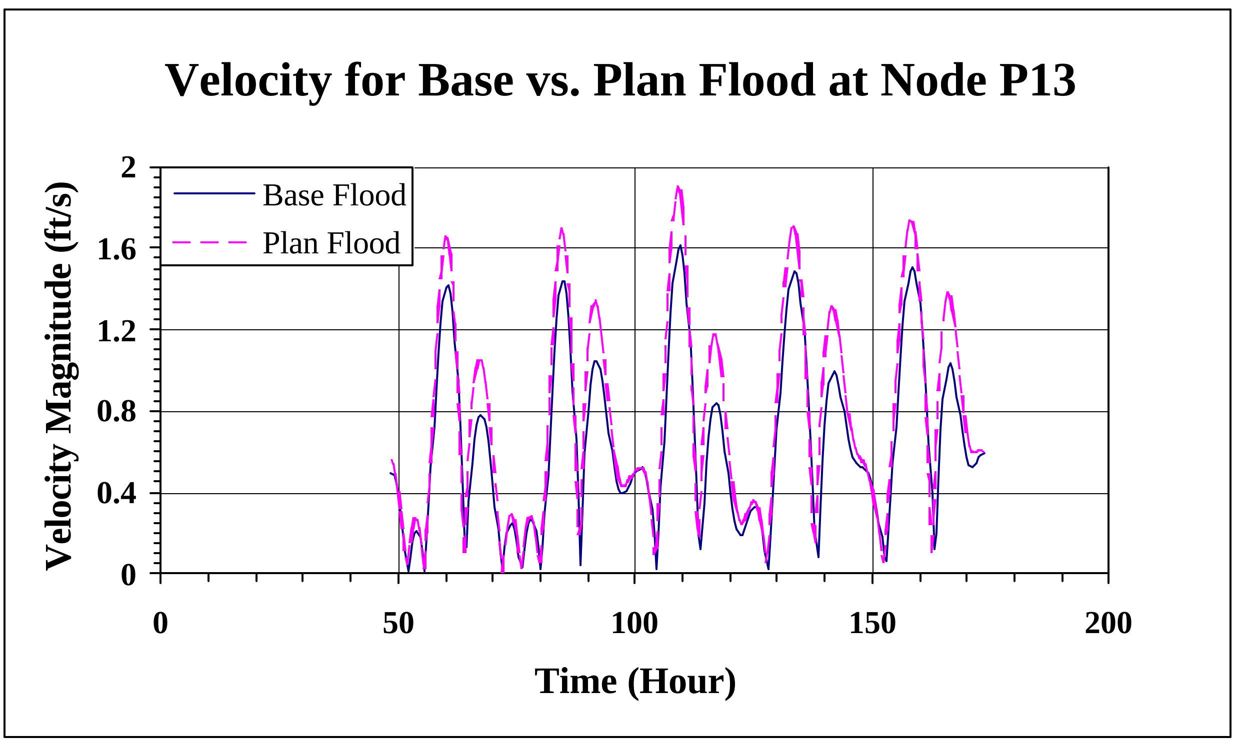

Velocity for Base vs. Plan Flood at Node P104
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

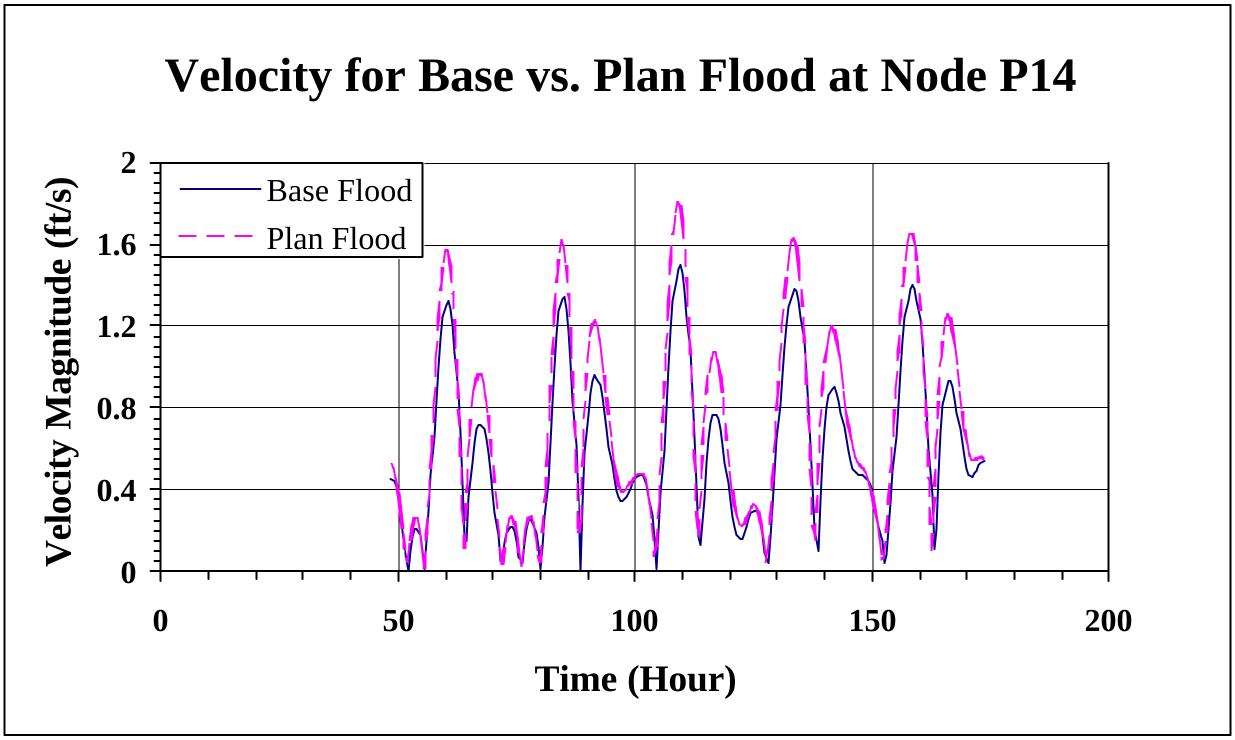

Velocity for Base vs. Plan Flood at Node P105
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

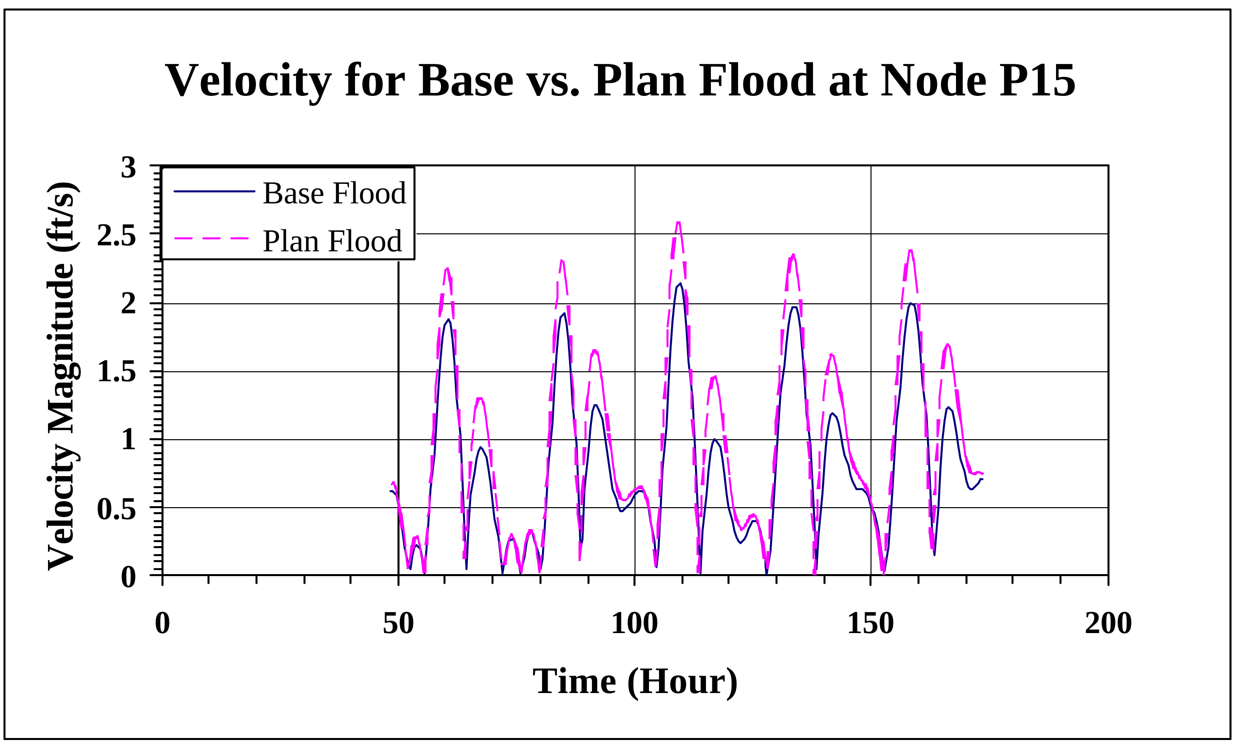

Velocity for Base vs. Plan Flood at Node P106
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

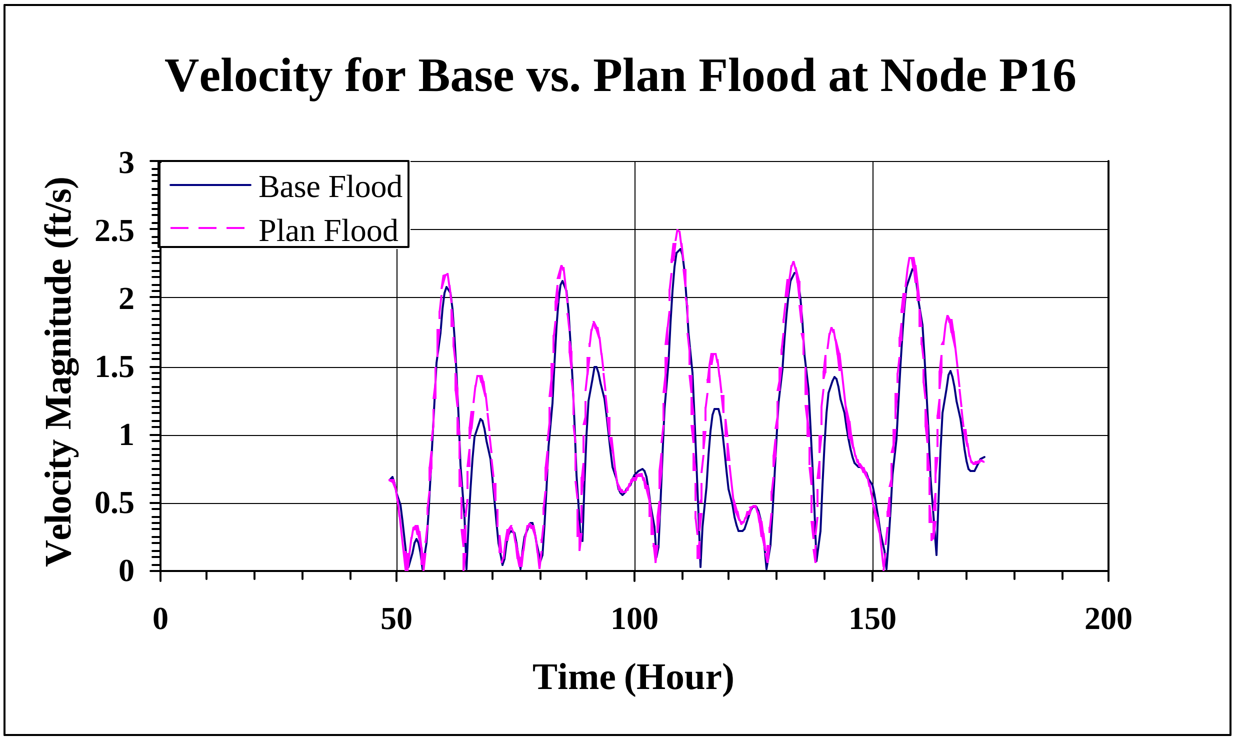

Velocity for Base vs. Plan Flood at Node P11
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

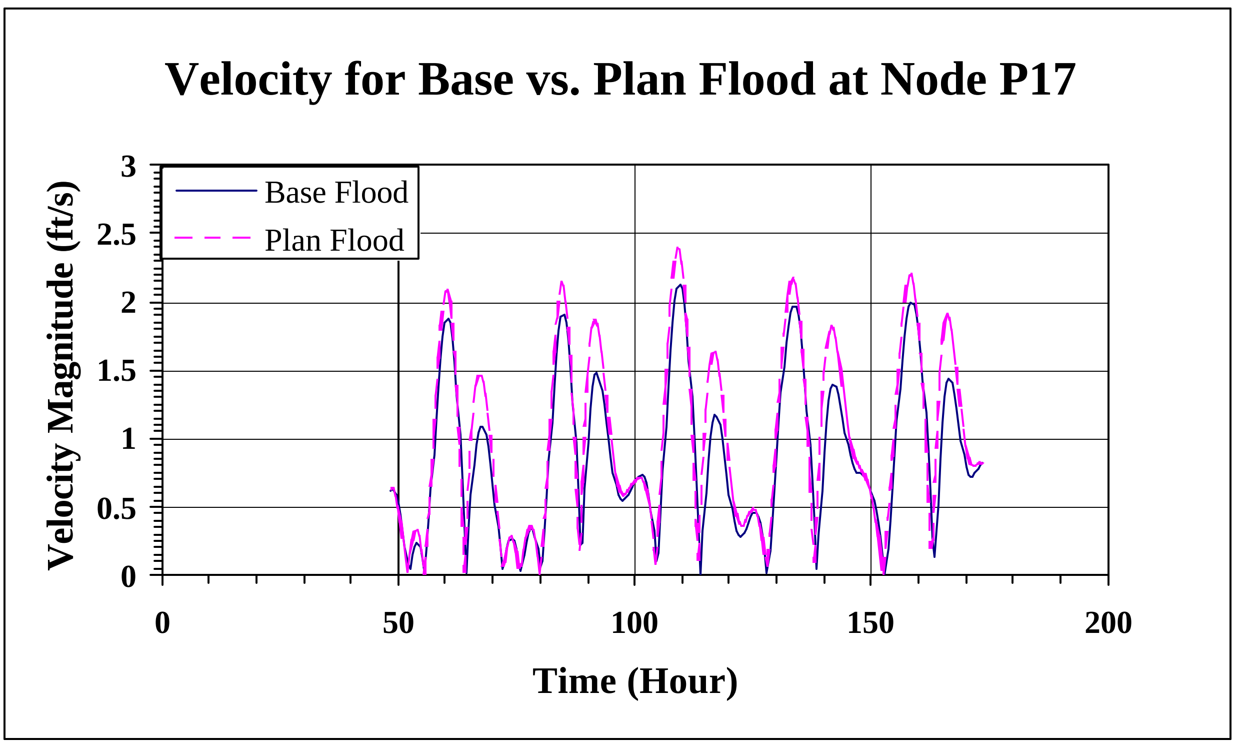

Velocity for Base vs. Plan Flood at Node P12
Velocity Magnitude (ft/s)
Base Flood
Plan Flood
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

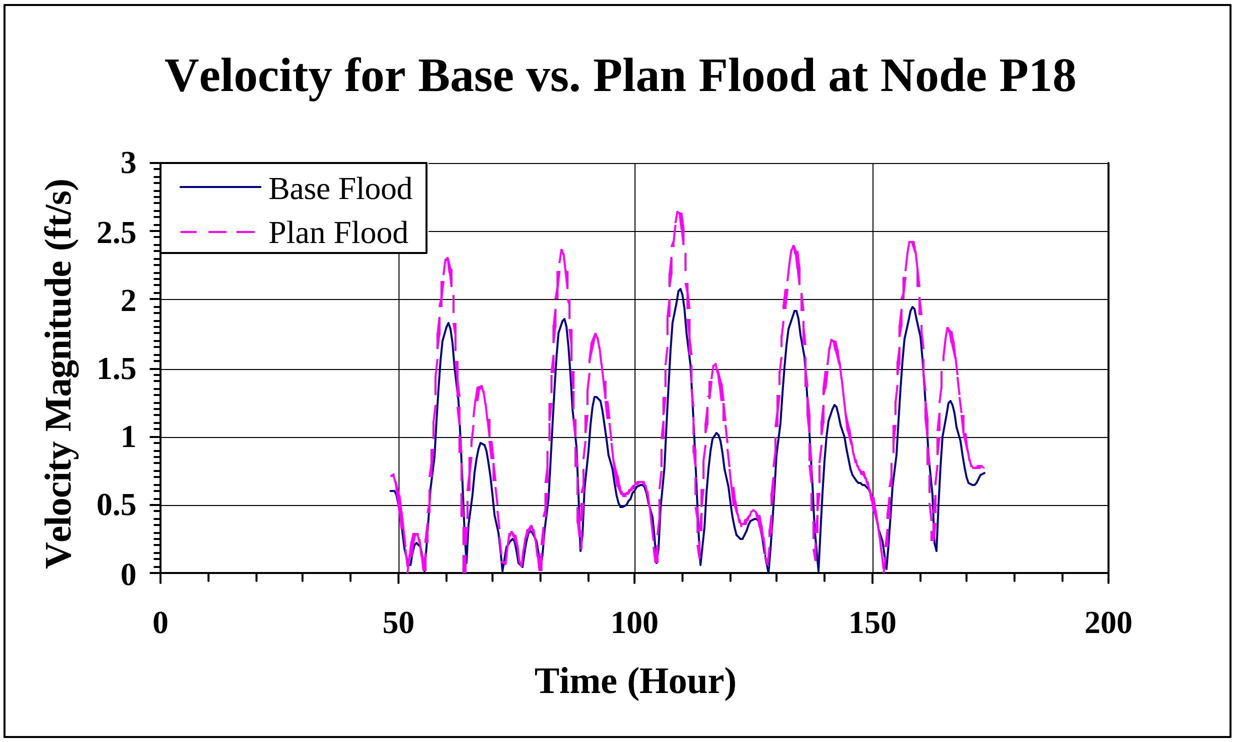

Velocity for Base vs. Plan Flood at Node P13
Velocity Magnitude (ft/s)
Base Flood
Plan Flood
2
1.6
1.2
0.8
0.4
0
0
50
100
150
200
Time (Hour)

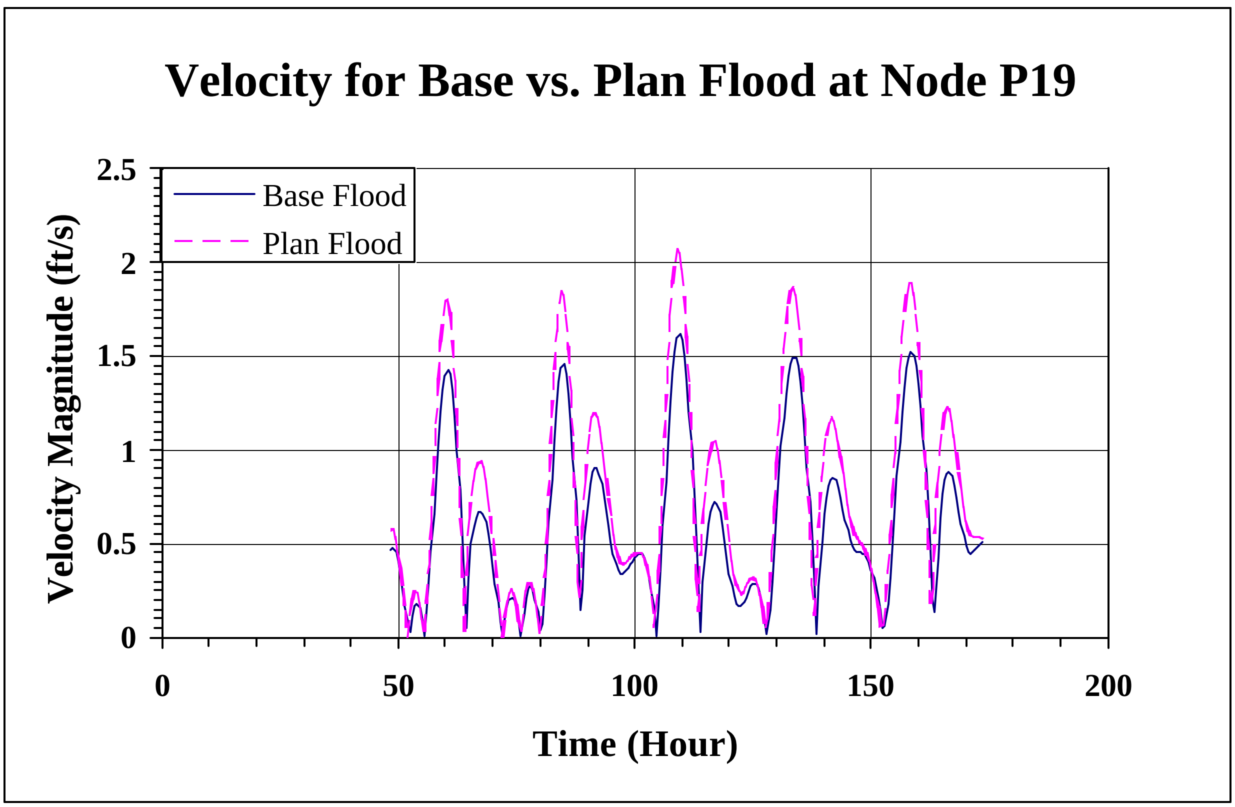

Velocity for Base vs. Plan Flood at Node P14
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
2
1.6
1.2
0.8
0.4
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node P15
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node P16
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200

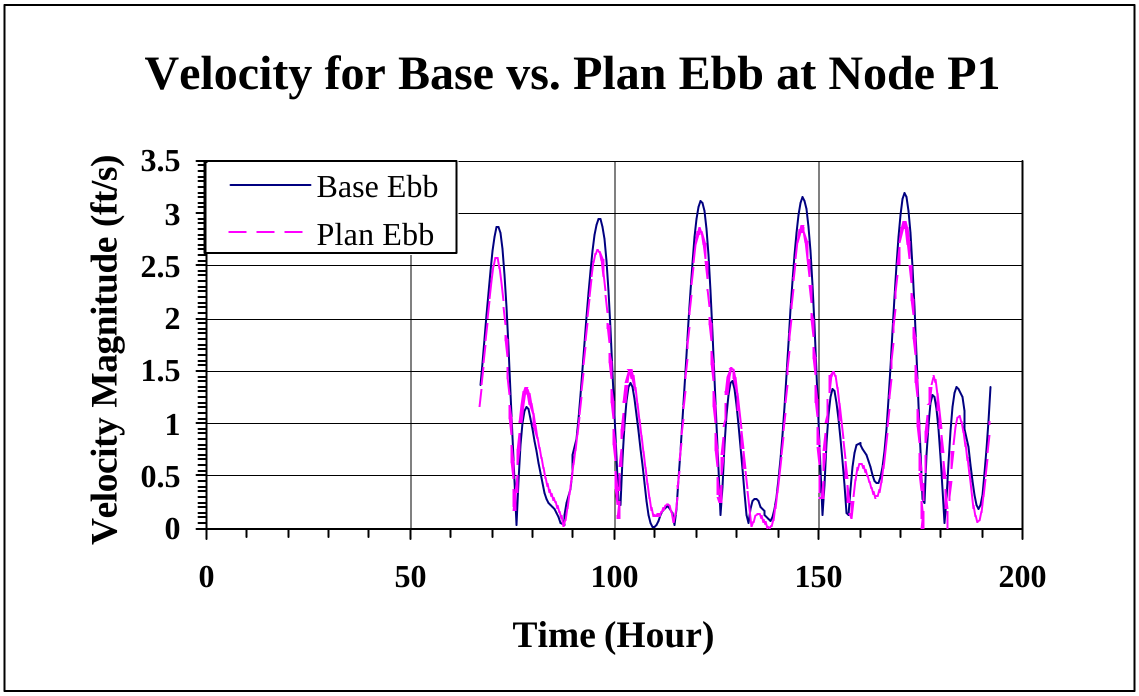

Velocity for Base vs. Plan Flood at Node P17
Velocity Magnitude (ft/s)
Time (Hour)
Base Flood
Plan Flood
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200

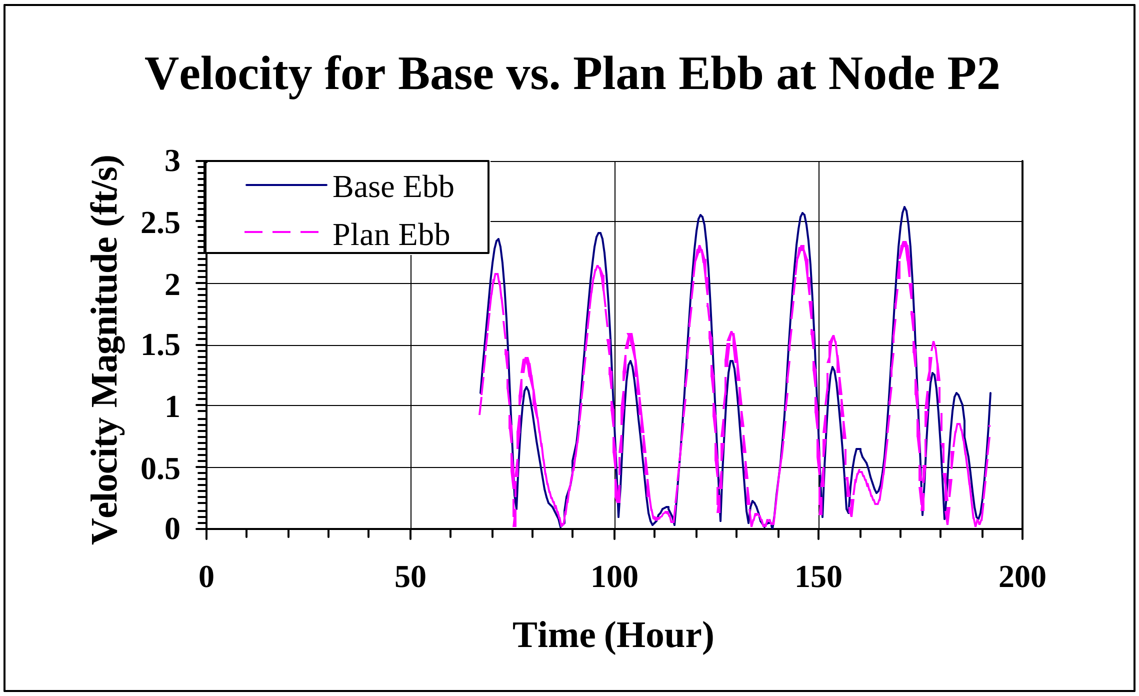

Velocity for Base vs. Plan Flood at Node P18
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200
Time (Hour)

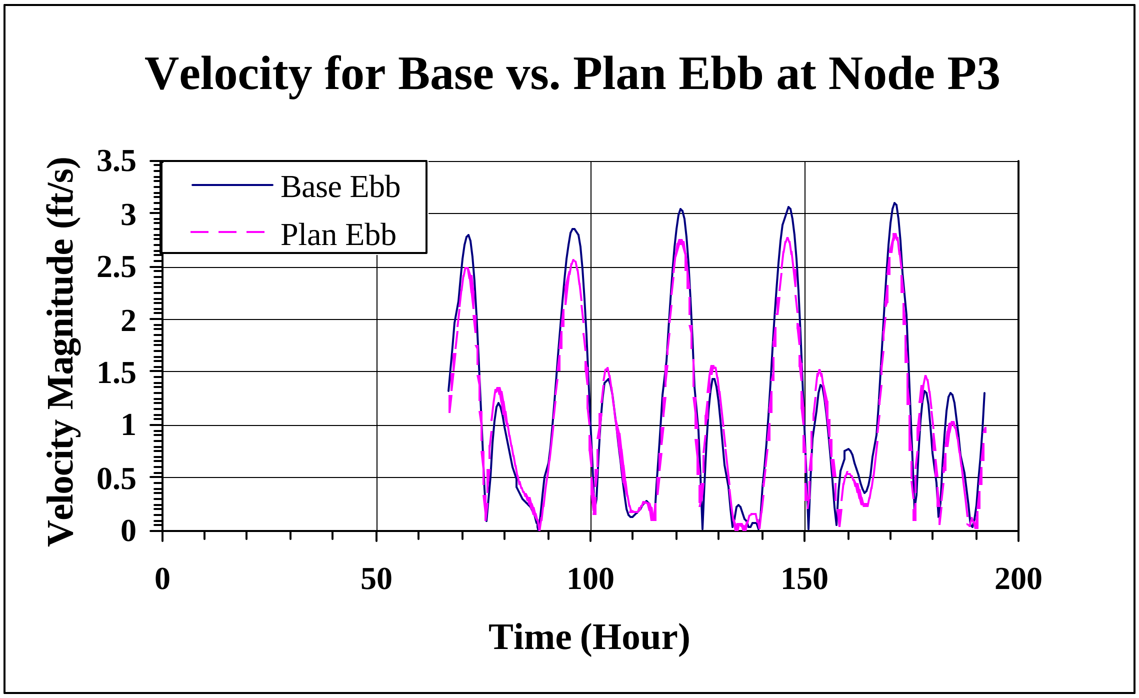

Velocity for Base vs. Plan Flood at Node P19
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0
0.5
1
1.5
2
2.5
0
50
100
150
200
Time (Hour)

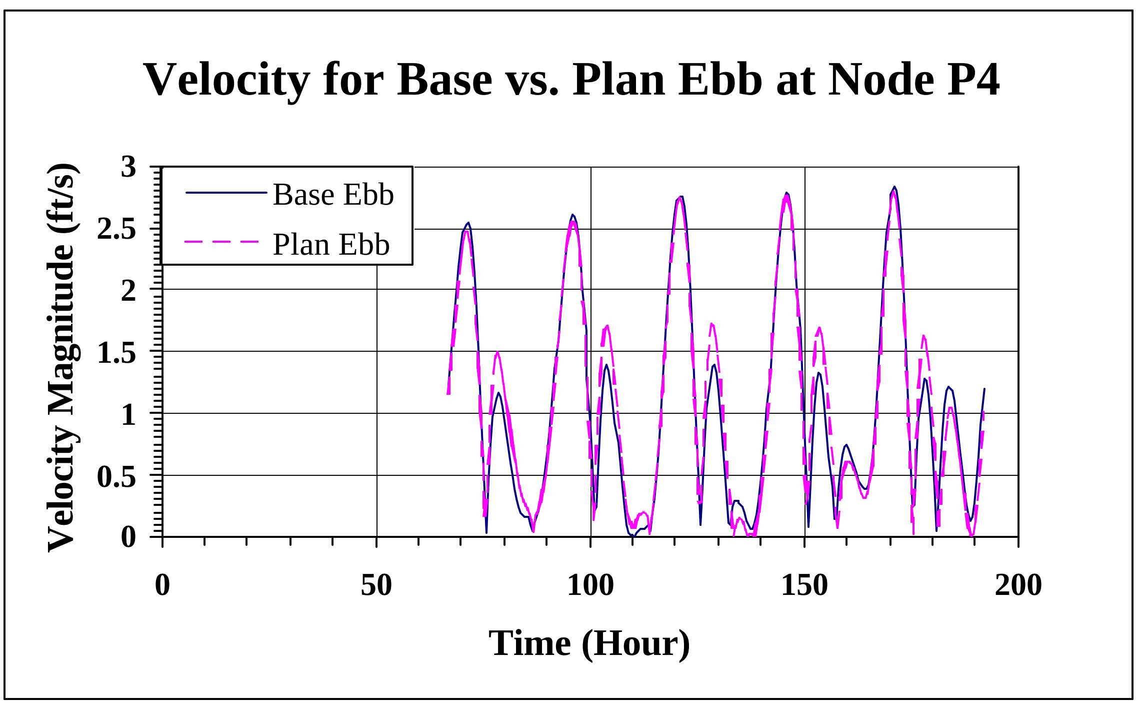
# Appendix F

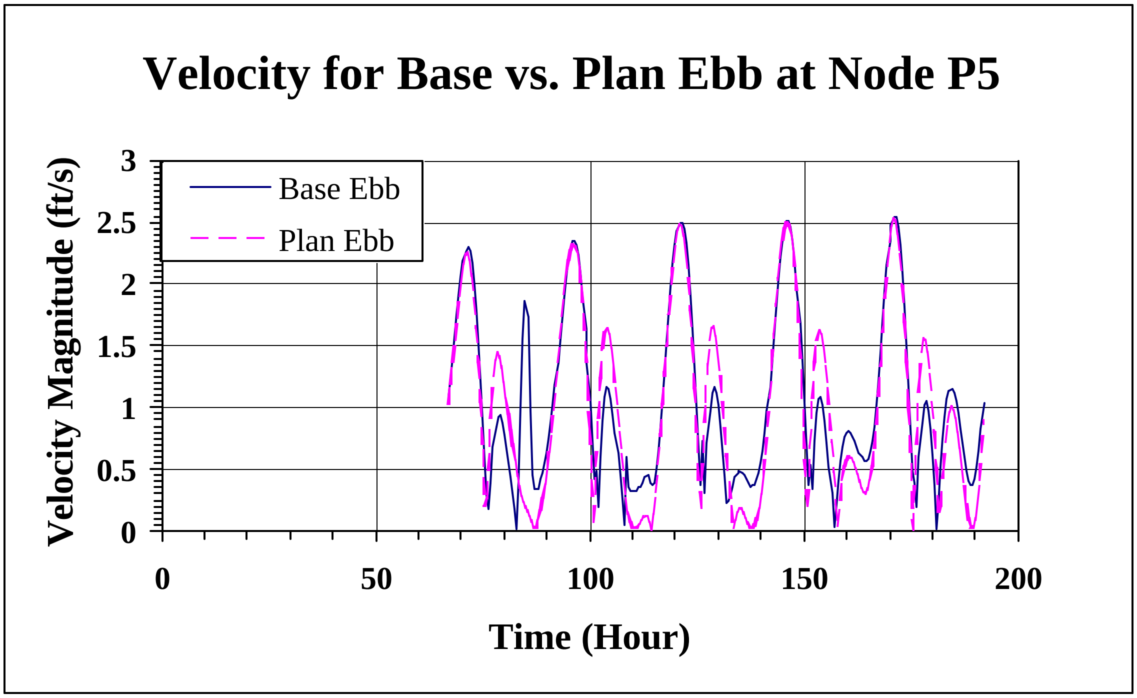
## Superposed Velocity Plots for Base and Plan for Ebb at Locations Along Pleasure Island West Shoreline

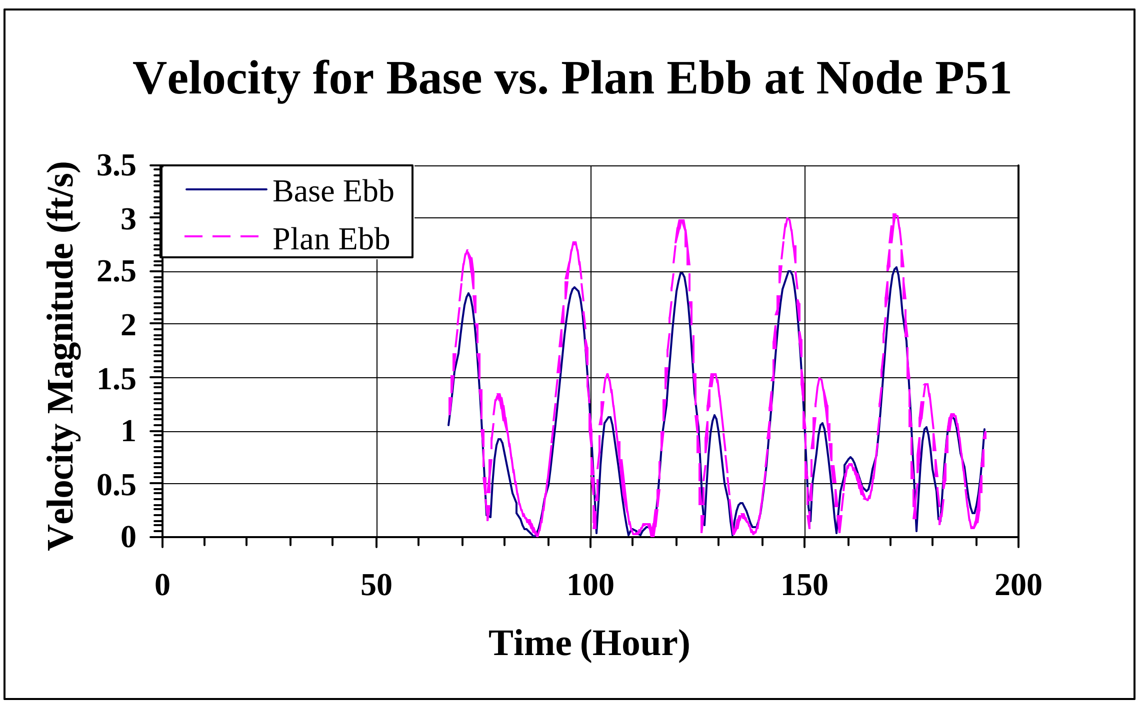

Velocity for Base vs. Plan Ebb at Node P1
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

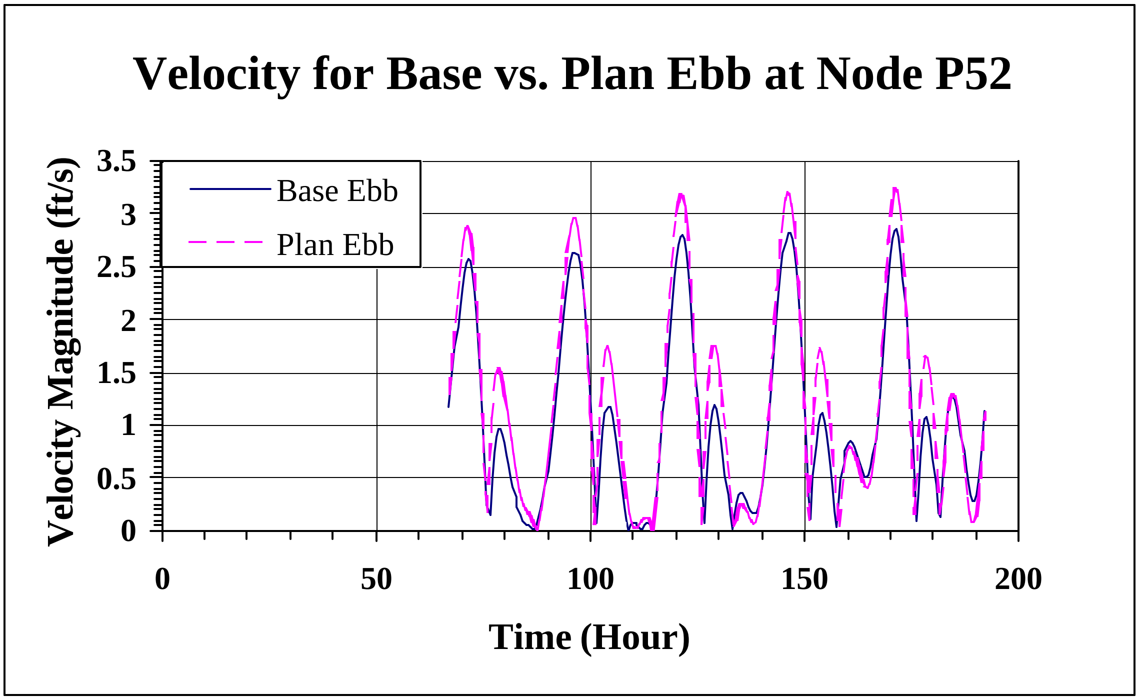

Velocity for Base vs. Plan Ebb at Node P2
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

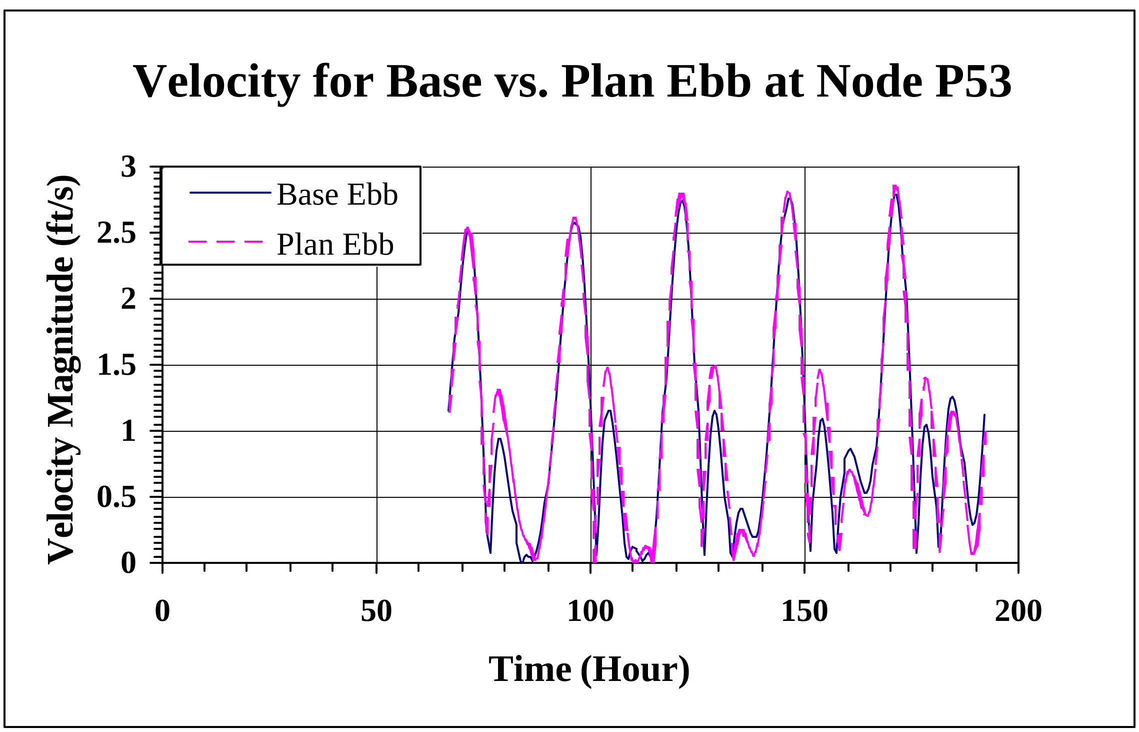

Velocity for Base vs. Plan Ebb at Node P3
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

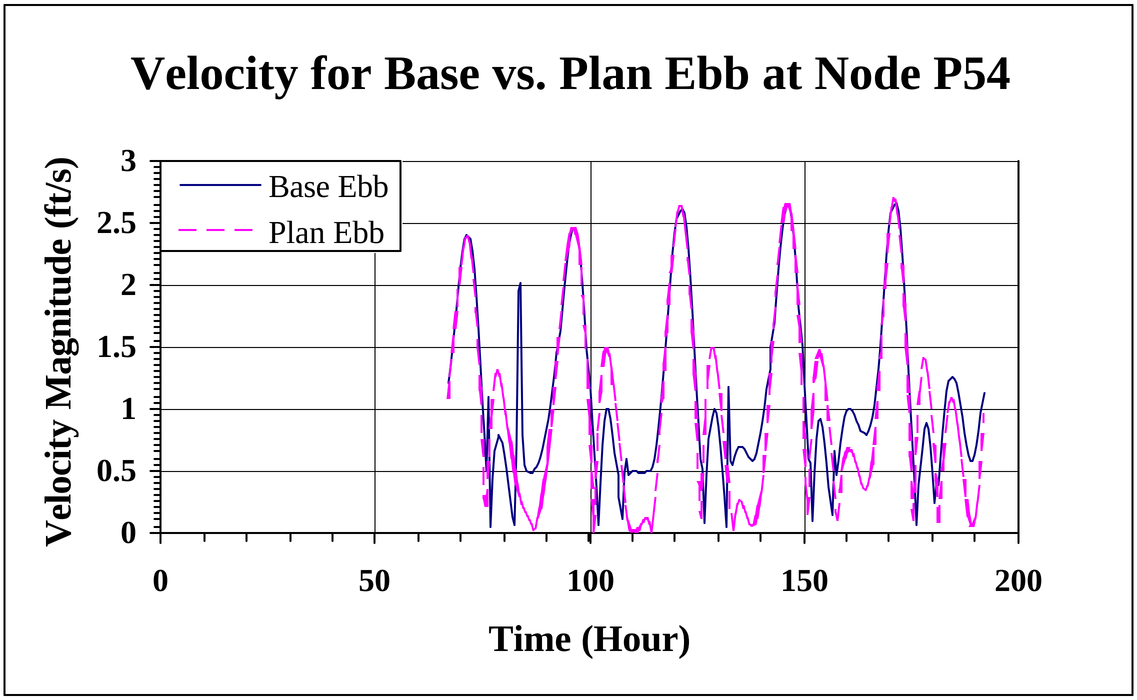

Velocity for Base vs. Plan Ebb at Node P4
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

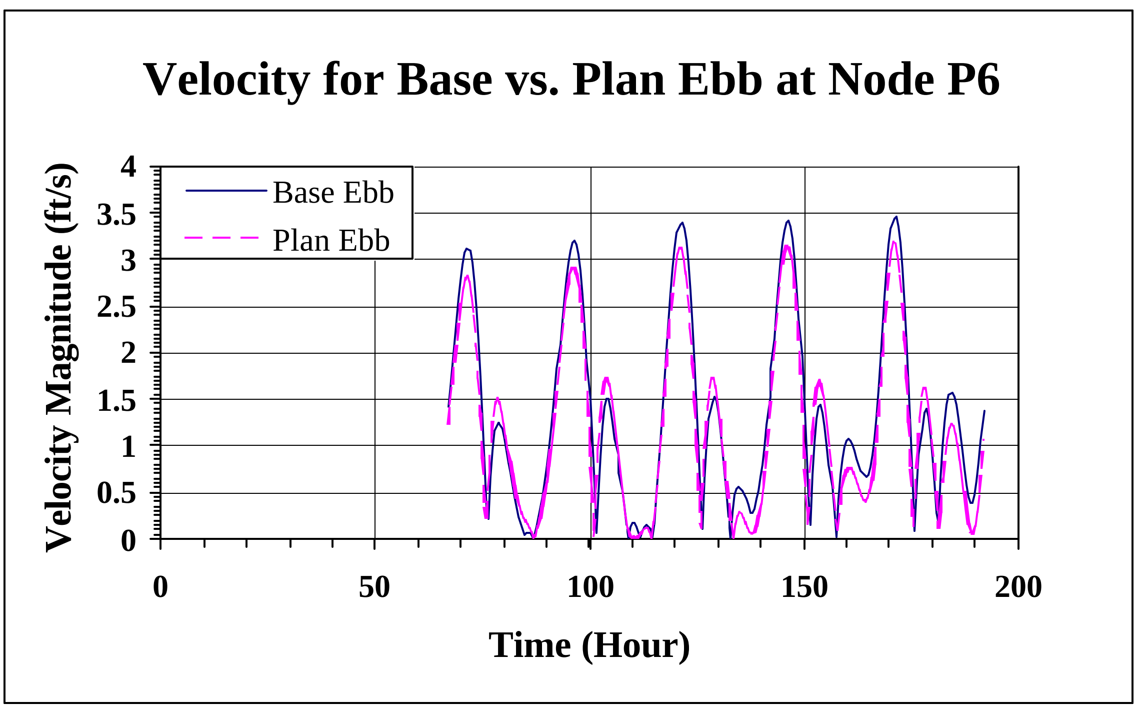

Velocity for Base vs. Plan Ebb at Node P5
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

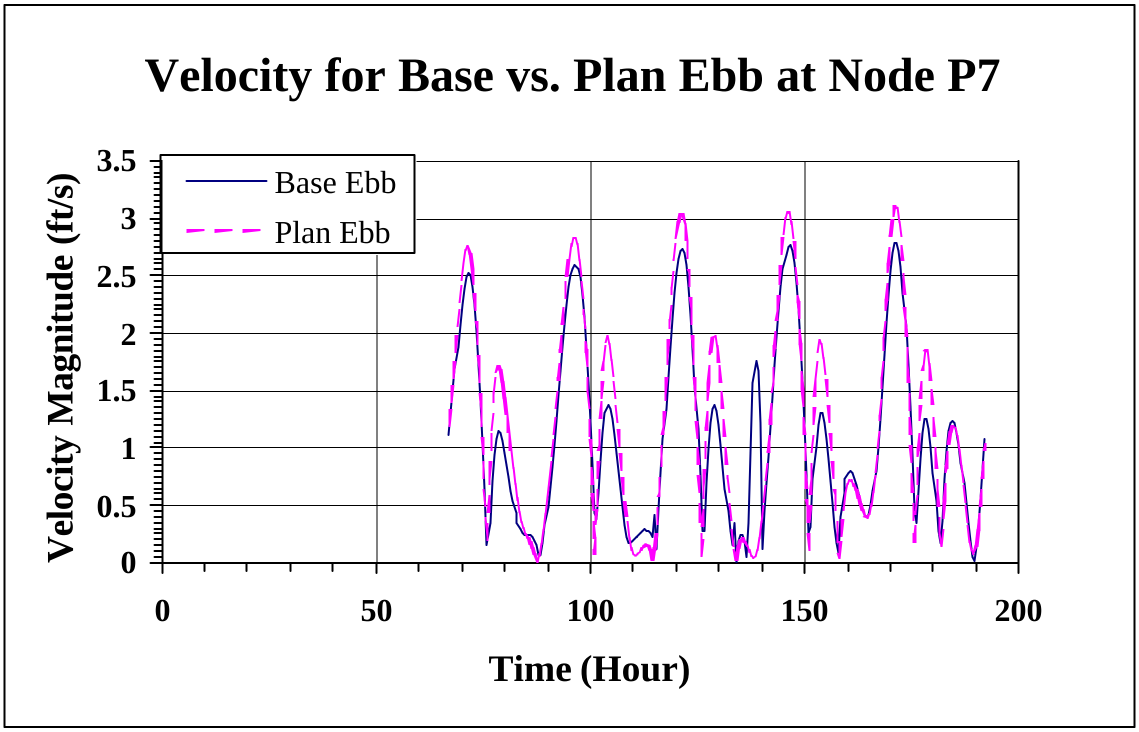

Velocity for Base vs. Plan Ebb at Node P51
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

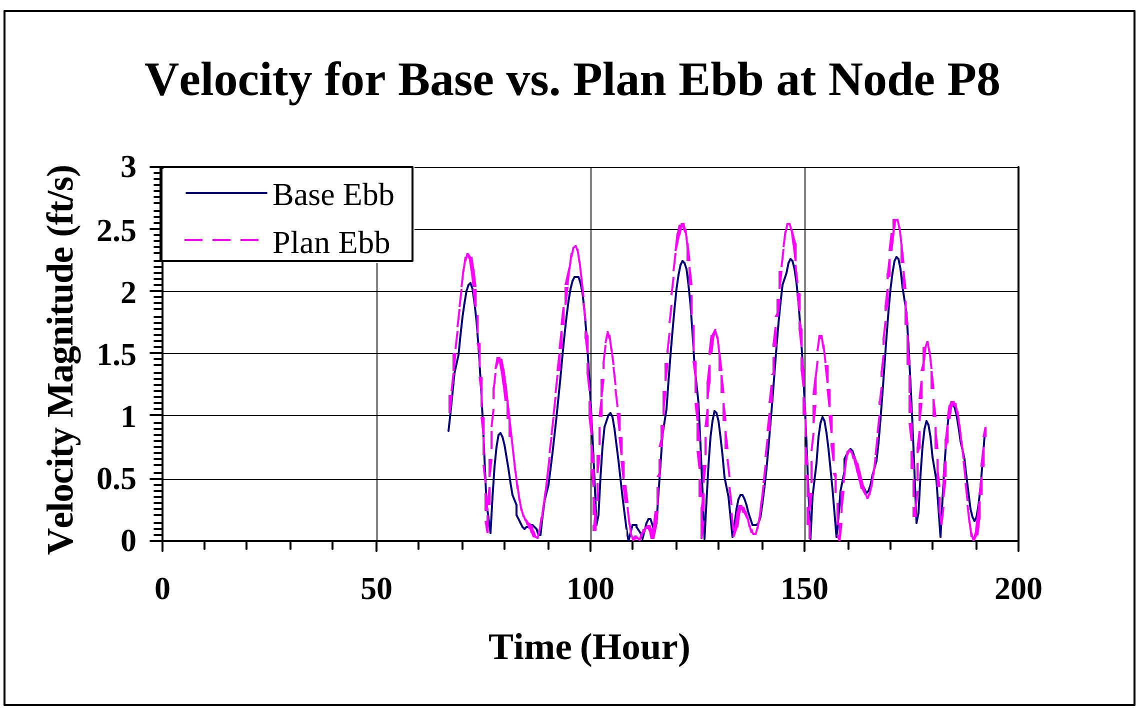

Velocity for Base vs. Plan Ebb at Node P52
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

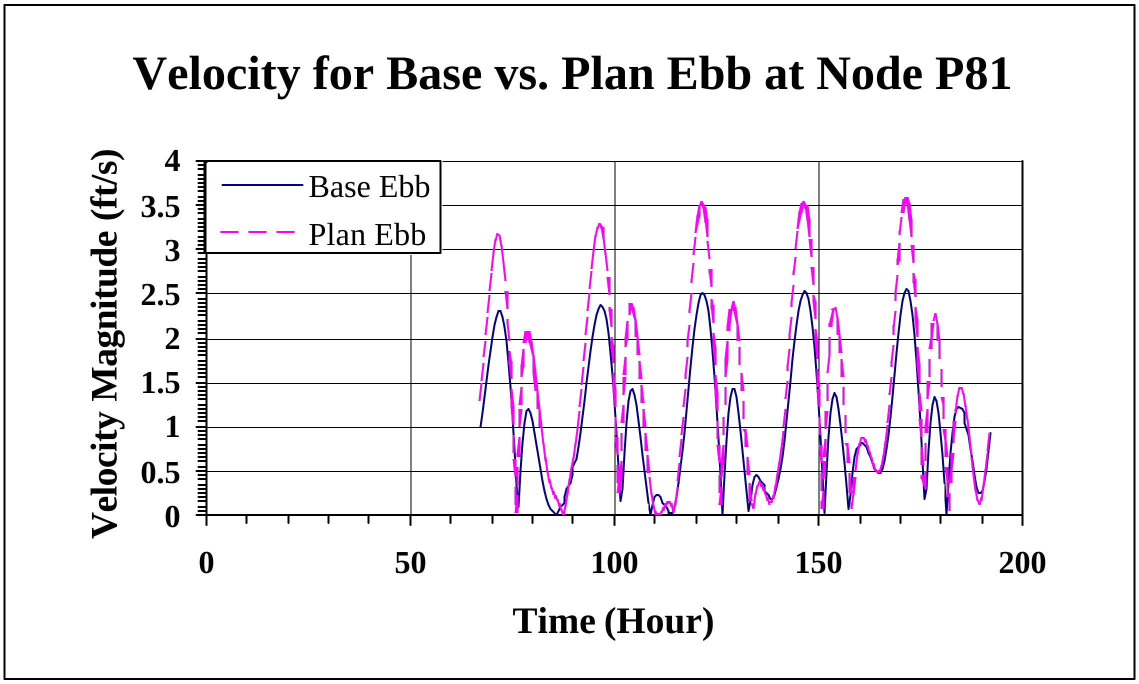

Velocity for Base vs. Plan Ebb at Node P53
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb


Velocity for Base vs. Plan Ebb at Node P54
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

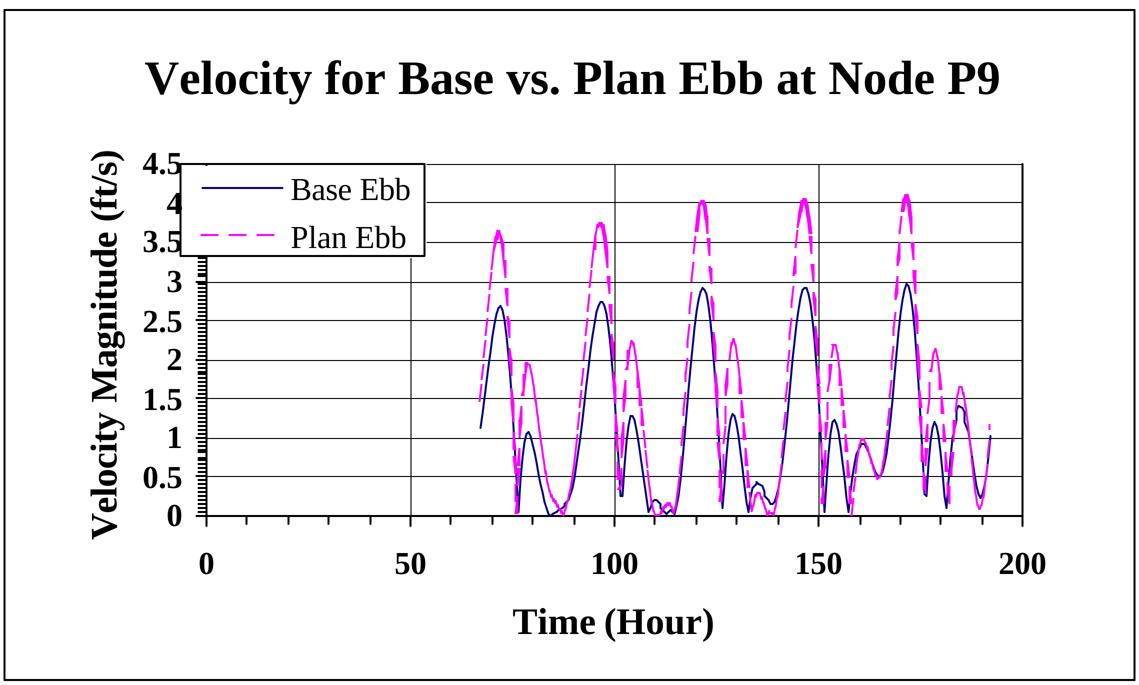

Velocity for Base vs. Plan Ebb at Node P6
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200


Velocity for Base vs. Plan Ebb at Node P7
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

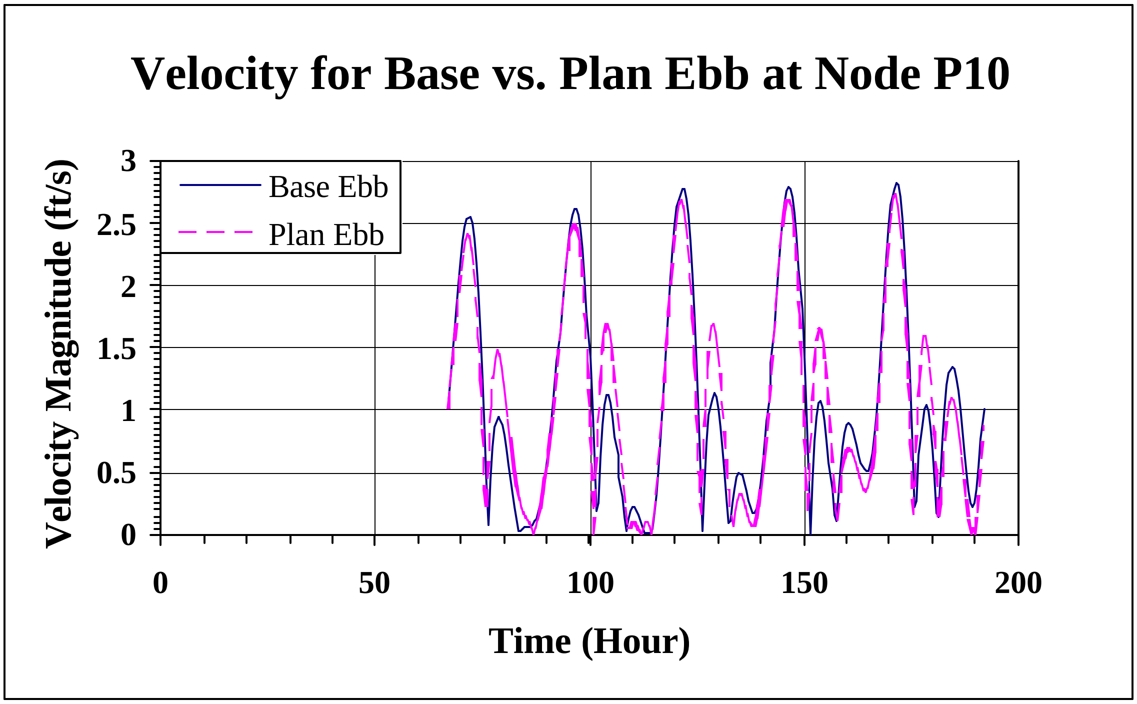

Velocity for Base vs. Plan Ebb at Node P8
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

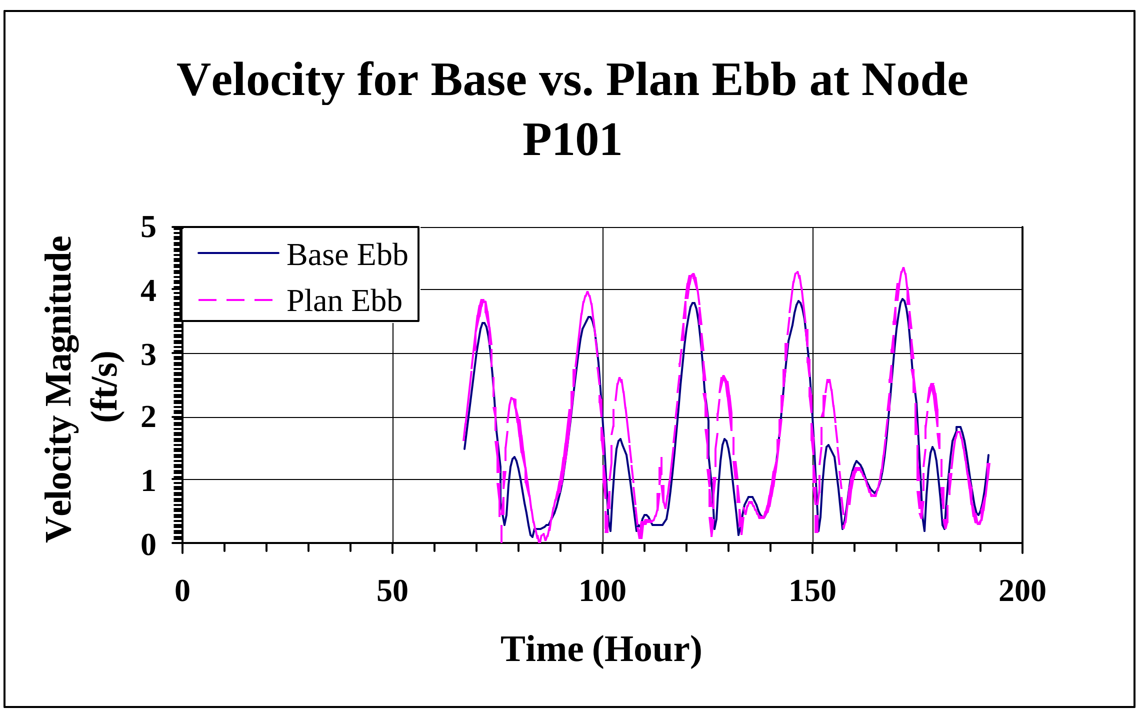


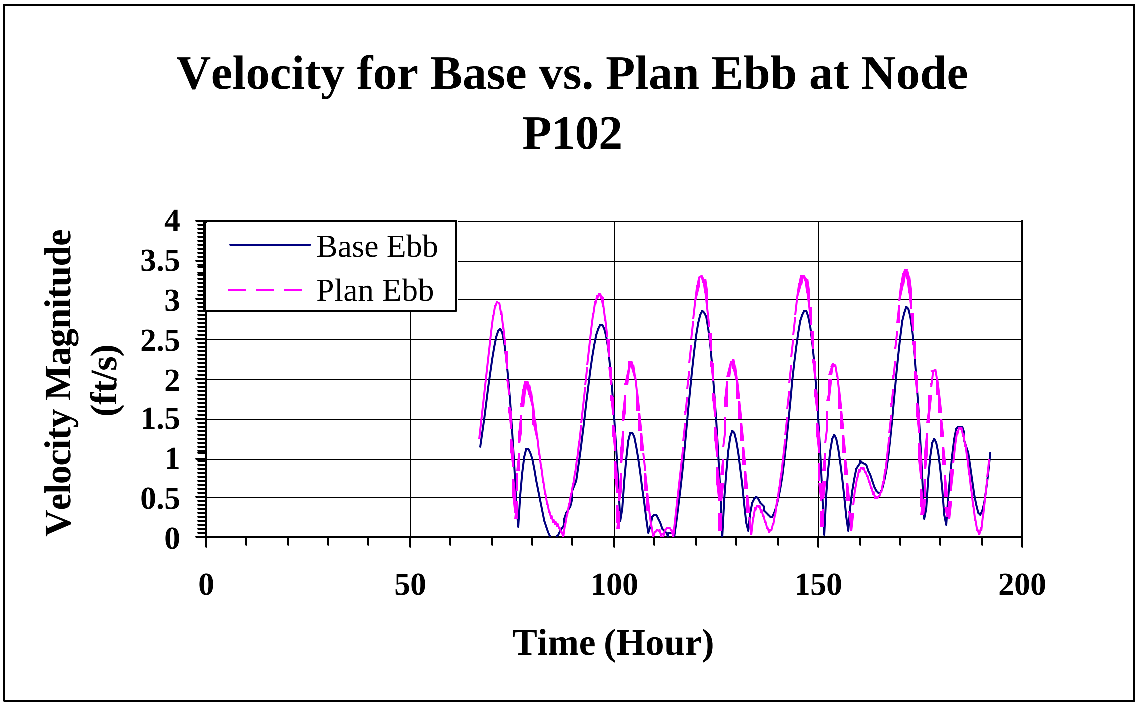
Velocity for Base vs. Plan Ebb at Node P81
Velocity Magnitude (ft/s)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb

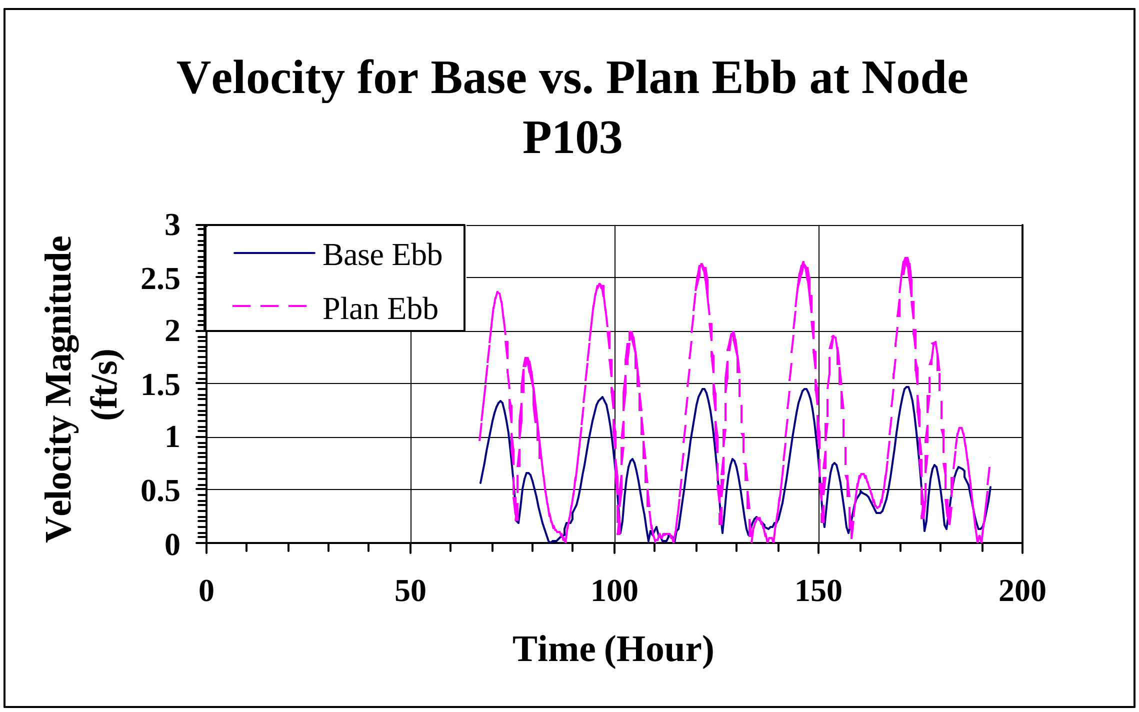
Velocity for Base vs. Plan Ebb at Node P9
Velocity Magnitude (ft/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)
Base Ebb
Plan Ebb


Velocity for Base vs. Plan Ebb at Node P10
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

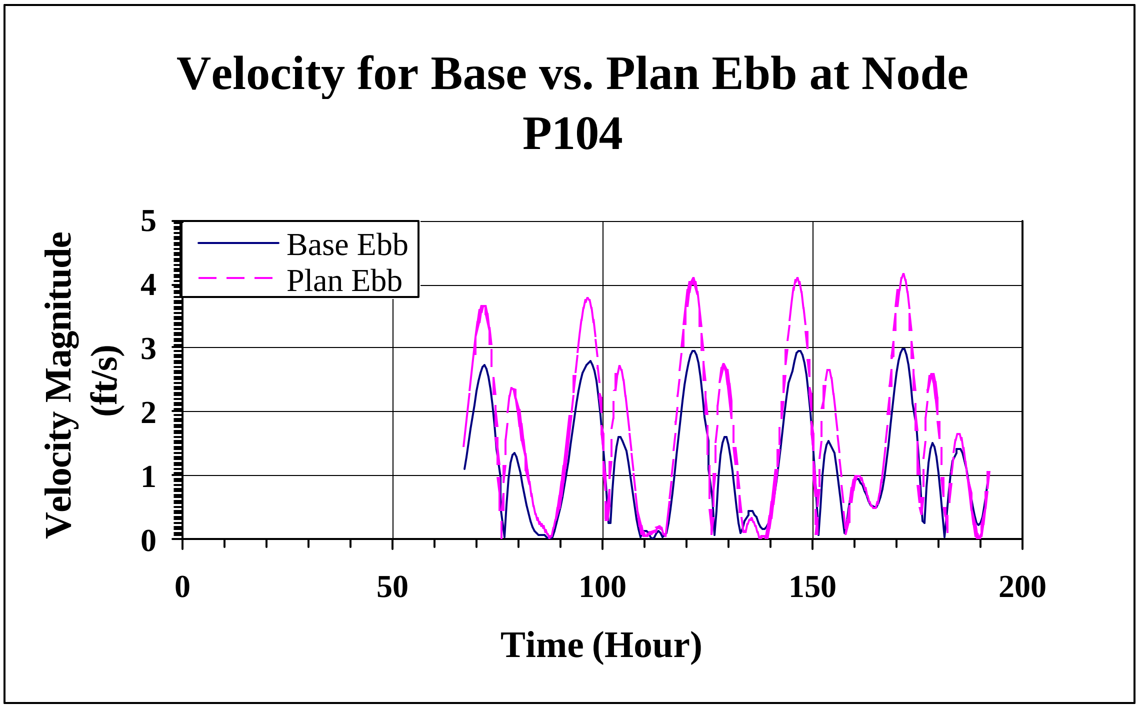

Velocity for Base vs. Plan Ebb at Node P101
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
1
2
3
4
5
0
50
100
150
200



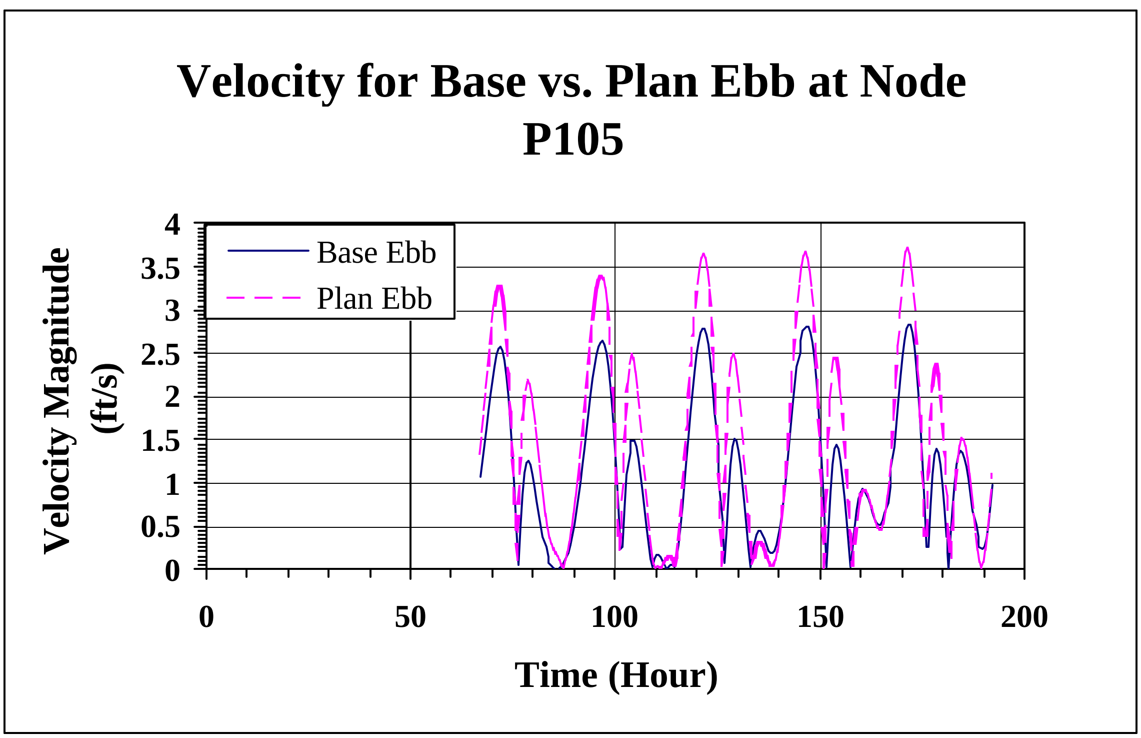
Velocity for Base vs. Plan Ebb at Node P102
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200

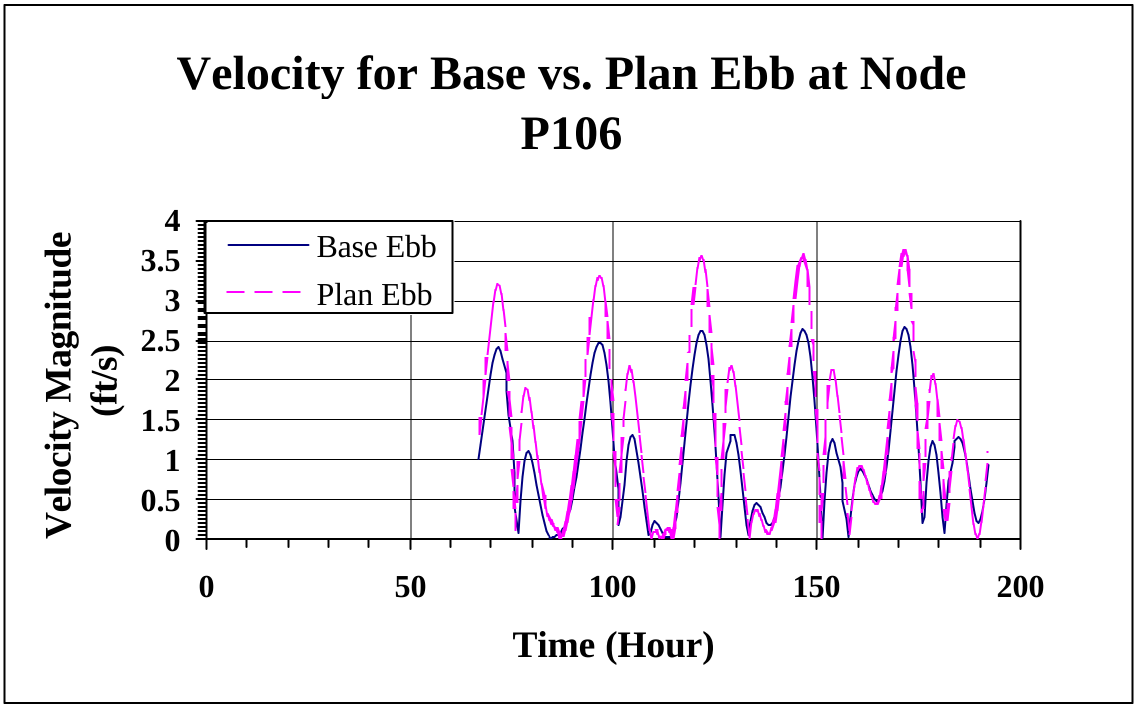
Velocity for Base vs. Plan Ebb at Node P103
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

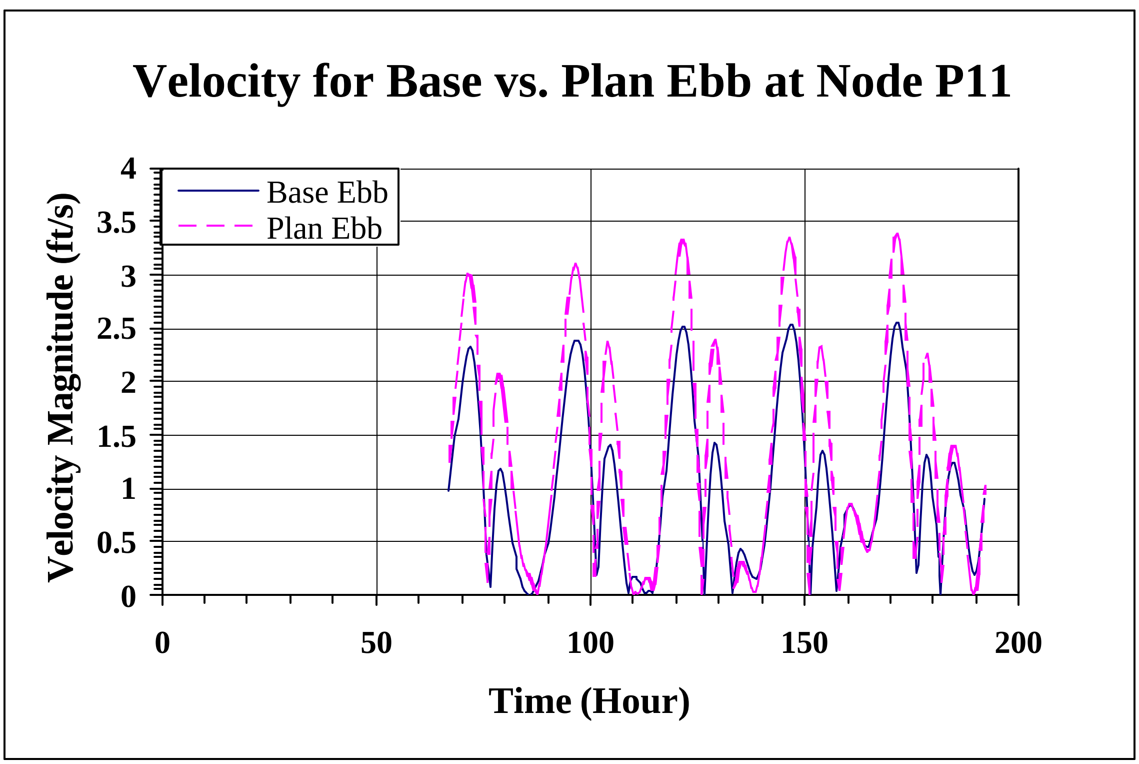


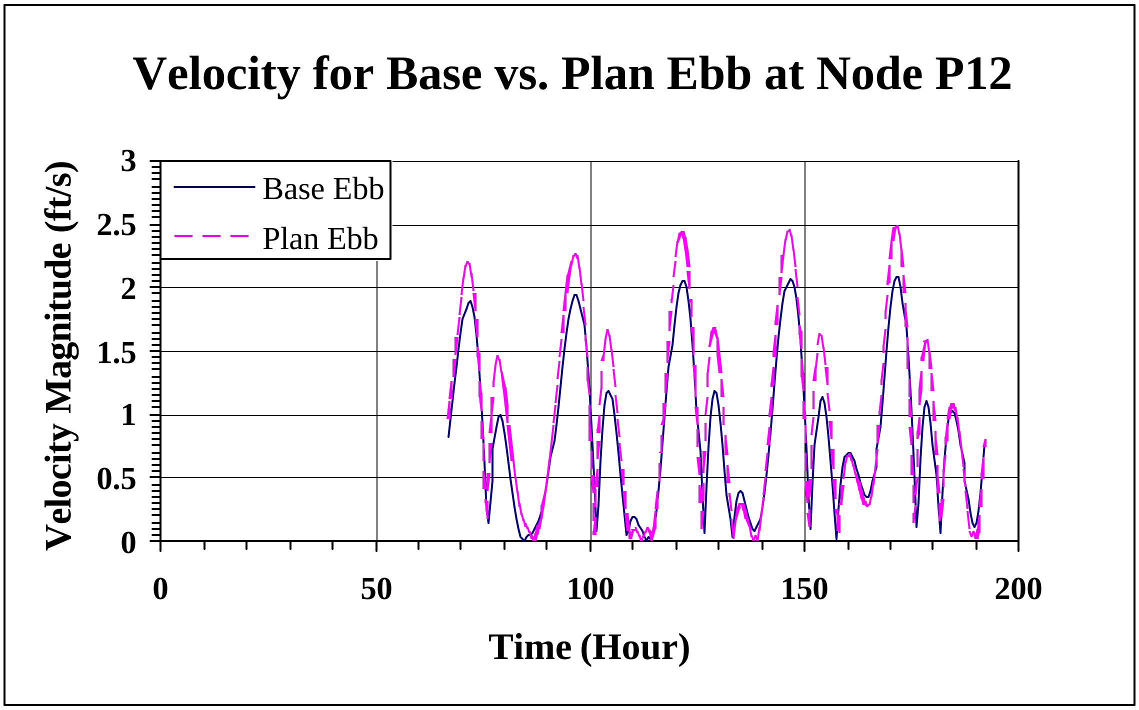
Velocity for Base vs. Plan Ebb at Node P104
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
1
2
3
4
5
0
50
100
150
200

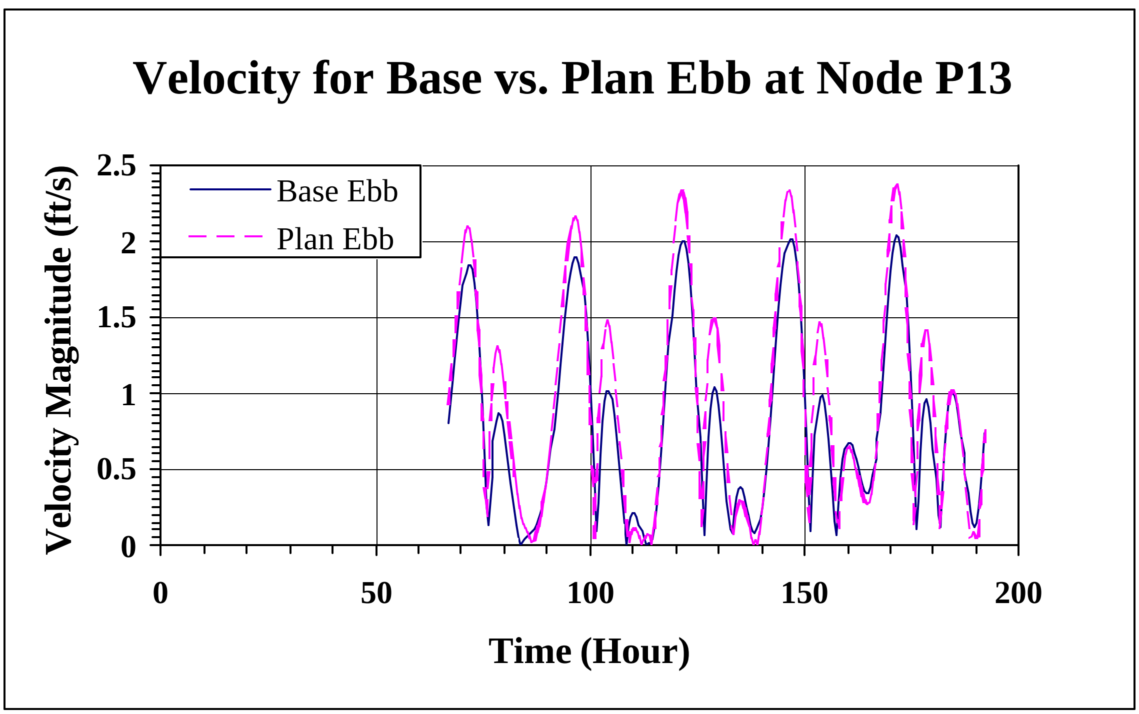



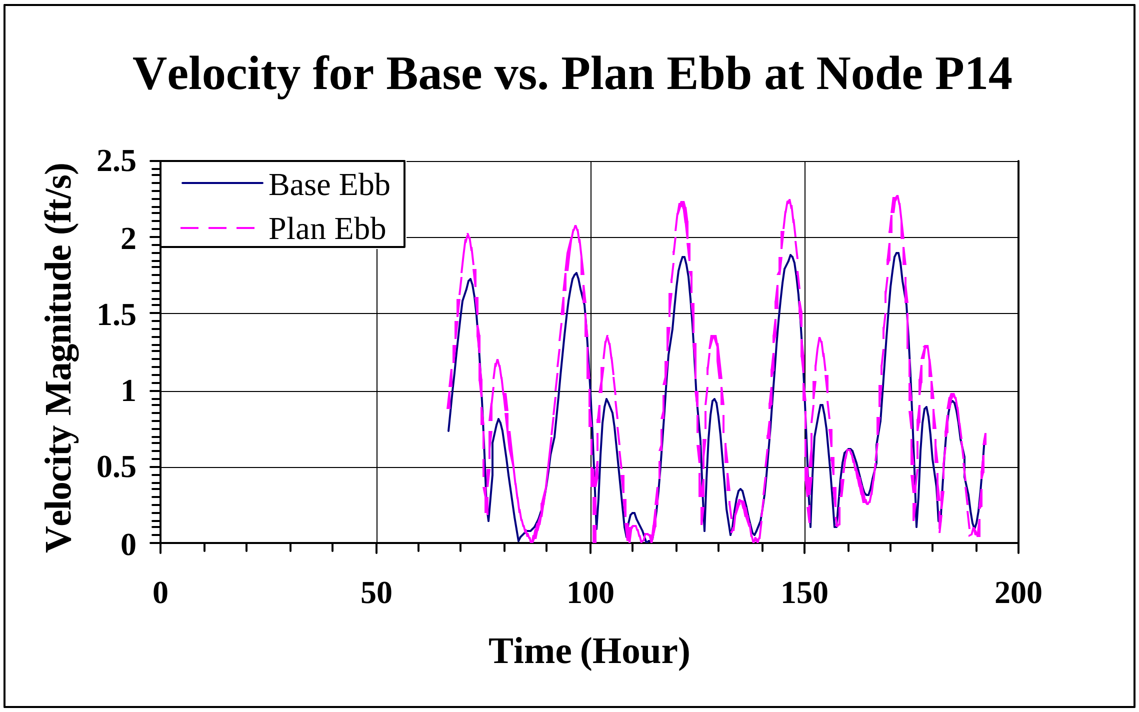
Velocity for Base vs. Plan Ebb at Node P105
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200

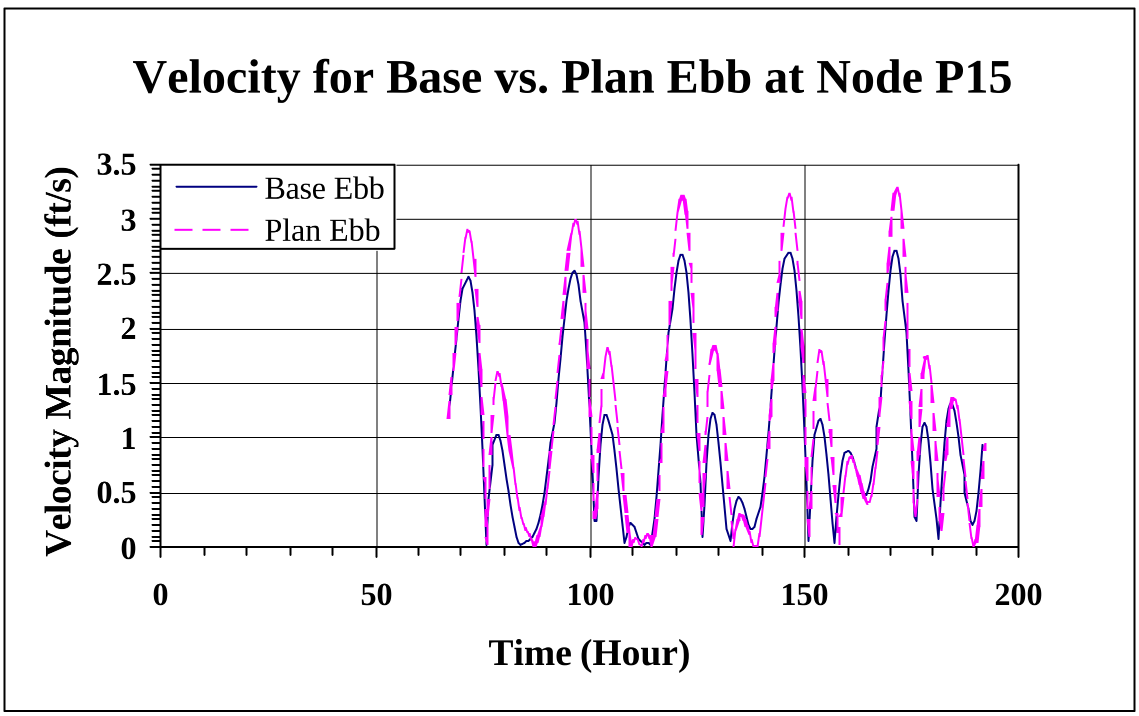

Velocity for Base vs. Plan Ebb at Node P106
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200

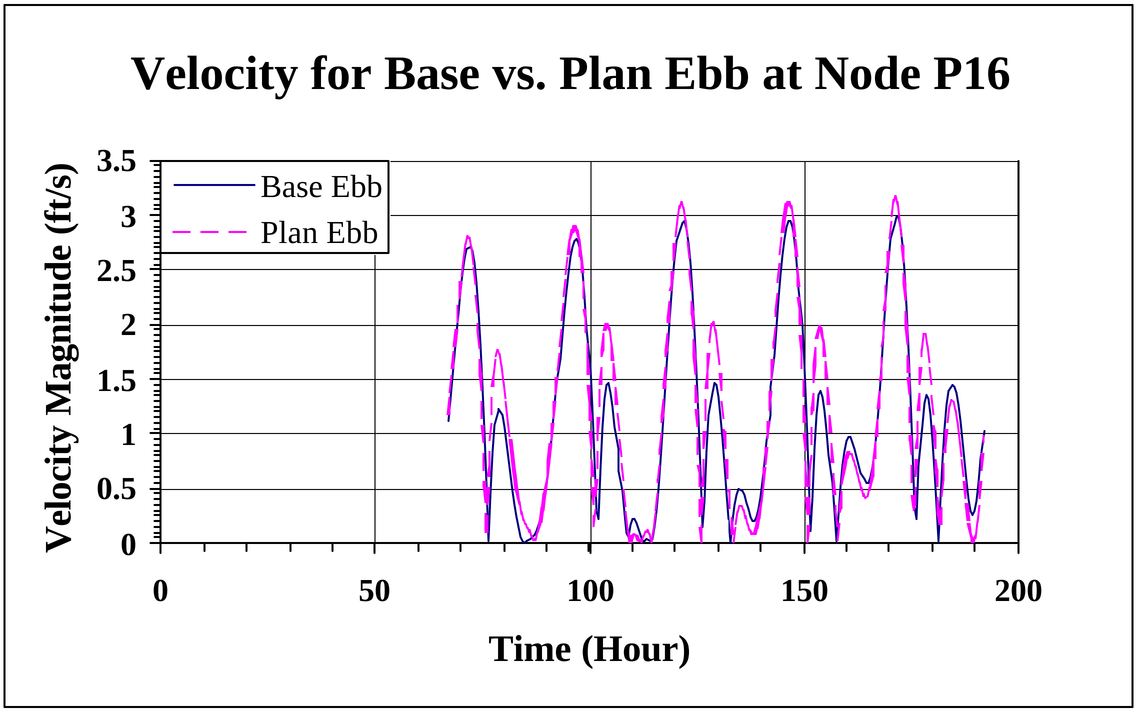

Velocity for Base vs. Plan Ebb at Node P11
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200

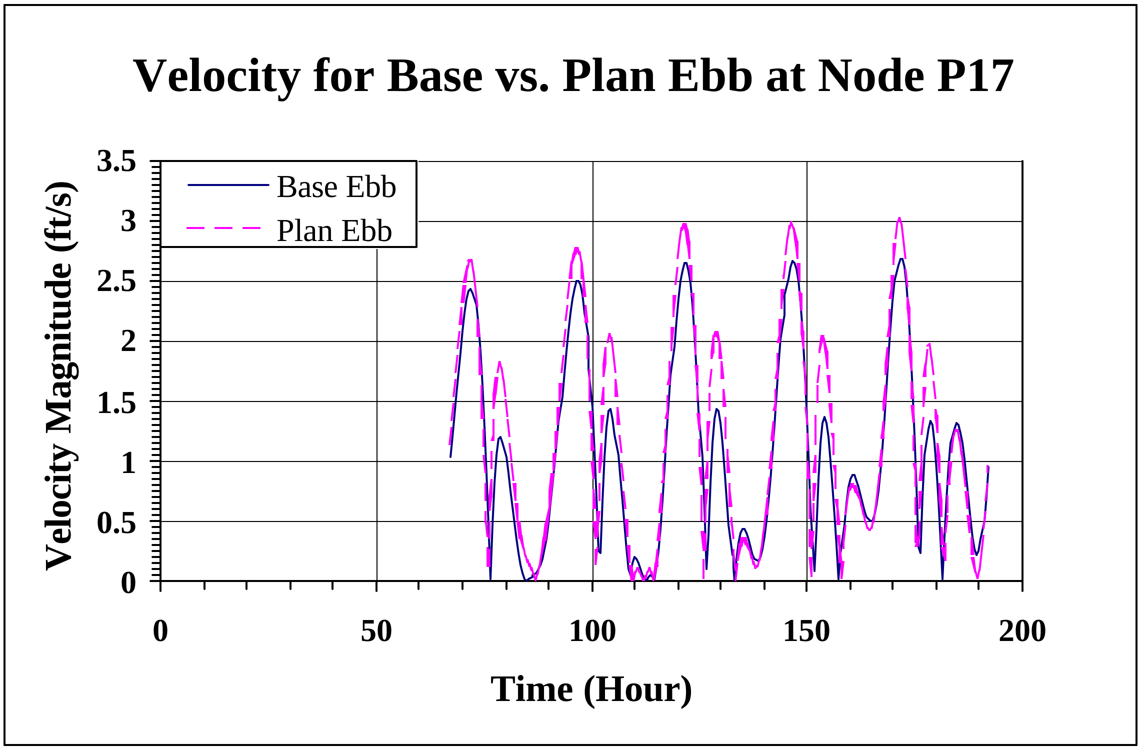

Velocity for Base vs. Plan Ebb at Node P12
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

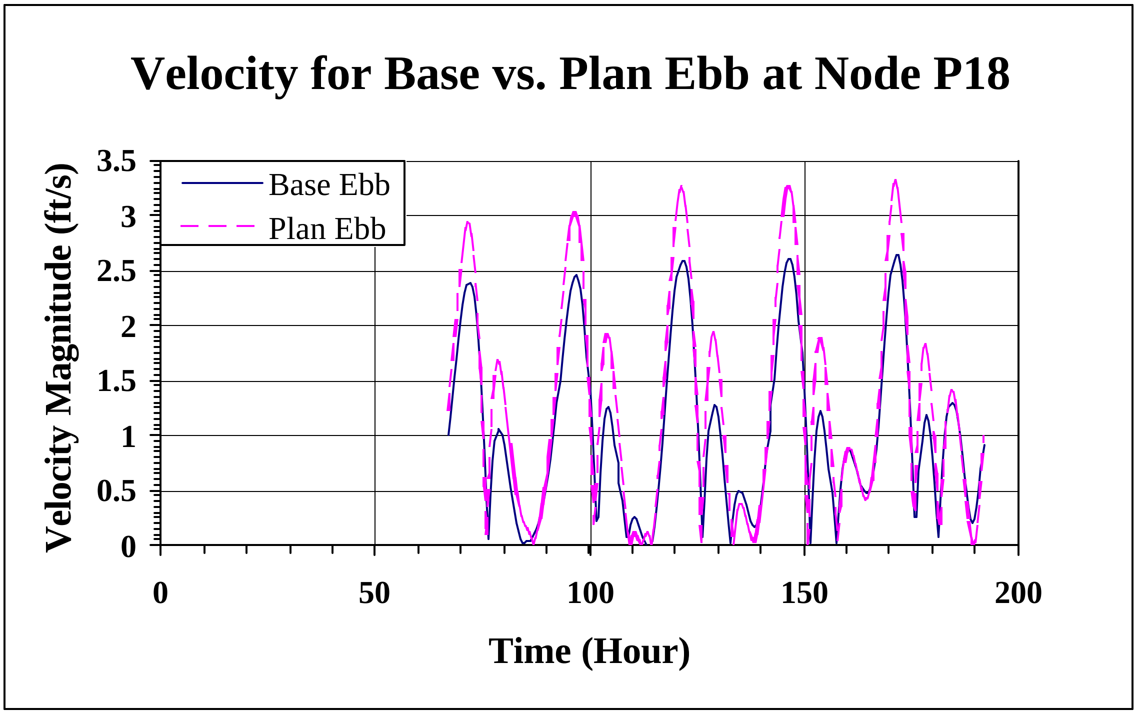

Velocity for Base vs. Plan Ebb at Node P13
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

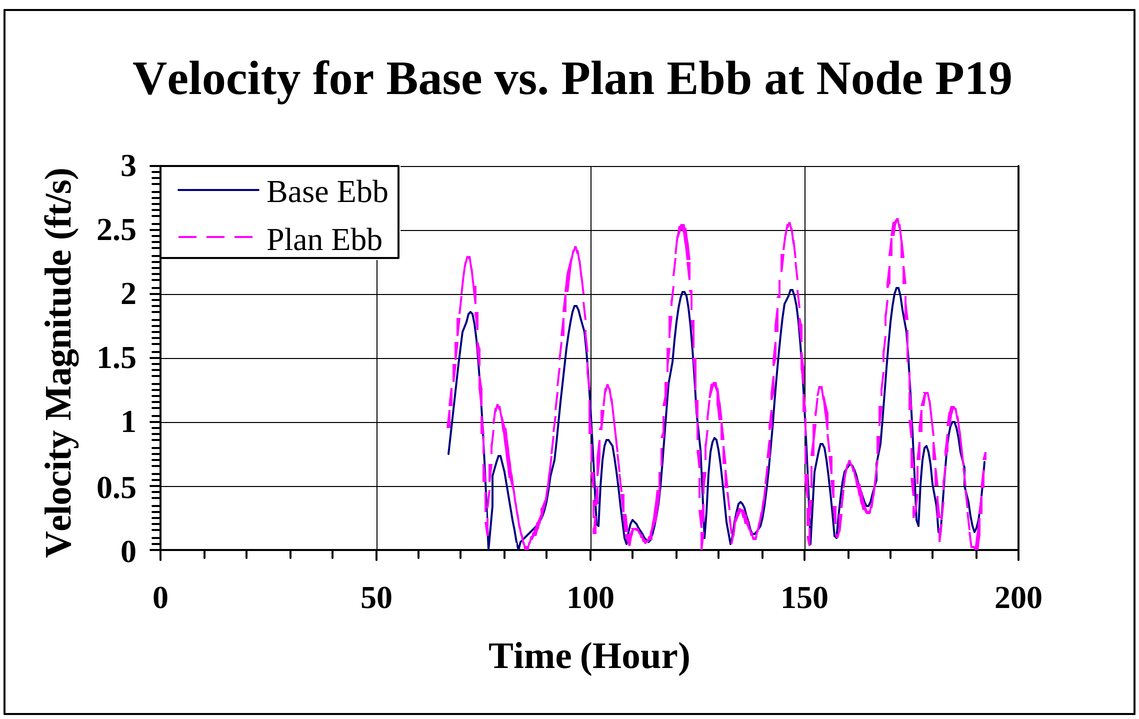

Velocity for Base vs. Plan Ebb at Node P14
Velocity Magnitude (ft/s)
2.5
2
1.5
1
0.5
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node P15
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node P16
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)

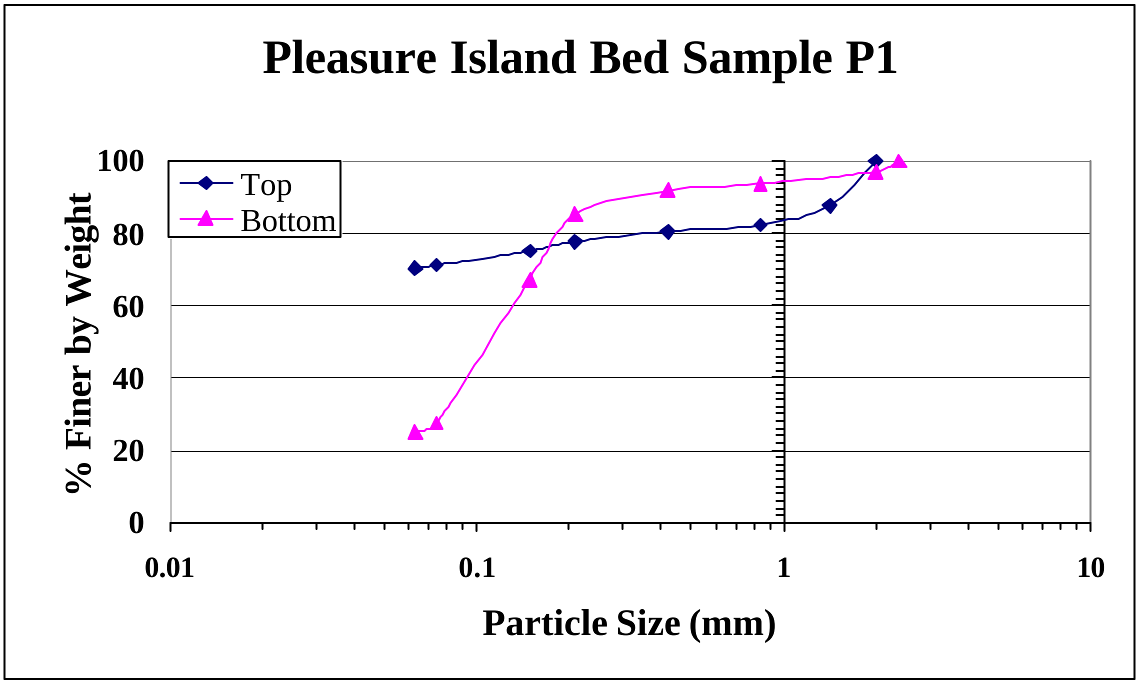

Velocity for Base vs. Plan Ebb at Node P17
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node P18
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

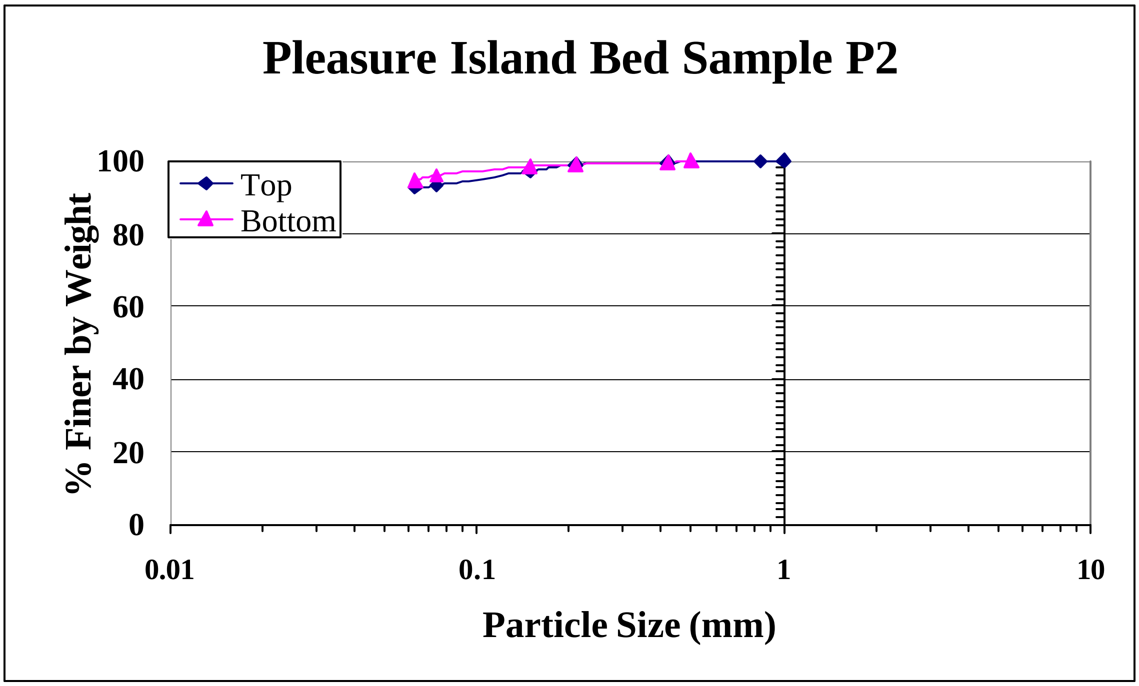

Velocity for Base vs. Plan Ebb at Node P19
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
Time (Hour)
0
0.5
1
1.5
2
2.5
3
0
50
100
150
200

# Appendix G

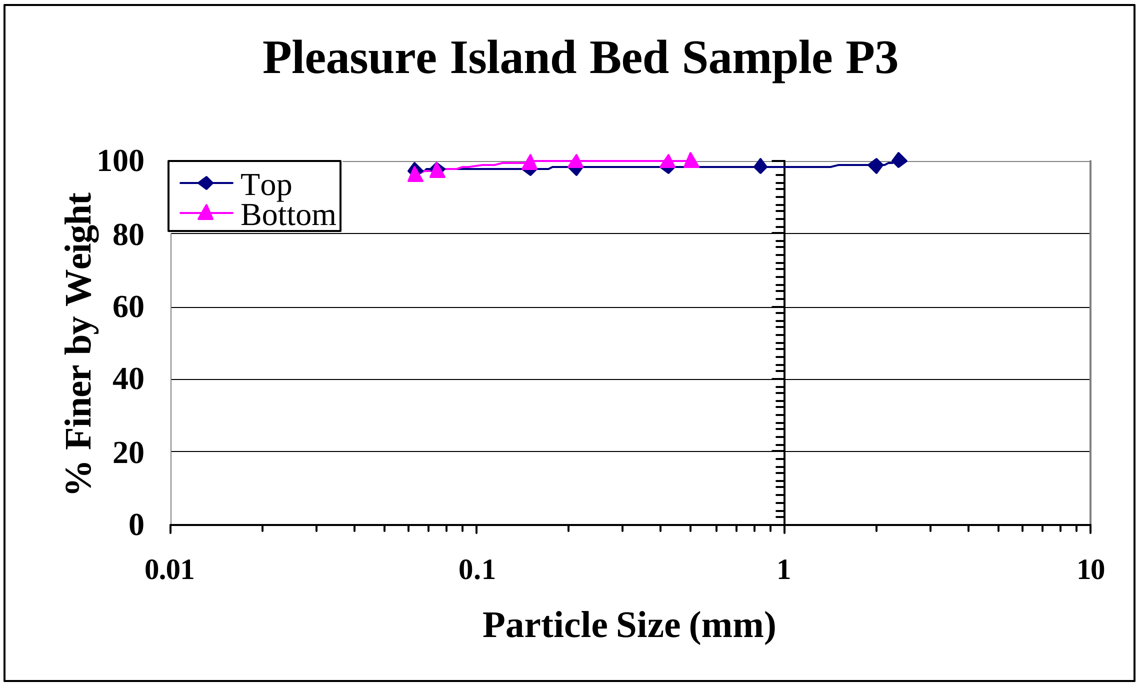
## Particle Size Distribution Curves at Pleasure Island Locations

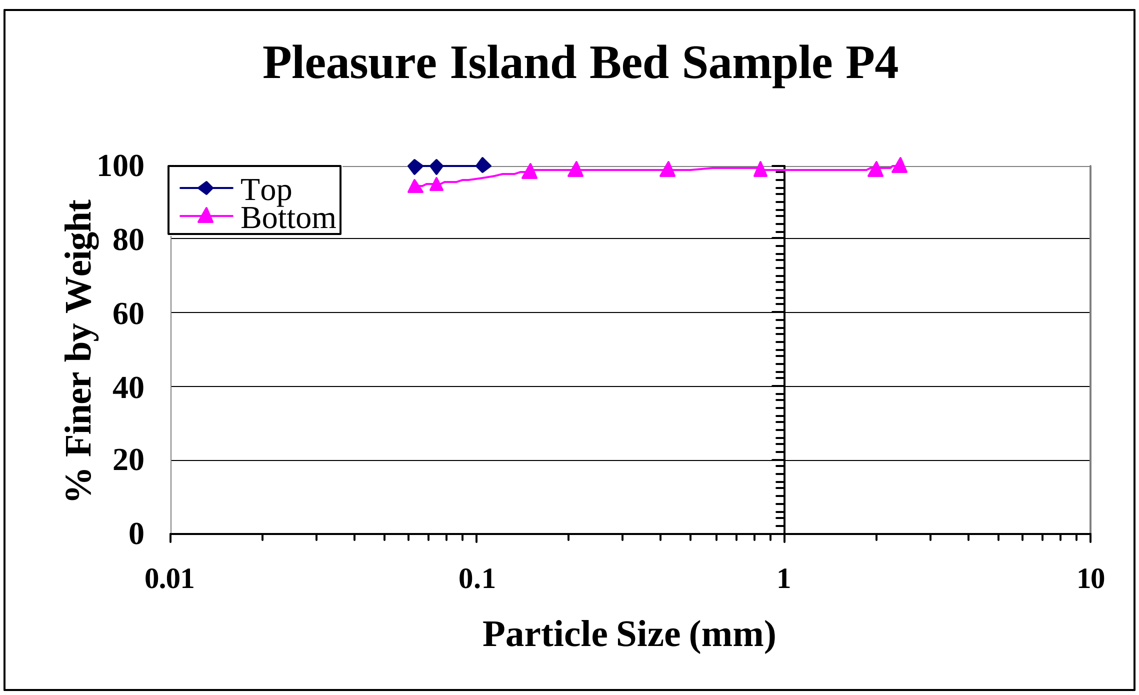


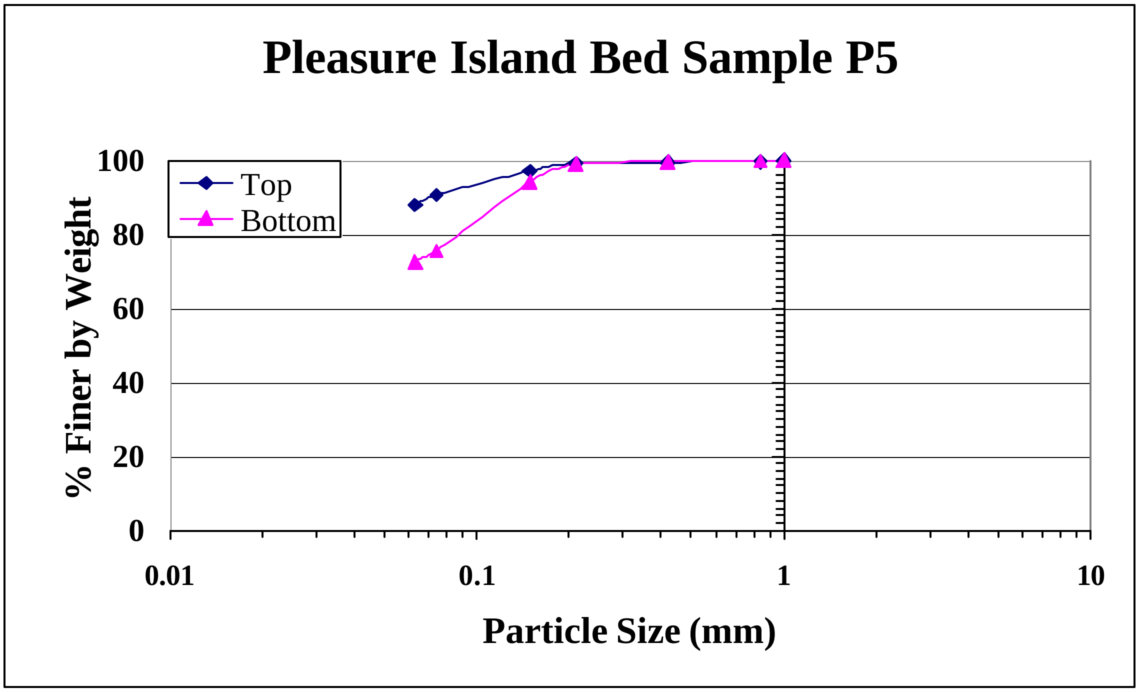
Pleasure Island Bed Sample P1
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)

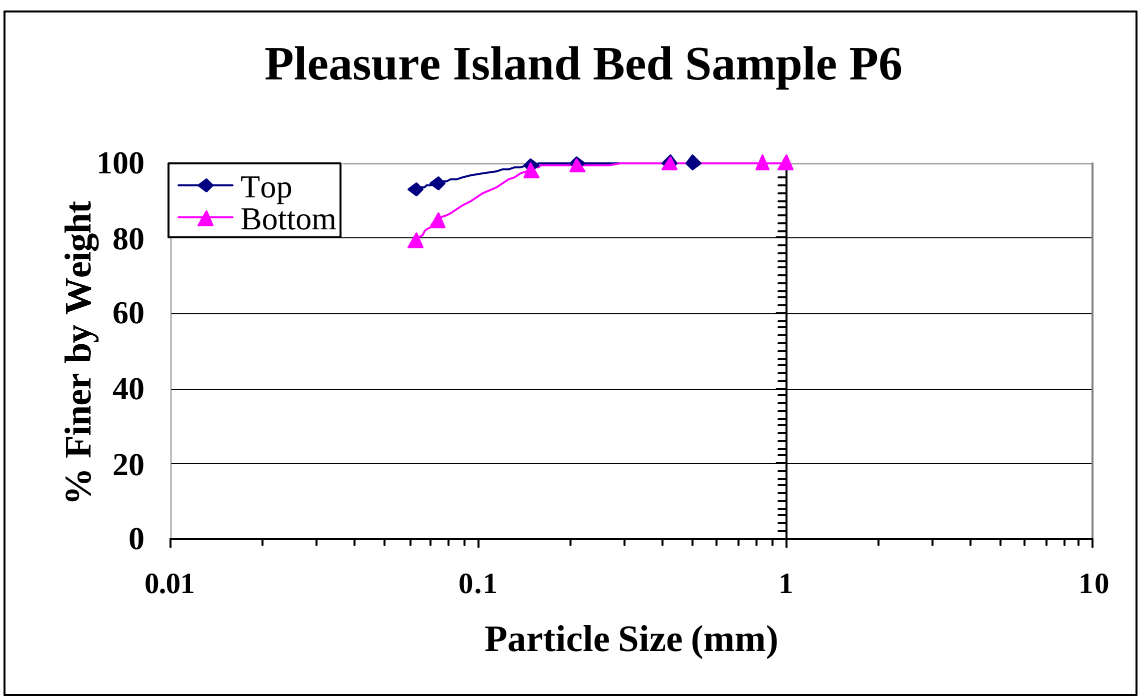



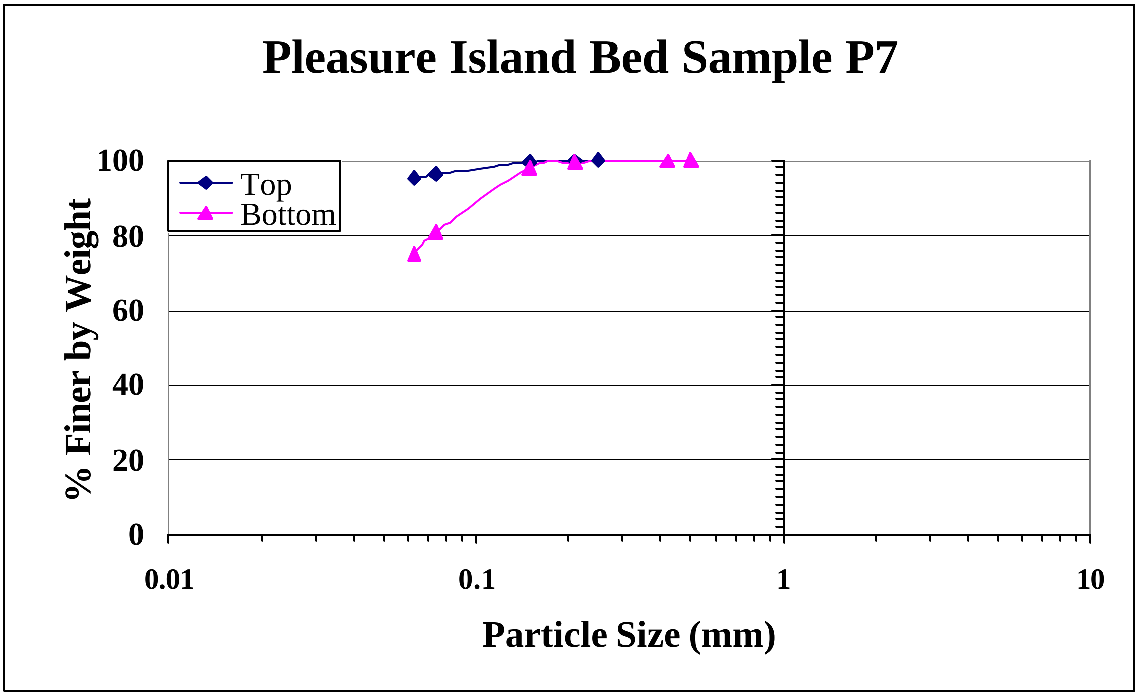
Pleasure Island Bed Sample P2
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)

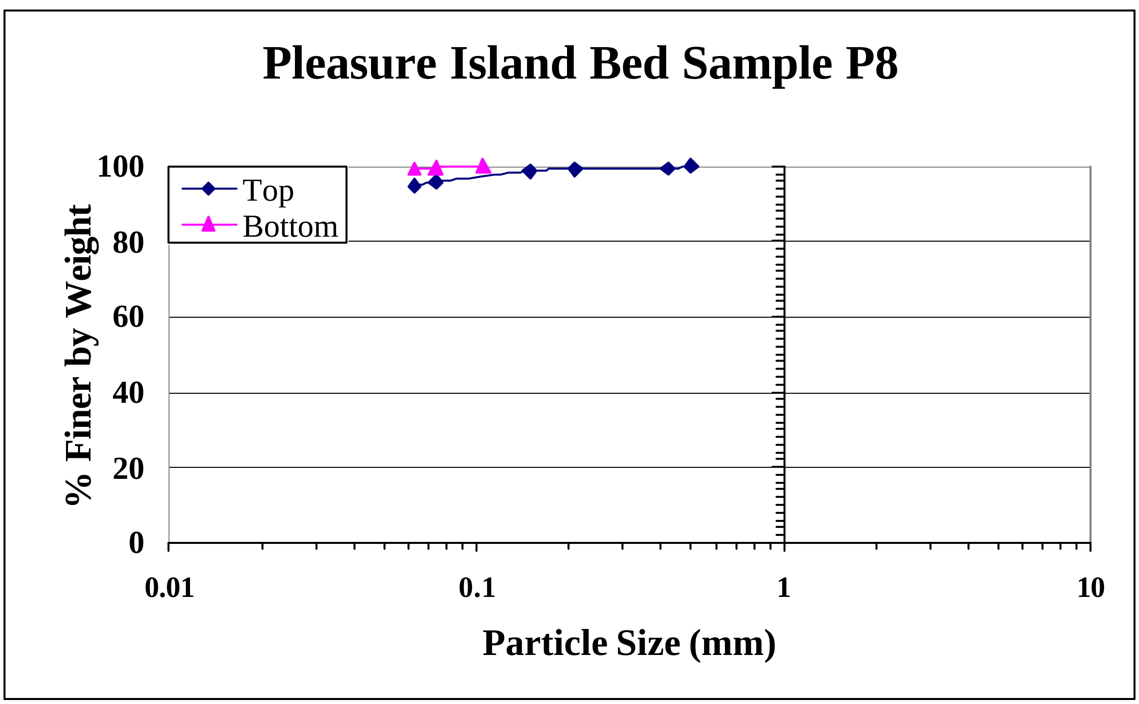

Pleasure Island Bed Sample P3
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

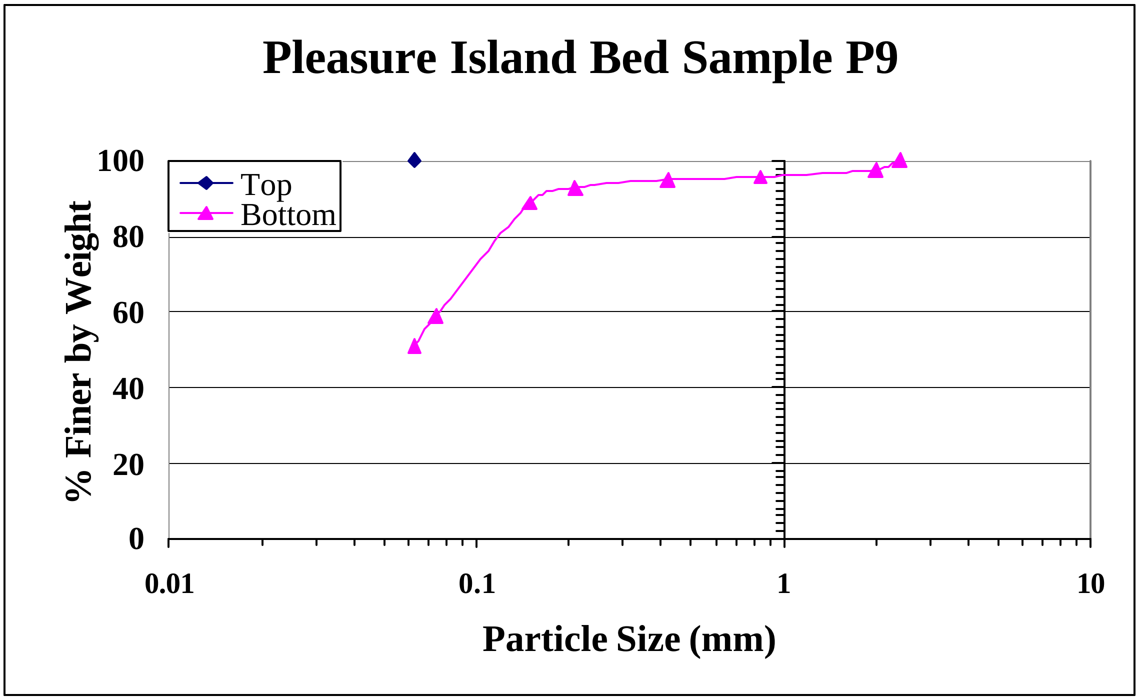

Pleasure Island Bed Sample P4
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

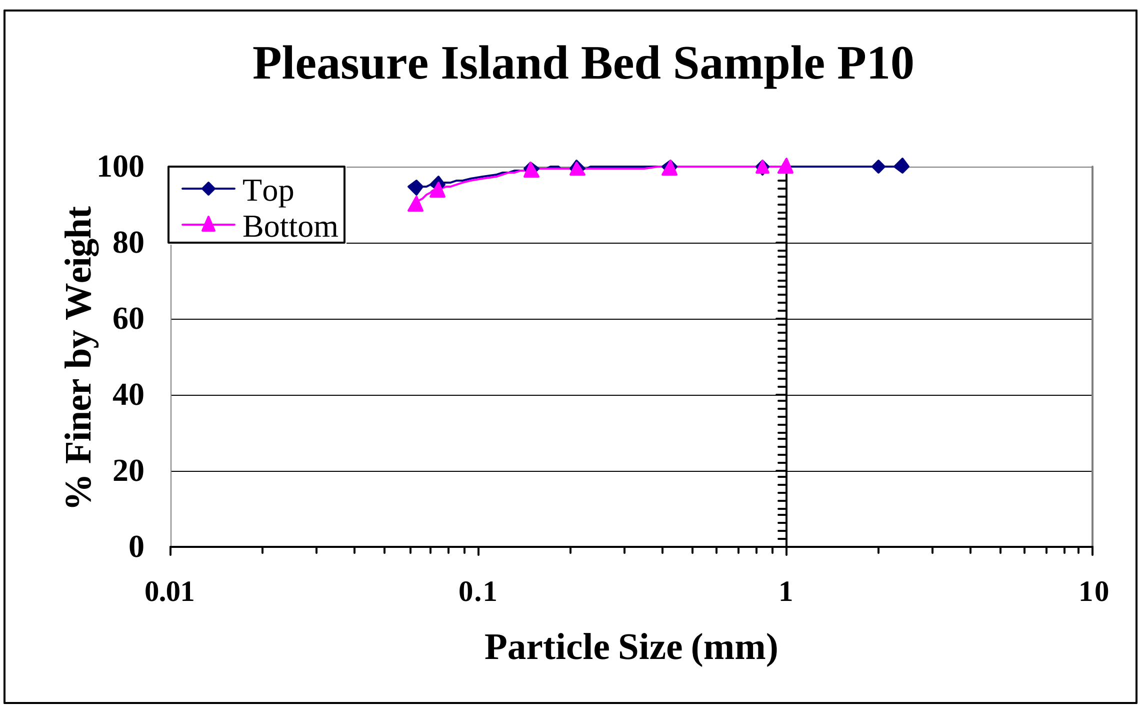

Pleasure Island Bed Sample P5
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

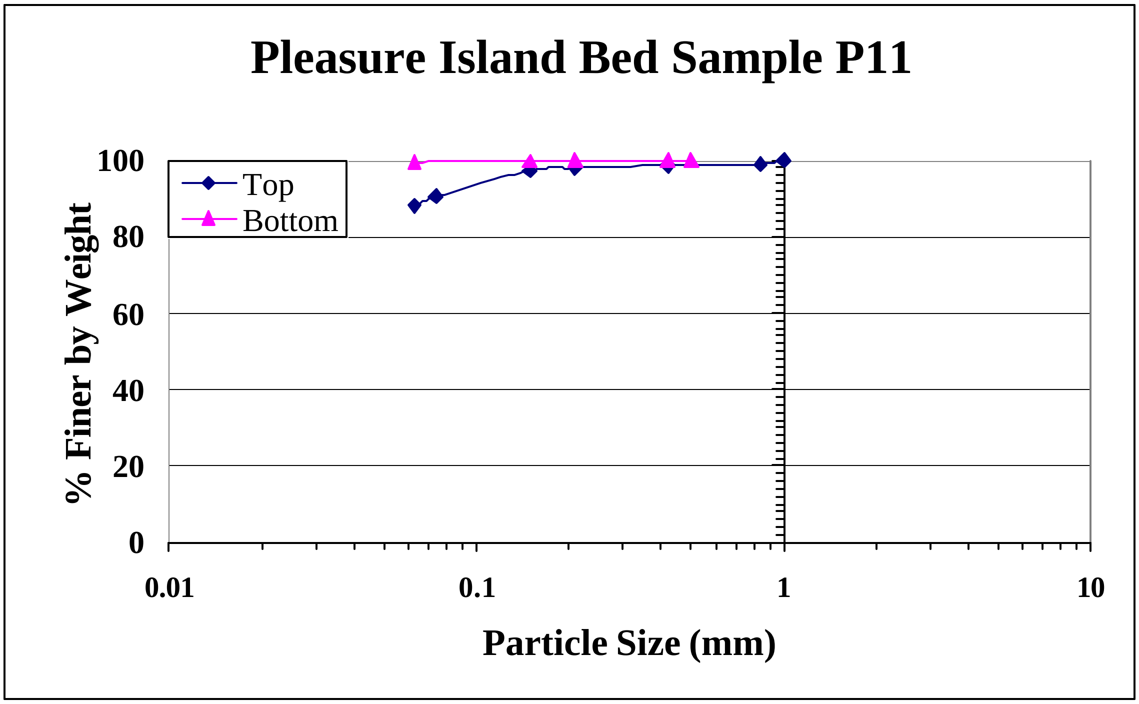

Pleasure Island Bed Sample P6
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Pleasure Island Bed Sample P7
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)
Top
Bottom

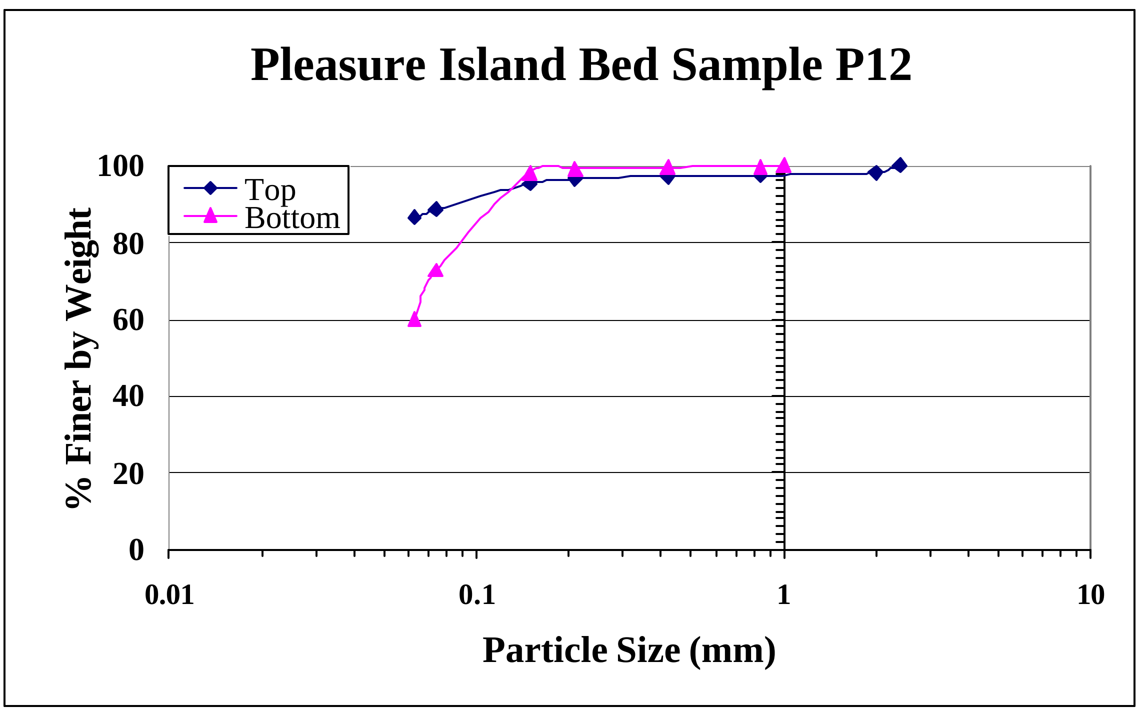

Pleasure Island Bed Sample P8
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)
Top
Bottom


Pleasure Island Bed Sample P9
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

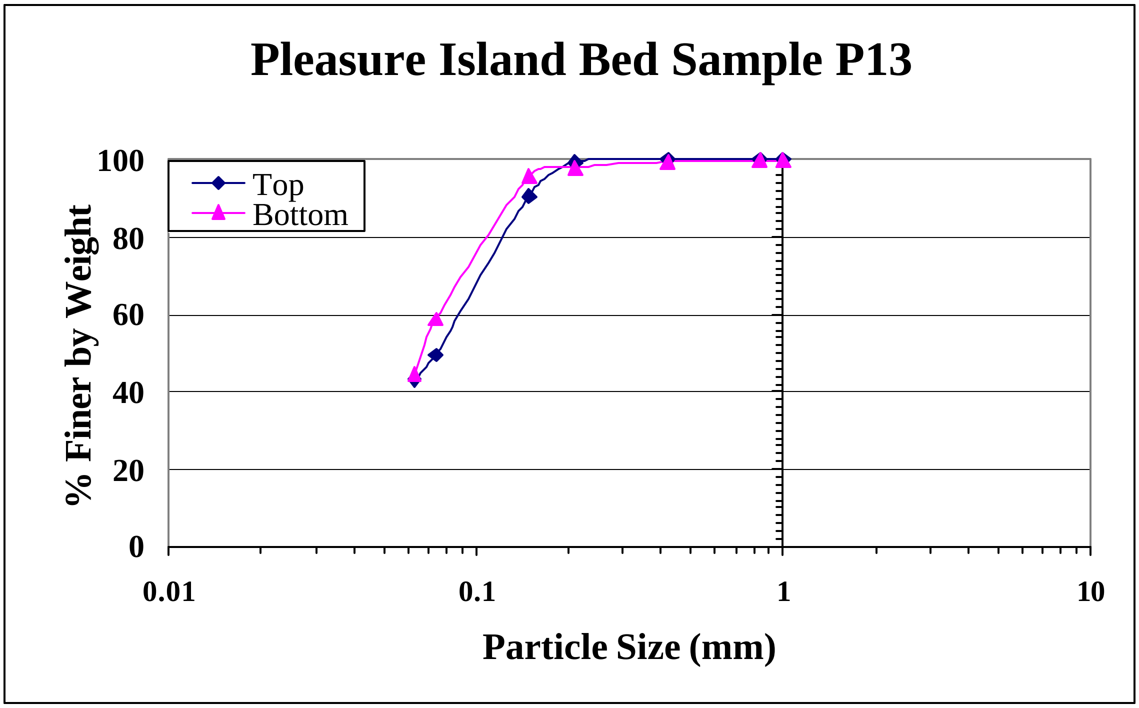

Pleasure Island Bed Sample P10
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

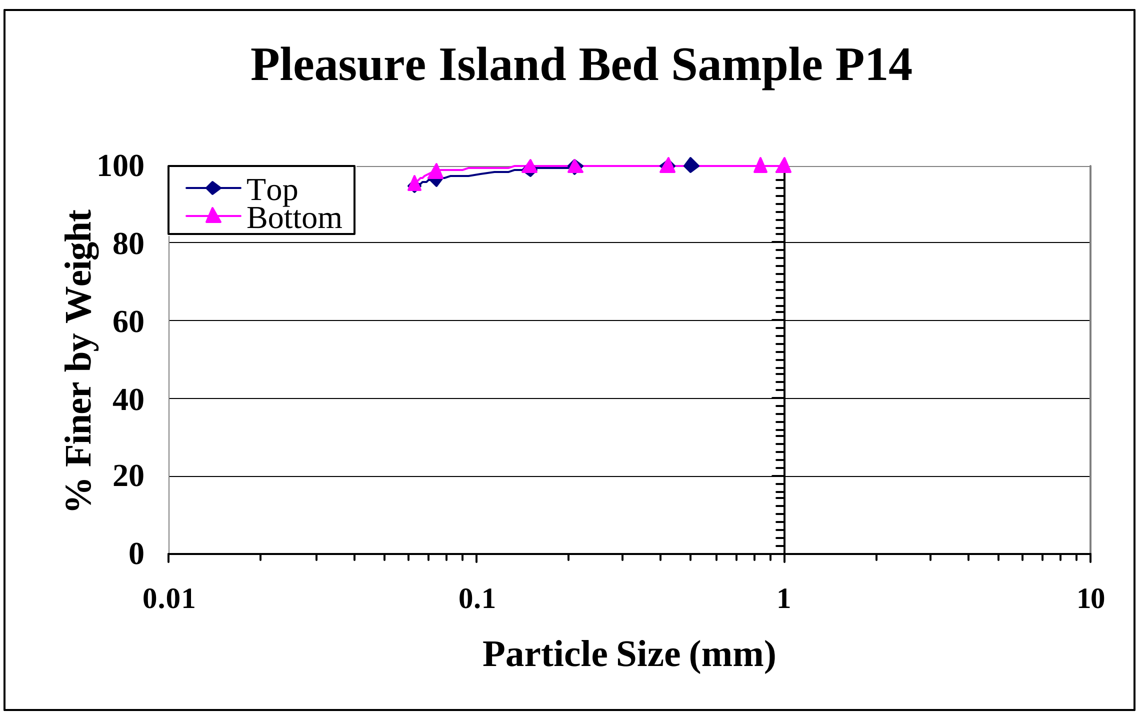


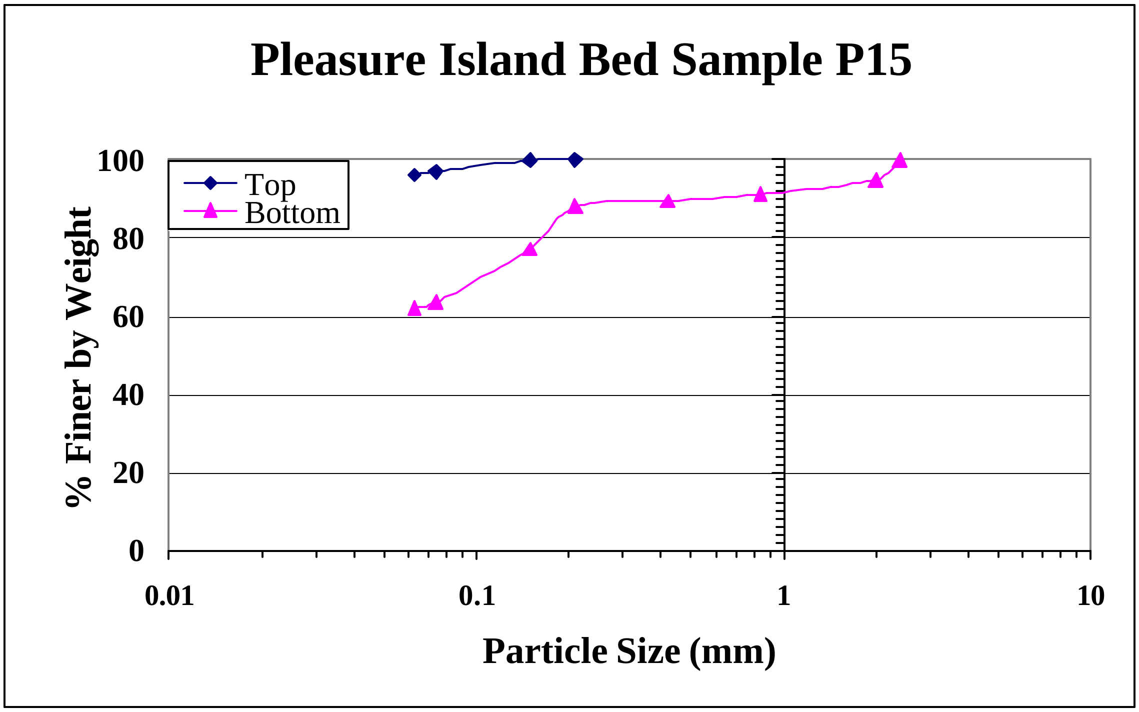
Pleasure Island Bed Sample P11
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)

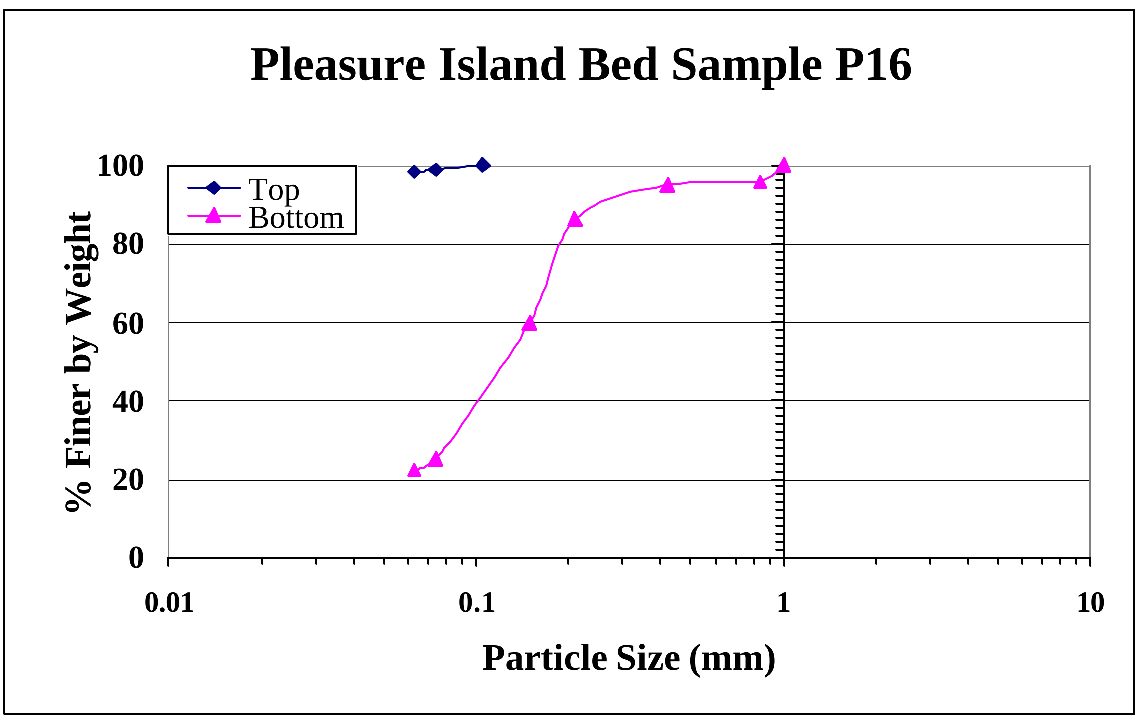



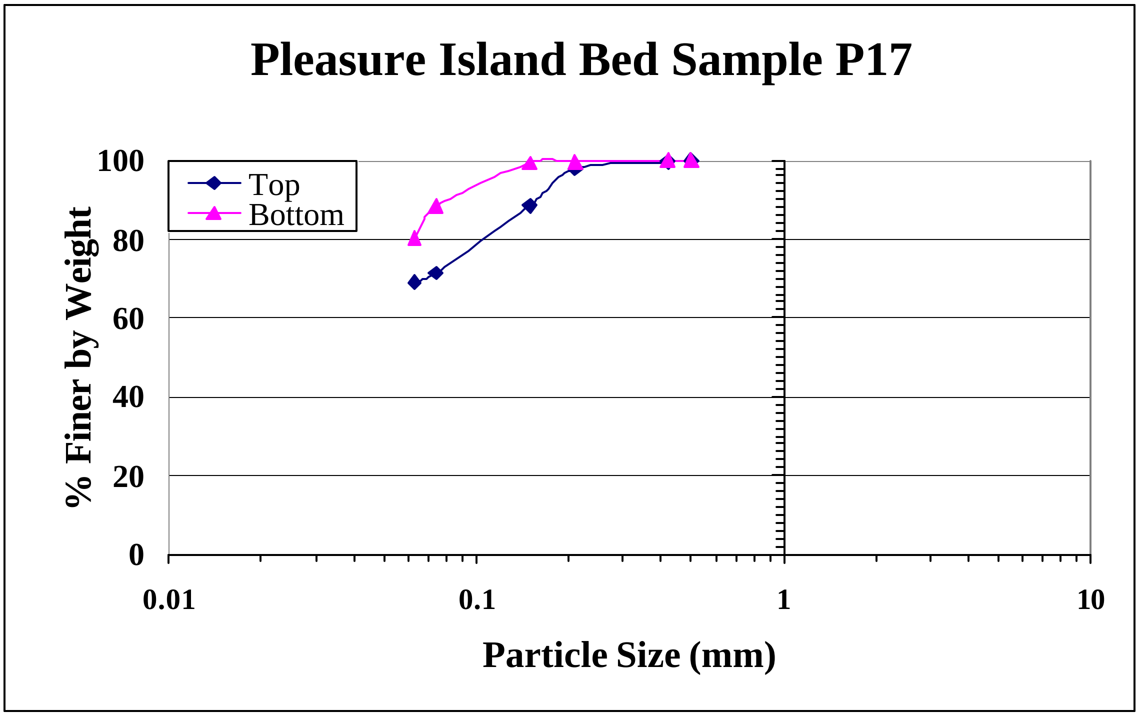
Pleasure Island Bed Sample P12
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)

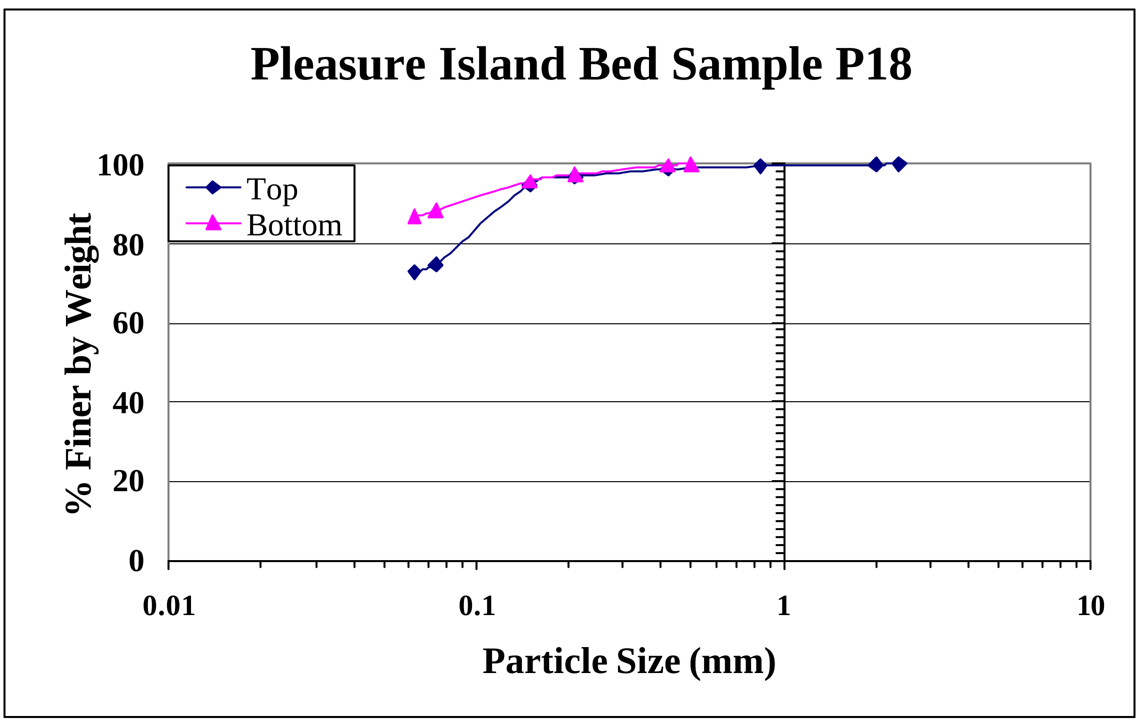

Pleasure Island Bed Sample P13
Top
Bottom
100
80
60
40
20
0
% Finer by Weight
0.01
0.1
1
10
Particle Size (mm)

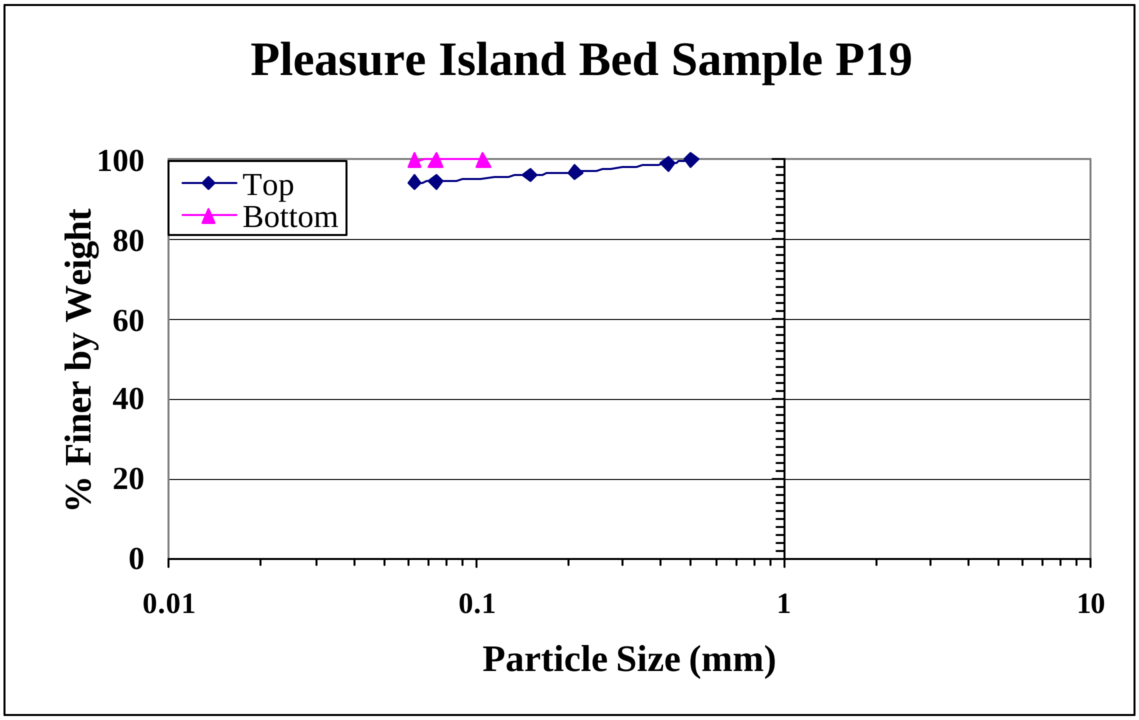

Pleasure Island Bed Sample P14
Top
Bottom
100
80
60
40
20
0
% Finer by Weight
0.01
0.1
1
10
Particle Size (mm)


Pleasure Island Bed Sample P15
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Pleasure Island Bed Sample P16
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Pleasure Island Bed Sample P17
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Pleasure Island Bed Sample P18
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)



Pleasure Island Bed Sample P19
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)

# Appendix H

## Photographs

# Appendix H_A

## Sequence of Photographs showing
## Propagation of
## Transverse Stern Waves
## Generated by Passage of Ship

# Appendix H _B

## Photographs showing
## Vessel-Generated Waves Attacking the Shore

# Appendix H_C

## Photographs showing
## Bank Erosion at Various Locations
## In Sabine Neches Project Area

# Appendix H_D

## Photographs showing
## Bank Protection Measures
## Adopted at Sabine

# Appendix H_E

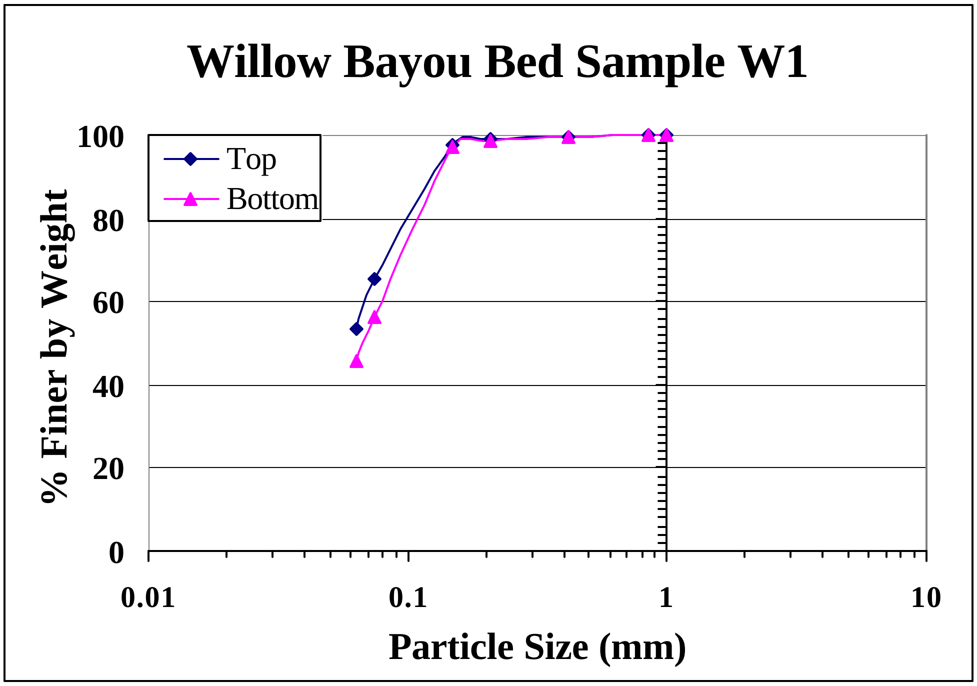
## Photographs showing
## Bank Sediment at Various Locations

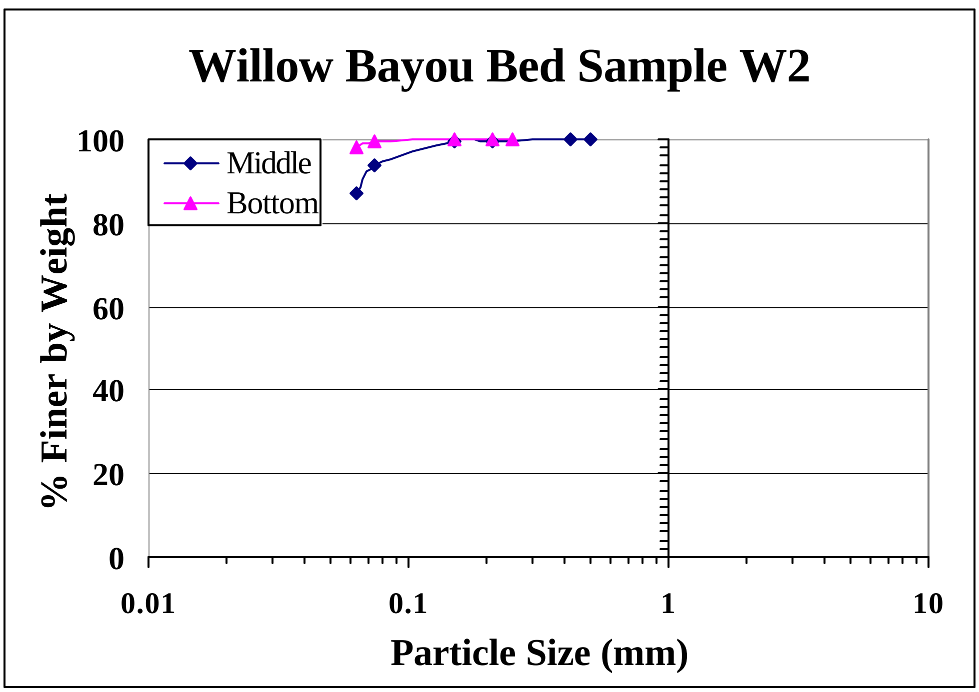
# Appendix H_F

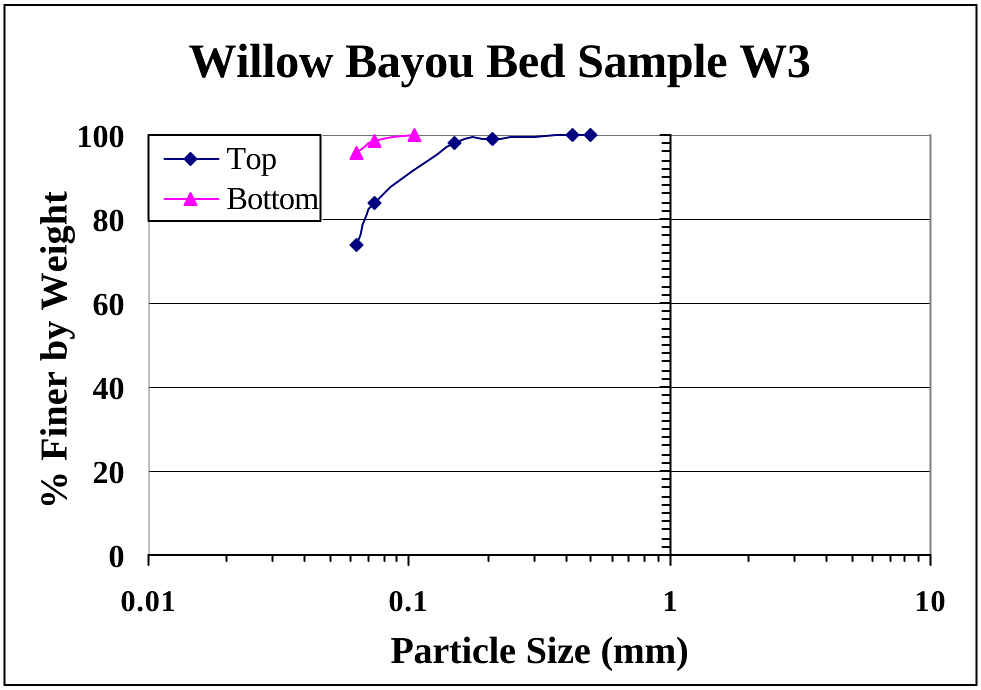
## Photographs showing
## Eastern Shoreline of Sabine Lake
## Near Willow Bayou

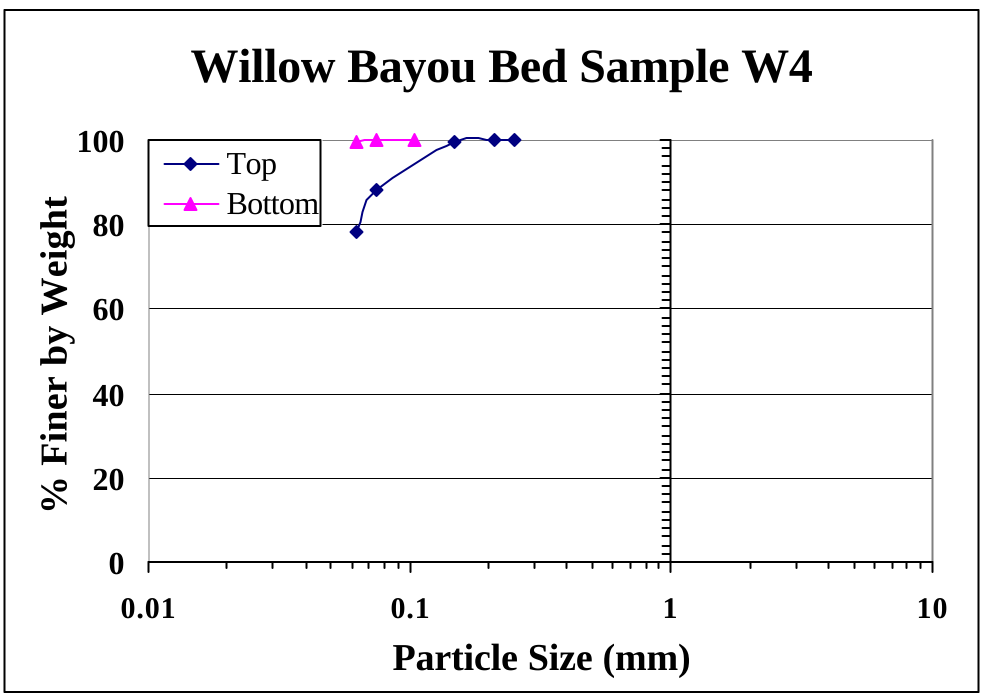
# Appendix I

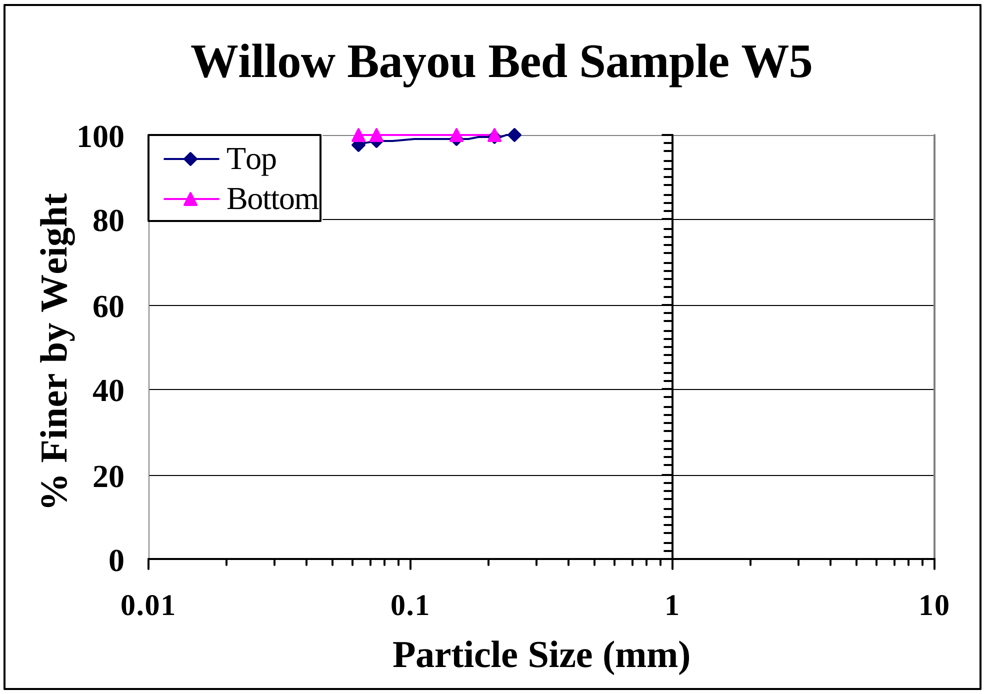
## Particle Size Distribution Curves for Willow Bayou Location


Willow Bayou Bed Sample W1
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

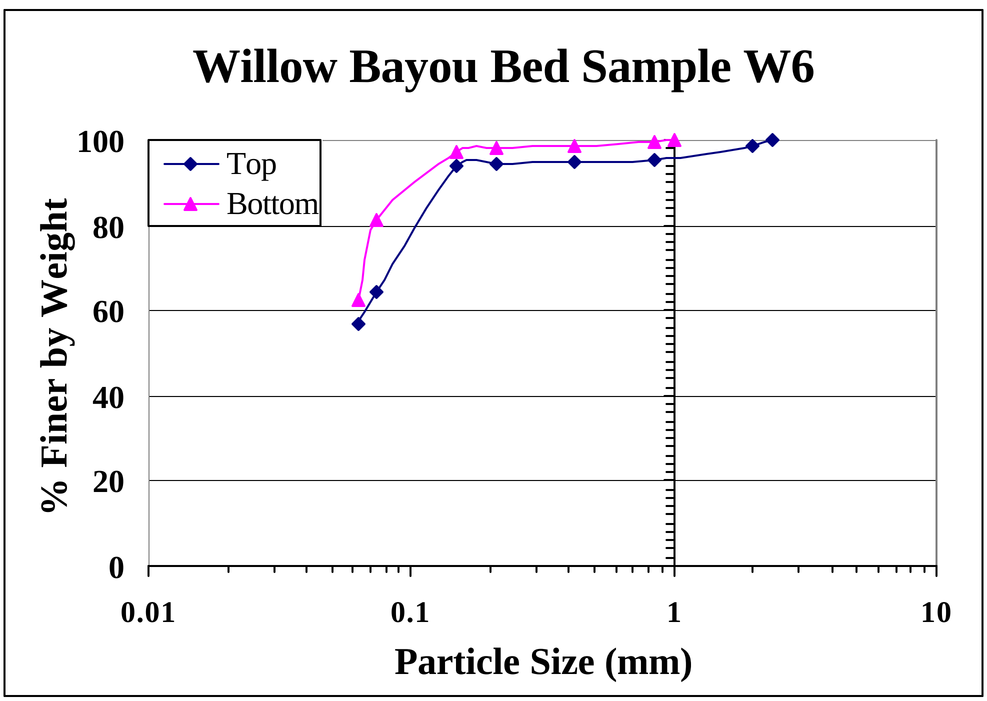

Willow Bayou Bed Sample W2
Middle
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Willow Bayou Bed Sample W3
% Finer by Weight
Particle Size (mm)
Top
Bottom
0
20
40
60
80
100
0.01
0.1
1
10

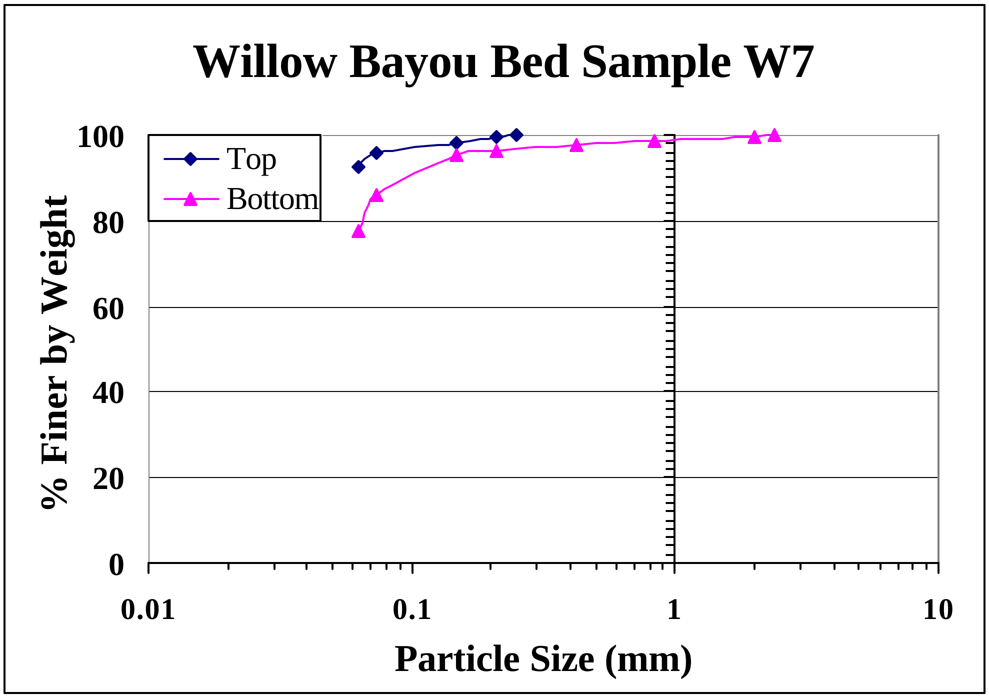

Willow Bayou Bed Sample W4
% Finer by Weight
Particle Size (mm)
Top
Bottom
0
20
40
60
80
100
0.01
0.1
1
10



Willow Bayou Bed Sample W5
% Finer by Weight
Particle Size (mm)
Top
Bottom
100
80
60
40
20
0
0.01
0.1
1
10

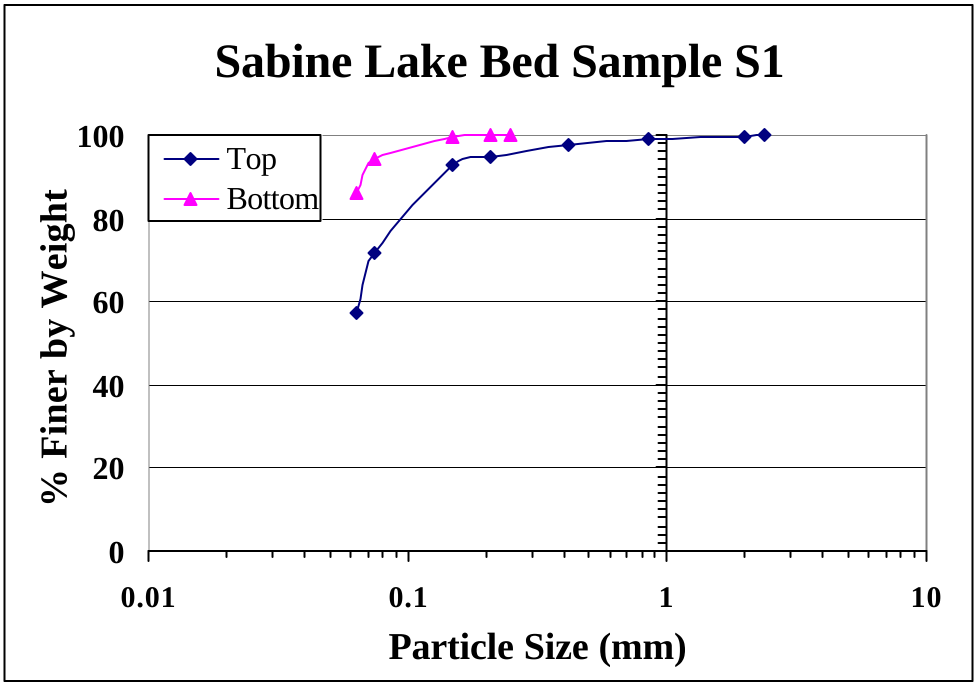
Willow Bayou Bed Sample W6
% Finer by Weight
Particle Size (mm)
Top
Bottom
100
80
60
40
20
0
0.01
0.1
1
10

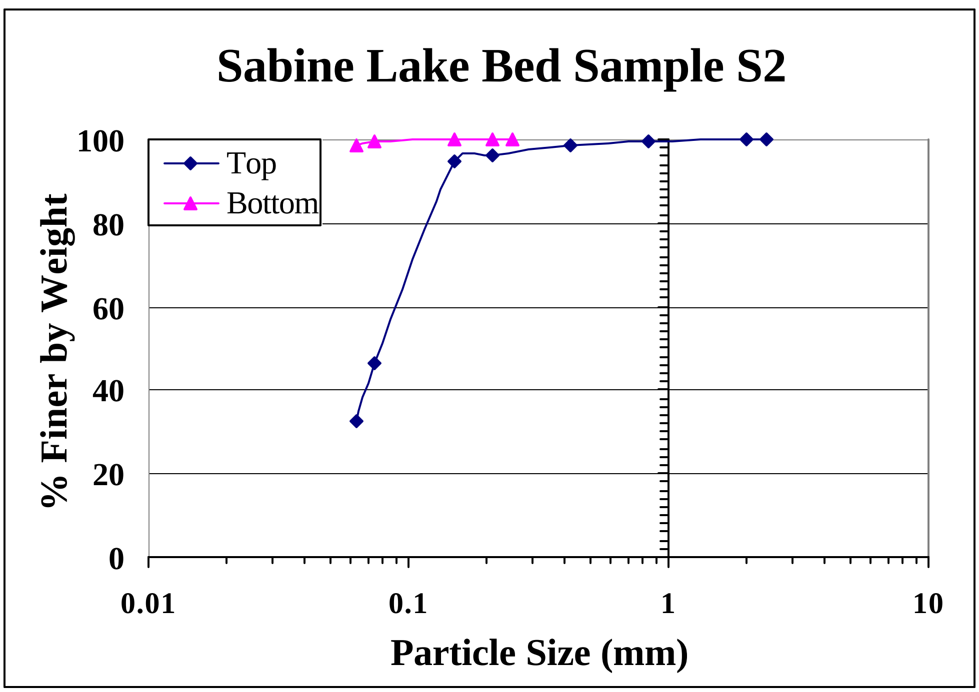


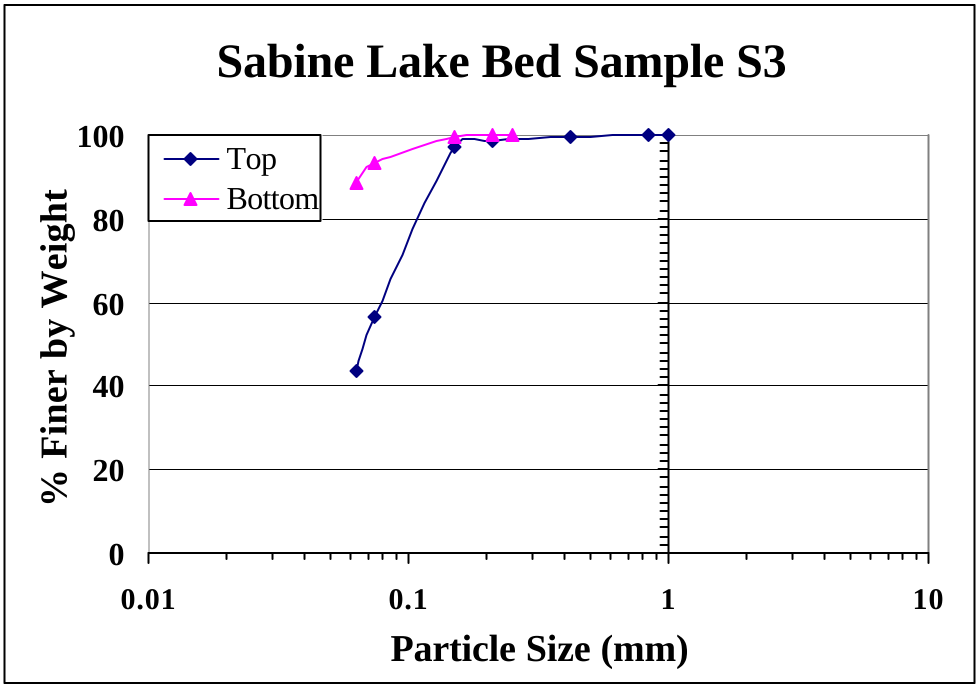
Willow Bayou Bed Sample W7
% Finer by Weight
Particle Size (mm)
Top
Bottom
100
80
60
40
20
0
0.01
0.1
1
10

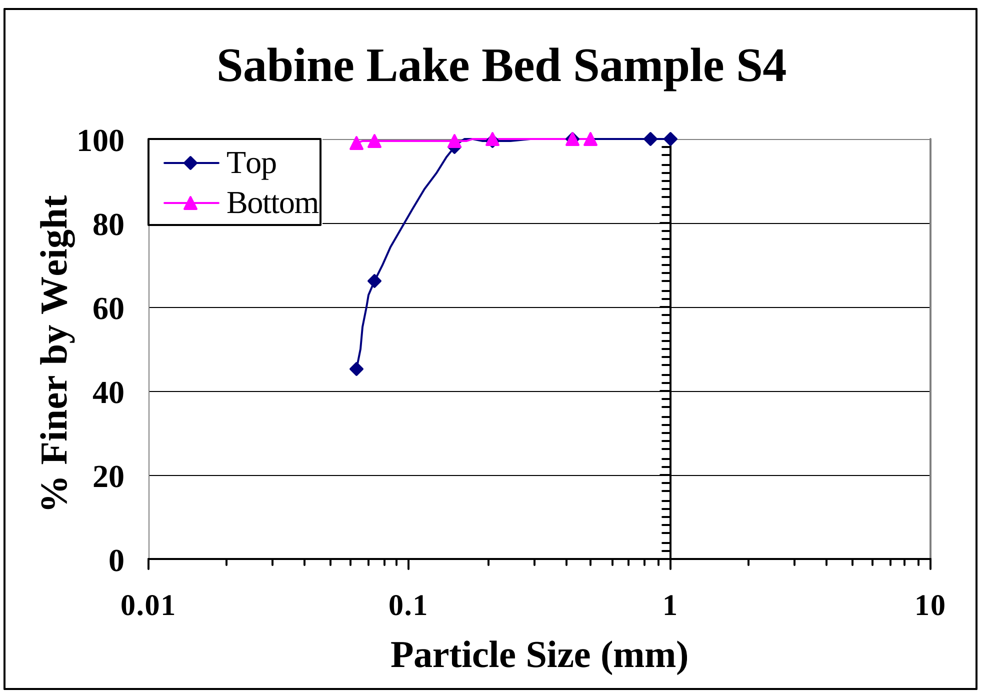
# Appendix J

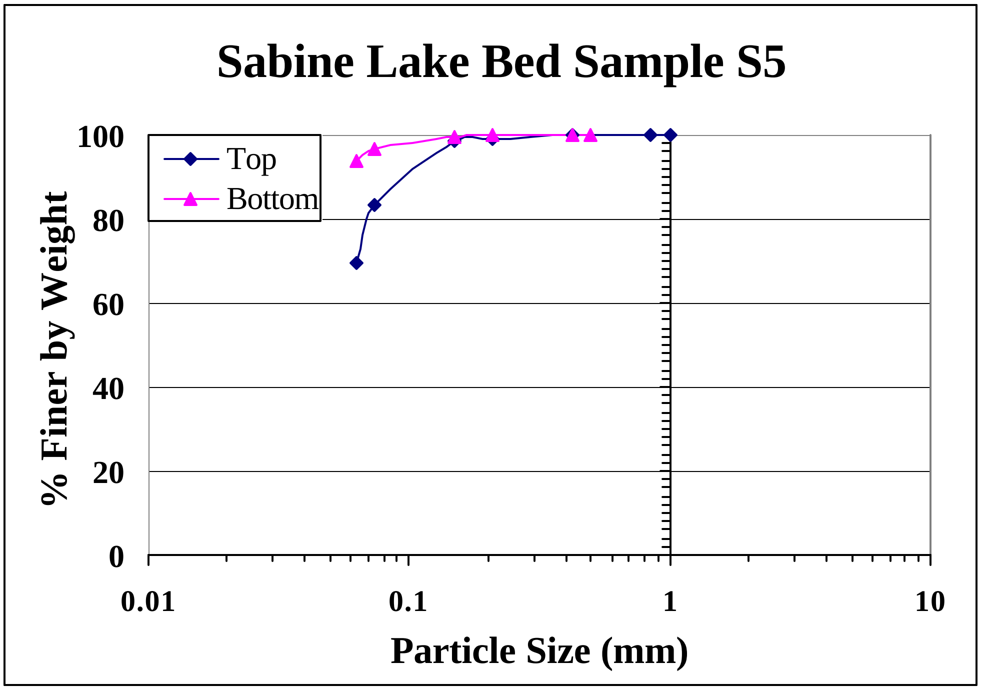
## Particle Size Distribution Curves for Sabine Lake East Shoreline Locations

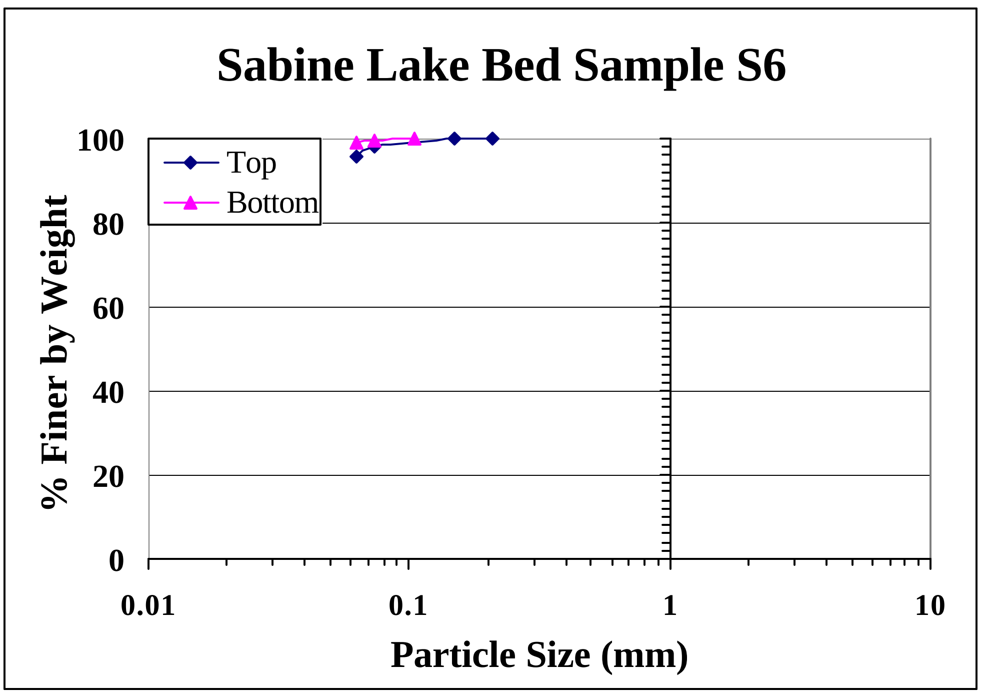

Sabine Lake Bed Sample S1
Top
Bottom
% Finer by Weight
0
20
40
60
80
100
0.01
0.1
1
10
Particle Size (mm)

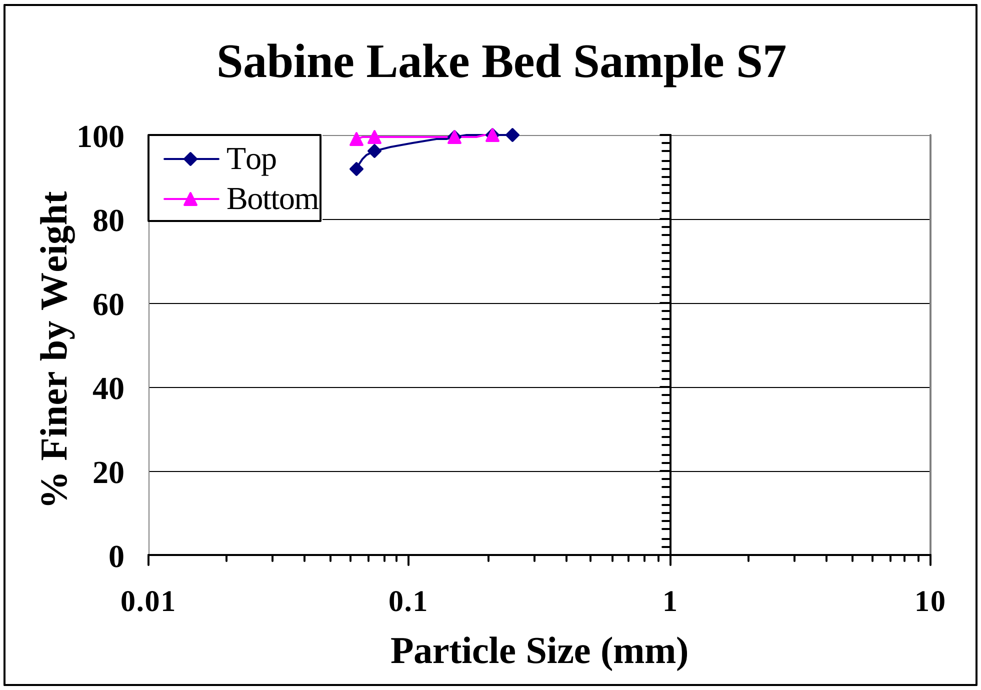

Sabine Lake Bed Sample S2
Top
Bottom
% Finer by Weight
0
20
40
60
80
100
0.01
0.1
1
10
Particle Size (mm)

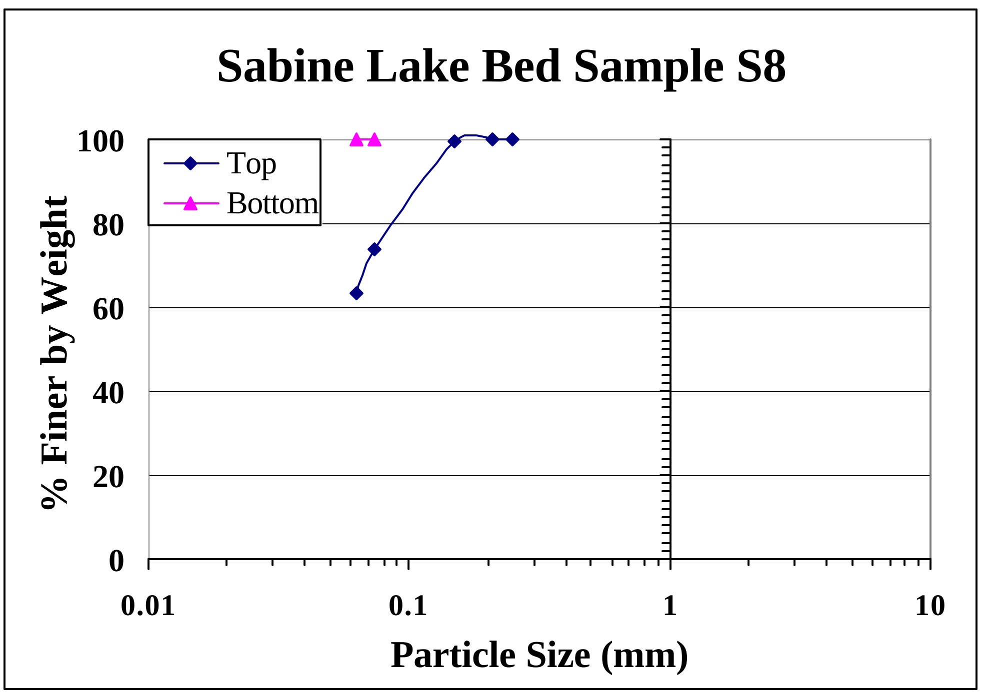

Sabine Lake Bed Sample S3
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

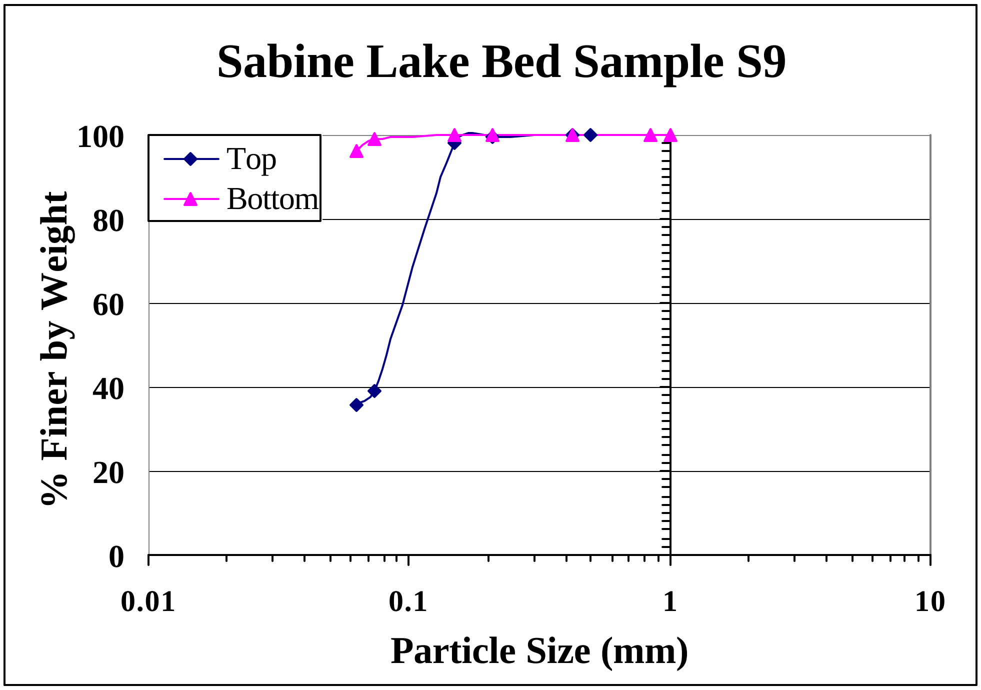

Sabine Lake Bed Sample S4
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Sabine Lake Bed Sample S5
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)

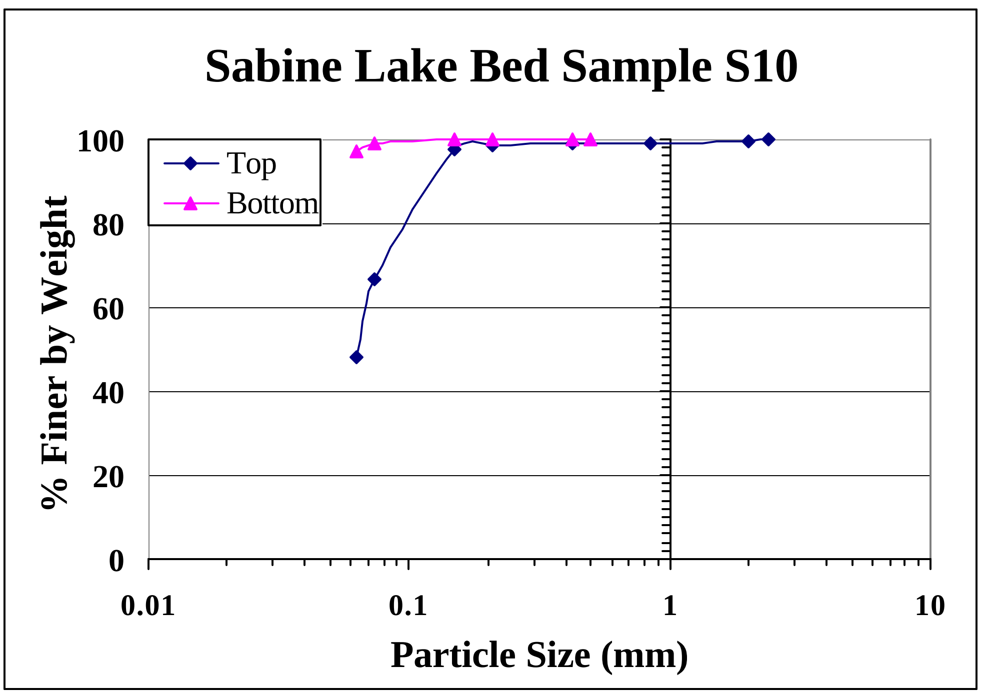

Sabine Lake Bed Sample S6
Top
Bottom
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)


Sabine Lake Bed Sample S7
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)


Sabine Lake Bed Sample S8
% Finer by Weight
100
80
60
40
20
0
Top
Bottom
0.01
0.1
1
10
Particle Size (mm)



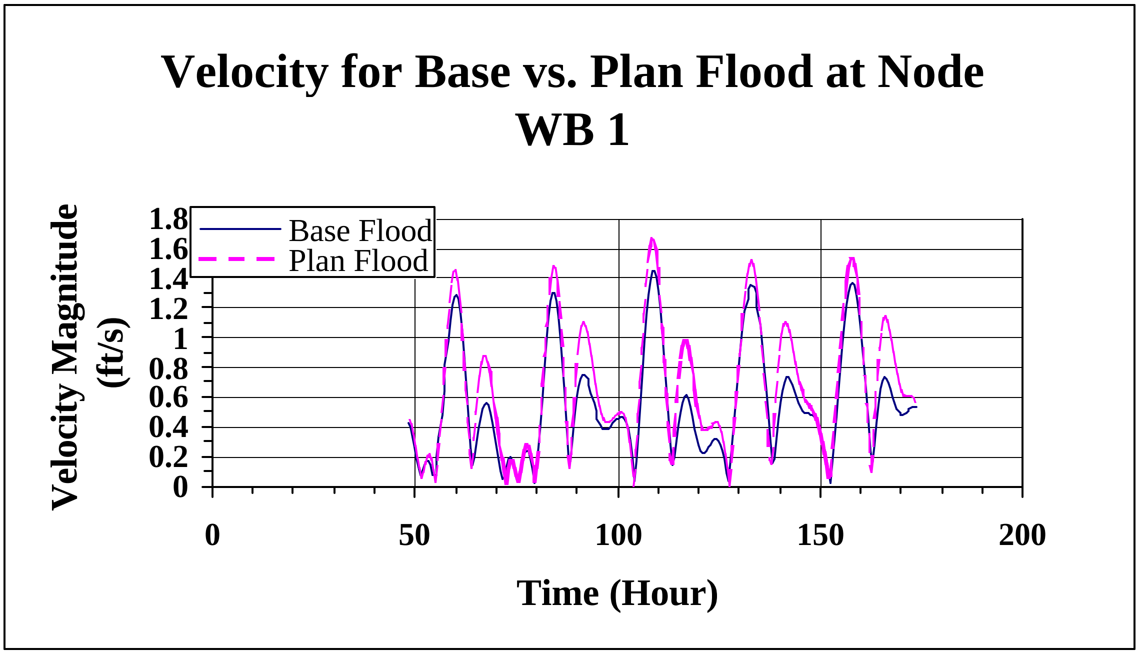
Sabine Lake Bed Sample S9
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)
Top
Bottom

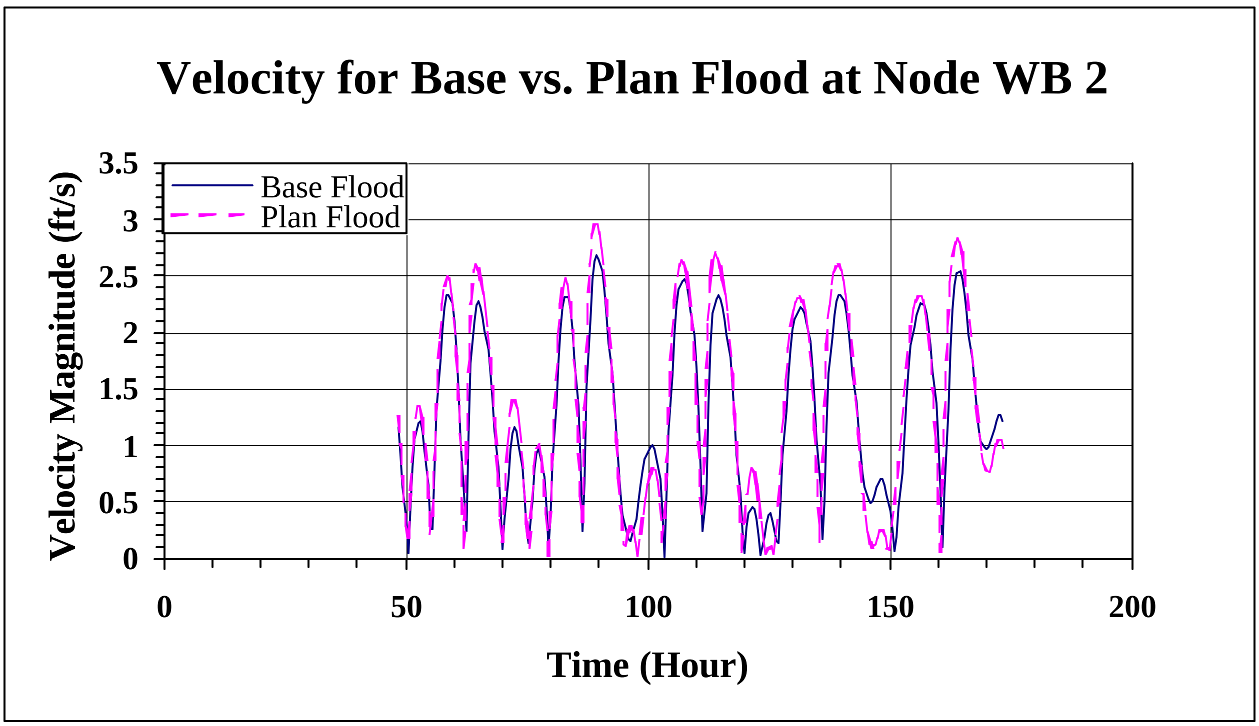



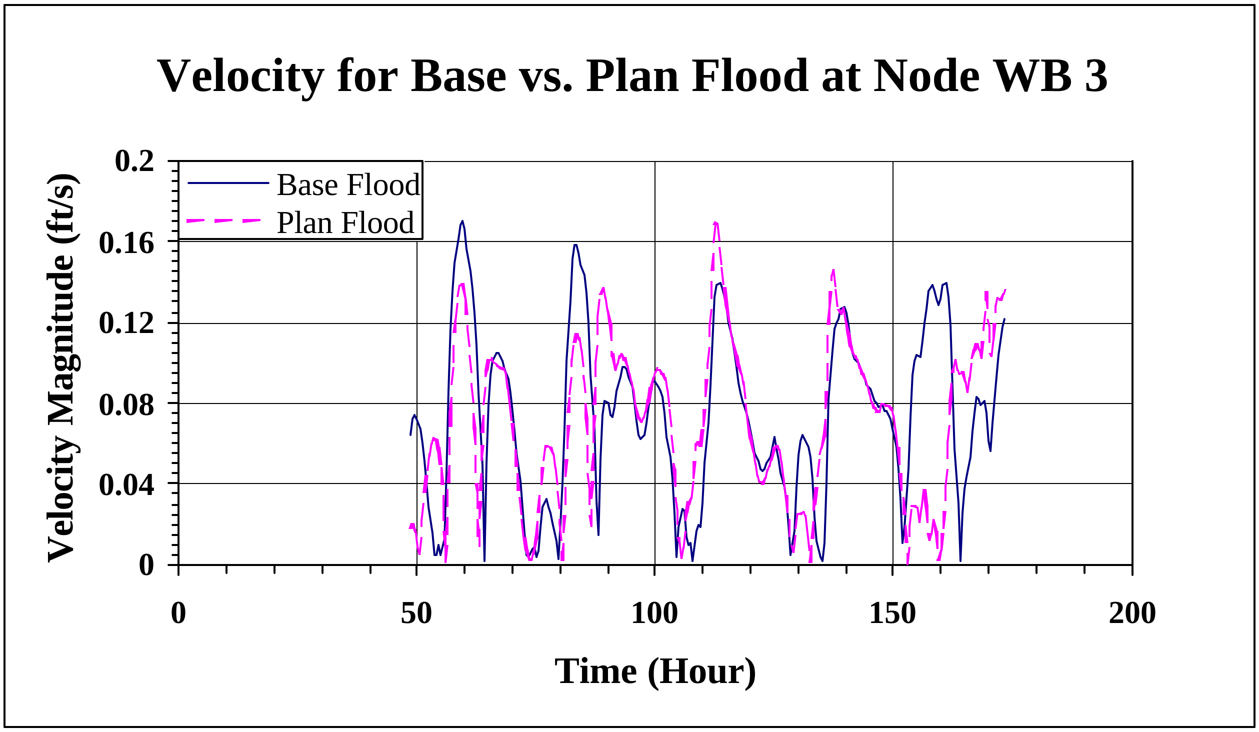
Sabine Lake Bed Sample S10
% Finer by Weight
100
80
60
40
20
0
0.01
0.1
1
10
Particle Size (mm)
Top
Bottom

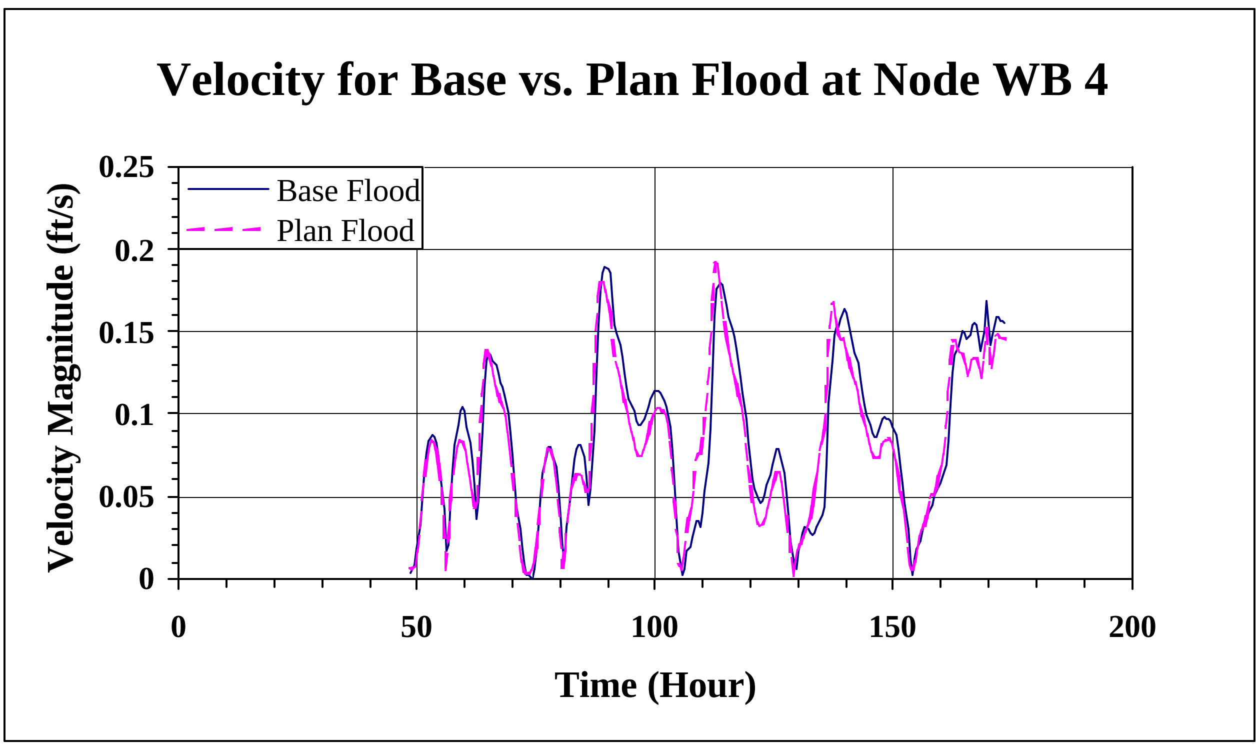
# Appendix K

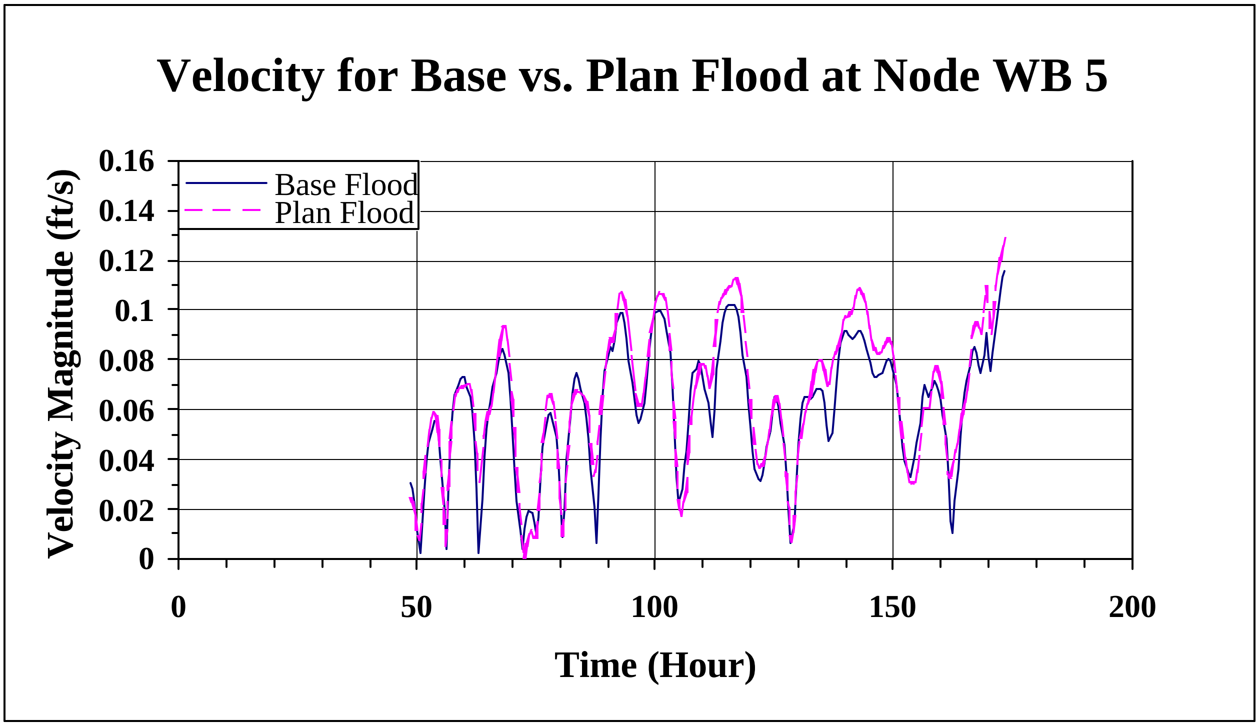
## Superposed Velocity Plots for Base and Plan for Flood at Willow Bayou Locations

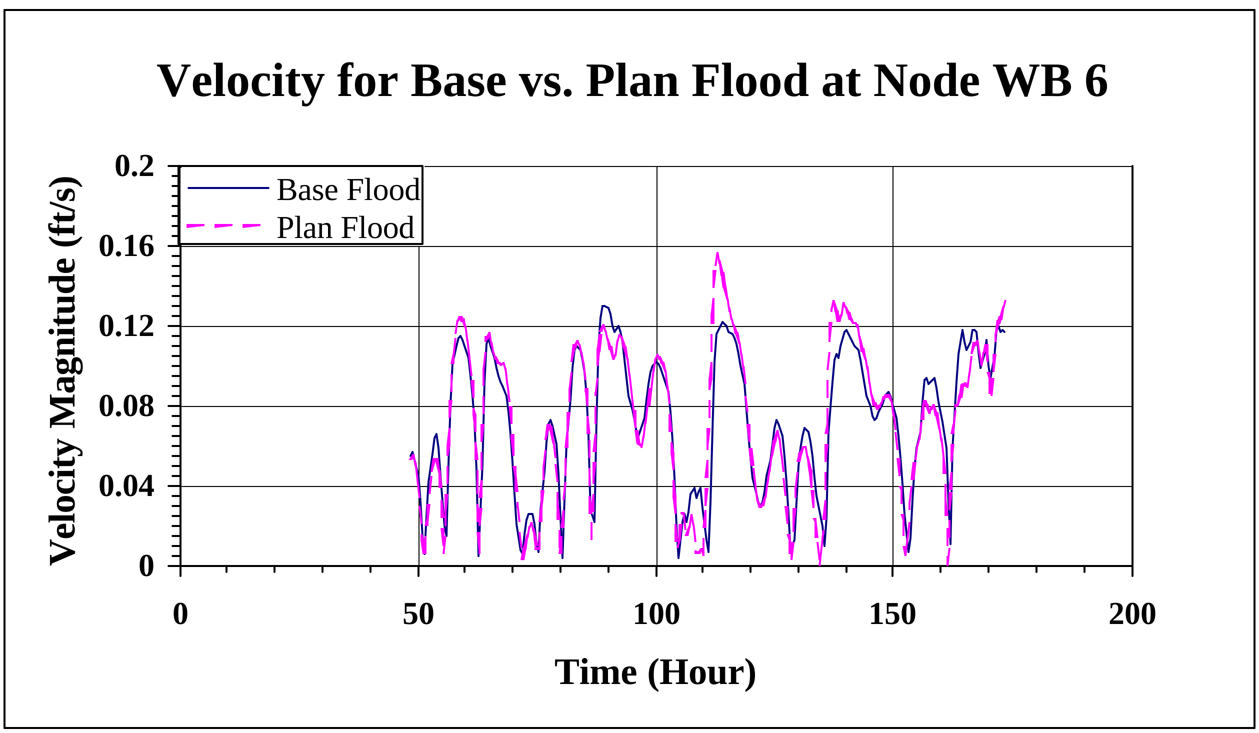

Velocity for Base vs. Plan Flood at Node WB 1
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Time (Hour)

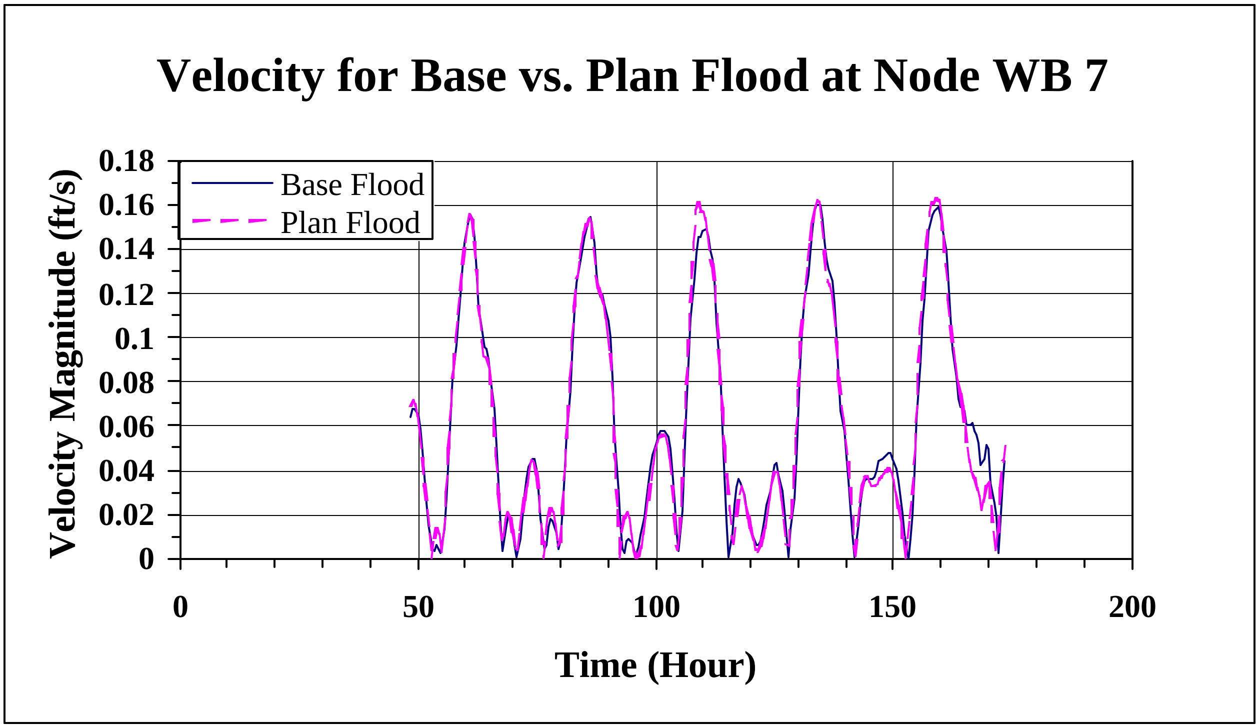

Velocity for Base vs. Plan Flood at Node WB 2
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node WB 3
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.2
0.16
0.12
0.08
0.04
0
0
50
100
150
200
Time (Hour)

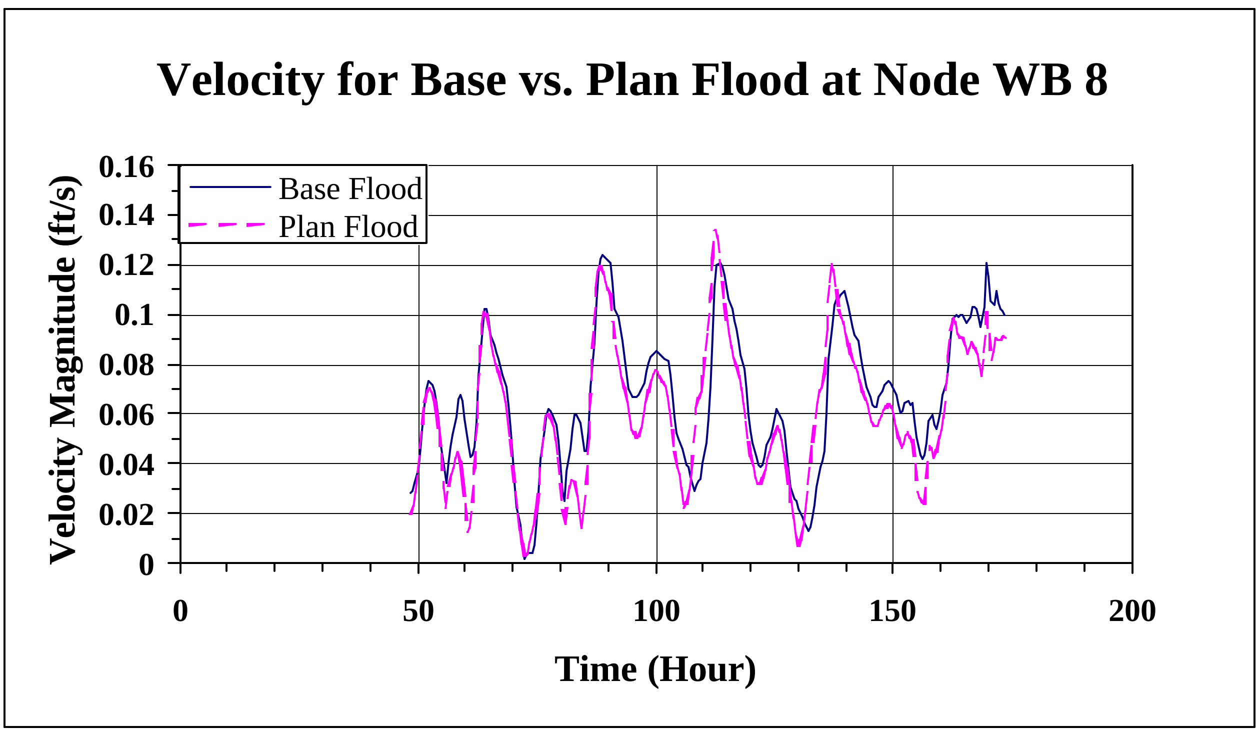

Velocity for Base vs. Plan Flood at Node WB 4
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node WB 5
Velocity Magnitude (ft/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

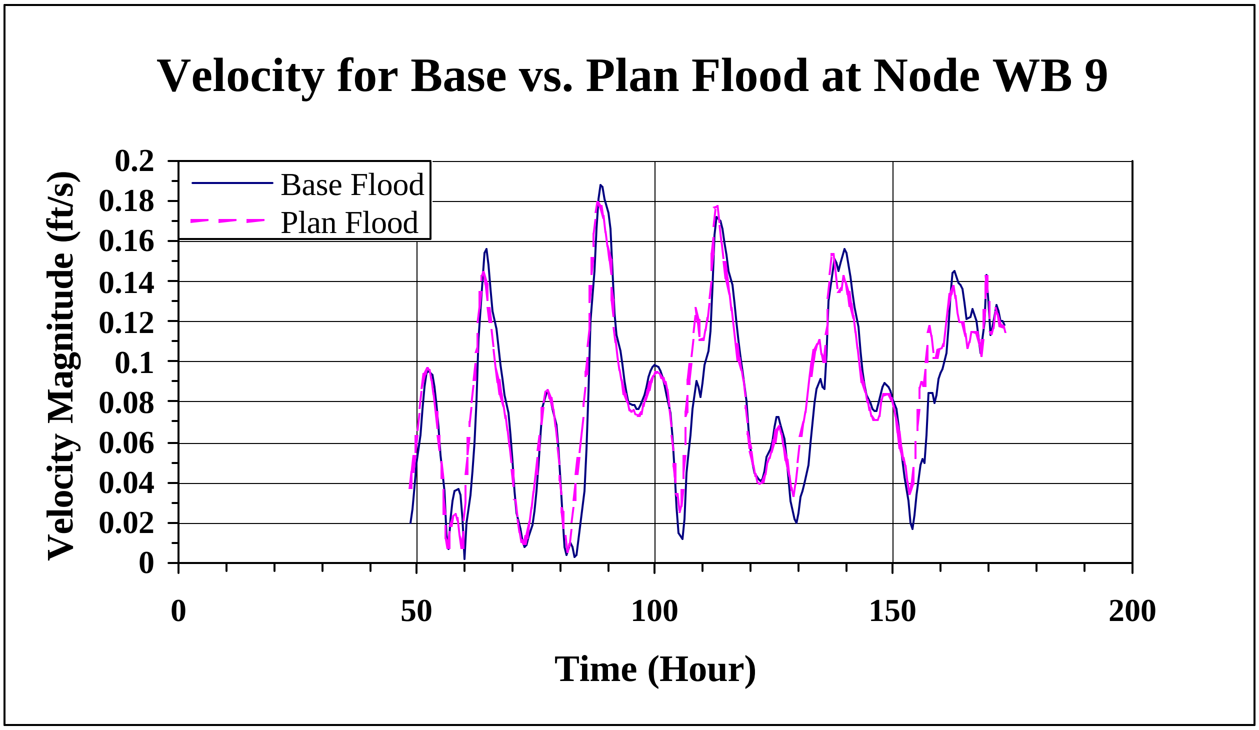

Velocity for Base vs. Plan Flood at Node WB 6
Velocity Magnitude (ft/s)
0.2
0.16
0.12
0.08
0.04
0
Base Flood
Plan Flood
0
50
100
150
200
Time (Hour)

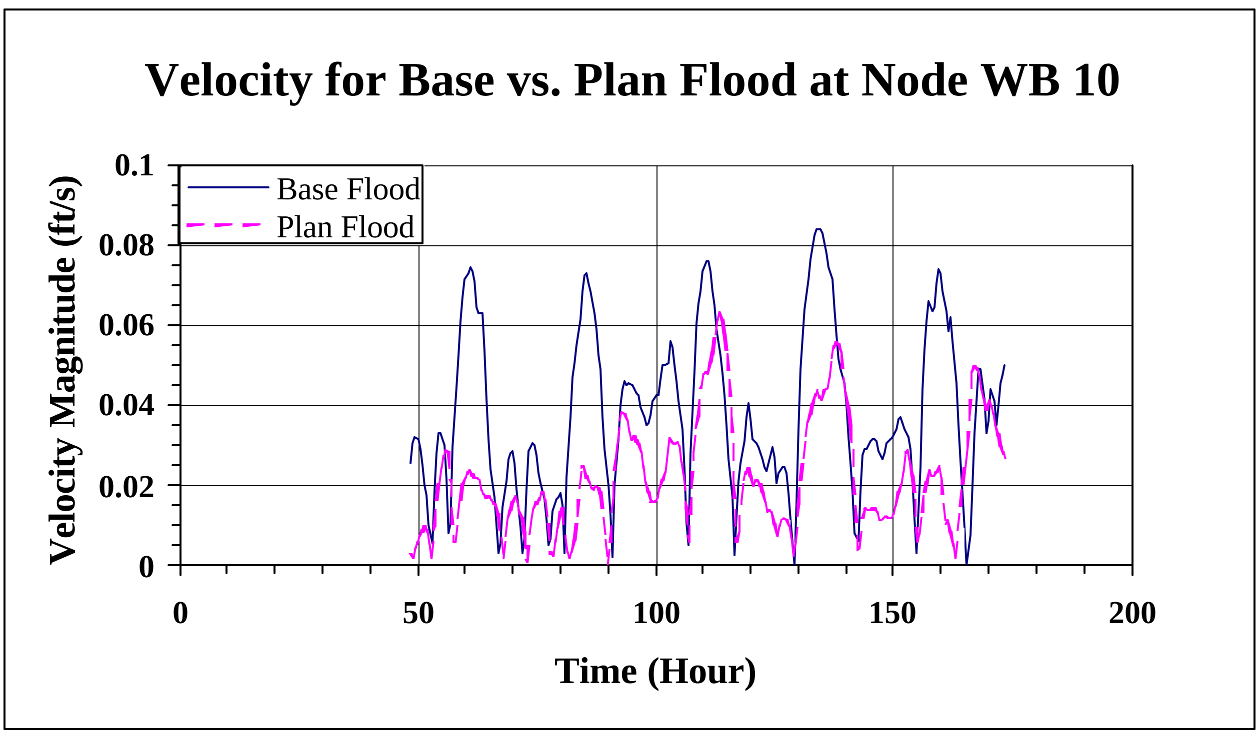


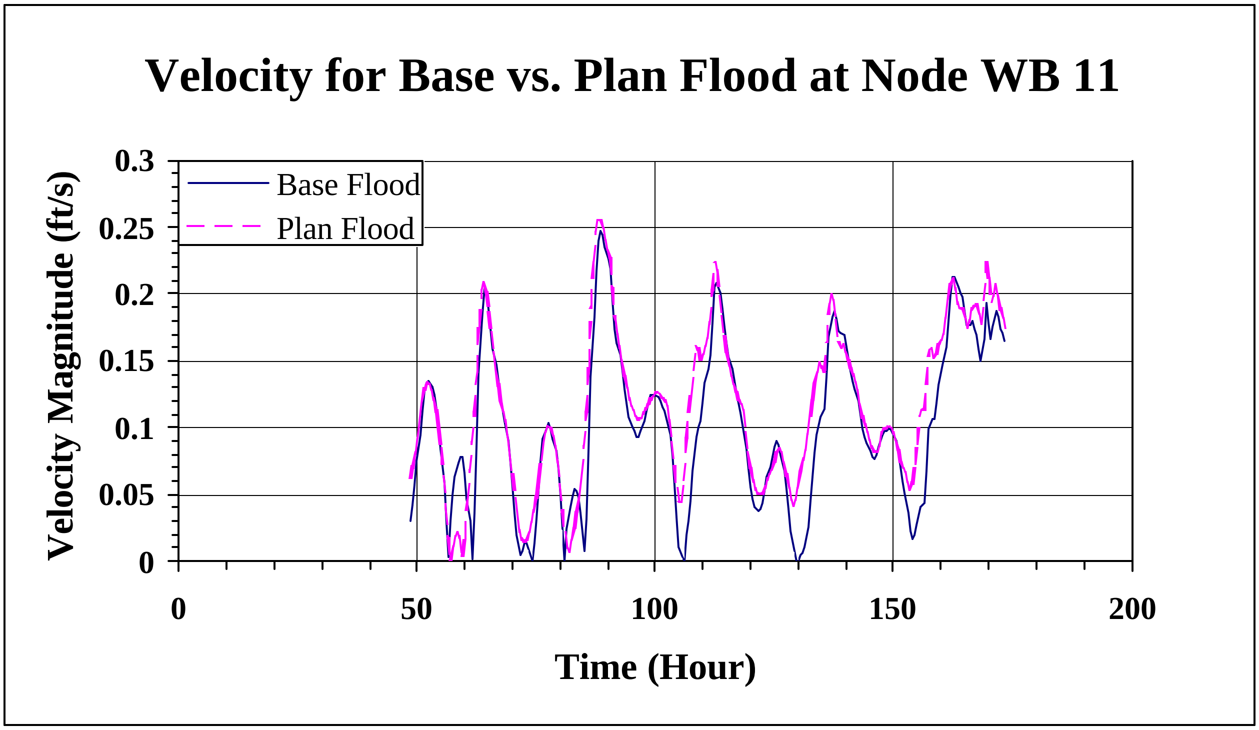
Velocity for Base vs. Plan Flood at Node WB 7
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)

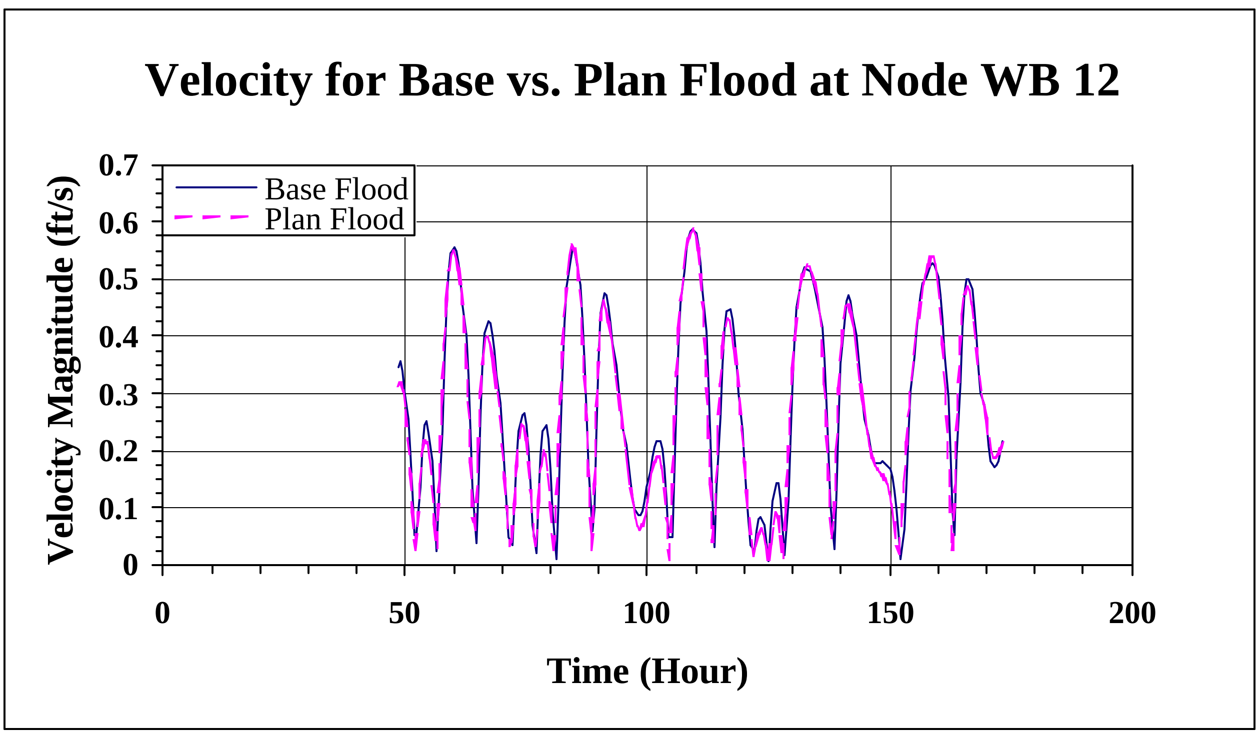



Velocity for Base vs. Plan Flood at Node WB 8
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Flood at Node WB 9
Velocity Magnitude (ft/s)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

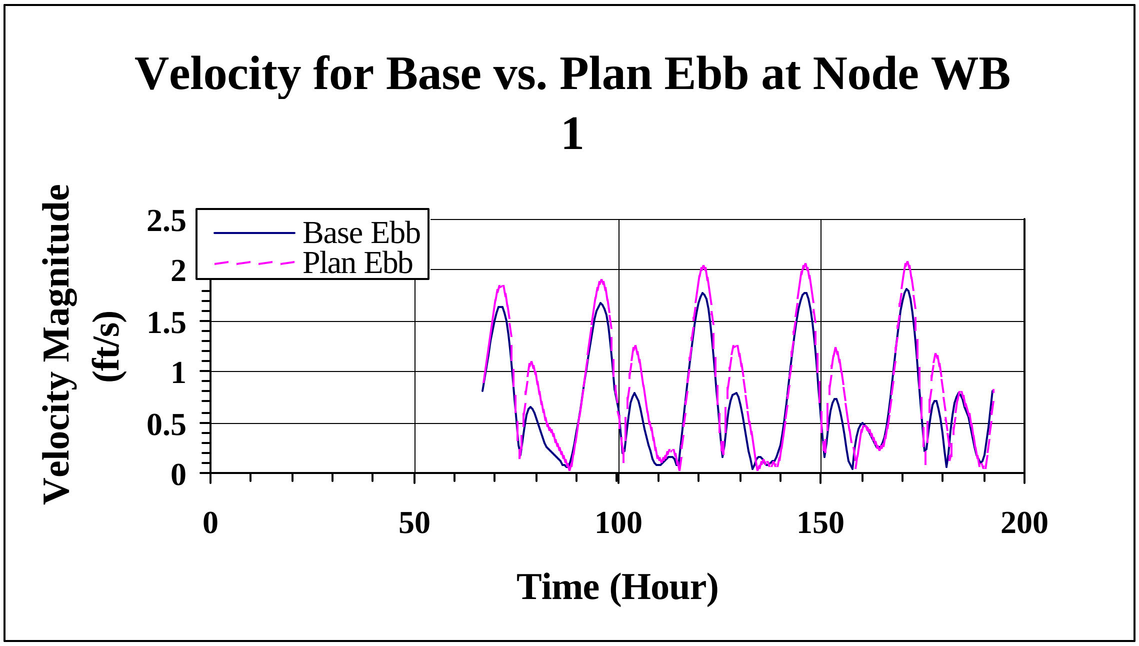

Velocity for Base vs. Plan Flood at Node WB 10
Velocity Magnitude (ft/s)
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)
Base Flood
Plan Flood

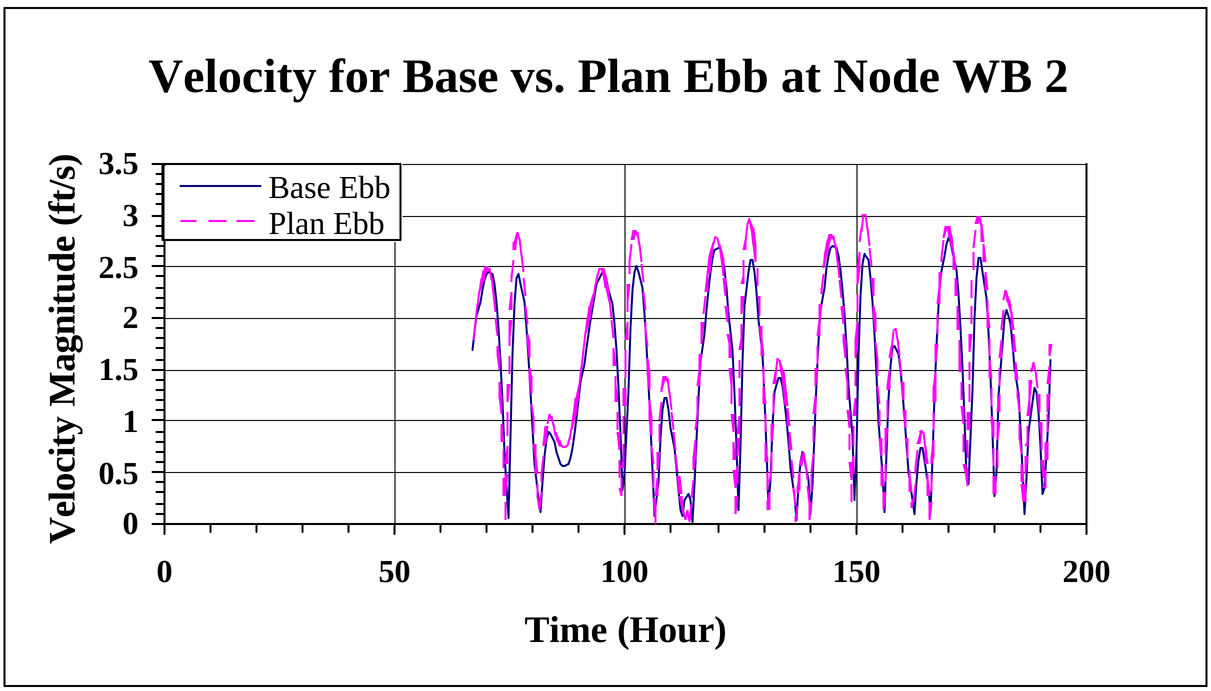

Velocity for Base vs. Plan Flood at Node WB 11
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
Time (Hour)

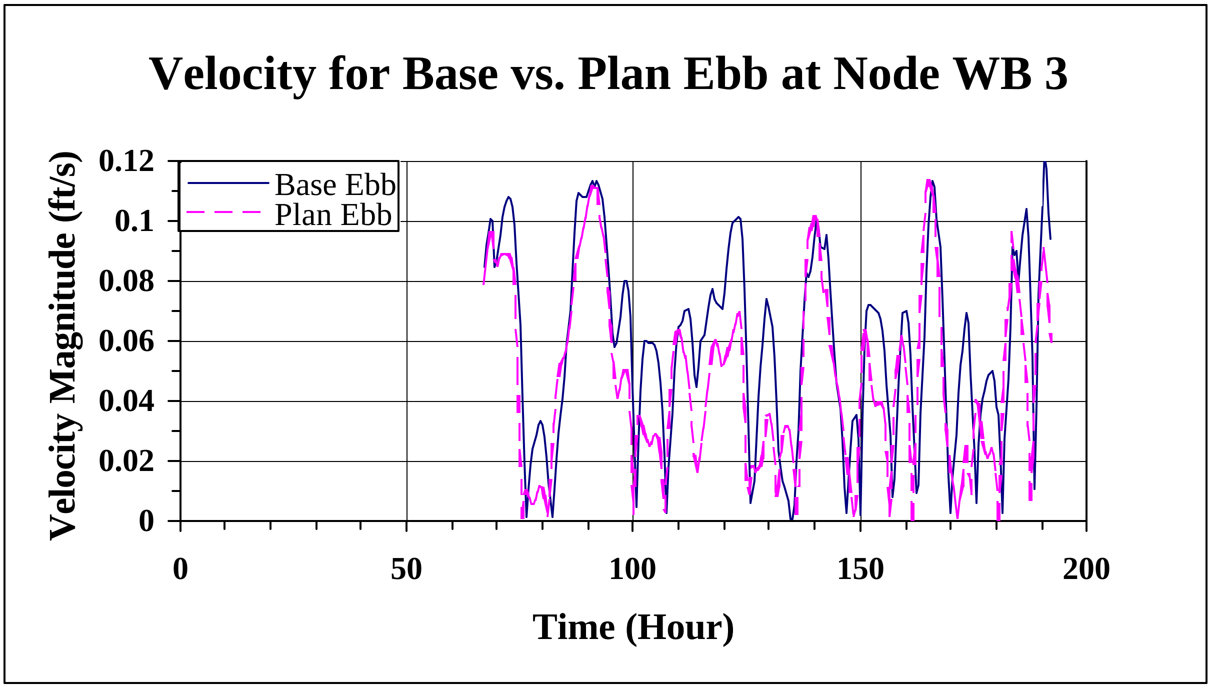

Velocity for Base vs. Plan Flood at Node WB 12
Base Flood
Plan Flood
Velocity Magnitude (ft/s)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
Time (Hour)

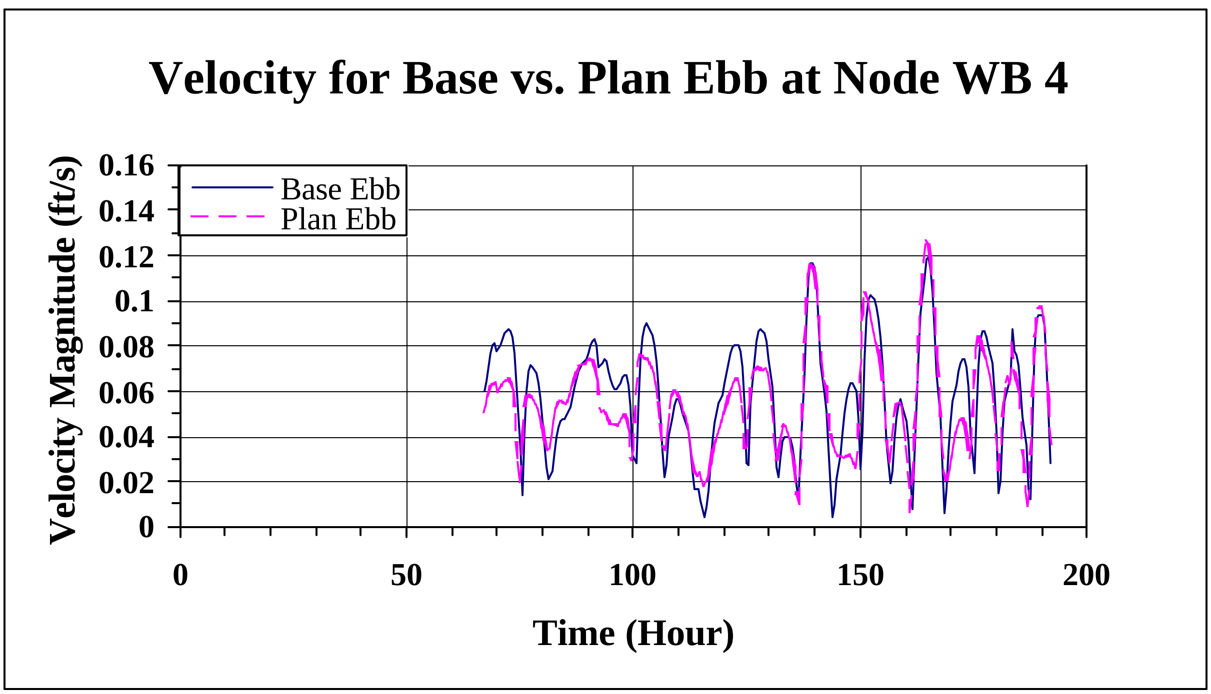
# Appendix L

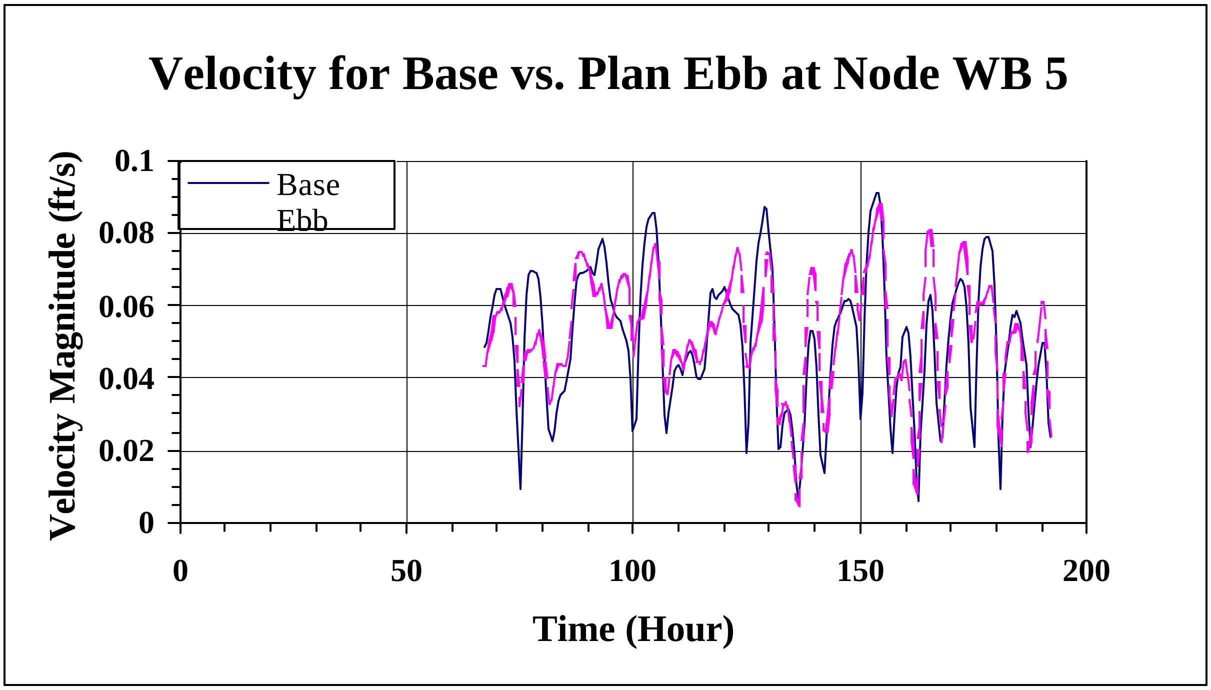
## Superposed Velocity Plots for Base and Plan for Ebb at Willow Bayou Locations

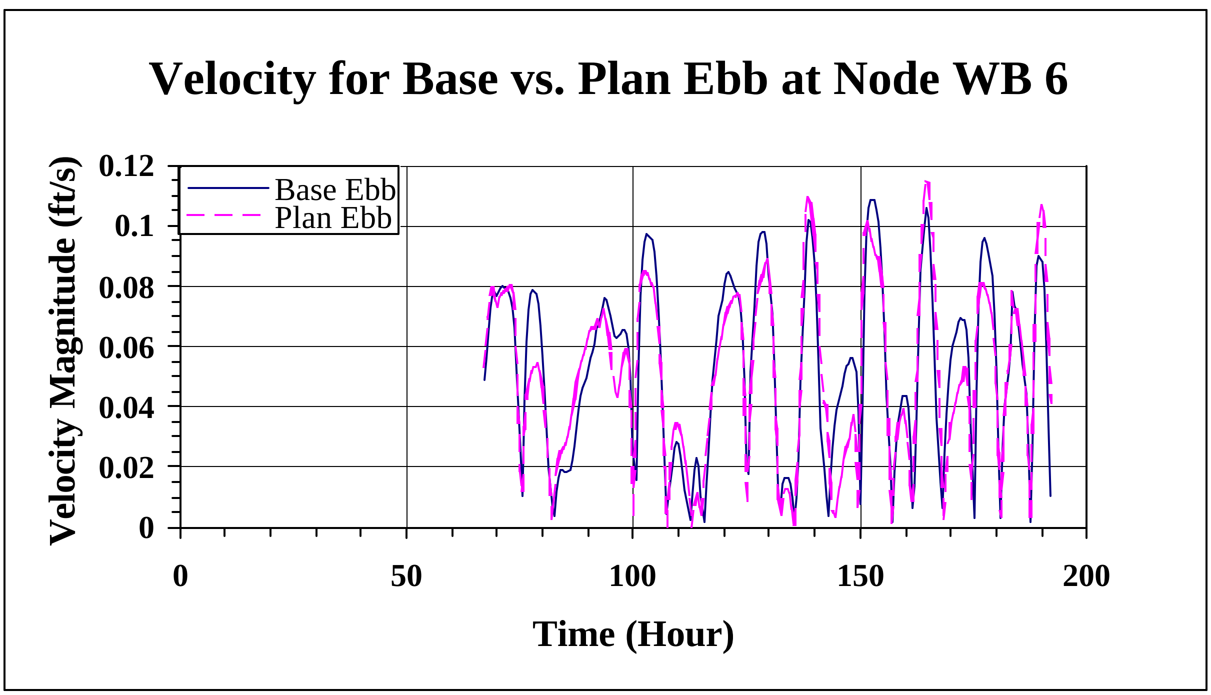

Velocity for Base vs. Plan Ebb at Node WB 1
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
0
50
100
150
200

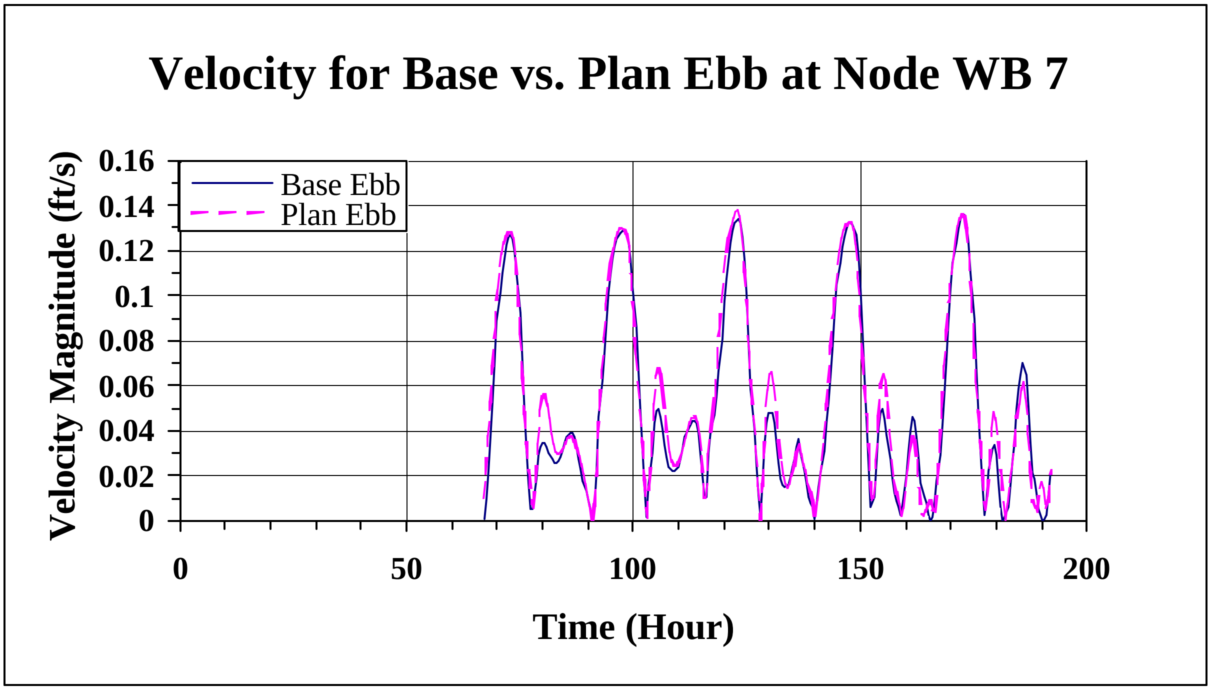

Velocity for Base vs. Plan Ebb at Node WB 2
Velocity Magnitude (ft/s)
Time (Hour)
Base Ebb
Plan Ebb
0
0.5
1
1.5
2
2.5
3
3.5
0
50
100
150
200

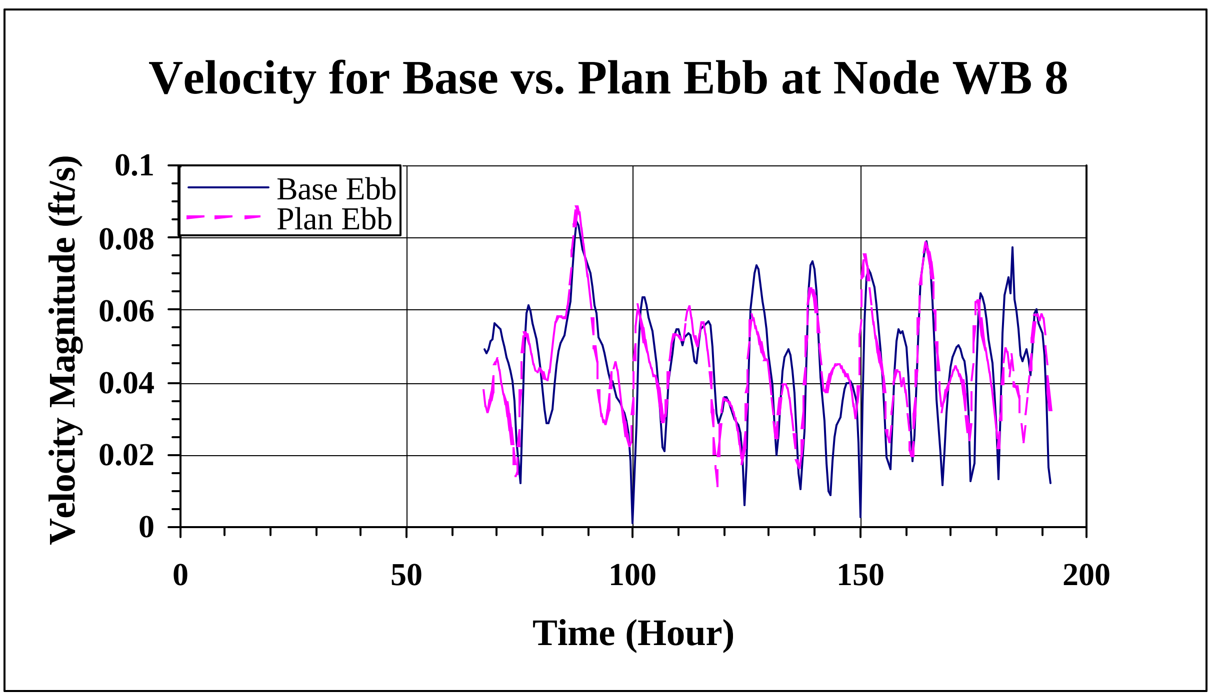

Velocity for Base vs. Plan Ebb at Node WB 3
Velocity Magnitude (ft/s)
0.12
0.1
0.08
0.06
0.04
0.02
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)

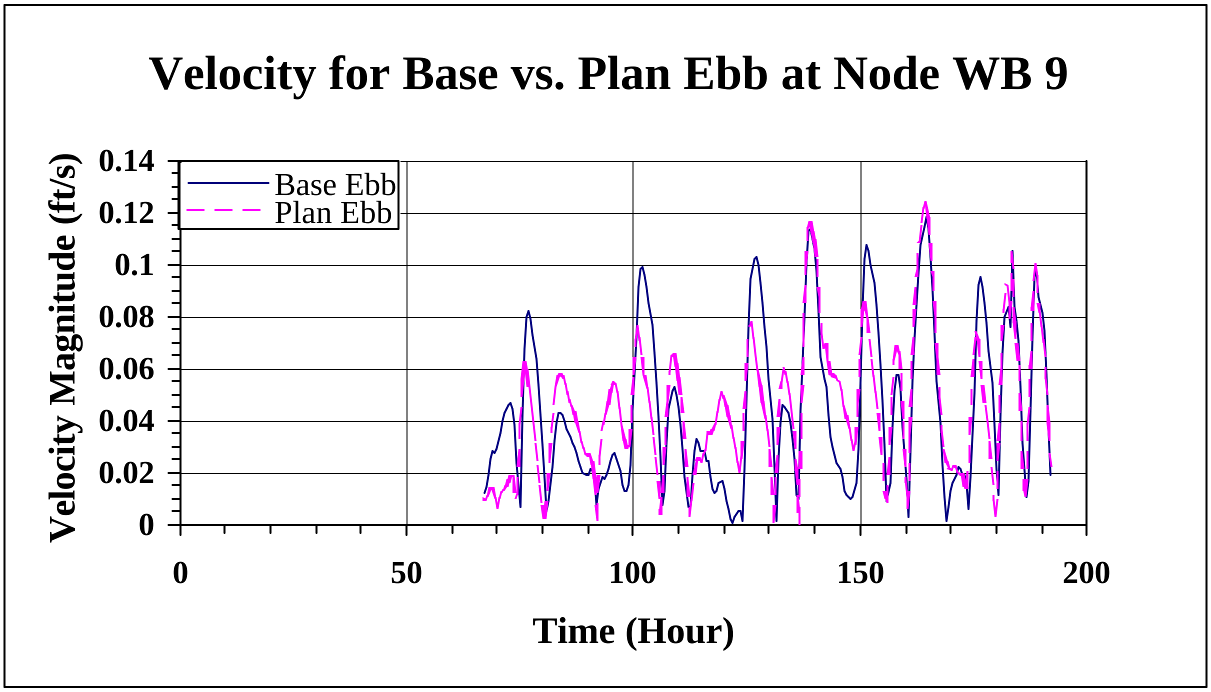

Velocity for Base vs. Plan Ebb at Node WB 4
Velocity Magnitude (ft/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)

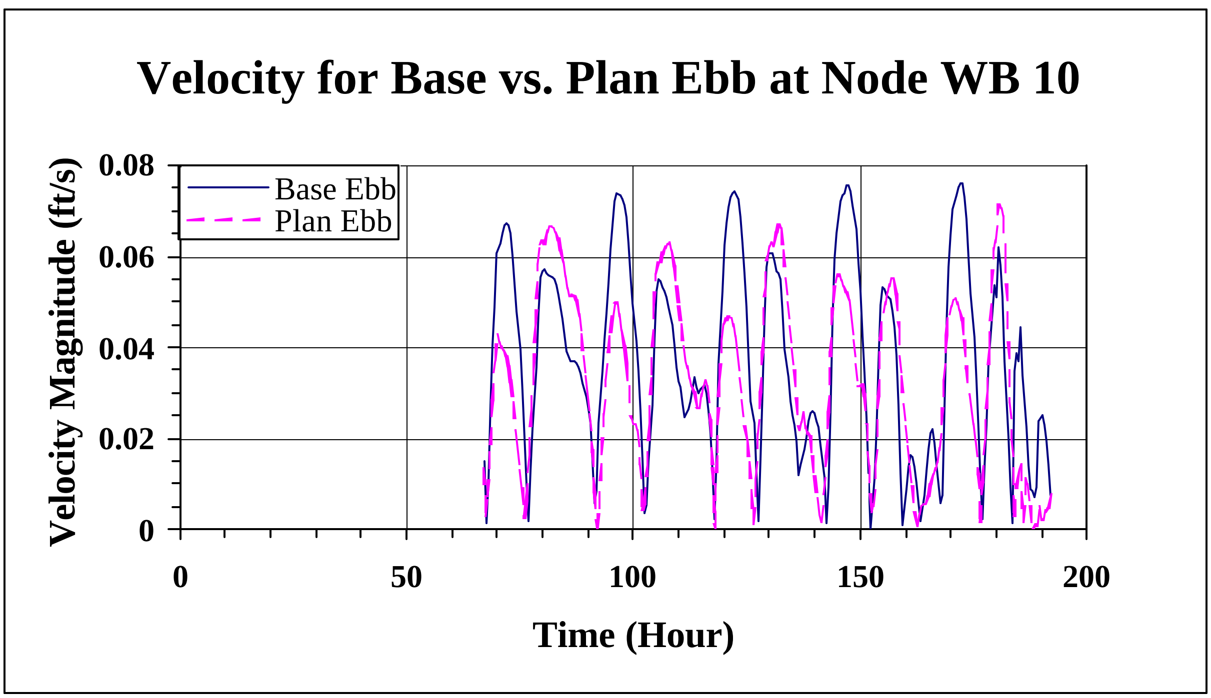

Velocity for Base vs. Plan Ebb at Node WB 5
Velocity Magnitude (ft/s)
0.1
0.08
0.06
0.04
0.02
0
Base
Ebb
0
50
100
150
200
Time (Hour)

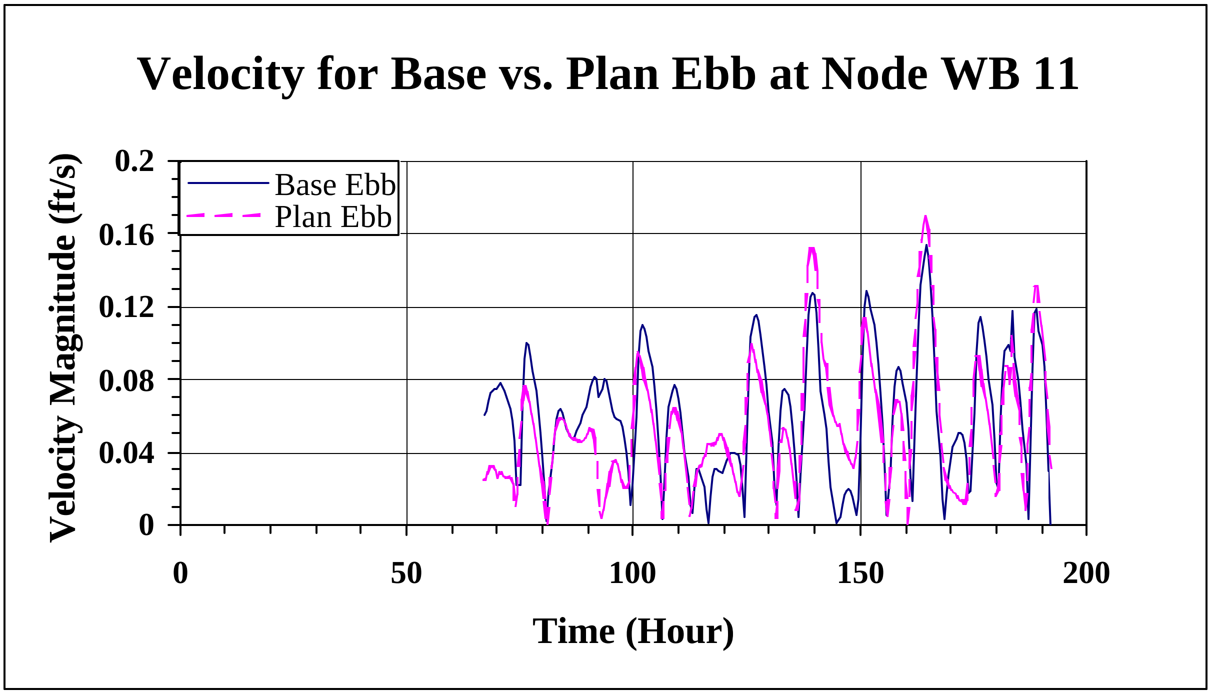

Velocity for Base vs. Plan Ebb at Node WB 6
Velocity Magnitude (ft/s)
0.12
0.1
0.08
0.06
0.04
0.02
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)

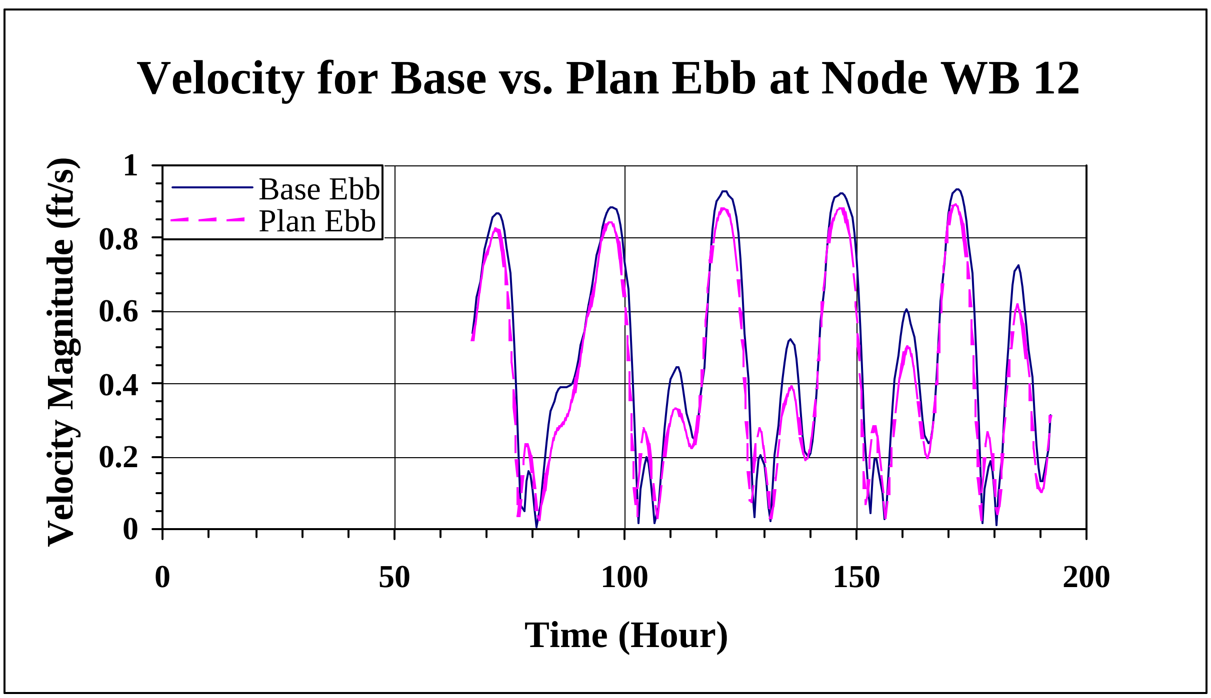

Velocity for Base vs. Plan Ebb at Node WB 7
Velocity Magnitude (ft/s)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node WB 8
Velocity Magnitude (ft/s)
0.1
0.08
0.06
0.04
0.02
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node WB 9
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node WB 10
Base Ebb
Plan Ebb
Velocity Magnitude (ft/s)
0.08
0.06
0.04
0.02
0
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node WB 11
Velocity Magnitude (ft/s)
0.2
0.16
0.12
0.08
0.04
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)


Velocity for Base vs. Plan Ebb at Node WB 12
Velocity Magnitude (ft/s)
1
0.8
0.6
0.4
0.2
0
Base Ebb
Plan Ebb
0
50
100
150
200
Time (Hour)