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Sediment Erosion and Transport at the Rio Grande Mouth

Report for the National Border Technology Program and International Boundary and Water Commission

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Abstract

The mouth of the Rio Grande has become silted up, obstructing its flow into the Gulf of Mexico. This is problematic in that it has created extensive flooding. The purpose of this study was to determine the erosion and transport potential of the sediments obstructing the flow of the Rio Grande by employing a unique Mobile High Shear Stress flume developed by Sandia's Carlsbad Programs Group for the US Army Corps of Engineers. The flume measures in-situ sediment erosion properties at shear stresses ranging form normal flow to flood conditions for a variable depth sediment core. The flume is in a self-contained trailer that can be placed on site in the field. Erosion rates and sediment grain size distributions were determined from sediment samples collected in and around the obstruction and were subsequently used to characterize the erosion potential of the sediments under investigation.

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CONTENTS

FIGURES

1.0 Introduction

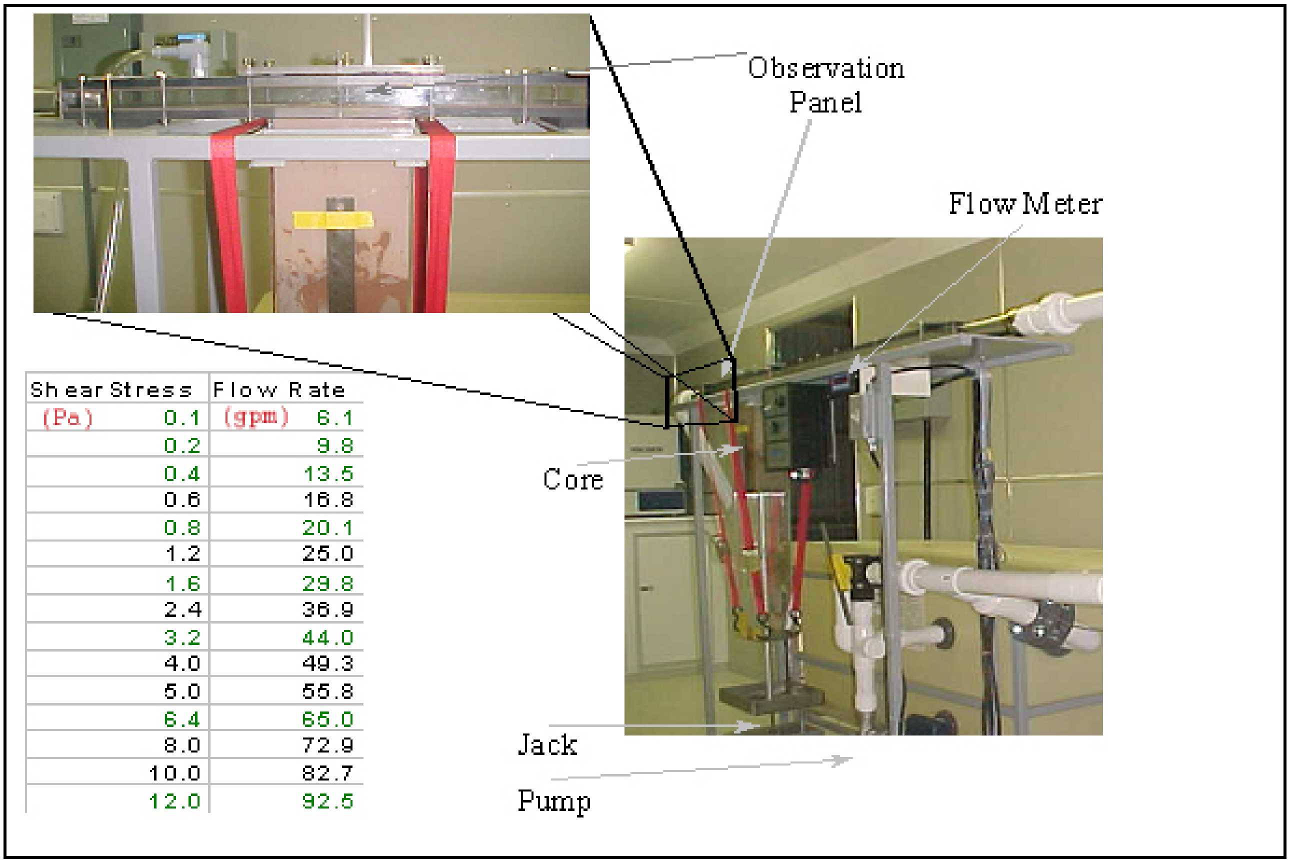
Sandia deployed a field measurement technology that enables the determination of erosion and transport potential of sediments. The study focused on the mouth of the Rio Grande where it enters the Gulf of Mexico. The mouth of the Rio Grande has become silted up, obstructing its flow into the Gulf of Mexico. This is problematic in that it has created extensive flooding on both the US and Mexican soil. The purpose of this study was to determine the erosion and transport potential of the sediments obstructing the flow of the Rio Grande by employing a unique Mobile High Shear Stress flume developed by Sandia's Carlsbad Programs Group for the US Army Corps of Engineers (USACE). The flume is also employed extensively in collaborative efforts on near shore and fluvial systems throughout the United States.

The technology deployed was the Mobile High Shear Stress Flume. This device measures in-situ sediment erosion properties at shear stresses ranging from normal flow to flood conditions for a variable depth sediment core. It is housed in a self-sufficient trailer that can be placed on site in the field. Sediment samples were collected and erosion rates and sediment grain size distributions were determined. The data derived from these tests will be used to characterize the erosion potential of the sediments analyzed, after which time concerns including: 1) water quality, use, management and conservation, 2) contaminant and sediment transport, 3) sand turbidity and intrachannel accumulation rates, 4) agricultural stress analyses, and 6) aquatic habitat evolution can be more accurately assessed.

2.0 Experimental Procedures

2.1. Description of the Mobile High Shear Stress Flume

The High Shear Stress Sediment Erosion Flume (Figure 2.1) is essentially a straight flume, which has a test section with an open bottom through which a rectangular, or circular cross-section coring tube containing sediment can be inserted. The main components of the flume are: 1) the coring tube, 2) the test section, 3) an inlet section for uniform, fully developed, turbulent flow, 4) a flow exit section, 5) a water storage tank, and 6) a pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic or polycarbonate so that the sediment-water interactions can be observed. The coring tube can be either rectangular with a 10 by 15 cm cross-section, or circular with a 10 cm diameter. The length can be up to 1 m. The table in Figure 2.1 correlates the associated shear (measured in Pa) along the smooth, channel bed for each applied flow rate (measured in gallons per minute) within the enclosed channel.



Shear Stress (Pa)	Flow Rate (gpm)
0.1	6.1
0.2	9.8
0.4	13.5
0.6	16.8
0.8	20.1
1.2	25.0
1.6	29.8
2.4	36.9
3.2	44.0
4.0	49.3
5.0	55.8
6.4	65.0
8.0	72.9
10.0	82.7
12.0	92.5

Figure 2.1. Mobile High Shear Stress Flume Illustration

The flume is housed in a 16 ft mobile trailer (Figure 2.2) so it can be easily moved to each site of interest. The trailer is self-contained with a 7 kW gas generator for electric power and pumps for water intake from external sources.

Figure 2.2. Mobile Flume

Water is pumped through the system from a 100-gallon storage tank, through a 5 cm diameter pipe, and then through a flow converter into the rectangular duct shown. This duct is 4.1 cm in height, 10 cm in width, and 130 cm in length, and connects to the test section, which has the same cross-sectional area and is 15 cm long (see Figure 2.1, observation panel). The flow converter changes the shape of the cross-section from circular to the rectangular duct. A three-way valve regulates the flow so that part of the flow goes into the duct while the remainder returns to the tank. Also, there is a small valve in the duct immediately downstream from the test section, which is opened at higher flow rates to keep the pressure in the duct and over the test section at atmospheric conditions.

Cores can either be taken in-situ from the field or reconstructed in the laboratory. The procedure for preparing the reconstructed sediments in the laboratory will be described later. The coring tube and the sediment it contains are then inserted into the bottom of the test section. An operator moves the sediment upward using a piston, which is inside the coring tube and is connected to a mechanical jack and then driven by a variable-speed controller. By this means, the sediments can be raised and made level with the bottom of the test section by a trained operator. The speed of the jack movement can be controlled at a variable rate in measurable increments as small as 0.25 mm.

Water is forced through the duct and the test section over the surface of the sediments. The shear produced by this flow causes the sediments to erode. The operator continually moves sediments within the core upwards into the channel so that the sediment-water interface remains level with the bottom of the test and inlet sections. The erosion rate is recorded as the upward movement of the sediments in the coring tube over time.

2.2. Hydrodynamics

For the flow rates of interest, it can be shown that fully developed turbulent flow exists in the test section. Turbulent flow through pipes has been studied extensively, and empirical functions have been developed which relate the mean flow rate to the wall shear stress. In general, flow in circular cross-section pipes has been investigated. However, the relations developed for flow through circular pipes can be extended to non-circular cross-sections by means of a shape factor. An implicit formula relating the wall shear stress to the mean flow in a pipe of arbitrary cross-section can be obtained from Prandtl's Universal Law of Friction (Schlichting, 1979). For a pipe with a smooth surface, this formula is:

$$\frac{1}{\sqrt{\lambda}} = 2.0\log\left[\frac{UD\sqrt{\lambda}}{\nu}\right] - 0.8 \qquad (2.1)$$

where U is the mean flow speed, ν is the kinematic viscosity, λ is the friction factor, and D is the hydraulic diameter defined as the ratio of four times the cross-sectional area to the wetted perimeter.

For a pipe with a rectangular cross-section, or duct, the hydraulic diameter is

$$D = 2hw/(h + w) \tag{2.2}$$

where *w* is the duct width and *h* is the duct height. The friction factor is defined by

$$\lambda = \frac{8\tau}{\rho U^2} \tag{2.3}$$

where ρ is the density of water and τ is the wall shear stress. Inserting Equations (2.2) and (2.3) into Equation (2.1) then gives the wall shear stress τ as an implicit function of the mean flow speed, ***U***.

For shear stresses in the range of 0.1–10 N/m^2, the Reynolds numbers (UD/ν) are on the order of 10^4–10^5. These values are sufficient for turbulent flow to exist for the stresses of interest in this study. For flow in a circular pipe, turbulent flow theory suggests that the transition from laminar to turbulent flow occurs within 25 to 40 diameters from the entrance to the pipe. Since the hydraulic diameter of the duct pipe is 5.9 cm, this suggests an entry length of approximately 150 cm. The length of the duct leading to the test section is 130 cm and is preceded by a 20 cm flow converter and several meters of inlet pipe. These arguments along with direct observations indicate that the flow is fully turbulent in the test section.

2.3. Core Retrieval

Sediment cores were obtained in situ by applying pressure to the top of the core sleeve and penetrating this sleeve into the sediment bed (Figure 2.3). The coring sleeve is then pushed as far as possible into the sediment bed. The distance of penetration will vary due to the characteristics of the sediment (i.e., further penetration will occur in a softer sediment than in a more compact sediment). This results in a sediment core that is obtained relatively undisturbed from its natural surroundings. The coring sleeve is then brought back and a plug is slid up into the core tube to act later as a piston, and the core is then capped. Sediment cores varying in length from 10 to 30 cm were obtained using this method.

Figure 2.3. Sediment Sampling Examples

2.4. Measurements of Sediment Erosion Rates

The procedure for measuring the erosion rates of the sediments in circular cores (Roberts and Jepsen, 2001a) as a function of shear stress and depth was as follows. The sediment cores were obtained as described above and then moved upward into the test section until the sediment surface was even with the bottom of the test section. A measurement was made of the depth to the bottom of the sediment in the core. The flume was then run at a specific flow rate corresponding to a particular shear stress. Erosion rates were obtained by measuring the remaining core length at different time intervals, taking the difference between successive measurements, and dividing by the time interval.

In order to measure erosion rates at multiple shear stresses using only one core, the following procedure was generally used. Starting at a low shear stress, the flume was run sequentially at higher shear stresses (each succeeding shear stress was twice the previous one). Generally, approximately three shear stresses were run sequentially. Each shear stress was employed until at least 1 to 3 mm, but no more than 2 cm was eroded. Also, each shear stress was run for a minimum of 20 seconds and a maximum of 10 minutes. Thus, the minimum and maximum erosion rates measured by the high shear stress sediment erosion flume are 1.67×10^{-4} and 0.1 $cm \cdot s^{-1}$ respectively. The time interval was recorded for each run with a stopwatch. The flow was then increased to the next shear stress, and so on until the highest shear stress run was complete. This cycle was repeated until all of the sediment within the core was eroded. If after three cycles a particular shear stress showed a rate of erosion less than approximately 1.7×10^{-4} $cm \cdot s^{-1}$, it was dropped from the cycle; if after many cycles the erosion rates decreased significantly, a higher shear stress was included in the cycle.

2.5. Measurements of Critical Shear Stress for Erosion

As the rate of flow of water over a sediment bed is increased, there is a range of velocities (or shear stresses) at which the movement of the smallest and easiest-to-move particles is first noticeable to an observer. These eroded particles then travel a relatively short distance until they come to rest in a new location. This initial motion tends to occur only at a few isolated spots. As the flow velocity and shear stress increase further, more particles participate in this process of erosion, transport, and deposition, and the movement of the particles becomes more sustained.

Because of this gradual increase in sediment erosion as the shear stress increases, it is difficult to precisely define a critical velocity or critical stress at which sediment erosion is first initiated. More quantitatively and with less ambiguity, a critical velocity or critical shear stress can be defined as the shear stress at which a small, but accurately measurable rate of erosion occurs. In the present study, this rate of erosion was chosen to be 10^{-4} cm·s^{-1}; this represents 1 mm of erosion in approximately 15 minutes. Since it would be difficult to measure all critical shear stresses at exactly 10^{-4} cm·s^{-1}, erosion rates were generally measured above and below 10^{-4} cm·s^{-1} at shear stresses that differ by a factor of two. The critical shear stress can be obtained by interpolation between the two points. This gives results with 20% accuracy for the critical shear stress.

Some of the samples could not be eroded at rates greater than 10^{-4} cm/s within the range of shear stresses possible. For these samples, the test was run at a particular shear stress for several hours in order to obtain a measurable amount of erosion.

2.6. Measurements of Sediment Bulk Properties

Particle sizes and particle size distributions were determined by use of a Malvern Mastersizer-S particle sizing package for sample diameters between 0.05 and 900 µm. Sieve analysis was performed for particle sizes larger than 900 µm. When using the Malvern particle sizer, approximately 5 to 10 grams of sediment is placed in a beaker containing about 500 mL of water and mixed by means of a magnetic stir bar/plate combination**.** Approximately 1 mL of this solution was then inserted into the sizer's sampling system and further disaggregated as it was recirculated through the sampling system by means of a centrifugal pump. The sample was allowed to disaggregate for five minutes on the stir plate and for an additional five minutes in the recirculating pump sampling system before analyses. To ensure complete disaggregation and sample uniformity, the sediment samples were analyzed multiple times and repeated in triplicate. From these measurements, the distribution of grain sizes and mean grain sizes as a function of depth were determined.

2.7. Core Descriptions

Core Nomenclature	Core Length (cm)	Textural Grain Size Analyses (mean)
SZN - Surf Zone North	15	260 µm sand
SZM - Surf Zone Middle	12	238 µm sand
SZS - Surf Zone South	25	233 µm sand
SZ1B - Surf Zone 1st Bar	12	248 µm sand
SZ2T - Surf Zone 2nd Trough	28	233 µm sand
RGMC - Rio Grande Mouth Crest	16	226 µm sand
RGM - Rio Grande Mouth	15	215 µm sand
RGC1- Rio Grande Channel 1	27	226 µm silt and sand
RGC2 - Rio Grande Channel 2	0-2	75 µm sand, silt, clay and organics
	2-4	28 µm silt, clay and organics
	7-9	100 µm sand, silt, clay and organics
	10-12	20 µm clay and organics

3.0 Sediment Sampling Results

The following section presents the results from erosion tests on a suite of samples extracted from the Rio Grande Delta region. The distance between **SZN** and **SZS** is approximately 300 m.

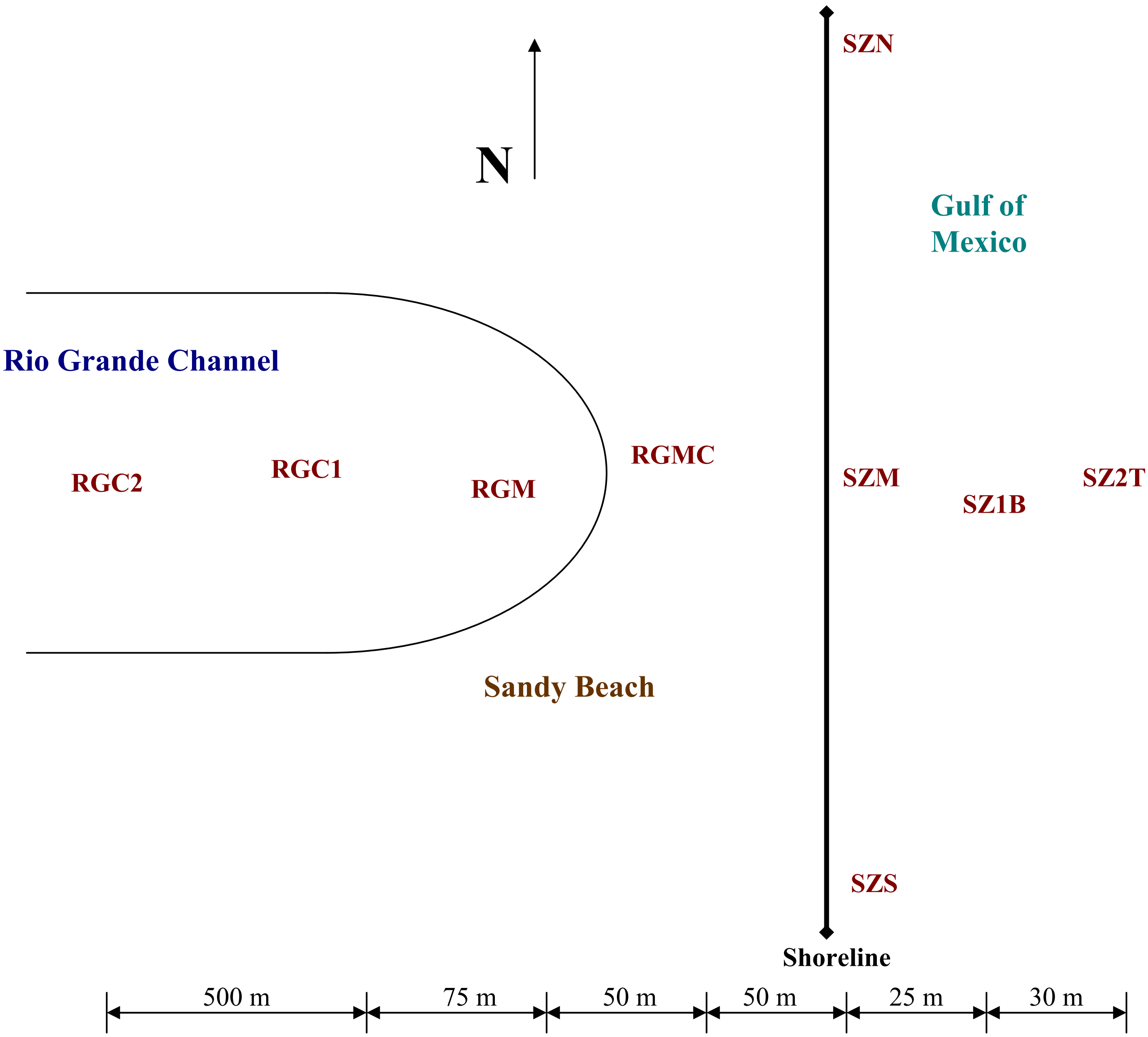


Figure 3.1.

Figure 3.1 is a generalized map showing the relative position of 9 (red) core sampling sites. The U-shaped line around the Rio Grande Channel illustrates that there was no surficial communication between the river and the Gulf of Mexico at the time of this study.

3.1. Surf Zone

3.1.1. Surf Zone North

The core obtained from the surf zone, north of the Rio Grande Mouth (SZN) was 15 cm in length. The core was observed to contain a homogeneous mixture of sand (mean grain size = 260 μm).

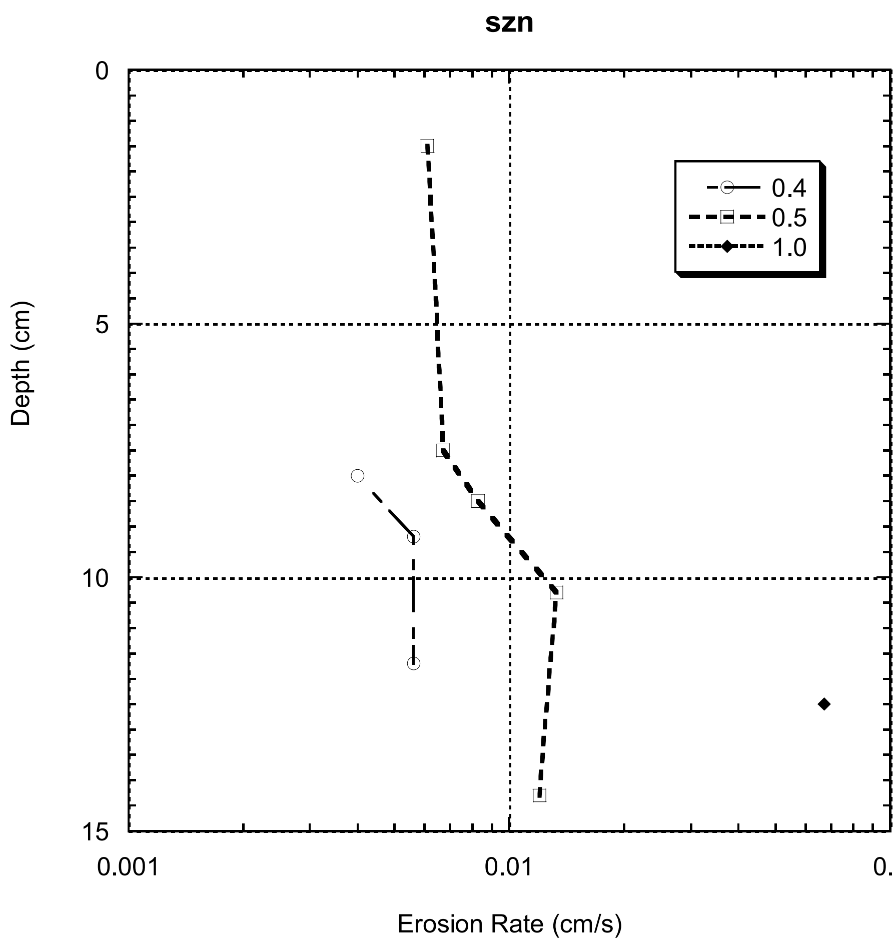


Figure 3.2.

The erosion data as a function of shear stress for sample taken for erosion testing within the SZN is shown in Figure 3.2. For each shear stress, the erosion rate generally increases with depth. The sediment was also observed to contain shells from the middle of the core to the bottom. The critical shear stress was approximately 0.3 Pa in the top half of the core sample and was not measured in the lower half. The sediment transported completely as bedload for the 0.5 Pa tests.

3.1.2. Surf Zone Middle

The core taken from the surf zone, at the mouth of the Rio Grande (SZM), for erosional (flume) testing was 12 cm long. This core was observed to contain a homogeneous mixture of sand. A different core also procured from the SZM for grain size analyses was 18 cm long. The mean grain size was measured as 238 µm, with a range at depth between 210 – 250 µm.

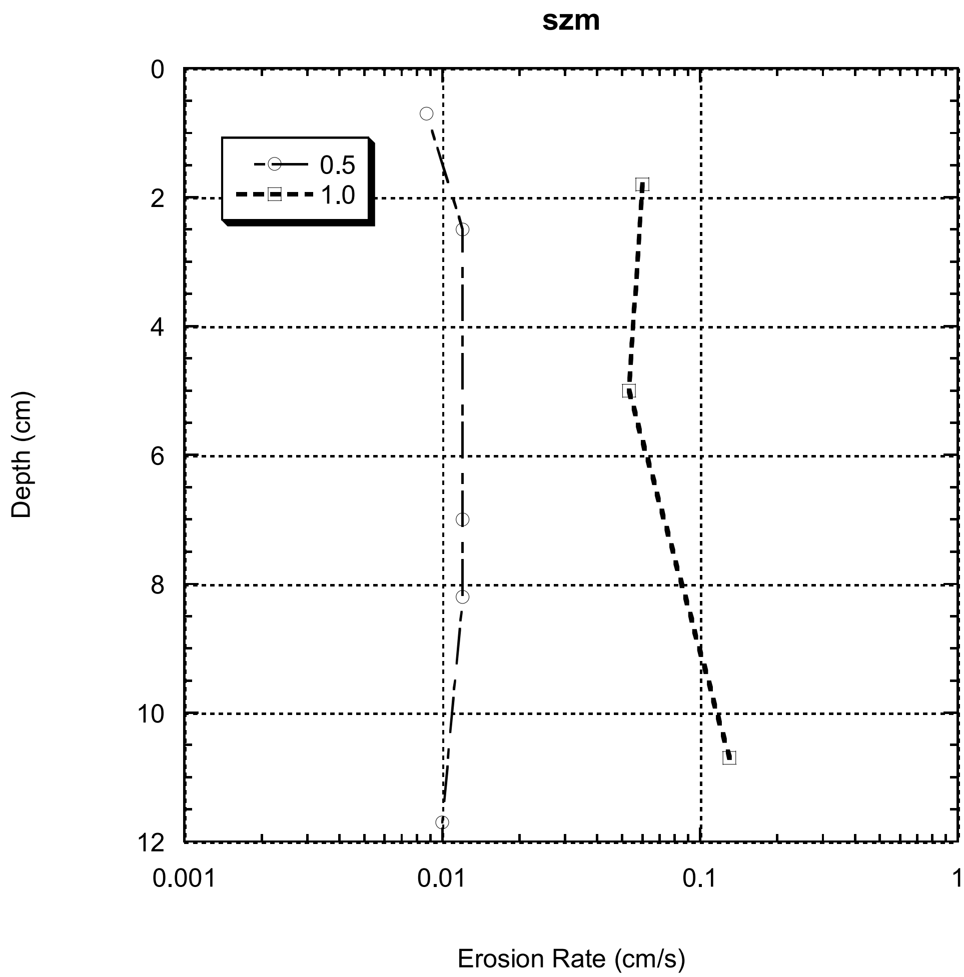


Figure 3.3.

The erosion data for SZM is shown in Figure 3.3. The erosion was nearly constant with depth with a critical shear stress of 0.3 Pa. The eroded sediment transported as 100% bedload for all 0.5 Pa tests.

3.1.3. Surf Zone South

The sample taken from the surf zone, south of the Rio Grande Mouth (SZS) was 25 cm long and was a homogeneous mixture of sand for the top 15 cm. Below 15 cm, the sand transitioned sharply to a placer sand material that was black in color. This beach placer is composed primarily of magnetite, deposited within the sand by the process of mechanically weathering mafic rocks (those containing dense or heavy minerals). The transition to this placer material, however, did not affect the observed erosion rates (Figure 3.4). The mean particle size was constant with depth (233 μm), with a range between 219 – 248 μm. The black placer material had the same mean grain size and spatial distribution as the rest of the core sample.

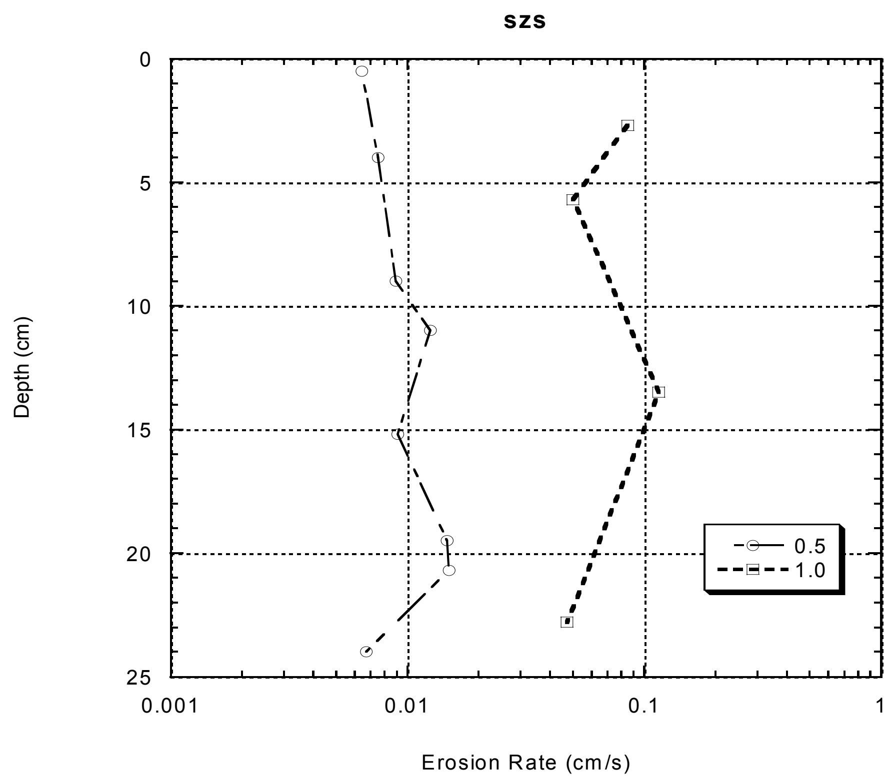


Figure 3.4.

The critical shear stress was approximately 0.3 Pa for the top 2 cm and increased to 0.35 Pa from 13 cm to the bottom of the cored sample. The eroded sediment transported as 100% bedload for all 0.5 Pa tests.

3.1.4. Surf Zone First Bar

The sample obtained from the first sand bar off shore in the surf zone (SZ1B) was 12 cm long. The erosion rate was relatively constant with depth, except for at the surface, where the erosion rate was slightly lower (Figure 3.5). The critical shear stress was 0.3 Pa for the entire core, of which 100% transported as bedload during the 0.5 Pa tests. The mean particle size for sample SZ1B was also consistent with depth, 248 μm. The grain size variation with depth was 235 – 255 μm.

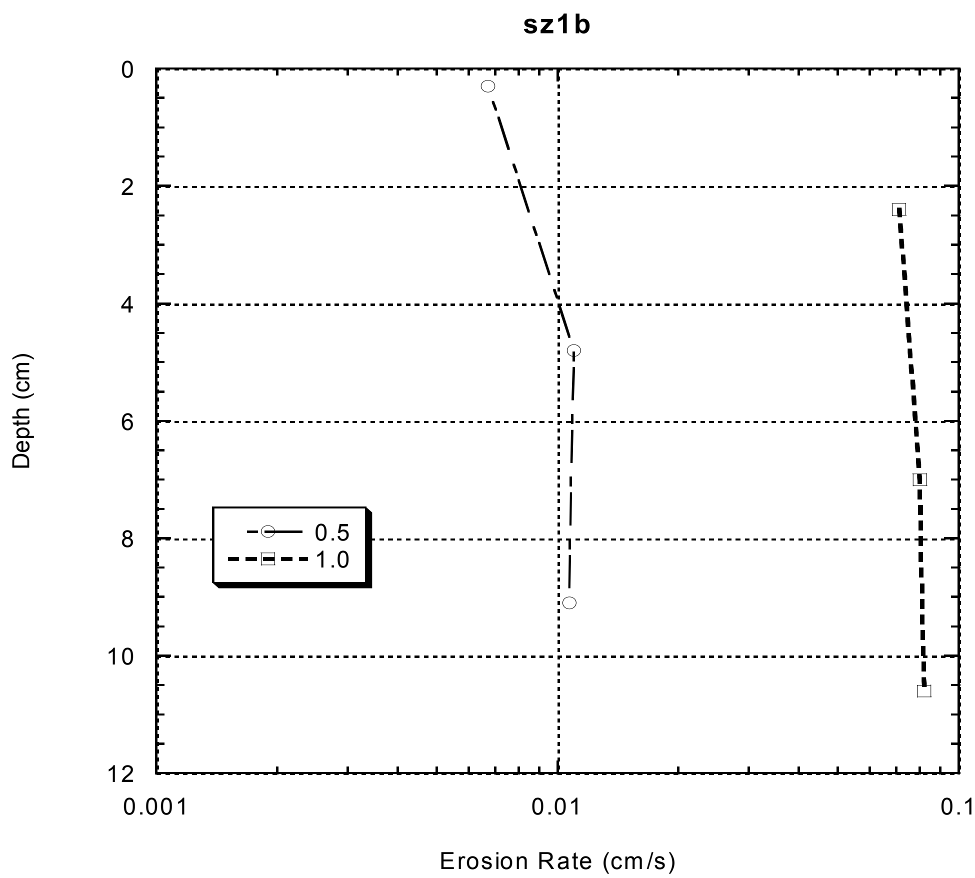


Figure 3.5.

3.1.5. Surf Zone Second Trough

The sample taken from the second trough within the surf zone (SZ2T) was 28 cm long and was fairly homogeneous throughout. The erosion rate was constant with depth (Figure 3.6) and the grain size variation with depth was 223 – 248 µm (mean grain size = 233 µm).

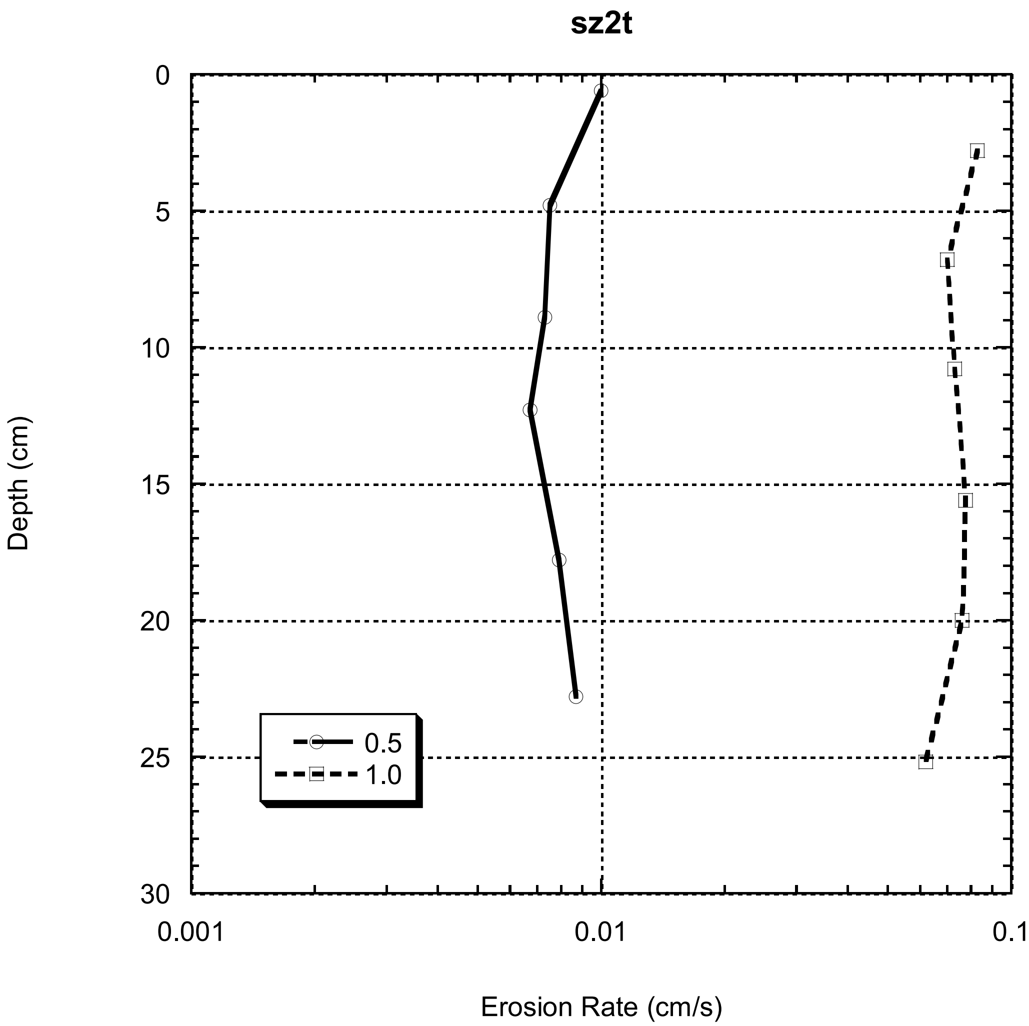


Figure 3.6.

3.2. Rio Grande

3.2.1. Rio Grande Mouth

Two samples were taken from the Rio Grande Mouth region. One was taken from the sand crest between the river and the Gulf of Mexico (RGMC), and the other was taken from the Rio Grande Mouth (RGM), where the river terminated at the sand obstruction. The erosion rate for sample RGMC (16 cm long) was constant with depth for the 0.5 Pa and 1.0 Pa tests (Figure 3.7). The eroded sediment transported as 100% bedload for all applied 0.5 Pa tests.

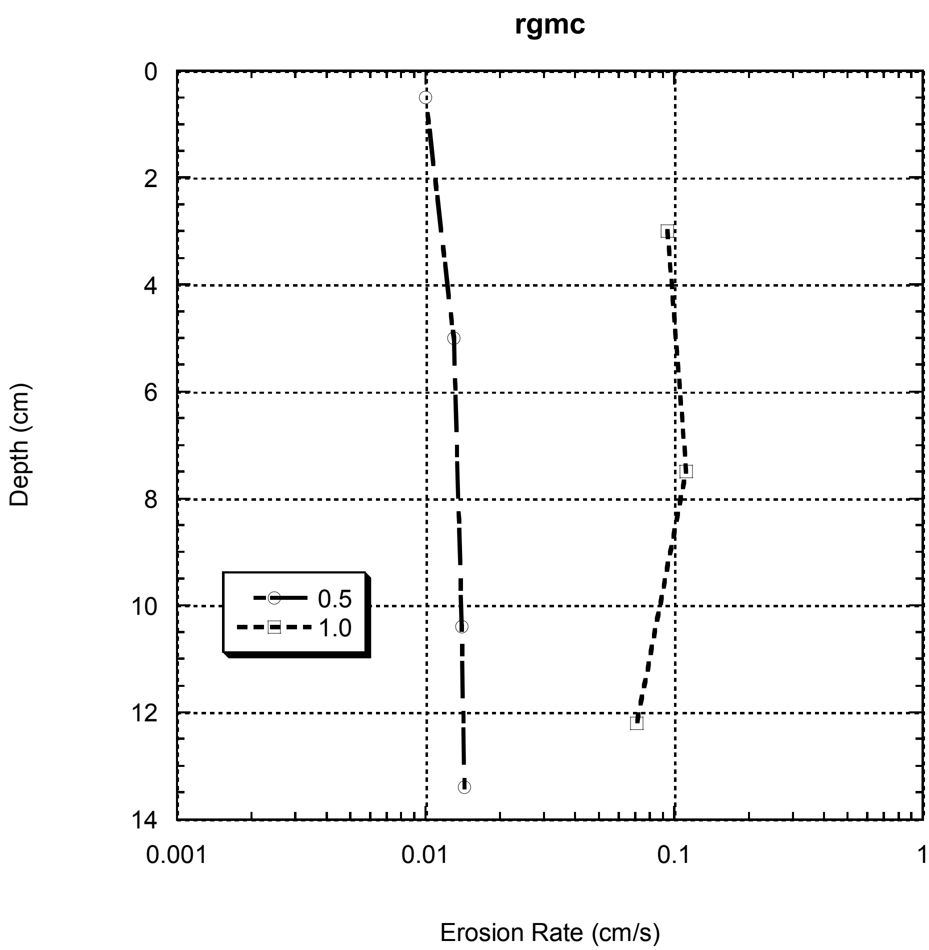


Figure 3.7.

The erosion rate of core RGM (15 cm long) was constant with depth for the 0.5 Pa and 1.0 Pa tests (Figure 3.8). The eroded sediment transported as 100% bedload for all applied 0.5 Pa tests and was generally lower than that measured in the RGMC core. The critical shear stress was determined to be 0.28 Pa for the top 5 cm of the core and was not measured below this depth.

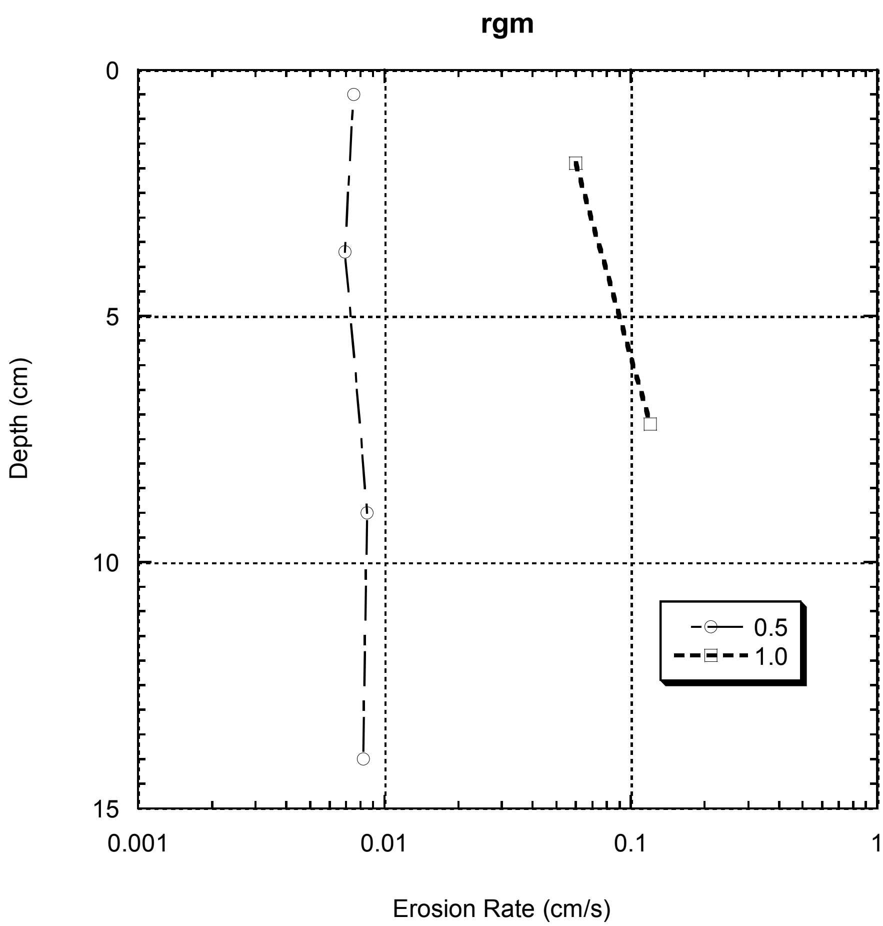


Figure 3.8.

The mean grain size of core RGMC was determined to be 226 μm, whereas the RGM sample was measured as a finer 215 μm. The particle cohesiveness of core RGM was slightly higher than that of core RGMC, due in part to the finer, measured mean grain size and a higher density of the clay-size fraction.

3.2.2. Rio Grande Channel

The samples procured from within the Rio Grande Channel were located 75 m (RGC1) and 500 m (RGC2) upstream from the delta (Figure 3.1). Sample RGC1 was collected in approximately 0.3 m water depth, whereas core RGC2 was collected at a depth of approximately 2.2 m.

RGC1 was 27 cm long and consisted predominately of fine sand throughout. The mean grain size was measured as 226 μm, with a range at depth between 213 – 240 μm. The critical shear stress was 0.35 Pa in the top 3 cm and 0.25 Pa for the remaining core. Erosion rates and mean particle size of this sample were very similar to that found in sample RGMC at the same shear stresses (Figure 3.9). The eroded sediment transported as 100% bedload for all 0.5 Pa tests.

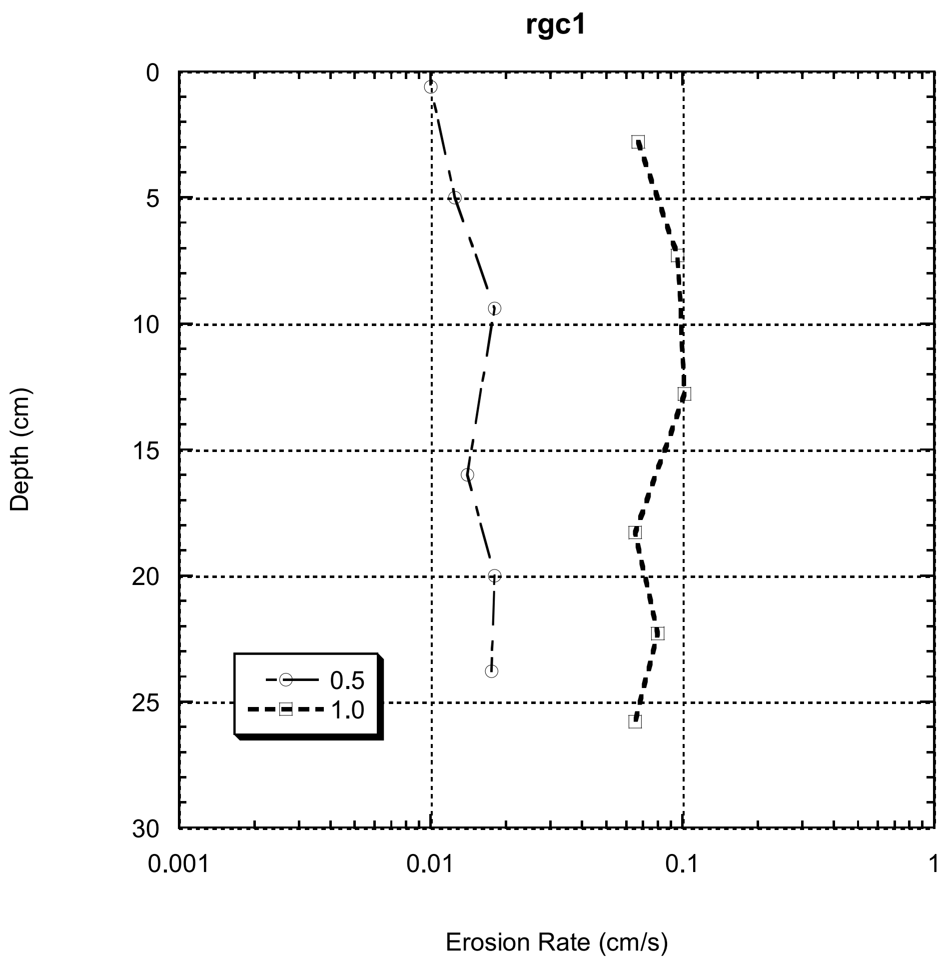


Figure 3.9.

Core RGC2 (17 cm long) was visibly stratified throughout and progressively more difficult to erode with increasing depth (Figure 3.10), where an order of magnitude decrease in the erosion rate was observed, primarily due to the presence of interstitial clay and organic material. The measured, mean particle size was 75 µm near the surface (first 2 cm), 28 µm (at 4 cm), 100 µm (7–9 cm), and 20 µm (bottom of the core). The 7 to 9 cm horizon of RGC2 was not eroded in the flume, as this section was selectively removed for the purpose of conducting particle size analysis only. We observed a noticeable increase in the mean particle size within this 2 cm seam, compared to the layers just above and below.

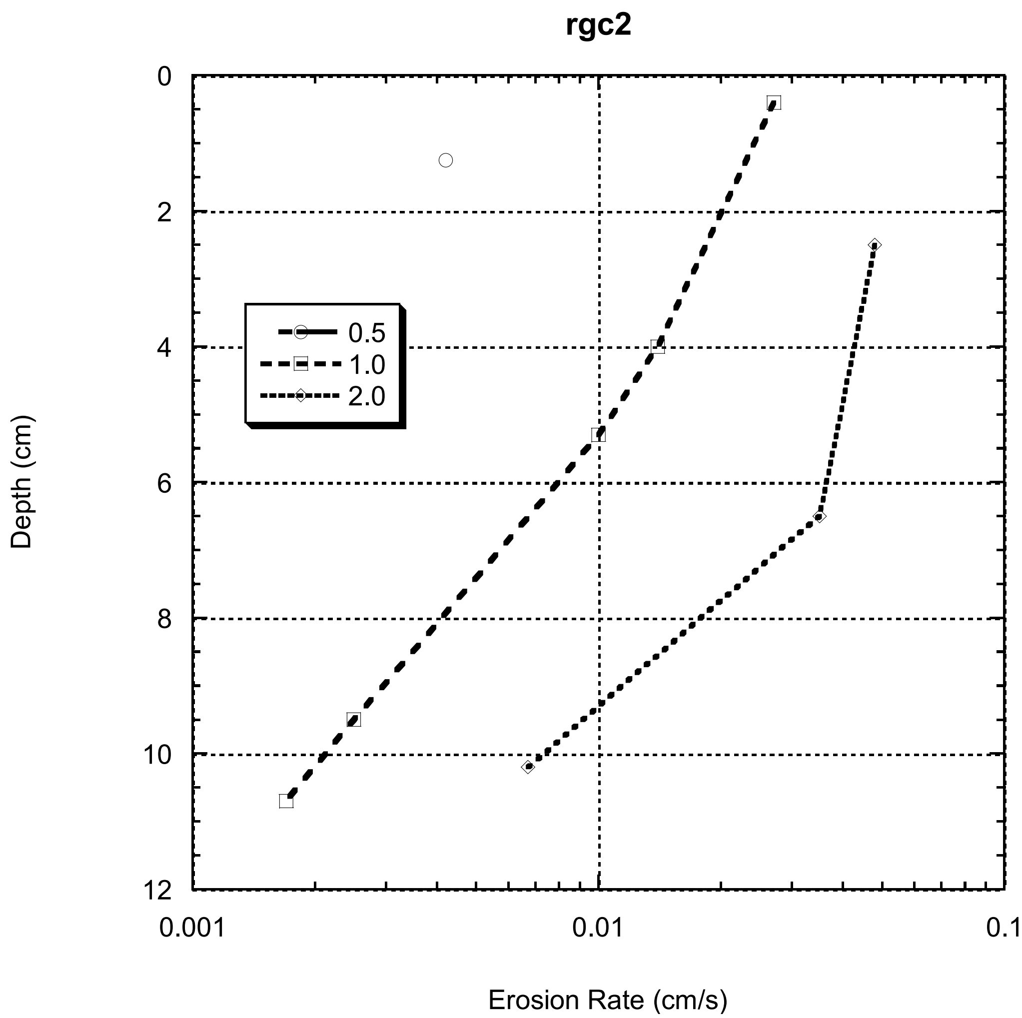


Figure 3.10.

A comparison of the distribution and the mean grain sizes for all (9) erosional test cores extracted from the Rio Grande Delta region are presented in Figure 3.11.

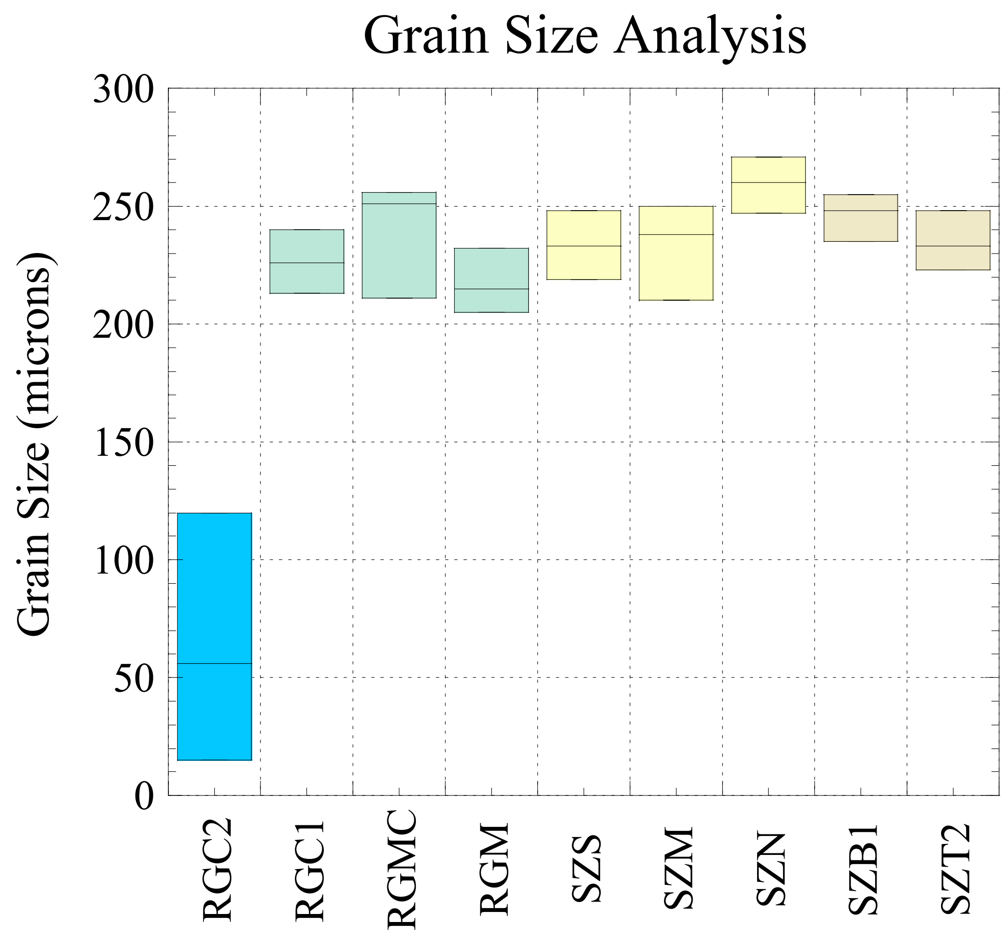


Figure 3.11.

4.0 Surf Zone Velocity Measurements

Velocity measurements were taken of the longshore current in both the SZN and the SZS (from the shoreline seaward to approximately 60 m offshore) at the Rio Grande Delta, U.S. and at the Mexican border. Longshore currents are wave induced currents that travel parallel to the shoreline, and are "refracted in a complex manner due to irregularities in depth of the shelf and in the coastline," (Reading, 1996). Waves operating in the surf and breaker zones deposit sediment not only shoreward, but also parallel (bilaterally) to the shoreline by these longshore currents. Such complex deposition of sand along the shoreline "produces zones of convergence and divergence even on a long, straight beach," (Reading, 1996). Sand deposited by the longshore drift contributes to the observed restrictive condition of the Rio Grande Mouth, abating its flow into the Gulf. A Marsh-McBirney, Inc. portable flowmeter (Model 2000) coupled with a Scientific Instruments, Inc. English units wading rod were employed for this purpose. All velocity measurements were collected while positioning the Marsh-McBirney's current meter in the direction of flow at 0.6 of the water depth. Two measurements were taken from the SZS along Transect A (A1–A2; Figure 4.1), whereas four current velocity measurements were taken from the SZN along Transect B (B1–B4; Figure 4.1).

The observed longshore current flow direction was from south to north for all measurements procured along the two transects. Water depths measured along Transect A and Transect B extended from 0.0 - 0.2 m at the shoreline, to approximately 1.1 m, 60 m offshore. The comprehensive, mean longshore velocities (30 second time averaged measurements) ranged between 0.2 and 0.3 $m \cdot s^{-1}$ (Figure 4.1). The highest mean current velocities were recorded in the first trough along both transects at A1 and B1 (between the shoreline and 25 m offshore), and just off the first sandbar along Transect B at B3. Measured depths of the first trough were between 0.3 and 0.6 m depending on the state of the tide. Maximum, instantaneous current velocities (2 second time averaged measurements) were observed as high as 0.43 $m \cdot s^{-1}$ in the first trough (B1), and 0.51 $m \cdot s^{-1}$ superior to the first bar (B2), both along Transect B and recorded between low and high tides. Note that high tide was observed at both 02:07:00 and 17:31:00, whereas low tide was recorded at 09:31:00 on October 21, 2002.

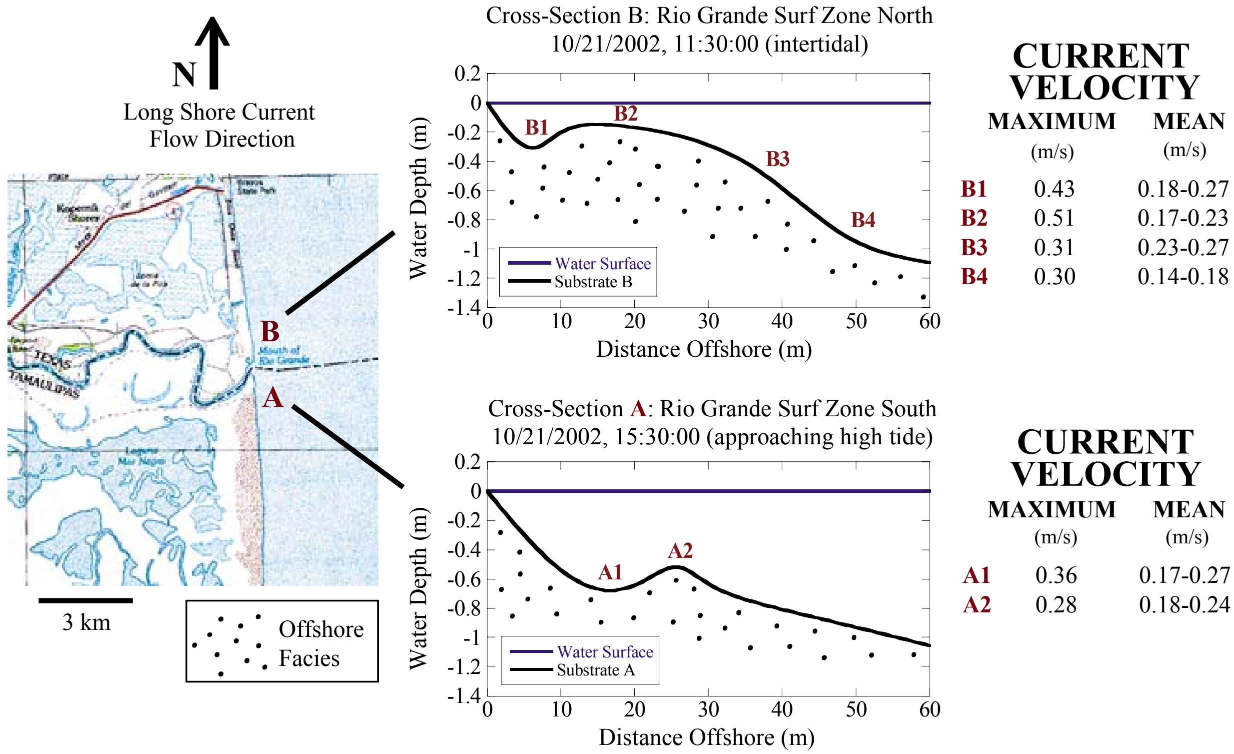


Figure 4.1 Longshore current velocity measurements recorded from the northern and southern surf zones of the Rio Grande Delta, U.S. and Mexican border. The maximum current velocity is an instantaneous, 2s time averaged measurement recorded over an interval of 180s. Mean current velocity is a 30s time averaged measurement taken over 180s intervals.

For open channel flow, the shear stress can be approximated by:

$$\tau = c_f \frac{1}{2} \rho U^2 \qquad (4.1)$$

where c_f is the friction coefficient, ρ is the density, and U is the fluid velocity. For a sandy substrate, similar to that observed in the northern and southern Rio Grande surf zone, the c_f is approximately 0.004. Therefore, employing Formula 4.1 and using a current velocity of 0.3 $m \cdot s^{-1}$, the calculated shear stress (τ) is approximately 0.20 Pa. Using a current velocity of 0.43 $m \cdot s^{-1}$, as measured at trough B1, the shear stress approaches 0.40 Pa.

Because the critical shear stress (τ_c) is greater than or equal to 0.25 Pa for all sediments analyzed, the mean current velocities do not generate enough shear to initiate erosion. Observations indicate that the sand-size fraction is transported during peak or maximum current velocities when greater than critical shear stresses are generated and the sand is transported as bedload.

5.0 Conclusions

The study demonstrated that the sediment observed within the surf zone, extending onshore through the Rio Grande Delta and at least 75 m into the Rio Grande Channel have very similar erosional properties and mean particle sizes. These sediments are predominately homogeneous mixtures of sand, having critical, erosional shear stresses between 0.25 and 0.35 Pa. Inchannel flow rates large enough to produce bottom shear stresses greater than this critical shear are required to transport sediments obstructing the Rio Grande Channel. All analyzed sediments transported completely as bedload at shear stresses of 0.5 Pa or lower. The finest grained sediments (sand, silt, clay and organic material) observed in core procured approximately 500 m upstream in the Rio Grande Channel (RGC2) were significantly more difficult to erode than the coarser grained sediments (sand) found proximal to the shore. This was to be expected, as the near-shore current is too strong to accumulate cohesive clay and organic deposits.

Longshore current velocity measurements taken in the surf zone correlate with erosional shear stresses of approximately 0.20 Pa or lower, with peaks approaching 0.40 Pa. When we compare these shear stress values to those measured in the erosion rate tests, all of the sediments analyzed would be eroded and transported northward by the Gulf's long shore current. Because the transport is 100% bedload at these velocities, none of the material would be carried offshore in the overlying water. If the velocities of the Rio Grande discharge are not higher than the Gulf's longshore current (> 0.3 $m \cdot s^{-1}$ [average], > 0.43 $m \cdot s^{-1}$ [peak]), the effects of longshore transport can and will introduce enough coarse material into the Rio Grande Delta Region capable of plugging the Rio Grande Channel, causing the river to breach its banks and inundate the adjacent flood plain.

References

Jepsen, R., Roberts, J., Lucero, A., and Chapin, M. 2001. Canaveral ODMDS Dredged Material Erosion Rate Analysis. SAND 2001-1989. Sandia National Laboratories, Albuquerque, NM.

McNiel, J.D. 1992. Rapid accurate mapping of soil salinity by electromagnetic ground conductivity meters. In *Advancements in methods of measuring soil physical properties: bringing theory into practice.* (ed G.C. Topp, and Reynolds, W. D.) **Special Publication No. 30**, pp. 209-229. Soil Science Society of America, Madison Wisconsin.

Reading, H.G. 1996. Sedimentary Environments: Processes, Facies and Stratigraphy. Third Ed, Blackwell Science.

Roberts, J., Jepsen, R., Gotthard, D. and Lick, W. 1998. "Effects of particle size and bulk density on erosion of quartz particles." Journal of Hydraulic Engineering, ASCE, 124(12), 1261-1267.

Roberts, J. and Jepsen, R. 2001a. Development for the Optional Use of Circular Core Tubes with the High Shear Stress Flume. SAND2001-0424. Sandia National Labs, Albuquerque, NM.

Roberts, J., Jepsen, R., Bryan, C., Chapin, M. 2001b. Boston Harbor Sediment Study. SAND 2001-2226. Sandia National Laboratories, Albuquerque, NM.

Schlichting, H., 1979. *Boundary-Layer Theory*. Seventh ed, McGraw-Hill.

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