SEDIMENT STAKE EROSION/ACCRETION MONITORING REPORT JULY 2002 – JANUARY 2004

PORTLAND HARBOR RI/FS

Prepared for
Lower Willamette Group

Prepared by

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March 2004

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1 INTRODUCTION

Bathymetric surveys and direct measurements of mudline elevation have been performed in the reach of the Willamette River flowing through Portland, Oregon, to investigate areas and patterns of accumulation or erosion of sediment. Bathymetric changes occur in response to tidal effects and seasonal changes in river stage. Because of the limitations imposed by shallow water and proximity to shoreline features, bathymetric surveys were not able to capture the potential bathymetric changes in the nearshore environment. Changes in beach elevation become important when evaluating the temporal stability of sediments and their associated sediment quality.

The objective of the monitoring project is to determine the erosion/deposition potential in nearshore areas and whether a relationship between those changes and changes farther offshore could be established. The nearshore data and possible relationship to erosion/deposition farther offshore are potentially useful in assessing various clean-up approaches, such as capping or dredging.

1.1 Previous Studies

A previous study, using sets of index stakes placed in the intertidal regime at eight locations between River Miles 2 and 9, was conducted to evaluate potential changes in the beach elevation and to relate those changes to changes farther into the river channel determined by the bathymetric surveys. The duration of the study was from July 17, 2002 to December 20, 2002. The results of the study were presented in a May 2003 draft report (Anchor 2003).

1.2 Additional Monitoring

Index stake measurements were continued into January 2004, and subsequent bathymetric surveys were conducted in September 2002 and May 2003. Table 1 lists the dates of bathymetric surveys and index stake measurements to the present. These data extend to time series to January 2004, and provide discrete measurements that span more than a single annual cycle. The combination of additional stake and bathymetric measurements, and the addition gage height and river discharge data, provide a better basis for evaluating longer-term sedimentation patterns than was possible with data from the previous study.

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1.3 The Approach of this Monitoring Report

This report will address the results of the field data since the initiation of monitoring. The focus will be on highlighting and discussing identifiable features and relationships. The primary means of presenting the data will be in tables and figures, rather than with detailed narrative text. This report will parallel the structure of the previous draft report and will excerpt the draft report as appropriate to supply background material or previous results. The approach taken in this (current) report is an effort to identify and discuss the salient features of the data and to avoid providing a "data-dump" presentation that reiterates in words what is more clearly apparent in tables and figures.

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2 OVERVIEW OF THE FIELD PROGRAM

This section, which was excerpted from the draft report, summarizes the various aspects of the field program.

2.1 Deployment of the Stakes

Sediment stakes were successfully deployed at eight of nine proposed locations in the study area (Figure 1). At location 2 (Schnitzer Steel), no suitable area for deployment and monitoring was available.

At each sample location, three stakes were placed along a transect perpendicular to the shoreline. The target mudline elevations for the locations of the stakes along each transect were the 10th percentile (low stakes), 50th percentile (median stakes), and 90th percentile (high stakes) of the river stage measured at United States Geological Survey (USGS) gage station 14211720. The stakes were driven into the sediment until the distance from the mudline to the top of a given stake was 30 cm. Table 1 lists the low, median, and high elevations relative to the gage datum, NGVD 29, and NAVD 88 (project datum). The distribution of stakes at different elevations along a given transect allowed measurement of sediment changes under a variety of water level/river flow conditions.

The precise horizontal location and vertical elevation of the top of each stake were determined and recorded by standard surveying methods during low tide intervals when all were visible. Mudline elevations at the point of penetration were determined by subtracting 30 cm (1 foot) from the elevation of the top of a given stake. Table 2 lists the horizontal coordinates and mudline elevations of all stakes at the point of penetration.

2.2 Monitoring Approach

Sediment levels relative to the tops of the stakes were recorded approximately once per month over the duration of the study from July 17 to December 20, 2002. Throughout 2003 until the latest measurement in January 2004, the interval between measurements averaged approximately 3.5 months. The mudline elevations were determined by measuring the distance from the top of each stake to the level of the surrounding unaffected sediment

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surface. Any debris such as trash, sticks/branches, weeds, and leaves that accumulated around the stakes was removed prior to making sediment level measurements. Local scour around the stakes was insignificant in all cases. The relationship between changes in beach mudline elevation and changes in mudline elevation farther offshore in the study area were investigated by comparing stake measurement data with bathymetric survey data collected in September 2002 and May 2003.

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3 RESULTS AND DISCUSSION

Results and discussion will include river stage and discharge, a summary of the sediment stake measurement data, and comparison, where possible, of sediment stake measurements with changes indicated by the bathymetric surveys.

3.1 River Stage, Tides, and Flow Volume

Figures 2 and 3, respectively, show the daily average the river stage and corresponding daily discharge recorded from February 2002 to February 2004. Over the study interval, the daily-averaged river stage varied from a low of 1.41 feet (gage datum) on September 20, 2003, to a high of 13.41 feet on February 1, 2003. The lowest river discharge recorded was 6,750 cubic feet per second (cfs) on July 28, 2003, and the highest was 156,000 cfs on February 1, 2003. Figures 2 and 3 clearly show the annual nature of variation, and also show that large fluctuations with time scales of a few weeks are imposed upon the typical gage height and flow discharge volume.

3.2 Erosion/Accretion at Shallow Stakes

Measurements of the mudline elevations at the shallow stakes during the study are presented in Table 3 and illustrated in Figures 4, 5, and 6. Figure 4 shows the data in a smoothed line plot, and Figure 5 shows the data in a bar chart. In both Figures 4 and 5, negative values indicate cumulative net sediment erosion, and positive values indicate cumulative net accretion. Figure 6 is a bar chart of the change in mudline elevation since the previous measurement, and is meant to highlight whether erosion or accretion is taking place rather than whether the net change has been erosion or accretion. In Figure 6, any negative value indicates the amount of erosion that has taken place since the last measurement, and any positive value indicates the amount of accretion. All three figures include a plot of the river discharge averaged over the interval, starting with the date of the previous round of stake measurements. Note in Table 3 that five of the eight low stakes were missing on January, 19, 2004, the date that the last stake measurements were made.

The largest ranges in mudline elevation occurred at the Equilon (0 to -18 cm), Terminal 4 (-5 to +12 cm), GATX (-13 to +2 cm), and Gasco (0 to +13 cm) locations (Figures 4 and 5). The

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general trend for most locations was of erosion through December 2002 (Figure 6), after which the erosion/accretion patterns were more mixed. The initial period of erosion roughly corresponded with increasing river discharge and the accompanying increasing flow speeds. One exception was the initial accretion at the Gasco location followed by erosion. After approximately March 2003, accretion occurred at the Coast Guard, Atofina, Gasco, and Terminal 4 locations. Accretion after March 2003 would be expected in conjunction with decreasing flow after March 2003. In contrast, erosion occurred after March 2003 at the Equilon and GATX locations. The difference may be related to the shoreline configurations at the various stake monitoring sites. The Equilon and GATX locations are exposed with no upstream obstructions, the Coast Guard and Terminal 4 locations are in small embayments, and the Atofina and Gasco locations are in the lee of docks extending offshore.

3.3 Erosion/Accretion at Median Stakes

The measurements made at the median stakes are presented in Table 4 and illustrated in Figures 7, 8, and 9, which correspond to the table and figures for the low stakes. Stakes could not be maintained at the Willamette Cove location, possibly because of human interference, so no consistent measurements could be made. As with the low stakes, an increasing number of median stakes disappeared toward the end of the monitoring sequence.

Because of varying differences between the actual mudline elevations and the target mudline elevation for the median stakes, the frequency and duration that each stake was influenced by river conditions varied among the locations. The stake at the Terminal 4 location was 0.86 feet higher, and the stake at the Equilon location was 1.07 feet lower than the target of +4.96 feet (gage datum). The other mudline elevations ranged from 0.04 feet higher to 0.92 feet lower.

Because the mudline elevation of the median stake at the Terminal 4 location was the highest, it would have been in water less frequently than any of the median stakes. Similarly, the Equilon location would have been in water most frequently. The degree to which river flow would have been able to influence sediment levels at each respective stake

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is not the same at all locations. Therefore, direct comparisons of the amount and timing of sediment level changes among the median stakes should be viewed with caution.

The largest ranges in mudline elevation occurred at the Equilon (0 to +20 cm), GATX (-17 to +4 cm), and Gasco (-29 to +10 cm) locations (Figures 7 and 8). Changes in mudline elevation at the Coast Guard, Willamette Cove, and General Electric locations were only a few centimeters between deployment in July 2002, and when measurements were made in March 2003. At the other locations, variations ranging up to approximately 25 cm occurred, and in general, mudline elevations increased through October 2002 and then decreased through March 2003. After March 2003, data were unavailable at several locations because of missing stakes. Available data indicated that the mudline elevations increased after March 2003 and then decreased toward then decreased through January 2004, when the final measurements were made.

Although the temporal patterns of variation among the different locations were not coincident, there is a discernable relationship to the variation in river discharge volume, which reflects water speed. Erosion and accretion are generally mixed during the first month of deployment, after which accretion generally prevails through September 2002 (Figure 9). Erosion and accretion are again generally mixed through October 2002, and then erosion prevails through July 2003, except at the Gasco location between March 2003 and July 2003. Erosion and accretion appear to be mixed during the interval from July 2003 to November 2003, and erosion prevails after that through January 2004.

The temporal changes described above roughly correspond to what might be anticipated to happen in response to the variation in flow speeds over the interval that monitoring occurred. Namely, erosion prevails during periods when flow increases, and accretion prevails when flow decreases. Mixed erosion and accretion tend to occur during transitions between increasing and decreasing flow.

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3.4 Erosion/Accretion at High Stakes

Changes in the mudline elevations measures at the high stakes are presented in Table 5 and illustrated in Figures 10, 11, and 12. The majority of high stakes were missing from December 2002 to January 2004, and the corresponding data are unavailable.

The data indicate little change in sediment levels at all locations except the Gasco and Equilon locations (Figures 10 and 11). At the Equilon location the mudline elevation varied little until December 2002, decreased into July 2003, and remained constant through January 2004. At the Gasco location, mudline elevation decreased into December 2002, after which the stake was missing. Figure 12 shows the erosion and accretion for high stakes over the monitoring interval.

Mudline elevations at the Equilon and Gasco high stakes were 1.3 feet lower and 2.9 feet lower, respectively, than the target of 9.99 feet gage datum. It is likely that discernable changes occurred at these locations and not at others because the lower elevations at these two locations placed them within the influence of river flow more often than the others.

Two exceptions are the Coast Guard location, which was 1.5 feet lower than the target elevation, and the GATX location, which was 1.3 feet higher. Little change occurred at the Coast Guard high stake, but small changes were apparent at the GATX high stake. The reason for the inconsistency may be that the Coast Guard location is in a protected area, while the GATX location is exposed on the shoreline.

The disparity among surface elevations of the high stakes and the difficulty in achieving long-term deployment render them questionable for evaluating effects of river flow on mudline elevation. It is unlikely that the high stake data are valid for subsequent comparison with elevations at the low and median stakes and with bathymetric data.

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3.5 Comparison of Measurements at the Low and Median Sediment Stakes

Figures 4 and 7 provide a means of visually comparing the changes in mudline elevation at the respective low and median stakes. Figures 9 and 12 illustrate the analogous patterns of erosion and accretion.

The patterns of temporal change for pairs of low and median stakes are most similar for the Gasco location, indicating that erosion and accretion tend to occur concurrently at both stakes. No other pairs of stakes demonstrate the same degree of consistency.

Changes in mudline elevation at the low and median stakes at the Coast Guard location were approximately mirror images of each other, although the magnitudes are small. If there is a relationship, it is that accretion at the low stake accompanies erosion at the median stake.

Changes in mudline elevation at the low and median stakes at the Equilon location were distinct from each other. At the low stake, an initial period of erosion occurred over a period of approximately five months, and after that, the trend is of slow erosion. At the median stake, an annual cycle of erosion and accretion appears to be related to the annual variation in river discharge. In contrast to initial erosion at the low stake, accretion occurred at the median stake over the first four months, after which erosion began. This may indicate offshore movement of sediment during the first several months of stake deployment; however, there is no compensating onshore movement later in the deployment, and the changes in mudline at the low and median stakes do not demonstrate any relationship.

With the exception of the Gasco location, the plots in Figures 4 and 7 show, for the most part, that there is no consistent relationship between fluctuations in mudline elevation at respective pairs of low and median stakes over the entire deployment interval. It also appears that there is not a consistent relationship between fluctuations of mudline elevations when all stake data are examined as a group.

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3.6 Sediment Stake Measurements and Sediment Level Changes Determined by Bathymetric Surveys

Bathymetric data and sediment stake measurements were used to explore the relationship between bathymetric changes and measured mudline elevation changes at the nearshore stakes. Figures 13 through 16 show the changes in bathymetry that occurred between September 2002 and May 2003. Bathymetric data collected during two surveys were differenced in order to map areas of net erosion and accretion. The set of stake height measurements corresponding with the September 2002 bathymetric survey was also collected in September 2002. In order to bracket the May 2003 bathymetric survey, the stake height measurements collected in March 2003 and July 2003 were used. September 2002 stake measurement data were taken as the initial sediment mudline elevations for comparison with bathymetric data. Estimates of the mudline elevations corresponding to the May 2003 bathymetric survey were obtained graphically from Figures 4 (low stakes) and 7 (median stakes).

The bathymetric change data mapped in Figures 13 through 16 was examined visually at the respective stake locations to makes estimates of changes in mudline elevation. The approach taken for interpreting the bathymetric change data was to look at the overall trend within a circle of approximately 100 feet. The minimum resolution of the bathymetric legends and vertical elevation mapping scheme is 7.5 cm, which is larger than the measured changes at approximately half of the sediment stakes. Within that circle there may be finer-scale indications of erosion or accretion, but interpretation of their importance relative to the overall trend inside the circle is subjective, given the vertical resolution of the visual display.

On the figures, the depth gradation legend gives values in feet. For the following discussion, bathymetric changes will be presented in centimeters for consistency with stake measurement data. Table 6 summarizes the changes indicated by stake measurement data and changes estimated from the bathymetric data.

In terms of collective changes at the stake locations from September 2002 to May 2003, the average changes at the low and median stakes were deepening of approximately 2 cm and

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9 cm, respectively. Mudline elevations deepened at six of the eight low stakes and at all seven of the median stake locations for which there were initial and final measurements.

Over the comparison interval, the average river discharge increased from approximately 11,000 cfs in September 2002 to 60,000 cfs in March 2003, and then decreased to approximately 50,000 cfs in May 2003. Deepening (erosion) is what would be expected under increasing speeds associated with increasing discharge volumes, and the sediment stake measurements show clearly that erosion dominated during this interval.

Figure 13 shows bathymetric changes for the General Electric and Terminal 4 locations. The indication at the General Electric location is of variation between 7.5 cm deepening and 7.5 cm shallowing, which is effectively indeterminate. Table 6 shows that this is consistent with the measurements at the low stake, but differs from the data from the median stake, which indicates deepening of 9 cm.

Figure 13 also shows the Terminal 4 location, at which the general trend is for shallowing of 7.5 to 15 cm. Sediment stake measurements indicate deepening of 1 cm at the low stake and deepening of 10 cm at the median stake. Both disagree with the bathymetric data.

Figure 14 shows the Gasco location. According to the bathymetric data, the trend is for variation between 7.5 cm deepening and 7.5 cm shallowing. Deepening of five cm at the low stake could be considered to agree with the change indicated by the bathymetric data, but the deepening of 10 cm at the median stake (Table 6) is not consistent with the change indicated by the bathymetric data.

Figure 15 shows four locations: Willamette Cove, Atofina, GATX, and the Coast Guard. In Willamette Cove, the indication from bathymetric data is of 15 to 30 cm deepening. This contrasts with 2 cm of shallowing measured at the low stake. Data from the end of the monitoring interval are not available for the median stake in Willamette Cove.

Bathymetric data at the Atofina location indicate deepening of 7.5 to 15 cm, which is somewhat consistent with deepening of 5 cm indicated by the median stake data. Low stake

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data show deepening of 1 cm, so the direction of change is the same, but the magnitudes are distinguishably different.

At the GATX location, low stake data indicate shallowing of three cm, while median stake data show deepening of 19 cm. Bathymetric data indicate a change that ranges 7.5 cm deepening and 7.5 cm shallowing, which is consistent with the low stake data, but not with the median stake data.

Data from low and median stakes at the Coast Guard location show deepening of 1 cm. Neither is consistent with deepening of 15 to 30 cm indicated by the bathymetric data. The discrepancy could be explained if the actual locations of the stakes were approximately 100 feet farther along the coastline toward the river than indicated on Figure 15. Bathymetric data for that area show variation from 7.5 cm deepening to 7.5 cm shallowing.

Figure 16 shows the Equilon location, at which low stake and median stake data indicate deepening of 6 cm and 16 cm, respectively. Bathymetric data indicate deepening of 7.5 to 15 cm, which roughly agrees with the data from both stakes.

Because of the high mudline elevations of the high stakes, and the seasonal period when the river stage is typically lowest, it is unlikely that erosion and accretion were influenced much by river processes. Comparison with erosion and accretion farther offshore would therefore have questionable validity and is not attempted in this analysis.

Table 6 qualitatively summarizes agreement and disagreement between the stake measurements and the bathymetric data.

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4 LIMITATIONS

Tidal excursions and runoff volumes influence the river stage and flow volume at Portland, so instantaneous data would consist of the fluctuating stage and flow values superimposed on daily-average values. Because successive index stake measurements and bathymetric surveys occurred as long as several months apart, it is not possible to resolve and correlate short term changes with stake or bathymetric data. Changes indicated by the stake measurements and bathymetric surveys can be assumed only to represent integrated effects when evaluating the data. This perspective can be false; for example, sediment levels might be stable for 11 weeks and then erode several centimeters as a result of a two-week storm event. Measurements taken after 11 weeks would yield a different snapshot of change than measurements collected after 13 weeks. Similarly, collecting stake measurements at 11 weeks and bathymetric data at 13 weeks could yield misleading results. In short, the data can support inferences about long term patterns, but cannot provide a basis for explaining the timing or probable cause.

Investigating the relationship between sediment level changes measured at the sediment stakes and changes determined farther offshore using successive bathymetric surveys is limited to intervals when each type of data are available. For this study, the only interval for which differenced bathymetric data and concurrent sediment stake data are available is between September 2002 and May 2003, which was primarily a period when flow volume made a transition from annual lows to annual highs, particularly in February 2003. As such, no stake data and differenced bathymetric data are available to characterize a transition from high flow to low flow when accretion might be expected to occur.

One impediment in comparing stake measurement data and bathymetric data is that the resolution for differences in successive bathymetric data is approximately 7.5 cm. The majority of differences in successive stake measurements are less than 7.5 cm, so comparisons should be viewed as coarse indicators of agreement or disagreement between the two types of data. The scatter of the data precludes making a strong quantitative relationship between stake measurements and differenced bathymetric data.

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5 RECOMMENDATIONS

Maintenance at high stakes yields little useful data for comparison with low and median stakes or with bathymetric data. High stakes are difficult to maintain, and measurements are subject to errors resulting from tampering by people. If the stake measurement program continues, high stakes could be abandoned without loss of useful data.

If the stake measurement program continues, more robust methods of deployment and marking should be considered. This is necessary to protect the long-term accuracy of the measurement records. This would include the redeployment of missing low and median stakes to fill in the data gaps that are currently occurring at some locations. Such efforts would require re-replacing and surveying the elevations of currently missing stakes and replacing existing PVC stakes with material such as steel that would resist breakage to a greater degree. These efforts would require additional expenditures beyond that normally needed for routine monitoring.

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6 REFERENCES

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