Chapter 4

ANALYSIS OF GRAIN SIZE OF THE BERKELEY BEACH

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The former existence of a sandy beach in Berkeley makes the idea of constructing a new beach attractive. The beach was a popular source of recreation, and it was an economic benefit to the community (Manning, 1979). The original Berkeley Beach was composed of fairly dark and fine sand which was used in various projects along the shoreline. The popular use of this sand resulted in its depletion and eventually the complete destruction of the beach. The Berkeley Beach Committee has proposed the construction of a permanent sandy beach along the Berkeley shoreline south of University Avenue, between the Brickyard and the Ashby Spit, as part of a proposed Eastshore State Park (Figure 1).

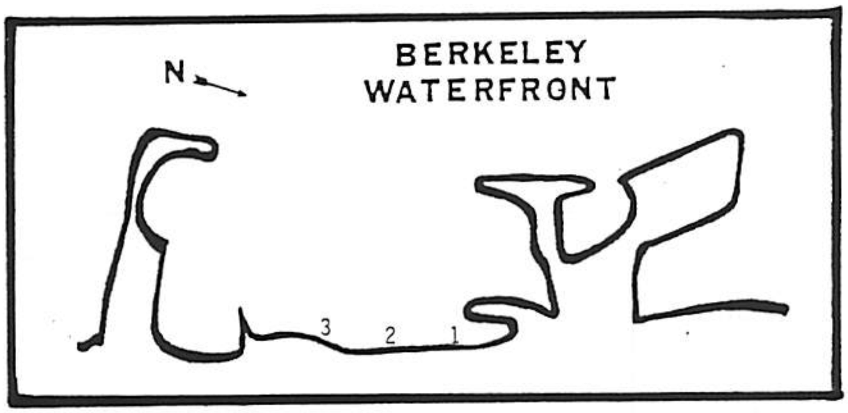

Figure 1. Location of Study Sites Along the Berkeley Shoreline.
Source: Monahan, 1984.

Construction of a beach is a complex process due to the variety of forces working to form the character of the beach. Care must be taken in choosing an appropriate site for construction and supplying it with sand similar in grain size to the sand presently at the site. The purpose of this report is to determine the trends in grain size at the present site of the proposed Berkeley Beach.

Background

The character of a beach is shaped by tidal, current, and wave action (Bascom, 1964). The most important features formed are the berms and bars. Berms are flat or gently sloping landforms that occupy the area we think of as a beach. They are created by low energy waves which tend to deposit sand along the shore during the summer months. The bars are underwater ridges of sand that run parallel to the shore. Bars are created by high energy waves that erode the shoreline and deposit materials on the bar, resulting in narrow berms characteristic of the winter months. In this annual cycle there is a net flow of material from bar to berm during the calm summer months and a reversal of flow in the more stormy winter months.

If proper studies are not conducted prior to construction of a beach, wave action can lead to serious erosion problems once the beach has been built and can result in economic as well as recreational disaster. For example, the Alameda State Beach along the western shoreline of the City of Alameda was constructed in 1959 by fill consisting of fine-grained sand dredged from San Francisco Bay (Corps, 1982). The problem with the beach since that time has been the erosion of the fill material by waves and currents. The continual erosion is due to wave action carrying off the fine-grained sand used for fill. A detailed study conducted by Moffatt and Nichol Engineers (1985) determined that the use of medium-grained sand dredged from San Francisco Bay in the vicinity of Angel Island would alleviate the erosion problem. A study along the Berkeley shoreline would prove useful in avoiding similar disasters.

Past Studies

Bachman (1982) conducted a study that determined the mean grain size of the average shore profile of the Berkeley shoreline and the Ashby Shoal. The purpose of his study was to determine if the Ashby Shoal could provide the sandy material needed for the construction of the Berkeley Beach. He sampled at Ashby Shoal and along transects perpendicular to shore and determined a mean grain size for each transect. He found that the beach consisted primarily of medium-and-fine-grained sand and that the shoal consisted of slightly coarser sediment than the shore. Thus, Bachman concluded that a stable beach could be formed from the Ashby Shoal material but that more detailed studies should be conducted.

Monahan (1984) conducted a study on the same strip of shore to determine fluctuation of grain size over time in relation to changes in weather. The purpose of her study was to determine the feasibility of a permanent beach along the Berkeley shoreline. She sampled four transects running perpendicular to the shore at three different times and analyzed the change in grain size along each transect. Monahan (1984) concluded that there are few characteristics common to all the study sites. The median grain size of all the samples became coarser as winter progressed, as is the trend for most beaches. Monahan (1984) found that the average mean grain size for all the transects was in the medium size range, whereas Bachman's (1982) results showed more fine-grained sand.

The difference between the findings of these two studies could be the result of different methodologies, drawbacks in methods used, or could be attributed to climatic and environmental variation between 1982 and 1984. In Bachman's (1982) study the samples taken along each transect were combined in the laboratory to give an average and median grain size for each transect. This made it impossible for Bachman (1982) to determine any trends in grain size along each transect. Monahan (1984) had difficulties in relocating the exact positions of her transects. The discrepancies in location may have led to inconsistent sampling. If one is going to compare data from one sample site over a period of time, it is important to collect samples from the exact same location every time.

In a Berkeley Beach Committee report (1982), Kurt Manning theorized about the various forces affecting the Berkeley shoreline. Manning postulates that minimal quantities of sand are being deposited on the beach from littoral flow in the Bay and that much of the sand presently at the beach may have been the residue of previous deposits of sand pumped for construction of the freeway. Other sources of sand may include Potter Creek near Ashby Avenue, and Strawberry Creek near University Avenue. Both creeks drain along the Berkeley shoreline and thus have the potential to contribute ample quantities of sediment.

Methodology

Samples were collected on February 5, 1986. It was a clear, warm day when samples were taken, and there had been little rain in the week prior. Three transects running perpendicular to the water were located by walking from north to south at a constant pace, and at each 5 minute interval a transect was designated. Compass readings were taken at each transect to make relocation of transects possible. Transect 1 is located farthest north, just south of the tip of the Brickyard and Transect 3 is located farthest south (Figure 1). At the first two transects, four samples (A-D) were collected at 50-foot intervals starting at the base of the riprap lining Frontage Road and continuing down towards the water. At the third transect only two samples (A and B) were collected due to the lack of beach exposed at the time of collection. On the day of collection the tide was at an extreme low of -1.4, which made it possible to collect all but one of the samples out of water; sample B on Transect 3 was collected under water. A coffee can was used in order to standardize the amount of material collected.

The sand was air-dried and 100g of the sample were wet-sieved through a succession of sieves of diminishing mesh size: 20 mesh, 120 mesh and 230 mesh. The residues were air-dried and then weighed. The sediment collected on the 120 mesh sieve was air-dried and then dry-sieved through sieves of 40 mesh and 60 mesh.

WENTWORTH SIZE CLASS	PHI SCALE
Coarse Sand	1-0
Medium Sand	2-1
Fine Sand	3-2
Very Fine Sand	4

Table 1. Wentworth Classification.

A statistical analysis was made of the data after the sediments had been classified according to the logarithmic transformation (phi) of the Wentworth scale (Table 1). On this scale, large-diameter particles have a negative value, and as the diameter decreases, the phi value increases. The statistical parameters of this analysis were based on typical characteristics of beach sediment, sorting, symmetry

RANGES OF VALUES OF SORTING (PHI UNITS)	SORTING VALUES
0.35·	Very Well Sorted
0.35-0.50	Well Sorted
0.50-0.80	Moderately Well Sorted
0.80-1.40	Moderately Sorted
1.40-2.00	Poorly Sorted
2.00-2.60	Very Poorly Sorted
2.60	Extremely Poorly Sorted

Table 2. Classification of Sands into Sorting Classes Based on Standard Deviation. Source: Friedman and Sanders (1978).

and skew. The tendency to be well-sorted (Table 2) means that the spread of distribution around the mean grain size is small. In addition, the grain size distribution tends to be asymmetrical and negatively skewed, having an excess of coarse particles in the sample.

A cumulative frequency curve was constructed from the data on grain size percentage for each sample and from these curves the 16th and 84th percentiles were determined for use in further statistical analysis. For normal distributions, 68.27 percent of the sample material is included between the 16th and 84th percentiles, which represents one standard deviation on either side of the mean (Spiegel, 1961). The mean, median, sorting, and skewness were then calculated for all samples.

Results

The mean grain size for the beach was 1.9 phi, medium sand, the median was 1.88 phi, medium sand, and the sorting was .71, moderately well-sorted.

The data for Transect 1 are shown in Table 3. The average mean for the transect, excluding sample C, was 2.1 phi, fine sand; the average sorting was moderately well-sorted, and the average skew was negative. Sample A was medium sand and samples B and D were fine sand. Because more than 16 percent of sample C consisted of silt and clay, statistical analysis was not possible.

	T1					T2					T3	
	A	B	C	D	AVG.	A	B	C	D	AVG.	A	B
MEAN	1.6	2.5	*	2.3	2.1	1.4	1.6	2.3	2.4	1.9	1.3	*
MEDIAN	1.7	2.5	*	2.2	2.1	1.3	1.6	2.1	2.1	1.9	1.3	*
SORTING	0.8	0.8	*	0.8	0.8	0.8	0.8	0.9	0.7	0.8	0.6	*
SKEW	-.09	0	*	0.07	-.01	0.09	-.03	0.24	0.08	0.09	0.14	*

Table 3. Mean, median, sorting, and skew for Transects 1-3. (* means more than 16 percent of sample was silt and clay, and statistical analysis was impossible. T=Transect).

Some typical beach characteristics are displayed along this transect but none of the samples display all of them. Samples A and B were moderately sorted, and sample D was moderately-well sorted. Sample A was negatively skewed, but samples B and D were positively skewed.

The data for Transect 2 are in Table 3. The average mean for the transect was 1.9 phi, medium sand; the average sorting was moderately well-sorted, and the average skew was positive. Samples A and B were medium sand and samples C and D were fine sand.

Transect 2 displays virtually none of the typical beach characteristics. Only sample B was negatively skewed, and all samples were moderately well-sorted except sample C which was moderately sorted.

The data for Transect 3 are shown in Table 3. Sample A mean was 1.3 phi, medium sand, moderately well-sorted, and positively skewed. Sample B was not aanalyzed because more than 16 percent of the sample was either silt or clay. Transect 3 displays none of the typical beach characteristics.

It is expected that along a transect the sand becomes finer going from onshore to offshore. Along Transect 1 the grain size is finer at the water line than on the berm. Within this general trend there is fluctuation in grain size along the transect; sample B and C are both finer than sample D. Transect 2 grain size becomes consistently finer toward the water, and Transect 3 changes from medium sand to fine sand over a very short distance (Table 3).

Discussion

The focus of the analysis was (1) the trend in grain size along the proposed beach site, and (2) the presence of typical beach characteristics.

The mean and median grain sizes at the site of the proposed Berkeley Beach (Table 3) show that the sand becomes coarser and the average sorting becomes better towards the south. The reason for this may be the tidal action along the shore. Most sand movement occurs underwater as a result of wave and current action. Along the Berkeley shore the flood tide has more of an effect on the shoreline than the ebb tide (Figure 2; CHNMB Assoc., 1982). Thus, the concentration of coarser sand at the south end may be explained by the stronger influence of the north-to-south tidal action. The weaker ebb tide may not have the energy to carry the coarser particles north.

The difference in trends in grain size between Transect 1 and Transect 2 could be due to the fact that Transect 2 has more protection than Transect 1. Transect 1 is protected by the tip of the Brickyard, but Transect 2 has no land formation to offer protection (Figure 1). Transect 2 and Transect 3 have more similar grain size trends and appear to have similar amounts of protection from land formations. Another explanation for the difference in grain size trends could be the effects of complex current and tidal action that run along the Berkeley shoreline.

It is difficult to say why typical beach characteristics are absent in these samples. Past studies by Monahan (1984) and Bachman (1982) have reported similar results.

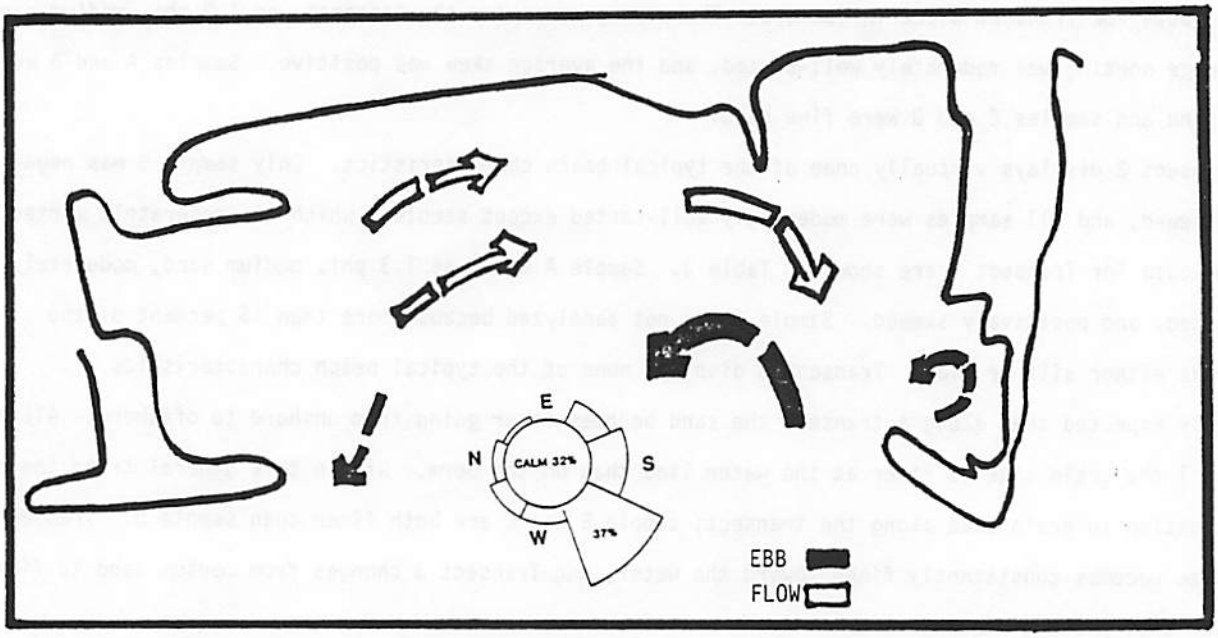

Figure 2. Ebb and Flow Tide Along the Berkeley Shoreline.
Source: CHNMB, 1982.

Comparison of grain size trends along the beach reveals variation between results of each of the studies. In Bachman's (1982) study the mean grain size for the beach was 2.4 phi, fine sand. In Monahan's (1984) study the average mean was 1.6 phi, medium sand, and in this study the mean is 1.9 phi, medium sand. The differences that exist between these three studies may be attributed to a number of factors. Methods of collection and analysis were different for each study. In addition the possibility of flaws in methodology could contribute to differences.

Another possibility is the difference in time of collection and also the changes in storm movement of sand over the 3-year period of collection. Monahan (1984) discussed the idea that the average mean varies over time in relation to weather, and thus is not a constant. Monahan (1984) collected data in November, January and late February. My study was done in early February. Monahan stated that the mean grain size becomes coarser as winter progresses, and this is supported by her data. When my data for average grain size for the beach are compared to Monahan's (1984) data, this idea is confirmed. They showed the same thing. My early February average grain size was coarser than both the November and January average grain size but was finer than the late February average grain size.

The complex and dynamic character of the beach itself may account for the differences between the findings of these studies and may also explain the lack of typical beach characteristics along this strip of shore. The data from this study alone suggest that this beach is very complex. Each transect shows different trends, which indicates that a variety of factors are affecting the formation of this shoreline. It is difficult to determine what these factors are and thus more research must be done on this strip of shore before speculation can be made concerning the possible effects of different forces acting on the shore.

Conclusion

The analysis of trends in grain size along a shoreline serves a double purpose. First, it examines a clearly defined problem; determining the grain size along a strip of shore in order that the shore can be supplied with sand similar in grain size to the sand presently at the site. Second, it reveals other areas of research relevant to the original problem.

This study found that the sand becomes coarser to the south, that few typical beach characteristics are displayed by this strip of shore and that the sand along the shore becomes coarser as winter progresses. How do these findings affect the possibility of constructing a beach along this strip of shoreline? These findings help by providing new information relevant to the construction, and they indicate other information needed before construction takes place.

The beach consists largely of medium sand, and thus a source of sand with similar medium sand must be found for use in construction. Bachman (1982) suggested that the Ashby Shoal would be an appropriate source. He found that sand along the shoal was similar in grain size to the sand along the Berkeley shoreline. More studies are needed to determine the feasibility of using the Ashby Shoal.

This study and the one done by Monahan (1984) found that the sand became more coarse to the south. The implications this may have on a constructed beach should be determined.

The progression of the beach sand from fine to coarse over the winter months may also be an important factor in the success of a constructed beach. Studies need to be done that analyze the trends in grain size throughout the entire year, not just the winter months.

The Berkeley shoreline is a very complex strip, and thus the construction of a beach along this piece of shore is a difficult project. In order to avoid problems, such as those at the Alameda State Beach, a detailed study analyzing numerous factors should be conducted to determine the various forces affecting the shore.

This report recommends that studies be done on (1) effects of tidal action on deposition of sediments along the Berkeley shore, and (2) the effects of climatic and seasonal factors on trends in grain size.

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