Sediment Characteristics of Managed Flood Control Channels in Southern San Francisco Bay

Authored by: David Gluchowski*, Sarah Pearce** and Lester McKee*** *davidg@sfei.org **sarahp@sfei.org ***lester@sfei.org

Abstract

In order to maintain floodwater capacity, managers must de-silt the channels, which can be very expensive and require difficult-to-obtain permits. In addition, removing the sediment from the channels prevents that sediment from ever reaching the Bay margin, and potentially being reworked and deposited in tidal flats or marshes. Data on the in-channel deposited sediment (volume, location, grain size) is lacking in the Bay Area. This study represents a first step of data collection on a regional scale to better understand sediment in managed flood control channels. The data from this study could be used to support numerical modeling of in-channel processes, explore alternatives to de-silting or more generally evolving management methods, or perhaps even to help managers consider alternative applications for the removed sediment, such as wetland restoration or beach nourishment.

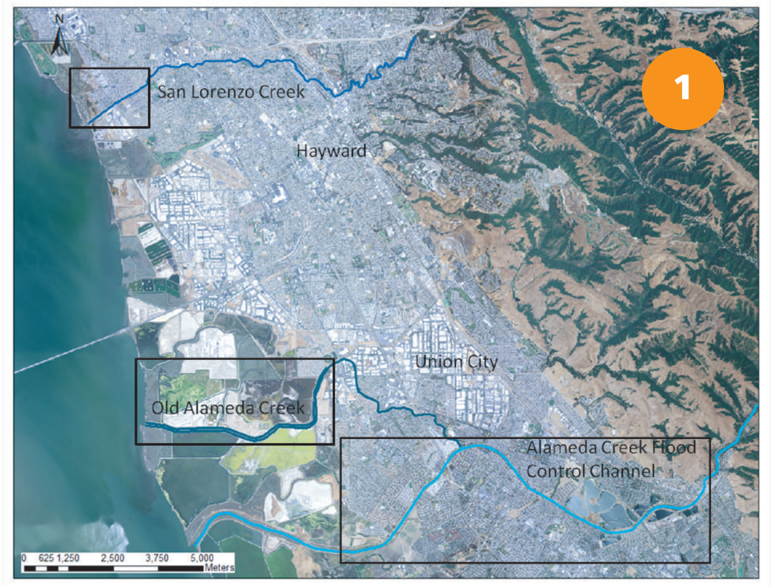
Introduction

Construction of flood control channels on many of the rivers and creeks draining to San Francisco Bay (California, USA) was prompted by the combination of the rapidly urbanizing Bay Area and the series of large regional devastating floods in the 1950s. Consequently, due to the constructed dimensions (width, depth, gradient, planform), these channels have been filling with sediment. Flood control channel construction in Alameda County began in the 1950s, primarily for routing floodwaters to the Bay. Construction often overlooked transport of sediment as well as other beneficial uses such as salmonid fish migration and wildlife habitat for birds and other species. In addition, both the Alameda Creek Flood Control Channel (ACFFC) and San Lorenzo Creek (SLC) have been aggrading since their construction. They have each been de-silted several times; SLC was most recently de-silted in 2004, ACFCC is scheduled for de-silting this year, and Old Alameda Creek (OAC) has likely been de-silted in the past as well. Data on sediment grain size is important for modeling channel processes in support of management decisions in the face of increasing demands on these channels to function for a broader array of beneficial uses such as fish migration, habitat for wildlife, or the possibility of sediment reuse for wetland restoration and beach nourishment.

Methods

SITE DESCRIPTION

Although the three watersheds are all located in Alameda County, and all enter the southeast portion of the San Francisco Bay, the watersheds vary greatly (**Figure 1**). Alameda Creek is the largest local tributary to the San Francisco Bay (1,682 km^2) draining upland, interior valley, and alluvial plain areas, through a 19 km long large earthen trapezoidal flood control channel (**Figure 2**). San Lorenzo Creek is a 124 km^2 watershed that drains upland and alluvial plain areas, through a 7.5 km long narrow concrete box and earthen trapezoidal flood control channel (**Figure 3**). Old Alameda Creek is a 57 km^2 watershed that only drains the alluvial plain area (receiving some overflow water and sediment from ACFCC), through an earthen trapezoidal flood control channel (**Figure 4**). The tidal reaches of all three channels are constrained by maintained levees.



FIELD METHODS

Samples were collected from both tidal and fluvial reaches of each channel, and for OAC, samples were taken in the north and south channels, as well as on the bar between the two channels. Aerial photographs showing the proposed sample locations were used alongside a handheld Garmin Etrex Legend GPS unit, to navigate the field team as close as possible to the proposed sample locations. Exact sample locations were selected based upon field conditions. At sample locations located in the tidal portion of the system, a boat was used to navigate to sample locations. A small, hand deployed petite Ponar dredge sampler was used to excavate sediment samples from the channel bed (**Figure 5**). The petite Ponar sampler was lowered over the edge of the boat collecting sediment from approximately the upper 5 cm of a 15 cm x 15 cm footprint in the bed. The sediment sample was then transferred from the Ponar sampler to a stainless steel bowl where it was mixed with a stainless steel spoon until homogenous. For smaller tidal channels accessible during low tide, samples were collected by hand using a plastic trowel to excavate sediment from a uniform area into the stainless steel mixing bowl. Sampling in the fluvial reaches targeted representative riffle locations, with sediment from a uniform area removed using a trowel. For more detailed methodology, see Gluchowski et al. 2012a and 2012b, as well as Pearce and McKee 2009.

Figure 1: Location of San Lorenzo Creek, Old Alameda Creek and the Alameda Creek Flood Control Channel. The reaches sampled are outlined in black.

Figure 2: The view upstream of the third rubber dam in the Alameda Creek Flood Control Channel.

Figure 3: The view looking upstream at the concrete channel and stilling basin in San Lorenzo Creek.

Figure 4: The view looking downstream in the tidal section of old Alameda Creek.

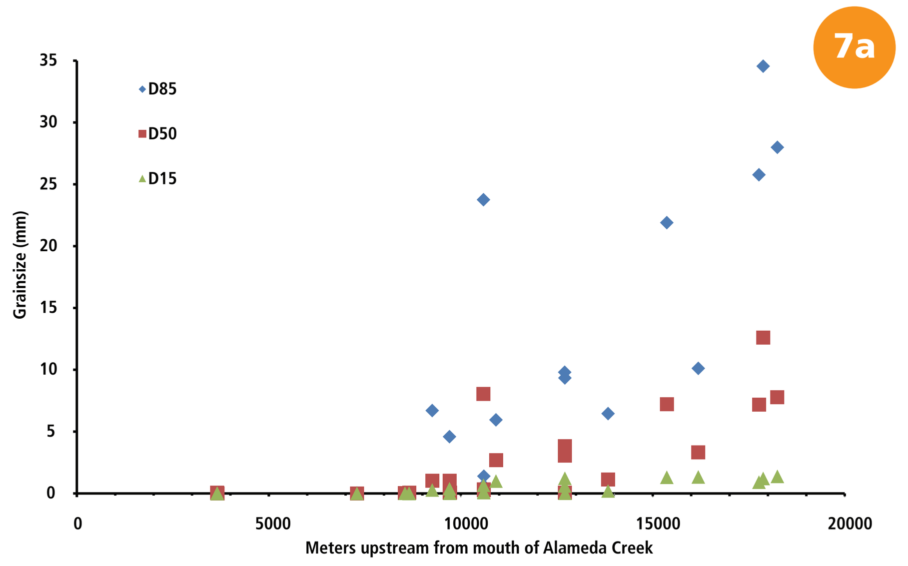
Figure 5: Deployment of the petite Ponar over the edge of the boat. This photo was taken in Old Alameda Creek and strictly shows the petite Ponar methodology.

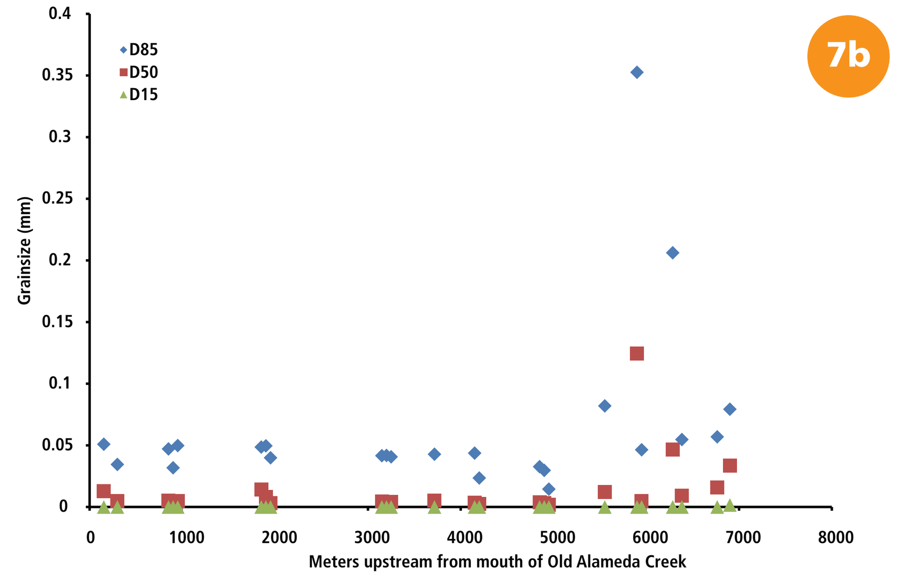
LAB METHODS

Samples from ACFCC were analyzed by Consolidated Engineering Laboratories and dry-sieved using 3", 1.5", ¾", 3/8", #4, #10, #20, #40, #60, #100, and #200 sieves. Samples from OAC and SLC were analyzed by ENGEO Inc. and dry-sieved using the same size sieves, as well as a hydrometer that determined grain size down to 0.0012 mm. Data was reported as the cumulative weight caught on each sieve and the percent finer than. In addition, the lab reported the percentage of material in each size category: coarse (76.2 – 8.00 mm) and fine gravel (8.00 – 4.76 mm), coarse (4.75 – 2.00 mm), medium (2.00 – 0.425 mm), and fine sand (0.425 – 0.074 mm), silt (0.074 – 0.005 mm), and clay (<0.005 mm). The D85, D60, D50, D30, D15, and D10 grain sizes were also reported by the lab.

Results

In general, San Lorenzo Creek had the coarsest sediment deposited in the flood control channel, with an average D50 of 3.4mm, the Alameda Creek Flood Control Channel had finer sediment with an average D50 of 2.5mm (**Figure 6**), and Old Alameda Creek had the finest sediment with an average D50 of 0.014mm (**Table 1**). Many factors such as channel gradient and geometry, along with upland sediment erosion and supply influence sedimentation in these types of channel systems. Sedimentation in each channel reflects watershed size, topography, geology, tectonics, land use, sediment sources, management, tidal prism, and climatic variability, among other factors. Engineered structures such as the tide gate in Old Alameda Creek (**Table 2**), as well as the stilling basin and concrete channel in San Lorenzo Creek (**Table 3**) seem to have an effect on grain size distribution. In OAC, the coarsest sediment was found upstream of the tide gate. The gate appears to cause preferential sorting and deposition of coarser sediment on its upstream side. In SLC, the finest sediment is present in the tidal section, with slightly coarser sediment just downstream of the stilling basin, and the coarsest sediment in the downstream section of the concrete channel. Sediment in the Alameda Creek Flood Control Channel is driven by supply from its large watershed; deposited sediment displays an overall downstream-fining trend (**Figure 7a**) reflecting distance downstream from the apex of the alluvial fan. In contrast, the grain size distribution in Old Alameda Creek and San Lorenzo Creek appears to be less driven by source characteristics, but instead controlled by the in-channel engineered structures (**Figures 7b and 7c**). Throughout the reaches in OAC and SLC there were some small variations in grain size, possibly caused by tributary channel inputs or channel geometry.





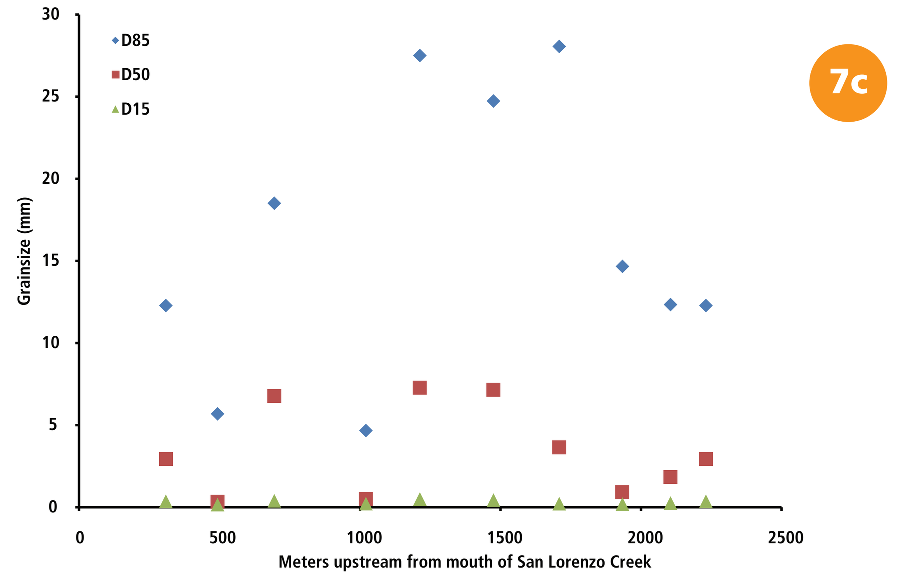


Figure 6: Sediment sample collected in Old Alameda Creek.

Figure 7: Grain size distribution (D85, D50, and D15) for each sample plotted with channel distance (meters) upstream from the Bay margin. Along the x axis, zero is the mouth of (a) Alameda Creek, (b) Old Alameda Creek, and (c) San Lorenzo Creek.

Table 1: Comparison of grain size in San Lorenzo Creek, Old Alameda Creek, and Alameda Creek Flood Control Channel.

Table 2: Average D85, D50, D15, and the percentage of material in each size category for the sections upstream and downstream of the tide gate in Old Alameda Creek.

Table 3: Average D85, D50, D15, and the percentage of material in each size category for the three sections downstream of the stilling basin in San Lorenzo Creek.

1

	D85 (mm)	D50 (mm)	D15 (mm)	% gravel	% sand	% silt	% clay
San Lorenzo Creek	16.1	3.44	0.311	38.9	56.8	2.33	1.97
Old Alameda Creek	0.064	0.014	0.002	0.096	8.62	43.7	47.6
Alameda Creek Flood Control Channel	7.91	2.5	0.45	20.9	43.5	26.1	9.53

2

Reach of Old Alameda Creek	D85 (mm)	D50 (mm)	D15 (mm)	% gravel	% sand	% silt	% clay
Upstream of Tide Gate	0.13	0.039	0.0016	0.38	21.5	45.0	33.1
Downstream of Tide Gate	0.04	0.005	<0.0012	0.00	4.32	43.2	52.5

3

Reach of San Lorenzo Creek	D85 (mm)	D50 (mm)	D15 (mm)	% gravel	% sand	% silt	% clay
Downstream of stilling basin	13.1	1.91	0.27	33.37	62.83	1.87	1.93
Straight concrete	26.8	6.03	0.39	53.80	43.13	1.83	1.23
Tidal channel	10.3	2.65	0.29	31.85	62.55	3.05	2.55

Conclusion

This work represents a first step towards characterizing and understanding sediment deposited in flood control channels across the San Francisco Bay area. Grain size data as presented here can be used to support numerical modeling efforts, explore alternatives to the de-silting process, and find alternative applications for the removed sediment such as beach nourishment and wetland restoration. This information is not only applicable to management of each flood control channel, but also District-wide and region-wide management, as well as for other flood control channels outside of the Bay Area.

References

Gluchowski, D., Beagle, J., Pearce, S., and McKee, L., 2012a. Old Alameda Creek Bulk Sediment Grain Size. A technical memo prepared by the San Francisco Estuary Institute Watershed Program for DHI Water & Environment, Inc. (DHI), Solana Beach, CA, and Alameda County Flood Control and Water Conservation District, Hayward, CA., 26pp.

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