Towards a Coarse Sediment Strategy for the Bay Area

MARCH 2021

PREPARED BY
San Francisco Estuary Institute

SFEI
SAN FRANCISCO ESTUARY INSTITUTE

IN PARTNERSHIP WITH
Alameda County Flood Control and Water Conservation District, Zone 7

FUNDED BY
San Francisco Bay Water Quality Improvement Fund, EPA Region IX

A PRODUCT OF **PREPARING FOR THE STORM**

FINAL ZONE 7
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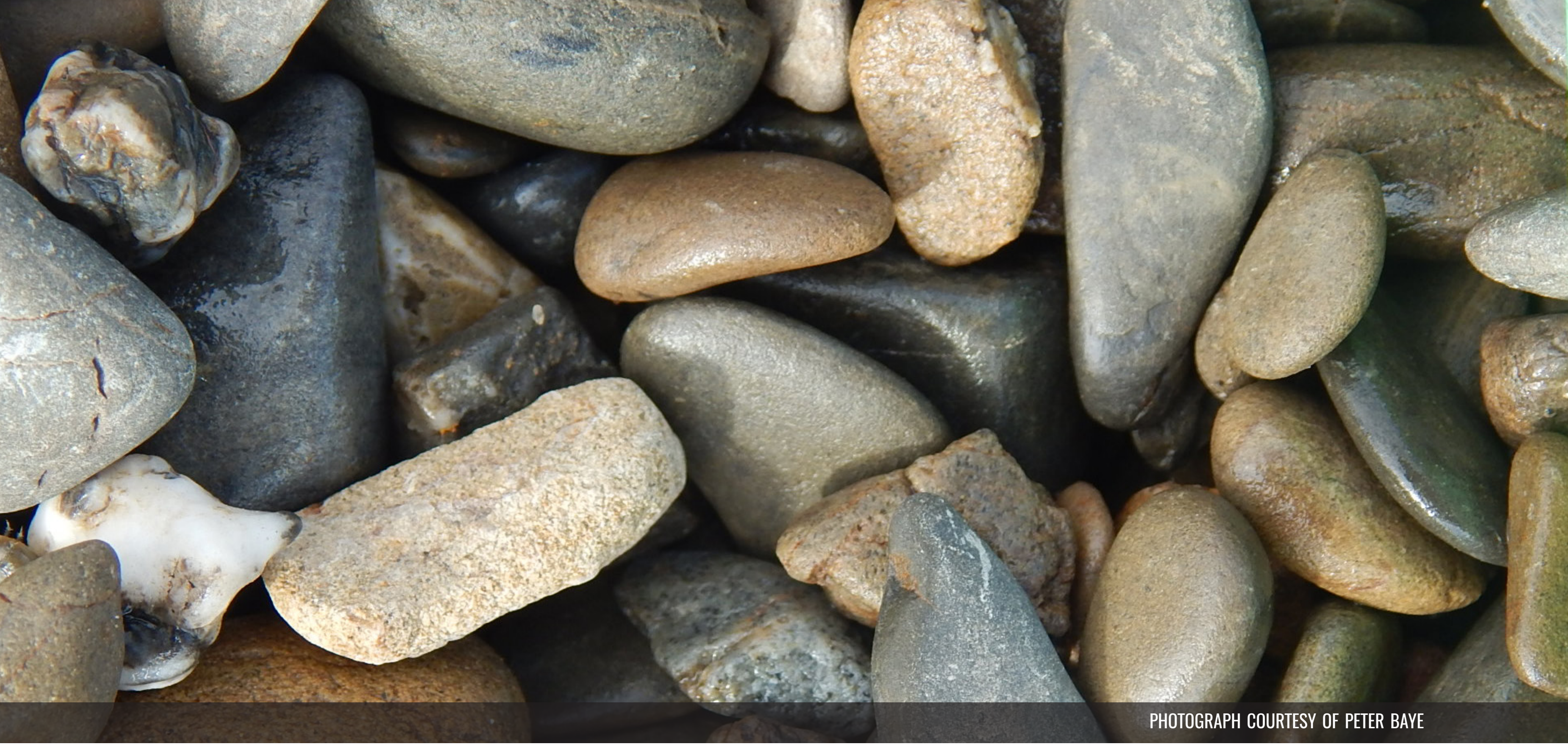


EXECUTIVE SUMMARY

Historic and current regional management of watersheds and channels for water supply and flood control across the San Francisco Bay Area has cut off much of the coarse sediment that was historically delivered to the Bay. Here we define coarse sediment as having grain sizes larger than 0.0625 mm, which includes sand, gravel and even cobble, as opposed to fine sediment that includes clay, mud and silt. Future projections indicate that sediment supply will not meet the demand from extant and restored tidal marshes to keep up with sea level rise.

The US EPA Water Quality Improvement Fund *Preparing for the Storm* grant has funded the Zone 7 Water Agency, the San Francisco Estuary Institute and the San Francisco Bay Joint Venture to support the future development of a successful regional coarse sediment reuse strategy. Development of such a strategy requires an understanding of logistical and regulatory hurdles and identification of key strategies for breaking down barriers. One potential solution for meeting the sediment demand along the Bay margin is to utilize coarse sediment that is removed from flood control channels by public agencies. To-date, very little of this sediment that is removed is beneficially reused for restoration along the Bay shoreline. The current economic and regulatory framework around sediment removal presents many challenges, barriers and lack of incentives for agencies to reuse their sediment.

This document represents a step forward towards beneficially reusing coarse flood control channel sediment by outlining reuse challenges, and identifying incentives for participation and potential solutions. It was informed by a workshop convened by the project team that engaged a large and diverse set of stakeholders from the region to gain knowledge and feedback from their experience in removing, transporting, reusing, and permitting coarse sediment. Also central to the workshop was an overview of the SediMatch Program, which has an online tool to facilitate matches between parties that have sediment and those that need sediment, and gathering feedback from the participants on how to improve the tool for coarse sediment reuse.

There are multiple barriers to the reuse of coarse sediment derived from flood control channels in baylands restoration. These barriers include contamination, haulage distance, relatively small volumes, limitations on use due to grain size, unpredictability of supply, incomplete records of removal, permitting uncertainties, and lack of regional guidance and leadership on the issue. In addition to these barriers, tools (such as SediMatch) and forums designed to facilitate sediment reuse have been developed, but are not yet widely used.

Breaking down these challenges and barriers will require cooperation and involvement from the entire community of stakeholders, as well as the utilization of a range of strategies. Here we summarize some of the key potential incentives and solutions that can increase coarse sediment reuse.

1. **Identifying people and organizations that can provide regional leadership** around sediment reuse, including fostering stronger relationships between stakeholders, creating coalitions of regulators to develop new guidance on reuse, and encouraging new partnerships that can enact creative solutions.
2. **Develop a collectively agreed-upon overarching regional plan to guide the future of reuse,** including laying out a pathway for the update of regional and statewide policies, ensuring regulatory consistency, and providing appropriate regulatory thresholds and technical guidelines.
3. **Update regulatory policies,** including consideration of developing a programmatic set of permits, developing CEQA/NEPA documentation for the region, reducing the permitting fees for sediment removals, increasing the length of time that permits are valid, and amending details within project QAPPs so that additional volumes of sediment could qualify for inclusion.
4. **Develop and enact incentives to encourage stakeholders to participate.** Incentives for flood control agencies could include mitigation credits for ensuring that the removed sediment is beneficially reused. Other credits could be offered to companies that haul or stockpile the sediment. The opportunity to make profit could entice aggregate companies, small businesses, and dirt brokers to participate. And, easier permitting processes or QAPP amendments could incentivize restoration project managers to accept coarse sediment.
5. **Better define contaminant thresholds for coarse sediment,** such as through writing a fluvial flood control channel specific version of the San Francisco Bay Regional Water Quality Control Board's Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines staff report.
6. **Encourage the development of pilot projects to test ideas and demonstrate the effectiveness of using coarse sediment.** For example, pilot projects using sediment with low levels of contamination could be monitored for any potential detrimental impacts and inform the definition of contaminant thresholds.

7. **Encourage solutions to address long haul distances.** This could include implementation of a "sediment ATM," where agencies make a "deposit" at a local stockpile location, and restoration managers can make an equivalent "withdrawal" from a stockpile location that is closer to the restoration site.

8. **Address small removal volumes (as compared to restoration needs) via stockpiling.** Stockpiles could be located at unconventional sites, perhaps including aggregate companies, non-active landfill property, Port of San Francisco or other port properties, or in a non-active area of a Bay shoreline restoration site.

9. **Increase the communication about the grain size of the sediment,** through the use of SediMatch, to update all parties about the availability of and need for coarse sediment specifically. This will allow restoration projects to include exclusively coarse grained elements, and potentially lead to new partnerships.

10. **Increase the predictability of coarse sediment supply through adjusting permit conditions** to encourage a pre-planned cyclic dredging approach. Also, prioritize sediment delivery to projects with short windows of time over longer-term projects that may have greater flexibility in timing.

11. **Improve the records of coarse sediment storage and removal,** including volume, grain size, current fate, and chemistry, to help determine the economics of reuse and provide confidence in the reliability and quality of supply.

12. **Continue to improve and increase the use of the SediMatch tool** to help make matches between the sediment supply and restoration communities. Improvements that focus on coarse sediment characteristics, planned removals, recurring removals, stockpiles, and links to other sediment databases will likely be the most effective in increasing use. The regulatory agencies can also require data entry as part of the permit requirements.

13. **Increase the timeliness of permits associated with removing and reusing coarse sediment** by negotiating 5-year or longer permits that include pre-authorized beneficial reuse, by increasing the trust between parties, and perhaps including private entities that track and haul aggregate for construction within the process, and by gaining assistance from the Bay Restoration Regulatory Integration Team in improving the permitting process.

1. INTRODUCTION

Agencies that own or maintain creek and river channels in San Francisco Bay Area watersheds see a combination of annual and episodic sedimentation in their channels and must obtain permits to remove portions of that sediment to maintain channel capacity for flood conveyance. Much of this sediment has a coarse texture, with grain sizes larger than 0.0625 mm, which includes sand, gravel and even cobble, as opposed to fine sediment that includes clay, mud and silt. At present, less than 40% of sediment removed from fluvial channels is beneficially reused for wetland and other restoration activities which are critical today for habitat and for adaptation to sea level rise and other climate impacts (SFEI-ASC, 2017a). Yet, there is a predicted deficit in the future amount of sediment the baylands will receive naturally compared to the amount needed to keep pace with sea-level rise (Dusterhoff et al., 2021). While most of the deficit requires fine grained sediment, there are important habitat uses of coarse sediment that can not utilize fine sediment. Flood protection agencies are therefore viewed as possible sources of sediment to help close this gap. Given the pace with which we need to be responding to the crisis of climate change, the question is how do we get from today's paradigm of "wasting" much of this coarse sediment to beneficially reusing most, if not all, of that material?

The Zone 7 Water Agency (Zone 7), in partnership with the San Francisco Estuary Institute (SFEI), the San Francisco Bay Joint Venture (SFBJV) and other organizations, received a U.S. Environmental Protection Agency San Francisco Bay Water Quality Improvement Fund grant, *Preparing for the Storm*. One of the primary tasks under the grant is to advance a framework for regular and systematic beneficial reuse of coarse sediment, with a focus on flood control channels. As part of this effort, a workshop was held on November 12, 2020 to engage the local community of stakeholders and more fully develop the list of challenges and possible solutions that will be essential for establishing a paradigm of beneficial coarse sediment reuse in the Bay Area. This document attempts to distill information gained from the workshop and use examples from Zone 7 to clearly outline the barriers, incentives and potential solutions for increasing coarse sediment reuse. While many of the ideas within this document are not new, this document brings ideas from regional stakeholders together in one place. This document is intended to be a record and a stepping stone towards the development of a regional sediment strategy that ensures that the region does not waste any supply of sediment.

Within this document, we aim to include the wealth of ideas and collective effort by many to outline a series of opportunities and strategies that could be acted upon to get more, if not all, of the Bay Area's valuable coarse sediment beneficially used over the next decade. Here we include input from flood control agency representatives, restoration managers, scientists and engineers, regulators, aggregate and sediment transport company staff, City, County, State and Federal agency staff, and other managers and planners. Our focus is on the potential for increased reuse of coarse sediment trapped in flood control channels for Bay restoration. However, we acknowledge that other sources of sediment, such as sediment trapped behind dams or sediment sourced from excavation for development (e.g. foundations or basements of buildings) will also likely need to be utilized to meet our regional Bay restoration sediment demand. We also acknowledge that there are other beneficial uses of coarse sediment beyond Bay restoration; for example, replenishment of coarse spawning gravels in regional streams.

We document challenges and provide high level potential incentives and solutions that could be enacted at the Baywide scale, and we include specific examples from the Zone 7 Water Agency that highlight the challenges of permitting, sediment removal, and sediment disposal for a local flood control agency. The main audience of this document is intended to be the staff of flood control agencies, restoration advocates and stakeholders, and the intermediaries between these groups such as private entities that excavate and haul primarily construction-related sediment from terrestrial areas ("dirt brokers"), aggregate companies, and regulatory agencies.

ZONE 7 CASE STUDY

Introduction to the Zone 7 Coarse Sediment Approach

The Zone 7 Water Agency (Zone 7) is a typical flood control agency that generates coarse sediment through its channel maintenance program. But Zone 7 is somewhat atypical in that it is situated far from the Bay in comparison to other Bay Area flood control agencies, making beneficial reuse in baylands restoration projects additionally difficult.

Every year, Zone 7, the City of Livermore, and other Tri-Valley agencies systematically inspect their facilities and then carry out any necessary maintenance and sediment removal within the scope of their permits to maintain channel capacity. Zone 7 currently reuses a portion of the removed sediment for local road and trail maintenance, particularly the coarsest fractions (gravel-sized and larger). Although Zone 7 has been committed to locally reusing sediment since 2007, until recently they have not strongly considered participation in a regional sediment reuse program that benefits bayland habitat projects, either for their entire volume of sediment that is removed or, more likely, for their unused sand fractions. The Tri-Valley agencies have growing interest in supporting beneficial reuse of sediment, ideally to support baylands restoration in the context of sea level rise, but also to potentially reduce their carbon footprint associated with sediment hauling and to reduce their overall costs (e.g. including associated mitigation). They recognize the challenges that must be overcome, but ultimately, they would like to be in a position to:

Reuse most if not all of the sediment that is produced through their annual facilities maintenance programs in a 5-10 year time horizon.

This is currently important to these agencies as they are in the process of developing a new flood master plan in addition to acquiring programmatic permits for their stream maintenance program which would include sediment removal activities for the next few years. The timing of these two actions represent an opportunity to make beneficial sediment reuse a priority.

One challenge is overcoming the hauling distance and cost; Zone 7 has no consistent or formal mechanism for getting sediment to a restoration site in a timely fashion, or at a cost that is a win-win for both the Zone 7 and a restoration recipient. There is also a general lack of incentives - either monetary or through mechanisms such as mitigation credits - for Zone 7 to participate. Details of the Zone 7 program will be highlighted throughout the remainder of this document as a real-world example for many of the challenges and potential solutions that are discussed for the larger Bay Area. This detailed information would not be possible to provide as an example without the discussion with and time provided by many of their dedicated staff.

2. REGIONAL SEDIMENT CONTEXT

Now, and into the near future, the baylands will require additional inputs of both fine and coarse sediment to maintain and build new mudflats, tidal marshes and other bayland habitats as sea level continues to rise. These Bay features are widely recognized as natural infrastructure needed to buffer communities from the effects of sea-level rise. This is a regional challenge, and will take the entire community of flood control agencies, regulators, restoration stakeholders, scientists, aggregate companies, and "dirt brokers" to address it. But fully understanding the challenge requires documentation of the context of sediment supply, delivery and need across the region.

The Bay is currently estimated to be in a net coarse sediment supply deficit, yet there is continued removal through in-Bay sand mining and dredging. Coarse sediment supply, transport and storage within the Bay is an on-going study question of BCDC and the sand mining community that is expected to be explored in more detail over the next two years. This supply deficit may not be fully realized for decades if the existing coarse sediment storage is relatively very large compared to the loss of supply. This is discussed more in the next section.

2.1 Sediment Storage

Part of the supply deficit is directly related to the history of Bay Area watershed management. During the early to mid 20th century, the construction of dams impounded approximately 618 mi^2 (or 20%) of the 3,147 mi^2 watershed draining to the Bay from the nine county Bay Area (McKee et al., 2013). The effect of these dams is a reduction in the delivery of coarse sediment from upper watershed areas to downstream creeks and the baylands. Subsequently, widespread flooding in the 1950s and 1960s caused massive damages across the Bay Area and raised concerns over the lack of flood protection for many of the rapidly urbanizing cities. The result was widespread construction of flood control channels (FCCs) by the US Army Corps of Engineers (USACE) and newly formed county public works agencies and special districts. The FCCs were built on the reaches of major creeks and rivers between the uplands and the Bay edge and commonly took the form of low gradient channels designed with capacity to convey very large floods, and thus typically have excessively wide cross sectional areas. Although they were mostly built by the USACE during the 1950s to 1970s, it was common practice for the FCCs to be handed over to local public flood control agencies for maintenance, though the USACE retained certification oversight.

Due to their position in the landscape where natural channel sedimentation, channel instability, and avulsion are normal processes, along with the typically overwide cross section, FCCs capture a considerable amount of sediment. Today it is estimated that just 55% of the sediment from Bay Area watersheds (an average of about 3 million cubic yards annually) makes it to the Bay (Figure 1). The majority of the sediment captured upstream of the Bay is coarse (SFEI-ASC, 2017a). For example, as is typical of Bay Area creeks, just 10% of the sediment in the Alameda Creek watershed that enters the FCC is >0.5 mm in size (mostly transported as bedload), yet 56% sediment caught in the FCC is >0.5 mm (Pearce and McKee, 2012). Such descriptive data are lacking for many other channels but anecdotally this is a common phenomenon.

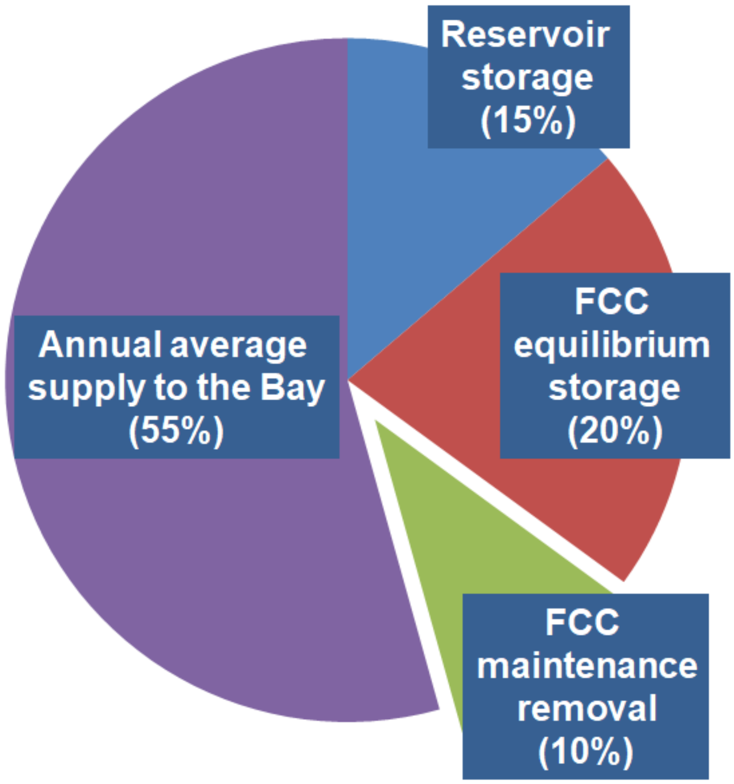


Figure 1. Estimated macroscale sediment budget for Bay Area local watersheds that drain the nine-county Bay Area. Total local watershed sediment production averages about 3 million cubic yards annually (McKee, 2014).

The best recent estimates indicate that the amount of coarse sediment stored or removed from FCCs each year is equivalent to the total supply of coarse sediment from both the Central Valley (the Sacramento and San Joaquin Rivers) and the local watersheds in the nine-county Bay Area. In other words, there is currently on average zero net supply (Schoellhamer et al., 2018) to the Bay. Sand is still being mined from the Bay for commercial use at a rate of about 0.8-1 million cubic yards per year (MCY/yr) (Perry et al., 2015). Thus, although it is not known if the Pacific Ocean is a net supply of sand to the Bay, without countervailing management and policies, it appears that the Bay may gradually be starved of coarse sediment, and this supply deficit may not show up for decades, having implications for the sand mining and baylands restoration communities.

Coarse sediment storage behind dams and in FCCs, along with continued sand mining in the Bay, is causing and will continue to cause a number of deleterious effects in the local creeks and the baylands. In local creeks, these and other changes have caused losses of critical gravel spawning habitat for local steelhead and other salmonids (Kondolf, 1997, Becker et al., 2007). In the Bay, lowered supply of coarse sediment has likely hindered the maintenance and formation of beaches (increasingly recognized as an essential Bay habitat). Reduced supply of coarse sediment also affects the ability of that coarse material to provide natural shoreline protection to mudflats, shoals and marsh edges from wave attack and other sea level rise (SLR) impacts. Sediment that does make it through to the Bay during wintertime floods is often wholly or partially cut off from immediately interacting with the adjacent marshes by FCC levees and dikes that cross the baylands. Many marshes where sedimentation processes were historically driven by a combination of fluvial and tidal energy, and both Bay and watershed sediment supplies, are now solely nourished by tidal energy and sediment from the Bay (McKee et al., 2013). So, not only is the Bay being gradually starved of coarse sediment, but there is also an altered delivery process, and fewer places for sediment to be deposited near the margins.

In addition to these supply and depositional changes and associated impacts to the shore habitats of the Bay, FCCs with excessive coarse sediment accumulation represent costly and time-consuming maintenance and disposal challenges for local flood control agencies. Since 1973, a total of 5.8 million cubic yards (MCY) of sediment has been removed from FCCs at a cost of $111 million (not adjusted for inflation) or about $2.8M per year. On average these FCCs cost about $700,000 per year per square mile of channel to maintain (SFEI-ASC, 2017a) (for the 11.36 square miles of total FCC in the Bay Area). Napa River, Walnut Creek, and Alameda Creek together account for 63% of those total costs.

Permits for single purpose repair and maintenance activities are harder to obtain and FCC managers now have expanded mandates to not only maintain flood capacity for the communities they serve (under USACE permits) but also to protect and enhance habitat (under permits from the San Francisco Bay Regional Water Quality Control Board [SFBRWQCB], CA Department of Fish and Wildlife [CDFW], and Bay Area Conservation and Development Commission [BCDC]). Through the permitting process, regulatory agencies are encouraging FCC managers to think broadly about beneficial reuse of sediment, potentially turning these maintenance and waste disposal challenges into collaborative opportunities. However, many disincentives and barriers still exist for widespread beneficial reuse of coarse sediment.

2.2 Bay Sediment Demand

As of 2009, the last time that the baylands were comprehensively mapped, the Bay had approximately 45,000 acres of tidal marshes (SFEI, 2017b). Nearly 8,000 more acres planned for tidal marsh have already been restored to the tides (SFEP, 2019). These acres contribute toward a region-wide goal of 100,000 acres of historical and restored marsh set by the Baylands Ecosystem Habitat Goals Project in 1999 (Goals Project, 1999). The Goals Project was a consortium of federal, state, and local agencies partnering with scientists and restoration practitioners to agree on restoration targets that would achieve a healthy estuary. Since then, the Science Update to the Goals Project (Goals Project, 2015) summarized evidence for a sediment deficit to achieve that goal, and a recent sediment supply and demand analysis focused on tidal marshes and mudflats quantifies that deficit and suggests management actions to address it (Dusterhoff et al., 2021).

To keep pace with sea-level rise of 1.9 ft by 2050, a total of 225 million metric tonnes (Mt) of sediment will be needed to bring areas slated for restoration up to tidal marsh elevation and to maintain both existing and restored tidal marsh and mud flats (Dusterhoff et al., 2021), or about 7.5 Mt/year for the next 30 years. To date, sediment dredged from the Bay has been the primary source for baylands restoration, however given the need, sediment removed from creeks and rivers for flood control is regarded as a potential source as well.

SIDEBAR HIGHLIGHTS

Sediment by the Numbers

- To keep pace with sea level rise of 1.9 ft by 2050, 225 Million metric tonnes (Mt) (or 7.5 Mt/year for the next 30 years) of sediment is needed to bring areas slated for restoration up to tidal elevation, and to maintain both existing and restored tidal marshes and mudflats.
- Current sediment supply to the Bay (local tributaries and Central Valley) is 2 Mt/year (ranging between <0.5 and 8 Mt/year) for the period WY 1995-2016.
- The proportion of sediment supply to the Bay from local tributaries versus the Central Valley is predicted to change, however the total supply is estimated to remain at approximately 2 Mt/year.
- From 2000-2013, 1.7 Million cubic yards (CY) (2.1 Mt) of sediment was removed from local flood control channels, with >60% disposed of as waste product.
- Sediment that is stored in or removed from local FCCs that could be available for restoration purposes is approximately 280,000-425,000 metric tonnes/year.

SAN FRANCISCO BAY, IMAGERY COURTESY OF EUROPEAN SPACE AGENCY, JANUARY 2019

2.3 Supply to the Bay

Currently, it is estimated that the watershed area draining to San Francisco Bay (inclusive of both the Sacramento and San Joaquin Rivers and the local tributaries draining directly to the Bay) supplies sediment at a rate of about 2 Mt/year, varying between <0.5 and 8 Mt/year depending on the season (Schoellhamer et al., 2018). The majority of this supply (about 70%) comes from local tributaries that drain directly to the Bay (Schoellhamer et al., 2018). Average annual sediment supply to the Bay from the Central Valley is estimated to increase over the next 30 years by between 15-45% depending on the climate change assumptions (Dusterhoff et al., 2021; Stern et al., 2020). Sediment supply will likely increase due to increased storminess, or greater intensity of each storm. Overall, average annual sediment supply to the Bay over the next 30 years from the Central Valley and local tributaries is estimated to be on the order of 2 Mt/year, with about 50-60% coming from the local tributaries (Dusterhoff et al., 2021). These load estimates remain well short of the projected bayland demands.

2.4 Waste sediment

From 2000 to 2013, 1.7 million CY (~120,000 CY/yr) of sediment was removed from 30 of the 33 largest FCCs, 72% of which was removed from tidal reaches (SFEI-ASC, 2017a). Of this total, most of this sediment came from nine individual channels that had total removal volumes greater than 50,000 CY. Although some sediment has been used for baylands restoration (e.g. Pond A8 and other salt marsh restoration including filling of borrow-ditches) and other habitat restoration purposes, most sediment (>60%) is currently being disposed of as a waste product (SFEI-ASC, 2017a). One of the key recommendations of the Science Update to the Baylands Goals (Goals

Project, 2015), was to recognize that the severe sediment deficit for the Bay means that all sediment should be considered a resource for the public good rather than a waste product.

In addition, sediment that has accumulated in channels but has not been removed is estimated to be 120,000-240,000 CY/year on a regionalized basis (estimates are hampered by a lack of systematically collected cross-section and longitudinal profile data in all but 14 of the 33 FCCs). Regardless of the actual storage and removal volumes, using a bulk density conversion factor of 1.25 tons/CY for finer grained sediment and 1.40 tons/CY for coarser grained sediment (SFEI-ASC, 2017a), between about 190,000-285,000 metric t of fine sediment (stored or removed from tidal reaches of FCCs) and between about 90,000-140,000 metric t of coarse sediment (stored or removed from fluvial reaches of FCCs) for a total of 280,000-425,000 metric t/year could be available annually for restoration purposes.

ZONE 7
CASE STUDY

Coarse Sediment in Flood Control Channels

Flood Control Channels in the Tri-Valley area, including those managed by Zone 7 and the City of Livermore, are generally efficient at transporting sediment. But there are locations of chronic sediment deposition that can reduce channel capacity, disrupt habitat, contribute to property and infrastructure damage, and undermine system integrity. Deposition occurs at discrete locations, including underneath several bridges, in sediment basins designed for capture, and at a few specific culvert outfalls, and is typically coarse sediment with grain sizes of medium to coarse sand, gravel, and cobble. While sediment basins are expected to require periodic sediment removals and were designed with maintenance time and costs in mind, the time and costs to the flood control agencies have increased since the basins were constructed due to the current permitting and regulatory compliance requirements. This has sometimes led to deferred or delayed sediment removal. Sediment deposition at other locations that were not intended or anticipated can cause additional costs and require additional agency staff time. This burden can affect agencies disproportionately depending on the regularity and magnitude of removal that is required.

For the period from 2005 to 2019, a total of 45,000 CY of sediment was removed from the Tri-Valley area, averaging about 3,000 CY/year (see Appendix). One particular location, Arroyo Mocho at Holmes Street, has had the largest single volume removal (8,900 CY in 2017), the most individual removal events (12 years with removals), and accounts for the largest total volume of removal for the Tri-Valley area (43% of the total). Just slightly downstream from Holmes Street, the sediment basin upstream of Isabel Ave has had three removals for a total volume of 15,400 CY, and is scheduled for 17,100 CY of removal in 2021. Other locations typically have removals <2,000 CY per event, with many locations only removing 10s to 100s of CYs per event. The removal record shows large year to year variations mainly related to flow but also complicated by funding or permitting constraints (e.g. 100 CY of total removal in both 2015 and 2016, but 21,000 CY of total removal in 2017).

3. SEDIMENT STRATEGY WORKSHOP

The overall *Preparing for the Storm* project objective is to improve watershed health and resilience in the Alameda Creek watershed by applying integrated strategies to reduce urbanization and climate change effects on floods, erosion, sedimentation, and water quality impacts, and by providing a regional model for enhancing hydrological and ecosystem resilience. One task within the larger project is the Coarse Sediment Reuse Strategy, with the goal of supporting a framework for the reuse of coarse sediment in restoration projects, especially projects that are restoring bayland wetlands and habitat. The project's proposed goal is:

> **All coarse sediment that is removed from flood control channels is beneficially used to support habitat restoration and shoreline adaptation to sea-level rise within the next decade. Such a timeline would support accelerated baylands restoration as called for in the 2015 Science Update (Goals Project, 2015).**

Many different agencies and individuals have been working to address this need. Despite the interest in reuse and the past work put in by these groups, a coherent strategy for the beneficial reuse of coarse sediment does not yet exist for the stakeholders to enact. This task within the *Preparing for the Storm* project aims to gather the collective knowledge of a large and diverse set of regional stakeholders and produce steps towards the development of a coherent strategy for the beneficial reuse of coarse sediment.

This effort is grounded in the project team's experience and knowledge, the current understanding of sediment delivery, removal and need in the Bay, as well as a known subset of existing barriers to reuse. The team augmented the information with additional knowledge provided by local experts and input from Zone 7 staff, based upon their experience in permitting, removing, and reusing sediment in Bay Area projects. This allowed the team to establish a more complete list of the variety of barriers or challenges that exist, and potential incentives and solutions that could encourage or increase beneficial reuse across the region. This provided the initial foundation upon which to seek the input of other agencies and individuals in the sediment community, those experiencing coarse sediment related challenges, and who have spent time thinking about challenges and potential solutions. The project team, led by SFBJV, organized a workshop to engage a larger group of stakeholders and more fully develop the set of challenges and possible solutions. In addition, the workshop provided a venue to receive feedback from stakeholders on the SediMatch Program and tool and its potential role in a coarse sediment reuse framework.

On November 12, 2020 a virtual workshop was held with over 60 local participants. Participants included staff from local flood control agencies, regulatory agencies, aggregate companies, "dirt brokers", consultants, and scientists who were interested in increasing the beneficial reuse of sediment. A wide variety of stakeholders was sought, including those who represent entities that remove sediment from channels, transport sediment, and need sediment, so as to gain the perspective of the entire community.

The workshop had a broad goal of increasing coarse sediment reuse from river and creek channels for baylands restoration. More specifically, the workshop aimed to:

- Receive input on how to improve a Bay Area sediment reuse planning "network" to be more inclusive of sediment removed from river and creek channels for reuse in the Bay,
- Generate new ideas and specific steps to address barriers to reuse, incentives, and potential solutions, and
- Explore how to improve existing programs and tools like SediMatch for additional beneficial reuse.

During the workshop, the team presented the regional status of sediment removal and fate, bayland sediment needs, and other related efforts that are in progress, before presenting the initial list of barriers, incentives and potential solutions. For part of the workshop, participants were asked to work in small groups, and were asked a series of specific questions:

- Are there any other barriers to sediment reuse that have not been discussed today?
- What are the main disincentives or barriers you face for sediment reuse?
- How can these disincentives and barriers be removed?
- What are some immediate steps that need to be taken?

The second part of the workshop focused on the SediMatch tool, and included education and real-time demonstrations of the tool. Participants were asked a number of live polling questions, focusing on receiving input on how to improve the tool, particularly as it relates to coarse sediment reuse.

Participants were highly engaged and provided insightful responses, and the workshop succeeded in gathering input and generating new ideas regarding beneficial coarse sediment reuse (as captured in 30+ pages of workshop notes, available upon request). The information gathered from the workshop supported the development of the following sections.

4. POTENTIAL BENEFICIAL USES OF COARSE SEDIMENT FOR HABITAT RESTORATION AND NATURE-BASED SHORELINE PROTECTION

Coarse sediment is a vital component of many restoration projects but unlike fine sediment, which is used in high volumes for marsh plain establishment, the uses of coarse sediment can be episodic and potentially targeted to specific project elements. Examples include:

- Protecting shorelines
    - Placement as berms or beaches along marsh scarps to reduce lateral erosion of the marsh
    - Placement in berms positioned slightly offshore to reduce wave action on the marsh scarp
    - Placement to form sand or cobble beaches for recreation and wave/storm surge defense (e.g. Crown Beach, Alameda)
    - Placement at coastal restoration sites that typically have higher energy as compared to in the Bay
- Building islands and mounds within salt ponds and restored marshes primarily for bird nesting, as finer material often develops desiccation cracks
- Repair of levees in certain circumstances (slumps, erosion failures)
- Foundations of horizontal levees, slope wetlands, and habitat islands (as long as finer grained cover materials can be compacted to fill any void spaces if the material is very coarse) or any other elements that are elevated above tidal processes (MHHW) and where there is no fluvial source directly connected
- Blending with contaminated (finer) sediment to reduce average contaminant burdens to concentrations below the reuse thresholds (blending sediment from multiple sources for beneficial reuse is hypothetical, and has never been allowed by the SFBRWQCB to date)
- Fill of polders (Perry et al., 2015), borrow ditches, or deeper areas that are either perennially wet (below MLLW) or regularly wet (between MLLW and MHW) earlier in the placement sequence before achieving marsh plain elevations (using coarse sediments as non-cover material)
- Constructed treatment wetlands (either vertical or horizontal flow systems) for secondary water quality treatment after solids and grease removal and/or ecotone slopes for high tide refuge
- Spawning gravels in river restoration projects (not the focus of this effort, but an important beneficial use of coarse sediment).

It should be noted that coarse sediment is the only material that is usable for some of these uses (like spawning gravel and beaches), while others (like fill of polders) might as easily use upland soils or construction waste for non-cover material. Should coarse sediment be reserved for where it is uniquely needed (e.g., for beaches or islands or for spawning gravels)? Perhaps coarse sediment shouldn't be used just to fill up holes or to dilute contaminated fine sediment? These policy decisions are beyond the scope of this document but may be important for managers and regulators to address.

5. BARRIERS AND CHALLENGES TO BENEFICIAL USE OF SEDIMENT FROM FLOOD CONTROL CHANNELS

There are multiple barriers to the reuse in wetland restoration of coarse sediment derived from flood control channels, with contamination, travel distance (cost), lack of stakeholder incentives, permitting challenges, and reliable timing being the biggest challenges. In this section we outline the barriers, many of which are interrelated.

5.1 Contamination with Inorganic and Organic Trace Pollutants

The cost of testing fluvial sediment for contamination is a major barrier, and often matters more than haulage distance. Fluvial sediments can be contaminated with legacy pollutants (PCBs, Hg, OC pesticides (e.g. DDT)), current use pollutants (e.g. As, Cd, Cr, PAHs), and natural geological sources. The guidelines for reuse are outlined in Table 4 of a SFBRWQCB beneficial reuse of dredged materials staff report (SFBRWQCB, 2000). The Water Board initially developed the list of contaminants for screening based upon reuse of sediment dredged from the Bay. Using these guidelines, typically every truckload of sediment removed from FCCs is tested for concentrations of the full list of contaminants. If the sediment shows contamination levels that are above the thresholds, there are limitations on where it can be reused, or the sediment simply must be disposed of in the appropriate landfill. For example, sediment that is contaminated could be reused as foundation material within a restoration. Allowed screening concentrations for foundation material (as long as it is buried by three feet of cover) are greater than for cover material. If the reuse is for spawning gravels, contamination testing also extends to biological material such as invasive species (e.g. New Zealand mudsnail (*Potamopyrgus antipodarum*)). With such biological material, transfer from one watershed to another is risky, but is less so within the same watershed, and permits are correspondingly a little easier. In general, testing costs and exceedance of contamination guidelines are barriers to reuse for fluvial sediment.

Assessing Contamination in Coarse Sediment

ZONE 7
CASE STUDY

Given the relatively low level of industrial development in the Tri-Valley Area both in the past and presently, concentrations of many contaminants may be low. However, pollutants associated with more general urbanization, agricultural use, and military use may be present. In addition, one random sample taken a few years ago had high concentrations of chromium, perhaps sourced from the Franciscan Formation (serpentinites) in the Arroyo Mocho watershed. Selenium and boron are also known to be high in the Tri-Valley Area. Chromium and selenium are both tested for under the Water Board's reuse guidelines. However, since the sediment removed in the Tri-Valley Area is coarse, and there is a general inverse relationship between contaminant concentrations and grain size, there may be a favorable situation for generally low contamination.

ZONE 7 CASE STUDY

Assessing Trade-offs in Sediment Disposal

Currently Zone 7 hauls sediment locally on the order of 4-6 miles to various locations where it is needed or can be stored, but sometimes hauls 22 miles to the Altamont Landfill where disposal fees are based on weight. To reduce costs, sediment is dried at a staging area first before loading it for a second time to be hauled to the landfill. For comparison, the distance from Dublin and Livermore to the Eden Landing Ecological preserve is 22 and 26 miles, respectively. Distance is likely to be a major factor in future decisions involving the reuse of Zone 7's sediment.

A recent example of hauling costs is from the Arroyo Mocho sediment basin upstream of Isabel Ave, which was cleaned out in 2017. Costs were $137,129 for the removal and hauling of 8,100 CY ($17/CY) to the nearby Cope Lake staging area for drying. However, instead of reloading the sediment and hauling it to a landfill, Zone 7 was able to locally reuse the material for road maintenance by crushing it, at a cost of $50K. Zone 7 has estimated a cost savings of roughly $10/ton by harvesting, processing, and reusing this coarse sediment from the sediment basin, in addition to non-monetary benefits (i.e., lesser impacts to roads and air quality).

5.2 Travel Distance Between the Removal and Restoration Sites

Haulage distance is a large factor in the cost of getting upland sediment to a Bay restoration site. Haulage creates greenhouse gas emissions and also places impacts on roads and air quality, especially concerning if the route passes through residential neighborhoods. These impacts associated with reuse must be reported and accounted for within the CEQA documents for the project. To make reuse attractive to the agency extracting the sediment, the haulage cost to a restoration site has to be cheaper than the haulage cost and disposal fee for taking it to landfill, and lesser than other impacts as reported within the CEQA documentation. This issue is site-specific; if the restoration site is farther than, for example 20 miles, yet is still closer than the nearest disposal site, the cost equation may still work.

Other challenges around haulage also factor into the decision of beneficial reuse. For example, there is no standard for which party is responsible for paying the transit costs or for reporting the impacts in their CEQA document, the sediment generator or the user. If sediment must be loaded/unloaded more than once, the double-handling costs may make the cost equation unworkable.

5.3 Low Volume of a Removal Event Relative to the Needs of a Restoration Site

Larger volumes of sediment create economies of scale. Usually the costs of testing, haulage, and preparing quality assurance project plans (QAPPs) get cheaper per unit of volume as the volume of sediment used by a restoration project increases. Low total sediment volume is thus another major barrier to reuse.

5.4 Grain Size of Material

Grain size limits the types of uses within Bay margin restoration sites. Although there are many potential uses of coarse material, some of which can be very high value, it cannot be used for marsh surfaces, cannot be placed on top of finer material, and cannot be used for levee construction (though small volumes could, in some circumstances, be used for levee repair). To-date, there have been relatively few projects that have exclusively required coarse grained sediment.

PHOTOGRAPH COURTESY OF ZONE 7 WATER AGENCY

ZONE 7
CASE STUDY

Volume of Sediment Removal

Zone 7 typically produces smaller volumes of sediment (an annual average of about 3,000 CY), as compared to the 50,000 CY or more of sediment (typically of finer texture) that most restoration projects require (except special projects such as beach nourishment or slope wetlands that would require smaller volumes and coarser sediment).

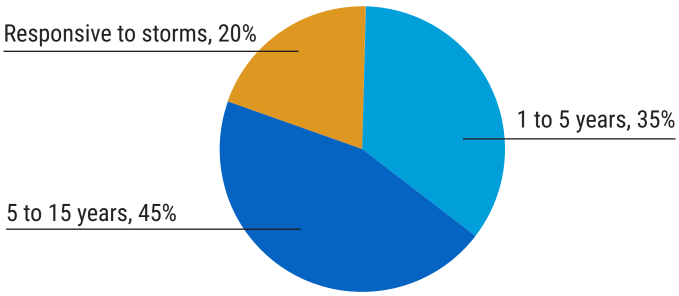
Three recent removals in 2019 illustrate typical volumes and costs of sediment generated from certain locations in the Tri-Valley area:

- Zone 7 conducted a sediment removal at the Line G fish ladder. The removal cost $11,100 for just 42 CY of sediment, equating to $264/CY (work had to be done entirely by hand labor, contributing to the large relative cost).
- The City of Livermore spent $80,000 to remove 670 CY of sediment from the Holmes Street location (equating to $119/CY).
- The City of Livermore spent $38,000 to remove 300 CY of sediment from the Airway Boulevard location (equating to $127/CY).

5.5 Unpredictability of Repair and Maintenance Events

Coarse sediment sources from FCCs may not be available every year and can be unpredictable, yet restoration needs are typically more predictable and needed at specific times. Most channel sediment removal events are in response to storm-based deposition. During larger flood events, coarse sediments tend to be transported at a higher rate and form a larger portion of the sediment in transport. When those sediments reach a FCC, preferential deposition of coarse material typically occurs, often resulting in the need for maintenance removal in the following summer work season. Some agencies do systematic removal every year or every other year (e.g., for maintenance or for navigation), while others wait for capacity thresholds to be crossed, for funding to be available, or for permits to be obtained. Since flood frequency is unpredictable, for many individual FCCs the supply of coarse sediment available for restoration projects is unpredictable (Figure 2), making finding a reuse partner more difficult. In the cases where removal is in response to storms or otherwise not predictable, there may be lost opportunities for reuse.

Figure 2. Frequency of removal of sediment from flood control facilities in the Bay Area watersheds (SFEI-ASC, 2017a).



ZONE 7 CASE STUDY

Variability in Sediment Volumes and Timing

In the Tri-Valley area, the need for sediment removal varies by location. For example, the City of Livermore has removed sediment from the Holmes Street location in 10 of the previous 13 years. However, for other locations in the Tri-Valley, coarse sediment is removed less frequently. In years that do have removals (for all locations combined), the volume varies considerably from just 100 CY to 21,000 CY averaging 3,000 CY with a median of 1,500 CY. Similar to other FCCs, sediment deposition in the Zone 7 facilities appears to correlate to flood magnitude, such that removal tends to occur in the summer following a wetter than normal winter. For example, peak flows during Water Year 2017 were the largest seen since the mid 1990s, causing damage to over 200 locations in the channel system and requiring 21,000 CY of sediment removal.

ZONE 7
CASE STUDY

Data Gaps

In the Tri-Valley area, data about the location, volume, and fate of removed sediment are often available, though not always complete. Records show that since 2005, sediment removed from channels has been disposed of as daily landfill cover, used for road base material, or stockpiled for an undesignated future use (Figure 3). Roughly a quarter of the total removal has an unknown fate, meaning that the records were not kept or were not complete.

Quantitative measures of the grain size of removed sediment is not standard practice; however, qualitatively we know that the removed sediment is coarse (>0.0625 mm). To date, grain size information has only been recorded at the Arroyo Mocho at Holmes Street location, and even there it was limited to describing the sediment as "gravel". In addition, until recently cost information was not being systematically recorded on a per cubic yard basis for each removal event. This cost data will be particularly important for Zone 7 to allow for future formal reuse agreements to be reached.

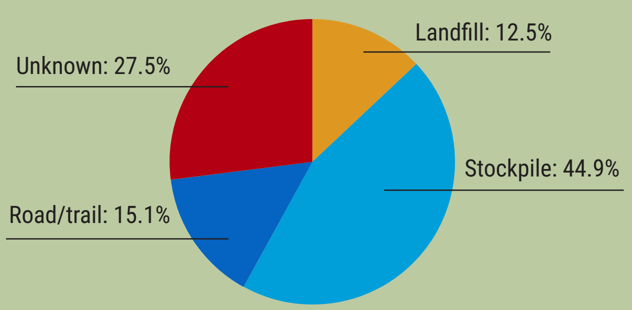


Figure 3. A summary of the fate of sediment removed from channel facilities in the Zone 7 Tri-Valley area, 2005-2019. For details of locations, volumes, grain size and fate, see Appendix. Note, sediment that is stockpiled is intended for local reuse.

5.6 Lack of Systematic Records of the Volume of Storage, Removal and Costs

Without systematic records of volume of storage and removal and associated costs for each FCC, the restoration manager will not be able to gain confidence in the estimated volumes and associated costs and timing of the source material. Very few flood control channels have ongoing regular channel cross-section or longitudinal profile surveys to document the change in channel bed elevation, and the associated change in stored sediment volume, over the long-term and directly following major storms or dredging events. Currently, there is little specific information about the location, volume, texture (grain size), removal and disposal costs, contaminant testing, and ultimate fate of sediment dredged from flood control channels for individual dredging events, as well as the total dredging cost (including coordination and permitting). Data pertaining to the location, volume, grain size, contaminant quality, and fate of dredged sediment are needed to help elucidate the amount of sediment that could be available, and cost data would help in determining the economic considerations of beneficial reuse.

5.7 Limited Adoption of the SediMatch Database

SediMatch is a collaborative program of the San Francisco Bay Joint Venture (SFBJV), the San Francisco Bay Conservation and Development Commission (BCDC), the San Francisco Estuary Institute (SFEI), the San Francisco Estuary Partnership (SFEP), and others to bring together the wetland habitat restoration, flood control, and dredging communities to discuss challenges and find mutually beneficial strategies to increase reuse of dredged sediment at habitat restoration sites. The goals are to 1) maximize beneficial reuse of sediment, 2) make available an easily accessible database where sediment needs can be matched with surplus sediment; and 3) provide opportunities for collaboration. Use of the SediMatch web tool has been limited with only a dozen projects entered and no successful matches identified to date. Among workshop participants (although we were unable to subset responses based upon employer or role), approximately two-thirds had never used SediMatch before, primarily because they were unaware of the tool. Some of the reported barriers include the difficulty in finding a suitable match because there is a greater number of dredging projects that have sediment available entered into the database as compared to restoration projects that need sediment. Some potential users have raised concerns that projects are committed to providing/receiving sediment if they enter their information into SediMatch.

Recent improvements included provisions in the data entry forms that are specific for entering upland sediment and recurring dredging events, useful for flood control agencies such as Zone 7.

5.8 Uncertainties About Obtaining Permits in a Timely Manner

Most FCCs are required by mission and/or by law to maintain functionality, and often also a certain level of channel capacity to convey flood waters. However, these same channels are subject to sediment deposition. In order to perform the necessary maintenance and remove sediment that has built up, FCC agencies must obtain permits from the regulatory agencies. The permitting process can be complicated to navigate, and can require approvals from multiple agencies that cover different jurisdictions, with different requirements for any given project (for more information see BCDC, 2017a). Due to habitat and species concerns and protections, sediment and other maintenance activities are usually only permitted between May 15th and October 1st. Any delays in the permitting process may cause additional costs for the FCC agency, and could even prevent the sediment removal from occurring during the targeted year, potentially causing the channel to be out of compliance and posing greater flood risk due to reduced capacity. In addition, a sediment removal often requires permits from multiple agencies, which can cause complexities and potential delays for the project. Because of these challenges, many FCC agencies are opting for developing a stream maintenance program, which is granted a 5-year permit to conduct sediment removal and other maintenance activities. These longer-term permits provide the agencies an annual framework for doing routine sediment removal activities, thus making the timing and volumes of those removals more predictable.

In addition, restoration projects also have to obtain permits and have strict timing for work seasons to do sediment placement and repair activities that revolve around habitat use for native and endangered species. Successful beneficial sediment reuse will require certainty around the timing and volume of sediment that is available, and alignment of the timing between removal and restoration projects or the cost-effective use of stockpiles.

5.9 Lack of Regional Planning, Guidance and Leadership

Making the transition to beneficially reusing sediment removed from flood control channels is an important regional issue. However, regional leadership to help unite the many different stakeholders and help the region reach this goal is generally lacking. The most significant coordinating entity in the region is the Bay Area Flood Protection Agency Association (BAFPAA), established to coordinate and provide mutual support in planning and implementing flood protection services amongst the flood protection agencies in the Bay Area. BAFPAA agencies voluntarily work together to improve flood protection projects, but have not formed a formal joint program focused on beneficial reuse of sediment similar to the program created by the Bay dredging community.

The Bay dredging community has the Long Term Management Strategy for the Placement of Dredged Material in the Bay Region (LTMS), a collaborative partnership involving regulatory agencies, resource agencies, the dredging community and stakeholders working together to maximize beneficial reuse of dredged sediment as a resource and minimize its disposal as a waste product. The LTMS Program is a 50-year program, with a programmatic CEQA/NEPA review in 1998, that resulted in the LTMS Management Plan (adopted in 2001), which describes the program goals, management measures, and requirements for voluntary implementation. As a result of the programmatic CEQA/NEPA process, the resource agencies provided programmatic ESA and EFH consultations, for projects occurring in the Bay. The LTMS agencies actively coordinate with dredging, restoration projects, and other beneficial reuse projects, and provide guidance on regional priorities. As a result, over 27 million cubic yards of sediment dredged from the Bay have been beneficially reused in the past 20 years.

There is no equivalent program for sediment removal from flood control channels in the Bay Area, and thus there is no plan for managing coarse sediment reuse collectively in the CEQA/NEPA realm. A significant effort was undertaken with the Flood Control 2.0 Project (SFEI-ASC, 2017a), that included an analysis of regulatory issues (BCDC, 2017a), and a short guidance document (BCDC, 2017b) that seeks to resolve some of these issues and provides steps to move towards a regional program. BCDC has provided some initial leadership for coarse sediment, however their jurisdiction is spatially limited. The SFBRWCQB is also examining this issue as part of a Basin Plan amendment. Further, regional prioritization of restoration projects is needed to ensure that the available coarse sediment is put toward the best or highest priority use. Many of the challenges discussed in sections above could more easily be overcome by addressing them at the regional level, however it would require a significant, coordinated effort and a willingness to tackle diverse projects with complex issues.

6. OVERCOMING THE BARRIERS AND CHALLENGES

The path towards real and meaningful change and reaching the goal of beneficially reusing all of the coarse sediment that is removed from flood control channels involves cooperation and involvement from the entire community of stakeholders. It is widely known that removal and disposal activities are expensive for the agencies that maintain channel or reservoir facilities, and that the managers are always actively seeking ways to reduce the need for removal or to reduce the cost. It is also known that restoration/mitigation/enhancement projects have a growing need for low-cost, timely, and guaranteed supplies of sediment. Increasing reuse of coarse sediment in the future will require reducing, or at least not increasing costs, for both parties, and providing new incentives to the full community of stakeholders to help create a reuse culture. To reach the goal, and change the paradigm of coarse sediment reuse in the Bay Area, a number of strategies, and likely a combination of many strategies, will need to be utilized.

SIDEBAR HIGHLIGHTS

Incentives and Solutions Overview

Overview of the key potential incentives and solutions discussed below that can increase coarse sediment reuse.

- Develop Regional Leadership
- Develop a Regional Overarching Plan
- Update Regulatory Policies
- Increase Regulatory or Monetary Incentives for Stakeholder Participation
- Better Define Contaminants Within FCC Sediment to Increase Reuse
- Increase the Use of FCC Sediment Even When Haul Distance Is Large
- Increase the Potential for Reuse of Small Volume Removal Events
- Increase Communication About Grain Size of Material
- Increase Predictability of Repair, Maintenance, and Sediment Removal Events for FCCs
- Improve Systematic Records of Storage and Removal Volumes and Costs
- Increase the Use of the SediMatch Web Tool
- Increase Timeliness of Permits

6.1 Develop Regional Leadership

A change to reuse culture begins with identifying people and organizations that can provide regional leadership around sediment reuse. This regional leadership can promote increased communication, adjustment of current permitting practices, new incentives, education, funding, and job development as they establish an overarching plan to address the region's sediment needs. The regional planning and guidance that they provide could more easily address many of the barriers and challenges discussed above, as compared to addressing these issues on a project-by-project basis. But most importantly, this leadership should communicate the true value of this coarse sediment, and help the region transition to thinking of it as a resource. For instance, perhaps the leadership could pursue a gubernatorial or legislative designation of sediment as an economically significant resource. In addition, the leadership should prioritize:

- fostering stronger relationships between different categories of stakeholders, including relationships between watershed managers and bayland managers, sediment producers and sediment users,
- creating a greater understanding of each category of stakeholder's barriers and challenges,
- encourage advanced planning by stakeholders and regulators, so that future opportunities for reuse are not lost,
- encouraging initial matches or pilot projects for flood control sourced sediment, to provide proof of concept and momentum,
- working with the regulatory community to create coalitions of regulators that can develop new guidance on sediment reuse, so as to increase predictability, and to work towards programmatic permits that allow greater flexibility and incentivize reuse,
- commissioning an economic analysis to quantify the costs associated with disposing of sediment at a landfill versus beneficially reusing it at a restoration site, and
- encouraging new partnerships that can enact creative solutions to overcome the barrier (for example, could landfill properties near the Bay margin provide temporary stockpile locations for sediment?).

Another important role for the leadership would be to engage and support other local groups with similar interests. For example, the Wetlands Regional Monitoring Program (WRMP) is an nascent effort to improve wetland restoration project success by implementing regional-scale monitoring to inform science-based decision making regarding baylands restoration. A partnership with the WRMP that includes the SediMatch Program and others could help quantify the future "market" for coarse sediment, help identify restoration sites, identify potential centralized stockpile locations, fill data gaps, and develop the regional strategy of where sediment is needed. The WRMP team could assist with prioritizing matches for projects that need sediment, communicating the regional implications of projects or groups of projects, implementing appropriate regional monitoring, and making progress towards the inclusion of upland sediment (soil, dirt) in regional beneficial reuse.

At this time, it is unclear what groups of individuals or organizations might be best suited to provide this leadership. Potentially the region could consider an existing Joint Powers Authority (JPA), creation of a new JPA, creation of a new organization via legislative mandate, expansion of duties provided by the San Francisco Bay Restoration Authority, or other groups or organizations identified by stakeholders.

6.2 Develop a Regional Overarching Plan

Changing the reuse paradigm will require a consensus-driven regional overarching plan to guide the future of reuse in the Bay Area. A successful plan will be developed with representatives of all stakeholder groups present at the table, to ensure the sense of ownership and to enable its implementation. The plan will need to accomplish many things including:

- providing a clear and broad definition of coarse sediment beneficial reuse that is inclusive of as many stakeholders and as much sediment as possible,
- helping to change the cultural perception of sediment and sediment removal by emphasizing that sediment is a resource or commodity for the region, not a pollutant,
- emphasizing the need for reuse, and lay out a pathway for the development of updated regional and statewide policies to facilitate reuse,
- exploring the appropriate timeframes that should be considered when evaluating the economics of sediment reuse,
- ensuring regulatory consistency, while providing appropriate regulatory thresholds and technical guidelines to the flood control agencies and restoration practitioners to make the process of reuse easier, and avoid having to negotiate the process on a permit-by-permit basis, and
- providing the regional justification for sediment removal and associated beneficial reuse, by highlighting that this restoration is contributing to wetland restoration and creation.

6.3 Update Regulatory Policies

Updated regulatory policies could encourage reuse of coarse sediment in the Bay Area. In particular, guidance and new policy initiatives by the Water Board could be very useful for the region and provide predictability for projects that want to incorporate beneficial reuse. And hand-in-hand with updated policies, a conscious decision by the regulatory agencies to be more flexible, especially over the next 5-10 years, could help establish beneficial reuse as standard practice. This flexibility could extend to analyzing regional risks in a holistic manner; for example, the need to balance the risk of contaminated sediment effects upon biota versus the risks of flooding and habitat loss due to sea level rise. Or this flexibility could extend to how regulatory agencies currently view sediment removal projects; the region would benefit from changing our view of these projects as "one-time" projects that require discrete mitigation, to part of a larger regional strategy to provide flood risk reduction and bayland habitat restoration.

For example, statewide policies could be adjusted to not penalize agencies for the additional transport that might be required to successfully implement coarse sediment reuse. These policies could also address local ordinances (e.g. truck traffic or noise) that might prohibit reuse, or encourage the development of "cleaner" trucking. Policies could be developed to allow sediment stockpiling, either along channels where sediment is removed, at centralized stockpile locations, or at designated locations within the restoration project footprint. Addressing any current limitations that discourage this practice will make the reuse of smaller volumes of sediment more attractive. Or policies could allow for different uses for sediment, such as filling in borrow ditches or construction of horizontal levees and other flood protection infrastructure that typically is not considered restoration, and thus is not considered a beneficial reuse of sediment. This is timely, as the regulatory community is currently actively seeking solutions for reuse both within the current legal framework (e.g. the LTMS) and in some cases by rewriting or reinterpreting the regulatory framework.

The region should be seeking a programmatic permit to allow and encourage beneficial reuse of coarse sediment for habitat restoration and other nature-based shoreline protection. This permit should include appropriate procedures, chain of custody details, and QAPP guidance. The permits could also include programmatic biological opinions, if appropriate. Developing the CEQA/NEPA documentation for the region that would be inclusive of all projects programmatically would help significantly. In addition, adjusting the thresholds within CEQA relating to greenhouse gas emissions associated with hauling of sediment would acknowledge and help balance the benefits being provided in relation to the impacts, and encourage additional reuse. And, since some of the existing flood control channels may be approaching the end of their operational use over the next decade or two, perhaps the flood control agencies can work with the regulators to design and permit flood control channel or sediment basin redesigns, so that sediment removal is easier, more predictable, and has less impact on the channels. For example, designing effective sediment basins, and designating them as facilities that are intended for regular sediment harvesting can reduce the costs to agencies for removal (by reducing the linear length of removal), while also reducing mitigation owed due to lesser impacts on habitat in the channels. For further discussion on the challenges associated with the permitting process and opportunities for increased coordination and collaboration see BCDC, 2017a.

Locally, the cost to a flood control agency of permitting a sediment removal is such that agencies often delay or minimize the amount of sediment they remove. Yet this sediment removal is essential to maintain low levels of flooding risk; in many instances sediment removal is not optional. Reducing the permitting fees would allow and encourage agencies to conduct more regular maintenance, making more coarse sediment available for reuse. This would allow these agencies to become more proactive, rather than reactive, in terms of maintaining flood protection and reducing risks.

In addition to costs, the timing of annual permits hampers beneficial reuse due to the very narrow window of time between when the permit is issued and when the seasonal work-window closes. A 5-year programmatic permit that is issued for stream maintenance programs would increase the predictability of sediment that is available for reuse. However, if longer-term programmatic permits could be issued for 10-20 years rather than just 5 years, it would better match our stated sediment reuse goal, and could promote regional long-range planning and allow for adaptive management that is proposed by permit applicants. If stakeholders and regulators are able to work hard now to develop and implement the permits and authorizations on 5 or even 10-20 year cycles, this will increase the likelihood of reuse occurring when projects are ready.

And finally, the quality assurance project plan (QAPP) that is required for each restoration/mitigation project could be amended so that the distinctions between fine and coarse sediment are clearer, and appropriate thresholds for coarse sediment contaminants are set. Typically contaminant concentrations vary inversely with sediment grain size, and thus we anticipate that guidelines that include a decision tree with grain size as the first determinant could be very helpful in reducing the total amount of contaminant testing that is needed. In addition, while updating the QAPP for coarse FCC sediment, perhaps changes could also allow other types of sediment. For example, there are large volumes of sediment generated in the region (e.g., from construction sites) that are disqualified from use in restoration projects due to standards and thresholds within each project QAPP, and thus are typically disposed of in landfills. Making reasonable adjustments in the QAPP will qualify significantly more volumes of sediment for use, as compared to what is currently allowable. These adjustments would likely allow restoration projects to utilize this relatively lower-cost sediment, rather than having to buy sediment for their projects.

While these regulatory issues may be difficult for the large, regionally important projects to overcome, they may entirely prevent smaller or opportunistic projects from proceeding. Understanding that not every sediment removal or baylands restoration project is the same, and allowing some flexibility between projects could increase the total amount of sediment that is made available for restoration in the region.

6.4 Increase Regulatory or Monetary Incentives for Stakeholder Participation

One essential strategy for increasing reuse is to develop and enact incentives to encourage stakeholders to participate. While the idea of reuse is well received by stakeholders, and many would like to participate, the financial or regulatory burdens or the lack of incentives are currently preventing their participation. Effective incentives likely span a broad range of categories, and should be tailored specifically to stakeholder groups (e.g., flood control agencies, restoration managers, "dirt brokers", and aggregate companies).

Currently, some flood control agencies are incentivized by internal needs or drivers to find local reuses for their sediment. For example, the agency might prioritize a local reuse of sediment if it can protect their own infrastructure or provide a benefit to the public they serve. Other agencies locally reuse sediment for landscaping needs to avoid paying for disposal. The region must therefore consider additional incentives to increase the participation by flood control agencies. For example, when flood control agencies wish to conduct a sediment removal, they must obtain permits, and are required to conduct measures to mitigate for the disturbance of the channel and its habitat. While agency staff agree that mitigation is an essential part of managing and protecting our resources, often the mitigation requirements put a large financial (over the lifetime of the mitigation project and its monitoring requirements) and staff-time burden on the agency, and can even delay or prevent a sediment removal from occurring. If the regulatory agencies were able to offer a mitigation credit to the flood control agency, that is either a reduction in or removal of the mitigation requirements in exchange for the beneficial reuse of the sediment, this could profoundly alter the equation and incentivize reuse. In other words, if the regulatory agencies analyze the net ecological cost/benefit across both the sediment removal and the sediment reuse project, the benefits of reuse could ameliorate some or all of the mitigation requirements of the removal project. If the flood control agencies specified a wetland reuse for the sediment in their permit applications (e.g. baylands restoration, spawning gravel augmentation), perhaps the regulatory agencies would be more inclined to issue the permit for the removal. In addition, if the reuse was within the same watershed, it could be even more appealing. These flood control agencies also often only conduct sediment removals when their channels or facilities are at capacity; if the region could incentivize more frequent removals, the consistency and predictability of available sediment for reuse would increase.

Credits could also be offered to parties that simply provide the hauling of the sediment. "Dirt brokers" (e.g., Graniterock or Pacific States Environmental Contractors), or aggregate companies (e.g., CEMEX or Vulcan) are not well known outside of the restoration community, but may be key to the reuse process. These companies regularly transport sediment to/from project sites across the Bay Area. For example, if a “dirt broker” was able to transport the sediment, the regulatory agencies could offer a beneficial credit for their business (e.g., in relation to greenhouse gas emissions associated with the company’s actions). This would essentially be a different type of mitigation credit. Other parties, such as Caltrans, could even be considered; Caltrans regularly needs to conduct mitigation for impacts caused by road projects. Because Caltrans has the hauling trucks and equipment, perhaps they could meet some mitigation requirements by simply transporting sediment for other parties.

In addition to credit-based incentives, there are other financial and social incentives for “dirt brokers”. Development regularly generates large volumes of sediment (e.g., digging a basement or foundation for a large building) and “dirt brokers” are hired to transport that sediment from construction sites to an appropriate disposal location. Often disposal occurs at a landfill, but this requires the brokers to pay a “tipping fee” to offload each truckload of sediment. To increase profits, the brokers want to avoid the landfill tipping fee. If the broker is able to transport the sediment to a project location, they can potentially make profits if the distance is less than that to the landfill, if they can avoid tipping fees, and if the extra costs of testing to meet QAPP requirements are less than the original bid for the job. Additionally, a social incentive for dirt brokers to participate in the reuse process would be if their actions are perceived as “doing the right thing” and they could gain favor with clients, who will want to buy more products or conduct more business with them.

Restoration project managers could be incentivized to accept coarse sediment through regulatory agencies offering adjusted permit requirements that encourage reuse. This could be accomplished by adjusting the contaminant concentration thresholds, allowing or encouraging on-site stockpiling, or allowing for flexibility in the timing of the delivery and placement within a project. For example, if stockpiling within the project footprint were encouraged, this could provide a financial incentive for the restoration project to design a stockpile location into the plans, so that they could utilize potentially lower-cost reused sediment, rather than purchasing newly-sourced sediment. Also, if State, Federal or bond funds were accessible to help offset the cost of hauling sediment, more projects could be incentivized to participate. And if additional pilot projects specifically using coarse sediment were to be designed and implemented, it would provide the design plans for other projects to mimic, and provide assurances that coarse sediment elements are functional and viable.

Finally, financial incentives could inspire other businesses to participate in the reuse market. For instance, aggregate companies could be financially incentivized to participate by allowing them to sell a portion of the material that is delivered to their properties for stockpiling. Perhaps a certification system could be developed to provide “green” certifications to these businesses that participate in reuse. Or perhaps other small businesses could create new jobs and make a profit by providing specific services (e.g., match-making, sorting, hauling, stockpiling, testing) within the reuse process.

As with Low Impact Development (LID), we need to move from random or pilot scale one-off projects (which tend to have high costs) to regionalized, institutionalized management paradigms and policies that systematize reuse as business as usual, thus making it the preferred cost-effective approach to sediment management (a reuse culture).

6.5 Better Define Contaminants Within FCC Sediment to Increase Reuse

Contamination is one of the main barriers to the reuse of coarse sediment, and has associated issues that must be addressed. Overall, contamination limits potential uses of coarse sediment. To date, the strategy to reuse sediment that carries contaminants beyond allowable limits has been two-fold. The contaminated sediment can be blended with cleaner sediment in a manner that is agreed upon through the development of the QAPP (although blending sediment from multiple sources for beneficial reuse is hypothetical, and has never been allowed by the SFBRWQCB to date). Alternatively, the contaminated sediment can be used for foundation material (burying it under three feet of cover material), where the limits of contamination are less stringent. This option carries the challenge of a restoration site needing to receive sediment in the right ratio of foundation to cover before design elevation is achieved. A restoration site can end up not being able to recover more foundation until enough clean cover sediment can be received.

Secondly, the guidelines for contamination levels of coarse sediment could be updated, since they are currently 20 years old. The current testing requirements for contamination are based on reuse of Bay sediment (SFBRWQCB, 2000), the list of contaminants is long, and many of these contaminants are not found in large quantities on sands and gravels. Therefore, it is likely that testing of FCC-sourced sediment will show many non-detects. A strategy for reducing these costs would be to write a fluvial FCC specific version (perhaps including excavated upland materials as well) of the Water Board staff report "Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines" that could include:

- a specific (smaller or at least targeted) list of contaminants found in fluvial FCC sediments,
- a new formulation of risk quotient based on better relationships between the contamination in FCC sediment and actual toxicity (a starting point could be the Stream Pollution Trends (SPoT) Monitoring Program (Phillips et al., 2020),
- a relationship for these contaminants and grain size so that reduced testing procedures could be exercised with appropriate risk factors built in,
- different concentration thresholds for coarse material used as foundation material (beneath at least three feet of cover sediment),

ZONE 7
CASE STUDY

Streamlined Pathways for Beneficial Reuse

Zone 7 is in a potentially unique position in that its sediment is relatively coarse and likely has low concentrations of anthropogenic contaminants. Pilot contaminant testing could be done to determine typical contaminant concentrations in relation to grain size. This information could be used to negotiate an agreement with the Water Board for reduced future testing requirements and more streamlined pathways for beneficial reuse of the sediment.

- allowances for sediment that is reused within the same watershed from which it was sourced, or along the Bay margin reused within the same Bayland Operational Landscape Unit (OLU) (SFEI and SPUR, 2019) that the watershed drains to,
- discussion around regional contaminant differences (e.g., higher levels of mercury within the Guadalupe River watershed).

Some reduction in costs for beneficially reusing sediment could be realized with this fluvial FCC specific version of the guidelines, in combination with amended project QAPPs that refine the distinctions between fine and coarse sediment. Together the guidelines and amended QAPPs could reduce the volume of sediment that is disposed of as "waste" and redirect it towards the appropriate reuse along the Bay margin.

In addition, a number of small pilot projects that use coarse sediment with varying levels of contamination could be developed and implemented, so that the appropriate monitoring can be conducted to provide data to help determine appropriate contamination thresholds. Also, incentives could be created to encourage a market to emerge that would help sort the removed sediment, so that the very coarse sediment is separated from the sand-sized sediment, which may have different uses as well as different (potentially lower) levels of contamination.

PHOTOGRAPH COURTESY OF ZONE 7 WATER AGENCY

6.6 Increase the Use of FCC Sediment Even When Haul Distance Is Large

Addressing haul distance comes down to an economic equation that is site specific. Is the cost of testing for contaminants and following all other QAPP procedures (including waiting for biological windows, etc.), and hauling to a restoration site cheaper than the cost of hauling to a landfill and paying a disposal cost? Ideally, projects that generate sediment would be spatially close to those that need sediment, and a match could be made. But often this is not the case. Strategies for dealing with haul distance relate to trading and technology.

Trading

A method that could be employed is referred to as a "Sediment ATM". This concept is similar to a banking system where money stored in an account can be withdrawn from any number of distributed ATMs as long as an accounting ledger is accurately maintained. Could a network of stockpile locations (perhaps including properties owned by flood control agencies, aggregate companies, "dirt brokers", landfills, or Ports) be developed where sediment can be "deposited" near sediment source areas in FCCs and then removed (a "withdrawal") from another stockpile location that is closer to where the sediment is needed? If this was successful, it could provide a regional sediment stockpiling, processing, and sharing method. However, there are a number of questions and challenges with this concept that need to be resolved:

- An accounting system would be required for the "ATM" idea to work, and some entity must manage the system. What would be the mechanism for maintaining stockpiles, such that those near restoration sites are depleted? Could the companies who run the stockpiles manage this challenge, while keeping the accounting ledgers accurate? Potentially, the SediMatch Program and webtool could fill this accounting need.
- Sustained funding would be needed to maintain and coordinate the management system.
- An entity or entities would need to perform oversight.
- Would "dirt brokers" or aggregate firms like Pacific States Environmental Contractors, Graniterock, CEMEX, Vulcan and others be interested in such a system and take part? Incentives for their participation might include increasing their environmental "good corporate citizen" profile as well as financial gain.
- Incentives for sediment producers (e.g., flood control agencies) and sediment users (e.g., restoration projects) would need to be developed.

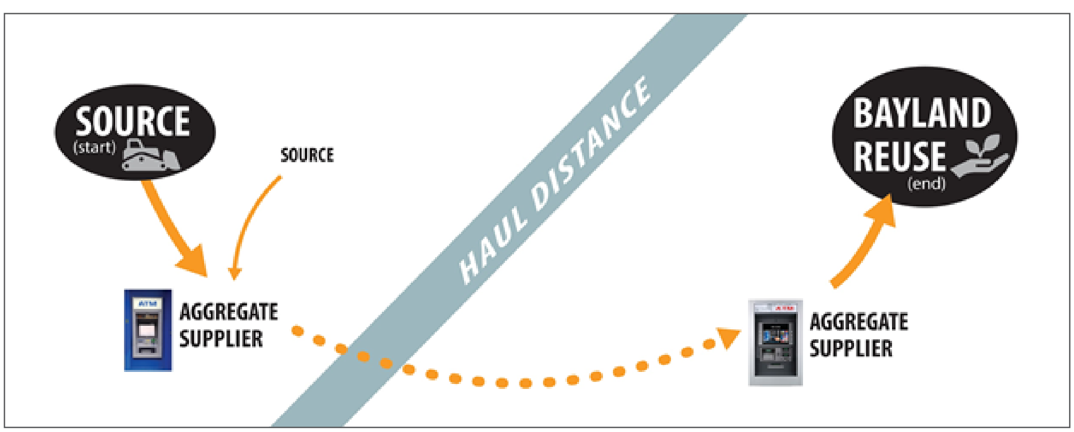


Figure 4. The concept of a "sediment ATM", where sediment suppliers (e.g. flood control agencies) can make a deposit of sediment to the network, and a user can make a withdrawal of sediment from the network closer to the reuse site.

Concept of a "Sediment ATM"

Conceptually, the "Sediment ATM" idea could be beneficial to Zone 7 due to its distance from the Bay and proximity of local aggregate companies. Zone 7 already works locally with Vulcan and CEMEX on groundwater monitoring and impacts of quarry activities, and also has several agreements regarding the condition of mining activities. Given these relationships, there is a possibility that this existing sediment network could be built upon.

Unfortunately Vulcan's Bay Area locations are not proximal to the Bay (Pleasanton, Half Moon Bay, and Los Gatos). However, Vulcan has expressed an interest in the sediment reuse program and have an extensive stockpile of gravel that is adjacent to Zone 7 property, a byproduct of their processing plant that they might be interested in finding a reuse home for, especially if it's a free (or relatively cheap) disposal option.

In contrast, CEMEX has operations in Pleasanton and its Richmond, San Francisco, and Palo Alto operations are proximal to the Bay. CEMEX is therefore possibly better positioned as a partner for reducing the impacts of distance on Zone 7's reuse potential, if they would be willing to receive materials at the Pleasanton quarry site and release an equivalent volume and grain size of material from Richmond, San Francisco, or Palo Alto. If it turns out that CEMEX can profit from receiving coarse material from Zone 7 but releasing coarse or fine material from Richmond, San Francisco, or Palo Alto, this would potentially solve reuse limitations associated with Zone 7s coarse material and could be a win for CEMEX if the economic value of the differing materials works in their favor.

The sediment ATM concept would also likely address the issue of reusing small volumes since presumably the ATM would accept any volume, large or small within the agreements set up with the manager of the ATM. This again could benefit Zone 7 and other agencies that only produce relatively small annual volumes.

Technology

The use of a slurry pipe from a large or reliable source or stockpile location may also be an option under certain circumstances. The basic concept is that sediment can be mixed with water at the source and piped downhill under gravity to a restoration site or a stockpile near the Bay margin. For example, sediment trapped behind dams presents an additional potential sediment source for consideration to augment bayland sediment needs. If the source is a dam, water from the reservoir could be used. If the source is a stockpile near a FCC, the use of treated wastewater may be an option. The source could also be large future tunneling projects (e.g., by Caltrans, BART or San Francisco Municipal Transportation Agency). So far however, there have been no pilot projects to explore the economics and there are many questions:

- Would the benefits outweigh the costs of construction and environmental impacts associated with building the pipeline?
- Would the small haul distance to the pipe and from the pipe to a restoration site be economically viable?
- What would be the system (e.g., holding ponds) for separating sediment from the water at the receiving site?

A study or pilot example that explores the specific pros and cons, including costs, greenhouse gas emissions, and environmental impacts, could be conducted to better understand the viability of this method.

Speeding Up the Reclamation Process

Another interesting incentive for Vulcan could be to involve Zone 7 in exploring ways of speeding up their reclamation process. Vulcan excavates sands and gravels from their properties near Pleasanton for commercial use in products such as concrete, asphalt, road base, and backfill. They have a permit exemption with the County to replace material back into the ground as long as it is designated "inert". The waste materials they produce (silts and clays that comprise about 20% by volume of their operation) are typically washed with onsite water and placed back into the ground. But they have about 10 million cubic yards of space that needs to be backfilled before they can sell off their property for another future use (e.g., to a real estate developer). They are allowed to receive sediment from other entities as long as the volumes are small (<5,000 cubic yards) and as long as the lab results indicate they are "inert." If Vulcan trucks are used to transport Zone 7 sediment to the Bay margin, after delivering the sediment they would make the return trip to Pleasanton empty. However, if other small loads of sediment (e.g. construction sediment) could be transported back to Pleasanton for backfill at the quarry site, Vulcan could receive some benefit, rather than just paying for the trucks to be driving empty. In other words, cost savings on making the truck trip could be achieved if sediment is hauled in both directions- the first leg of the trip hauling sediment for bayland beneficial reuse, and the return leg of the trip hauling inert sediment for quarry backfill. If the timing and costs were a win-win for both entities, this would help to facilitate Zone 7 sediment reuse on the Bay margin.

Focusing on the closest Bay restoration sites may be the other option for Zone 7. Eden Landing is perhaps the nearest restoration site that is actively in need of coarse sediment. There are two aspects to the potential reuse of sediment at this restoration site.

- Levee repair: In the long run, the existing levees at Eden Landing need to periodically be shored up to create onsite decanting cells to settle the sediment in the wetlands before release of the water back to the Bay. The provision of material from Zone 7 may allow more frequent levee maintenance and increase the reuse of material. The amount that Zone 7 produces would be appropriate for levee maintenance especially if Zone 7 were able to place it roughly where it would be needed; and as long as there was no active construction happening, there would be no liability for Zone 7.

- Resilient by design - gravel cobble beach dune and berm: The 30% design for a beach and berm project has been completed by SCAPE (https://www.scapestudio.com/people/gena-wirth/) through a Proposition 1 grant, and the remaining design work will be completed by Ducks Unlimited. The project will likely involve about 300 linear feet of beach needing about 2,200-3,000 CYs of gravel. This could be a good match for about a year's worth of Zone 7 sediment if it's clean enough and in the right size range (D50 between 2-8 mm). In addition to the volume, grain size, and contaminant levels, the haulage costs would need to add up to less than the "business as usual" disposal costs. To get conversations and negotiations started, some sampling and analysis for chemistry and grain size would need to be done on stockpiled materials following QAPP guidelines (USFWS, n.d.).

6.7 Increase the Potential for Reuse of Small Volume Removal Events

The relative costs of writing and adhering to a QAPP, managing a sediment hauling contract, contaminant testing, QAQC, data management and a number of other one-time fixed costs are lower per unit volume as total volume increases. This can be a challenge for flood control agencies since, in many cases, removal volumes are relatively small. One way of increasing the chances of reuse is for the agency or for a third party to stockpile sediment until a large enough volume is generated to become financially attractive.

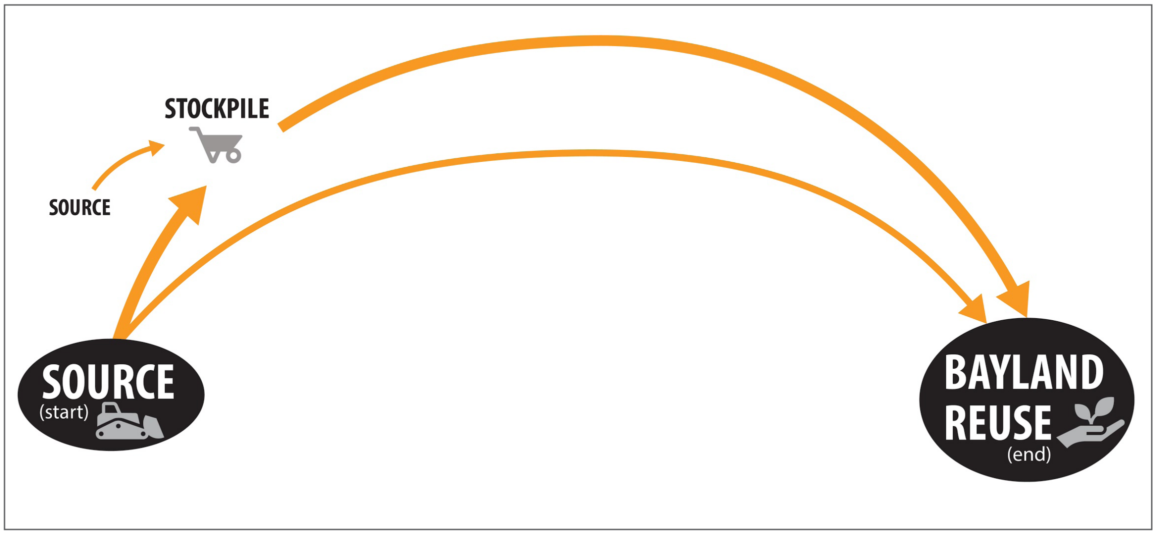


Figure 5. The concept of sediment stockpiling, where the stockpile acts as a buffer for small or unpredictable volumes, or mismatches in work windows.

Oftentimes relatively small volumes (100s to 1000s of cubic yards) of sediment are removed from FCCs in a single project. Given the associated costs, it would not be economical to transport this small amount of sediment to a baylands restoration site, nor would it be efficient for the restoration to receive such small volumes of sediment. Stockpiling sediment provides a potential solution. If a network of stockpile locations could be developed, and those stockpiles were only a short distance from the removal sites, it would be relatively inexpensive to transport and offload the removed sediment. Once enough sediment was accumulated, the agency that manages the stockpile could request bids for the transport of the total large volume of sediment for the longer distance to the restoration site as a single project. The cost savings is in conducting a single large sediment transport project, rather than a number of much smaller transport projects, and the efficiency for the restoration project in receiving a singular large volume of sediment. Additional savings could be realized if the stockpile could separate "clean" sediment, that is sediment with laboratory testing showing low levels of contamination. If the sediment is clean, a lower total volume in the stockpile may be needed before transport to a restoration site occurs, since other costs are also reduced and the array of beneficial uses increases.

However, there are three particular issues associated with stockpiling that would need to be addressed. Firstly, stockpiling causes a double handling cost to be incurred, and could be prohibitive if the cost adds up to more than the haulage savings. However, there is evidence that material is at least sometimes already double handled for drying, perhaps stockpiling at specific strategic locations might reduce the total overall costs. Secondly, stakeholders must consider finding an appropriate location for the stockpile, and the length of time that material will be stored (as there is potential for the stockpile to become habitat). Stakeholders could explore the idea of stockpiles at unconventional locations (e.g., aggregate company property, unutilized non-active areas on landfill property, Port of San Francisco and other port property, or even non-active areas within the footprint of restoration projects). Many stakeholders have noted that including stockpile locations in the restoration project plans and allowing for these stockpiles within the permits would be very beneficial to the restoration project, and would help to solve many of the challenges and barriers that were discussed above. Finally, there are various limitations on stockpiling within the current permitting process. Changes to the regulatory permits (as discussed above) could address this issue, and encourage the future use of more stockpile locations.

6.8 Increase Communication about Grain Size of Material

Coarse materials such as sands and gravels have unique properties (e.g., high specific density, low organic carbon, low contaminant concentrations, high interstitial space) that can be desirable for constructing specific wetland habitat features and nature-based shoreline protection, as described in Section 4. However, these same properties, coupled with the small volumes that are typically available, also render it less desirable for general wetland restoration projects where the bulk of material needed is fine grained. Bay margin restoration projects typically avoid including the specific habitat features that require coarse sediment due to the unreliability of sourcing the materials.

Increased communication about the availability of, and need for coarse-grained material will be key for increasing the total volume that is reused. Greater use of the SediMatch Program and webtool provides an opportunity for this communication to occur. This could encourage more projects to include the specific exclusively coarse grained habitat elements or shoreline protection elements, and could lead to new partnerships between entities that have not worked together in the past.

ZONE 7 CASE STUDY

Stockpiling Sediment

Zone 7 already utilizes stockpiling for a portion of sediment that they remove. When sediment is disposed of at a landfill, there are disposal fees that are based on weight, currently charged at $20 a ton. Thus, it is economical to let the sediment dry out before taking it to the landfill. The stockpile at Cope Lake is currently used for this purpose. But, this also shows that sediment is already double handled, which adds cost. Could the Cope Lake or another viable location be utilized to not only dry the material, but also stockpile material until a large enough volume is generated that then becomes financially attractive to utilize in a restoration site?

In addition, Zone 7 is also working with other Tri-Valley agencies, such as the City of Livermore, to reuse or stockpile their material. For example, in 2020, a portion of the gravels removed by the City from the Arroyo Mocho at Holmes Street was reused for local roadways, however an arrangement was reached with Zone 7 to stockpile the remaining portion for Zone 7's future reuse.

6.9 Increase the Predictability of Sediment Available from Repair, Maintenance, and Sediment Removal Events in FCCs

Coarse sediment from FCCs may not be available every year, and the mis-match in timing with the needs of restoration projects could create some lost opportunities for beneficial reuse. There are two main strategies that can be used to address this issue:

- Adjusting the permit conditions or maintenance/removal paradigm for a steadier stream of sediment available for reuse. The volume of sediment delivery to channels varies from channel to channel and year to year, and is largely driven by hydrologic conditions. Sediment removal also varies from channel to channel and year to year, but the management and frequency of removal is not only driven by sediment transport processes, but also by thresholds for sediment removal (e.g., for maintaining channel capacity), and time needed to plan, design, permit and implement sediment removal projects. Typically agencies will wait until after the winter flows subside before making a decision if sediment removal is warranted. Once the decision to remove sediment has been made, additional time is needed to plan, design, and submit permit applications. Because sediment removal can often only occur before mid-October, removal may be delayed until the following year if the work window is too small. In order to increase the predictability of the volume of sediment available from removals in FCCs, one management approach could be to move away from individual sediment removal projects, and move towards a more programmatic approach to stream maintenance and sediment removal. This approach could have many benefits for the FCCs as well as the restoration project:
    - › The permit conditions could be written so that agencies would conduct planned sediment removals at regular time intervals, despite the volume of sediment that was supplied to and deposited in the channel since the previous removal event. Conducting regular removals on a pre-planned schedule would provide predictability in the timing and volume of sediment that would be available for restoration. This approach would apply to, and be particularly important for channels that have large storage volumes or large removal volumes. There are nine channels that have had total removal volumes greater than 50,000 CY (Alameda Creek, Walnut Creek, Petaluma River, Gallinas Creek, Novato Creek, San Tomas Aquino Creek, Napa River, Old Alameda Creek, and Sunnyvale East Channel). These channels happen to be close to marsh restoration sites and could be targeted for increasing the reliability of supply to increase reuse opportunities.
    - › Having a long-term permit in place for sediment management activities would allow FCCs to start planning, design, and implementation earlier, and could lengthen the work window for FCCs to conduct removal.
    - › Permit conditions could be written that identify mitigation requirements that incentivize sediment reuse for restoration and encourage FCCs to participate in regional sediment reuse. In some cases, mitigation requirements might be greatly reduced in cases where sediment can be contributed to a restoration project.
- Framework for prioritizing restoration projects in need of sediment based on project timeframe or other relevant factors. Given the current uncertainty in the volume of coarse material that is available annually to restoration projects (due to year-to-year

variations in watershed sediment transport and deposition, obtaining permits, having the necessary funding to conduct sediment removal, etc.) another method that can help increase the predictability of volume of sediment available to restoration projects is to create a sediment reuse prioritization framework to funnel available sediment supply to restoration projects based upon the restoration project timeframe instead of a first come, first served approach. In the case of baylands restoration projects, short term projects must receive sediment during a shorter window of time, and are better positioned to utilize sediment from predictable sources, such as pre-planned removals from specific FCCs. Longer-term projects might have more flexibility in the timing of sediment delivery, and could perhaps utilize the less predictable supplies of sediment, in combination with sediment from stockpiles. Given these two different time scales, the matching and delivery of coarse FCC sediment to restoration projects could be carefully coordinated and prioritized.

ZONE 7 CASE STUDY

Increasing Predictability

Managing channel capacity in the Tri-Valley area and creating a more predictable volume of available coarse sediment requires an understanding of the location of the Valley within the larger watershed, and how sediment sourcing, transport, and deposition processes control the timing and location of coarse sediment deposition. Zone 7 and the City of Livermore recognize that coarse sediment is preferentially deposited in the Arroyo Mocho channel as it exits the uplands and moves downstream onto the Valley floor. Two existing locations of regular sediment removal (the Zone 7 sedimentation basin at Isabel Ave, and the City of Livermore removals at Holmes Street) are located within this area and additional sedimentation basins along this reach are being explored. Livermore already has a stream maintenance program in place with associated programmatic permits and Zone 7 is working on acquiring permits for their proposed routine maintenance program. A regular and predictable schedule of sediment removal at these locations would help increase the predictability of sediment that is available for reuse. With the right incentives in place for both agencies, these basins could become the keystone for the development of a sustainable sediment harvesting and flood risk reduction program.

6.10 Improve Systematic Records of Storage and Removal Volumes and Costs

Systematic records of volume of storage and removal (volume, grain size, current fate, and chemistry) are currently lacking. The main strategy would be to start systematically collecting this data, potentially through FCC permitting, and putting it into a regional database (e.g., SediMatch) which would clarify how much, and how often useful sediment is being generated. This information would provide baseline data for stakeholders to begin assessing source reliability and the economics of beneficial reuse. A regionally consistent standardized methodology that includes longitudinal profiles and cross sections in channels (either collected through standard surveying, unmanned aerial vehicle, or LiDAR) could also be developed and used.

PHOTOGRAPH COURTESY OF ZONE 7 WATER AGENCY

PHOTOGRAPH COURTESY OF ZONE 7 WATER AGENCY

6.11 Increase the Use of the SediMatch Web Tool

SediMatch was developed as a collaborative forum to help the region reach our shared goals of sediment reuse. However, use of the SediMatch web tool has been limited despite recent improvements, including provisions specific for entering upland sediment and recurring dredging events. A tool like SediMatch needs to reach critical mass before it begins to fully function and perform up to or beyond expectations. The more data that is entered and the more numerous and diverse the user community is, the more likely it will be that matches are made.

During the workshop, participants responded that SediMatch would be a useful tool for them; many agencies have sediment available for reuse, many projects could benefit from reused sediment, and a wide variety of sediment types are needed. Participants that had not used the tool indicated that they simply were not yet aware of the tool. Those participants that had used the tool indicated that it was easy to navigate and they were hopeful to be part of a successful match. Participants were then asked to provide feedback on how to improve the tool, and what might incentivize them to utilize the tool. Based upon this feedback and past discussions, we suggest that increasing tool use could be supported through the following mechanisms:

- Improving the SediMatch data entry forms and querying features
  - Modify form to capture ongoing or periodic monitoring
  - Adapt form for entering proposed or longer term entries, recurring dredging, and existing stockpiles
  - Add additional grain size information
  - Add information on sediment quality and testing results
  - Add information on hauling logistics
  - Add a calculator to convert volume to number of truckloads, and to calculate distance (miles) between locations. These features will assist in calculating costs.
  - Create a new form for submitting successful matches
  - Add guidance information/definitions
- Increasing data entry (content) and linkage to other pertinent databases and processes
  - BCDC, Water Boards, and other regulators could include language in permits related to adding the information into SediMatch web tool and/or assign staff to enter the relevant details into the tool
  - Establish an internship or funded initiative to enter restoration project information
  - Link to other data sources (e.g., testing results, Project Tracker)
- Performing direct outreach and automated communications
  - Expand user community email list
  - Add emphasis and increase deliberate personal discussions with key stakeholders. Target the big projects (e.g., South Bay Salt Pond Restoration Project, Bel Marin Keys). Target the consultants and agencies who design big projects (e.g. Moffett & Nichol, Environmental Science Associates (ESA), Ducks Unlimited, AECOM, ICF, WRA Inc., East Bay Regional Park District (EBRPD), U.S. Fish and Wildlife Service (USFWS), etc.). Target entities generating sediment (e.g., East Bay Municipal Utility District, PG&E

    - and other utilities, Flood Control Districts, developers, "dirt brokers" and aggregate companies (Pacific States Environmental Contractors, Graniterock, Vulcan, CEMEX, and others)
    - Webinars/Workshops to bring sediment removal activities and restoration projects together
    - Communicate that data entry is not a commitment to supply/receive sediment
    - Utilize existing workshops and existing regional collaborations/entities (e.g. BAFPAA meetings)
    - Target outreach to new members, including quarry owners who may be producing coarse rock materials as a byproduct of their operations and "dirt brokers" who may be interested in cheaper disposal options for their sediment (in the form of beneficial reuse opportunities)
    - Advertising and celebrating successful matches
- Consider expanding beyond the sediment generated by public agencies (e.g. Flood Control agencies), and explore opportunities for requiring data entry for private developers (generating construction-related sediment) as a part of their permit requirements
- Develop additional incentives and/or requirements within management agencies
    - Write a sentence into the Dredged Material Management Office (DMMO) letter
    - Require flood control agencies that have to pull permits for sediment removal to enter their data
    - Require restoration planners to enter their data as part of pulling their permits
    - Have regulators recommend and encourage the use of the tool

6.12 Increase Timeliness of Permits

Both flood control agencies and restoration entities need to obtain permits in a timely fashion to ensure they can carry out their activities in the targeted work season. Any delays in the permitting process can affect the timing of sediment removal work and even cause deferment to the following year, potentially adding extra costs and exposing the FCC to flood risk. At this time there are several identified avenues available to address this issue:

- Long-term permits for FCCs including sediment removal activities would reduce the scheduling uncertainty associated with individual project permits. To increase the timeliness of decisions around sediment removal from FCCs and beneficial reuse, FCC agencies could consider negotiating 5-year (or even 10-20 year) programmatic permits with the regulatory agencies that include agreed-upon beneficial reuses. Perhaps negotiations could even include pre-authorized beneficial reuse conditions for sediment removal. Although these types of permits take longer to negotiate in the beginning, they can be more efficient and reliable in terms of building relationships with entities wishing to reuse the sediment.
- Consider reaching out to the Bay Restoration Regulatory Integration Team (BRRIT), which consists of staff from six State and Federal regulatory agencies with jurisdiction over habitat restoration projects in the Bay, to gain their assistance in the permitting process to help make the beneficial reuse of sediment more clear and efficient for groups that generate sediment as well as those that need sediment. They could also facilitate the incorporation of regional ideas and solutions into individual projects.

7. CONCLUSIONS

Establishing a paradigm of beneficial reuse of sediment will require the entire community of stakeholders to come together to develop a framework to support the reuse of coarse flood control channel sediment in bayland wetland and habitat restoration projects. Given the number of existing challenges and barriers to reuse, stakeholders must collaborate and cooperate to implement the identified incentives and solutions. While all are important, a number will be essential for the region to successfully reach the goal. These include developing regional leadership to provide planning and guidance and a consensus-driven regional overarching plan to guide the future of coarse sediment reuse in the Bay Area. Updating regulatory policies regarding programmatic and longer-term permits, QAPP standards and thresholds, and mitigation credits for the transport and reuse of sediment will be a catalyst for change. It is essential that we find a way to provide or increase incentives for each party to participate in the beneficial reuse network. Enacting creative solutions, such as a "Sediment ATM" for the region, and increasing the use of the SediMatch web tool, will provide the practical mechanism for successfully reusing all coarse sediment.

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SIDEBAR HIGHLIGHTS

"Thinking Outside the Box" Potential Solutions

The sections above describe the many important and intriguing incentives and solutions that could be enacted to help increase beneficial coarse sediment reuse in the region. However, some of those potential incentives and solutions are more unconventional, or "outside the box" as compared to others. Here we highlight some of those "outside the box" ideas that were described in sections above, not because they are more important than the other more conventional ideas, but because they are more unique.

- **Newly identified regional leadership could work towards communicating the true value of sediment,** and even could pursue a gubernatorial or legislative designation of sediment as an economically significant resource. They can also work with the regulatory community to create coalitions of regulators that can develop new guidance on sediment reuse, so as to increase predictability, and to work towards programmatic permits that allow greater flexibility and incentivize reuse.

- **Encourage the regulatory agencies to be more flexible,** especially over the next 5-10 years, so that beneficial reuse can be established as standard practice in the region and part of a solution to provide flood risk reduction and bayland habitat restoration.

- **Statewide policies could be adjusted to not penalize agencies for the additional truck transport** that might be required to successfully implement coarse sediment reuse at the Bay margin.

- **A project's quality assurance project plan (QAPP) could be amended so that other types of sediment (e.g., from construction sites) are allowed,** increasing the total volume of sediment that is available for reuse.

- **If the regulatory agencies were able to offer a mitigation credit to the flood control agency,** that is either a reduction in or removal of the mitigation requirements in exchange for the beneficial reuse of the sediment, this could alter the financial equation and incentivize beneficial reuse.

- **Credits could also be offered to parties that simply provide the hauling of the sediment** (e.g., "dirt brokers", aggregate companies, or Caltrans). For example, Caltrans regularly needs to conduct mitigation for impacts caused by road projects. Because Caltrans has the hauling trucks and equipment, perhaps they could meet some mitigation requirements by simply transporting sediment for other parties.

- **Write a fluvial FCC specific version** of the Water Board staff report "Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines" to better define contaminants and reuse thresholds in coarse sediment.

- **Develop a regional "Sediment ATM"** where a network of stockpile locations (perhaps including properties owned by flood control agencies, aggregate companies, "dirt brokers", landfills, or Ports) can accept "deposits" of sediment near sediment source areas, and release "withdrawals" from another stockpile location that is closer to where the sediment is needed.

- **Encourage greater use of the SediMatch Program and webtool** by continuing to improve the forms and queries, by increasing data content and linkages to other databases, by performing direct outreach, by expanding into new groups of stakeholders, and by developing additional incentives or requirements within management agencies.

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9. APPENDIX: ZONE 7 COARSE SEDIMENT DATA COMPILATION

Introduction

Historically the Livermore-Amador Valley (Valley) portion of the Northern Alameda Creek watershed has been the location of net sediment deposition. Sediment sourced from the upper watershed was transported downstream into the Valley, where stream power rapidly decreased due to lower channel gradient, causing the streams to spread out, water to sink in, and sediment to be deposited. Due to loss of stream power, the coarse sediment, with grain sizes of sand, gravel and cobble (> 0.62 to 256 mm) was deposited closest to the uplands, fining to silts and clays (<0.62 mm) further downstream towards the historic Pleasanton Marsh Complex near the outlet of the Valley (Stanford et al., 2013). However, since European contact, extensive modification of the channel network, including the construction of Del Valle Dam, has led to large changes in how water and sediment derived from upland areas pass through the Valley. Additionally, the Valley has experienced many land use changes, in particular, significant urbanization over the past 50 years, causing changes in the timing and amount of water and sediment delivered to the channel network. These changes have led to the current condition of overall net sediment transport through the Valley (Stanford et al., 2013; Pearce et al., 2015).

Despite this situation of overall net transport, there are locations of chronic sediment deposition in the Valley that can reduce channel capacity, disrupt habitat, contribute to property and infrastructure damage, and undermine system integrity. Chronic deposition occurs at discreet locations in certain channel reaches, underneath several bridges, in sediment basins designed for capture, and at a few specific culvert outfalls, which requires removal and can be costly. The sediment that is deposited is typically coarse sediment, with grain sizes of medium to coarse sand, gravel, and cobble. The fine sediment (clay, silt, and fine grained sand) is more easily transported downstream, and typically comprises only a very small proportion of the sediment deposited in these locations. Once removed from the channel network, due to the grain size distribution, this sediment is typically disposed of by using it for daily landfill cover, road base material, or stockpiled for an undesignated future use (Personal communication with Zone 7 staff; Alameda County RCD, 2018).

The grain size distribution, as well as the location within the watershed are important factors in the fate of the removed sediment from the Alameda County Flood Control and Water Conservation District, Zone 7 (hereafter "Zone 7 Water Agency" or "Zone 7") watershed area (the upper watershed). However, despite the excess coarse sediment in the upper watershed, many restoration or mitigation projects in the lower watershed or along the San Francisco Bay margin are struggling to obtain enough sediment to meet elevation, substrate, or energy dissipation objectives. Hauling sediment to the project location, often from long distances, adds cost. In many instances, sediment is not available in suitable quality, volume or at suitable times. Further, formal sediment sharing and exchange mechanisms are not in place. Given this disconnect, the EPA-funded *Preparing for the Storm* project aims to support the future development of a successful regional coarse sediment reuse strategy and to use the Zone 7 watershed area as a case study that will not only serve the local community, but also serve as a demonstration for other Bay Area communities.

As part of this case study, data records on the current sediment removal regime within the Zone 7 watershed area were gathered and assessed, and are summarized in this appendix. This dataset of removal volumes is necessary to understand the volume of sediment historically removed, and thus the volume likely to be available for removal and potential beneficial reuse in the future. This is the first step in finding successful beneficial use matches for Zone 7 sediment with other entities with a need for sediment.

Methods

Information concerning sediment removals were collated from local agencies. Sediment removal data spanning the period 2005 to 2014 was previously collated (Pearce et al., 2015), and provided the starting point for this expanded data compilation. To obtain earlier and the more recent records on sediment removal, agencies/entities that own or maintain channels within the Zone 7 watershed area were contacted. These included:

- Zone 7 Water Agency: Joe Seto and Andrew Chamberlain
- City of Livermore: Pamela Lung and Edward Reyes
- Caltrans: Michael Rodrigues
- City of Pleasanton: Dan Sequeira, contacted but no reply
- City of Dublin: Obaid Khan, contacted but no reply

VIEW LOOKING UPSTREAM, ARROYO MOCHO AT HOLMES ST BRIDGE, PHOTOGRAPH COURTESY OF PAUL FRANK, FLOWWEST

Based upon the responses to these enquiries, it appears that data prior to 2005 does not exist, either because records were not kept, or because the location of records is unknown. However, data from 2015 to 2019 were obtained and collated. All records were compiled into an Excel spreadsheet for analysis.

Results

The data records vary in quality and completeness, between agencies and through time. Some agencies confirmed that they conduct sediment removal in multiple locations (Zone 7, City of Livermore), while Caltrans confirmed that they only conduct removal in a single location. For all removal records, the volume of sediment that was removed, or alternatively the weight, was present. Only some records included information about removal costs (permitting, staff time, equipment, hauling, disposal). Additionally, grain size information was rarely measured or recorded, aside from qualitative comments in limited instances indicating that the sediment is "gravel".

Sediment Removal Locations

Within the Northern Alameda Creek watershed, a number of discrete locations have had sediment removed. Removal locations include sediment basins, underneath bridges and in culverts, in-channel upstream of constrictions, at culvert outfalls, and in natural depositional areas within the channel network. Many of the removals occur at locations of natural historical deposition; for example, the multiple removal locations on the Arroyo Mocho occur where channel gradient and stream power is decreasing. However, removals don't always occur just in the historical locations of deposition, but rather occur at multiple locations across the Northern Alameda Creek watershed area. This means that removal, transport and stockpiling are not centralized in a single location, but rather are spread out, making transport and reuse more costly and challenging (Figure A.1).

Sediment Removal Volumes

An accurate accounting of the removal volumes is a necessary component of a larger beneficial reuse strategy. Based upon the data collated, a total of 45,200 CY of sediment has been removed from channels in the Northern Alameda Creek watershed from 2005-2019 (Table A.1). The largest single volume of removal occurred at Arroyo Mocho at Holmes Street (8,900 CY in 2017). This location also has had the most sediment removed (19,610 CY) since 2005, and the most frequent removal, with 12 events (2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2017, 2018, 2019). However, the dry Water Years of 2013, 2015 and 2016 experienced low flows throughout the season and did not require removal at this location likely because of relatively low transport and deposition rates.

Five other locations are associated with single event removal of volumes of 1,000 CY or larger (Sediment basin upstream of Isabel Blvd, Arroyo las Positas at Airway Blvd, Line J-1 at Amador Valley Blvd (Chuck E. Cheese's), Arroyo Mocho at Stanley Blvd, and Collier Canyon Creek). The sediment basin upstream of Isabel Blvd has had three removal events (2007, 2013, 2017) for a total volume of 13,200 CY. Arroyo las Positas at Airway Blvd has had three removals, in 2006 (2,700 CY), 2018 (1,000 CY), and 2019 (300 CY). In 2017 Line J-1 at Amador Valley Blvd (at Chuck E. Cheese's) had a removal of 1,000 CY, Arroyo Mocho at Stanley Blvd had a removal of 1,600 CY, and Collier Canyon Creek had a removal of 1,300 CY. The remainder of the locations had much smaller removals, typically <100 CYs.

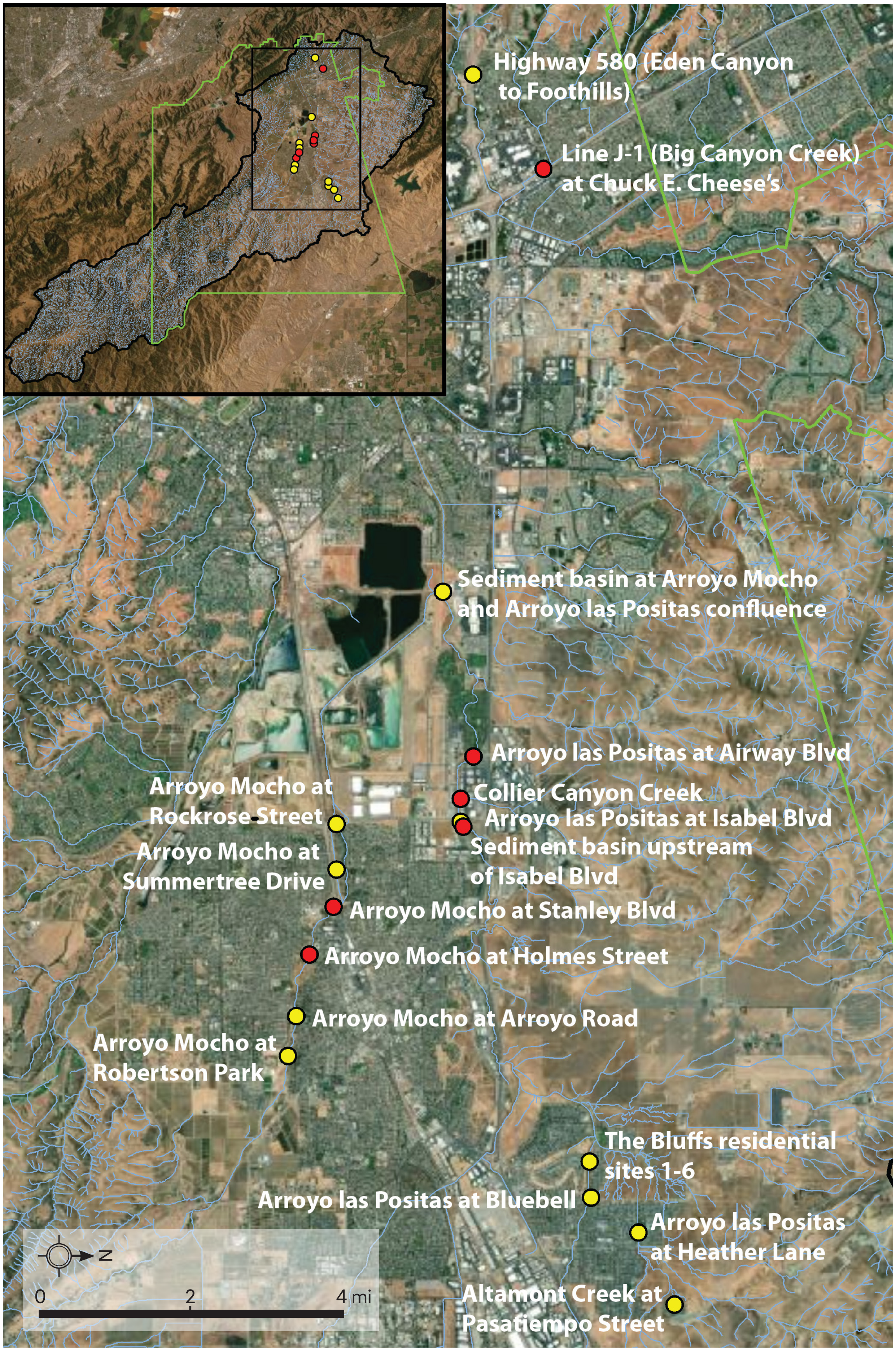

Figure A.1. Locations of sediment removal within the Northern Alameda Creek watershed. Locations marked in red have had single event sediment removals of 1,000 CY or greater, while locations marked in yellow have only had removals less than 1,000 CY.

Table A.1. Known removal of in-stream sediment in the Northern Alameda Creek Watershed, 2005 to 2019*.

Location	Grain Size	Weight (m tonnes)	Cubic yards (CY)	Fate
2005				
Arroyo Mocho at Arroyo Road	n/a	170	120	Construction of bike trail
Arroyo Mocho at Holmes Street	gravel	390	270	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2005)		***700***	***490***	
2006				
Arroyo las Positas at Airway Blvd	n/a	3900	2700	Landfill
Arroyo Mocho at Holmes Street	gravel	1900	1300	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2006)		***5940***	***4100***	
2007				
Sediment basin at Arroyo Mocho and Arroyo las Positas confluence	n/a	140	100	
Sediment basin upstream of Isabel Blvd	n/a	10400	7300	Roadbase material
Arroyo Mocho at Holmes Street	gravel	980	690	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2007)		***11660***	***8190***	
2008				
Arroyo Mocho at Holmes Street	gravel	2300	1600	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2008)		***2440***	***1700***	
2009				
Arroyo Mocho at Holmes Street	gravel	1200	830	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2009)		***1340***	***930***	
2010				
Arroyo Mocho at Holmes Street	gravel	1700	1200	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2010)		***1840***	***1300***	
2011				
Arroyo Mocho at Holmes Street	gravel	1300	900	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2011)		***1440***	***1000***	

Location *(continued)*	Grain Size	Weight (m tonnes)	Cubic yards (CY)	Fate
2012				
Arroyo Mocho at Holmes Street	gravel	1200	830	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2012)		***1340***	***930***	
2013				
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2013)		***140***	***100***	
2014				
Arroyo Mocho at Holmes Street	gravel	2400	1700	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2014)		***2540***	***1800***	
2015				
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2015)		***140***	***100***	
2016				
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2016)		***140***	***100***	
2017				
Sediment basin upstream of Isabel Blvd	n/a	11600	8100	Roadbase material
Line J-1 (Big Canyon Creek) at Chuck E. Cheese's	n/a	1400	1000	Landfill
The Bluffs residential sites 1-6	n/a	100	70	Went to Vasco landfill
Arroyo las Positas at Heather Lane	n/a	37	26	Old Springtown Golf Course stockpile
Arroyo Mocho at Rockrose Street	n/a	24	17	Went to Vasco landfill
Arroyo Mocho at Summertree Drive	n/a	46	32	Went to Vasco landfill
Arroyo Mocho at Robertson Park	n/a	13	9	Went to Vasco landfill
Arroyo Mocho at Holmes Street	gravel	13000	8900	El Charro stockpile and reused in Project 25
Arroyo Mocho at Stanley Blvd	n/a	2300	1600	Stockpiled in Tracy for reuse
Collier Canyon Creek	n/a	1900	1300	Stockpiled in Tracy for reuse
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2017)		***30600***	***21200***	

Location *(continued)*	Grain Size	Weight (m tonnes)	Cubic yards (CY)	Fate
2018				
Arroyo las Positas at Airway Blvd	n/a	1400	1000	
Arroyo las Positas at Bluebell	n/a	500	350	
Arroyo Mocho at Holmes Street	gravel	1000	700	
Altamont Creek at Pasatiempo Street	n/a	110	80	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Subtotal (2018)		***3150***	***2230***	
2019				
Fish ladder adjacent to Sediment Basin at Arroyo Mocho and Arroyo las Positas confluence	n/a	60	40	Stockpiled at Cope Lake
Arroyo las Positas at Airway Blvd	n/a	430	300	
Highway 580 (Eden Canyon to Foothills)	n/a	140	100	Landfill
Arroyo Mocho at Holmes Street	gravel	960	670	
Subtotal (2019)		***1590***	***1110***	
TOTAL		**65,000**	**45,200**	
AVERAGE per year				
(2005-2019, 15 years)		**4,300**	**3,000**	

* The conversion from weight to cubic yards uses the conversion 0.70 cubic yards/metric t (Pearce, et al., 2015). The sediment budget (Pearce, et al., 2015) drew upon NHC (2010) which used a conversion factor of 0.73 yds3/metric t for suspended sediment, and 0.65 yds3/metric t for bedload. The authors of this report chose to use a middle density of 0.70 yds3/metric t to take into account the heterogeneous mix of coarse and fine sediment that comprises the typical removed sediment.

* All data rounded to 2 significant figures - please contact the authors if the unedited data are required.

Some locations have had multiple removals during this time period (Arroyo Mocho at Holmes Street, Highway 580 (Eden Canyon to Foothills), Arroyo las Positas at Airway Blvd, and the Sediment basin upstream of Isabel Blvd), while most have had just a single removal.

The volume removed across the whole system and across multiple agencies averaged ~3,000 CY per year for the 2005-2019 time period, inclusively. However, sediment did not get delivered to the channels, transported, and deposited at a uniform rate. For example, for the relatively dry period of Water Years 2007-2014 only approximately 2,500 CY of sediment passed through the Arroyo Mocho at Pleasanton (AMP) gauge station (Pearce, et al., 2015). More sediment is supplied to the channels from the watershed during wetter years, due to higher than normal rainfall and higher flows leading to both increased transport, as well as increased sedimentation in downstream channels and facilities (Pearce et al., 2015). Wetter years typically require greater volumes of subsequent removal by the local agencies. For example, greater volumes were removed following wet years at Arroyo Mocho at Holmes Street, while smaller volumes or no removal occurred following dry years. This pattern is likely occurring at the other removal locations in the watershed, although the relationship between sediment removal and climate may be complicated by funding or permitting constraints. For example, although a location may require sediment removal due to significant deposition during the previous wet year, sometimes the necessary permits cannot be acquired in time for the sediment removal work to occur during the permitted window of time.

Of the sediment that has been removed during 2005-2019, some has been reused for roadbase material or bike trail construction, some has been stockpiled for later reuse, some is sent to landfills for daily cover, and the fate of the remainder is unknown (Table A.2). Given the annual average of approximately 3,000 CY per year, sediment removed from the Northern Alameda Creek watershed would likely be most useful for reuse in smaller scale restoration projects, or projects that require exclusively coarse sediment, such as sand, gravel, and cobble.

Other Data and Data Gaps

An effort was made to collect data from all entities that remove in-stream sediment within the Northern Alameda Creek Watershed, however, it is possible that some sources were missed. For example, typical bank repairs carried out by agencies (e.g. Zone 7) include some excavation of bank material to allow for placement of rock material, which is then covered by a 1-2 ft layer of sediment. This maintenance process can result in a net export of sediment from the site, which is not captured in this data inventory. Additional outreach or consultation with regulatory agencies would confirm if additional data exists.

In addition to volumetric data, some sources record other data which will be important for the development and implementation of a successful sediment reuse strategy. These data fields include: grain size, removal/disposal cost, and fate. To date, grain size information has only been recorded at the Arroyo Mocho at Holmes Street location, and even there it was limited to describing the sediment as “gravel”.

The records on relatively small removals (~100 CY) conducted in the western side of the watershed by Caltrans have cost data associated with them; Caltrans notes that these removals cost between $10,000 and $20,000 for the labor, equipment and disposal fees. The records on sediment fate are more complete, with data on a handful of earlier removal events, and data on all of the 2017 removal events.

Table A.2. Fate of sediment removed from the Northern Alameda Creek watershed, 2005-2019.

Fate	Sum of Cubic Yards (CY)	Percent of Total
Landfill	5,330	12%
Stockpiled	11,900	26%
Road/trail	15,500	34%
Unknown	***12,500***	***28%***
TOTAL	**45,200**	**100%**

In general, record keeping on grain size, removal/disposal cost, contaminant tests completed, and fate is inconsistent and generally lacking. These represent key information gaps that should be filled in the future. A successful strategy will need to include further discussion and justification on the need for the development of a standard data protocol for addressing these information gaps.

Conclusions

This collation and assessment of sediment removal records from 2005-2019 illustrates that sediment was, and by inference is likely to continue being removed from various locations within the Northern Alameda Creek Watershed. The records indicate that some sediment is actively being reused (trails or road base), or stockpiled for future use; however, plenty of sediment is still disposed of at landfills. This sediment could be made available for beneficial reuse, rather than disposal. The volumes of removed sediment are relatively small, averaging approximately 3,000 CY per year. However, at some locations, for instance at the Holmes Street location, a relatively consistent volume of exclusively coarse sediment is frequently removed.

This compilation of sediment removal data also illustrates the information gaps that typically exist in the records of sediment removal, including historical missing records, and lack of grain size, cost, quality, or fate information. Future successful sediment reuse will require more complete and standardized data entry concerning sediment supply. This data compilation provides the initial support needed for the development of a strategy to improve agency coordination and sediment reuse within and beyond the Northern Alameda Creek Watershed.

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