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# memorandum

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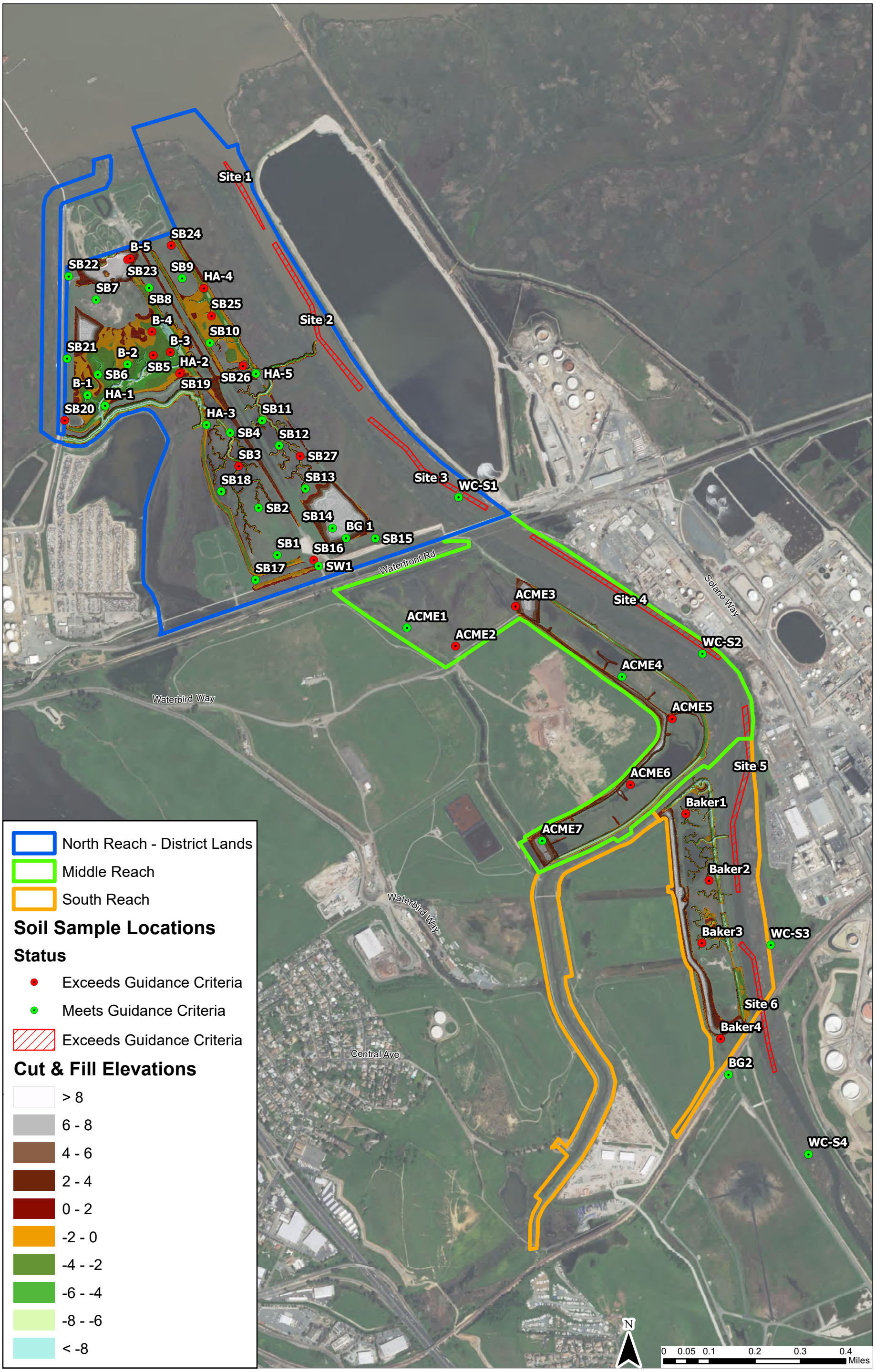
|---|---|
| date | May 28, 2019 |
| to | Paul Detjens, CCCFCWCD |
| cc | Michelle Orr, Environmental Science Associates |
| from | Michael G. Burns, PG, CEG, CHG and Melissa Carter, PE Environmental Science Associates |
| subject | Updated Soil Quality Assessment Report |

## Introduction

The Lower Walnut Creek Restoration Project (Project), led by the Contra Costa County Flood Control District (District), proposes to restore and enhance tidal wetlands along the southern shore of Suisun Bay and from Suisun Bay upstream along Walnut Creek and its tributary Pacheco Creek, to provide sustainable flood protection, and to create opportunities for future public access through the Project area. The proposed project is described in ESA's report titled *Lower Walnut Creek Restoration Project, Project Study Report*, dated December 2017 (ESA, 2017). The Project area consists of the North Reach, located between Waterfront Road and Suisun Bay in the area historically called "Pacheco Marsh"; the Middle Reach, located between Pacheco Creek and the Union Pacific Railroad (UPRR) embankment; and the South Reach, located between the BNSF Railroad embankment and the confluence of Pacheco and Walnut Creeks (see Figures 1 and 2).

The purpose of this assessment is to consolidate the available site-specific soil and sediment (soil) testing data from investigations conducted within the footprint of the proposed project and compare those soil testing results to reuse guidelines and background levels, as available. The testing data was consolidated from the following reports:

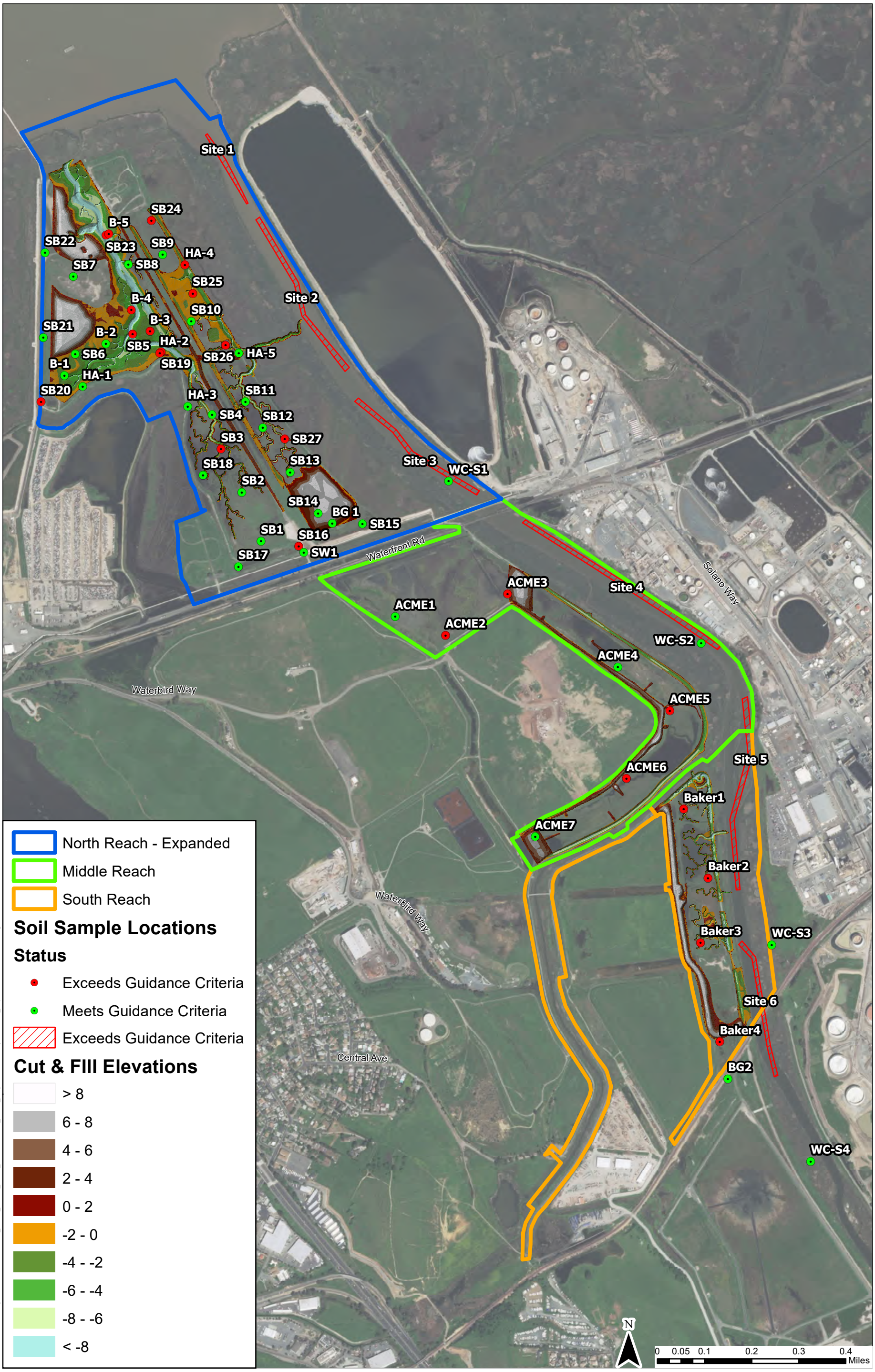
- ESA, 2017, *Analytical Report, Lower Walnut Creek Restoration Project*, September 11
- US Army Corps of Engineers (USACE), 2009, laboratory analytical results based on *Draft Field Sampling Plan, Lower Walnut Creek Flood Control, Contra Costa County*, November 2008
- Ninyo & Moore, 2007, *Sediment Sampling along Walnut Creek and Grayson Creek, Concord, California*, May 11
- Jonas & Associates, 2002, *Site Characterization Report, Praxis Property, Martinez, California, Contra Costa County, Public Works Department*, January 22
- ENGEO and Advanced Biological Testing, 1994, *Final Report, Results of Chemical, Physical and Bioassay Testing of Sediments from the Lower Walnut Creek Flood Control Channel*, April 20




Lower Walnut Creek Restoration Project . D170378.00

**Figure 1**
Soil Sampling Locations - District Land Alternative

ESA




Lower Walnut Creek Restoration Project . D170378.00

**Figure 2**
Soil Sampling Locations - Expanded Land Alternative

ESA

The above-listed investigations analyzed soil for a suite of various chemicals. All of the investigations analyzed soil for metals and petroleum hydrocarbons. Some of the investigations did not analyze for the entire suite of other listed chemicals, as summarized below in Table 1. One set of bioassay testing was performed, also as listed below. Finally, the USACE sampling event included the collection and analyses of samples considered to represent local background. In addition, the Engeo samples were collected from within the Lower Walnut Creek channel, which would not be disturbed as a part of the proposed project. Instead, the Engeo samples represent the "background" level of chemicals in sediment being washed down to channel from inland areas.

**Table 1. Summary of Analytical Testing**

| | ESA, 2017 | USACE, 2009 | Ninyo & Moore, 2007 | Jonas, 2002 | ENGEO, 1994 |
|---|---|---|---|---|---|
| **Metals** | X | X | X | X | X |
| **Petroleum hydrocarbons** | X | | X | X | X |
| **Volatile organic compounds (VOCs)** | | X | ?? | X | |
| **Organochlorine Pesticides and polychlorinated biphenyls (PCBs)** | | X | | X | X |
| **Semivolatile organic compounds (SVOCs)** | | X | | X | |
| **Organophosphorous pesticides & herbicides** | | X | | | |
| **Dioxins and furans** | | X | | | |
| **Polynuclear aromatic hydrocarbons (PAHs)** | | | | | X |
| **Phthalate esters** | | | | | X |
| **Organotins** | | X | | | X |
| **Other inorganics** | | | | X | X |
| **Bioassay** | | | | | X |

The locations of the soil samples are shown on Figure 1 – District Land Alternative, and Figure 2 – Expanded Alternative, which show the overall project boundary and the subset of that area where soil movement and/or relocation is proposed. Overall, the soil sample locations are more concentrated in the North Reach and more limited in and adjacent to the South and Middle Reaches, reflecting the nature and extent of the earthwork needed to restore each reach of the project. As shown in Figures 1 and 2, a majority of the grading within the Project area is located in the North Reach, whereas the grading in the South and Middle Reaches is limited to removing existing levees, creating new setback levees, raising existing access roads, and excavating tidal channels.

The purpose of this soil quality assessment is to evaluate if the soil that may be moved and reused within the proposed project footprint is suitable for reuse. Note that at this time, soil quality data for the Suisun Property parcel at the far northwest corner of the proposed project is not available. It is assumed that any soil quality issues that are inconsistent with habitat restoration of the Suisun Property parcel will be resolved as part of a separate effort between the current land-owner a third party. It is also important to note that the proposed project is a net zero import-export project. In other words, the existing soil at the site would be rearranged to create tidal channels and levees but no soil would be brought on to the site and no soil would be exported offsite.

# Comparison Methodology

To evaluate the suitability of the existing site soils for reuse in a wetlands habitat setting, the testing results were compared to beneficial reuse guidelines or background levels published by the sources cited below.

- Germano, 2004, *An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development*, February
- US EPA, 2005 thru 2007, *Ecological Screening Levels*, various metals and DDT
- RWQCB, 2000, *Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines*, May
- USACE, 2009, Analytical results for samples considered to represent background levels

The above-listed guidelines are focused on the beneficial reuse of soil or background levels. However, guidelines or background levels have not been developed for all of the tested chemicals. To provide some guidance for chemicals without beneficial reuse guidelines, the May 2016 *Environmental Screening Levels* (ESLs) developed by the San Francisco Bay Regional Water Quality Control Board (RWQCB) were used for petroleum hydrocarbons (i.e., total petroleum hydrocarbons [TPH] as gasoline, diesel, or motor oil), and volatile organic compounds (VOCs), where detected. ESLs are screening levels use by regulatory agencies throughout the state to assess whether further investigation and possibly cleanup is needed at sites where hazardous materials are suspected to have been spilled. ESLs are risk-based levels largely based on human health and are therefore not directly applicable to an ecological habitat. Nonetheless, the use of ESLs provides at least some comparative guidance as to whether a given chemical is present in soil at levels that might be unsuitable for a wetland habitat.

The chemical testing results are first compared to background levels, where available. If the concentration of a chemical is below background levels, then the soil at that location is considered suitable for reuse relative to that chemical. Note that in some cases, background levels have not been developed for some chemicals. If a chemical concentration is above background levels or no background level is available, then that chemical is compared to the guidelines listed above. If the chemical concentration is below the guidelines, then the soil at that location is considered suitable for reuse relative to that chemical. If the chemical concentration for that chemical is above one or more of the guidelines, then the soil at that location may be considered unsuitable for reuse due to that chemical. However, as discussed further below, the exceedance of a guideline level at one or a few sample locations due to the presence of one chemical does not necessarily mean the soil for the entire project site is unsuitable. As the project site is graded and recontoured, the soil at one location with an exceedance would be blended in with the rest of the soil at the project site and the overall concentrations of that given chemical will likely decrease to below the guideline.

# Testing Results

The analytical testing results are tabulated on the following tables, along with guidelines and background levels, if available. Concentrations that exceeded background and guidance levels are in bold text. Note that tables are not provided for those suites of chemicals where there were no detections, as discussed further below.

**Table 2**

**Summary of Metals Sampling Results, ESA, 2017**

| | All Samples within the North Reach | | | | | | | | | | | | | | | | | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | San Francisco Bay Sediments Ambient Concentrations (c) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B1 | | B2 | | B3 | | B4 | | | B5 | | HA1 | HA2 | HA2 | HA3 | HA4 | | HA5 | | | | |
| Chemical | Upper 5 feet | 6.5-7 / 9.9.5 feet | Upper 5 feet | 4-4.5 / 8-8.5 feet | Upper 5 feet | 3.5-4 / 8.5-9 feet | Upper 1 foot | Upper 5 feet | 6.3-6.8 / 8.2-8.7 feet | Upper 5 feet | 7-7.5 / 9.5-10 feet | Upper 5 feet | Upper 1 foot | Upper 5 feet | Upper 5 feet | Upper 1 foot | Upper 5 feet | Upper 1 foot | Upper 5 feet | Surface | Foundation | | |
| Antimony | 0.36 | -- | 0.36 | -- | 0.46 | -- | 0.13 | 0.17 | -- | 0.16 | -- | 0.67 | 0.40 | 0.59 | 0.57 | 0.74 | 0.66 | 0.64 | 0.54 | -- | -- | 78 | -- |
| Arsenic | 6.6 | -- | 7.3 | -- | 9.6 | -- | 5.0 | 5.4 | -- | 11 | -- | 10 | 8.5 | 11 | 12 | 16 | 14 | 13 | 12 | 40.0 | 40.0 | 18 | 15.3 |
| Barium | 83 | -- | 96 | -- | 120 | -- | 45 | 54 | -- | 38 | -- | 72 | 80 | 76 | 74 | 81 | 100 | 81 | 47 | -- | -- | 330 | -- |
| Beryllium | 0.34 | -- | 0.38 | -- | 0.49 | -- | 0.20 | 0.19 | -- | 0.19 | -- | 0.49 | 0.40 | 0.46 | 0.41 | 0.49 | 0.59 | 0.46 | 0.24 | -- | -- | 40 | -- |
| Cadmium | 0.25 | -- | 0.20 | -- | 0.30 | -- | ND | 0.067 | -- | 0.080 | -- | 0.31 | 0.28 | 0.31 | 0.091 | 0.31 | 0.59 | 0.22 | ND | 0.250 | 0.620 | 32 | 0.33 |
| Chromium | 53 | -- | 51 | -- | 66 | -- | 52 | 48 | -- | 170 | -- | 63 | 56 | 67 | 59 | 62 | 78 | 70 | 47 | 119 | 320 | -- | 112 |
| Cobalt | 8.0 | -- | 11 | -- | 13 | -- | 13 | 13 | -- | 14 | -- | 9.5 | 11 | 13 | 7.0 | 11 | 14 | 10 | 5.0 | -- | -- | 13 | -- |
| Copper | 34 | -- | 33 | -- | 44 | -- | 10 | 14 | -- | 15 | -- | 47 | 38 | 49 | 33 | 57 | 68 | 41 | 36 | 50.0 | 150 | 70 | 68.1 |
| Lead | 12 | -- | 19 | -- | 19 | -- | 3.9 | 4.2 | -- | 5.5 | -- | 21 | 16 | 24 | 12 | 23 | 21 | 17 | 19 | 200 | 200 | 120 | 43.2 |
| Mercury | 0.078 | 0.15 / 0.27 | 0.090 | 0.12 / 0.12 | 0.15 | 0.31 / 0.28 | 0.019 | 0.023 | 0.044 / 0.25 | 0.058 | 0.30 / 0.12 | 0.23 | 0.11 | 0.20 | 0.11 | 0.27 | 0.24 | 0.17 | 0.18 | 1.18 | 1.18 | -- | 0.43 |
| Molybdenum | 0.73 | -- | 0.54 | -- | 0.67 | -- | ND | ND | -- | 0.29 | -- | 0.97 | 0.59 | 1.0 | 1.3 | 0.94 | 0.74 | 1.7 | 0.85 | -- | -- | -- | -- |
| Nickel | 50 | -- | 57 | -- | 77 | -- | 63 | 65 | -- | 160 | -- | 57 | 63 | 61 | 45 | 59 | 85 | 60 | 34 | 230 | 230 | 38 | 112 |
| Selenium | 0.27 | 0.31 / 0.30 | 0.25 | 0.28 / 0.27 | 0.36 | 0.41 / 0.27 | ND | ND | 0.22 / 0.39 | ND | 0.34 / 0.42 | 0.38 | 0.31 | 0.41 | 0.36 | 0.42 | 0.50 | 0.53 | 0.25 | -- | -- | 0.52 | 0.64 |
| Silver | 0.16 | -- | 0.11 | -- | 0.14 | -- | ND | ND | -- | 0.062 | -- | 0.20 | 0.14 | 0.18 | 0.25 | 0.17 | 0.28 | 0.17 | 0.090 | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | ND | -- | 0.11 | -- | 0.13 | -- | ND | ND | -- | ND | -- | 0.13 | 0.10 | 0.13 | 0.11 | 0.12 | 0.14 | 0.14 | ND | -- | -- | -- | -- |
| Vanadium | 53 | -- | 52 | -- | 68 | -- | 50 | 45 | -- | 44 | -- | 63 | 56 | 62 | 67 | 65 | 78 | 73 | 50 | -- | -- | -- | -- |
| Zinc | 64 | -- | 64 | -- | 86 | -- | 48 | 49 | -- | 40 | -- | 92 | 81 | 98 | 60 | 98 | 120 | 83 | 46 | 1,200 | 1,200 | 120 | 158 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
-- = not analyzed or not established
ND = Not detected above reporting limit

**Table 3**

**Summary of Metals Sampling Results – USACE, 2009**

| Group | LWC-Acme | | | | | | | Acme Background | LWC-Baker | | | | | | | Baker Background | | Guidelines and Background | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Boring** | 01 | 02 | 03 | 04 | 05 | 06 | 07 | BG1 | 01 | 01 | 02 | 03 | 03 | 04 | 04 | BG2 | BG2 | **Wetland Beneficial Use Guidelines (a)** | | **Ecological Soil Screening Levels (b)** | **San Francisco Bay Sediments Ambient Concentrations (c)** |
| **Chemical / Depth in Feet** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 2.0 | 0.5 | 0.5 | 4.0 | 0.5 | 5.0 | 0.5 | 4.5 | **Surface** | **Foundation** | | |
| Antimony | 0.72 | 0.30 | 0.53 | 0.20 | 0.62 | 0.41 | 0.66 | 0.33 | <0.9 | <0.8 | <0.7 | <0.7 | <0.7 | <0.7 | 0.22 | <0.7 | 0.21 | -- | -- | 78 | -- |
| Arsenic | 10.2 | 8.2 | 9.8 | 10.2 | 7.8 | 11.3 | 9.5 | 8.1 | 7.3 | 7.7 | 6.5 | 10.0 | 4.6 | 6.7 | 11.2 | 5.7 | 2.7 | 40.0 | 40.0 | 18 | 15.3 |
| Barium | 282 | 186 | 278 | 325 | 339 | 326 | 267 | 203 | 134 | 227 | 192 | 134 | 161 | 313 | 153 | 180 | 91.2 | -- | -- | 330 | -- |
| Beryllium | 0.72 | 0.74 | 0.78 | 0.51 | 0.72 | 0.76 | 0.60 | 0.52 | 0.48 | 0.65 | 0.44 | 0.16 | 0.26 | 0.74 | 0.31 | 0.43 | 0.11 | -- | -- | 40 | -- |
| Cadmium | 0.25 | 0.46 | 0.33 | 0.11 | **0.68** | **0.64** | 0.25 | **0.63** | **0.34** | **0.53** | **0.43** | 0.21 | 0.23 | 0.31 | **0.33** | **0.20** | **0.11** | **0.250** | 0.620 | 32 | **0.33** |
| Chromium | 68.6 | 60.9 | 62.5 | 34.8 | 60.1 | 58.7 | 56.6 | 56.7 | 78.4 | 68.0 | 57.2 | 80.1 | 33.4 | 69.5 | 60.6 | 52.7 | 21.8 | 119 | 320 | -- | 112 |
| Cobalt | 13.8 | 18.2 | 17.1 | 13.1 | 14.9 | 17.1 | 13.0 | 14.2 | 11.0 | 13.5 | 13.7 | 7.2 | 7.4 | 14.3 | 11.2 | 11.5 | 5.3 | -- | -- | 13 | -- |
| Copper | 57.7 | 58.6 | 49.5 | 42.0 | 46.4 | 41.9 | 40.5 | 41.6 | 48.0 | 46.5 | 38.0 | 50.5 | 24.5 | 45.6 | 34.4 | 33.5 | 11.9 | 50.0 | 150 | 70 | 68.1 |
| Lead | 50.0 | 29.5 | 41.7 | 17.5 | 32.8 | 18.5 | 59.0 | 20.0 | 20.7 | 18.8 | 20.5 | 14.5 | 12.6 | 18.7 | 20.1 | 15.4 | 7.2 | 200 | 200 | 120 | 43.2 |
| Mercury | **0.14** | 0.23 | 0.16 | 0.12 | 0.16 | 0.17 | 0.11 | 0.14 | 0.10 | 0.11 | 0.10 | 0.13 | 0.091 | 0.11 | 0.096 | 0.082 | 0.045 | 1.18 | 1.18 | -- | 0.43 |
| Molybdenum | **1.3** | 1.2 | 1.2 | 0.86 | 0.83 | 1.1 | 1.3 | 1.6 | 1.0 | 0.71 | 0.95 | 1.6 | 0.64 | 0.74 | 0.60 | 0.77 | 0.53 | -- | -- | -- | -- |
| Nickel | **74.3** | 100 | 89.1 | 36.6 | 74.1 | 74.9 | 68.2 | 66.2 | 72.0 | 73.1 | 59.8 | 53.6 | 32.6 | 70.5 | 73.2 | 61.4 | 19.9 | 230 | 230 | 38 | 112 |
| Selenium | **0.58** | 0.82 | 0.96 | 0.78 | 0.67 | 0.63 | 0.51 | 1.3 | **1.3** | **0.96** | **0.65** | **0.95** | 0.43 | **1.0** | **0.75** | **0.58** | **<0.7** | -- | -- | **0.52** | **0.64** |
| Silver | **<0.1** | <0.2 | <0.1 | <0.1 | <0.2 | <0.1 | <0.2 | <0.2 | <0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | <3.1 | <3.5 | <2.7 | <2.6 | <3.2 | <3.1 | <3.2 | <3.7 | <3.5 | <3.0 | <3.0 | <3.0 | <2.7 | <2.7 | <2.7 | <2.7 | <2.7 | -- | -- | -- | -- |
| Vanadium | **78.3** | 87.2 | 63.2 | 60.2 | 65.5 | 61.6 | 75.9 | 58.0 | 81.2 | 64.4 | 66.8 | 76.7 | 37.3 | 70.6 | 46.2 | 52.3 | 29.7 | -- | -- | -- | -- |
| Zinc | **122** | **184** | 125 | 98.6 | 118 | 89.3 | 103 | **117** | 94.0 | 88.0 | 77.0 | 71.3 | 50.6 | 93.3 | 71.3 | 78.2 | 33.0 | 1,200 | 1,200 | **120** | **158** |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
(J) = Estimated concentration below the reporting limit
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 4**

**Summary of Metals Sampling Results – Ninyo & Moore, 2007**

| Chemical | All Samples just east of North Reach | | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | San Francisco Bay Sediments Ambient Concentrations (c) |
|---|---|---|---|---|---|---|---|
| | WC-S1 | WC-S2 | WC-S3 | Surface | Foundation | | |
| Antimony | <2.0 | <2.0 | <2.0 | -- | -- | 78 | -- |
| Arsenic | 3.1 | 3.1 | 5.1 | 40.0 | 40.0 | 18 | 15.3 |
| Barium | 62 | 52 | 150 | -- | -- | 330 | -- |
| Beryllium | <1.0 | <1.0 | <1.0 | -- | -- | 40 | -- |
| Cadmium | <1.0 | <1.0 | <1.0 | 0.250 | 0.620 | 32 | 0.33 |
| Chromium | 31 | 20 | 37 | 119 | 320 | -- | 112 |
| Cobalt | 6.7 | 2.8 | 9.6 | -- | -- | 13 | -- |
| Copper | 22 | 13 | 24 | 50.0 | 150 | 70 | 68.1 |
| Lead | 40 | 3.1 | 13 | 200 | 200 | 120 | 43.2 |
| Mercury | 0.10 | 0.14 | <0.10 | 1.18 | 1.18 | -- | 0.43 |
| Molybdenum | <1.0 | <1.0 | <1.0 | -- | -- | -- | -- |
| Nickel | 32 | 16 | 44 | 230 | 230 | 38 | 112 |
| Selenium | <1.0 | <1.0 | <1.0 | -- | -- | 0.52 | 0.64 |
| Silver | <1.0 | <1.0 | <1.0 | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | <1.0 | <1.0 | <1.0 | -- | -- | -- | -- |
| Vanadium | 32 | 24 | 39 | -- | -- | -- | -- |
| Zinc | 58 | 21 | 54 | 1,200 | 1,200 | 120 | 158 |

Notes:
All samples collected within the upper 5 feet
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 5a**

**Summary of Metals Sampling Results – Jonas, 2002**

| | All Samples within the North Reach | | | | | | | | | | | | | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | San Francisco Bay Sediments Ambient Concentrations (c) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SB1 | SB2 | SB3 | SB4 | SB5 | SB6 | SB7 | SB8 | SB9 | SB10 | SB11 | SB12 | SB13 | SB14 | | | | |
| **Chemical** | Composites of 0.5-1 and 3.5-4 feet | | | | | | | | | | | | | | **Surface** | **Foundation** | | |
| Antimony | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | -- | -- | 78 | -- |
| Arsenic | **2.4** | **3.5** | **5.7** | **7.2** | **4.8** | **2.7** | **5.2** | **3.9** | **10** | **7.1** | **5.0** | **6.6** | **5.0** | **3.3** | 40.0 | 40.0 | 18 | 15.3 |
| Barium | **84** | **110** | **110** | **59** | **42** | **93** | **29** | **30** | **61** | **51** | **72** | **100** | **100** | **63** | -- | -- | 330 | -- |
| Beryllium | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | -- | -- | 40 | -- |
| Cadmium | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | 0.250 | 0.620 | 32 | 0.33 |
| Chromium | **16** | **26** | **47** | **45** | **30** | **36** | **26** | **32** | **43** | **45** | **40** | **36** | **32** | **30** | 119 | 320 | -- | 112 |
| Cobalt | **6.3** | **7.8** | **12** | **8.1** | **8.8** | **13** | **4.2** | **5.9** | **8.4** | **7.2** | **8.9** | **12** | **8.3** | **6.1** | -- | -- | 13 | -- |
| Copper | **11** | **22** | **48** | **43** | **16** | **26** | **8.9** | **18** | **54** | **45** | **31** | **35** | **29** | **21** | 50.0 | 150 | 70 | 68.1 |
| Lead | **14** | **23** | **21** | **15** | **3.4** | **4.2** | **3.4** | **6.3** | **31** | **17** | **12** | **18** | **15** | **12** | 200 | 200 | 120 | 43.2 |
| Mercury | **0.057** | **0.063** | **0.18** | **0.22** | **0.076** | **<0.050** | **<0.050** | **0.088** | **0.37** | **0.28** | **0.13** | **0.14** | **0.096** | **0.095** | 1.18 | 1.18 | -- | 0.43 |
| Molybdenum | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | -- | -- | -- | -- |
| Nickel | **21** | **32** | **52** | 43 | **41** | 61 | **23** | **31** | 42 | **36** | 45 | **42** | **37** | **29** | 230 | 230 | 38 | 112 |
| Selenium | **<2.0** | **<2.0** | 2.4 | **<2.0** | **2.4** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | -- | -- | **0.52** | **0.64** |
| Silver | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | -- | -- | -- | -- |
| Vanadium | **19** | **29** | **51** | 47 | **40** | 44 | **29** | **33** | 46 | **45** | 42 | **40** | **36** | **36** | -- | -- | -- | -- |
| Zinc | **34** | **53** | **73** | 51 | **31** | 47 | **25** | **39** | 72 | **59** | 65 | **70** | **51** | **41** | 1,200 | 1,200 | 120 | 158 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
(J) = Estimated concentration below the reporting limit
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 5b**

**Summary of Metals Sampling Results – Jonas, 2002**

| | All Samples within the North Reach | | | | | | | | | | | | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | San Francisco Bay Sediments Ambient Concentrations (c) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SB15 | SB16 | SB17 | SB18 | SB19 | SB20 | SB21 | SB22 | SB23 | SB24 | SB25 | SB26 | SB27 | | | | |
| **Chemical** | Composites of 0.5-1, 2.5-3, 4.5-5, & 9.5-10 | | | | | | | | | | | | | **Surface** | **Foundation** | | |
| Antimony | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | **<2.0** | -- | -- | 78 | -- |
| Arsenic | **<1.0** | **1.8** | **<1.0** | **4.7** | **2.8** | **8.7** | **8.1** | **4.5** | **5.2** | **1.5** | **11** | **1.9** | **1.2** | 40.0 | 40.0 | 18 | 15.3 |
| Barium | **27** | **97** | **56** | **56** | **52** | **40** | **44** | **51** | **44** | **34** | **36** | **34** | **59** | -- | -- | 330 | -- |
| Beryllium | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | -- | -- | 40 | -- |
| Cadmium | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | **<0.50** | 0.250 | 0.620 | 32 | 0.33 |
| Chromium | **29** | **31** | **30** | **43** | **47** | **38** | **42** | **38** | **31** | **37** | **30** | **39** | **37** | 119 | 320 | -- | 112 |
| Cobalt | **6.8** | **6.4** | **5.4** | **9.3** | **7.9** | **6.8** | **7.0** | **8.3** | **11** | **6.8** | **8.8** | **6.7** | **6.3** | -- | -- | 13 | -- |
| Copper | **17** | **32** | **25** | **43** | **35** | **40** | **26** | **32** | **31** | **21** | **28** | **22** | **23** | 50.0 | 150 | 70 | 68.1 |
| Lead | **7.2** | **11** | **15** | **12** | **14** | **12** | **11** | **10** | **11** | **9.3** | **8.9** | **8.4** | **8.1** | 200 | 200 | 120 | 43.2 |
| Mercury | **<0.050** | **0.058** | **0.057** | **0.29** | **0.13** | **0.22** | **0.21** | **0.16** | **0.72** | **0.16** | **0.14** | **0.10** | **0.094** | 1.18 | 1.18 | -- | 0.43 |
| Molybdenum | **2.6** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **1.2** | **<1.0** | **<1.0** | -- | -- | -- | -- |
| Nickel | **31** | **35** | **31** | 42 | **41** | 31 | **35** | **34** | 38 | **30** | 27 | **31** | **33** | 230 | 230 | 38 | 112 |
| Selenium | **<2.0** | **2.4** | **<2.0** | **<2.0** | **3.1** | **2.3** | **<2.0** | **<2.0** | **2.0** | **2.8** | **2.8** | **2.5** | **2.4** | -- | -- | **0.52** | **0.64** |
| Silver | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | -- | -- | -- | -- |
| Vanadium | **34** | **32** | **32** | **47** | 46 | **46** | 53 | **51** | **47** | 42 | **37** | 41 | **40** | -- | -- | -- | -- |
| Zinc | **34** | **46** | **53** | 52 | **62** | 57 | **42** | **42** | 44 | **37** | 54 | **38** | **45** | 1,200 | 1,200 | 120 | 158 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 6**

**Summary of Metals Sampling Results - ENGEO, 1994**

| Chemical | North Reach | | | Middle Reach | Middle and South Reach | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | San Francisco Bay Sediments Ambient Concentrations (c) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Surface | Foundation | | |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | 78 | -- |
| Arsenic | 9.11 | 4.64 | 6.93 | 8.01 | 7.36 | 5.55 | 40.0 | 40.0 | 18 | 15.3 |
| Barium | -- | -- | -- | -- | -- | -- | -- | -- | 330 | -- |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- | 40 | -- |
| Cadmium | **0.521** | 0.325 | **0.435** | **0.469** | **0.521** | **0.481** | **0.250** | 0.620 | 32 | **0.33** |
| Chromium | 71.5 | 45.6 | 60.8 | 54.7 | 56.9 | 47.6 | 119 | 320 | -- | 112 |
| Cobalt | -- | -- | -- | -- | -- | -- | -- | -- | 13 | -- |
| Copper | 54.9 | 29.7 | 44.8 | 43.0 | 43.6 | 36.0 | 50.0 | 150 | 70 | 68.1 |
| Lead | 29.6 | 26.5 | 34.5 | 31.4 | 34.8 | 36.0 | 200 | 200 | 120 | 43.2 |
| Mercury | **6.2** | **3.00** | **4.71** | **4.64** | **4.7** | **4.0** | **1.18** | **1.18** | **--** | **0.43** |
| Molybdenum | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | 66.8 | 37.8 | 58.0 | 53.4 | 55.2 | 49.7 | 230 | 230 | 38 | 112 |
| Selenium | <0.213 | <0.113 | <0.186 | <0.182 | <0.196 | <0.170 | -- | -- | 0.52 | 0.64 |
| Silver | <0.170 | <0.090 | <0.151 | <0.147 | <0.157 | <0.137 | 0.280 | 2.00 | 560 | 0.58 |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Zinc | 114 | 65.6 | 97.9 | 86.6 | 95.7 | 87.4 | 1,200 | 1,200 | 120 | 158 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 7**

**Summary of Petroleum Hydrocarbon Sampling Results – ESA, 2017, and Ninyo & Moore, 2007**

| | All Samples within the North Reach | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **B1** | **B1** | **B1** | **B2** | **B2** | **B2** | **B3** | **B3** | **B3** | **B4** | **B4** | **B4** | **B4** | **B5** | **B5** | **B5** | **HA1** | **HA2** | **HA2** | **HA3** | **HA4** | **HA4** | **HA5** | **HA5** | **Environmental Screening Levels (a)** |
| **ESA Samples** | **Upper 5 feet** | **6.5 feet** | **9-9.5 feet** | **Upper 5 feet** | **4-4.5 feet** | **8-8.5 feet** | **Upper 5 feet** | **3.5-4 feet** | **8.5-9 feet** | **Upper 1 foot** | **Upper 5 feet** | **6.3-6.8 feet** | **6.3-6.8 feet** | **Upper 5 feet** | **7-7.5 feet** | **9.5-10 feet** | **Upper 5 feet** | **Upper 1 foot** | **Upper 5 feet** | **Upper 5 feet** | **Upper 1 foot** | **Upper 5 feet** | **Upper 1 foot** | **Upper 5 feet** | |
| TPH-Gasoline | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | 100 |
| TPH – Diesel | <1.0 | **2.6** | **<1.0** | **1.4** | **1.1** | **3.0** | **<1.0** | **1.4** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **7.9** | **5.5** | **3.8** | **1.3** | **<1.0** | **1.4** | **4.4** | **1.7** | **1.0** | **1.8** | **<1.0** | **<1.0** | 230 |
| TPH – Motor Oil | 5.5 | **9.4** | **<5.0** | **7.2** | **7.4** | **6.2** | **<5.0** | **5.6** | **<5.0** | **< 5.0** | **12** | **11** | **18** | **140** | **12** | **6.0** | **6.8** | **9.1** | **21** | **7.7** | **11** | **8.7** | **10** | **<5.0** | 5,100 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | All Samples within the North Reach | | | | | | | | | | | | | | | | | | | | | | | | |
| **Ninyo & Moore Samples** | **WC-S1** | **WC-S2** | **WC-S3** | | | | | | | | | | | | | | | | | | | | | | |
| TPH-Gasoline | **<1.8** | <0.98 | <0.96 | | | | | | | | | | | | | | | | | | | | | | 100 |
| TPH – Diesel | 2.4 | **<1.0** | **3.7** | | | | | | | | | | | | | | | | | | | | | | 230 |
| TPH – Motor Oil | 3.1 | **2.2** | **8.1** | | | | | | | | | | | | | | | | | | | | | | 5,100 |
| Benzene | <0.0089 | <0.0049 | <0.0048 | | | | | | | | | | | | | | | | | | | | | | 0.044 |
| Toluene | <0.0089 | <0.0049 | <0.0048 | | | | | | | | | | | | | | | | | | | | | | 2.9 |
| Ethylbenzene | <0.0089 | <0.0049 | <0.0048 | | | | | | | | | | | | | | | | | | | | | | 1.4 |
| Xylenes | <0.018 | <0.0098 | <0.0096 | | | | | | | | | | | | | | | | | | | | | | 2.3 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
(a) SF RWQCB, 2016, Environmental Screening Levels, February
<## = not detected above the cited reporting limit

**Table 8**

**Summary of Organics Sampling Results – USACE, 2009**

| **Group** | LWC-Acme | | | | | | | Acme Background | LWC-Baker | | | | | | | | Baker Background | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Boring** | 01 | 02 | 03 | 04 | 05 | 06 | 07 | BG1 | 01 | 01 | 02 | 03 | 03 | 04 | 04 | | BG2 | BG2 | **Environmental Screening Levels (a)** |
| **Chemical / Depth in Feet** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 2.0 | 0.5 | 0.5 | 4.0 | 0.5 | 5.0 | | 0.5 | 4.5 | **Surface** |
| Benzene | <7.7 | <18.0 | 1.1 J | <6.4 | <16.0 | 1.3 J | 1.0 J | 2.4 J | <8.9 | <7.5 | 1.4 J | <7.4 | 2.4 J | <6.8 | <6.8 | | 1.0 J | 1.3 J | 44 |
| Toluene | <7.7 | <18.0 | <6.8 | <6.4 | <16.0 | <7.6 | >7.9 | <18.0 | <8.9 | <7.5 | <7.4 | <7.4 | <6.8 | <6.8 | <6.8 | | <6.8 | <6.6 | 2,900 |
| Ethylbenzene | <7.7 | <18.0 | <6.8 | <6.4 | <16.0 | <7.6 | >7.9 | <18.0 | <8.9 | <7.5 | <7.4 | <7.4 | <6.8 | <6.8 | <6.8 | | <6.8 | <6.6 | 1,400 |
| Xylenes | <7.7 | <18.0 | <6.8 | <6.4 | <16.0 | <7.6 | >7.9 | <18.0 | <8.9 | <7.5 | <7.4 | <7.4 | <6.8 | <6.8 | <6.8 | | <6.8 | <6.6 | 2,300 |
| Bromoform | <7.7 | <18.0 | 1.7 J | <6.4 | <16.0 | <7.6 | >7.9 | <18.0 | <8.9 | <7.5 | <7.4 | <7.4 | <6.8 | <6.8 | <6.8 | | <6.8 | <6.6 | 1,700 |
| Chloromethane | <7.7 | <18.0 | 5.9 J | <6.4 | <16.0 | <7.6 | >7.9 | <18.0 | <8.9 | <7.5 | <7.4 | <7.4 | <6.8 | <6.8 | <6.8 | | <6.8 | <6.6 | 29,000 |

Notes:
All concentrations in micrograms per kilogram, approximately equivalent to parts per billion
Results in bold exceed background and one or more guidance levels
(a) SF RWQCB, 2016, Environmental Screening Levels, February
(J) = Estimated concentration below the reporting limit
-- = not analyzed or not established
<## = not detected above the cited reporting limit

**Table 9**

**Summary of Petroleum Hydrocarbon Sampling Results – Jonas, 2002, and ENGEO, 1994**

| All Samples within the North Reach | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jonas Samples** | **SB1** | **SB2** | **SB3** | **SB4** | **SB5** | **SB6** | **SB7** | **SB8** | **SB9** | **SB10** | **SB11** | **SB12** | **SB13** | **SB14** | **Environmental Screening Levels (a)** |
| TPH-Gasoline | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | 100 |
| TPH – Diesel | 6.0 | **3.5** | **8.9** | **11** | **5.9** | **17 - 81** | **3.0** | **5.0** | **2.2 - 26** | **9.7** | 2.2 | 8.7 - 18 | 2.3 to 27 | 8.9 | 230 |
| TPH – Motor Oil | <50 | <50 | <50 | <50 | <50 | <50 - 120 | <50 | <50 | <50 - 67 | <50 | <50 | <50 - 140 | <50 – 51 | <50 | 5,100 |
| Benzene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.044 |
| Toluene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 2.9 |
| Ethylbenzene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 1.4 |
| Xylenes | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 2.3 |
| MTBE | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 42 |
| | | | | | | | | | | | | | | | |
| **All Samples within the North Reach** | | | | | | | | | | | | | | | |
| **Jonas Samples** | **SB15** | **SB16** | **SB17** | **SB18** | **SB19** | **SB20** | **SB21** | **SB22** | **SB23** | **SB24** | **SB25** | **SB26** | **SB27** | | |
| TPH-Gasoline | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | **<1.0** | | 100 |
| TPH – Diesel | **8.2** | **2.7** | **9.5** | 2.4 | **11** | 11 | 3.4 - 62 | 9.6 | 3.5 - 19 | **2.1** | 10 | 8.9 | 7.9 - 70 | | 230 |
| TPH – Motor Oil | <50 | <50 | <50 | <50 | <50 | <50 | <50 - 120 | <50 | <50 - 51 | <50 | <50 | <50 | <50 - 86 | | 5,100 |
| Benzene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | | 0.044 |
| Toluene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | | 2.9 |
| Ethylbenzene | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | | 1.4 |
| Xylenes | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | | 2.3 |
| MTBE | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 | | 42 |
| | | | | | | | | | | | | | | | |
| **All Samples just east of North Reach** | | | | | | | | | | | | | | | |
| **ENGEO Samples** | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** | **Site 6** | | | | | | | | | |
| TRPH | 146 | 72.7 | 100 | 102 | 83.8 | 99.3 | | | | | | | | | 230; 5,100 |

Notes:
All concentrations in milligrams per kilogram, approximately equivalent to parts per million
TRPH = total recoverable petroleum hydrocarbons
(a) SF RWQCB, 2016, Environmental Screening Levels, February
<## = not detected above the cited reporting limit

**Table 10**

**Summary of Phthalate Esters Sampling Results - ENGEO, 1994**

| Chemical | All Samples within North Reach | | | | | | Wetland Beneficial Use Guidelines (a) | | Ecological Soil Screening Levels (b) | TEL / PEL (c) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Surface | Foundation | | |
| Bis (2-ethylhexyl) phthalate | **204** | 49.9 | 120 | 124 | **187** | **228** | -- | -- | -- | **182** / 2,647 |
| Butylbenzyl phthalate | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- |
| Di-n-butyl phthalate | ND | ND | 169 | 182 | 180 | 165 | -- | -- | -- | -- |
| Diethyl phthalate | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- |
| Dimethyl phthalate | ND | ND | ND | ND | ND | ND | -- | -- | -- | -- |
| Di-n-octyl phthalate | 204 | 49.9 | 289 | 367 | 393 | 477 | -- | -- | -- | -- |

Notes:
All concentrations in micrograms per kilogram, approximately equivalent to parts per billion
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) Threshold Effects Levels (TELs) are levels below which biological effects are unlikely and Probable Effects Levels (PELs) above which biological effects are likely, a cited in RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
ND = not detected
-- = not analyzed or not established

**Table 11**

**Summary of Organochlorine Pesticides and PCBs Sampling Results – USACE, 2009**

| | LWC-Acme | | | | | | | Acme Background | LWC-Baker | | | | | | | Baker Background | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Boring** | 01 | 02 | 03 | 04 | 05 | 06 | 07 | BG1 | 01 | 01 | 02 | 03 | 03 | 04 | 04 | BG2 | BG2 | **Wetland Beneficial Use Guidelines (a)** | | **Ecological Soil Screening Levels (b)** | **San Francisco Bay Sediments Ambient Concentrations (c)** |
| **Chemical / Depth in Feet** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 2.0 | 0.5 | 0.5 | 4.0 | 0.5 | 5.0 | 0.5 | 4.5 | **Surface** | **Foundation** | | |
| **DDD** | <77.0 | <88.0 | 9.3 J | <64.0 | <79.0 | <76.0 | <79.0 | <92.0 | <89.0 | <75.0 | <74.0 | <74.0 | <68.0 | 12 J | <68.0 | <68.0 | <66.0 | 250 | 250 | -- | 7.0 |
| **DDE** | <77.0 | <88.0 | 4.4 J | <64.0 | <79.0 | <76.0 | <79.0 | <92.0 | <89.0 | <75.0 | <74.0 | <74.0 | 4.6 J | <68.0 | <68.0 | <68.0 | <66.0 | 250 | 250 | -- | 7.0 |
| **DDT** | <77.0 | <88.0 | 8.7 J | <64.0 | <79.0 | <76.0 | <79.0 | <92.0 | <89.0 | <75.0 | <74.0 | <74.0 | 5.4 J | <68.0 | 6.8 J | 6.4 J | <66.0 | 250 | 250 | -- | 7.0 |
| **Chlordane** | <77.0 | <88.0 | <68.0 | <64.0 | <79.0 | <76.0 | <79.0 | <92.0 | <89.0 | <75.0 | <74.0 | <74.0 | <68.0 | <68.0 | 3.3 J | 3.4 J | <66.0 | 69.2 | 69.2 | -- | 0.44 |
| **Dieldrin** | <77.0 | <88.0 | **3.0 J** | <64.0 | <79.0 | <76.0 | <79.0 | <92.0 | <89.0 | <75.0 | <74.0 | <74.0 | <68.0 | <68.0 | <68.0 | **2.7 J** | <66.0 | -- | -- | -- | **0.44** |
| **PCBs** | <770 | <880 | <680 | 640 | 790 | 760 | 790 | 920 | 890 | 750 | 740 | 740 | 680 | 680 | 680 | 680 | 680 | 600 | 600 | -- | 14.8 |

Notes:
All concentrations in micrograms per kilogram, approximately equivalent to parts per billion
Results in bold exceed background and one or more guidance levels
(a) Germano, 2004, An Evaluation of Existing Sediment Screening Guidelines for Wetland Creation/Beneficial Reuse of Dredged Material in the San Francisco Bay Area Along with a Proposed Approach for Alternative Guideline Development, February
(b) US EPA, 2005 thru 2007, Ecological Screening Levels, various metals (screening is lowest among soil invertebrates and plants)
(c) RWQCB, 2000, Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, May
(J) = Estimated concentration below the reporting limit
-- = not analyzed or not established
<## = not detected above the cited reporting limit

# Metals

As listed above on Table 1, all five sampling investigations included testing for metals. Overall, the large majority of the testing results were below background levels, indicating the soil is suitable for reuse in a wetlands habitat. A few sample results for a few chemicals exceeded background and guidance levels, as discussed below. There were no exceedance results in the 2007 Ninyo & Moore samplings.

## Cadmium and Mercury

As listed on Tables 2, 3 and 6, cadmium exceeded background and guidance levels in 12 samples out of the 64 samples tested for cadmium, as listed on all of the tables. As listed on Table 6, mercury exceeded background and guidance levels in 6 out of the 69 samples tested for mercury, as listed on all of the tables. However, as shown on Figures 1 and 2, many of these samples are located within the active Lower Walnut Creek channel (i.e., Sites 1 through 6 that include five of the six ENGEO samples that exceeded cadmium guidelines and all six of the ENGEO samples that exceeded guidelines for mercury), suggesting that the creek flow and sedimentation processes in the channel results in the accumulation of cadmium and mercury. Although the channel for Lower Walnut Creek is within the overall project boundary, the channel deposits are not proposed for reuse or dredging. Thus, only seven out of 58 samples have exceedances for cadmium. In addition, and as listed in Table 3, the cadmium exceedances are only slightly above background levels. For the soil at the seven remaining cadmium exceedances, the reworking of soil within the project area would result in reducing the concentrations of the smaller number of samples with cadmium concentration exceedances to below background and guidance levels. Therefore, the soil within the project area is considered suitable for reuse relative to cadmium and mercury.

## Cobalt

As listed on Table 2, six of the total of 64 samples equaled (four results) or exceeded (two) the cobalt ecological screening level of 13 mg/kg by just 1 mg/kg, as listed on all tables. Note that background levels have not been developed for cobalt. The Kearney Foundation conducted a study of background concentrations of various major and trace elements, including cobalt, throughout the state of California (Kearney, 1996). Naturally occurring background cobalt concentrations ranged from 2.7 to 46.9 mg/kg, with a mean concentration of 14.9 mg/kg. This suggests that the concentrations of cobalt detected in the project site soils are typical of background levels and the soil is suitable for reuse.

## Selenium

As listed on Tables 3, 5a, and 5b, selenium exceeded background and guidance levels in 14 out of the 69 samples tested for selenium, as listed on all of the tables. Selenium is known to naturally accumulate in wetland habitats. Note that the samples with selenium exceedances in the 2002 Jonas data set have a relatively higher reporting limit of 2.0 mg/kg, compared to all of the other data sets with reporting limits of 1.0 mg/kg or less. This suggests that the Jonas data set was not as sensitive, and perhaps not at accurate compared to the other data sets. The USACE data set has a lower reporting limit, suggesting greater sensitivity. In any case, the reworking of soil within the project area would result in reducing the selenium concentrations of the smaller number of samples with exceedances to below background and guidance levels. Therefore, the soil within the project footprint is considered suitable for reuse relative to selenium.

### Zinc

As listed on Table 3, one of the total of 64 samples equaled or exceeded the zinc ecological screening level of 120 mg/kg and various background levels, as listed on all tables. Given that only one sample exceeded guideline and background levels, the reworking of soil within the project area would result in reducing the zinc concentration in the one sample with an exceedance to below background and guidance levels. Therefore, the soil within the area is considered suitable for reuse relative to zinc.

## Petroleum Hydrocarbons

As listed above on Table 1, four of the five sampling investigations included testing for petroleum hydrocarbons, quantified as TPH as gasoline, diesel, and motor. The USACE sampling investigation included testing for volatile organic compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX), which are components of petroleum fuels. As listed on Tables 6 and 7, TPH as gasoline was not detected above reporting limits. TPH as diesel and TPH as motor oil were detected in many samples at concentrations up to 81 and 140, respectively. No reuse guidelines have been developed for petroleum hydrocarbons. The ESLs for diesel and motor oil are 230 and 5,100 mg/kg, respectively, for a residential setting. As previously discussed, ESLs are risk-based levels based on human health and are therefore not directly applicable to an ecological habitat. Nonetheless, the use of ESLs provides some comparative guidance as to whether a given chemical is present in soil at levels that might be deleterious to a wetland habitat. Given that the detections are below the residential TPH ESLs, the soil is considered suitable for reuse in a wetlands habitat. Note that Tables 6, 7, and 8 also include some testing results for BTEX, and methyl tertiary butyl ether (MTBE). BTEX and MTBE are components of fuels. All of the BTEX and MTBE testing results were below reporting limits, also indicating the soil is suitable for reuse.

Table 7 includes the 1994 ENGEO testing result for total recoverable petroleum hydrocarbons (TRPH) that used an analytical method that combines diesel and motor oil range petroleum hydrocarbons. As listed, all of the test results are below both the diesel and motor soil ESLs, indicating the soil is suitable for reuse.

## Phthalate esters

As listed above on Table 1, one sampling investigation included testing for phthalate esters (e.g., plasticizers); the results are listed on Table 10. Bis (2-ethylhexyl) phthalate, di-n-butyl phthalate, and di-n-octyl phthalate were detected above reporting limits in most of the samples. Guidelines have been developed only for bis (2-ethylhexyl) phthalate. Threshold Effects Levels (TELs) are levels below which biological effects are unlikely and Probable Effects Levels (PELs) above which biological effects are likely (RWQCB, 2000). Four of the samples had concentrations above the TEL; all of the sample results were below the PEL. However, as previously discussed, all of these ENGEO samples are located within the Lower Walnut Creek channel, which is not proposed for reuse or dredging.

## Organochlorine Pesticides, PCBs, Volatile and Semivolatile Organic Compounds, Polynuclear Aromatic Hydrocarbons, and Organotins

Some sampling investigations included testing for organochlorine pesticides, PCBs, VOCs, SVOCs, polynuclear aromatic hydrocarbons (PAHs) and organotins. These chemicals were not detected above reporting limits in any of

the samples, with one exception. Dieldrin, an organochlorine pesticide, was detected in on sample at an estimated concentration of 3.0 micrograms per kilogram (ug/kg), well below the reporting limit of 68 ug/kg. An estimated detection means that the laboratory analysis detected a trace amount of the constituent but the concentration is an uncertain estimate. Given that dieldrin was detected in only one sample, the reworking of soil within the project area would result in reducing the diedrin concentration in the one sample to below background and guidance levels. Therefore, the soil within the area is considered suitable for reuse.

## Other Organic and Inorganic Compounds

Various other tests were conducted for naturally occurring organic and inorganic chemicals, including sulfate, sulfides, nitrate, ammonia, and total organic carbon. These naturally occurring organic and inorganic chemicals do not have beneficial reuse guidelines, are naturally occurring, and are not considered to be able to adversely affect the wetland habitat.

## Bioassay

The 1994 ENGEO investigation included liquid/suspended-particulate bioassay testing and solid phase bioassay testing. As previously discussed, all of the ENGEO samples are dredge sediment samples located within the Lower Walnut Creek channel, which is not proposed for reuse or dredging. The investigation was conducted for a separate project to evaluate whether ocean disposal of the dredged sediments would be acceptable or whether the dredged sediments would require disposal in upland areas that have a higher tolerance level.

The liquid/suspended-particulate bioassay tests were conducted by mixing dredged sediments with seawater from Bodega Bay and using the elutriate. This seawater would be more saline than the Suisun Bay water that would periodically inundate portions of the proposed project area. Bay mussels (*Mytilus edulis*) were added to the elutriate and the rate of abnormal versus normal development of larvae that resulted were counted.

The soil-phase bioassay tests were conducted on the whole sediment by adding a small amphipod (*Eohaustorius estuarius*) that burrows into the sediment and counting the survival rate. Similar to the liquid/suspended-particulate bioassay tests above, Bodega Bay seawater was added over the sediments.

The results if the bioassay tests indicated that there are a few locations where the channel sediments would not be suitable for ocean disposal of the sediments. The results indicated that all of the sediments could be deposited in upland areas, such as the footprint of the proposed project.

# Discussion

The testing results indicated some sample locations that exceeded guidelines for a few chemical compounds. Almost all of the exceedances are for metals; wetland areas are known to accumulate metals. Consequently, given the location of the proposed restoration project along the Carquinez Straight, Suisun Bay, Lower Walnut Creek, and Pacheco Creek, this area would be expected to naturally accumulate metals over time; the presence of metals at elevated levels is expected.

However, the number of samples with concentrations that exceed background and guidance levels relative to the total number of samples collected and analyzed indicates a relatively low rate of exceedances, largely ten percent or less of the total number of samples. This indicates that while anthropomorphic activities have likely slightly increased the concentrations of a few metals above background or guidance levels in a few locations, the overall dataset shows the large majority of soil has metals concentrations that are below background and guidance levels. Consequently, the reworking of onsite soil within the project area would blend soil with the exceedances with other onsite soil, resulting in reducing overall concentrations to below guidance and background levels. The bioassay test results also indicated that the soil would be suitable for upland disposal.

As shown on Figures 1 and 2, the locations of samples with chemical concentrations that exceed guideline and background levels are located within both cut and fill areas in no particular pattern. As previously discussed, the proposed project is a net zero import-export project, meaning that soil will be moved around but not removed from the site. More importantly, the soil excavated from the cut areas would be placed on fill areas increasing the elevation at those locations. This would result in relocating soil, including some soil with exceedances, to higher elevation locations further above areas to be periodically flooded by tidal action. By reducing the exposure of some soil to tidal action, the project would also result in reducing the potential for tidal water to mobilize metals, thereby leaving the metals onsite and reducing their ability to migrate offsite.

The reworking of soil on this site in a manner that results in a net zero import-export of soil also avoids consuming the capacity of offsite landfills with material that, while slightly above some background and guidance levels, is well below hazardous waste levels. For example, the hazardous waste level (Total Threshold Limit Concentration) for selenium is 100 mg/kg, well above the maximum reported onsite concentration of 3.1 mg/kg. In other words, the few soil samples with concentrations above background or guidance levels are not hazardous waste.

Finally, given the relatively low number of and sporadic distribution of guidance level exceedances in soil, the risk to the visiting public would also be low. The proposed design of the trails would prevent exposure of the public to onsite soil because the trails are proposed to constructed of 4 inches of decomposed granite on top of 6 inches of aggregate base (sand/gravel mix). The 10-inch thick trails would isolate the few soil exceedances from the public.

During the construction activities, construction workers would be in contact with the soil. However, the chemicals detected above guidance levels are relatively immobile. Unlike volatile compounds such as gasoline, the detected chemicals would not present a respiratory hazard. The exposure route would be dermal (touch) or ingestion (eat). During construction activities, construction workers that may directly or indirectly be exposed to onsite soil or groundwater would perform work in accordance with the California Occupational Safety and Health Administration (Cal OSHA) regulations. All site construction activities associated with exposure to onsite soil or groundwater would be required to be conducted in compliance with a site-specific Health and Safety Plan (HASP) to protect workers and the environment from site contaminants. The site specific HASP would be prepared according to Title 8, California Code of Regulations, Section 5192 and Title 29 Code of Federal Regulations 1910.120. The HASP would include provisions for personal protective equipment to be worn by workers during site redevelopment activities. The District would be required to provide this Soil Quality Assessment report to the contractors to inform the preparation of their HASP.

Given the sampling results and the discussion above, the soil is considered suitable for reuse for the proposed project.

# References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