APPENDIX I

DDT Analysis

Sensitivity Analysis of Potential DDT Deposition in the Otay River Estuary Restoration Plan (ORERP) Post-100 Year and 50-Year Floods

by:

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ABSTRACT: This analysis focuses on an assessment of potential impacts on the ORERP from erosion of soils containing DDT by the 100 yr. flood, with additional analysis of the 50-year flood impacts. Scour potential associated with the 100-year flood on the ORERP have been evaluated in a companion study (Everest 2014). The present analysis evaluates the effects associated with erosion of soils containing DDT from the floodplain under the 100-year flood event that may release DDT to downstream portions of the project. Because the duration of the 100-yr flood is only 24 hours, it was assumed that tidal exchange will quickly re-establish flow dominance post-flood; and that the transport and settling dynamics of potentially contaminated silts and clays will be driven and limited by the tidal hydraulics and tidal residence times.

A sensitivity analysis was developed based on a parameter sweep of the amounts of soils containing DDT that might be eroded by the 100-year flood. Sediment coring data indicates that the depth of erosion in the area of soils containing DDT might vary between 1 ft. and 3 ft.; and the concentrations of DDT in the eroded soils could vary between 790 µg/kg and 310 µg/kg, depending on the depth of erosion. These eroded soils containing DDT could mix with as much as 438,000 cubic yards (cy) of "clean" (*i.e.*, assumed to be free of DDT) fine-grained sediments from the Otay River watershed below the Savage Dam; but that estimate was based on a surrogate watershed (Buena Vista Creek) for which more complete sediment yield data was available. Based on the uncertainties of applying that surrogate analysis to the Otay River watershed, it is sensible to consider the sensitivity of the final outcome to omitting consideration of that flux of what is believed to be "clean" sediments from upstream sources by eliminating the dilution effects that blending with clean fines exerts on DDT concentrations during the post-flood deposition. From this assessment of the possible sediment erosion input assumptions, a sensitivity analysis **is provided** for the post 100-year flood DDT deposition that is based on

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erosion fluxes from three erosion depths (1 ft., 2 ft. and 3 ft.) in the floodplain that are each combined with two possible fluxes of “clean” fines (0 cy and 438,000 cy) from the watershed below the Savage Dam. In addition, the biological risk assessment of these six possible deposition scenarios also considers bioturbation exposures occurring post-flood within the top 20 mm, 40 mm and top 80 mm of the muddy sediments in the tidal basins of the ORERP. This range of parameters yields a sensitivity analysis with 18 possible outcomes including worst-case scenarios.

It was found that the post 100-year flood will result in the deposition of less than 1 mm to as much as 8 mm of partially consolidated mud in the tidal basins of either restoration alternative that will have an average dry bulk DDT concentration of 42 μ g/kg to 790 μ g/kg, depending on the particular scenario. The DDT concentrations in the muds deposited in the ORERP can range as high as 310 μ g/kg to 790 μ g/kg, but the deposition thicknesses of these scenarios reduce to only fractions of a millimeter once these muds become consolidated. Using a depth-proportional exposure approach, and assuming all exposure occurs within the top 20 mm under worst-case, we calculated that the DDT concentration experienced by the benthic biota would range from approximately 13 μ g/kg to 29 μ g/kg initially, and would decrease with compaction and consolidation to a final 20 mm-based dry bulk concentration of 4.2 μ g/kg to 7.9 μ g/kg. The controlling variable in worst-case exposure determination is the total mass of DDT in the post-flood sediment deposition, which is maximized by the scenarios in which the largest volumes of DDT-contaminated sediments that were eroded, (*i.e.*, the 3ft. erosion depth scenarios) in the absence of mixing with additional sediments from upstream sources. Worst case exposures were found to be relatively insensitive to the dilution provided by sediments from upstream sources, while the mixing depth of bioturbation has a much stronger influence. DDT concentrations experienced by the benthic biota under worst-case are reduced 2 to 4 fold when bioturbation extends over the top 40 mm or top 80 mm of the muddy sediments in the tidal basins of the ORERP. The depth of bioturbation will be determined by the species that ultimately colonize the tidal basins, but we would not expect that to be less then approximately 20 mm.

Upon advice from the California Coastal Commission Science Advisory Panel, the above analysis was repeated for the 50-yr flood, to assure the most extreme potential DDT exposure outcomes have been modeled. The DDT deposition results for the 50-yr flood were found to be within the range of those for the 100-yr flood. The DDT concentrations in the muds deposited in the ORERP post 50-year flood can range as high as 111 μ g/kg to 790 μ g/kg, and again, deposition thicknesses of these scenarios reduce to only fractions of a millimeter once these muds become consolidated. Using a depth-proportional exposure approach within the top 20 mm under worst-case, we calculated that the DDT concentration experienced by the benthic biota would range from approximately 12 μ g/kg to 26 μ g/kg initially after the 50-year flood, and would decrease with compaction and consolidation to a final 20 mm-based dry bulk concentration of 4.0 μ g/kg to 7.1 μ g/kg.

Relative to impacts on the benthic organisms as the prey base, the maximum short-term DDT concentrations in the post-flood deposition fall between the ER-L and ER-M values. Thus, we would expect that impacts on benthic organisms could occur occasionally during the short-term. Given the likelihood of effects combined with the short-term nature of this condition, population level impacts are expected to be limited in nature and extent. Once these post-flood muddy deposits have compacted and consolidated, the DDT concentrations in the top 20 mm of muddy sediment are very close to the ER-L, and even lower for the top 40 mm and top 80 mm of sediment; so that negative effects are expected to be rare. This condition is not likely to have a measurable effect on the prey base for aquatic-dependent species.

In regards to the aquatic-dependent birds' exposures to DDT in prey , comparison of the 20 mm-based DDT concentrations to screening levels indicates that these concentrations fall within the range of highest and lowest NOAELs. Given the species known to be the most sensitive are pelicans and cormorants, (which are very closely related, and our target species are not members of groups believed to be particularly sensitive), impacts on aquatic-dependent birds are unlikely to result from the anticipated deposition of sediments in the ORERP following either a 100-year or 50-year flood event.

Upon advice from the California Coastal Commission Science Advisory Panel, the above analysis was repeated for the 100-yr flood in the absence of the ORERP (*i.e.,* No Project Alternative). Those results are given in APPENDIX-B. The DDT deposition results in Ponds 10 & 11 of the No Project Alternative were found to be within the range of those for the ORERP tidal basins post 100-yr flood, so that the above conclusions on potential flood-induced DDT impacts to the existing wetlands ecology are upheld; and it can be concluded that the ORERP does not increase the risk of exposure of wetland ecology to DDT, a risk that exists with or without the project.

Sensitivity Analysis of Potential DDT Deposition in the Otay River Estuary Restoration Plan (ORERP) Post-100 Year Flood

Scott A. Jenkins, Ph. D., Ying Poon, D.Sc., Catherine Zeeman, Ph.D., and Carol Roberts

1.0) Introduction:

In this study we estimate rates of fine-grained sediment deposition in the tidal basins of the ORERP *Intertidal and Subtidal Alternatives* for a model problem in which the wash load source is defined by the sediment yield of the Otay River during the 100 year flood. Because of the nearby Savage Dam, the sediment yield is assumed to be derived from scour and erosion of the Otay River floodplain, downstream from the dam. Scour impacts from the 100 year flood on the ORERP have been evaluated in a companion study Everest, (2014). The primary concern of the present analysis is that a portion of the floodplain that could be scoured and eroded by the 100 year flood has surficial layers of soil comprised of a high percentage of silts and clays that contain various concentrations of DDT; and that some of those fine-grained sediments might re-settle in the tidal basins of the ORERP post-flood. Because the duration of the 100-yr flood is only 24 hours, we assume that tidal exchange will quickly re-establish flow dominance post-flood; and that the transport and settling dynamics of potentially contaminated silts and clays will be driven and limited by the tidal hydraulics and tidal residence times detailed in Sections 4 and 5.

This study is a multi-disciplinary effort of four scientists. The study begins with a soil characterization and erosion analysis of the 100 year flood in Sections 2 and 3, respectively, which was conducted by Ying Poon, D.Sc. of Everest International. Section 2 provides the essential sediment flux initial conditions for a post-flood suspended sediment tidal transport and deposition analysis in Sections 4 and 5 that was performed by Scott Jenkins, Ph.D. of Michael Baker International. The post flood deposition thicknesses and DDT concentrations in the tidal basins that were calculated in Sections 5 were throughput to a biological impact assessment presented in Section 6 that was conducted by Catherine Zeeman, Ph.D. and Carol Roberts of the Environmental Contaminants Division, Carlsbad Fish and Wildlife Office. Deposition results for the 50-year flood appear in APPENDIX-B and were found to remain within the range of variability of scenarios for the 100-year flood.

2.0) Erosion Analysis for the 100-Year Flood in the Otay River Basin:

Everest International Consultants (Everest) conducted an analysis on the potential for the DDT containing soils in the Otay River Floodplain (ORF) to be eroded and transported to the proposed wetland during a 100-year flood event. The analysis was based on numerical simulations conducted with the two-dimensional hydrodynamic model – TUFLOW, which simulated the velocities over the ORF during a 100-year flood event. The analysis was also based on soil property data from the soil sampled in the ORF to evaluate the potential for soil erosion. Details of the TUFLOW model setup can be found in Everest (2014).

The 100-year flood hydrographs for the Otay River, Poggi Canyon Creek and Nestor Creek are shown in Figure 1. The total flow volume during a 100-year flood for the Otay River is 35,200,000 cubic yards (cy), or 26,911,315 cubic meters (m^3). The corresponding flow volumes for Poggi Canyon Creek and Nestor Creek are respectively 2,240,000 cy (1,712,254 m^3) and 1,748,800 cy (1,337,003 m^3), so that the combined flow through the floodplain is $\overline{Q} =$ 39,188,800 cy (29,960,856 m^3), or 24,290 acre ft. The flow for the Otay River is an order of magnitude higher than those for Poggi Canyon Creek and Nestor Creek. The percent of Nestor flow that would pass through the wetland was not analyzed, but since Nestor Creek directly flows into the proposed wetland area, it was assumed that all of the Nestor Creek flow would enter the wetland. Figures 2 & 3 give the distributions of maximum stream flow velocities for the 100-year flood velocity throughout the Otay River floodplain and adjacent pond complexes for the ORERP Intertidal and Subtidal Alternatives, respectively.

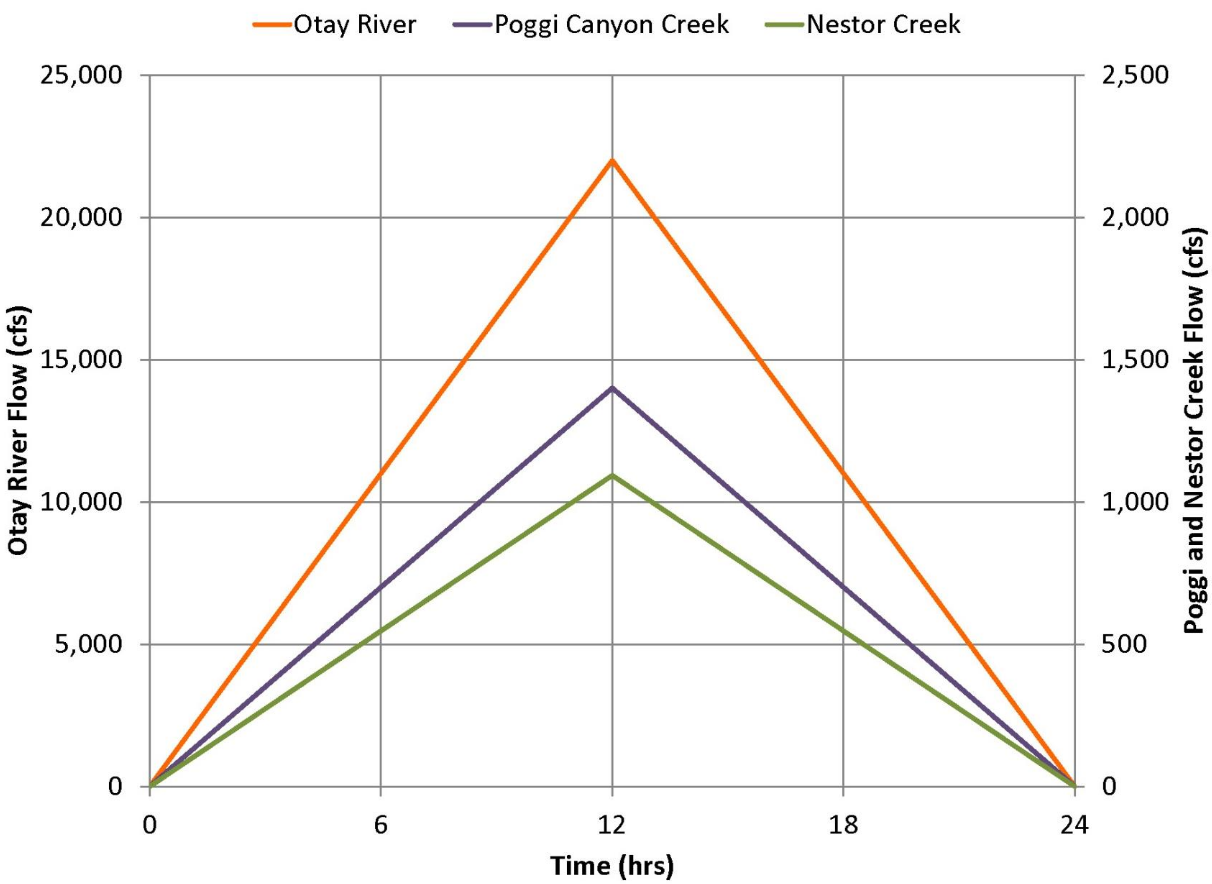

Figure 1. The 100-Year Return Period Flood Hydrographs**.**

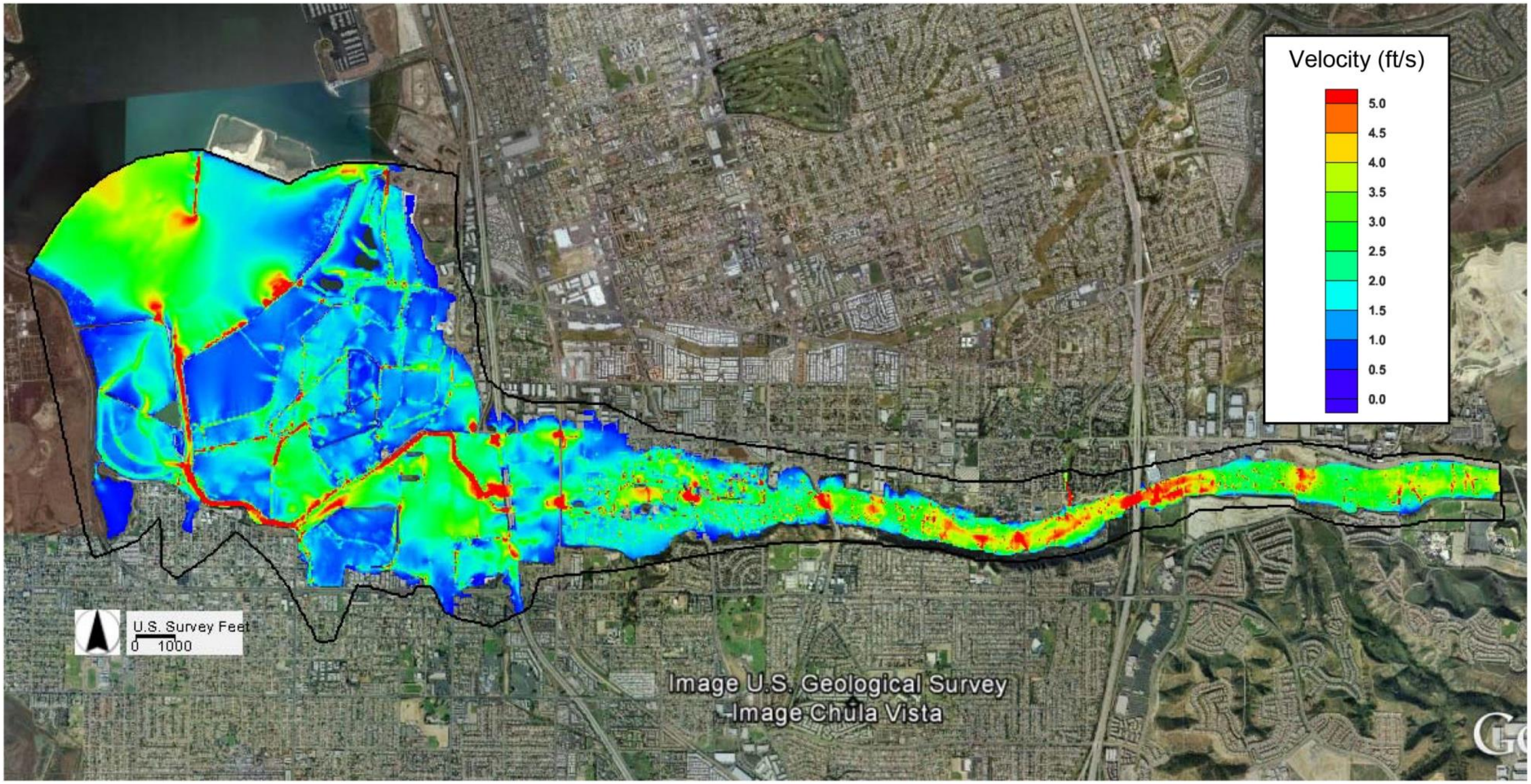

Figure 2: Distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain with the fully implemented Intertidal Alternative, (after Everest, 2014)

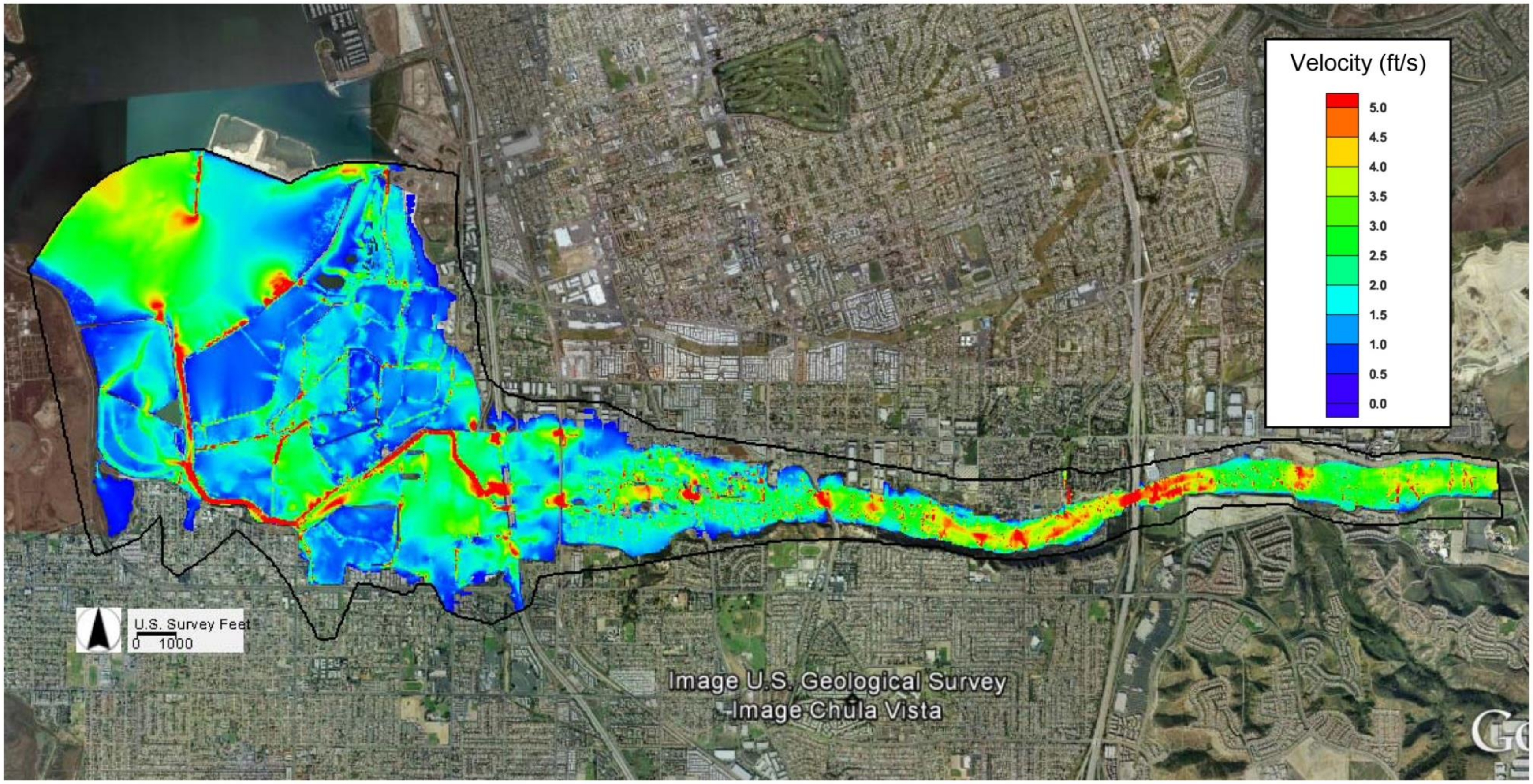

Figure 3: Distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain with the fully implemented Subtidal Alternative, (after Everest, 2014).

Data were not available for the sediment discharge from the Otay River Watershed during a 100-year flood event; hence, it was estimated based on sediment discharge from the Buena Vista Creek (BV) Watershed for which sediment discharge during a 100-year study was available. In an earlier fluvial hydraulic and sediment transport study, Everest (2008) estimated that the sediment discharge during a 100-year flood event for the BV Watershed would be about 603,000 cy. Characteristics of the Otay River Watershed and BV Watershed are compared in Table 1. The area for the BV Watershed is approximately 19 square miles, while the Otay River Watershed (portion below the dam) is about 46 square miles with the entire Otay Watershed covering 143 square miles. Compared with the BV Watershed, the Otay River Watershed (below dam) is less urbanized with more open space land use, potentially more susceptible to soil erosion during a flood event. Nevertheless, simply based on scaling by the watershed size, sediment discharge from the Otay River Watershed is about 1,460,000 cy during a 100-year event. Based on Taylor (1981), about 50% of the sediment delivered from the Otay River Watershed is fine grain size ($d < 0.065$ mm), and the other 50% is sand. Hence, the fine portion is about 730,000 cy. It is estimated that during a 100-year flood, approximately 60% of the fine grain sediment discharge, i.e. 438,000 cy (334,880 m^3) would pass through the proposed wetland.

Table 1: Comparison between Otay River and Buena Vista Creek Watersheds

COMPARISON	OTAY RIVER	BUENA VISTA CREEK
Watershed Area	46 mi^2 *	19 mi^2
Urban Land Uses	39.1%	75.2%
Agricultural Land Uses	0.6%	22.4%
Open Space Land Uses	60.3%	2.4%

**Watershed area below dam*

2.1) Soil Erosion from Otay River Floodplain: The potential for soil erosion from the ORF during a 100-year flood event is evaluated based on the flood velocities and soil properties. In general, silt and clay are less susceptible to erosion while sand is relatively easier to be eroded. Based on the sediment characterization study conducted by Anchor QEA (2013), the top three feet of sediment consists of fine to coarse sand (i.e., easy to be eroded), and below three feet, based on data for samples taken between 3 to 5 ft below ground, sediments are cohesive, consisting mainly of silt and clay (less susceptible to erosion). As illustrated by the Hjulstrom Curve shown in Figure 4, sediments consisting mainly of fine sand to coarse sand (the blue shaded area in Figure 4) are likely to be scoured (eroded) when the flood flow velocity is higher than approximately 0.6 ft/sec. The TUFLOW model simulated maximum flood velocities over the ORF area during a 100-year flood event is shown in Figure 5. The color scale of the figure is selected such that the lowest velocity shown is 0.6 ft/sec (threshold for scouring). As can be seen in the figure, the maximum flood velocities over the entire ORF are higher than 0.6 ft/sec; hence likely to be eroded based on the Hjulstrom curve. In addition, based on the TUFLOW model results, (Figures 2 & 3) the bed shear stress over the ORF ranges from about 0.2 N/m^2 to 0.9 N/m^2 during a 100-year flood event. Based on empirical data relating sediment erosion to bed shear stress, these bed shear stresses are high enough to result in sediment erosion (Roberts et al, 1998).

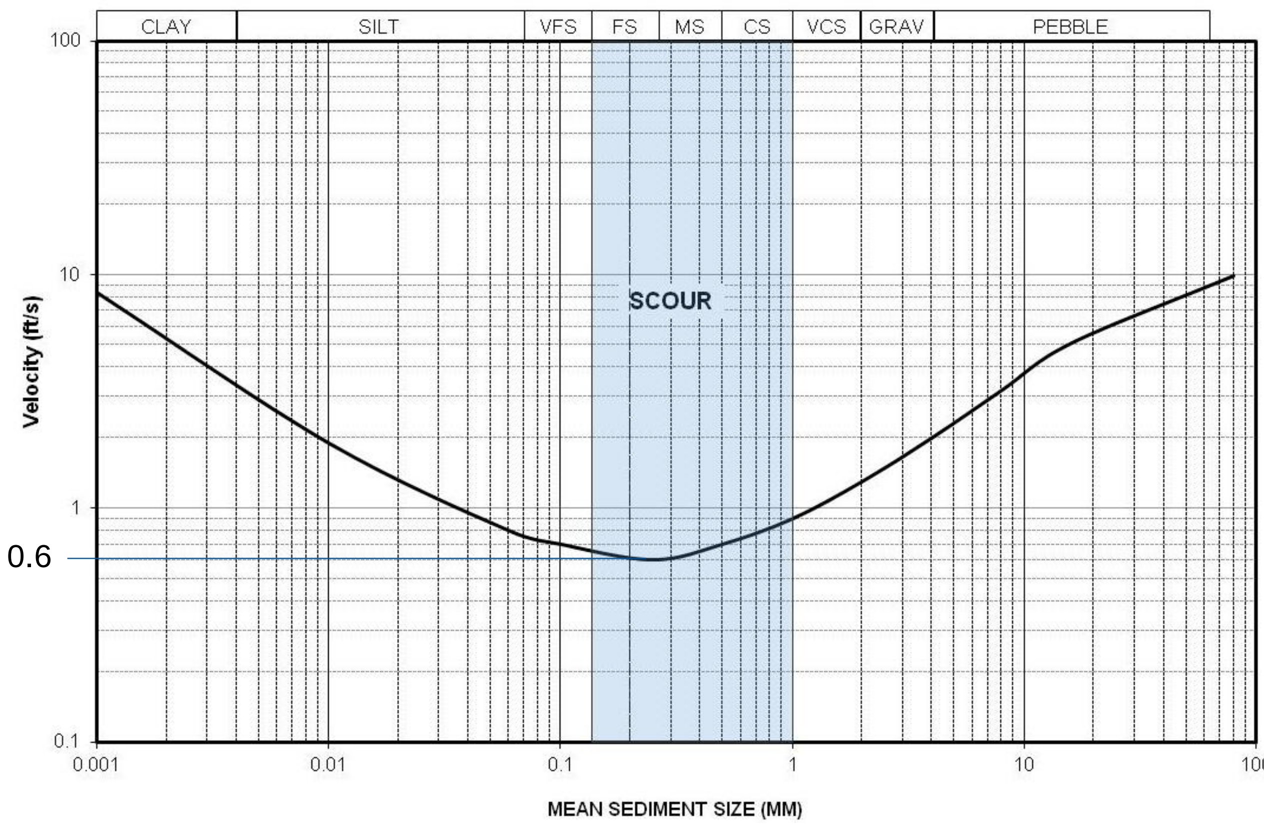

Figure 4. Hjulstrom Curve

Not all the sediment being eroded from the ORF would be transported and delivered to the proposed wetland. Sediment being eroded may simply move along the bed from one location to another, or remain suspended in the water column (portion that are likely to be transported). Some of the suspended sediment may be re-deposited in another area (not entering the wetland). In lieu of conducting a sediment transport modeling study, it is not easy to quantify the amount of eroded soil from the ORF that would be transported to the proposed wetland. Hence, for this study, three erosion scenarios for erosion depths of 1 ft, 2 ft, and 3 ft over the entire ORF were considered for the evaluation of potential transport and deposition of DDT contaminated soils from the ORF to the proposed wetland. The volume of eroded soil, percent fines (d < than 0.065 mm), and volume of fines for these three scenarios are summarized in Table 2.

Table 2: Volume and Properties of Eroded Soils of ORF

EROSION DEPTH (ft.)	**VOLUME OF ERODED SOIL (cy)**	**PERCENT FINES**	**VOLUME OF FINES (cy)**
1	114,890	21.1%	24,260
2	229,780	33.2%	76,350
3	344,700	37.2%	128,300

2.2) DDT Concentrations of the Eroded Soils: Two soil sampling and analysis datasets were utilized to evaluate the DDT concentrations of the ORF soils under the three erosion scenarios described above. The two datasets include data from an earlier Anchor QEA study (2013) along with newer data from a U.S. Fish and Wildlife Service study (Zeeman 2014). The two datasets consist of data for different sampling locations and boring depths. The Anchor data consist of 11 borings over the ORF, with DDT concentrations for depth layers of 0 to 1, 1 to 3, and 3 to 5 feet below ground. Soil data from the U.S. Fish and Wildlife Service consists of 14 sampling locations, and data were collected from the top 0.5 feet below ground.

Based on discussion with the project team, it was decided to assume that the DDT concentrations for the U.S. Fish and Wildlife samples would apply to the top one foot of soils; hence can be combined with the Anchor data for the top 1 ft to evaluate the DDT concentrations for the top 1 ft. of soil over the ORF. From these data, the DDT concentrations of the ORF were estimated using Voronoi diagrams, in which each cell area is partitioned based on the sampling locations. Figure 6 shows the resulting Voronoi diagram for the top 1 ft of the soil over the ORF

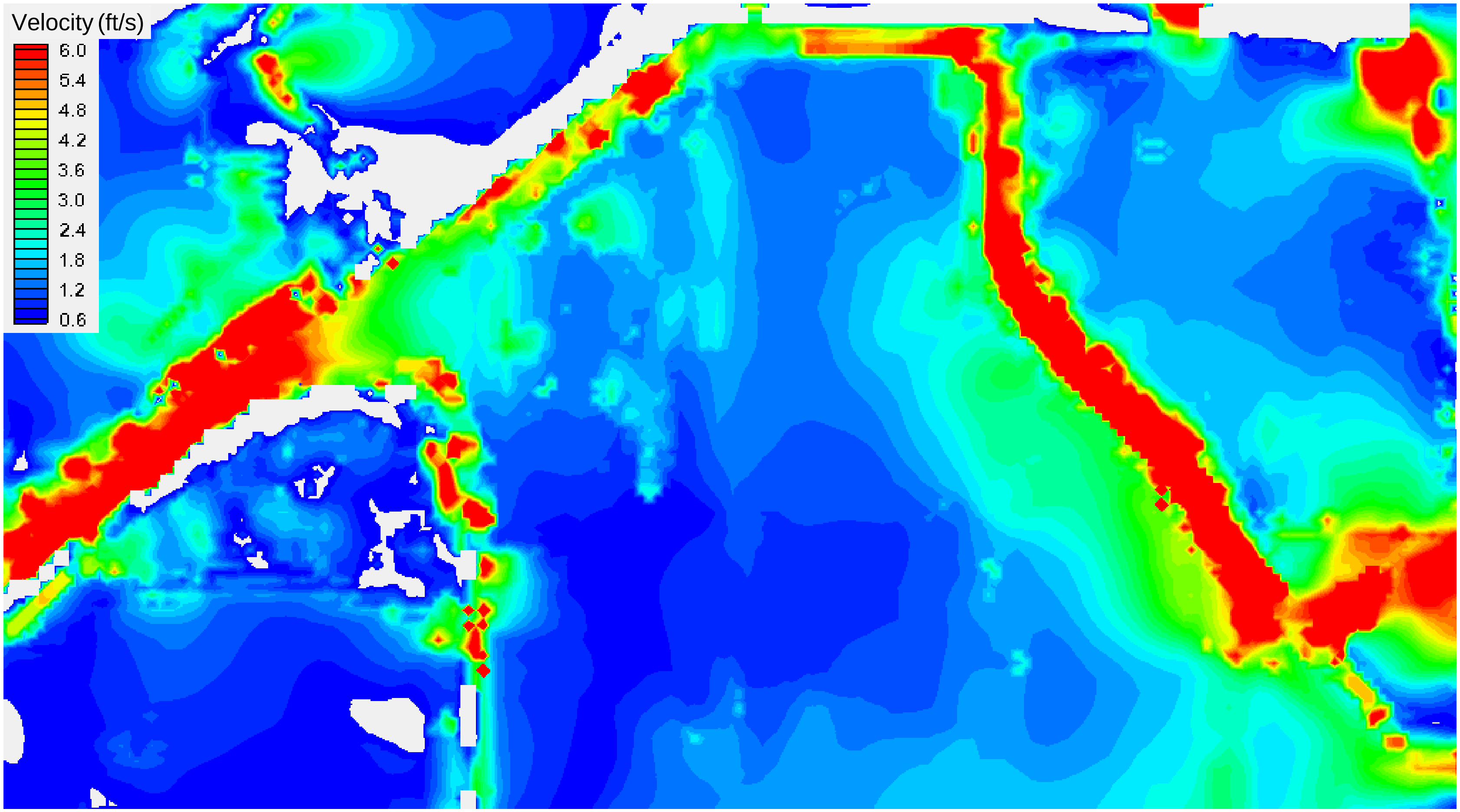

Figure 5. Maximum Velocity during a 100-year Flood under Existing Conditions. Note: white color indicates maximum velocity less than 0.6 ft/s

using both datasets (a total of 25 locations—11 from Anchor QEA and 14 from the U.S. Fish and Wildlife Service). The numbers shown in the figure are the Voronoi cell size in square feet and associated DDT concentrations in µg/kg. Similar Voronoi diagram for soil layer from 1 to 3 feet below ground is provided in Figure 7. This diagram is developed using only the Anchor QEA data. The number of cells in Figure 7 is fewer than those shown in Figure 6 since there are only 11 relevant boring locations for this layer. From these Voronoi diagrams, the average DDT concentration (weighted by soil volume) under the three erosion scenarios over the ORF were calculated and summarized in Table 3.

Table 3: Average DDT Concentrations for Three Erosion Scenarios

EROSION DEPTH (ft.)	AVERAGE DDT CONCENTRATION (µg/kg)
1	790
2	430
3	310

3.0) Specifying the Sensitivity Analysis for the Post 100-Year Flood DDT Deposition

The sensitivity analysis is based on a parameter sweep of the amounts of DDT containing sediments that might be eroded by the 100-year flood; and Section 2.2 has provided coring analysis that indicates the concentration of DDT in the eroded fine sediments could vary between 790 µg/kg to 310 µg/kg, depending on the depth of erosion. Section 2.0 indicates that these eroded contaminated sediments could mix with as much as 438,000 cy of fines (assumed to be uncontaminated) from the upper watershed below the Savage Dam. This estimate was based on a surrogate watershed (Buena Vista Creek) for which more complete sediment yield data was available. Based on the uncertainties of applying that surrogate analysis to the Otay River watershed, it is sensible to consider the sensitivity of the final outcome to omitting the flux of supposedly “clean” sediments from upstream sources altogether. In the absence of any new information revealing additional upstream sources of DDT, that omission will eliminate the dilution effects that blending with “clean” fines exerts on DDT concentrations during the post-flood deposition. From this assessment of the possible sediment erosion input assumptions, a sensitivity analysis **is posed** for the post 100-year flood DDT deposition that is based on erosion fluxes from three possible erosion depths (1 ft, 2 ft, and 3 ft) in the DDT contaminated area of the floodplain that are each combined with two possible fluxes of clean fines (0 cy and 438,000 cy) from the watershed below the Savage Dam; yielding a sensitivity analysis comprised of 6 separate deposition scenarios. The ensembles of input parameters for this sensitivity analysis are summarized in Table 4.

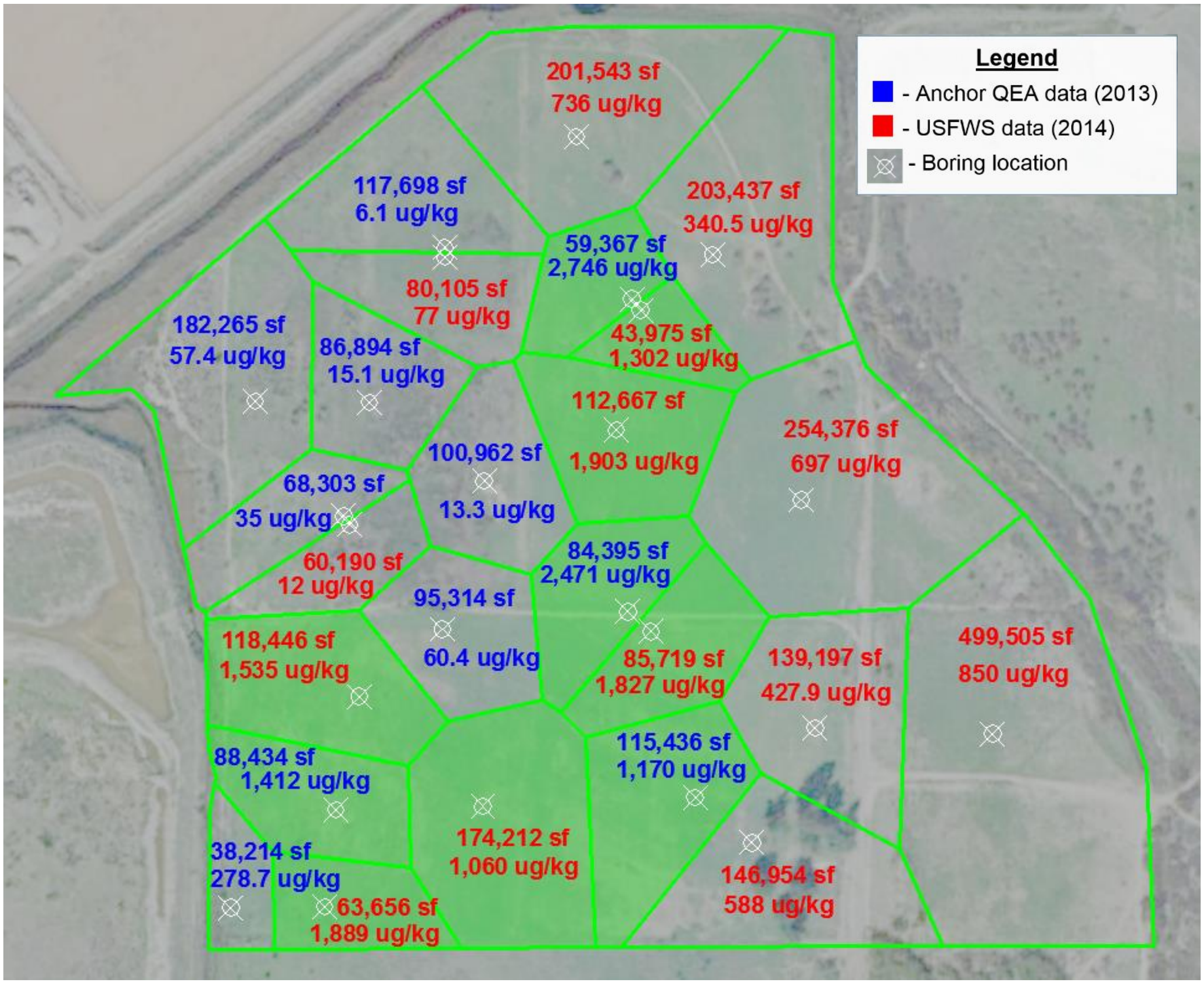

Figure 6. Voronoi Diagram for Soils 0 ft. to 1 ft. below ground surface - Cell Areas and DDT Concentrations

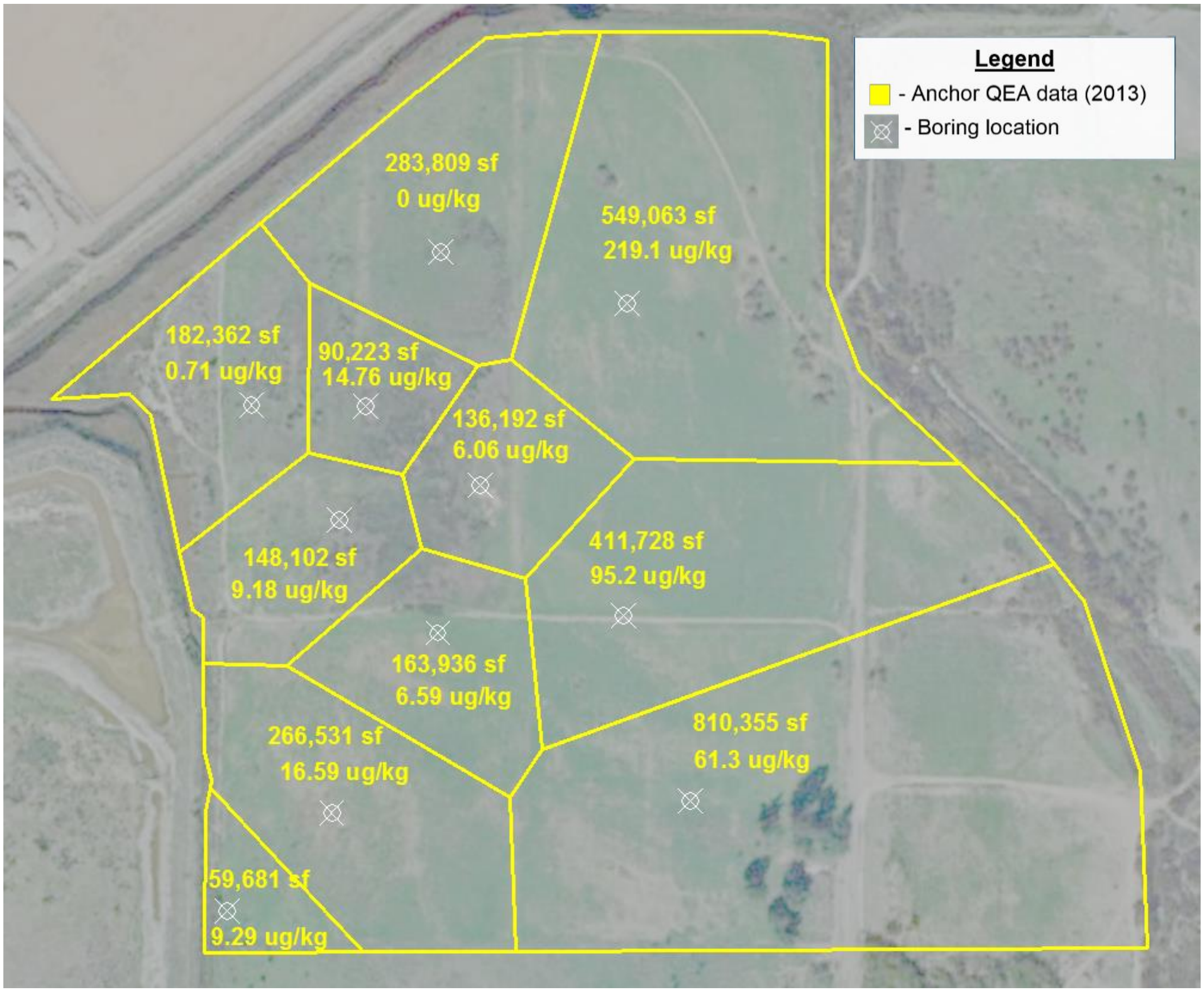

Figure 7. Voronoi Diagram for Soils 1 ft - 3 ft below ground surface - Cell Areas and DDT Concentrations

The suspended sediment concentrations in Table 4 are based on a dry bulk density for eroded soil of 2700 lb per cy, or 1.225 metric tons per cy; where a metric ton is 1000 kg. This conversion factor is applied to the sum of the volume of eroded DDT- bearing fines (column_2) and the volume of eroded fines from the upper Otay watershed (column_4) to obtain the total flux of suspended fine grained sediment in tons/day during the 24-hour flood period of the 100-year flood (cf. Figure 1). The sand and gravel sized fractions eroded from the floodplain by the 100-year flood are assumed to be transported as bed load. The suspended sediment flux component (column_2 + column_4) is divided by the flow volume of $\overline{Q}$ = 29,960,856 m^3 during the 24-hour flood period to give the average suspended sediment concentration in column_6 upon conversion of metric tons to grams and cubic meters to liters.

Table 4: Input Parameters for Sensitivity Analysis of Post 100-Year Flood DDT Deposition

Scenario	Volume of Eroded DDT-Bearing Fines	Average DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.
Erode top 3 ft. of Contaminated Area + Upper Watershed*	128,300 cubic yards	310 μ g/kg	438,000 cubic yards	24,290 acre ft	23.15 g/l.
Erode top 1 ft. of Contaminated Area + Upper Watershed	24,260 cubic yards	790 μ g/kg	438,000 cubic yards	24,290 acre ft	18.90 g/l
Erode top 2 ft. of Contaminated Area + Upper Watershed	76,350 cubic yards	430 μ g/kg	438,000 cubic yards	24,290 acre ft	21.03 g/l
Erode top 3 ft. of Contaminated Area Only*	128,300 cubic yards	310 μ g/kg	0 cubic yards	24,290 acre ft	5.25 g/l
Erode top 1 ft. of Contaminated Area Only*	24,260 cubic yards	790 μ g/kg	0 cubic yards	24,290 acre ft	0.99 g/l
Erode top 2 ft. of Contaminated Area Only*	76,350 cubic yards	430 μ g/kg	0 cubic yards	24,290 acre ft	3.12 g/l

4.0) Suspended Sediment Transport and Deposition:

Because DDT is hydrophobic, it can only be adsorbed and transported by the silt and clay fractions of floodplain soils eroded by the 100 year flood. These fine-grained fractions are transported as suspended load (commonly referred to as wash load), and capable of becoming re-distributed into the tidal basins of the restoration project; while the remaining coarser erodible fractions (primarily sands and gravels) are transported as bedload and remain confined to the streambeds of the Otay River, Poggi Canyon Creek and Nestor Creek, (Everest, 2014). For this reason, we focus on the tidally influenced suspended sediment transport dynamics of fine-grained silts and clays in the post-flood period.

While the duration of the 100 year flood is relatively brief (24 hr), the transport, redistribution and settling of the washload sediments can linger on for days, even weeks under the influence of tidal exchange. Typically in calm water, silt particles will require 4.3 hr. to settle to the bottom in 1 meter of water depth, while clay-sized particles can take as long as 18 days. The residence time of water in South San Diego Bay can be as long as 40 days (Largier, 1995); consequently, washload discharged into South San Diego Bay from the 100-year flood can potentially recirculate back into the tidal basins of the restoration project for many tide cycles before the fine-grained washload sediments completely settle out of the South Bay water mass.

From Anchor (2013), the average grain size of the silts and clays that make up the 37.2% of the sediments found in the top three feet of erodible sediments in the black outlined area of Figures 6 & 7 is only 25 microns ($\bar{d}_{fines} \cong 0.025$ mm). The settling velocity is only w_s = 0.030 cm/sec based upon 25 micron median aggregate size of silts and clays (Figure 8). Because of these very low settling rates, (*Stokes settling regime*), subsequent deposition of the silts and clays that contain DDT will be a slow process, which will extend for many tide cycles depending on the local water depth. In posing the problem of tidal flushing of these fine-grained sediments from the tidal basins of the restoration project, we shall neglect any hydrodynamic effect on the tidal hydraulics due to the river flow. This assumption is supported by the short duration of the flood hydrograph relative to the duration of settling and deposition processes. By this assumption, we are basically saying that the hydrodynamics are dominated by the fluvial processes during the first 24 hours, since the flow volume of the 100-year flood is 56 times larger than the combined tidal prisms of the restoration project tidal basins. Thereafter, tidal processes ensue; so that fluvial and tidal processes occur sequentially without interaction. In addition, we shall assume that the sediment yield of the 100-year flood is uniformly dispersed at the end of the flood period, with an initial suspended sediment concentration $\bar{C}_0$ given by column_6 in Table 4 that is uniform throughout the floodplain and adjacent South San Diego Bay as far north as the nodal points at the Chula Vista Wildlife Reserve (Figures 2 & 3). This initial uniform suspended concentration is subsequently modified by the action of tidal advection and diffusion and by gravity-induced settling that we shall represent by the following form of the sediment continuity equation:

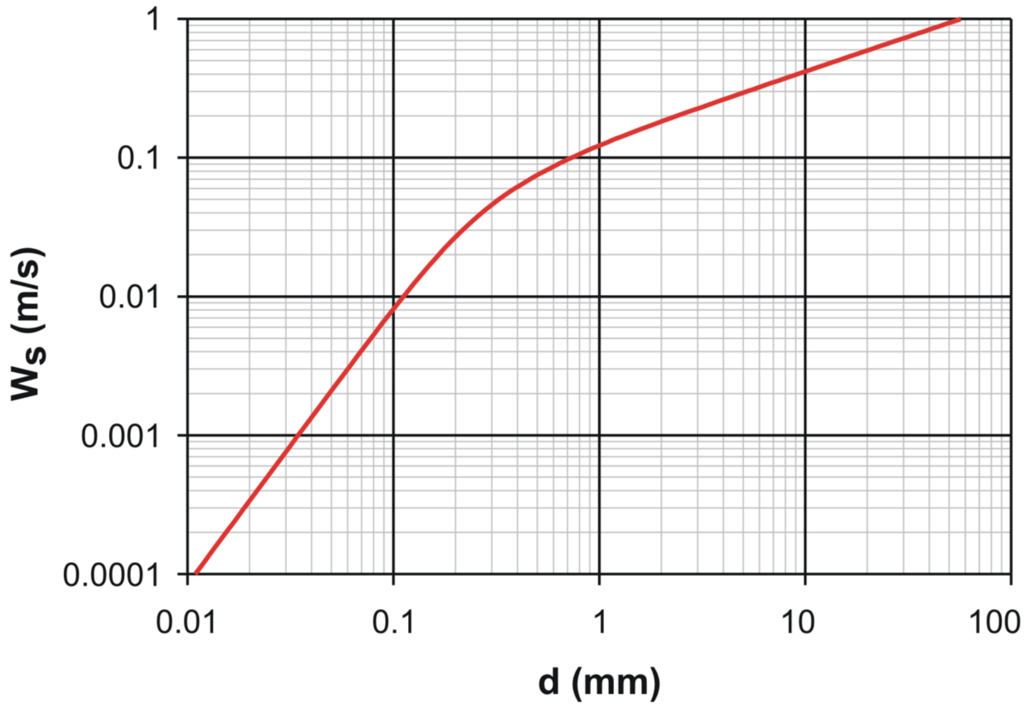

Figure 8: Settling velocity of quartz grains as a function of median grain size.

$$\frac{\partial}{\partial t} cH + \frac{\partial}{\partial x} J_x + \frac{\partial}{\partial y} J_y = \varepsilon_m \left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2} \right) - Sc \qquad (1)$$

where $c = c(x, y, t)$ is the local suspended sediment concentration; S is the settling (sink) coefficient, $S \sim f(w_0)$; w_s is the settling velocity of the sediment that is independent of (*x, y, t*) and is a single valued function of grain size only according to Figure 8; the water depth at any finite element node is $H = \eta + h$; h is the local bottom elevation in NAVD 88; η is the tidal amplitude in NAVD 88; ε_m is the mass diffusivity, and J_x, J_y are local sediment flux components due to the local depth averaged tidal velocities, $(\bar{u}, \bar{v})$:

$$J_x = c \int_{-h}^{\eta} \bar{u} dz \qquad (2)$$

$$J_y = c \int_{-h}^{\eta} \bar{v} dz$$

Equation (1) is forced by the solutions for the water surface elevations, η , and tidal velocities, $(\bar{u}, \bar{v})$ generated by the TIDE_FEM finite element tidal hydraulics model applied to the grading designs of the Intertidal and Subtidal Alternatives for the ORERP. These TIDE_FEM tidal hydraulics solutions are documented in Jenkins and Wasyl (2014).

The term Sc in Equation (1) represents a sink for suspended sediment, often referred to as the deposition flux, $D(x, y, t)$, that is the net of settling and re-suspension:

$$Sc = D(x,y,t) = c(x,y,t)\,w_s - \frac{\alpha\left[\tau(x,y,t) - \tau_c\right]}{\tau_c} \tag{3}$$

Where the term $c\,w_s$ is the downward-directed settling flux, while the upward flux of sediment re-suspended by bottom shear stress is $E(x,y,t)=\alpha(\tau-\tau_c)/\tau_c$. Here, α is an empirical coefficient, α = 2.356 X 10^{-4} g/cm^2/sec after Mehta (1981); τ_c = 0.5 dynes/cm^2 is the cohesive yield stress for unconsolidated mud after Mehta, et al. (1982); and $\tau = (\tau_x^2 + \tau_y^2)^{1/2}$ is the tidally induced bottom shear stress from the that is quasi-linearized by Chezy-based friction using Manning's roughness factor, n_o:

$$\begin{aligned} \tau_x &= -\frac{g}{\rho H^2 C_z^{\,2}}\, q_x \left(q_x^{\,2} + q_y^{\,2}\right)^{1/2} \\ \tau_y &= -\frac{g}{\rho H^2 C_z^{\,2}}\, q_y \left(q_x^{\,2} + q_y^{\,2}\right)^{1/2} \end{aligned} \tag{4}$$

$$q_x = \rho\int_{-h}^{\eta} \bar{u}\,dz \quad ; \quad q_y = \rho\int_{-h}^{\eta} \bar{v}\,dz$$

Here, C_z is the Chezy coefficient calculated as:

$$C_z = \frac{1.49}{n_0} H^{1/6} \tag{5}$$

By Equations (1) – (5), the post flood deposition processes of settling and re-suspension are posed as a time-dependent, two-dimensional boundary value problem in which the forcing is provided by the depth averaged tidal velocities, $(\bar{u}, \bar{v})$ resolved by the TIDE_FEM tidal hydraulics model detailed in Sections 2 and 3 of Jenkins and Wasyl, (2014). Boundary conditions and initial conditions on Equation (1) are imposed at the land-water and open water boundaries and open-water boundaries and nodes. Flux quantities normal to these boundary contours are denoted with "n" subscripts and tangential fluxes are given "s" subscripts. At any point along a boundary contour, the normal and tangential suspended sediment fluxes are:

$$J_n = \int_{-h}^{\eta} c u_n dz = \alpha_{nx} J_x + \alpha_{ny} J_y$$
$$J_s = \int_{-h}^{\eta} c u_s dz = -\alpha_{nx} J_x + \alpha_{ny} J_y \qquad (6)$$
$$\alpha_{nx} = \cos(n, x)$$
$$\alpha_{ny} = \cos(n, y)$$

On land-boundary contours, the suspended sediment flux components are prescribed as:

$$J_n = J_s = 0 \qquad \text{on land-water boundaries} \qquad (7)$$

On the open-water boundaries and nodes of the computational mesh, an initial post-flood condition is imposed requiring that the suspended sediment concentration is a constant, $\overline{C}_0$, given by the eroded area values from column_6 in Table 4, or $c = \overline{C}_0$ in Equation (6) at $t = 24$ hr.

Equation (1) is solved over the same finite element mesh as the ORERP tidal hydraulics simulations using the Galerkin weighted residual method detailed in Gallagher,(1981), Weiyan (1992). By this approach, the sediment continuity equation (1) reduces to a simple oscillator equation forced by the collection of algebraic terms which is easily integrated over time. The time integration scheme used over each time step of the post-flood tidal forcing period is based upon the *trapezoidal rule*. This scheme was chosen because it is known to be unconditionally stable, and in tidal propagation problems has not been known to introduce spurious phase differences or damping. It replaces time derivatives between two successive times, $\Delta t = t_{n+1} - t_n$, with a truncated Taylor series.

Solutions to Equation (1) for the post-flood suspended sediment concentration $c = c(x, y, t)$ are combined with solutions for the tidally induced bottom shear stress, $\tau(x, y, t)$, from the TIDE_FEM model to compute the deposition flux, $D(x, y, t)$ using Equation (3). As these solutions continue forward in time post-flood, $D(x, y, t) \rightarrow 0$ as the suspended sediments progressively fall out of suspension and $c(x, y, t) \rightarrow 0$. The deposition flux is integrated over this post-flood deposition period to compute the deposition thickness, but initially this deposition represents unconsolidated of fluid mud. With this initial deposition to consolidate and compact from an initial fluid-mud layer whose bulk concentration is C_f ; to some partially consolidated mud layer whose bulk density is C_s , after Krone (1978), Mehta (1989). The deposition thickness at time $t = j\,\Delta t$ for any given nodal point is calculated [Krone, 1962]:

$$\Delta Z(x,y,t) = \int_0^{j\Delta t} \frac{D(x,y,t) - K_s C_s\, g}{1 - C_f \,/\, C_s}\, dt \qquad (8)$$

where K_s = 4 x 10^{-13} sec is the sedimentation coefficient after the work of Fujita (1962). The fluid mud layer bulk concentration shall be set at C_f = 100g/l and the partially consolidated mud concentration shall be set at a rather low value of C_s = 200 g/l to allow for the effects of bioturbation. These are conservative values which will tend to overestimate deposition thickness. The mass diffusivity shall be set at ε_m = 4.9 cm^2/sec based upon work conducted in tidal basins in the San Francisco Bay Estuary, Jenkins and Wasyl (1980, 1983, and 1990).

5.0) Post-Flood Tidal Deposition Simulations for the 100-Year Flood:

The TIDE_FEM model was run for 276 hours immediately following the 100-year flood using tidal forcing with Δt = 2 sec time step intervals at the mouth of the Otay River, derived from a spectral correction applied to the NOAA tide gage #941-0170 located at the Navy Pier, as detailed in Section 3.4 of Jenkins and Wasyl (2014). The post-flood tidal deposition simulations were run on the same finite element grid using the TIDE_FEM outputs for depth averaged tidal velocities, $(\bar{u}, \bar{v})$, tidally induced bottom shear stress $\tau(x, y, t)$, and local water surface elevations, η as forcing functions to Equation (1).

Initial conditions post flood were a uniform dispersion throughout the model grid of a suspension of silt and clay sized sediment characterized by a 20 micron median grain size with a settling rate of w_s = 0.030 cm/sec to account for some degree of flocculation. The initial conditions were specified as a uniform suspended sediment concentration, $\overline{C}_0$, and companion DDT concentration for each scenario of the sensitivity analysis according column_6 and column_3 respectively in Table 4. The finite element model grid included the lower Otay River channel beginning at the presently contaminated area shown in Figures 6 & 7; the tidal basins of the restoration with all of the salt pond complexes; and extended out into south San Diego Bay as far as the Chula Vista Wildlife Reserve as shown in Figures 2 & 3. Boundary conditions on this grid consisted of no normal fluxes of suspended sediment through the land-water boundaries, and continuity of normal and tangential fluxes of suspended sediment across the open water boundaries where a constant suspended sediment concentration $c = \overline{C}_0$ from column_6 in Table 4 prevailed at time $t = 24$ hr at the start of the deposition simulation. For each time step, the TIDE_FEM model solves equations (3) and (8) for deposition flux and deposition thickness at each finite element node in the grid mesh. The deposition of partially consolidated mud in the tidal basins of the restoration was characterized by averaging deposition flux and deposition thickness at 6 (ea.) nodes distributed across the Floodplain Tidal Basin and 9 (ea.) nodes distributed across the Pond 15 Tidal Basin of the Intertidal and Subtidal Alternatives.

Figure 9 gives the time evolution of the post-flood deposition flux and deposition thickness for the first scenario (row_2 of Table 4) in the Floodplain Tidal Basin of the Intertidal and Subtidal Alternatives; and Figure 10 gives results for those same quantities in the Pond 15 Tidal Basin of the Intertidal and Subtidal Alternatives. This scenario is based on maximum flood-induced erosion depths of 3 ft. in the contaminated area adjacent the Floodplain Tidal Basin mixed with 438,000 cubic yards of fine-grained sediments from upstream erosion of the portion of the watershed below the Savage Dam. Results are similar for both tidal basins and restoration alternatives with dry bulk DDT concentrations of 70.2 μ g/kg everywhere in the post-flood deposition, because the initial post-flood suspended sediment concentration is the same in all areas in and around the restoration as a consequence of the 100 year flood over topping and flowing through these areas with its washload (cf. Figures 2 & 3). The general depositional features are that deposition flux peaks within one diurnal tide cycle after cessation of the flood in both basins of both restoration alternatives, with an initial deceleration in flux during the first semidiurnal ebb tide. After the first post-flood diurnal tidal cycle, the deposition flux declines as progressive settling depletes the suspended sediment concentration, and tidal residence times in the tidal basins limits the amount of time for settling and deposition to occur. Meanwhile, deposition thickness, which results from the cumulative sum of deposition flux over time, rapidly builds during the peak deposition flux period, and then gradually approaches a constant limit for partially consolidated mud at 200 g/l bulk density as the deposition flux vanishes after 120 to 150 hours post-flood. The minor differences in deposition flux and deposition thickness among tidal basins and restoration alternatives in Figures 9 & 10 is due to differences in residence times and grading elevations (i.e. water depth).

The Floodplain Tidal Basin, which has the shortest residence time (2 days for the Intertidal Alternative and 2.5 days for the Subtidal Alternative), has the lowest peak deposition flux (16.5 – 18.3 ton/acre/day) and the shortest deposition period (~120 hours); and accumulates only 3.3 to 3.4 mm of partially consolidated mud after 276 hours post-flood (Figure 9). Because of the sub-tidal channel graded into the Floodplain Tidal Basin design for the Subtidal Alternative, the residence time and consequently the deposition fluxes and thickness are slightly greater than for the Intertidal Alternative.

On the other hand, tidal residence times are nearly a day longer for the Pond 15 Tidal Basin of both alternatives (where residence times are 3.0-3.2 days), and consequently deposition fluxes and thickness are notably greater in Figure 10 than for the Floodplain Tidal Basin in Figure 9. In Pond 15, the deposition flux peaks at 18.9-19.9 ton/acre/day, and the deposition period is longer, about 150 hours post-flood. Consequently the deposition thickness is nearly double in Pond 15, with 7.6 to 8.0 mm of partially consolidated mud laid down after 276 hours post-flood. Because more dredge fill from the Floodplain Tidal Basin construction is deposited in Pond 15 of the Subtidal Alternative, its storage volume and residence times are less than for the Intertidal Alternative, whence the deposition fluxes and thickness are slightly less for the Subtidal Alternative in Figure 10 than for the Intertidal Alternative.

The initial post 100-year flood accumulations of partially consolidated mud computed in Figures 9 & 10 will, over time, dewater and compact under its own immersed weight. If

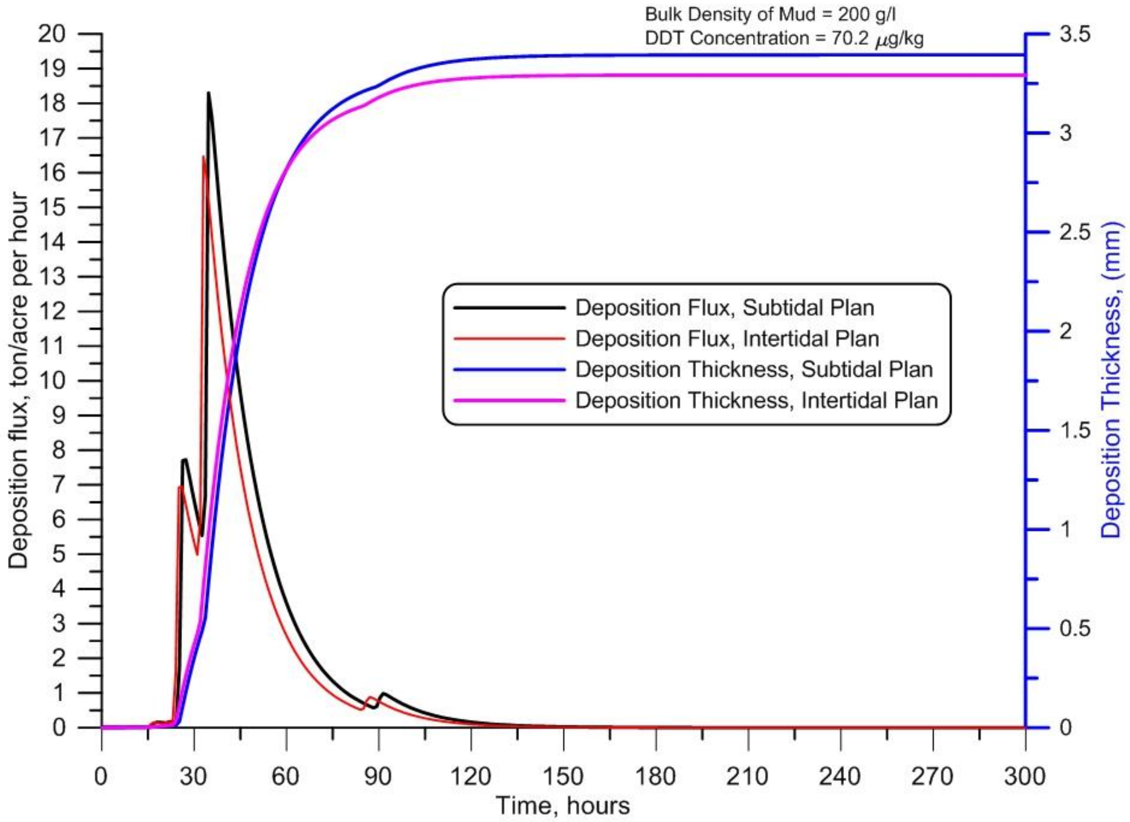

Figure 9. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

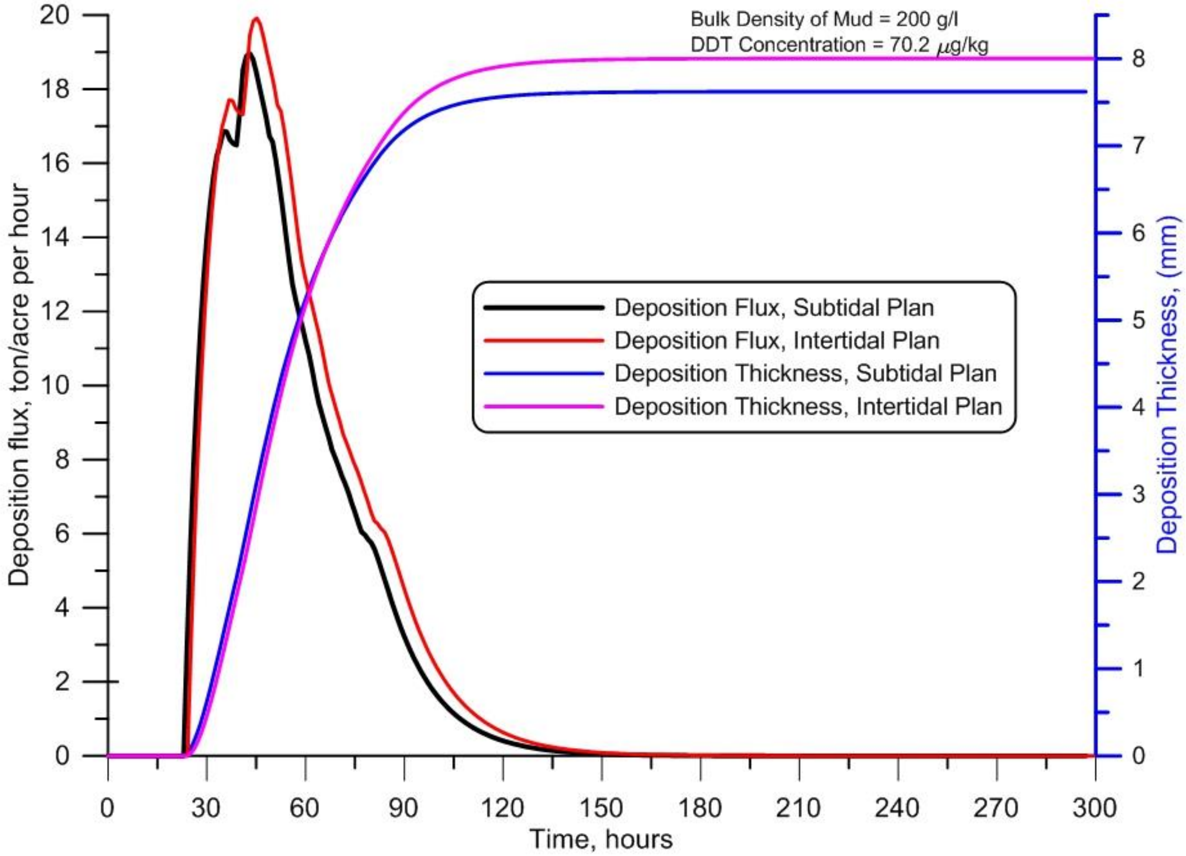

Figure 10. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

we assume that the 3mm to 7mm of initial deposition would consolidate and compact to a maximum saturated density for fully consolidated mud, 1200 g/l, then the 100-year flood deposition for the first scenario in Table 4 (row_2) would eventually become a layer of consolidated mud only 0.5 mm to 1.2 mm thick; or:

$$\text{Floodplain Basin: } 3.3\,mm\ @\ 200g/l \ \Rightarrow\ \left\{\frac{dewatering}{consolidation}\right\} \ \Rightarrow\ 0.55\,mm\,@\,1{,}200g/l$$

$$\text{Pond 15 Basin: } 8\,mm\ @\ 200g/l \ \Rightarrow\ \left\{\frac{dewatering}{consolidation}\right\} \ \Rightarrow\ 1.4\,mm\,@\,1{,}200g/l$$

Consolidation only involves a reduction in the water content of the post-flood deposition, and therefore does not alter the DDT dry bulk concentration, which remains 70.2 μ g/kg once the muds have consolidated to a density of 1,200 g/l. The amount of time required for this degree of consolidation is uncertain, but experience with dredge material disposal ponds at Mare Island, CA and Charleston, SC [Jenkins, 1980; Jenkins et al., 1981; Jenkins and Skelly, 1983] suggests that consolidation to 600 g/l could occur within three months while full consolidation to saturation could take several years.

Next, consider how such results may be affected if we assume no erosion of soils occurs in the portion of the watershed upstream of the floodplain and below the Savage Dam. This scenario is specified by the fifth row in Table 4 and is based on maximum erosion depths of 3 ft. in the contaminated area only; and is considered *worst-case.* Here, runoff from the 100 year flood consists of a uniform suspended load of silts and clays with concentration of $\overline{C}$ = 5.25 g/l. Figure 11 gives the time evolution post-flood for deposition flux and deposition thickness in the Floodplain Tidal Basin of the Intertidal and Subtidal Alternatives; and Figure 12 gives results for those same quantities in the Pond 15 Tidal Basin of the Intertidal and Subtidal Alternatives. Again, results are similar for both tidal basins and restoration, but the dry bulk concentration of DDT in the post-flood deposition has increased to 310 μ g/kg, while the deposition thicknesses are greatly diminished. Again, the Floodplain Tidal Basin, with the shortest residence time (Figure 11), has the lowest peak deposition flux (3.7 – 4.1 ton/acre/day) and the shortest deposition period (~120 hours); and accumulates only 0.75 to 0.77 mm of partially consolidated mud after 276 hours post-flood. Deposition fluxes and thickness are slightly greater for the Floodplain Subtidal Alternative than for the Intertidal Alternative, due to its deeper sub-tidal channel and longer residence time. With tidal residence times being nearly a day longer for the Pond 15 Tidal Basin of both alternatives, deposition fluxes and thickness are notably greater in Figure 12 than for the Floodplain Tidal Basin in Figure 11. In Pond 15, the deposition flux peaks at 4.3 - 4.5 ton/acre/day, and the deposition period is longer, about 150 hours post-flood. Consequently the deposition thickness is nearly double in Pond 15, with 1.7 to 1.8 mm of partially consolidated mud laid down after 276 hours post-flood. Because more dredge fill is deposited in Pond 15 under the Subtidal Alternative, its storage volume and residence times are less than for the Intertidal Alternative, whence the deposition fluxes and thickness are slightly less in Figure 12 for the Subtidal Alternative. After dewatering and compaction to a density of 1200 g/l, the post-flood deposition for this worst case eventually become a layer of consolidated mud on the order of

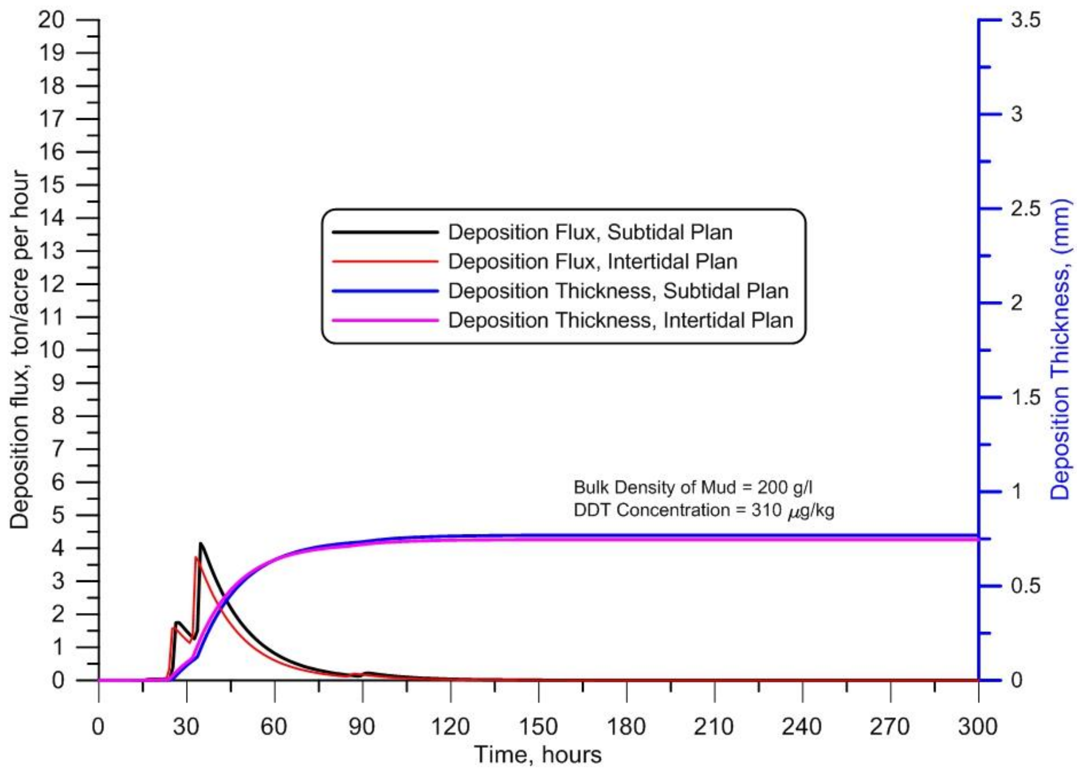

Figure 11. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration

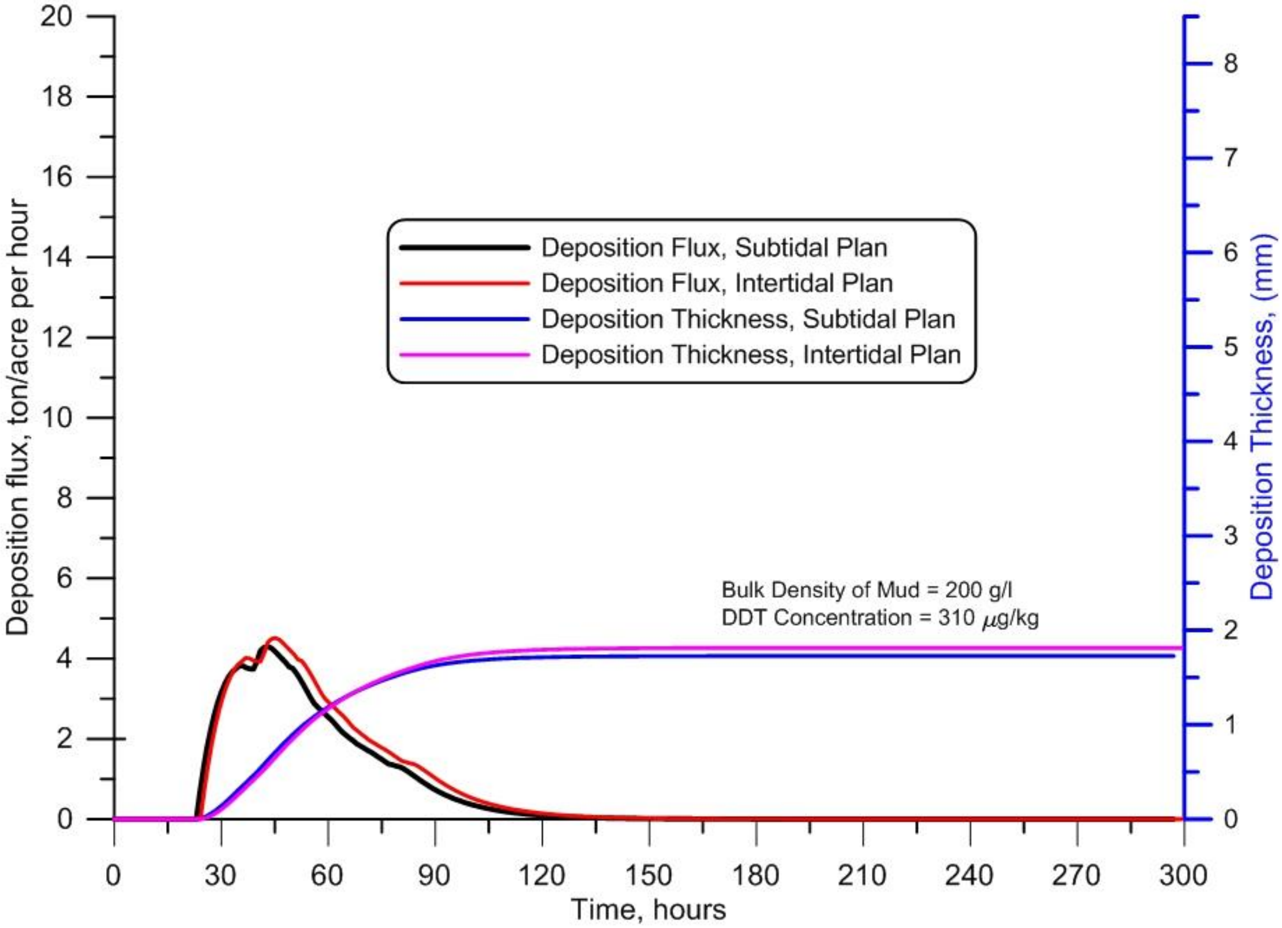

Figure 12. Sensitivity analysis of deposition of fine-grained sediment (mud) in Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration

only 0.2 mm to 0.4 mm thick; or:

Floodplain Basin: $0.75\,mm\ @\ 200 g/l \Rightarrow \left\{\frac{dewatering}{consolidation}\right\} \Rightarrow 0.17\,mm\,@\,1{,}200 g/l$

Pond 15 Basin: $1.8\,mm\ @\ 200 g/l \Rightarrow \left\{\frac{dewatering}{consolidation}\right\} \Rightarrow 0.41\,mm\,@\,1{,}200 g/l$

Again, dewatering and consolidation does not alter the dry bulk DDT concentrations in the post-flood muddy deposits, which will remain at 310 μ g/kg even if these muds consolidate to full saturation.

Plots of the deposition flux and deposition thickness time series for the other scenarios of the sensitivity analysis are found in APPENDIX-A. The complete ensemble of deposition scenarios from this sensitivity analysis are summarized in Table 5 below. Entries in the last three rows are based on the assumption of no erodible fine-grained sediments anywhere else in the Otay River watershed outside of the contaminated area adjacent the ORERP Floodplain Tidal Basin. While the DDT concentrations in the muds deposited under these scenarios of no upstream sources can range as high as 310 μ g/kg to 790 μ g/kg, the deposition thicknesses reduce to only fractions of a millimeter once these muds become consolidated (cf. column_8, Table 5). To assess the potential biological impacts of these simulation results, a risk assessment analysis based on screening levels of keystone wetland species is presented in Section 6 below.

6) Post-Flood Tidal Deposition Simulations for the 50-Year Flood:

6.1 Input Assumptions: The 50-year flood hydrographs for the Otay River, Poggi Canyon Creek and Nestor Creek are triangular with 24-hour durations, similar to those shown in Figure 1 for the 100-year flood, but involving significantly less flow volumes. The total flow volume during a 50-year flood for the Otay River is 19,200,000 cubic yards (cy), or 14,679,545 cubic meters (m^3). The corresponding flow volumes for Poggi Canyon Creek and Nestor Creek are respectively 1,488,000 cy (1,137,664 m^3) and 1,584,000 cy (1,211,062 m^3), so that the combined flow through the floodplain is $\overline{Q}$ = 22,272,000 cy (17,028,272 m^3), or 13,805 acre ft. The flow for the Otay River is an order of magnitude higher than those for Poggi Canyon Creek and Nestor Creek. It was estimated that during the 50-year flood, only about 60% of the Otay and Poggi flow would pass through the proposed wetland restoration areas, while the remainder would flow through the adjacent salt ponds and into South San Diego Bay. The percent of Nestor flow that would pass through the wetland was not analyzed, but since Nestor Creek directly flows into the proposed wetland area, it was assumed that all of the Nestor Creek flow would enter the wetland. Based on these flow volumes and the sediment stratigraphy revealed by the borings taken by Anchor 201, it was estimated that the 50-year flood would erode the top 1 ft of soil over the entire ORF. The eroded volume of soil in the ORF due to the 50-year flood was estimated to be 114,900 cy (87,848 m^3), of which 21.1% (24,260 cy or 18,545 m^3) are DDT bearing fin grained sediments. The average dry bulk DDT concentration in these fine grained sediments is 790 µg/kg.

Scenario	Volume of Eroded DDT-Bearing Fines	Average DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.	Initial Post-Flood Deposition Thickness (200 g/l Mud)	Final Post-Flood Deposition Thickness (1,200 g/l Mud)	DDT Conc. in Post-Flood Mud Deposition (dry bulk)
Erode top 3 ft. of Contaminated Area + Upper Watershed*	128,300 cubic yards	310 μ g/kg	438,000 cubic yards	24,290 acre ft	23.15 g/l.	3.3 mm to 8.0 mm	0.5 mm to 1.4 mm	70.2 μ g/kg
Erode top 1 ft. of Contaminated Area + Upper Watershed	24,260 cubic yards	790 μ g/kg	438,000 cubic yards	24,290 acre ft	18.90 g/l	2.7 mm to 6.5 mm	0.4 mm to 1.1 mm	41.5 μ g/kg
Erode top 2 ft. of Contaminated Area + Upper Watershed	76,350 cubic yards	430 μ g/kg	438,000 cubic yards	24,290 acre ft	21.03 g/l	3.0 mm to 7.3 mm	0.45 mm to 1.3 mm	63.8 μ g/kg
Erode top 3 ft. of Contaminated Area Only**	128,300 cubic yards	310 μ g/kg	0 cubic yards	24,290 acre ft	5.25 g/l	0.75 mm to 1.8 mm	0.17 mm to 0.41 mm	310 μ g/kg
Erode top 1 ft. of Contaminated Area Only	24,260 cubic yards	790 μ g/kg	0 cubic yards	24,290 acre ft	0.99 g/l	0.14 mm to 0.34 mm	0.02 mm to 0.06 mm	790 μ g/kg
Erode top 2 ft. of Contaminated Area Only	76,350 cubic yards	430 μ g/kg	0 cubic yards	24,290 acre ft	3.12 g/l	0.44 mm to 1.1 mm	0.07 mm to 0.12 mm	430 μ g/kg

Table 5: Matrix of Sensitivity Analysis of Potential DDT Deposition in the ORERP post-100 year flood.

The 50-year flood will cause additional soil erosion from the watershed below the Savage Dam. Based on scaling by the watershed size relative to the Buena Vista watershed, it was estimated that sediment discharge from the Otay River watershed below Savage Dam during the 50-yr flood is about 501,000 cy of which 50% is fine, or 250,500 cy. Because only 60% of flow from the upper Otay River watershed would pass through ORF, the eroded contaminated sediments from the ORF could mix with as much as 150,300 cy (114,913 m^3) of fines not known to contain DDT from the upper watershed below the Savage Dam.

From this assessment of possible sediment erosion input assumptions, we pose a sensitivity analysis for the post 50-Year flood DDT deposition that is based on erosion fluxes from one possible erosion depth (1 ft.) in the DDT contaminated area of the floodplain that is each combined with two possible fluxes of clean fines (0 cy and 150,300 cy) from the upper watershed below the Savage Dam; yielding a sensitivity analysis comprised of two separate deposition scenarios. The ensembles of input parameters for this sensitivity analysis are summarized in Table 6.

Table 6: Input Parameters for Sensitivity Analysis of Post 50-Year Flood DDT Deposition

Scenario	Volume of Eroded DDT-Bearing Fines	DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.
Erode top 1 ft. of Contaminated Area + Upper Watershed	24,260 cubic yards	790 μg/kg	150,300 cubic yards	13,805 acre ft	12.60 g/l
Erode top 1 ft. of Contaminated Area Only*	24,260 cubic yards	790 μg/kg	0 cubic yards	13,805 acre ft	1.8 g/l

The suspended sediment concentrations in Table 6 are based on a dry bulk density for eroded soil of 2700 lb per cy, or 1.225 metric tons per cy; where a metric ton is 1000 kg. This conversion factor is applied to the sum of the volume of eroded DDT- bearing fines (column_2) and the volume of eroded fines from the upper Otay watershed (column_4) to obtain the total flux of suspended fine grained sediment in tons/day during the 24 hour flood period of the 50-year flood. The sand and gravel sized fractions eroded from the floodplain by the 50 year flood are assumed to be transported as bed load. The suspended sediment flux component (column_2 + column_4) is divided by the flow volume of $\overline{Q}$ = 17,028,272 m^3 during the 24 hour flood period to give the average suspended sediment concentration in column_6 upon conversion of metric tons to grams and cubic meters to liters.

6.2 Deposition Results: Plots of the deposition flux and deposition thicknesses in the ORERP tidal basins for the 50-year flood scenarios are found in Figures 13 through Figure 16. The complete ensemble of 50-year flood deposition scenarios from this sensitivity analysis are summarized in Table 7 below. With initial dilution from mixing with the clean sediments from upstream sources, DDT concentrations post-50 year flood in the tidal basins of the ORERP are on the order of 110 μ g/kg. This concentration is higher than the companion result for the 100-year flood in row_1, column_9, Table 5. This is due to the fact that the 50-year flood causes proportional less erosion in the upper water shed of the Otay River than the 100 year flood. Entries in the last row of Table 7 are based on the assumption of no erodible fine-grained sediments anywhere else in the Otay River watershed outside of the contaminated area adjacent the ORERP Floodplain Tidal Basin and represent *worst case* for the 50-year flood. While the DDT concentrations in the muds deposited under worst case scenarios of no upstream sources can range as high as 790 μ g/kg, the deposition thicknesses are initially only 0.62 mm to 0.26 mm reduce to only fractions of a millimeter (0.06 mm to 0.14 mm) once these muds become consolidated (cf. column_8, Table 7). However, the DDT deposition results for 50-yr were found to be within the range of those for the 100-yr flood, so that the conclusions put forth previously in Section 6 on potential flood-induced DDT impacts to the ORERP wetlands ecology are upheld.

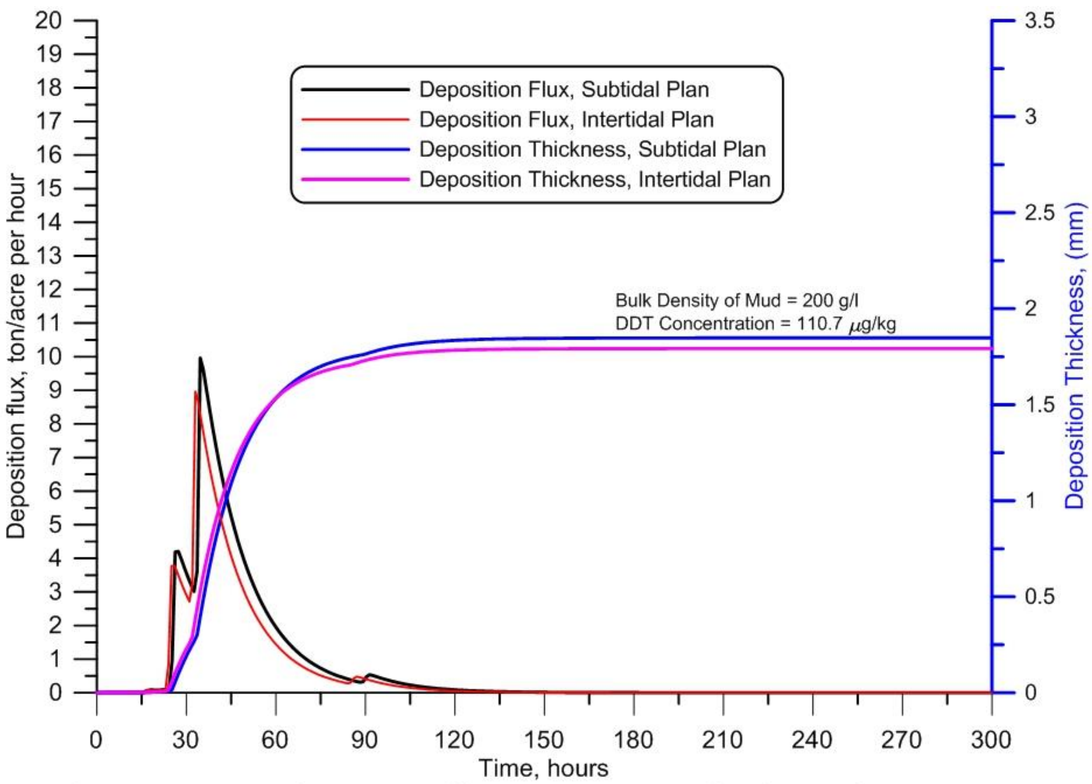

Figure 13. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 50-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,500 cubic yards of contaminated fines from erosion of the top 1 ft. and 150,300 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

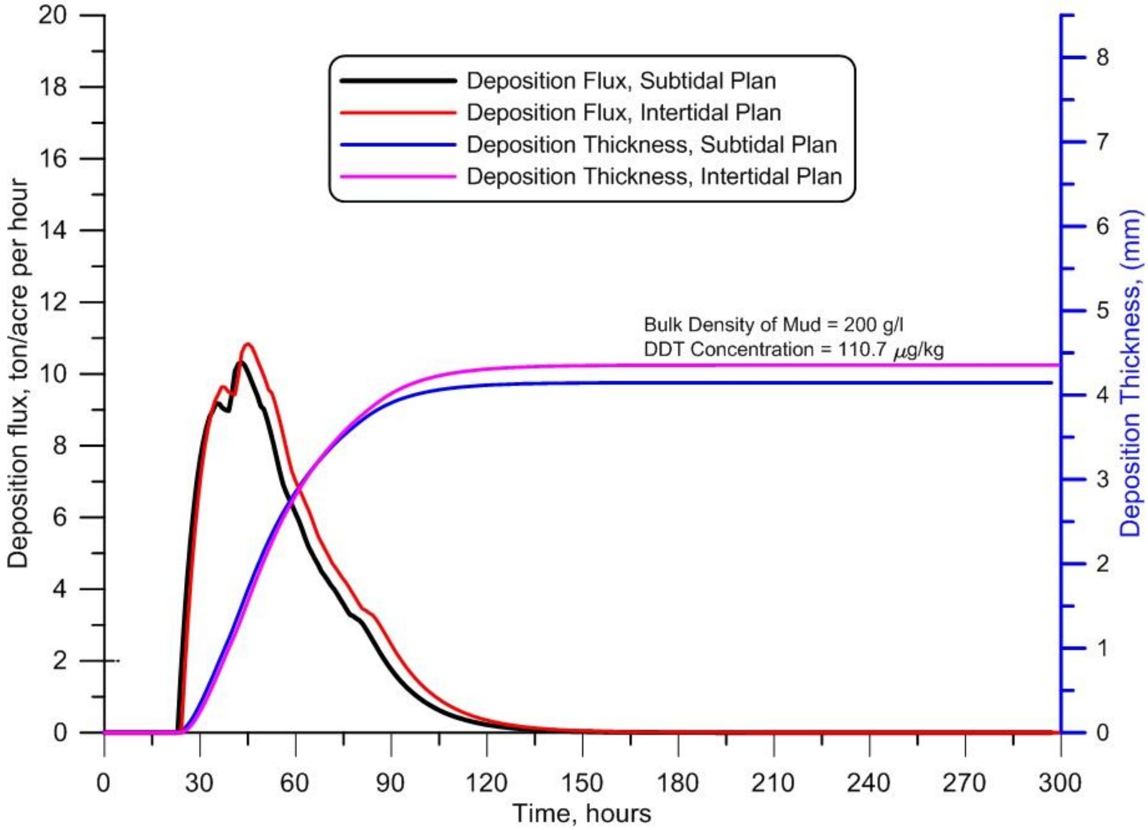

Figure 14. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 50-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,500 cubic yards of contaminated fines from erosion of the top 1 ft. and 150,300 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

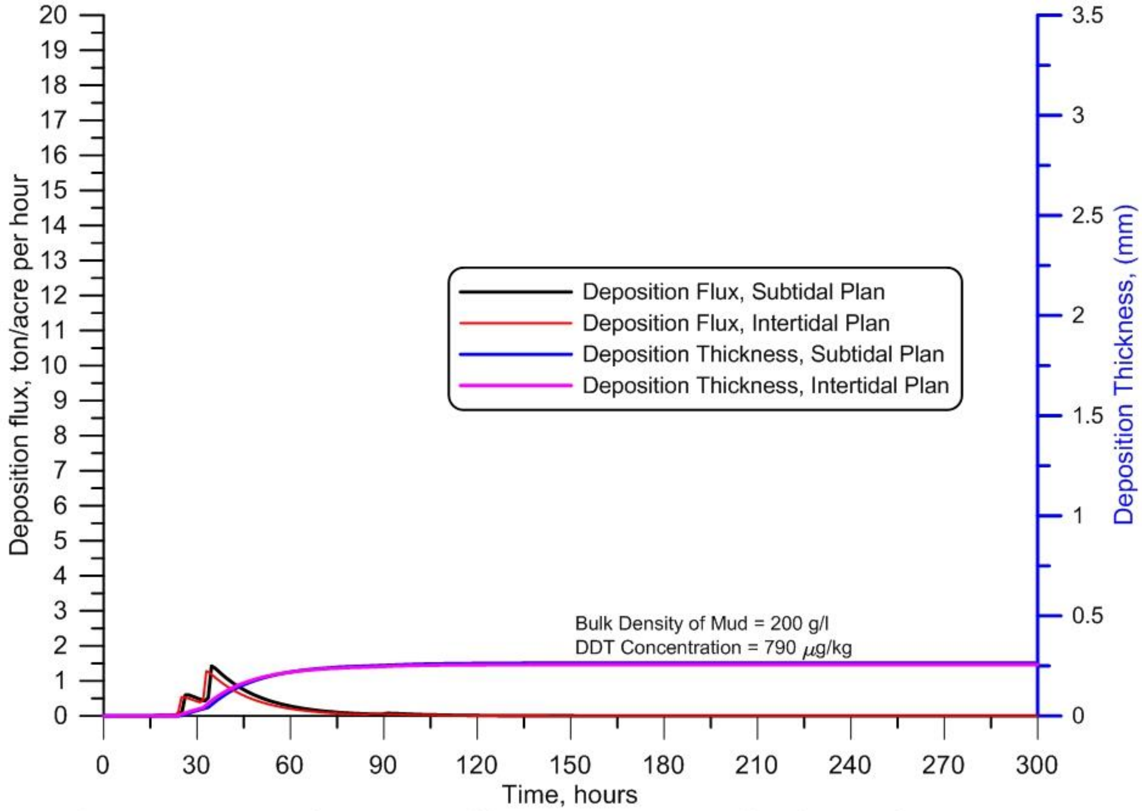

Figure 15. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 50-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,260 cubic yards of contaminated fines from erosion of the top 1 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

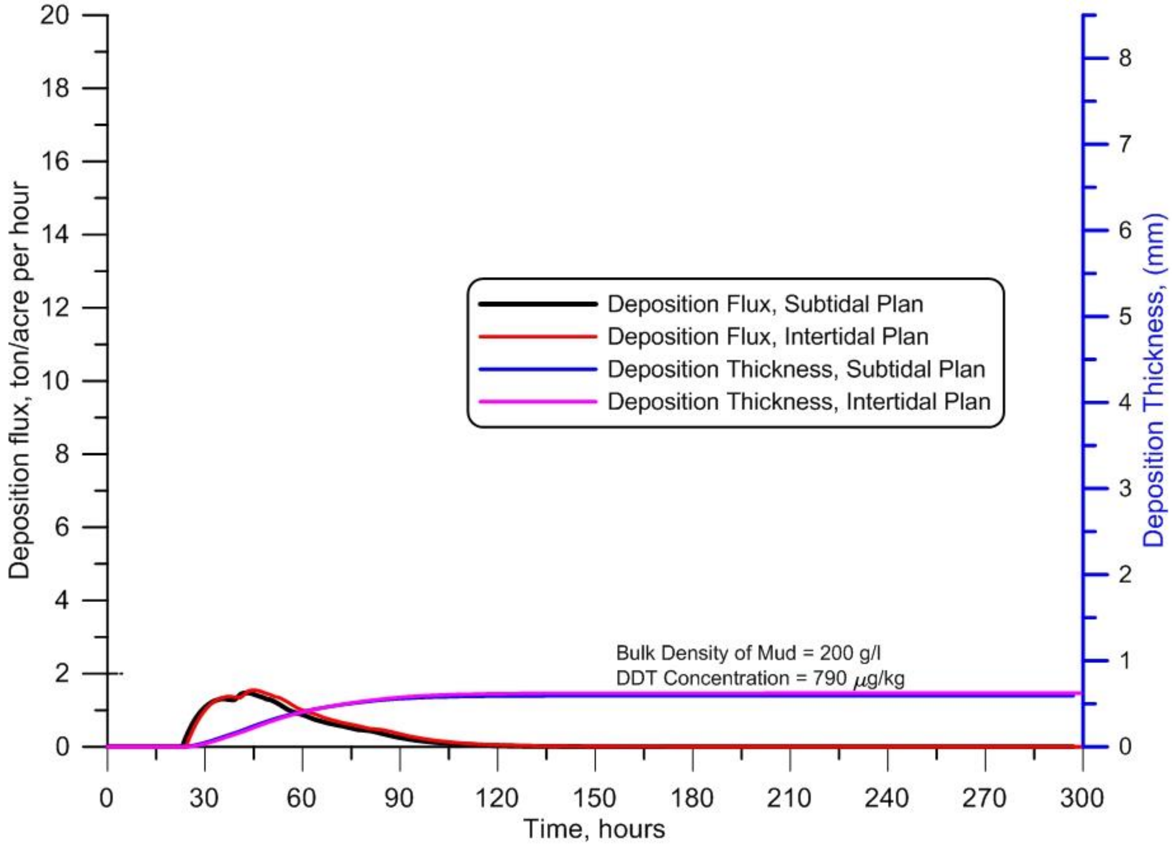

Figure 16. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 50-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,500 cubic yards of contaminated fines from erosion of the top 1 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

Scenario	Volume of Eroded DDT-Bearing Fines	Average DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.	Initial Post-Flood Deposition Thickness (200 g/l Mud)	Final Post-Flood Deposition Thickness (1,200 g/l Mud)	DDT Conc. in Post-Flood Mud Deposition (dry bulk)
Erode top 1 ft. of Contaminated Area + Upper Watershed	24,260 cubic yards	790 μ g/kg	150,300 cubic yards	13,805 acre ft	12.60 g/l	1.8 mm to 4.3 mm	0.30 mm to 0.72 mm	110.7 μ g/kg
Erode top 1 ft. of Contaminated Area Only	24,260 cubic yards	790 μ g/kg	0 cubic yards	13,805 acre ft	1.8 g/l	0.26 mm to 0.62 mm	0.06 mm to 0.14 mm	790 μ g/kg

Table 7: Matrix of Sensitivity Analysis of Potential DDT Deposition in the ORERP post-50 year flood.

*Entries in RED are based on the assumption of NO erodible fine-grained sediments anywhere else in the Otay River watershed below Savage Dam outside of the contaminated area adjacent the ORERP Floodplain Tidal Basin.**,** and represent *Worst-Case* for the 50-year flood

7.0) Biological Implications of the Post-Flood Deposition Simulations

The approach used for this analysis was to focus on critical and applicable information. The focus was on sensitive and potentially most exposed species, and data that would be applicable to the specific area (i.e., salt marshes in San Diego Bay). A risk assessment approach was used to identify wildlife risk-based screening levels for DDT in salt marsh sediment. A screening level approach was used, in that estimates were based on most exposed and/or sensitive species, and conservative assumptions used when there was uncertainty. This analysis entails the identification of no-effects based screening levels (doses and dietary concentrations) for birds, and factors that can be used to relate DDT concentrations in the bird's diet (specifically marsh invertebrates and forage fish) to concentrations in sediment. The availability of applicable data is greatest for effect levels in birds, while data on biota/sediment relationships are limited, especially for forage fish. Consequently, while it is possible to identify conservative dietary screening levels for avian receptors, whether factors used to relate DDT concentrations in biota to DDT concentrations in sediment are particularly conservative is not possible to tell at this time. In other words, this is not necessarily a worst case relative to this element of the analysis.

7.1 Screening Levels For DDT and Metabolites In Salt Marsh Sediment Relative to Proposed ORERP Activities: DDT in environmental media usually occurs as a mixture of parent compound (p,p'-DDT), and impurities and metabolites (i.e., o,p'-DDT, o,p'-DDD, o,p'-DDE, p,p'-DDD and p,p'-DDE). The metabolite, p,p'-DDE is the most persistent and the dominant of the six isomers (forms) in biological samples and in environmental media where there have been no recent DDT applications. The p,p'-DDE isomer is also the one associated with the most sensitive adverse effects in avian species. Consequently, some studies focus on p,p'-DDE only, while others consider the sum of the six isomers (total DDT). Data from studies on p,p'-DDE were considered in the development of the sediment screening levels. However, because of concerns about ongoing conversion of DDT to DDE, and because isomers other than p,p'-DDE are associated with adverse effects, sediment screening levels are used for comparison with total DDTs even though they are derived based on data for the most sensitive effects that are associated with p,p'-DDE.

Sediment-borne DDT and its metabolites (especially p,p'-DDE) can be toxic to directly exposed benthic organisms, and to indirectly exposed aquatic-dependent wildlife. Sediment-borne DDT and metabolites are known to enter and accumulate in the tissues of aquatic food web organisms. Through bioaccumulation and biomagnification (with trophic transfer), concentrations of DDT and metabolites can reach levels in tissues of aquatic food chain organisms that are unsafe for wildlife that rely on the aquatic biota for food. Sediment screening levels for DDT and metabolites must consider; 1) potential for toxicity to benthic invertebrates, and 2) potential for uptake and food chain transfer and therefore adverse effects via dietary exposure among aquatic-dependent wildlife.

The focus of this exercise is on avian species because marsh habitats on San Diego Bay NWR: 1) are specifically managed for federally listed species (birds and one plant) and migratory birds[1], and 2) do not support mammalian or reptile species of concern nor other species that (based on feeding habits) are likely to experience significant exposure to sediment-borne DDT. Avian species that are present during the nesting season are of particular concern because DDT (specifically p,p'-DDE) impairs eggshell production by adult females (thin shells) and, because it is readily transferred to eggs, may adversely affect developing embryos. Eggshell thinning is a well-documented effect in many species of birds, and it may be one of the most sensitive of sub-lethal effects leading to population-level impairments. Sensitivity to the thinning effects of p.p'-DDE varies among species. Species that are less sensitive to eggshell thinning may be at risk of endocrine disrupting effects of o,p'-DDT on developing embryos (e.g., developmental feminization) (Fry and Toone 1981). It is assumed that screening levels based on the toxicity of p,p-DDE but applied to total DDTs will protect against adverse effects associated with any of the isomers.

7.2: Wildlife Receptors: Two species of birds were considered as representatives of potentially most exposed aquatic-dependent wildlife to DDT in marsh sediments: One is the light-footed Ridgeway's rail (*Rallus obsoletus longirostrus* or LFRR; formerly light-footed clapper rail), and the other is the snowy egret (*Egretta thula*).

1. The LFRR is a federally endangered bird that is a year-round resident of salt marshes of coastal southern California, including at the San Diego Bay NWR. LFRR forage for food in vegetated marsh and tidal creek channels by gleaning and probing for benthic organisms. Their primary foods are snails and crabs, but they are opportunistic and will eat bivalves, shrimps, worms and fish (Zembal and Fancher 1988). LFRR exposure to sediment-borne DDT is almost completely via diet, but there may be some exposure via incidental ingestion of sediment while foraging as well. The LFRR is larger than two other rallid species with similar feeding habitats that might occur in the restored salt marsh (i.e. the Sora and the Virginia rail), but only infrequently and generally not during the nesting season (SDSU San Diego Bird Atlas). However, it is the same size or smaller, therefore has equal or greater nutritional needs, than most species with similar feeding habits that commonly forage in San Diego Bay salt marshes (e.g., willet, long-billed curlew and whimbrel). Given the estimated nutritional needs, and year-round residency, the LFRR is considered a reasonably conservative representative of marsh birds that rely on resident mid-trophic level invertebrates for food, and will be exposed to site-specific DDT during the nesting season.

2. The snowy egret is a wading bird that can be found foraging for fish in San Diego Bay marshes while nesting in colonies at nearby locations. The snowy egret mainly eats fish, but may opportunistically consume invertebrates and small terrestrial vertebrates. Because most of their diet is fish, snowy egrets are considered upper trophic level aquatic-dependent predators that may encounter even higher DDT concentrations in their diet than will species such as the LFRR. The snowy egret is one of the smaller wading bird species, which include egrets, herons and bitterns, and as such has proportionally

[1] Note: the highlights are provided to bring the reader’s attention to the specific steps in this analysis.

greater nutritional needs than other larger species. Because of its diet, food requirements and foraging habits, snowy egrets are considered a conservative representative of piscivorous birds given they rely on upper trophic level salt marsh biota (fish) for food and are relatively small among wading birds.

7.3 General Approach: A couple approaches were used to derive wildlife risk-based sediment screening levels, determined largely by the kinds of data available for assessing effects thresholds in birds and relating thresholds for eggs and diet to concentrations in sediment. This is provided because each approach will give somewhat different but valid results relative to the question of risk posed by the sediments.

1. Tissue targets for p,p'-DDE and/or total DDTs in avian eggs: recommend 1.5 mg $_{DDT}$/kg wet weight (ww).

Total DDT and p,p'-DDE concentrations in eggs have been related to eggshell thinning and reduced nesting success of numerous avian species. Eggshell thinning appears to be one of the most sensitive of the adverse effects in birds (i.e., occurs at lower dose levels than other adverse effects such as neurotoxicity).

1a) There are species differences in sensitivity, reflected by DDE concentrations associated with eggshells that are 20% thinner than shells collected before DDT was in heavy use (e.g., pre 1940s). This is a convenient benchmark for comparison, but this extent of thinning (15–20%), when it is persistent over several years, is associated with population level impacts in many species. DDE concentrations in eggs associated with 20% shell thinning (as mg /kg ww; from Blus 2011) include:

- 5 - 10 mg $_{DDT}$/kg ww (pelican, condor, prairie falcon, osprey, sparrowhawk, ibis)
- 10 - 20 mg $_{DDT}$/kg ww (loon, great blue heron, peregrine falcon, and merlin)
- >50 mg $_{DDT}$/kg ww (black crowned night heron and bald eagle)

1b) DDE concentrations associated with adverse effects at <20% shell thinning – pelicans (Blus 1984)

- 3.0 mg $_{DDT}$/kg ww is associated with colony collapse (= effect concentration for productivity)
- 2.0 mg $_{DDT}$/kg ww is associated with productivity that is indistinguishable from productivity observed with non-detectable DDE levels in eggs (= potential no effect concentration for productivity). This concentration may affect eggshell thickness, but not to the extent that productivity is affected.

1c) Estimated no effect threshold for eggshell thinning in sensitive species - Using regression equations from Fry (1994) relating p,p'-DDE concentration to percent of pre-DDT eggshell thickness, one can estimate DDE concentration for an eggshell with no thinning (equal to 100% of pre-DDT eggshell thickness). This would be a true no-effect level for pp'-DDE relative to all endpoints, given it applies to the most sensitive endpoint.

- 1.5 mg $_{DDT}$/kg ww for brown pelican, and 1.2 mg/kg ww for double-crested cormorant.

1d) Data specific to rails and/or snowy egrets.

- 1.0 – 2.0 mg $_{DDT}$/kg ww in CA clapper rail eggs; no effect for shell thinning (Lonzarich et al. 1992)
- 0.45 & 1.02 mg $_{DDT}$/kg ww (means; range 0.197 – 1.78) in light footed clapper rail from Tijuana Slough and Seal Beach NWRs; no effect on shell thinning (Goodbred et al 1996).
- 2.13 mg $_{DDT}$/kg ww (mean; range 0.63-5.60) in light footed clapper rail eggs from Mugu Lagoon; no effect on shell thickness relative to pre-DDT, but shells thinner than for eggs from Seal Beach and Tijuana Slough NWRs (Goodbred et al 1996). Although we have a difference between sites in terms of measured eggshell thickness, this is not likely to have been manifested in adverse effects in productivity given the eggshell measurements were, for the most part, similar to pre-DDT era eggshells.
- 0.41, 0.97 and 1.3 mg $_{DDT}$/kg ww (means; overall range 0.1 – 6.4 mg/kg ww) in clapper rail eggs collected in 1972-73 from 3 Atlantic coast locations. No effect levels for eggshell thickness compared with pre-1947, but there were location-specific variations for both pre- and post- 1947 eggs (Klaas et al 1980).
- 1.05 mg $_{DDT}$/kg ww in single light-footed clapper rail egg; eggshell thickness within range for pre-DDT use, but thinner than eggs collected at the same time and location, but with lower concentrations (~0.45 – 0.70 mg/kg ww; Sutula et al 2005).
- 1.0 – 5.0 mg $_{DDT}$/kg ww in snowy egret egret eggs; no effect on productivity (Henny et al 1985)
- 5.0 – 10 mg $_{DDT}$/kg ww in snowy egret eggs; effect level for productivity (Henny et al 1985)

These species-specific concentrations give us confidence that our proposed target in avian eggs of 1.5 mg DDT/kg ww is appropriately protective for the rail and the egret.

Based on concentrations of DDE/total DDT in eggs, pelicans are among, if not the most sensitive species for eggshell thinning (compared with pre-DDT use) and productivity effects of DDT (primarily DDE). For pelicans, productivity in the field is impacted @ 3.0 mg/kg ww, but DDE-related impacts are not detectable @ 2.0 mg/kg ww, and an estimated no effect level for eggshell thinning is 1.5 mg/kg ww.

For rails, no shell thinning (compared with pre-DDT eggs) has been detected with mean concentrations of 1.02 mg/kg ww (Goodbred et al. 1996), and 1.3 mg/kg ww (Klaas et al. 1980). There is limited information to suggest that subtle thinning (but not different from pre-DDT eggs) may occur with concentrations as low as ~1.0 mg/kg ww. But the effect may be due to population-related variation in shell thickness or statistical artifact. The available data suggest that light-footed Ridgeway's rails are no more sensitive than pelicans to the eggshell thinning and productivity effects of DDT. Data are insufficient to determine if rails are less sensitive than pelicans. In comparison, data on snowy egrets indicate that they are less sensitive to DDT than pelicans. The recommended screening level is based on no effects in pelicans and as such will be protective of other species as well.

A screening level of 1.5 mg $_{DDT}$/kg egg ww is recommended for total DDT concentration in eggs. This value is based on data for pelicans. It is considered protective of rails and is within the range of no effect levels for snowy egrets.

2. Tissue targets for p,p'-DDE and/or total DDTs in avian diets (mg $_{DDT}$/kg fish or invertebrate ww).

2a) Combining the screening level for eggs (1.5 mg $_{DDT}$/kg egg ww), with egg-to-diet concentration ratios. Wet weight-based ratios were used, consistent with concentrations and ratios reported in the literature.

- Egg/invertebrate ratios in clapper rail studies - rail egg/crab ratios ~25 (Goodbred et al. 1996 & Foehrenrich et al. 1972), and rail egg/snail ratio ~73 (Foehrenrich et al. 1972). Given the target concentration of 1.5 mg/kg in rail eggs, corresponding target concentrations in crabs is 0.06 mg/kg ww and in snails, it would be 0.021 mg/kg ww, or an overall average of 0.03 mg/kg ww, assuming a 50:50 mix.
- Egg/forage fish ratios in studies of piscivorous birds - egg/fish ratios are generally between 20 and 60 (Davis et al 2007). Values of 32 to 45 have been reported for herring gulls on Lake Ontario (Braune and Norstrom 1989), and values between 15 and 32 are indicated by data for California brown pelican (Anderson et al. 1975). In one study by Zeeman et al (2008), the average concentration of total DDT in forage fish from South San Diego Bay was 0.042 mg/kg ww. Corresponding bird egg/fish concentration ratios were 43 using black skimmer and Caspian tern eggs and approximately 10 using elegant and California least tern eggs. If using the geometric mean concentration for all seabird egg samples (1.08 mg $_{DDT}$/kg egg ww), the average ratio is 25. With a target DDT concentration of 1.5 mg $_{DDE}$/kg egg ww, the target DDT concentration in forage fish consumed by egrets (or other piscivorous birds) based on the ratios of 10-43 identified above would be between 0.150 mg/kg ww and 0.034 mg/kg ww, or an overall average (based on the mean of 25) of 0.060 mg $_{DDT}$/kg fish ww.

Ratios used to estimate dietary screening levels from the avian egg screening level, are averages. For rails, geometric mean concentrations for snails and crabs were used. Similarly, for piscivorous birds, geometric mean concentrations of multiple species of forage fish were used. This was done because (1) data are limited, and (2) birds generally consume a variety of species. Also, data from four species of piscivorous birds were combined to produce a geometric mean concentration of DDT in bird eggs. This was done to simplify the analysis (using an average rather than a range), and we deemed it appropriate given we know that the snowy egret is not among the most sensitive species.. The outcome (estimated dietary concentration) is less conservative than what the worst case value would be, but the difference is less than 2-fold. If you assume the worst case at every step, it is possible to end up with a totally protective, yet totally unrealistic, result. We were trying to strike a balance between these two. Overall, the egg/diet ratios used for estimates in this analysis are: Rail eggs/invertebrates = 50 and piscivorous bird egg/fish = 25.

2b) Reference dose (TRV)-based (combined with food ingestion rates estimated from Nagy 2001)

- TRV @ 0.014 mg/kg-d (a hybrid approach using field data, and therefore some uncertainty about actual concentrations in diet): This TRV is a chronic value for California brown pelican, a species known to be sensitive to these effects (USEPA 1995), adjusted downward by a Lowest Observed Adverse Effect Level (LOAEL) to No Observed Adverse Effect Level (NOAEL) uncertainty factor of 2.0 (based on observed low effect- and estimated no effect concentration in egg for eggshell thinning), combined with an egg/diet concentrations ratio of 32X (from Anderson et al. 1975). Using ingestion rates from Nagy (2001), combined with a TRV of 0.014 mg/kg-d, the estimated dietary screening level for LFRR (concentrations in invertebrates) is 0.027 mg $_{DDT}$/kg ww and the screening level for snowy egret (concentrations in fish) is 0.029 mg $_{DDT}$/kg ww.

- TRV @ 0.227 mg/kg-d (from lab studies with known concentrations in diet): Highest bounded NOAEL lower than the lowest bounded LOAEL for effects on growth, reproduction and survival in multiple avian species including waterfowl and double-crested cormorants (a sensitive species; EPA ECO-SSL). It is equal to or less than bounded and unbounded NOAELs for biochemical effects, pathology, survival and growth in sub-chronically (9 week) exposed double-crested cormorants. Other than cormorants and kestrels, most of the species represented by the TRV are not among the most sensitive (Item 1a above). Consequently, this TRV is considered an upper bound of no effects-based TRVs. This approach is a reasonable one to use in assessing risk more broadly among species, as it is not based on the most sensitive endpoints nor on the most sensitive species. Using ingestion rates from Nagy (2001), combined with a TRV of 0.227 mg/kg-d, the estimated upper bound dietary screening level for LFRR (concentrations in invertebrates) is 0.432 mg $_{DDT}$/kg ww and the screening level for snowy egret (concentrations in fish) is 0.465 mg $_{DDT}$/kg ww.

2c) Literature values: 3.0 mg/kg ww: Concentration in avian diet which could cause adverse impacts (Goodbred et al. 1996)

Table 8: Screening levels for total DDT in marsh bird diets (mg $_{total\ DDT}$/kg diet ww)

Approach	Rails – Concentration in invertebrates
Egg SL/invertebrate ratio[+]*	0.030
Dose rate (hybrid)*	0.027
Dose rate (lab based)**	0.432
Approach	**Egrets – Concentration in forage fish**
Egg SL/fish ratio[+]*	0.060
Dose rate (hybrid)*	0.029
Dose rate (lab based)**	0.465

[+] Based on field collections from southern California
* Based on No Observed Adverse Effects Levels in most sensitive species
** Based on No Observed Adverse Effects Levels in a few studies on most sensitive, but primarily in studies on less sensitive species; considered here as an upper bound no observed adverse effect level for avian species that forage in salt marsh habitats.

3. Sediment targets for total DDTs

3a) Benthic community:

ER-L = 0.00158 mg/kg dry weight (dw) and ER-M = 0.0461 mg/kg dw, (Long et al 1995). These two guidelines delineate three concentration ranges: concentrations below the ER-L represent "minimal-effects range" (adverse effects rarely observed), concentrations between the ER-L and ER-M represent a "possible effects range" (adverse effects may occur occasionally), and concentrations equal to or greater than the ER-M represent the "probable effects range" and at which effects to benthic invertebrates would frequently occur. (Note: the effect levels are considered to apply to an “active zone” that is 20 mm deep. These benchmarks would not be applicable to a thin layer such as that associated with our modeled sediment deposition as that thin layer is not biologically meaningful to the species and circumstances evaluated in this compellation.)

3b) Reference concentrations for San Diego Bay, with the term "reference" representing DDT concentrations measured in sediments from San Diego Bay, and not in the immediate vicinity of known contaminated sites

0.001 mg/kg ww, or between 0.0013 and 0.0016 mg/kg dw. These are geometric mean concentrations from the USFWS south San Diego Bay mudflats study (unpublished) and the F&G Street Marsh study (Zeeman et al. 2008a)

3c) Wildlife risk-based sediment screening levels using target concentrations in invertebrates and forage fish, combined with biota/sediment ratios (data are very limited)

Ratios are wet weight-based using geometric mean concentrations. USFWS south San Diego Bay mudflats study (unpublished) California horn snail/sediment = 2.5, fiddler crab/sediment = 6.8, and forage fish/sediment = 27. The ratio for invertebrates in general (fiddler crabs and snails combined) = 4.1. Goodbred et al. (1996) report shore crab/sediment ratios of 1.3 and 2.2, for two southern California salt marshes. (dry weight-based ratios available in Sutula et al. 2005; wet weight-based ratios would be lower than reported). These are the actual relationships derived from the field data collected by the Carlsbad Fish and Wildlife Office.

Overall, the biota/sediment ratios used for estimates in this analysis are: 3.0 for invertebrates /sediment and 27 for forage fish/sediment (all wet weight). The former ratio is another case where we avoided pursuing the worst case scenario into what would be an unrealistic result. We know that rails do eat more than one prey type.

Table 9: Inputs and estimates of wildlife risk-based screening levels for DDT in marsh sediment

Dietary screening levels (mg DDT/kg diet ww)	diet/sediment ratio (ww / ww)	Sediment screening level (mg $_{DDT}$/kg sediment ww)	Sediment screening level (mg $_{DDT}$/kg sediment dw)*
Rails (invertebrates)			
0.030	3	0.010	0.017
0.027	3	0.009	0.015
0.432	3	0.144	0.240
Snowy egrets (fish)			
0.060	27	0.002	0.003
0.029	27	0.001	0.002
0.465	27	0.017	0.028

* wet weight-dry weight conversion based on geometric mean moisture contents for sediment samples from the south San Diego Bay mudflats study (=35) and in F&G street marsh study (=43%);

Table 10: Summary of estimated wildlife risk-based screening levels for DDT in salt marsh sediments, San Diego Bay NWR

Dietary screening levels (mg/kg ww)		Sediment screening levels (ug/kg dw)#
Rails - Concentration	**Approach**	**Concentration**
0.030	Egg SL/invertebrates ratio*	17
0.027	Dose rate (hybrid)*	15
0.432	Dose rate (lab based)**	240
Egrets - Concentration	**Approach**	**Concentration**
0.060	Egg SL/fish ratio*	3
0.029	Dose rate (hybrid)*	2
0.465	Dose rate (lab based)**	28

For comparison: more broadly, surficial sediments in San Diego Bay have concentrations of 1.3-1.6 ug/kg dw, ER-L = 1.58 ug/kg dw, and ER-M = 46.1 ug/kg dw .
* Based on No Observed Adverse Effects Levels in most sensitive species
** Based on No Observed Adverse Effects Levels in a few studies on most sensitive, but primarily in studies on less sensitive species; considered here as an upper bound no observed adverse effect level for avian species that forage in salt marsh habitats.

7.4) Risk Assessment of DDT Deposition in the ORERP for the 100-Year Flood: The results of the first deposition scenario, (cf. row_2 of Table 5; Figures 9 & 10) were used as the starting point for the risk evaluation. This evaluation considers the potential for sediment concentrations of DDTs to impact the benthic organisms and thus the prey base for aquatic dependent wildlife and the potential for bioaccumulation of these compounds to result in impacts on the aquatic-dependent birds that are expected to use the restored areas. In evaluating these concerns, we needed to take into consideration not only the concentration of DDTs in the deposited materials, but how those deposited materials would result in exposure by the benthic organisms. For this element of the evaluation, we calculated exposure concentrations in the context of a vertical sediment layer. We assumed that sediments exposed by the restoration, but before deposition of flood-associated particles, have low levels of DDT equal to what has been observed in sediments from mudflats and marshes of south San Diego Bay (see notes in Table 8 above).

The vertical layer that was used was 20 mm (2 cm), as that thickness is used as the “active layer” for a variety of studies related to evaluation of sediment toxicity, including laboratory bioassays and in-situ mussel data (Long et al. 1995), and was deemed reasonable to represent the potential trophic relationships for the species evaluated here. The model outputs included the estimated depths of deposition of the contaminated materials in addition to the estimated concentration (70.2 ug/kg dw). In consideration of the range of particle sizes and the locations in which deposition would occur, the model results in Figures 9 & 10 indicated that a 3.3 to 8.0 mm layer of contaminated material would be deposited in restored areas over clean sediments (as based on soil and sediment sampling at depth). Over time, this would become fully consolidated into a layer 0.55 to 1.4 mm thick (Table 5, row-2, column_8). Using a depth-proportional exposure approach, assuming all exposure occurs within the top 20 mm, we calculated that the contamination experience by the benthic biota would range from approximately 13 to 29 ug/kg (dw) initially and would decrease with settlement to a final 20 mm-based concentration of 3.5 to 6.4 ug/kg (dw), see Table 9, row_2, column_10. While this approach does not take into consideration the potential effects of sediment density on the foraging behaviors of benthic organisms (and any resultant changes in exposure), we see this as a reasonable way to incorporate the thickness of the deposited material into our consideration of near-term and long-term potential effects in the restored areas (note that colonizing benthic organisms are not likely to be present in the early stages of settling). Given many benthic species burrow and forage to considerably deeper depths within the sediments, thus averaging the exposure over much thicker layers of clean sediment, we considered this to be a conservative approach.

Results for the 20 mm-based concentrations of the worst-case sediment deposition scenario appear in red font in column_10 of Table 9. The estimated post-flood DDT concentration for this worst case scenario is based on the assumption that DDT- contaminated soils from the former agricultural fields are the only source of sediment settled in restored marsh following a 100-year flood (column_10, row_5 through row_7 in Table 9). These results are considered worst case because higher concentrations could only occur if sediment from other (upstream) sources, and with higher DDT concentrations than those from the former agricultural fields, were added to the mix entering the restored marshes of the ORERP. Given the mixed but predominantly urban land uses in the Lower Otay River watershed (Aspen Environmental Group 2005), suspended fine-grained sediment entering the Otay River floodplain from upstream sources are expected to have lower DDT concentrations than fines from the former agricultural fields (e.g., Mahler et al. 2006). Consequently, the estimated DDT concentration in post-flood sediments under worst the case scenario (i.e., all from the former agricultural fields) forms the upper limit on what may occur in the marsh, and actual concentrations, which include contributions from less contaminated upstream sources, will be lower. Other, lower impact cases for the worst case scenario have also been considered in column_11 and in column_12 of Table 9 where depth-proportional exposure approach of the sensitivity analysis includes bioturbation exposures occurring within the top 40 mm and top 80 mm of the muddy sediments in the tidal basins of the ORERP for comparison. The depth of bioturbation will be determined by the species that ultimately colonize the tidal basins, but we would not expect that to be less then approximately 20 mm, and it could be more than 80 mm.

The final step in this evaluation was comparing our 20 mm, 40 mm and 80 mm-based DDT concentrations to our screening values. Relative to impacts on the benthic organisms as the prey base, the maximum short-term concentrations in Table 11 (initial concentrations) of 13-29 ug_{DDT}/kg dw fall between the ER-L and ER-M values (1.58 ug/kg dw and 46.1 ug/kg dw, respectively). Thus, we would expect that impacts on benthic organisms could occur occasionally during the short-term. Given the likelihood of effects combined with the short-term nature of this condition, population level impacts are expected to be limited in nature and extent. Once post-flood muddy deposits in the ORERP have compacted and consolidated, the DDT concentrations in the top 20 mm of muddy sediment, at 4.2-7.9 ug_{DDT}/kg dw are very close to the ER-L, and even lower for the top 40 mm and top 80mm of sediment; so that negative effects are expected to be rare. This condition is not likely to have a measurable effect on the prey base for aquatic-dependent species.

In regards to the aquatic-dependent birds' exposures to contaminated prey resulting in impacts, comparison of the 20 mm-based concentrations to our screening levels indicates that these concentrations fall within the range of our highest and lowest NOAELs. Given the species known to be the most sensitive are pelicans and cormorants, which are very closely related, and our target species are not members of groups believed to be particularly sensitive, impacts on aquatic-dependent birds are unlikely to result from the anticipated deposition of DDT-contaminated sediments following a 100-year flood event.

Scenario	Volume of Eroded DDT-Bearing Fines	Average DDT Conc. in DDT-Bearing Fines	Volume of Eroded Clean Fines	Flood Flow Volume	Suspended Sediment Conc.	Initial Post-Flood Deposition Thickness (200 g/l Mud)	Final Post-Flood Deposition Thickness (1,200 g/l Mud)	DDT Conc. in Post-Flood Mud Deposition (dry bulk)	Average DDT Concentration in top 20 mm of Sediment Post-Flood		Average DDT Concentration in top 40 mm of Sediment Post-Flood *		Average Concentration in top 80 mm of Sediment Post-Flood*	
									Initial	Final	Initial	Final	Initial	Final
Erode top 3 ft. of Contaminated Area + Upper Watershed	128,300 cubic yards	310 µg/kg	438,000 cubic yards	24,290 acre ft	23.15 g/l.	3.3 mm to 8.0 mm	0.5 mm to 1.4 mm	70.2 µg/kg	13 – 29 µg/kg	3.5 – 6.4 µg/kg	7.3 – 15 µg/kg	2.5 – 4.0 µg/kg	4.4 – 8.5µg/kg	2.1 – 2.8 µg/kg
Erode top 1 ft. of Contaminated Area + Upper Watershed	24,260 cubic yards	790 µg/kg	438,000 cubic yards	24,290 acre ft	18.90 g/l	2.7 mm to 6.5 mm	0.4 mm to 1.1 mm	41.5 µg/kg	7.0 – 15 µg/kg	2.4 – 3.8 µg/kg	4.3 – 8.1µg/kg	2.0 – 2.7 µg/kg	2.9 – 4.8 µg/kg	1.8 – 2.1 µg/kg
Erode top 2 ft. of Contaminated Area + Upper Watershed	76,350 cubic yards	430 µg/kg	438,000 cubic yards	24,290 acre ft	21.03 g/l	3.0 mm to 7.3 mm	0.45 mm to 1.3 mm	63.8 µg/kg	11 – 24 µg/kg	3.0 – 5.6 µg/kg	6.3 - 13µg/kg	2.3 – 3.6µg/kg	3.9 – 7.3µg/kg	1.9 – 2.6 µg/kg
Erode top 3 ft. of Contaminated Area Only**	128,300 cubic yards	310 µg/kg	0 cubic yards	24,290 acre ft	5.25 g/l	0.75 mm to 1.8 mm	0.17 mm to 0.41 mm	310 µg/kg	13 – 29 µg/kg	4.2 – 7.9 µg/kg	7.4 – 15 µg/kg	2.9 – 4.8 µg/kg	4.5 – 8.5 µg/kg	2.3 – 3.2 µg/kg
Erode top 1 ft. of Contaminated Area Only	24,260 cubic yards	790 µg/kg	0 cubic yards	24,290 acre ft	0.99 g/l	0.14 mm to 0.34 mm	0.02 mm to 0.06 mm	790 µg/kg	7.1 – 15µg/kg	2.4 – 4.0 µg/kg	4.4 – 8.3 µg/kg	2.0 – 2.8 µg/kg	3.0 – 5.0 µg/kg	1.8 – 2.2 µg/kg
Erode top 2 ft. of Contaminated Area Only	76,350 cubic yards	430 µg/kg	0 cubic yards	24,290 acre ft	3.12 g/l	0.44 mm to 1.1 mm	0.07 mm to 0.12 mm	430 µg/kg	11 – 25 µg/kg	3.1 – 4.2 µg/kg	6.3 – 13 µg/kg	2.3 – 2.9 µg/kg	4.0 – 7.5 µg/kg	2.0 – 2.2 µg/kg
Erode top 1 ft. of Contaminated Area + Upper Watershed: 50-year event	24,260 cubic yards	790 µg/kg	150,300 cubic yards	13,805 acre ft.	12.60 g/l	1.8 mm to 4.3 mm	0.30 mm to 0.72 mm	110.7 µg/kg	11 - 25µg/kg	3.3 – 5.5µg/kg	6.5 - 13 µg/kg	2.4 – 3.6µg/kg	4.1 – 7.5 µg/kg	2.0 – 2.6 µg/kg
Erode top 1 ft. of Contaminated Area Only: 50-year event**	24,260 cubic yards	790 µg/kg	0 cubic yards	13,805 acre ft.	1.8 g/l	0.26 mm to 0.62 mm	0.06 mm to 0.14 mm	790 µg/kg	12 – 26 µg/kg	4.0 – 7.1 µg/kg	6.7 - 14µg/kg	2.8 – 4.4µg/kg	4.2 – 7.7µg/kg	2.2 – 3.0µg/kg

Table 11: Matrix of Sensitivity Analysis of Potential DDT Deposition in the ORERP post-100 and post-50 year flood events.

***** Values initially calculated for these columns were calculated incorrectly; these are the revised values (please see comparison below).

**Entries in blue are based on 50-year floods.

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APPENDIX-A: Additional Deposition Flux and Deposition Thickness Simulations Supporting Tables 5 and 11

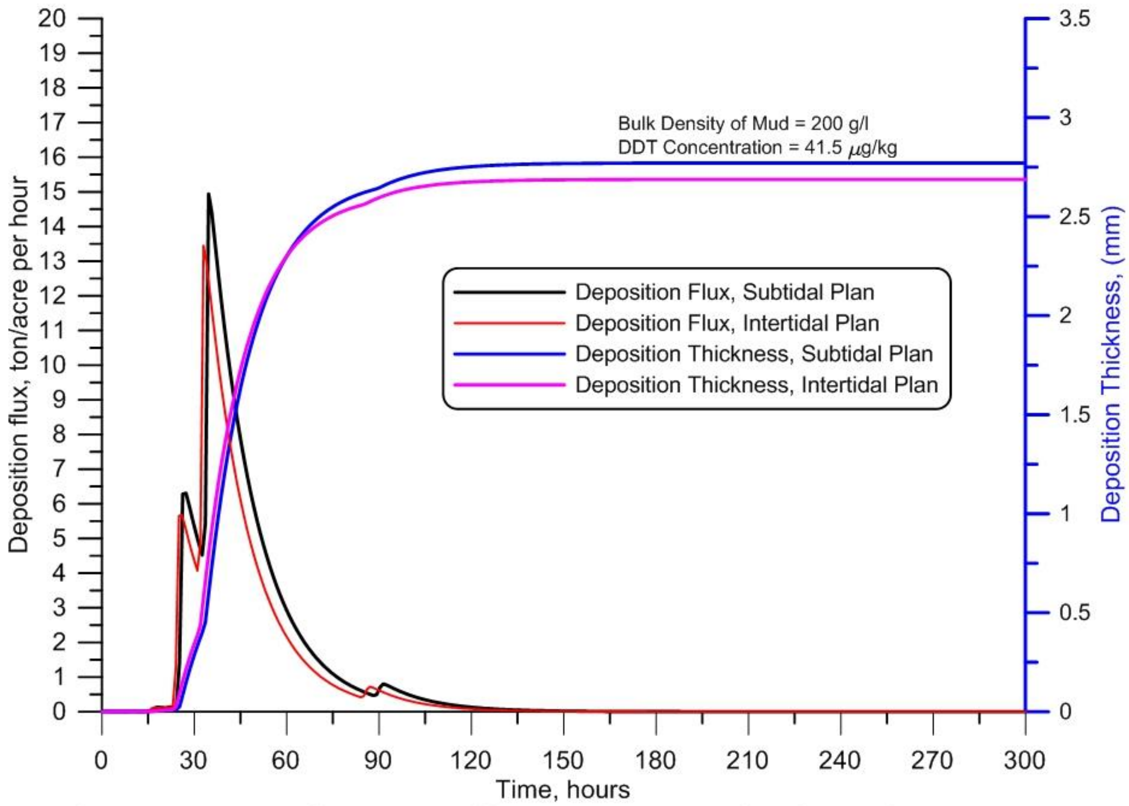

Figure A1. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,260 cubic yards of contaminated fines from erosion of the top 1 ft. and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

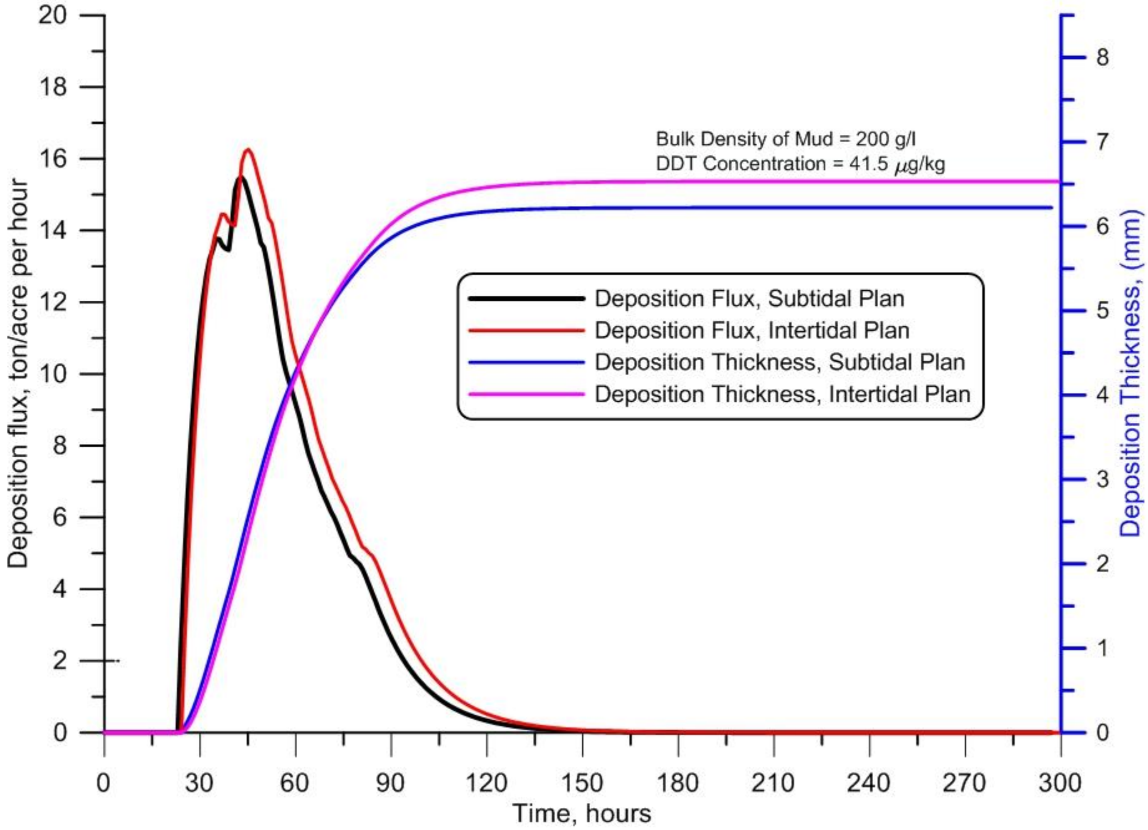

Figure A2. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,260 cubic yards of contaminated fines from erosion of the top 1 ft. and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

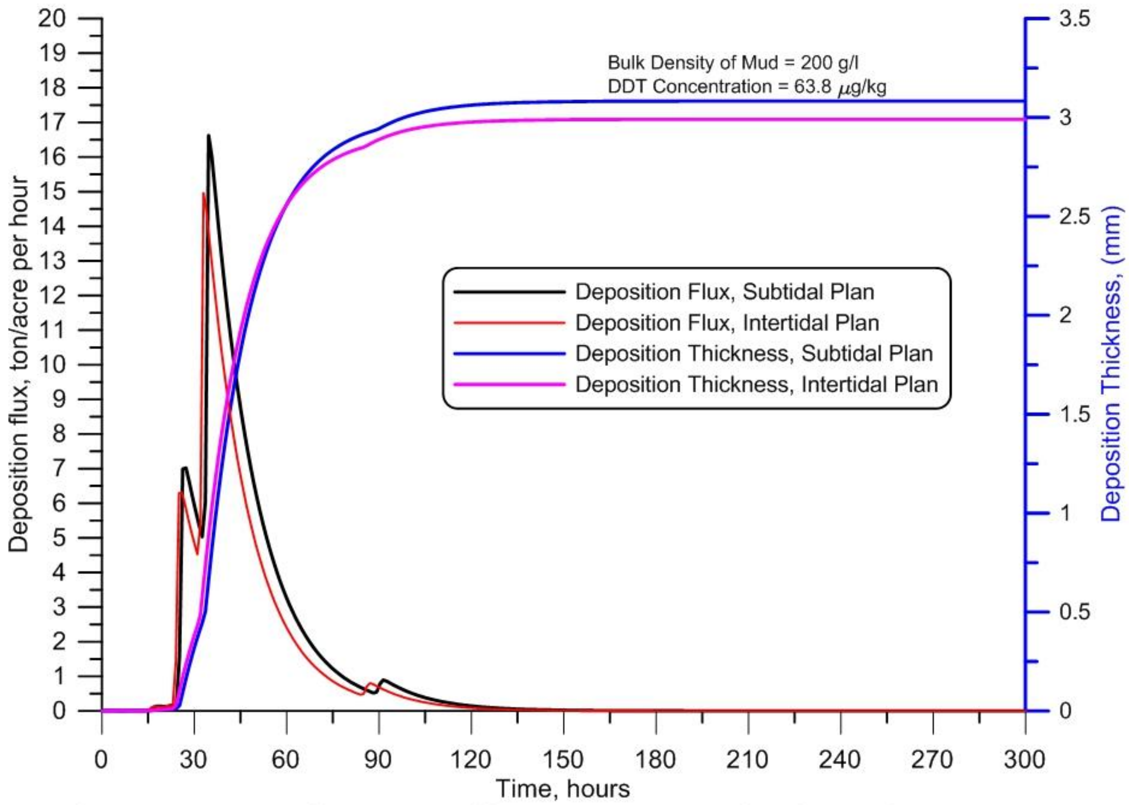

Figure A3. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 76,350 cubic yards of contaminated fines from erosion of the top 2 ft. and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

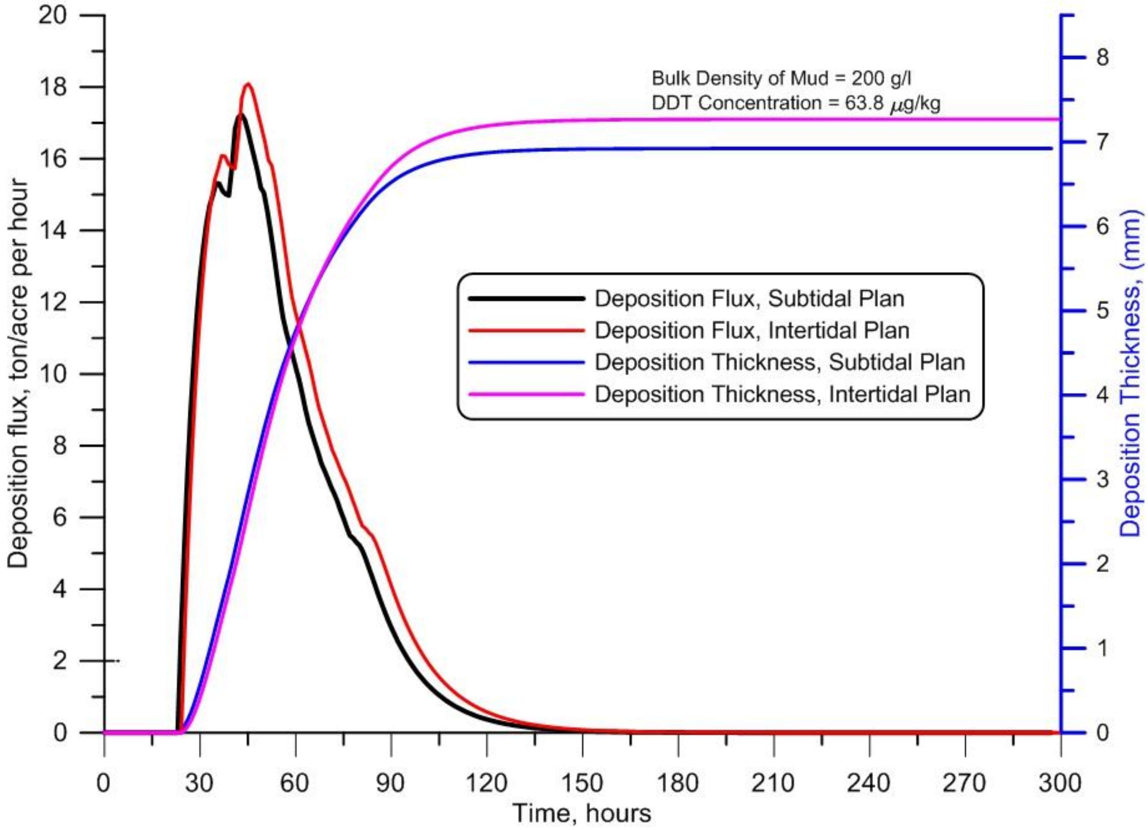

Figure A4. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 76,350 cubic yards of contaminated fines from erosion of the top 2 ft. and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

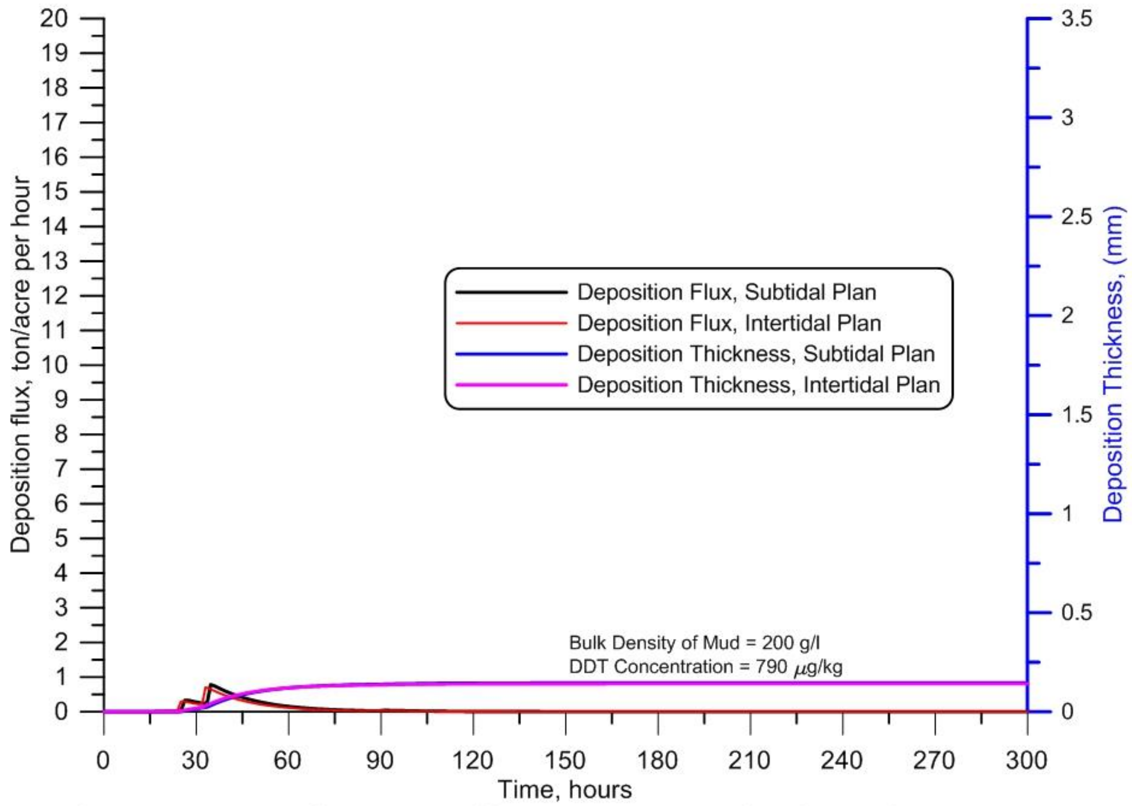

Figure A5. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,260 cubic yards of contaminated fines from erosion of the top 1 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

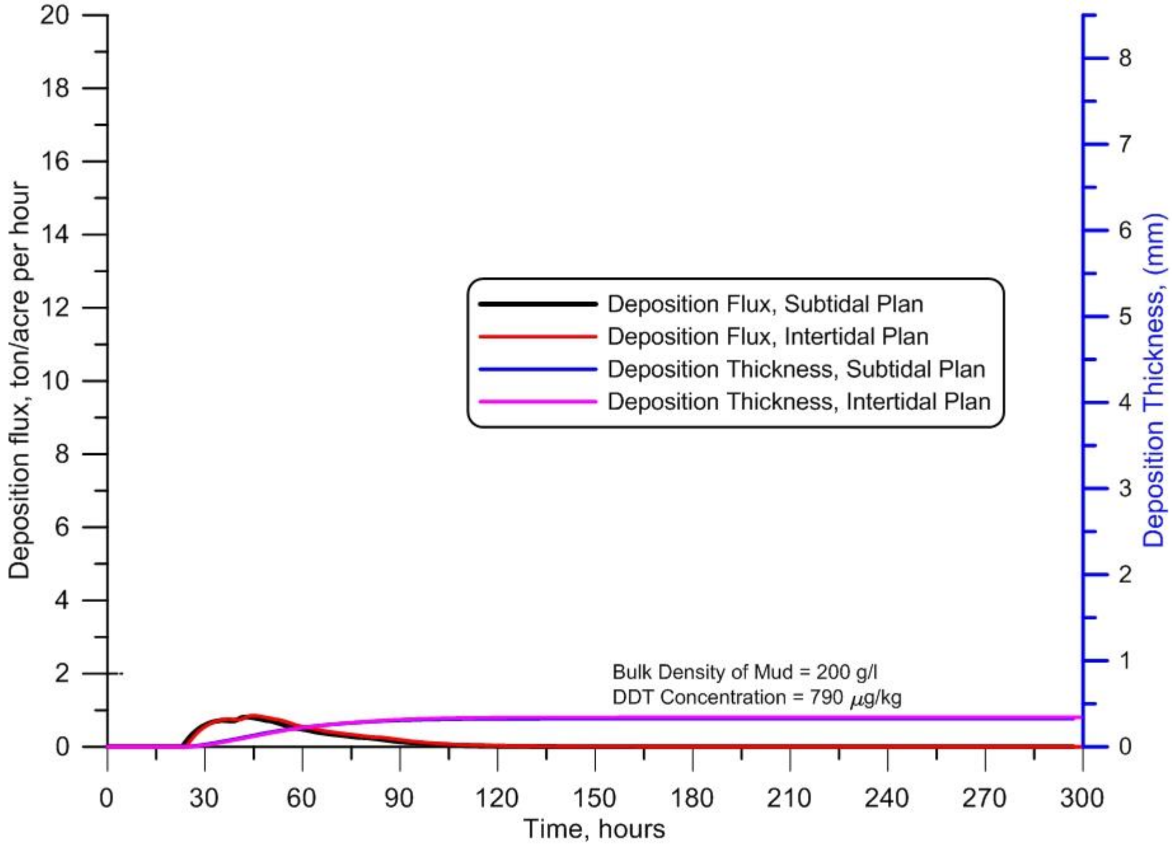

Figure A6. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 24,260 cubic yards of contaminated fines from erosion of the top 1 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

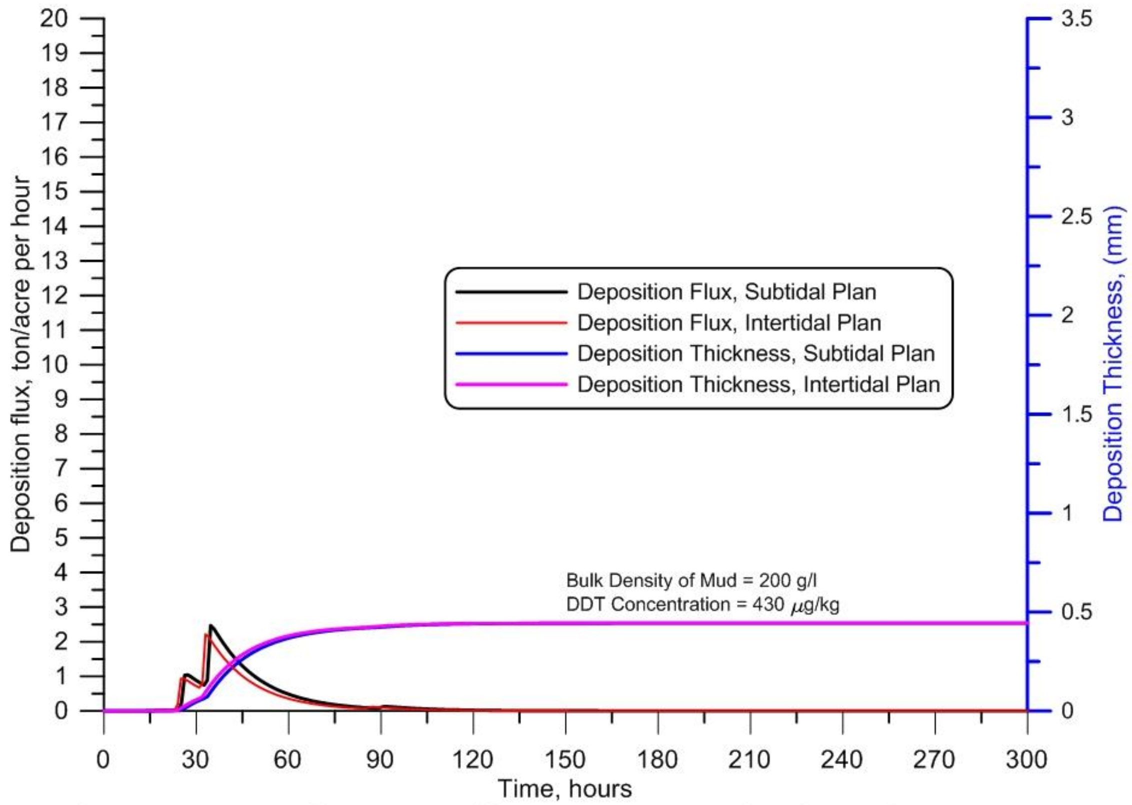

Figure A7. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Otay River Floodplain Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 76,350 cubic yards of contaminated fines from erosion of the top 2 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

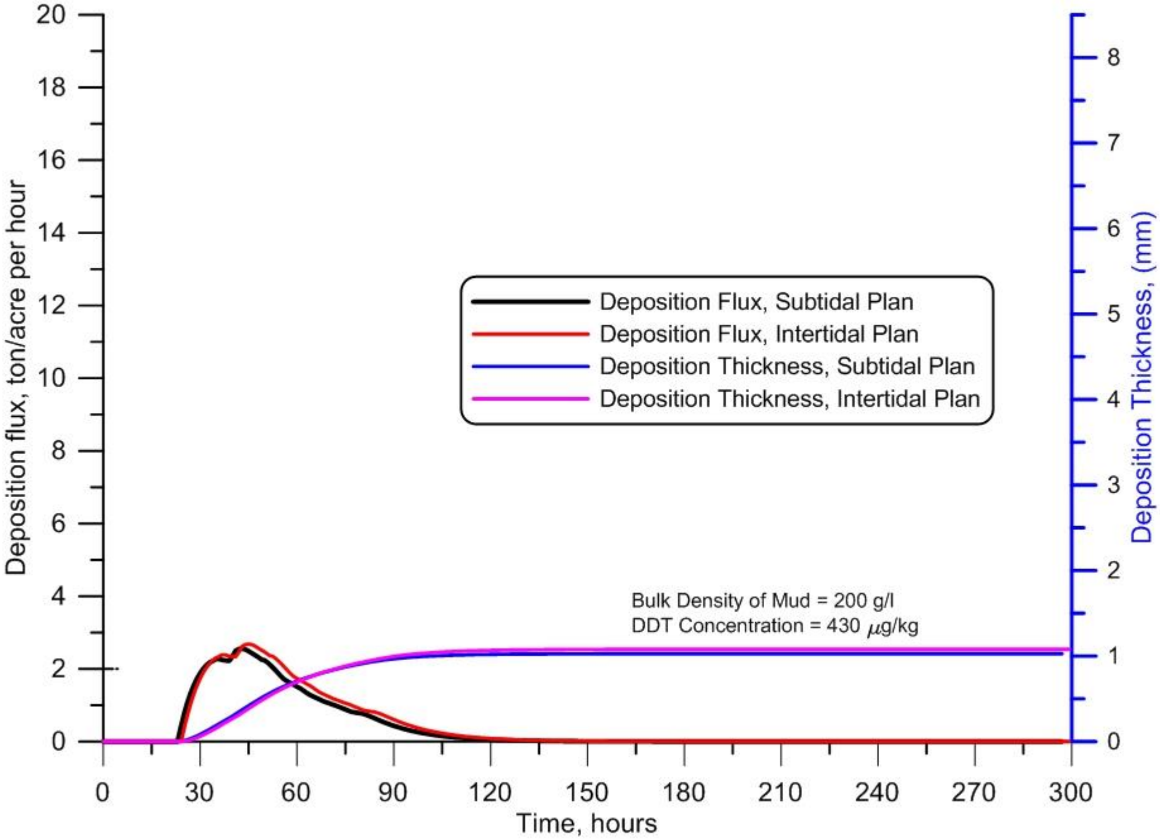

Figure A8. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Pond-15 Tidal Basin following the 100-year flood. Deposition flux (black & red); deposition thickness (blue & magenta). Results for 76,350 cubic yards of contaminated fines from erosion of the top 2 ft. and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

APPENDIX-B: Additional Deposition Flux and Deposition Thickness Simulations for the *No-Project Alternative* Post 100-Year Flood.

Input Assumptions: The 100-year flood hydrographs for the Otay River, Poggi Canyon Creek and Nestor Creek are unchanged by the presence of the ORERP. The total flow volume during a 100-year flood for the no-project alternative is 35,200,000 cubic yards (cy), or 26,911,315 cubic meters (m^3) for the Otay River. The corresponding flow volumes for Poggi Canyon Creek and Nestor Creek are respectively 2,240,000 cy (1,712,254 m^3) and 1,748,800 cy (1,337,003 m^3), so that the combined flow through the floodplain is $\overline{Q}$ = 39,188,800 cy (29,960,856 m^3), or 24,290 acre ft. Figure B1 give the distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain and salt pond complex for the no-project alternative, (after Everest, 2014); while Figure B2 gives the velocity distribution for the ORERP Intertidal Alternative and Figure B3 gives the Subtidal Alternative. In each of these figures, the DDT contaminated area is bounded by a yellow polygon in the lower left hand corner.

Comparing the velocities in the DDT contaminated area among Figures B1 – B3, we find the maximum flood velocities for the 100-yr flood are about 0.5 ft/s to 1.0 ft./s greater for the Intertidal and Subtidal Alternatives relative to the no-project alternative. At first impression, this would suggest that the ORERP might cause more soil erosion in the DDT contaminated area than the no-project alternative. However, the sediment stratigraphy in this area indicates this is not the case, as revealed by sediment coring conducted by Anchor QEA (2013). In the DDT contaminated area of the floodplain, the top 3 ft of soils are comprised of 27 % silt and clay ($d < 0.0625$ mm) and 63 % fine sands to coarse sand ($d > 0.0625$ mm). However, from 3 ft to 5 ft below existing grade, 74.1 % of the soils are comprised of silt and clay, and 25.9 % are fine sand to coarse sand. Hence, there is an abrupt transition from more sandy, erodible, material in the top 3 ft, to more cohesive erosion-resistant soil below 3 ft. It was this difference in grain sizes that the original assumption set forth in Section 2.1 was based, whereby the top 3-ft of soil could be completely eroded during a 100-year flood. It is also this abrupt transition in grain sizes at 3 ft below existing grade in the DDT contaminated area that creates a hard enough basement on the depth of erodible soil so that erosion below 3 ft will not occur, with or without the project during a 100-year flood, (given the maximum flood velocities shown in Figures B1 – B3). Therefore we can assume the same amounts of DDT contaminated soils will be eroded from the floodplain for the no-project alternative as for the ORERP alternatives. From that assumption we formulate the model inputs for the post 100-yr floor flood analysis of the no-project alternative as listed in Table B1. The inputs for the no-project alternative are based on erosion fluxes from one possible erosion depth (3 ft.) in the DDT contaminated area of the floodplain, and is combined with two possible fluxes of clean fines (0 cy and 438,000 cy) from the upper watershed below the Savage Dam; yielding a sensitivity analysis comprised of 2 separate deposition scenarios. Thus, the ensemble of input parameters for the no-project sensitivity analysis are comparable to inputs used for the ORERP in Table 4, rows 2 & 5.

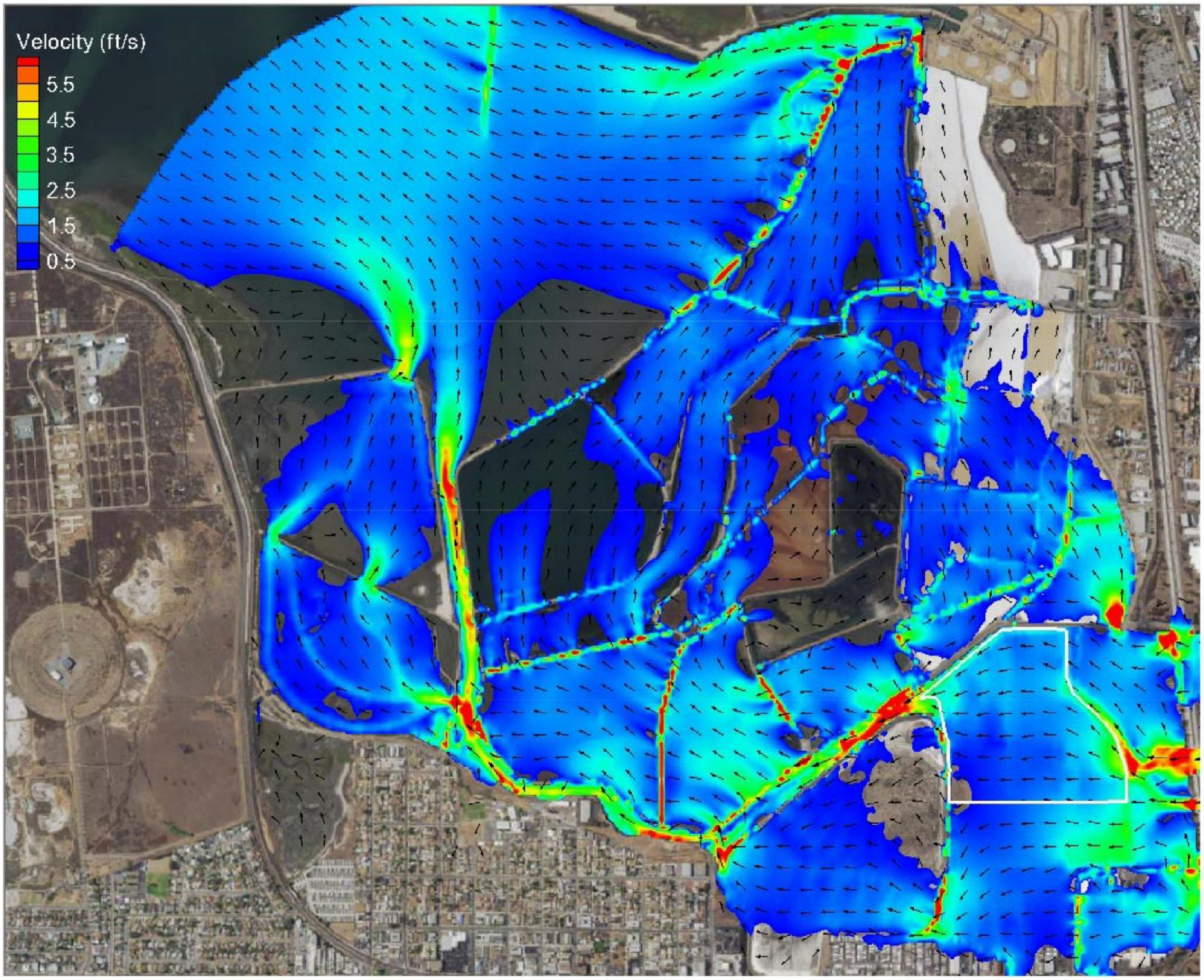

Figure B1: Distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain and salt pond complex for the no-project alternative, (after Everest, 2014). DDT contaminated area bounded by yellow polygon in the lower right hand corner. Ponds 10 & 11 shown in the lower left corner.

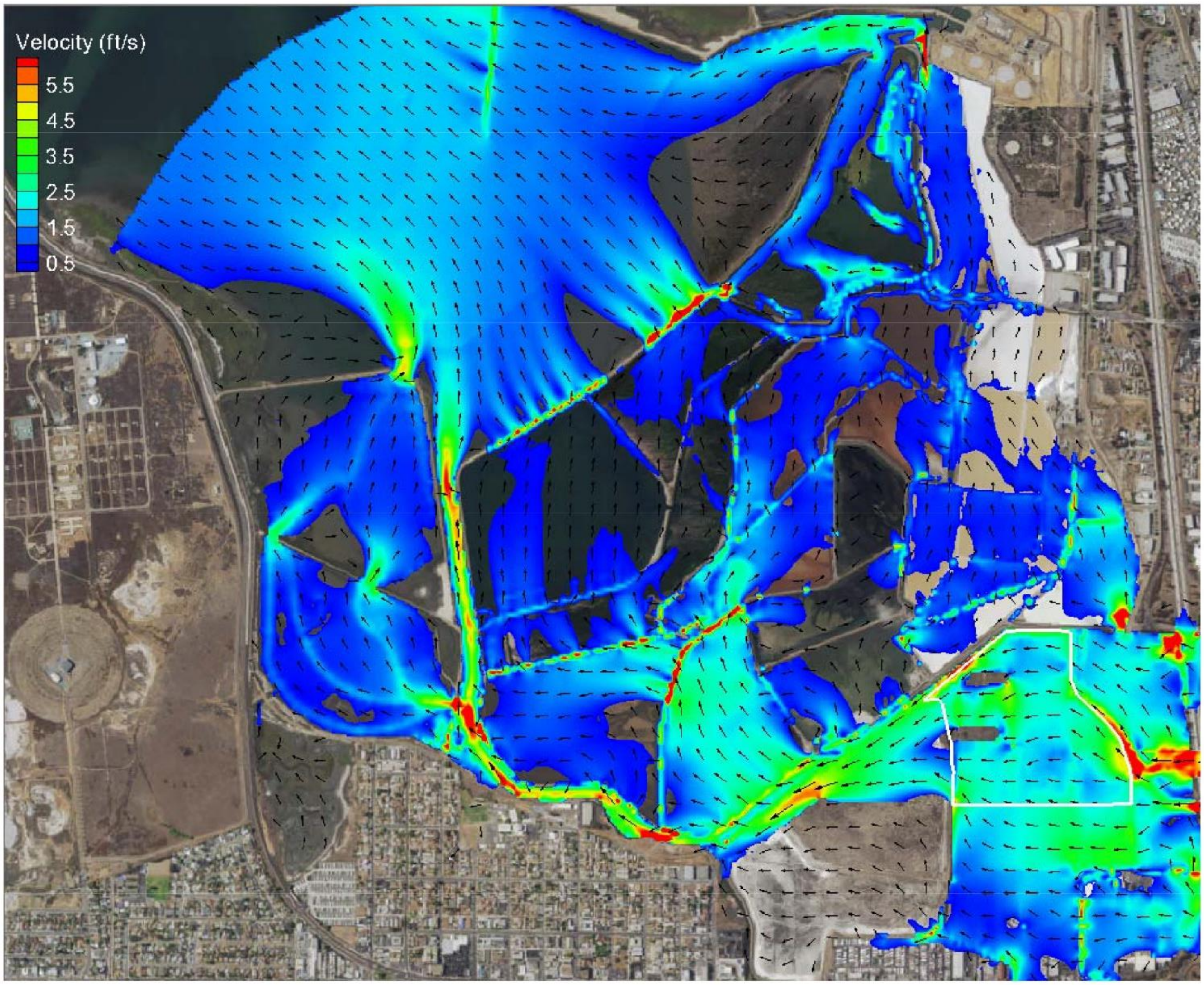

Figure B2: Distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain and salt pond complex for the fully implemented Intertidal Alternative, (after Everest, 2014). DDT contaminated area bounded by yellow polygon in the lower right hand corner. Ponds 10 & 11 shown in the lower left corner.

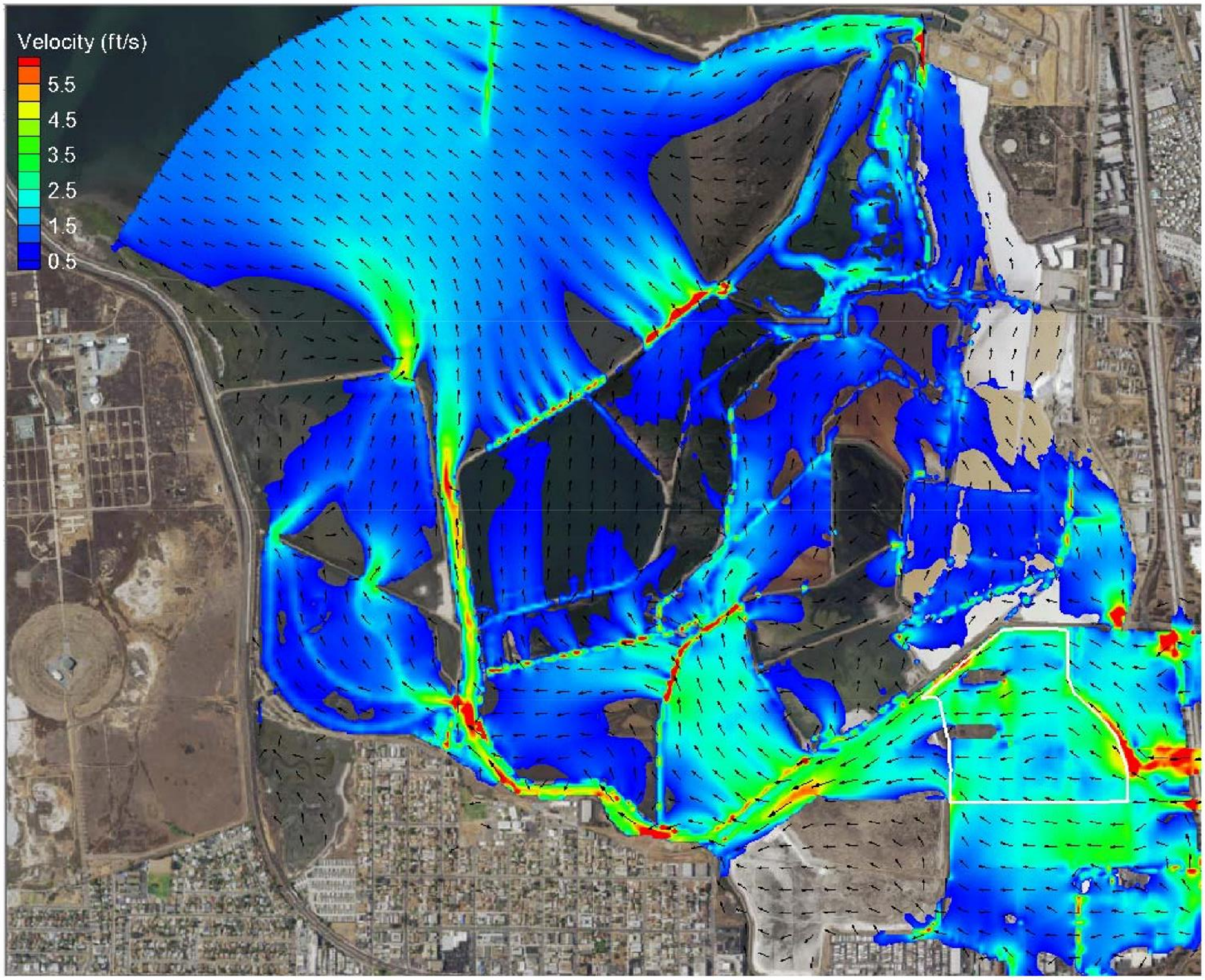

Figure B3: Distribution of maximum stream flow velocities for the 100-year flood in the lower Otay River flood plain and salt pond complex for the fully implemented Subtidal Alternative, (after Everest, 2014). DDT contaminated area bounded by yellow polygon in the lower right hand corner. Ponds 10 & 11 shown in the lower left corner.

Table B1: Input Parameters for Sensitivity Analysis of Post 100-Year Flood DDT Deposition for the No-Project Alternative

Scenario	Volume of Eroded DDT-Bearing Fines	DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.
Erode top 3 ft. of Contaminated Area + Upper Watershed*	128,300 cubic yards	310 μ g/kg	438,000 cubic yards	24,290 acre ft	23.15 g/l.
Erode top 3 ft. of Contaminated Area Only*	128,300 cubic yards	310 μ g/kg	0 cubic yards	24,290 acre ft	5.25 g/l

The suspended sediment concentrations in Table B-1 are based on a dry bulk density for eroded soil of 2700 lb per cy, or 1.225 metric tons per cy; where a metric ton is 1000 kg. This conversion factor is applied to the sum of the volume of eroded DDT- bearing fines (column_2) and the volume of eroded fines from the upper Otay watershed (column_4) to obtain the total flux of suspended fine grained sediment in tons/day during the 24 hour flood period of the 100-year flood for the no-project alternative. The sand and gravel sized fractions eroded from the floodplain by the 100 year flood (292,000 cy) are assumed to be transported as bed load and remain in the Otay River channel. The suspended sediment flux component (column_2 + column_4) is divided by the flow volume of $\overline{Q}$ = 29,960,856 m^3 during the 24 hour flood period to give the average suspended sediment concentration in column_6 upon conversion of metric tons to grams and cubic meters to liters.

Deposition Results: We use the 2011 bathymetric survey conducted by WRA for modeling post-flood deposition in no-project alternative (Figure B4), and use the deposition results from Ponds 10 and 11 as a proxy for evaluating potential wetlands impacts from the 100-yr flood. In Section 5, it was shown that the deposition thickness in the tidal basins is proportional to the water depths and tidal residence times in those basins, where greater deposition thickness was observed in Pond 15 where water depths are greater and residence times longer than in the Otay River Floodplain Basin of the ORERP, (cf. Figures 9 vs. 10). Figures B4 reveals that water depths in Ponds 10 and 11 are comparable to water depths in the Subtidal Alternative of the ORERP, and the TIDE_FEM solutions indicate that the residence times are also comparable (on the order of 2.5 days). Thus it is not surprising to find that the plots of the deposition flux and deposition thicknesses in the Ponds 10 and 11 in Figures B5 and B6 for the 100-year flood are very similar to those in Figures 9 and 11 for the Subtidal Alternative; although the exact time response (shape) of the two sets of curves are different than for the ORERP simulations.

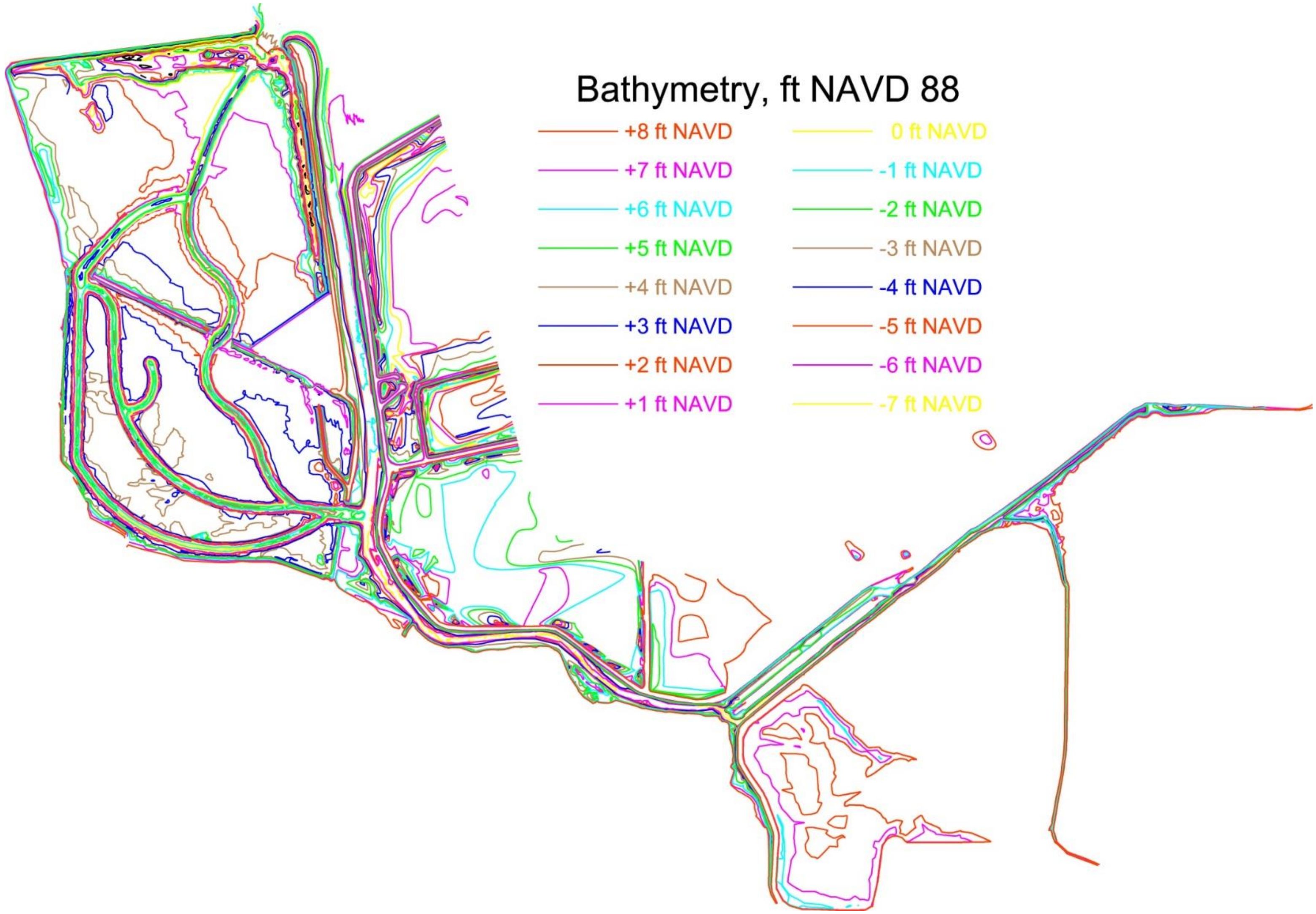

Figure B4: Bathymetry for the *No-Project Alternative* with Ponds 10 & 11 shown on the left hand side (west bank) of the Otay River at the river mouth. Bathymetry shown in ft. NAVD based on bathymetric survey by WRA (2011).

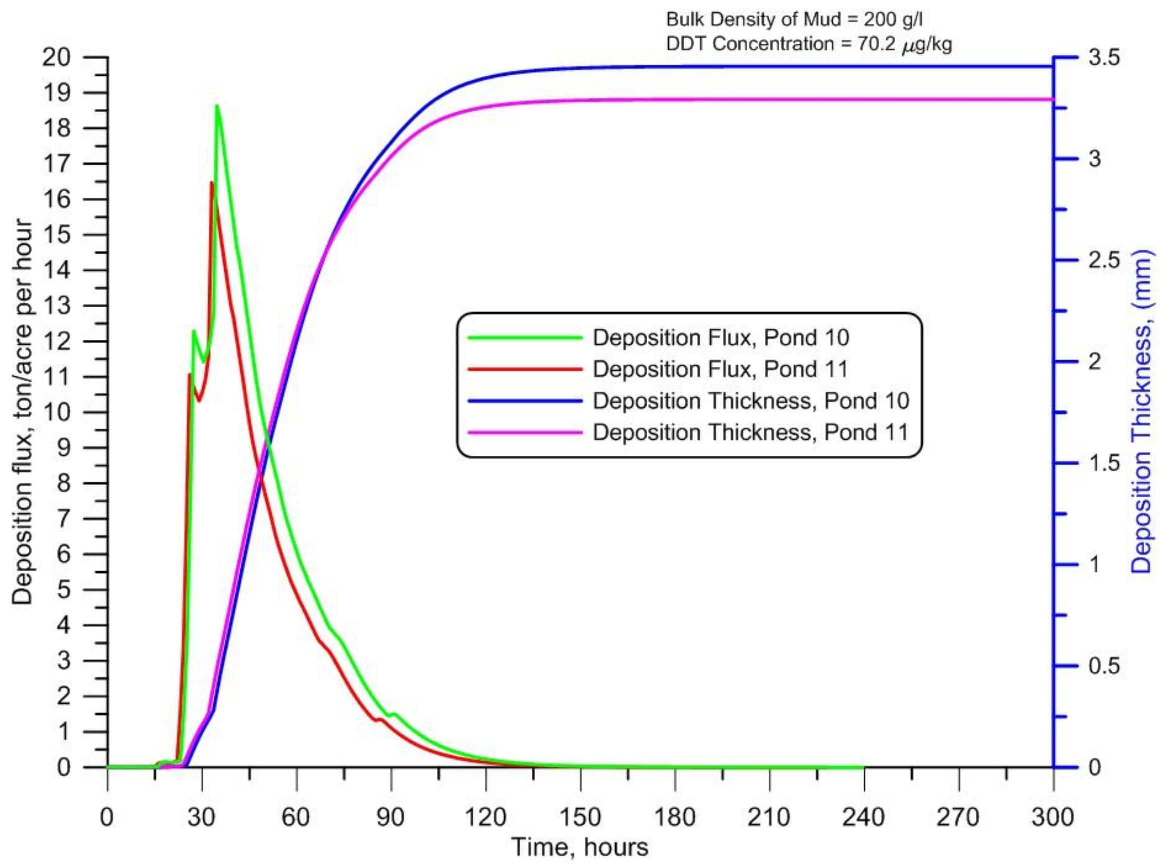

Figure B5. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Ponds 10 and 11 in the Otay River Floodplain (*No-Project Alternative*) following the 100-year flood. Deposition flux (green & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and 438,000 cubic yards of clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

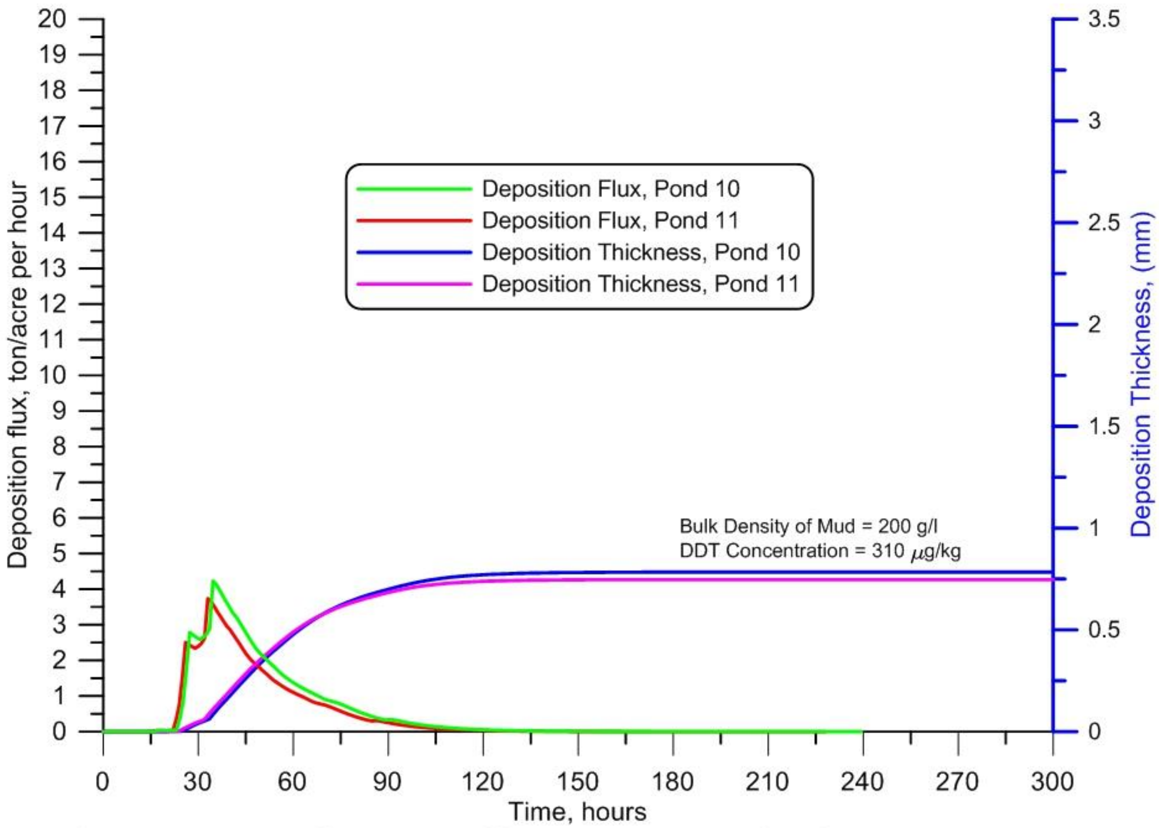

Figure B6. Sensitivity analysis of deposition of fine-grained sediment (mud) in the Ponds 10 and 11 in the Otay River Floodplain (*No-Project Alternative*) following the 100-year flood. Deposition flux (green & red); deposition thickness (blue & magenta). Results for 128,300 cubic yards of contaminated fines and no additional clean sediment from the upper Otay River watershed. DDT given as dry bulk concentration.

Figure B5 gives the time evolution of the post-flood deposition flux and deposition thickness for the first scenario (row_2 of Table B1) in Ponds 10 and 11 of the no-project alternative. This scenario is based on maximum flood-induced erosion depths of 3 ft. in the contaminated area adjacent the Floodplain Tidal Basin mixed with 438,000 cubic yards of fine-grained sediments from upstream erosion of the portion of the watershed below the Savage Dam. Results are similar for both Ponds 10 and 11 showing that accumulations range from 3.4 to 3.7 mm of partially consolidated mud after 276 hours post-flood, with dry bulk DDT concentrations of 70.2 μ g/kg everywhere in the post-flood deposition. The initial post-flood suspended sediment concentration is the same in all areas of the floodplain and salt pond complex because the 100 year flood overtops and flows through these areas with its washload, (cf. Figure B1). The general depositional features are that deposition flux peaks within one diurnal tide cycle after cessation of the flood in both basins of both restoration alternatives, with an initial deceleration in flux during the first semidiurnal ebb tide. After the first post-flood diurnal tidal cycle, the deposition flux declines as progressive settling depletes the suspended sediment concentration, and tidal residence times in the ponds limits the amount of time for settling and deposition to occur. Meanwhile, deposition thickness, which results from the cumulative sum of deposition flux over time, rapidly builds during the peak deposition flux period, and then gradually approaches a constant limit for partially consolidated mud at 200 g/l bulk density as the deposition flux vanishes after 120 to 150 hours post-flood. The minor differences in deposition flux and deposition thickness among the ponds and restoration alternatives are due to differences in residence times as a consequence of proximity of outlets to The Bay and river.

Next, consider in Figure B6 how such results may be affected if we assume no erosion of soils occurs in the portion of the watershed upstream of the floodplain and below the Savage Dam. This scenario is specified by the third row in Table B1 and is based on maximum erosion depths of 3 ft. in the contaminated area only. Here, runoff from the 100 year flood consists of a uniform suspended load of silts and clays with concentration of $\overline{C}$ = 5.25 g/l. Figure B6 gives the time evolution post-flood for deposition flux and deposition thickness in Ponds 10 and 11 of the no-project alternative. Again, results are similar for both ponds, but the dry bulk concentration of DDT in the post-flood deposition has increased to 310 μ g/kg, while the deposition thicknesses are greatly diminished. Ponds 10 & 11 accumulate only 0.74 to 0.78 mm of partially consolidated mud after 276 hours post-flood.

The initial post 100-year flood accumulations of partially consolidated mud computed in Figures B5 & B6 will, over time, dewater and compact under its own immersed weight. The initial deposition will consolidate and compact to a maximum saturated density for fully consolidated mud, 1200 g/l, so that the 100-year flood deposition for the two scenarios in Table B1 would eventually become a very thin layer of consolidated mud on the order of a fraction of a millimeter thick; or:

Deposition with upper watershed sediments:

$$3.4 - 3.7\ mm\ @\ 200 g/l \quad \Rightarrow \quad \left\{ \frac{dewatering}{consolidation} \right\} \quad \Rightarrow \quad 0.5 - 0.6\ mm\ @\ 1{,}200 g/l$$

Deposition without upper watershed sediments:

$$0.74 - 0.78\ mm\ @\ 200 g/l \quad \Rightarrow \quad \left\{ \frac{dewatering}{consolidation} \right\} \quad \Rightarrow \quad 0.17 - 0.18\ mm\ @\ 1{,}200 g/l$$

Consolidation only involves a reduction in the water content of the post-flood deposition, and therefore does not alter the DDT dry bulk concentration, which remains 70.2 μ g/kg when there is dilution from upper watershed sediments and 310 μ g/kg when there is no deposition of upper watershed sediments. The amount of time required for this degree of consolidation is uncertain, but experience with dredge material disposal ponds at Mare Island, CA and Charleston, SC [Jenkins, 1980; Jenkins et al., 1981; Jenkins and Skelly, 1983] suggests that consolidation to 600 g/l could occur within three months while full consolidation to saturation (1,200 g/l) could take several years.

The DDT deposition results in Ponds 10 and 11 for the 100-yr flood under the no-project alternative are summarized in Table B2 below. These results are found to be within the range of those for the ORERP post 100-yr flood as detailed in Section 5. From that finding, we submit that the conclusions on potential flood-induced DDT impacts to the existing wetlands ecology, as detailed in Section 7 are upheld; and it can be concluded that the ORERP does not increase the risk of exposure of wetland ecology to DDT, (a risk that exists with or without the project).

Scenario	Volume of Eroded DDT-Bearing Fines	Average DDT Conc. in DDT-Bearing Fines	Volume of Eroded Upper Watershed Fines	Flood Flow Volume	Suspended Sediment Conc.	Initial Post-Flood Deposition Thickness (200 g/l Mud)	Final Post-Flood Deposition Thickness (1,200 g/l Mud)	DDT Conc. in Post-Flood Mud Deposition (dry bulk)
Erode top 3 ft. of Contaminated Area + Upper Watershed*	128,300 cubic yards	310 μ g/kg	438,000 cubic yards	24,290 acre ft	23.15 g/l.	3.4 mm to 3.7 mm	0.5 mm to 0.6 mm	70.2 μ g/kg
Erode top 3 ft. of Contaminated Area Only**	128,300 cubic yards	310 μ g/kg	0 cubic yards	24,290 acre ft	5.25 g/l	0.74 mm to 0.78 mm	0.17 mm to 0.18 mm	310 μ g/kg

Table B2: Matrix of Sensitivity Analysis of Potential DDT Deposition in Ponds 10 and 11 for the *No-Project Alternative* post-100 year flood.