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Appendix to the Supplemental EIS/EIR

Placement Site Optimization Analysis for the Sacramento River Deep Water Ship Channel (SRDWSC) Deepening and Widening Project – DRAFT

February 2012

Fall Back Placement Site S16, courtesy of USACE SPN

San Francisco District
U.S. Army Corps of Engineers

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3.0 INTRODUCTION & PURPOSE

The Sacramento River Deep Water Ship Channel (SRDWSC) is anticipated to be deepened from the maintained depth of 30-feet below mean lower low water (MLLW) to the authorized depth of 35-feet below MLLW. To achieve this effort, approximately 9.8 million cubic yards (mcy) of material will be excavated from the channel. The 9.8 mcy of material includes excavation to 35-feet MLLW plus an additional two feet of over depth. The excavated material will be placed in 13 primary and fallback placement sites.

The purpose of this memorandum is to propose a schedule for placement of dredged material at each placement site in such a way that dredging efforts will not be limited by effluent water quality or environmental work windows as well as provide adequate capacity to for the anticipated volume of dredged material to be excavated as part of the SRDWSC Deepening and Widening Project. Site operations can be a function of multiple variables, including: dredge equipment and operations, placement site design, environmental work windows, sediment characteristics, and approximated effluent discharge criteria. These data are described in Section 4.0. The project was incorporated into a six-year construction schedule, presented in Section 5.0. The proposed schedule assumes there will not be any construction delays a result of limited funding. Approximate site capacities, or site volume, and anticipated volumes, or approximate insitu volume, to be placed at each site are presented in Table 1.

Each placement site was given a designation of primary or fall back. Primary sites are intended to be utilized during construction. Fallback sites serve as a secondary alternative in the event that a primary use site becomes unavailable or does not perform as intended.

A second, six-year, alternate placement site schedule was developed, and is presented in Section 7.0. This schedule was designed under the assumption that the Montezuma Wetland Restoration Project (MWRP), Asta – McCormick Pit, Asta – Deterding Pit and Asta – St. Francis Pit sites would become unavailable, which would trigger the use of all of the identified fall back sites, i.e. S35, S20, S14 and S16. The placement site schedule is referred to as the Fall Back Site Plan.

Table 1 – Estimate Sediment Volume to be Placed at Each Site

	Site Designation	**Volume Intended to be Placed of Insitu Material Per Site** (cy)**	**Site Capacity (cy)**
Montezuma Wetland Restoration Project (MWRP)	Primary	684,000	1,000,000
S19*	Primary	3,537,000	2,470,000
Asta - McCormick Pit*	Primary	356,000	1,020,000
Asta - Deterding Pit*	Primary	153,000	428,000
Asta – St. Francis Pit*	Primary	107,000	299,700
S31 – I	Primary	699,000	1,162,000
S31 – II	Primary	391,000	622,900
S31 – III	Primary	1,281,000	2,050,400

Table 1 – Estimate Sediment Volume to be Placed at Each Site			
	Site Designation	**Volume Intended to be Placed of Insitu Material Per Site** (cy)**	**Site Capacity (cy)**
S1	Primary	700,000	1,000,000
S4	Primary	1,896,000	2,670,000
S35	Fall Back	112,000	181,000
S20	Fall Back	112,000	568,000
S14	Fall Back	158,000	355,000
S16	Fall Back	21,000	91,000
*Beneficial use site, intended to be harvested annually and, accordingly, regain initial capacity ** Volumes are rounded to the nearest thousand			

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4.0 DATA ANALYSIS

This analysis was conducted with anticipated dredge equipment and operations, design specifications of each placement site, incremental volume of material to be excavated, environmental work windows and sediment characteristics, namely based on laboratory sediment testing data. This section reviews information on each data set.

4.1 Anticipated Dredge Equipment and Operations

During project construction of the SRDWSC Deepening and Widening Project, it is anticipated that the channel will be hydraulically dredged with discharge pipeline diameters ranging between 16 and 24 inches in diameter. The estimated volumetric flow rates of slurry for the aforementioned pipeline diameters range between 2,747 and 6,280 cubic yards per hour (cy/hr) (USACE, 1987). Slurry is a mixture of insitu sediment and water.

The largest pipeline diameter has the highest dredge production rate, and therefore is able to dredge material the most efficiently. Proportionally, larger discharge pipelines allow dredged slurry to enter the placement site with higher velocities than smaller discharge pipelines. For the purposes of this analysis, a hydraulic dredge with a 24-inch diameter pipeline was assumed because it creates the largest slurry velocity to enter the placement site creating the worst case placement site operation scenario. Although a 24-inch diameter pipeline is anticipated to be utilized, production and volumetric flow rates will likely be adjusted to accommodate effluent discharge criterion established in Section 4.6 or to increase annual storage capacity discussed in Section 5.4. Production rate is referred to as the rate that insitu sediment is dredged, described with the unit cubic yards per hour (cy/hr).

Dredging operations are typically scheduled to occur 24 hours a day and 7 days a week. However, typically only 18 hours of actual dredging occurs daily (Ross Island, 2008, 2009). Reduced dredging hours can be related to necessary equipment mobilization or repair, changes in sediment characteristics, and so forth. Historical dredging records from operation and maintenance (O&M) dredging along the SRDWSC were reviewed between 2008 and 2010 to

estimate realistic daily hours of operation. The mean and maximum daily hours of operation were 18 and 22 hours, respectively. Mean hours were calculated using the highest 85 percent of hourly operations, i.e. daily operating hours greater than 10. In this analysis, 18 hours was used as the mean daily hours of operation. Based on these assumptions, the dredging to achieve the authorized depth can be completed in 6 years.

Each placement site was incorporated into a six-year construction scenario that incorporates both new work and O&M dredging. The new work dredging occurs between Reach 1 and Reach 4. Reach 5 was previously deepened, in 1991, to the authorized project depth of 35-feet; however, O&M dredging has not been conducted to maintain the channel in Reach 5. As a result, O&M dredging will be conducted in Reach 5 to remove the accumulated 1,878,715 cy of material to obtain the authorized depth of 35-feet. This O&M dredging is anticipated to occur simultaneously with the new work dredging during construction years five and six. During this period, two dredges will be operating in tandem. The first dredge is anticipated to be performing the new work dredging in Reach 4 and the second dredge is anticipated to be performing the O&M dredging in Reach 5. As a result of the dual operations two operating scenarios are tabulated for construction years five and six. The first will be for the new work dredging occurring in Reach 4 and the second will be for the O&M dredging occurring in Reach 5.

The construction scenario allocated dredged material from the channel to each placement site. Material allocation was limited by site capacity. The Primary Plan placement site schedule is presented in Table 2.

In order to maintain a six year schedule and ensure that the dredging contractor can work efficiently without being limited by the ability of any of the placement sites to process and decant water; it may become necessary for the contractor to alternate placement between disposal sites in any one year. The dredged material that is located between river miles 0 and 10.5 have approximately 42.9 percent or less fine grained material (Table 5). Column settling tests indicate that the fine fraction quickly settles out of suspension, suggesting that this dredged material will settle out very quickly in the placement sites and allow the designated sites to be decanted very efficiently. In the portion of the project between river miles 10.5 and 20.5, the dredged material also has a low percentage of fine sediment; however, the column settling test indicate that these fine particles do not settle quickly, rather they remain in suspension (Section 4.5.3). In this area of the river, it is anticipated that it will be difficult for the designated sites to process effluent efficiently. It is also anticipated that the Contractor will make use of multiple sites and alternate placement between them to avoid slowing down or stopping the dredging operations.

Depending on the location of any of the designated placement sites in relation to the location of the dredging, operations will likely require the use of one or more booster pumps to assist the placement of dredged material in sites that may be as far away as 10 miles from the area that is being dredged. A typical 24-inch diameter hydraulic dredge is capable of pumping dredged material slurry approximately three miles and each 24-inch diameter booster pump can pump the slurry an additional 2.5 miles. Although pumping distances as far as 10 miles may appear to be costly and unnecessary in light of that fact that there may be placement sites that are much closer, there are no other beneficial use sites in close proximity (less than 10 miles away) that

could be permitted or constructed for less cost than the cost to pump 10 miles. All of the booster pumps will be affixed to floating barges and anchored in the river outside of the channel toes. The pumps will be monitored daily and tended with tugs as needed. Assuming an average daily production rate of approximately 10,000 cubic yards per day, each additional booster pump would be in use for 30 to 60 days, depending on the location of the booster with respect to the dredge plant.

Primary placement sites S19, Asta – McCormick Pit, Asta – Deterding Pit, Asta – St. Francis Pit are considered to be beneficially used placement sites that are anticipated to be harvested annually; as such, placement site capacity reported in Table 1 will be available every construction year that the site is intended for use. Montezuma Wetland Restoration Project (MWRP) is also a beneficial use placement site, but all of its water management operations are handled by the MWRP site managers. The MWRP has its own waste discharge requirements (WDR) and will be responsible for meeting the water quality standards that are detailed in the MWRP WDR. Accordingly, management of the dredged slurry pumped to MWRP is the responsibility of the site managers, and not quantified as part of this analysis. Placement sites S31 – I, S31 – II, S31 – III, S1 and S4 are not intended to be used beneficially, i.e. material will be stockpiled at these sites until site capacity has been reached. As a result of the stockpiling, additional computations were made to determine site adequacy (Section 5.0).

It is anticipated that most placement sites will require decanting. Typically, there is a time lag between when the placement site begins to receive material and when the site has received enough volume to necessitate decanting. It is anticipated that dredging operations will slow once decanting occurs, as it is assumed that the maximum allowable decant rate will dominate site operations. Accordingly, it is assumed that the placement site will receive material prior to decant at a rate that is typical of a 24-inch hydraulic dredge, with a maximum volumetric flow rate of 6,280 cy/hr and a mean rate of 4,200 cy/hr. The mean volumetric flow rate, 4,200 cy/hr, was computed based on historical dredge records from O&M dredging of the SRDWSC (Ross Island, 2008, 2009). The volumetric flow rate represents the dredge slurry flow rate, i.e. the rate at which the mixture of insitu sediment and water enter the placement site. Table 3 presents the estimated time, in days, to fill each placement site. This was computed by dividing the mean volumetric flow rate into each respective site capacity. The estimated fill duration ranges between 3.96 and 35.32 days. In the situations where the placement sites are not intended to be decanted, i.e. ponding only, the fill duration shown Table 3 presents the fill duration utilized in the placement duration calculations show in Section 5.3.

Table 2 – Allocated Dredged Material in Cubic Yards for the Primary Plan

Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
Montezuma						
S19	1,116,486	1,630,151	790,000			
Asta – McCormick Pit		98,900	124,785	132,750		
Asta – Deterding Pit		41,500	55,700	55,700		
Asta – St. Francis Pit		29,000	39,000	39,000		
S31-I				165,000	367,624	166,596
S31-II					325,000	66,000

Table 2 – Allocated Dredged Material in Cubic Yards for the Primary Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S31-III				800,095	320,000	161,000
S1					230,000	470,000
S4					470,746	1,424,791

4.2 Placement Site Design

Typically during construction activities, the placement site foot print is provided to the dredging contractor and interior placement site design is up to the discretion of the operating contractor. However, some general placement site information and assumptions were made to enable the determination of adequate placement site operations. Table 3 presents the general characteristics of each placement site used in this analysis, including site area, estimated capacity and interior depth. Interior depth is the mean depth from berm crest to the interior sediment bed of the placement site. The mean depth is referred to as the theoretical depth because placement site interior bed and crest elevations are not uniform in practice. As such, an idealized mean depth was computed. The capacity of each placement site was computed assuming that sediment would fill the placement site to an approximate elevation two feet below the design berm crest elevation, allowing for two feet of freeboard, or one foot of freeboard and one foot of ponded water surface elevation. For the purposes of this analysis, it was assumed that the sites would be operated with one foot of freeboard and one of ponding. Other assumptions used in this analysis include:

1. the operating Contractor would maximize the hydraulic efficiency of the site; as such, a hydraulic efficiency of each site is assumed to be 60 percent
2. the ponded water depth is equivalent to the withdrawal depth of the effluent discharge
3. the placement site would be covered by slurry or that there would be 100 percent ponding
4. the placement sites would be continuously operated, allowing for the effluent flow rate to equal the influent flow rate to yield a total suspended solids concentration less than the total suspended solids concentration limit.
5. when decant operations will not be conducted at a placement site the fill duration will be equal to the placement duration and ranges between 4.0 and 35.3 days.

Table 3 – General Information for Each Placement Site – Primary and Fall Back Plan					
Index	Placement Site Name	Site Area (acres)	Estimated Site Capacity (cy)	Mean Depth (ft)	Estimated Fill Period (days)
1	MWRP	-	1,000,000	-	13.23
2	S19	149.5	2,470,000	12.2	32.67
3	Asta – McCormack Pit	25.1	1,020,000	27.1	13.49
4	Asta – Deterding Pit	16.8	428,000	17.8	5.66
5	Asta - St. Francis Pit	11.2	299,700	18.6	3.96

Table 3 – General Information for Each Placement Site – Primary and Fall Back Plan					
Index	Placement Site Name	Site Area (acres)	Estimated Site Capacity (cy)	Mean Depth (ft)	Estimated Fill Period (days)
6	S31-I	80.9	1,162,000	10.9	15.37
7	S31-II	44.0	622,900	10.8	8.24
8	S31-III	220.0	2,050,400	7.8	27.12
9	S1	65.7	1,000,000	11.1	13.23
10	S4	87.2	2,670,000	21.0	35.32
11	S35	25.6	181,000	6.4	4.6
12	S20	14.2	568,000	26.8	11.4
13	S14	42.0	355,000	7.2	4.7
14	S16	5.4	91,000	12.4	2.0

4.3 Channel Dredged Material

Dredge volumes presented in Table 4 indicate the total dredged volume to deepen the channel to the authorized depth of 35-feet MLLW with an additional two feet of over depth, i.e. to dredge the channel to 37-feet MLLW. It is assumed that the dredged volume per river reach is evenly distributed throughout. Therefore, the mean dredged volume per river mile is also reported in Table 4.

Table 4 – Dredged Volume for Each River Reach		
Reach	**Total Volume to 37-feet MLLW (cy)**	**Mean Volume Per River Mile (cy)**
Reach 1 (River Miles: 0.00 to 4.10)	442,460	107,917
Reach 2 (River Miles: 4.10 to 14.53)	3,877,412	371,756
Reach 3 (River Miles: 14.53 to 18.75)	405,108	95,997
Reach 4 (River Miles: 18.75 to 35.50)	3,200,401	191,069
Reach 5 (River Miles: 35.50 to 43.50)	1,878,715	234,839

4.4 Environmental Work Window

Environmental work windows were also considered in this analysis. Two environmental windows are proposed during construction. The first window occurs annually between June first and November 30 allowing approximately 180 days for construction. This window is available for use while construction efforts are underway between river miles 0.00 and 18.75 or Reach 1 and Reach 3. Based on the proposed six year construction scenario, this window will be approximately applicable between construction years one and three. The second window occurs annually between August first and November 30, allowing approximately 120 days for construction. This window is applicable while construction efforts are underway between river

miles 18.75 and 43.50. Based on the proposed six year construction scenario, this window will be approximately applicable between construction years four and six.

4.5 Sediment Characteristics

Sediment information was used from the U.S. Army Corps of Engineers Research and Development Center (ERDC), Environmental Processes and Engineering Division, Environmental Laboratory located in Vicksburg, MS. The Environmental Laboratory conducted column settling tests and geotechnical characterization along the SRDWSC for project planning purposes. One column settling test was conducted on each of the seven composite sediment samples obtained from the SRDWSC (Table 5). Each composite sample represented five miles along the SRDWSC. For example, the first column settling test represents river miles between one and five, and is identified by the Sample ID 08SACR 1/5 where 08 is the year the sample was collected, SARC is the project ID and 1/5 are the river miles the composite sample represents. Compression, zone, and flocculent settling measurements were conducted and recorded for each sample. The focus of this analysis is on the compression and flocculent settling tests. Compression settling results were used as input to compute the storage volume required at each placement site to place the allocated insitu material. Flocculent settling results were used as input to compute the maximum allowable site discharge rate to achieve the desired effluent criteria (USACE, 1987).

4.5.1 General Sediment Characteristics

For the purposes of this analysis, some general sediment characteristics were utilized from the composite samples. These characteristics include the insitu sediment concentration of the deepening and widening project, the fine and coarse grained fraction, and the computed influent solids concentration entering each placement site. The influent solids concentration is computed with an empirical equation developed by the USACE Engineering Research and Development Center (ERDC) Environmental Lab shown in Equation 1. General sediment characteristics are presented in Table 5.

Equation 1: *CIN= FFRAC + 3* CFRAC* (Bailey, 2011)

where

1. CIN = the influent solids concentration (g/L)
2. FFRAC = the fine sediment grain fraction as a percent
3. CFRAC = the coarse sediment grain fraction as a percent

As part to the analysis, the Environmental Lab also developed linear relationships between turbidity in nephelometric turbidity units (NTU) and total suspended solids (TSS) in milligrams per liter (mg/L), where TSS could be computed as a function of turbidity in the form of Equation 2. Table 5 presents the linear coefficient, C_{TSS}, for each composite sample. The mean linear coefficient is approximately 1.00. For the purposes of this analysis, it is assumed that the mean linear coefficient, C_{TSS}=1.00, is representative of the SRDWSC. Therefore, it is further assumed that one mg/L of TSS is equivalent to one NTU.

Equation 2: $TSS = C_{TSS} * Turbidty$

where

1. TSS = Total suspended solids concentration (mg/L)
2. C_{TSS} = Linear coefficient
3. Turbidity = Turbidity measurement in NTU

Table 5 **– General Sediment Characteristics**

Sample ID	Insitu Sediment Concentration, CSITU (g/L)	% Coarse	% Fine	Influent Solids Concentration, CIN (g/L)	C_{TSS}*	Specific Gravity
08 SAC 1/5	1033.5	57.1	42.9	185.8	1.45	2.62
08 SAC 6/10	1326.2	75.7	24.3	148.6	0.86	2.65
08 SAC 11/15	1391.3	82.5	17.5	135.0	0.66	2.66
08 SAC 16/20	1384.1	59.9	40.1	180.2	0.68	2.63
08 SAC 21/25	1300.6	44.2	55.8	211.6	0.95	2.64
08 SAC 26/30	1393.0	55.5	44.5	189.0	1.26	2.64
08 SAC 31/35	1099.6	24.0	76.0	252.0	1.04	2.63
*Mean value is 1.0						

4.5.2 Compression Settling Data and Results

Compression settling results for each composite sample are summarized in Table 6 and Figure 1 through Figure 7. The compression settling laboratory data was fit to a linear power equation presented in Equation 3. The fitted curves had computed correlation coefficients ranging between 0.99 and 1.0, indicating the curve fit is well correlated to the data.

Equation 3: $C = AT^B$

where

1. T = the time in days of each laboratory measurement.
2. C = the sediment concentration (g/L) of the sample variables
3. A, B = curve fitting coefficients.

Table 6 **– Compression Settling Data Summary**

Sample ID	Compression Settling Curve Coefficient, A	Compression Settling Curve Coefficient, B	Correlation Coefficient, R (%)
08 SAC 1/5	256.5886	0.1759	100.0
08 SAC 6/10	225.3321	0.2127	100.0
08 SAC 11/15	193.3472	0.2057	99.9
08 SAC 16/20	213.8136	0.1654	99.5
08 SAC 21/25	214.0797	0.1846	99.5
08 SAC 26/30	201.9287	0.2247	99.6

08 SAC 31/35	236.5125	0.2349	99.7

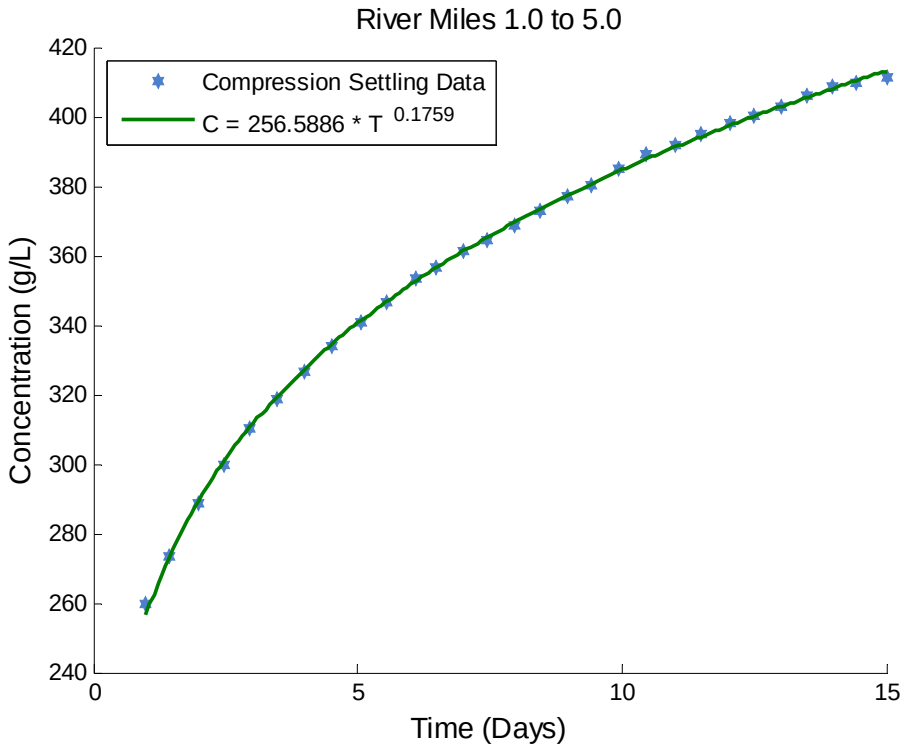

Figure 1 – Compression settling data and fitted curve for river miles 1.0 to 5.0

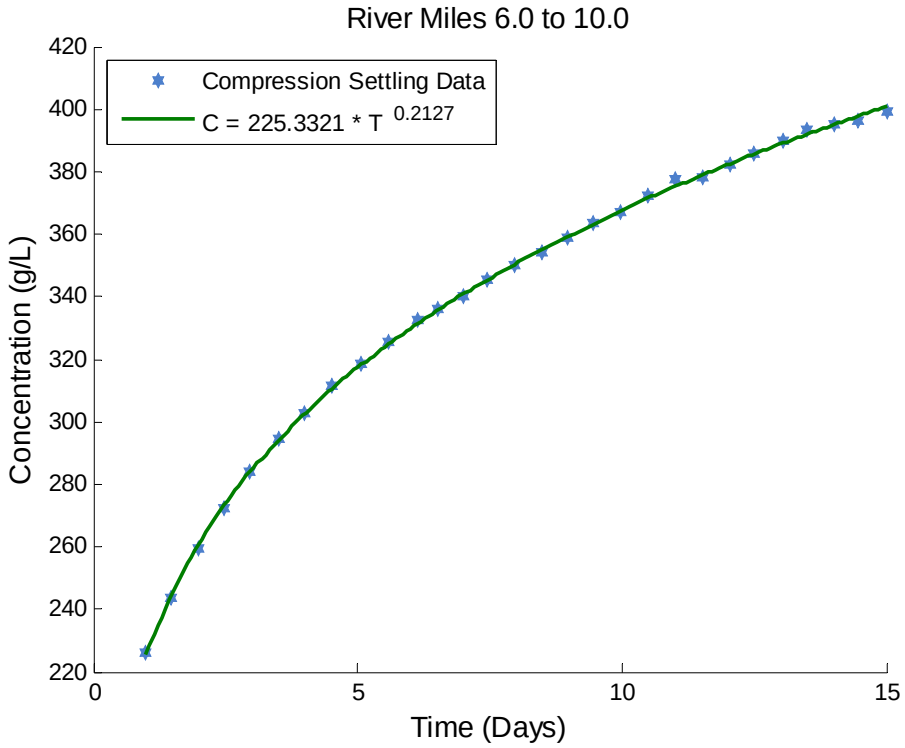

Figure 2 – Compression settling data and fitted curve for river miles 6.0 to 11.0

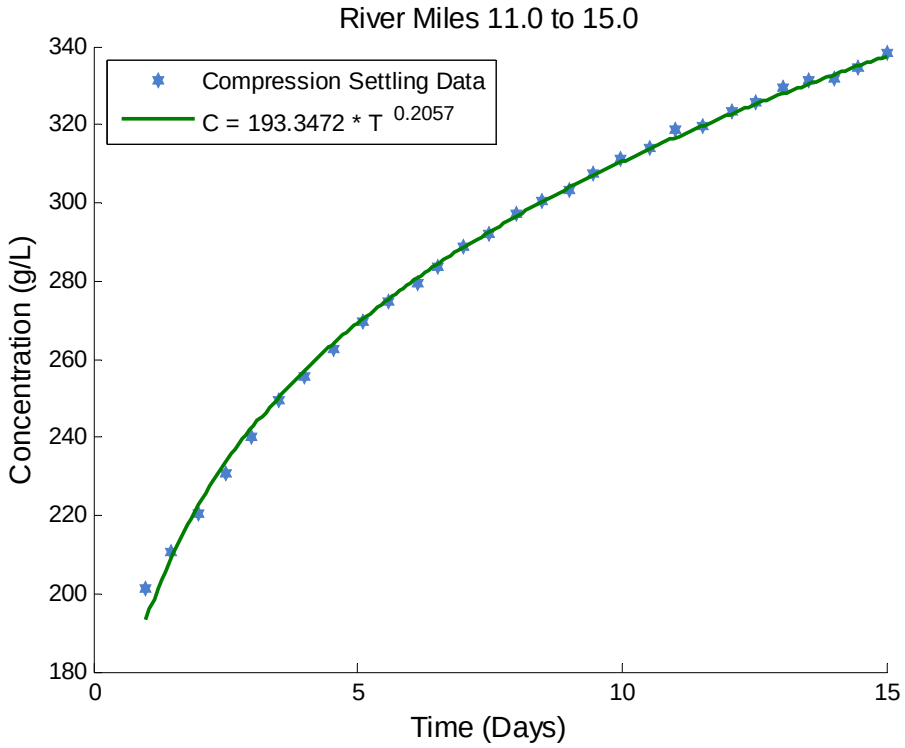

Figure 3 – Compression settling data and fitted curve for river miles 11.0 to 15.0

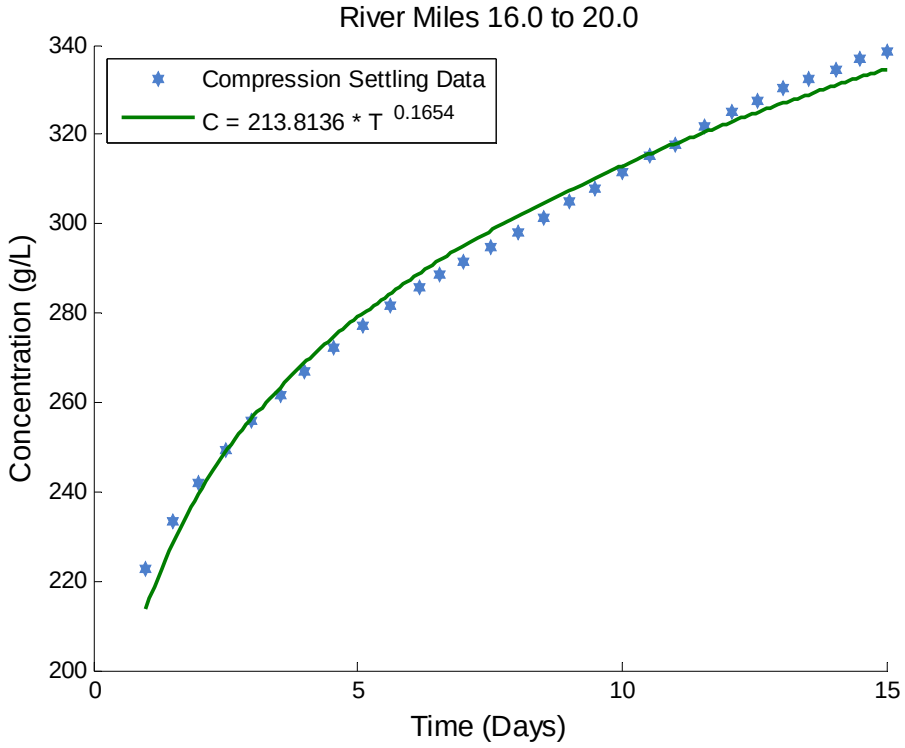

Figure 4 – Compression settling data and fitted curve for river miles 16.0 to 20.0

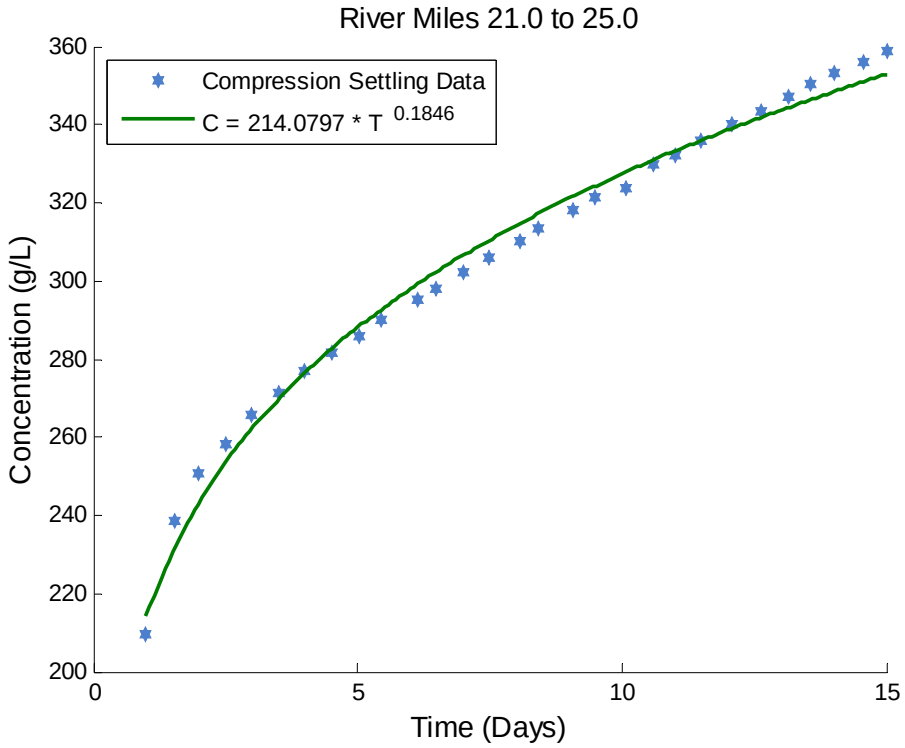

Figure 5 – Compression settling data and fitted curve for river miles 21.0 to 25.0

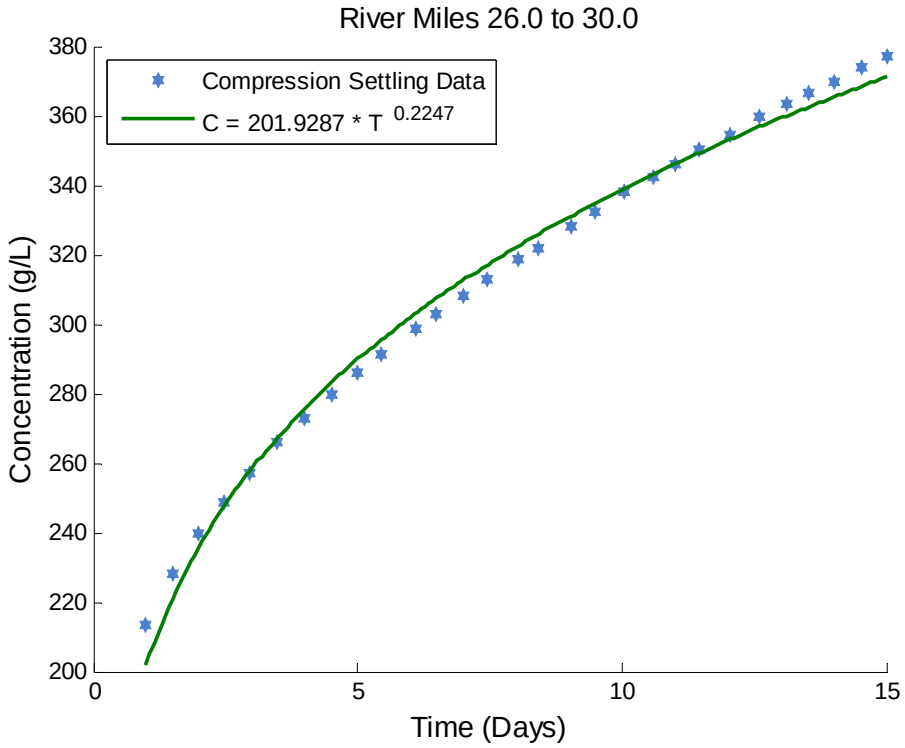

Figure 6 – Compression settling data and fitted curve for river miles 26.0 to 30.0

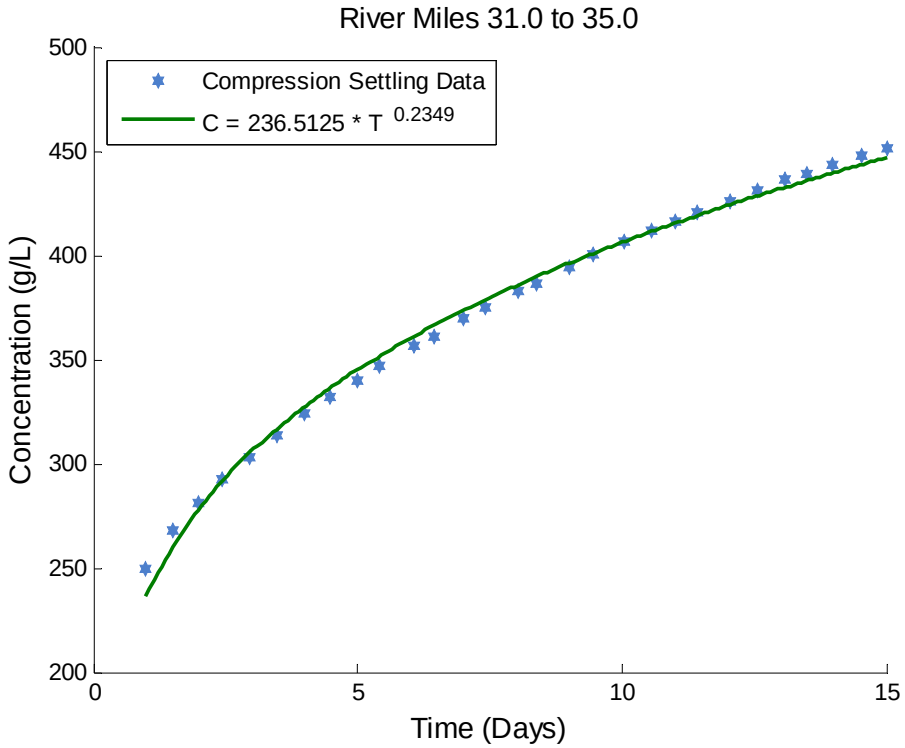

Figure 7 – Compression settling data and fitted curve for river miles 31.0 to 35.0

4.5.3 Flocculent Settling Data and Results

Flocculent settling results for each composite sample are presented in Figure 8 to Figure 14. The flocculent settling laboratory data was fit to an exponential decay equation presented in Equation 4. The correlation coefficient ranged between 0.93 and 0.97 indicating a high correlation between the laboratory data and the fitted curve.

Equation 4: $C = CFLOC * e^{-KT}$**+D**

where

1. C = the sediment concentrations (g/L) at various water depths over time
2. CFLOC = the initial sediment concentration (g/L)
3. K = the exponential solids decay rate (1/hr)
4. D = the constant added to the equation where it appears to have reached an asymptotic limit
5. T = the time in hours at which the concentration was measured

It is expected that between river miles 11.0 and 20.0 dredge operations will slow as a result of the high suspended sediment concentrations. Both composite samples, 08SAC11/15 and 08SAC16/20, have comparatively high concentrations of neutrally buoyant particles although the fine grained sediment fraction is very small (Table 5). This is observed by noting the asymptotic limit of the exponential decay curve, represented by the constant D in Equation 4, of 226.9 and 133.3 mg/L, respectively.

Table 7 – **Flocculent Settling Data Summary**					
Sample ID	**Initial Concentration, CFLOC (mg/L)**	**Solids Concentration of Insitu Material, CSITU (g/L)**	**Exponential Solids Concentration Decay Rate, K (1/hr)**	**Constant, D (mg/L)**	**Correlation Coefficient, R (%)**
08 SAC 1/5	500.0	1033.5	0.0595	24.1	96.05
08 SAC 6/10	2060.0	1326.2	0.3278	58.4	97.24
08 SAC 11/15	2030.0	1391.3	0.0625	261.2	94.64
08 SAC 16/20	1760.0	1384.1	0.0379	237.5	88.57
08 SAC 21/25	78.0	1300.6	0.0355	3.2	94.53
08 SAC 26/30	690.0	1393.0	0.1358	16.7	99.06
08 SAC 31/35	275.0	1099.6	0.1331	7.1	99.55

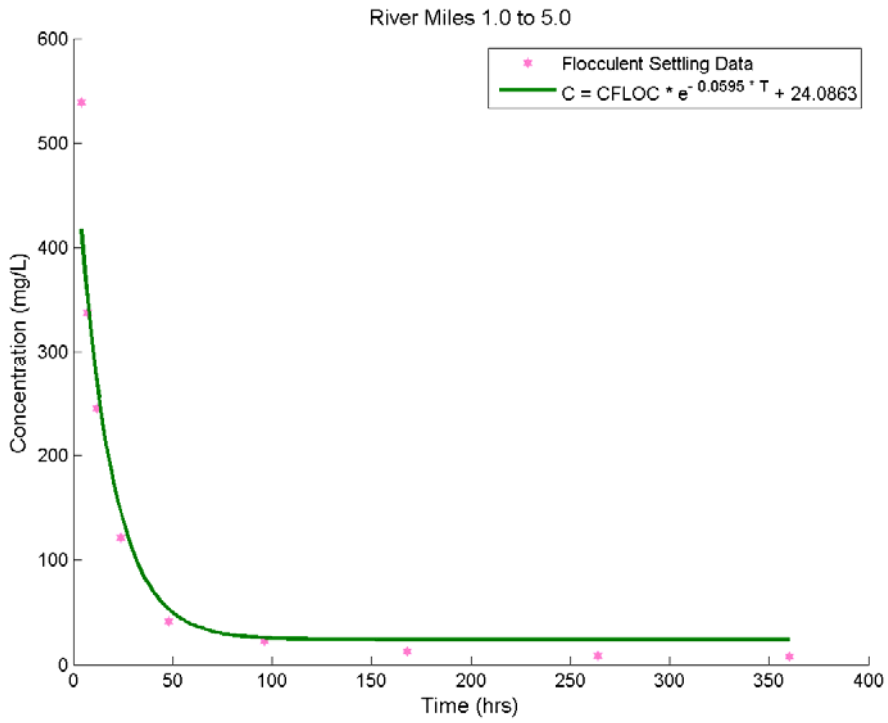

Figure 8 – Flocculent settling data and fitted curve for river miles 1.0 to 5.0

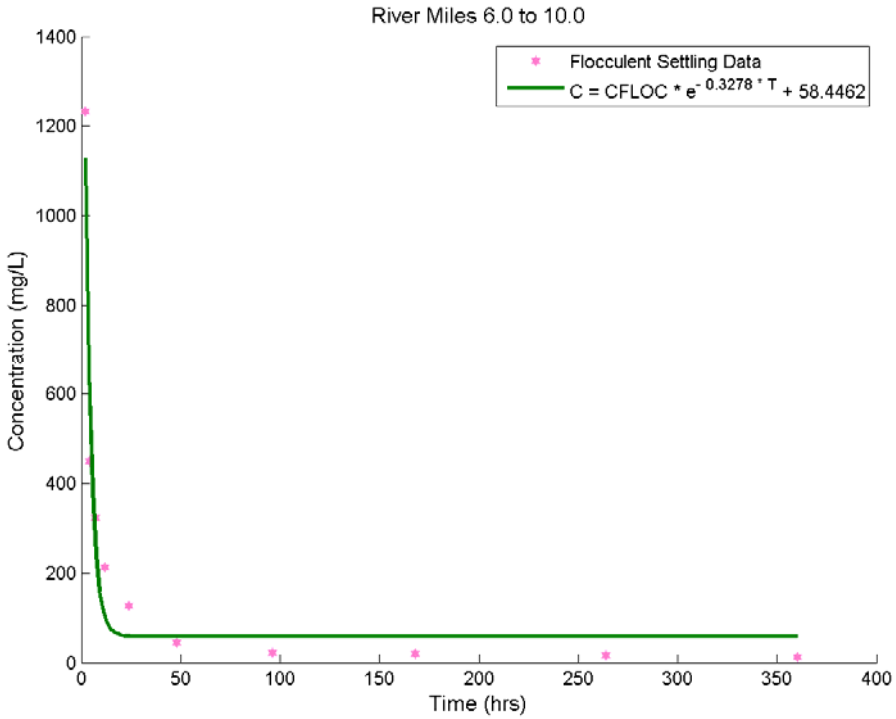

Figure 9 – Flocculent settling data and fitted curve for river miles 6.0 to 10.0

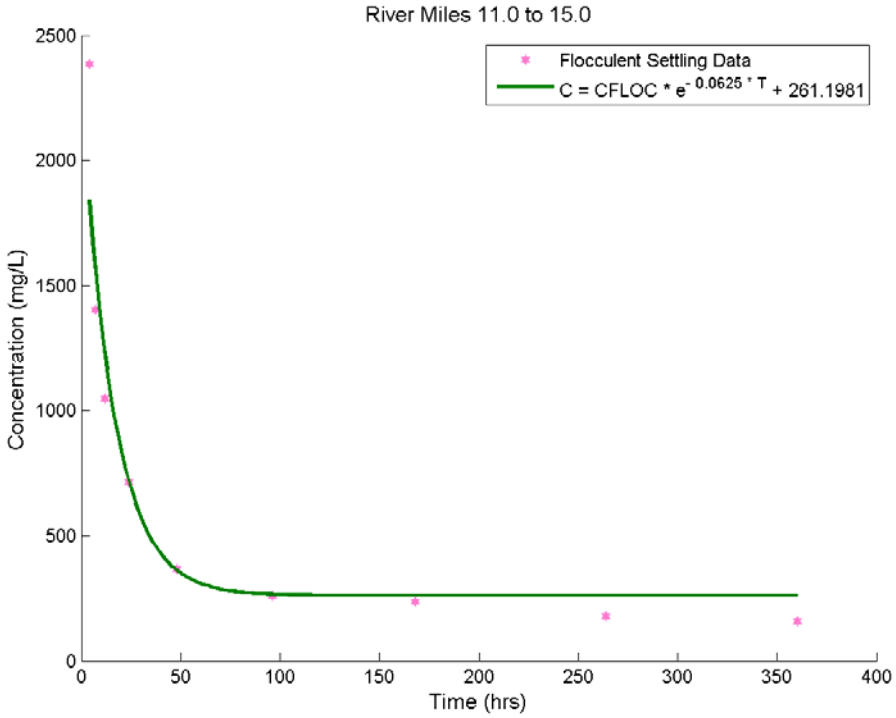

Figure 10 – Flocculent settling data and fitted curve for river miles 11.0 to 15.0

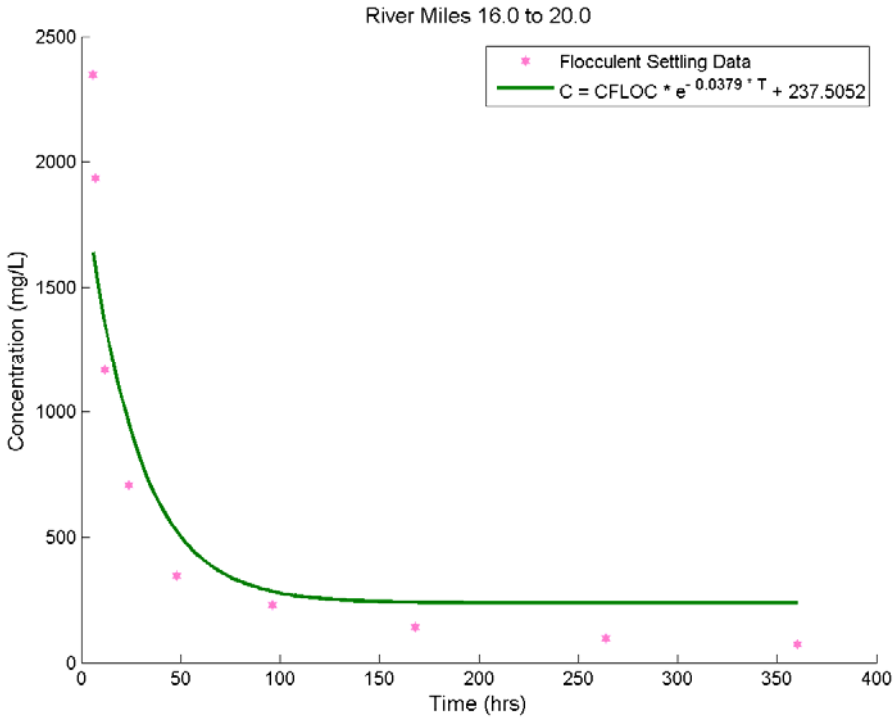

Figure 11 – Flocculent settling data and fitted curve for river miles 16.0 to 20.0

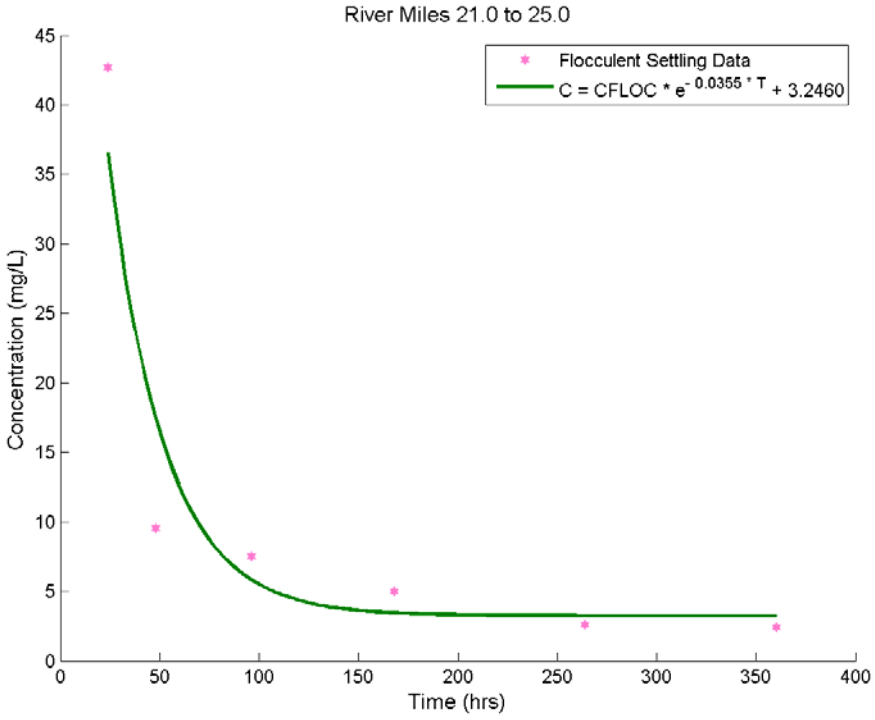

Figure 12 – Flocculent settling data and fitted curve for river miles 21.0 to 25.0

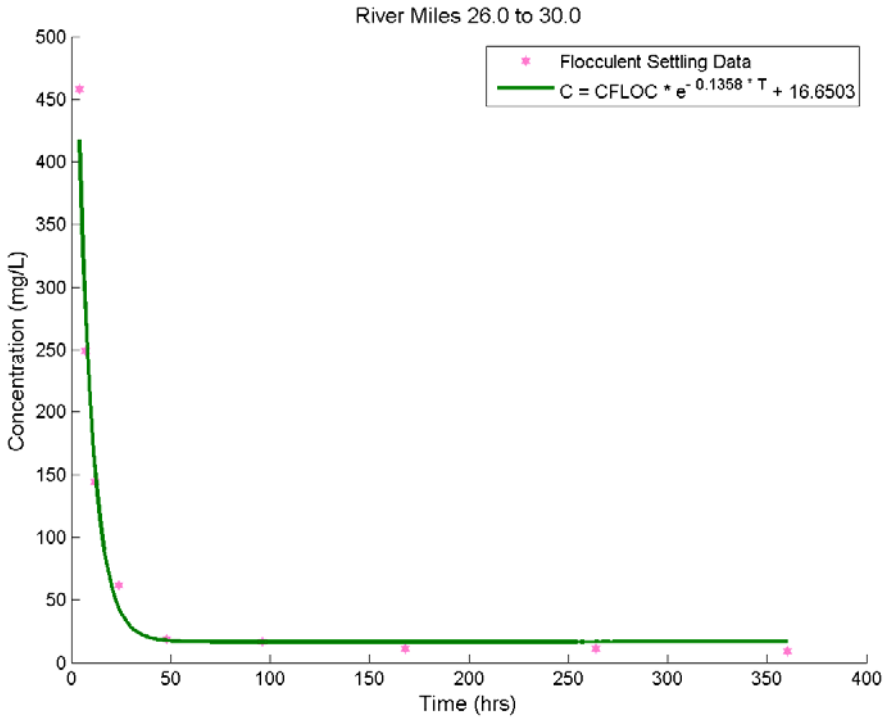

Figure 13 – Flocculent settling data and fitted curve for river miles 26.0 to 30.0

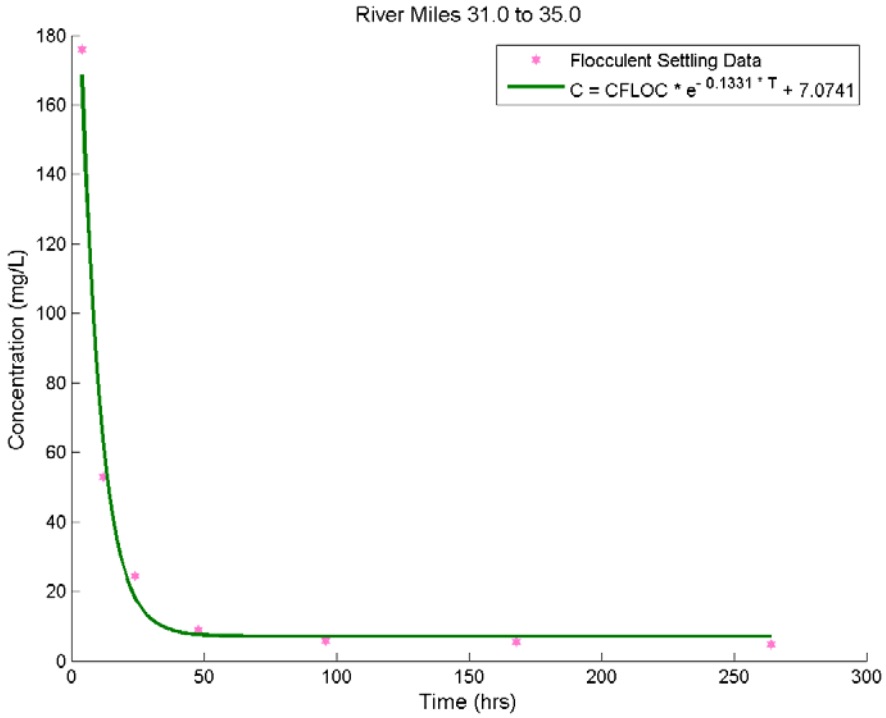

Figure 14 – Flocculent settling data and fitted curve for river miles 31.0 to 35.0

4.6 Effluent Discharge Criteria

Placement operations were investigated to determine if the effluent suspended sediment concentration from each placement site is below the anticipated water quality limit or if production rates need to be reduced to meet anticipated effluent criteria. To assess the water quality standard for suspended sediment concentration, the water quality standards developed to meet the Clean Water Act (CWA) and California Water Code requirements contained in the State Water Resources Control Board (SWRCB) and Central Valley Regional Water Quality Board's (RWQCB) *Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin* (Basin Plan) were reviewed (Central Valley RWQCB 2009). The water quality limit for suspended sediment concentration is defined as turbidity in units of NTU. Water quality criterion is presented below.

> *The discharge shall not cause an increase in turbidity exceeding the following limits in the receiving water:*
> *a. 1.0 NTUs where natural turbidity is between 0 and 5 NTUs;*
> *b. 20.0 percent where natural turbidity is between 5 and 50 NTUs;*
> *c. 10.0 NTUs where natural turbidity is greater than 50 NTUs.*

As part of the column settling test analysis relationships between total suspended sediment and turbidity were developed (Table 5). The mean relationship between turbidity and TSS was 1.0. As such, it is assumed for purposes of this analysis that a measure of turbidity of 1.0 NTU is approximately equivalent to 1.0 mg/L. Sediment analysis was conducted, for planning purposes of the deepening and widening of the SRDWSC, in 2009. As part of the analysis, modified elutriate tests (MET) were conducted on 46 samples along the SRDWSC. MET testing is designed to simulate the water quality of the effluent discharge (USACE, 1991). Suspended sediment concentrations for every river mile ranged between 0.0 and 1790.0 mg/L (Figure 15). To estimate background ambient suspended sediment concentrations, a mean TSS value was established for each placement site to estimate an ambient suspended sediment concentration. Mean TSS values are computed based on an average of the MET TSS samples collected at the river mile upstream and downstream of the placement site. For example, placement site S35 is located between river miles 3.0 and 4.0; therefore, the mean TSS value for S35 is the mean of the TSS samples collected at river mile 3.0 and 4.0. Table 8 presents the anticipated ambient condition and estimated effluent criteria for each composite sample. The estimated effluent criterion is established based on the water quality control plan criteria discussed above.

Table 8 – **Estimated Effluent Discharge Concentration Criterion**

Placement Site	River Miles between	Estimated Mean Ambient Condition (mg/L)	Estimated Effluent Criteria, CEFF (mg/L)
MWRP	0.0 to 0.0	-	-
S19	6.0 to 8.0	50.7	60.7
Asta – McCormack Pit	10.0 to 11.0	118.0	128.0
Asta – Deterding Pit	11.0 to 12.0	133.0	143.0
Asta – St. Francis Pit	13.0 to 14.0	849.0	859.0
S31-I	23.0 to 27.0	52.4	62.4

Table 8 – **Estimated Effluent Discharge Concentration Criterion**

Placement Site	River Miles between	Estimated Mean Ambient Condition (mg/L)	Estimated Effluent Criteria, CEFF (mg/L)
S31-II	26.0 to 28.0	91.0	101.0
S31-III	28.0 to 33.0	67.3	77.3
S1	42.0 to 43.5	20.0	24.0
S4	38.0 to 39.0	20.0	24.0
S20	5.0 to 6.0	46.5	55.8
S35	3.0 to 4.0	16.0	19.2
S14	14.0 to 15.0	1,560.0	1,570.0
S16	9.0 to 11.0	118.0	128.0

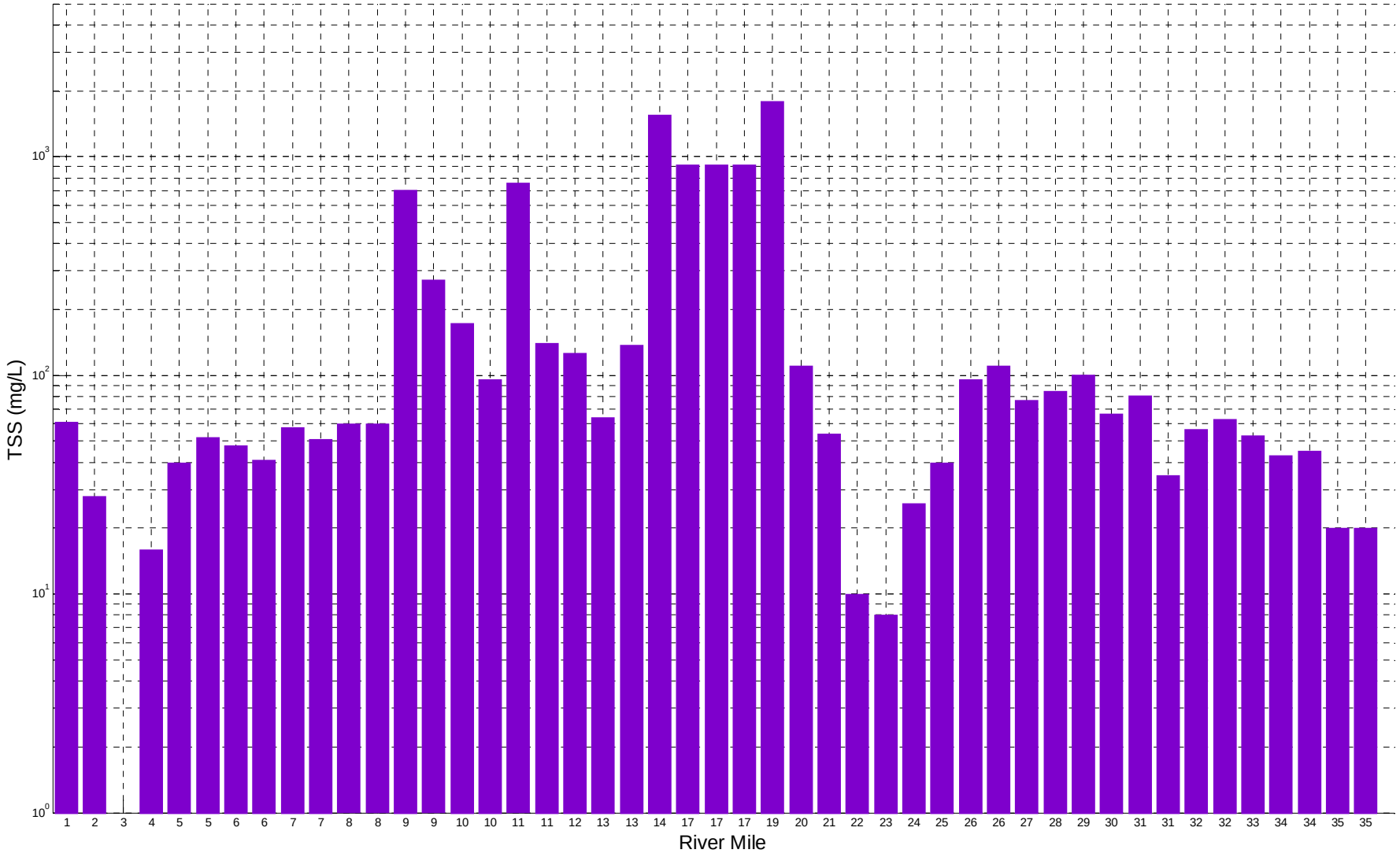

Figure 15 – Mean river mile MET total suspended solids

5.0 METHODOLOGY AND RESULTS

This section presents the methodology and results used to compute minimum theoretical retention time, estimated effluent discharge rates, placement duration and necessary storage volume. Minimum theoretical retention time was computed to estimate the number of hours the dredged slurry would likely need to remain in the placement site to allow the sediment in the slurry mixture to adequately settle to maintain the anticipated water quality criteria (Section 5.1). The computed effluent discharge rate (Section 5.2) and duration of placement (Section 5.3) were computed as a function of the computed retention time.

An additional comparison was made between the available storage volume in the placement site and the storage volume required for the allocated material to be placed at the placement site (Section 5.4). In some cases, namely in construction years four through six, placement site operations were not limited by effluent discharge, rather were controlled by site capacity limitations. In these cases the time to dredge (DTIME) had to be increased beyond the requirements calculated to meet effluent limits in order to achieve the desired capacity. These modifications are discussed in Section 5.3.

5.1 Minimum Theoretical Retention Time

The estimated ambient suspended sediment concentration and estimated effluent criterion, Table 8, was used to estimate the minimum retention time of the dredged material (Equation 5). Minimum retention time is computed as a function of the sediment properties of the material being placed, the surface area of the placement site, the estimated ponded water depth and the anticipated effluent criteria. In some instances the material being placed at the placement sites was a combination to two adjacent composite sediment samples. For example, in construction year one, placement site S19 is anticipated to receive 1,116,486 cy of new work dredged material between river miles 4.75 to 7.75. To assess the retention time required for placement in site S19, sediment characteristics between river miles 4.75 and 5.49 were evaluated using composite sediment sample ID 08SAC 1/5 and between river miles 5.50 and 7.75 (Table 9), sediment characteristics were evaluated using composite sediment sample ID 08SAC 6/10. Conservatively, the maximum computed minimum retention time of the two samples was used as the required retention time for each site (Equation 6). Site surface area is used to identify a re-suspension factor used as input into Equation 5 (USACE, 1987). Re-suspension criteria and computed values are presented in Table 10 and Table 11, respectively. Table 12 presents the computed minimum retention times for each year of use and each placement site.

$$\textbf{Equation 5: } RTIME = \ln\left(\frac{CFLOC * RF}{CEFF}\right) * \left(\frac{1}{K(wd)}\right)$$

$$\textbf{Equation 6: } RTIME_{MAXIMUM} = MAX(RTIME)$$

where:

1. RTIME = the minimum mean theoretical retention time (hr) to achieve effluent discharge limits
2. $RTIME_{MAXIMUM}$ = the maximum computed minimum mean theoretical retention time (hr)
3. CFLOC = the initial sediment concentration (mg/L) (Table 7)
4. K(wd) = the exponential solids decay rate (1/hr) (Table 6)
5. RF = the resuspension factor (Table 11)
6. CEFF = the maximum effluent suspended solids concentration (mg/L) (Table 8)

Table 9 – Estimated Dredge Plan by River Mile – Primary Plan

Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
MWRP	0.00 to 4.75					
S19	4.75 to 7.75	7.75 to 12.13	12.98 to 16.78			
Asta – McCormack Pit		12.13 to 12.64	16.78 to 18.45	19.10 to 19.95		
Asta – Deterding Pit		12.64 to 12.83	18.45 to 18.90	19.95 to 20.24		
Asta – St. Francis Pit		12.83 to 12.98	18.90 to 19.10	20.24 to 20.44		
S31-I				20.44 to 20.73	24.91 to 26.84	30.21 to 31.08
S31-II					26.84 to 28.54	31.08 to 31.43
S31-III				20.73 to 24.91	28.54 to 30.21	31.43 to 32.27
S1					40.51 to 41.49	38.51 to 40.51
S4					41.49 to 43.50	32.27 to 38.51

Table 10 – Resuspension Factor Criteria

Anticipated Ponded Area	Anticipated Averaged Ponded Water Depth	
	Less than two feet	Greater than two feet
less than 100 acres	2.0	1.5
greater than 100 acres	2.5	2.0

Table 11 – Placement Site Specific Resuspension Factor (RF) – Primary Plan

Site	RF
MWRP	2.0
S19	2.5
Asta – McCormack Pit	2.0
Asta – Deterding Pit	2.0
Asta – St. Francis Pit	2.0
S31-I	2.0

Table 11 – Placement Site Specific Resuspension Factor (RF) – Primary Plan	
Site	**RF**
S31-II	2.0
S31-III	2.5
S1	2.0
S4	2.0

Table 12 – Minimum Theoretical Retention Time (hours) – Primary Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
MWRP	-					
S19	51	71	113			
Asta – McCormack Pit		55**	87**	87**		
Asta – Deterding Pit		53**	85**	85**		
Asta – St. Francis Pit		25**	37**	37**		
S31-I				106	26	23
S31-II					19	13
S31-III				26	23	16
S1					24*	24*
S4					24*	24 / 24*
*O&M dredging of Reach 5 **The site is not intended to be decanted during the dredge season, as such retention is not reported						

5.2 Effluent Discharge Rate

Equation 7 was used to compute the maximum effluent discharge to maintain the water quality criteria established in Section 4.6 and weighted with Equation 8. Water quality criterion is temporally and spatially variable and an ambient condition is recommended to be established at the time of effluent discharging for each placement site. Results are presented in Table 13. Similar to the retention time analysis, material being placed at the placement sites was a combination of two adjacent composite sediment samples. Both computed flocculent settling discharge rates, Q_{FLOC}, time values were weighted by the distribution of dredged material for each composite sample to compute a representative Q_{FLOC}. In this example, approximately 279,233cy of material is anticipated to be dredged between river miles 4.75 and 5.49, and between 5.50 and 7.75, approximately 837,253 cy, this was calculated using the estimated insitu material to be dredged per river mile presented in Table 4. Computed Q_{FLOC} results are presented in Table 13. This weighted average approach was also used in the estimated disposal period (Equation 10 and Table 14) computations.

Equation 7: $Q_{FLOCCULENT} = \frac{AREA*\%POND*PD*HE*24}{RTIME*OPHR*100\%*100\%} * \frac{CF}{C_{AMP}}$

Equation 8: $WEIGHTED\_Q_{FLOCCULENT} = \frac{\sum AVOL * Q_{FLOCCULENT}}{\sum AVOL}$

where

1. $Q_{FLOCCULENT}$ = Dredge flow rate (cfs) for flocculent or compression settling to achieve RTIME
2. WEIGHTED_ $Q_{FLOCCULENT}$ = weighted average flocculent discharge rate (cfs)
3. AREA = the surface area of the placement site (acres) (Table 1)
4. RTIME = retention time required to achieve effluent discharge limits (days)
5. %POND = the percent of the placement site that is intended to be ponded
6. PD = the average depth of ponding in the ponded area (ft)
7. HE = the hydraulic efficiency (60%)
8. OPHR = the operating hours per day (18 hours)
9. CF = unite conversion factor (ft^2/acre*hr/sec=12.1)
10. C_{AMP} = the amplification factor used to slow flocculent to allow for more settlement of material further explained in Section 5.3

Table 13 – Mean Effluent Discharge Rate (cfs) – Primary Plan

Site	YR 1	YR 2	YR 3	YR 4**	YR 5**	YR 6**
MWRP	-					
S19	88	75	20			
Asta – McCormack Pit* **						
Asta – Deterding Pit* **						
Asta – St. Francis Pit* **						
S31-I				26	23	32
S31-II					16	24
S31-III				82	64	93
S1					16*	28*
S4					20*	26 / 36*

*O&M dredging of Reach 5
**An amplification factor was applied to slow outflow to reach the desired allocated insitu placement volume. This is described in Section 5.3.
***The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported

5.3 Annual and Placement Site Construction Duration

Equation 9 was used to compute the number of days necessary to dredge and place the desired material and the designated site. This computation is a function of the maximum allowable effluent discharge rate computed using Equation 7. Placement period, i.e. the number of days, was used to determine if the proposed dredged schedule would not exceed the 180 or 120 day proposed environmental work window described in Section 4.4. Computed placement duration for each placement site is presented in Table 14. The cumulative total placement site duration is also presented in Table 14.

In some cases, an amplification factor, C_{AMP}, was applied to slow construction to enhance sediment deposition in the slurry mixture to reach the desired placement volumes. Amplification factors were applied to calculations for construction years four through six for both new work and O&M dredging operations. Table 14 presents the applied amplification factors. When the amplification factor is equal to one, DTIME was controlled by effluent discharge limits; accordingly, when DTIME is greater than one DTIME was dominated by site storage capacity.

Equation 9: $$DTIME_{FLOCCULENT} = C_{AMP}\left(\frac{CSITU*AVOL*27*7}{CIN*Q_{FLOCCULENT}*OPHR*3600*OPD}\right)$$

Equation 10: $$WEIGHTED\_DTIME_{FLOCCULENT} = \sum DTIME_{FLOCCULENT}$$

where:

1. DTIME $_{FLOCCULENT}$ = the estimated duration in days required to place the allocated material (days)
2. WEIGHTED_ DTIME $_{FLOCCULENT}$ = the weighted average placement duration (days)
3. Q $_{FLOCCULENT}$ = the maximum Dredge flow rate (cfs) based on flocculent settling to achieve the minimum retention time to meet discharge limits
4. AVOL = the allocated volume to be placed at the placement site (cy) (Table 1)
5. OPHR = the mean dredge operating hours per day (18 hours per day)
6. OPD = the number of operating days per week (7 days per week)
7. CSITU = the solids concentration of the insitu material (g/L) (Table 5)
8. CIN = the influent solids concentration (g/L) (Table 5)
9. C_{AMP} = the amplification factor used to slow flocculent to allow for more settlement of material

Table 14 – Total Duration of Operation (days) – Primary Plan

Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
MWRP	-					
S19	37	86	97			
Asta – McCormack Pit		13	13	13		
Asta – Deterding Pit		6	6	6		
Asta – St. Francis Pit		4	4	4		
S31-I				9	46	17
S31-II					60	9
S31-III				29	14	6
S1					48*	54*
S4					74*	75 / 62*
C_{AMP}	1.0	1.0	1.0	1.0	1.5 / 1.8*	1.4 / 1.0*
Total Annual Placement Period (days)	37	109	120	61	120 / 122*	107 / 116*

*O&M dredging of reach 5.

5.4 Storage Volume

Equation 11 through Equation 20 represent the methodology used to determine if the proposed placement site schedule, provided adequate storage volume for the material allocated to each placement site. The storage volume was evaluated in three ways. First, the required site volume was computed to determine if it was sufficient to contain the annual allocated insitu sediment volume at the time of placement (Equation 11 through Equation 14). This is referred to as the required storage volume and refers to the volume that is required for placement of material for each dredge season and is described in Section 5.4.1. The placement sites are evaluated to ensure that the placement site has adequate storage volume to account for the bulking of material as it is being placed in the site during the dredge season.

The second volume storage computation is used to project the long term site capacity after multiple dredge seasons (Equation 15 through Equation 19) and is described in Section 5.4.2. It is anticipated that after the dredged material has been initially placed at the site, the material will continue to consolidate, or reduce in volume, at the rate predicted by the compression settling curve (Section 4.5.2). When the placement site is used for multiple years the site capacity is reduced from year to year by the consolidated material from the previous dredge seasons. In this analysis, the consolidate dredge material volume is referred to as the long term storage volume.

The final volume calculation was used to determine if the Asta – McCormack Pit, Asta – Deterding Pit and Asta – St. Francis Pit would have sufficient capacity to pond the entire slurry volume to achieve the desired annual placement volume (Equation 20) and is described in Section 5.4.3.

5.4.1 Required Storage Volume

Equation 11 through Equation 14 present the approach used to compute the required storage volume anticipated to be needed for each placement site during each construction year of intended use. Table 15 presents a comparison of the required storage volume for the allocated volumes, reported in Table 2, and the available storage volume of the placement site. Placement sites S19, Asta – McCormick Pit, Asta – Deterding Pit, Asta – St. Francis Pit are beneficial use sites and anticipated to be harvested annually after each year of use to regain the estimated original capacity. As a result, there is no change in available storage volume for these placement sites after each year of intended use. Placement site MWRP will not be managed by USACE, therefore no calculations of seasonal storage volume were made. Placement sites S31 – I, S31 – II, S31 – III, S1 and S4 are not anticipated to be harvested annually, resulting in the annual stockpiling of dredged material and the annual reduction of available storage of each placement site.

Placement site S1 is anticipated to be used during O&M dredging during construction years five and six. Placement site S4 will be used for O&M during construction year five and both new work and O&M dredging during construction year six. Placement sites S31 – I, S31 – II and S31 – III are anticipated to be used during construction years four through six. Long term storage volume calculations are presented in Section 5.4.2. Long term storage computations were made for two to three years of subsequent use to adequately assess the change in capacity for multiple

years of project construction. This computation is specifically made for S31 – I, S31 – II, S31 – III, S1 and S4 as these sites are anticipated to be used, and not harvested for two to three years during project construction. The seasonal storage volume and available site volume comparison is presented in Table 15. Table 15 indicates the required seasonal dredged volume for each placement site during the six construction schedule does not exceed the available storage volume of the placement site for any placement site, suggesting that the proposed dredge plan can adequately handle the anticipated seasonal dredged volumes for each year of use.

Equation 11: $VOL_{REQUIRED} = (VOLF + VOLC)$

Equation 12: $CEND_{REQUIRED} = A * (\frac{DTIME}{2})^{B}$

Equation 13: $VOLC = \frac{AVOL*CSITU*(100\%-FFRAC)}{CSAND*100\%}$

Equation 14: $VOLF = \frac{AVOL*CSITU*FFRAC}{CEND_{REQUIRED}*100\%}$

where

1. $VOL_{REQUIRED}$ = the storage volume required for the allocated volume of dredged material to be placed at the respective placement site (cy)
2. VOLF = the volume of fines at the end of placement (cy)
3. VOLC = The volume of sands at the end of placement (cy)
4. $CEND_{REQUIRED}$ = the concentration of settled fines at the end of placement (g/L)
5. AVOL = the allocated volume to be placed at the placement site (Table 2) (in situ cy)
6. CSITU = the solids concentration of the insitu material (Table 5) (g/L)
7. FFRAC = the fine grained fraction, in percent, of the sediment sample (Table 5)
8. CSAND = the solids concentration of settled sands (1603 g/L)
9. DTIME = the placement duration (days) (Table 14)
10. A, B = the curve fitting coefficients computed from the compression settling tests of the respective composite sample (Table 6)

Table 15 – Estimated Required / Available Site Volume (cy) for the Primary Plan

Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
MWRP	684,272 / ∞					
S19	1,707,063 / 2,470,000	2,335,870 / 2,470,000	1,154,020 / 2,470,000			
Asta – McCormack Pit		244,322 / 1,020,000	287,134 / 1,020,000	288,686 / 1,020,000		
Asta – Deterding Pit		96,378 / 428,000	108,040 / 428,000	108,041 / 428,000		
Asta – St. Francis Pit		79,743 / 299,700	83,173 / 299,700	83,172 / 299,700		
S31-I				177,231 / 1,162,000	850,027 / 1,075,065	445,775 / 559,824
S31-II					622,397 /	176,655 /

Table 15 – Estimated Required / Available Site Volume (cy) for the Primary Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
					622,900	183,661
S31-III				1,951,455 / 2,050,400	789,865 / 790,921	477,472 / 498,638
S1					843,838 / 1,000,000	424,286 / 477,443
S4					1,823,696 / 2,670,000	707,666 / 1,470,666

5.4.2 Long Term Storage Volume

Placement sites S31 – I, S31 – II, S31 – III, S1 and S4 were evaluated to estimate the change in site capacity over subsequent years of use; as these sites are intended to be used for up to three years during project construction. The methodology to compute the long term volume change of the placed dredged material is similar to the approach used to calculate the required storage volume; however, an additional parameter was added to Equation 12 to consider the placement site rest time or time between dredged seasons (Equation 17). The rest time, defined as variable RT, refers to the time between dredging episodes when the site is undisturbed by the inflow of dredged material. For the SRDWSC project the dredge season, or environmental work window (construction period), is 180 days for Reaches 1 through 3, and 120 days for Reaches 4 and 5. Reaches 1 through 3 are estimated to be dredged during the first three years of construction and Reaches 4 and 5 are estimated to be dredged during the last three years, assuming a six year construction schedule.

After the 180 day work window, it is estimated that the placement site will not be in operation, or will have a rest time, for approximately 185 calendar days between the first and second year of use. Between the first and third year of use 365 days was added to the total rest time to equal a total rest time of 550 days between the placement at the first year of use and the start of the third year of use.

After the 120 day work window it is estimated that the placement site will not be in operation, or have a rest time, for 245 days, between the first and second year of use. Between the first and third year of use 365 days was added to the total rest time to equal a total rest time to equal 610 days between the placement at the first year of use and the start of the third year of use.

For example, placement site S31 – III is anticipated to be used between construction years four and six. During the construction year four, the first year of use, approximately 800,095 cy of insitu sediment is schedule to be placed at the site. During placement the 800,095 cy of material will occupy an initial / required storage volume is 2,031,987 cy (Table 15). At the start of construction year five the initial volume was reduced to 1,260,637 cy leaving 790,363 cy available for material placement. During construction year five approximately 320,000 cy of material will be placed at the site. Initially, the 320,000 will occupy 783,198 cy. At the start of construction year six the material placed during construction year four will occupy 1,115,886 cy and the material placed during construction year five will occupy 437,854 cy, leaving 496,658 cy

available for material placement. During construction year six approximately 161,000 cy will be placed at the site and the material will occupy 493,955 cy initially. If the placement site is only anticipated to be used for two years the same approach is used; however, the above example would stop at the end of construction year five. Table 16 compares the stored volume of placed material with the available site capacity at the start of the construction year. This approach does not consider sediment desiccation between dredge seasons or accelerated consolidation due to the weight of additional layers of material; as a result the estimated storage volume is likely a conservative estimate.

Equation 15: $VOL_{LONGTERM} = (VOLF + VOLC)$

Equation 16:
$VOL_{LONGTERM} = (VOL_{BETWEEN\ 1^{ST}\ AND\ 2^{ND}\ YEAR\ OF\ USE} + VOL_{BETWEEN\ 2^{ND}\ AND\ 3^{RD}\ YEAR\ OF\ USE})$

Equation 17: $CEND_{LONGTERM} = A * (\frac{DTIME}{2} + RT)^{B}$

Equation 18: $VOLC = \frac{AVOL*CSITU*(100\%-FFRAC)}{CSAND*100\%}$

Equation 19: $VOLF = \frac{AVOL*CSITU*FFRAC}{CEND_{LONGTERM}*100\%}$

where

1. $VOL_{LONGTERM}$ = the storage volume required for the allocated volume of dredged material to be placed at the respective placement site (cy)
2. VOLF = the volume of fines at the end of placement (cy)
3. VOLC = The volume of sands at the end of placement (cy)
4. $CEND_{LONGTERM}$ = the concentration of settled fines at some time after placement (g/L)
5. AVOL = the allocated volume to be placed at the placement site (cy) (Table 2)
6. CSITU = the solids concentration of the insitu material (g/L) (Table 5)
7. FFRAC = the fine grained fraction, in percent, of the sediment sample (Table 5)
8. CSAND = the solids concentration of settled sands (1603 g/L)
9. DTIME = the placement duration (days) (Table 14)
10. A, B = the curve fitting coefficients computed from the compression settling tests of the respective composite sample (Table 6)
11. RT = the rest time between dredge seasons (days)

Table 16 – Utilized Site Volume / Available Site Volume (CY)

Site	YR 4	YR 5	YR 6
S31-I	0,000 / 1,162,000	86,935 / 1,075,065	602,176 / 559,824
S31-II		0,000 / 622,900	439,239 / 183,661
S31-III	0,000 / 2,050,400	1,259,479 / 790,921	1,551,762 / 498,638
S1		0,000 / 1,000,000	522,557 / 477,443
S4		0,000 / 2,670,000	1,312,155 / 1,357,845

5.4.3 Adequate Site Capacity for Slurry Volume

This section evaluates if there is adequate storage volume within a placement site to pond the entire slurry volume, i.e. the entire volume of the water and sediment mixture, in the event that suspended sediment concentrations are too high to decant efficiently or site decanting does not occur. It is anticipated that the placement sites Asta – McCormack Pit, Asta – Deterding Pit and Asta – St. Francis Pit will not be decanted as part of the construction activities of the SRDWSC. As a result, it was necessary to ensure that each Asta site had sufficient capacity to pond the entire slurry volume necessary to achieve the allocated annual placement volume (Table 2). Equation 20 presents the approach used to compute the total slurry volume entering the placement site. The slurry volume computed was compared to the estimated site capacity to ensure there is sufficient storage capacity for the anticipated slurry volume (Table 17). The analysis indicated that each Asta site has sufficient capacity.

Equation 20: $VOL_{SLURRY} = AVOL * \frac{CSITU}{CIN}$

where

1. VOL_{SLURRY} = the placement site volume occupied between dredge seasons required for the allocated volume to be placed at the site
2. AVOL = the allocated volume to be placed at the placement site (Table 1)
3. CSITU = the solids concentration of the insitu material (Table 5)
4. CIN = the influent solids concentration (Table 5)

Table 17 – Estimated Slurry / Available Storage Volume (cy) – Primary Plan*

Site	YR 2	YR 3	YR 4
Asta – McCormack Pit	997,536 / 1,020,000	1,012,351 / 1,020,000	1,018,554 / 1,020,000
Asta – Deterding Pit	371,188 / 428,000	350,748 / 428,000	350,748 / 428,000
Asta – St. Francis Pit	288,761 / 299,700	245,587 / 299,700	245,586 / 299,700

*the table presents the estimated slurry volume on the left of the dash and the estimated sight capacity on the right of the dash.

5.5 Estimated Decant Volume

The equation used to computation of slurry volume (Equation 20) entering each placement site was used to compute the estimated decant volume of the effluent discharge. This was computed by subtracting the slurry volume from the available site capacity (Equation 9). Table 18 presents the estimated decant volume.

Equation 21: $VOL_{DECANT} = VOL_{SLURRY} - VOL$

where:

1. VOL $_{DECANT}$ = the estimated volume to be decanted from the placement site (cy)
2. VOL $_{DECANT}$ = the estimated slurry to be placed at the placement site (cy)
3. VOL = the available site capacity at the start of the dredge season (cy)

Table 18 –Decant Volume (cy) – Primary Plan

Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	Total Site (cy)
MWRP							
S19	3,294,006	6,114,256	1,806,968				11,215,230
Asta – McCormack Pit							
Asta – Deterding Pit							
Asta – St. Francis Pit							
S31-I				-	1,385,608	632,208	2,017,816
S31-II					1,522,716	306,701	1,829,417
S31-III				3,472,718	1,321,686	697,548	5,491,952
S1					2,491,973	1,231,395	3,723,368
S4					2,587,767	7,947,887	10,535,654
Total Annual (cy)	3,294,006	6,114,256	1,806,968	3,472,718	9,309,750	10,815,739	34,813,437

6.0 PRIMARY PLAN SUMMARY

A placement site schedule is proposed that is not likely to be limited by effluent water quality, assuming placement site specific effluent water quality limits (Table 8) and that there would be adequate storage volume within the placement sites to contain the anticipated maximum volume of dredged material to be excavated as part of the SRDWSC Deepening and Widening Project, including the two feet of over depth tolerance. Site operations can be a function of multiple variables, including site dimensions, dredge equipment, environmental work windows and sediment characteristics. Each placement site was incorporated into a six-year construction scenario. Approximate site capacities, or site volume, and anticipated volumes, or approximate insitu volume, to be placed at each site are presented in Table 1.

To evaluate the placement site operations, a theoretical minimum retention time was computed based on the estimated water quality criteria established in Section 4.6 and the exponential decay factor computed from the flocculent settling laboratory analysis presented in Section 4.5.3. Computed retention times ranged between 12 and 96 hours (Table 12).

The theoretical retention time was computed and used as input to compute an effluent discharge rate and material placement duration for each placement site, presented in Section 6.0. Effluent discharge rates are presented in Table 13. The computed disposal period for each placement site

are presented in Table 14. This is acceptable as the required dredge time is less than 183 days for reaches 1 through 3 and less than 122 days for reaches 4 and 5.

To evaluate if adequate storage volume was provided for the estimated material allocation, the storage volume required was calculated using the placement duration (Table 14) and the estimated curve fitting coefficients from the compression settling laboratory analysis, presented in Section 4.5.2. The results indicate that the proposed dredge plan meets the anticipated storage volume requirements (Section 5.4) for the SRDWSC project.

Table 12, Table 23, Table 24 and Table 18 summarize the placement site computed retention time, effluent discharge rate, placement duration and estimated decant and slurry volumes.

7.0 FALL BACK PLACEMENT SITE RESULTS AND SUMMARY FOR THE 35' DEEPENING SCENARIO:

A second, six-year, alternate placement site schedule was developed anticipating that either the Montezuma and/or the Asta sites may not be available for the period when they are scheduled to receive dredged material from the SRDWSC project. At the present time, neither of these placement sites has been confirmed with agreements between all interested parties. This second schedule is designed under the assumption MWRP, Asta – McCormick Pit, Asta – Deterding Pit and Asta – St. Francis Pit would become unavailable, which would initiate the use of all of the identified "fall back" sites, i.e. S35, S20, S14 and S16. The alternate placement site schedule is referred to as the Fall Back Plan. The allocated annual volumes for the Fall Back plan are presented in Table 19.

To evaluate the placement site operations a theoretical minimum retention time was computed based on the estimate water quality criteria established in Section 4.6 and the exponential decay factor computed from the flocculent settling laboratory analysis presented in Section 4.5.3. Computed retention times are presented in Table 22.

The theoretical retention time was computed and used as input to compute an effluent discharge rate and material placement duration for each placement site, presented in Section 5.0. Effluent discharge rates are presented in Table 23. The computed disposal period for each placement site are presented in Table 24.

The required storage volume for the estimated material allocation was calculated using the placement duration (Table 19) and the estimated curve fitting coefficients from the compression settling laboratory analysis, presented in Section 4.5.2. The proposed alternate site dredge plan meets the anticipated storage volume requirements (Table 25, Table 26 and Table 27) for the SRDWSC project.

Table 30 and Table 31 summarize the placement site computed retention time, effluent discharge rate, placement duration and estimated necessary storage volume.

Table 19 – Allocated Dredged Material – Fall Back Site Plan

Table 19 – Allocated Dredged Material – Fall Back Site Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S35	112,000					
S20		83,600	78,000			
S19	1,658,134	1,682,172	1,125,061			
S14				158,000		
S16			13,840	10,400		
S31-I				95,000	440,559	143,730
S31-II					322,000	72,000
S31-III				867,104	267,900	161,900
S1					500,985	226,000
S4					596,387	634,324 / 555,000

Table 20 – Estimated Dredge Plan by River Mile – Fall Back Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S35	0.00 to 1.04					
S20		7.67 to 7.89	12.41 to 12.62			
S19	1.04 to 7.67	7.89 to 12.41	12.62 to 18.82			
S14				18.89 to 19.72		
S16			18.82 to 18.89	19.72 to 19.78		
S31-I				19.78 to 20.27	24.81 to 27.11	30.20 to 30.95
S31-II					27.11 to 28.80	30.95 to 31.33
S31-III				20.27 to 24.81	28.80 to 30.20	31.33 to 32.17
S1					38.83 to 40.96	37.86 to 38.83
S4					40.96 to 43.50	32.17 to 37.86

Table 21 – Placement Site Specific Resuspension Factor – Fall Back Site Plan	
Site	**RF**
S35	2.0
S20	2.0
S19	2.5
S14	2.0
S16	2.0

Table 21 – Placement Site Specific Resuspension Factor – Fall Back Site Plan	
Site	**RF**
S31-I	2.0
S31-II	2.0
S31-III	2.5
S1	2.0
S4	2.0

Table 22 – Mean Minimum Retention Time (hours) for the Fall Back Site Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S35	66					
S20		13**	69**			
S19	51	71	113			
S14				21		
S16			87**	87**		
S31-I				106	26	23
S31-II					19	13
S31-III				106.63	23	16
S1					24*	24*
S4					24*	24 / 24*

*O&M dredging
**The site is not intended to be decanted during the dredge season, as such retention is not reported

Table 23 – Mean Effluent Discharge Rate (cfs) for the Fall Back Site Plan						
Site	YR 1	YR 2	YR 3	YR 4**	YR 5**	YR 6**
S35	4					
S20* **		11**	3**			
S19	67	71	19			
S14				16		
S16* **			1**	1**		
S31-I				6	47	29
S31-II					32	23
S31-III				63.00	132	89
S1					41*	28*
S4					54*	25 / 36*

*O&M dredging
**An amplification factor was applied to slow outflow to reach the desired allocated insitu placement volume. This is described in Section 5.3.
***The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported

Table 24 – Total Duration of Operation (days) for the Fall Back Site Plan						
Site	YR 1	YR 2	YR 3	YR 4**	YR 5**	YR 6**
S35	61					
S20		8***	8***			
S19	77	97	153			
S14				28		
S16			1***	1***		
S31-I				43	53	15
S31-II					57	10
S31-III				44	12	6
S1					39*	58*
S4					72*	81 / 72*
C_{AMP}	1.0	1.0	1.0	1.3	1.5 / 1.0*	/ 1.5*
Total Annual Placement Period (days)	138	97	153	115	122 / 110*	112 / 110*

*O&M dredging

**An amplification factor was applied to slow outflow to reach the desired allocated insitu placement volume. This is described in Section 5.3.

***The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported

Table 25 – Estimated Required/ Available Storage Volume Needed (cy) for the Fall Back Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S35	147,525 / 181,000					
S20		127,707 / 568,000	101,267 / 476,639			
S19	2,362,556 / 2,470,000	2,391,983 / 2,470,000	1,678,883 / 2,470,000			
S14				347,569 / 355,000		
S16			27,595 / 91,000	20,866 / 69,067		
S31 -I				197,693 / 1,162,000	994,160 / 1,014,959	395,040 / 399,691
S31 -II					621,963 / 622,900	187,037 / 187,377
S31 -III				2,041,192 / 2,050,400	688,149 / 689,017	474,387 / 476,385
S1					887,309 / 1,000,000	435,781 / 443,717
S4					1,080,878 /	1,983,776 /

Table 25 – Estimated Required/ Available Storage Volume Needed (cy) for the Fall Back Plan						
					2,670,000	2,006,355

Table 26 – Utilized Site Volume / Available Site Volume (cy) for the Fall Back Plan						
Site	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
S35	0,000 / 181,000					
S20		0,000 / 568,000	91,361 / 476,639			
S19	0,000 / 2,470,000	0,000 / 2,470,000	0,000 / 2,470,000			
S14				0,000 / 355,000		
S16			0,000 / 91,000	19,698 / 69,067		
S31-I				0,000 / 1,162,000	147,041 / 1,014,959	762,309 / 399,691
S31-II						435,523 / 187,377
S31-III				0,000 / 2,050,400	1,361,383 / 689,017	1,574,015 / 476,385
S1					0,000 / 1,000,000	556,283 / 443,717
S4					0,000 / 2,670,000	663,645 / 2,006,355

Table 27 – Estimated Decant (cy) for the Primary Plan							
Site	**YR 1**	**YR 2**	**YR 3**	**YR 4**	**YR 5**	**YR 6**	**Site Total (cy)**
S35	359,392						359,392
S20							
S19	5,893,645	6,386,047	3,777,645				16,057,337
S14				639,940			639,940
S16							
S31-I				0,000	1,933,488	620,229	2,553,717
S31-II					1,502,910	347,564	1,850,474
S31-III				3,909,158	1,079,631	726,489	5,715,278
S1					2,722,183	1,235,402	3,957,585
S4					1,760,994	7,528,535	9,289,529
Total Annual (cy)	6,253,037	6,386,047	3,777,645	4,549,098	8,999,207	10,458,218	40,423,251

Table 28 – Primary Plan

	Site	MWP	S19	Asta – McCormack Pit	Asta – Deterding Pit	Asta - St. Francis Pit	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (CY)
	Area		149.5	25.1	16.8	11.2	80.9	44.0	220.0	65.7	87.2		
	Capacity		2,470,000	1,020,000	428,000	299,700	1,162,000	622,900	2,050,400	961,000	2,670,000		
	Theoretical Depth	-	12.2	27.1	17.8	18.6	10.9	10.8	7.8	11.1	21.0		
YR 1	**Estimate Volume of Sediment (CY)**	684,272	1,116,486									37	1,800,758
	River Miles to Be Dredged	0.00 to 0.00	4.75 to 7.75										
	Maximum Effluent Flow Rate (CFS)		88										
	Duration of Disposal Period (Days)		37										
	Retention Time (Hours)		51										
	Decant Volume (CY)		3,294,006										
YR 2	**Estimate Volume of Sediment (CY)**		1,630,151	190,000	70,700	55,000						109	1,945,851
	River Miles to Be Dredged		7.75 to 12.13	12.13 to 12.64	12.64 to 12.83	12.83 to 12.98							
	Maximum Effluent Flow Rate (CFS)		75	-	-	-							
	Duration of Disposal Period (Days)		86	13	6	4							
	Retention Time (Hours)		71	-	-	-							
	Decant Volume (CY)		6,114,256	PONDING ONLY	PONDING ONLY	PONDING ONLY							
YR 3	**Estimate Volume of Sediment (CY)**		790,056	160,765	55,700	39,000						120	1,045,521
	River Miles to Be Dredged		12.98 to 16.78	16.78 to 18.45	18.45 to 18.90	18.90 to 19.10							
	Maximum Effluent Flow Rate (CFS)		20	-	-	-							
	Duration of Disposal Period (Days)		97	13	6	4							
	Retention Time (Hours)		113	-	-	-							
	Decant Volume (CY)		1,806,968	PONDING ONLY	PONDING ONLY	PONDING ONLY							

Table 29 – Primary Plan (continued)

	Site	MWP	S19	Asta – McCormack Pit	Asta – Deterding Pit	Asta - St. Francis Pit	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (cy)
	Area		149.5	25.1	16.8	11.2	80.9	44.0	220.0	65.7	87.2		
	Capacity		2,470,000	1,020,000	428,000	299,700	1,162,000	622,900	2,050,400	1,000,000	2,670,000		
	Theoretical Depth		12.2	27.1	17.8	18.6	10.9	10.8	7.8	11.1	21.0		
YR 4	**Estimate Volume of Sediment (CY)**			161,750	55,700	39,000	55,022		800,058			61	1,111,530
	River Miles to Be Dredged			19.10 to 19.95	19.95 to 20.24	20.24 to 20.44	20.44 to 20.73		20.73 to 24.91				
	Maximum Effluent Flow Rate (CFS)			-	-	-	26		82				
	Duration of Disposal Period (Days)			13	6	4	9		29				
	Retention Time (Hours)			-	-	-	106		26				
	Decant Volume (CY)			PONDING ONLY	PONDING ONLY	PONDING ONLY	0,000		3,472,718				
YR 5	**Estimate Volume of Sediment (CY)**						367,604	325,000	320,000	230,000	470,727	120 / 122	1,012,604 / 700,727
	River Miles to Be Dredged						24.91 to 26.84	26.84 to 28.54	28.54 to 30.21	40.51 to 41.49	41.49 to 43.50		
	Maximum Effluent Flow Rate (CFS)						23	16	64	16	20		
	Duration of Disposal Period (Days)						46	60	14	48	74		
	Retention Time (Hours)						26	19	23	24	24		
	Decant Volume (CY)						1,385,608	1,522,716	1,321,686	708,838	3,497,374		
YR 6	**Estimate Volume of Sediment (CY)**						166,614	66,000	161,000	470,000	615,825 / 707,666	107 / 116	1,009,439 / 1,177,666
	River Miles to Be Dredged						30.21 to 31.08	31.08 to 31.43	31.43 to 32.27	38.51 to 40.51	32.27 to 38.51		
	Maximum Effluent Flow Rate (CFS)						32	24	93	28	36		
	Duration of Disposal Period (Days)						17	9	6	54	75 / 62		
	Retention Time (Hours)						23	13	16	24	24		
	Decant Volume (CY)						632,208	306,701	697,548	2,748,300	2,150,279		

Table 30 – Fall Back Site Plan

	Site	S35	S20	S19	S14	S16	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (cy)
	Area	25.6	14.2	149.5	42.0	5.4	80.9	44.0	220.0	65.7	87.2		
	Capacity	181,000	568,000	2,470,000	355,000	91,000	1,162,000	622,900	2,050,400	1,000,000	2,670,000		
	Theoretical Depth	6.4	26.8	12.2	7.2	12.4	10.9	10.8	7.8	11.1	21.0		
YR 1	**Estimate Volume of Sediment (CY)**	112,000		1,658,134								138	1,658,134
	River Miles to Be Dredged	0.00 to 1.04		1.04 to 7.67									
	Maximum Effluent Flow Rate (CFS)	4		67									
	Duration of Disposal Period (Days)	61		77									
	Retention Time (Hours)	66		51									
	Decant Volume (CY)	359,392		5,893,645									
YR 2	**Estimate Volume of Sediment (CY)**		83,600	1,682,172								105	1,765,772
	River Miles to Be Dredged		7.67 to 7.89	7.89 to 12.41									
	Maximum Effluent Flow Rate (CFS)		-	71									
	Duration of Disposal Period (Days)		8	97									
	Retention Time (Hours)		-	71									
	Decant Volume (CY)		PONDING ONLY	6,386,047									
YR 3	**Estimate Volume of Sediment (CY)**		78,000	1,125,061		13,840						162	1,216,901
	River Miles to Be Dredged		12.41 to 12.62	12.62 to 18.82		18.82 to 18.89							
	Maximum Effluent Flow Rate (CFS)		-	19		-							
	Duration of Disposal Period (Days)		8	153		1							
	Retention Time (Hours)		-	113		-							
	Decant Volume (CY)		PONDING ONLY	3,777,645		PONDING ONLY							

Table 31 – Fall Back Site Plan (continued)

	Site	S35	S20	S19	S14	S16	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (cy)
	Area	25.6	14.2	149.5	42.0	5.4	80.9	44.0	220.0	65.7	87.2		
	Capacity	181,000	568,000	2,470,000	355,000	91,000	1,162,000	622,900	2,050,400	961,000	2,670,000		
	Theoretical Depth	6.4	26.8	12.2	7.2	12.4	10.9	10.8	7.8	11.1	21.0		
YR 4	**Estimate Volume of Sediment (CY)**				158,000	10,400	95,000		867,104			116	1,130,504
	River Miles to Be Dredged				18.89 to 19.72	19.72 to 19.78	19.78 to 20.27		20.27 to 24.81				
	Maximum Effluent Flow Rate (CFS)				16	-	6		63				
	Duration of Disposal Period (Days)				28	1	43		44				
	Retention Time (Hours)				21	-	106		107				
	Decant Volume (CY)				639,940	PONDING ONLY	0,000		3,909,158				
YR 5	**Estimate Volume of Sediment (CY)**						867,104	322,000	267,900	500,985	500,985	122 / 110	1,457,004 / 1,001,970
	River Miles to Be Dredged						24.81 to 27.11	27.11 to 28.80	28.80 to 30.20	38.83 to 40.96	40.96 to 43.50		
	Maximum Effluent Flow Rate (CFS)						47	32	132	28	36		
	Duration of Disposal Period (Days)						53	57	12	58	52		
	Retention Time (Hours)						26	19	23	24	24		
	Decant Volume (CY)						1,933,488	1,502,910	1,079,631	2,722,183	147,041 / 1,014,959		
YR 6	**Estimate Volume of Sediment (CY)**						143,730	72,000	161,900	226,000	634,324 / 555,000	112 / 111	634,324 / 781,000
	River Miles to Be Dredged						30.20 to 30.95	30.95 to 31.33	31.33 to 32.17	37.86 to 38.83	32.17 to 37.86		
	Maximum Effluent Flow Rate (CFS)						29	23	89	41	54		
	Duration of Disposal Period (Days)						15	10	6	39	81 / 72		
	Retention Time (Hours)						23	13	16	24	24		
	Decant Volume (CY)						620,229	347,564	726,489	1,760,994	7,528,535		

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9.0 SUPPLEMENTAL A: 33 FOOT DEEPEING ALTERNATIVE ANALYSIS

This supplemental is intended to follow the assumptions and methodology used in the document *Placement Site Optimization Analysis for the Sacramento River Deep Water Ship Channel (SRDWSC)* (USACE, 2011) to provide analysis for the Sacramento River Deep Water Ship Channel Deepening and Widening Project for the 33-feet Mean Lower Low Water (MLLW) deepening alternative. The *Placement Site Optimization Analysis for the Sacramento River Deep Water Ship Channel (SRDWSC)* (USACE, 2011) will be referred to as the *35-Foot Scenario Summary* from this point forward in the document. Presented herein are the analysis results, as the methodology is presented in the Placement Site Optimization Analysis Summary. Similar to the 35-foot deepening design alternative, a primary and fall back placement site schedule was developed. The first schedule that was developed utilized all of the identified placement sites, i.e. S19, Asta – McCormick Pit, Asta – Deterding Pit and Asta – St. Francis Pit, S31 – I, S31 – II, S31 – III, S1 and S4. The second, alternate placement site schedule was developed anticipating that the Asta sites may not be available for the period when they are scheduled to receive dredged material from the SRDWSC project. At the present time, these placement sites have not been confirmed with agreements between all interested parties. This second alternate schedule is designed under the assumption that Asta – McCormick Pit, Asta – Deterding Pit and Asta – St. Francis Pit would become unavailable, which would initiate the use of all of the identified fall back sites, i.e. S35, S20, S14 and S16. The alternate placement site schedule is referred to as the Fall Back Plan.

Table 32 – Estimated Sediment Volume to be Placed at Each Site

	Site Designation	Volume Intended to be Placed of Insitu Material Per Site (cy*)	Site Capacity (cy*)
S19*	Primary	2,231,772	2,470,000
Asta - McCormick Pit*	Primary	230,500	1,020,000
Asta - Deterding Pit*	Primary	97,000	428,000
Asta – St. Francis Pit*	Primary	68,000	299,700
S31 – I	Primary	602,594	1,162,000
S31 – II	Primary	261,810	622,900
S31 – III	Primary	725,055	2,050,400
S1	Primary	499,828	1,000,000
S4	Primary	511,470	2,670,000
S35	Fall Back	50,000	181,000
S20	Fall Back	102,100	568,000
S14	Fall Back	124,013	355,000
S16	Fall Back	11,800	91,000
* cy represents the unit cubic yards			

9.1 Data analysis for the 33-foot deepening scenario

Similar to the 37-foot deepening scenario (35-foot deepening with 2-foot overdepth), this analysis is conducted with the anticipated dredged equipment and operations, design specifications for each placement site, and laboratory sediment testing data utilized in the 37-Foot Scenario Summary. This section describes the unique modifications made for analysis of the 35-foot design scenario.

9.1.1 Anticipated Dredge Equipment and Operations

There is no anticipated change in dredge equipment under the 35-foot scenario. The key modifications to the 35-foot scenario are:

1. the 35-foot scenario was designed in a three year construction schedule, whereas the 35 foot deepening scenario had a six year construction schedule
2. the 35-foot deepening scenario does not utilize the Montezuma Wetland Restoration Project (MWRP), whereas the 37-foot scenario allocates 684,272 cy of material to the MWRP in the first year of construction.

Table 2 and Table 34 present the allocated dredge material for the 35-foot construction scenario for both the Primary Plan and the Fall Back Plan, respectively.

Table 33 – Allocated Dredged Material in Cubic Yards for the Primary Plan

Site	YR 1	YR 2	YR 3
S19	1,631,709	596,549	
Asta – McCormick Pit	98,500	132,500	
Asta – Deterding Pit	41,500	55,500	
Asta – St. Francis Pit	29,000	39,000	
S31-I			550,516
S31-II			286,050
S31-III		755,732	205,068
S1			100,000*
S4			706,405*
*O&M Dredging			

Table 34 – Allocated Dredged Material in Cubic Yards for the Fall Back Plan

Site	YR 1	YR 2	YR 3
S35	50,000		
S20	102,100		
S19	1,700,067	500,000	
S14		124,013	
S16		11,800	

Table 34 – Allocated Dredged Material in Cubic Yards for the Fall Back Plan			
Site	YR 1	YR 2	YR 3
S31-I		150,000	445,832
S31-II			282,031
S31-III		625,029	431,242
S1			497,700*
S4			308,215*
*O&M Dredging			

9.1.2 Placement Site Design

There are no anticipated changes to the placement site design with the 35-foot deepening scenario. It is assumed that the placement sites will be built to full capacity under both the 37- and 35-foot scenarios. Under the 35-foot scenario it is assumed that if there is any remaining capacity in a placement site after the deepening material has been placed, then it will be utilized for Operation and Maintenance (O&M) dredging material in future years. Please refer to the 35 Foot Scenario Summary, Table 3, for more details on the placement site information.

9.1.3 Channel Dredged Material

In the 35-foot deepening scenario, the total volume has been reduced from 9.8 million cubic yards (mcy) in the 37-foot scenario to 5.2 mcy in the 35-foot scenario. Dredge volumes presented in Table 35 indicate the total dredged volume to deepen the channel to the depth of 33-feet MLLW with an additional two feet of over depth, i.e. to dredge the channel to 35-feet MLLW. It is assumed that the dredged volume per river reach is evenly distributed throughout. Therefore, the mean dredged volume per river mile is also reported in Table 35.

Table 35 – Dredged Volume for Each River Reach		
Reach	**Total Volume to 35 feet MLLW (cy)**	**Mean Volume Per River Mile (cy)**
Reach 1 (River Miles: 0.00 to 4.10)	68,647	16,743
Reach 2 (River Miles: 4.10 to 14.53)	2,275,054	218,126
Reach 3 (River Miles: 14.53 to 18.75)	141,198	33,459
Reach 4 (River Miles: 18.75 to 35.50)	1,936,599	115,618
Reach 5 (River Miles: 35.50 to 43.50)	806,531	100,816

9.1.4 Environmental Work Window

It is not anticipated that there will be any change to the environmental work windows. Two environmental windows will be proposed during construction. The modification in the 35-foot scenario relates to when the environmental work windows are applicable.

1. The first environmental window occurs annually between June 1 and November 30 allowing for approximately 180 days of construction. This window is available for use while construction efforts are underway between river miles 0.00 and 18.75, or Reaches 1, 2, and 3. Based on the proposed three year construction scenario, this window will be approximately applicable between construction years one and the beginning of year two.
2. The second environmental window occurs annually between August 1 and November 30, allowing for approximately 120 days of construction. This window is applicable while construction efforts are underway between river miles 18.75 and 43.50, or Reaches 4 and 5. Based on the proposed three year construction scenario, this window will be approximately applicable between end of construction year two and construction year three.

9.1.5 Sediment Characteristics

It is not anticipated that there will be any change to the sediment characteristics from the 35 foot to 33 foot scenario, including general composition or flocculent and compression settling analysis.

9.1.6 Effluent Discharge Criteria

It is not anticipated that there will be any change to the sediment effluent criteria for any of the placement sites. Effluent discharge criteria documented in the 37-Foot Scenario Summary is applied herein, and shown here in Table 34.

Table 36 – **Estimated Effluent Discharge Concentration Criterion**

Placement Site	River Miles between	Estimated Mean Ambient Condition (mg/L)	Estimated Effluent Criteria, CEFF (mg/L)
MWRP	0.0 to 0.0	-	-
S19	6.0 to 8.0	50.7	60.7
Asta – McCormack Pit	10.0 to 11.0	118.0	128.0
Asta – Deterding Pit	11.0 to 12.0	133.0	143.0
Asta – St. Francis Pit	13.0 to 14.0	849.0	859.0
S31-I	23.0 to 27.0	52.4	62.4
S31-II	26.0 to 28.0	91.0	101.0
S31-III	28.0 to 33.0	67.3	77.3
S1	42.0 to 43.5	20.0	24.0
S4	38.0 to 39.0	20.0	24.0
S20	5.0 to 6.0	46.5	55.8
S35	3.0 to 4.0	16.0	19.2
S14	14.0 to 15.0	1,560.0	1,570.0
S16	9.0 to 11.0	118.0	128.0

9.2 Results for the 33-foot deepening scenario

To evaluate the placement site operations a theoretical minimum retention time was computed based on the estimated water quality criteria and exponential decay factors established in the 35-Foot Scenario Summary. Estimated river miles to be dredged for each placement site during each construction year are presented in Table 37 and Table 38. The river miles reported in the tables are based on estimated dredged volumes presented in Table 35.

Computed retention times for the Primary Plan ranged between 12 and 101 hours (Table 39) and for the Fall Back Plan ranged between 16 and 96 hours (Table 40). It is important to note the same methodology presented in the 35 Foot Scenario Summary was utilized herein.

Table 37 – Estimated Dredge Plan by River Mile – Primary Plan

Site	YR 1	YR 2	YR 3
S19	0.00 to 11.26	12.03 to 16.12	
Asta – McCormick Pit	11.26 to 11.71	16.12 to 19.14	
Asta – Deterding Pit	11.71 to 11.90	19.14 to 19.62	
Asta – St. Francis Pit	11.90 to 12.03	19.62 to 19.95	
S31-I			26.49 to 31.24
S31-II			31.24 to 33.72
S31-III		19.95 to 26.49	33.72 to 35.50
S1			35.50 to 36.49
S4			36.49 to 43.50

Table 38 – Estimated Dredge Plan by River Mile – Fall Back Plan

Site	YR 1	YR 2	YR 3
S35	0.00 to 2.98		
S20	2.98 to 4.48		
S19	4.48 to 12.27	12.27 to 14.78	
S14		14.78 to 18.48	
S16		18.48 to 18.78	
S31-I		18.78 to 20.07	25.48 to 29.33
S31-II			29.33 to 31.77
S31-III		20.07 to 25.48	31.77 to 35.50
S1			35.50 to 40.44
S4			40.44 to 43.50

*O&M Dredging
**The site is not intended to be decanted during the dredge season, as such retention is not reported

Table 39 – Mean Theoretical Retention Times (hrs) - Primary Plan			
Site	YR 1	YR 2	YR 3
S19	71	113	
Asta – McCormick Pit**	55**	87**	
Asta – Deterding Pit**	53**	85**	
Asta – St. Francis Pit**	25**	37**	
S31-I			23
S31-II			13
S31-III		107	16
S1			24*
S4			24*
*O&M Dredging **The site is not intended to be decanted during the dredge season, as such retention time is not reported			

Table 40 – Minimum Retention Times (hrs) - Fall Back Plan			
Site	YR 1	YR 2	YR 3
S35	66		
S20**	49**		
S19	71	71	
S14		21	
S16**		87**	
S31-I		106	26
S31-II			19
S31-III		107	16
S1			24*
S4			24 / 24*
*O&M Dredging **The site is not intended to be decanted during the dredge season, as such retention is not reported			

The theoretical retention time was computed and used as input to compute an effluent discharge rate and material placement duration for each placement site. Effluent discharge rates for the Primary Plan are presented in Table 41 and for the Fall Back Plan are presented in Table 42.

Table 41 – Effluent Discharge Rates (cfs) - Primary Plan			
Site	**YR 1**	**YR 2**	**YR 3**
S19	66		
Asta – McCormick Pit**	49**		
Asta – Deterding Pit**	71	71	
Asta – St. Francis Pit**		21	
S31-I		87**	

Table 41 – Effluent Discharge Rates (cfs) - Primary Plan			
Site	**YR 1**	**YR 2**	**YR 3**
S31-II		106	26
S31-III			19
S1		107	16
S4			24*
*O&M Dredging **The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported			

Table 42 – Effluent Discharge Rates (cfs) - Fall Back Plan			
Site	**YR 1**	**YR 2**	**YR 3**
S35	3		
S20**	2**		
S19	50	21	
S14		21	
S16**		1**	
S31-I		8	23
S31-II			19
S31-III		77	84
S1			28*
S4			36*
*O&M Dredging **The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported			

The computed disposal period that was calculated for each placement site for the Primary Plan are presented in Table 43. The computed disposal period that was calculated for each placement site for the Fall Back Plan are presented in Table 44.

Table 43 – Total Duration of Operation (days) - Primary Plan			
Site	**YR 1**	**YR 2**	**YR 3**
S19	67	66	
Asta – McCormick Pit	13	13	
Asta – Deterding Pit	6	6	
Asta – St. Francis Pit	4	4	
S31-I			65
S31-II			40
S31-III		33	8
S1			12*
S4			61*

Table 43 – Total Duration of Operation (days) - Primary Plan			
Site	**YR 1**	**YR 2**	**YR 3**
C_{AMP}	1.0	1.5	1.0
Total Annual Placement Period (days)	90	122	113 / 73*
*O&M dredging of Reach 5			

Table 44 – Total Duration of Operation (days) - Fall Back Plan			
Site	**YR 1**	**YR 2**	**YR 3**
S35	42		
S20	8**		
S19	124	54	
S14		16	
S16		1**	
S31-I		54	56
S31-II			48
S31-III		27	16
S1			57*
S4			27*
C_{AMP}	1.6	1.0	1.6 / 1.0*
Total Annual Placement Period (days)	174	152	120 / 84*
*O&M Dredging **The site is not intended to be decanted during the dredge season, as such effluent discharge is not reported			

The required storage volume for the estimated material allocation was calculated using the placement duration (Table 43 and Table 44) and the estimated curve fitting coefficients from the compression settling laboratory analysis, presented in the 37-Foot Scenario Summary. The 35-foot Primary and Fall Back proposed placement site plans meet the anticipated storage volume requirements (Table 45 and Table 46) for the SRDWSC project.

Table 45 – Estimated Required / Available Storage Volume Needed (cy) - Primary Plan			
Site	YR 1	YR 2	YR 3
S19	2,417,336 / 2,470,000	829,028 / 2,470,000	
Asta – McCormick Pit	134,785 / 1,020,000	242,115 / 1,020,000	
Asta – Deterding Pit	59,684 / 428,000	107,699 / 428,000	
Asta – St. Francis Pit	45,041 / 299,700	83,172 / 299,700	
S31-I			1,130,625 / 1,162,000
S31-II			548,087 / 622,900
S31-III		2,014,005 / 2,050,400	567,711 / 837,266

Table 45 – Estimated Required / Available Storage Volume Needed (cy) - Primary Plan			
S1			251,018 / 1,000,000
S4			1,234,898 / 2,670,000

Table 46 – Estimated Required / Available Storage Volume Needed (cy) - Fall Back Plan			
Site	YR 1	YR 2	YR 3
S35	69,035 / 181,000		
S20	124,461 / 568,000		
S19	2,377,999 / 2,470,000	678,245 / 2,470,000	
S14		287,896 / 355,000	
S16		23,994 / 91,000	
S31-I		303,701 / 1,162,000	873,550 / 923,843
S31-II			620,985 / 622,900
S31-III		1,610,170 / 2,050,400	1,006,746 / 1,027,173
S1			882,727 / 1,000,000
S4			643,767 / 2,670,000

Table 47 – Utilized Site Volume / Available Site Volume (cy) - Primary Plan			
Site	YR 1	YR 2	YR 3
S19*	0,000 / 2,470,000	0,000 / 2,470,000	
Asta – McCormick Pit*	0,000 / 1,020,000	0,000 / 1,020,000	
Asta – Deterding Pit*	0,000 / 428,000	0,000 / 428,000	
Asta – St. Francis Pit*	0,000 / 299,700	0,000 / 299,700	
S31-I			0,000 / 1,162,000
S31-II			0,000 / 622,900
S31-III		0,000 / 2,050,400	1,213,134 / 837,266
S1			0,000 / 1,000,000
S4			0,000 / 2,670,000
*The placement site has been identified as a beneficial reuse site and is anticipated to be harvested annually to regain initial capacity between subsequent years of use			

Table 48 – Utilized Site Volume / Available Site Volume (cy) - Fall Back Plan			
Site	YR 1	YR 2	YR 3
S35	0,000 / 181,000		
S20	0,000 / 568,000		
S19	0,000 / 2,470,000	0,000 / 2,470,000	
S14		0,000 / 355,000	
S16		0,000 / 91,000	
S31-I		0,000 / 1,162,000	238,157 / 923,843

Table 48 – Utilized Site Volume / Available Site Volume (cy) - Fall Back Plan			
Site	YR 1	YR 2	YR 3
S31-II			0,000 / 622,900
S31-III		0,000 / 2,050,400	1,023,227 / 1,027,173
S1			0,000 / 1,000,000
S4			0,000 / 2,670,000
*The placement site has been identified as a beneficial reuse site and is anticipated to be harvested annually to regain initial capacity between subsequent years of use			

Table 49 – Slurry Volume (cy) / Available Site Storage Volume (cy) - Primary Plan and Fall Back Plan			
Site	YR 1	YR 2	YR 3
Primary Plan			
Asta – McCormick Pit	517,144 / 1,020,000	834,364 / 1,020,000	
Asta – Deterding Pit	217,883 / 428,000	349,488 / 428,000	
Asta – St. Francis Pit	152,255 / 299,700	245,586 / 299,700	
Fall Back Plan			
S20	492,625 / 568,000		
S16		74,306 / 91,000	

Table 50 – Anticipated Decant Volume (cy) - Primary Plan				
Site	**YR 1**	**YR 2**	**YR 3**	**Estimated Placement Site Decant Volume (cy)**
S19	5,964,958	683,925		6,648,884
Asta – McCormick Pit				
Asta – Deterding Pit				
Asta – St. Francis Pit				
S31-I			2,543,778	2,543,778
S31-II			1,502,374	1,502,374
S31-III		3,094,005	686,334	3,780,339
S1			0,000*	0,000*
S4			0,000*	0,000*
Estimated Annual Decant Volume (cy)	5,964,958	3,777,930	4,732,486	14,475,375
* Although the placement site has been intended for use, sufficient material has not been placed at the site to necessitate decanting.				

Table 51 – Anticipated Decant Volume (cy) - Fall Back Plan				
Site	YR 1	YR 2	YR 3	**Estimated Placement Site Decant Volume (cy)**
S35	60,246			60,246
S20				
S19	6,388,521	155,094		6,543,615
S14		400,648		400,648
S16				
S31-I		0,000*	2,020,369	2,020,369
S31-II			1,360,321	1,360,321
S31-III		2,234,431	2,176,838	4,411,269
S1			2,697,776	2,697,776
S4			0,000*	0,000*
Estimated Annual Decant Volume (cy)	6,448,768	2,790,173	10,545,259	19,784,199
* Although the placement site has been intended for use, sufficient material has not been placed at the site to necessitate decanting.				

Table 52 and Table 30 summarize the placement site computed retention time, effluent discharge rate, placement duration and estimated necessary storage volume.

Table 52 – Primary Plan

	Site	MWP	S19	McCormick	Deterding	St. Francis	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (CY)
	Area (acres)		149.5	25.1	16.8	11.2	80.9	44.0	220.0	65.7	87.2		
	Capacity (cy)		2,470,000	1,020,000	428,000	299,700	1,162,000	622,900	2,050,400	961,000	2,670,000		
	Mean Depth (ft)	-	12.2	27.1	17.8	18.6	10.9	10.8	7.8	11.1	21.0		
YR 1	**Estimate Volume of Sediment (CY)**		1,631,709	98,500	41,500	29,000						90	1,800,709
	River Miles to Be Dredged		0.00 to 11.26	11.26 to 11.71	11.71 to 11.90	11.90 to 12.03							
	Maximum Effluent Flow Rate (CFS)		81	-	-	5							
	Duration of Disposal Period (Days)		67	13	6	4							
	Retention Time (Hours)		71	-	-	25							
	Slurry Volume / Decant Volume (CY)		5,964,958	PONDING ONLY	PONDING ONLY	PONDING ONLY							
YR 2	**Estimate Volume of Sediment (CY)**		596,549	132,500	55,500	39,000			755,732			122	1,579,281
	River Miles to Be Dredged		12.03 to 16.12	16.12 to 19.14	19.14 to 19.62	19.62 to 19.95			19.95 to 26.49				
	Maximum Effluent Flow Rate (CFS)		21	-	-	3			79				
	Duration of Disposal Period (Days)		66	13	6	4			33				
	Retention Time (Hours)		113	-	-	37			107				
	Slurry Volume / Decant Volume (CY)		683,925	PONDING ONLY	PONDING ONLY	PONDING ONLY			3,094,005				
YR 3	**Estimate Volume of Sediment (CY)**						550,516	286,050	205,068	0	0,000	113 / 112	1,041,634 / 806,531
	River Miles to Be Dredged						26.49 to 31.24	31.24 to 33.72	33.72 to 35.50	35.50 to 36.49	36.49 to 43.50		
	Maximum Effluent Flow Rate (CFS)						25	23	87	28	36		
	Duration of Disposal Period (Days)						65	40	8	12	61		
	Retention Time (Hours)						23	13	16	24	24		
	Slurry Volume / Decant Volume (CY)						2,543,778	1,502,374	686,334	0,000	0		

Table 53 – Fall Back Site Plan

	Site	S35	S20	S19	S14	S16	S31-I	S31-II	S31-III	S1	S4	Number of Days Required To Dredge	Annual Volume (CY)
	Area (acres)	25.6	14.2	149.5	42.0	5.4	80.9	44.0	220.0	65.7	87.2		
	Capacity (cy)	181,000	568,000	2,470,000	355,000	91,000	1,162,000	622,900	2,050,400	961,000	2,670,000		
	Mean Depth (ft)	6.4	26.8	12.2	7.2	12.4	10.9	10.8	7.8	11.1	21.0		
YR 1	**Estimate Volume of Sediment (CY)**	50,000	102,100	1,700,067								174	1,852,167
	River Miles to Be Dredged	0.00 to 2.98	2.98 to 4.48	4.48 to 12.27									
	Maximum Effluent Flow Rate (CFS)	3	-	50									
	Duration of Disposal Period (Days)	42	8	124									
	Retention Time (Hours)	66	-	71									
	Slurry Volume / Decant Volume (CY)	241,246 / 181,000	PONDING ONLY	8,858,521 / 2,470,000									
YR 2	**Estimate Volume of Sediment (CY)**			500,000	124,013	11,800	150,000		625,029			152	1,410,842
	River Miles to Be Dredged			12.27 to 14.78	14.78 to 18.48	18.48 to 18.78	18.78 to 20.07		20.07 to 25.48				
	Maximum Effluent Flow Rate (CFS)			21	21	-	8		77				
	Duration of Disposal Period (Days)			54	16	1	54		27				
	Retention Time (Hours)			71	21	-	106		107				
	Slurry Volume / Decant Volume (CY)			2,625,094 / 2,470,000	755,648 / 355,000	PONDING ONLY	944,563 / 1,162,000		4,284,831 / 2,050,400				
YR 3	**Estimate Volume of Sediment (CY)**						445,832	282,031	431,242	497,700*	308,215*	120 / 37	1,394,392 / 806,532
	River Miles to Be Dredged						25.48 to 29.33	29.33 to 31.77	31.77 to 35.50	35.50 to 40.44	40.44 to 43.50		
	Maximum Effluent Flow Rate (CFS)						23	19	84	28	36		
	Duration of Disposal Period (Days)						56	48	16	57	27		
	Retention Time (Hours)						26	19	16	24	24		
	Slurry Volume / Decant Volume (CY)						2,944,212 / 923,843	1,983,221 / 622,900	3,204,012 / 1,027,173	3,697,776 / 1,000,000	2,289,954 / 2,670,000		