Appendix C

OU1 SWAC White Paper

OU1 SWAC Estimation
November 2007

Introduction:

Regulatory decision documents associated with the Fox River PCB Superfund Site require that the surface weighted average concentration (SWAC) of PCBs within each operable unit (OU) achieve certain targets after completion of planned remedial activities. However, without rigorous definition, SWAC calculation methods may vary and cause ambiguity in the final SWAC estimate. As a result of the Boldt Oversight Team June 20, 2007 draft memorandum "SWAC Estimation Procedure", and subsequent OU1 SWAC workgroup discussions, OU1 SWAC calculation methods have been more formally defined.

The purpose of this whitepaper is twofold. First, summarize and provide an example of computational methods which arose from the June 20, 2007 draft memorandum and OU1 SWAC work group discussions. This is referred to as the stratified procedure. Second, review methods of using the sediment bed model (GMS-SED) in calculating SWAC. This method was previously used in the November, 2006 OU1 Final Plan submittal, and is still used for isolated areas without representative sample core data.

Stratified Estimation Procedure:

The June 20, 2007 Boldt Oversight Team draft technical memo "SWAC Estimation Procedure" described a calculation methodology for producing an unbiased SWAC estimate and quantifying the associated estimate uncertainty. This formed the basis of subsequent OU1 SWAC workgroup discussions, which in large maintained the approach.

The SWAC estimation procedure utilizes stratification, where the strata are defined by OU1 remedy techniques. Each stratum is associated with an area (A_h) and an estimated surface concentration ($\bar{x}_h$). The overall OU1 SWAC based on stratified design is calculated as:

$$SWAC_{estimate} = \frac{\sum_h \left(A_h \times \bar{x}_h\right)}{\sum_h A_h}.$$

The uncertainty in the SWAC estimate is quantified by a statistical confidence interval. Because the SWAC is based on sample data, it is only an estimate of the true (population) average surface concentration. While we do not know the true concentration, we can quantitatively describe the expected error associated with the estimate.

Because of the large sample sizes associated with the SWAC estimate, the sampling variation is expected to be approximately normally distributed. A 95% confidence interval of the SWAC estimate is provided by

$$SWAC_{estimate} \pm z_{1-0.05/2} \times \sqrt{\mathrm{var}(SWAC_{estimate})}$$

where $z_{1-0.05/2}$ is the upper 97.5th percentile of the standard normal distribution and var($SWAC_{estimate}$) is the variance associated with the SWAC estimate, namely

$$\mathrm{var}(SWAC_{estimate}) = \frac{1}{A^2}\sum_h A_h^2 \times \mathrm{var}(\bar{x}_h) .$$

The target attainment goal of the OU1 SWAC estimate is 0.25 ppm. If the confidence interval described above for the SWAC estimate contains 0.25, it cannot be stated with statistical certainty that the true average surface concentration differs significantly from 0.25 ppm.

The strata for OU1 are defined as follows:

Table 1
Strata Definitions

Stratum	Name	Description	Area (Ac)
1	Engineered Cap	13-inch cap placement areas	111.9
2	Dredge Only	Areas where only dredging occurred	168.1
3	Interdeposit	Areas of less than 1 ppm in any 8-inch sample	466.6
4	Void	Sampled areas with no soft sediment recovery	225.4
5	Null	No sediment areas (unsampled)	246.8
6	3-Inch Sand Cover Only	Undredged areas with 3-inch sand placement	67.5
7	6-Inch Sand Cover Only	Undredged areas with 6-inch sand placement	46.2
8	Dredge and Sand Cover	Dredged and residual sand cover areas	30.2
9	Artifact/Shoreline	Artifact and shoreline areas modeled (GMS-SED Model) with > 1 ppm, but remedial action not possible	0.7

The boundaries for each stratum were developed in the OU1 Design Supplement utilizing the GMS-SED model and data collected through August 8, 2007. These strata are illustrated in Figure D1.

Data used to estimate the stratum surface concentration, $\bar{x}_h$, and variance, var($\bar{x}_h$), are dependent on the corresponding remedial action. Post-dredge sample core data are used for calculations in stratum 2 (dredge only), and pre-design and re-characterization sample core data are used in stratum 3 (interdeposit). Imputed values are used for stratum 1 and strata 4 through 9 as follows:

- Engineered cap areas (stratum 1) are assumed to have a surface concentration of half the current detection limit, i.e., 0.0065 ppm.

- Void areas are assumed to have a surface concentration of 0.0168 ppm. As given in the 2006 RA Summary Report (page 4-18), this value is the average PCB concentration of 12 native clay samples from different sub-areas within OU1 collected during pre-design sampling in 2003/2004.

- Null areas are assumed to have a surface concentration of 0 ppm.

- 3-Inch and 6-inch sand cover only areas and residual sand cover areas are assumed to have a surface concentration of half the current detection limit, i.e., 0.0065 ppm.

- The artifact/shoreline area differs from the other strata in that it does not have sample core data located within its boundaries, but also is not assumed to have a constant PCB surface concentration. The surface average in this case is obtained from the GMS-SED (pre-dredge) model interpolation.

When calculating $\bar{x}_h$ and var($\bar{x}_h$) from core data (strata 2 and 3), it is necessary to use a weighting scheme to prevent biased estimates of the mean and variance. Specifically, the pre-design sample data were collected at differing sample densities depending on the OU1 Subarea. To account for this, Thiessen polygon weights are used in estimating the sample mean and variance.

The Thiessen polygon weights are calculated as follows:

1) Identify sediment cores within stratum boundaries.
2) Develop a Thiessen polygon shapefile for this data subset.
3) Clip Thiessen polygon shapefile to the stratum boundaries.

An illustration of Thiessen polygon weights is given in Figure D2. The surface average for the stratum is then calculated as:

$$\bar{x}_h = \frac{\sum_i w_i x_{h,i}}{\sum_i w_i}$$

where $x_{h,i}$ are the sediment surface sample results and w_i are the associated Thiessen polygon weights.

The stratum sample variance and variance of the mean are similarly weighted using the Thiessen polygons, and calculated as:

$$s_h^2 = \frac{\sum_{i=1}^{n} w_i \left(x_{h,i} - \bar{x}_h\right)^2}{(n-1)\sum_{i=1}^{n} w_i \Big/ n} \quad ; \qquad \mathrm{var}\left(\bar{x}_h\right) = \frac{s_h^2}{n} \quad .$$

For strata in which imputed values are used for the surface average, $\bar{x}_h$, (strata 1 and 4 through 9) imputed values are also used for var($\bar{x}_h$). In these cases, since it is not possible to estimate the stratum sample standard deviation s_h directly from the data, s_h will instead be estimated by dividing the expected concentration range by six. This procedure, which among other references is given in *Guidance on Choosing a Sampling Design for Environmental Data Collection* (USEPA, 2002), utilizes the normal distribution for which six standard deviations cover 99.8% of the distribution. The expected concentration range divided by six then provides a rough estimate of the standard deviation.

The concentration range will be taken as a minimum of zero and a maximum of two times the imputed value $\bar{x}_h$. While a sample size *n* is not available, in order to obtain an estimate of var($\bar{x}_h$) we will simply take 1/10th the value of s_h^2. Hence for strata with imputed values,

$$\mathrm{var}(\bar{x}_h) = \frac{\left(\frac{2 \cdot \bar{x}_h}{6}\right)^2}{10}.$$

Note that our choice of *n* is somewhat marginal, since the imputed values for strata 1 and 4 through 8 are either zero or very small. While the imputed concentration value for strata 9 will be larger, the associated area is only 0.7 acres, resulting in very little influence in the overall variance estimate of OU1 SWAC. Hence again the choice of *n* is somewhat marginal.

Surface Sample Thickness:

The surface concentration thickness represents the biologically active layer in the sediment. As discussed in the June 20, 2007 Boldt Oversight Team memo, it is assumed that surface concentrations represent a fixed depth.

Sediment cores collected in OU1 have been sampled at varying interval lengths. Most pre-dredge and post-dredge cores were sampled at either 4-inch or 6-inch intervals. For the purpose of SWAC estimation, the surface depth will be assumed to be six inches. Surface samples collected at 4-inch interval depths will be converted by simple depth weighted averaging as follows:

1) If only a single 4-inch interval exists (total soft sediment thickness is less than six inches) the surface concentration will be the resulting 4-inch sample concentration.

2) If two 4-inch intervals exist, a depth weighted 6-inch average will be calculated as [(4 x Top Interval ppm) + (2 x Second Interval ppm)] / 6.

Stratified SWAC Example:

A summary of the SWAC estimate and 95% confidence interval based on the stratified procedure is given in Table 2. The surface average $\bar{x}_h$, the sample variance s_h^2, variance of the mean $\mathrm{var}(\bar{x}_h)$ and area A_h are given for each stratum, and the overall SWAC estimate and confidence interval are provided at the end of the table.

Both pre-dredge and post-dredge data collected through August 8, 2007 are used in calculation of the Table 2 estimates. Also, to produce example estimates for all strata, areas delineated in the OU1 Design Supplement (illustrated in Figure D1) for sand cover and engineered cap strata are included. Residual sand cover is taken to be areas over 1.7 ppm based on actual post-dredge results.

Table 2
Stratified SWAC Example

Strata	weighted $\bar{x}_h$ (ppm)	weighted s_h^2 (ppm)	$\mathrm{var}(\bar{x}_h)$ (ppm)	A_h (Ac)	Data Source
Engineered Cap	0.0065	0.000005	0.0000005	111.9	Imputed Value
Completed Dredge Areas (Excluding Residual Sand Cover and Void Areas)	0.49	0.16	0.00014	103.4	Post-Dredge Sample Cores
Remaining Dredge Areas	1.01	0.16	0.00014	64.7	Imputed Value
Interdeposit (Excluding Void Areas)	0.391	0.091	0.00028	466.6	Pre-Design Sample Cores plus 2007 Recharacterization Data
Void (Sampled Areas with No Sediment Recovery)	0.0168	0.000031	0.0000031	225.4	Imputed Value Based on 12 Native Clay Samples
Null (No Soft Sediment - Unsampled)	0	0	0	246.8	Imputed Value
3-Inch Sand Cover Only	0.0065	0.000005	0.0000005	67.5	One-Half Current Detection Limit
6-Inch Sand Cover Only	0.0065	0.000005	0.0000005	46.2	One-Half Current Detection Limit
Dredge and Sand Cover	0.0065	0.000005	0.0000005	30.2	One-Half Detection Limit
Artifact/Shoreline (No Action in Unsampled Areas)	6.15	4.20	0.42	0.7	Model Interpolated Surface Average
$\mathrm{SWAC}_{estimate}$	0.23				
$\mathrm{var}(\mathrm{SWAC}_{estimate})$	0.00003				
$\mathrm{SWAC}_{estimate}$ LCL	0.21				
$\mathrm{SWAC}_{estimate}$ UCL	0.24				

The SWAC estimate based on these data and strata delineations is 0.23 ppm with a 95% confidence interval of (0.22 ppm, 0.24 ppm). As a note, the SWAC estimate performed with this stratified procedure closely matches the model based estimates generated in the November 2006 Final Plan.

A description of the calculations of the surface average estimate $\bar{x}_h$, sample variance s_h^2, and the variance of the mean $\operatorname{var}(\bar{x}_h)$ for each of the h strata follows.

<u>1. Engineered Cap</u>

This stratum covers 112 acres proposed for capping. The surface average $\bar{x}_h$ for this stratum is assumed to be 0.0065 ppm. The stratum sample variance s_h^2 is assumed to be $\left(\frac{2 \cdot 0.0065}{6}\right)^2$ and the variance of the mean is assumed to be

$$\operatorname{var}(\bar{x}_h) = \frac{\left(\frac{2 \cdot 0.0065}{6}\right)^2}{10}.$$

<u>2. Dredge Only</u>

This stratum covers 168 acres of dredged areas, or areas proposed to be dredged. (It excludes areas designated as residual sand cover areas, and void areas of no soft sediment recovery.)

The surface average $\bar{x}_h$ for completed dredge areas is calculated from 1069 sample locations. In dredged areas, only post-dredge samples are used. Post-dredge composite sample locations are each assigned the resulting concentration of the composite.

The sample collection grids differ in density, and likewise the sample average, sample variance and variance of the mean are weighted with Thiessen polygon areas. The Thiessen polygon weights are calculated as:

1) Identify sediment cores within stratum boundaries. Only post-dredge cores are used within dredged areas.
2) Develop a Thiessen polygon shapefile for this data subset.
3) Clip Thiessen polygon shapefile to the stratum boundaries.

The surface average, sample variance and variance of the mean for this stratum are then calculated as:

$$\bar{x}_h = \frac{\sum_{i=1}^{1069} w_i x_{h,i}}{\sum_{i=1}^{1069} w_i} = 0.49\,ppm$$

and

$$s_h^2 = \frac{\sum_{i=1}^{1069} w_i \left(x_{h,i} - \bar{x}_h\right)^2}{1068 \sum_{i=1}^{1069} w_i \big/ 1069} = 0.16 \qquad \mathrm{var}\left(\bar{x}_h\right) = \frac{s_h^2}{1069} = 0.00014 .$$

For the "remaining dredge areas" calculation, s_h^2 and $\mathrm{var}\left(\bar{x}_h\right)$ are assumed to be the same as for the dredge completed areas, but including post-dredge results from areas designated as residual sand cover areas, and void areas of no soft sediment recovery . The stratum average, $\bar{x}_h$, is calculated from the dredge completed data as above, but including an additional 198 sample locations in dredged areas exceeding 1.7 ppm designated for residual sand cover, as well as 164 no soft sediment recovery locations found in the dredge completed areas.

3. Interdeposit

This stratum covers approximately 467 acres (excluding void no soft sediment recovery areas). It includes areas of undredged sampled soft sediments with eight inch concentrations less than 1 ppm. The strata boundaries are taken from pre-dredge GMS-SED model.

The surface average $\bar{x}_h$ is calculated from 331 sediment samples analyzed within the top interval of **pre-dredge** sediment cores located within the stratum boundaries. Since the sample collection grids differ in density within the varying subareas, a weighted average is calculated using Thiessen polygon areas as in stratum 2 above. Six inch surface concentrations were calculated from four inch sample intervals by depth weighting as:

6-inch ppm = [(4 x Top Interval ppm) + (2 x Second Interval ppm)] / 6.

The surface average for this stratum is then calculated as:

$$\bar{x}_h = \frac{\sum_{i=1}^{331} w_i x_{h,i}}{\sum_{i=1}^{331} w_i} = 0.391 ppm$$

where $x_{1,i}$ are the sediment surface sample results and w_i are the associated Thiessen polygon weights.

The stratum sample variance and variance of the mean are similarly weighted using the Thiessen polygons, and calculated as:

$$s_h^2 = \frac{\sum_{i=1}^{331} w_i \left(x_{h,i} - \bar{x}_h\right)^2}{330 \sum_{i=1}^{331} w_i \Big/ 331} = 0.091 \qquad \mathrm{var}\left(\bar{x}_h\right) = \frac{s_h^2}{331} = 0.00028 .$$

4. Void (sampled areas with no soft-sediment recovery)

Void areas (no soft-sediment recovery) are areas where sediment sample cores have been attempted but insufficient soft sediment was recovered to analyze. This stratum is defined in both pre-dredge and post-dredge areas, and is bounded by Thiessen polygons surrounding the no soft-sediment recovery core locations. It covers 225 acres. The stratum boundaries are developed as follows:

1) Create a combined spatial dataset of pre-dredge and post-dredge core samples. Use only post-dredge core samples in dredged areas.
2) With the combined spatial dataset, create a Thiessen polygon shapefile.
3) Clip the Thiessen polygon shapefile to OU1 boundaries.
4) Clip all sand cover, cap and null regions from the Thiessen polygon shapefile.
5) Select only Thiessen polygons from the shapefile that correspond to no recovery cores.
6) The resulting shapefile defines the stratum boundaries.

The surface average $\bar{x}_h$ for this stratum is assumed to be 0.0168 ppm. The stratum sample variance s_h^2 is assumed to be $\left(\frac{2 \cdot 0.0168}{6}\right)^2$ and the variance of the mean is assumed to be

$$\mathrm{var}(\bar{x}_h) = \frac{\left(\frac{2 \cdot 0.0168}{6}\right)^2}{10} .$$

5. Unsampled Areas Designated Null

This stratum covers 247 acres designated as null. The surface average $\bar{x}_h$ for this stratum is assumed to be 0 ppm, and the stratum sample variance s_h^2 and variance of the mean $\mathrm{var}\left(\bar{x}_h\right)$ are assumed to be 0.

6. Three Inch Sand Cover Only

Three inch sand cover only areas are undredged areas designated for sand cover. The boundaries are developed by the GMS-SED (pre-dredge) model as areas with one eight inch interval with PCB concentrations between 1 and 1.4 ppm, and all other eight inch intervals less than 1 ppm. This stratum covers 68 acres.

The surface average $\bar{x}_h$ for this stratum is assumed to be 0.0065 ppm, this is half the detection level, based on the non-detect 2007 results obtained from samples collected and analyzed from sand-covered dredged residuals and the sand-chemical isolation layer placed for the 2007 Cap Placement Test. The stratum sample variance s_h^2 is assumed to be $\left(\frac{2 \cdot 0.0065}{6}\right)^2$ and the variance of the mean is assumed to be

$$\mathrm{var}(\bar{x}_h) = \frac{\left(\frac{2 \cdot 0.0065}{6}\right)^2}{10}.$$

7. Six Inch Sand Cover Only

Six inch sand cover only areas are undredged areas designated for sand cover. The boundaries are developed by the GMS-SED (pre-dredge) model as areas with one eight inch interval with PCB concentrations between 1.4 and 2 ppm, and all other eight inch intervals less than 1 ppm. This stratum covers 46 acres. The average, $\bar{x}_h$, sample variance, s_h^2, and variance of the mean, $\mathrm{var}(\bar{x}_h)$, are calculated as in stratum 6 above.

8. Residual Sand Cover Only

This stratum covers 30 acres, which have been dredged and are candidates for sand cover. The average, $\bar{x}_h$, sample variance, s_h^2, and variance of the mean, $\mathrm{var}(\bar{x}_h)$, are calculated as in stratum 6 above.

9. Artifact/Shoreline

This stratum consists of 0.7 acres bounded by the artifact area and 2005 shoreline area which could not be dredged. This stratum differs from the others in that it does not have sample core data located within its boundaries, but also is not assumed to have a constant PCB surface concentration. The PCB surface average, stratum sample variance and variance of the mean in this case are obtained from the GMS-SED (pre-dredge) model, similarly percent solids values, if needed, would have to be obtained from the GMS-SED model.

The GMS-SED model bounded by this stratum contains 146 model nodes (horizontal), each associated with a node surface area and interpolated PCB concentration. The surface average for this stratum is calculated as from the model as:

$$\bar{x}_h = \frac{\sum_{i=1}^{146} w_i y_{h,i}}{\sum_{i=1}^{146} w_i} = 6.15\,ppm$$

where $y_{h,i}$ is the PCB concentration associated with model node i, and w_i is the associated model node surface area (Thiessen polygon area). The stratum sample variance s_h^2 is assumed to be $\left(\frac{2 \cdot 6.15}{6}\right)^2$ and the variance of the mean is assumed to be

$$\mathrm{var}(\bar{x}_h) = \frac{\left(\frac{2 \cdot 6.15}{6}\right)^2}{10}.$$

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GMS-SED Model Based SWAC:

SWAC estimates made using the GMS-SED model were presented in the November, 2006 OU1 Design Supplement. This procedure also is necessary for the artifact/shoreline stratum (stratum 9), since it does not have sample core data located within its boundaries. Although the core-based approach given above will be the preferred SWAC calculation method, the model based procedure is presented here for completeness.

To begin with, a two-dimensional "surface PCB" layout is created from the three-dimensional GMS-SED interpolation. At each two-dimensional XY location, a surface concentration which represents the top four inches is calculated as follows:

1. Determine the nodes (vertically) which represent the top four-inches of sediment. Each node corresponds to the midpoint of a horizontal layer.

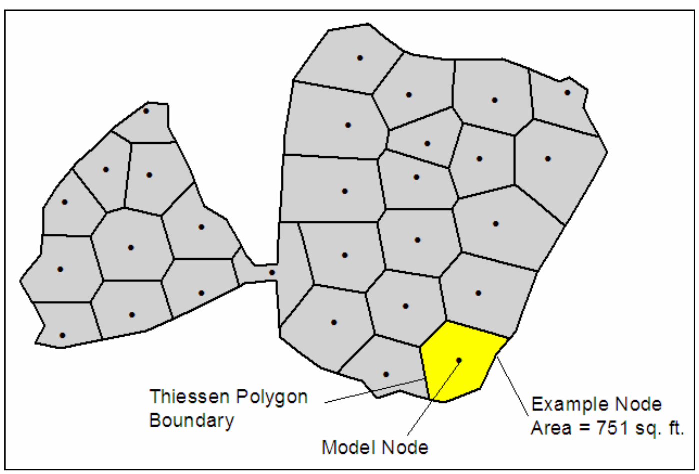
2. Find the interpolated PCB concentration and percent solids at each of these nodes.

3. Calculate the associated volume with each of these nodes (or partial volume if a layer does not end precisely at a four-inch depth).

4. Using the PCB, percent solids and volume data, calculate the PCB mass and sediment dry weight associated at each vertical node.

5. Sum the PCB mass and sediment dry weight (vertically) which represents the top four-inches. The estimated surface concentration for the XY location is the PCB mass divided by the sediment dry weight mass.

An example calculation for an XY location from Sub-area A DMU 4 is illustrated here. The XY location selected for the example is highlighted in yellow. This location has an influence area (Thiessen polygon area) of 751 sq.ft.



At this XY location, there are 19 corresponding vertical model nodes, each with an associated thickness, interpolated PCB concentration and interpolated percent solids. These results are given in Table 3 for the post-dredge model.

In Table 3 (post-dredge model following second dredge attempt in DMU 4) the total soft sediment thickness at the XY location is 2.52 inches. Therefore all vertical nodes are included in the surface concentration calculation.

The associated volume with each vertical node element is found by multiplying the horizontal influence area (Thiessen polygon area) by the layer thickness. The associated PCB mass is found by multiplying the PCB concentration with the element volume and sediment dry mass. Some of the key mathematical relationships are:

$$PCB\ Mass\,(lb.)_j = \left[PCB_j\ (ppm)\right]\left[\gamma_{d,j}\left(\tfrac{lb.}{ft.^3}\right)\right]\left[V_j\ (ft.^3)\right]\left(\frac{1x10^{-6}}{ppm}\right)$$

$$Sediment\ Dry\ Mass\,(lb.)_j = \left[\gamma_{d,j}\left(\tfrac{lb.}{ft.^3}\right)\right]\left[V_j\ (ft.^3)\right]$$

where

PCB_j is the total (interpolated) PCB concentration (ppm or mg/kg) in layer *j* at a given XY location,

$\gamma_{d,j}$ is the dry unit weight (or dry density) of the sediment in layer *j* , at the same XY location, which is estimated (for saturated conditions) from the unit weight of water (γ_w = 62.4 pcf), the percent solids concentration P_j (also interpolated to the 3D mesh) and a selected value for specific gravity of solids, *Gs*, for the sub-area :

$$\gamma_{d,j} = \frac{\gamma_w}{\dfrac{1}{G_s} + \dfrac{1}{P_j} - 1}$$

and V_j is elemental volume of the mesh profile slice j at the same XY location.

The surface average for the XY location is then the sum of the PCB mass divided by the sum of the sediment dry mass for elements which (vertically) represent the top four-inches of soft sediment, i.e.,

$$C = PCB\ Surface\ \ (ppm)\ =\ \frac{\sum_j PCB\,Mass_j}{\sum_j Sediment\ Dry\ Mass_j}\left(\frac{10^6\ ppm}{1}\right)$$

For the example XY location, the post-dredge surface concentration in Table 3 is 2.5 ppm

Table 3
Example of Vertical Model Node Data and Calculation of Top 4-Inch Average PCB Concentration
Post-Dredge Sediment Bed Model

Vertical Layer	Horizontal Footprint Area (sq. ft.)	Layer Thickness(1) (Inches)	Model Node Volume (cy)	Top of Layer Elevation (MSL)	Percent Solids	Dry Sediment Mass(2) (lbs.)	PCB (ppm)	PCB Mass (lbs.)	Total Depth to Layer Bottom (Inches)	Total Dry Sediment Mass in Top 4 Inches(3) (lbs.)	Total PCB Mass in Top 4 Inches(3) (lbs.)	Surface PCB Concentration for XY Location(4) (ppm)
1	751	0.07	0.162	732.00	51.5	203	2.6	0.00053	0.07			
2	751	0.14	0.324	731.99	51.4	406	2.6	0.00105	0.21			
3	751	0.14	0.324	731.98	51.3	405	2.6	0.00104	0.35			
4	751	0.14	0.324	731.97	51.2	404	2.6	0.00103	0.49			
5	751	0.14	0.324	731.96	51.2	403	2.5	0.00102	0.63			
6	751	0.14	0.324	731.94	51.1	402	2.5	0.00101	0.77			
7	751	0.14	0.324	731.93	51.0	401	2.5	0.00100	0.91			
8	751	0.14	0.324	731.92	51.0	401	2.5	0.00099	1.05			
9	751	0.14	0.324	731.91	50.9	400	2.5	0.00098	1.19			
10	751	0.14	0.324	731.90	50.8	399	2.4	0.00098	1.33			
11	751	0.14	0.324	731.89	50.8	399	2.4	0.00097	1.47			
12	751	0.14	0.324	731.87	50.7	398	2.4	0.00096	1.61			
13	751	0.14	0.324	731.86	50.7	398	2.4	0.00096	1.75			
14	751	0.14	0.324	731.85	50.7	398	2.4	0.00096	1.89			
15	751	0.14	0.324	731.84	50.7	398	2.4	0.00095	2.03			
16	751	0.14	0.324	731.83	50.7	398	2.4	0.00095	2.17			
17	751	0.14	0.324	731.82	50.7	398	2.4	0.00096	2.31			
18	751	0.14	0.324	731.80	50.7	398	2.4	0.00096	2.45			
19	751	0.07	0.162	731.79	50.8	199	2.4	0.00048	2.52	7207	0.0178	2.5

(1)In this example, during GMS modeling 19 node layers were created, each node representing a layer midpoint. However, since the top and bottom nodes are placed at the top and bottom of soft sediment, respectively, the representative thickness of the top and bottom nodes is one-half the thickness of the remaining layers.

(2)Sediment dry density calculated as 62.4/(1/G_s + 100/Percent Solids - 1) where G_s = 2.5.

(3)Since only 2.52 inches of soft sediment exists, the sum represents less than the top 4 inches.

(4)Calculated as PCB mass / sediment mass * 10^6. The average represents the 2.52 inches of soft sediment.

The SWAC can be calculated for any subset region of Thiessen polygons (such as the artifact/shoreline strata). The SWAC calculation is straightforward:

$$SWAC = \frac{\sum_i (C_i)(A_i)}{\sum_i (A_i)}$$

where the C_i are the surface concentrations and A_i are the Thiessen polygon areas associated with the set of i two-dimensional node (XY) locations within the horizontal footprint of interest.