

Use of site-specific data is recommended when it is available. Use of literature-based information may be deemed acceptable for variables to which the cap design is not typically sensitive (e.g., chemical diffusivity in water) and parameters that are not expected to vary substantially on a site-specific basis (e.g., hydrodynamic dispersivity). Typical industry approaches for data collection of key input parameters are described below.

A. Contaminant of Concern Sediment Concentrations

Site-specific COC concentrations are frequently measured by collecting sediment samples that are sent for chemical analysis at laboratories. Methods of core collection include vibracoring, gravity cores, and piston cores. Vibracoring is effective in both shallow and deep environments and can retrieve cores of different lengths, depending on sediment lithology. For stiff sediments where vibracore recoveries are low, sonic drilling may be required to get core samples of the required length.

Depending on the vertical depth of contamination, surface sediment sampling techniques using Ponar or grab samplers may be acceptable in some cases. Knowing the vertical distribution of contaminants is important to the long-term performance of cap. A thick layer of contamination, or a layer with more highly contaminated zones at depth, may result in sustaining or even increasing the contaminant flux through a cap over time (ITRC 2014).

It is more common to collect sediment chemistry data for site characterization purposes, but CIL models also simulate contaminant migration through a cap and sediments based on porewater concentrations. Equilibrium partitioning equations discussed in Section 5 can be used to determine porewater concentrations from sediment concentrations. Site-specific sediment and porewater concentrations are required for CIL modeling.

B. Contaminant of Concern Porewater Concentrations

CIL models (such as CapSim or RECOVERY) simulate contaminant transport in a cap or sediments based on porewater concentrations. Site-specific porewater concentrations of COCs can be obtained by centrifugation and filtration of sediment samples, direct porewater collection techniques, and porewater passive sampling. Direct porewater collection techniques include in situ porewater sampling using devices such as Trident probes and may be suitable depending on the site-specific COC type and distribution. In some cases, direct porewater measurements require relatively large volumes of porewater to meet analytical detection limits for certain COCs, which may lead to depletion of porewater that is representative of the targeted in situ sediment conditions due to surface water intrusion. Passive sampling techniques allow freely dissolved porewater concentrations to be measured at lower analytical detection limits without requiring a large volume of porewater to be collected. Passive sampling techniques can be used to determine porewater concentrations for a variety of COCs commonly present at contaminated sediment sites (Lydy et al. 2014; Mayer et al. 2014). Examples of passive samplers include solid-phase microextraction and low-density polyethylene. Passive samplers should be researched to make sure the selected sampler is appropriate for a particular site and COC. Passive sampling can be conducted in situ or ex situ.

C. Seepage Rates

Terms like seepage rates, groundwater seepage rates, and Darcy velocity refer to the same concept of water moving at a rate defined by the quantity of water that moves over a linear distance per unit time. Pore velocity, however, is the rate at which water moves through the pore spaces (which is not linear due to the tortuous path the porewater takes as it moves through a granular material). In modeling, the input is typically a Darcy velocity, and the model divides that number by the porosity to calculate the pore velocity. It is therefore important to know which term is expected in the model.

Seepage rate is a key input parameter for all CIL models and drives contaminant transport via advection. Seepage can vary over a wide range (including negative values—flow into the sediments from surface water) and is highly dependent on the hydraulic conditions at a site. Therefore, site-specific data are required for CIL design. Seepage rates can be measured directly using seepage meters, which measure the volumetric discharge over a period of time to determine seepage rates (Zamora 2008). Seepage meters are typically deployed over a period of days. Hydraulic gradient and hydraulic conductivity data may also be used to calculate seepage rates. Measuring vertical hydraulic gradients can be conducted using paired piezometers, screened at different depth intervals. Piezometers can be left in place over long periods of time, and therefore, a long-term data set of hydraulic gradients can be collected to cover diurnal and seasonal differences. Methods for measuring hydraulic conductivity include slug tests (Zamora 2008) and measurement by gravity drainage (Gefell, Larue, and Russell 2019). Data collection should target all areas of a site that are expected to have different hydraulic regimes and different types of sediment substrate.

Locations for collecting seepage rates can be determined using temperature sensing surveys or Trident probe surveys that

measure specific conductance in addition to temperature data. Seasonal variability in seepage rates is common. It is important to understand which times of year represent the highest and lowest potential seepage rates and plan data collection accordingly. A statistically robust number of seepage measurement locations should be identified that provide adequate spatial density. Professional judgment based on the heterogeneity of the site may be used.

D. Organic Carbon

TOC or fraction of organic carbon data can be obtained from organic carbon testing of sediment samples. Porewater samples collected using direct porewater collection techniques discussed above can be similarly tested for DOC concentrations. Passive sampling techniques typically do not support measurement of DOC.

For CILs modeled using linear sorption (e.g., organic carbon partition coefficient [K_{oc}] $\times$ fraction organic carbon [f_{oc}]), the fraction of organic carbon may be considered a key model input parameter. This may be the case for caps using sand or beneficially reused sediment in the CIL. Amendments such as activated carbon are often modeled using nonlinear sorption based on amendment-specific sorption parameters.

E. Sediment-Porewater Partition Coefficients

Sediment-porewater partition coefficients describe the relationship of a chemical between the sediment and porewater phases. For organic contaminants, the organic carbon partition coefficient (K_{oc}) is used, and partitioning of inorganic contaminants is described by an equilibrium partition coefficient, K_d . For both organic and inorganic contaminant partition coefficients, paired sediment and porewater data collected using the techniques described above can be used to estimate site-specific partition coefficients. Additionally, passive samplers can be used in either in situ or ex situ laboratory experiments to quantify freely dissolved porewater concentrations from sediment samples collected at a site.

To obtain a representative estimate of K_d or K_{oc} across a site that is not influenced by sample-to-sample or location-to-location variability, estimating a partition coefficient for the full data set using regression analyses is recommended. Measured sediment concentrations for each COC are plotted against measured freely dissolved porewater concentrations. If the regression is performed on a linear scale with the intercept set to zero, this provides a relationship with a slope that is equivalent to K_d or K_{oc} for inorganic and organic contaminants, respectively. Because such regressions can be strongly influenced by a limited number of high-concentration data pairs, the regression analysis can be performed on a log-transformed basis with the slope of the regression forced to one, which results in the y-axis intercept of the regression being equal to the K_d or K_{oc} for inorganic and organic contaminants, respectively.

Literature-based partition coefficients can also be used if paired sediment-porewater data are not available, especially for organic contaminants. Partition coefficients for inorganic contaminants tend to vary over a wide range and are often dependent on the sediment geochemical conditions at a site.

F. Cap Material Partition Coefficients

Treatability studies are recommended for determining cap material partition coefficients. These studies typically include laboratory isotherm experiments with synthesized or site porewater using procedures similar to those established by Gomez-Eyles and colleagues (2013). Treatability testing is performed as a means to obtain performance data on amendments with respect to the actual contaminants and conditions expected in the remedy (e.g., concentrations, seepage rates, etc.). Testing should be done using amendments from the same suppliers and in the same physical form as the amendments that will be used in the full-scale construction of the remedy. Best practices for treatability testing include the following:

- Using site porewater for isotherm experiments is recommended for carbon-based amendments, such as activated carbon, because competitive sorption due to NOM is known to reduce the sorption capacity of carbon amendments under site conditions.
- Where possible, treatability tests should use commercially available amendments that are likely to be used in full-scale application.
- If GAC is contemplated for use, it should not be pulverized for testing. If it is, or if literature values were determined with pulverized GAC, then it is important to note and account for the improvement in performance due the particle-size reduction (e.g., results should be noted as PAC and would require a kinetic factor correction when evaluating performance).

- Because sorption kinetics are important to understanding the specified amendment material performance, experiments should be conducted to understand COC adsorption at various time intervals.

Partition coefficients may be available in existing literature for commonly used amendment materials and COCs typically encountered at contaminated sediment sites. A literature survey may be performed to determine appropriate literature-based partition coefficients for cap materials. When using literature-based isotherms, it is important to ensure that the literature values are relevant to actual site conditions. Care must be taken to make sure literature-based partition coefficients are related to the actual amendment materials being included in the design and construction specifications of a CIL.

G. Bioturbation Depth and Rates

Bioturbation depths can be estimated through multiple lines of evidence. Most often, bioturbation depths and intensity are quantified through evaluation of radionuclide profiles. SPI surveys collect photographic images of the sediment bed and surficial sediments, providing another method for quantifying bioturbation depth. Such information can be used with additional lines of evidence such as biological surveys to determine the type of bioturbating organisms present at a site and their typical burrowing depths. The USEPA (2015b) recommends a typical BAZ depth of 10 to 15 cm in most estuarine and tidal freshwater environments, 15 cm in lentic environments, and from 15 to 35 cm in lotic systems depending on water depth and habitat type. Intensity of particle reworking (i.e., particle biodiffusion coefficients) ranges from 1 to 100 square cm per year (Danny Reible, Shen, and Lampert 2021).

H. Erosion

Erosion potential may be estimated using combined Sedflume measurements, flow measurements, and bathymetric and hydrodynamic evaluations. Multiple lines of evidence may be useful for developing sediment erosion-rate estimates. The evaluation of erosion potential must consider the effect of infrequent high-energy events such as floods and hurricanes as well as frequent events such as vessel wake and wave action.

I. Deposition

Sediment deposition rates may be estimated using sediment traps and geochronology cores. Multiple lines of evidence may be useful for developing quantitative estimates of sediment deposition rates, including items such as dredge records, historical bathymetry surveys, and sediment dating.