REMEDIAL DESIGN WORK PLAN
REVISION 1

REMEDIAL DESIGN SERVICES
SWAN ISLAND BASIN PROJECT AREA
CERCLA DOCKET NO. 10-2021-001

PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

Prepared for:

Swan Island Basin Remedial Design Group

Prepared by:

HGL

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Reston, Virginia 20190

With assistance from:

PACIFIC groundwater GROUP
MOTT MACDONALD
BRIDGEWATER GROUP
COAST & HARBOR ENGINEERING

February 2025

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LIST OF ACRONYMS AND ABBREVIATIONS

3-D	three dimensional
ft	foot or feet
AIDP	Archaeological Inadvertent Discovery Plan
ARAR	Applicable or Relevant and Appropriate Requirements
ASAOC	Administrative Settlement Agreement and Order on Consent
BA	Biological Assessment
BEHP	bis(2-ethylhexyl)phthalate
BMP	best management practice
BO	Biological Opinion
BODR	Basis of Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
City	City of Portland
COC	contaminant of concern
CQA/QCP	Construction Quality Assurance/Quality Control Plan
CUL	cleanup level
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDx	DDD + DDE + DDT
DRM	dredge residuals management
DSL	Department of State Lands
DTNA	Daimler Truck North America LLC
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
ER	Evaluation Report
ESA	Endangered Species Act
FCR	field change request
FEMA	Federal Emergency Management Agency
GIS	geographic information system
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HGL	HydroGeoLogic, Inc.
IC	institutional control
ICIAP	Institutional Control Implementation and Assurance Plan

MNR	monitored natural recovery
NAPL	non-aqueous phase liquid
NMFS	National Marine Fisheries Service
O&M	operation and maintenance
ORS	Oregon Revised Statutes
PAH	polycyclic aromatic hydrocarbon
PAMP	Project Area Monitoring Plan
PC	Project Coordinator
PCB	polychlorinated biphenyl
PCSWMM	Personal Computer Storm Water Management Model
PDI	Pre-Design Investigation
PHSS	Portland Harbor Superfund Site
PMP	Project Management Professional
POC	point of contact
Port	Port of Portland
PQL	practical quantitation limit
PTW	principal threat waste
QA	quality assurance
QC	quality control
RA	remedial action
RAL	remedial action level
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDGC	Remedial Design Guidelines and Considerations
RDWP	Remedial Design Work Plan
RM	river mile
ROD	Record of Decision
SAR	Sufficiency Assessment Report
SIB	Swan Island Basin
SMA	sediment management area
SOW	statement of work
TBC	To Be Considered
TODP	Transportation and Off-Site Disposal Plan
TPH-Dx	total petroleum hydrocarbons - diesel range hydrocarbons
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

USGS	U. S. Geological Survey
VE	value engineering
Vigor	Vigor Industrial LLC

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Record of Changes/Summary of Revisions

Revision No.	Revision Date	Document Name (If other than entire document, list revised sections or pages.)
1	02/06/2025	Revisions per EPA comments received 12/20/2024

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REMEDIAL DESIGN WORK PLAN
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1.0 INTRODUCTION

This Remedial Design (RD) Work Plan (RDWP) presents the approach and procedures that will be used to implement the RD activities for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. HydroGeoLogic, Inc. (HGL) prepared this RDWP on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (EPA, 2017a) and the Administrative Settlement Agreement and Order on Consent at the Swan Island Basin Project Area (ASAOC) (EPA, 2021a). This RDWP includes references to the previously published Pre-Design Investigation (PDI) Evaluation Report (ER), submitted in April 2024 (HGL, 2024a) and conditionally approved by the U.S. Environmental Protection Agency (EPA) in May 2024. References also are made to the Final Sufficiency Assessment Report (SAR) that was submitted to EPA in August 2024 (HGL, 2024b), and the Basis of Design Report (BODR) that was submitted to EPA in September 2024 (HGL, 2024c). The BODR was conditionally approved by EPA in October 2024 on the stipulation that a revised Cap Evaluation Appendix is submitted with this RDWP (See Section 4.1.1).

1.1 PURPOSE AND OBJECTIVES

The purpose of this RDWP is to define the scope and schedule of RD activities, outline key deliverables, describe the nature of the work to be performed, and identify major work tasks. These elements will guide the process and work to develop the Final 100% RD. The scope of this RDWP (as required by the ASAOC) is as follows (EPA, 2021a):

- Identify plans for implementing RD activities identified in the ASAOC statement of work (SOW); BODR (HGL, 2024c); or as required by EPA to be conducted to develop the RD for the SIB Project Area.
- Describe the overall management strategy for performing the RD, including a proposal for phasing of design and construction, if applicable.
- Describe the proposed general approach to contracting, construction, operation, maintenance, and monitoring of the Remedial Action (RA), as necessary to implement the RD work.
- Describe the responsibility and authority of the organizations and key personnel involved with development of the RD.
- Describe any areas requiring clarification and/or any anticipated problems (such as data gaps).
- Describe studies and design phases required for any on-site facility to be used to transload dredged materials from the SIB Project Area or any other area of the PHSS.

- Describe plans for the proposed porewater study.
- Describe any applicable permitting and other regulatory requirements.
- Describe plans for obtaining access in connection with the RD work, such as access agreements, property acquisition, property leases, and/or easements.

1.2 PROJECT AREA LOCATION AND DESCRIPTION

The SIB Project Area is an active cleanup site located on the northeast side of the Willamette River, spanning approximately 1.1 miles between river miles (RMs) 8.1 and 9.2 (Figure 1-1). This 117-acre area encompasses riverbanks from the top of the bank to the river. A federal navigation channel, with an authorized depth of - 45 feet (ft) Columbia River Datum, exists within the Willamette River and extends from the confluence of the Lower Willamette River with the Columbia River to RM 11.6. The U.S. Army Corps of Engineers (USACE) maintains the navigation channel, which does not extend into the SIB.

As described in Section 2 of the BODR (HGL, 2024c), the SIB Project Area is a roughly rectangular lagoon that is backwatered from the main Willamette River Channel. It is bounded by the uplands of Swan Island to the southwest and Mocks Bottom to the northeast. The entire shoreline was constructed by fill placement and other modifications that occurred over many decades. The Portland Harbor reach of the Willamette River, including the SIB Project Area, has been extensively altered since 1888 (Section 2.1.4 of the BODR; HGL, 2024c). These changes have significantly reshaped the landscape and waterways of the SIB Project Area. Currently, the SIB is an active navigable industrial waterway, and the SIB Project Area hosts light and heavy industrial activities, with limited commercial use. The shoreline supports various industrial structures and activities, reflecting its importance as a hub for industrial operations in the Portland area. This mix of industrial and limited commercial uses characterizes the current state of the SIB Project Area and its immediate surroundings.

Contaminants of concern (COCs) detected above cleanup levels (CULs), remedial action levels (RALs)/practical quantitation limits (PQLs), and/or principal threat waste (PTW) thresholds for the SIB Project Area are described in the PDI ER (HGL, 2024a) and summarized below.

- ROD COCs in sediment included various dioxins/furans, total petroleum hydrocarbons - diesel range hydrocarbons (TPH-Dx), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals, and tributyltin.
- ROD COCs in stormwater samples included PCBs, dioxins/furans, pesticides, PAHs; hexachlorobenzene, metals, and bis(2-ethylhexyl)phthalate (BEHP).
- ROD COCs in stormwater sediment included PCBs, dioxins/furans, pesticides, metals, BEHP, and DDx (DDD+DDE+DDT).
- Chemicals present in riverbank soils included PCBs, dioxins/furans, pesticides, metals, BEHP, TPH-Dx, and DDx. The extent of riverbank contamination may also present an important recontamination pathway at the SIB Project Area, as discussed in the SAR (HGL, 2024b).

1.3 PREFERRED REMEDIAL APPROACH

As discussed in the BODR (HGL, 2024c), the preferred remedial approach assigns remedial technologies by applying the PDI dataset (HGL, 2024a) to the SIB Remedial Technology Assignment Decision Tree based on ROD Figure 28 (EPA, 2017a) to all areas exceeding CULs, with subsequent refinement of the sediment management area (SMA) for areas where RALs/PQLs were exceeded vertically or horizontally. The SMA comprises 79% of the SIB Project Area, while riverbanks and other areas outside the SMA comprise 11% and 10%, respectively.

The majority of the SIB Project Area will be remediated with a combination of dredging and/or capping. The approach to determining specific areas for variations of dredging/capping will consider the depth of contamination, target maintenance dredging depths, and continuity of the finished riverbed surface to prevent the formation of anoxic zones. The areas within the SIB Project Area but outside the SMA may be treated using enhanced natural recovery (ENR), monitored natural recovery (MNR), or the same technologies in the adjacent andin-water-SMA area, including dredging and/or capping, when needed for constructability purposes. The remedial technologies for riverbanks adjacent to in-water SMA will also be remediated using dredging or excavation with or without capping, capping, ENR, MNR. Additional determinations are also made for work around structures and bank stabilization for potential erosive banks. Most areas in the SIB Project Area will be subject to institutional controls (ICs) and applicable operation and maintenance (O&M) requirements.

The preferred remedial approach identified defined zones around shoreline and overwater structures as well as steep riverbank slopes that will require special considerations. These special considerations may involve area-specific evaluation of work around structures and geotechnical considerations. These area-specific special considerations will be developed as part of the Draft 50% RD.

Remedial technology assignments for riverbanks will be developed in close coordination with the remedy for adjacent contaminated sediments. The remedial technology applied to sediments at the toe of riverbank slopes may be limited by the potential impacts of the remedy on geotechnical slope stability. Construction sequencing for remediation of riverbank soils and adjacent sediments will consider completing soil remediation before adjacent sediments to reduce the potential for recontamination of the sediments. That sequence of events would also provide an opportunity to apply slope modification and/or stabilization measures to address the risk of geotechnical slope instability.

1.4 REPORT ORGANIZATIONAL OVERVIEW

This RDWP is organized into the following sections:

- Section 1 presents an introduction, including purpose and objectives, preferred remedial approach, and report organizational overview;
- Section 2 presents the RD Management Plan, including the RD management strategy, project team organization, responsibility and authority of key personnel, and general approach to contracting the RA;

- Section 3 provides the SIB RD Project Overview, including RD activities completed to date, data collection used to inform the RD, and permitting and other regulatory requirements;
- Section 4 describes the RD Process, including engineering design analyses, area-specific technology assignment evaluation, plans for obtaining access, and construction sequencing and phasing;
- Section 5 presents the RD Deliverables and Sequencing for the Draft 50% RD, Pre-Final 90% RD, and Final 100% RD; and
- Section 6 lists the references cited in this RDWP.

2.0 REMEDIAL DESIGN MANAGEMENT PLAN

This section describes the overall RD management strategy, project team organization, responsibilities, and authority of all organizations and key personnel involved with development of the RD.

2.1 REMEDIAL DESIGN MANAGEMENT STRATEGY

Work on the RD will be completed pursuant to the ASAOC and its incorporated SOW. The RD progress schedule will be monitored and updated by the RD Consultant Team Senior Project Manager. The RD Consultant Team and Performing Parties will meet at least bi-weekly to discuss the status of the RD process and supporting documentation. Although some tasks will be conducted concurrently, some will depend on the successful completion of others. The interrelationships among tasks have been identified and are being closely monitored by the RD Consultant Team Project Manager. The Performing Parties will be notified of any proposed changes to RD tasks or activities, particularly any changes adversely impacting the duration and/or completion date of key project milestones. Coordination between the Performing Parties occurs with the EPA and the Technical Coordination Team through the submission of quarterly progress reports, periodic coordination meetings, and the submittal of design deliverables. Table 2-1 presents the RD deliverables and the preliminary schedule for completion. EPA will review and approve the design deliverables to ensure that the completed RD meets the goals and objectives described in the ROD, as per Section 2.5 of the Remedial Design/Remedial Action Handbook (EPA, 1995).

2.2 REMEDIAL DESIGN GROUP ORGANIZATION

The following are the key parties involved with the RD:

- **Regulatory Oversight.** EPA is the regulator overseeing the RD at the SIB Project Area.
- **Technical Coordinating Team (TCT).** The TCT will review and provide technical input on RD documents. The TCT comprises the following member organizations:
    - Oregon Department of Environmental Quality
    - Confederated Tribes and Bands of the Yakama Nation
    - Confederated Tribes of the Grand Ronde Community of Oregon
    - Confederated Tribes of Siletz Indians
    - Confederated Tribes of the Umatilla Indian Reservation
    - Confederated Tribes of the Warm Springs Reservation of Oregon
    - Nez Perce Tribe
    - National Oceanic and Atmospheric Administration
    - Oregon Department of Fish and Wildlife
    - U.S. Department of the Interior
- **Performing Parties.** The project proponents responsible for performing the RD are:
    - Daimler Truck North America LLC (DTNA)
    - Vigor Industrial LLC (Vigor) and its affiliates:
        - Cascade General, LLC; and
        - Shipyard Commerce Center LLC.

- **Funding Parties.** The other parties that contribute funding to accomplish the project efforts are called Funding Parties. This larger group of Funding Parties includes:
  - Settling Federal Agencies:
    - Maritime Administration, U.S. Coast Guard;
    - U.S. General Services Administration;
    - Bonneville Power Administration; and
    - U.S. Department of Defense Settling Federal Agencies.
  - Settling Public Entities:
    - State of Oregon,
    - City of Portland (City), and
    - Port of Portland (Port).
  - Other Private Entities
- **Project Coordinator.** The ASAOC requires the Performing Parties to appoint a Project Coordinator (PC) as the main interface between EPA and the Client Team. The Client Team selected Philip Spadaro of Urban Waterway Associates, LLC (formerly The Intelligence Group and Verdantas) as the PC.
- **Project Consultant.** HGL is the engineering consultant responsible for preparing the RD deliverables. The RD Consultant Team consists of HGL as the prime consultant, plus teaming partners Mott MacDonald and Pacific Groundwater Group. Additionally, key subcontractors, including Coast & Harbor Engineering and Bridgewater Group, Inc., are included as needed to support the RD development. HGL, together with its teaming partners and subcontractors, are herein referred to as the RD Consultant Team.
- **Community Involvement Coordinator.** The ASAOC requires the Performing Parties to appoint a Community Involvement Coordinator (CI Coordinator) to support community involvement activities. The Client Team appointed Barbara Smith of Harris & Smith to be the CI Coordinator.

Key points of contact (POCs) for the RD Consultant Team are listed in Table 2-2. The organizational chart on Figure 2-1 shows the project lines of communication and authority.

2.3 RESPONSIBILITY AND AUTHORITY OF KEY PERSONNEL

Key project personnel have the following roles and responsibilities:

Performing Parties. The RD is being completed by the Performing Parties. The Performing Parties include DTNA, which is represented by attorneys from Ogden Murphy Wallace, P.L.L.C, and Vigor. The Performing Parties collectively provide direction to the RD Consultant, ensure compliance with the ASAOC, and oversee the project budget, schedule, and execution.

Funding Parties. The Funding Parties review and comment on documents before regulatory submission. The PC provides the Funding Parties with a quarterly progress and financial update.

Client Team. The Client Team is comprised of representatives from each of the two Performing Parties. The role of the Client Team is to provide the RD Consultant Team with direction, complete initial reviews of documents scheduled to be delivered to the regulators, and stay apprised of the project status (including budget and schedule).

Project Coordinator. The PC is the primary POC to schedule meetings and document delivery schedules and reviews with the Performing Parties, Funding Parties, and regulators.

CI Coordinator. The CI Coordinator is responsible for providing community involvement support to EPA, including coordinating with EPA's CI Coordinator regarding responses to public inquiries about the RD work or the SIB Project Area.

Remedial Design Consultant Team. The RD Consultant Team is responsible for developing RD documents that meet the requirements of the ASAOC (EPA, 2021a) and PHSS ROD (EPA, 2017a). Team members and their responsibilities include:

- **Principal-in-Charge.** Jeff Hodge, Project Management Professional (PMP), of HGL serves as the Principal-in-Charge. Principal-in-Charge is responsible for overseeing the timely and successful completion of the work and administrative tasks needed to complete the RD.
- **Technical Director.** Shane Cherry, Licensed Geologist, of HGL serves as the Technical Director. His responsibility is to provide technical direction to the RD Consultant Team and communicate with the Client Team, PC, subcontractors, and suppliers, as necessary. Other responsibilities of the technical director include serving as the senior technical reviewer of all deliverables and directing technical efforts.
- **Project Manager.** Tana Jones, PMP, of HGL serves as the RD Consultant Team Project Manager. As the Project Manager, she acts as the direct line of communication between HGL and the Performing Parties. Ms. Jones is responsible for overseeing all aspects of the RD, including ensuring documents, procedures, and project activities meet the RD objectives; managing the schedule and budget; and providing overall programmatic guidance to support staff and subcontractors.
- **Deputy Project Manager.** Phyllis Chase, Certified Hazardous Materials Manager, of HGL serves as the Deputy Project Manager. Her responsibilities include assisting the Project Manager, tracking staff assignments and due dates, and compiling monthly progress reports and invoices.
- **Lead Engineer.** Currie Mixon, Professional Engineer, of HGL serves as the Lead Engineer for RD plans and specifications, providing senior review and consultation and resolving project concerns or conflicts related to technical matters.

2.4 GENERAL APPROACH TO THE REMEDIAL ACTION

This section discusses options for contracting and constructing the RA at the SIB, including procurement and construction. The SIB RD Group will not be responsible for contracting or constructing the RA. Contracting for the RA Contractor will be conducted by a yet-to-be-determined "RA Performing Party" that will be responsible for managing future RA implementation.

2.4.1 Procurement and Contracting

The RA Performing Party should establish the process and criteria for selecting RA Contractor selection criteria based on qualifications, experience, and cost-effectiveness. The RA Contractor should develop the preferred procurement approach. The preferred procurement approach should consider the number of contracts, breakdown of work between contracts (if multiple contracts are used), contract administration processes, and insurance and bonding requirements. Alternatives to the project delivery method including design-bid-build, design-build, and Construction Manager at Risk may be considered based on project needs and stakeholder input. Certain project elements will likely use performance specifications, allowing contractors to leverage their expertise to meet performance criteria using innovative, cost-effective solutions. Determining the contracting approach early is important as it will impact certain details of the design specifications and how the specifications and contract requirements are developed. The RA Performing Party will coordinate with EPA on any anticipated changes to the project delivery method.

2.4.2 Construction

Remedial construction in the SIB Project Area will commence after source control sufficiency determinations, adhering to allowable in-water construction windows designated for the Willamette River (summer fish window from July through October and winter fish window from December to January) to protect threatened or endangered species under the Endangered Species Act (ESA). Remedial construction in the SIB Project Area will span multiple seasons.

The RA Performing Party will provide overall quality assurance (QA) of RA construction, executing the Construction Quality Assurance/Quality Control Plan (CQA/QCP), developed during the RD (Section 5.1.7.5). The CQA/QCP will detail QA activities performed before, during, and after construction, including administration, on-site inspection, environmental monitoring, confirmatory sampling, and communication/coordination with EPA.

Elements of the CQA/QCP will be designed to work with the construction QC requirements in the specifications. The selected construction contractor will be responsible for providing QC of its work. The bid document specifications will identify pre-construction and construction submittals that must be prepared by the contractor, and contractor QC requirements during construction.

2.4.3 Monitoring, Operation, and Maintenance

Monitoring will be done in accordance with the Project Area Monitoring Plan (PAMP) which will be developed in the Draft 50% RD in accordance with ASAOC and the Draft Long-Term Monitoring Program Work Plan (EPA, 2024a). The PAMP will provide a comprehensive strategy for monitoring contamination in the SIB Project Area before, during, and after the RA and will describe the categories of long-term monitoring efforts designed to assess remedy performance and progress of the implemented remedy at the SIB Project Area.

Requirements for inspecting, operating, and maintaining the remedy will be documented in the Operation and Maintenance (O&M) Plan in Draft 50% RD. The O&M Plan will also describe required deliverables and corrective actions, and a contingency plan for handling abnormal activities (e.g., floods and earthquakes). The O&M Manual, a companion to the O&M Plan, will serve as a guide to the purpose and function of the remedy and will include system descriptions of dredging and sediment process operations, record keeping requirements, and emergency operating and response programs.

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3.0 SWAN ISLAND BASIN REMEDIAL DESIGN PROJECT OVERVIEW

This section lists RD activities completed to date, data collections that will be used to inform the RD and permitting and other regulatory requirements to design and construct the selected remedy.

3.1 REMEDIAL DESIGN ACTIVITIES COMPLETED

This section describes activities conducted and information collected to support the RD for the SIB Project Area. Additional details and results of these activities were documented in the PDI ER (HGL, 2024a), SAR (HGL, 2024b), and BODR (HGL, 2024c).

3.1.1 Pre-Design Investigation

The overarching objective of the PDI focused on compiling a body of data and analysis to inform development of the BODR, the SAR, and the RD to produce a robust, sustainable, and effective remedy for the SIB Project Area. The PDI ER (HGL, 2024a) presented PDI field activities performed to address the existing data gaps and included sediment-related field sampling, porewater upwelling assessment, stormwater and stormwater solids sampling, riverbank evaluation and riverbank soil sampling, bathymetric surveying, geotechnical investigation, structure inspections and condition assessments, utility and debris surveys, hydrodynamics and sediment dynamics surveys, habitat conditions surveys, and facility owner/operator interviews. Each element of the PDI was evaluated to determine whether (1) data gaps previously identified had been adequately addressed and (2) the sufficiency of those results for use in the BODR, SAR, and RD. The evaluation concluded that the data generated during the PDI adequately addressed data gaps and is sufficient to inform the development and evaluation of an RD for the SIB Project Area.

3.1.2 Basis of Design Report

The purpose of the BODR (HGL, 2024c) was to refine the conceptual site model, describe the preferred remedial approach, and provide technical underpinnings for the remedial design approach for the SIB Project Area. Considerations included design requirements and performance standards, remedial technology descriptions and considerations for the preferred remedial approach selection, description of the preferred remedial approach, assessment of remediation implementability, and considerations for flood impact, climate change, and habitat impacts. The BODR discussed monitoring and maintenance requirements, an approach to develop conceptual-level quantity and cost analysis, and future design studies and RD sequencing that will be further developed and conducted during the RD. The BODR also provided extensive cap and dredging evaluations that included modeling and design parameters and considerations that will be used as a basis for developing area-specific designs during the RD.

3.1.3 Sufficiency Assessment Report

The SAR (HGL, 2024b) evaluated the upland and in-water pathways to determine whether potential contaminant sources have been adequately investigated and sufficiently controlled so that the RA can proceed without concern of recontamination. The Final SAR identified the presence of a substantial risk of post-RA recontamination attributable to a combination of sources. The dominant risk of recontamination is the downriver transport of suspended and bedded sediments containing COCs into the SIB with a notable but much less significant secondary contribution from ongoing stormwater discharges to the SIB. These recontamination risks support the need for EPA and the Oregon Department of Environmental Quality to pursue characterization of uncontrolled sources associated with the identified recontamination pathways followed by implementation of additional source control measures before proceeding with the RA. EPA submitted comments on the Final SAR on November 6, 2024, expressing disagreement with the conclusion that additional source control investigation and actions are needed prior to the start of RA.

3.2 DATA COLLECTION AND ANALYSIS TO INFORM REMEDIAL DESIGN

This section summarizes the data and information that have been collected thus far, additional data that needs to be collected, and analyses performed, or to be performed, which will inform the RD. It also discusses any data insufficiencies, potential problems, and areas requiring clarification.

3.2.1 Archived Sediment Sample Analysis

As detailed in the field change request (FCR) form variance number 16, Figure 1 (HGL, 2024d), EPA requested that 29 archived core interval samples located along Mocks Bottom near the head of SIB be analyzed for PCB Aroclors and dioxin/furans. These efforts are ongoing and the potential implication of the results of this analysis may be a refinement of the horizontal and vertical extent of the SMA. Based on the current RD schedule and turnaround time for the analysis, the results and any remaining data gaps will be presented and the SMA boundary assessment will be updated in the Draft 50% RD.

3.2.2 Non-Aqueous Phase Liquid Mobility Testing

As outlined in the FCR form variance number 16, non-aqueous phase liquid (NAPL) mobility testing was performed on 17 archived core interval samples where NAPL was observed. The testing was performed to determine the presence of NAPL and, where present, categorically rank the NAPL in accordance with ASTM E3281-21 *Standard Guide for NAPL Mobility and Migration in Sediments – Screening Process to Categorize Samples for Laboratory NAPL Mobility Testing* (ASTM, 2021). Additionally, four archived core interval samples where NAPL was observed were analyzed for ROD Table 21 COCs (EPA, 2017a) to support interpretation of the NAPL testing results.

The completed NAPL centrifuge testing found the NAPL to be immobile. NAPL mobility testing will be documented in a technical memorandum in the Draft 50% RD submittal. Results of the testing will be used to inform the development of the RD in the Draft 50% RD.

3.2.3 Buried Contamination Evaluation

As indicated in the BODR, an evaluation of buried contamination will be performed based on areas inside the SMA where sediments with COC concentrations exceeding RALs or PTW thresholds are buried beneath sediments with concentrations that do not exceed RALs or PTW thresholds and an engineered cap is not designated as the remedial action. The objective will be to assess whether the remedial action objectives (ROD Section 9 [EPA, 2017a]) can be achieved in areas in the SIB where buried contamination can be left in place without an engineered cap. If needed, the chemical and physical stability of the buried contamination will be evaluated in the RD using an approach that is analogous to the conservative approach used in Cap Evaluation (using CapSIMCapSIM model) (Appendix A). If the design assigns and engineered cap for the entire SMA, a buried contamination would not be needed.

3.2.4 Treatability Study

A treatability study is intended to help design an effective engineered cap. The key challenge in the current cap design (detailed in Appendix A) involves the protectiveness of Table 17 COCs, which include metals, aldrin, BEHP, lindane, and pentachlorophenol. Due to these challenges, multiple approaches for treatability study are under consideration.

As indicated in the BODR (HGL, 2024c), one approach is to complete a porewater chemistry study in late summer/early fall of 2025 in lieu of a treatability study. This study would involve collecting porewater chemistry data using passive sampling technology. The collected data, combined with depth-specific sediment data collected during PDI efforts, could be used to obtain site-specific chemical partitioning sediment coefficients for ROD Table 17 and Table 21 (EPA, 2017a) COCs driving the cap design, as discussed in Appendix A.

If this approach is selected, the porewater chemistry study plan would be submitted in April 2025. The porewater chemistry study would need to be completed in late summer/early fall to obtain porewater chemistry data associated with the timing of maximum porewater migration. As such, the timing of this study would result in data not being available for incorporation into the RD until the Final 100% RD stage. In addition, the collected data might not be useful in resolving the protectiveness challenges indicated above that are being evaluated for an effective cap design. Alternatively, where data from completed porewater chemistry studies in other PHSS Project Areas are available, these could help verify the reasonableness of selected literature values for SIB Project Area-specific parameters.

An alternative approach may be selected to obtain information about uncertain or overly conservative estimates in the current cap design (e.g., alternative amendments, cap composition(s), and their performance). The RD team is currently evaluating the sensitivity of parameters that may be the most pertinent to designing a cap that is protective of all Table 17 COCs, if feasible and constructible (as currently designed, the cap is protective of all Table 21 COCs). Based on this evaluation, a treatability study may be recommended to address key uncertainties. The findings of this evaluation will be reported in the technical memorandum and/or as an appendix to Pre-Final 90% RD.

3.2.5 Existing Utilities

Utilities identified in the SIB Project Area are described in the PDI ER (HGL, 2024a). Known utilities include numerous upland utilities, outfalls located in water and on riverbanks, and a potential cable crossing. As outlined in the BODR, requests will be sent to utility owners to inquire about information on existing utilities on their properties. The information will be combined with known utilities information to assemble a preliminary, unified map. This unified map prepared from utility owners' feedback, existing surveys, GIS, and as-built information will then be shared with the Port, City, and utility providers for comment and corrections to maximize vertical and horizontal accuracy of utilities that could be impacted during the RA. The final Utility Map is targeted for completion before the submittal of the Draft 50% RD, assuming the willingness of all parties to expeditiously participate in this process. While uncertainties in location of buried utilities within the SIB Project Area will remain during RD, the RA Performing Party will be responsible for confirming the locations of all utilities prior to conducting the RA.

3.2.6 Community Impact Mitigation

The BODR (HGL, 2024c) outlines potential community impacts for the SIB Project Area, including interruptions in public access for boat launches, beaches, and parking lots, as well as effects on waterfront businesses and increased traffic due to RA construction. Additional concerns include possible noise, light, odor, and air quality impacts during the RA. To address these issues and in accordance with PHSS Community Impact Mitigation Plan (EPA, 2024b), the RD will develop a monitoring plan and best management practices (BMPs) and mitigation measures to minimize construction impacts on the community. Formal community engagement began with the Portland Harbor Community Information Session on September 11, 2024, following the BODR submission. This session sought feedback to incorporate in the RD. It is a goal of the RD performing parties to keep owners, operators, and stakeholders informed and engaged during the RD process.

3.2.7 Habitat Impact Evaluation

Implementation of the remedy will involve in-water and nearshore work that will substantially modify the existing riverbanks and riverbed within the SIB Project Area, all of which are considerably degraded from natural conditions due to the extent of development and industrial/commercial activity. The habitat impacts discussion included in the BODR (HGL, 2024c) refers to the baseline habitat survey results published in the PDI ER (HGL, 2024a) and presents a qualitative discussion of the types of habitat impacts that would occur as a result of remedy implementation based on the preferred remedial approach.

The impacts described in the BODR will be further refined and evaluated concurrently with refinements to the RD for the SIB Project Area. The habitat impact evaluation will be conducted in accordance with the Remedial Design Guidelines and Considerations (RDGC) (EPA, 2021b) to demonstrate compliance of the RA approach with action-specific or location-specific Applicable or Relevant and Appropriate Requirements (ARARs) (see Section 3.3) and will emphasize habitat avoidance and minimization measures outlined in the 2021 Programmatic Biological Assessment (BA) (EPA, 2021c). Where avoidance measures are not viable, the evaluation will identify BMPs to minimize habitat impacts during and after construction of the remedy.

The discussion of potential RA impacts to existing habitat will be included in the Habitat Impact Evaluation Report that will be presented in the Draft 50% RD and updated as design elements are further refined in the Pre-Final 90% RD and Final 100% RD. Updates during the Pre-Final 90% RD will include identification of potential habitat enhancement opportunities within the SIB Project Area (including a figure depicting distribution of edge habitat and photographic images of the locations for enhancement).

3.2.8 Flood Impact Evaluation

A flood rise evaluation will be performed after the Draft 50% RD and presented in the Pre-Final 90% RD to ensure compliance with state regulatory requirements for flood rise management and to be consistent with the Executive Orders for Floodplain Management (Executive Orders 11988 and 13690) and Federal Emergency Management Agency (FEMA) regulations in 44 Code of Federal Regulations (CFR) Part 9 and 44 CFR 60.3(d)(2) and (3). The objective of this evaluation is to ensure the selected remedy does not result in unacceptable flood rise.

Flood impact modeling will be conducted using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) and the EPA-approved Corrected Effective Model to evaluate potential flood impact and to demonstrate that the RA in the SIB Project Area does not result in flood rise. Recent changes made to the PHSS HEC-RAS model (CDM Smith, 2024) include:

- Addition of elevation transects to the Existing Conditions Model to capture proposed changes to channel bathymetry as a result of fill in the PHSS remedial areas;
- Calibration of the updated Existing Conditions Model, including assignment of Manning's roughness coefficients and assignment of ineffective flow areas (including SIB); and
- Development of an initial Conservative Future Conditions Model to evaluate potential flood impacts resulting from the combination of all PHSS RAs.

The initial Conservative Future Conditions Model assumed that 3 ft of fill would be applied on current grade to all nearshore SMAs as shown in the ROD, to represent a potential worst-case scenario. From the results of the initial conservative future condition simulations, the updated PHSS Existing and Conservative Future Conditions Model (CDM Smith, 2024) concludes, "*The water surface elevations predicted from this model have a maximum rise of 0.017-feet which is not a cause for concern based on the assumptions included in the simplified conservative future conditions case model*."

The updated Portland Harbor Existing Conditions Model will be used to demonstrate that the proposed RA in SIB is not likely to cause unacceptable flood rise based on the anticipated SIB post-construction elevations.

3.2.9 Climate Change Impact Assessment

Climate change analysis will be performed to confirm resiliency of the cap erosion protection layer to future conditions. The climate change analysis will include river conditions and outfall flows. Climate change scenarios for other processes such as winds/wind-waves have not been developed in the industry. Therefore, resiliency of riverbank protection or other cap areas where these processes govern design will be ensured through conservatism in the RD. Wind-waves will be evaluated at a range of river stages developed in the climate change analysis.

Analysis of future river conditions will be performed using the U.S. Geological Survey (USGS) Climate Change Model. The USGS model (Delft3D) spans the Pacific Ocean to Oregon City on the Willamette River, and Bonneville Dam on the Columbia River. This model will be used to develop boundary conditions for the SIB-nested Delft3D 4 structured hydrodynamic model used during the cap evaluation (Appendix A of BODR; HGL, 2024c), which provides high resolution hydrodynamics at the SIB. The river discharge inputs from the USGS model will be extracted and applied to the SIB-nested Delft3D 4 structured hydrodynamic model. The water levels at the downstream boundary of the nested Delft3D 4 structured hydrodynamic model will be taken from the water levels in the USGS model, which will predict how sea level rise affects the Willamette River, both excluding and including higher future river discharges. Modeling will include a complete range of scenarios, in terms of higher and lower water levels, as well as current velocities. The list of scenarios is anticipated to include variants of the following input conditions:

- Pacific Ocean water levels: Typical present-day Pacific Ocean tidal conditions (zero sea level rise), as well as sea level rise of 0.25 meter and 1.0 meter (USACE scenarios included in the USGS model approved by EPA); and
- River discharges: Discharges ranging from zero (pure tidal conditions) to 100-year discharges, for both present-day conditions and future conditions.

The analysis is intended to capture the complete range of bed shear stresses resulting from river conditions to ensure that maximum bed shear stresses over cap areas are included in the Draft 50% RD. From each simulation, a maximum bed shear stress map will be computed for SIB. The maximum bed shear stress maps will be combined to create a map of maximum bed shear stresses from any simulation, which can be used to ensure that the erosion protection layer design for caps will be resilient to climate change.

Analysis of future City outfall discharge conditions will be performed using the Personal Computer Storm Water Management Model (PCSWMM) and Computational Fluid Dynamics (CFD) model (FLOW3D) used in the preliminary cap stability analysis as part of the cap evaluation. The analysis will include refinement of the rainfall inputs to the PCSWMM model and use of higher flows to account for future increase in rainfall intensity as input to the CFD model. Conservative water level conditions will be used in the outfall CFD modeling (e.g., extreme low water) to ensure cap resiliency under a full range of reasonably anticipated future conditions. Results of the modeling will consist of maximum bed shear stress and velocity maps that can be used to design scour protection around the City outfalls.

Following analysis of all maximum velocity/bed shear stress calculations for each physical process, the maximum velocity/bed shear stress map computed during the cap evaluation will be updated, resulting in a climate-resilient and complete erosion protection design criteria map to be used during the Draft 50% RD. The climate change assessment and associated analysis and modeling will be documented in the Design Criteria Report.

3.2.10 Facility Considerations

Existing facilities located within the SIB were described in the BODR (HGL, 2024c), and additional information on in-water structures has been summarized in the PDI ER (HGL, 2024a). Facilities include waterfront facility berthing, overwater structures (e.g., piers, docks, floats, wharves), piling (e.g., remnant piles, fendering, mooring piles), and utilities (e.g., outfalls). In addition, bank infrastructure includes armored banks and bulkheads. The RD will consider, and will not preclude, reasonably anticipated future land uses.

Potential conflicts between marine traffic in SIB and RA construction equipment and the full range of potential locations where construction equipment may be located during the RA is compiled in the BODR (HGL, 2024c). Possible mitigation measures to minimize RA impacts on vessel traffic and facility operations identified in the BODR will be considered in the RD. Along with this, outreach to upland property and business owners will be conducted during the Draft 50% RD to confirm information and seek feedback on the preliminary design.

3.2.11 Existing Structures Analyses

The primary load carrying members of existing in-water structures are assumed to remain intact during the RA unless changes are determined necessary during the RD. The RD will consider the location, condition, and type of existing structures as presented in the Structure Condition Assessment Report (PDI ER, Appendix G) by analyzing RA methods (such as dredging and capping) assigned during the Draft 50% RD and how these methods impact existing structures. Building on the structural analysis completed in advance of the BODR, analysis will be performed to assess the impact of the area-specific technology assigned and determine if additional structures or modifications to existing structures are needed. The following may be evaluated:

- Potential impacts to existing infrastructure from the RA will be evaluated (e.g., considering stability of structures and banks adjacent to dredging or capping areas).
- Protective setback distances from existing structures and other protective measures will be determined to prevent adverse impacts.
- Remedial technologies that can be effectively used adjacent to existing infrastructure will be determined through assessing constructability (e.g., considering equipment access constraints) and equipment capabilities during the RD.
- Protective measures versus demolition and replacing in-kind will be evaluated. This is a standard practice of design and is an iterative design process.
- Potential impacts of the RA on maintenance, repair, or replacement of existing infrastructure will be evaluated.

3.2.12 Operational Water Depth Requirements

Operational water depths (navigation depths) to be incorporated into the Draft 50% RD will be based on multiple factors. Between August 2022 and February 2023, interviews were conducted with owners/operators in the SIB Project Area. The owner/operator interviews resulted in requests for specific navigation depths adjacent to existing facilities. In most instances, the requested navigation depths were similar to historically maintained depths in SIB at those facilities. At those facilities, it is anticipated that the requested navigation depths will be incorporated into the Draft 50% RD. However, in instances where the depths requested are not similar to historically maintained depths, or where mobility of capping materials can be mitigated during design (e.g., in front of the Wind Tunnel), those operational/navigation depths may not be incorporated into the Draft 50% RD, in particular if they create isolated deep areas in the SIB. The navigation depth requested at Berth 311 is similar to the originally constructed depth, but deeper than the historically maintained depth. The design will generally incorporate historically maintained depths, subject to review for impacts to structures and other factors. No navigation depths are proposed in SIB that create isolated pockets of water, since continuous depth is required for arrival and departure into SIB (to each berth) from the main river.

The spatial extents of operational/navigable depth areas were developed for the BODR (HGL, 2024c). The spatial extents generally consist of a width off-the-dock and a length along the dock. The conceptual extents in the BODR were developed based on maneuvering areas indicated to be sufficient by owners/operators, as well as reasonable extents based on observed mooring locations in aerial photos from 2001 to 2023 and engineering judgement. For the Draft 50% RD, these navigable depth polygons will be reviewed and further refined, if necessary, based on coordination with owners/operators. In addition, a 50-ft lateral buffer from the federal navigation channel boundary and the depth noted in Section 1.2 (-45 ft Columbia River Datum) will be incorporated into the RD where the SIB Project Area abuts the federal navigation channel.

3.2.13 Lease Requirements

There are 23 shoreline and overwater structures (21 actively in use) and 10 property owners/operators in the footprint where some RA activity will occur. Additional constraints to be considered include in-water uses in areas where current owners/operators hold an Oregon Department of State Lands (DSL) authorization to use state owned submerged or submersible land, in-water uses on state-owned submerged or submersible land where the current owners/operators do not hold a DSL authorization, and uses of submerged or submersible land not owned by the State that do not require DSL authorization, each of which will require additional coordination.

Owners/operators may have leases or licenses with Oregon DSL with requirements related to structure repair/removal upon lease renewal or termination. These leases and licenses, and other uses that do not require a lease or license, need to be understood during RD, especially for RA work around structure areas. Best efforts will be made during the RD to inquire and understand the lease, license, and other requirements as they pertain to structures and the RD, including conferring with Oregon DSL, lessees, and other users. The RA Performing Party ultimately will be responsible for obtaining any leases or access agreements to perform the RA.

3.2.14 Business Operation Interruptions

Several active businesses operate in the waterfront area of SIB. The RD will consider minimizing the impact from the RA on these businesses. The impact on waterfront business continuity will be considered when assessing the constructability of the RA. The BODR (HGL, 2024c) provides an assessment of the potential impacts of RA activities on the operations of existing facilities within SIB and potential mitigation measures for those impacts. BODR Figure 6-29 (HGL, 2024c) shows existing facilities with marine operations that could be impacted by RA activities. Engagement and coordination efforts with the waterfront business community will occur during the RD prior to the Draft 50% RD. The Final 100% RD will include a plan for establishing communication channels before the RA begins.

3.3 PERMITTING AND OTHER REGULATORY REQUIREMENTS

3.3.1 Substantive Compliance with Applicable or Relevant and Appropriate Requirements and To Be Considered Items

The ROD (EPA, 2017a) identifies ARARs and To Be Considered (TBC) items for the PHSS. ROD Table 3-1 summaries ARARs and TBCs that pertain to the SIB Project Area and describes the RD documents and design elements where the substantive requirements and considerations will be applied. This initial analysis of ARARs and TBCs informs the Draft 50% RD design development process by identifying specific design requirements (e.g., BMPs, timing of construction, monitoring requirements, etc.). Technical review of the Draft 50%, Pre-Final 90%, and Final 100% design submittals will include a compliance check and documentation of how ARARs and TBCs are addressed in each of those design packages.

3.3.2 Water Quality and Waterway Protection

The water quality standards listed in Table 3-1 will be evaluated in the Clean Water Act (CWA) analysis (Section 3.3.2.1), and the results of the CWA analysis will be used to inform the CQA/QCP (Section 5.1.7.6). The CQA/QCP will include a table of applicable water quality standards confirmed by the CWA analysis along with the construction activities subject to those standards. Preliminary volume estimates of water generated during dredging, in barges, and at stockpile areas, along with recommendations for water treatment and/or disposal, will be presented in the Draft 50% RD. Water quality monitoring requirements during the RA will be documented in the CQA/QCP included in the Draft 50% RD and updated with the subsequent design submittals.

3.3.2.1 Clean Water Act Analysis

A CWA Analysis is required for the RD to demonstrate compliance of the proposed RA with the substantive requirements of Section 404(b)(1) and other applicable sections of the CWA and water quality standards established by the State of Oregon. The CWA Analysis will be documented in a technical memorandum that includes the following elements:

- Tabulated summary of the substantive requirements of the CWA pertaining to the proposed RA for the SIB Project Area and identification of the components of the RA that will be designed to address and satisfy each requirement.
- Tabulated summary of water quality standards established by CWA and by the State of Oregon that will apply during RA implementation. The table will be accompanied by a narrative that provides reasonable assurance of compliance with those water quality standards.
- Characterization of long-term and short-term impacts the RA would have on Waters of the United States. The habitat impact evaluation (see also Section 3.2.7) will be based on the baseline habitat conditions documented as part of the PDI ER (HGL, 2024a) and an evaluation of RD elements that will affect those habitats within the SIB Project Area.
- Determination of mitigation requirements. Conventional mitigation sequencing is required to satisfy the substantive requirements of the CWA. Mitigation sequencing prioritizes avoidance of impacts where feasible. Any unavoidable impacts must then be minimized as part of design development. Unavoidable impacts that have been minimized would require compensatory mitigation that replaces the ecological functions of the impacted habitat. The

determination of mitigation requirements will rely on and incorporate the habitat impact evaluation described in Section 3.2.7.

The Draft 50% RD will include a draft CWA Analysis Technical Memorandum with a preliminary determination of whether compensatory mitigation is required and identification and description of potential mitigation opportunities within the SIB Project Area. Between the Draft 50% RD and the Pre-Final 90% RD, the design team will continue to identify, evaluate, and incorporate opportunities for impact avoidance and minimization as part of design development. The draft CWA Analysis Technical Memorandum will be updated for the Pre-Final 90% RD. If the CWA Analysis determines that compensatory mitigation is required to address unavoidable impacts of the RA, the Pre-Final 90% RD will include proposed mitigation.

3.3.3 Cleanup Standards

Cleanup standards were developed by EPA using multiple approaches including human health risk, ecological risk, ARARs, and site-specific background concentrations. Table 3-1 summarizes the analysis of ARARs and TBCs including ARARs that informed the development of CULs for surface water, groundwater, riverbank soil, sediment, and tissue.

Cleanup standards are applied throughout the RD to inform key design decisions. The 3-D extent of COCs in sediments and riverbank soils determines the fundamental focus of the RD. Cleanup standards will be applied within these RD elements.

- **Dredging and Capping** – The vertical and horizontal extent of RAL exceedances will be used to determine the locations, dredge depths, and finished riverbed elevations for dredging and capping. Cap performance evaluation relies on cleanup standards to inform breakthrough analysis.
- **Riverbank Designs** – RALs and CULs will be applied per the RDGC (EPA, 2021b) to determine which riverbanks require remediation (riverbank soils above RALs) and which riverbanks require stabilization to prevent post-RA recontamination (riverbank soils above CULs and below RALs/PQLs). The design of riverbanks that include a soil cover will rely on CULs to evaluate the effectiveness of the soil cover as a chemical isolation layer.
- **Enhanced Natural Recovery** – Cleanup standards will be used to determine the locations where ENR is an appropriate and effective remedial technology.
- **Confirmation Sampling** – Confirmation sampling will be conducted at the end of RA construction to confirm that the RA has achieved cleanup standards at the finished riverbed surface.

3.3.4 Waste Management

The Draft 50% RD Report will include a Waste Designation Memorandum (Section 5.1.9.2) that identifies waste material intended for off-site disposal derived from RD dredging and excavation activities. The Waste Designation Memo will describe the characterization of the waste material with respect to Resource Conservation and Recovery Act (RCRA) landfill disposal requirements. Dredged sediment and soil requirements for characterizing, treating, handling, and off-site disposal are listed in applicable solid and hazardous waste regulations. These regulations will be used to characterize waste before disposal and determine appropriate landfill disposal. Regulations pertaining to waste management include RCRA, Land Disposal Restrictions, Toxic Substances Control Act, and Occupational Safety and Health Act. These regulations are action-specific, as listed in Table 3-1, and are further discussed in ROD Section 15.2.3 (EPA, 2017a).

3.3.5 Cultural Resources

Prior to initiating PDI activities in the SIB Project Area, an Archaeological Inadvertent Discovery Plan (AIDP) was prepared that applied to the PDI field data collection (HGL, 2022). That plan will be adapted for inclusion in the Draft 50% RD as an example plan to guide the RA contractor in developing a site-specific AIDP for the RA to ensure compliance with the National Historic Preservation Act (16 United States Code [U.S.C.] 470 et seq., 36 CFR 800, 16 U.S.C. 469a-1) and State of Oregon regulations (Oregon Revised Statutes [ORS] 97.740-760, ORS 358.905, and ORS 390.235).

The AIDP provided procedures in the event that archaeological sites, objects, or human remains are found during PDI activities within the SIB Project Area. As stated in the AIDP, "*The majority of the Swan Island Basin shoreline is indicated as having archeological probability areas of "moderate probability", with the northern portion of Swan Island rated as "low probability" and one <1 mi [mile] portion of the Mocks Bottom shoreline, northern end, rated as "high probability"* (HGL, 2022). In addition, a professional archaeology firm, Archaeological Investigations Northwest, Inc., retained by the SIB RD Group, reviewed the Oregon State Historic Preservation Office's database and found no listed findings for the SIB Project Area (HGL, 2022). Moreover, the SIB Project Area site history included extensive landscape modification through fill placement, dredging, and shaping of Swan Island and the shoreline of the river channel. Those past activities have a profound effect on reducing the possibility of finding cultural or archeological resources within the soils and sediments that will be disturbed during the RA. Lastly, since EPA intends to use the Draft 50% RD as a check in with the tribal archaeological experts and the State Historic Preservation Officer, input from these experts will be incorporated in the Pre-Final 90% RD.

3.3.6 Endangered Species Act

EPA prepared a Programmatic BA as part of its ESA Section 7 consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) (EPA, 2021c). That consultation will produce a Programmatic Biological Opinion (BO) prepared by NMFS and USFWS. The Programmatic BO will identify BMPs and limitations on RA activities to be incorporated into the RD to conserve and protect endangered and threatened species and their habitats. The Programmatic BO has not yet been published as of the time of this RDWP.

RD parties have the option to rely on the Programmatic BO to satisfy the substantive requirements of the ESA within the RD and RA. Alternatively, RD parties may elect to prepare a project-area-specific BA and conduct a project-area-specific ESA Section 7 consultation with NMFS and USFWS. The SIB RD parties have determined that the RD for the SIB Project Area will rely on the Programmatic BO and that there are not sufficient project-area-specific considerations to warrant a separate consultation.

When the Programmatic BO is published and available, the substantive requirements of the BO as they pertain to the RD will be organized in a tabulated summary and cross referenced to the design elements to which they apply. The Pre-Final 90% RD will include the tabulated summary along with tabular documentation of how specific design elements apply and satisfy the requirements of the Programmatic BO.

3.3.7 Floodplains

Section 3.2.8 of this RDWP describes the flood impact evaluation that will be performed during the Pre-Final 90% RD to ensure compliance with the ARARs and TBCs in Table 3-1 pertaining to state and federal regulatory requirements for flood rise management. The objective of the flood impact evaluation is to ensure the selected remedy does not result in unacceptable flood rise.

3.3.8 Anticipated Access Agreements and Permits Required for Remedial Action

The Draft 50% RD will include an evaluation of permits and access agreements needed to implement the RA. The evaluation will include identifying the required off-site disposal and discharge permits, the time required to process the permit applications, and a schedule for submitting permit applications. Many permits are not required for on-site activities due to federal exemptions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); however, the substantive requirements of any permits that would otherwise be required must be described and met in coordination with the applicable regulatory agencies.

Table 3-1 identifies ARARs and TBCs, their substantive requirements, and the applicability of those requirements to specific design elements. Other requirements may include, but are not limited to, authorizations from Oregon DSL to conduct RA work on state lands, City permits for work on City outfalls, and access agreements to conduct RA work on riverbanks and shoreline structures on public and private properties.

The Draft 50% RD will include a tabulated summary of the shoreline properties within the SIB Project Area that will require an access agreement to conduct RA construction on riverbanks and around shoreline and overwater structures. The tabulated summary will be accompanied by a map showing the subject property boundaries and the footprints of the shoreline and overwater structures.

The Pre-Final 90% RD will include an evaluation and definition of permit and permit equivalency requirements; however, the RA Performing Party ultimately will be responsible for ensuring that either it obtains or the RA contractor obtains the appropriate permits and access agreements, and that permit requirements are satisfied during the performance of the RA.

4.0 REMEDIAL DESIGN PROCESS

This section describes the engineering design analyses to be completed in support of the area-specific technology assignment evaluations, and other design components such as the plan for obtaining access and construction sequencing and phasing. Design analyses, technology assignments, and other design components will be included in the Design Criteria Report of the Draft 50% RD and refined as needed in the Pre-Final 90% RD and Final 100% RD.

The design will specify performance requirements for project elements where prescriptive requirements are unsuitable. Performance-based specifications outline the criteria that must be met during RA construction, allowing for project-specific methods that leverage contractor expertise and allow for innovation. The contractor will propose these methods in a Remedial Action Work Plan, subject to EPA approval. This approach supports adaptive management, incorporating real-time lessons learned during construction. Prescriptive specifications will be used for inflexible design elements (e.g., minimum cap layer thickness, sequencing, access constraints) and to set project-wide minimum requirements for communications, environmental protection, and health and safety.

4.1 ENGINEERING DESIGN ANALYSES

This section provides descriptions of the engineering design analyses that will be performed and/or updated including a milestone schedule for completion of the analyses. Design analysis summaries will be included as attachments to the Design Criteria Report.

4.1.1 Cap Design

The Draft 50% RD will establish area-specific cap designs protective of human health and the environment. This will include details on the cap chemical isolation layer composition (e.g., sand or activated carbon amended sand) and thickness, geotechnical and erosion protection layer considerations, and habitat requirements. The chemical isolation layer component of the caps will be designed based on its performance at 30 centimeters below the sediment-water interface or below any armoring layer. As noted in the BODR, 30 centimeters is considered sufficient to contain contamination below the bioturbation layer to mitigate the risk of benthic organisms coming into contact with underlying contaminated sediments (HGL, 2024c).

During the Draft 50% RD, cap design will use conservative estimates for the most sensitive area-specific modeling parameters, including 95th percentile contaminant concentrations for historical and PDI surface and subsurface data, and the highest recorded nearby porewater upwelling velocity (recorded during ebb tide as summarized in Appendix B of the PDI ER; HGL, 2024a). Cap design will use literature values for partitioning coefficients. Other area-specific parameters will be assessed to optimize cap effectiveness and cost. The area-specific parameters include depth of contamination, underlying sediment physical characteristics (fraction of organic carbon, porosity, grain size distribution), erosion protection, and the proximity and impact of dredging activities. These parameters will be assessed for area-specific conditions while maintaining cap effectiveness and optimizing cost. Area-specific cap designs will be built on the Cap Evaluation provided as Appendix A, revised and appended herein to address EPA comments on the Cap Evaluation Appendix of the BODR (HGL, 2024c) and will include erosion protection requirements based on area-specific geotechnical considerations, as well as habitat requirements. Habitat requirements for capping may include the placement of a sand layer with an additional top layer of beach mix at the surface in shallow areas. Furthermore, as specified in the ROD, based on area-specific evaluation and design, engineered caps or vegetation with beach mix will be placed as the final cover (EPA, 2017a). Erosion protection design will consider hydrodynamic forces from vessels, wind-waves, river currents including climate change, dry dock operations, and outfall discharges. Geotechnical considerations will include bearing capacity of underlying sediment, settlement after cap placement, and slope stability during static and seismic conditions.

The Cap Design Technical Memorandum will document this process, and the capping components design including drawings of area-specific cap designs will be presented in the Draft 50% RD as an appendix to the Design Criteria Report. The design will also address the static and seismic slope stability of caps. The cap design will be revised as needed in subsequent deliverables (Pre-Final 90% RD and Final 100% RD). If a protective cap cannot be feasibly designed to address all ROD Table 17 (EPA, 2017a) chemicals in an area within SIB, then dredging or a combination of dredging and capping will be considered instead of capping alone.

4.1.2 Dredging Design

The dredging design process will define the horizontal and vertical extents of dredging based on area-specific PDI data, potential construction costs, and other considerations outlined in Appendix B of the BODR (HGL, 2024c). Dredging areas and volumes will be calculated using these defined horizontal and vertical extents and refined throughout the RD process considering constructability and protection of infrastructure and utilities. Dredging equipment and material transport systems will be evaluated based on the following factors influencing the potential dredging methodology and equipment selection:

- Dredged material local in-water transport and transloading capability,
- Quantity and type of debris,
- Sediment type/geotechnical characteristics,
- Dredging production rates,
- Navigation depth requirements and water depth to accommodate equipment,
- Site access constraints, and
- Environmental monitoring requirement.

Throughout the design process, dredge prisms will be refined based on concurrent design activities related to navigation, berthing at docks, potential impacts on structures, riverbanks, and utilities, capping, and other dependencies. The dredging design will evaluate riverbank and side slope stability resulting from dredging, which will affect the dredge prisms. Debris removal including removal of remnant piles will be performed prior to dredging, as needed to enable access for future remedial action and to maximize dredging production rates.

Dredging production rates will be evaluated, alongside bucket size, number of dredges, and expected dredge cuts. Cultural resources, critical habitats, and utilities may require modifications to the dredging design. Habitat considerations, such as placing beach mix in nearshore areas for foraging habitat (EPA, 2021c), may be incorporated into the design. Debris handling, treatment, and disposal methods will be further evaluated, including the proposed methodology for targeting debris to be removed prior to dredging and/or capping, determining cost-effective removal methods for pre-dredging (or pre-capping) debris removal, and establishing disposal procedures and requirements, as well as recommendations regarding construction sequence (if applicable).

Given uncertainties regarding transload sites, potential development of transload sites, and multiple ongoing remediation projects in Portland Harbor, it may be preferable to use a performance-based approach. A performance-based approach may also better take advantage of advances in construction equipment and techniques.

The Dredging Design Technical Memorandum will document this process, and the draft dredging design will be documented in the Draft 50% RD as an appendix to the Design Criteria Report. The Draft 50% RD also will include a list of the relevant technical specifications governing dredging.

4.1.2.1 Dredge Residuals Management

Dredge residuals management (DRM) is typically performed in areas where contaminated sediments remain after dredging. Contaminated sediments may remain as a thin veneer on the post-dredge surface in areas where dredging to RAL (vertically) has been specified, as opposed to areas where a cap with a chemical isolation layer is specified. DRM typically consists of placing a layer of clean sand (1 ft or less), but its use in SIB may depend on the results of post-dredge compliance testing. If dredge to RAL areas are prescribed in the Draft 50% RD, DRM application areas will be shown in the Draft 50% RD drawings, and DRM material placement will be included in specifications during the Pre-Final 90% RD. However, if all areas are capped, no further work regarding dredge residuals will be needed. Dredging performance standards (specifications), a monitoring and response framework in the CQA/QCP, and additional requirements in the drawings and specifications may be used for addressing DRM in the RD.

4.1.2.2 Post-Dredge Backfilling

Isolated deeper areas resulting from targeted dredging to remove more contaminants may be backfilled if deemed appropriate to avoid anoxic zones, to assist with residuals management, or for habitat purposes. Backfilling is not anticipated to be required in SIB due to variations from equipment tolerances (variability in over-dredging). However, if needed, backfilling will be designed in a manner consistent with other capping materials during the Draft 50% RD, and relevant backfill specifications will be developed during the Pre-Final 90% RD.

4.1.3 Material Transport and Disposal Update

Dredged material in-water transport methods will depend on the dredging equipment and dewatering process anticipated during the RD. Minimum performance requirements for in-water transport will be developed during the Pre-Final 90% RD and will be included as performance specifications. These will include a Vessel Management Plan to be prepared by the RA contractor (vessel types, access points, and vessel arrival/departure frequency).

Prior to landfill disposal, the dredging process will include material handling, potential dewatering, and potential water treatment. Material handling will be informed by the removal technology (e.g., mechanical dredging), constraints identified on transport routes, upland transport methods, and disposal facility requirements. The Draft 50% RD will consider the following:

- Debris (amount, type);
- Dredging volumes and production rates;
- Dredged material characteristics (e.g., geotechnical);
- Water treatment and discharge requirements (e.g., local sanitary sewer capacities, barge discharge regulations, transload facility capabilities);
- Potential dewatering and potential water treatment;
- Transload facility availability and capacity;
- Transport of dredge material from dredge site to transload facility (e.g., barge).
- Upland transport to disposal facility (truck and/or rail capacity, haul routes, associated regulatory requirements); and
- Disposal facility requirements.

Specifications will be developed during the Pre-Final 90% RD, which will identify applicable requirements for the topics listed above based on the 90% design that are compatible with site constraints and comply with ARARs and EPA requirements. It is anticipated that the water processing and treatment methods will be developed by the RA contractor subject to appropriate regulatory requirements and approval.

4.1.4 Geotechnical and Design Analyses

Geotechnical analyses performed during the RD will support justification or elimination of proposed remedial technologies and ultimately inform design and construction of the selected remedy, including development of any area-specific special considerations required for work on and adjacent to slopes and around existing structures.

Geotechnical analyses will be performed based on the RDGC (EPA, 2021b) and the additional guidance documents referenced within. Necessary geotechnical analysis elements will likely include, but will not be limited to, the following:

- Development of subsurface profiles and cross-sections that illustrate soil stratigraphy and include relevant geotechnical design parameters at key locations throughout the project area.
- Bearing resistance evaluation of cap foundation materials.
- Settlement analysis of both cap and cap foundation materials (underlying sediments).
- Development of seismic design parameters for a contingency level event (10% probability of exceedance in 50 years) and other seismic event return periods required for RD.
- Slope stability analysis, static and seismic (pseudo-static), of caps placed on slopes, proposed dredge cuts, and riverbank slopes.
- Seismic hazard analysis, including liquefaction triggering, liquefaction induced settlement, and lateral spreading potential.

- Development of lateral earth pressures for static and seismic loading conditions.
- Axial geotechnical resistance evaluation for existing deep foundation elements (e.g., existing timber, steel, and concrete piles).
- Lateral pile response of existing deep foundation elements (e.g., existing timber, steel, and concrete piles).

The geotechnical analyses performed as part of the Draft 50% RD will be presented in a technical memorandum and included as an appendix to the Design Criteria Report. The technical memorandum will include a detailed description of the analysis methodology, assumptions, input parameters, calculations, and results of each analysis performed.

A geotechnical design report will be prepared as part of the Pre-Final 90% RD and included as an appendix in the Revised Design Criteria Report. The geotechnical design report will include any refinements made to the analyses presented as part of the Draft 50% RD and geotechnical recommendations and construction considerations for significant design elements.

4.1.5 Analysis of Effects of Outfalls and Utilities on Remedial Technologies

Remedial technology assignments will consider outfall and utility offsets, constructability, restrictions on future waterway use, required modifications to outfalls, and utility protection requirements. Outfall locations will also be evaluated for scour protection.

The Draft 50% RD will develop preliminary plans for protection or reconstruction of outfalls showing extents of scour protection. Scour protection details, replacement concrete outfall headwall details, and other necessary utility modifications will be prepared in the Pre-Final 90% RD.

4.1.6 Quantity and Cost Analysis

Primary quantities of interest for the SIB Project Area RD will include volumes of dredging and tonnage of capping materials, debris removal, and potential structural elements. Volumes/tonnages of all material quantities will be computed in GIS and/or with Python tools using 3-D surfaces generated as part of the area-specific technology assignment evaluation (Section 4.2).

A cost estimate will be developed for each version of the RD (Draft 50%, Pre-Final 90%, and Final 100%). The cost estimating task will be used to inform engineering design and strategic decisions throughout the RD development, with the level of detail developing as the design progresses. Each cost estimate will be based on a cost analysis of the central work elements, including the following:

- Structural elements;
- Debris removal;
- Dredging;
- Capping;
- MNR;
- ENR;
- In situ treatment;

- Riverbank remediation;
- Material handling, transport, and disposal; and
- Construction management (inspection, compliance monitoring, administration).

The cost analysis will be developed in compliance with the Methodology and Organization of Selected Remedy Cost Estimate Memorandum in the ROD (EPA, 2017a). The cost estimate will be derived from the output of probabilistic cost modeling to incorporate the potential range of cost impacts as influenced by the likelihood of occurrence for a range of project risk elements. Unit costs for work elements will be continually updated during the design process based on the latest cost information available from recent, relevant sources. The project risk register will be continually updated to reflect newly recognized risks throughout the RD process.

4.2 AREA-SPECIFIC REMEDIAL DESIGN

This section summarizes how the work elements outlined in Section 4.1 were used to build on the preferred remedial approach (HGL, 2024c) to designate area-specific remedial technology assignments.

4.2.1 Sediment Management Area

The SMA comprises the locations where sediment concentrations exceed RALs/PQLs and/or PTW thresholds (Appendix L of the PDI ER; HGL, 2024a). Areas where capping, dredging, or capping with dredging will occur will be evaluated on an area-specific basis and assignment of area-specific remedial technologies will be presented in the Draft 50% RD. The area-specific technology assignments will be informed by the capping and dredging evaluation update, feasibility evaluation, cost analysis, communications with the shoreline facility owners and operators to finalize navigable depths for SIB, and resolution of additional considerations, including recontamination potential and work around structures.

4.2.2 Riverbanks and Areas Outside Sediment Management Area

Riverbanks and in-water areas outside of the SMA comprise the following:

1. **Areas below CULs.** These areas do not require active remediation ("no further action"); however, as discussed in Section 5.1 of the BODR and based on PDI results, these areas have a very small relative size (HGL, 2024c). Consequently, implementability considerations will impact the RD for these limited areas. Area-specific technology assignment defined in the Draft 50% RD likely will be based on contamination adjacent to "no further action" areas.
2. **Areas between CULs and RALs/PQLs.** In these areas, erodibility will be further evaluated, along with recontamination risk results from the final SAR (HGL, 2024b). Remedial technology assignments will be made in the Draft 50% RD on an area-specific basis and will include ENR or MNR, with potential bank stabilization efforts based on the erosive potential evaluation. For these areas, ENR is assumed in accordance with ROD Figure 31d (EPA, 2017a). MNR will potentially only apply to areas outside the SMA between mean high water (13 ft North American Vertical Datum of 1988) and the top of the bank where riverbank soil erosion is not of concern.

3. **Riverbanks with RAL/PQL and/or PTW exceedances.** This category will include riverbank considerations adjacent to SMA areas before assigning area-specific riverbank technology in the Draft 50% RD. These considerations include evaluating erodibility recontamination potential (included in SAR; HGL, 2024b) and potential bank stabilization measures. The RD approach to remediating contaminated riverbank soils combines measures that isolate contaminated soil in place using capping and stabilizing the new riverbank soil surface to prevent erosion. Assignment of riverbank remedial technologies, including dredging, excavation, capping, grading, and bank stabilization, will be presented on an area-specific basis in the Draft 50% RD.

Evaluation of revegetation and/or other surface treatments to assist with erosion control and habitat considerations will be included in accordance with the ROD (EPA, 2017a). Area-specific remedial technology assignments presented in the Draft 50% RD will be updated as needed in the Draft Final 90% RD and Final 100%RD.

4.2.3 Work Around Structures and Outfalls

The Draft 50% RD will assign area-specific technology based on COC concentrations, while considering the impacts of RA construction on existing in-water structures and outfalls that will remain in place. Structural stability evaluations will determine where dredging offsets are needed from slopes and structures, with offset distances based on structure conditions and bank slopes. The RD considerations will also account for potential use of specialized equipment in areas with limited access, alternative remedial technologies where structures and large-diameter outfalls may impose limitations, and the possible removal or replacement of obstacles like derelict structures, armored banks, and buried utilities. Some of these obstacles may require engineering assessment before removal, and alternative remedial approaches will be evaluated individually. Additionally, the RD will consider interactions between the remedy and existing shoreline features, including structures, outfalls, riverbank slopes, and utilities. The Draft 50% RD will present comprehensive area-specific remedial technology assignments that incorporate all these factors for work around structures and outfalls.

The development of structural alternatives for each in-water structure will be based on area-specific technology assignments. The level of analysis will be aligned with a performance-based design approach. The process will involve evaluation of remedial technologies based on all relevant data collected and evaluations completed. Before the remedial approach is presented in the Draft 50% RD, a preferred approach will be presented to facility owners and operators in individual meetings. Following these meetings, the concept designs will be further developed. The analysis and structural design criteria will then be summarized in an appendix of the Design Criteria Report, with corresponding design drawings and specifications prepared.

4.3 PLAN FOR OBTAINING ACCESS

The SIB Project Area is located in an area with multiple property owners, privately-owned submerged and submersible land, and submerged and submersible land owned by the State of Oregon, see BODR Figure 2-1 (HGL, 2024c). Site access will be necessary to conduct the RA, which will be accommodated through future access agreements. As stated in the BODR (HGL, 2024c), six facility owners and operators indicated a willingness to allow upland construction access to the SIB Project Area through their property during RA construction. The BODR provides a discussion of the operations at existing maritime facilities that could potentially be affected by RA activities. The work, including construction, staging, ingress and egress, will require access agreements. Potentially affected properties will be identified in the Draft 50% RD.

The RA Performing Party will coordinate with SIB Project Area property owners and operators to establish access for the RA, which may be accomplished through access agreements, leases, and/or easements. Depending on the owner and the nature and duration of the access, written agreements or other legal documentation (e.g., leases, easements, deed restrictions) may be required. The RA Performing Party will engage Oregon DSL and other property owners to identify potential RA constraints and requirements. It is crucial to begin communications early with property owners to avoid potential delays in the RA work.

4.4 CONSTRUCTION SEQUENCING AND PHASING

Sequencing remediation of higher-elevation (e.g., riverbanks, shallower areas) and upstream locations will be prioritized over adjacent sediments to reduce potential for recontamination. Work will be scheduled in a way that considers what activities must be done as predecessors to subsequent activities, what activities can be accomplished concurrently, and what activities must be done as successors to completed activities. Dependencies of RA activities were described briefly in the BODR (HGL, 2024c), including first completing surveys/inspections, structural work, and riverbank/higher-elevation area RAs. Secondary surveying (i.e., post-debris removal) would likely follow, with dredging, capping, ENR, and in situ treatment occurring afterwards, followed by post-construction surveys. During the Draft 50% RD and Pre-Final 90% RD, more detailed sequencing will be developed, such as where capping can occur prior to dredging (if anywhere). In order to complete these detailed sequencing evaluations, a more refined design concept and understanding of anticipated construction methodologies is required.

SIB is an active waterway with multiple facilities, waterway uses, and vessel traffic in potential conflict with RA construction activities. Construction sequencing will need to consider the impact of vessel traffic and facility operations, with the objective of reducing interruptions to waterway use to a practical extent. Analysis performed previously and presented in the BODR regarding potential vessel traffic conflicts will be coordinated with waterway users in greater detail and included in the sequencing and phasing assessment. Outreach to facility owners and operators will be performed during the Draft 50% RD to gather recommendations on how to improve the construction-phase coordination process.

Specifications included with the Final 100% RD design package will establish RA contractor requirements for coordination and outreach activities to waterfront facilities. Specifications will identify and refine known constraints based on ongoing coordination with facility owners and operators and develop preliminary construction sequencing that considers each waterfront facility's operation. The specifications will also require the RA contractor to develop a detailed work plan and schedule that presents the sequencing and duration of each project element. Throughout construction, the detailed schedule will be regularly updated considering actual construction progress and ongoing coordination with waterway users.

The RA Performing Party should work closely with the RA contractor to obtain access agreements and information necessary to develop and adapt the construction schedule throughout the RA. Sequencing of active construction during the RA will be completed based on available work windows and within appropriate river/weather conditions that would minimize recontamination and maximize efficiency.

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5.0 REMEDIAL DESIGN DELIVERABLES AND SEQUENCING

This section provides an overview of the RD sequencing. After finalization and approval of this RDWP, the schedule for RD deliverables will be further established as the project progresses in discussions with EPA. The Draft 50% RD and supporting documents will be submitted in the first quarter of 2025. The Draft 50% RD will progress in stages through the Pre-Final 90% and Final 100% RD.

Additional RD investigations may be pursued if data gaps are identified between the submittal of this RDWP and the Draft 50% RD. Any additional investigations will be coordinated with EPA and the RD design team to determine an appropriate schedule in support of the RD.

5.1 DRAFT 50% REMEDIAL DESIGN

The primary elements of the Draft 50% RD will include the following:

- A Design Criteria Report, as described in EPA's Remedial Design/Remedial Action Handbook (EPA, 1995);
- Preliminary drawings and technical specifications;
- Descriptions of permit requirements;
- Description of monitoring and control measures to protect human health and the environment;
- Updates to supporting deliverables required to accompany this RDWP;
- Additional supporting deliverables, including:
    - Site-specific analysis of ARAR applicability (including ESA and CWA),
    - Institutional Controls Implementation and Assurance Plan,
    - Waste Designation Memorandum,
    - Habitat Impact Evaluation Report,
    - Green Remediation Plan (including a description of how the RA will be implemented in a manner that minimizes environmental impacts in accordance with EPA's Principles for Greener Cleanups (EPA, 2009), and the outline described in Appendix M of the Portland Harbor Feasibility Study (EPA, 2016).
    - PAMP,
    - CQA/QCP,
    - Transportation and Off-Site Disposal Plan (TODP), and
    - O&M Plan and O&M Manual.
- Demonstration that an existing transload facility may be appropriate for handling and transloading dredged materials. A future on-site or alternative transload facility may have been developed (by others) prior to the start of construction. It will be up to the RA contractor to demonstrate that the transload facility it intends to use will be appropriate

for handling and transloading contaminated sediments and other materials that might be dredged.

5.1.1 Design Criteria Report

A Design Criteria Report will be prepared to describe the technical parameters upon which the RD will be based. The report will include a compilation of major design items reflecting approximately 50% completion of the RD.

An engineering technical memorandum for each design element (cap design, dredging design, geotechnical and cost analyse) described in Section 4 will be prepared following completion of design analyses, representing approximately 50% completion of design. These memoranda will be included as appendices to the Design Criteria Report.

5.1.2 Preliminary Drawings

Preliminary drawings represent the basic components of the preferred remedial approach showing site layouts, existing site plans, utility layouts, area-specific cross-sections (including visualization of core locations and how they helped define SMA boundaries), bank stabilization concepts, habitat improvement concepts, existing structure shoring and repair work concepts, temporary structure concept plans, and conceptual level dredging and capping plans and sections.

5.1.3 Preliminary Specifications

Preliminary technical specifications will be prepared for the Draft 50% RD, representing approximately 50% completion of design. The specifications will follow the most current edition of Construction Specifications Institute’s Master Format (2020).

5.1.4 Permit Requirements

The RD will evaluate how requirements for permits needed to implement the RA will be identified and satisfied. The evaluation will include identifying the required off-site disposal and discharge permits, the time required to process the permit applications, and a schedule for submitting permit applications. Many permits are not required for on-site activities due to federal exemptions under CERCLA; however, the substantive requirements of any permits that would otherwise be required must be described and met in coordination with the applicable regulatory agencies.

Section 3.3 identifies ARARs and TBCs, their substantive requirements, and the applicability of those requirements to specific design elements. Other requirements may include but are not limited to authorizations from Oregon DSL to conduct RA work on state-owned lands, City permits for work on City outfalls, and access agreements to conduct RA work on riverbanks and shoreline structures on public and private properties. The RD will include an evaluation and definition of permit and permit equivalency requirements; however, the RA Performing Party ultimately will be responsible for obtaining permits and/or satisfying permit requirements during the performance of the RA.

5.1.5 Habitat Impact Evaluation

The habitat impacts discussion included in the BODR (HGL, 2024c) refers to the baseline habitat survey results published in the PDI ER (HGL, 2024a) and presents a qualitative discussion of the types of habitat impacts that would occur as a result of remedy implementation based on the preferred remedial approach. The habitat impact evaluation presented in the Draft 50% RD will include a quantification of potential RA impacts based on pre (baseline)- and post-RA conditions. Post-RA conditions consider habitat that will result from restoration activities within the SIB Project Area that are included in the RD.

5.1.6 Clean Water Act Analysis

The CWA Analysis will be prepared to demonstrate compliance of the proposed RA with the substantive requirements of Section 404(b)(1) and other applicable sections of the CWA and water quality standards established by the State of Oregon. The CWA Analysis will include a preliminary determination of whether compensatory mitigation is required and identification and description of potential mitigation opportunities within the SIB Project Area. Between the Draft 50% RD and the Pre-Final 90% RD, the design team will continue to identify, evaluate, and incorporate opportunities for impact avoidance and minimization as part of design development.

5.1.7 Value Engineering Screening

A value engineering (VE) screening will be completed on the Draft 50% RD consistent with the Remedial Design/Remedial Action Handbook (EPA, 1995) and EPA's Circular No. A-131, Value Engineering (For Fund-Financed Superfund Remedial Design/Remedial Action Projects) (EPA, 2005). A key outcome of this task will be to determine if the project will require any high-cost, non-industry standard items and if there is a need for a VE study. Factors to be considered during the VE screening include the following components:

1. Is it a high-volume item? Can a simple change in one item produce large savings in the total project?
2. Does the item use critical materials?
3. Is it difficult to construct?
4. Does it have high O&M costs?
5. Does it require specialized skills to construct and operate?
6. Does it use obsolete materials and methods?
7. Was the design rushed?
8. Does it use traditional design?
9. Is the competition producing the item at a lower cost?
10. Does the design advocate using proprietary technology?
11. Will it require highly trained personnel to operate?

12. Is the design treating everything using a single piece of equipment, when several pieces of equipment would be more cost-effective?
13. Is the design using technology already proven in industry in similar (not necessarily in the hazardous waste field) commercial applications?
14. Has the design used predesigned skids or equipment packages effectively?

The VE screening will identify key design elements that could increase remedial effectiveness and/or reduce the cost associated with implementation of the RA. The results of the VE screening will be provided in the Draft 50% RD. If a VE study is required, it will be included in the Pre-Final 90% RD and will document methods to improve the RA and optimize implementation.

5.1.8 Preliminary Remedial Action Schedule

A preliminary RA schedule will be developed covering the scope of the anticipated activities and will include an evaluation of a phased approach to expedite the RA. The RA schedule will include inputs for construction sequencing and phasing and potential effects on the overall RA timeline.

5.1.9 Plans

The following subsections include brief descriptions of the plans to be developed as part of the Draft 50% RD.

5.1.9.1 Institutional Control Implementation and Assurance Plan

The Institutional Control Implementation and Assurance Plan (ICIAP) will be designed to protect human health and the environment by limiting exposure to contamination left in place and to protect the long-term integrity of the engineered components of the remedy. The ICIAP will be developed in accordance with 1) Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites (EPA, 2012a); 2) Institutional Controls: A Guide to Preparing Institutional Controls Implementation and Assurance Plans at Contaminated Sites (EPA, 2012b); and 3) PHSS Programmatic ICIAP (City and State of Oregon, 2022) or as amended or superseded. The SIB Project Area ICIAP will follow the example outline provided in the PHSS Programmatic ICIAP.

5.1.9.2 Waste Designation Memorandum

The Waste Designation Memorandum will identify the types of waste media (debris, sediment, water) generated during implementation of the RD that will require RCRA characterization for treatment and/or disposal. The Waste Designation Memorandum will identify chemical sampling parameters for each media type required for regulatory compliance during generation, storage, transport, and disposal of waste.

5.1.9.3 Project Area Monitoring Plan

The PAMP will be developed in accordance with ASAOC and the Draft Long-Term Monitoring Program Work Plan (EPA, 2024a). The PAMP will provide a comprehensive strategy for monitoring contamination in the SIB Project Area before, during, and after the RA. The PAMP will outline steps for establishing baseline contamination levels by evaluating available data, and for gathering short-term and long-term data. Key components of the PAMP will include detailed procedures for data collection, evaluation, and reporting monitored environmental media; schedule; and details on ICs associated with the in-water remedy. It will include details on monitoring equipment, monitoring frequency, sampling and analytical methods, management of investigation-derived waste, and QA/QC measures needed to determine if performance standards are met or if additional actions are needed. Additional actions may include increases in the frequency of monitoring and/or installation of additional monitoring points in the affected areas where results from monitoring efforts indicate changed conditions, such as higher than expected concentrations of COCs.

5.1.9.4 Construction Quality Assurance/Quality Control Plan

The CQA/QCP will be prepared during the Draft 50% RD and updated during subsequent phases of the RD. The plan will ensure compliance with all plans, specifications, and related requirements and identify and describe the following:

- Performance standards required to be met to achieve the RA;
- Activities to be performed to provide confidence that performance standards will be met as well as determine whether performance standards have been met;
- Inspections, sampling, testing, monitoring, and production controls activities to be performed, and associated industry standards and technical specifications;
- Construction deficiencies tracking procedures from identification through corrective action; and
- Documentation procedures, both during RA and final storage document retention.

5.1.9.5 Operations and Maintenance Plan and Manual

The O&M Plan will guide post-RA inspection, operation, and maintenance efforts required to be met to implement the ROD. It will include a description of performance standards and activities to provide confidence that the performance standard will be met and/or determine whether they have been achieved. The O&M Plan will be developed in accordance with EPA's Guidance for Management of Superfund Remedies in Post Construction (EPA, 2017b). The plan will outline O&M reporting requirements, including monthly and annual reports to EPA and state agencies. Additionally, it will specify corrective actions for system failures, covering alternative procedures to prevent waste material release, vulnerability analysis, resource requirements for failures, notification and reporting protocols for system failures or imminent failures, and community notification requirements.

The O&M Manual, a companion to the O&M Plan, will serve as a guide to the purpose and function of the equipment and systems comprising the remedy, providing system descriptions of dredging and sediment process operations, performance sampling, installed equipment details, and requirements for records and reporting. It will also document emergency operating and response programs, as well as include necessary drawings, schematics, and checklists for implementing the RA.

5.1.9.6 Transportation and Off-Site Disposal Plan

The TODP will describe the approach for transportation and disposal to ensure compliance with the requirements for off-site shipping. The TODP will include:

- Proposed routes for off-site shipment of material;
- Identification of communities affected by shipment of waste material; and
- Description of plans to minimize impacts on affected communities.

5.1.9.7 Green Remediation Plan

The Green Remediation Plan will describe how the RA will be implemented in a manner that minimizes environmental impacts in accordance with EPA's Principles for Greener Cleanups (EPA, 2009), the Superfund Green Remediation Strategy (EPA, 2010), the ROD (EPA, 2017a), RDGC (EPA, 2021b), and the information described in Appendix M of the Portland Harbor Feasibility Study (EPA, 2016).

The Green Remediation Plan will include findings from the environmental impact footprint analysis and best practice recommendations for reduction of energy use, air pollutants, water usage, waste, and habitat impacts during RA implementation.

5.2 PRE-FINAL 90% REMEDIAL DESIGN

The Pre-Final 90% RD will be a continuation and expansion of the 50% RD and address EPA comments on the Draft 50% RD. The Pre-Final 90% RD will include the following deliverables:

- Revised Design Criteria Report (including updated technical memoranda appendices)
- Constructability assessment memorandum
- Permit applications and access requirements
- Pre-Final (90%) Drawings
- Pre-Final Specifications
- Pre-Final RA Schedule
- Pre-Final Construction Cost Estimate
- A complete set of certified construction drawings and specifications
- Plans Update (See Section 5.1.9)

5.3 FINAL 100% REMEDIAL DESIGN

The Final 100% RD will address EPA comments on the Pre-Final 90% RD and include final versions of all pre-final deliverables described in Section 5.2 for EPA approval. According to the terms of the ASAOC (Section XXVII. Notice of Work Completion), the Performing Parties will request that EPA make the determination that all work has been fully performed in accordance with the terms of the ASAOC and provide written notice of this to the Performing Parties, the Settling Federal Agencies, and the Settling Public Entities.

6.0 REFERENCES

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EPA, 2021b. *Remedial Design Guidelines and Considerations*, Portland Harbor Superfund Site, Portland, Oregon. April.

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EPA, 2022. *Buried Contamination Guidelines for Portland Harbor Site*. U.S. Environmental Protection Agency. January.

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EPA, 2024b. DRAFT Portland Harbor Superfund Sitewide Community Impacts Mitigation Plan (as of 06/06/2024), Region 10. June 2024, at URL https://phcimp.konveio.com/draft-portland-harbor-community-impacts-mitigation-plan-cimp.

TABLES

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Table 2-1
Preliminary Remedial Design Deliverable Schedule
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Deliverable	Scheduled Date	Timeline	Note
Final BODR		Submitted on 9/16/2024.	
Draft Remedial Design Work Plan	November 2024	Due 90 days after completion of the Final BODR.	Per ASAOC
Final Remedial Design Work Plan	February 2025	Due 45 days after EPA's comments on the Draft RDWP.	
Draft (50%) RD and Design Studies*	March 2025	Due 270 days after EPA approves the Final RDWP.	Per ASAOC. Includes Supporting Deliverables: Design Criteria Report, Preliminary Drawings, Preliminary Specifications, Value Engieering Screening, Preliminary RA Schedule, Institutional Controls Implementation and Assurance Plan, Waste Designation Memo, Project Area Monitoring Plan, Construction Quality Assurance/Quality Control Plan, O&M Plan and Manual, Transportation and Off-Site Disposal Plan, Green Remediation Plan, Habitat Impact Evaluation, and Clean Water Act Analysis.
Porewater Chemistry Study Work Plan	April 2025	Submitted prior to fieldwork, which is anticipated for August 2025.	In lieu of a Treatibility Study, as described in the BODR.
Pre-final (90%) RD	September 2025		
Final (100%) RD and Porewater Chemistry Study Report	February 2026		
RA**	To be determined		Outside of ASAOC

Notes:

* Design studies are listed in Section 11 of the BODR, and include all studies except for porewater chemistry and flood impact evaluation (reported in Final 100% RD).

** RA is outside of current ASAOC, and will also include permitting, bidding/contracting, construction, and post-construction monitoring.

ASAOC = *Administrative Settlement Agreement and Order on Consent for Remedial Design. Swan Island Basin Project Area* , CERCLA Docket No. 10-2021-001 - 7, Region 10. January 20.

BODR = B*asis of Design Report. Revision 1. Preliminary Remedial Design Services Swan Island Basin Project Area,* CERCLA Docket No. 10-2021-001. September 16, 2024.

% = percent
EPA = U.S. Environmental Protection Agency
ERP = Emergency Response Plan
FSP = Field Sampling Plan
HASP = Health and Safety Plan
QAPP = Quality Assurance Project Plan
RA = Remedial Action
RD = Remedial Design
RDWP = Remedial Design Work Plan

Table 2-2
Remedial Design Consultant Team Points of Contact
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Name	Project Title/Role	Telephone Number	Email
HydroGeoLogic, Inc. (HGL)			
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Mike Hrachovec, PE	Project Engineer	206-594-5876	mhrachovec@hgl.com
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Melissa Svoboda, PE	Project Engineer	913-378-2312	msvoboda@hgl.com
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Scott Minahan, P.Eng.	Structural Engineer	604-608-1477	scott.minahan@mottmac.com
Evan Edgecomb, PE	Structural Engineer	425-977-2592	evan.edgecomb@mottmac.com
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Janet Knox, LG	Technical Leader	206-329-1893	janet.knox@mottmac.com
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Coast & Harbor Engineering (CHE)			
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Table 2-2
Remedial Design Consultant Team Points of Contact
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Name	Project Title/Role	Telephone Number	Email
Bridgewater Group (BWG)			
Anna St John, RG, LHG, PG	Technical Leader	503-675-2737	astjohn@bridgeh2o.com

Notes:
ASQ CQA = American Society for Quality Certified Quality Auditor
CEng MICE = Chartered Engineer
CHMM = Certified Hazardous Materials Manager
CIH = Certified Industrial Hygienist
CPG = Certified Professional Geologist
CQCM = Construction Quality Control Manager
D.CE = Diplomate, Coastal Engineering
D.PE = Diplomate, Port Engineering
EIT = Engineer in Training
ENV SP = Envision Sustainability Professional
LEED AP = Leadership in Energy and Environmental Design Accredited Professional
LEED AP BDC = Leadership in Energy and Environmental Design Accredited Professional (Building Design & Construction)
LG = Licensed Geologist
LHG = Licensed Hydrogeologist
PE / P. Eng. = Professional Engineer
PhD = Doctor of Philosophy
PM = Project Manager
PMP = Project Management Professional
QA = Quality Assurance
RG = Registered Geologist
RoGEP = Register of Ground Engineering Professionals
SE = Structural Engineer

Table 3-1
Application of the PHSS ROD ARARs and TBC Regulations/Citations and Documentation Anticipated to Demonstrate Compliance
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Medium	Regulation/Citation	ARAR or TBC?	Documents that will speak to Compliance with ARARs	Workplan for compliance measures
Chemical-Specific ARARs (see ROD Table 25a [EPA, 2017] for further details)				
Protection of surface water	CWA, 33 USC 1313 and 1314 (Sections 303 and 304). Most recent 304(a) list of recommended water quality criteria.	Relevant and Appropriate	50/90/Final Design Criteria Report, CWA Analysis, PAMP	Use OAR established water quality standards and testing to develop project-specific CQA/QCP and incorporate in CWA Analysis.
	Water Pollution Control Act ORS 468B.048. Statewide Numeric Water Quality Criteria set forth in OAR Part 340, Division 41, including Toxic Substances criterion at OAR Part 340 41 0033 (Tables 30 and 40), and Designated Uses for the Willamette Basin and Numeric Water Quality Criteria specified for the Willamette Basin at OAR 340 041 340 and 340 041 0345.	Applicable, Relevant, and Appropriate		
Protection of potential drinking water sources	Safe Drinking Water Act, 42 USC 300f, 40 CFR Part 141, Subpart O, Appendix A. 40 CFR Part 143.	Relevant and Appropriate	CWA Analysis, PAMP	Develop action-specific standards for minimizing discharges of contaminants during construction that meet MCL goals.
	EPA RSL for Groundwater. Office of Superfund Remediation and Technology Innovation, Assessment and Remediation Division. November 2015.	TBC		Consider RSLs to establish acceptable risk levels where no MCLs or MCLGs are applicable.
Measure of protectiveness of human health and the environment in all media	Oregon Environmental Cleanup Law ORS 465.315(b)(A). Oregon Hazardous Substance Remedial Action Rules OAR 340 122 0040(2)(a) and (c), 0115(2 4).	Applicable	50/90/Final Design Criteria Report, PAMP, CQA/QCP, TODP, O&M Plan, ICIAP	Using OAR established water quality standards to develop project-specific CQA/QCP and incorporate in CWA Analysis.
Action-Specific ARARs (see ROD Table 25b [EPA, 2017] for further details)				
Actions that discharge dredged or fill material into navigable waters	CWA, Section 404, 33 USC 1344 and Section 404(b)(1) Guidelines, 40 CFR Part 230 (Guidelines for Specification of Disposal Sites for Dredged or Fill Material)	Applicable	50/90/Final Design Criteria Report, PAMP, CQA/QCP, TODP, CWA Analysis, Habitat Impact Evaluation, EPA determination consistent with comprehensive mitigation framework developed in coordination with NMFS and USFWS	Evaluate habitat impacts for RA approaches to demonstrate consistency with CWA Section 404. Provide inputs for HEA model to be developed by EPA.
Actions that discharge pollutants to Waters of the United States	CWA, Section 402, 33 USC 1342	Relevant and Appropriate	50/90/Final Design Criteria Report, PAMP, CWA Analysis, Habitat Impact Evaluation, CQA/QCP, TODP, EPA Section 401 Water Quality Certification or equivalent	Evaluate habitat impacts for RA approaches to demonstrate consistency with CWA Section 404. Provide inputs for HEA model to be developed by EPA.
Actions that discharge pollutants to Waters of the United States	CWA, 33 USC 1341, (Section 401), 40 CFR Section, 121.2(a)(3), (4) and (5). Also see OAR 340 048 0015 "When Certification Required" pursuant to Oregon state law.	Relevant and Appropriate		
Actions resulting in discharges to Waters of the State of Oregon, including removal and fill activities	ORS 468B.025 and State water quality standards established by rule: OAR 340 041 0002 through 0059, and Willamette Basin Designated Uses and Basin specific water quality standards at OAR 340 041 340 and OAR 340 041 345.	Relevant and Appropriate	50/90/Final Design Criteria Report, PAMP, CQA/QCP, TODP, CWA Analysis, Habitat Impact Evaluation, EPA determination consistent with comprehensive mitigation framework developed in coordination with NMFS and USFWS	Evaluate habitat impacts for RA approaches to demonstrate consistency with CWA Section 404. Provide inputs for HEA model to be developed by EPA.
Actions resulting in discharges from removal and fill activities	ORS 196.825(5) Statutory requirement to mitigate for expected adverse effects of removal and fill activities. Applicable substantive mitigation rules are: OAR 141 085 510, 141 085 680, 141 085 0685, 141 085 0690, 141 085 0710, and 141 085 715.	Applicable		
Actions in federal navigation channels	River and Harbors Act of 1899, Section 10, 33 USC Section 403 and implementing regulations at 33 CFR Sections 322(e), 323.3, 323.4(b) (c), and 329.	Applicable	50/90/Final Design Criteria Report, CQA/QCP, TODP, ICIAP	CQA/QCP plan identifies areas where dedging and capping are assigned with over dredge allowances or buffer zones as specified in Section 3 of RDGC.

Table 3-1 (Continued)
Application of the PHSS ROD ARARs and TBC Regulations/Citations and Documentation Anticipated to Demonstrate Compliance
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Medium	Regulation/Citation	ARAR or TBC?	Documents that will speak to Compliance with ARARs	Workplan for compliance measures
Action-Specific ARARs (see ROD Table 25b [EPA, 2017] for further details) (Continued)				
Actions generating pesticide residue	Hazardous Waste and Hazardous Materials II. Identification and Listing of Hazardous Waste OAR 340 101 0033(6) and (7); OAR 340 100 0010(j); and OAR 340 109 0010(3) and (4).	Applicable	Waste Designation Memorandum, TODP	Identify pesticide COC in Waste Designation Memorandum based on RD characterization efforts. Incorporate handling considerations in TODP.
Actions handling PCB remediation wastes and PCB containing material	Toxic Substances Control Act,. 15 USC §2601 et seq., 40 CFR Part 761, Subpart D and OAR 340 110 0065 (1) and (2)	Applicable	TODP, Waste Designation Memorandum	Develop action-specific standards for handling PCB contaminated materials and remediation wastes consistent with guidelines. Include standards in Waste designation Memorandum and TODP.
Risk based limits protective of human health for air emissions associated with soil or sediment removal	Clean Air Act, 40 CFR Parts 50 and 52	Relevant and Appropriate	50/90/Final Design Criteria Report, PAMP, TODP	Develop and incorporate green remediation and emission control considerations for inclusion in RD and TODP.
Actions generating air emissions	Oregon Air Pollution Control ORS 468A et seq., General Emissions Standards OAR 340 226	Applicable		
Actions that involve handling of dredged sediment or riverbank soils containing asbestos	National Emission Standards for Asbestos, 40 CFR 61.150(a)(1)(i)(v)	Relevant and Appropriate	Waste Designation Memorandum, PAMP, TODP	Waste Designation Memorandum/TODP to note the need for asbestos sampling prior to excavation/transport/disposal. PAMP to address monitoring requirements for asbestos.
	National Emission Standards for Asbestos, 40 CFR 61.150(b)(1) and (2) and (c)	Applicable		
Actions on the riverbanks that expose and manage on site soils containing asbestos	National Emission Standards for Asbestos, 40 CFR 61.151(a)(2) and (3), 40 CFR 61.151(b)(1)(i) through (iii) and 40 CFR 61.151(b)(2)	Applicable	PAMP	
Actions generating air emissions	Fugitive Emission Requirements OAR 340 208 0205, 0208, and 0209	Applicable	50/90/Final Design Criteria Report, Green Remediation Plan, PAMP, TODP	Develop and incorporate green remediation and emission control considerations for inclusion in RD.
Actions that may alter waterbodies and that may effect fish and wildlife	Fish and Wildlife Coordination Act. 16 USC 662 and 663, 50 CFR 6.302(g)	Applicable	50/90/Final Design Criteria Report, PHSS Biological Assessment, PAMP, CWA Analysis, EPA determination consistent with comprehensive mitigation framework developed in coordination with NMFS and USFWS	Define construction strategies for adherence to timing windows, including fish exclusion plan. Define reasonable and prudent measures to minimize impacts of RA on essential habitats.
Actions that may affect Endangered Species Act listed and State protected fish and wildlife species	Oregon Department of Fish and Wildlife Fish Management Plans for the Willamette River. OAR 635, div 500	Applicable		
Actions that may affect marine mammals	Marine Mammal Protection Act. 16 USC § 1361 et seq. 50 CFR 216	Applicable		
Actions that may affect migratory birds	Migratory Bird Treaty Act. 16 USC §703 50 CFR §10.12	Applicable	Habitat Impact Evaluation, PAMP	In Habitat Impact Evaluation evaluate migratory bird timing windows and incorporate avoidance strategies in RD. Incorporate in PAMP.
On-site actions that involve generating, handling, and disposal of hazardous waste	OAR 340 100 0001(3) and OAR 340 100 0002(1)	Applicable	Waste Designation Memorandum, PAMP, TODP	Complete Waste Designation Memorandum and TODP.

Table 3-1 (Continued)
Application of the PHSS ROD ARARs and TBC Regulations/Citations and Documentation Anticipated to Demonstrate Compliance
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Medium	Regulation/Citation	ARAR or TBC?	Documents that will speak to Compliance with ARARs	Workplan for compliance measures
Action-Specific ARARs (see ROD Table 25b [EPA, 2017] for further details) (Continued)				
Actions generating solid wastes or hazardous wastes for off-site disposal	Solid waste defined in 40 CFR 261.2. Determining if solid waste is hazardous per 40 CFR § 262.11(a c) and OAR 340 102 0011 Hazardous Waste Determination	Applicable	Waste Designation Memorandum, TODP	Complete Waste Designation Memorandum and TODP to include action-specific handling considerations.
Actions generating dredged material hazardous waste	40 CFR § 261.4(g)	Applicable		
Actions generating RCRA hazardous waste that will be disposed of in a permitted off-site disposal facility	40 CFR § 264.13(a)(1)	Applicable		
Actions generating RCRA hazardous waste	40 CFR § 268.7(a)(1)	Applicable		
	40 CFR § 268.9(a)	Applicable		
Actions generating industrial wastewater	40 CFR § 261.4(a)(2)	Applicable	50/90/Final Design Criteria Report, PAMP	Define RD sampling approach. Conduct evaluations on bulk sediment samples to provide data for evaluation of dredge water clarification amendments.
Actions requiring temporary storage of hazardous waste	OAR 340 102 0034 40 CFR § 262.34(a); 40 CFR § 262.34(a)(1)(i); 40 CFR § 262.34(a)(2) and (3) 40 CFR § 262.34(c)(1)	Applicable	50/90/Final Design Criteria Report, Waste Designation Memorandum	Complete Waste Designation Memorandum and TODP to include action-specific handling considerations.
Actions resulting in the storage of solid waste	OAR 340 093 0210 and 0220	Applicable		
	OAR 340 095 0010, 0020, 0030, 0050(1) & (2), 0070(2)	Applicable		
Actions transporting hazardous materials	49 CFR § 171.1(b)	Applicable	TODP	Identify specific handling requirements in TODP.
Actions that involve storage and treatment of hazardous waste at the transloading facility	40 CFR Part 264, Subparts B, C, F, G, I, J, K, L, M, AA, BB, CC, and DD	Applicable	50/90/Final Design Criteria Report, Waste Designation Memorandum	Identify specific storage requirements and include in TODP.
Location-Specific ARARs (see ROD Table 25c [EPA, 2017] for further details)				
Presence of archaeologically or historically sensitive area	Native American Graves Protection and Reparation Act, 25 USC 3001 3013, 43 CFR 10	Applicable	AIDP (example), ICIAP	Provide AIDP example as a guide for the RA contractor that will be responsible for preparing the AIDP in advance of RA construction.
	Indian Graves and Protected Objects ORS 97.740 760	Relevant and Appropriate		
	Archaeological Objects and Sites ORS 358.905 955 ORS 390.235	Relevant and Appropriate		
Presence of archaeologically or historically sensitive area	National Historic Preservation Act. 16 USC 470 et seq. 36 CFR Part 800	Applicable		
	Archaeological and Historic Preservation Act. 16 USC 469a 1	Applicable		
Presence of floodplain as designated on FEMA Flood Insurance map	44 CFR 60.3(d)(2) and (3)	Relevant and Appropriate	50/90/Final Design Criteria Report, Flood Impact Evaluation, CWA Analysis	Define FEMA regulated floodplain as it pertains to SIB Project Area. Conduct flood impact evaluation to demonstrate that RA will not result in unacceptable flood rise.
Presence of floodplain as designated on map	FEMA regulations at 44 CFR 9 (which sets forth the policy, procedure and responsibilities to implement and enforce Executive Orders 11988 (Management of Floodplain) as amended by Executive Order 13690 and 11990 (Protection of Wetlands)	Regulations: Relevant and Appropriate Executive Order: TBC		

Table 3-1 (Continued)
Application of the PHSS ROD ARARs and TBC Regulations/Citations and Documentation Anticipated to Demonstrate Compliance
Remedial Design Work Plan, Swan Island Basin Project Area, Portland, Oregon

Medium	Regulation/Citation	ARAR or TBC?	Documents that will speak to Compliance with ARARs	Workplan for compliance measures
Location-Specific ARARs (see ROD Table 25c [EPA, 2017] for further details) (Continued)				
Presence of wetlands	Executive Order for Wetlands Protection. Executive Order 11990 (1977)	TBC	50/90/Final Design Criteria Report, Habitat Impact Evaluation, CWA Analysis	Review and evaluate SIB Project Area for any nascent wetlands. Incorporate into RD and CWA analysis if present.
Presence of state listed threatened or endangered wildlife species	Protection and Conservation Programs ORS. 496.171 to 496.182. Survival Guidelines OAR 635 100 0135	Relevant and Appropriate	PHSS Biological Assessment, Habitat Impact Evaluation	In Habitat Impact Evaluation distinguish differences between state and federally protected species. Identify preferred habitats and the presence or absence thereof. Incorporate into RD.
Presence of essential fish habitat	Magnuson Stevens Fishery Conservation and Management Act. 50 CFR Part.600.920	Applicable	50/90/Final Design Criteria Report, PHSS Biological Assessment, Habitat Impact Evaluation	Define construction strategies for adherence to timing windows, including fish exclusion plan. Define reasonable and prudent measures to minimize impacts of RA on essential habitats.
Presence of federally endangered or threatened species	Endangered Species Act. 16 USC 1536 (a)(2), Listing of endangered or threatened species per 50 CFR 17.11 and 17.12 or designation of critical habitat of such species listed in 50 CFR 17.95	Applicable		

Notes:

EPA, 2017. *Record of Decision, Portland Harbor Superfund Site,* Portland, Oregon. EPA Region 10, Seattle, Washington. January.

AIDP = Archaeological Inadvertent Discovery Plan
ARAR = Applicable or Relevant and Appropriate Requirements
CFR = Code of Federal Regulations
COC = contaminant of concern
CQA/QCPP = Construction Quality Assurance/Quality Control Plan
CWA = Clean Water Act
EPA = U.S. Environmental Protection Agency
FEMA = Federal Emergency Management Agency
HEA = Habitat Equivalency Analysis
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
NMFS = National Marine Fisheries Service
OAR = Oregon Administrative Rule
ORS = Oregon Revised Statute
O&M = operation and maintenance
PAMP = Project Area Monitoring Plan
PCB = polychlorinated biphenyls
PHSS = Portland Harbor Superfund Site
RA = remedial action
RCRA = Resource Conservation and Recovery Act
RD = Remedial Design
RDGC = Remedial Design Guidelines and Considerations
ROD = Record of Decision
RSL = Regional Screening Level
SIB = Swan Island Basin
SMA = sediment management area
TBC = To Be Considered
TODP = Transportation and Off-Site Disposal Plan
USC = U.S. Code
USFWS = U.S. Fish and Wildlife Service

FIGURES

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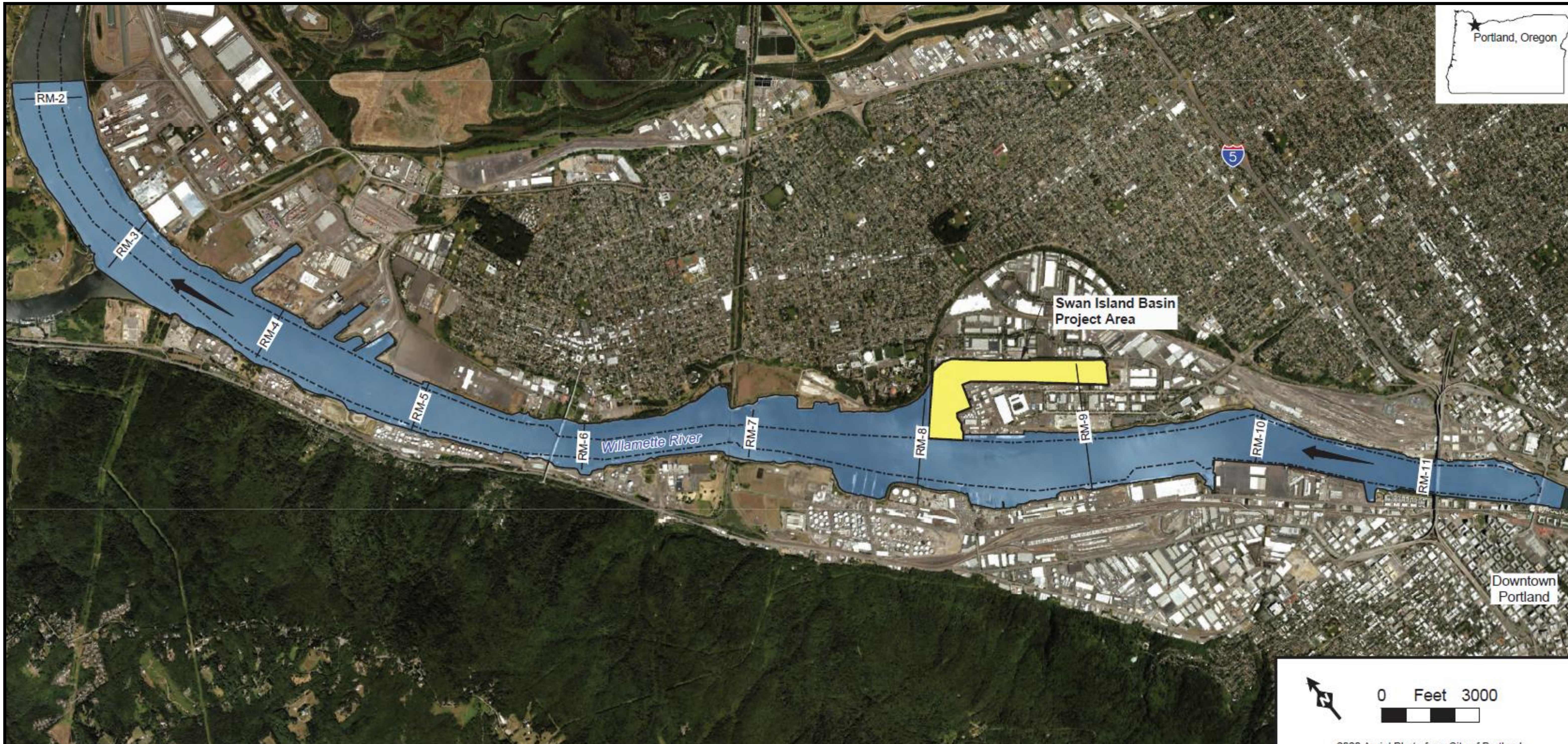


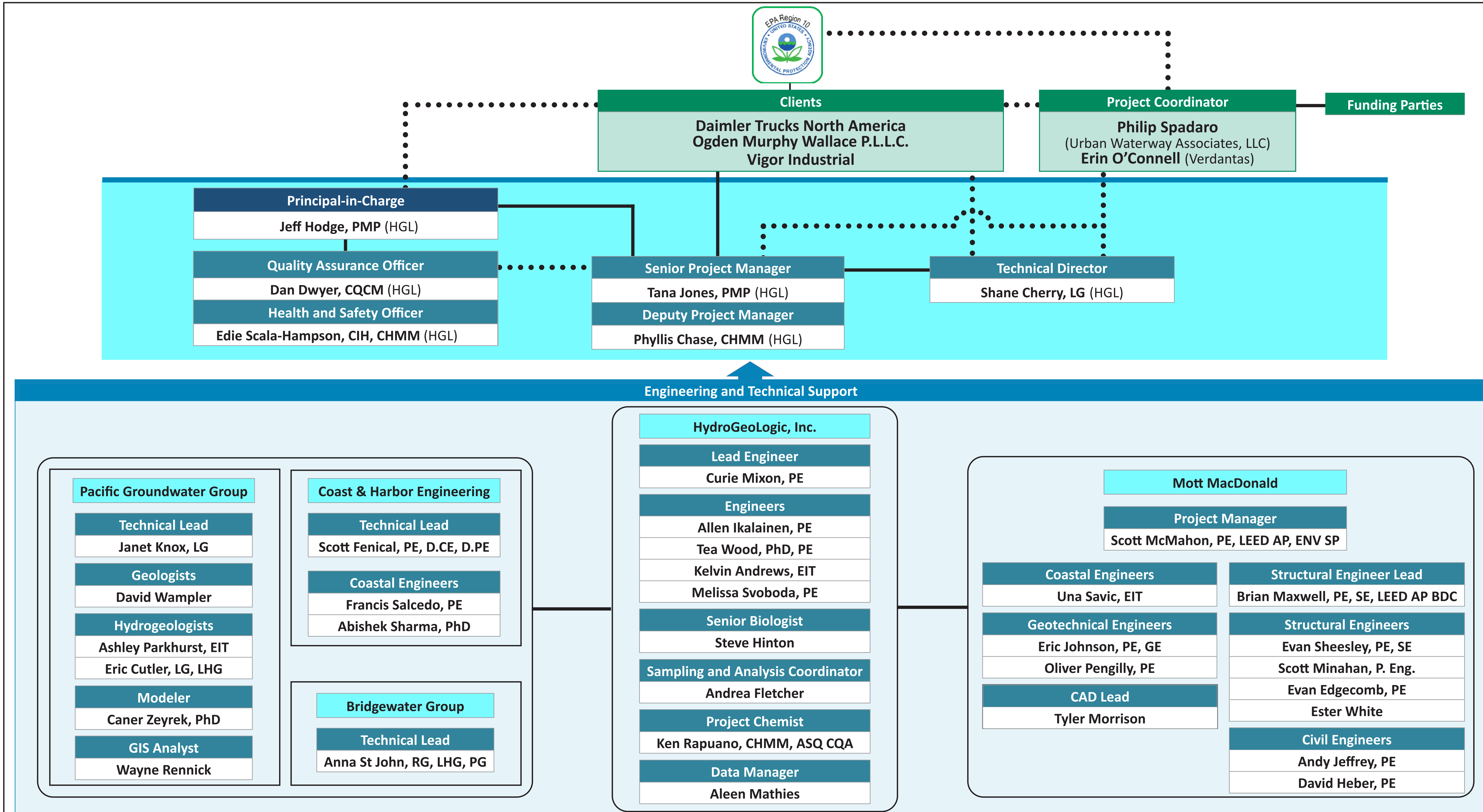
Federal Navigation Channel (USACE 2020)
River Flow Direction
Swan Island Basin Project Area
Portland Harbor Superfund Site Boundary (River Mile 1.9 to 11.8)

Notes:
NOAA - National Oceanic and Atmospheric Administration
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers
Source:
NOAA, 2016. Booklet Chart, Willamette River – Swan Island Basin, NOAA Chart 18527 at URL:
https://www.charts.noaa.gov/BookletChart/18527_BookletChart.pdf
- Navigation Channel

Figure 1-1
SIB Project Area Location Map

Prepared on 9/13/2024
Remedial Design Work Plan
Swan Island Basin

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Reporting
Communication
Management Team
Technical Team

Notes:
ASQ = American Society for Quality
CHMM = Certified Hazardous Materials Manager
CIH = Certified Industrial Hygienist
CQA = Construction Quality Assurance
CQCM = Construction Quality Control Manager
D.CE = Diplomate, Coastal Engineering
D.PE = Diplomate, Port Engineering
ENV SP = Envision Sustainability Professional
LEED AP = Leadership in Energy and Environmental Design Accredited Professional
LEED AP BDC = Leadership in Energy and Environmental Design Accredited Professional (Building Design & Construction)
LG = Licensed Geologist
LHG = Licensed Hydrogeologist
PE / P. Eng. = Professional Engineer
PG = Professional Geologist
PhD = Doctor of Philosophy
PM = Project Manager
PMP = Project Management Professional
QA = Quality Assurance
RG = Registered Geologist
SE = Structural Engineer

Figure 2-1
Project Team Organizational Chart

Prepared on 2/5/2025
Remedial Design Work Plan
Swan Island Basin

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

APPENDIX A

CAP EVALUATION

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APPENDIX A - CAP EVALUATION - REVISION 2
REMEDIAL DESIGN SERVICES, SWAN ISLAND BASIN PROJECT AREA
CERCLA DOCKET NO. 10-2021-001
PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

APPENDIX A - CAP EVALUATION

The Cap Evaluation Technical Memorandum was included as Appendix A of the Basis of Design Report (BODR) (HGL, 2024a) and has been updated and appended to the Remedial Design Work Plan (RDWP). This Technical Memorandum presents an update to the conceptual cap evaluation used for the Remedial Design (RD) conducted for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. The updates were completed to address the U.S. Environmental Protection Agency (EPA) comments on Revision 1 presented in the BODR (HGL, 2024a). The HydroGeoLogic, Inc. (HGL) team performed the work on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (EPA, 2017) and the Administrative Settlement Agreement and Order on Consent (EPA, 2021a). The data used in this cap evaluation were collected in accordance with the final Pre-Design Investigation (PDI) Work Plan, which the EPA approved in May 2022 (HGL, 2022), and were reported in the PDI Evaluation Report (ER) (HGL, 2024b).

The objective of this cap evaluation is to provide a preliminary evaluation of chemical criteria and physical constraints to evaluate a conceptual cap that is protective of human health and the environment. This evaluation will help with determining whether capping is a viable remedial approach for SIB. Information from this cap evaluation will be used in the future refinement of the capping assessment during the Draft 50% RD.

Cap evaluation includes chemical isolation and physical considerations. Section 1 discusses capping as a remedial approach. Section 2 describes the evaluation of the chemical isolation component considerations used in this cap evaluation. Section 3 discusses the physical considerations used in this cap evaluation including cap footprint, erosion protection layer for the engineered cap, and geotechnical factors. Section 4 outlines additional considerations to include work around structures, capping monitoring, capping operation and maintenance, design life, and consistency with anticipated and in-river uses. Section 5 summarizes the findings of this cap evaluation that will be utilized in the development of the RD.

1.0 CAPPING AS A REMEDIAL APPROACH

Capping is a remedial approach involving the placement of clean covering or isolating material to cover and separate subaqueous contaminated sediment from the water column to mitigate risks posed by contaminated sediments to human health and the environment. The material used in capping may consist of layers of sand, sediments, and/or other materials. Capping creates a physical barrier between contaminated sediments and benthic organisms populating the top sediment layer; reduces contaminant fluxes due to organism-induced mixing of contaminated

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sediments (bioturbation); stabilizes contaminated sediments to prevent resuspension during high-flow conditions; and provides resistance to the transport processes that result in chemical release from the sediments (Lampert and Reible, 2009). In situ capping refers to the placement of the cap at the contaminated site, while ex situ capping, which is not being considered for the SIB SMA, refers to the capping of contaminated sediment dredged and moved to a separate location (Randall and Chattopadhyay, 2013). Sand or coarse media is often used as a cap layer, which facilitates in situ placement of the cap. Because contaminants are often associated with fine-grained particles, contaminated sediments often have high water content, low load-bearing capacity, and low shear strength, which is a concern with regards to cap displacement or resuspension that needs to be addressed as part of this design (Reible, 2008). A reactive cap incorporates sorbent material (such as granular activated carbon [GAC]) within the capping material and relies on the sorptive properties of contaminants to slow down the contaminant migration through the cap by accumulation within the clean cap layer (Lampert and Reible, 2009).

As summarized in Processes, Assessment and Remediation of Contaminated Sediments (Reible, 2014), capping contaminated sediments following dredging operations and capping dredged material has been a common practice by the U.S. Army Corps of Engineers (USACE) since the 1970s. Field studies including sediment coring were performed on these early USACE sites to evaluate long-term effects of caps on contaminant levels. Those studies revealed sharp gradients in concentration between the underlying material and the caps. However, the analysis was based on bulk solids and was inherently biased due to differences in partitioning between the sediment and sand. The application of sand and sediment caps as a remediation technology for contaminated sediments was subsequently investigated. Thibodeaux et al. (1991) proposed using capping with clean sediments to create a diffusive barrier for reducing the concentrations and fluxes from sediments contaminated with polychlorinated biphenyls (PCBs). Wang et al. (1991) found that a layer of clean sediment successfully reduced concentrations of 2,4,6-trichlorophenol. Later laboratory studies used a sorption-diffusion model to predict the observed behavior (Thoma et al., 1993). Based on initial successes, other studies were employed using clean sands and other “active” materials that attempted to sequester or enhance degradation of the contaminants (Reible, 2014). More recently, capping has been used on a variety of sites such as Aberdeen Proving Ground, Anacostia River, Barge Canal, Bellingham Bay, Bremerton Naval Complex (OU B), Callahan Mining, Commencement Bay, Detroit River, Eagle (East) Harbor, Fox River & Green Bay, Galaxy/Spectron, Grasse River, Hudson River, Lower Duwamish, McCormick & Baxter Site on Willamette River, Penobscot River, etc. (ITRC, 2023).

1.1. CAPPING DESIGN EVALUATION

This engineered cap design evaluation was performed in accordance with the following cap design guidance documents:

- *Contaminated Sediments Remediation: Remedy Selection for Contaminated Sediments* (CS-2) (ITRC, 2014)
- *Sediment Cap Chemical Isolation Guidance* (SD-1) (ITRC, 2023)
- *Guidance for Subaqueous Dredged Material Capping* (Palermo et al., 1998a)

Generally, caps are designed to:

- Prevent resuspension and transport of sediment contaminants through processes such as advection, dispersion/diffusion, and surface exchange (stabilization);
- Attenuate and/or prevent migration of contaminants in porewater (chemical isolation); and
- Prevent benthic communities from direct contact with underlying contaminated sediments (bioturbation) (ITRC, 2023).

Geotechnical analysis is included in this cap evaluation to assess the stability of an engineered cap against bearing failure, settlement, sliding or slope displacement, and both cap and sediment material migration or mixing. Evaluation of seismic risk was also considered.

1.2. CAPPING DESIGN CRITERIA

Capping design criteria were defined in ROD Section 14.2.9.1 (EPA, 2017) and are applicable to the entire PHSS, including general applicability to the SIB. ROD design criteria are further described below.

- Caps designed to consider the following elements:
  - Sufficient chemical isolation layer to reliably contain underlying contamination;
  - Use of reactive material to contain contamination to meet remedial action objectives;
  - Use of reactive material to prevent contamination migration through the cap, accounting for the degrees of upland source control;
  - Potential for adverse impacts to the floodway due to flood rise;
  - Ability of cap to withstand more frequent floods with higher peak flows anticipated to be more common with climate change;
  - Logistics of the placement of caps below or adjacent to structures;
  - The presence of debris that could hinder cap performance;
  - The slope of the sediment bed;
  - Consistency with anticipated land and in-river uses; and
  - Appropriate earthquake design elements for contingency level events.
- Caps constructed to minimize adverse effects on the in-river and riparian habitat, including the loss of shallow water habitat;
- Caps constructed with suitable habitat materials, where applicable;
- Caps constructed on sediment bed that can support the cap during placement;
- Caps constructed with sufficient armor material to remain in place when subject to erosive forces from wind-and vessel-generated waves, river current; and propeller wash (propeller [prop] wash); and

- Where the cap is installed within the navigation channel and future maintenance dredge areas, verifying that the cap is compatible with current and anticipated waterway use and consideration of the current and authorized channel depth, the potential for an increase to the currently authorized channel depth, future navigation and maintenance dredging, and an appropriate buffer depth to ensure the integrity of the cap. The U.S. Army Corps of Engineers (USACE) maintains the navigation channel, which does not extend into the SIB. Future maintenance dredging areas are discussed in Section 2.6.3 of the BODR.

1.3. CAPPING DESIGN PERFORMANCE STANDARDS

Caps will be designed to achieve suitable chemical isolation that is protective of human health and the environment, which was evaluated using cleanup levels (CULs) as a performance standard. The targeted design life, or the time period over which the cap is designed to meet the performance standards for contaminants of concern (COCs), is 100 years (EPA, 2021b). The 100-year design life selected is a widely accepted design life for caps (ITRC, 2023), as well as design life used for representative site and capping options modeling as identified in the ROD Section 6.5.1 (EPA, 2017).

The ROD Errata #2 Table 17 (EPA, 2020) provides applicable CULs, which are summarized for modeled contaminants in Table 1-1. The analytes 1,2,3,4,7,8-HxCDF, 1,2,3,7,8-PeCDD, 2,3,4,7,8 PeCDF, and 2,3,7,8-TCDF do not have surface water or groundwater CULs; therefore, indicator surface water concentrations were derived from the 2,3,7,8-TCDD surface water CUL based on their respective Toxic Equivalency Factor from Table 17 CULs for 2,3,7,8-TCDD (EPA, 2017).

2.0 CHEMICAL ISOLATION LAYER CONSIDERATIONS

Based on Appendix L of PDI ER (HGL, 2024), the refined sediment management area (SMA) contains 1,419,000 cubic yards of in situ sediments exceeding remedial action levels (RALs)/Practical Quantitation Limits (PQLs) and PTW thresholds for ROD Table 21 COCs. Per the ROD Section 10, SMAs were identified as areas where containment or removal technologies were considered to immediately reduce risks upon implementation (EPA, 2017). As a result, capping is evaluated as a containment remedial technology in this section.

Chemical isolation layer components were evaluated using a modeling tool in order to design a cap that effectively contains underlying contamination to meet remedial action objectives established in the ROD. The modeling analyses were used to evaluate cap characteristics (e.g., thickness, composition) and the quantity of reactive amendment required to control the migration of contaminants under fate and transport mechanisms such as advection, diffusion, dispersion, biodegradation, and bioturbation. The modeling was performed in accordance with the ROD (EPA, 2017), Remedial Design Guidelines and Considerations (RDGC; EPA, 2021b), EPA (Palermo et al. 1998a) and Sediment Cap Chemical Isolation Guidance (SD-1) (ITRC, 2023). This section includes details regarding the inputs used in modeling efforts conducted using CapSIM, including site-specific concentrations and chemical, sediment, and cap material characteristics.

The purpose of this evaluation is to provide proof of concept of capping as an effective containment technology. This evaluation contains the most conservative input parameters with the intention of demonstrating that if the capping is effective in this most conservative scenario, it is also effective for each individual area-specific scenario. Development of various capping designs for area-specific parameters will be completed during RD. One-dimensional chemical mass transport modeling was performed to develop a conceptual-level chemical isolation layer design for an engineered sand cap included in remedial alternatives. The engineered sand cap modeling was performed using CapSIM Version 4.2 modeling software (Shen et al, 2018; Reible, 2023) and following Sediment Cap Chemical Isolation Guidance (SD 1) guidance (ITRC, 2023). CapSIM modeling evaluated the effectiveness of the cap in maintaining solid and porewater concentrations below sediment and groundwater CULs, respectively. This evaluation was completed at 30 centimeters (cm) below the top of the cap. The evaluation was for the 100 year design life (EPA, 2021b).

2.1. CapSIM MODELING SOFTWARE

The CapSIM modeling software was utilized to analyze fate and transport of contaminants in sediments and caps (Shen et al, 2018; ITRC, 2023). CapSIM simulates contaminant transport and reaction through sediment and caps for the purposes of assessing natural recovery processes and supporting cap and in situ treatment design. CapSIM simulates fate and transport processes in both the porewater and solid phases based on porewater concentrations of contaminants. CapSIM can also be used to model conditions that affect contaminants, including advection, diffusion, hydrodynamic dispersion, bioturbation, consolidation, benthic exchange, deposition, multispecies reaction, sorption, and desorption. The governing numerical equation for the model is a mass conservation equation for a one-dimensional stratified system composed of multiple layers with various physical and chemical properties. The model simulates all layers as saturated porous media with the solid particles as immobile except near the surface where particles can move due to bioturbation, erosion, deposition, or consolidation (Shen et al, 2018; ITRC, 2023).

2.2. CHEMICAL TRANSPORT MODELING APPROACH

The CapSIM modeling software was used to predict the mobility and partitioning of COCs. The analytical model was applied using site-specific characteristics to simulate the effectiveness of an engineered cap in reliably containing the flux of COCs into surface sediments. Reliable containment is defined in the PHSS Feasibility Study (FS) as having a contaminant concentration in the sediment cap porewater just below the sediment cap-surface water interface that meets regulatory levels for a period of 100 years (EPA, 2016). Based on the RDGC, the "results of the cap modeling should confirm that the cap can keep COC concentrations in the top 30 cm of the sediments and in associated porewater below the cleanup levels for the design period of 100 years" (EPA, 2021b). The applicable regulatory levels are detailed in Tables 17 and 21 of the ROD Errata #2 and Errata #3, respectively (EPA, 2020 and 2022) and summarized in Table 1-1. The methods and assumptions described below were used to provide an initial, conservative assessment of the cap characteristics and reactive amendments required to reliably contain the migration of contaminants for a 100-year period. Area-specific analysis of cap design will be completed during the Draft 50% RD.

The CapSIM modeling software also predicted the reliable time for containment of sediment and porewater (as groundwater) concentrations below CULs at the top surface of the chemical isolation layer for 37 individual contaminants and 3 COC summations (total carcinogenic polycyclic aromatic hydrocarbons [cPAHs], total polycyclic aromatic hydrocarbons [PAHs], and total polychlorinated biphenyls [PCBs]). The analytes included in this evaluation are based on the Focused COCs and Additional Contaminants included in Table 21 of the ROD Errata #3 (EPA, 2022). Individual cPAHs and PAHs for which sediment data was available were modeled and summed over the model run time as another point of evaluation for Total cPAHs and Total PAHs. In addition to Total PCBs, 9 individual PCB congeners with high concentrations relative to other congeners detected within the SMA were modeled. These were additionally summed over the model run time, however, as the nine congeners do not represent all PCB detections, their summation analogue provides a more qualitative indicator of COC migration. Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the depth of interest. The cap performance detailed in Section 2.4 is reported as the time-to-breakthrough. Cap scenarios that did not experience breakthrough within the modeled 100-year design life are reported to have a time-to-breakthrough of more than 100 years.

The model input parameters were based on site-specific data, where available, or literature values for comparable conditions. All chemical concentrations and 13 percent of capping material and sediment process input parameters were site-specific values. Site-specific input parameters were supplemented by typical modeling values or available literature values for chemical and material properties where needed. Sensitivity testing was performed to confirm that selected literature values produced a conservative cap design, as detailed in Section 2.5.

The following four conceptual chemical isolation layer cap design alternatives were modeled.

Cap alternatives with erosion protection layer (EPL):

- **Cap Alternative 1:** 2 feet (ft) (60 cm[1]) of unamended sand with overlying 2 ft (60 cm) erosion protection layer, and
- **Cap Alternative 2:** 1.97 inches (5 cm) of GAC-amended sand with overlying 2 ft (60 cm) erosion protection layer.

Cap alternatives without EPL[2]:

- **Cap Alternative 3:** 3 ft (90 cm) of unamended sand (2 ft [60 cm] unamended sand for CIL with overlying 1 ft [30 cm] unamended sand for bioturbation layer), and

[1] CapSIM uses metric measurements, while the rest of this BODR uses imperial measurements. As a result, this appendix contains rounded metric measurements in parenthesis, with converted imperial measurements in front of the parenthesis to remain consistent with other sections of this BODR. Tables and Attachment A related to CapSIM modeling are all in metric measurements due to being related to CapSIM input and output parameters.

[2] Cap Alternatives 3 and 4 included an additional 1 ft (30 cm) of unamended sand (Sand Layer). Unamended sand was chosen as a cost-efficient approach to evaluate that the chemical isolation layer cap can keep COC concentrations in the top 1 ft (30 cm) of the sediment and associated porewater below cleanup levels for the design period of 100 years per Section 5.2.6 (EPA, 2021b). This 1 ft (30 cm) also include a conservative bioturbation layer thickness of 7.87 inches (20 cm). All four alternatives were evaluated at the CPP for a conservative performance estimate in accordance with RDGC (EPA, 2021b) and comparability of alternative results.

- **Cap Alternative 4:** 1.97 inches (5 cm) of GAC-amended sand with overlying 1 ft (30 cm) unamended sand layer as a bioturbation layer.

The point of compliance was selected to be at the top surface of the chemical isolation layer (60 cm [2ft]) for cap alternatives 1 and 2, and 1 ft (30 cm) below the cap top surface for cap alternatives 3 and 4) based on the RDGC requirement to evaluate a cap's ability to contain COC concentrations below cleanup levels in the top 1 ft (30 cm) of the sediments and in associated porewater, and to ensure consistency in evaluation between the cap alternatives. These 12 inches (30 cm) include a conservative estimate of the thickness of the modeled depth of bioturbation reported in the ROD of 7.87 inches (20 cm) (EPA, 2017). See Section 2.3.6 for further discussion on bioturbation. Because the point of compliance was 2 ft (60 cm) or 1 ft (30 cm) below the top of the cap and surface water interface, it is very likely outside of the influence of bioturbation and therefore represents a conservative estimate of reliable containment.

Figure 2-1 illustrates the four conceptual chemical isolation layer cap design alternatives. modeled.

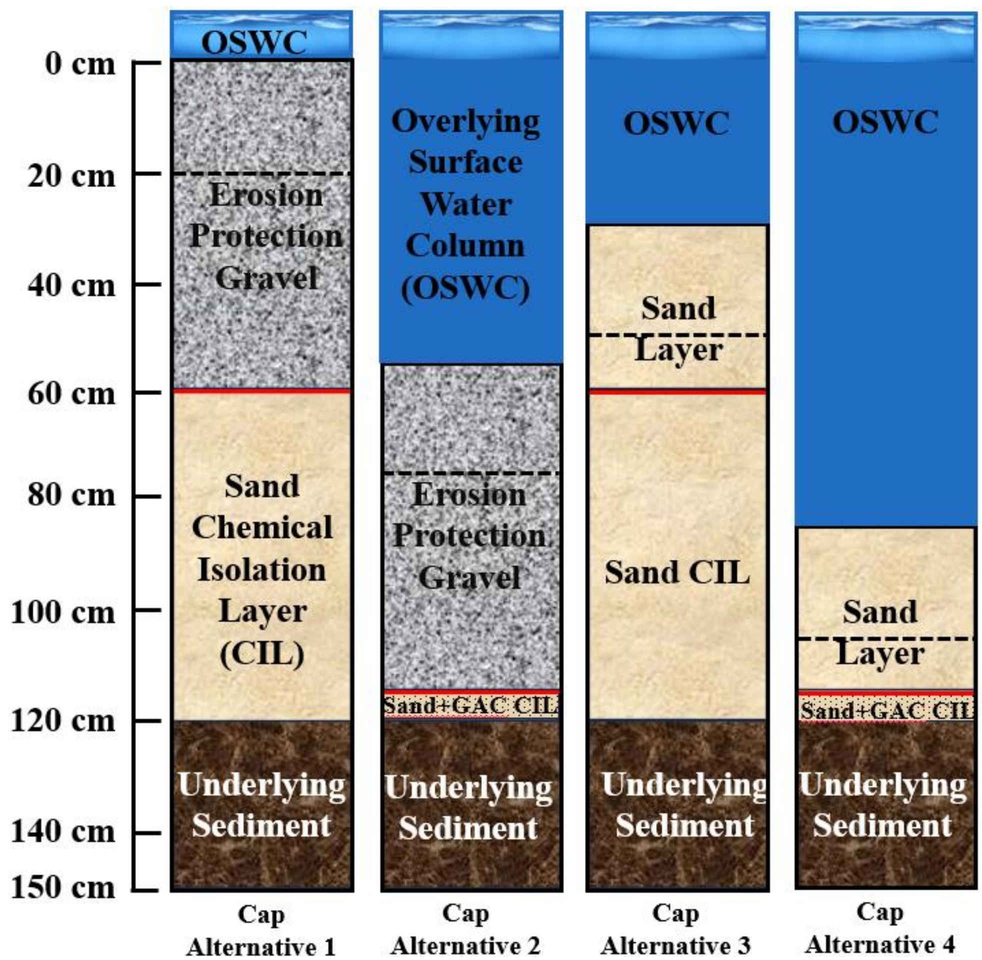

Figure 2-1. Depictions of Cap Alternatives 1 through 4.

The red line represents the depth at which the cap performance was evaluated, also referred to as the cap performance point (CPP). CPP was determined as the top of the chemical isolation layer. The dashed line represents the presumed maximum depth of bioturbation. Materials above and below the dashed line are the same. The layer thickness is in cm.

2.3. MODEL INPUTS

Input parameters were based on site-specific data when available, such as upwelling velocities and sediment COC concentrations, along with information from scientific literature, including inputs from other regional CapSIM applications (Tables 2-1 and 2-2). Conservative estimates were utilized throughout this cap evaluation that may have compounding effects and result in a very high safety factor incorporated into the design evaluated. Area-specific cap design, conducted during the RD, may include area-specific inputs that are less conservative to optimize cost while maintaining the effectiveness of the remedial cap. Details on the development of the various model input parameters are provided in the following sections.

Since the intent of this capping evaluation was to evaluate capping as a remedial approach to be used in the RD, a conservative approach was taken to evaluate if capping would be able to contain the contamination in the "worst-case scenario" observed on site. To evaluate the most conservative cap design, a “worst-case” scenario was used by evaluating 95th percentile of the observed sediment concentrations across the SIB. The 95th percentile was used instead of maximum concentration encountered on site to evaluate representative site-wide conditions that are not impacted by potential maximum concentration outliers that would cause overly conservative cap design. In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSIM and used as the initial underlying sediment porewater concentration, consistent with the same guidance.

2.3.1. Native Sediment and Thickness of Model Domain

The underlying sediment was assumed to be composed primarily of clayey silt based on observations noted in the Appendix A of the PDI ER (HGL, 2024). In anticipation of dredging or removal prior to cap installation, the total organic carbon (TOC) results of the subsurface sediment (deeper than 15.8 inches [40 cm]) core samples (D-8.90, E-9.02, and D-9.09) presented in Appendix I of the *Head of Swan Island Lagoon Field Sampling Data Report* (Pacific Groundwater Group, 2019) were averaged. From the surface and subsurface core samples, the TOC of sample G-9.15-0 to 18-102418, which was composed of 95.5 percent sand, was used to select the native sand fraction organic carbon (f_{OC}) of 0.62 percent. This native sand f_{OC} and the average percentage of sand per core sample were used to adjust the average TOC to a TOC for site-specific clayey-silt, 35,530 milligrams per kilogram (3.553 percent f_{OC}). Sediment thickness was modeled as 1 foot (ft) (30 cm), consistent with ROD Section 6.5.2 and Interstate Technology & Regulatory Council (ITRC) guidance (EPA, 2017; ITRC, 2023).

2.3.2. Initial Sediment and Porewater Concentrations

The 95th percentile surface or subsurface sediment concentrations from the historical and PDI sediment dataset for each of the 37 individual contaminants and 3 COC summations were selected within the area of each modeled scenario (HGL, 2024). These concentrations were assigned uniformly throughout the modeled sediment thickness. The initial sediment concentrations are included in Table 2-3. Table 2-3 also includes the equivalent porewater concentration that would result from equilibrium phase partitioning using the assumed partitioning coefficients (Table 2-1) and f_{OC} of the existing sediment. These model-calculated porewater concentrations were also used as the bottom boundary concentrations and provided a constant supply of contamination, without depletion through time. The referenced PDI sediment dataset is pending approval by EPA and initial sediment concentrations are subject to change as part of EPA review.

2.3.3. Darcy Velocity

The upwelling velocity is based on a steady, uniform Darcy velocity across the basin. The highest 50-hour maximum specific discharge (1.07 cm per day at Station 10A), presented in the Appendix B of PDI ER (HGL, 2024), was rounded to 1.1 cm per day, converted to units of cm per year, and rounded up to the next whole number for use within CapSIM (402 cm per year; 158.3 inches per year).

2.3.4. Partition Coefficients

All chemical partition coefficients were gathered from scientific literature (Table 2-1). The linear sorption model was applied to the sediment, sand, and erosion protection materials, while Freundlich sorption isotherm was applied to the GAC amendment. The linear sorption model is a widely accepted model for sorption of hydrophobic organic compounds onto sediments (Karickhoff et al., 1979) as follows:

$$K_d = K_{oc} * f_{oc}$$

Where K_d is a constant related to the organic carbon normalized partitioning coefficient, K_{OC} is organic carbon normalized partition coefficient, and f_{OC} is fraction of organic carbon primarily responsible for accumulation of contaminates to sediments (Goring CA, 1962; Reible, 2014).

The Freundlich sorption isotherm is frequently used to predict particle concentrations (q) from porewater concentrations (C) for activated carbon. The relation is as follows:

$$q = K_f * C^{1/n}$$

Where K_f is the adsorption capacity at unit concentration and 1/n (N) is the adsorption intensity (Reible, 2014).

In the amended cap layer models, it was assumed that GAC and clean sand were evenly mixed within the chemical isolation layer and the above sorption isotherms applied to their respective particles in the mixture.

The organic carbon partition coefficients, K_{OC}, and sources for each are presented in Table 2-1. For DDx (comprising DDD, DDE, and DDT); PCDDs/PCDFs; and naphthalene, K_{OC} values were available from multiple sources. The minimum, maximum, and average K_{OC} were each modeled and the value that resulted in the highest porewater and total solid concentrations near the surface of the cap was retained. In the cases where the same K_{OC} value did not result in both the highest porewater and total solid concentrations, judgement was employed to select the value that would be the most conservative across media.

The K_f values and sources for each are presented in Table 2-1. For each COC, K_f and 1/n (N) values originated from the same source. To ensure a conservative cap evaluation during preliminary Table 21 COC modeling, K_f values for DDx (comprising DDD, DDE, and DDT);

dioxins/furans; and naphthalene were modified by a factor of $10^{\pm 1}$ to create high, medium, and low alternatives. These were each modeled and, as with K_{OC}, the K_f that resulted in the highest porewater and total solid concentrations near the surface of the cap was retained (Table 2-4). Based on the generally consistent results of this sensitivity testing, the K_f used in later modeling for each COC was the scientific literature value reduced by a factor of 10 ($K_f \cdot 10^{-1}$). The Freundlich adsorption intensity exponent was not modified.

2.3.5. Fraction Organic Carbon in Capping Materials

The fraction organic carbon in the isolation layer sand was not available from nearby materials suppliers. Other regional remediation projects assumed the capping material to have between 0.05 percent and 2.0 percent f_{OC}. The Former Portland Gas Manufacturing Site (Anchor QEA, 2020) and the Crawford Street Site (GeoEngineers, 2022), both in Portland, Oregon, are among several projects that assumed the sand to have an f_{OC} of 0.1 percent for CapSIM modeling as it "represents the lower end of the range for dredged Columbia River sand" (GeoEngineers, 2022).

In all modeling scenarios, the sand present in the chemical isolation layer was assumed to have a f_{OC} of 0.1 percent. Sensitivity testing assuming a sand f_{OC} of 0.05 percent as a low organic carbon condition was additionally completed, as detailed in Section 2.5.6.

The modeled erosion protection layer in Cap Alternatives 1 and 2 was assumed to be composed of gravel with a f_{OC} of 0.0 percent as this layer is not intended to provide chemical sequestration. The GAC amendment to the chemical isolation layer is assumed to have a f_{OC} of 100 percent, which is the CapSIM default for the material (Reible, 2023).

2.3.6. Bioturbation and Benthic Boundary Layer Condition

Bioturbation is a mixing process that affects both the porewater and solids and is caused by benthic organism activities. Bioturbation accounts for biological activities such as burrowing, sediment ingestion, and bioirrigation as benthic organisms flush their burrows with overlying water (ITRC, 2023). Bioturbation enhances particle mixing in the biologically active zone and exchange of dissolved substances between the porewater and overlying surface water (ITRC, 2023). This zone is typically limited to near surface (5 to 15 cm below sediment-surface water interface) (Reible, 2014). The feeding habits of benthic organisms may lead to uptake of contaminants. For this reason, caps at SIB will be designed with intent to contain contaminants below the zone where bioturbation occurs, also known as bioturbation layer or biologically active zone. Per ROD Section 14.2, "The biologically active zone of the Site that supports benthic communities is in the 'shallow' sediment (less than 38 cm deep) and is generally 10 to 20 cm deep, based on sediment profiling imaging data" (EPA, 2017). In this zone, the physical and chemical characteristics, such as organic carbon and redox conditions, may be significantly different as compared to underlying sediment (Shen, 2017). In addition to designing a cap that would minimize risk of exposure of benthic organisms to contaminants in sediment and porewater, cap evaluation simulations also modeled bioturbation using a conservative bioturbation layer thickness of 20 cm. The bioturbation modeling approach was incorporated in CapSIM assuming the mixing process is random, and the bioturbation flux is a Fickian diffusion process[3] for both the free molecular (porewater) and the sediment-associated contaminant (Shen, 2017; Shen et al, 2018).

Following CapSIM recommendations (Reible, 2023), the mass transfer benthic boundary condition type was used for modeling. To ensure conservative near-surface concentrations, the mass transfer coefficient was set to 0.1 cm per hour (876 cm/year) for all COCs. Sensitivity testing was performed on the mass transfer coefficient (Section 2.5.14) and the difference in resulting porewater concentrations was found to decrease with increasing depth. At the depth of interest, the difference between mass transfer coefficients is negligible.

In addition to evaluating the impact of bioturbation on contaminant fate and transport through the cap, cap evaluation efforts included additional consideration of protection of the benthic community or aquatic life. To achieve this, the cap design was evaluated at CPP, which was beneath the conservative benthic boundary of 20 cm below sediment-surface water interface. This evaluation at CPP was done with the intent of implementing a cap that would contain contamination below the bioturbation layer to mitigate the risk of benthic organisms coming into contact with underlying contaminated sediments (ITRC, 2023).

During the Draft 50% RD, additional consideration will be taken to consider the substrate needed to support or enhance the existing or desired benthic community. Cap design may also consider the potential for short-term impacts to the benthic community from the amendment dose. Cap design will also consider the option to promote ecosystem recovery to the extent practicable, in addition to protection from chemical contaminant impacts (ITRC, 2023).

2.3.7. Model Input Summary

All chemical properties and partitioning coefficients are presented in Table 2-1. The non-chemical specific model input parameters are presented in Table 2-2. This table is divided into sections that are specific to the sediment or capping materials and those that are general system parameters. Capping material-specific input parameters will be based on manufacturer specifications in the Draft 50% RD.

2.4. RESULTS OF CAP MODELING EVALUATION

The results of the cap chemical transport modeling indicate that chemical isolation layer comprising 5 cm of 5.0 percent GAC-amended sand is predicted to reliably contain the flux of Table 21 COCs into overlying cap layer and water column. This conclusion is applicable regardless of whether erosion protection gravel or sand layers are placed on top of the chemical isolation layer (Cap Alternatives 2 and 4). This conclusion also applies to the concentration-based scenarios that were sensitivity tested in Section 2.5.1. The time-to-breakthrough for each modeled scenario for the amended cap (Cap Alternatives 2 and 4) alternatives are available in Table 2-5. The efficacy of the GAC amendments in this modeling effort were driven by Total cPAHs surpassing its groundwater CUL. The time-to-breakthrough for each modeled scenario for the unamended cap (Cap Alternatives 1 and 3) alternatives are available in Table 2-6. Resulting porewater

[3] The Fickian diffusion process is diffusion driven by concentration gradient (e.g., flux moves from areas with high concentration into areas of low concentration).

concentrations for the Initial Scenario – Whole Basin are graphed against depth and time for each of the four modeled cap alternatives (Attachment A).

According to modeling results, unamended sand caps are insufficient for containing the flux of COCs into surface sediments for any contaminated sediment within the SIB SMA. The time-to-breakthrough was primarily driven by porewater concentrations of DDT.

2.5. SENSITIVITY ANALYSES

Several of the model input parameters have uncertainty or variability associated with them, such as initial COC concentrations, material f_{OC} and sorption parameters, groundwater upwelling velocity, sand cap thickness, and temporal and spatial discretization.

Unless otherwise noted, the sensitivity analyses were performed for the Whole Basin scenario (Section 2.5.2) using a 1.97-inch (5-cm) thick sand cap amended with 1.0 percent GAC by weight and topped with 1 ft (30 cm) of clean sand (Cap Alternative 4) with an upwelling velocity of 158.3 inches/year (402 cm/year), which is equal to the highest 50-hour maximum specific discharge presented in Appendix B of the PDI ER (HGL, 2024). The CPP for all sensitivity scenarios, except when related to CPP variation, is the top of the chemical isolation layer (30 cm below the cap-surface water interface). The reported percentage change in time-to-breakthrough or of input parameter values is the Relative Percent Difference (RPD)[4]. A list of completed sensitivity analyses and the resulting differences in time-to-breakthrough are detailed in Table 2-7a. Sensitivity analyses for unamended cap thickness, K_{OC} variation, upwelling velocity, material f_{OC}, CPP, and spatial discretization were additionally performed for the Whole Basin scenario (Section 2.5.2) using a 2-ft (60-cm) thick unamended sand cap topped with 1 ft (30 cm) of clean sand (Cap Alternative 3) with an upwelling velocity of 158.3 (402 cm/year), and are presented in Table 2-7b.

2.5.1. Initial COC Concentrations

Three conceptual scenarios were modeled to understand the potential range of necessary cap compositions and amendments based on changes in initial COC concentrations. The assumptions regarding infinite supply, no degradation, and uniform concentration throughout the sediment profile provide a safety factor for the design.

The initial and bottom boundary concentrations for each scenario are listed in Table 2-3.

- **Initial Scenario (Section 2.3.2) –** Whole Basin: Representative of sediment with the ‘worst-case’ sediment-wide concentrations to understand the upper range of potential cap amendments. Initial sediment concentrations were set to the 95th percentile of the observed sediment concentrations across the SIB. 95th percentile was used instead of maximum concentration to evaluate representative site-wide conditions that are not impacted by maximum concentration outliers. In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated

[4] RPD is the ratio of the absolute difference between two values to the average of the two values, calculated as a percentage [$(absolute\ difference\ /\ average) * 100$].

within CapSIM and used as the initial underlying sediment porewater concentration, consistent with ITRC guidance (ITRC, 2023).

- **Alternative Scenario 1 –** Low concentration: To better understand the difference between compliance with sediment CULs as compared to porewater CULs, and to explore the minimum requirements of a sediment cap designed for cleanup, initial sediment concentrations were set to the ROD Table 17 sediment CULs (EPA, 2017 and 2020). The associated equilibrium porewater concentrations were calculated within CapSIM and used as the bottom boundary concentration, consistent with ITRC (ITRC, 2023) guidance. For contaminants with only groundwater or surface water CULs, the groundwater or surface water CULs were used instead, and the sediment concentrations were calculated within CapSIM. Contaminants with neither sediment, groundwater, nor surface water CULs were not modeled in this scenario. The reasoning for inclusion of each contaminant has been expanded upon in Section 2.3.2. Some individual PAHs and all individual PCBs do not have CULs but were summed over the 100-yr period and evaluated against the Total PAH and Total PCB CULs.
- **Alternative Scenario 2 –** End of Basin: This scenario focuses on the end of the basin, defined by grid cell columns 24 and higher (Figure 2-2). This area of the basin experiences less vessel traffic and has a deeper vertical extent of contamination than other areas within the SMA; therefore, the area has higher potential to be capped, although area-specific analysis will be completed during RD. Initial sediment concentrations were set to the 95th percentile observed sediment concentrations in this area of the SIB (HGL, 2024). In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSIM and used as the bottom boundary concentration, consistent with ITRC guidance (ITRC, 2023).

Alternative Scenarios 1 and 2 were reliably contained for 100 years by a 1.97 in (5 cm) sand cap amended with 5.0 percent GAC by weight, when topped by either erosion protection (Cap Alternative 2) or clean sand (Cap Alternative 4) when assuming area-specific highest 50-hour maximum specific discharge (Table 2-5). Additionally, the Whole Basin (Initial Scenario) scenario and Alternative Scenario 2 were reliably contained for 100 years by Cap Alternatives 2 and 4 when amended with 1.0 percent GAC by weight. In the 1.0 percent GAC amended caps, Alternative Scenario 1 would exceed sediment CULs after 59 years, driven by Total (summed) PAHs, with the highest contributing individual PAHs being acenaphthene, fluorene, and naphthalene. Increasing the thickness of the 1.0 percent GAC amended isolation layer to 3.54 inches (9 cm) would extend the reliable containment of sediment concentrations at the cleanup levels to greater than 100 years. These three PAHs were all detected well below the calculated sediment concentrations that correspond to their respective groundwater CULs.

2.5.2. Whole Basin Analysis

Sediment COC concentrations at the 95th percentile observed concentrations from within the whole SIB are reliably contained for 100 years by a 1.97-inch (5-cm) sand cap amended with either 5.0 percent or 1.0 percent GAC by weight, when topped by either erosion protection (Cap Alternative 2) or clean sand (Cap Alternative 4) as shown in Table 2-5.

2.5.3. Capping of Low Concentration Sediments

Modeling indicates that initial low concentration ("clean") sediment COC concentrations at the sediment CULs partition under equilibrium conditions to porewater concentrations in excess of the groundwater CULs for Total cPAHs, DDD, DDE, and DDT. When modeling with an upwelling velocity of 402 cm/year, the reliable containment time at the top surface of the chemical isolation layer, driven by naphthalene and DDT porewater concentrations, is as follows:

- 4 years for Cap Alternative 1, 2 ft (60 cm) unamended sand with overlying 2 ft (60 cm) erosion protection layer; and
- 6 years for Cap Alternative 3, 3 ft (90 cm) unamended sand.

The low concentration sediment was effectively contained for the 100-year design life at the CPP by Cap Alternatives 2 (1.97-inch [5-cm] GAC-amended sand with overlying 2 ft (60 cm) erosion protection layer) and 4 (1.97-inch [5-cm] GAC-amended sand with overlying 1 ft [30 cm] sand layer) with GAC amendment of 5.0 percent. The time-to-breakthrough for the low concentration sediment was 59 years at the CPP for Cap Alternatives 2 and 4 with a GAC amendment of 1.0 percent, with the highest contributing individual PAHs being acenaphthene, fluorene, and naphthalene.

These modeling findings show that even areas of SIB that are at the sediment CULs will require amended capping to achieve the more stringent porewater CULs; therefore, the remaining results discussion focus on Cap Alternatives 2 and 4.

2.5.4. Groundwater Upwelling Velocity

Appendix B of the PDI ER (HGL, 2024) reported measurements of 50-hour maximum specific discharges ranging from 0.1 inches/day (0.264 cm/day or 96.4 cm/year) at Station 8D to 0.433 inches/day (1.1 cm/day or 402 cm/year) at Station 10A[5]. As reported in Section 2.4, Cap Alternative 4 with a 5 cm chemical isolation layer using the highest 50-hour maximum specific discharge from Station 10A had a time-to-breakthrough of 100+ years.

Measured 50-hour average specific discharges ranged from -0.001 cm/day (negative value indicating recharge that equals -0.144 inches/year [-0.365 cm/year]) at Station 1D to 0.087 inches/day (0.22 cm/day or 80.3 cm/year[5]) at Station 10A. The average 50-hour average specific discharge across all 21 stations is 0.025 inches/day (0.064 cm/day or 23.5 cm/year). As a sensitivity analyses, the Whole Basin scenario was modeled using the average 50-hour average specific discharge (rounded up to 24 cm/year) (PDI ER, 2024). A very high upwelling velocity of 600 cm/year was additionally modeled as a sensitivity test. The time-to-breakthrough for the 1.97-inch (5-cm) chemical isolation layer was 100+ years in both upwelling sensitivity scenarios. The Darcy velocities used in sensitivity analyses and their sources are summarized in Table 2-8.

The SIB SMA is subject to tidal influence, which was modeled using a diurnal oscillation period with variable magnitudes based on the recorded 50-hour maximum specific discharge values.

[5] Values used in CapSIM modeling were rounded up during conversions, so a more conservative value of 158.3 inches/year (402 cm/year) was used in modeling efforts.

The highest 50-hour maximum specific discharge was 0.433 inches/day (1.1 cm/day, rounded up to 402 cm/year) observed at Station 10A, which was used as the base value in a conservative model with an oscillating upwelling velocity of 158.3±79.1 inches/year (402±201 cm/year). For the high concentration Whole Basin scenario under these assumptions, the time-to-breakthrough for Cap Alternative 4 with 1.0 percent GAC by weight remains at 100+ years.

2.5.5. Impact of Dredging

The potential impact of dredging was evaluated for the End of Basin alternative scenario 2 discussed above. In this scenario (also referred to as Alternative Scenario 3), cap evaluation was completed for the End of Basin concentrations following 3 ft (91 cm) dredge. This scenario aides in conceptual understanding of the impact of a moderate surface dredge on cap performance. Initial sediment concentrations were set to the 95th percentile observed sediment concentrations in the end of basin area of the SIB that have an upper depth of 3 ft or deeper. In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSIM and used as the bottom boundary concentration, consistent with ITRC (2023) guidance. The area-specific highest 50-hour maximum specific discharge used in Alternative Scenarios 2 and 3 was recorded at Station 2D (0.32 inches/day [0.808 cm/day, which equals 295 cm/year]).

The end of basin, with and without dredging (Alternatives Scenarios 2 and 3), are both reliably contained for 100 years by a 1.97-inch (5-cm) thick sand cap amended with 1.0 percent or 5.0 percent GAC by weight[6] (Cap Alternatives 2 and 4).

2.5.6. Material f_{OC}

The f_{OC} of the sand in the chemical isolation layer and the gravel in the erosion protection layer was conservatively assumed from relevant scientific literature values, and the f_{OC} in acquired materials is subject to variation based on the material source. As a sensitivity analysis, the time-to-breakthrough was determined for a low organic carbon (0.05 percent f_{OC}) sand condition in Cap Alternative 4 amended with 1.0 percent and 5.0 percent GAC by weight for the Initial Scenario–Whole Basin (see Section 2.5.1). The time-to-breakthrough was not impacted by the change in sand f_{OC}, as the relative change in sorptive capacity is minimal compared to the available GAC. This sensitivity test was also performed for unamended Cap Alternative 3 to quantify the impact of sand f_{OC} when sand alone is providing chemical sequestration. The time-to-breakthrough in total solid was reduced from 29 to 21 years, an RPD of 32 percent, driven by Total PCBs. The time-to-breakthrough in porewater was reduced from 6 to 3 years, an RPD of 66.7%, driven by PeCDF. These results are reported in Tables 2-5 and 2-6 alongside the results for the 0.1 percent f_{OC} sand and modeling used the highest 50-hour maximum specific discharge.

[6] During area-specific remedial design in the RD, parameters such as foc of the sand and percentage of the amendments will need to be verified by the supplier. Percentage of GAC used here is strictly for modeling purposes to be able to complete sensitivity testing and obtain meaningful differences in measurements. Field application rates will be higher.

Any innate f_{OC} that is present in the sand or gravel in excess of the modeling assumptions at the time of cap construction or acquired by the capping materials due to normal life-cycle activities of benthic organisms will increase the potential for COC adsorption by the capping materials and extend the reliable containment time.

2.5.7. GAC Amendment Percentage

The weight percentage of the GAC amendment in the amended caps that were modeled (Cap Alternatives 2 and 4) was assumed to be 5.0 percent by weight for constructability. Natural inconsistencies in mixing have the potential to increase or reduce the GAC percentage present in areas of an amended cap. As a sensitivity test, all concentration-based scenarios were additionally modeled assuming a GAC amendment of 1.0 percent by weight. These results are presented alongside the 5.0 percent GAC by weight results in Table 2-5. The time-to-breakthrough for the Whole Basin (Initial Scenario) when modeled with 1.0 percent GAC by weight and the highest 50-hour maximum specific discharge (158.3 inches/year [402 cm/year]) remained 100+ years.

2.5.8. Chemical Isolation Layer Thickness

For ease of comparison across sensitivity scenarios, the thickness of the amended chemical isolation layers was assumed to be 1.97 inches (5 cm) (Section 2.4). Chemical isolation layer thickness for Cap Alternative 4 was additionally varied to 0.98 inches (2.5 cm) to understand the potential impact of variability during the application of capping materials. The CPP for each modeled cap thickness was the top of the chemical isolation layer (30 cm below the cap-surface water interface). Reducing the isolation layer thickness to 0.98 inches (2.5 cm) decreased the time-to-breakthrough of the cap to 70 years, a reduction in reliable containment time of 35.3 percent. The time-to-breakthrough was driven by Total cPAHs in porewater.

Sensitivity analysis was also performed for low concentrations (Alternative Scenario 1) using Cap Alternative 3, unamended sand without the erosion protection layer, to determine the necessary cap thickness to achieve reliable containment of sediment CULs without GAC amendments. The CPP for this sensitivity test was 30 cm below the cap-surface water interface. Modeling using an upwelling velocity of 158.3 inches/year (402 cm/year) suggests that the isolation layer thickness required for a 0.1 percent f_{OC} unamended sand cap to increase time-to-breakthrough from 6 years to 100 years at the CPP is 243.3 inches (618 cm), a 219.7-inch (558-cm) increase in total cap thickness from Cap Alternative 3 as described in Section 2.2.

2.5.9. Sorption Parameters

The derivation of the conservative organic carbon and Freundlich sorption parameters that were used in modeling is described in Section 2.3.4. ITRC guidance states that "If site-specific testing is not conducted, literature values may be used, although isotherms derived from the literature may not account for particle size differences (e.g., GAC vs. PAC), competition of sorption sites for the full suite of chemicals present in the sediment porewater at a site, the potential for fouling or dechlorination and the formation and precipitation of metal sulfides, or the competitive effects of NOM. It may be appropriate to reduce the sorptive capacity of activated carbon by a factor of 2 to 5 to account for the effects of NOM" (ITRC, 2023). As a sensitivity analysis, the K_f values were decreased by a factor of two times from the base model values (i.e., to one-twentieth the literature K_f values) for all modeled COCs. The time-to-breakthrough decreased from 100+ to 78 years, a 24.7+ percent decrease in reliable containment time.

Additionally, the K_{OC} values of each COC were increased by 10 percent as another sensitivity analysis. The organic carbon partition coefficients used in modeling are based on literature values as site-specific sorption measurements are not available. The K_{OC} modification was performed for a 3-ft (90-cm) cap of unamended sand with an upwelling velocity of 402 cm/year, to be compared to the Initial Scenario – Whole Basin Cap Alternative 3 results presented in Table 2-6. In the unamended cap alternatives, the organic carbon present in the sand or erosion protection materials is the only chemical sequestration mechanism. The time-to-breakthrough increased from 29 to 100+ years in total solid, a 110.1 percent increase in reliable containment time. It increased from 6 to 100+ years in porewater, a 177.4 percent increase in reliable containment time.

2.5.10. Spatial Discretization

CapSIM guidance suggests using a uniform number of grid cells in each layer. For this initial modeling, 20 grid cells per layer were selected. Sensitivity testing was completed by using 40 grid cells per layer to understand the impact of smaller spatial increments between CapSIM calculations. The thinner step size discretization resulted in lower individual COC concentrations near the sediment cap-water interface but did not impact the modeled reliable containment time.

As a baseline, the sand layer in Cap Alternative 3, which modeled the 2-ft (60-cm) chemical isolation and 1-ft (30-cm) bioturbation layer as a single 3-ft (90-cm) layer, used a spatial discretization of 60 grid cells to maintain the 1.5 cm grid size consistent with the bioturbation layer grid size in Cap Alternative 4 and enable CPP evaluation at a depth of 30 cm. As a sensitivity test, 20 grid cells was used in the 90-cm sand layer. Based on available depths in the output, the CPP for this sensitivity test was 31.5 cm. The sensitivity test was compared to the baseline at a depth of 31.5 cm, which has a time-to-breakthrough of 7 years, driven by DDT in porewater. The time-to-breakthrough for the sensitivity test was 6 years, a 15.4 percent decrease in reliable containment time, and was also driven by DDT in porewater.

2.5.11. Outlier Influence

As described in Section 2.3.2, the 95th percentile sediment concentrations were used for modeling to mitigate undue influence from outliers. The Whole Basin (Initial Scenario) scenario was additionally modeled using the maximum observed sediment concentrations as the initial sediment and bottom boundary concentrations to conceptualize the upper range of potential outcomes from very high concentration sediments. When modeling with the maximum observed concentrations the time-to-breakthrough was reduced from 100+ years to 34 years, a decrease in reliable containment time of 98.5 percent. The time-to-breakthrough was driven by Total PAHs in total solid.

2.5.12. Cap Performance Point

The CPP for Cap Alternatives 3 and 4 was chosen to be 1 ft (30 cm) based on ITRC guidance. Porewater and total solid concentrations were additionally evaluated one centimeter deeper, within the chemical isolation layer, 12.2 inches (31 cm), to evaluate the potential accumulation within the chemical isolation materials. The time-to-breakthrough remained 100+ years.

To sensitivity test the CPP for Cap Alternative 3, porewater and total solid concentrations were evaluated at a depth of 8.3 inches (21 cm), to evaluate the protection to burrowing organisms provided by an unamended cap. The time-to-breakthrough was increased from 6 to 8 years, an increase in reliable containment time of 28.6 percent, and was driven by PeCDF in porewater. In total solid, the time-to-breakthrough increased from 29 to 38 years, an increase of 26.9 percent, and was driven by Total PCBs.

2.5.13. Hydrodynamic Dispersivity

CapSIM guidance describes dispersivity as being "largely associated with the length scale of heterogeneities in the sediment layers" and suggests setting the value to 5-10 percent of the travel path of groundwater flow. In all cap alternatives and initial concentration scenarios, the dispersivity in each layer was set to be 10 percent of the layer thickness (Table 2-2). In layers thinner than 3.94 inches (10 cm), it is suggested to set the dispersivity to 0.39 inches (1 cm) as a conservative approximation, which equates to 20 percent of the 1.97-inch (5-cm) amended chemical isolation layer thickness used for sensitivity analysis. Cap Alternative 4 was modeled with the dispersivity of the chemical isolation layer set to 0.39 inches (1 cm), and the dispersivity of the sediment and sand layers remained at 10 percent of the layer thickness (3 cm). Under these assumptions, the time-to-breakthrough remained 100+ years. This sensitivity analysis was also performed for low concentrations (Alternative Scenario 1) using Cap Alternative 4 with 1.0 percent GAC, and the time-to-breakthrough was reduced from 59 to 55 years, a reduction in reliable containment time of 7 percent. The time-to-breakthrough was driven by Total PAHs in total solid.

2.5.14. Mass Transfer Coefficient

To ensure conservative near-surface concentrations, the mass transfer coefficient was set to 0.04 inches/hour (0.1 cm/hour or 876 cm/year) for all COCs. CapSIM guidance (Reible, 2023) suggests a mass transfer coefficient on the order of 0.39 inches/hour (1 cm/hour or 8760 cm/year). Sensitivity testing was conducted using a mass transfer coefficient of 0.2 inches/hour (0.5 cm/hour or 4,380 cm/year) to simulate more rapid flux of contaminants into the surface water from the capping material, and the difference in resulting concentrations was found to decrease with increasing depth. The reliable containment time was unaffected.

2.5.15. Bottom Conditions

The bottom boundary condition type was conservatively assumed to be a fixed concentration. The flux-matching bottom boundary condition is commonly used to model advective, reactive transport (Reible, 2023). Sensitivity testing using the flux matching bottom boundary condition type did not result in a change in time-to-breakthrough.

2.5.16. Underlying Sediment Thickness

Sediment thickness was modeled as 1 ft (30 cm), consistent with ITRC guidance (ITRC, 2023). Many sediment cores sampled from within SIB have contamination above the RAL extending multiple feet, so as a sensitivity test, sediment thickness was modeled as 47.2 inches (120 cm). The increase in the underlying sediment thickness did not impact the modeled reliable containment time.

2.5.17. Dissolved Organic Carbon in Overlying Water

The overlying water was assumed to have a dissolved organic carbon (DOC) concentration of 1.0 milligram per liter (mg/L) and the porewater was assumed to have a DOC concentration of 0.0 mg/L. Sensitivity analysis was performed with an overlying water DOC of 8.0 mg/L to determine if the presence of organic carbon in the water column impacted contaminant transport. The higher water DOC did not result in a change of the modeled reliable containment time.

2.5.18. Time Step

The time step used for the modeling results reported in Section 2.4 was the default value of 0.1 years. To test the sensitivity of the model to more continuous evaluation, the time step was shortened to 0.01 years. The shorter time steps did not impact the modeled reliable containment time.

2.5.19. Absolute Model Error Tolerance

The absolute model error tolerance used for the modeling results reported in Section 2.4 was the default value of 1E-8 µg/L. Reible (2023) suggests reducing the error tolerance in the iterative solver when working with nonlinear systems to ensure the results do not change significantly. Sensitivity testing using an absolute error tolerance of 1E-10 did not result in a change in time-to-breakthrough.

2.5.20. Sediment f_{OC}

The sediment f_{OC} used for the modeling results reported in Section 2.4 was adjusted from PDI ER cores based on the sand content (Section 2.3.1). A sensitivity test was performed using the unadjusted sediment f_{OC} of 0.62 percent to represent the average organic content of the slightly sandy and sandy silt that is present in the sediment within SIB. The reduction in sediment f_{OC} reduced the reliable containment time from 100+ to 48 years, a reduction of 70.3 percent. The time-to-breakthrough was driven by anthracene in porewater.

2.5.21. Additional Chemicals

A sensitivity test including Table 17 chemicals with a sediment or groundwater CUL that have been detected in SIB and that are not included in the ROD Table 21 was performed using Cap Alternative 4. These analytes are aldrin, arsenic, BEHP, benzene, cadmium, chlordanes, chromium, copper, dieldrin, lead, lindane, manganese, mercury, pentachlorophenol, TPH-diesel, tributyltin, vanadium, xylenes, and zinc. Five additional PCB congeners (PCB-1, PCB-15, PCB-31, PCB-206, PCB-209) with high detection rates for their respective homolog groups were additionally modeled so that one or more congeners from each homolog group were included in the analysis. The chemical properties and partitioning coefficients for each analyte are included in Table 2-9. The modeled sediment and bottom boundary concentrations were the 95^{th} percentile of detections from the historical and PDI sediment dataset collected within Swan Island Basin and are included in Table 2-10. Resulting porewater concentrations for the Table 17 chemicals are graphed against depth and time for Cap Alternative 4 and a 1 ft (30 cm) thick sand cap amended with 5.0 percent GAC by weight and topped with 1 ft (30 cm) of clean sand (Attachment A).

The five additional PCB congeners that were included in modeling were effectively contained by a 1.97 in (5 cm) sand cap amended with 1 percent GAC by weight, when topped by clean sand (Cap Alternative 4). The behavior of these congeners is comparable with the six congeners included in Tables 2-2 and 2-3.

Of the additional Table 17 analytes, the following times-to-breakthrough were noted (Table 2-11):

- Total Solid: arsenic (1 year), cadmium (1 year), copper (3 years), mercury (4 years), lindane (14 years), BEHP (36 years), aldrin (42 years).
- Porewater: arsenic (1 year), cadmium (1 year), copper (1 year), manganese (1 year), zinc (1 year), pentachlorophenol (8 years), vanadium (11 years) chromium (14 years), lead (84 years).

When increasing the modeled isolation layer to be a 11.81 in (30 cm) sand cap amended with 5 percent GAC by weight, the following times-to-breakthrough were noted:

- Total Solid: arsenic (3 years), cadmium (2 years), copper (5 years), mercury (93 years).
- Porewater: arsenic (1 year), cadmium (1 year), copper (1 year), zinc (2 year), manganese (3 years), vanadium (60 years), chromium (74 years).

In the Draft 50% RD, additional evaluation of the proposed cap design will be performed to address these exceedances. The goal is to design a protective cap that will address all area-specific contaminants. The evaluations will include:

- Assessing the need for increased cap thickness;
- Evaluating additional amendments such as bauxite, organoclay, and apatites;
- Increasing the percentage of activated carbon in the CIL; and
- Considering the use of reactive core mats in the cap design.

Additionally, if a protective cap cannot be feasibly designed to address all Table 17 and 21 chemicals, then dredging or a combination of dredging and capping may be considered instead of capping alone.

2.5.22. Summary of Sensitivity Testing

The preceding sensitivity analyses indicate that, for an amended cap, the most sensitive modeling parameters are:

- Outlier removal and initial concentration,
- GAC amendment percentage,
- Porewater upwelling velocity,
- CPP depth,
- Amended chemical isolation layer thickness, and

- Sorption parameters.

For RD, cap design will emphasize using area-specific upwelling velocity measurements and initial COC concentrations. Conservative decisions will be made regarding outlier removal, CPP depth selection, and modeled sorption parameters. Additionally, sensitivity evaluations of GAC amendment percentage and isolation layer thickness will be completed for the area-specific cap designs to ensure chemical containment.

3.0 PHYSICAL DESIGN CONSIDERATIONS

Physical design considerations that pertain to cap evaluation include geotechnical (Section 3.1) and erosion protection layer (Section 3.2) factors. An erosion protection layer may be needed to prevent damage to cap placements. Consideration of geotechnical factors is needed for evaluation of cap stability.

3.1. GEOTECHNICAL CONSIDERATIONS

Geotechnical factors were considered as they pertain to capping design and the underlying sediment. Geotechnical considerations are important in capping because contaminated sediments are typically fine-grained and may have high water contents and low shear strengths (Palermo et al., 1998a). Geotechnical considerations for this cap evaluation included bearing capacity, consolidation, slope stability, liquefaction, and filter design. The objective of this evaluation is to assess the stability of an engineered cap against bearing failure, settlement, sliding or slope displacement, and both cap and sediment material migration or mixing. Geotechnical analysis was driven by chemical isolation and erosion protection layer hypothetical alternatives. Conceptual cap design alternatives identified in Section 2.2 were evaluated to identify relevant geotechnical risks and potential cap failure modes. Representative sections were developed based on the conceptual cap alternatives and evaluated to identify relevant geotechnical risks and potential cap failure modes. Based on the evaluation of the geotechnical alternative listed above, the potential risks and failure modes identified included bearing failure, differential and total settlement, liquefaction susceptibility, slope stability, and material migration.

3.1.1. Requirements

The geotechnical evaluation was performed following the methods described in the PDI Work Plan (HGL, 2022); *Remedial Design Guidelines and Considerations (EPA, 2021b); and Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al., 1998b). Geotechnical considerations evaluated for cap stability included:

- Representative section development and identification of risks and failure modes,
- Bearing capacity analysis,
- Settlement analysis,
- Filter design analysis,
- Evaluation of potential liquefaction susceptibility, and
- Static and pseudo-static slope stability analysis.

The geotechnical evaluations also included seismic effects, proximity to steep riverbanks and shoreline structures, and geotechnical considerations related to the sediments below the cap and surface preparation prior to cap placement. Detailed capping evaluations in different locations around the basin, including at individual structures and existing slopes, will be developed during RD.

3.1.2. Bearing Capacity

Bearing capacity of near surface sediment material was evaluated using methods described in *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al., 1998b).

An allowable cap thickness was estimated based on an undrained analysis, considering local shear failure for a cap load applied at the ground surface (zero foundation embedment). The analysis is based on a constant value of undrained shear strength and a safety factor of 3. Soil parameters used in the analysis included an undrained shear strength value of 250 pounds per square ft (based on in-water unconsolidated undrained triaxial test results within 3.5 ft [1 meter] of the mudline), a total unit weight of 115 pounds per cubic ft (pcf) for the clean sand portion of the cap, and a total unit weight of 140 pcf for the erosion protection layer (the effective unit weights when submerged are 53 and 78 pcf, respectively). Unit weights were estimated based on the anticipated cap and erosion protection material types as well as published correlations for cohesionless soils (Bowles, 1977).

Based on this analysis, the estimated maximum allowable cap thicknesses for the aggregate cap unit weights associated with the geotechnical alternatives are as follows:

- The maximum allowable cap thickness for Geotechnical Alternative 1 (2 ft [60 cm] of clean sand topped with 2 ft [60 cm] of erosion protection, effective unit weight: 65.1 pcf) is 4.4 ft;
- The maximum allowable cap thickness for Geotechnical Alternative 2 (4.33 inches [11 cm] of clean sand evenly mixed with GAC topped with 2 ft [60 cm] of erosion protection, effective unit weight: 73.7 pcf) is 3.9 ft;
- The maximum allowable cap thickness for Geotechnical Alternative 3 (3 ft [90 cm] of clean sand, effective unit weight: 52.6 pcf) is 5.4 ft; and
- The maximum allowable cap thickness for Alternative 4 (1 ft [30 cm] of clean sand and 4.33 inches [11 cm] of clean sand evenly mixed with GAC, effective unit weight: 52.6 pcf) is 5.4 ft.

3.1.3. Liquefaction Susceptibility

The liquefaction susceptibility was evaluated using a cone penetration test (CPT)-based liquefaction triggering assessment (Boulanger and Idriss, 2014) and the commercially available software CLiq Version 3.3.2.9 by GeoLogismiki. The analysis was based on sand-like behavior only (classic cyclic liquefaction); clay-like behavior (cyclic softening of clays and plastic silts) was not considered in the analysis. Seismic design parameters were based on the 2018 Conterminous U.S. National Seismic Hazard Map and a return period of 10 percent probability in 50 years (475 years). A peak ground acceleration of 0.234 g and moment magnitude of 9.08 (Mw) were used in the liquefaction triggering analysis. The CPT and groundwater data utilized to perform the liquefaction triggering assessment are presented in the *Geotechnical Data Report* (Appendix F of the PDI ER [HGL, 2024]).

Based on liquefaction susceptibility analysis (Figure 3-1), estimated CPT seismic settlement ranged from 3.3 to 15.8 inches (8.3 to 40 cm), with the maximum estimated seismic settlement of 15.7 inches (40 cm) observed at sCPTW-11.

3.1.4. Settlement Analysis

A differential and total consolidation settlement analysis was based on multiple cap alternatives. Consolidation settlement was evaluated using Settle3 by Rocscience, a soil settlement and consolidation analysis software. The 3D stress distributions were computed using Boussinesq and Westergaard computation methods. Uniform polygonal loads were used for Geotechnical Alternatives 1 and 2, applied in a single stage. One-dimensional consolidation test results for in-water geotechnical samples were used. A uniform pre-capping dredge depth of 4 feet (120 cm) was considered during analysis of each cap alternative. Additional settlement evaluations, based on a refined understanding of anticipated pre-capping dredge depths at various locations within the basin, will be performed during RD. Existing sediments were assumed to have an effective unit weight of 28 pcf.

Based on settlement analysis, the following conclusions were made for each geotechnical alternative considered:

- Estimated cap load for Geotechnical Alternative 1 (2 ft [60 cm] of clean sand topped with 2 ft [60 cm] of erosion protection) is 0.15 kilopound per square ft (ksf). Total predicted consolidation settlement ranged from 0.2 inches (0.5 cm) to 7.2 inches (18.3 cm), which represents the maximum predicted consolidation settlement (based on Boussinesq stress distribution) found for the SIB (Figure 3-2);
- Estimated cap load for Geotechnical Alternative 2 (4.33 inches [11 cm] of clean sand evenly mixed with GAC topped with 2 ft [60 cm] of erosion protection) is 0.06 ksf. Total predicted consolidation settlement is estimated to be up to 4.3 inches (11 cm , Figure 3-3);
- Estimated cap load for Geotechnical Alternative 3 (3 ft [90 cm] of clean sand) is 0.05 ksf. Total predicted consolidation settlement is estimated to be up to approximately 4 inches (10 cm); and
- Estimated cap load for Geotechnical Alternative 4 (1 ft [30 cm] of clean sand and 4.33 inches [11 cm] of clean sand evenly mixed with GAC) was -0.04 ksf, indicating a net load reduction. Settlement estimates were not performed due to the net load reduction following Alternative 4 dredging and capping.

3.1.5. Filter Design

A preliminary evaluation of grain size compatibility between cap materials and native sediment was completed with respect to the potential for vertical migration of both sediment and cap materials. Filter design was evaluated based on Gradation Design of Sand and Gravel Filters (USDA, 2017). Sediment soils evaluated included elastic silt (MH) from BW-15 (sample #2 at 3 ft

[90 cm]), which is representative of the controlling material type with respect to grain size compatibility between cap materials and native sediment. Sand cap material was based on Oregon Department of Transportation (ODOT) fine concrete aggregate (based on Table 02690-5). The erosion protection material (gravel) evaluated was based on ODOT coarse concrete aggregate (ODOT, 2021), which is comprised primarily of aggregates with a nominal size of less than 1 inch, and greater than the aperture of a #4 sieve. The materials evaluated for the filter design are consistent with erosion protection requirements described in Section 3.2.

A preliminary evaluation of grain size compatibility indicated the anticipated cap material types adequately limit the potential of vertical migration of both sediment and cap materials. Potential sand cap and erosion protection material gradations should be generally consistent with the corresponding ODOT gradations. The potential for vertical migration may be determined in RD using guidance developed for the design of sand and gravel filters (USDA, 2017).

The use of filter fabric (geotextile) in cap design was considered. Although it is not likely to be feasible site-wide due to the time and challenges with placement, it is still maintained as a consideration for challenging areas that will need special consideration in RD. Filter fabric may be required to prevent differential movement during placement, although, the analysis of all results available to date indicates that vertical sediment migration can be adequately limited without the use of filter fabric for even the most conservative scenarios.

3.1.6. Slope Stability and Seismic Evaluation Analyses

Cap slope stability was evaluated with 2D limit-equilibrium analysis using Slide2 by Rocscience. A static analysis based on a minimum safety factor of 1.5 was completed, in addition to pseudo-static (non-liquefied) analysis based on a minimum safety factor of 1.0. The potential for liquefaction-induced flow failure was evaluated using conventional limit equilibrium slope stability analyses and residual undrained shear strength parameters for the liquefied cap material (analysis decoupled from all seismic inertial forces). The 2D limit-equilibrium analysis results were checked against infinite slope chart solutions for general agreement.

A horizontal seismic coefficient of 0.12 was used in pseudo-static stability analyses. The horizontal seismic coefficient was estimated as a half of the mapped peak ground acceleration of 0.234 g (2018 Conterminous U.S. National Seismic Hazard Map) for a 10 percent probability in 50 years (475-year) return period.

Based on slope stability analysis, the static safety factor of a 1.2-meter sand cap at a 25-degree slope is approximately 1.6 (Figure 3-4). Based on an infinite slope chart solution, the static safety factor for a 1.2-meter sand cap at a 22-degree slope is 1.5. The pseudo-static safety factor for a 1.2-meter sand cap at a 25-degree slope is approximately 1.0 (Figure 3-5). The safety factor against liquefaction-induced flow failure for a 1.2-meter sand cap at a 25-degree slope is approximately 1.3 (Figure 3-6).

Preliminary cap design should be based on slope gradients of 2.5 horizontal to 1 vertical (±22 degrees) or flatter. Detailed cap stability evaluations will be performed during RD to determine final cap slopes and configurations.

3.2. EROSION PROTECTION LAYER CONSIDERATIONS

Erosive forces may impact stability of the cap; therefore, an erosion protection layer may be needed in some areas to prevent short-term and long-term damage to the cap's chemical isolation layer (Palermo et al., 1998a; ITRC, 2023). An assessment of the erosive forces (natural and anthropogenic) was completed to determine the characteristics of the erosion protection layer potentially needed to prevent erosion of the cap, including layer thickness and material size. The erosion protection layer design considered the magnitude and probability of occurrence of relatively extreme erosive forces estimated at the capping site (Palermo et al., 1998b). The erosive forces evaluated included wind- and vessel-generated waves, prop wash, river currents during a 100-year flood, stormwater outfall discharges, rainfall runoff, and Dry Dock activities. The following sections summarize the evaluation of each erosive force and its implications for erosion protection layer design.

3.2.1. Currents in Swan Island Basin

Erosive forces created by river currents during a 100-year flood were evaluated to design the appropriate erosion protection layer thickness and utilize appropriate material size.

Numerical modeling of river flow and tides was conducted using the 3D hydrodynamic model Delft3D-FLOW for high-flow and low-flow events (Deltares, 2023a and 2023b). The numerical model solves the motion and continuity equation derived from the 3D Navier-Stokes equation for incompressible free surface flow. Time integration was performed using a first order implicit scheme. Delft3D-FLOW was selected for the analysis based on its accurate 3D simulation of hydrodynamics and robustness.

For the cap evaluation, the hydrodynamic model consisted of a large-scale model for boundary forcing, and a nested model to resolve the finer-scale processes in the SIB. The global domain (Figure 3-7, bottom left) included the Willamette River, Columbia River, and Multnomah Channel and was created using the Delft3D Flexible Mesh module using a combination of unstructured elements (both triangular and quadrilateral). To better resolve processes at the project site, a nested Delft3D 4 model was created using a detailed structured/curvilinear grid encompassing the SIB and its geographic context. Nested model boundary conditions were taken from the results of the large-scale model. The large-scale model (Flexible Mesh) included 19,000 elements, with element sizes ranging from 250 meters to 15 meters. The nested model (structured/curvilinear) included 12,000 elements, with element sizes ranging from 45 meters to 15 meters.

Both hydrodynamic models were evaluated in 3D with a vertical grid defined by a sigma coordinate approach. In a sigma coordinate approach, the number of vertical elements is composed of a fixed number of layers assigned a fraction of the water column; the cell size and cell center coordinates change as function of depth during the simulation. For both models, five layers were chosen to resolve vertical stratification.

Model grid bathymetry was compiled from several data sources, including the following:

- HGL Survey within SIB (PDI ER Appendix E; HGL, 2024);
- USACE Navigation Survey of Willamette River (USACE, 2022);

- David Evans Associates Survey of Willamette River (David Evans Associates, 2018);
- Vigor Survey of Portland Facilities (eTrac, 2018);
- National Oceanic and Atmospheric Administration (NOAA) Lower Columbia River DEM (USACE, 2010); and
- Oregon LiDAR Consortium (OLC) – Oregon LiDAR for upland areas (OLC, 2014).

Where there was overlap between multiple datasets, priority was given to the most recent data.

The large-scale model included six upstream discharge boundaries and one downstream elevation boundary. The upstream large-scale model boundaries were based on locations of dams (Bonneville Dam and Willamette Falls) located in the Columbia River and Willamette River, respectively. Discharge at Columbia River was developed using historical Bonneville Dam flow data from USACE. U.S. Geological Survey (USGS) Station 14142800 Beaver Creek (USGS, 2023a) and USGS Station 14142500 Sandy River (USGS, 2023b) data were used to develop the other discharges along the Columbia River.

Flow data from USGS Station 14211010 Clackamas River (USGS, 2023c); USGS Station 14211315 Tryon Creek (USGS, 2023d); and USGS Station 14211550 Johnson Creek (USGS, 2023e) were used to develop discharges for tributaries along the Willamette River. Discharge at Willamette Falls was developed using the difference between historical flow data from USGS Station 14211720 Willamette River (USGS, 2023f) and the sum of discharges from Willamette River tributaries (no direct flow measurements at Willamette Falls are available).

The downstream boundary of the large-scale model is located at the NOAA gage station at St. Helens, where historical water surface elevation data are available. Historical winds measured at Portland Airport were used as input to the model in all simulations using spatially constant but temporally varying wind speed and direction (Meteostat, 2023).

The large-scale model was validated using measured water levels at USGS Station 14211720 Willamette River, also referred to as Morrison Street Bridge Portland and Morrison Street (USGS, 2023a). The water level validation at Morrison Street showed excellent correlation for a range of various Willamette River flow periods including low flow, medium flow, and higher flow. As seen on Figure 3-7, coefficient of determination exceeded 0.90 for low-flow conditions, 0.99 for high-flow conditions, and 0.99 for the validation period.

The nested/structured Delft3D model was validated using multiple velocity datasets. Acoustic doppler current profiler (ADCP) data, reported in the *Hydrodynamics and Sediment Dynamics Surveys Report* (Appendix I of the PDI ER; HGL, 2024), were used to validate the model for the SIB. ADCP1 was deployed during Deployment 1 from February 21 to April 1, 2022 (38 days of data collected), whereas ADCP2 collected data for a full 2-month duration (Figure 3-8). The combination of extremely low turbidity and extremely low water velocities resulted in moderate levels of noise that required further processing and filtering of the raw data. Overall, ADCPs measured very low velocities (less than 0.1 ft per second), which demonstrated very little exchange/influence between the SIB and the Willamette River. The Delft3D model also predicts extremely low velocities in the SIB (less than 0.1 ft per second [0.03 meters per second]). Measured current speeds in SIB Stations 1 and 2, as well as differences between measured velocities and modeled velocities at these station locations, are less than 0.1 ft/second, which is roughly one order of magnitude below velocities potentially influencing cap design.

ADCP data were also collected at River Miles 1.4 through 2.8 in 2017 and 2018 at two locations (North Platform and South Platform) downstream of the Multnomah Channel confluence in the Willamette River. The North Platform was located at River Mile 1.4 and was used for validation of the large-scale hydrodynamic model. No validation of the nested hydrodynamic model was performed here because it is outside the nested model domain; however, results between the large-scale and nested model at a location in the nested domain nearest River Mile 1.4 were consistent. Figure 3-9 shows validation during the Winter Deployment at the North Platform. The nested model validation was successful, with coefficients of determination ranging from 0.85 to 0.93 at different vertical levels in the water column.

Flood modeling was performed using the nested Delft3D model. Results were verified to be consistent with the validated large-scale unstructured model. For the purposes of cap erosion protection evaluation, the nested model simulated 100-year flood event conditions provided by the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FEMA, 2010). A constant discharge of 380,000 cubic ft per second (cfs) was used as the upstream boundary condition with a constant water level of 9.45 meters (31 ft) North American Vertical Datum of 1988 (NAVD88) used as the downstream boundary condition. The downstream boundary water level was taken from the results of the Corrected Effective Model (CDM Smith, 2022). Bed shear stresses were extracted from the model results. Figure 3-10 shows maximum depth-averaged velocity and Figure 3-11 shows maximum bed shear stresses. Results indicate that bed shear stresses from river currents are small and likely do not govern erosion protection design anywhere in the SIB.

3.2.2. Wind-Waves

Wind-waves are generated by winds blowing over the water surface. The Simulating Waves Nearshore (SWAN) model (Delft, 2012) was used to predict wave conditions generated by winds during a 100-year storm from all directions. SWAN predicts random, short-crested wind-generated waves in coastal regions and inland waters from given wind, water depth, and current conditions. The model domain consisted of a structured uniform 2-meter grid. The 100-year wind speeds were taken from the FS Table C-1 (EPA, 2016). Table 3-1 lists 100-year wind directions and speeds used in SWAN modeling efforts (EPA, 2016). Simulations were performed at water levels corresponding to mean low water (MLW) and ordinary high water (OHW) elevations.

Wave conditions were extracted at transects around the SIB with spacing of 30.5 meters (100 ft). Wave runup velocities on the slopes were computed using the SWASH model (Delft, 2018). Maximum bottom velocities during the storm event were extracted at each transect. Shear stresses were computed using the maximum velocity on the slope and quadratic bed friction formulation with drag coefficient based on a Manning's roughness coefficient of 0.02. The areas between MLW and OHW are anticipated to have similar bed shear stresses as those computed at MLW and OHW; therefore, the shear stress is shown as a constant value on the slope between elevations at each transect.

Significant wave heights reaching 1.1 ft (33.5 cm) were observed near the head of the basin (Figure 3-12). The largest significant wave heights reach 1.6 ft (48.8 cm) near the mouth of the basin. Bed shear stresses of up to 50 Pascals (Pa) were observed on the slopes, indicating that more robust erosion protection will be required on steeper slopes (Figure 3-13). Slopes/banks will be further evaluated using coastal engineering methods and consideration of suitable habitat materials during Draft 50% RD.

Vessel wakes were measured in the SIB; however, they were found to be similar in nature to wind-waves and smaller in height. This is anticipated because vessel traffic moves relatively slowly in the SIB. Since wind-waves control the design of the erosion protection layer in shallow water, vessel wakes were not further evaluated in erosion protection design.

3.2.3. Propeller Wash

High-frequency (30-second) Automatic Information System (AIS) data collection was commissioned for the SIB and a portion of the river surrounding the SIB for the 3 months from February 21 to May 27, 2022 (HGL, 2024). The data points are shown in Figure 3-14 (top left). The majority of the transits within SIB were made by tugs (Figure 3-14, bottom left). For prop wash analysis, AIS pings were separated into passing events (vessel tracks) based on unique Maritime Mobile Service Identity (MMSI) voyage numbers. Events with speeds below 1 knot were not considered. For each event, the data points were splined to provide a smooth and continuous vessel track at 1-meter intervals (Figure 3-14, top right).

Prop wash was simulated for each transit using the 3D empirical Dutch Method (PIANC, 2015), as demonstrated in Figure 3-14 (bottom left). The prop wash and bottom velocities were computed while vessels progressed along the routes observed in the AIS data. Applied power used for computing prop wash velocities by each vessel was prescribed per the FS Table C-18 recommendations for design (EPA, 2016). The high applied power values result in a more conservative prop wash bottom velocity estimate considering the SIB site conditions. At the SIB, vessels are expected to move at slower velocities and thus cause less prop wash. Propeller diameters were estimated based on vessel type and vessel size using industry data. No alternative propulsion systems were considered in the analysis.

Bottom velocity was computed on the riverbed (unified elevation model) with time-varying river water levels at every 1 meter along each passing route. Bottom velocities were computed on the riverbed using the Unified Elevation Model. The Unified Elevation Model is a seamless 1-ft by 1-ft elevation grid in feet relative to NAVD88. Source elevation data was prioritized by date, with newer data being included where datasets overlapped. The in-water data sources included multibeam bathymetry from 2022, 2018, and 2015. In the above-water areas, data sources included Mobile Terrestrial LiDAR collected by eTrac in 2022, as well as LiDAR from the City of Portland collected in 2019. The 2022 eTrac LiDAR was refined to remove structures (e.g., timber piles) and was primarily used for areas under wharves (Lagoon Wharf and Willamette Wharf). Manual methods were used to remove the wharf structures and interpolation was used to create a seamless elevation dataset in these areas. A polygon representing the boundary where the 2019 bare earth Lidar was returning valid ground values was used to restrict the use of this dataset to areas with actual bare earth returns. At Pier A and the Quay Wall, data from 2019 Lidar First Return dataset was used after manual refinement to remove surface structures. Finally, the 2019 bare earth

LiDAR from the City of Portland was used to fill in the upland areas. The remaining relatively small areas between the above-water data and the below-water data were filled by linear interpolation to create a seamless elevation dataset. Figures 3-14 and 3-15 show the Unified Elevation Model elevations, and locations where each elevation data source was applied, respectively.

Bed shear stress was computed using near-bed velocity and shear stress as a function of tow parameters (Maynord, 2000). An example bed shear stress calculation is shown for a single vessel position in Figure 3-16 (bottom right). Results show that prop wash maximum bed shear stresses reach approximately 10 to 15 Pa and are focused in the main navigation areas in the SIB (deeper water, see Figure 3-17). Results indicate that shear stresses from prop wash would require relatively modest armor protection (e.g., coarse sand or gravel).

3.2.4. Dry Dock Activities

Dry Dock operations were discussed with operations staff at Shipyard Commerce Center prior to the analysis and the erosion protection assessment was performed in accordance with documented shipyard practices (Appendix K of PDI ER; HGL, 2024). Dry Dock operations that may generate bottom velocities consist of (1) lowering and raising the Dry Dock, and (2) ballast water intake and discharge. Lowering and raising Dry Dock (hull movement displacing water) was analyzed only in the unladen configuration (no vessel inside) because the dry dock raises and lowers much faster, resulting in higher bottom velocities. Lowering and raising of the dry docks with vessels inside was not evaluated because it typically occurs over 4 to 5 hours and would not generate bottom velocities of concern. Ballast water intake/discharge (localized water jets) was analyzed because it can impact the side slopes of the dredge cut or bulkheads and can interact with other dry docks to create zones of accelerated flow.

Computational Fluid Dynamics (CFD) modeling was performed to evaluate bed shear stresses from both types of dry dock operations. CFD model input parameters included bathymetry created from the unified elevation model. For simulations evaluating lowering and rising of dry dock, mesh resolution typically ranged from 0.5 meter along the dredge cut slopes and near the bed to 3 meters at the distant corners of the model domain. For simulations evaluating ballast water intake and discharge, higher-resolution mesh blocks were used to resolve the water jets (resolution as high as 3.93 inches [10 cm]). Figure 3-18 (top right, bottom right) shows, as an example, the model setup for Dry Dock 3 and typical ballast water discharge simulation results.

Lowering of unladen Vigorous Dry Dock was simulated over a 90-minute period. Lowering of unladen Dry Dock 3 was simulated over a 40-minute period. Lowering and raising of unladen Dry Dock 5 was simulated over a 2-hour period and included the presence of Dry Dock 3.

Dewatering (raising) of Vigorous Dry Dock was simulated using 10 discharge jets with a 0.5-meter diameter on both port and starboard sides. Discharge was 13,000 gallons per minute (gpm) at each port. Dewatering (raising) of Dry Dock 3 was simulated using 12 discharge jets with a 0.5-meter diameter on both port and starboard side. Discharge was 8,400 gpm at each port. When Dry Dock 5 is in the lowered position, the discharge jets on the starboard side of Dry Dock 3 may cause flow acceleration under Dry Dock 5 (if in the lowered position). Dewatering (raising) of Dry Dock 5 was simulated using 8 discharge jets with flows of 16,500 gpm each, with a 0.6-meter diameter.

Discharge jets on the pontoon are directed at the Quay Wall, travel downwards, and interact with the riverbed, potentially mobilizing sediment.

For the dry dock lowering and raising simulations, hull movements displacing water produced relatively low velocities due to dry dock movements occurring over long time periods. Modest currents were generated at the slopes of the dredge cut. Figure 3-18 (left) shows peak bed shear stresses from all simulations performed, for all dry docks. Peak shear stress of up to 0.25 Pa was produced due to lowering of Dry Dock 3 and Vigorous Dry Dock. Lowering Dry Dock 5 caused negligible bed shear stress. In these areas, only affected by dry dock hull movements, erosion protection may not be required if the chemical layer consists of medium-to-coarse sand.

Ballast water intake/discharge jets may impact the slopes of the dredge cuts and bulkheads and could also interact with other dry docks if they are in the lowered position. Dewatering jets cause peak bed shear stress of 0.60 Pa at Dry Dock 5 where they impinge upon the Quay Wall, but much lower elsewhere. Peak bed shear of 0.45 Pa was observed on the south side of Vigorous Dry Dock (outside the dredge cut). Peak bed shear stress of 0.16 Pa was observed on the north side of Dry Dock 3. Coarse to very coarse sand is likely to provide sufficient cap erosion protection based on bed shear stresses induced by dewatering jets. Inside the dredge cuts themselves, where maintenance dredging is likely to take place, no erosion protection layer is likely required (pending material specification for the chemical isolation layer).

3.2.5. Outfalls

Erosion protection requirements around outfalls are the most robust of any location in the SIB. During peak rainfalls, outfall discharges result in large water velocities and bed shear stresses, which are presently resisted by riprap and/or concrete headwalls surrounding the outfalls. Discharges were estimated using the Pacific Coast Stormwater Management Manual (PCSWMM) stormwater system model (advanced modeling software for EPA SWMM 5 stormwater, wastewater, and watershed systems) created to represent the City of Portland outfalls. Outfall discharges were simulated with a CFD model for time periods with high discharge and low water level (worst-case velocities).

The 100-year design outfall flow rates were developed using a PCSWMM water management model of the SIB stormwater system and catchment basin. Inputs used included a 100-year, 24 hour rainfall of 4.5 inches (per NOAA Precipitation Atlas Volume 2) and a recommended Type1 rainfall distribution (per Natural Resources Conservation Service TR-55).

A CFD model was developed with M-1, M-2, M-3, S-1, S-2 100-year outfall flow rates ranging from 38 to 135 cfs, including 134 cfs, 135 cfs, 118 cfs, 38 cfs, and 46 cfs, respectively. The CFD model simulated discharges at a conservative low river water level of 0 meters (0 ft) Columbia River Datum. The CFD model incorporated topography/bathymetry from the unified elevation model, with outfalls inserted at the actual location/orientations including real geometry and existing wing walls/aprons. Additional inputs factored into modeling, including invert elevations taken from city drawings, as well as pipe diameter, slope, and material. The CFD model used grid cell sizes of 0.1 meter at city outfalls S-1/S-2 and 0.15 meter at city outfalls M-1, M-2, and M-3.

Figure 3-19 shows the maximum bed shear stresses predicted in the CFD model for all five city outfalls. Maximum resulting bed shear stresses were extracted from the 60-second CFD simulations of each outfall scenario (no ambient currents/waves/winds included in CFD). As a result of outfall modeling efforts, peak shear stresses of up to 60 Pa were identified. Shear stresses associated with stormwater outfalls confirm that heavier, more robust protection is needed near the outfalls. Outfall erosion protection design and the potential impact on habitat will be evaluated in the habitat impact evaluation.

3.2.6. Rainfall Runoff

Bed shear stresses due to rainfall runoff were evaluated using the MORPHO model (Kivva et al, 2006). MORPHO is a 2D model that simulates depth-averaged surface water flow, sediment transport, and bottom-change morphology in the near-shore zone. The maximum 5-minute interval rainfall rate from 2018 to 2022 (2.64 inches per hour [6.7 cm per hour]) was used in the simulations. Additional assumptions used in the model included no infiltration; no canopy/ground cover; no flow diversion incorporated (i.e., curbs, swales, drains, straw bales, etc.); and Manning's roughness coefficient of 0.03 for all surfaces.

Peak bed shear stresses induced by rainfall were modest (Figure 6-1), even under peak rainfall intensity. Based on results of the rainfall runoff modeling, rainfall runoff can cause downslope movement of finer material but will likely not govern any slope erosion protection requirements (wind-waves and overall slope stability will likely govern design of erosion protection).

3.2.7. Stable Material Sizes

Peak bed shear stresses (Figure 6-2) from each hydrodynamic process were overlaid onto a 1 meter grid, and maximum values were taken from each process to identify stable grain sizes. Stable particle classifications were identified using Table 7 in USGS Scientific Investigations Report 2008–5093 (USGS, 2008). For each particle classification, maximum particle diameters were conservatively assigned to peak bed shear stresses across the SIB. Figure 6-3 illustrates the stable bed material sizes.

The largest bed shear stresses were found on banks and slopes surrounding the outfalls. The second largest material requirements are on the submerged slopes and riverbanks, due to exposure to storm waves. In both of these areas, specialized considerations are necessary and erosion protection material sizes will be generated during RD. In most of the SIB, gravel ("coarse," "very coarse," [Berenbrock et al, 2008]) is large enough to provide static material stability against erosion. In limited quiescent areas, it is likely that medium-to-coarse sand used for the chemical isolation layer will be generally stable (i.e., no erosion protection layer may be required).

3.2.8. Material Availability

Material availability and costs will be discussed in detail in the cost analysis. However, preliminary material availability efforts have been completed assuming a hypothetical need of 420,000 cubic yards of both sand and gravel (2 ft [60 cm] chemical isolation layer and 2 ft [60 cm] erosion protection layer, both applied sitewide). Local rock quarries were surveyed to assess the feasibility of the conservative volume of capping material that may be needed. Information requested included feasibility of producing and delivering large volumes of material, transportation logistics, lead time required for material, and source material information.

The survey of local suppliers concluded:

- For the volume of material required, more than one supplier will likely be needed;
- Suppliers may need to accommodate multiple ongoing projects planned in the Central Harbor area of Portland that are requiring or will require large volumes of material;
- The estimated volume represents a large portion of yearly production quantity for some suppliers;
- Different suppliers may be needed for gravel and sand;
- Lead times for estimated quantity is approaching up to 1 year;
- Transportation is quarry-dependent; some have availability to barge locally; and
- Most quarries do not provide organic carbon concentrations for material. Organic carbon content of interest for chemical isolation layer design will require on-site sampling and testing for the project.

4.0 OTHER CAPPING CONSIDERATIONS

In addition to chemical isolation layer and physical design considerations, there are additional considerations with cap placement. These considerations include structures, debris, and flood rise and navigation, consistency with anticipated land and in-river uses land, capping monitoring and maintenance, and design life.

4.1. WORK AROUND STRUCTURES

For structures that are permanent and functional, placement of cap around them may be challenging and limited, and the ability to effectively place a cap will have to be closely examined in the Draft 50% RD.

4.2. CAPPING MONITORING

Cap monitoring will be performed in accordance with Section 14.2.7 of the ROD and RDGC Appendix C (EPA, 2021b) to include construction monitoring, remedy performance monitoring, and remedial action objective monitoring (EPA, 2021b). Monitoring performed may result in operation and maintenance activities based on potential damage to the cap. Additional considerations for cap monitoring needs will be identified in the Draft 50% RD.

4.3. CAPPING OPERATION AND MAINTENANCE

Additional considerations for cap monitoring and additional potential maintenance are summarized in BODR Section 9. Damage to the cap from flooding, seismic events, prop wash, etc. is discussed as an O&M concern Additional considerations and potential maintenance needs will be identified in the Draft 50% RD.

4.4. DESIGN LIFE

This cap was designed for 100-year performance. Continued monitoring results can be used to compare performance encountered against the design predicted in this evaluation. At 100 years, a re-evaluation of cap performance should be completed to evaluate if the existing remedy is still protective of human health and the environment for areas that were capped or dredged and capped. If the outcome of that evaluation concludes that additional work is needed, effort should be taken to re-evaluate COC concentrations at the top layer and implement the most applicable available remedial design at the time of the evaluation.

4.5. CONSISTENCY WITH ANTICIPATED LAND AND IN-RIVER USES

As indicated in PDI ER, current land uses within and adjacent to the SIB Project Area consist of light and heavy industrial uses and limited commercial uses. SIB is an active navigable industrial waterway, and the shoreline hosts many structures supporting light and heavy industrial activities (HGL, 2024). The waterway within the SIB Project Area currently supports commercial/industrial, recreational, and government vessel traffic related to the ongoing uses of the shoreline. Shoreline facilities support light and heavy industrial uses, vessel mooring, U.S. Coast Guard (USCG) operations, U.S. Navy operations, and public access (HGL, 2024). As seen in Section 2.6 of BODR, the anticipated future use for existing SIB Project Area facilities is the same as the current use. As a result, the cap is designed with anticipated future use as well so that the cap is not destroyed or damaged by those uses. If future land use changes, RD would have to be re-evaluated to help maintain cap effectiveness aligned with that change.

5.0 SUMMARY OF CAP DESIGN CONSIDERATIONS

This section summarizes findings from chemical isolation layer, erosion protection layer, and geotechnical considerations. The following conclusions were made based on chemical isolation considerations:

- Results of modeling suggest that an amendment of 5.0 percent GAC by weight will be sufficient for ROD Table 21 COC chemical isolation for a 100-year time-to-breakthrough in a 1.97-inch (5-cm) amended sand cap with overlying 2 ft (60 cm) of erosion protection (Cap Alternative 2) or with a overlying 1 ft (30 cm) of clean sand (Cap Alternative 4). Both amended cap alternatives and the respective CPPs will be carried forward into RD and referenced depending on area-specific erosion-protection needs. The approach of using the 95th percentiles and maximum upwelling velocities will also be carried forward into RD, though the values used will be area specific;
- The 95th percentile concentrations of metals, aldrin, BEHP, lindane, and pentachlorophenol from Table 17 are not effectively contained by the presented cap alternatives. Additional cap amendments, such as organoclay, reactive core mats, and bauxite, will be modeled using CapSIM and evaluated for their effectiveness during the area-specific cap design.
- Four of the COCs, when modeled at the sediment CULs, would partition under equilibrium conditions to porewater at concentrations exceeding the groundwater CULs by one to three orders of magnitude. To address this consideration, modeling efforts

suggest that sediment concentrations at the sediment CUL would require remediation to prevent porewater migration into overlaying water column at concentrations exceeding groundwater CULs. Upon further examination of remedial options, unamended 3 ft (90 cm) sand cap time-to-breakthrough at the CPP would occur 6 (Cap Alternative 3) to 7 (Cap Alternative 1) years after cap installation. As a result, these sediments at CUL COC concentration would have to be remediated by placing a GAC-amended cap to keep porewater concentrations below the groundwater CULs;

- Calculated Total PAH concentrations in total solids is the primary driver of amended cap time-to-breakthrough, particularly anthracene, fluorene, and naphthalene;
- Calculated porewater concentrations of DDT and cPAHs are the primary drivers of unamended cap breakthrough at the CPP well before the desired 100-year design life; and
- Further refinement of the SIB SMA sub-areas in the RD will enable cap recommendations that are more tailored to specific chemical isolation, erosion protection, and geotechnical consideration requirements.

The following conclusions were made based on erosion protection considerations:

- The majority of the SIB SMA can be capped with relatively cost-efficient EPL material (gravel) in a single-layer approach as compared to armor and bedding layer) directly above chemical isolation layer containing medium or coarse sand;
- Gravel sizes from “medium” to “very coarse” (Berenbrock et al, 2008) are feasible for use in various locations throughout the SIB SMA;
- Gravel armor layer allows for convenient and efficient placement, which reduces the overall cost of the remedy; and
- Armor layer requirements are fairly minimal except on steeper slopes and near outfalls, where material will be larger than gravel.

Variations in armoring size within the site-specific areas will be further evaluated in the Draft 50% RD.

The following conclusions were made based on the geotechnical considerations:

- Cap designs all have a safety factor of at least 3 against bearing failure (based on near surface in situ sediment shear strengths);
- Predicted consolidation settlement of sediment material under anticipated cap loads and liquefaction-induced settlement magnitudes are variable across the basin;
- Detailed analysis will be required during RD to assess the potential for differential settlement;
- A preliminary evaluation of grain size compatibility indicates the anticipated cap material types adequately limit the potential of vertical migration of both sediment and cap materials;

- Preliminary slope stability analysis indicates minimum required factors of safety are met for submerged cap slopes at gradients of up to 2.5 horizontal to 1 vertical (±22 degrees);
- Detailed analysis will be completed next to assess cap stability on emergent slopes basin wide; and
- Detailed analysis will be completed next in different locations around the basin, including cap placement around and under individual structures.

Area-specific cap design incorporating these considerations will be performed during Draft 50% RD.

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Table 1-1
Cleanup Levels and Criteria by Media for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Chemicals Analyzed	Sediment			Groundwater	Surface Water
	RAL (µg/kg)	PTW (µg/kg)	CUL (µg/kg)	CUL (µg/L)	CUL (µg/L)
DDD	160	7,050	114	3.10E-05	3.10E-05
DDE			50	1.80E-05	1.80E-05
DDT			246.0	2.20E-05	2.20E-05
DDx			6.1	0.001	0.01
1,2,3,4,7,8-HxCDF	-	0.4	0.0004	-	5.10E-09^
1,2,3,7,8-PeCDD	0.0008	0.01	0.0002	-	5.10E-10^
2,3,4,7,8-PeCDF	0.2	0.2	0.0003	-	1.70E-09^
2,3,7,8-TCDD	0.0006	0.01	0.0002	-	5.10E-10
2,3,7,8-TCDF	-	0.6	0.000407	-	5.10E-09^
Total PCBs	75	200	9	0.014	6.40E-06
PCB-44	-	-	-	-	-
PCB-99	-	-	-	-	-
PCB-141	-	-	-	-	-
PCB-153	-	-	-	-	-
PCB-174	-	-	-	-	-
PCB-177	-	-	-	-	-
PCB-180	-	-	-	-	-
PCB-183	-	-	-	-	-
PCB-199	-	-	-	-	-
cPAHS [B(a)P Eq.]	-	774,000	85	0.00012	0.00012
Benzo(a)anthracene	-	-	-	0.0012	0.0012
Benzo(a)pyrene	-	-	-	0.00012	0.00012
Benzo(b)fluoranthene	-	-	-	0.0012	0.0012
Benzo(k)fluoranthene	-	-	-	0.0013	0.0013
Chrysene	-	-	-	0.0013	0.0013
Dibenz(a,h)anthracene	-	-	-	0.00012	0.00012
Indeno(1,2,3-c,d)pyrene	-	-	-	0.0012	0.0012
Total PAHs	30,000	-	23,000	-	-
1-Methylnaphthalene	-	-	-	-	-
2-Methylnaphthalene	-	-	-	2.1	-
Acenaphthene	-	-	-	23	-
Acenaphthylene	-	-	-	-	-
Anthracene	-	-	-	0.73	-
Benzo(e)pyrene		-	-	-	-
Benzo(g,h,i)perylene	-	-	-	0.4	-
Beta-chloronaphthalene	-	-	-	-	-
Fluoranthene	-	-	-	6.2	-
Fluorene	-	-	-	3.9	-
Naphthalene	-	>140,000	-	12	12
Phenanthrene	-	-	-	6.3	-
Pyrene	-	-	-	10	-

Table 1-1
Sediment and Surface Water Criteria for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Notes:

$ Groundwater cleanup levels from Table 17 used in lieu of surface water

^ Surface water cleanup levels TEF-adjuted 2,3,7,8-TCDD eq.

> = greatear than

µg/kg = micrograms per kilogram

DDx

µg/L = micrograms per liter

B(a)P = benzo(a)pyrene

COC = contaminant of concern

cPAHs = carcinogenic polycyclic aromatic hydrocarbons

CUL = cleanup level

DDD = dichlorodiphenyldichloroethane

DDE = dichlorodiphenyldichloroethylene

DDT = dichlorodiphenyltrichloroethane

DDx = DDD + DDE + DDT

Eq. = equivalents

HxCDF = hexachlorodibenzofuran

N/A = not applicable

PAHs = polycyclic aromatic hydrocarbons

PCBs = polychlorinated biphenyls

PeCDD = pentachlorodibenzo-p-dioxin

PeCDF = pentachlorodibenzofuran

PTW = principal threat waste

RAL = remedial action level

TCDD = tetrachlorodibenzo-p-dioxin

Table 2-1
Chemical Properties and Partitioning Coefficients for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeled COCs			Molecular Weight	Diffusivity in Water, D_w[b] [cm^2/s]	Log K_{oc}[c] [log(L/kg)]	Log K_{doc}[d] [log(L/kg)]	K_F[e] [$\mu g/kg/(\mu g/L)^N$]	Log K_F[e] [$log(\mu g/kg/(\mu g/L)^N)$]	N[e]
Dioxins/Furans	Individual Dioxins/Furans	1,2,3,4,7,8-HxCDF	374.9	4.23E-06	7.4	6.86	6.310E+06	6.80	0.61
		1,2,3,7,8-PeCDD	356.0	4.16E-06	6.6	6.31	1.259E+06	6.10	0.61
		2,3,4,7,8-PeCDF	340.0	8.00E-06	5.15	6.23	1.995E+06	6.30	0.61
		2,3,7,8-TCDF	305.98	4.85E-06	5.18	5.44	6.310E+05	5.80	0.61
	Total Dioxins/Furans	2,3,7,8-TCDD Eq.	322.0	5.10E-05	5.4	5.65	3.981E+05	5.60	0.61
PAHs	cPAHs	Benzo(a)anthracene	228.3	9.00E-06	5.55	4.95	6.830E+05	5.83	0.5
		Benzo(a)pyrene	252.32	9.00E-06	5.77	5.65	1.610E+05	5.21	0.44
		Benzo(b)fluoranthene	252.31	5.56E-06	6.08	5.65	4.420E+06	6.65	0.37
		Benzo(k)fluoranthene	252.31	5.56E-06	6.09	5.65	3.550E+05	5.55	0.57
		Chrysene	228.3	6.21E-06	5.49	4.95	3.030E+06	6.48	0.458
		Dibenz(a,h)anthracene	278.36	5.18E-06	6.28	6.35	3.900E+05	5.59	0.75
		Indeno(1,2,3-cd)pyrene	276.33	5.66E-06	6.54	6.35	1.995E+07	7.30	0.82
	Total cPAHs[a]		252.32	9.00E-06	5.77	5.65	1.610E+05	5.21	0.44
	PAHs	1-Methylnaphthalene	142.2	7.80E-06	3.4	4.59	2.010E+06	6.30	0.43
		2-Methylnaphthalene	142.2	7.80E-06	3.4	4.78	2.010E+06	6.30	0.43
		Acenaphthene	154.21	7.69E-06	3.6	3.34	2.660E+06	6.42	0.457
		Acenaphthylene	152.2	6.98E-06	3.7	3.09	3.303E+06	6.52	0.302
		Anthracene	178.23	7.74E-06	4.37	3.56	4.560E+05	5.66	0.62
		Benzo(g,h,i)perylene	276.34	5.23E-06	6.29	6.35	1.070E+03	3.03	0.37
		Benzo(e)pyrene	252.32	5.49E-06	6.25	6.35	2.512E+07	7.40	0.82
		Beta-chloronaphthalene	162.61	8.79E-06	3.39	3.00	2.800E+04	4.45	0.46
		Fluoranthene	202.25	6.35E-06	4.69	4.26	2.300E+06	6.36	0.341
		Fluorene	166.22	7.88E-06	3.96	3.18	1.040E+06	6.02	0.604
		Naphthalene	128.18	7.50E-06	3.3	2.18	7.250E+05	5.86	0.43
		Phenanthrene	178.24	7.47E-06	4.22	3.56	5.129E+07	7.71	1.11
		Pyrene	202.26	7.24E-06	4.58	4.26	2.000E+06	6.30	0.386
	Total PAHs[a]		213.0	6.52E-06	5.4	4.40	1.450E+06	6.16	0.47
DDx	DDD		320.04	4.76E-06	5.51	4.78	1.995E+07	7.30	0.73
	DDE		318.02	5.87E-06	5.64	4.91	3.162E+07	7.50	0.69
	DDT		354.48	4.95E-06	5.14	5.70	1.020E+06	6.01	0.5
PCBs	Individual PCBs	PCB-44	291.99	5.38E-06	4.92	3.58	3.981E+07	7.60	0.92
		PCB-99	326.43	5.19E-06	5.46	4.04	5.012E+06	6.70	0.71
		PCB-141	360.88	5.03E-06	5.82	4.34	1.995E+08	8.30	0.95
		PCB-153	360.88	5.03E-06	5.9	4.41	2.512E+07	7.40	0.72
		PCB-174	395.32	4.89E-06	6.06	4.55	2.512E+07	7.40	0.71
		PCB-177	395.32	4.89E-06	6.03	4.53	3.802E+06	6.58	0.69
		PCB-180	395.32	4.88E-06	6.27	4.73	1.259E+08	8.10	0.82
		PCB-183	395.32	4.88E-06	6.13	4.61	1.995E+07	7.30	0.69
		PCB-199	429.77	4.75E-06	6.13	4.61	1.000E+07	7.00	0.7
	Total PCBs[a]		376.0	5.23E-06	5.28	3.81	2.100E+07	7.32	0.812

Table 2-2
CapSIM Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Underlying Sediment					
Thickness	h_{sed}	cm	30	N/A	Selected largest value in range of sediment thicknesses suggested by ITRC, 2023
Porosity	f_{sed}		0.449	No	Table 3.2 Total Porosity values assuming an even mixture of fine and coarse sand (Yu et al.,1993) and the average clay, silt, and sand content in subsurface cores (D-8.90, E-9.02, and D-9.09) in the Head of Swan Island Lagoon FSDR Appendix I (PGG, 2019).
Bulk Density	r_{sed}	g/cm^3	1.28	No	Table 2.1 (Yu et al, 1993) assuming the average clay, silt, and sand content in the subsurface cores (D-8.90, E-9.02, and D-9.09) in the Head of Swan Island Lagoon FSDR Appendix I (PGG, 2019).
Total Organic Carbon	f_{ocsed}	%	3.553	Yes	From Total Organic Carbon results for core samples deeper than 40cm in the Head of Swan Island Lagoon FSDR (2019) Appendix I, and assuming based on those results that the native sand f_{oc} is 0.62%, values were derived for a predominately silt sediment.
Fraction Organic Carbon	f_{ocsed}		0.03553		
Particle Size		mm	0.06	No	CapSIM default
Permeability		cm^2	6.0E-08	No	Kozeny & Carman calculation completed within CapSIM
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSIM default
Capping Sand					
Porosity	f_{sand}		0.32	No	Table 3.2 Effective Porosity for medium sand (Yu et al, 1993).
Bulk Density	r_{sand}	g/cm^3	1.6	No	Regularly cited bulk density for dry sand
Total Organic Carbon	$f_{tocsand}$	%	0.1	Yes	Mode of regionally tested and assumed sand cap f_{oc} including the following sites: Former Portland Gas Manufacturing Site (Anchor QEA, 2020), Crawford Street BODR (GeoEngineers, 2022), Pacific Gas & Electric Pier 39 (Haley & Aldrich, 2020), Quendall Terminals Site FS (Aspect & Arcadis, 2013)
Fraction Organic Carbon	f_{ocsand}		0.001		
Particle Size		mm	1.2125	No	Table 3-1 median of United Soil Classification System range of medium sand (0.425-2.0mm) (USDA, 2012)
Permeability		cm^2	5.8E-06	No	Kozeny & Carman calculation completed within CapSIM
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSIM default
Activated Carbon					
Porosity	f_{ac}		0.6	No	CapSIM default
Bulk Density	r_{ac}	g/cm^3	0.4	No	CapSIM default
Total Organic Carbon	f_{tocac}	%	100	No	CapSIM default
Fraction Organic Carbon	f_{ocac}		1.0		
Particle Size		mm	0.5	No	CapSIM default
Permeability		cm^2	1.9E-05	No	Kozeny & Carman calculation completed within CapSIM
Sorption Isotherm			Freundlich	N/A	CapSIM default

Table 2-2
CapSIM Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Erosion Protection Material					
Thickness	h_{ep}	cm	60	N/A	A 60 cm erosion protection layer is only included in cap alternatives 1 and 2
Porosity	f_{ep}		0.3	No	Yu et al. (1993) Table 3.2 Total Porosity average of range for coarse gravel
Bulk Density	r_{ep}	g/cm^3	1.8	No	From Table 2 from Sakr et al. (2016)
Total Organic Carbon	f_{tocep}	%	0	No	Assumed 0% organic carbon for clean gravel to remove possibility for chemical adsorption in the erosion protection layer
Fraction Organic Carbon	f_{ocep}		0.0		
Particle Size		mm	39.624	No	Mean equivalent diameter based on a distribution for type 2 bedding stone (10% = 0.6", 40% = 1.5", 50% = 1.8")
Permeability		cm^2	4.8E-03	No	Kozeny & Carman calculation completed within CapSIM
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSIM default
General Input					
Darcy Velocity		cm/year	402 / 295	Yes	Steady flow upwelling assumed. The value for the main evaluation used was 402 cm/year, consistent with the maximum porewater upwelling recorded during the Porewater Upwelling Study and reported in Appendix B of the PDI ER (HGL, 2024). Additionally, 295 cm/year was used for End of Basin sensitivity scenarios and is the highest 50-hour maximum specific discharge within the End of Basin area from the Porewater Upwelling Study (HGL, 2024).
Hyporheic Exchange			None	N/A	Assumed
Erosion			None	N/A	Assumed
Bioturbation		cm	20	Yes	Uniform bioturbation within modeled depth with particle size impact. Depth estimated is the high end of the estimated range reported in Portland Harbor RI/FS Appendix D (EPA, 2016)
Particle Biodiffusion Coefficient		cm^2/year	8.74	No	Selected average literature values (Reible 2014, Sections 2.3.2 and 2.3.3)
Pore Water Biodiffusion Coefficient		cm^2/year	173	No	
Maximum Consolidation Depth		cm	20.0	No	Assumed
Time to 90% Consolidation		year	5	No	Assumed
Ionic Activity			None	N/A	Assumed
Deposition			None	N/A	Conservatively assumed no sediment deposition
Decay			None	N/A	Conservatively assumed no contaminant decay
Depth of Interest		cm	30 / 60	No	For all cap alternatives, time to breakthrough was evaluated at the top boundary of the chemical isolation layer. When erosion protection was present (Cap Alternatives 1 and 2), breakthrough was evaluated at the interface of the chemical isolation and erosion protection layers (60 cm). When erosion protection was not present (Cap Alternatives 3 and 4), breakthrough was evaluated at the interface of the chemical isolation and sand layers (30 cm).

Table 2-2
CapSIM Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Number of Grids per Layer			20 / 60	N/A	CapSIM guidance documents recommends using a uniform number of grid cells in each layer (Reible, 2022). Fewer grid cells per layer is more conservative. The sand layer in Cap Alternative 3, modeled as one 90 cm combined chemical isolation and bioturbation layer, used 60 grid cells to maintain the 1.5 cm grid size consistent with the bioturbation layer grid size in Cap Alternative 4 and enable CPP evaluation at a depth of 30 cm.
Time Step Size		year	0.1	N/A	CapSIM default
Hydrodynamic Dispersivity		%	10	N/A	CapSIM guidance documents recommend 10% of layer thickness (Reible, 2022)
Porewater DOC Concentration		mg/L	0.0	No	Assumed
Boundary Conditions					
Benthic Boundary Condition Type			Mass Transfer	N/A	CapSIM guidance documents recommendation for evaluating cap breakthrough (Reible, 2022)
Water Dissolved Organic Matter		mg/L	1.0	No	Assumed
Benthic Boundary Water DOC Concentration		µg/L	1.0E-25	No	Assumed value close to 0
Mass Transfer Coefficient		cm/year	876	No	Equivalent to 0.1 cm/hr, which falls within EPA recommendation of using a mass transfer coefficient less than 0.5 cm/hr.
Bottom Boundary Condition Type			Fixed Concentration	N/A	Conservatively assumed constant supply of contaminants
Bottom Concentration		µg/L	Variable	N/A	See Table 2-3 for boundary concentrations for each modeled scenario

Notes:
Sources referenced are listed in the references section of the BODR.
% = percent
cm = centimeter
cm/hr = centimeter per hour
cm/year = centimeter per year
cm^2 = centimeter squared
cm^2/year = centimeter squared per year
g/cm^3 = grams per meter cubic
µg/L = micrograms per liter
mg/L = milligrams per liter
mm = millimeter
BODR = basis of design report
N/A = not applicable

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Table 2-3
Chemical Concentrations for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeling Scenario	Initial Scenario - Whole Basin		Alternative Scenario 1 - Cleanup Levels			Alternative Scenario 2 - End of Basin		Alternative Scenario 3 - End of Basin Following 3ft Dredge	
COC	**Csed (µg/kg)**	**Calc Cpw (µg/L)**	**Csed (µg/kg)**	**Cpw (µg/L)**	**Source C**	**Csed (µg/kg)**	**Calc Cpw (µg/L)**	**Csed (µg/kg)**	**Calc Cpw (µg/L)**
DDD	13	0.00113	114	0.00992	Sediment CUL	7.4	0.000644	7.07	0.000615
DDE	12	0.000774	50	0.00322	Sediment CUL	8.4	0.000542	8.89	0.000573
DDT	43.3	0.00883	246	0.0502	Sediment CUL	14	0.00286	5.50	0.00112
1,2,3,4,7,8-HxCDF	0.03	3.36E-08	0.0004	4.48E-10	Sediment CUL	0.0206	2.31E-08	0.0205	2.30E-08
1,2,3,7,8-PeCDD	0.00518	3.66E-08	0.0002	1.41E-09	Sediment CUL	0.0049	3.46E-08	0.00535	3.78E-08
2,3,4,7,8-PeCDF	0.0111	2.21E-06	0.0003	5.98E-08	Sediment CUL	0.0114	2.27E-06	0.0117	2.33E-06
2,3,7,8-TCDD	0.0367	4.11E-06	0.0002	2.24E-08	Sediment CUL	0.032	3.59E-06	0.0357	4.00E-06
2,3,7,8-TCDF	0.00660	1.23E-06	0.000407	7.56E-08	Sediment CUL	0.00591	1.10E-06	0.00597	1.11E-06
Total PCBs	1,284	0.190	94.8	0.014	Total PCB Groundwater CUL	625	0.0923	688	0.1016
PCB-44	35.8	0.0121	41.4	0.014	Total PCB Groundwater CUL	10.7	0.00361	5.17	0.00175
PCB-99	50.9	0.00497	144	0.014	Total PCB Groundwater CUL	14.0	0.00136	7.55	0.000737
PCB-141	14.9	0.000634	329	0.014	Total PCB Groundwater CUL	5.62	0.000239	3.26	0.000139
PCB-153	73.9	0.00262	395	0.014	Total PCB Groundwater CUL	34.5	0.00122	18.6	0.000657
PCB-174	21.6	0.000531	571	0.014	Total PCB Groundwater CUL	11.5	0.000282	5.80	0.000142
PCB-177	13.5	0.000354	533	0.014	Total PCB Groundwater CUL	7.43	0.000195	3.88	0.000102
PCB-180	47.3	0.000715	926	0.014	Total PCB Groundwater CUL	21.5	0.000325	13.2	0.000200
PCB-183	17.5	0.000365	671	0.014	Total PCB Groundwater CUL	8.36	0.000175	3.36	7.00E-05
PCB-199	16.8	0.000351	671	0.014	Total PCB Groundwater CUL	2.6	5.43E-05	3.36	7.02E-05
cPAHs [B(a)P Eq.]	692	0.0331	85	0.00406	Sediment CUL	477	0.0228	409	0.0196
Benzo(a)anthracene	700	0.0555	15	0.0012	Groundwater CUL	360	0.0286	224	0.0177
Benzo(a)pyrene	584	0.0279	2.51	0.00012	Groundwater CUL	368	0.0176	294	0.0141
Benzo(b)fluoranthene	860	0.0201	51.3	0.0012	Groundwater CUL	428	0.0100	317	0.00742
Benzo(k)fluoranthene	473	0.0108	56.8	0.0013	Groundwater CUL	199	0.00455	120	0.00275
Chrysene	738	0.0672	14.3	0.0013	Groundwater CUL	474	0.0431	312	0.0284
Dibenz(a,h) anthracene	113	0.00167	8.12	0.00012	Groundwater CUL	58.3	0.000860	38	0.000561
Indeno(1,2,3-cd) pyrene	430	0.00349	148	0.0012	Groundwater CUL	251.6	0.00204	215	0.00174
Total PAHs	8,510	0.954	23,000	2.58	Sediment CUL	5,468	0.613	3,930	0.440
1-Methylnaphthalene	133	1.49	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	110	1.23	187.4	2.1	Groundwater CUL	92.4	1.04	94.7	1.06
Acenaphthene	306	2.16	3,253	23	Groundwater CUL	110	0.778	89.0	0.629
Acenaphthylene	87	0.489	N/A	N/A	N/A	63.6	0.357	56.0	0.314
Anthracene	425	0.511	608	0.73	Groundwater CUL	160	0.192	140	0.168
Benzo(e)pyrene	301	0.00476	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene	380	0.00549	27,710	0.4	Groundwater CUL	265	0.00383	240	0.00346

Table 2-3
Chemical Concentrations for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeling Scenario	Initial Scenario - Whole Basin		Alternative Scenario 1 - Cleanup Levels			Alternative Scenario 2 - End of Basin		Alternative Scenario 3 - End of Basin Following 3ft Dredge	
COC	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Cpw (µg/L)	Source C	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Calc Cpw (µg/L)
Beta-chloronaphthalene	53.8	0.617	N/A	N/A	N/A	43.8	0.502	12.4	0.142
Fluoranthene	1,694	0.974	10,790	6.2	Groundwater CUL	1,100	0.632	655	0.376
Fluorene	340	1.05	1,264	3.9	Groundwater CUL	140	0.432	120	0.370
Naphthalene	190	2.68	851	12	Groundwater CUL	190	2.68	206	2.91
Phenanthrene	1,855	3.15	3,715	6.3	Groundwater CUL	848	1.44	598	1.01
Pyrene	1,545	1.14	13,510	10	Groundwater CUL	1,100	0.814	743	0.550

Notes:

µg/kg = micrograms per kilogram
µg/L = micrograms per liter
ft = feet
C = concentration
Csed = sediment concentration
Cpw = porewater concentration
Calc = calculated
COC = contaminant of concern
B(a)P = benzo(a)pyrene
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
DDx = DDD + DDE + DDT
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
Eq. = equivalents
HxCDF = hexachlorodibenzofuran
N/A = not applicable
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzofuran

Table 2-4
Freundlich Coefficient Sensitivity Analyses
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

COC	Base Case (Literature Value ÷ 10)				Literature Value				Literature Value x 10			
	K_F	Porewater (µg/L)	Total Solid (µg/kg)	Time-to-Breakthrough	K_F	Porewater (µg/L)	Total Solid (µg/kg)	Time-to-Breakthrough	K_F	Porewater (µg/L)	Total Solid (µg/kg)	Time-to-Breakthrough
DDD	1.995E+07	3.67E-04	3.21	69 (PW)	1.995E+08	0.0	0.0	100+	1.995E+09	0.0	0.0	100+
DDE	3.162E+07	0.0	2.72E-13	100+	3.162E+08	0.0	0.0	100+	3.162E+09	0.0	0.0	100+
DDT	1.020E+06	8.79E-03	5.99	8 (PW)	1.020E+07	4.06E-03	33.1	77 (PW)	1.020E+08	0.0	0.0	100+
HxCDF	6.310E+06	0.0	0.0	100+	6.310E+07	0.0	0.0	100+	6.310E+08	0.0	0.0	100+
Naphthalene	1.420E+06	2.68	114	100+	1.420E+07	2.68	1.09E+03	100+	1.420E+08	2.43	1.04E+04	100+
PeCDD	1.259E+06	0.0	0.0	100+	1.259E+07	0.0	0.0	100+	1.259E+08	0.0	0.0	100+
PeCDF	1.995E+06	0.0	0.0	100+	1.995E+07	0.0	0.0	100+	1.995E+08	0.0	0.0	100+
TCDD	3.981E+05	3.74E-06	1.07E-02	19 (SW); 20 (TS)	3.981E+06	0.0	0.0	100+	3.981E+07	0.0	0.0	100+
TCDF	6.310E+05	3.00E-07	3.35E-03	78 (SW); 80 (TS)	6.310E+06	0.0	0.0	100+	6.310E+07	0.0	0.0	100+

Notes:

Modeled concentrations were compared for Cap Alternative 4 with a 5 cm isolation layer, 0.005% GAC, and upwelling velocity of 402 cm/year.

Concentrations were evaluated at the CPP (top of the chemical isolation layer).

÷ 10 = divided by 10

x 10 = multiplied by 10

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

cm = centimeter

COC = contaminant of concern

CPP = Cap Performance Point

DDD = dichlorodiphenyldichloroethane

DDE = dichlorodiphenyldichloroethylene

DDT = dichlorodiphenyltrichloroethane

HxCDF = hexachlorodibenzofuran

K_F = Freundlich partition coefficient

PeCDD = pentachlorodibenzo-p-dioxin

PeCDF = pentachlorodibenzofuran

PW = Porewater CUL Exceeded

SW = Surface Water CUL Exceeded

TCDD = tetrachlorodibenzo-p-dioxin

TCDF = tetrachlorodibenzofuran

TS = Total Solid CUL Exceeded

Table 2-5
Time-to-Breakthrough Results of Amended Cap Modeling
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Initial Sediment Concentration Scenario	% GAC by Weight	Darcy Velocity (cm/year)	With Erosion Protection Layer (Alternative 2) Time-to-Breakthrough		Without Erosion Protection Layer (Alternative 4) Time-to-Breakthrough		Material f_{OC} Sensitivity Test Alternative 4: 0.05% f_{OC} Sand Time-to-Breakthrough	
			Total Solid	Porewater	Total Solid	Porewater	Total Solid	Porewater
Initial Scenario - Whole Basin	5.0%	402	100+	100+	100+	100+	100+	100+
Alternative Scenario 1 - Low Concentration		402	100+	100+	100+	100+	100+	100+
Alternative Scenario 2 - End of Basin		295	100+	100+	100+	100+	100+	100+
Alternative Scenario 3 - End of Basin Following 3 ft Dredge		295	100+	100+	100+	100+	100+	100+
Initial Scenario - Whole Basin	1.0%	402	100+	100+	100+	100+	100+	100+
Alternative Scenario 1 - Low Concentration		402	59	100+	59	100+	59	100+
Alternative Scenario 2 - End of Basin		295	100+	100+	100+	100+	100+	100+
Alternative Scenario 3 - End of Basin Following 3 ft Dredge		295	100+	100+	100+	100+	100+	100+

Notes:
100+ = time-to-breakthrough exceeds 100 years
% = percent
cm = centimeter
cm/year = centimeter per year
CPP = cap performance point
CUL = cleanup level
foc = fraction of organic carbon
ft = feet
GAC = granular activated carbon
Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the CPP.

Table 2-6
Time-to-Breakthrough Results of Unamended Cap Modeling
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Initial Sediment Concentration Scenario	Darcy Velocity (cm/year)	With Erosion Protection Layer (Alternative 1) Time-to-Breakthrough		Without Erosion Protection Layer (Alternative 3) Time-to-Breakthrough		Material f_{OC} Sensitivity Test Alternative 3: 0.05% f_{OC} Sand Time-to-Breakthrough	
		Total Solid	Porewater	Total Solid	Porewater	Total Solid	Porewater
Initial Scenario - Whole Basin	402	28	8	29	7	21	4
Alternative Scenario 1 - Low Concentration	402	42	4	48	6	46	3
Alternative Scenario 2 - End of Basin	295	45	12	48	12	34	6
Alternative Scenario 3 - End of Basin Following 3 ft Dredg	295	44	15	46	14	32	7

Notes:
100+ = time-to-breakthrough exceeds 100 years
% = percent
cm = centimeter
cm/year = centimeter per year
foc = fraction of organic carbon
Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the depth of interest.

Table 2-7a
Cap Modeling Input Parameters Sensitivity Analyses - Cap Alternative 4
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sensitivity Analysis	Base Case Scenario		Sensitivity Analysis Scenario			Time-to-Breakthrough RPD (%)
	Parameter Value	Time-to-Breakthrough	Parameter Value	Time-to-Breakthrough	Breakthrough COC + Media	
Outlier Impact	95th Percentile Concentration	100+	Maximum Concentration	34	Total PAHs; Total Solid	98.5+
Sediment f_{OC}	3.55%	100+	0.62%	48	Anthracene; Porewater	70.3+
Amended Isolation Layer Thickness	5 cm	100+	2.5 cm	70	Total cPAHs; Porewater	35.3+
Sorption Parameters	Literature K_F ÷ 10	100+	Literature K_F ÷ 20	78	Total cPAHs; Porewater	24.7+
GAC Amendment	1% GAC	100+	0.5% GAC	79	Total cPAHs; Porewater	23.5+
			5.0% GAC	100+	N/A	0
Hydrodynamic Dispersivity of Isolation Layer	10% (0.5 cm) - Initial Scenario	100+	20% (1.0 cm) - Initial Scenario	100+	N/A	0.0
	10% (0.5 cm) - Alternative 1	59	20% (1.0 cm) - Alternative 1	55	Total PAHs; Total Solid	7.0
CPP	30 cm	100+	31 cm	100+	N/A	0
Upwelling Velocity	402 cm/year	100+	24 cm/year	100+	N/A	0
			600 cm/year	100+	N/A	0
			402 ± 201 cm/year	100+	N/A	0
Material f_{OC}	0.10%	100+	0.05%	100+	N/A	0.0
Absolute Error Tolerance	1.00E-08	100+	1.00E-10	100+	N/A	0.0
Benthic Mass Transfer Coefficient	0.1 cm/hr	100+	0.5 cm/hr	100+	N/A	0.0
Benthic Boundary Condition Type	Fixed Concentration	100+	Flux-Matching	100+	N/A	0.0
Sediment Thickness	30 cm	100+	120 cm	100+	N/A	0.0
Spatial Discretization	20 grids/layer	100+	40 grids/layer	100+	N/A	0.0

Table 2-7a
Cap Modeling Input Parameters Sensitivity Analyses - Cap Alternative 4
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sensitivity Analysis	Base Case Scenario		Sensitivity Analysis Scenario			Time-to-Breakthrough RPD (%)
	Parameter Value	Time-to-Breakthrough	Parameter Value	Time-to-Breakthrough	Breakthrough COC + Media	
Surface Water DOC	1 mg/L	100+	8 mg/L	100+	N/A	0.0
Time Step	0.1 year	100+	0.01 year	100+	N/A	0.0

Notes:
The base case for sensitivity analyses is a 5-cm thick sand cap amended with 1.0 percent GAC by weight and topped with 30 cm of clean sand (Cap Alternative 4) with an upwelling velocity of 402 cm/year. The CPP for all sensitivity scenarios, except when related to CPP variation, is the top of the chemical isolation layer (30 cm below the cap-surface water interface).

% = percent

cm = centimeter

cm/hr = centimeter per hour

cm/year = centimeter per year

mg/L = milligrams per liter

COC = contaminant of concern

cPAH = carcinogenic polycyclic aromatic hydrocarbons

CPP = cap performance point

DOC = dissolved organic carbon

f_{oc} = fraction organic carbon

GAC = granular activated carbon

PAH = polycyclic aromatic hydrocarbons

RPD = relative percent difference [*(absolute difference / average)* · *100*]

Table 2-7b
Cap Modeling Input Parameters Sensitivity Analyses - Cap Alternative 3
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sensitivity Analysis	Base Case Scenario		Sensitivity Analysis Scenario			Time-to-Breakthrough RPD (%)
	Parameter Value	Time-to-Breakthrough	Parameter Value	Time-to-Breakthrough	Breakthrough COC + Media	
Unamended Isolation Layer Thickness	60 cm	7	618 cm	100	DDT; Porewater	173.8
Sorption Parameters	Literature K_{OC}	7	Literature $K_{OC} \cdot 1.1$	100+	N/A	173.8+
Upwelling Velocity	402 cm/year	7	24 cm/year	100+	N/A	173.8+
			81 cm/year	35	DDT; Porewater	133.3
Material f_{OC}	0.1% - Cap 3	7	0.05% - Cap 3	4	DDT; Porewater	54.5
Spatial Discretization in Sand Layer	60 grids	7	20 grids	4	DDT; Porewater	54.5
CPP	30 cm	7	21 cm	9	DDT; Porewater	25.0

Notes:
The base case for sensitivity analyses is a 60-cm thick unamended sand cap topped with 30 cm of clean sand (Cap Alternative 3) with an upwelling velocity of 402 cm/year. The CPP for all sensitivity scenarios, except when related to CPP variation, is the top of the chemical isolation layer (30 cm below the cap-surface water interface).

% = percent

cm = centimeter

cm/year = centimeter per year

COC = contaminant of concern

CPP = cap performance point

PeCDF = 2,3,4,7,8-pentachlorodibenzofuran

RPD = relative percent difference [*(absolute difference / average) · 100*]

TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin

Table 2-8
Modeled Darcy Velocities
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Darcy Velocity (cm/year)	Applicable Scenarios	Source
402	Initial Scenario (Whole Basin): Cap Alternatives 1, 2, 3, and 4 Alternative Scenario 1 (Low Concentration): Cap Alternatives 1, 2, 3, and 4	The highest single 50-hour maximum specific discharge measured with UltraSeep within SIB was 1.1 cm/day (PDI ER Appendix B, Table 4-3 [HGL, 2024]). Converted to cm/year and rounded up.
295	Alternative Scenario 2 (End of Basin): Cap Alternatives 1, 2, 3, and 4 Alternative Scenario 3 (End of Basin Following 3 ft Dredge): Cap Alternatives 1, 2, 3, and 4	The area-specific highest 50-hour maximum specific discharge measured with UltraSeep was 0.808 cm/day (PDI ER Appendix B, Table 4-3 [HGL, 2024]). Converted to cm/year and rounded up.
24	Sensitivity Analyses (Caps 3 and 4): Upwelling Velocity	The average 50-hour average specific discharge across all 21 stations measured with UltraSeep is 0.064 cm/day (PDI ER Appendix B, Table 4-3 [HGL, 2024]). Converted to cm/year and rounded up.
81	Sensitivity Analyses (Cap 3): Upwelling Velocity	The highest 50-hour average specific discharge measured with UltraSeep was 0.22 cm/day (PDI ER Appendix B, Table 4-3 [HGL, 2024]). Converted to cm/year and rounded up.
600	Sensitivity Analyses (Cap 4): Upwelling Velocity	A theoretical very high upwelling velocity used for sensitivity testing.
402 ± 201	Sensitivity Analyses (Cap 4): Upwelling Velocity (oscillations)	The highest 50-hour maximum specific discharge measured with UltraSeep (1.1 cm/day) (PDI ER Appendix B, Table 4-3 [HGL, 2024]) that oscillates to reach 1.5 times the steady-flow value. Converted to cm/year and rounded up.

Notes:
% = percent
± = plus or minus
cm = centimeter
cm/day = centimeter per day
cm/year = centimeter per year
CPP = cap performance point
DOC = dissolved organic carbon
f_{oc} = fraction organic carbon
GAC = granular activated carbon
HGL = HydroGeoLogic, Inc.
PDI ER = Pre-Design Investigation Evaluation Report
SIB = Swan Island Basin

Table 2-9
Chemical Properties and Partitioning Coefficients for Sensitivity Analyses COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeled COCs		Molecular Weight	Diffusivity in Water, D_w[a] [cm^2/s]	Log K_{oc}[b] [log(L/kg)]	K_d[c] [L/kg]	Log K_{doc}[d] [log(L/kg)]	K_F[e] [µg/kg/(µg/L)^N]	Log K_F[e] [log(µg/kg/(µg/L)^N)]	N[e]
Hydrocarbons	Benzene	78.11	8.00E-06	2.53	$K_{oc} f_{oc}$	0.90	1.260E+05	5.10	0.533
	TPH-Diesel	200	1.00E-05	5.40	$K_{oc} f_{oc}$	0	1.170E+00	0.07	0.324
	Xylenes	106.17	8.75E-06	3.11	$K_{oc} f_{oc}$	2.08	1.93E+06	6.29	0.381
Metals	Arsenic	74.92	1.75E-05	0	29	0	-	-	-
	Cadmium	112.41	1.75E-05	0	6.7	0	4.615E+02	2.66	0.667
	Chromium (III)	52	2.48E-05	0	1000	0	1.100E+04	4.04	0.44
	Copper	63.55	2.50E-05	0	22	0	1.520E+04	4.18	0.49
	Lead	207.2	1.43E-05	0	10000	0	5.424E+04	4.73	0.39
	Manganese	54.94	4.56E-05	0	65	0	1.323E+05	5.12	0.082
	Mercury	200.95	6.30E-06	0	52	0	8.340E+04	4.92	0.46
	Vanadium	50.94	4.25E-05	0	1000	0	1.768E+02	2.25	0.51
	Zinc	64.39	4.10E-05	0	62	0	1.403E+03	3.15	0.555
Organochloride	Aldrin	364.9	4.86E-06	4.68	$K_{oc} f_{oc}$	5.66	1.060E+05	5.03	0.93
	Chlordanes	409.78	4.37E-06	5.10	$K_{oc} f_{oc}$	5.51	1.770E+06	6.25	0.38
	Dieldrin	380.91	4.74E-06	4.59	$K_{oc} f_{oc}$	4.44	6.060E+04	4.78	0.51
	Lindane	290.83	7.34E-06	3.17	$K_{oc} f_{oc}$	2.25	2.850E+04	4.45	0.43
	Pentachlorophenol	266.34	6.10E-06	3.71	$K_{oc} f_{oc}$	3.90	4.360E+04	4.64	0.34
Organotin	Tributyltin	291.04	5.35E-06	4.22	$K_{oc} f_{oc}$	3.95	8.862E+02	2.95	0.996
PCBs	PCB-1 (2-chlorobiphenyl)	188.65	6.07E-06	3.84	$K_{oc} f_{oc}$	2.67	7.943E+06	6.90	0.34
	PCB-15 (4,4'-dichlorobiphenyl)	223.1	5.83E-06	4.54	$K_{oc} f_{oc}$	3.26	3.981E+07	7.60	1.01
	PCB-31 (2,4',5-trichlorobiphenyl)	257.54	5.59E-06	4.85	$K_{oc} f_{oc}$	3.53	7.943E+07	7.90	0.99
	PCB-206 (2,2',3,3',4,4',5,5',6-nonachlorobiphenyl)	464.21	4.62E-06	6.88	$K_{oc} f_{oc}$	5.24	1.000E+07	7.00	0.60
	PCB-209 (decachlorobiphenyl)	498.66	4.51E-06	6.96	$K_{oc} f_{oc}$	5.31	7.943E+05	5.90	1
Phthalates/Plasticizers	BEHP	390.56	3.66E-06	5.05	$K_{oc} f_{oc}$	6.35	1.130E+06	6.05	1.5

Notes:

a. Diffisivities were sourced from: NJDEP (2014) for Chlrodanes, Dieldrin, Lindane, Pentachlorophenol, BEHP; Center for Environmental & Human Toxicology, University of Florida (2005) for Vanadium; RAIS Toxicity Values and Physical Parameters Search (n.d.) for Tributyltin; California Department of Toxic Substances Control (2009) for Diesel; and the CapSIM defaults for Aldrin, Arsenic, Benzene, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, PCBs, Toluene, Xylenes (Average), Zinc.

b. Log K_{oc} were sourced from: Poulson et al. (1997) for Toluene, Benzene; Bureau of Habitat (2014) for Xylenes; an average of values from CLARC data tables (2023), Bureau of Habitat (2014), NJDEP (2014), Technical Background Document Part 5: CHEMICAL-SPECIFIC PARAMETERS (n.d.) for Chlordanes, Dieldrin; Technical Background Document Part 5 for Lindane, BEHP; NJDEP (2014) for Pentachlorophenol; Ma et al. (2000) for Tributyltin; California Department of Toxic Substances Control (2009) for Diesel; and the CapSIM defaults for Aldrin and PCBs.

c. K_d were sourced from: CLARC data tables for metals (2024).

d. Log K_{doc} were sourced from: Technical Background Document Part 5 and the Burkhard (2000) method for BEHP; Burgess et al. (2012) for Dieldrin; Fukushima et al. (2005) for Lindane, Pentachlorophenol, Tributyltin; and the CapSIM defaults for Aldrin, Arsenic, Benzene, Cadmium, Chlordanes, Chromium, Copper, Lead, Manganese, Mercury, Toluene, Zinc, Xylenes. Data was unavailable for Diesel, and 0 was assumed.

e. Freundlich parameters are sourced from the following literature values and were reduced by an order of magnitude. $K_{F,}$ Log $K_{F,}$ and N values were sourced from: Lin (2014) for Dieldrin, Lindane, Pentachlorophenol, BEHP; Ma et al. (2000) for Tributyltin; Patnukao et al. (2008) for Copper and Lead; Erto et al. (2015) for Cadmium and Zinc; Adeyoye, A. O. (1999) for Diesel; bin Jusoh et al. (2005) for Manganese; Chattopadhyay (2011) for PCB-1; Gomez-Eyles et al. (2013) for PCB-15, PCB-31, PCB-206; Keńczyk et al. (2022) for Vanadium; and the CapSIM defaults for Aldrin, Benzene, Chlordanes, Chromium, Mercury, Toluene, Xylenes. Data was unavailable for Arsenic and PCB-209. PCB-209 was assumed to be equal to the minimum Kf for PCBs reporting in Table S2 in Gomez-Eyles et al. (2013). Arsenic was assumed to sorb linearly to GAC equal to Kd.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

cm = centimeter

BEHP = bis(2-ethylhexyl) phthalate

COC = chemical of concern

K_{oc} = organic carbon-water partition coefficient

K_{doc} = dissolved organic carbon-water partition coefficient

K_F = Freundlich partition coefficient

PCBs = polychlorinated biphenyls

TPH = total petroleum hydrocarbons

K_F = Freundlich partition coefficient

PCBs = polychlorinated biphenyls

TPH = total petroleum hydrocarbons

Table 2-10
Concentrations for Sensitivity Analyses COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

COC		Whole Basin Concentrations		Cleanup Levels	
		Csed (µg/kg)	Calc Cpw (µg/L)	Sediment (µg/kg)	Porewater (µg/L)
Hydrocarbons	Benzene	0.11	9.14E-03	-	0.44
	TPH-Diesel	819,500	91.82	91,000	-
	Xylenes	1.1	0.024	-	13
Metals	Arsenic	11,420	393.8	3,000	0.018
	Cadmium	710	106	510	0.094
	Chromium (III)	48,060	48.06	-	11
	Copper	355,400	16,150	359,000	2.74
	Lead	110,000	11	196,000	0.54
	Manganese	858,400	13,210	-	430
	Mercury	580	11.15	85	-
	Vanadium	118,100	118.1	-	20
	Zinc	436,400	7,039	459,000	36.5
Organochloride	Aldrin	2.56	1.51E-03	2	*7.70E-07*
	Chlordanes	9.045	2.02E-03	1.4	*8.10E-05*
	Dieldrin	4.575	3.31E-03	0.07	-
	Lindane	6.675	0.127	5	-
	Pentachlorophenol	180	0.9878	-	0.03
Organotin	Tributyltin	5,400	9.158	3,080	*0.063*
PCBs	PCB-1 (2-chlorobiphenyl)	1.092	4.44E-03	9*	0.014*
	PCB-15 (4,4'-dichlorobiphenyl)	1.17	9.50E-04	9*	0.014*
	PCB-31 (2,4',5-trichlorobiphenyl)	5.094	2.03E-03	9*	0.014*
	PCB-206 (2,2',3,3',4,4',5,5',6-nonachlorobiphenyl)	4.628	1.72E-05	9*	0.014*
	PCB-209 (decachlorobiphenyl)	2.5	7.72E-06	9*	0.014*
Phthalates/Plasticizers	BEHP	2,575	0.6459	135	*0.2*

Notes:

Cleanup levels in italics are Surface Water CULs.

Non-detect and riverbank results were excluded from Whole Basin concentration calculations.

* Criteria for Total PCBs

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

BEHP = bis(2-ethylhexyl) phthalate

C = concentration

Csed = sediment concentration

Cpw = porewater concentration

Calc = calculated

COC = contaminant of concern

ND = not detected

TPH = total petroleum hydrocarbons

Table 2-11
Results of Sensitivity Analyses COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

COC		5 cm Isolation Layer with 1% GAC				30 cm Isolation Layer with 5% GAC			
		100-Year Concentrations at CPP		Time-to-Breakthrough		100-Year Concentrations at CPP		Time-to-Breakthrough	
		Csed (µg/kg)	Calc Cpw (µg/L)	Sed (years)	PW (years)	Csed (µg/kg)	Calc Cpw (µg/L)	Sed (years)	PW (years)
Hydrocarbons	Benzene	2.21E-20	0	N/A	100+	0	0	N/A	100+
	TPH-Diesel	22,800	91.6	100+	N/A	21,700	90.7	100+	N/A
	Xylenes	0	0	N/A	100+	4.72E-11	0.0	N/A	100+
Metals	Arsenic	11,400	394	1	1	11,400	394	3	1
	Cadmium	806	106	1	1	1,190	106	2	1
	Chromium (III)	45,500	45.3	N/A	14	22,600	21.6	N/A	74
	Copper	369,000	16,100	3	1	425,000	16,100	5	1
	Lead	10,300	0.986	100+	84	1.93E-07	0	100+	100+
	Manganese	852,000	13,200	N/A	1	829,000	13,200	N/A	3
	Mercury	3,100	11.1	4	N/A	2,830	0.423	93	N/A
	Vanadium	109,000	110	N/A	11	55,400	58.2	N/A	60
	Zinc	434,000	7,030	100+	1	424,000	7,030	100+	2
Organochloride	Aldrin	2.55	1.48E-03	42	*8*	7.48E-10	1.52E-14	100+	*100+*
	Chlordanes	3.49E-15	0	100+	*100+*	1.34E-14	0	100+	*100+*
	Dieldrin	2.71E-13	0	100+	N/A	1.52E-19	0	100+	N/A
	Lindane	118	0.127	14	N/A	2.81E-14	0	100+	N/A
	Pentachlorophenol	439	0.987	N/A	8	7.03E-11	0	N/A	100+
Organotin	Tributyltin	231	9.16	100+	*1*	546	9.15	100+	*2*
PCBs	PCB-1 (2-chlorobiphenyl)	0.021	4.64E-20	100+	100+	1.93E-09	0	100+	100+
	PCB-15 (4,4'-dichlorobiphenyl)	1.04E-16	0	100+	100+	0	0	100+	100+
	PCB-31 (2,4',5-trichlorobiphenyl)	0	0	100+	100+	0	0	100+	100+
	PCB-206 (2,2',3,3',4,4',5,5',6-nonachlorobiphenyl)	0	0	100+	100+	0	0	100+	100+
	PCB-209 (decachlorobiphenyl)	0.0014	8.27E-08	100+	100+	1.91E-18	0	100+	100+
Phthalates/Plasticizers	BEHP	1,210	0.223	36	*92*	1.49	8.49E-04	100+	*100+*

Notes:

Time-to-Breakthrough in italics references Surface Water CULs.

Non-detect and riverbank results were excluded from Whole Basin initial concentration calculations.

µg/kg = micrograms per kilogram
C = concentration
CPP = cap performance point
N/A = no applicable cleanup level
µg/L = micrograms per liter
Calc = calculated
Sed = sediment
PCB = polychlorinated biphenyls
BEHP = bis(2-ethylhexyl) phthalate
COC = contaminant of concern
PW = porewater
TPH = total petroleum hydrocarbons

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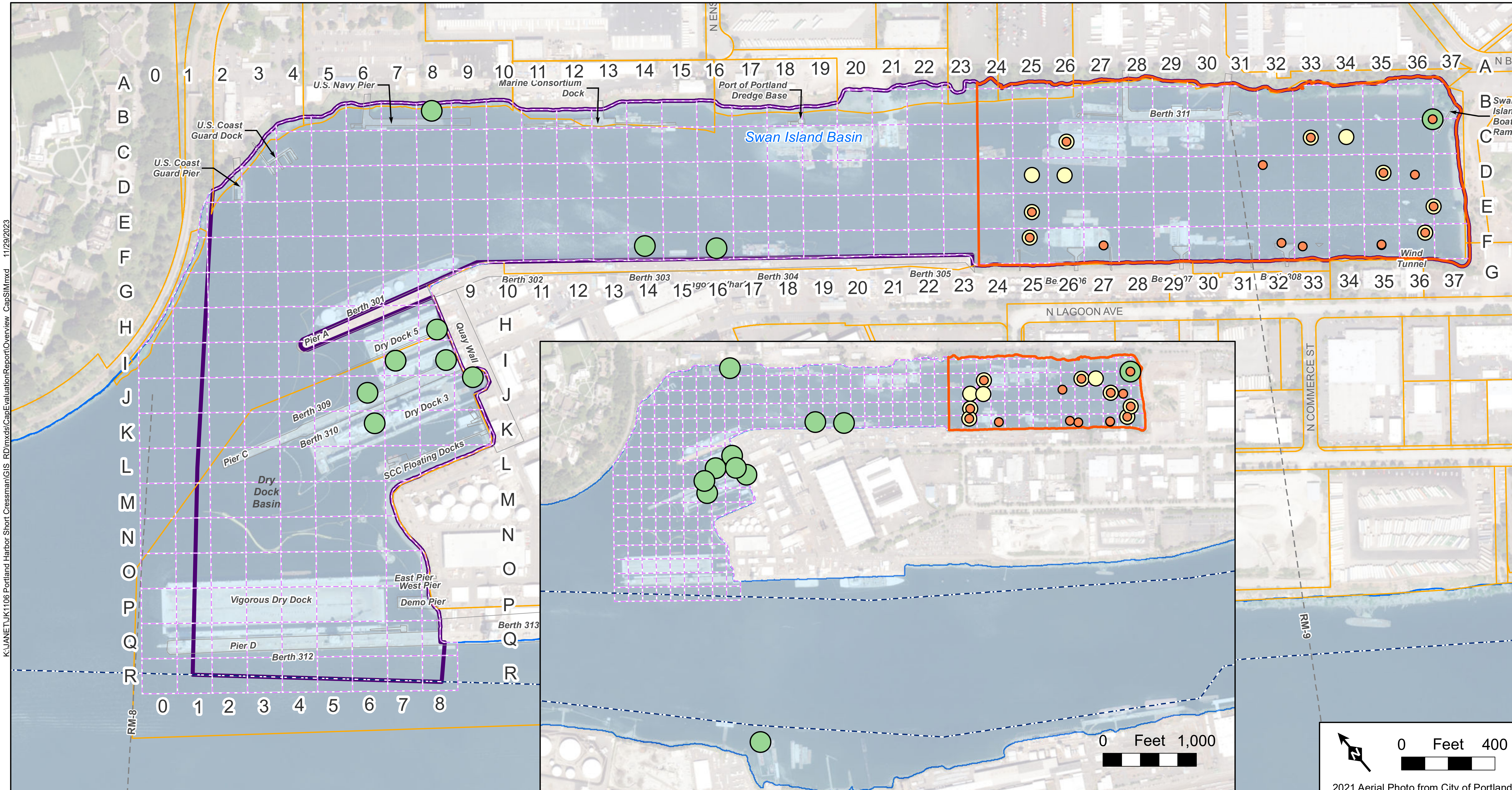
FIGURES



Project Area Grid	End of Basin
River Mile (RM)	**Modeled Sample Locations**
Swan Island Sediment Decision Unit (SDU)	End Basin
Federal Navigation Channel (USACE, 2020)	End Basin 3-foot Dredge
Docks and Structures	Whole Basin
Tax Lot Boundary	
Ordinary High Water (City of Portland, 2013)	
River Flow Direction	

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Figure 2-2
CapSIM Model Overview

Date Prepared: 11/29/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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Cone Penetration Test

Seismic Cone Penetration Test

River Mile (RM)

Federal Navigation Channel (USACE, 2020)

River Flow Direction

Liquefaction Induced Settlement

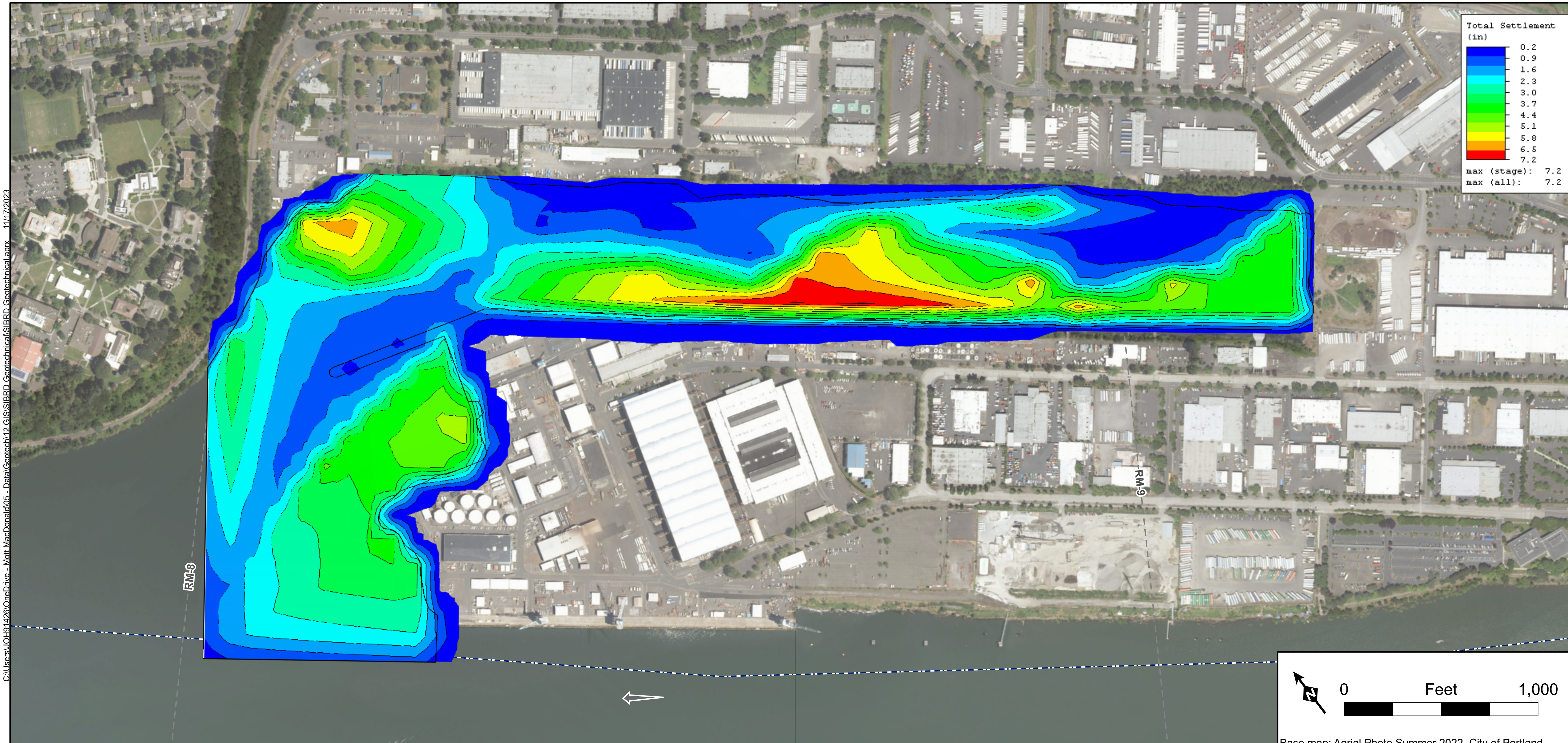
- less than 4 inches
- 4 to 7 inches
- 7 to 10 inches
- 10 to 13 inches
- greater than 13 inches

Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-1

Liquefaction Induced Settlement SIB

Date Prepared: 5/2/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group



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River Mile (RM)

Federal Navigation Channel (USACE, 2020)

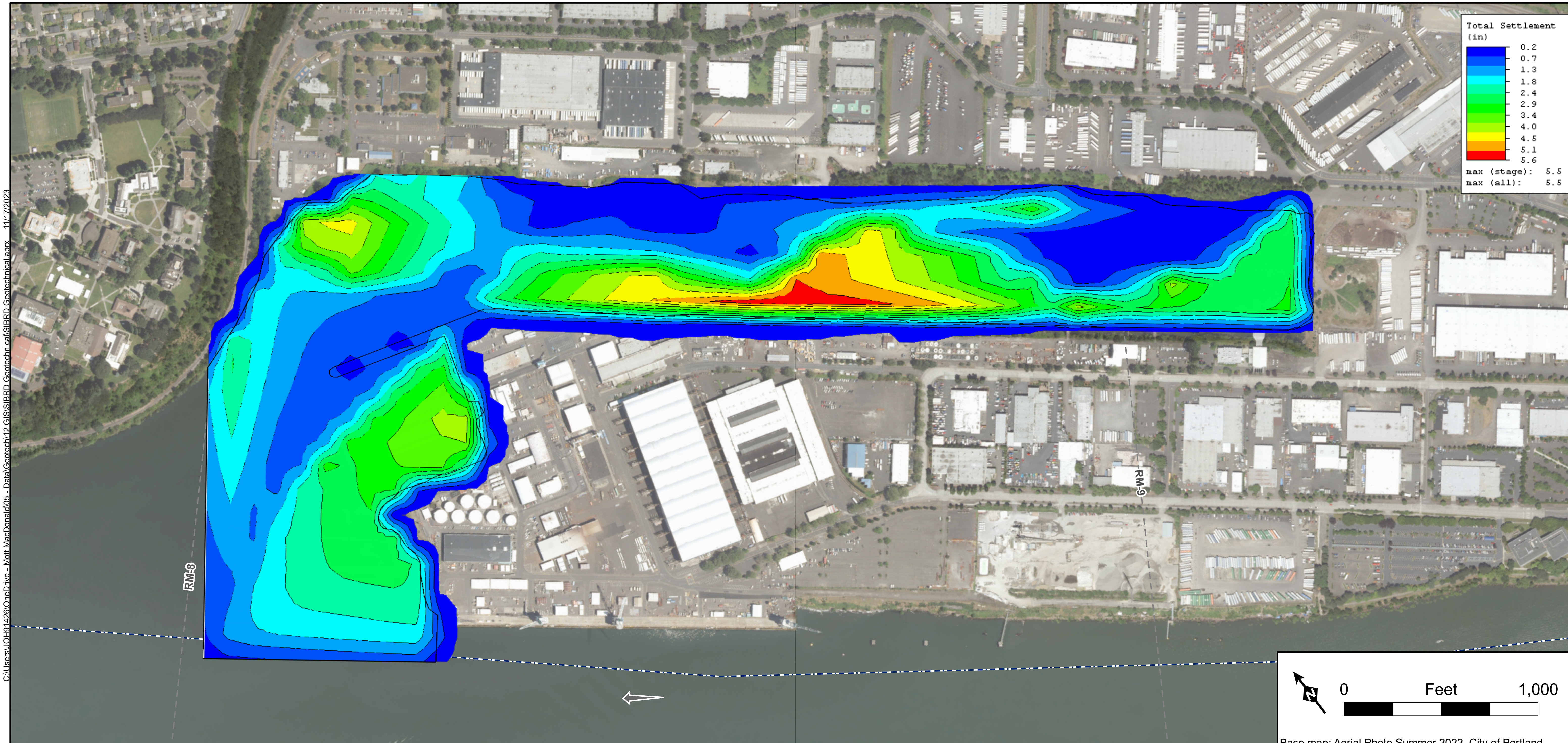
River Flow Direction

Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
in. - inch
max - maximum
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-2

Estimated Consolidation Settlement Hypothetical Cap Alternative 1 SIB

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group



River Mile (RM)

Federal Navigation Channel (USACE, 2020)

River Flow Direction

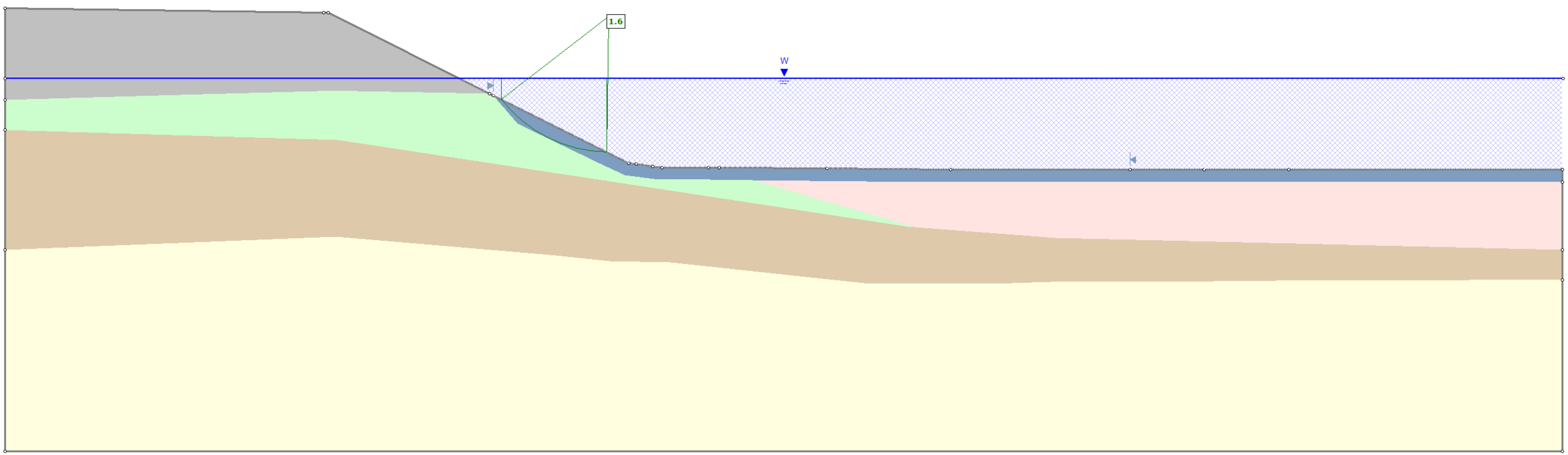
Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
in. - inch
max - maximum
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-3

Estimated Consolidation Settlement Hypothetical Cap Alternative 2 SIB

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		135	Mohr-Coulomb	20	36
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

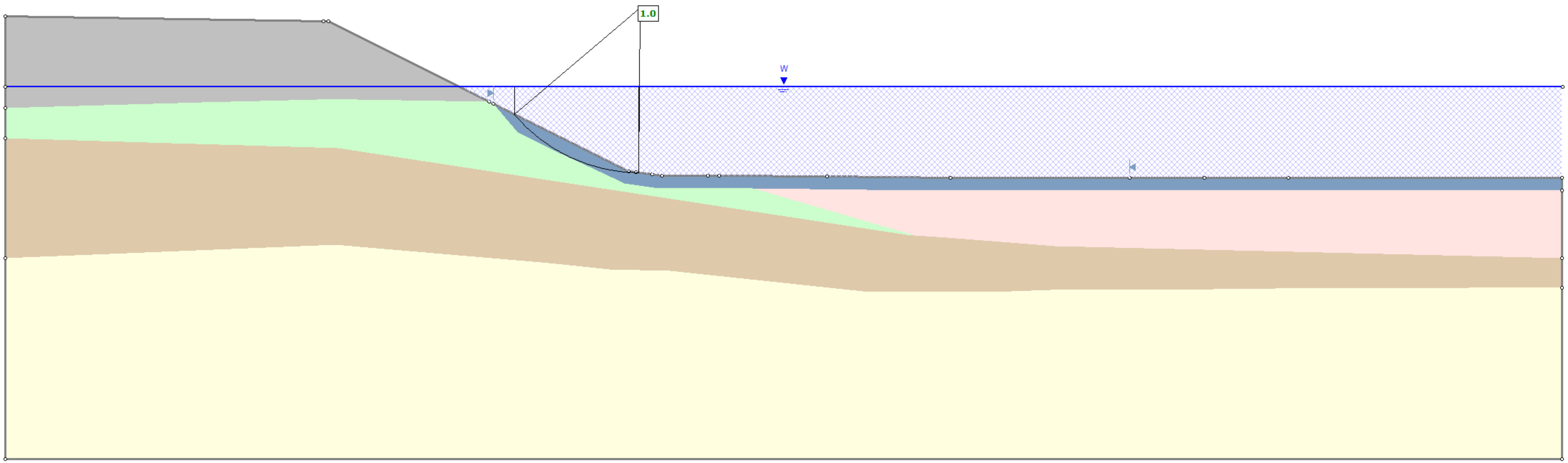
Figure 3-4

Static Slope Stability Analysis of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		135	Mohr-Coulomb	20	36
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



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Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

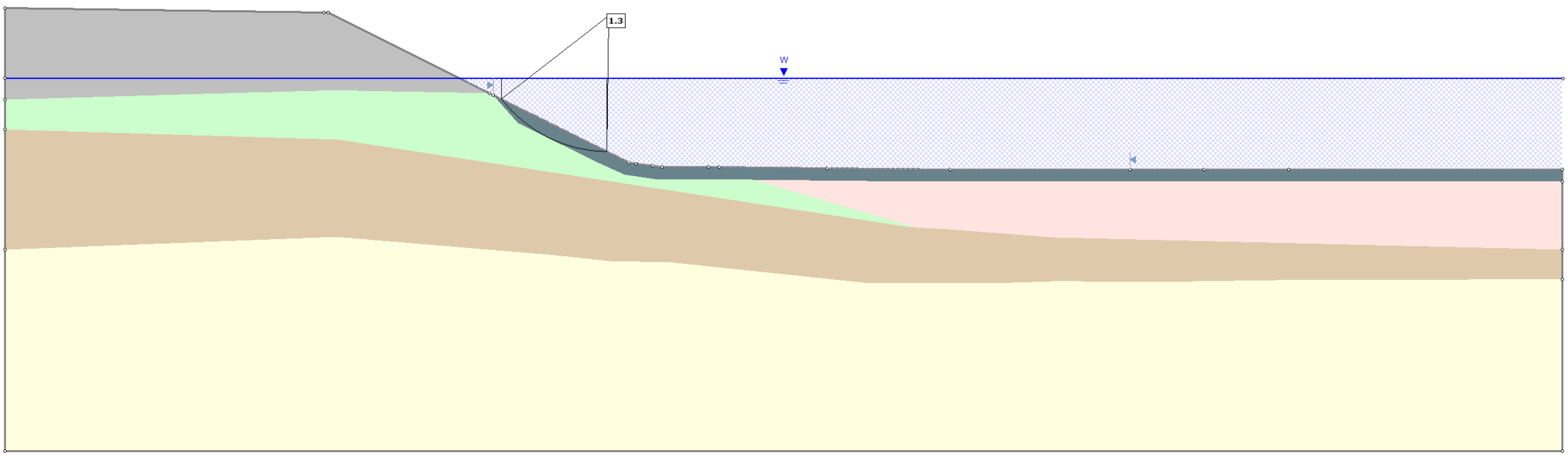
Figure 3-5

Pseudo-Static Slope Stability Analysis of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

Pacific Groundwater Group
HGL
Mott MacDonald
Bridgewater Group

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		135	Mohr-Coulomb	20	36
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



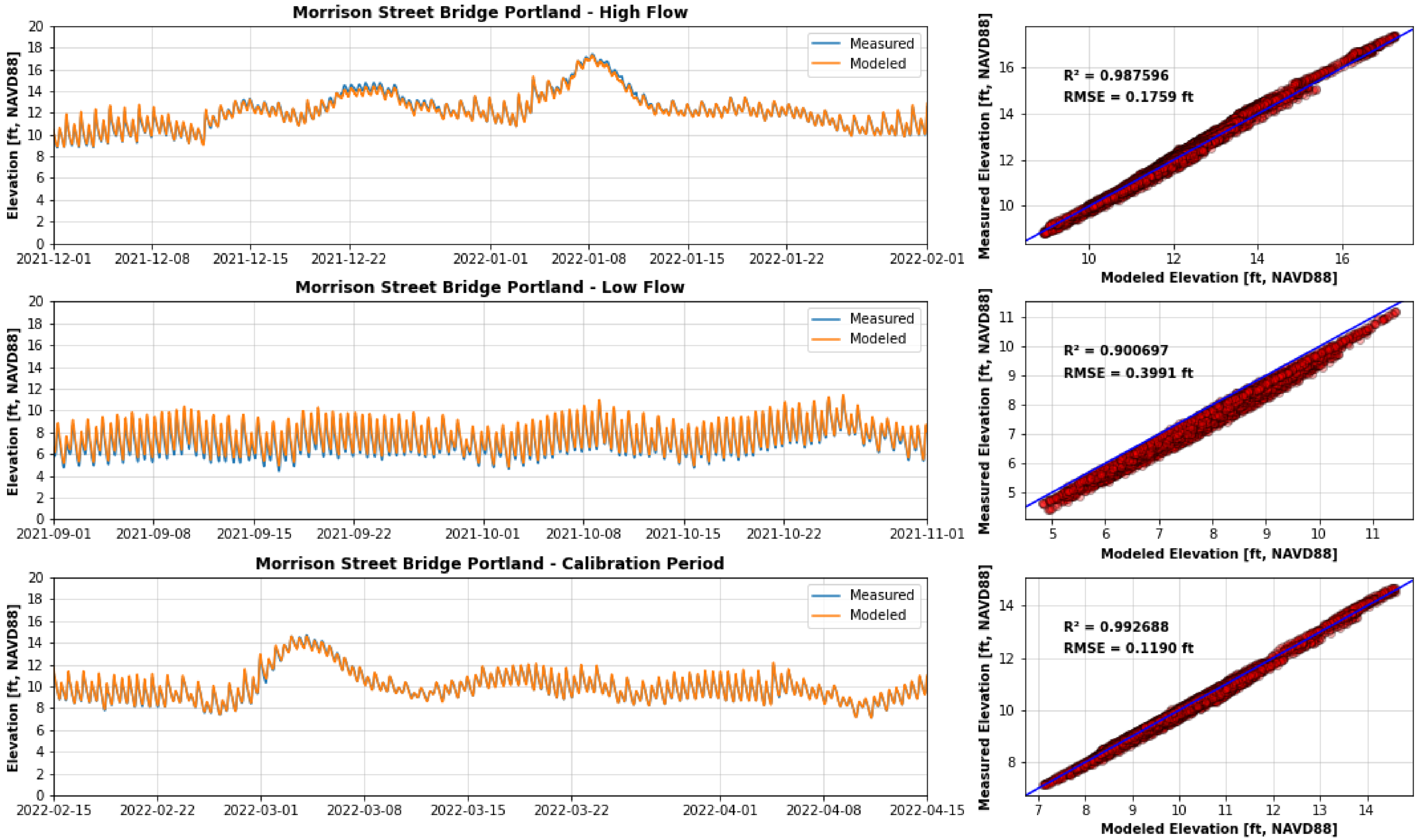
Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

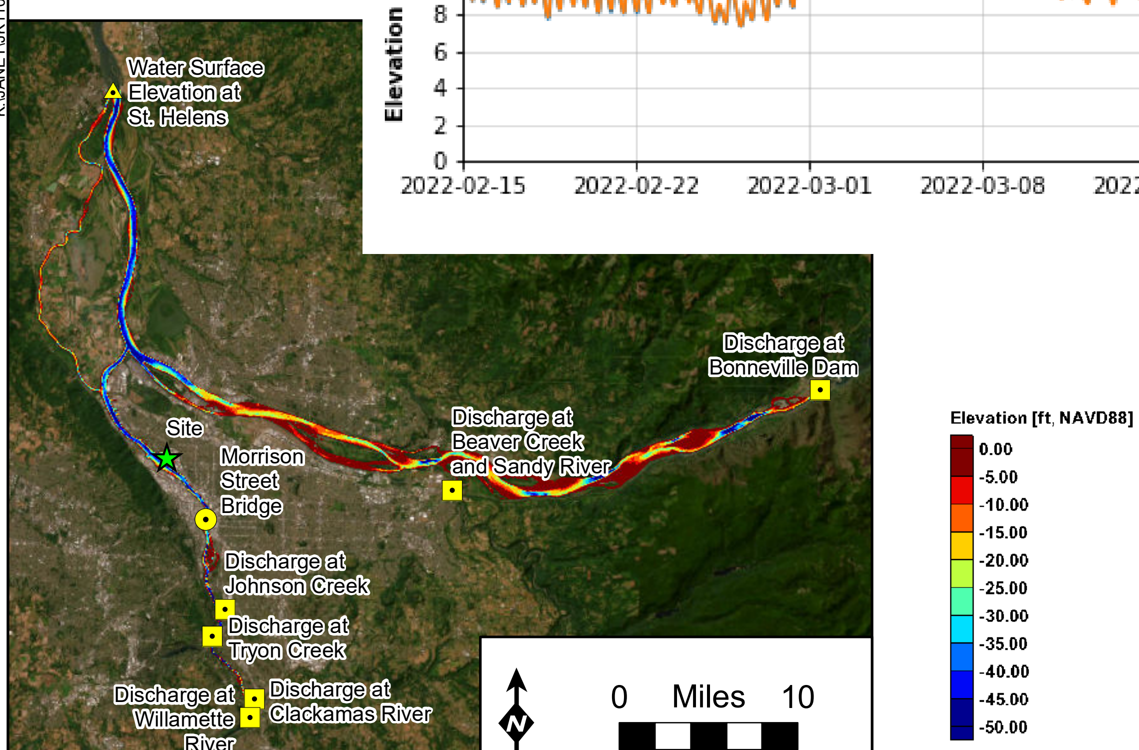
Figure 3-6

Liquefaction Induced Flow Failure of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP





Notes:
ft/s – feet per second
NAVD88 – North American Vertical Datum of 1988
R^2 – coefficient of determination
RMSE – Root Mean Square Error

Figure 3-7
Hydrodynamic Model Validation at Morrison Street

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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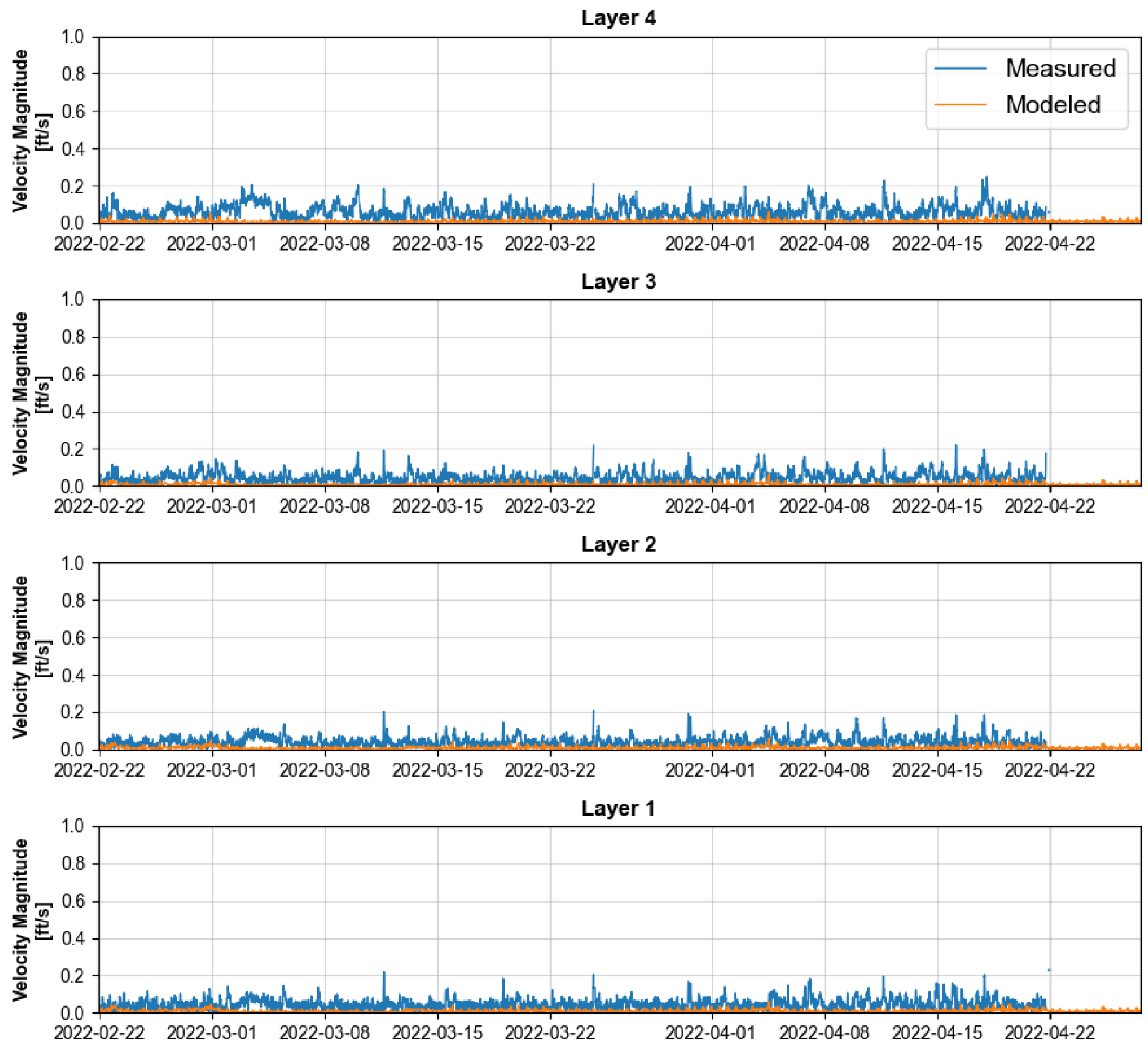
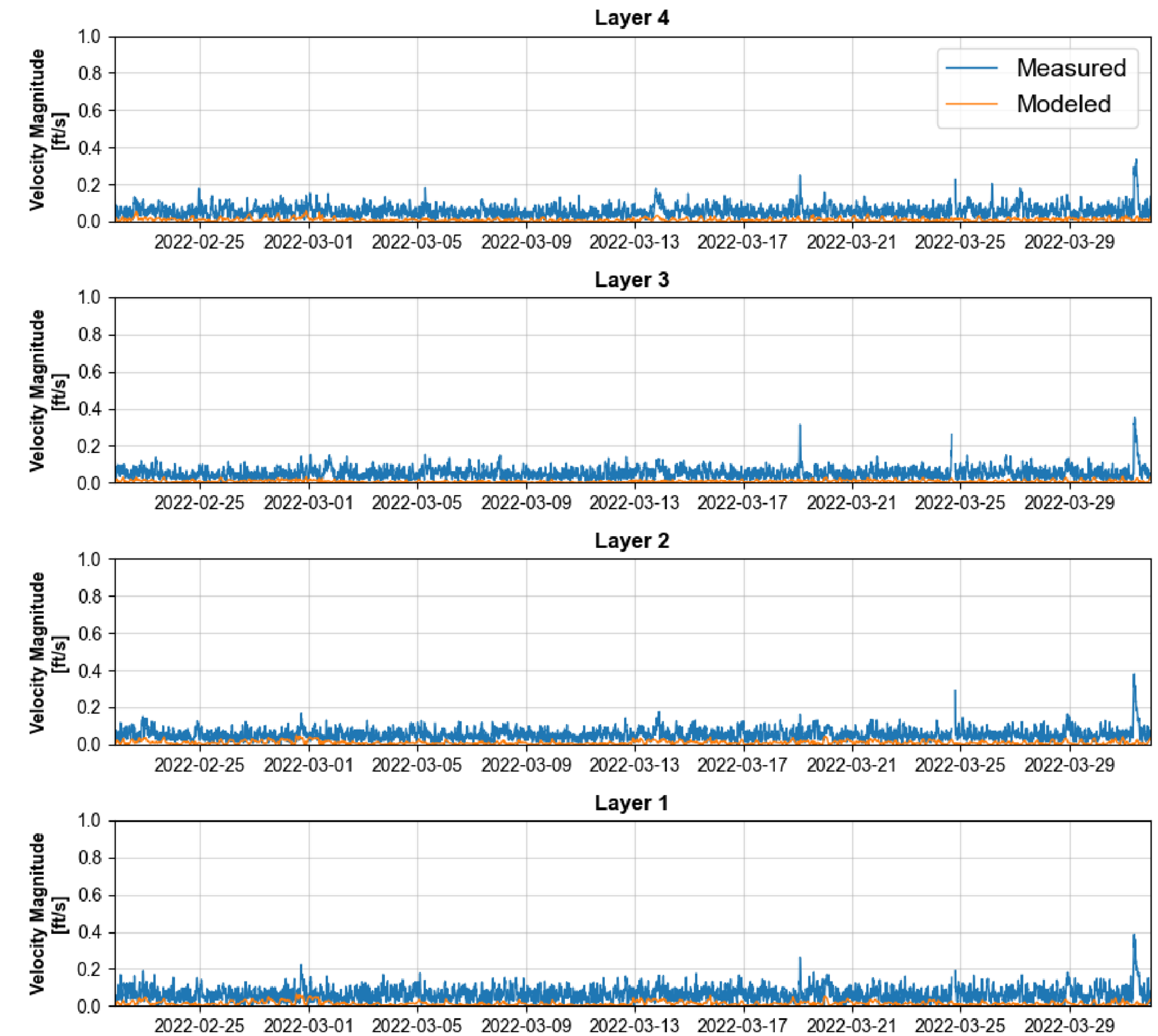
Delft3D Comparison
Station 2



Delft3D Comparison
Station 1



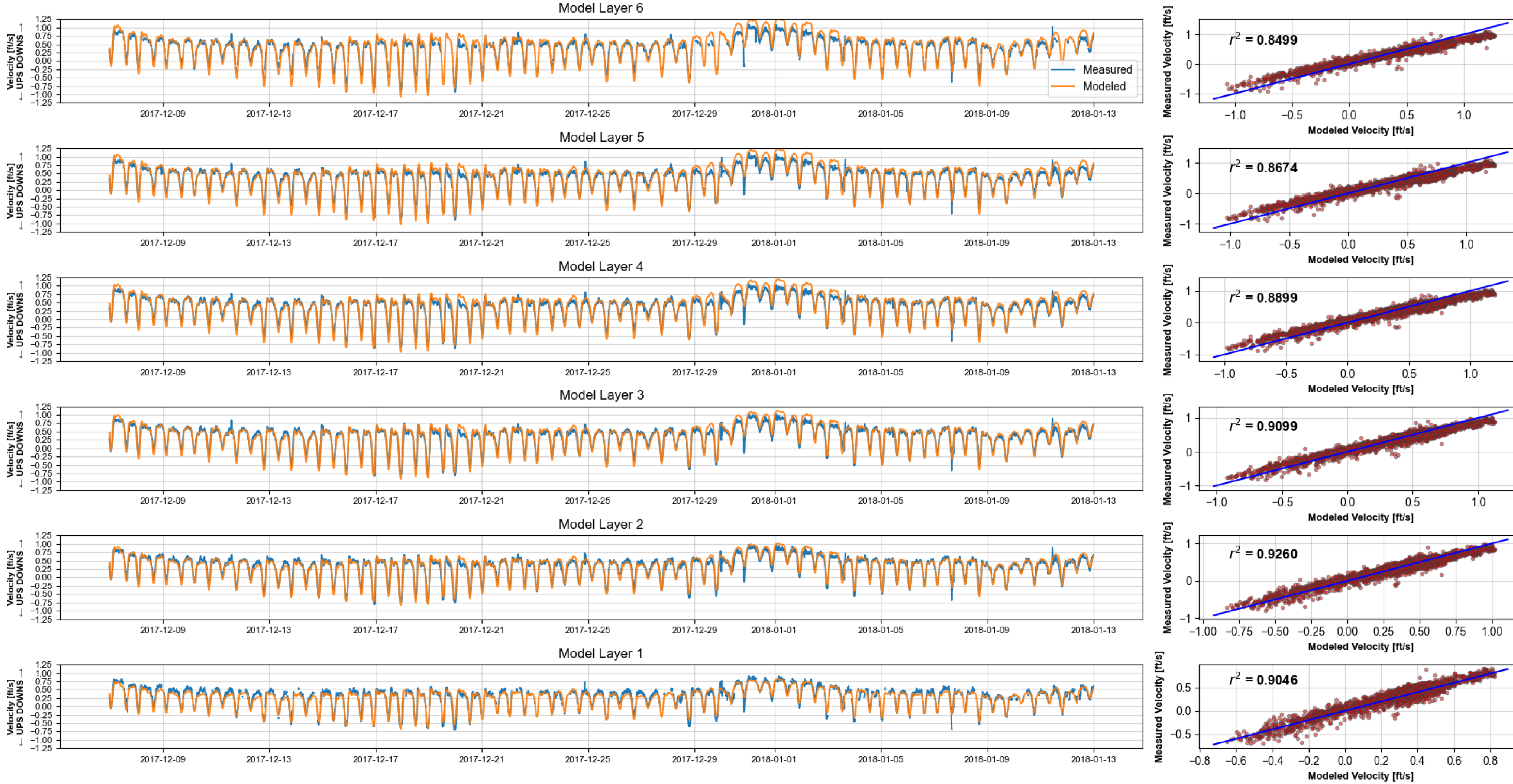
Notes:
ADCP – Acoustic Doppler Current Profiler
ft/s – feet per second

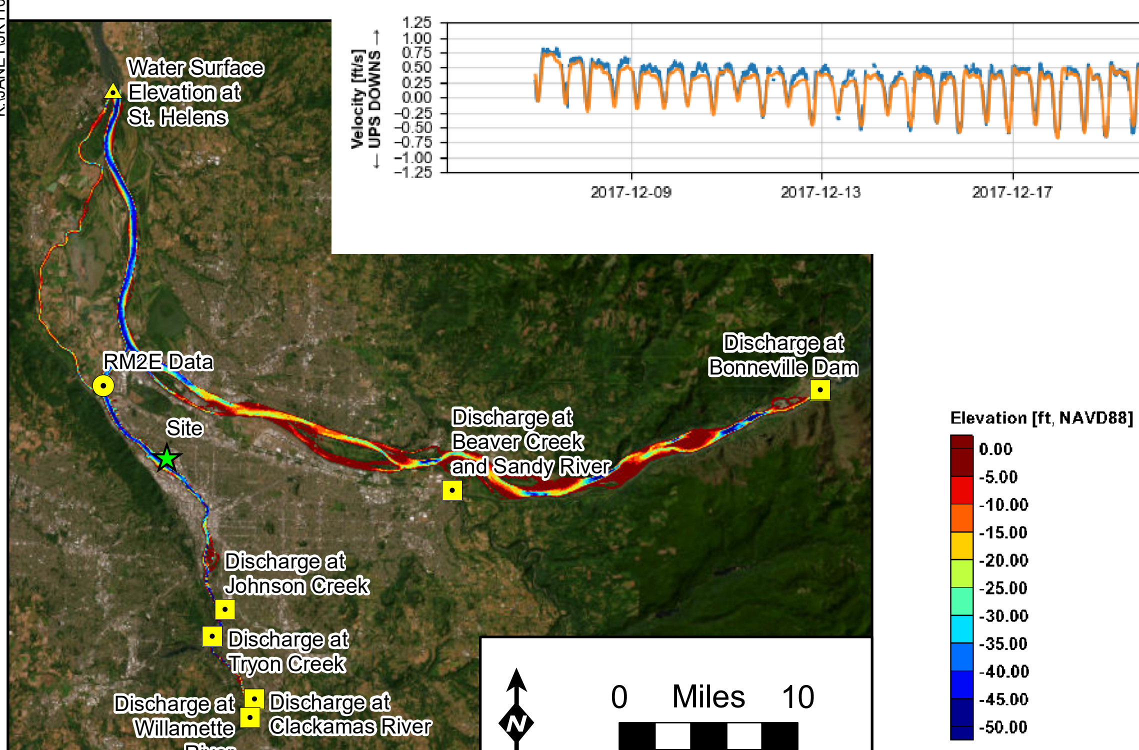
Figure 3-8

Hydrodynamic Model Validation in Swan Island Basin

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP





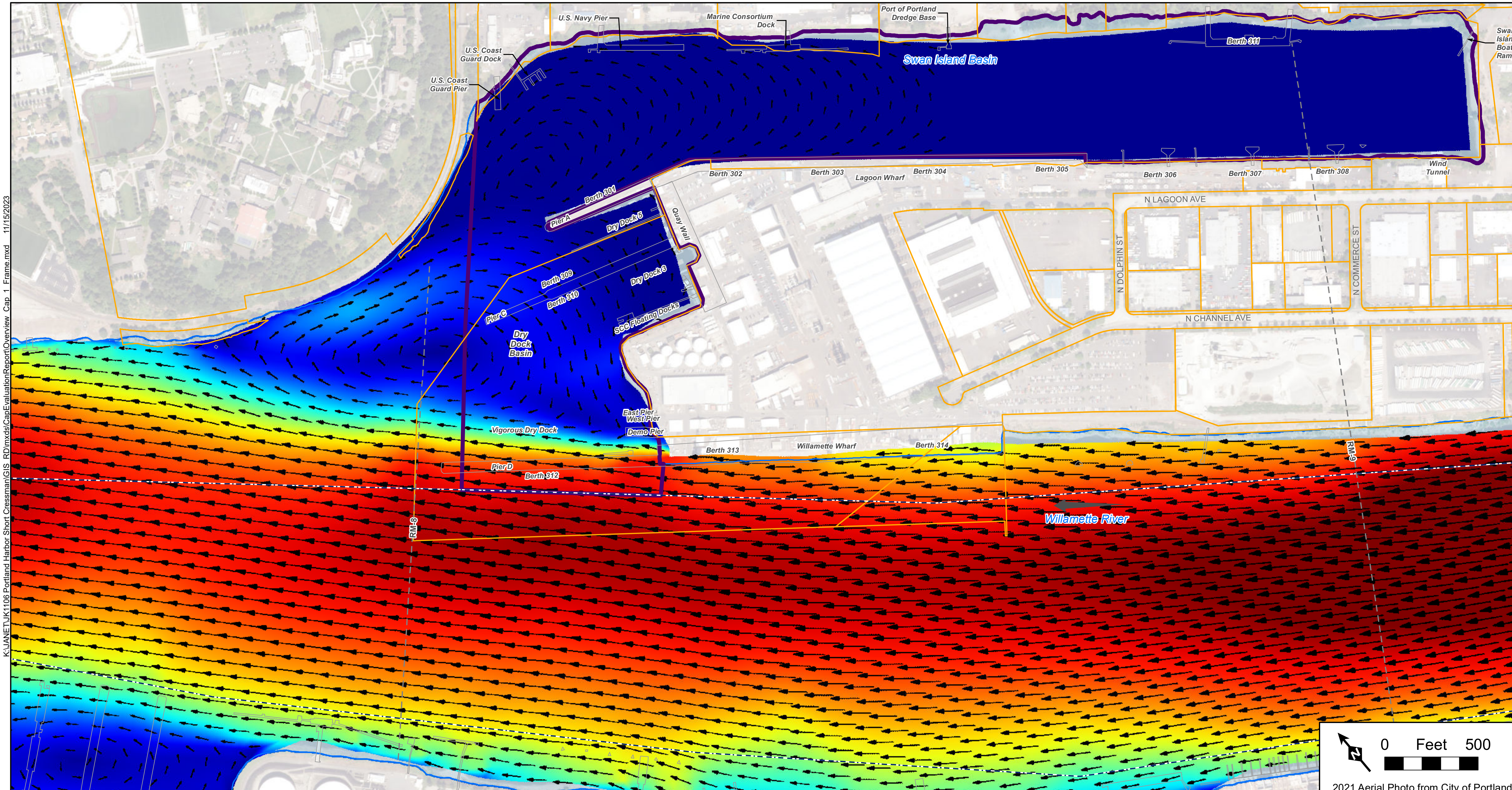
Notes:
ft/s – feet per second
NAVD88 – North American Vertical Datum of 1988
r^2 – coefficient of determination

Figure 3-9

Hydrodynamic Model Validation at River Mile 2 East

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Depth Average Velocity [ft/s]

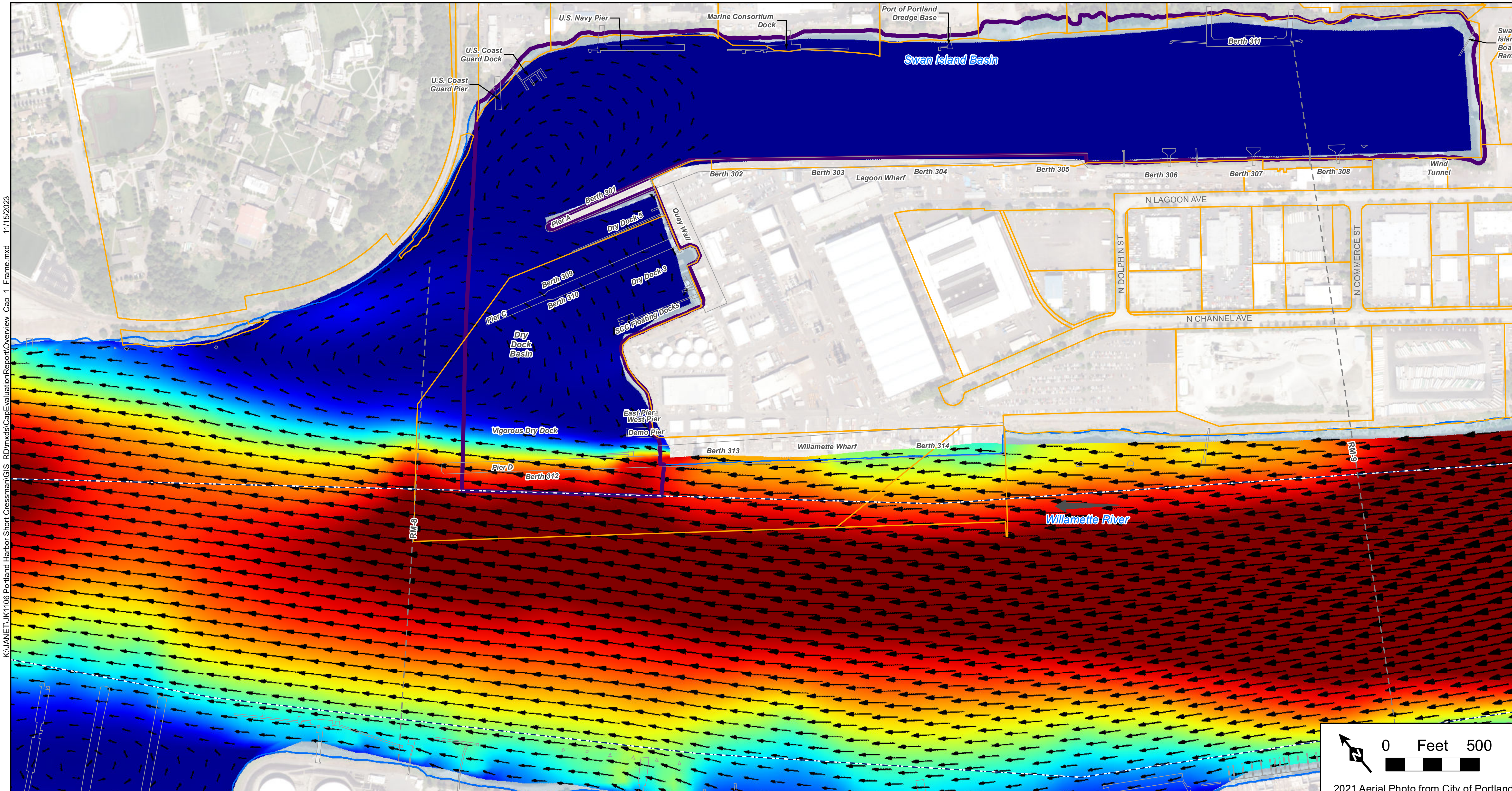
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00

Notes:
ft/s – feet per second
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-10

100-year Flood Event
Peak Depth-Averaged Velocities

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group



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City Stormwater Outfall
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

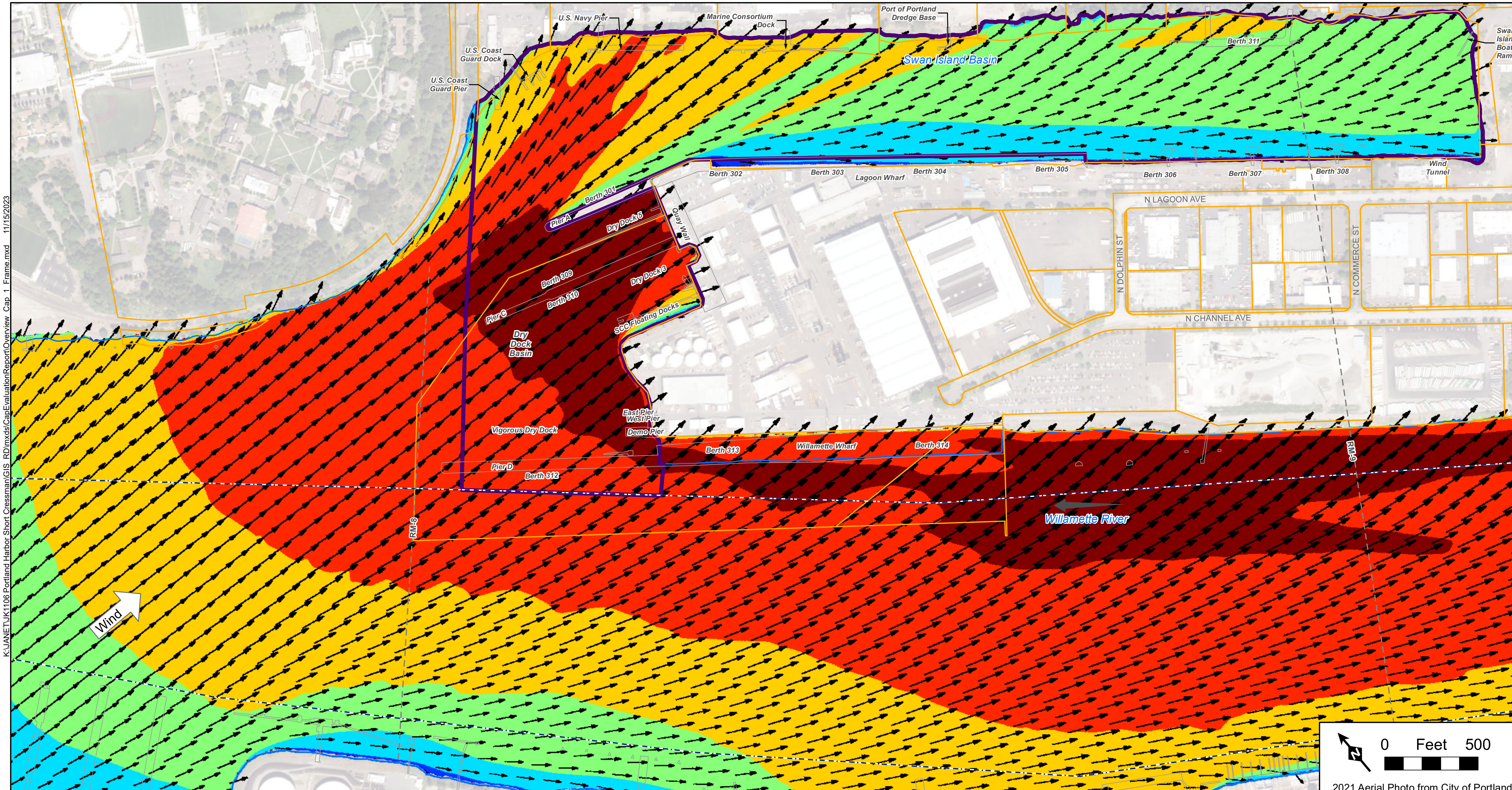
Bed Shear Stress [Pa]
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-11
100-year Flood Event Bed Shear Stresses

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



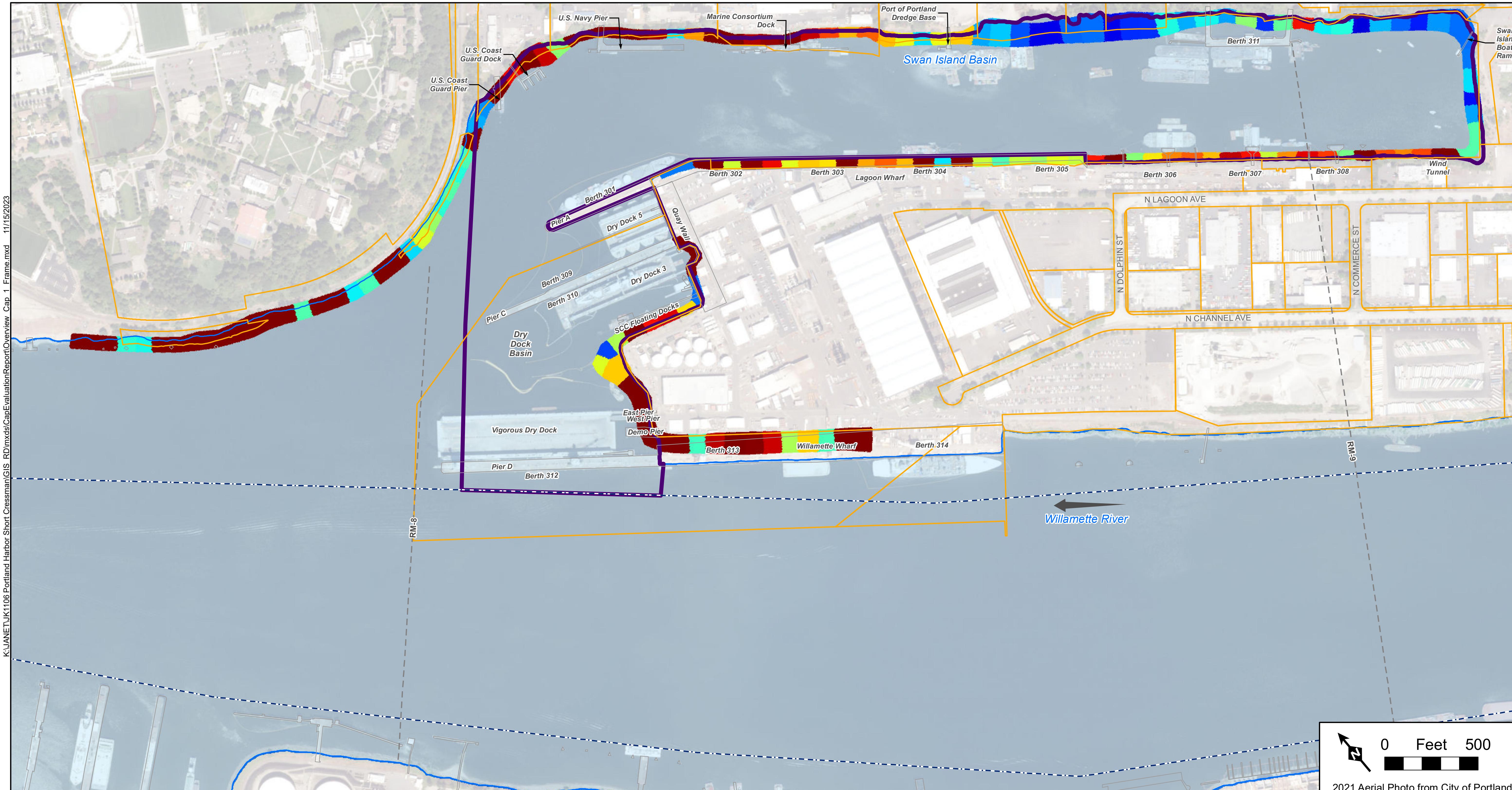
Notes:
ft – feet
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-12

100-year Storm Waves, Example from West

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Bed Shear Stress [Pa]
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00

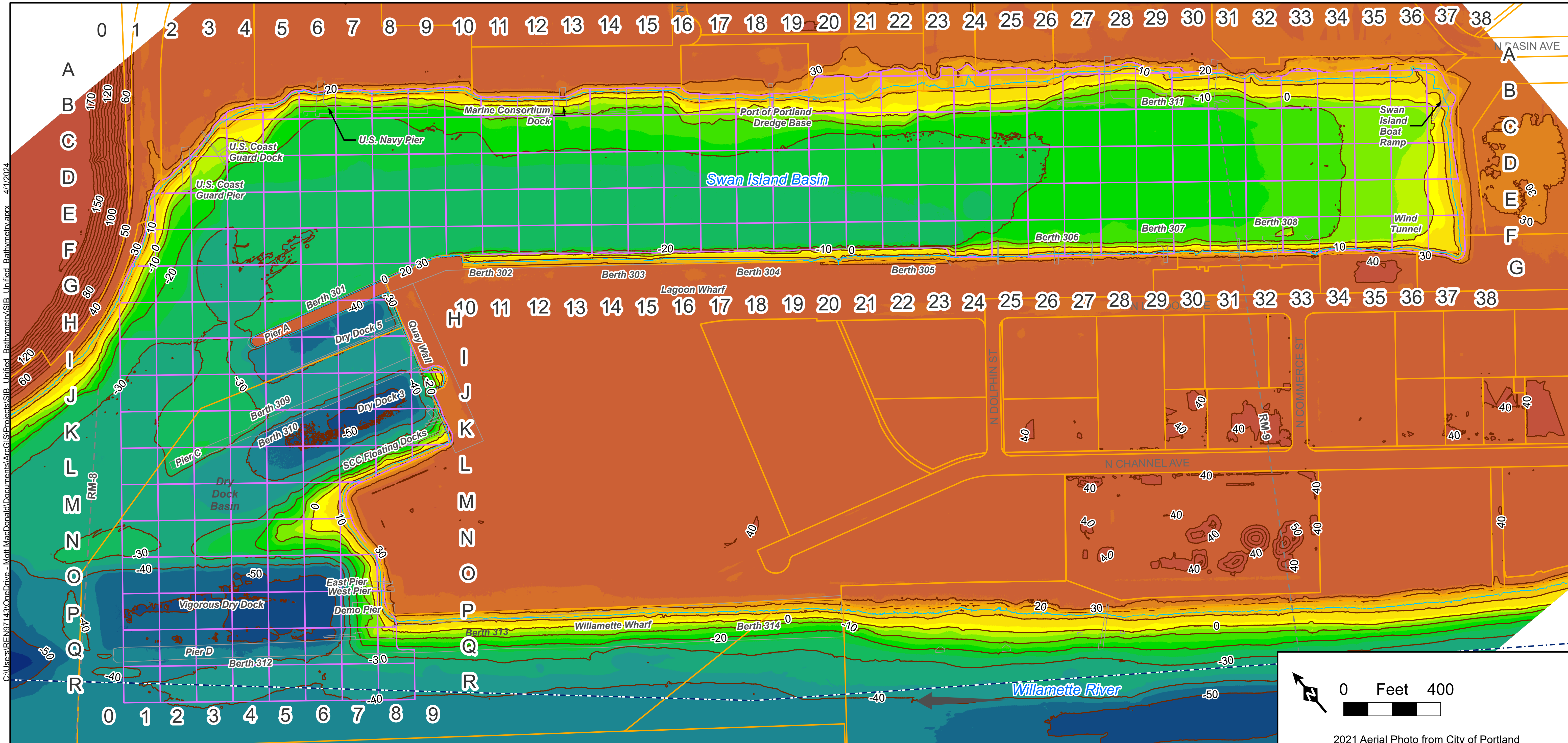
Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-13

100-year Storm Waves, Peak Bed Shear Stresses

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



- - - River Mile (RM)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
13-foot NAVD88 Contour
10-ft Elevation Contours (NAVD88)

Unified Elevation Model (Feet, NAVD88)

- -57.4 - -55
- -54.9 - -50
- -49.9 - -45
- -44.9 - -40
- -39.9 - -35
- -34.9 - -30
- -29.9 - -25
- -24.9 - -20
- -19.9 - -15
- -14.9 - -10
- -9.9 - -5
- -4.9 - 0
- 0.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30
- 30.1 - 35
- 35.1 - 40
- 40.1 - 180

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Elevation Sources:
David Evans and Associates, 2015
David Evans and Associates, 2018
City of Portland LiDAR, 2019
HydroGeoLogic, 2022

River Flow Direction

Figure 3-14
Unified Elevation Model

Date Prepared: 11/29/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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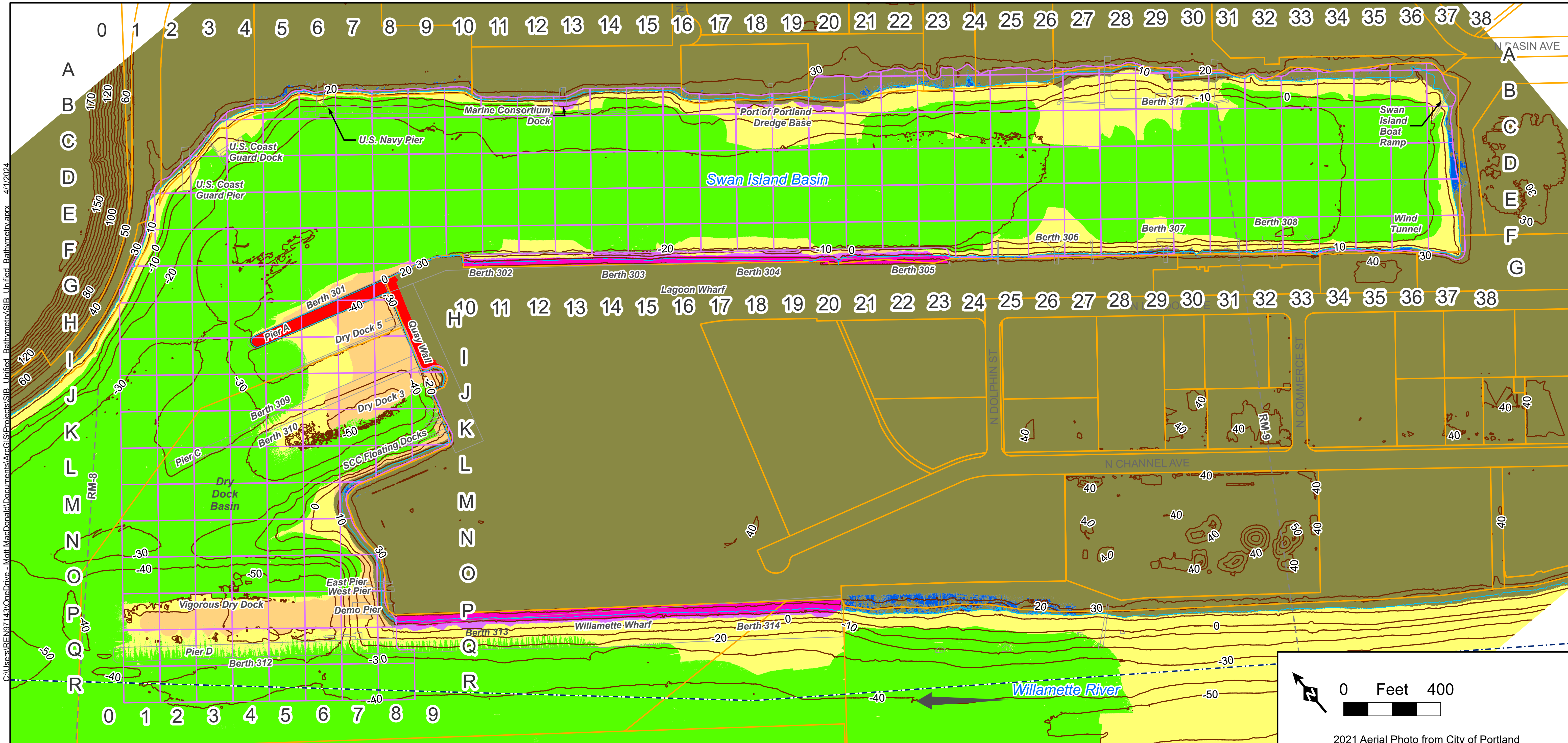
BRIDGEWATER GROUP



- - - River Mile (RM)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
13-foot NAVD88 Contour
10-ft Elevation Contours (NAVD88)

Elevation Data Sources
- 2022 HydroGeoLogic - Multibeam Bathymetry
- 2022 eTrac Mobile Terrestrial LiDAR
- Under Warf Interpolation (2022 eTrac Mobile Terrestrial LiDAR)
- 2019 LiDAR - City of Portland
- 2019 LiDAR, First Return Interpolation - City of Portland
- 2018 David Evans & Associates - Multibeam Bathymetry
- 2015 David Evans & Associates - Multibeam Bathymetry
- Interpolation

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

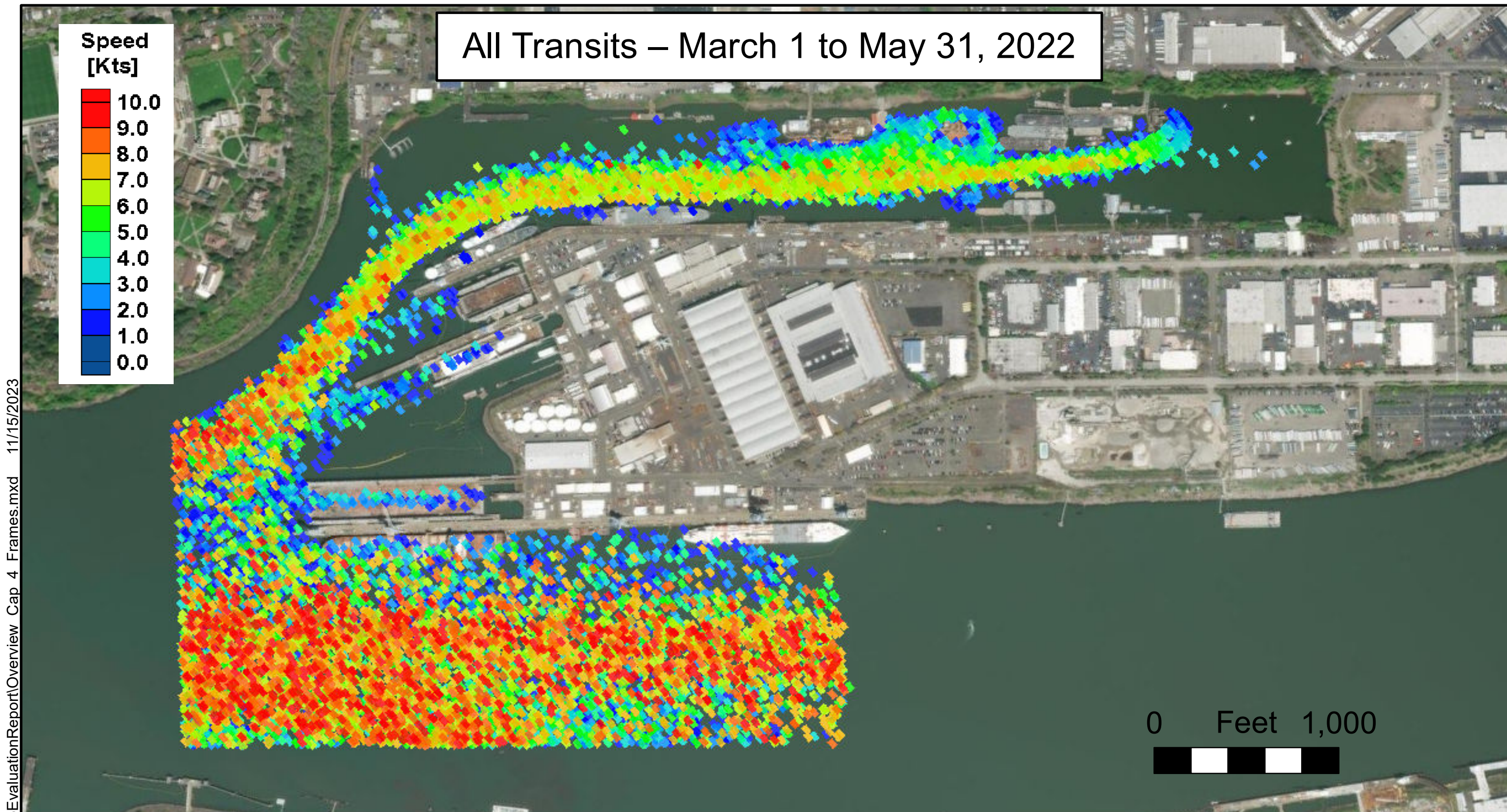
Elevation Sources:
David Evans and Associates, 2015
David Evans and Associates, 2018
City of Portland LiDAR, 2019
HydroGeoLogic, 2022

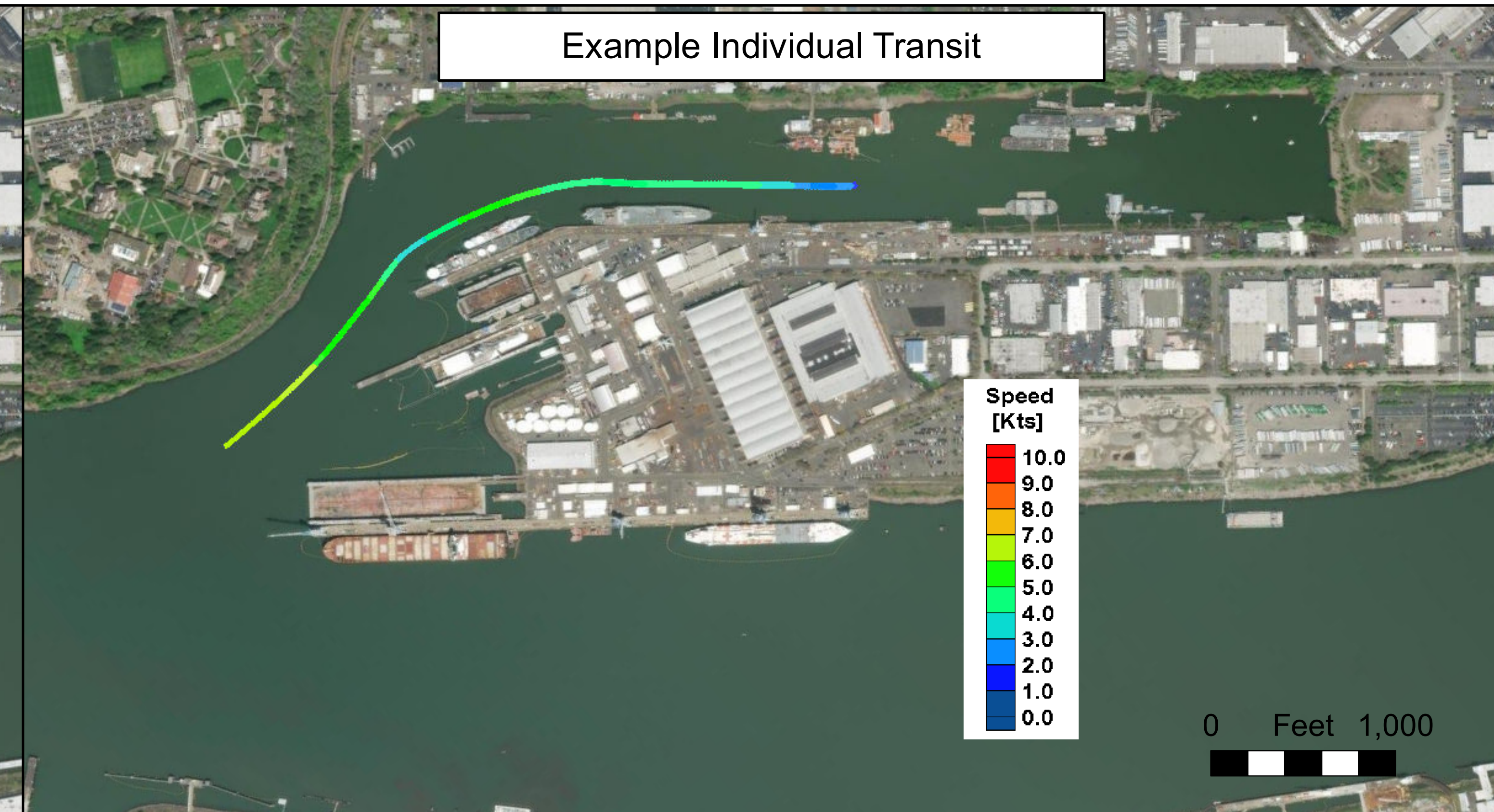
River Flow Direction

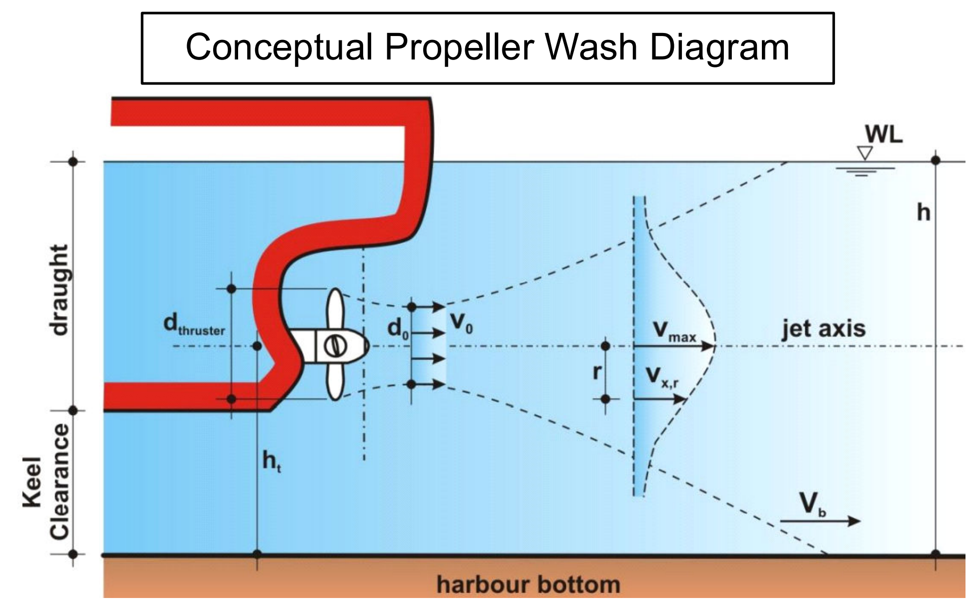
Figure 3-15
Data Sources Used in Unified Elevation Model

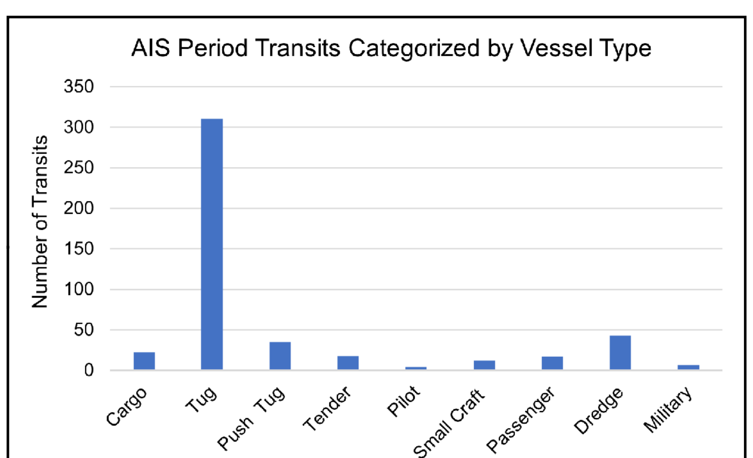
Prepared on: 4/1/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

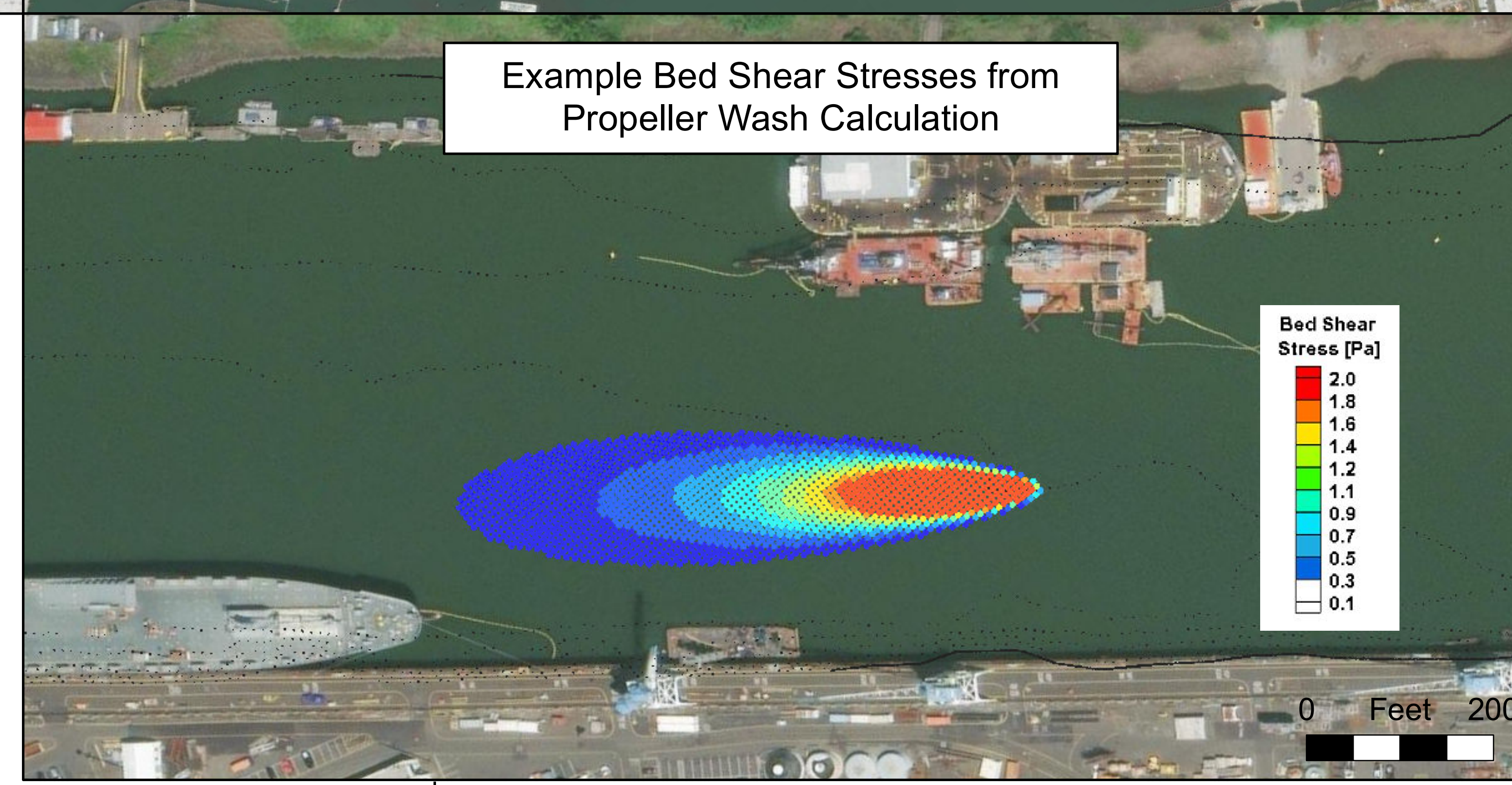
PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP











Notes:
d – diameter
kts – knots
Pa – Pascals
USACE – U.S. Army Corps of Engineers
V – velocity
WL – Water Level

Figure 3-16

Observed Vessel Traffic in Swan Island Basin and Example Propeller Wash Calculation

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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BRIDGEWATER GROUP

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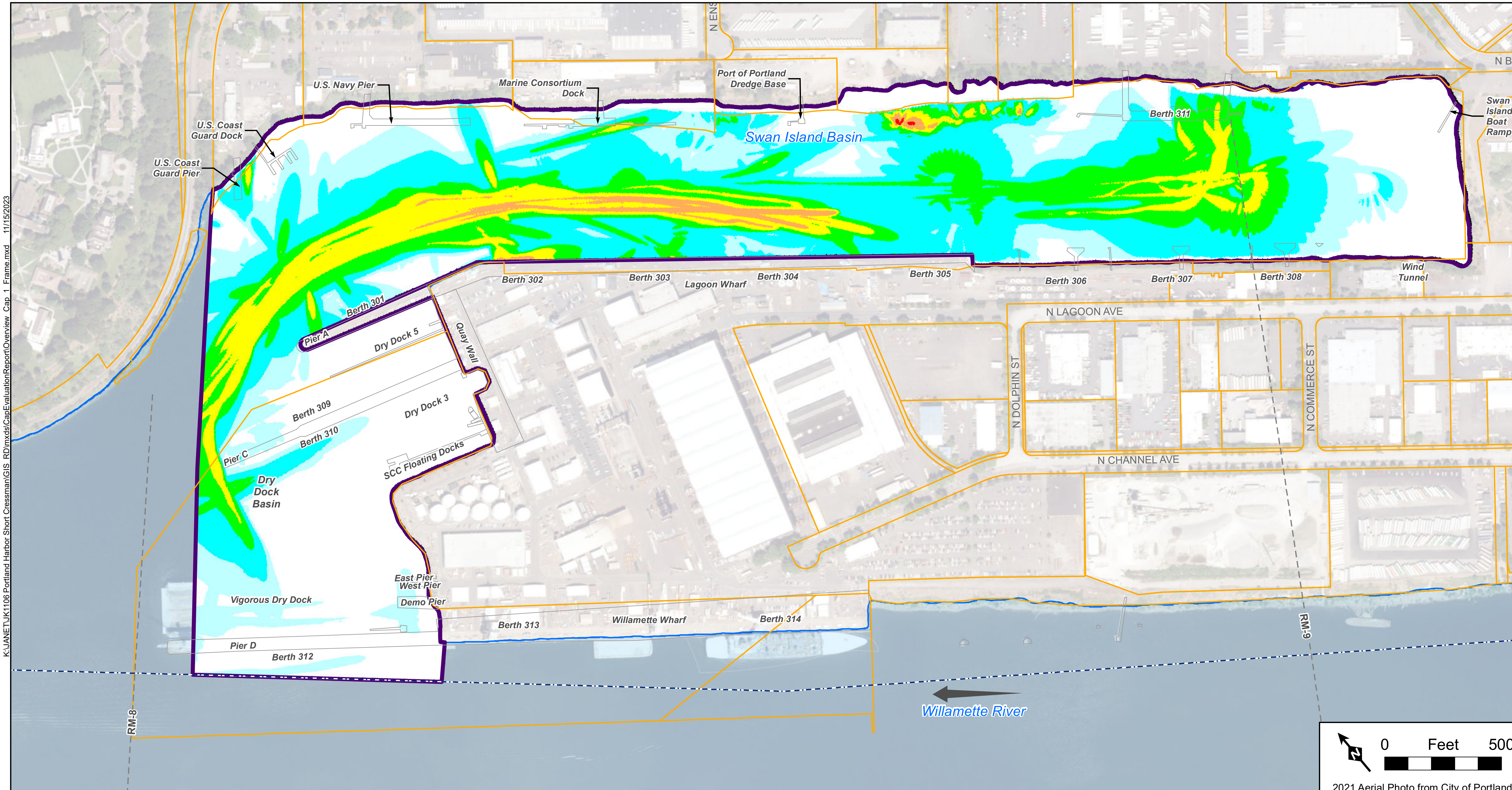

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- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Bed Shear Stress [Pa]

25.9
12.2
5.7
2.7
1.3
0.47
0.27
0.0

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-17

Peak Bed Shear Stresses from Propeller Wash

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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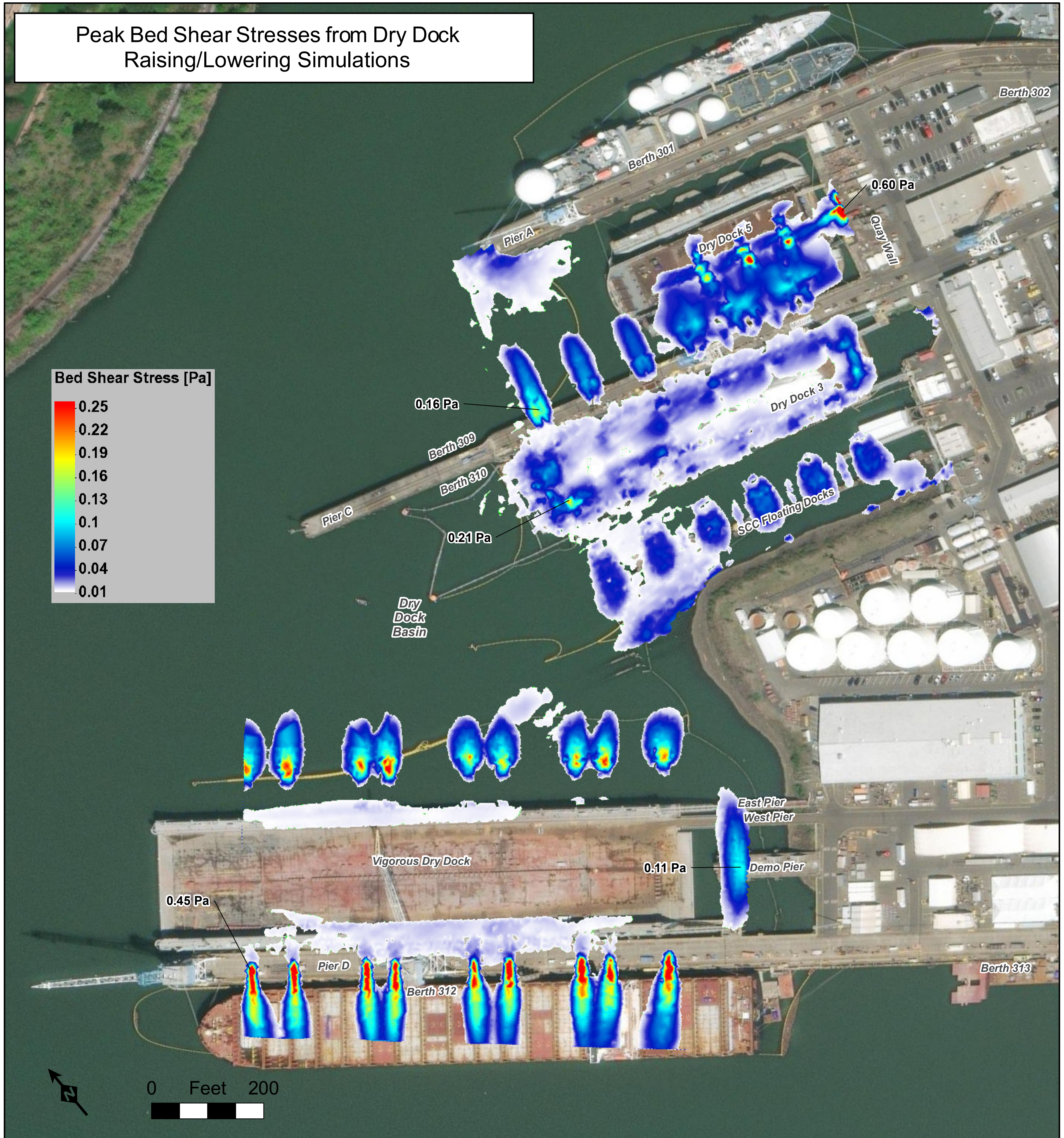
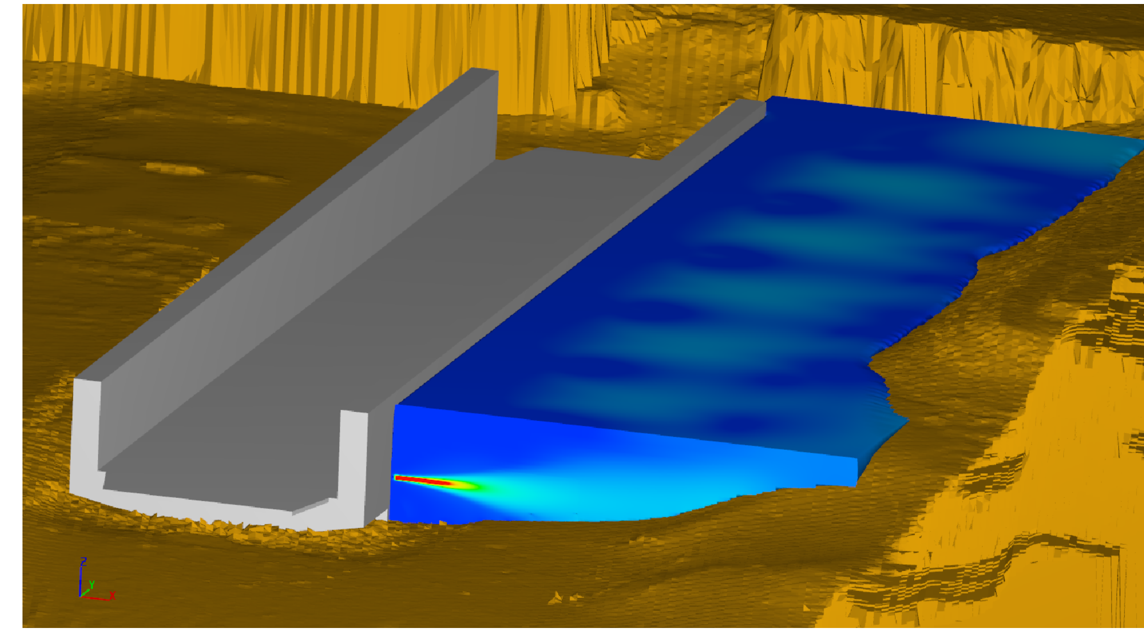
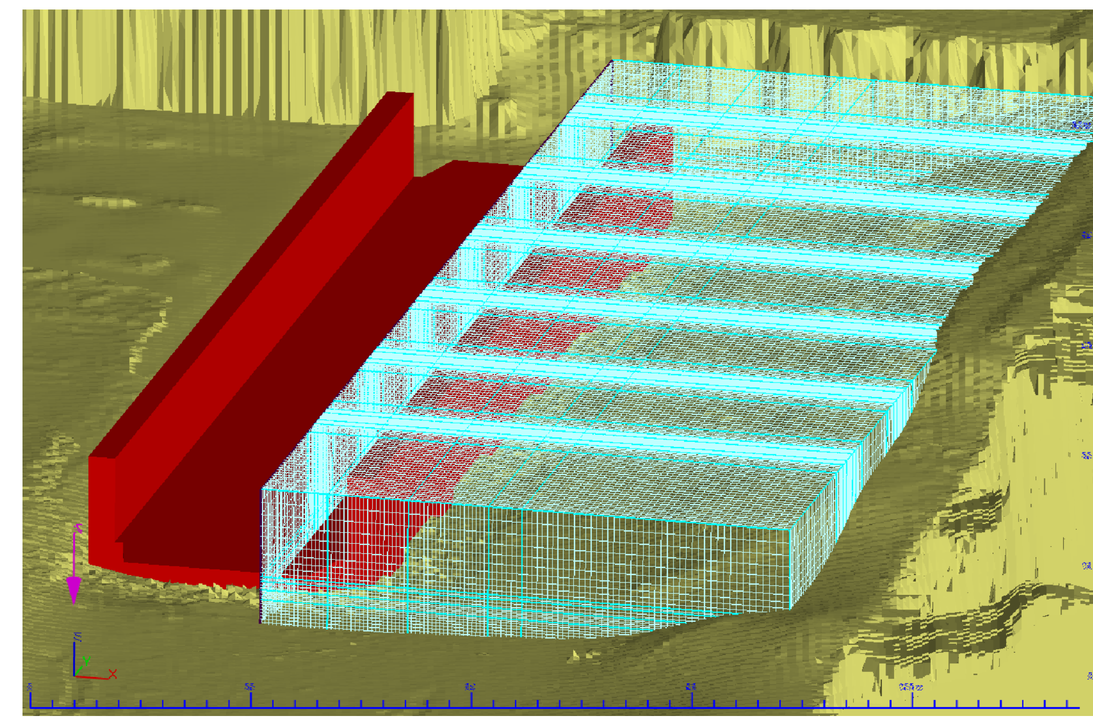
BRIDGEWATER GROUP





CFD Model Setup for Dry Dock 3



Notes:
CFD – Computational Fluid Dynamics
Pa – Pascals
SCC – Shipyard Commerce Center

Figure 3-18
Peak Bed Shear Stresses from Dry Dock Operations

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
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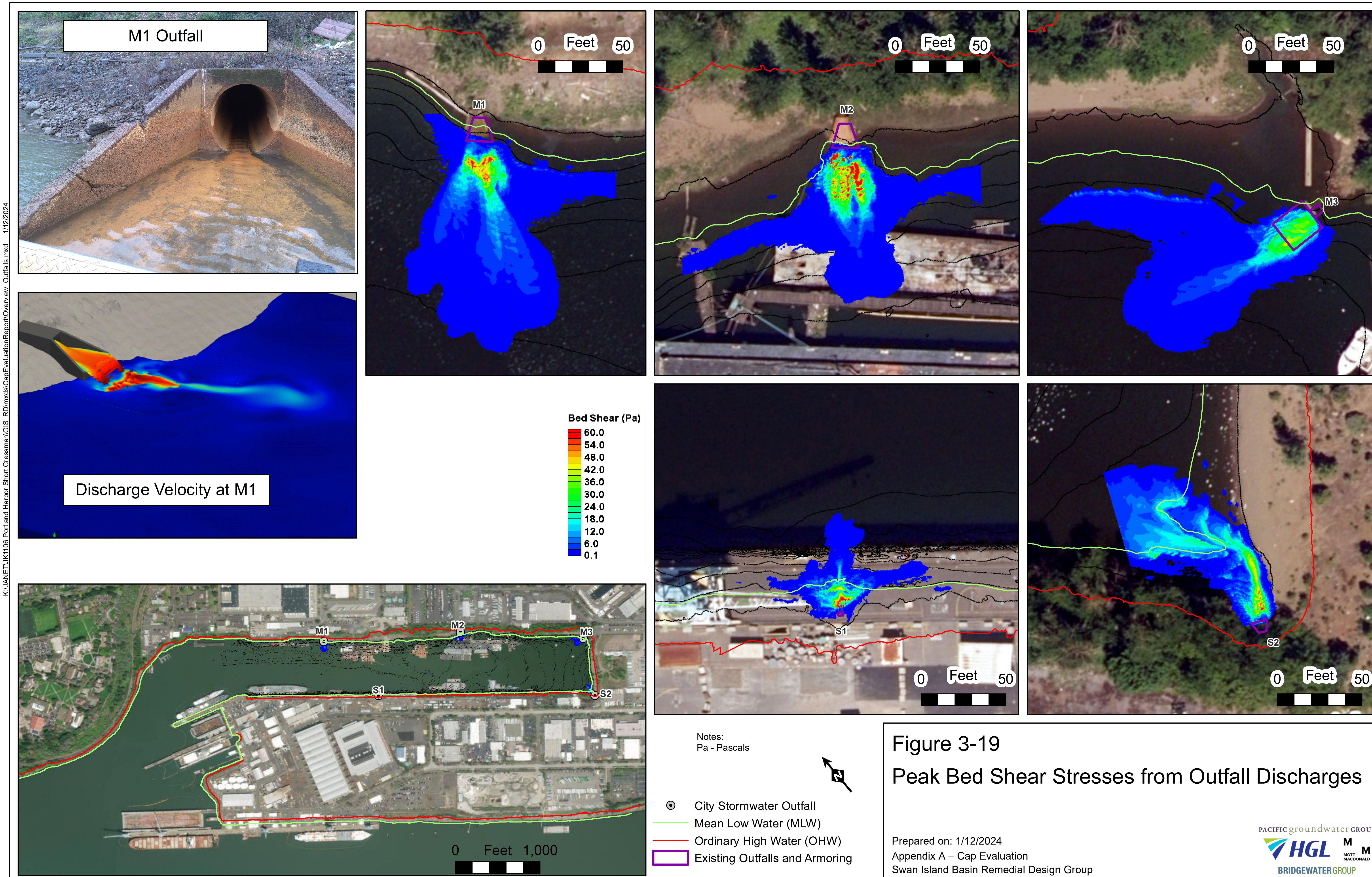
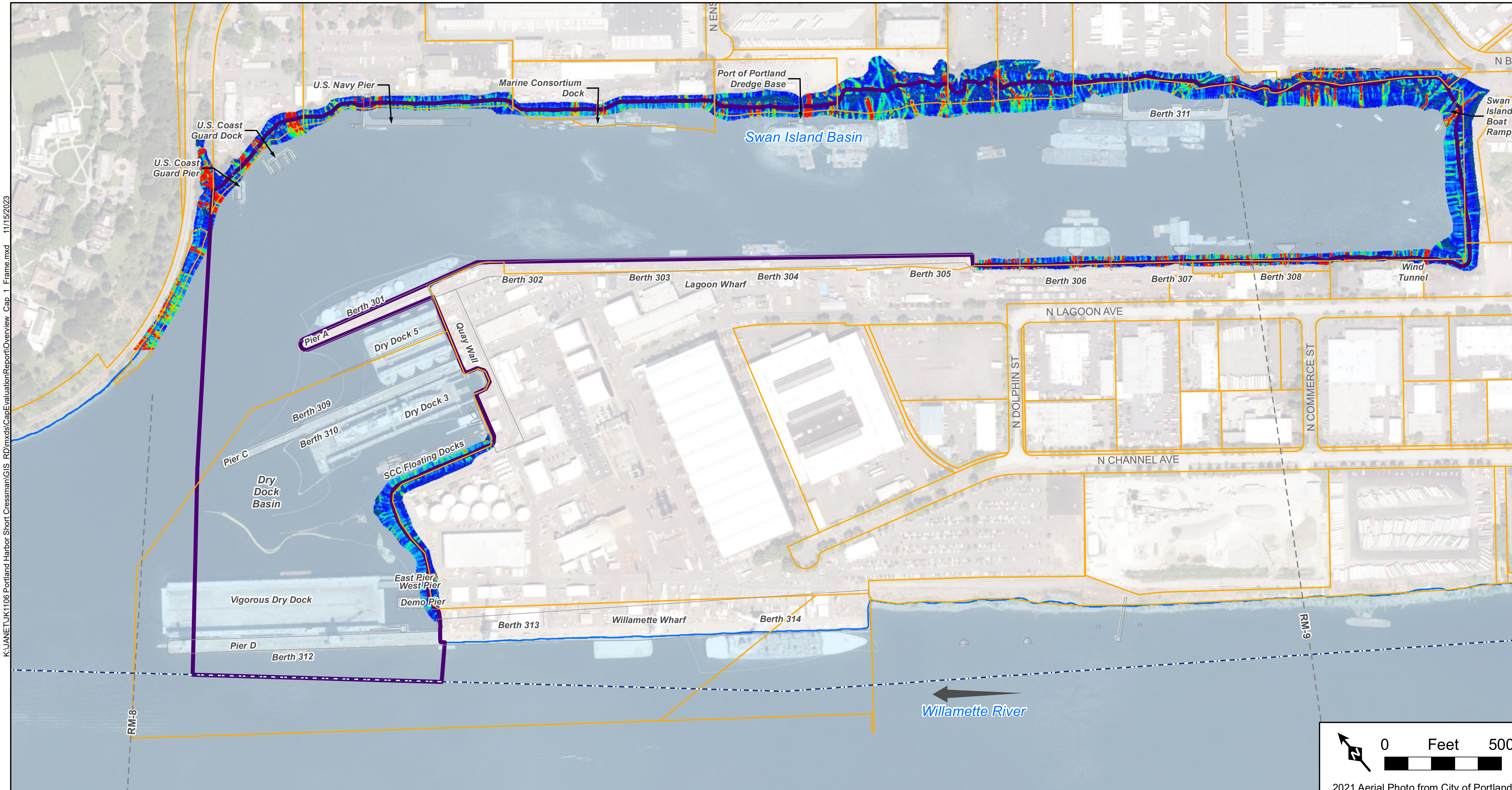


Figure 3-19
Peak Bed Shear Stresses from Outfall Discharges

Prepared on: 1/12/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group



River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

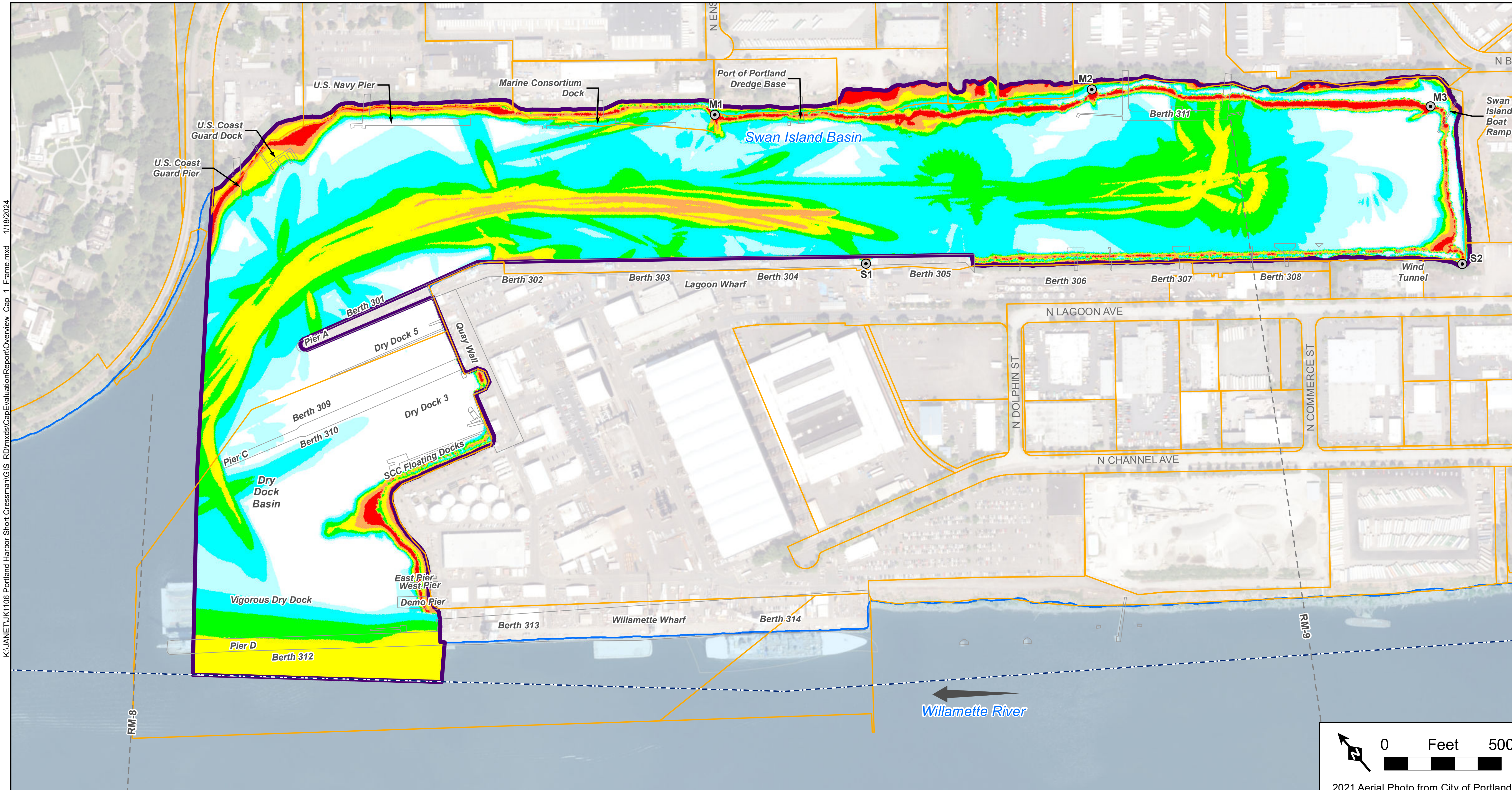
Bed Shear Stress [Pa]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 6-1
Peak Bed Shear Stresses from Rainfall Runoff

Prepared on: 11/18/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



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- City Stormwater Outfall
- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Bed Shear Stress [Pa]
25.9
12.2
5.7
2.7
1.3
0.47
0.27
0.0

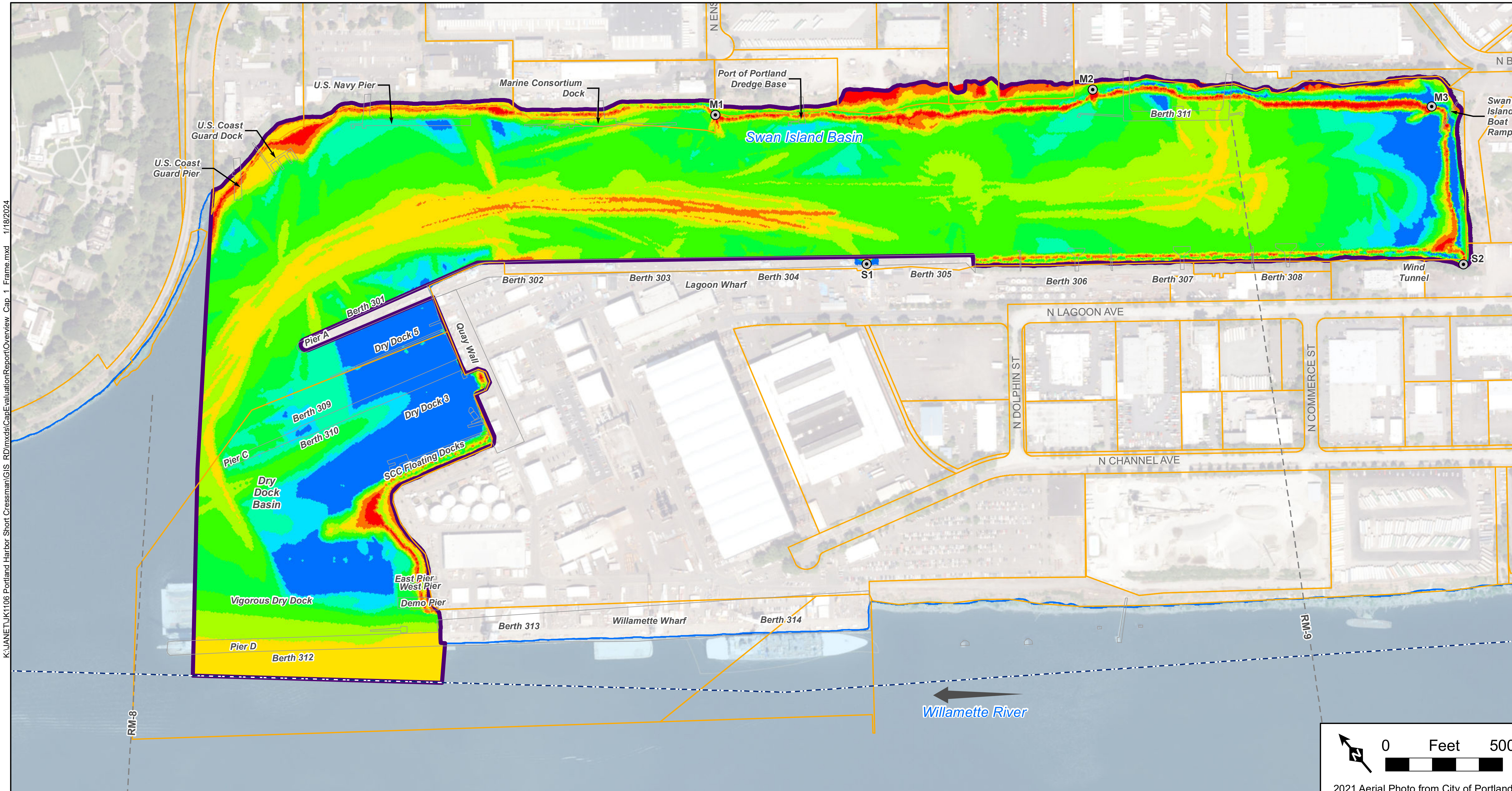
Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Shear stresses exceeding scale limits (25.9 Pa) that are as high as 60 Pa occur in localized areas of SIB embankment slopes due to outfall discharge and wave action and do not show up on this figure.

Figure 6-2
Peak Bed Shear Stresses from All Hydrodynamic Effects

Prepared on: 1/18/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



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City Stormwater Outfall
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Stable d50[mm]

64.0
32.0
16.0
8.0
4.0
2.0
1.0
0.5
0.25
0.125
0.0

Notes:
d50 – median sediment particle size
mm – millimeter
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Stable grain size d50 exceeding scale limits (64mm) occur in localized areas of SIB embankment slopes due to outfall discharge and wave action.

Figure 6-3

Stable Bed Material Size Based on Peak Bed Shear Stresses

Prepared on: 1/18/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

ATTACHMENT

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ATTACHMENT A

CapSIM EVALUATION CONCENTRATION PROFILES

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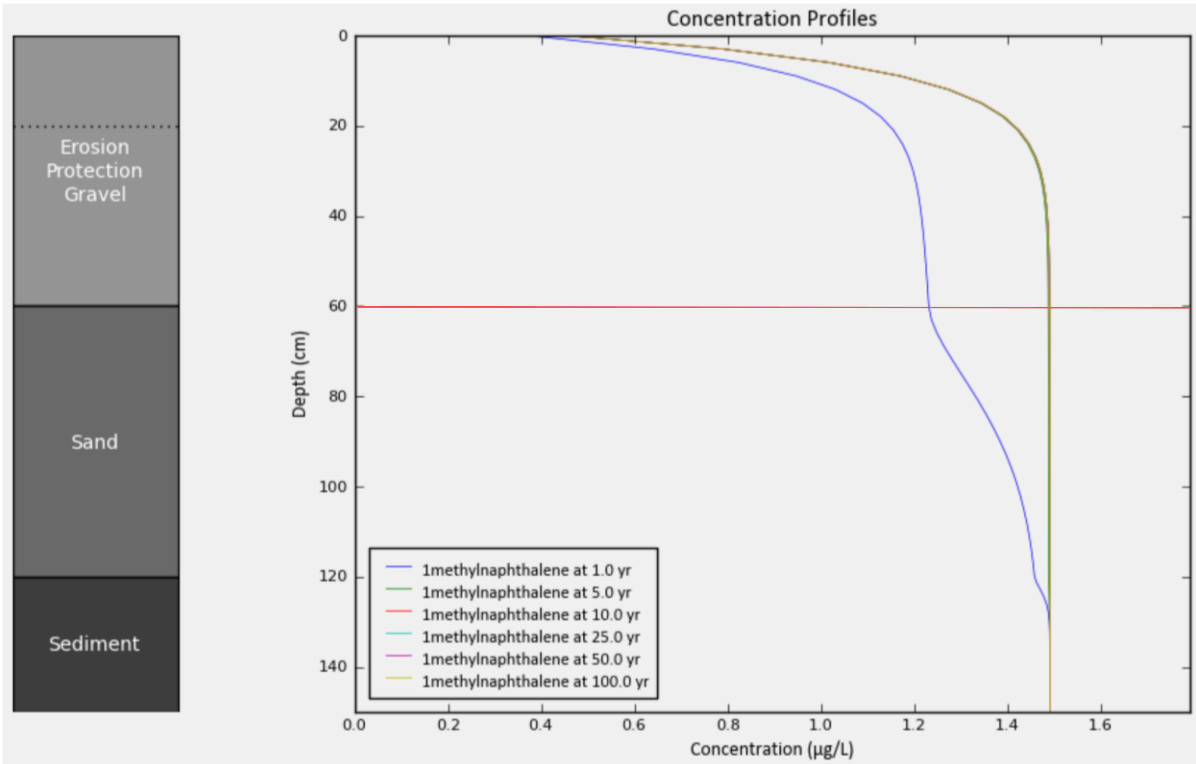
Contents

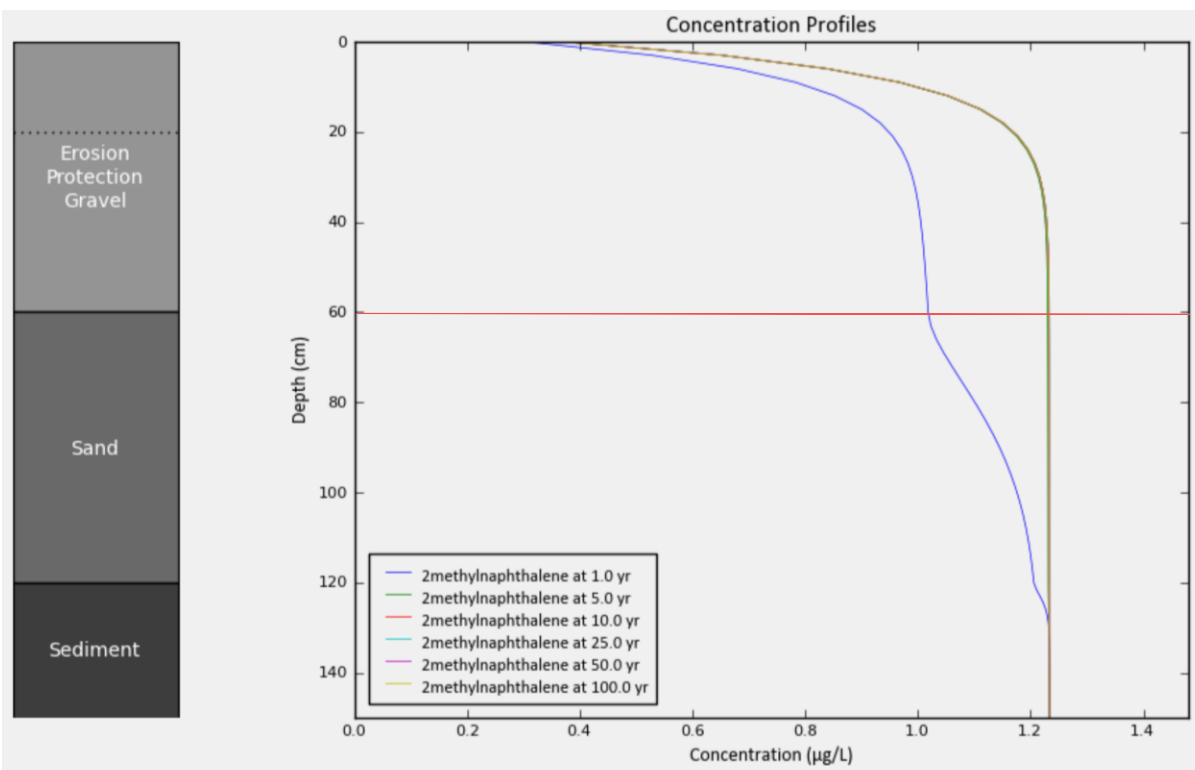
The cap performance point (CPP) is indicated by a horizontal red line on the depth-based concentration profiles. The CPP is at the top surface of the chemical isolation layer.

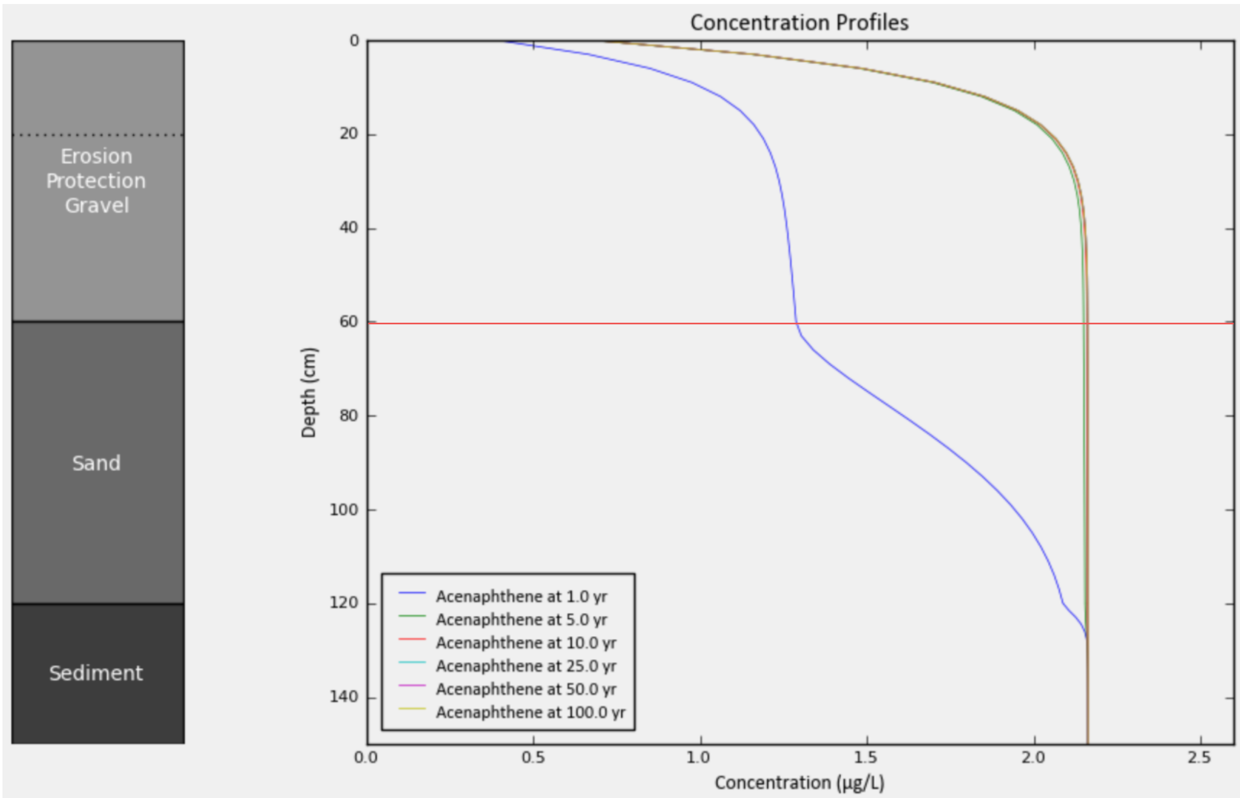
The groundwater cleanup levels (CUL) from Appendix A Table 1-1 are indicated by a vertical red line on the depth-based concentration profiles, and by a horizontal red line on the time-based concentration profiles. The CUL is not shown on curves where the CUL is beyond the upper bound of the concentration axis, for individual polychlorinated biphenyl (PCB) congeners that are only subject to CULs on the summed total (Total PCBs), or for time-based profiles that do not deviate from a concentration of 0 µg/L.

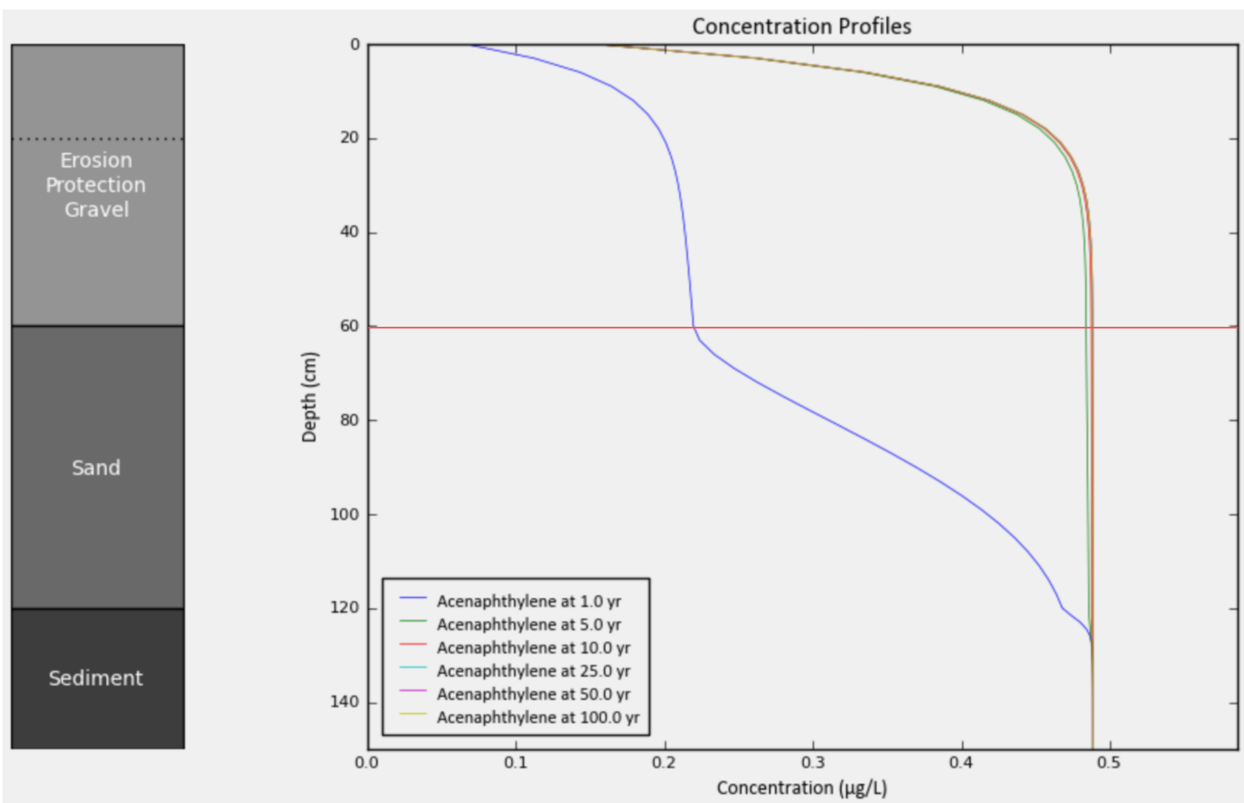
Cap Alternative 1: 60 centimeters [cm] of unamended sand with 60 cm erosion protection layer

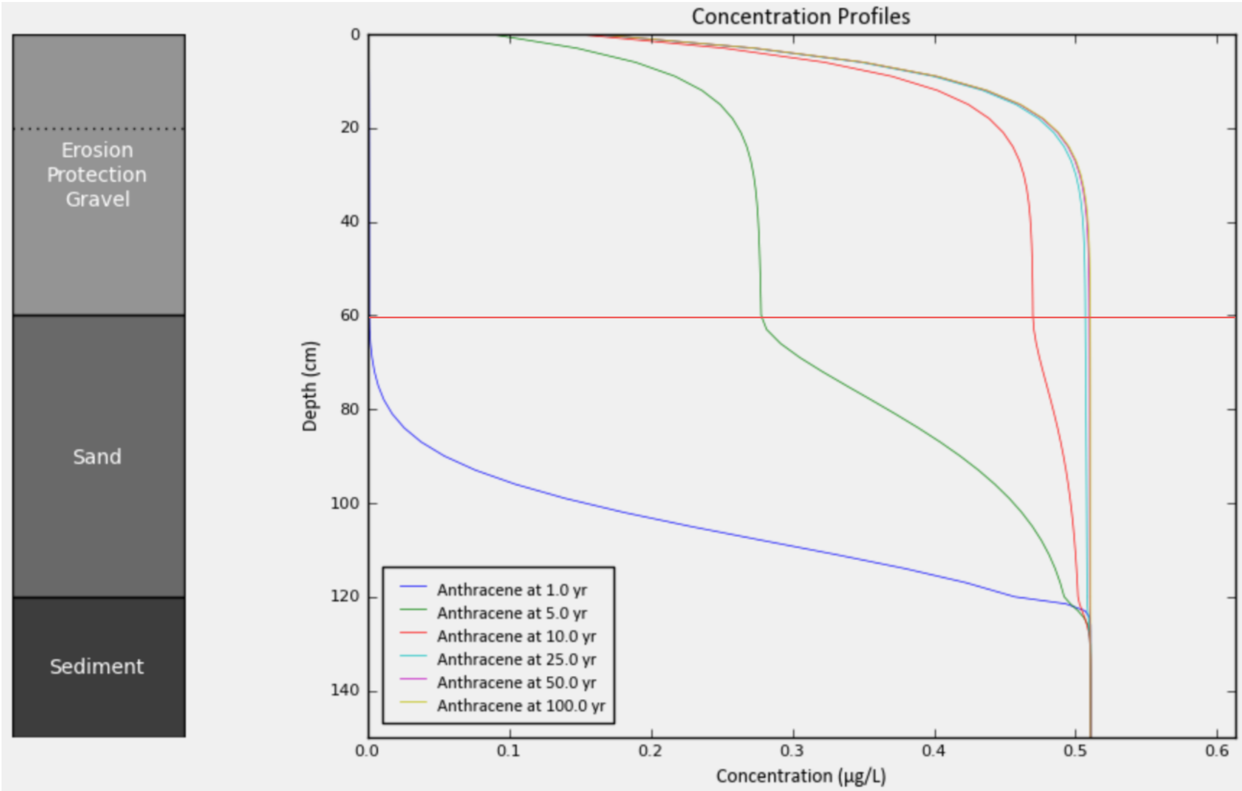
Porewater Concentration – Depth

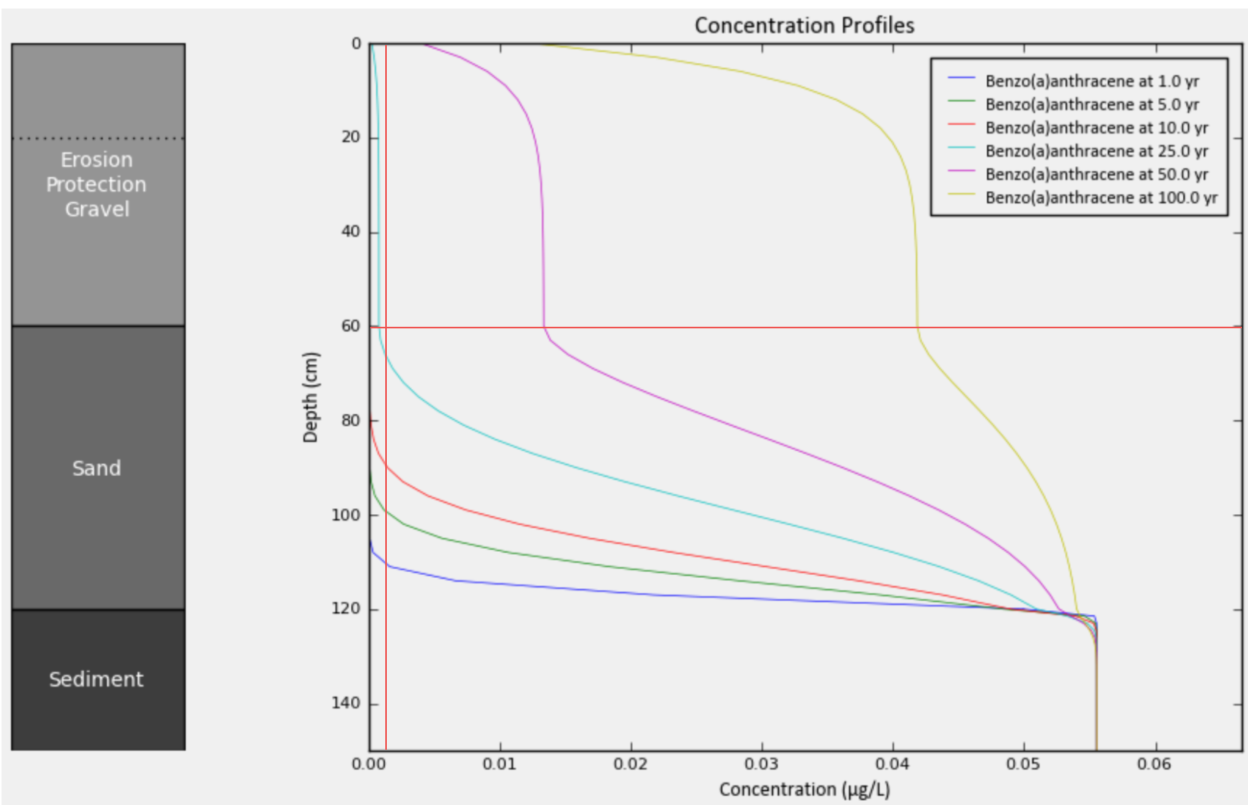


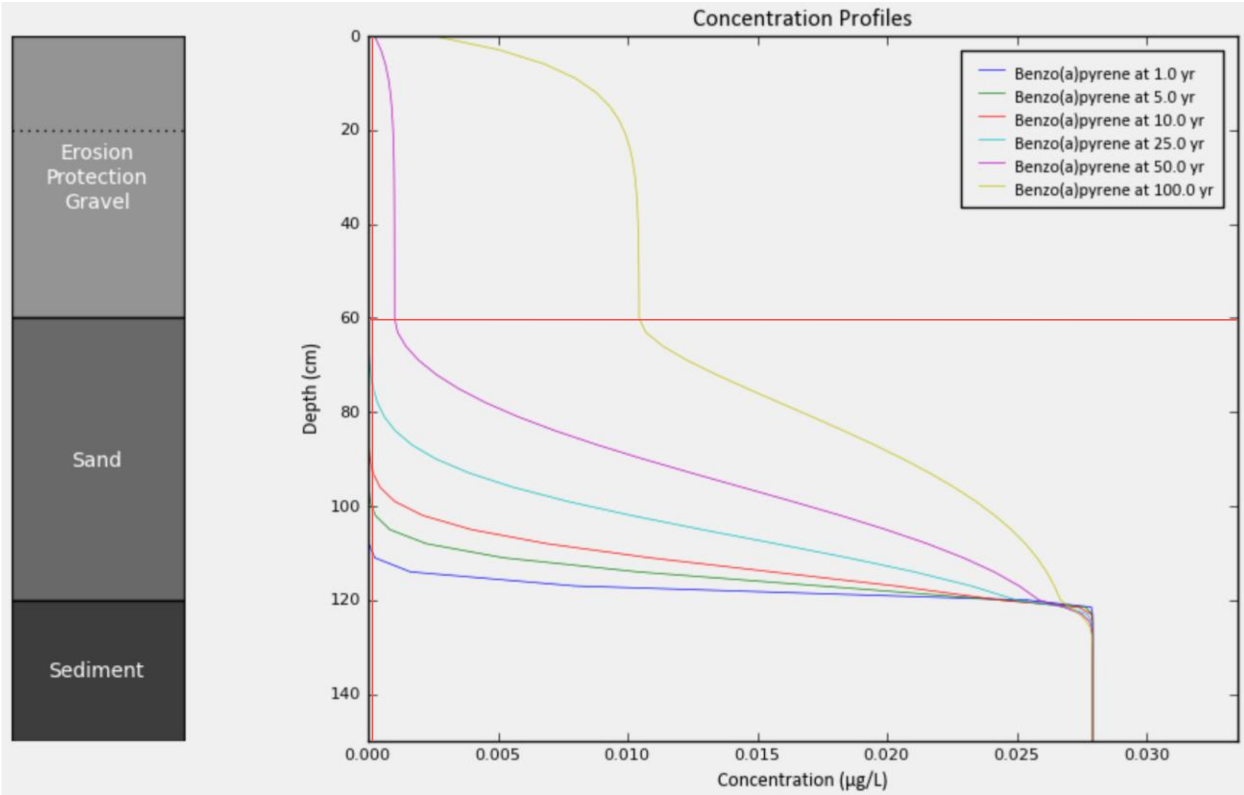


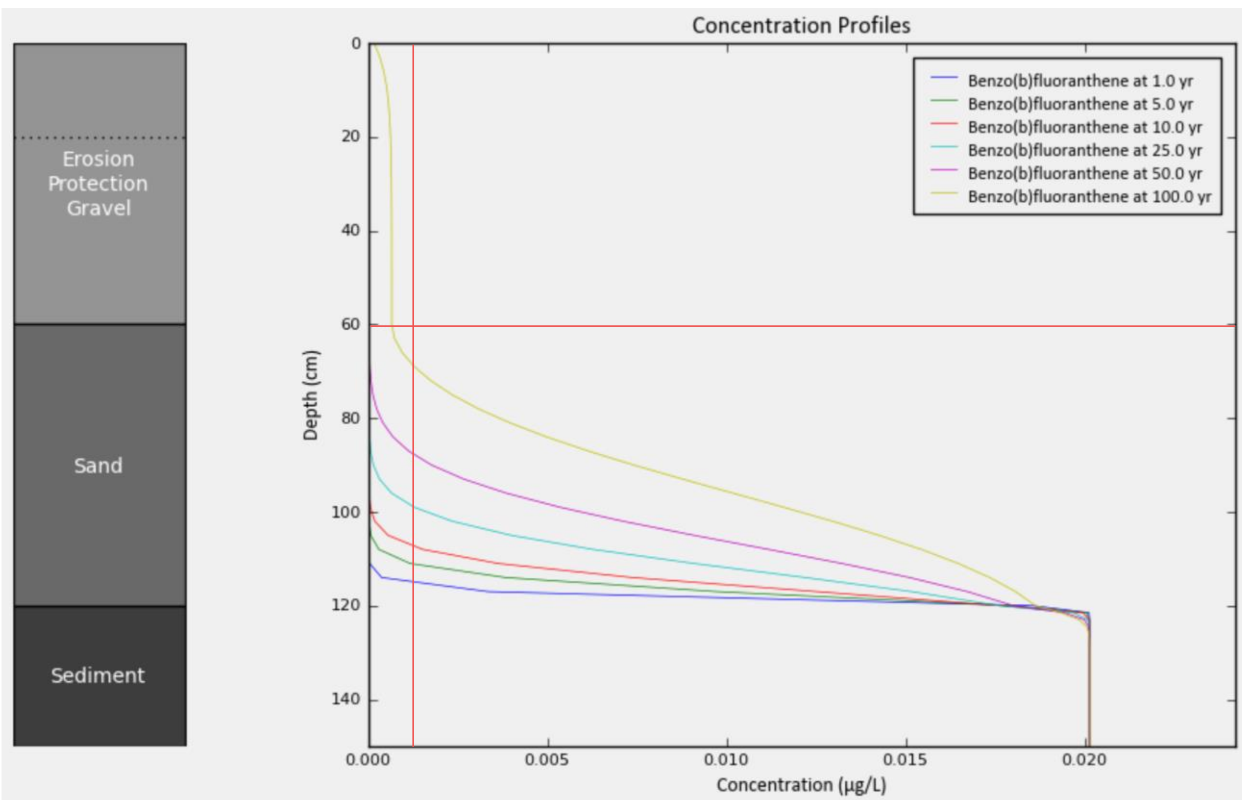

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

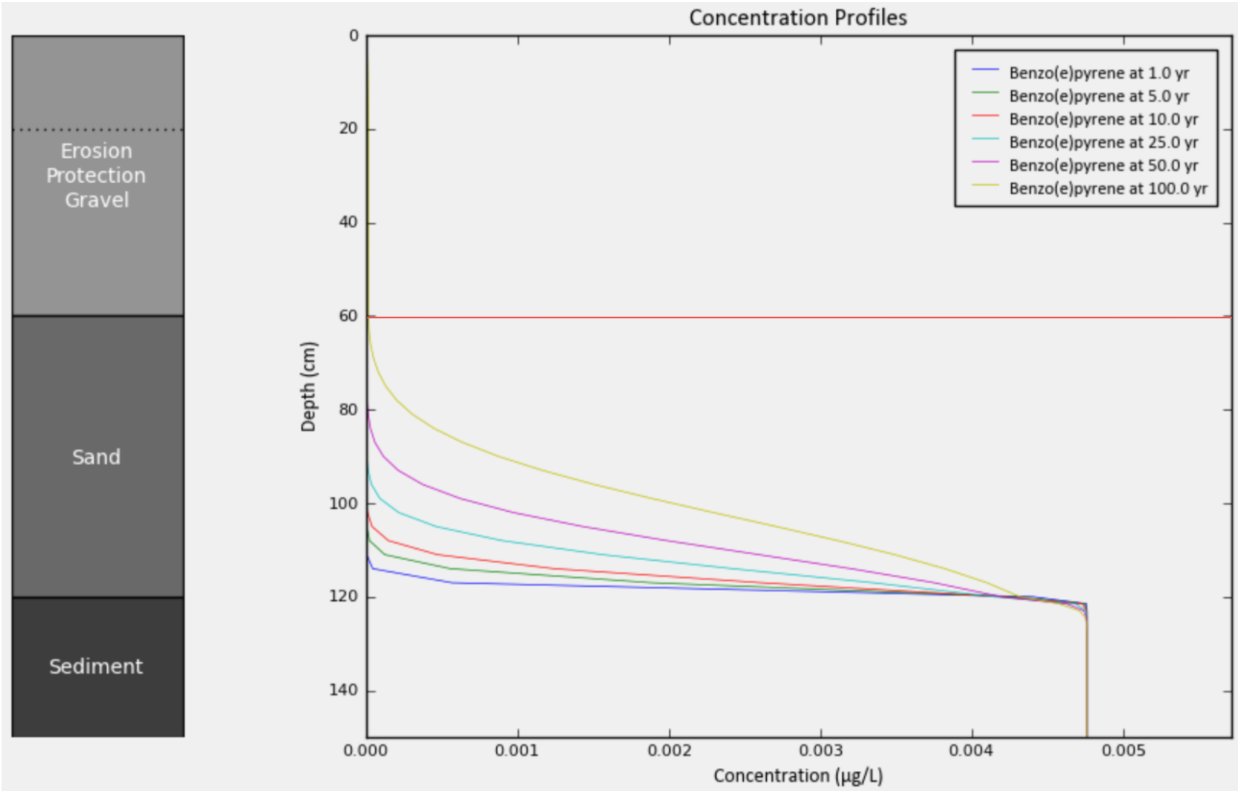

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

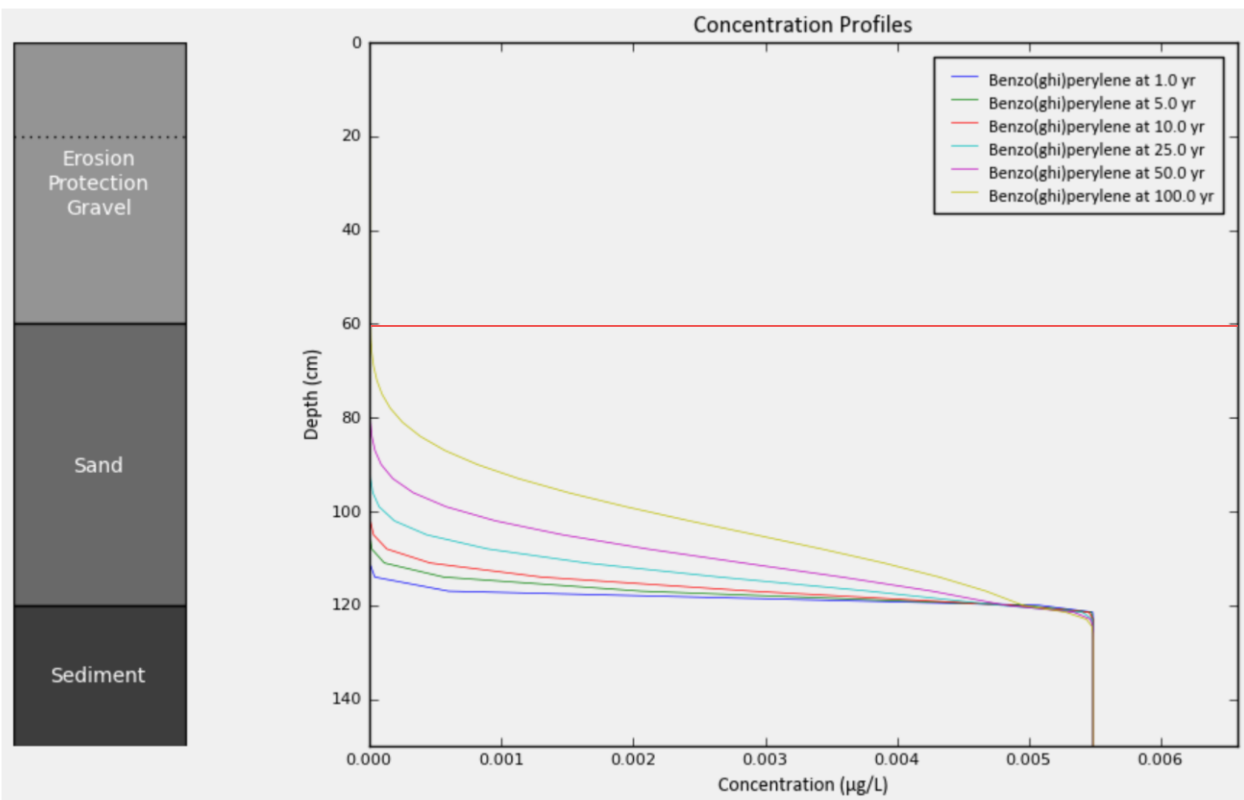

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

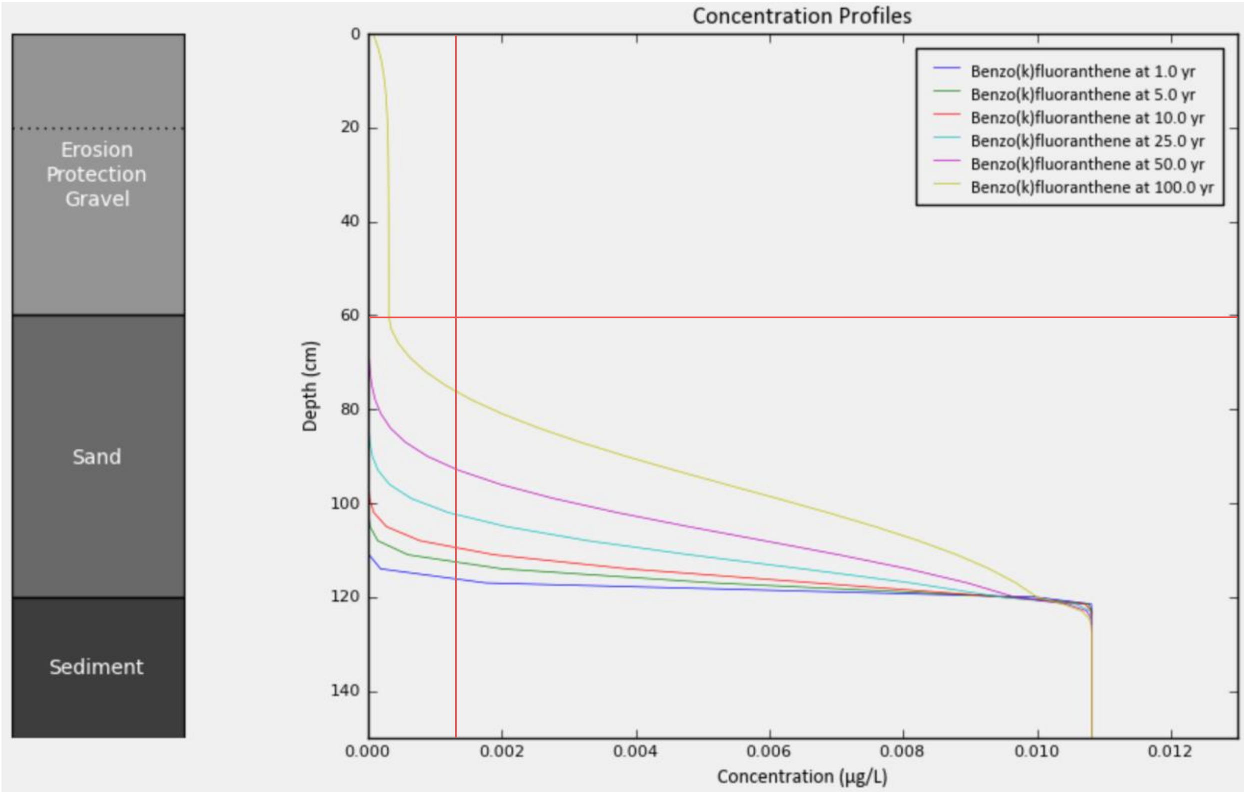

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

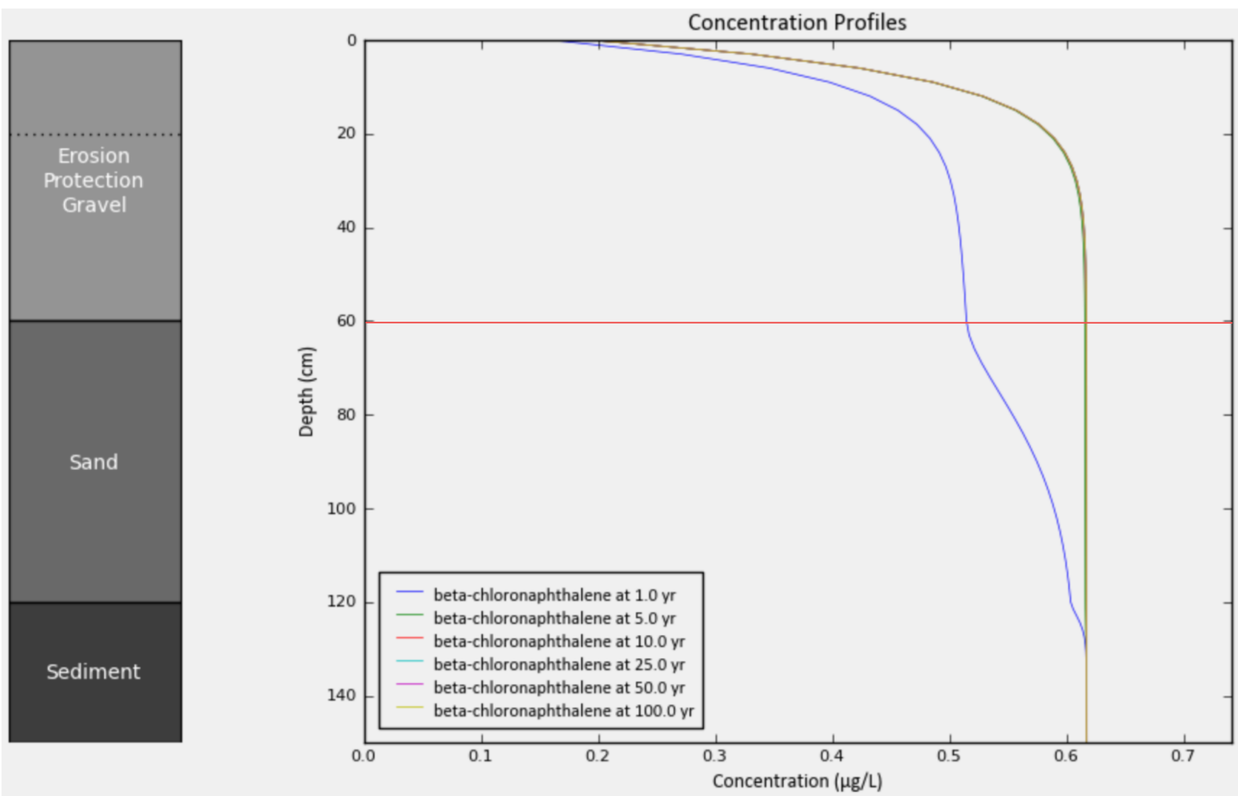

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr
0
20
40
60
80
100
120
140
0.000
0.005
0.010
0.015
0.020
0.025
0.030

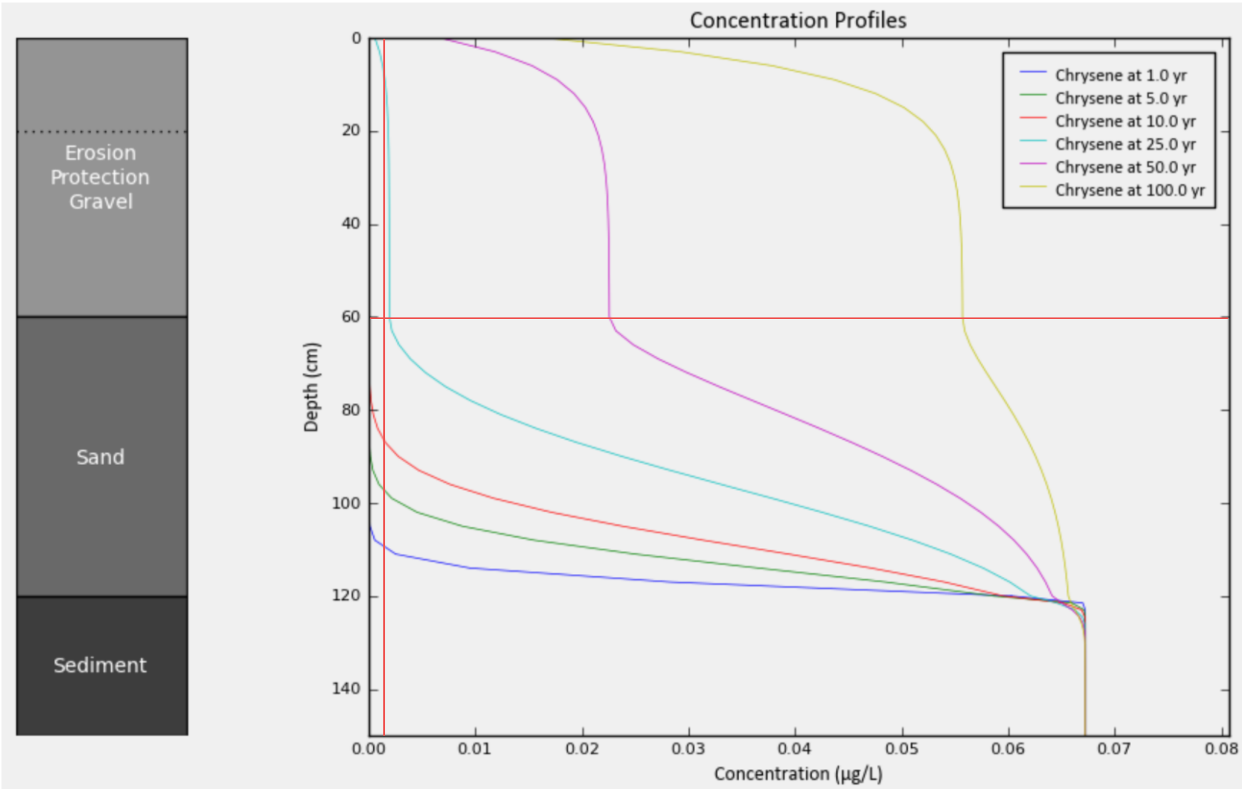

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr
0
20
40
60
80
100
120
140
0.000
0.005
0.010
0.015
0.020

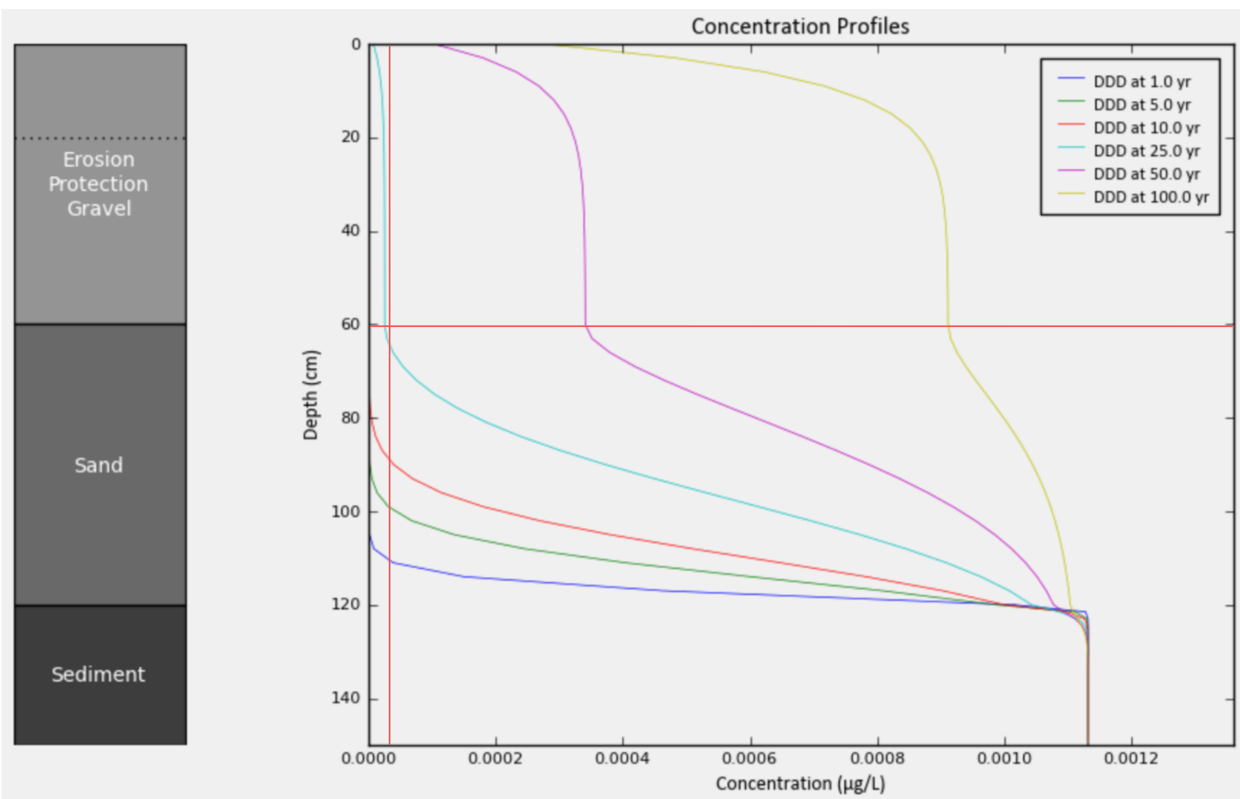

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

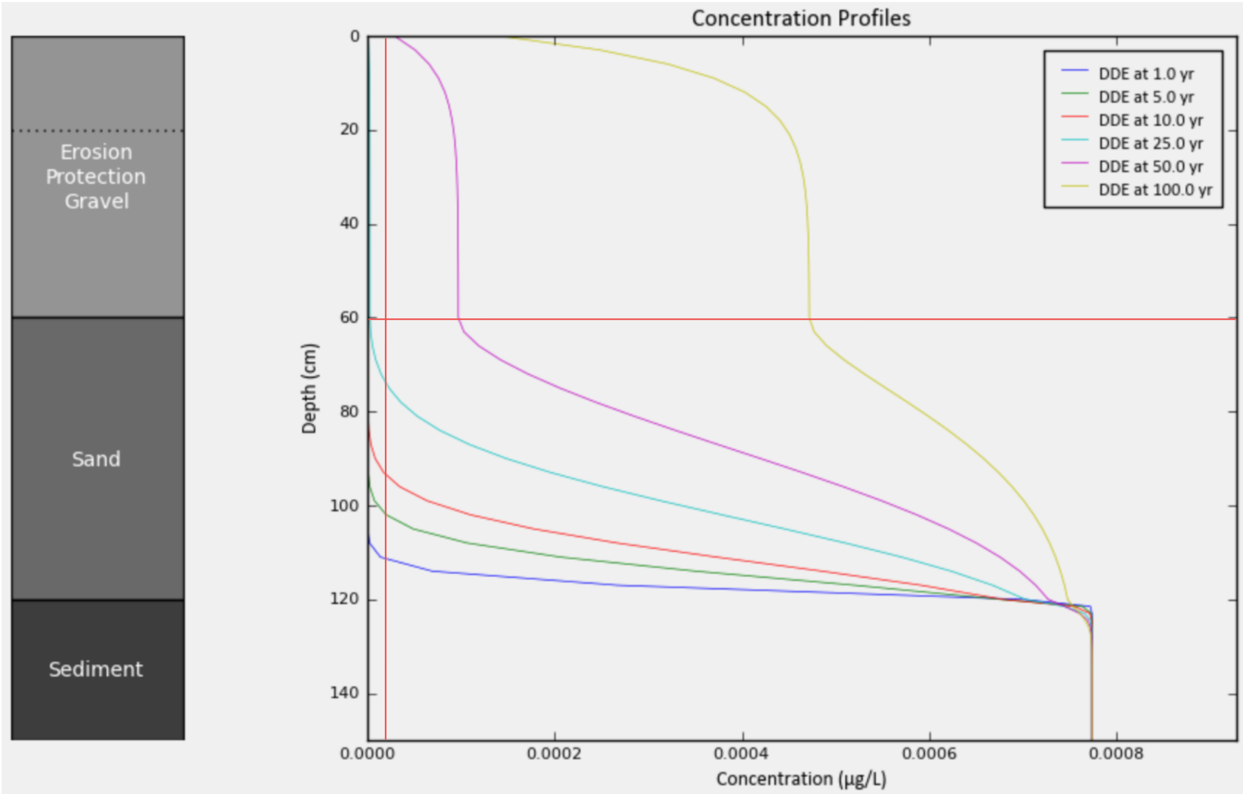

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

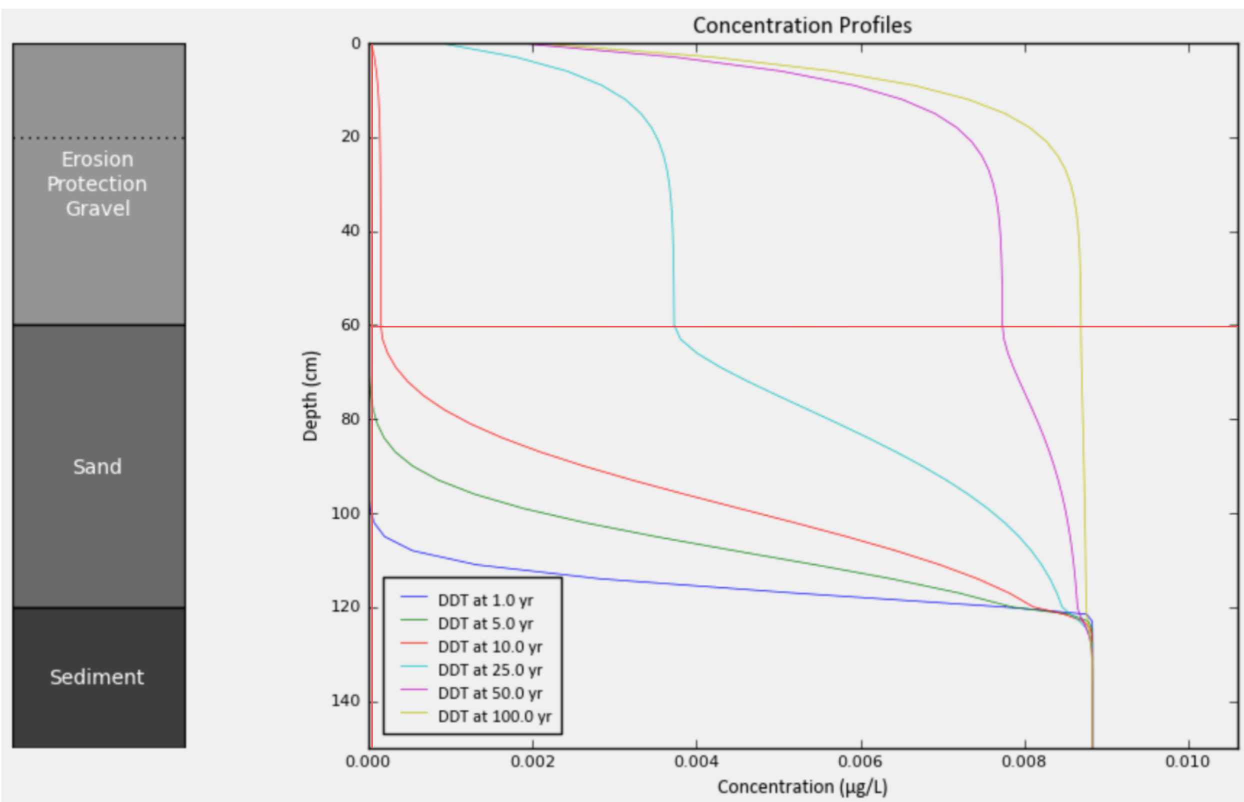

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr

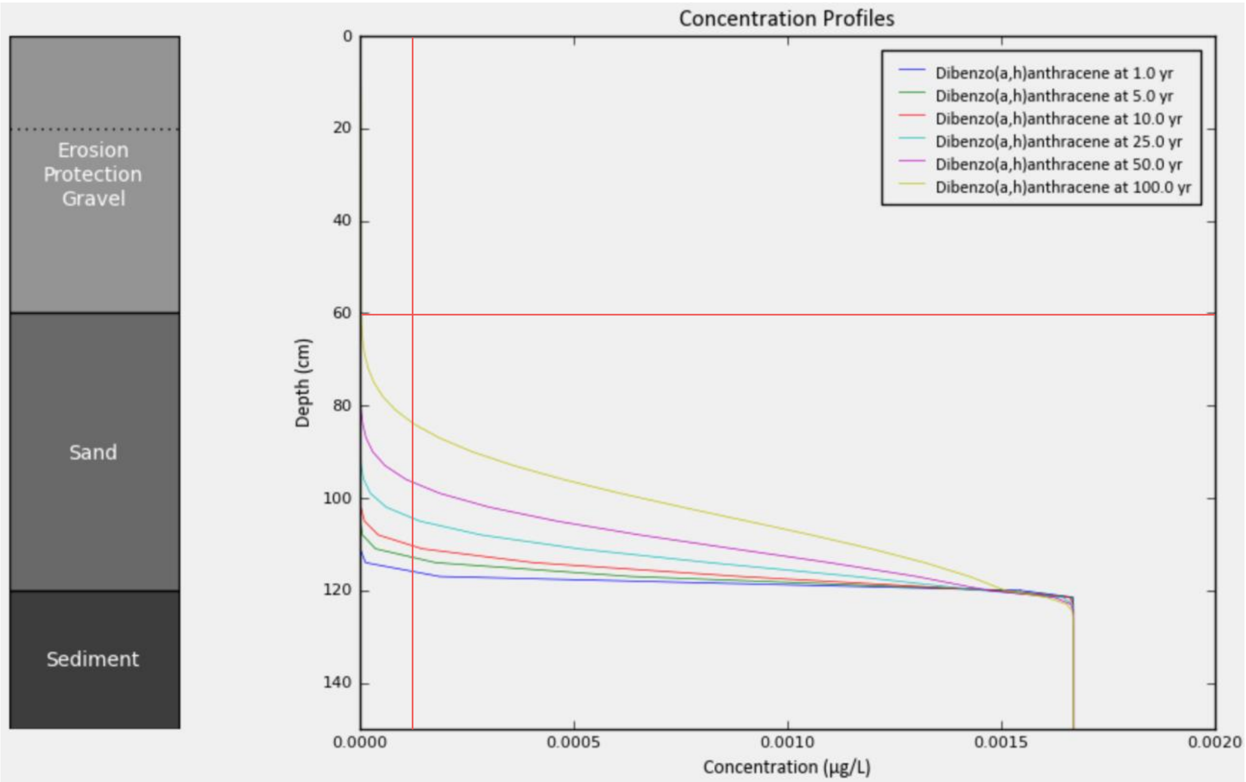

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr

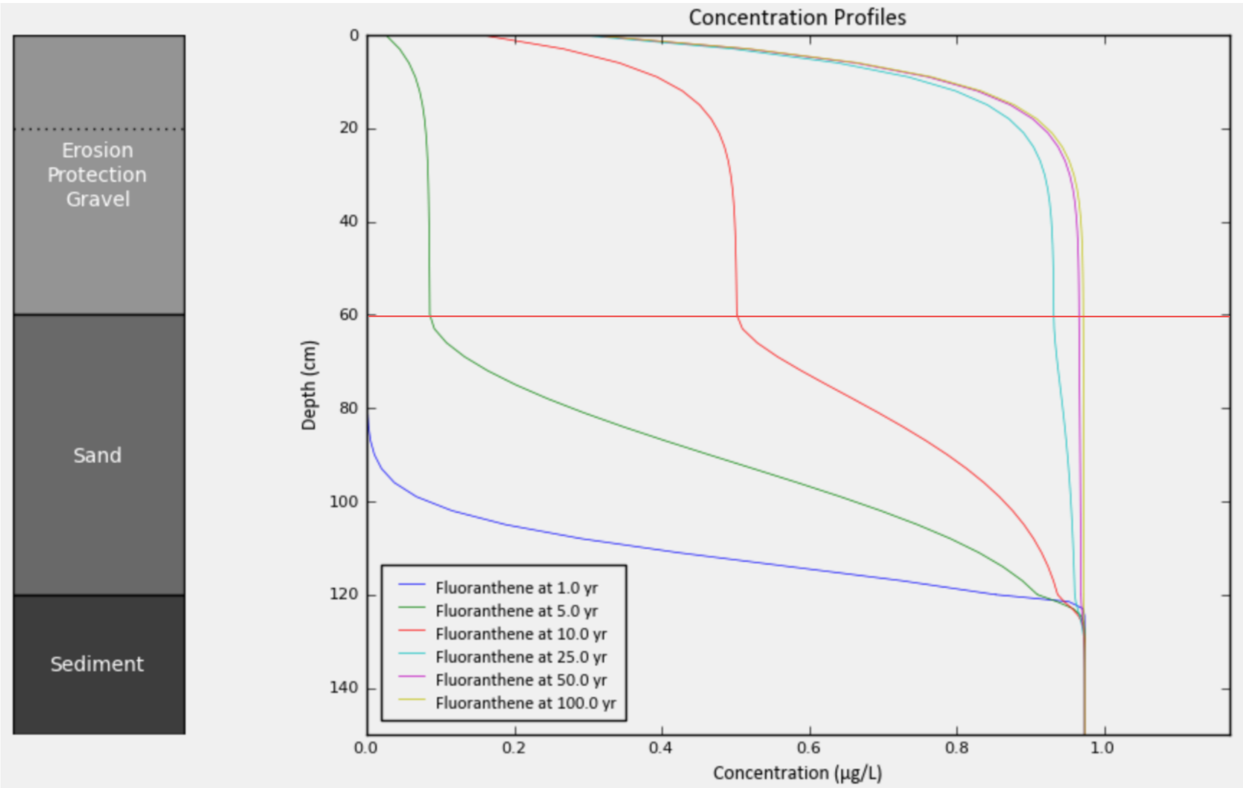

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr

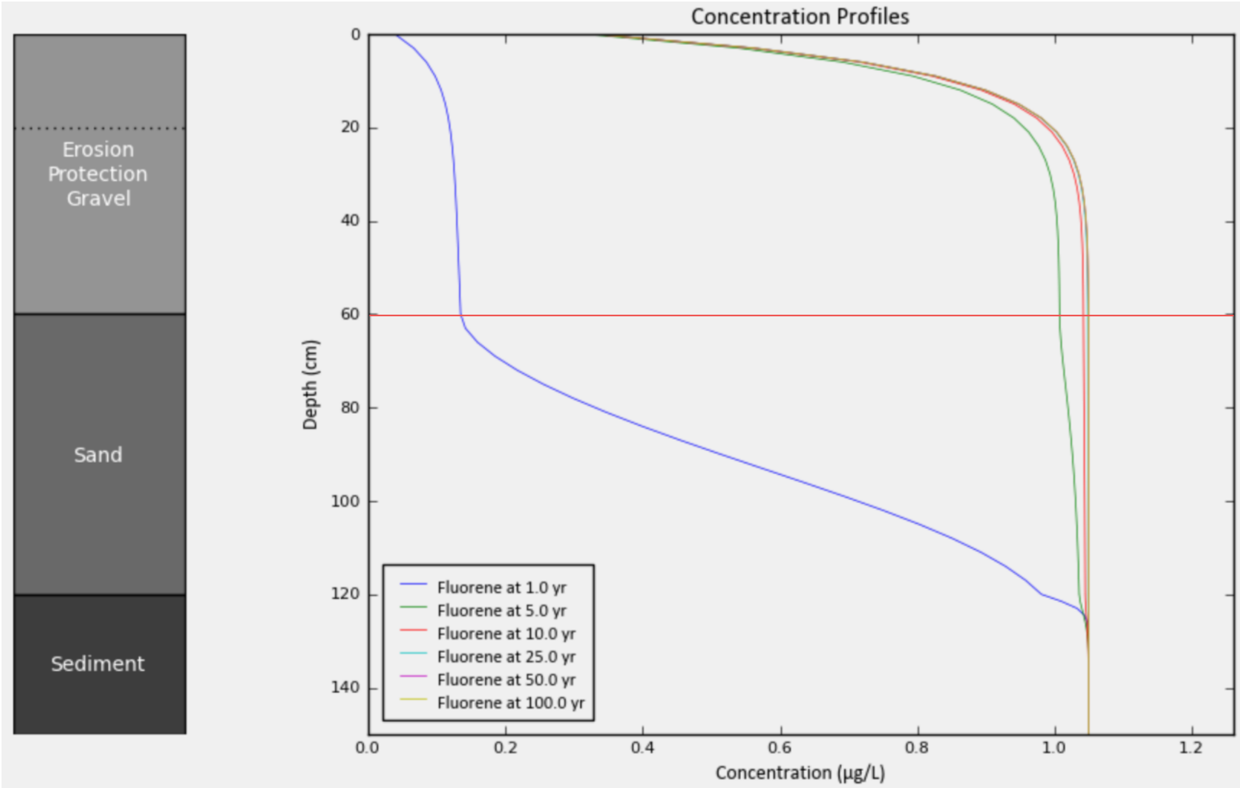

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr

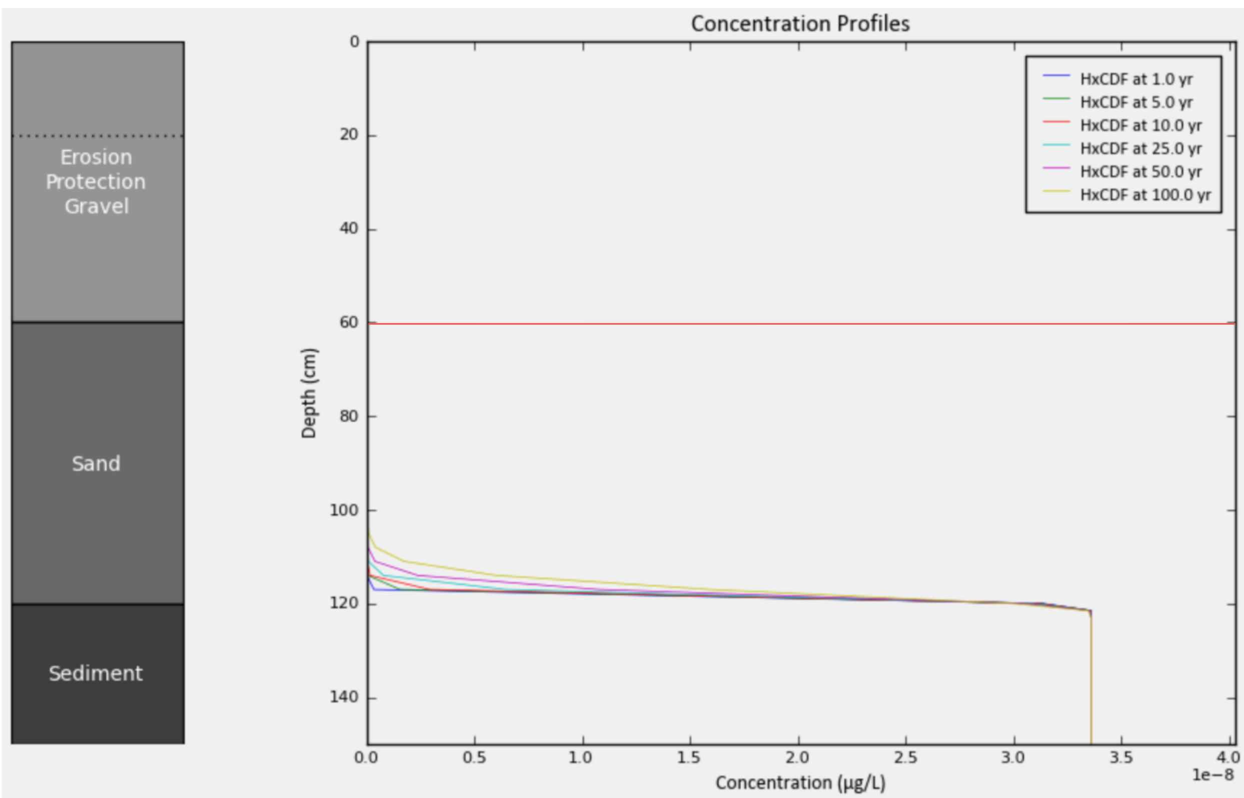

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
0
20
40
60
80
100
120
140
0.0000
0.0002
0.0004
0.0006
0.0008

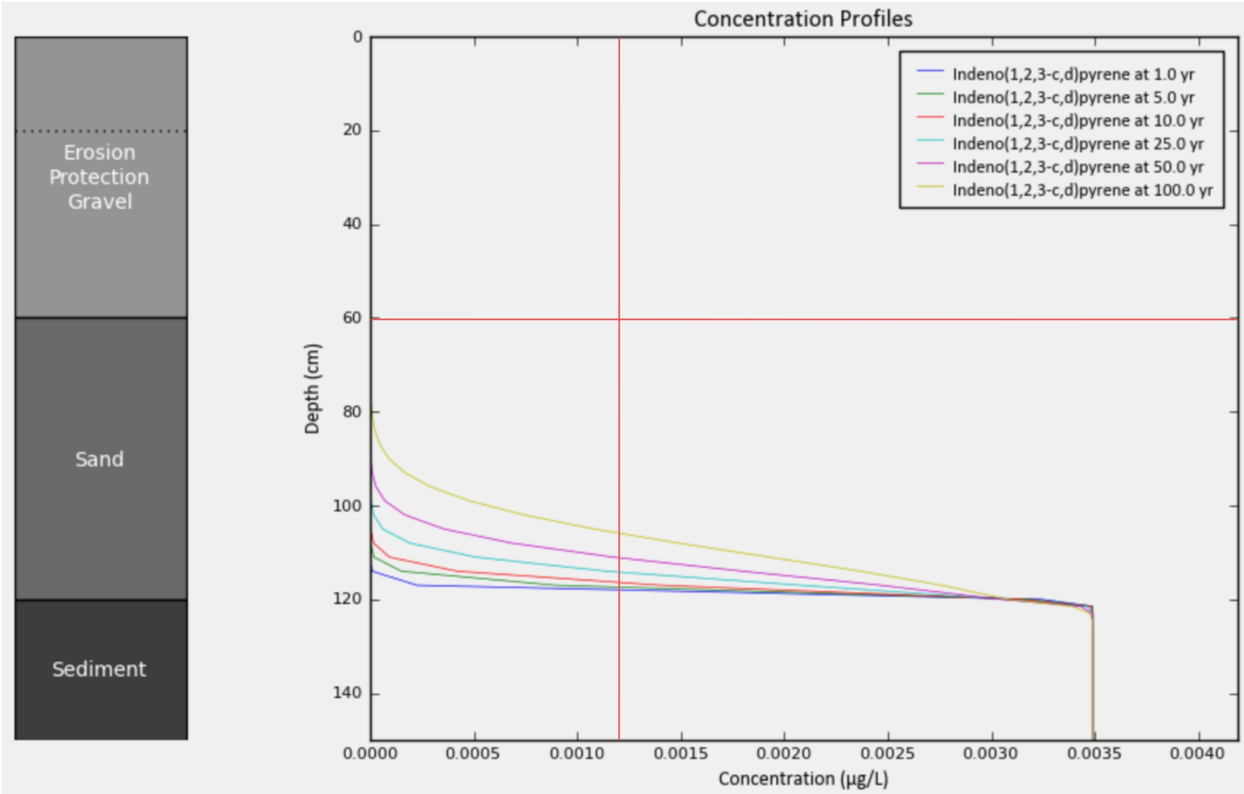

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
0
20
40
60
80
100
120
140
0.000
0.002
0.004
0.006
0.008
0.010

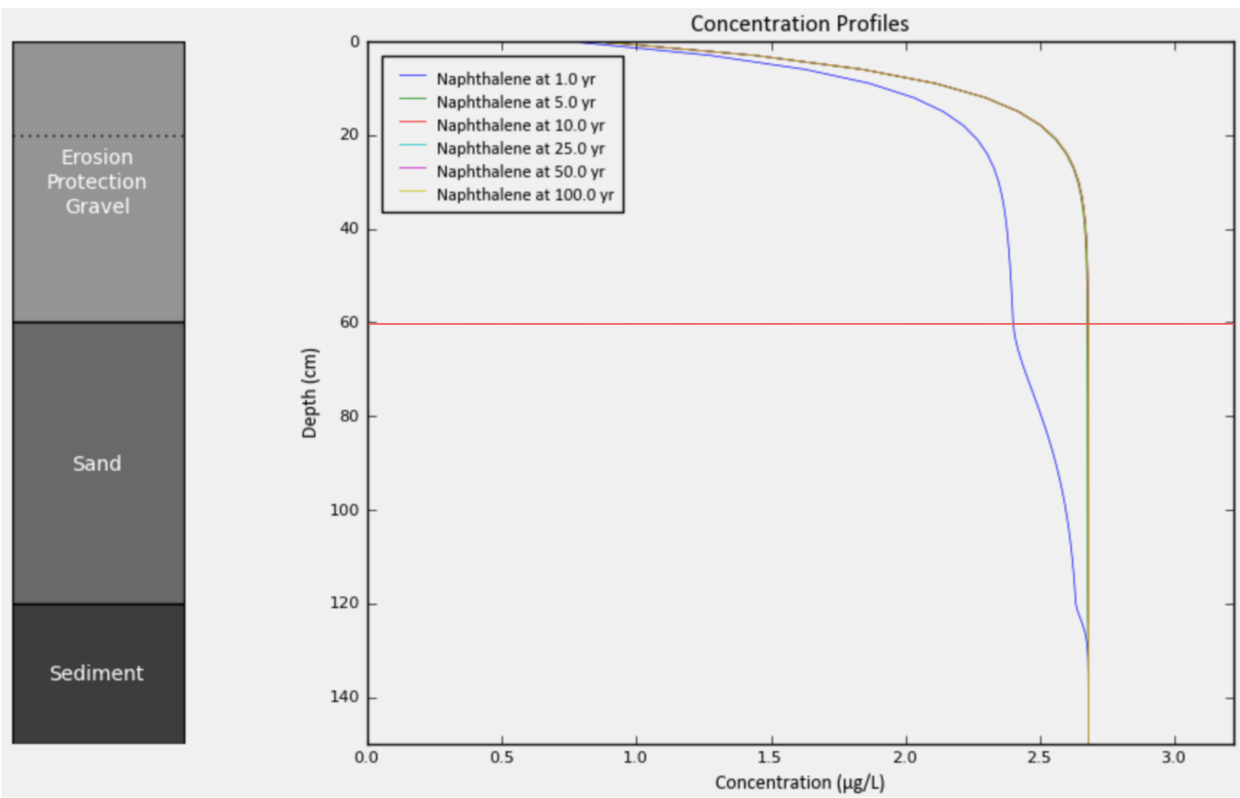

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
0
20
40
60
80
100
120
140
0.0000
0.0005
0.0010
0.0015
0.0020

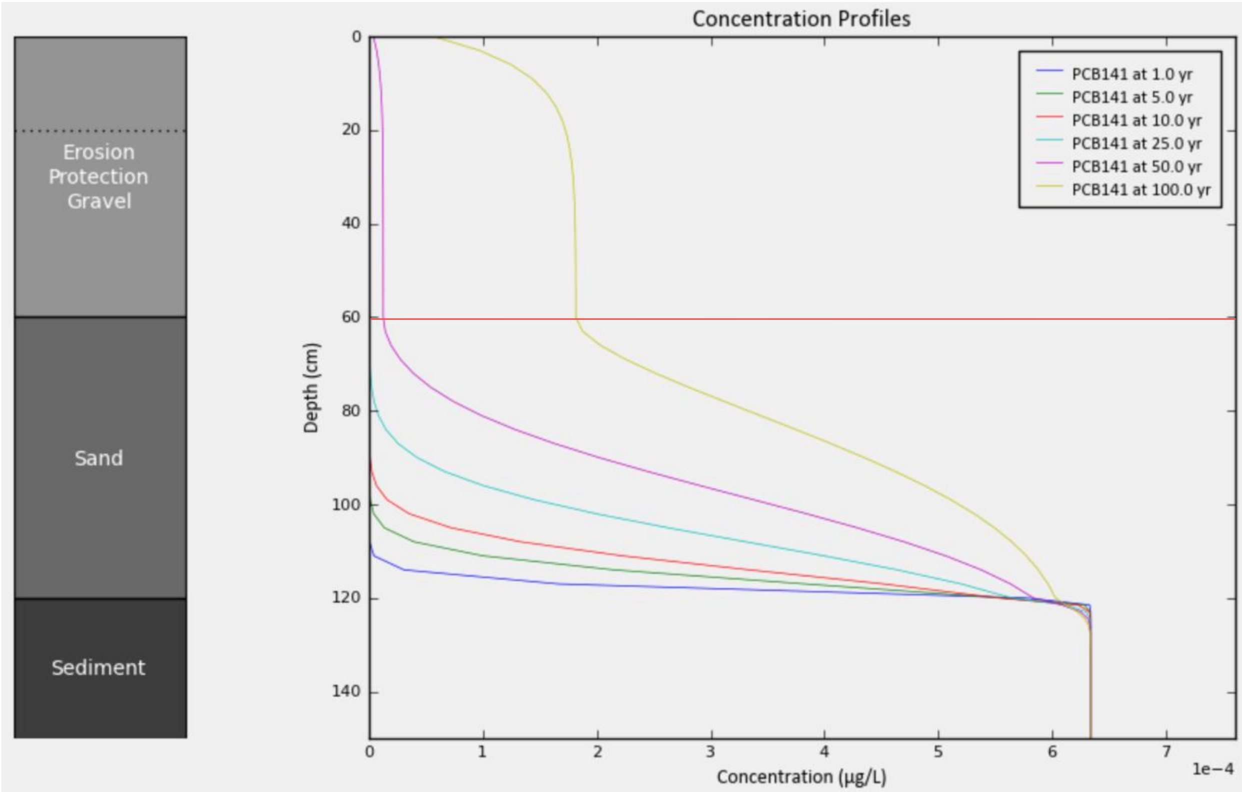

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
0
20
40
60
80
100
120
140
0.0
0.2
0.4
0.6
0.8
1.0

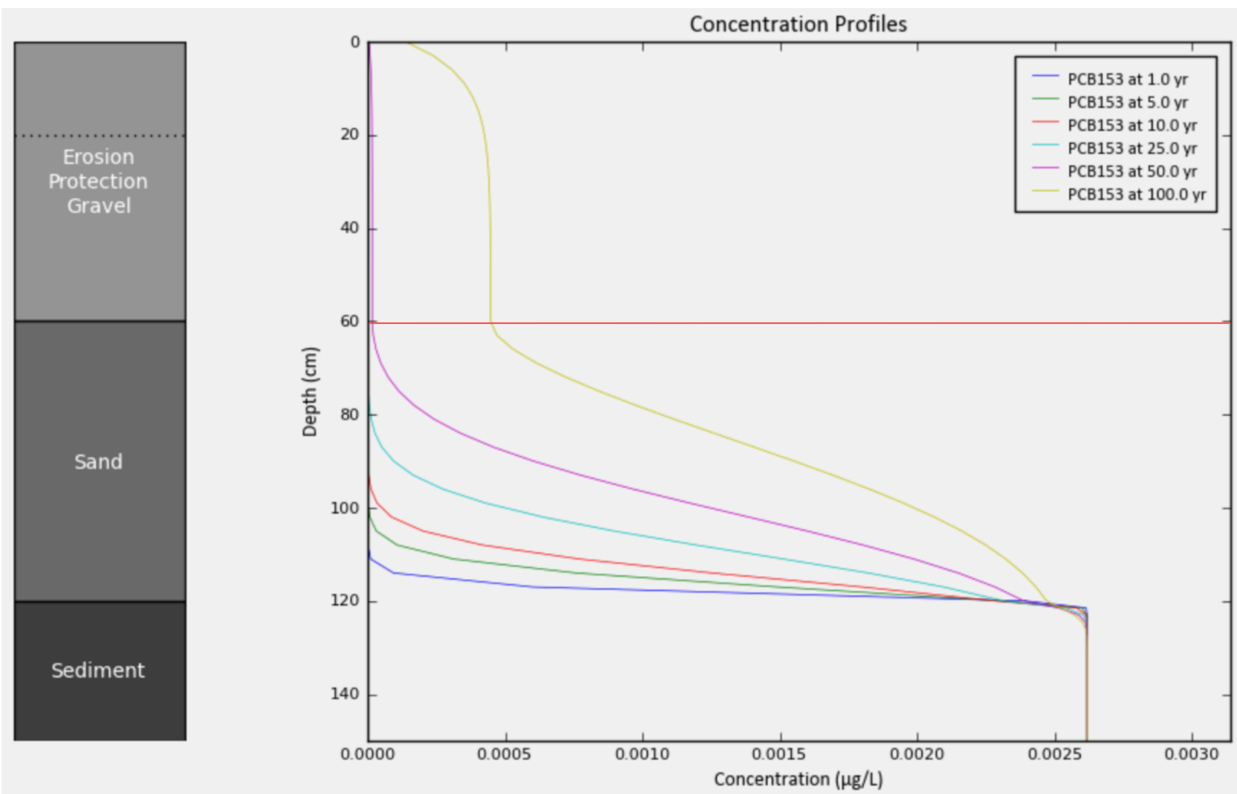

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr

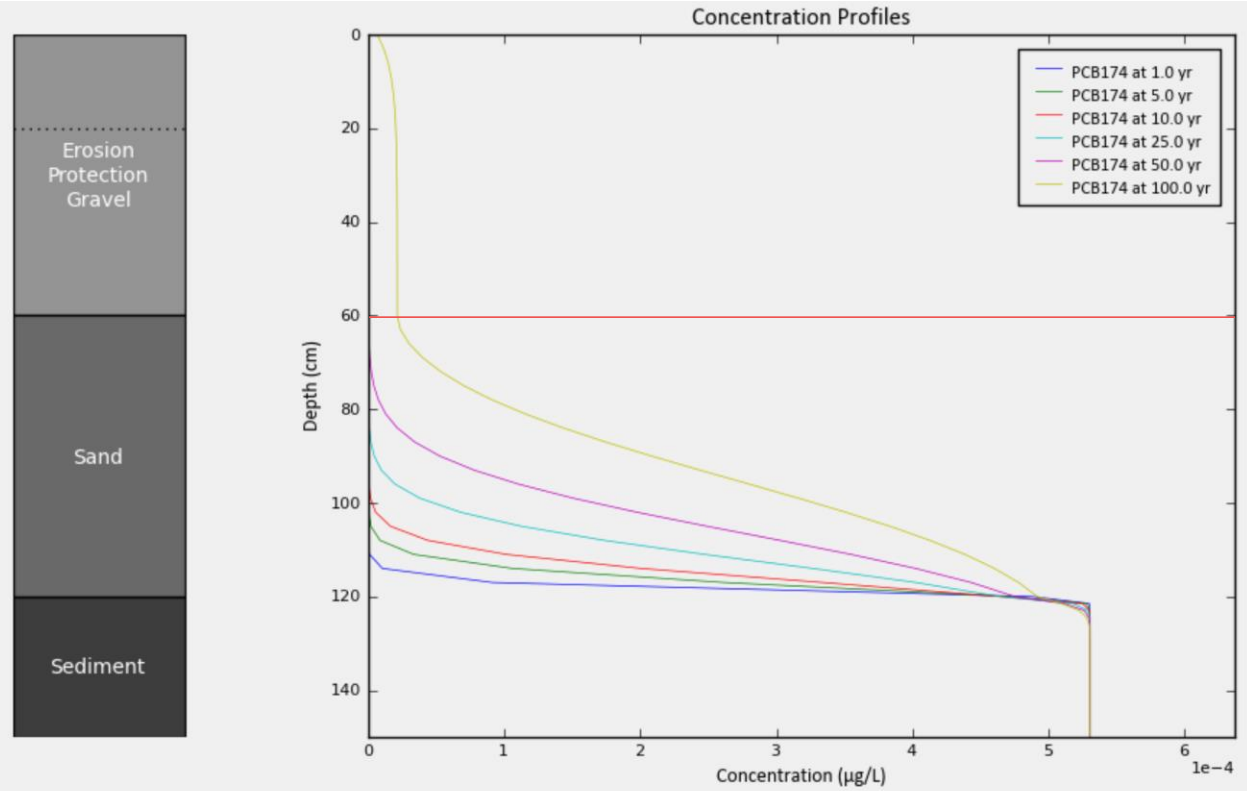

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−8
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr


Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr
Depth (cm)
Concentration (μg/L)

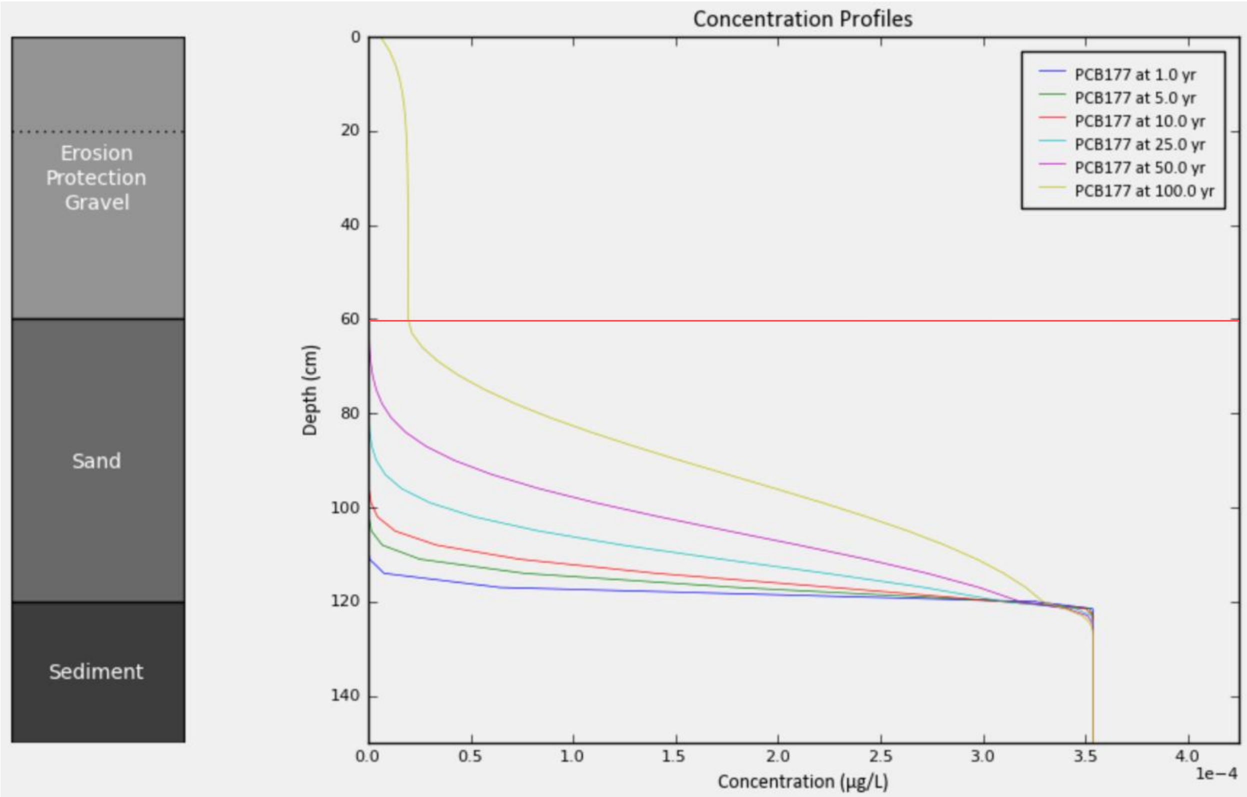

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr
Depth (cm)
Concentration (μg/L)


Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr

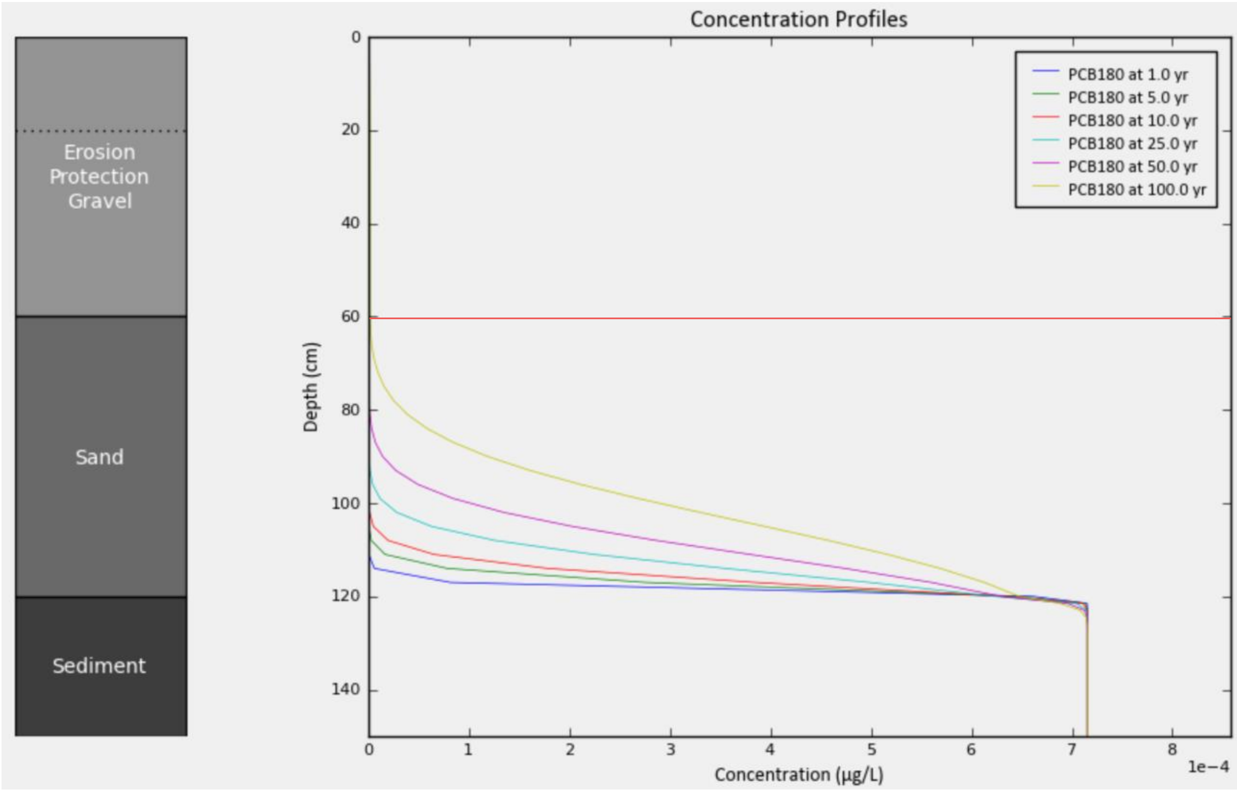

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr

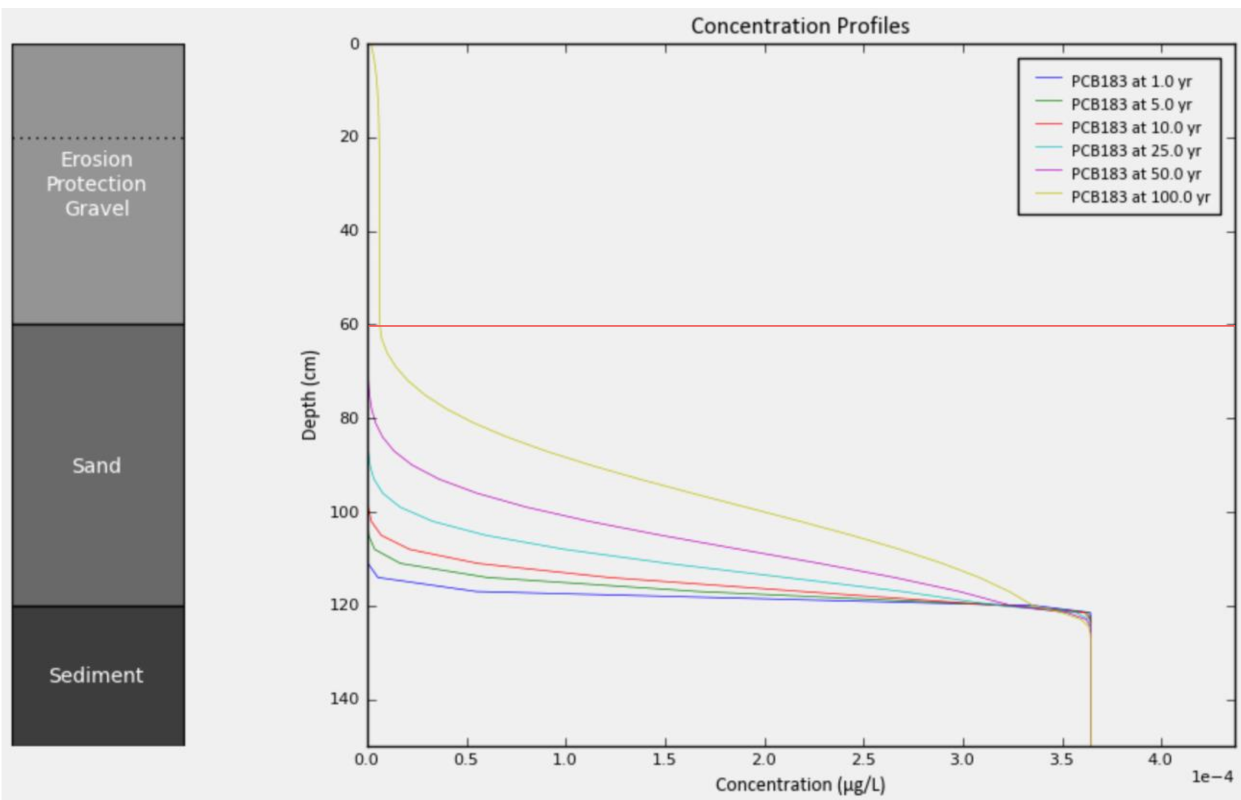


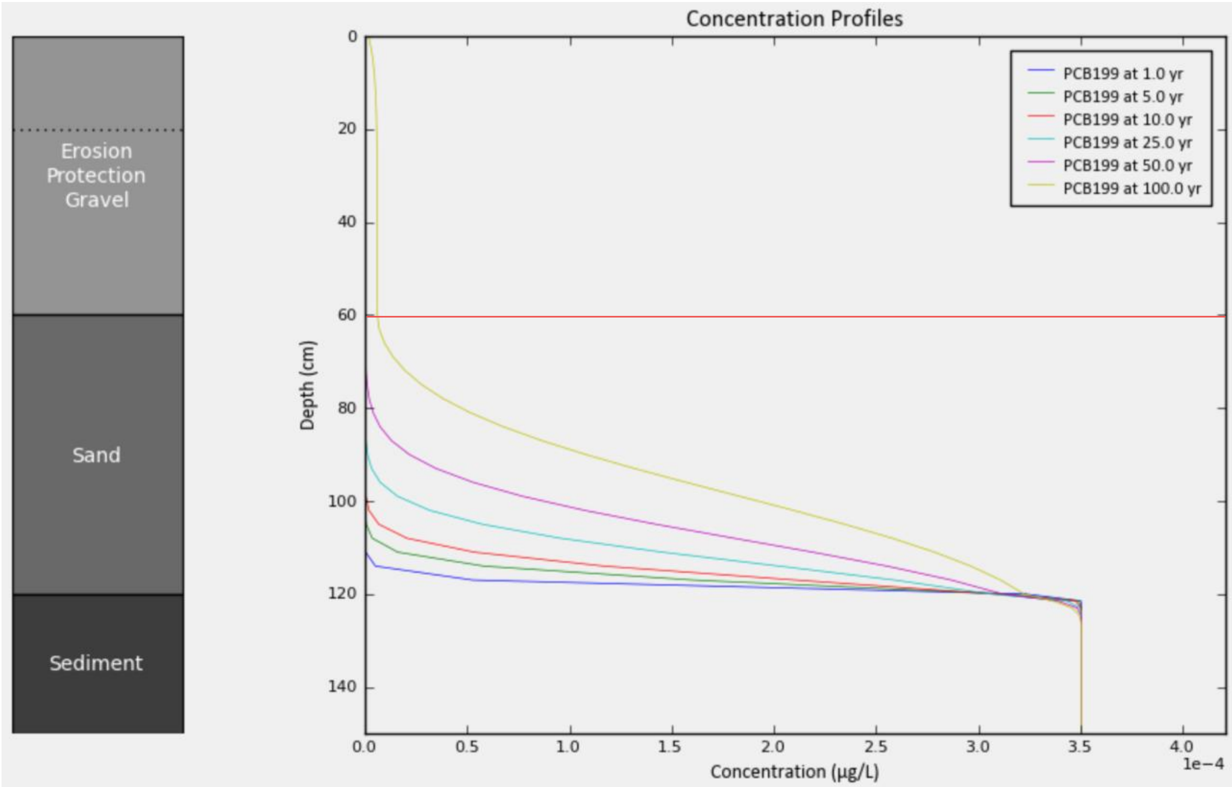
Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

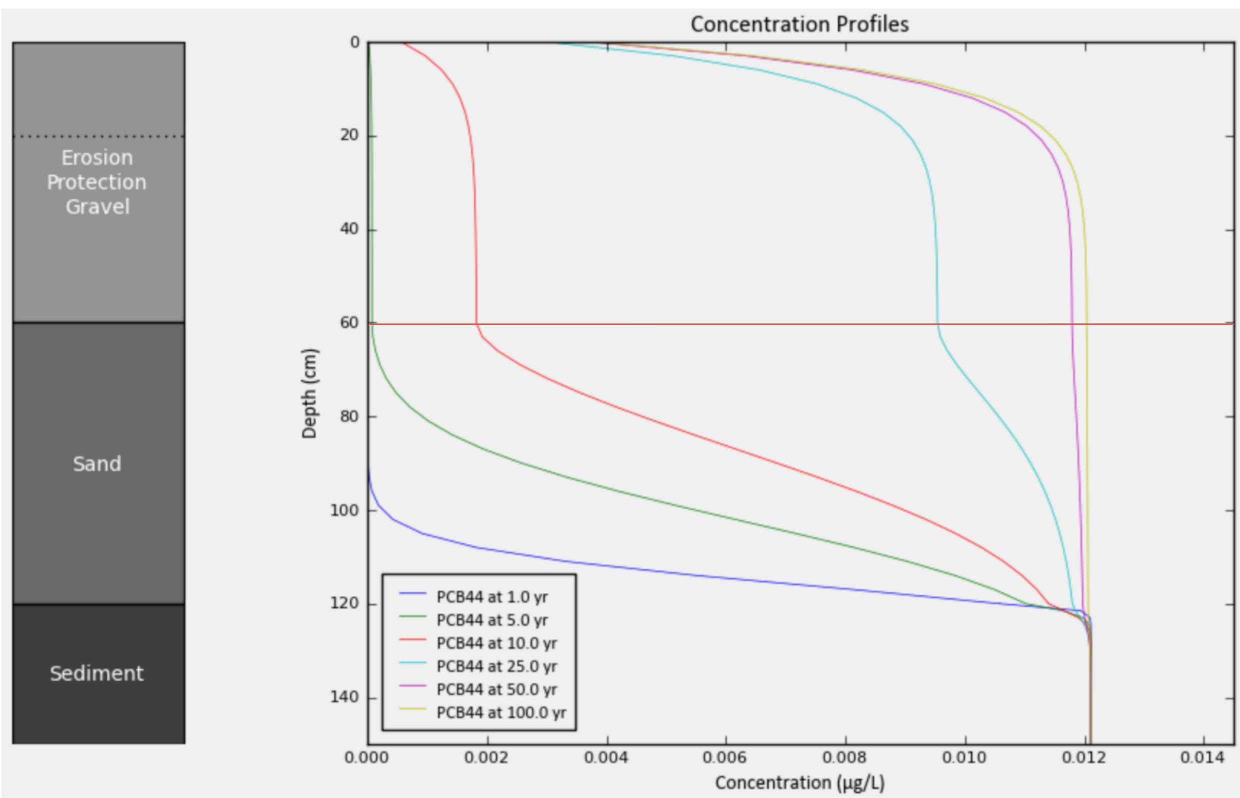


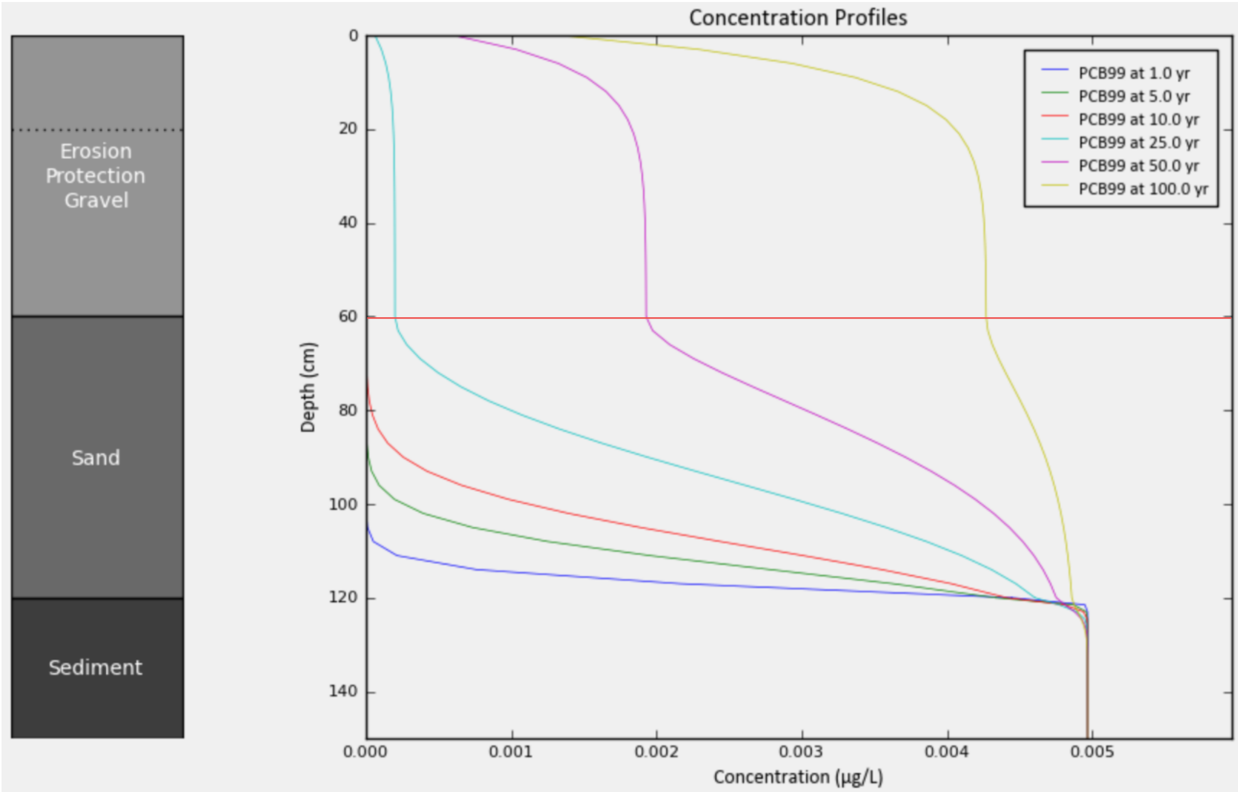
Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

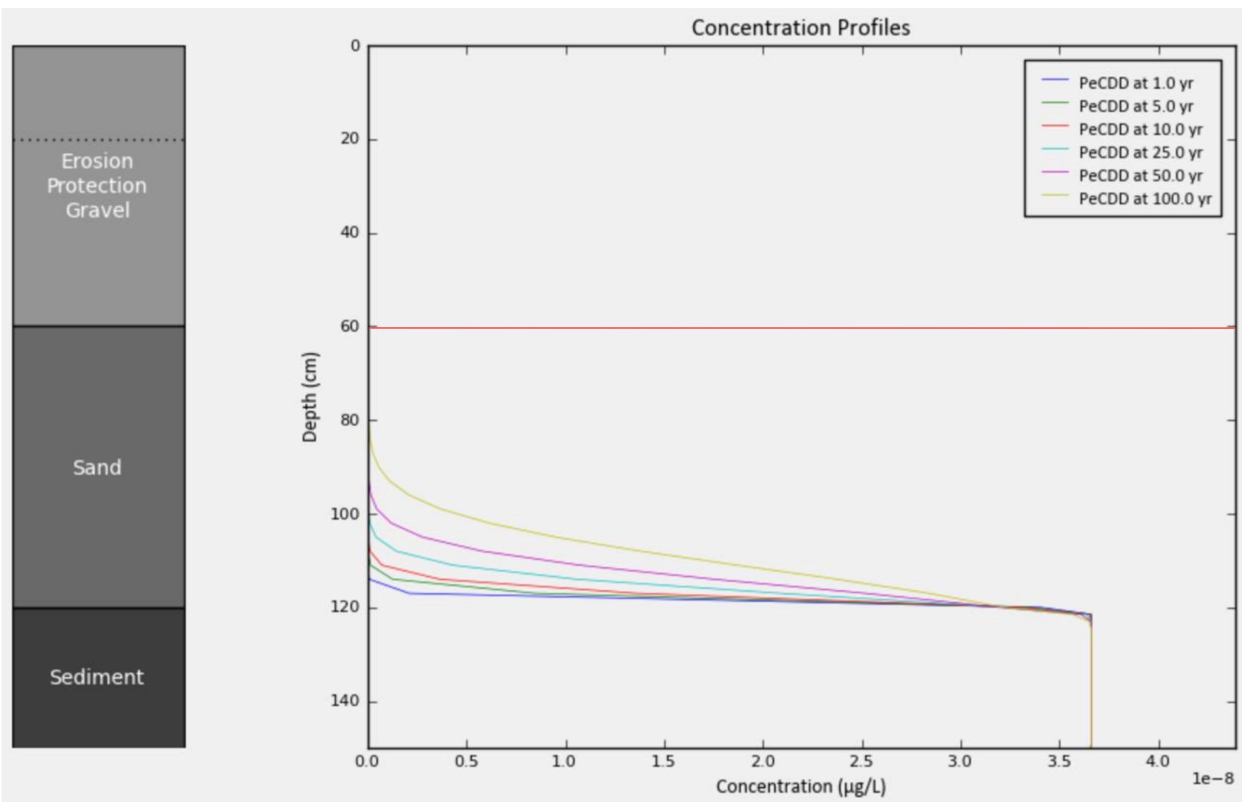

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

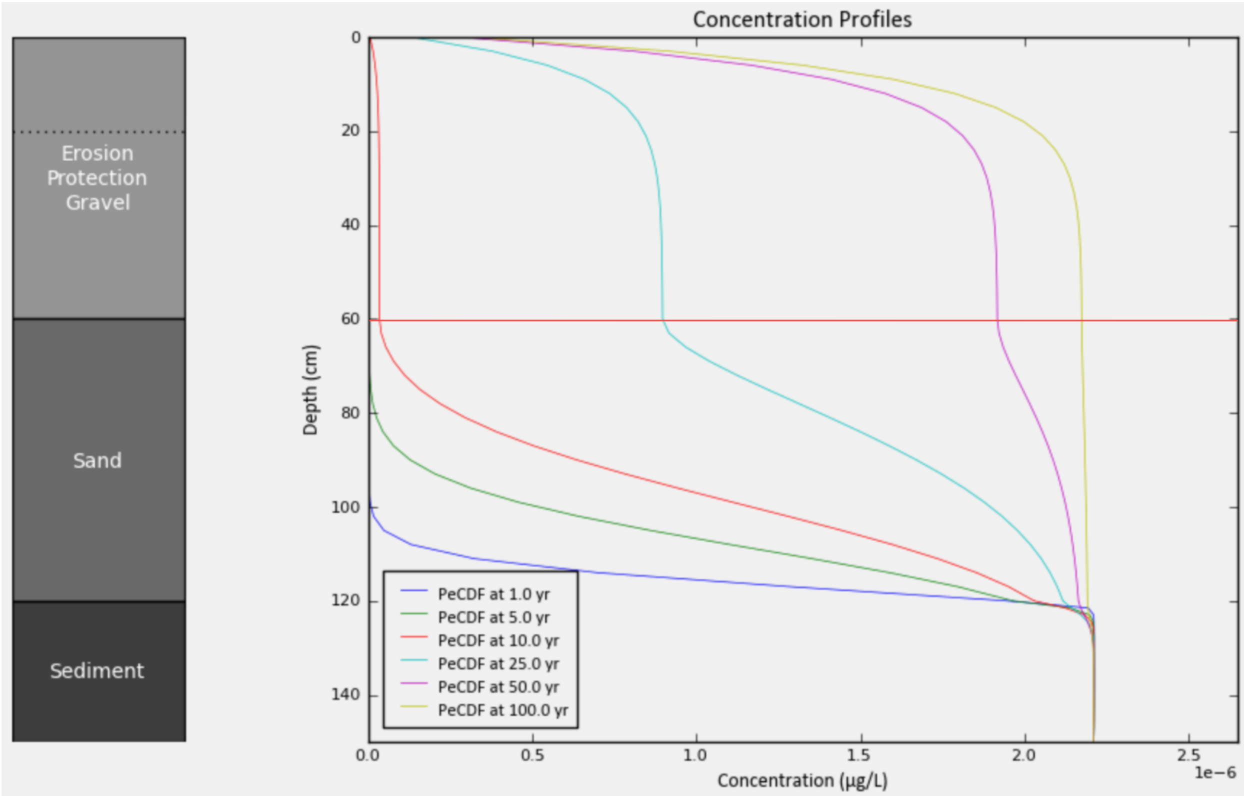

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

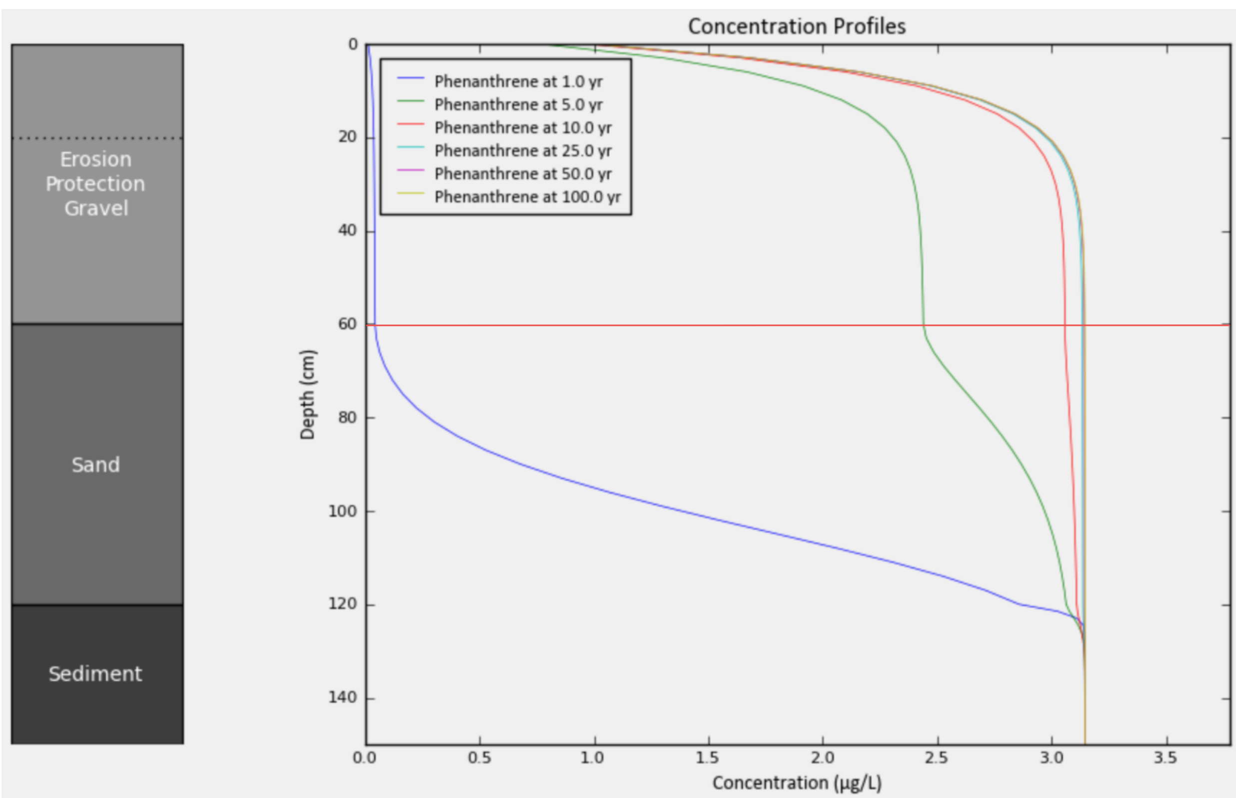

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−4
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr

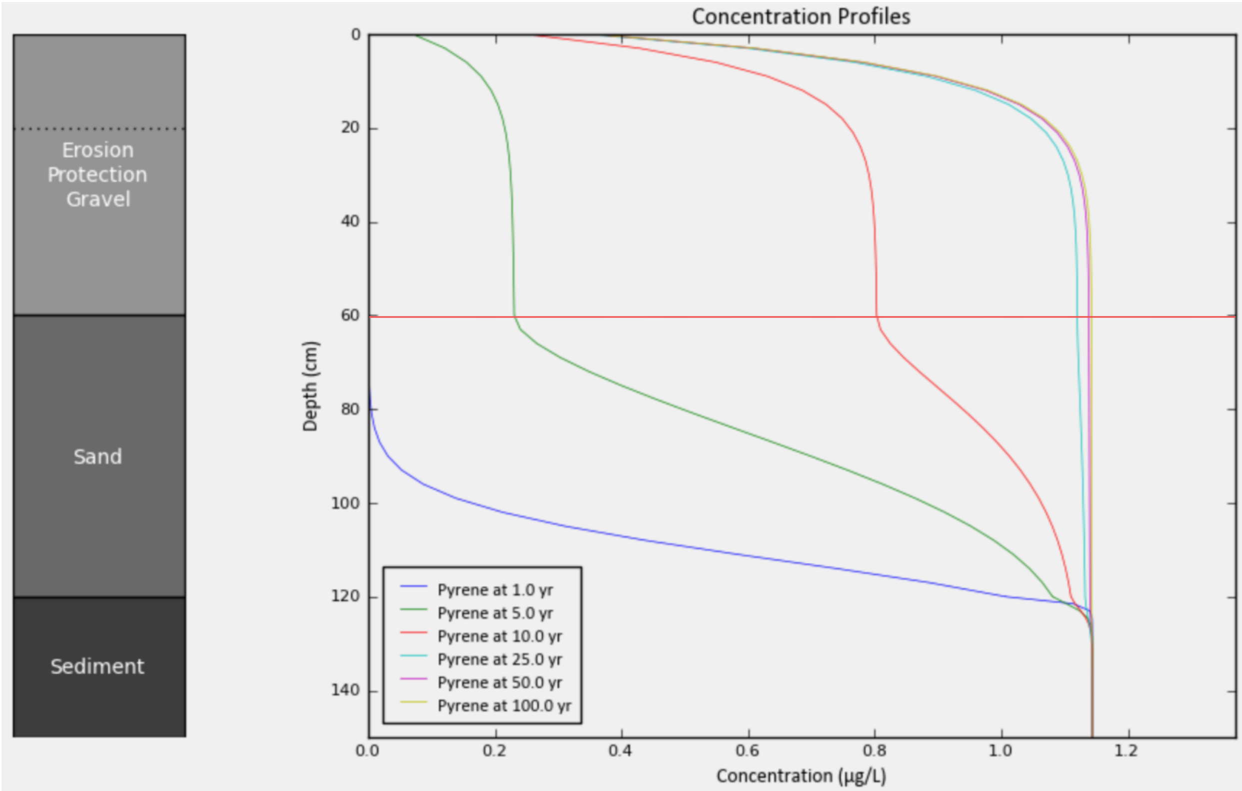

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr

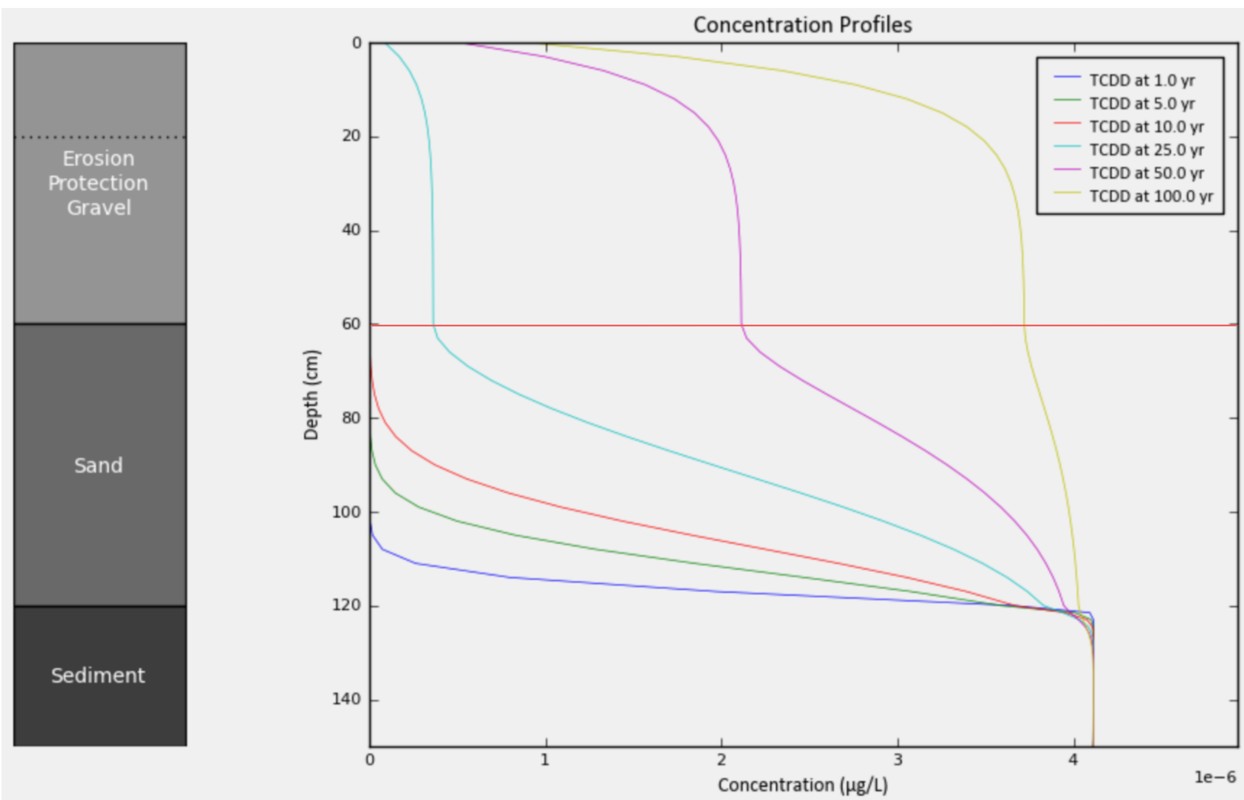

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
Depth (cm)
Concentration (µg/L)

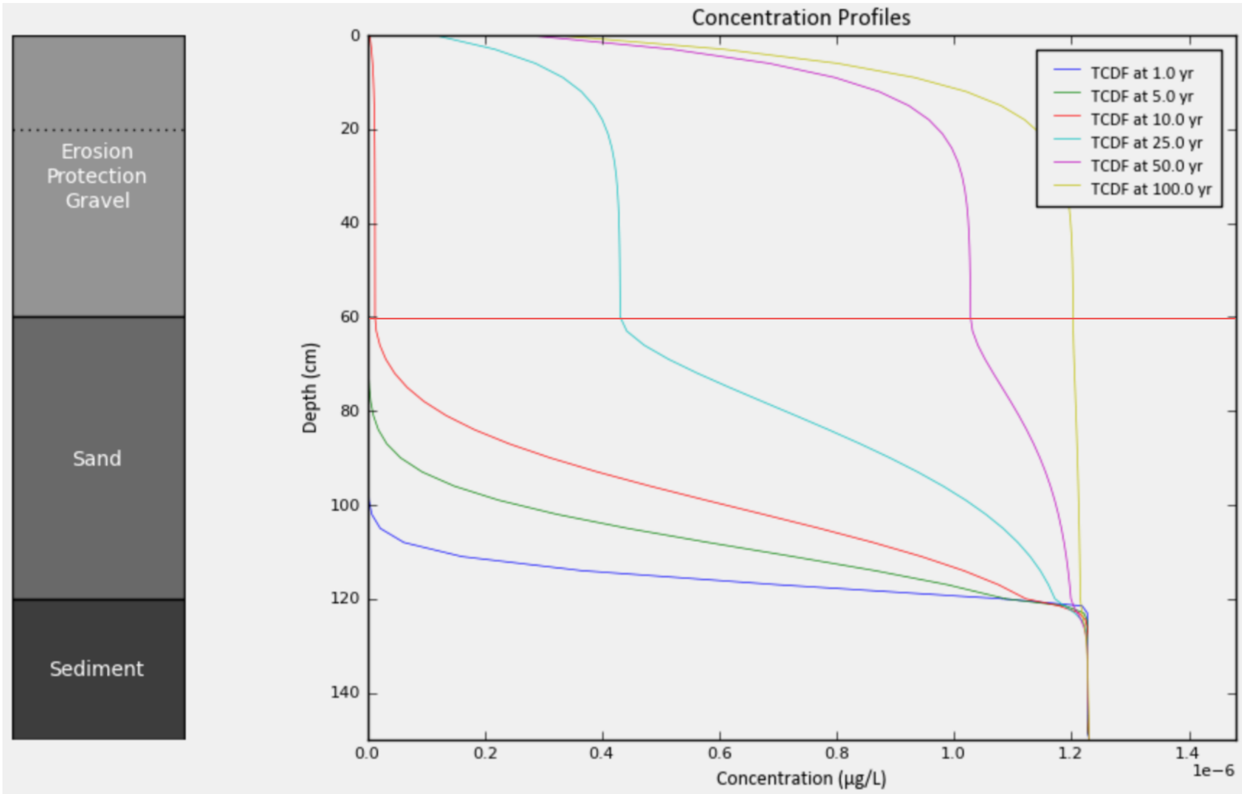

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−8

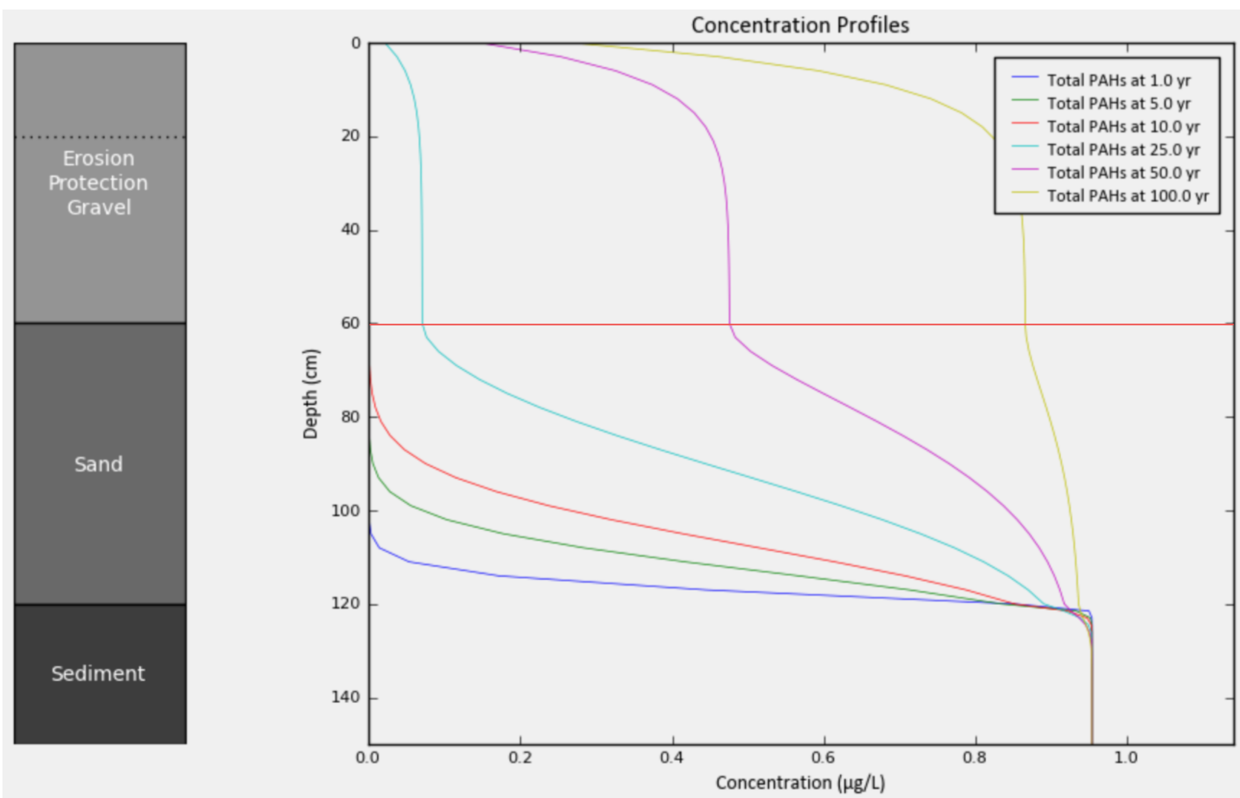

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr

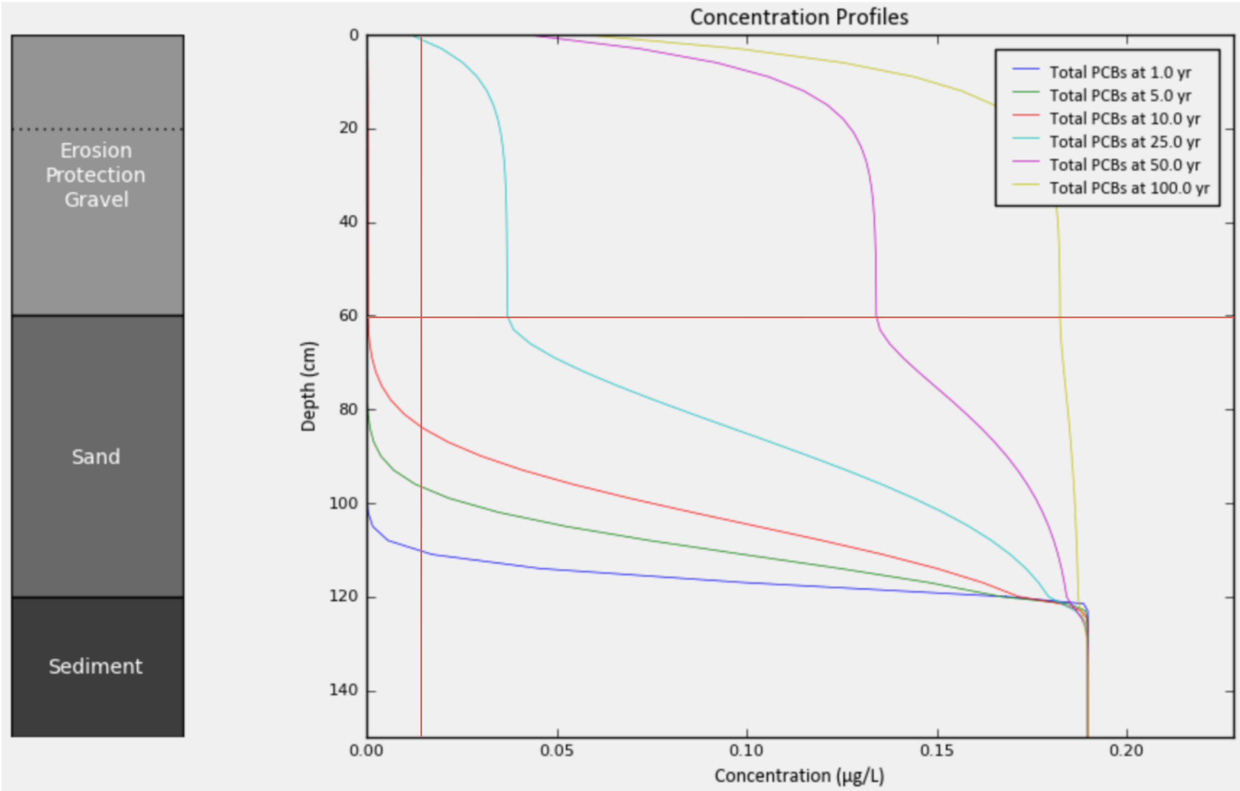

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr


Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr

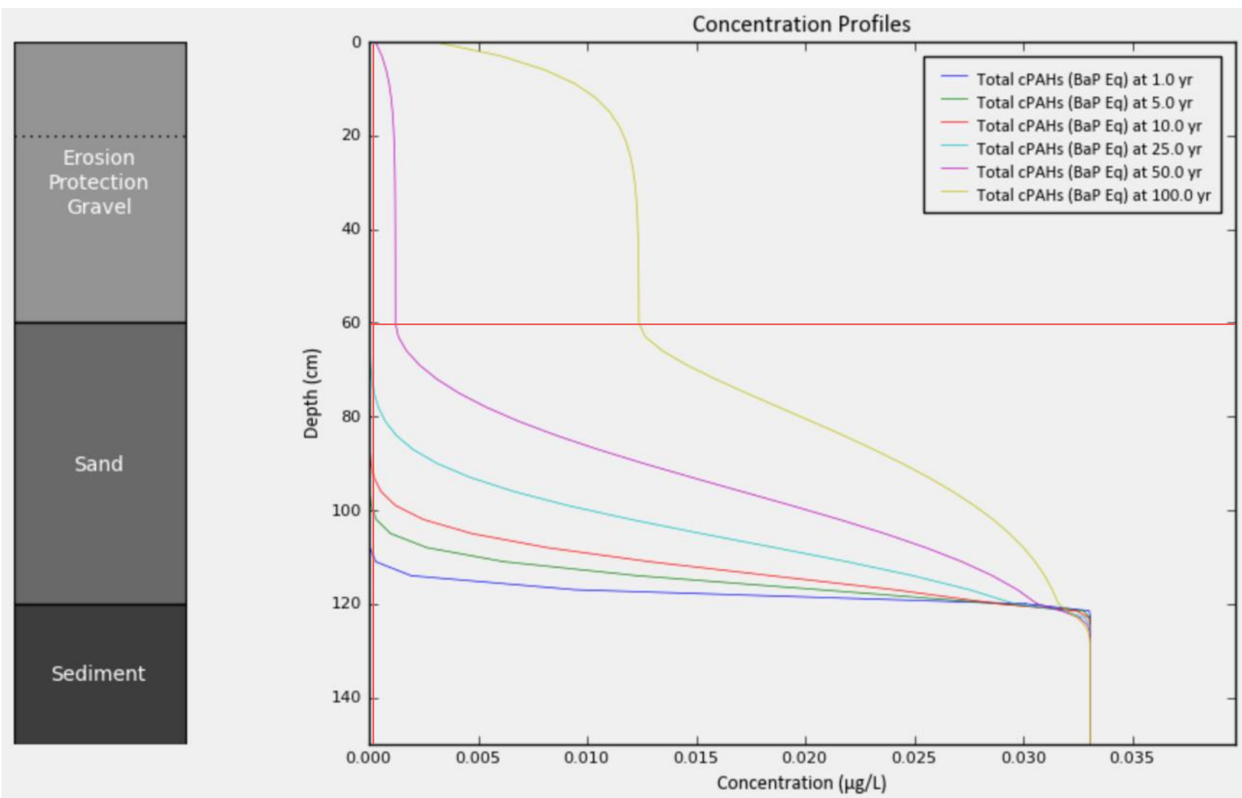

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−6
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr


Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr


Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

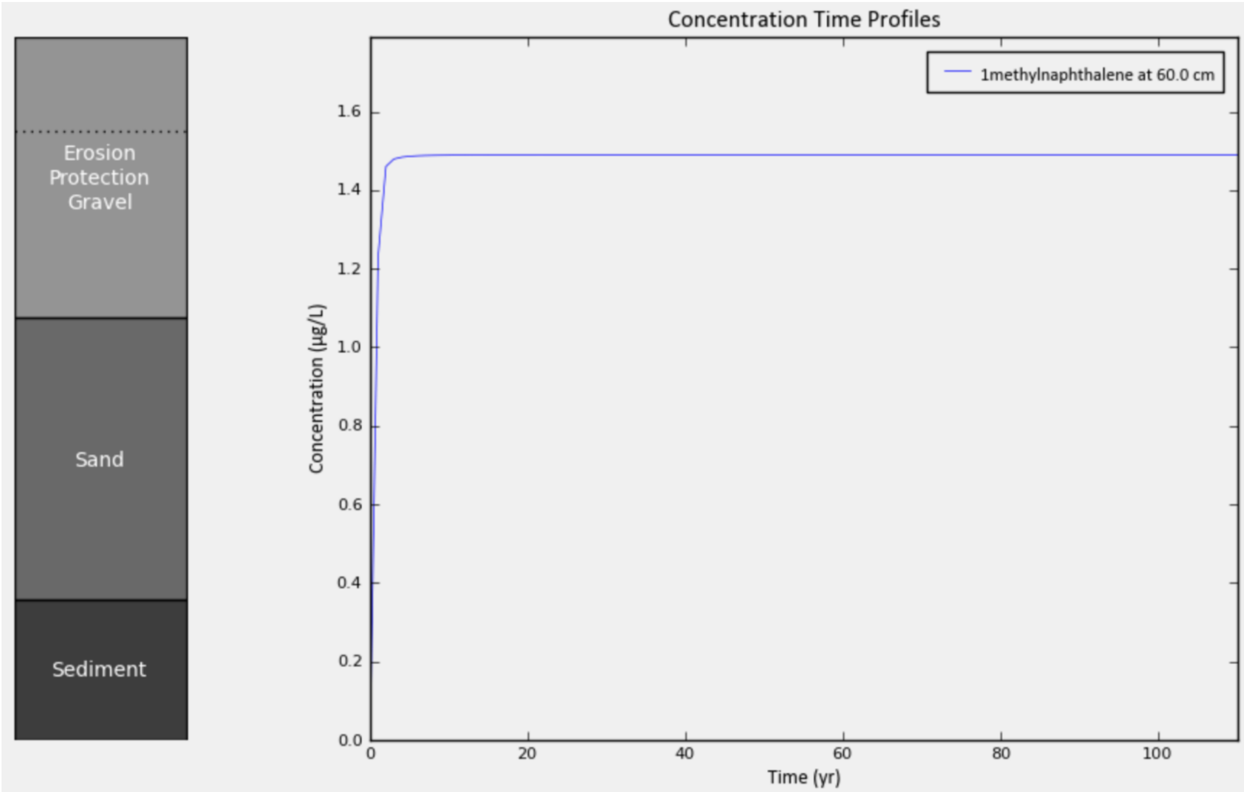


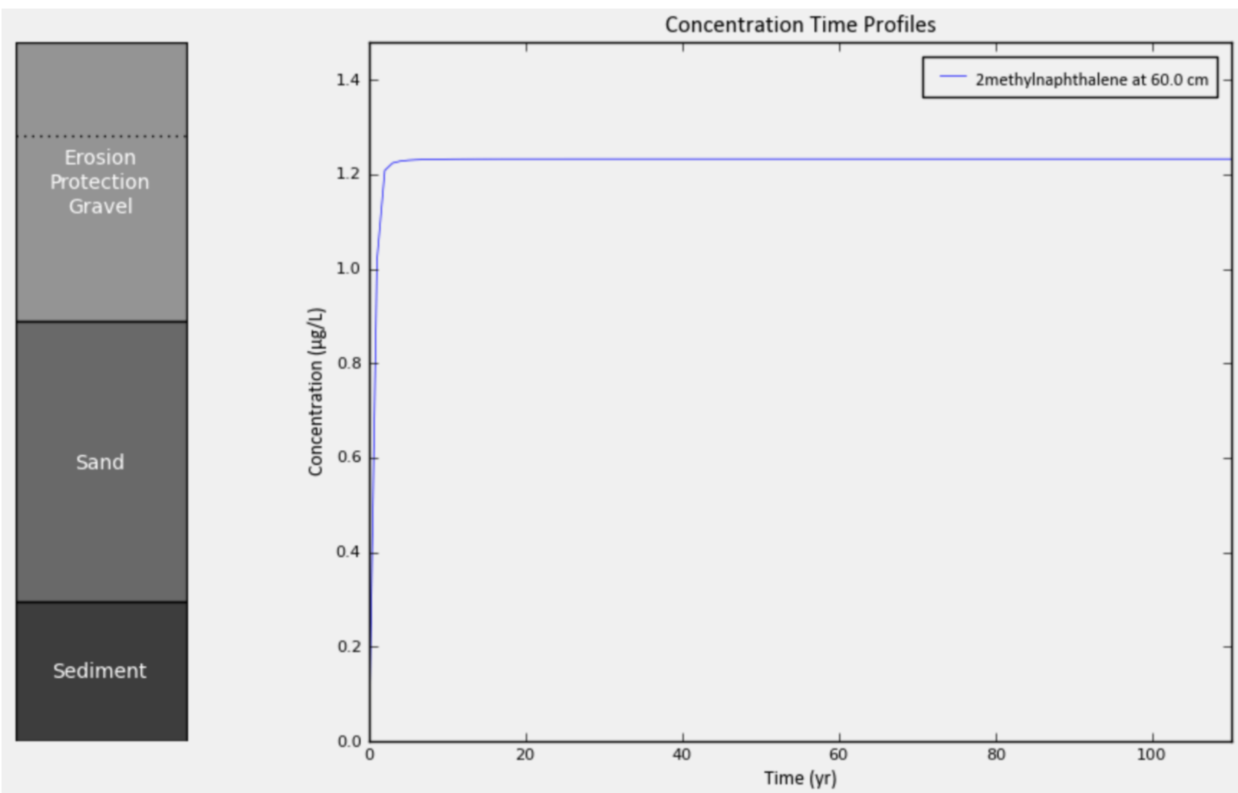
Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr
Depth (cm)
Concentration (µg/L)

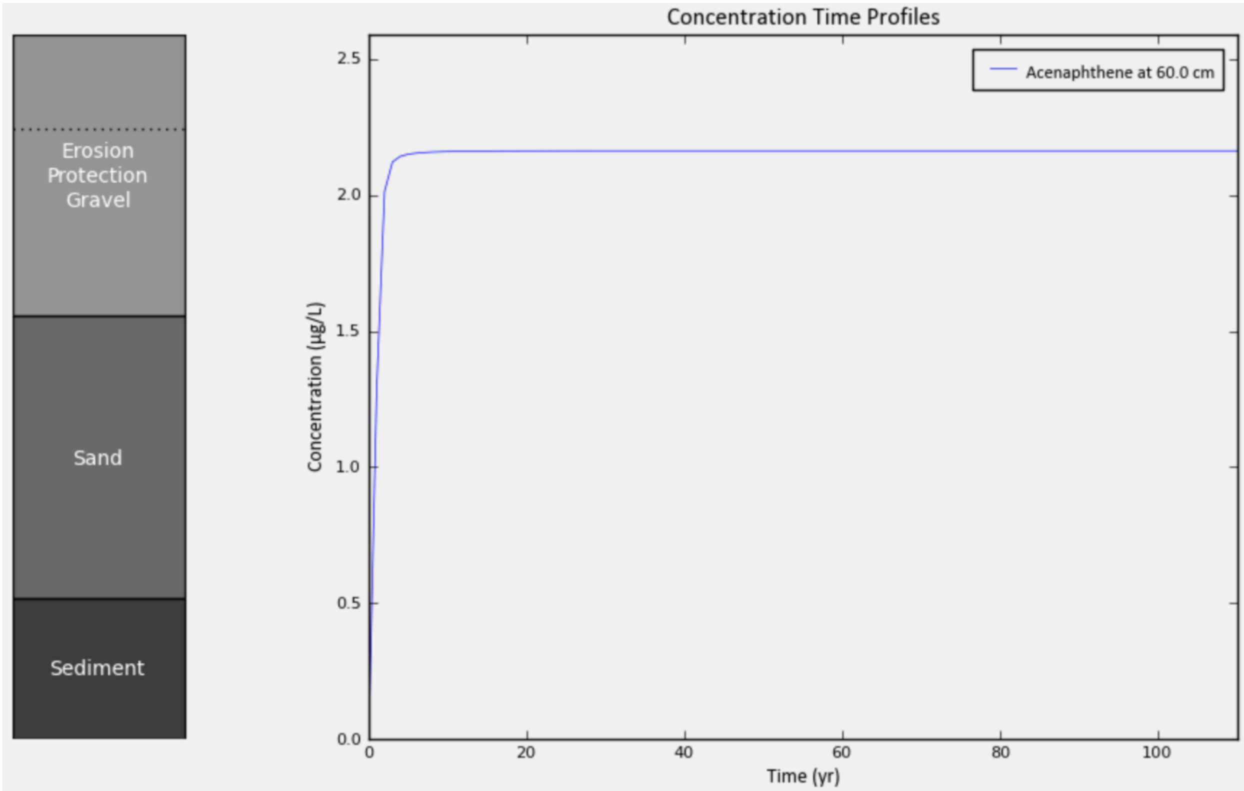


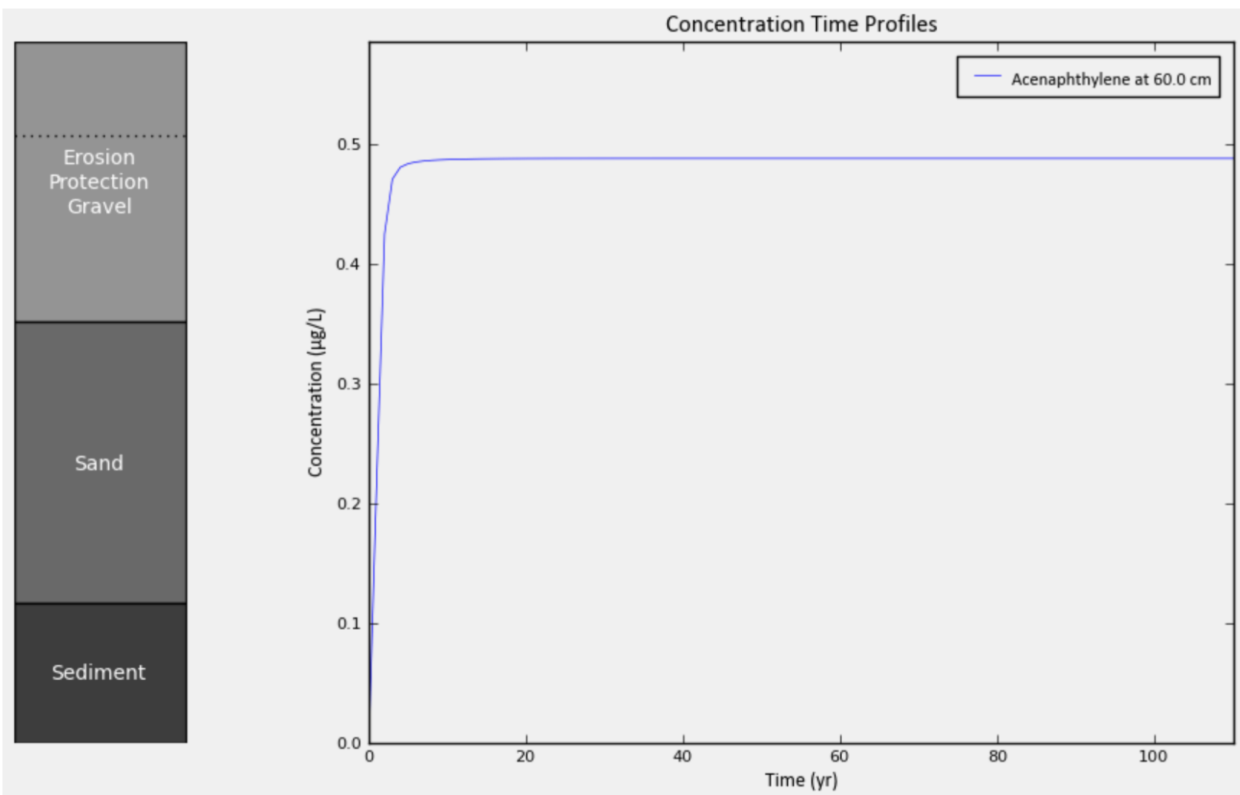
Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr
Depth (cm)
Concentration (µg/L)

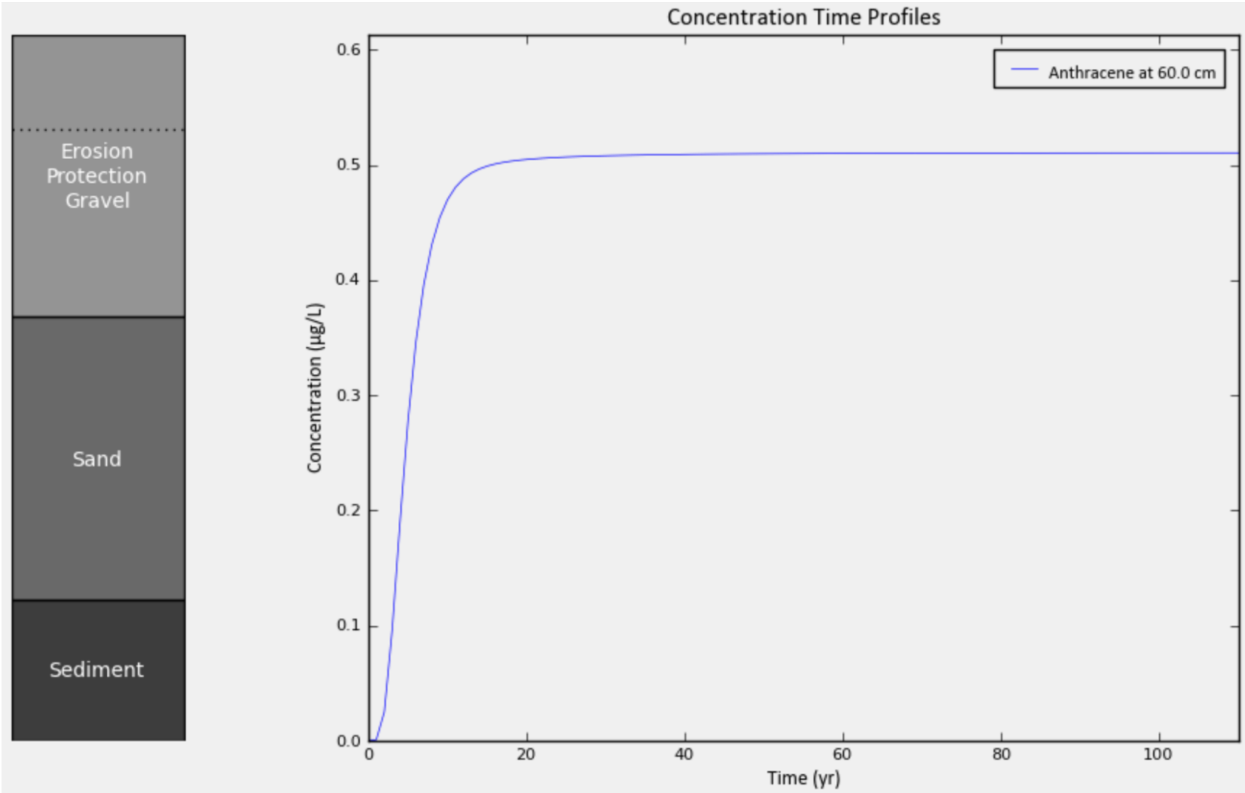
Porewater Concentration – Time

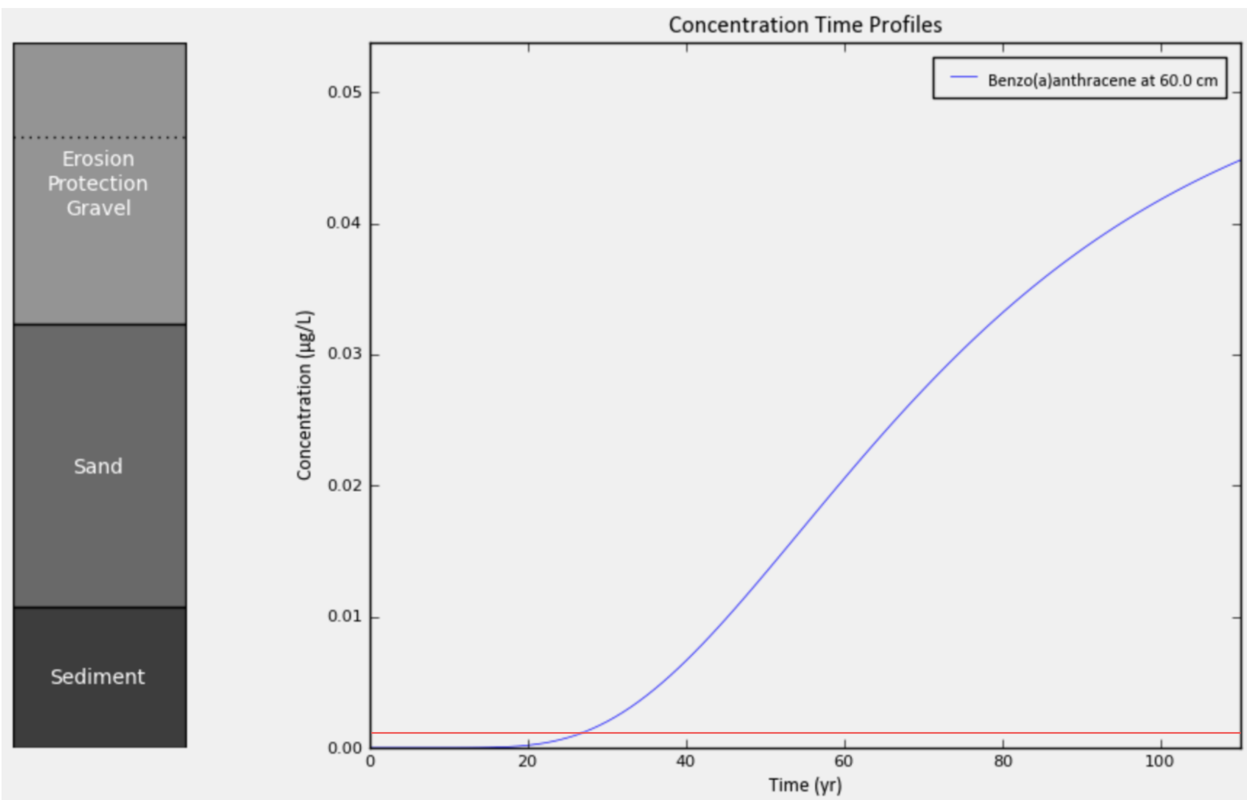


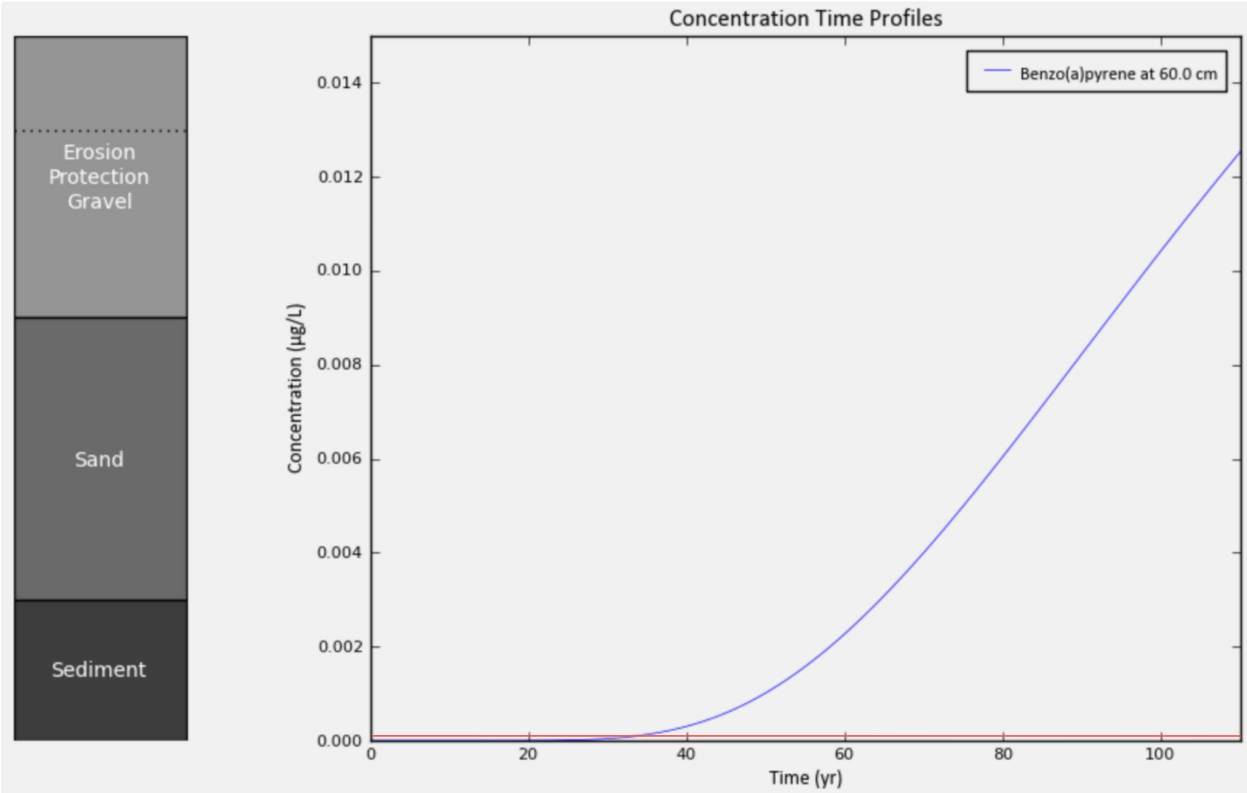


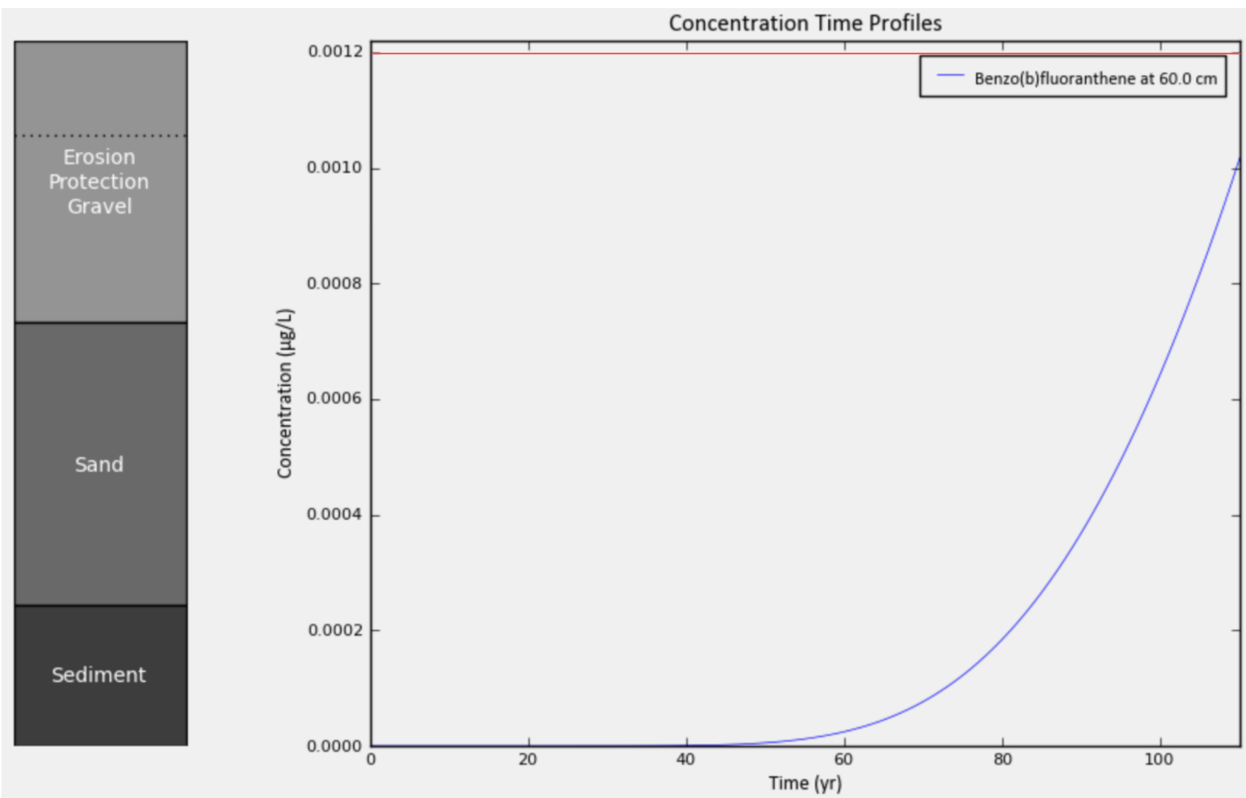

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Acenaphthene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100

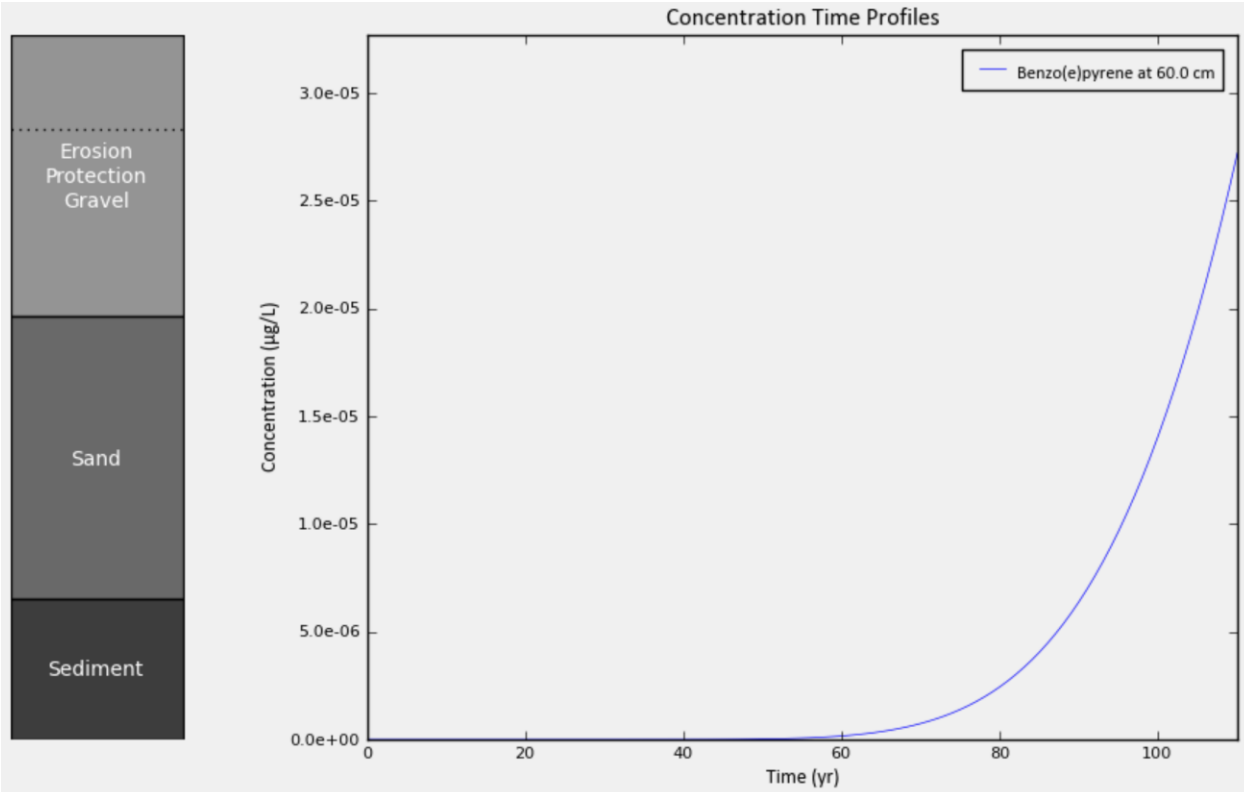

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Acenaphthylene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100

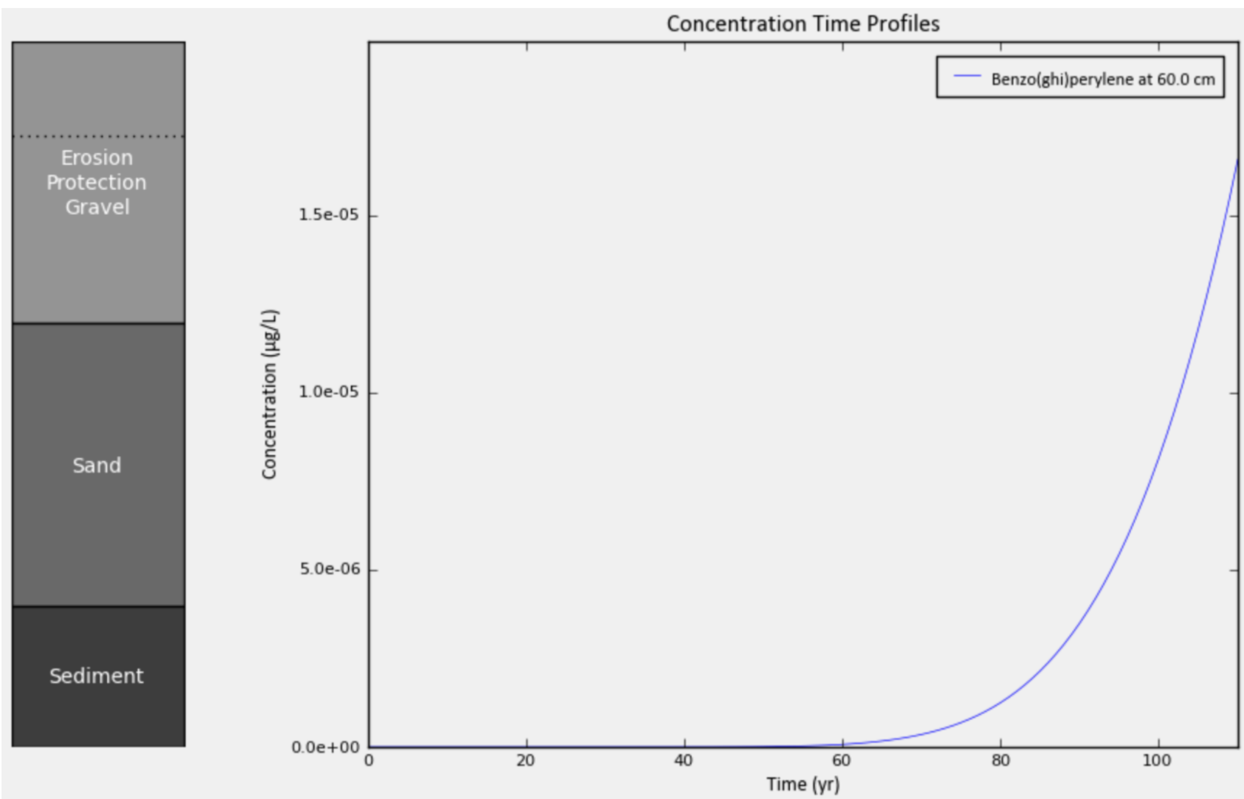

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

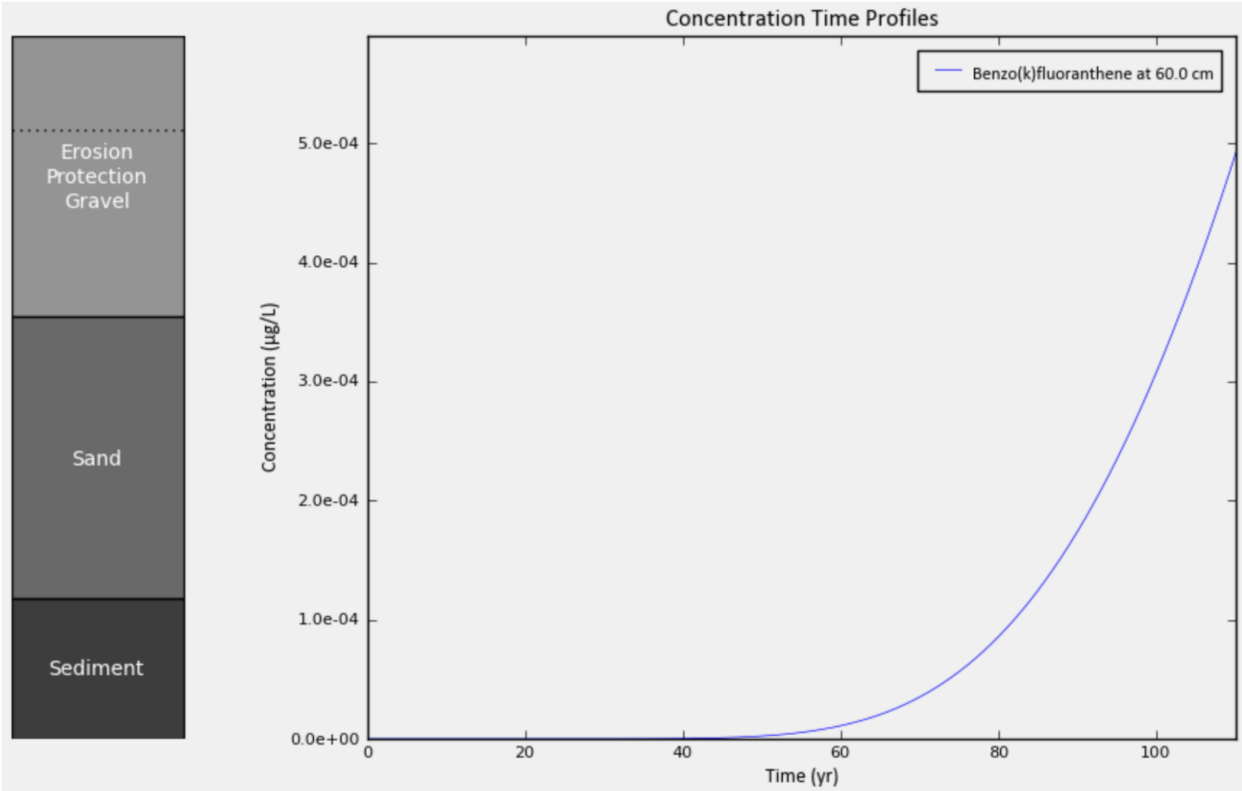

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.00
0.01
0.02
0.03
0.04
0.05
0
20
40
60
80
100

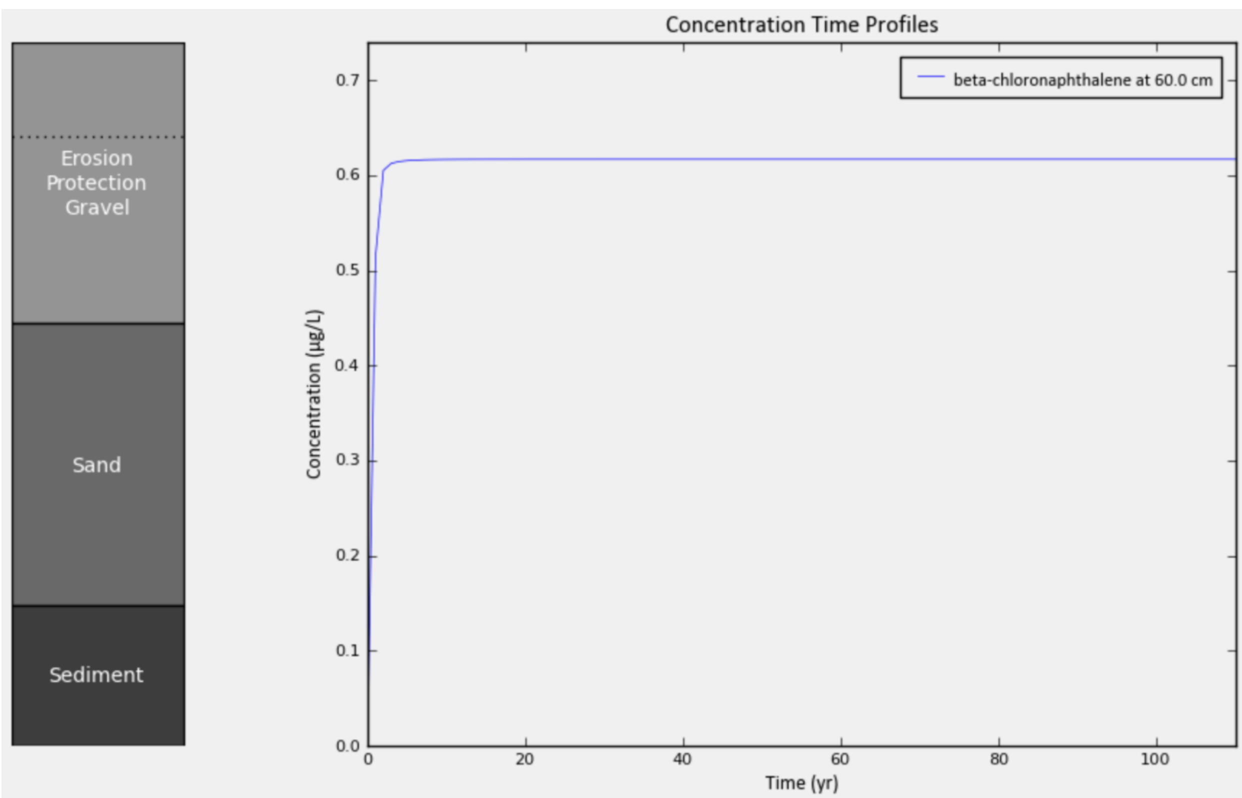

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(a)pyrene at 60.0 cm
Concentration (µg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

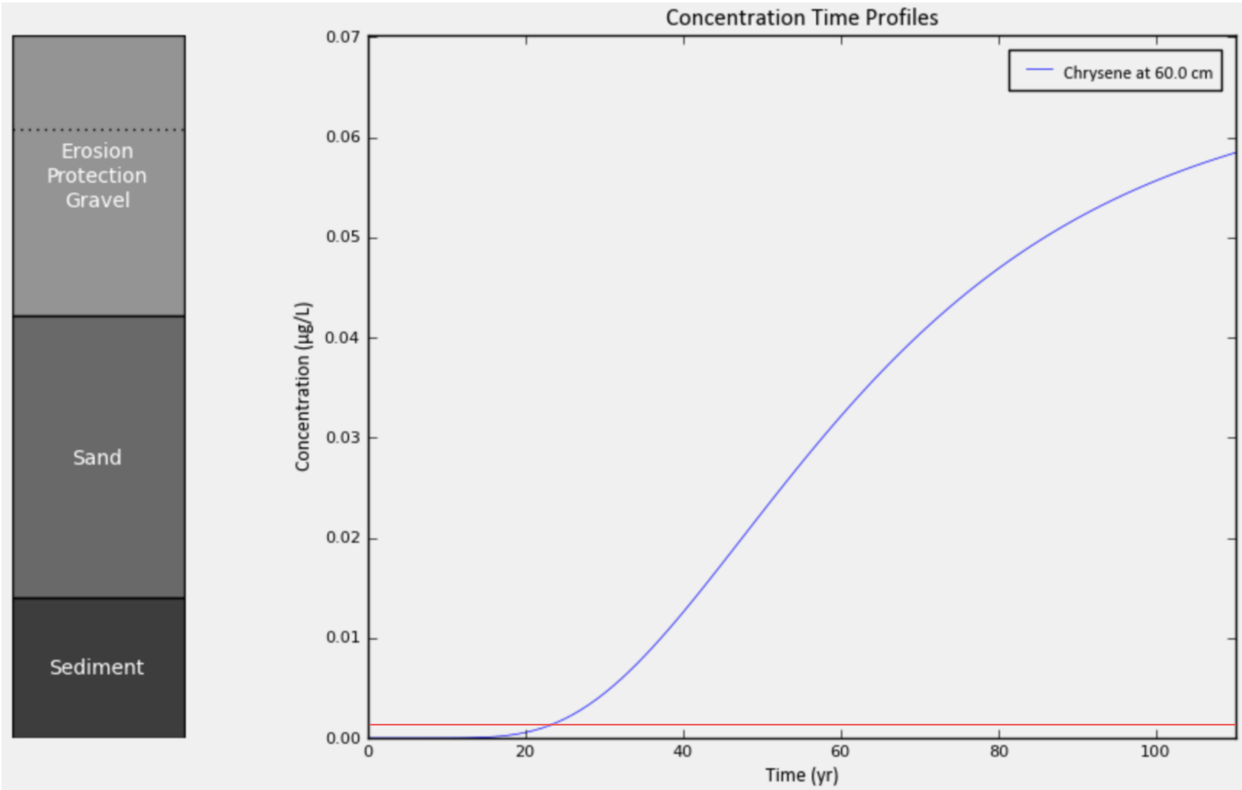

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(b)fluoranthene at 60.0 cm
Concentration (µg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0
20
40
60
80
100
Time (yr)

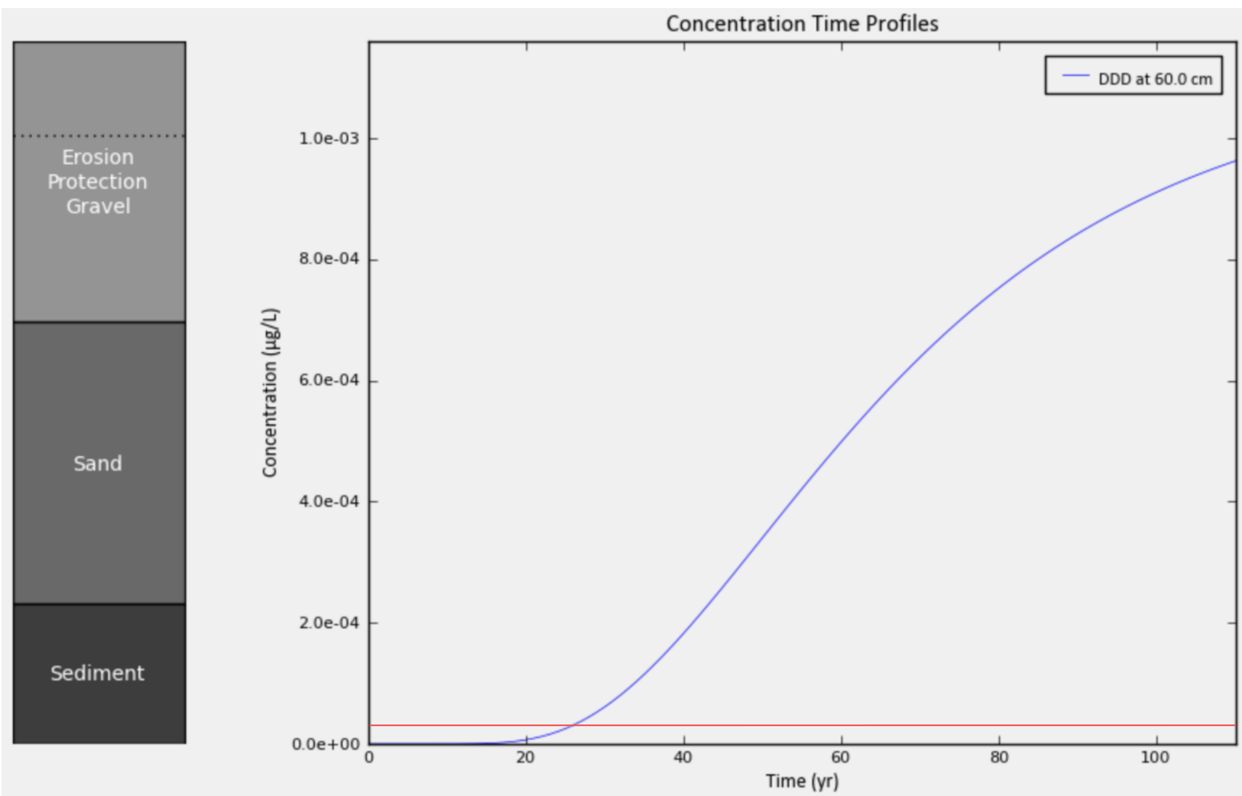

Concentration Time Profiles
Benzo(e)pyrene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

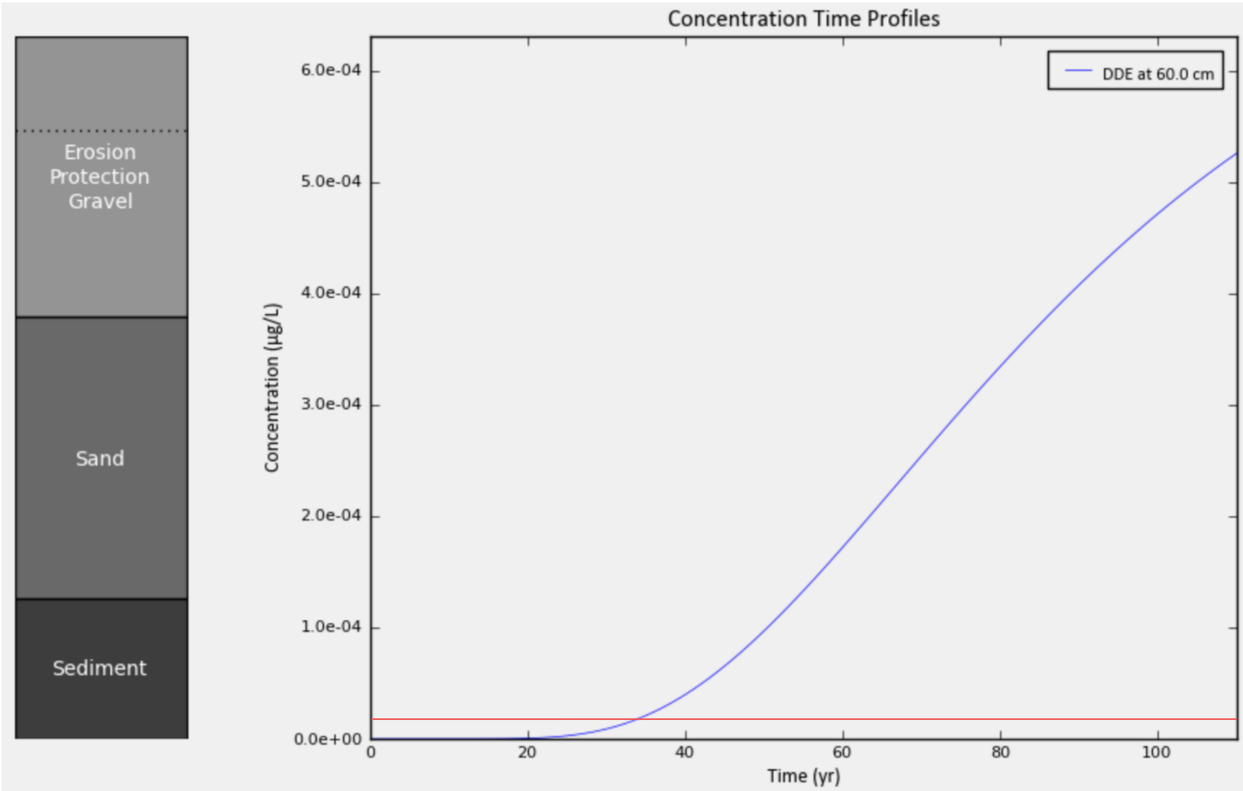

Concentration Time Profiles
Benzo(ghi)perylene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

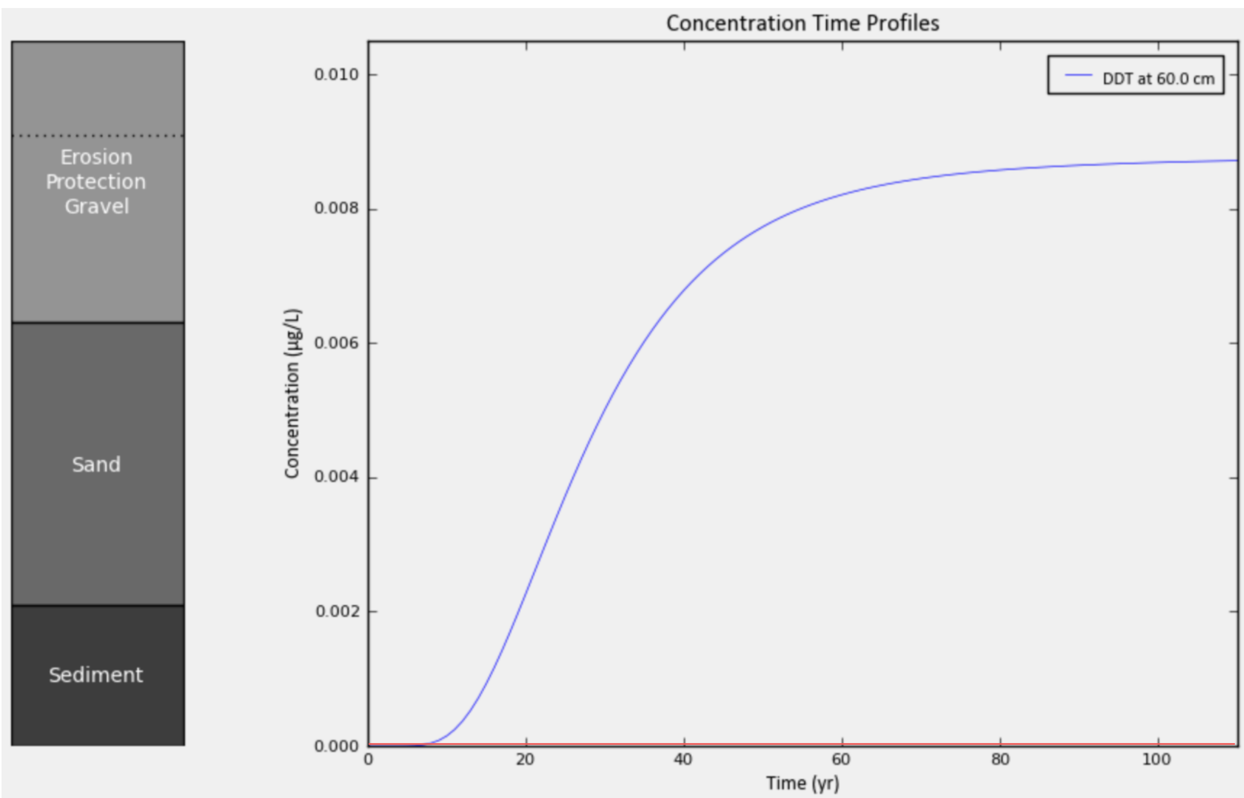

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 60.0 cm
Concentration (µg/L)
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

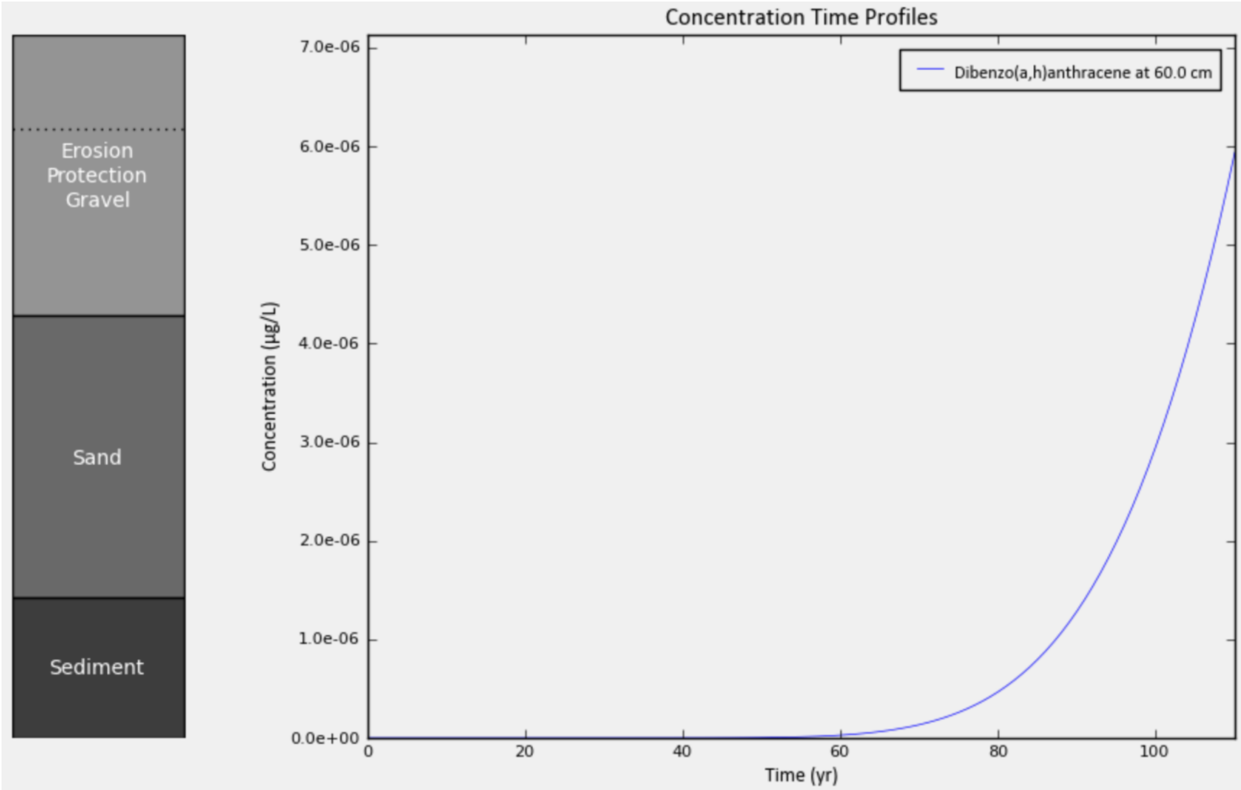

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 60.0 cm
Concentration (µg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
Time (yr)

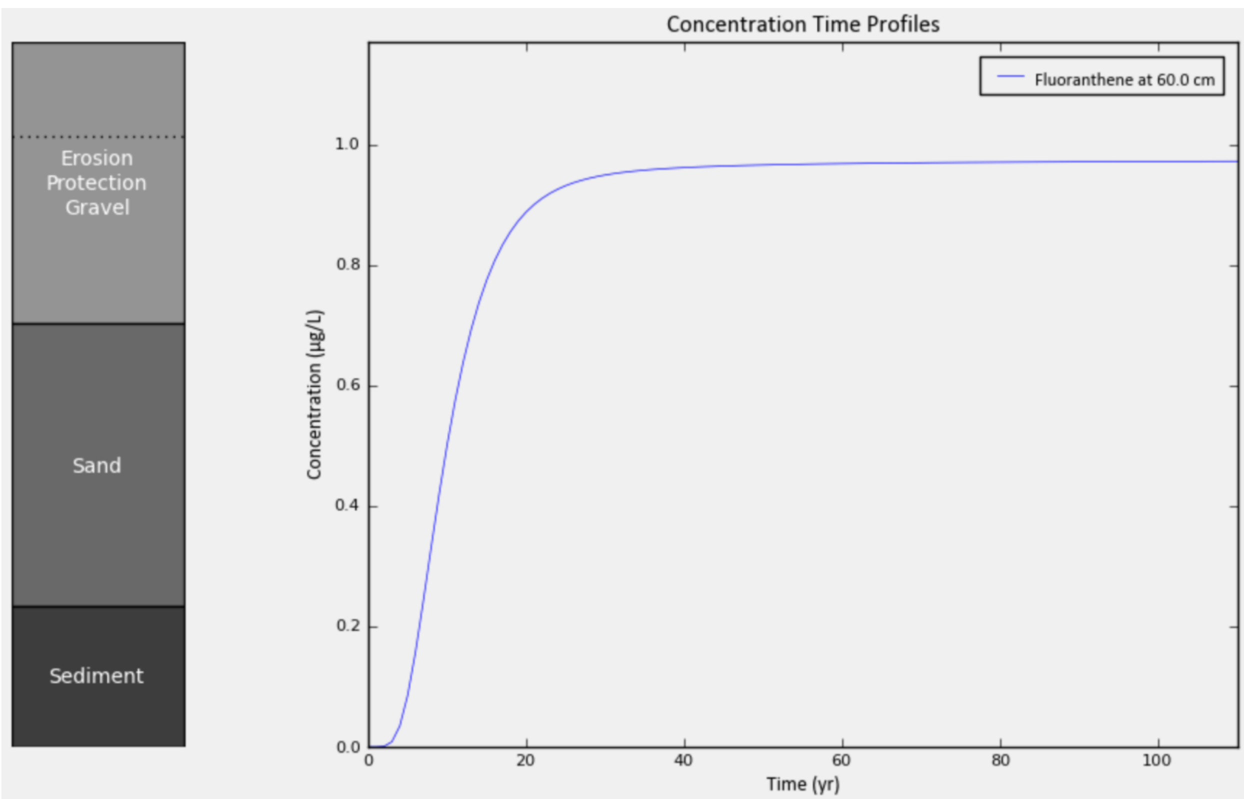

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Chrysene at 60.0 cm
Concentration (µg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
Time (yr)

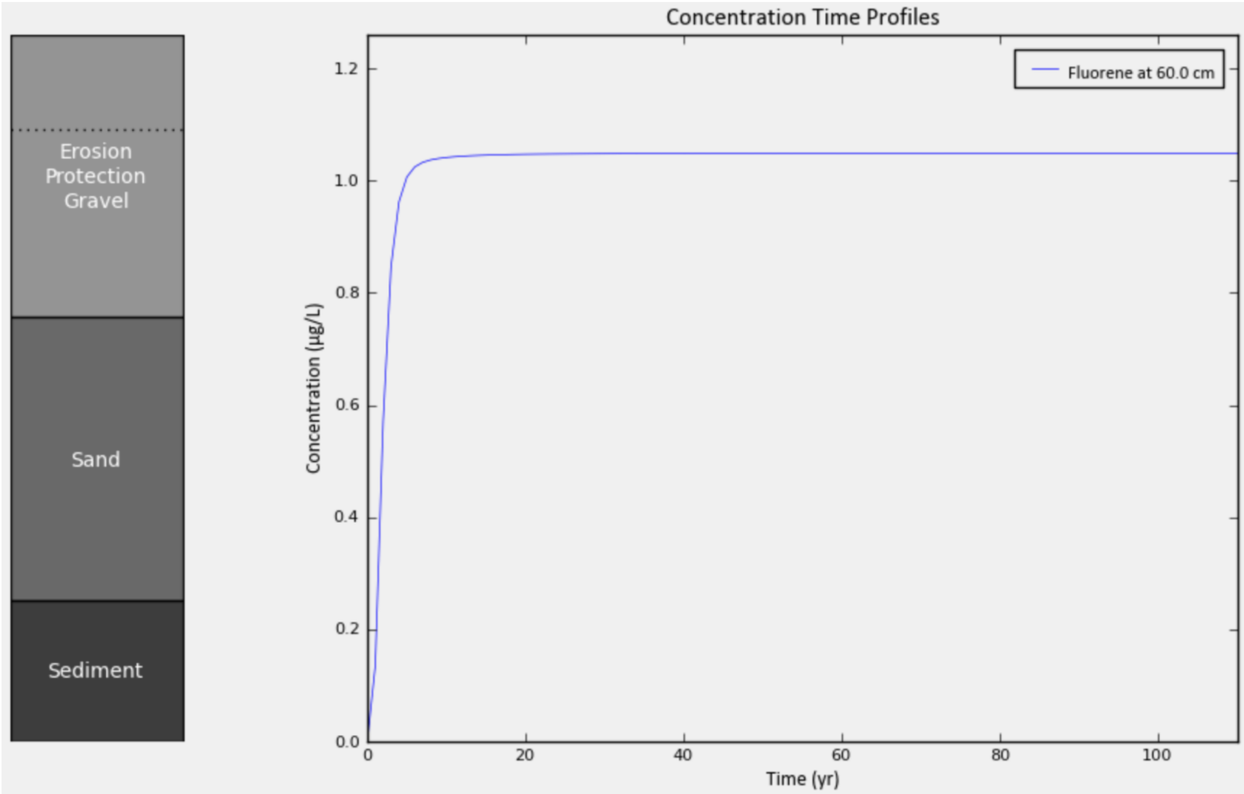

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
DDD at 60.0 cm
Concentration (µg/L)
1.0e-03
8.0e-04
6.0e-04
4.0e-04
2.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

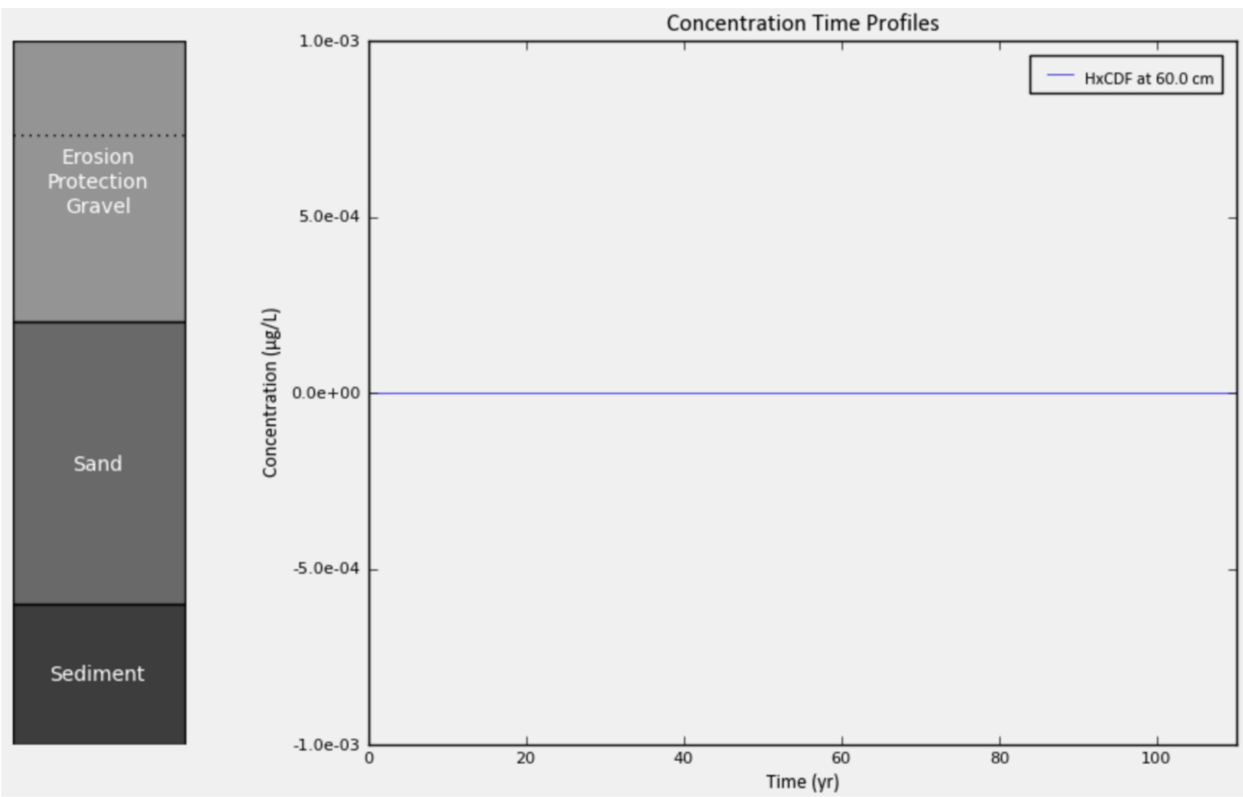

Concentration Time Profiles
DDE at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
Time (yr)
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100

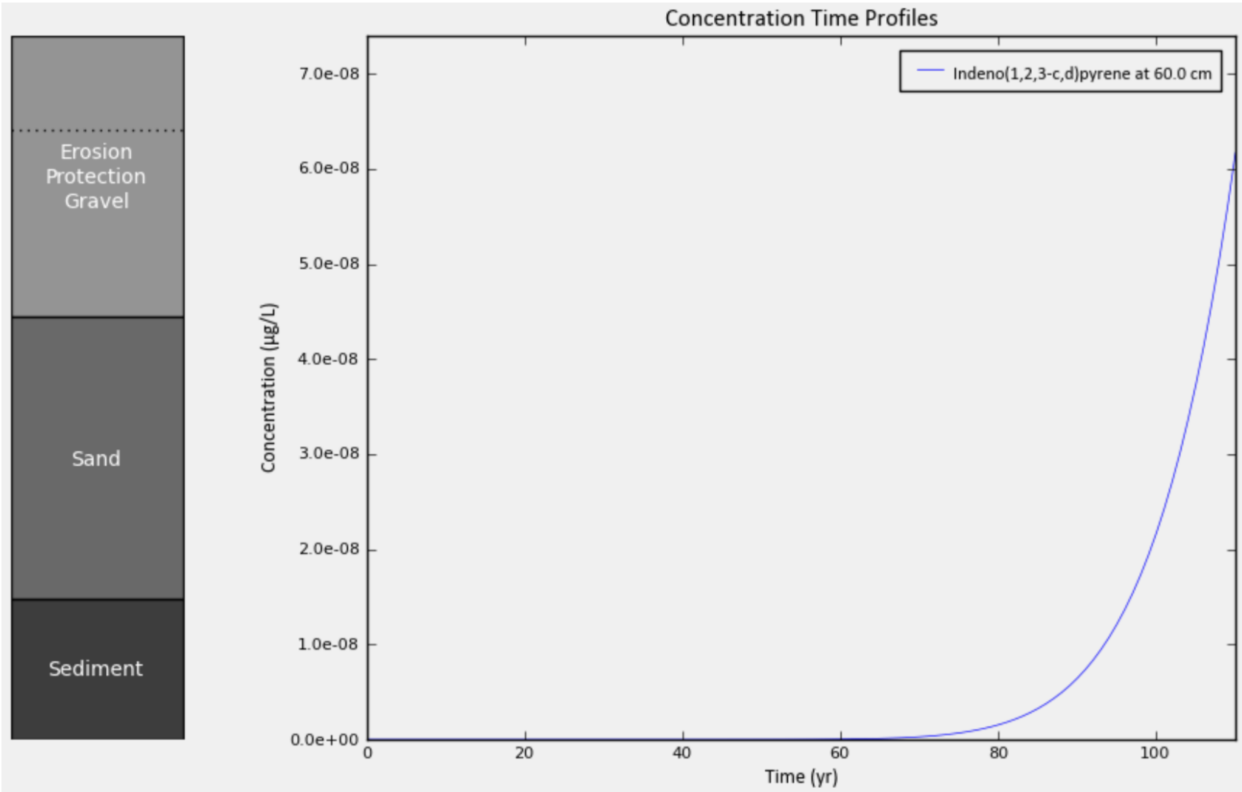

Concentration Time Profiles
DDT at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100

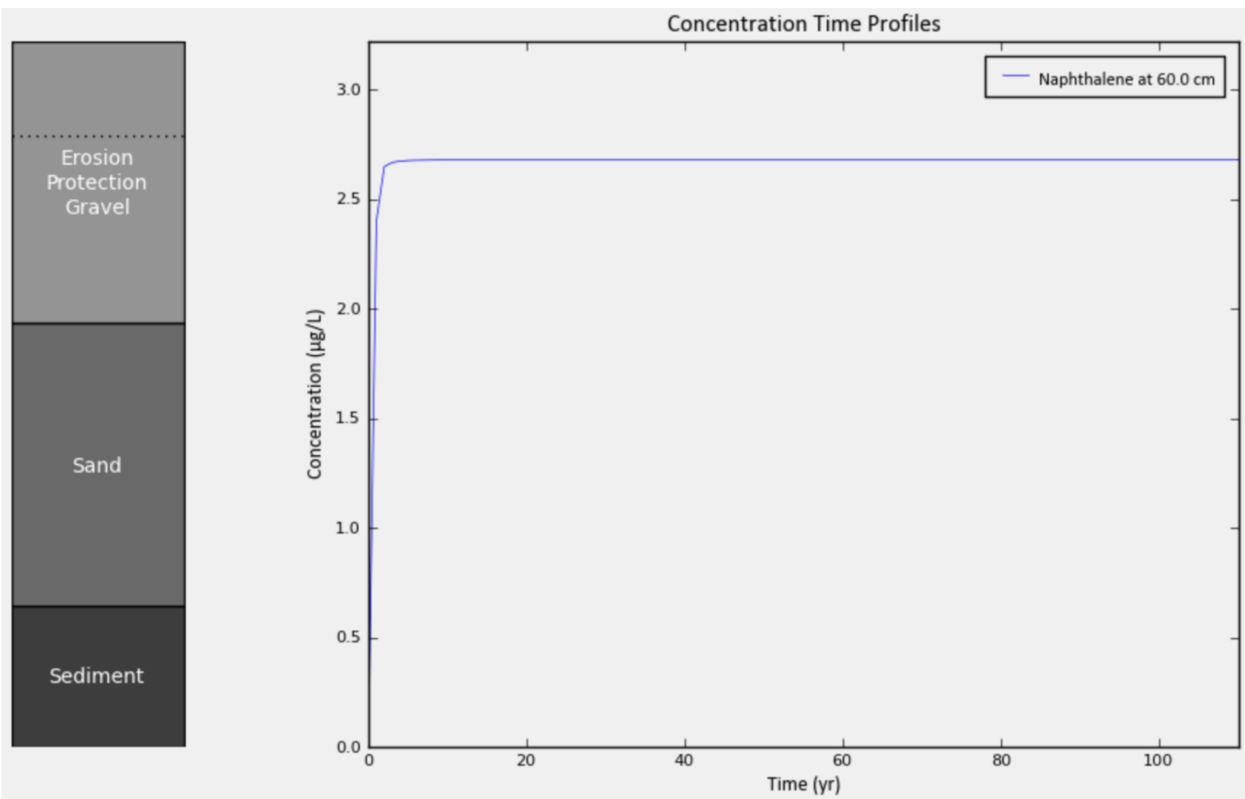

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
Dibenzo(a,h)anthracene at 60.0 cm
Concentration (µg/L)
7.0e-06
6.0e-06
5.0e-06
4.0e-06
3.0e-06
2.0e-06
1.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

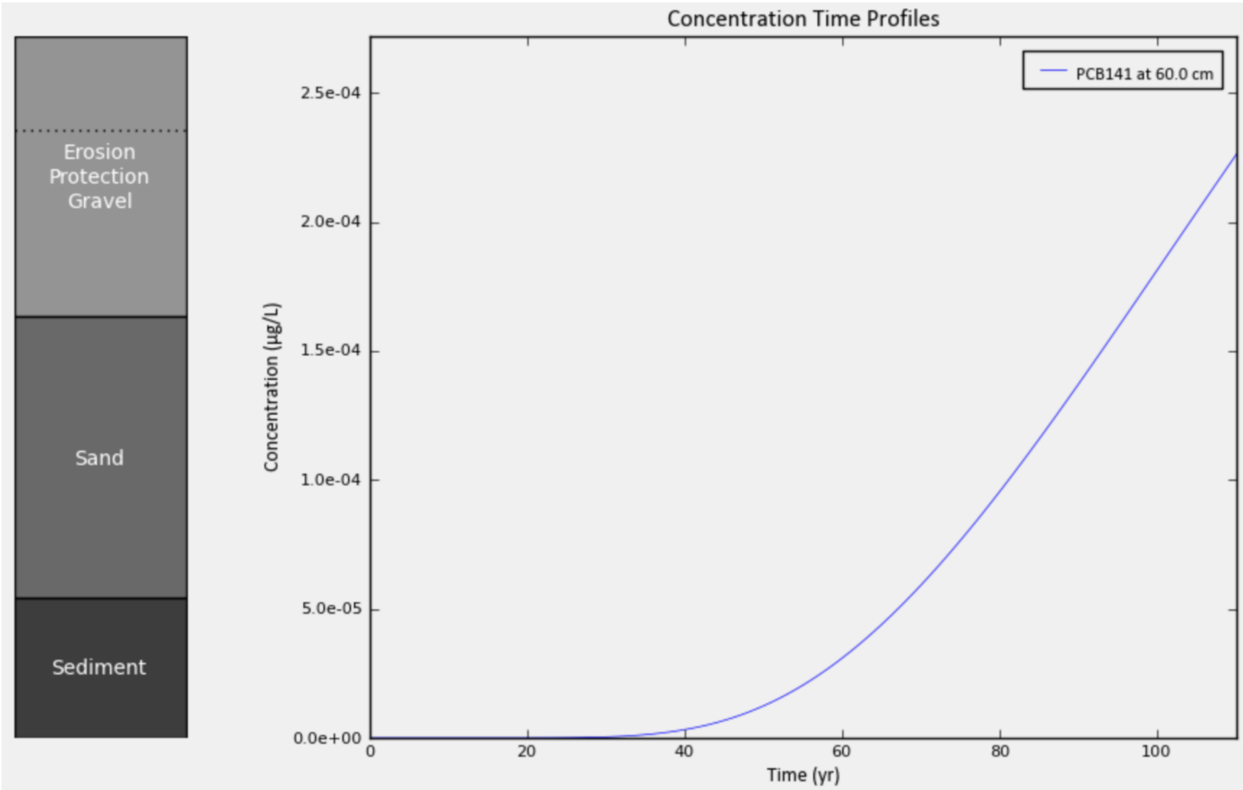

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
Fluoranthene at 60.0 cm
Concentration (µg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Time (yr)

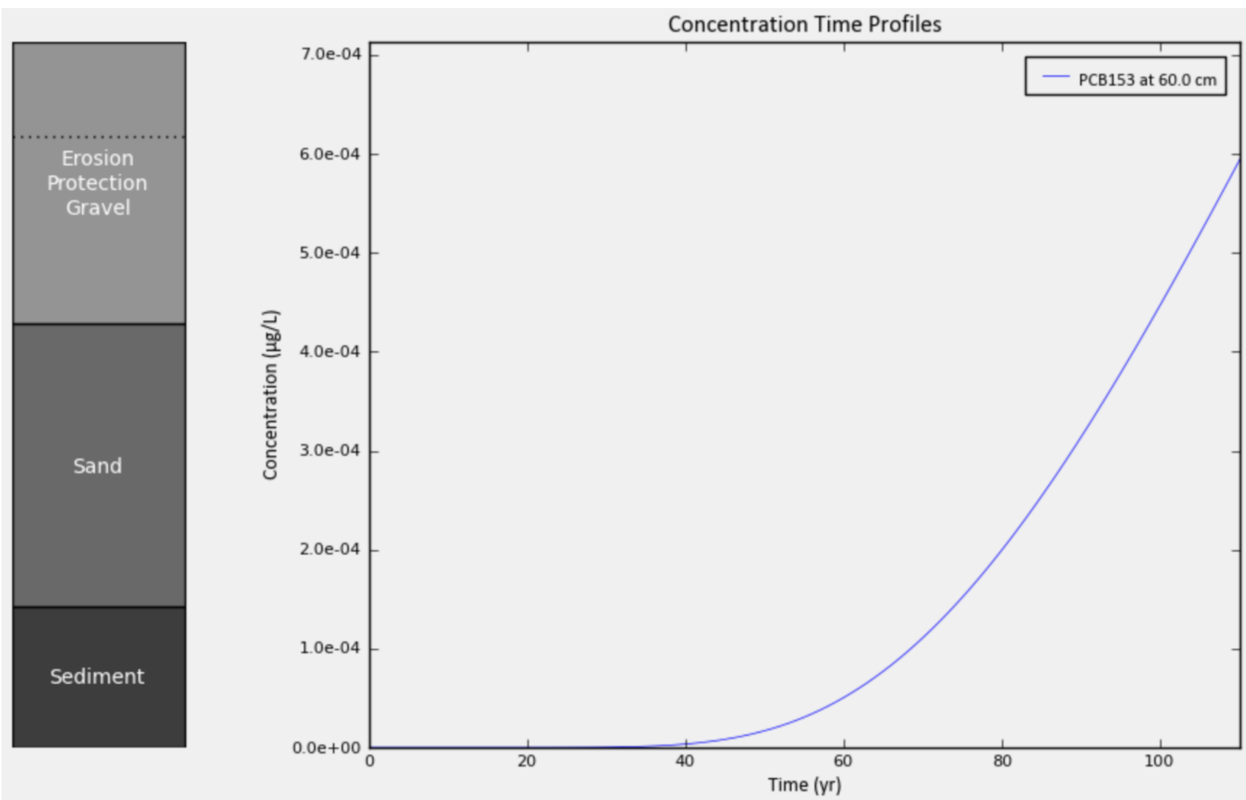

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
Fluorene at 60.0 cm
Concentration (µg/L)
Time (yr)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100

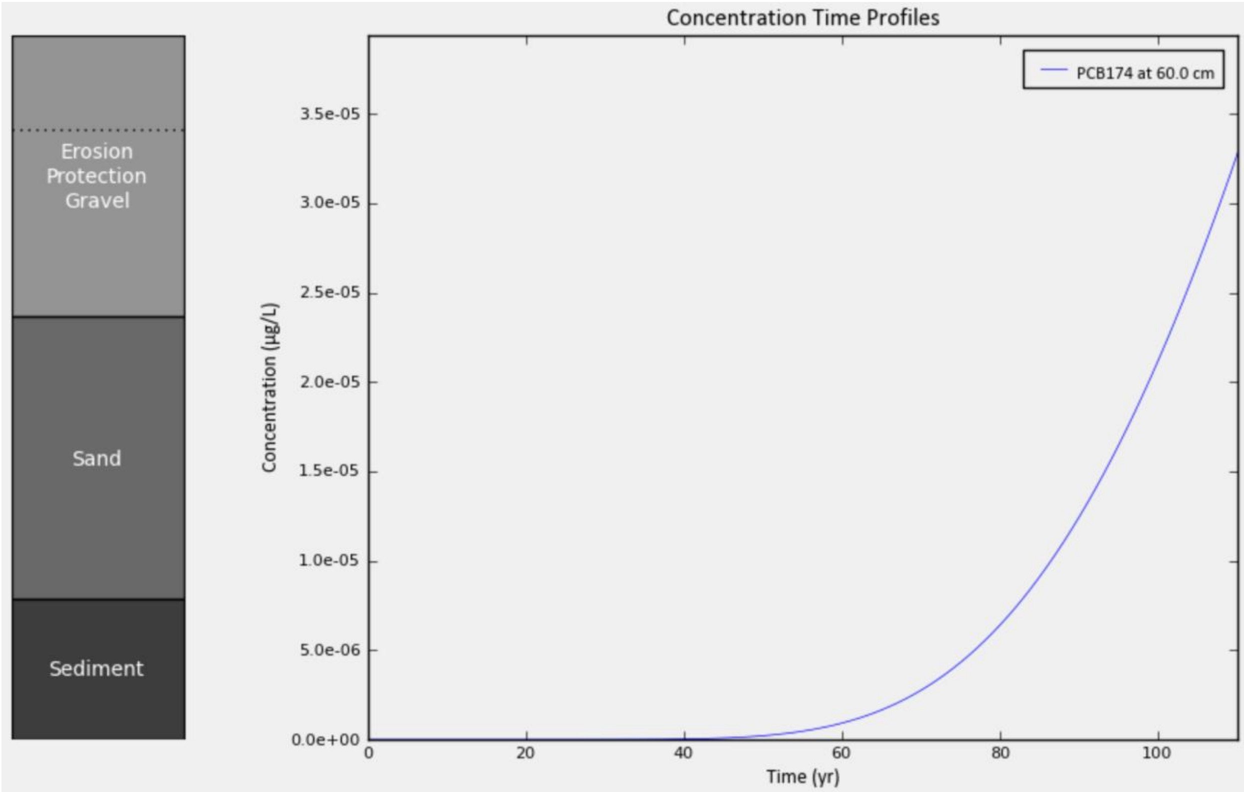

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
HxCDF at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

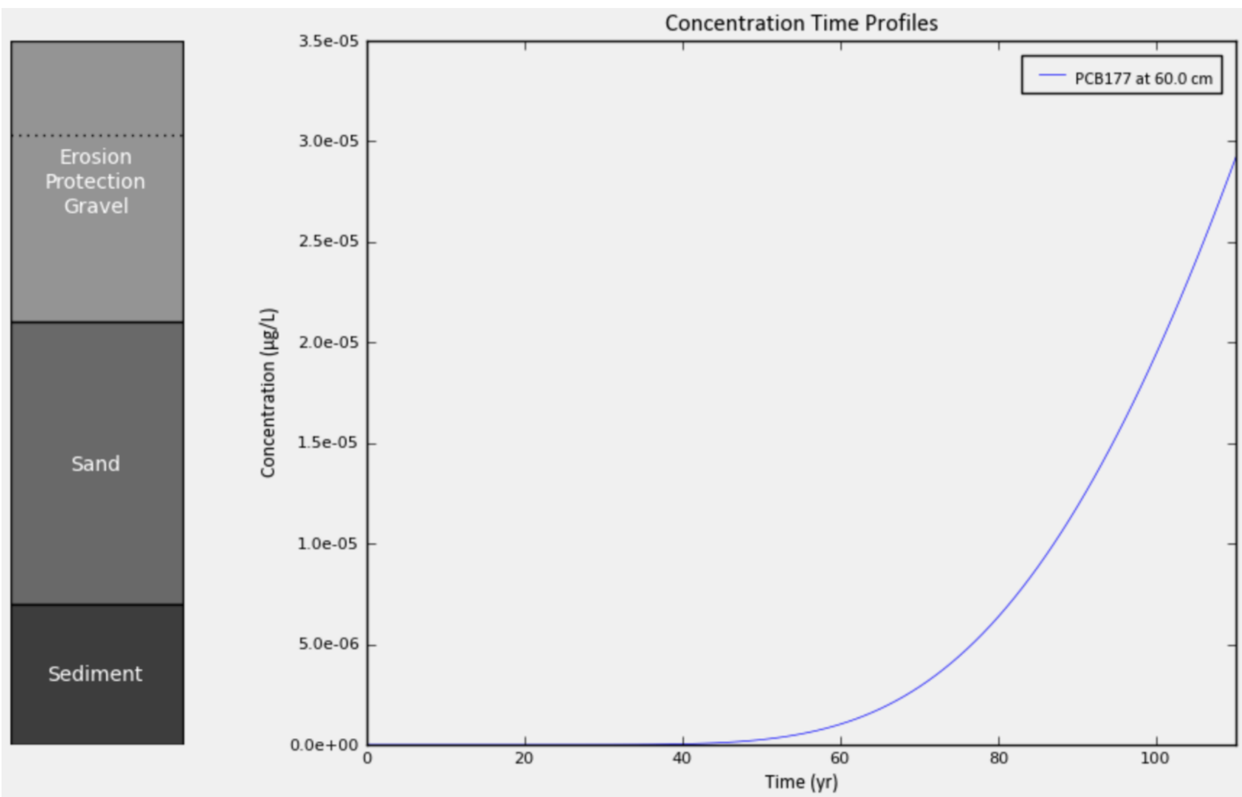

Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
7.0e-08
6.0e-08
5.0e-08
4.0e-08
3.0e-08
2.0e-08
1.0e-08
0.0e+00
0
20
40
60
80
100
Time (yr)

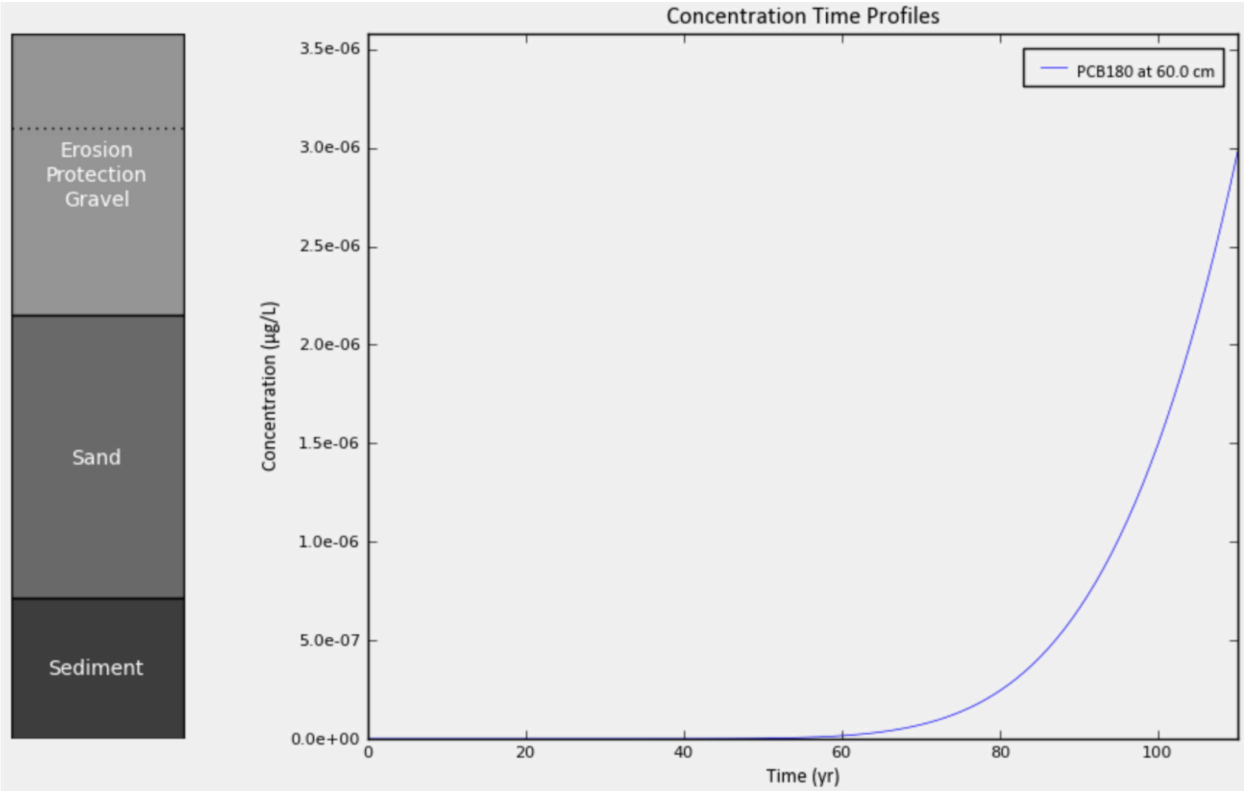

Concentration Time Profiles
Naphthalene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)

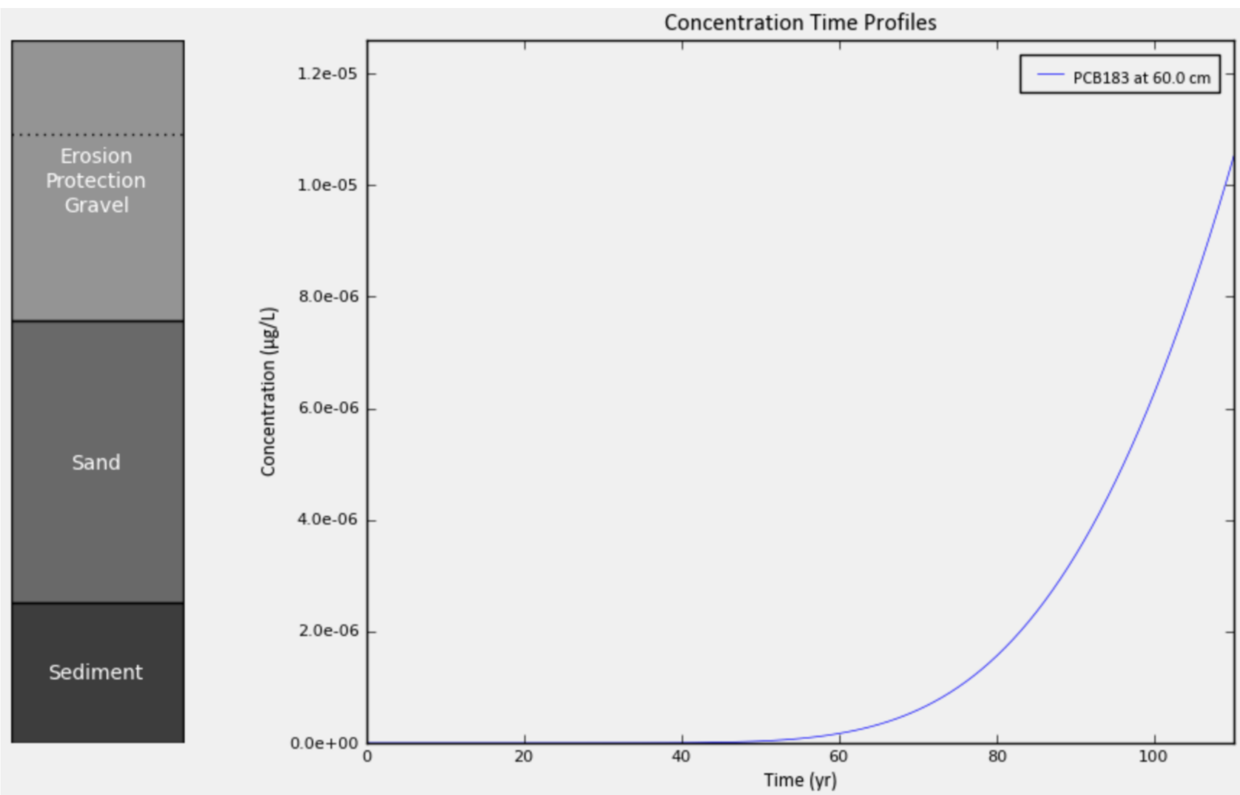

Concentration Time Profiles
PCB141 at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
2.5e-04
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

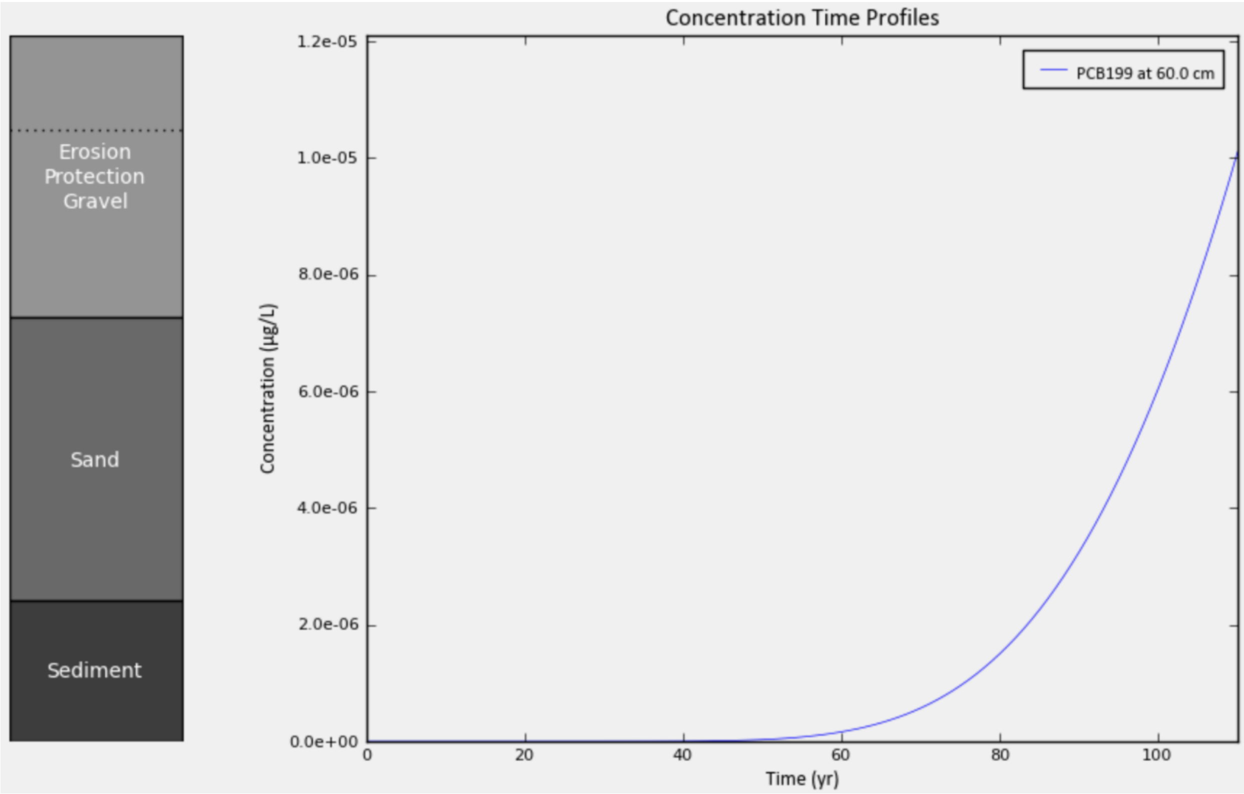

Concentration Time Profiles
PCB153 at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
7.0e-04
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

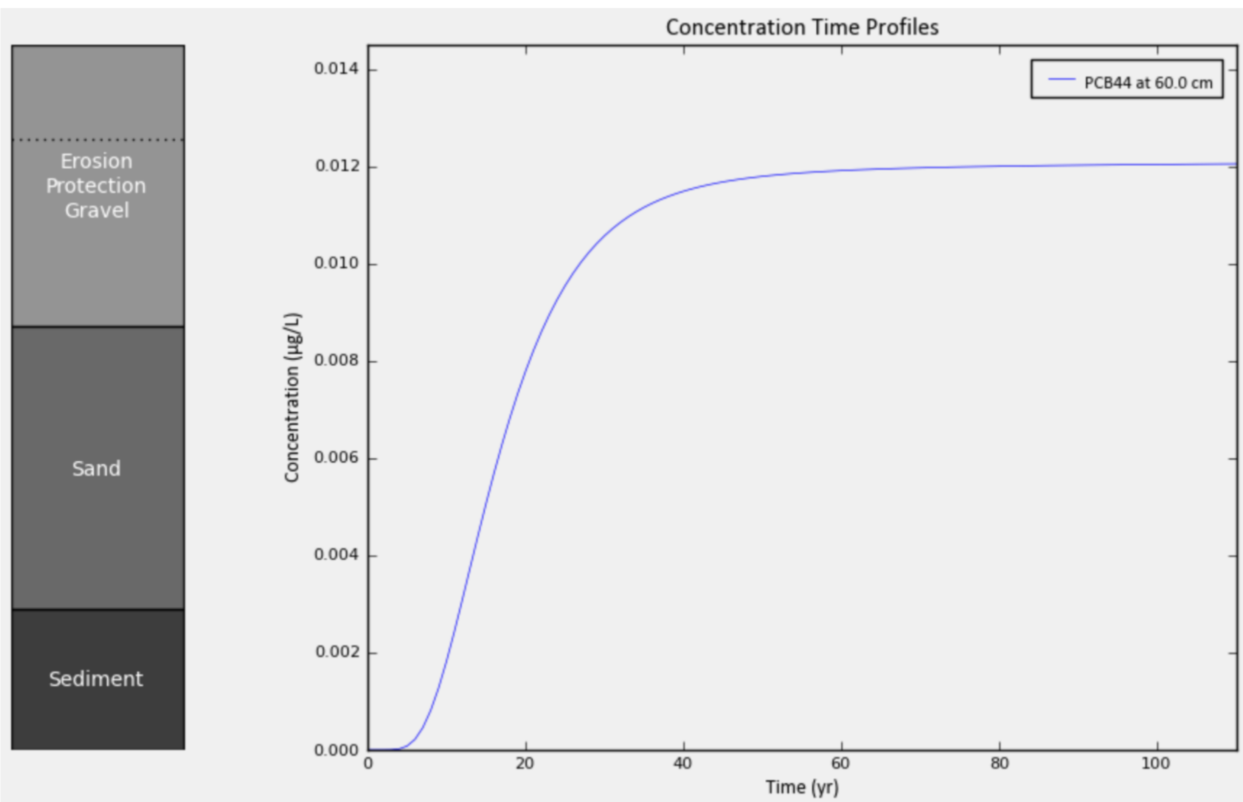

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
PCB174 at 60.0 cm
Concentration (μg/L)
3.5e-05
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

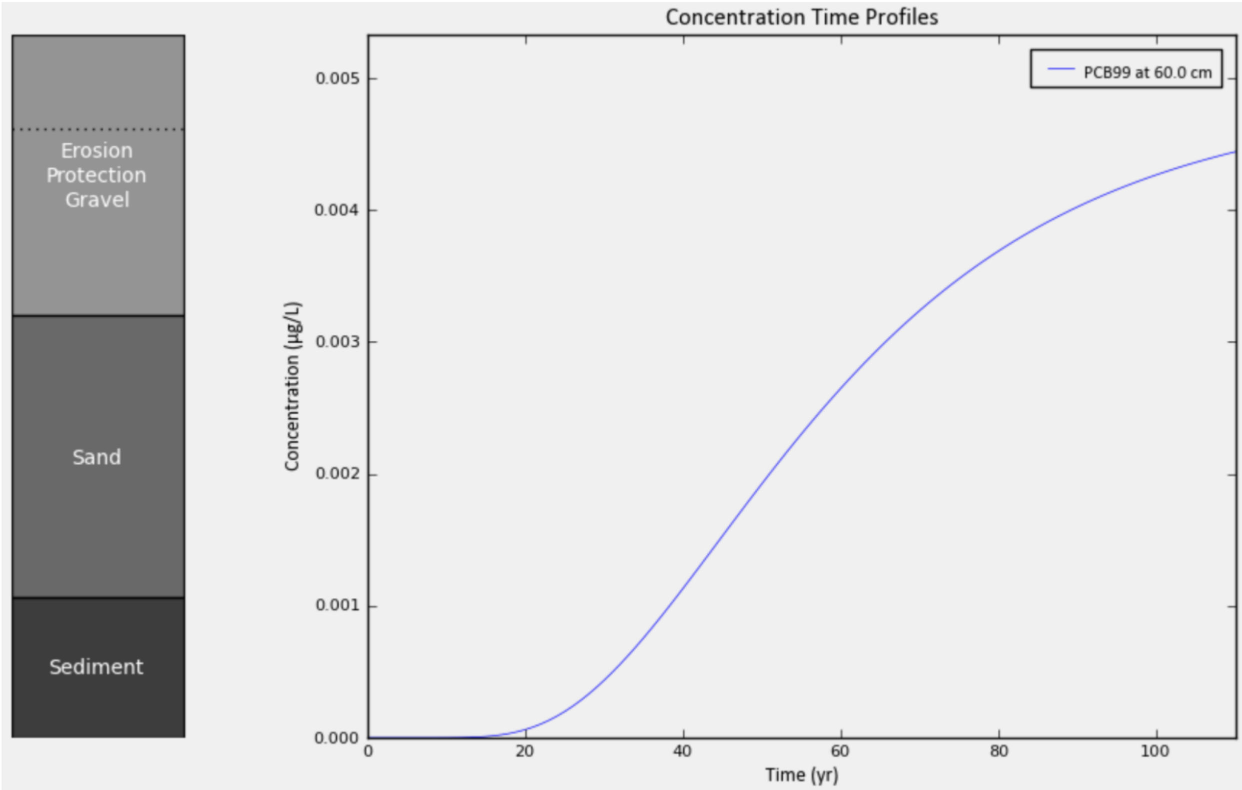

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
PCB177 at 60.0 cm
Concentration (μg/L)
3.5e-05
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

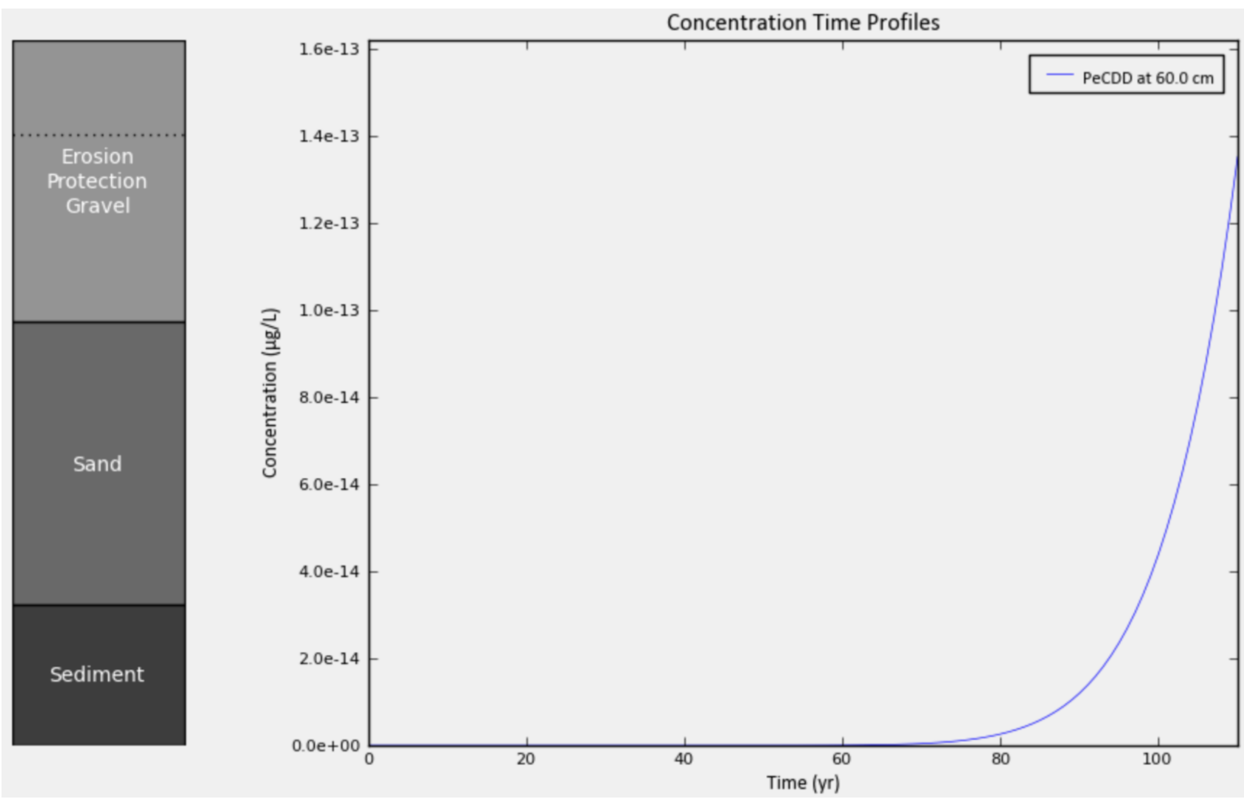

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB180 at 60.0 cm
Concentration (µg/L)
3.5e-06
3.0e-06
2.5e-06
2.0e-06
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

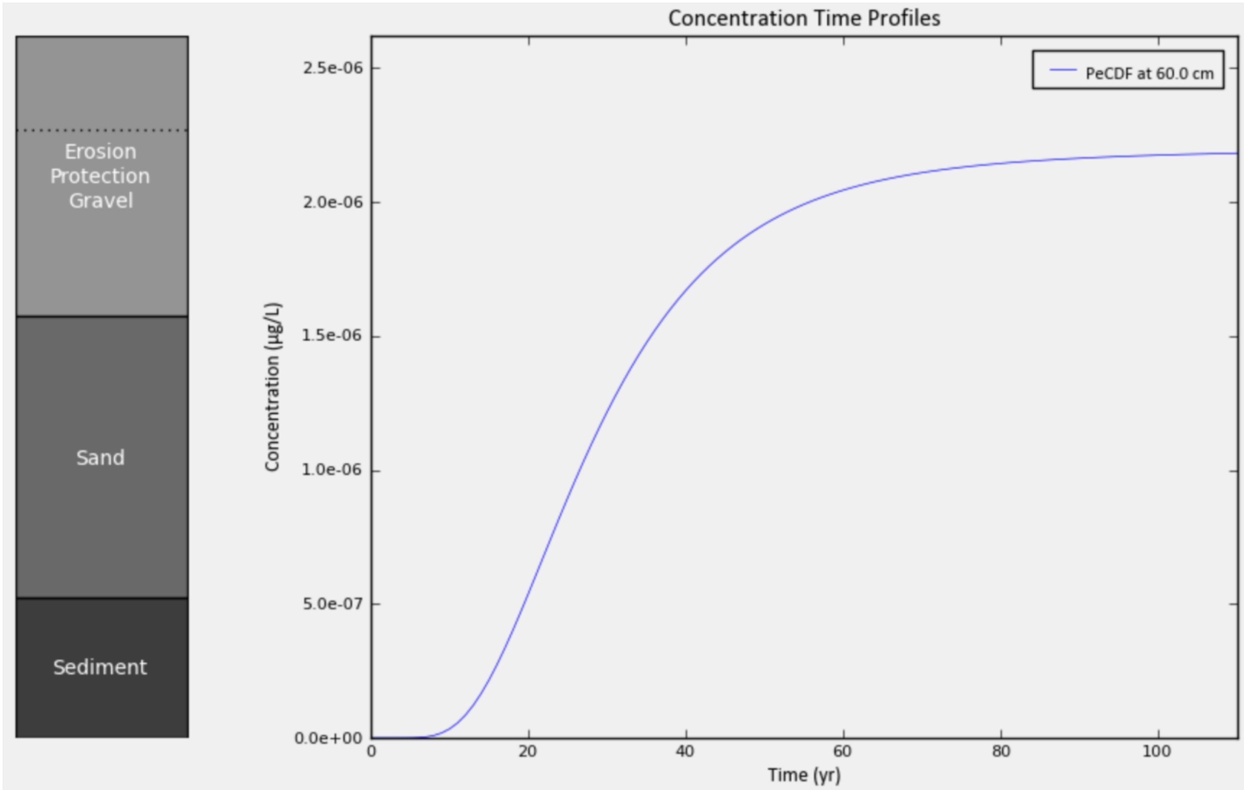

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB183 at 60.0 cm
Concentration (µg/L)
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

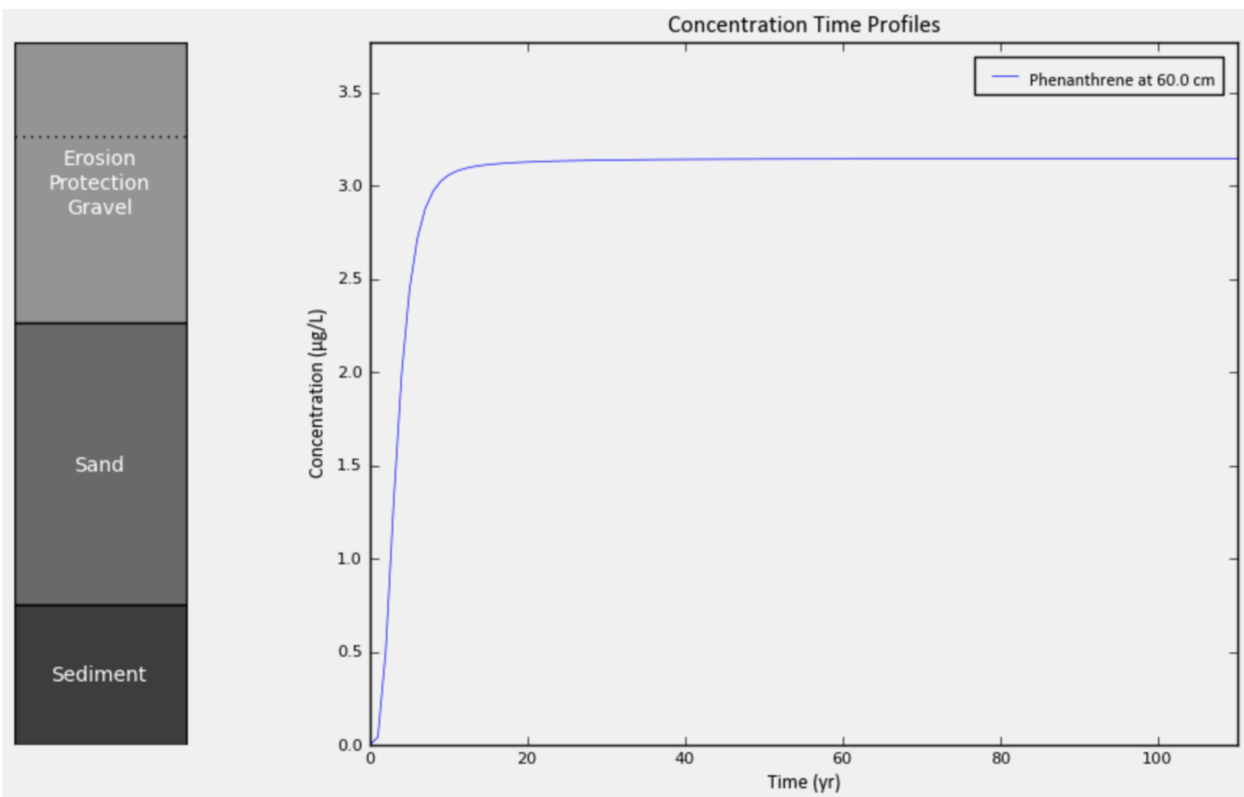

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB199 at 60.0 cm
Concentration (µg/L)
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

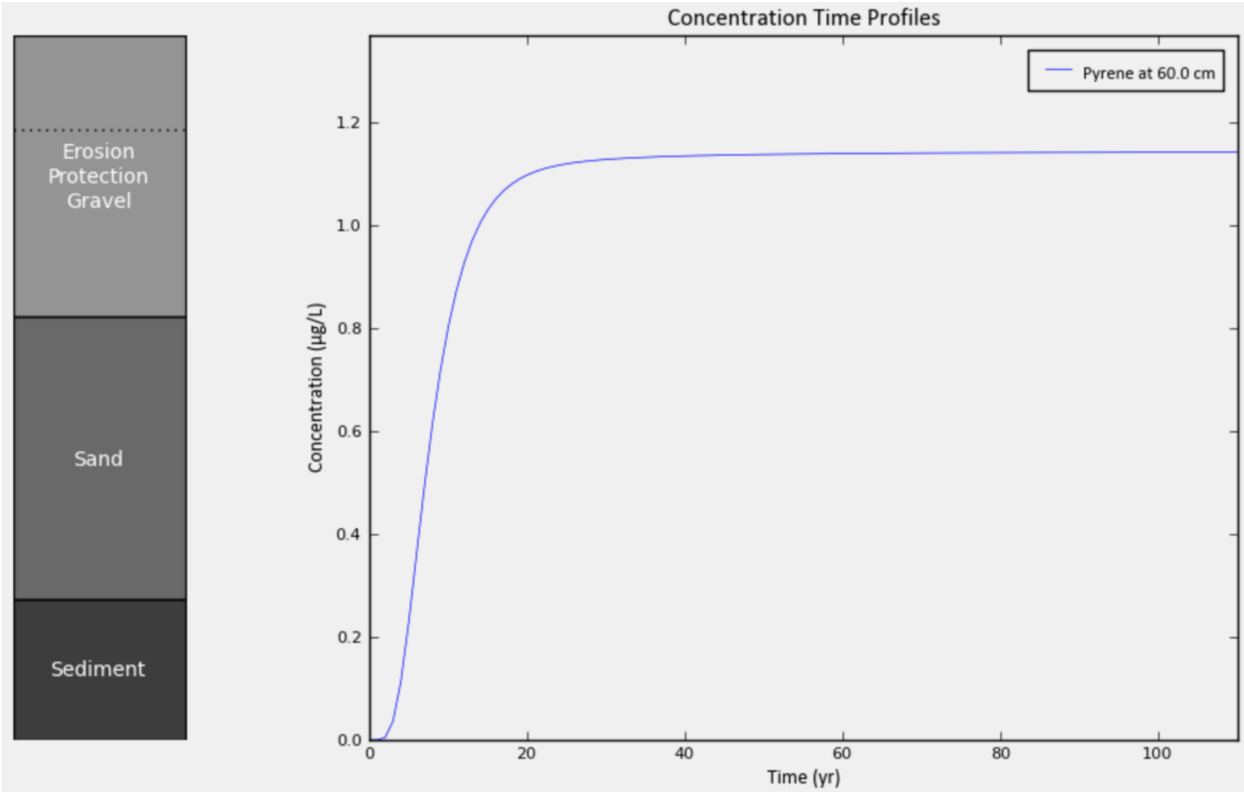

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB44 at 60.0 cm
Concentration (µg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

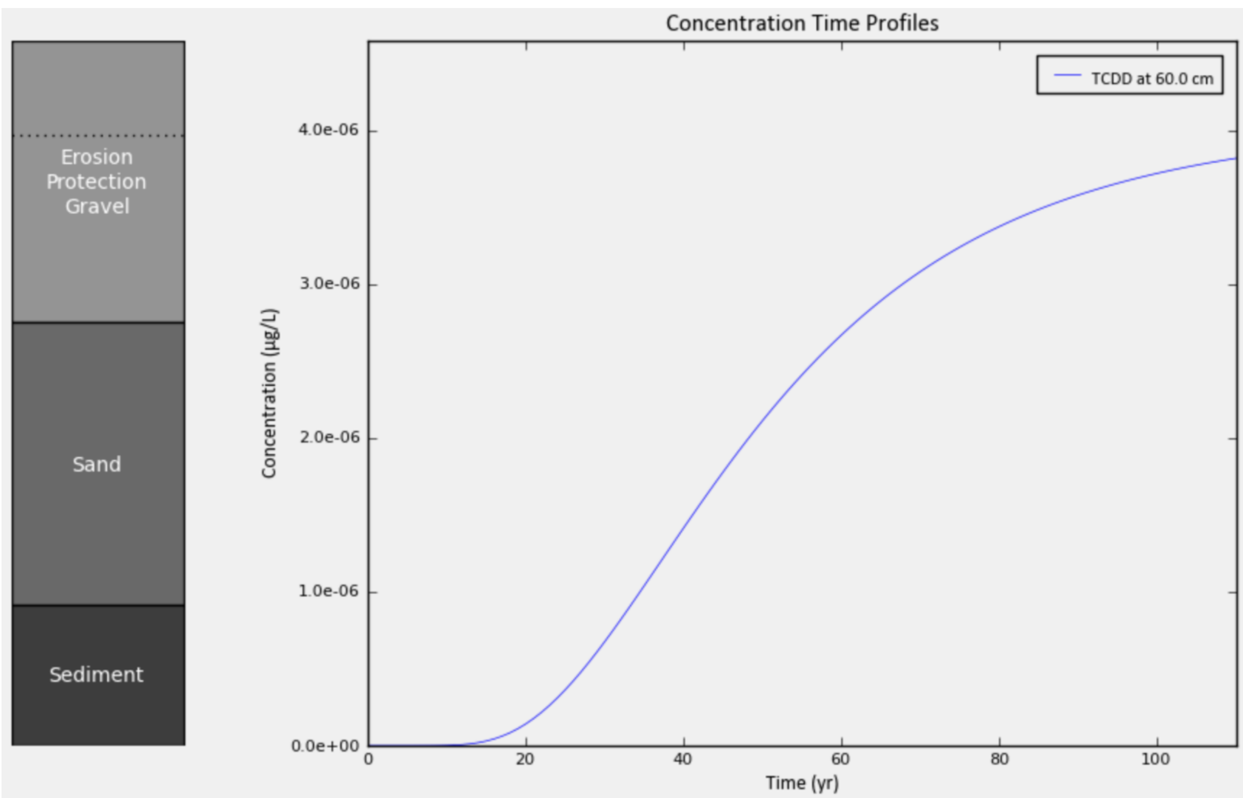

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
PCB99 at 60.0 cm
Concentration (µg/L)
0.000
0.001
0.002
0.003
0.004
0.005
0
20
40
60
80
100
Time (yr)

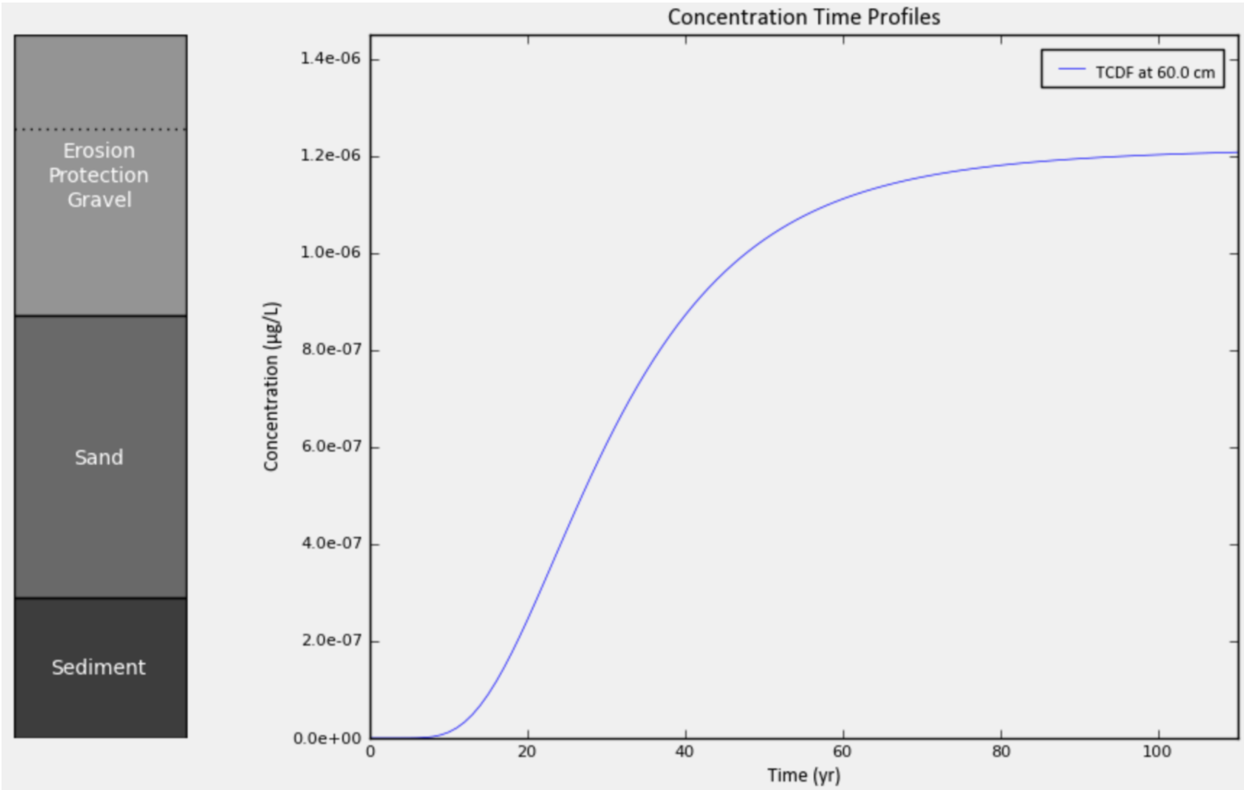

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
PeCDD at 60.0 cm
Concentration (µg/L)
0.0e+00
2.0e-14
4.0e-14
6.0e-14
8.0e-14
1.0e-13
1.2e-13
1.4e-13
1.6e-13
0
20
40
60
80
100
Time (yr)

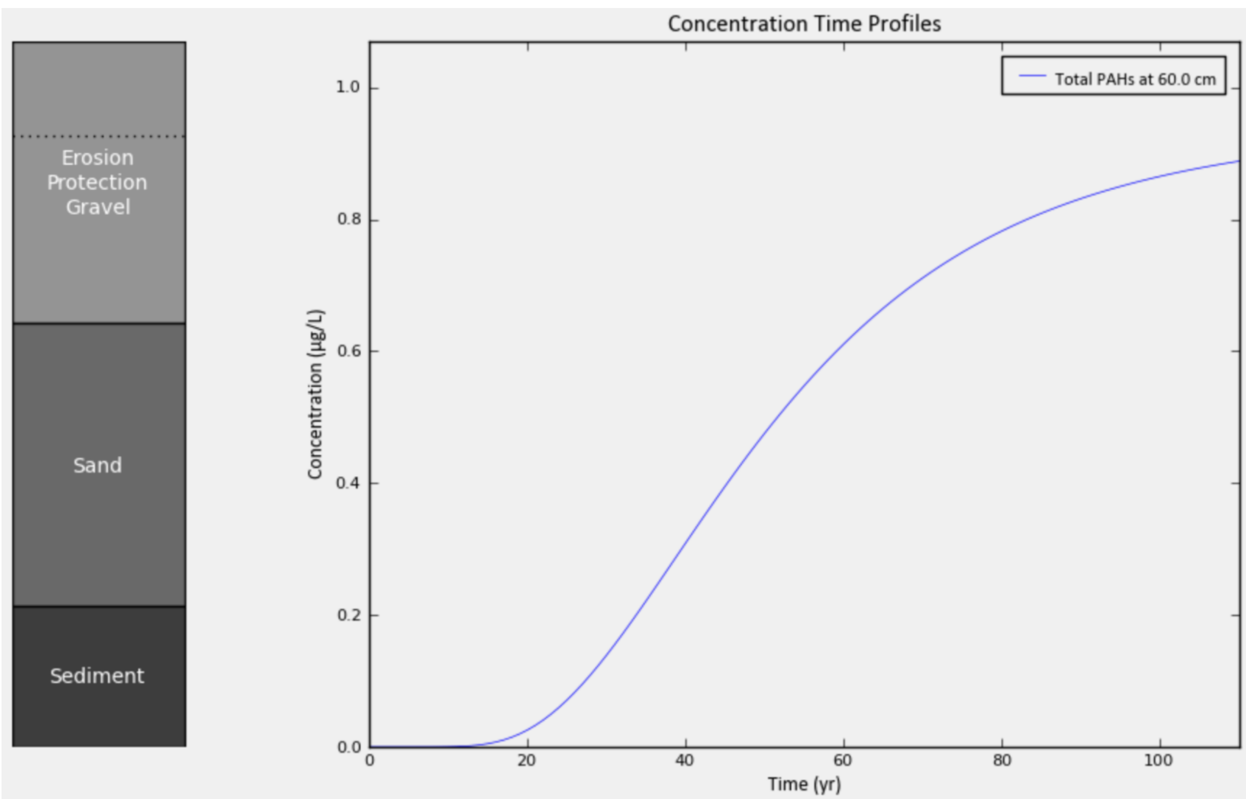

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
PeCDF at 60.0 cm
Concentration (µg/L)
2.5e-06
2.0e-06
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

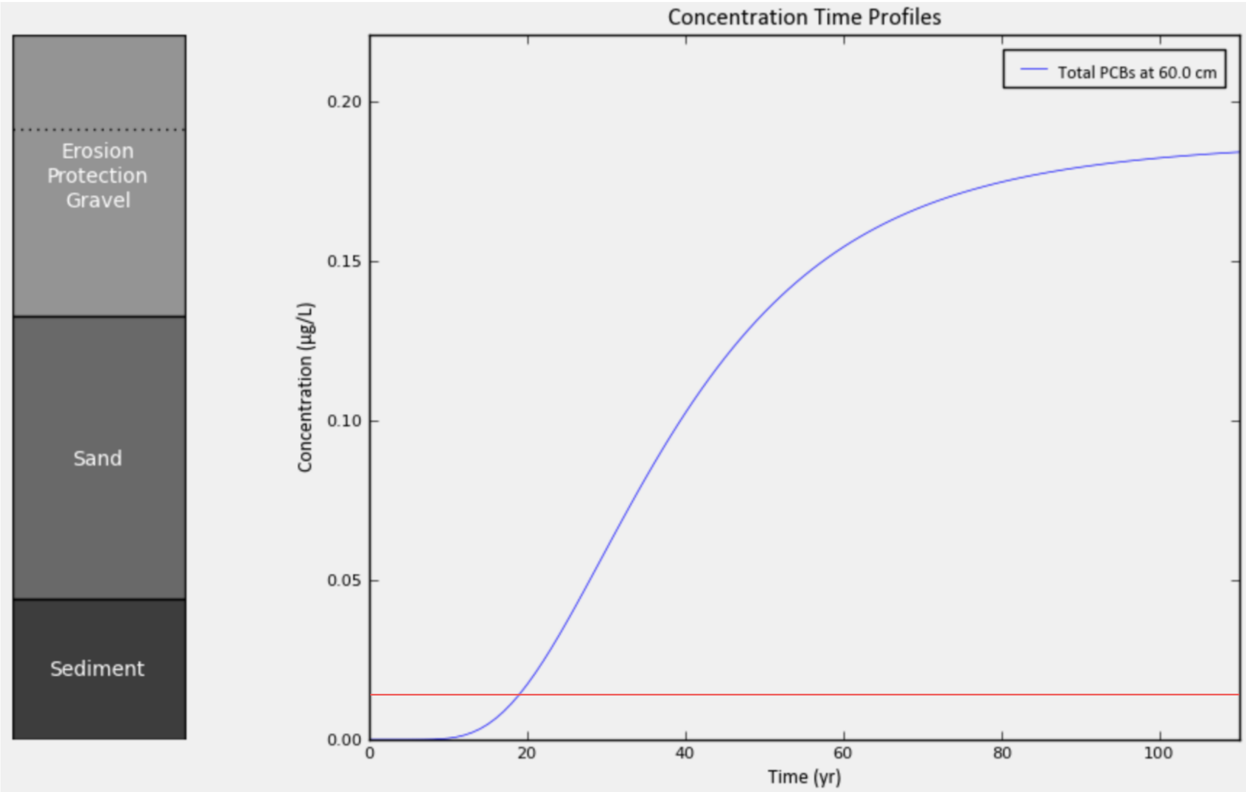

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
Phenanthrene at 60.0 cm
Concentration (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)

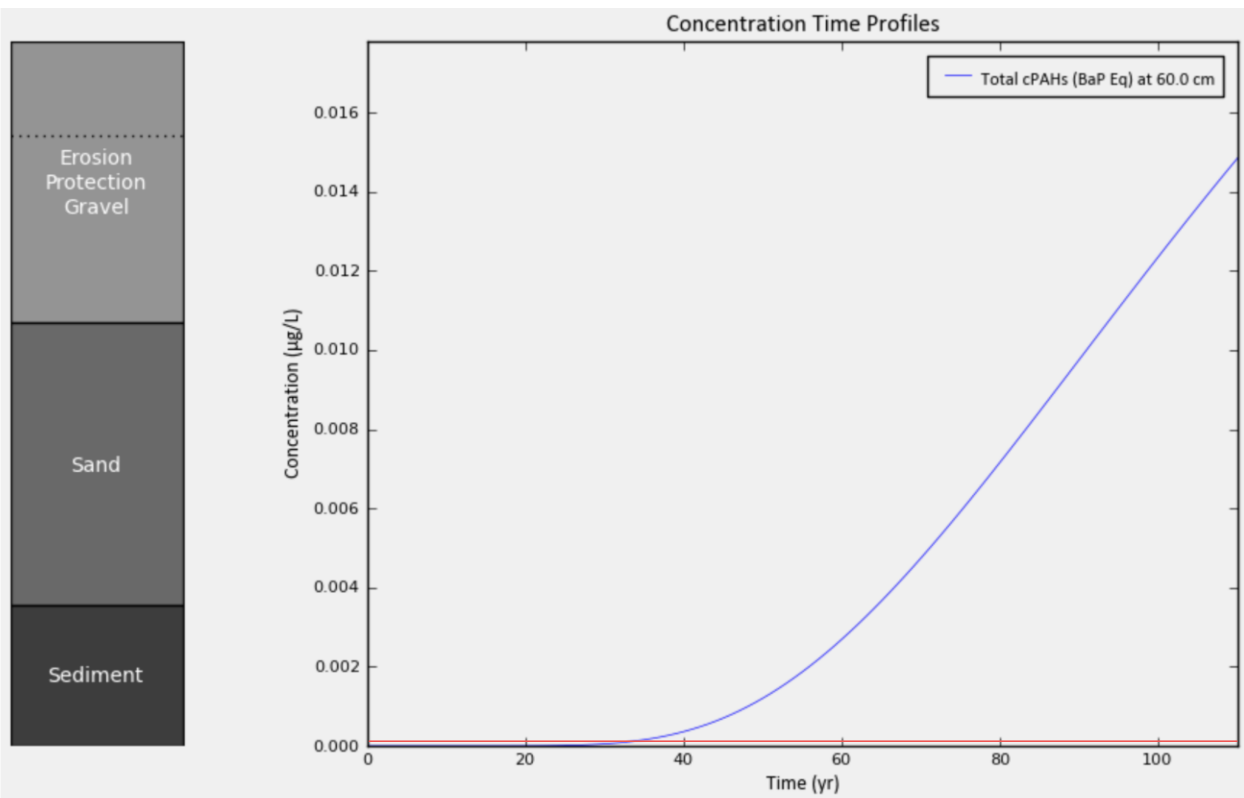

Concentration Time Profiles
Pyrene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (μg/L)
Time (yr)


Concentration Time Profiles
TCDD at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (μg/L)
Time (yr)


Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
TCDF at 60.0 cm
Concentration (µg/L)
Time (yr)
1.4e-06
1.2e-06
1.0e-06
8.0e-07
6.0e-07
4.0e-07
2.0e-07
0.0e+00
0
20
40
60
80
100

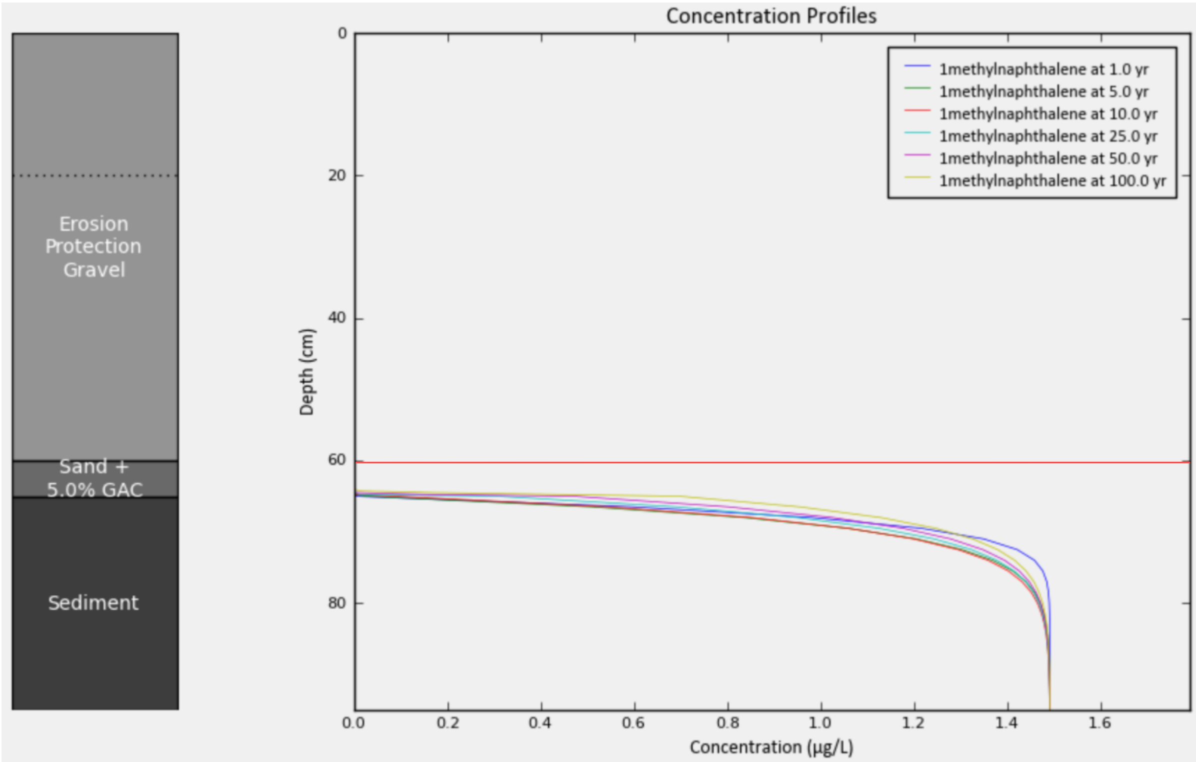

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Total PAHs at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100

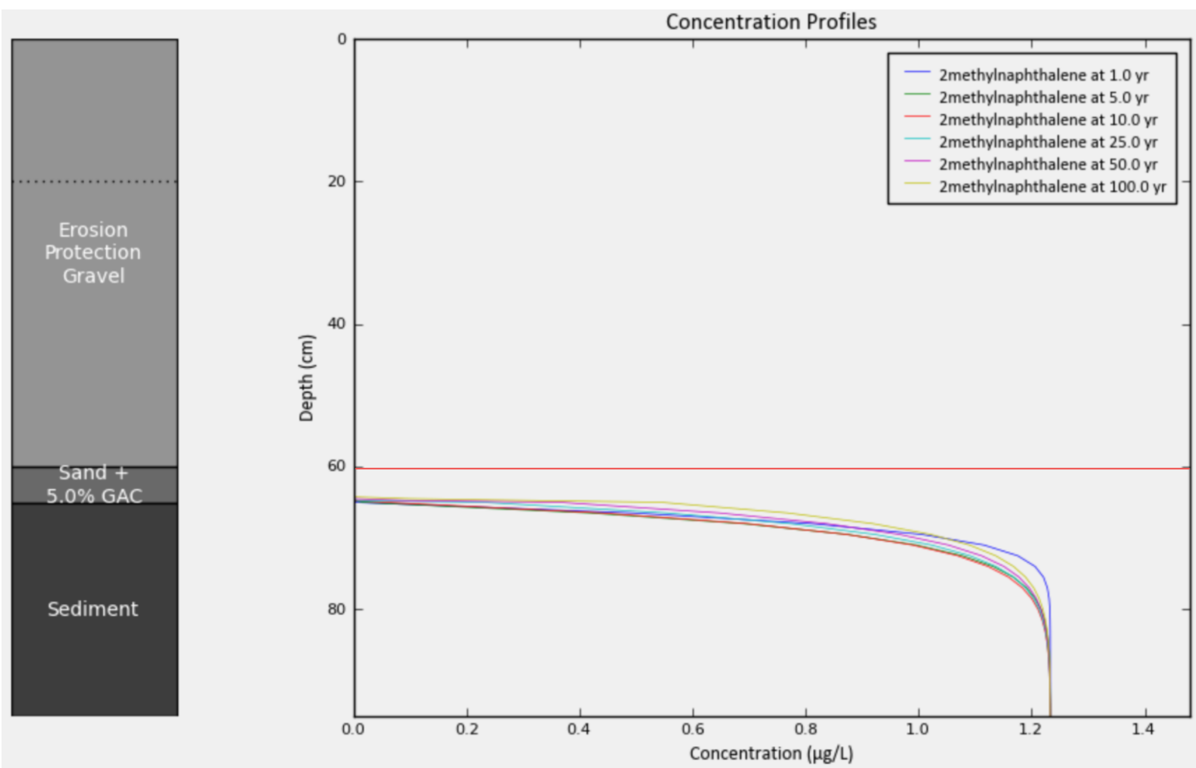

Concentration Time Profiles
Erosion
Protection
Gravel
Sand
Sediment
Total PCBs at 60.0 cm
Concentration (µg/L)
0.00
0.05
0.10
0.15
0.20
Time (yr)
0
20
40
60
80
100

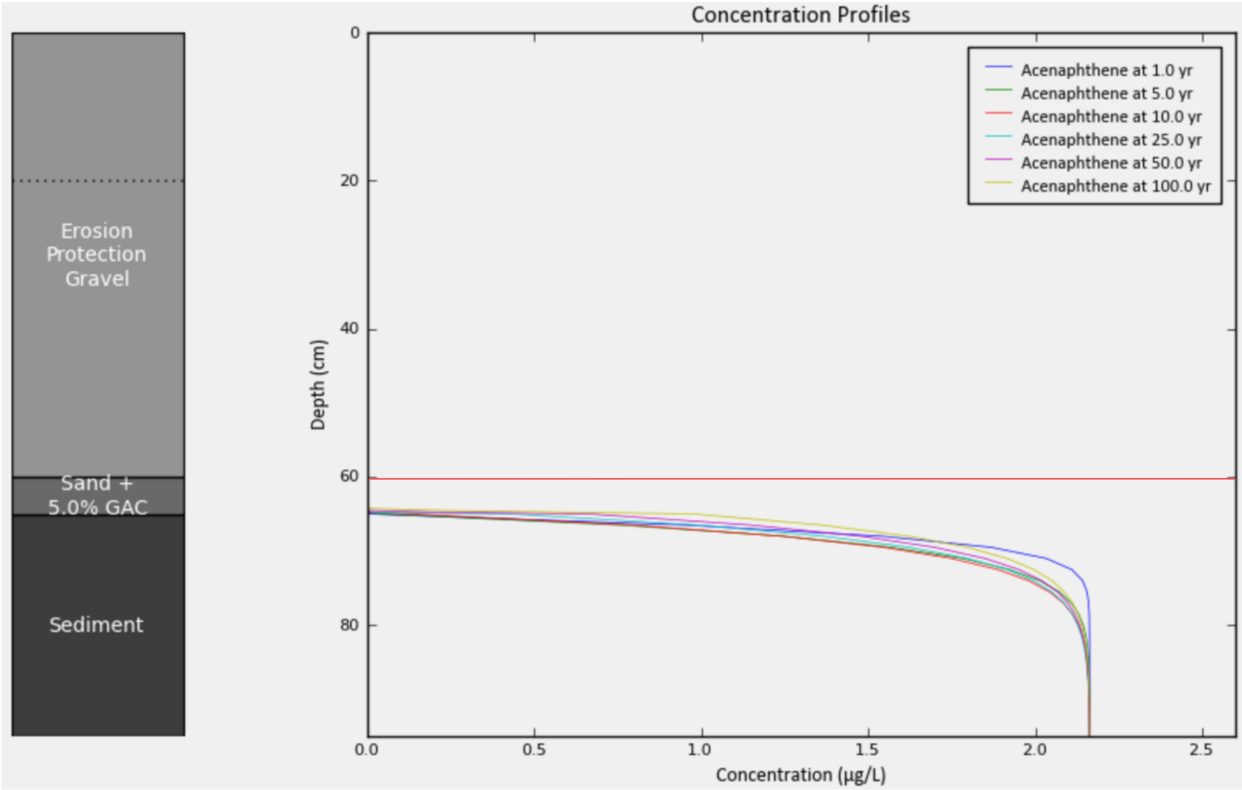

Concentration Time Profiles
Erosion
Protection
Gravel
Sand
Sediment
Total cPAHs (BaP Eq) at 60.0 cm
Concentration (µg/L)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016
Time (yr)
0
20
40
60
80
100

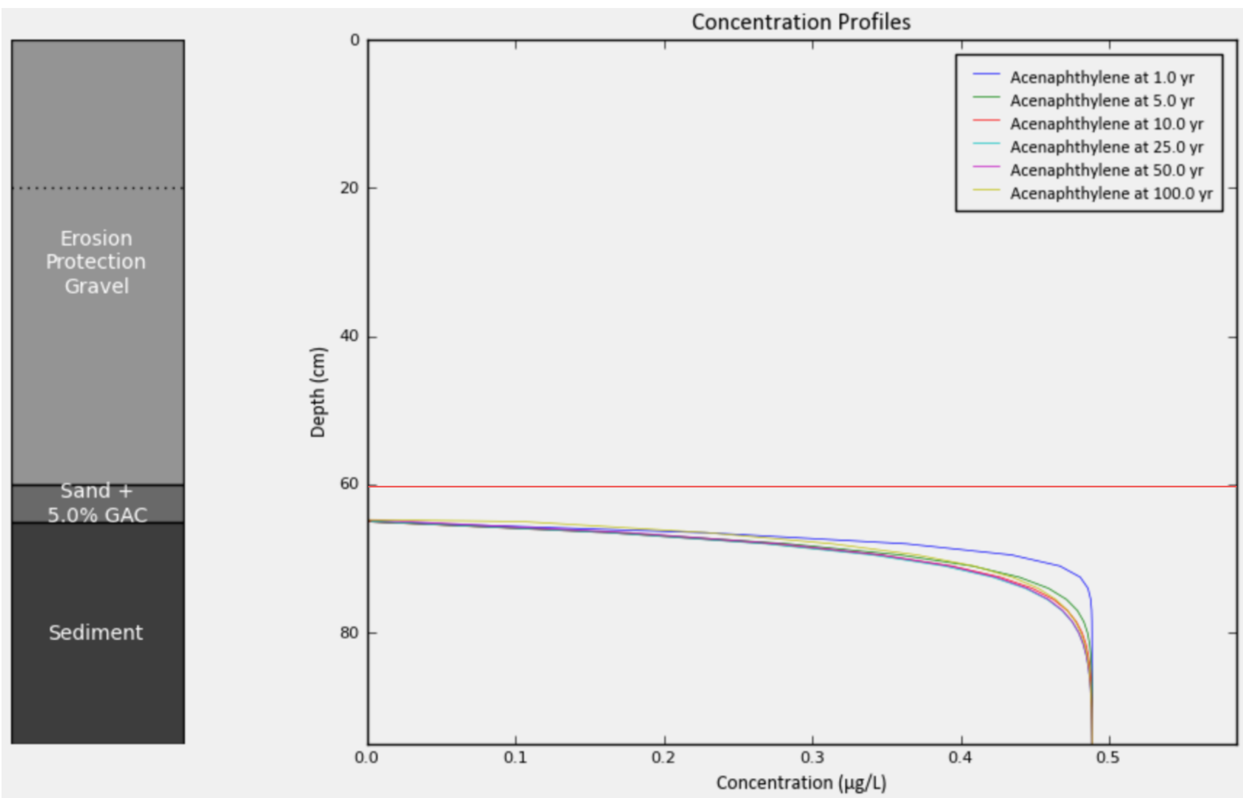
Cap Alternative 2: 5 cm of 5.0% GAC amended sand with 60 cm erosion protection layer

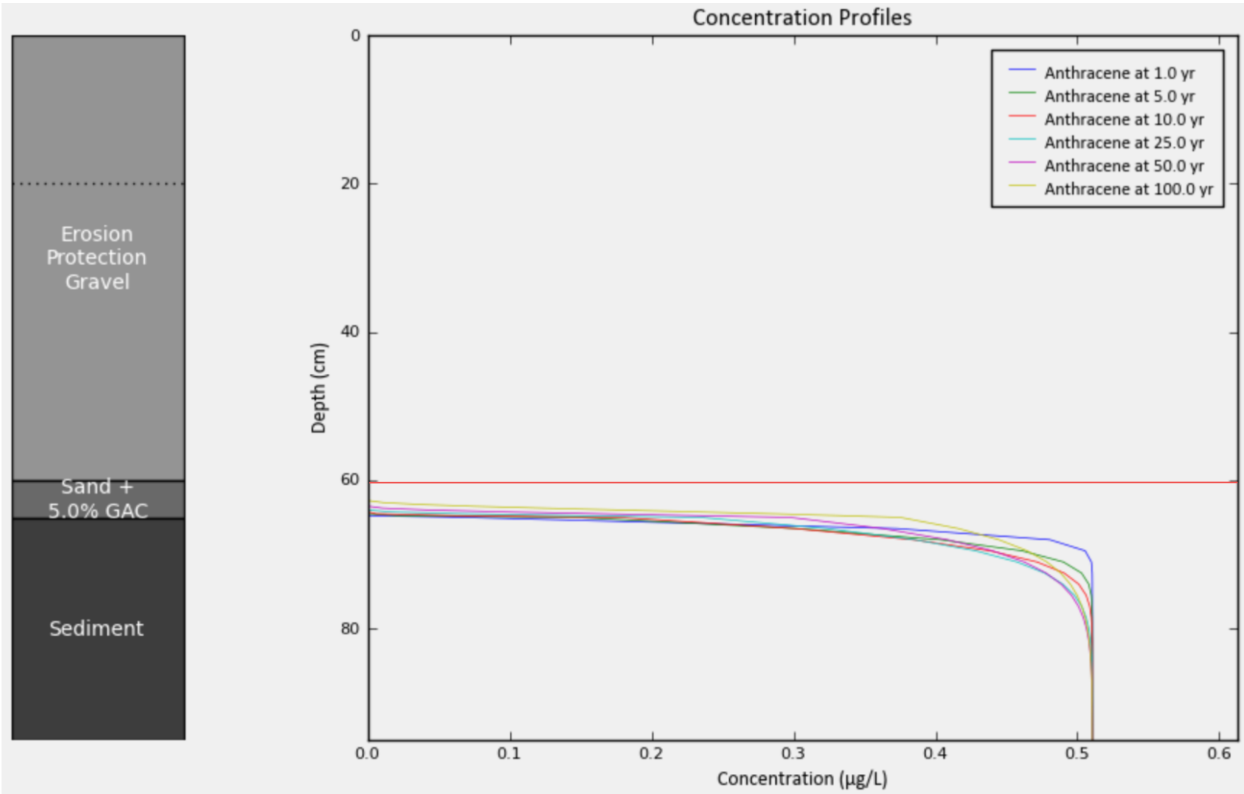
Porewater Concentration – Depth

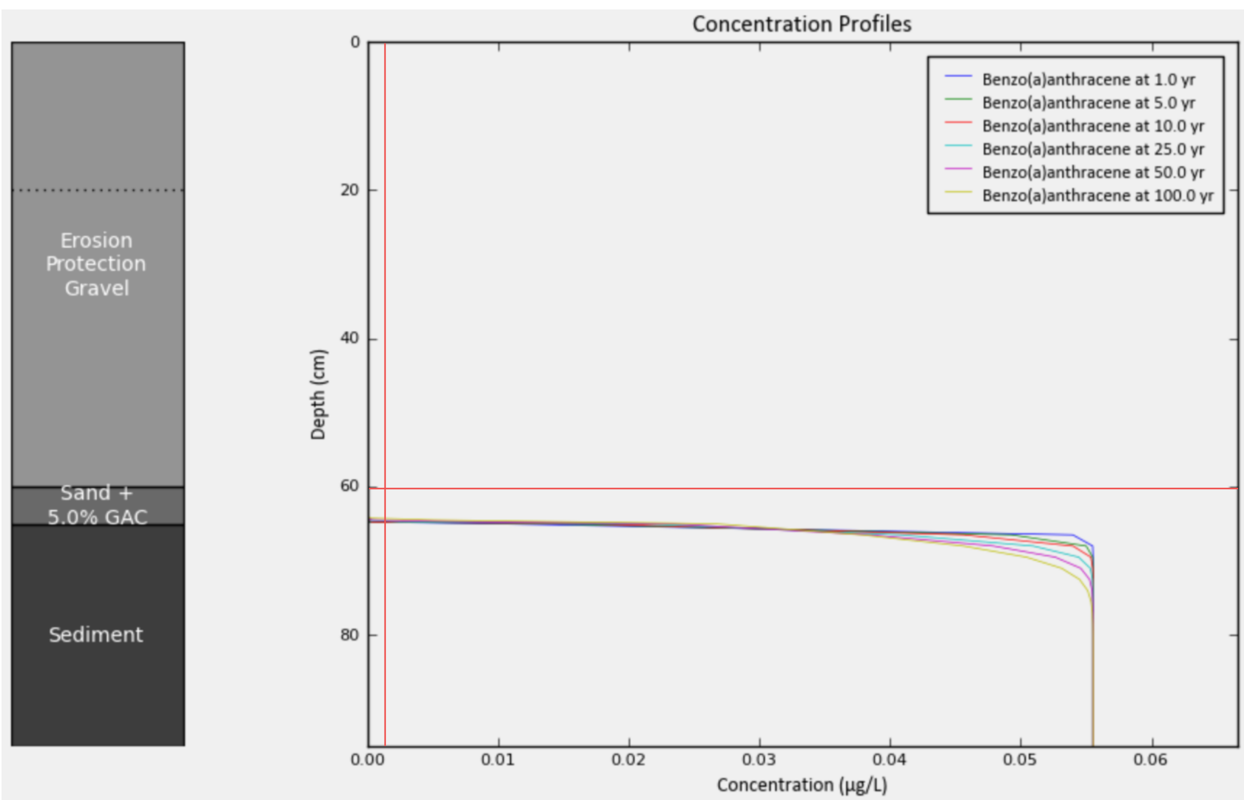


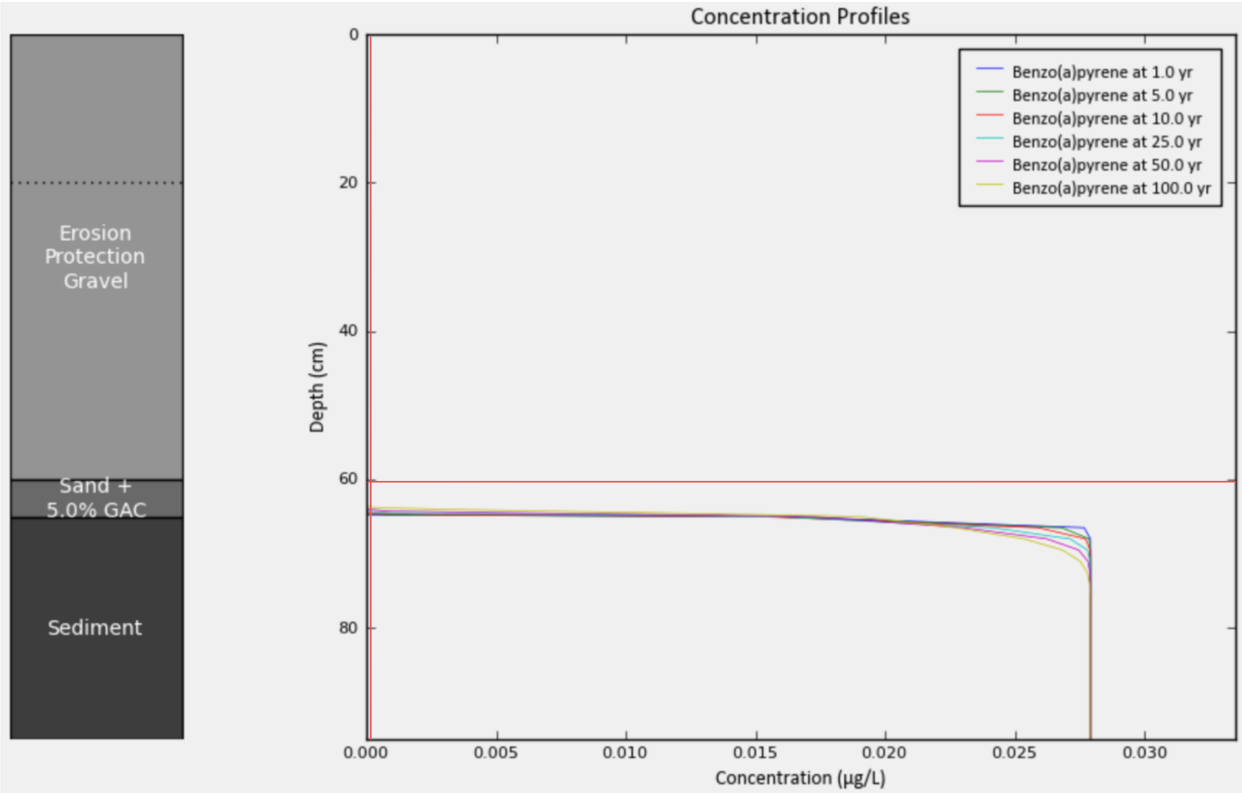


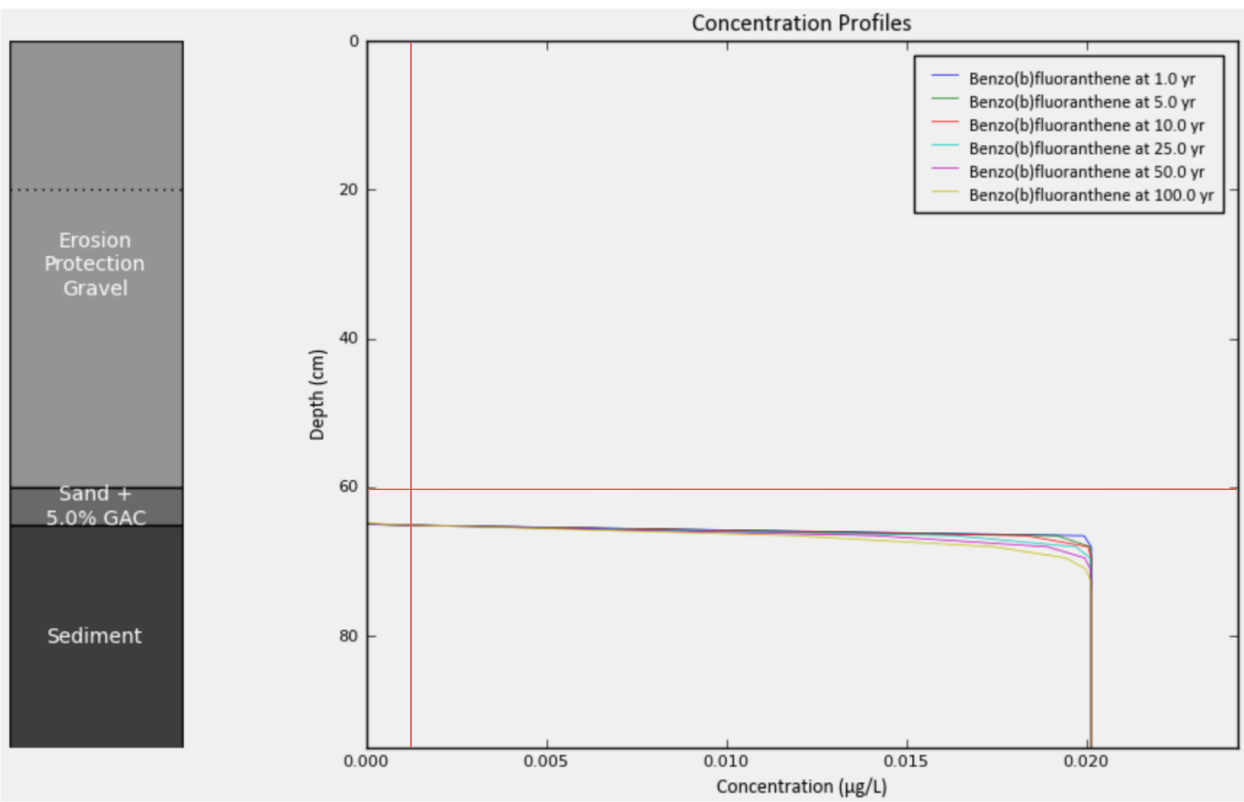

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

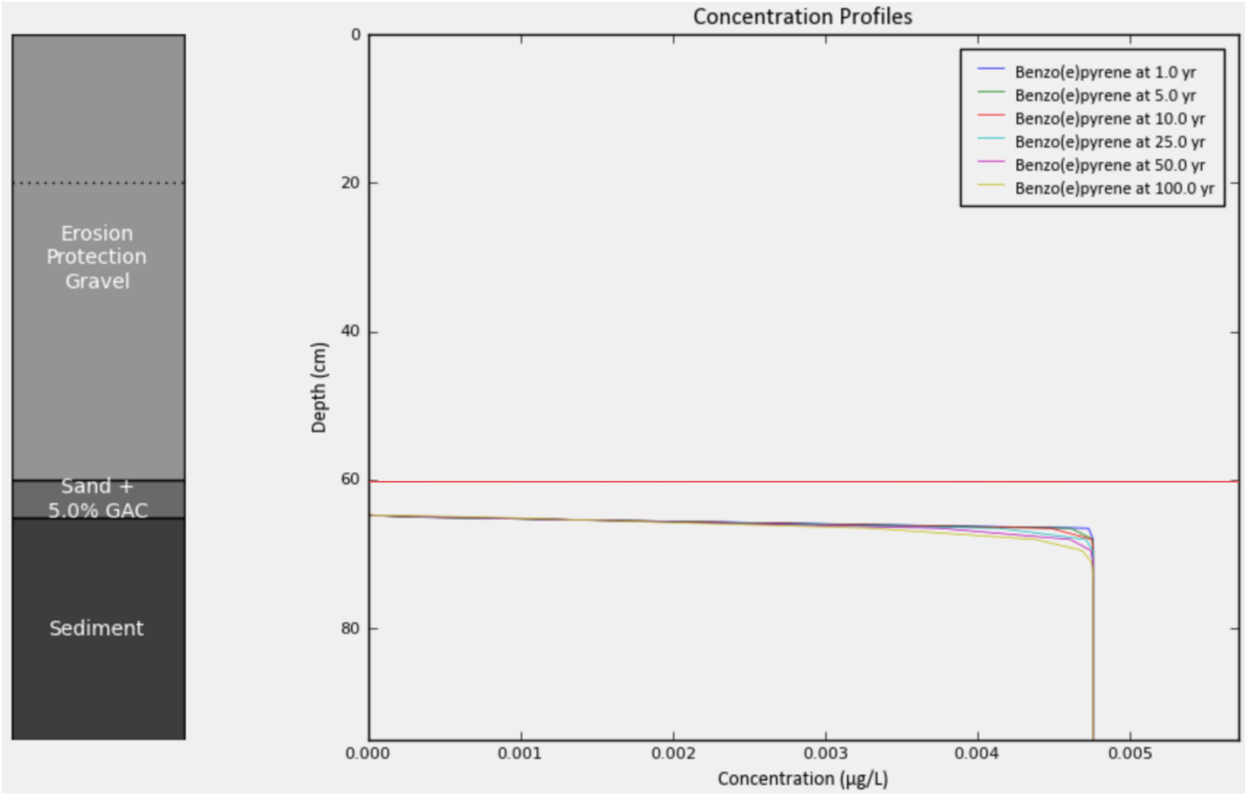

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

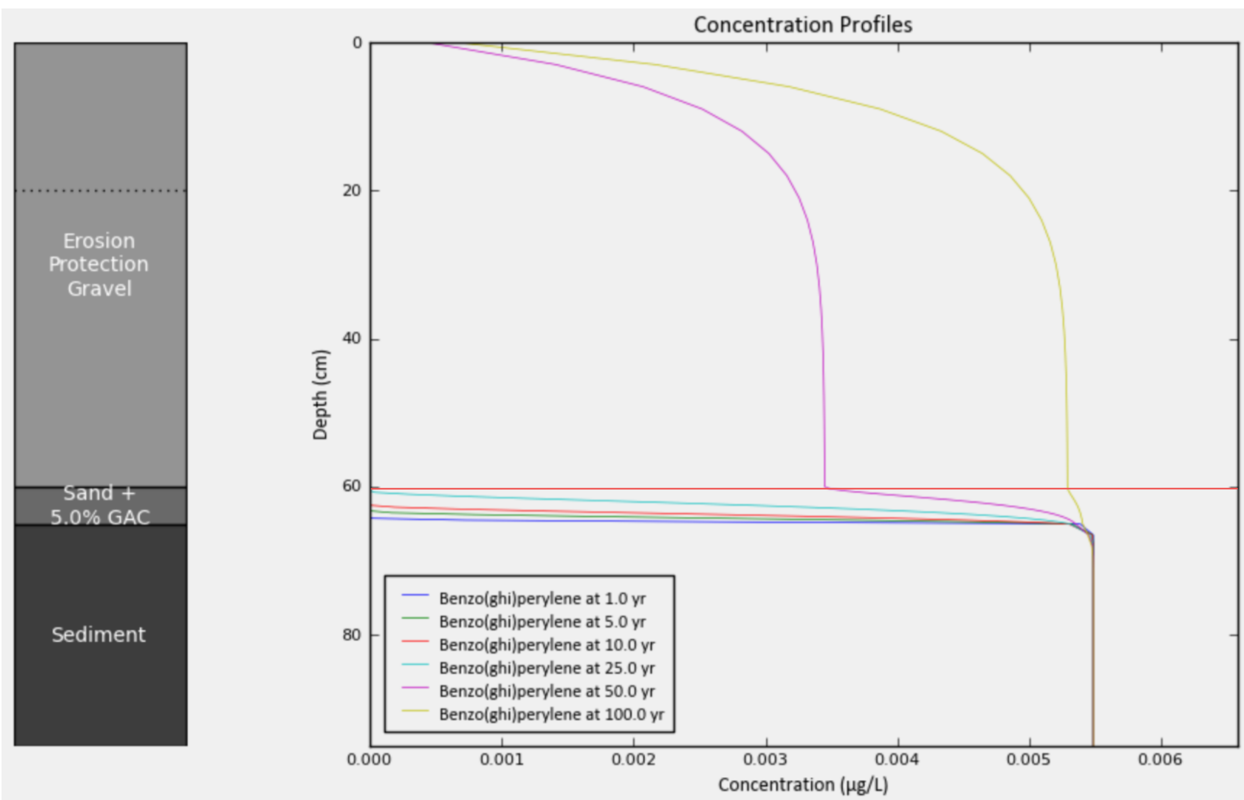

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

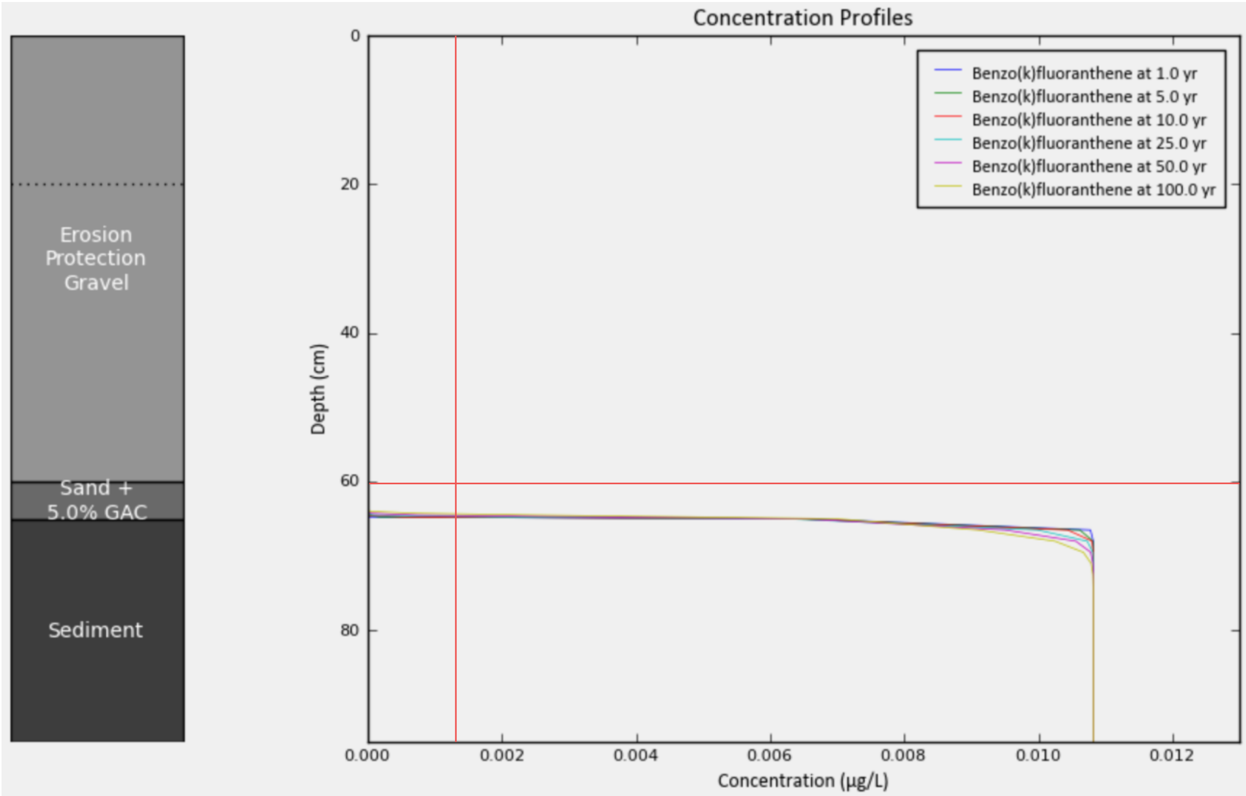

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

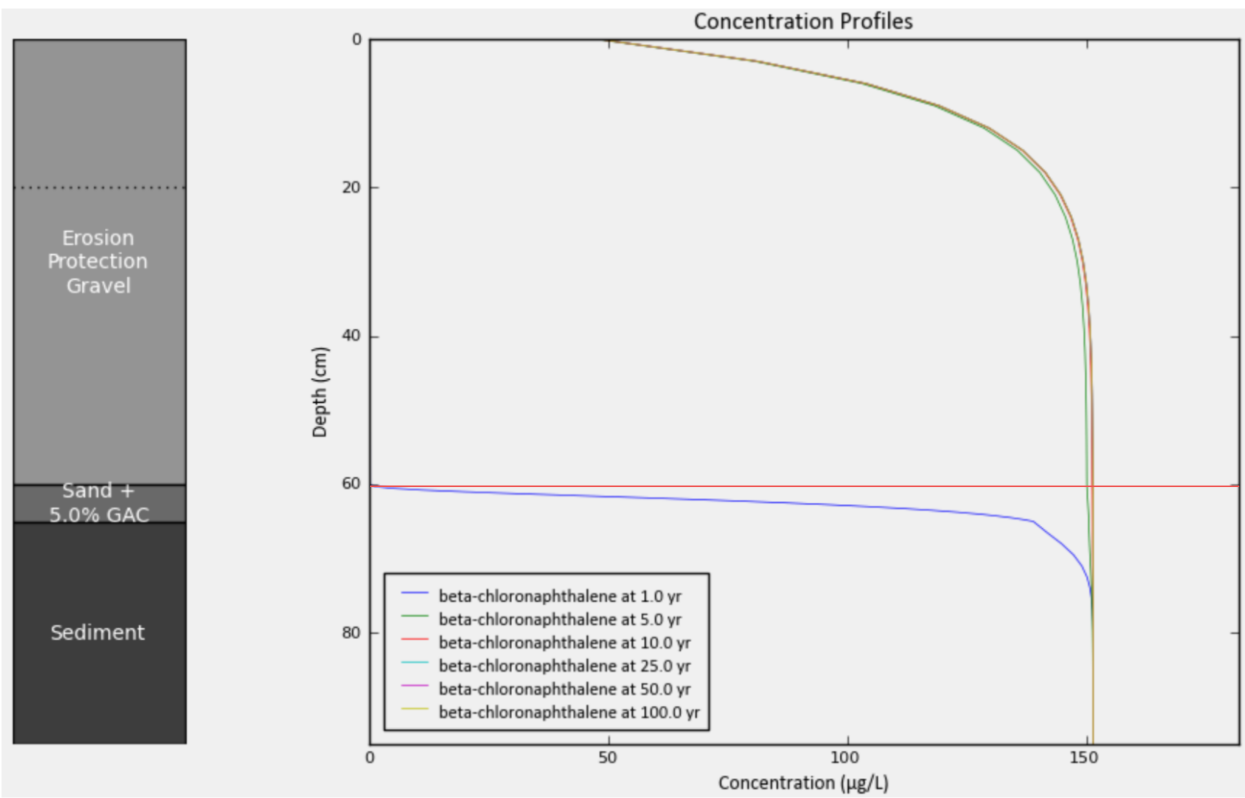

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr

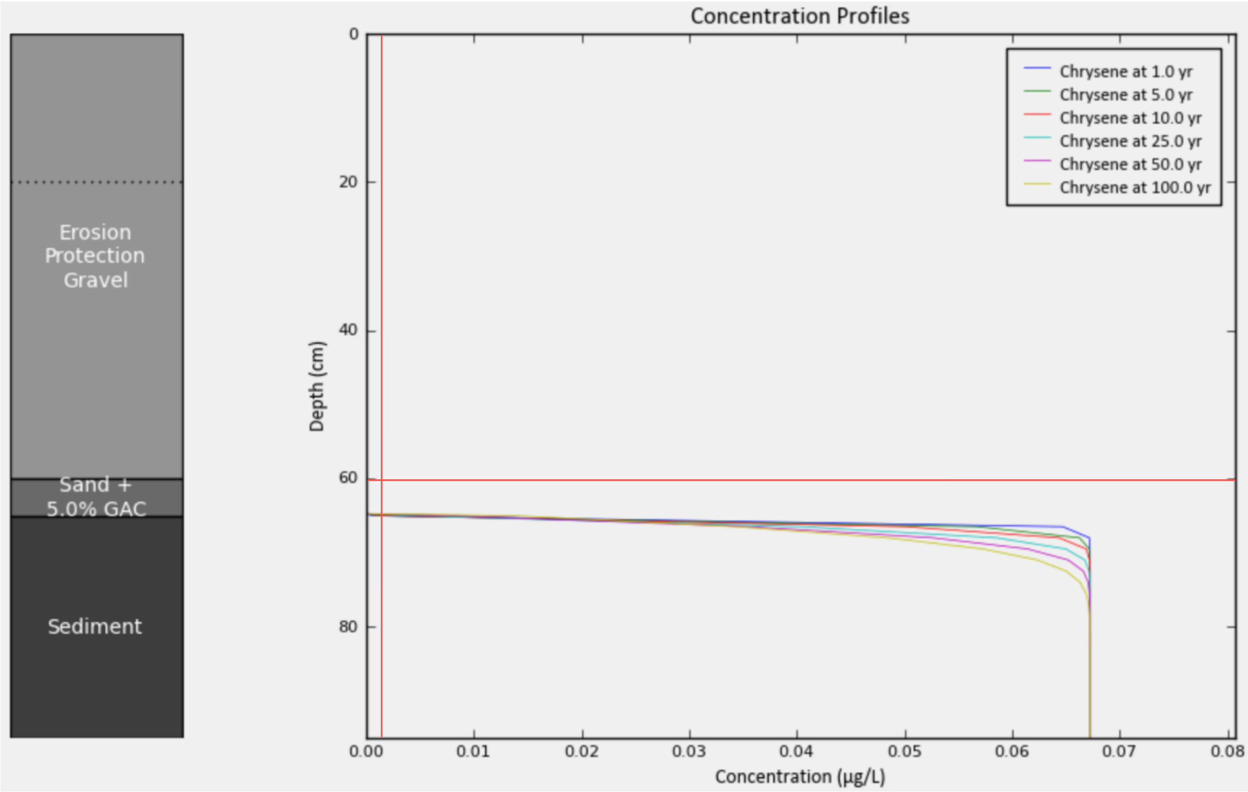

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr

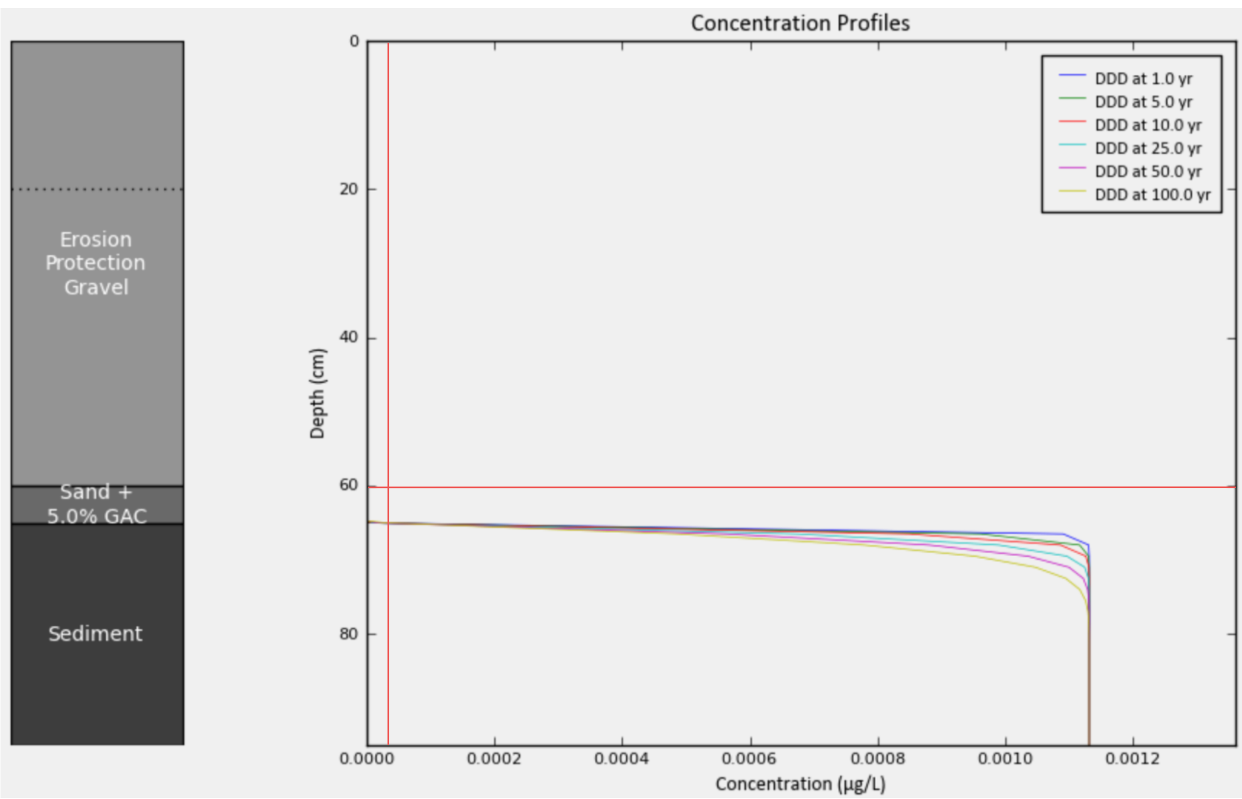

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
0.000
0.001
0.002
0.003
0.004
0.005
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

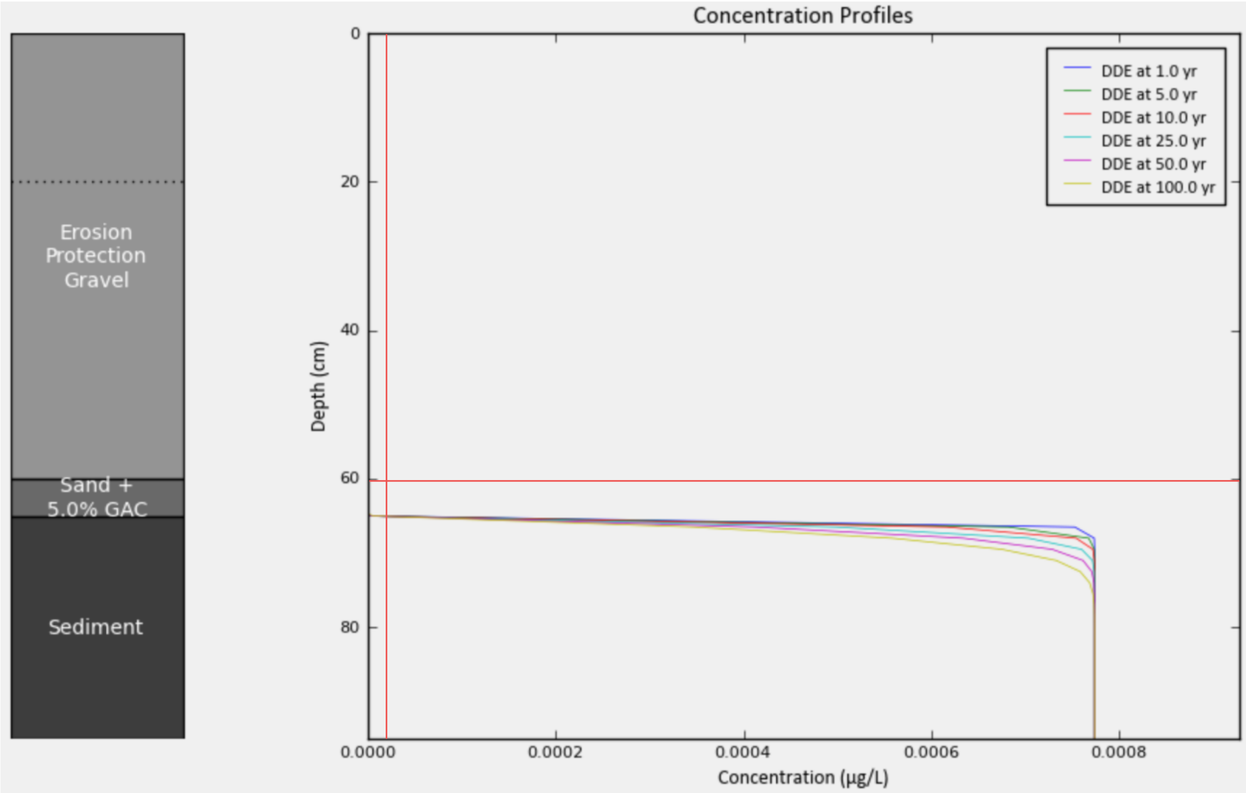

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
0.000
0.001
0.002
0.003
0.004
0.005
0.006
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

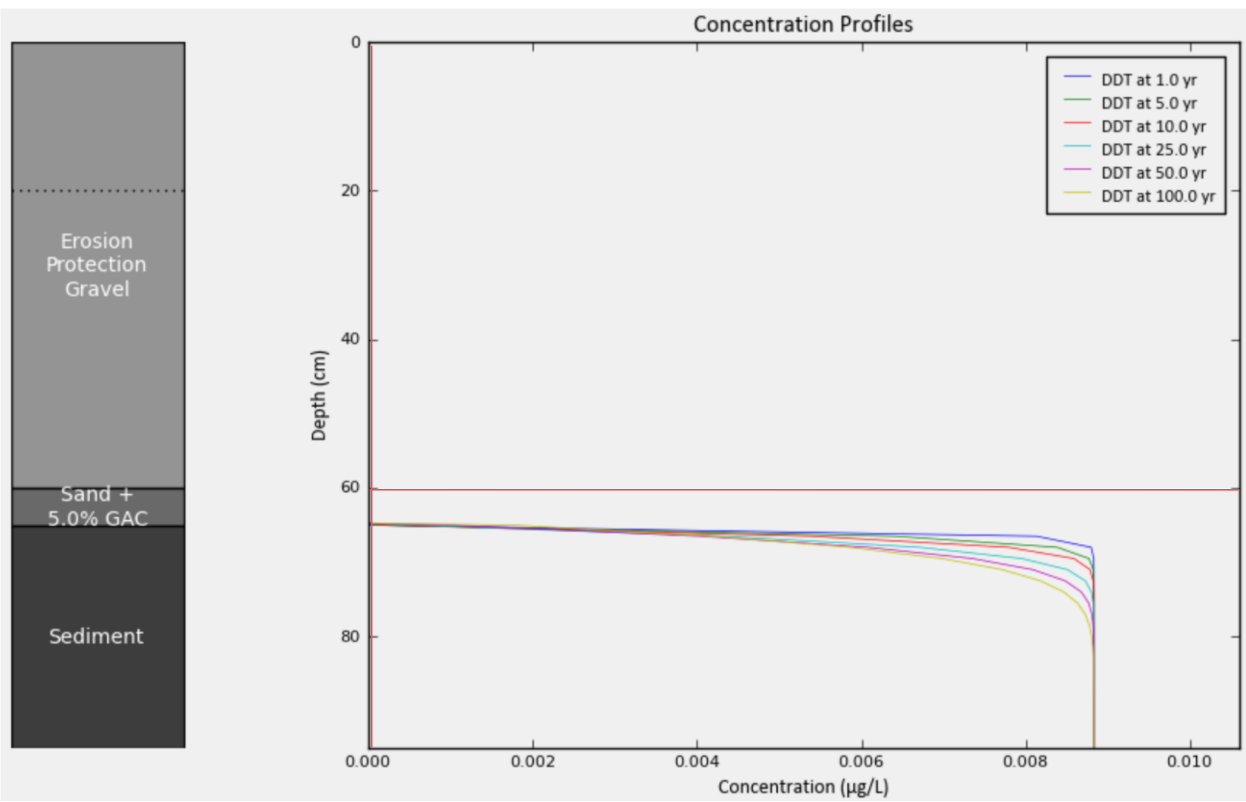

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr
0
20
40
60
80
0.000
0.002
0.004
0.006
0.008
0.010
0.012

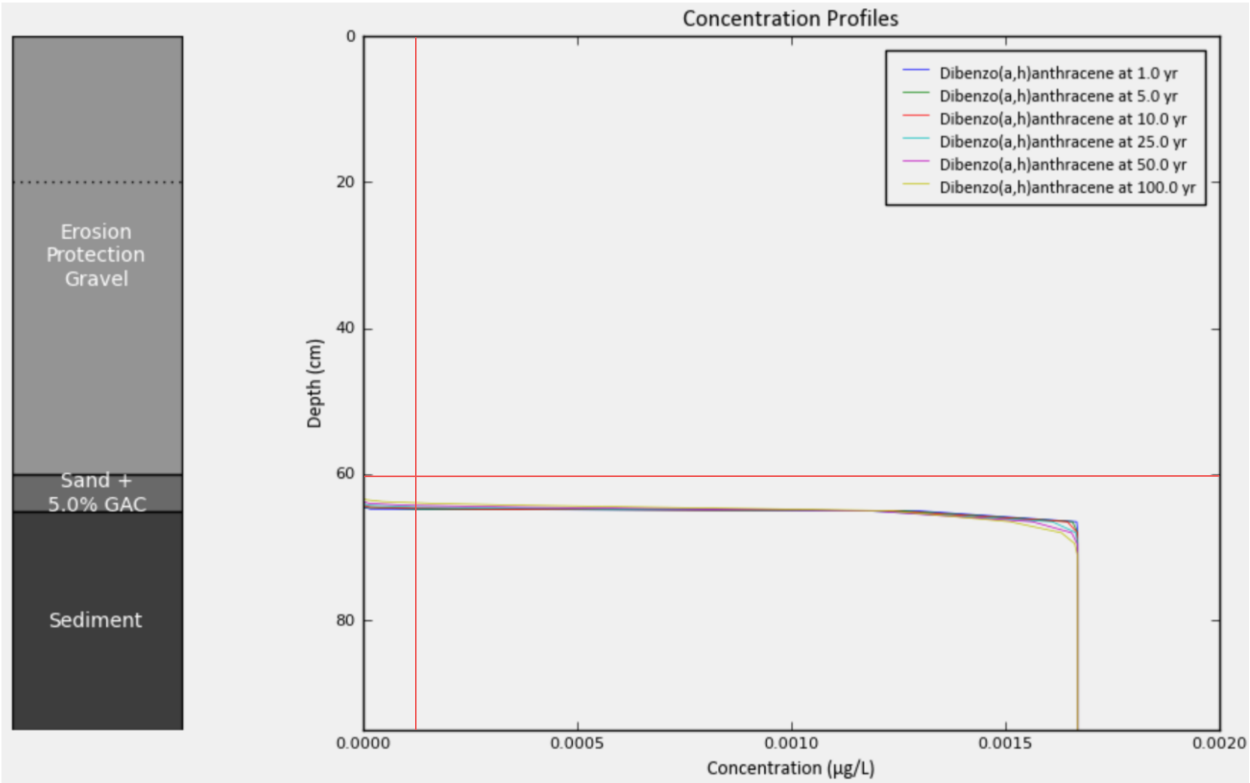

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr
0
20
40
60
80
0
50
100
150

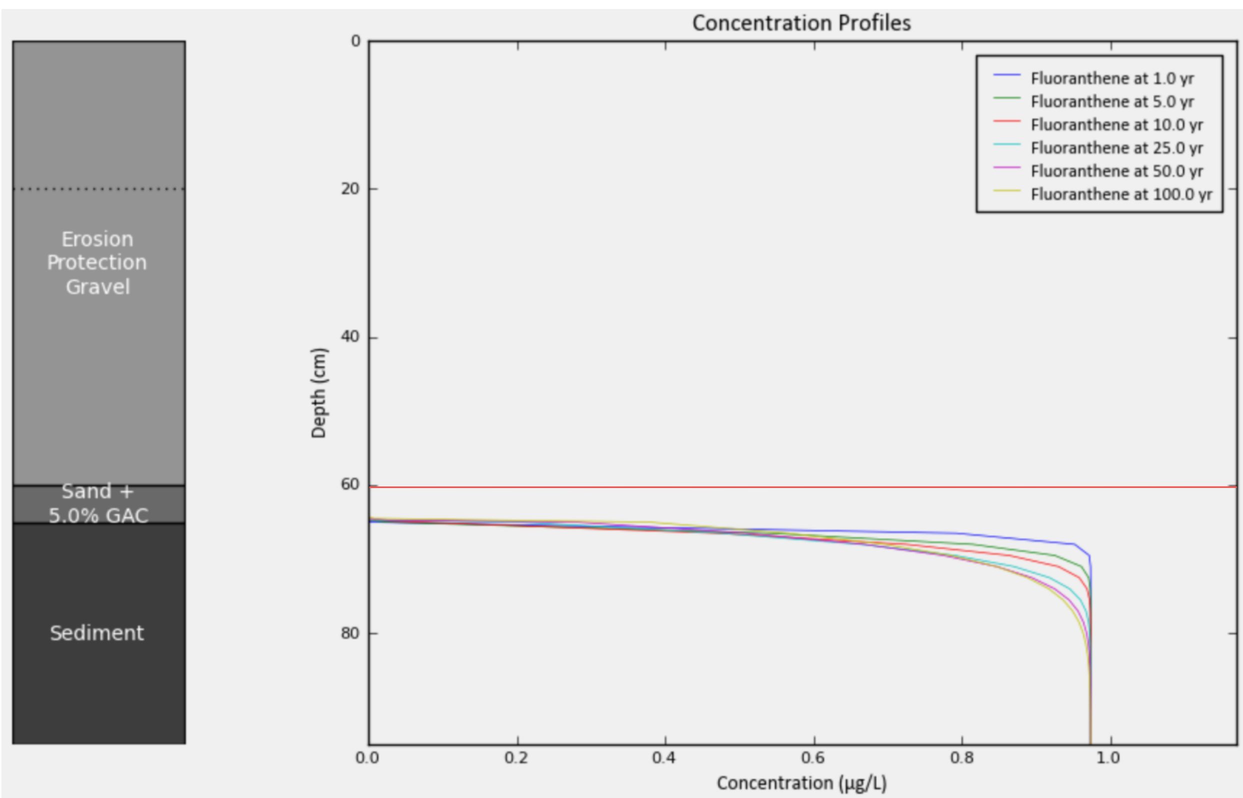

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
0
20
40
60
80
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

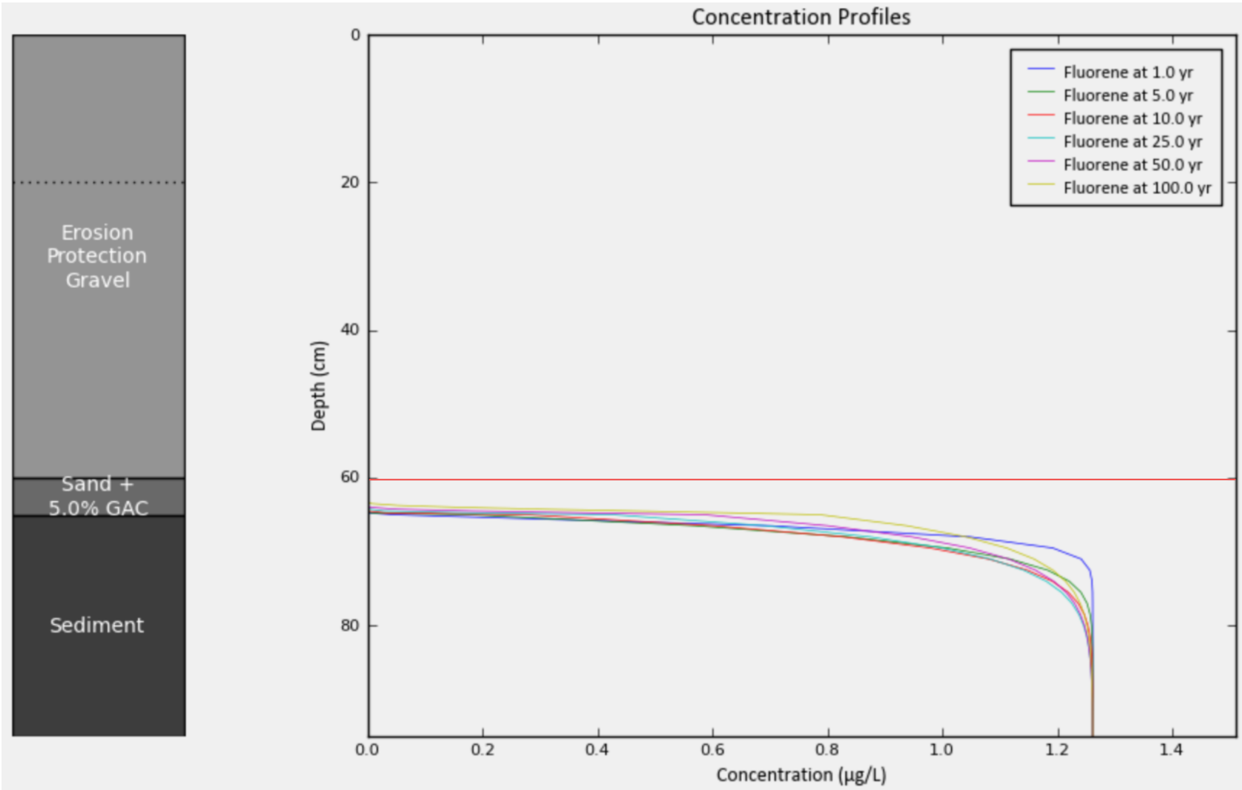

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
0
20
40
60
80
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012

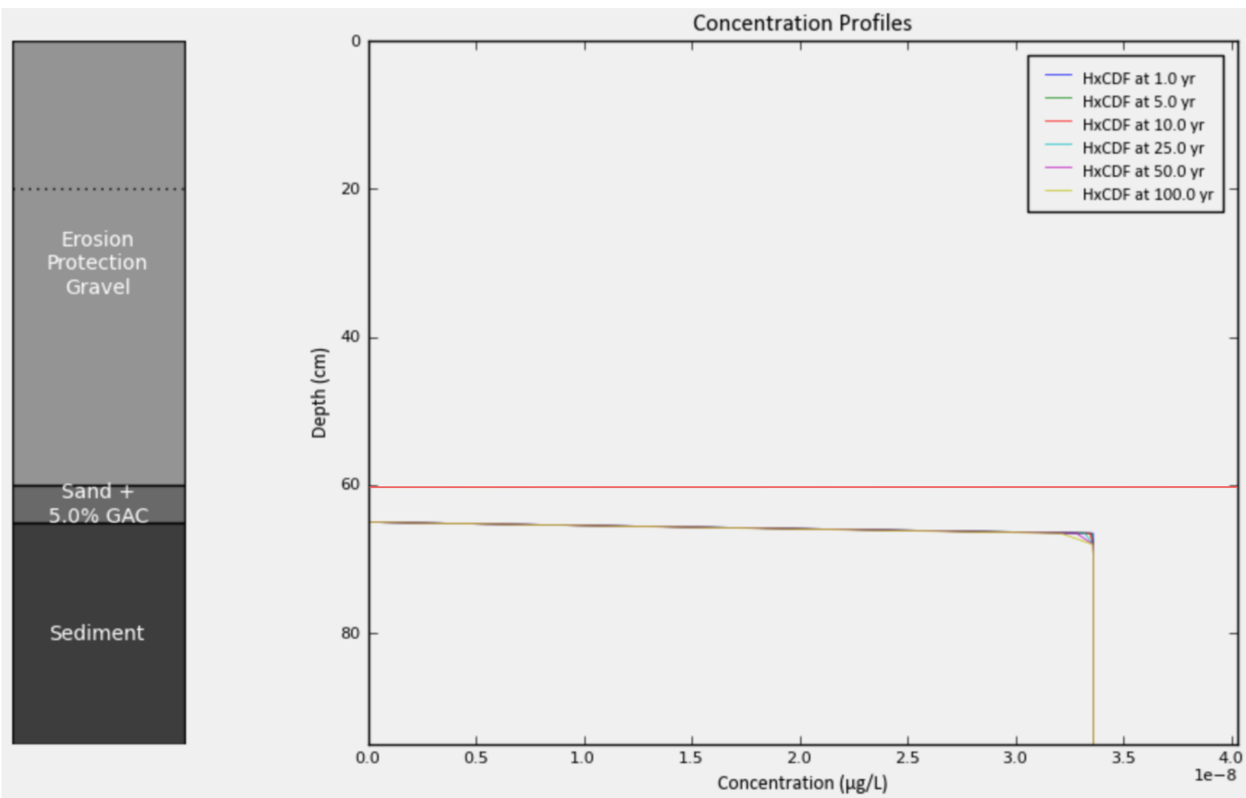

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
Depth (cm)
0
20
40
60
80
0.0000
0.0002
0.0004
0.0006
0.0008
Concentration (µg/L)

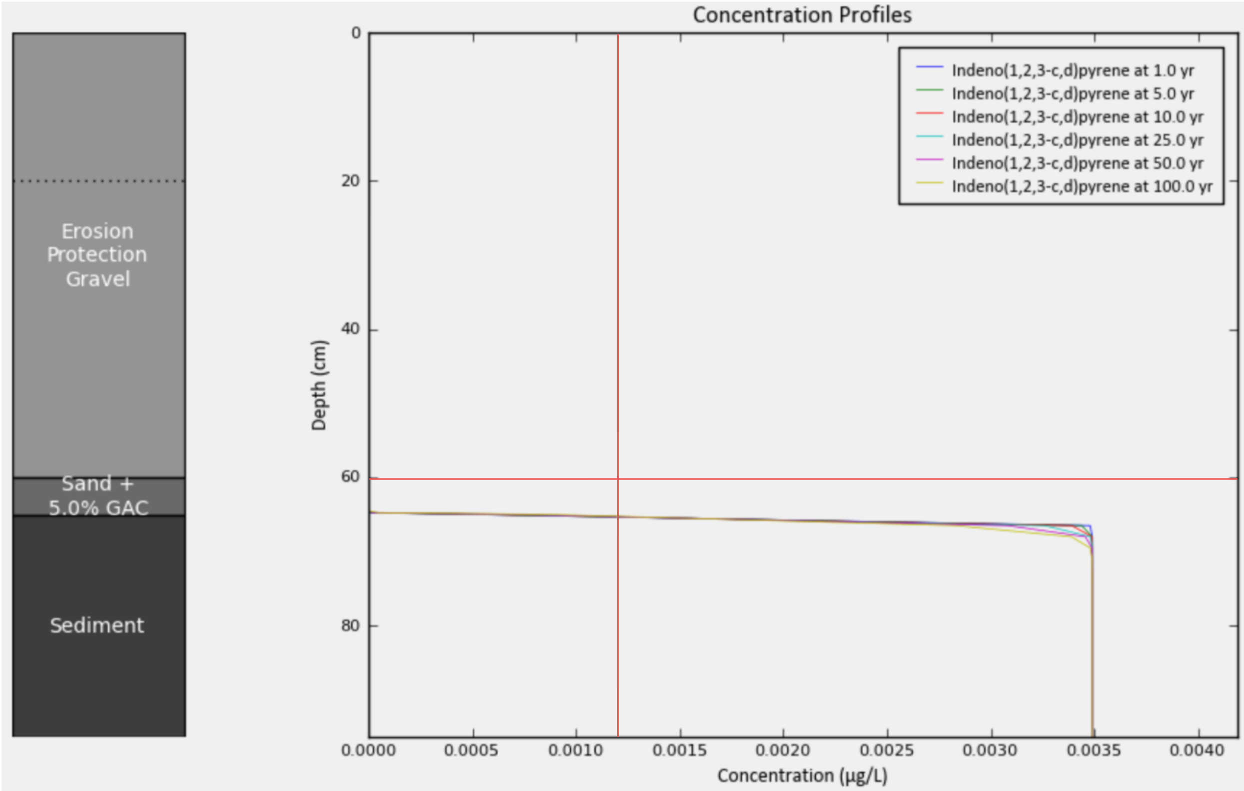

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
Depth (cm)
0
20
40
60
80
0.000
0.002
0.004
0.006
0.008
0.010
Concentration (µg/L)

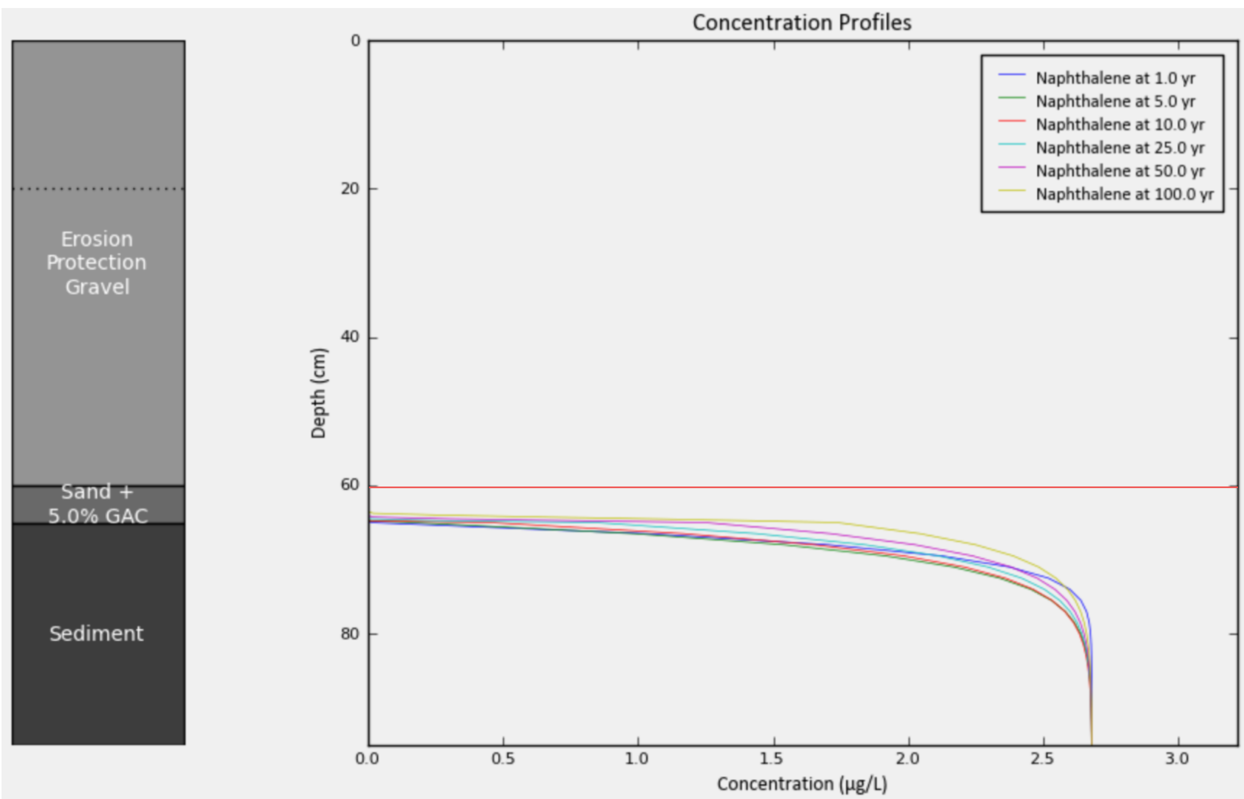

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
0
20
40
60
80
0.0000
0.0005
0.0010
0.0015
0.0020
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr

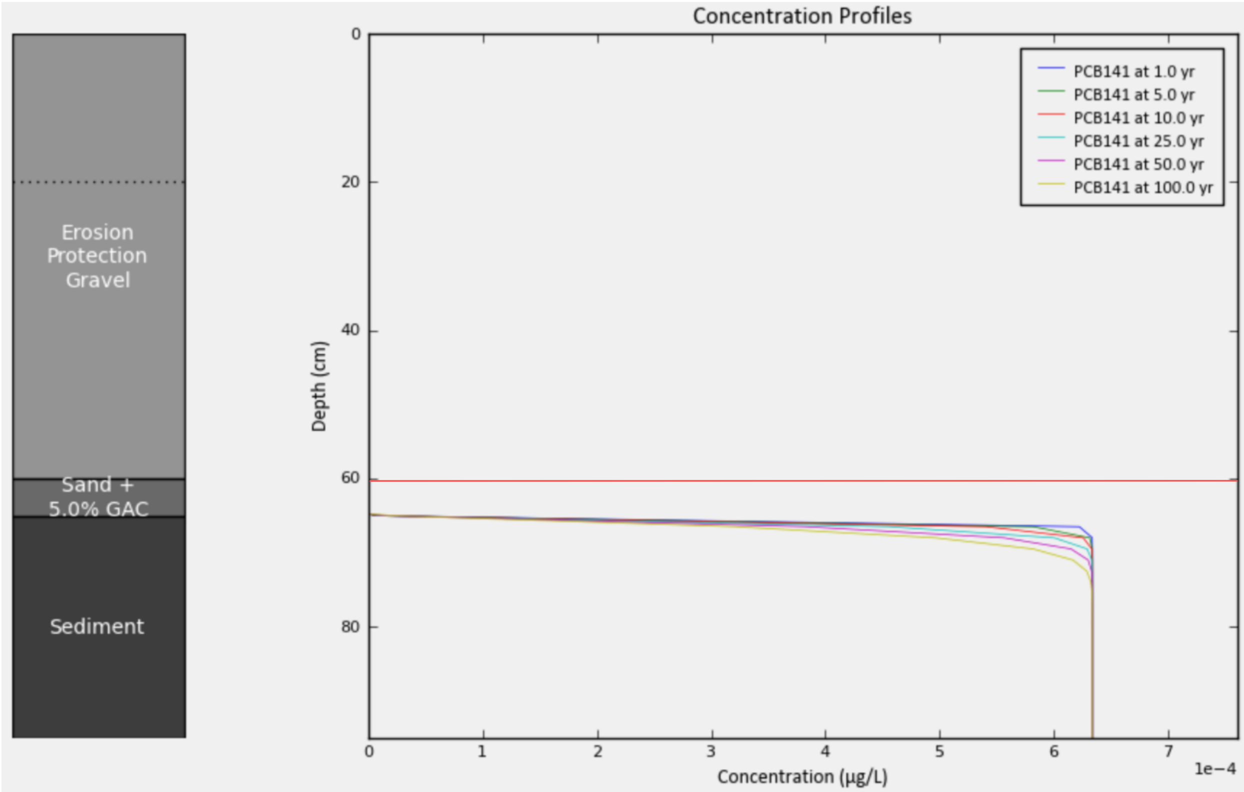

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
0
20
40
60
80
0.0
0.2
0.4
0.6
0.8
1.0
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr

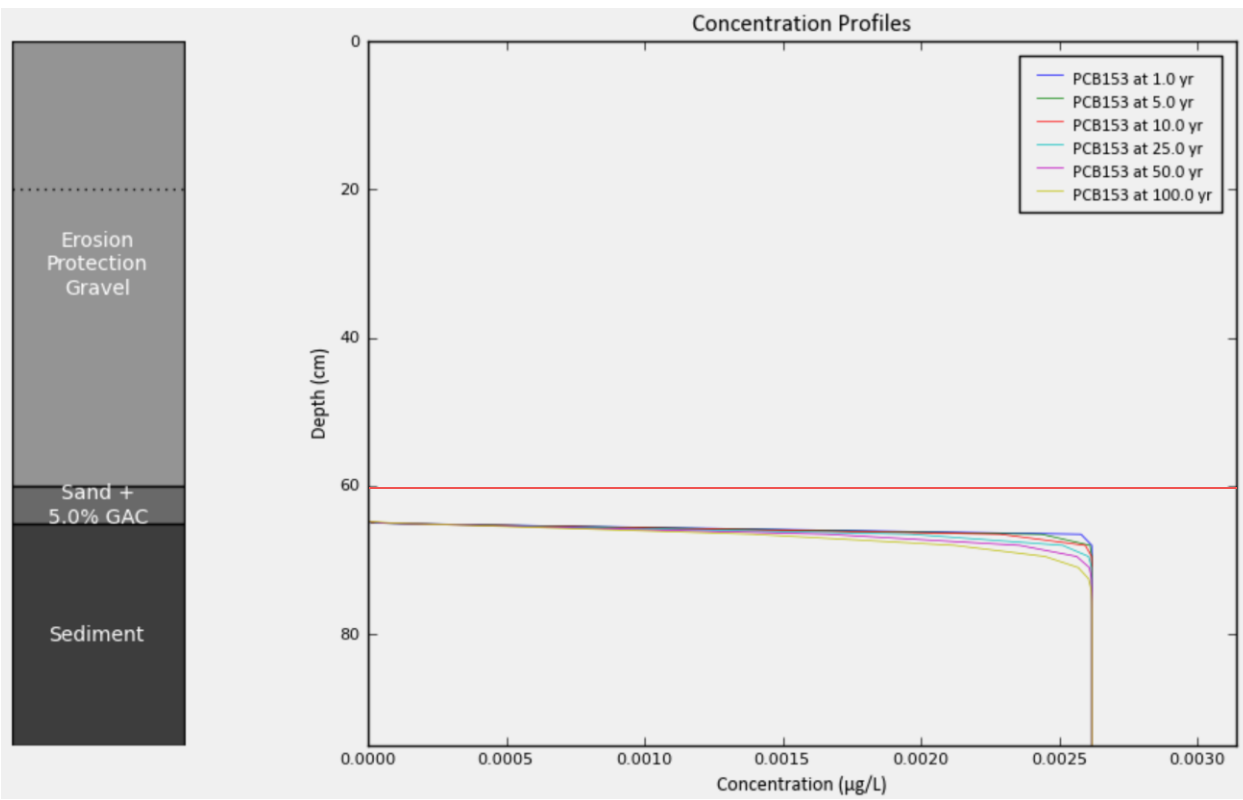

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr
Depth (cm)
Concentration (μg/L)

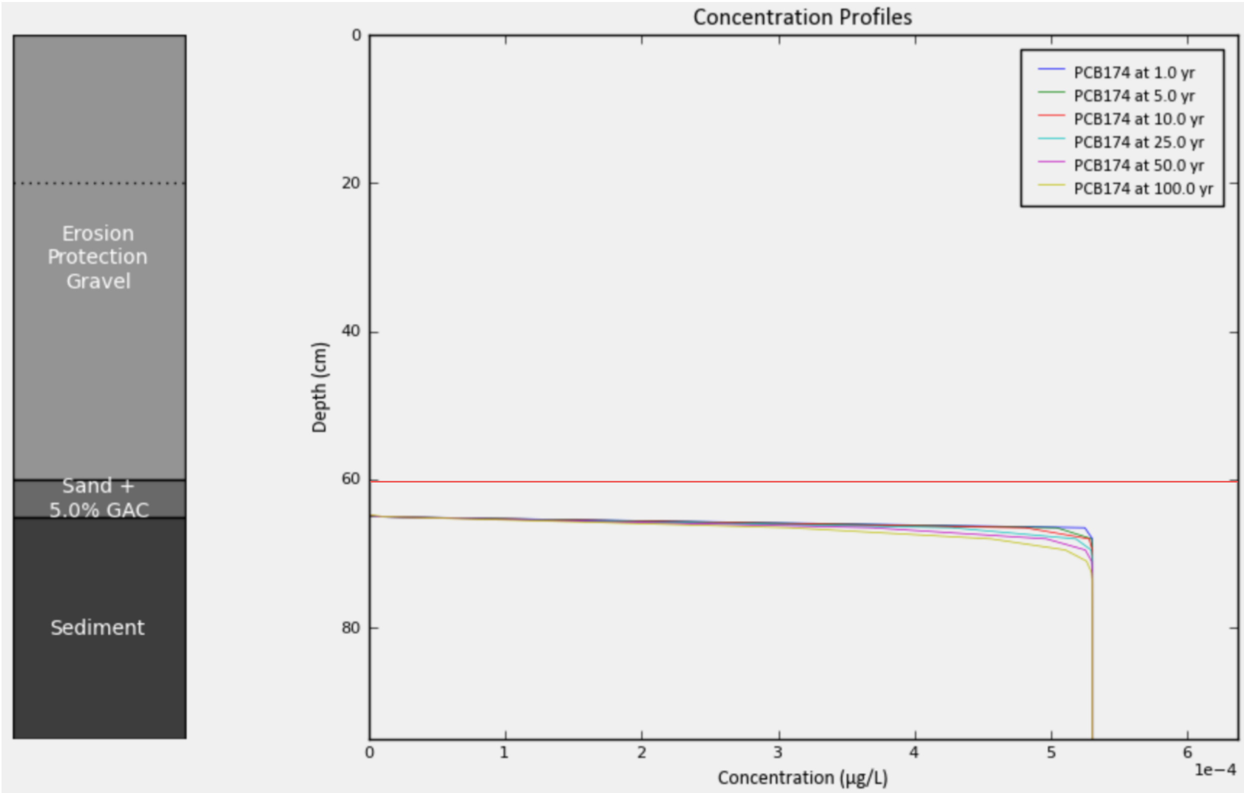

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−8

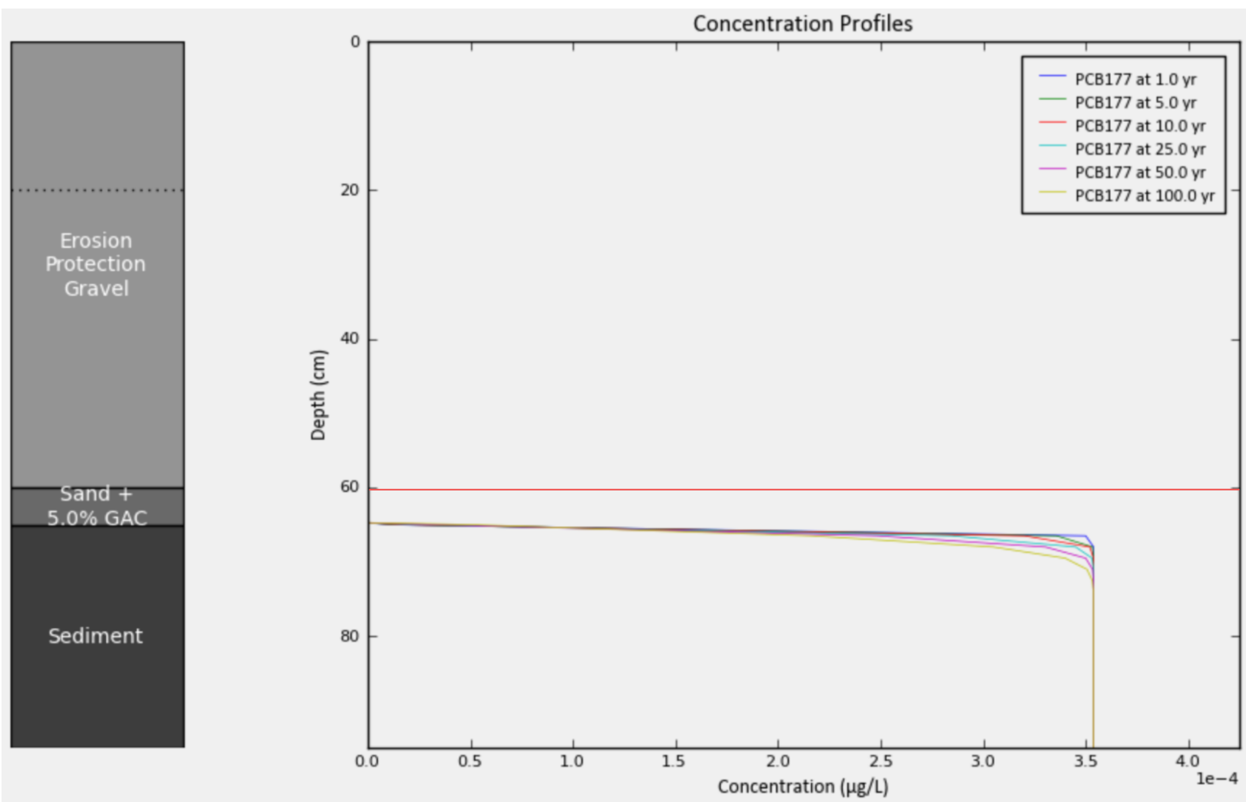

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr

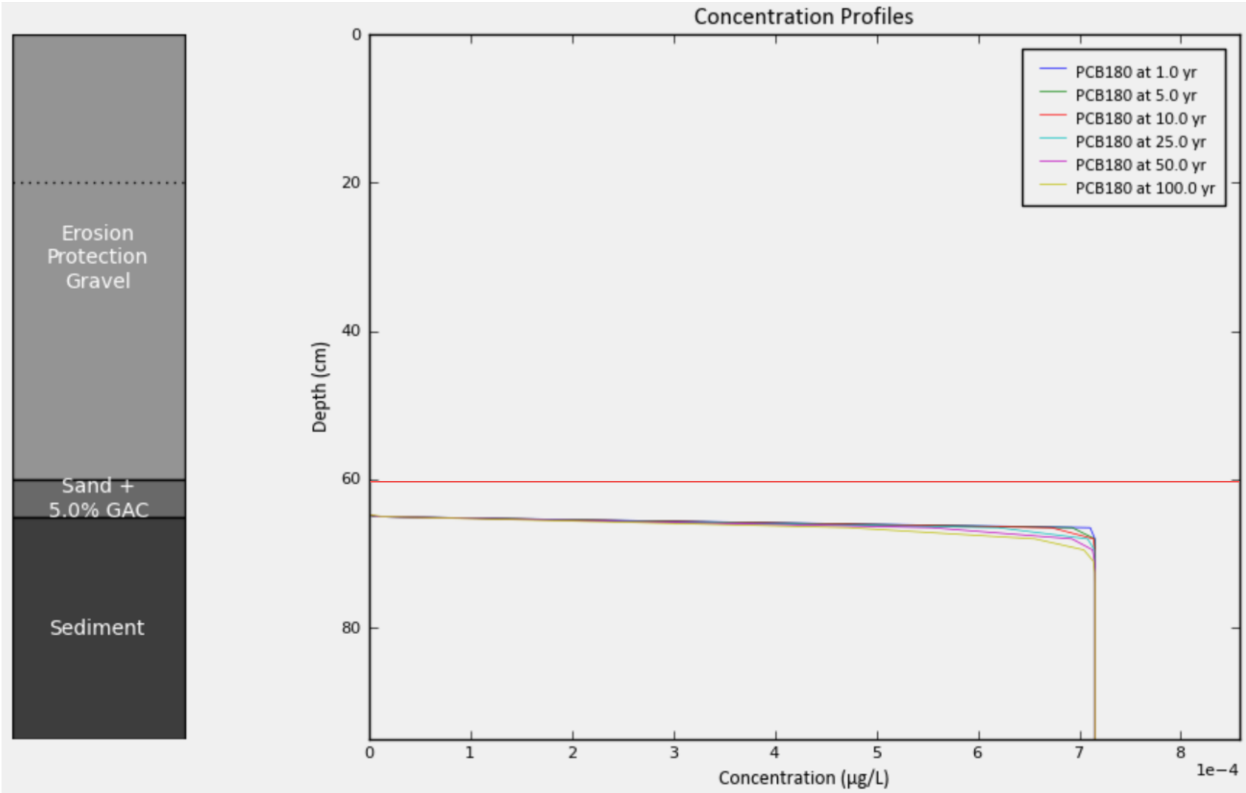

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr

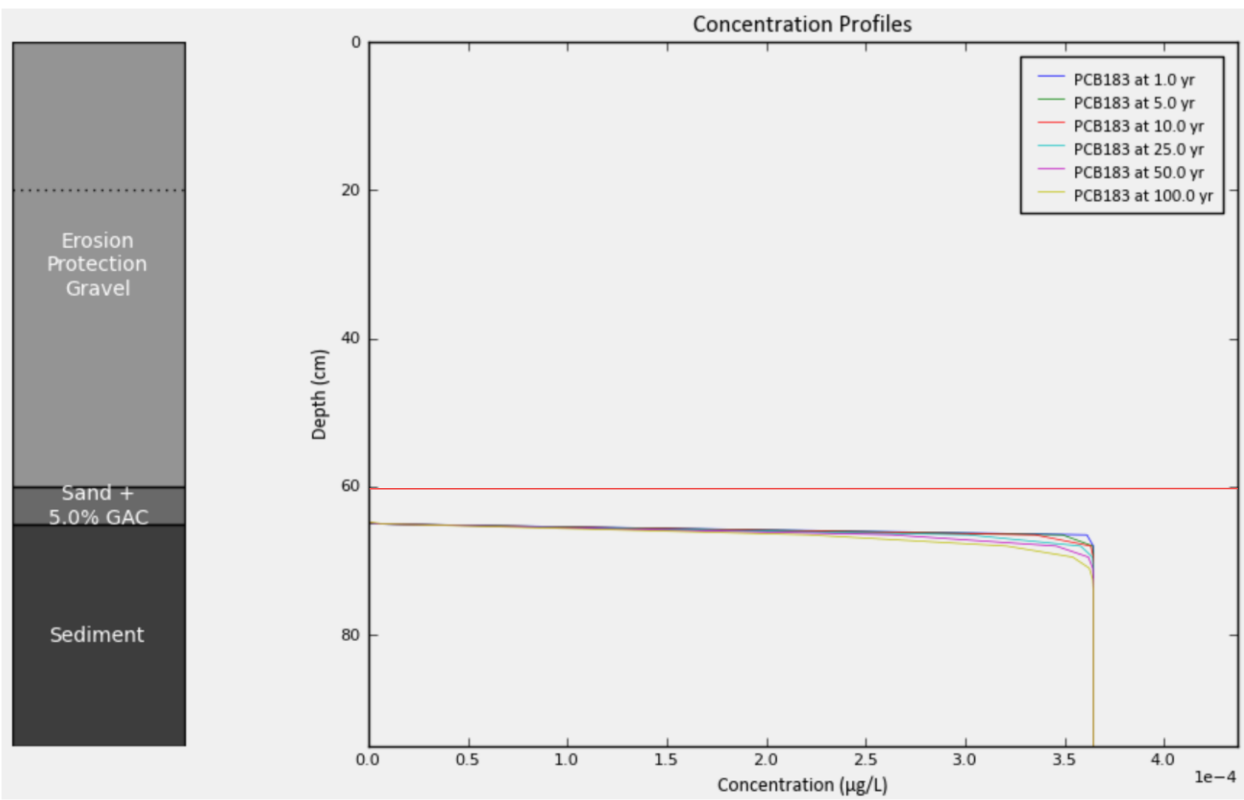

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr

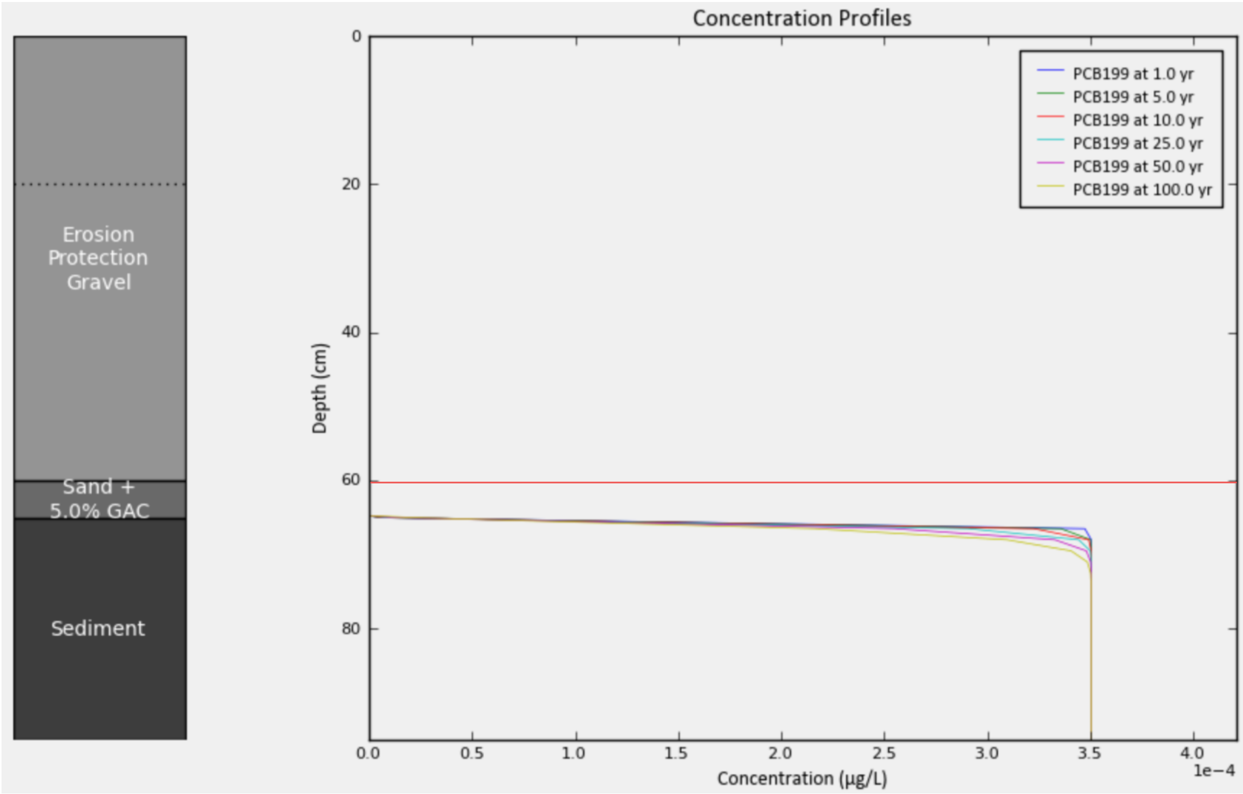

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr

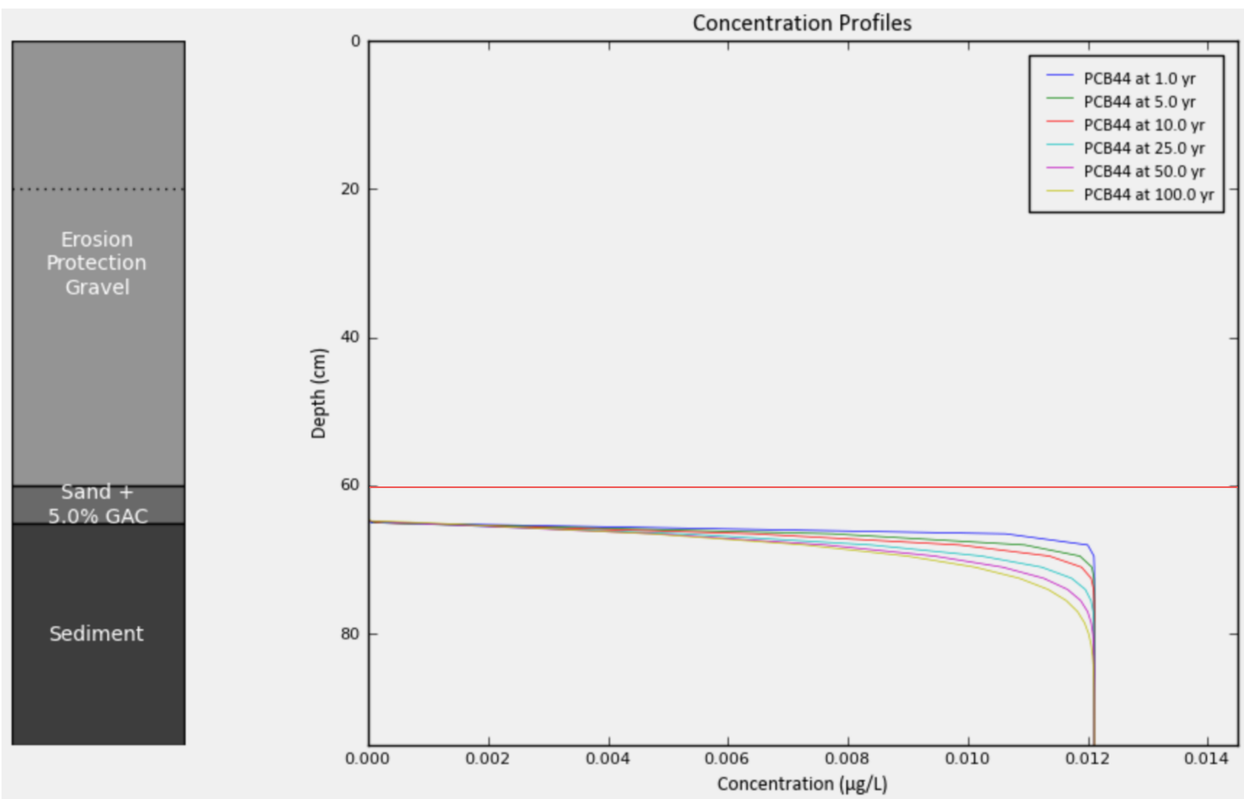

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr

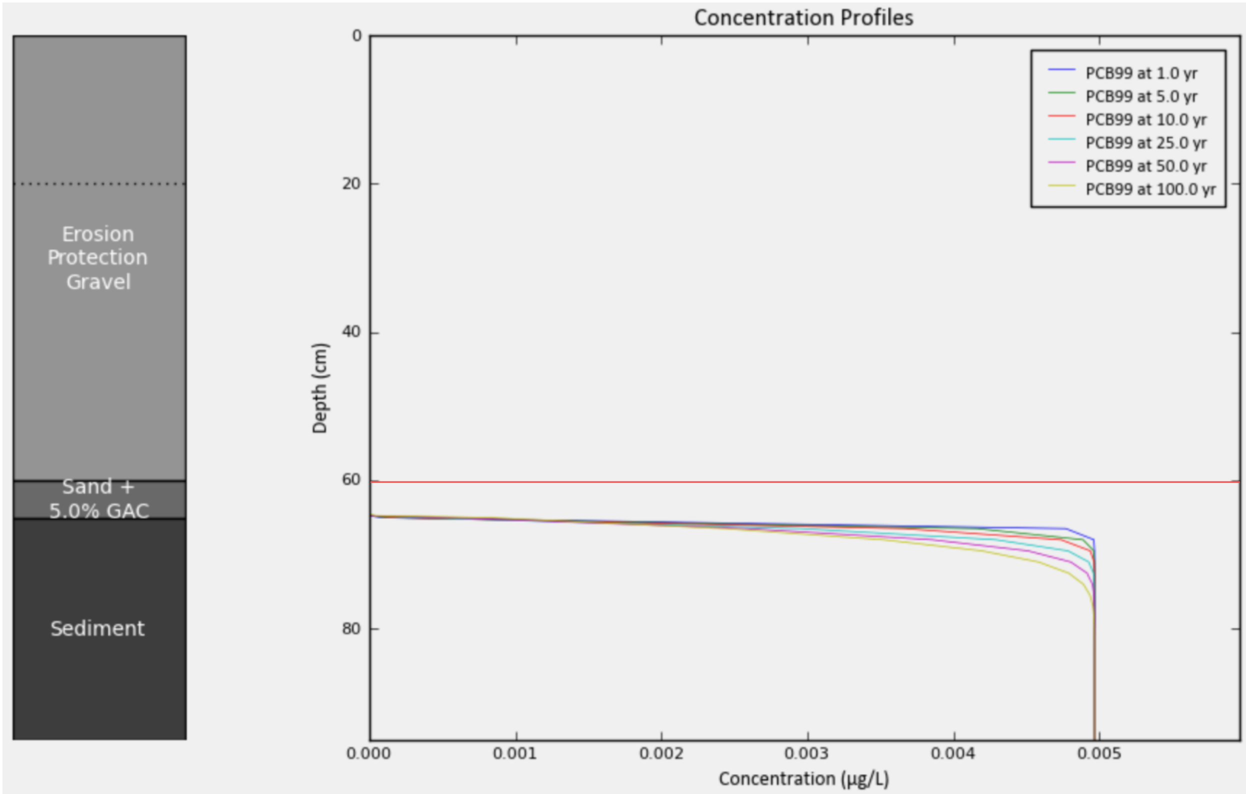

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr

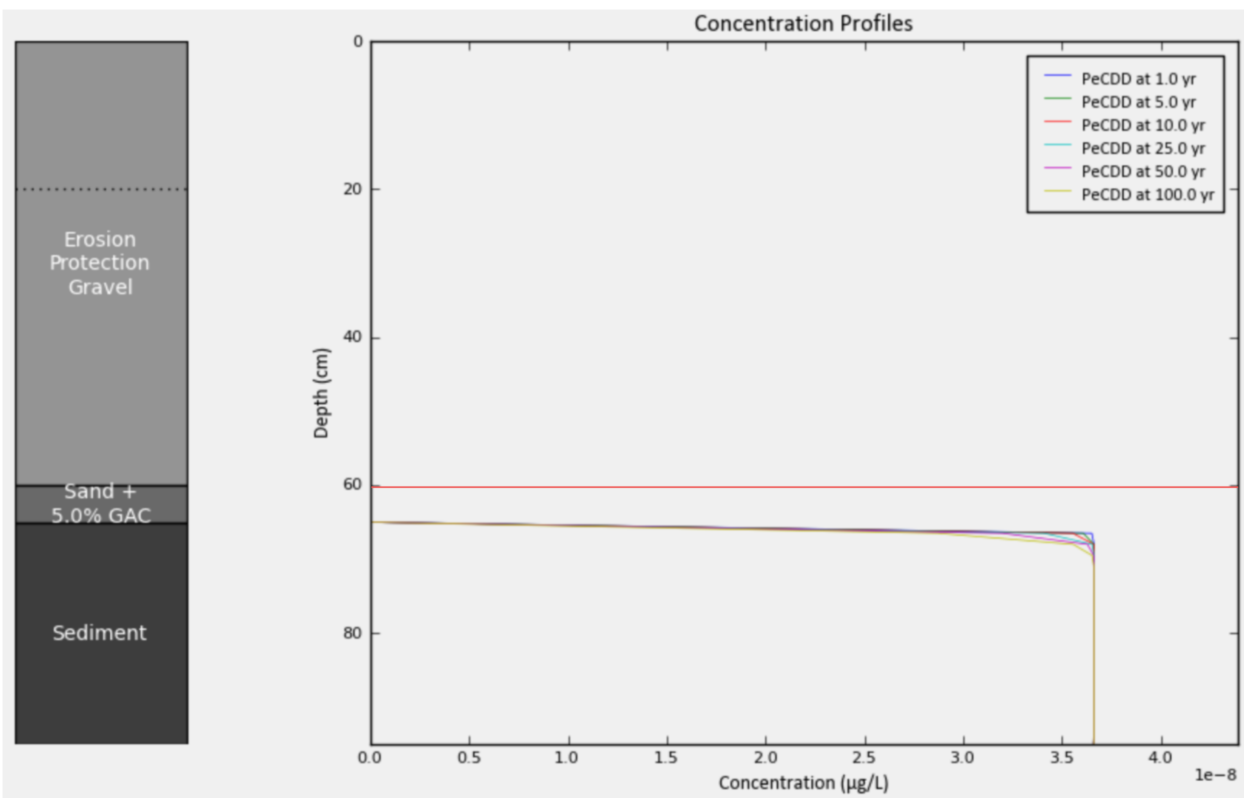

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr

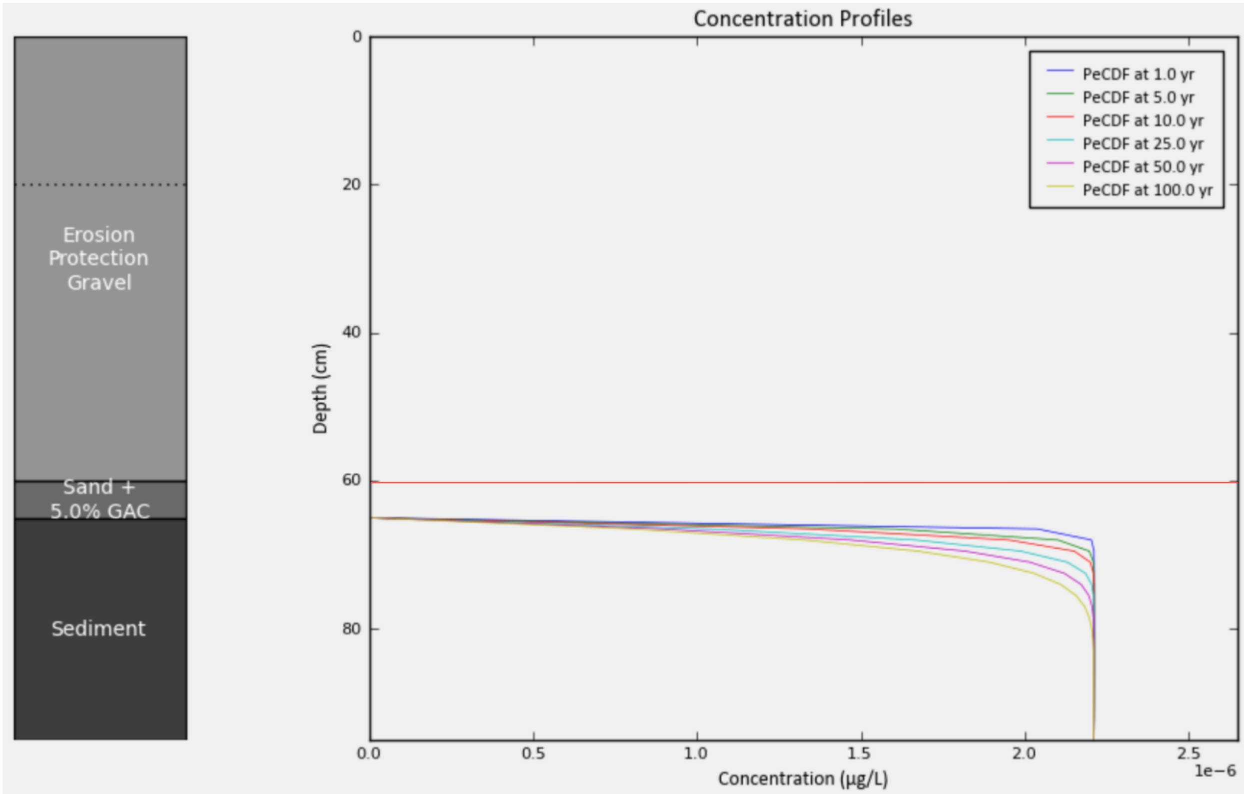

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr

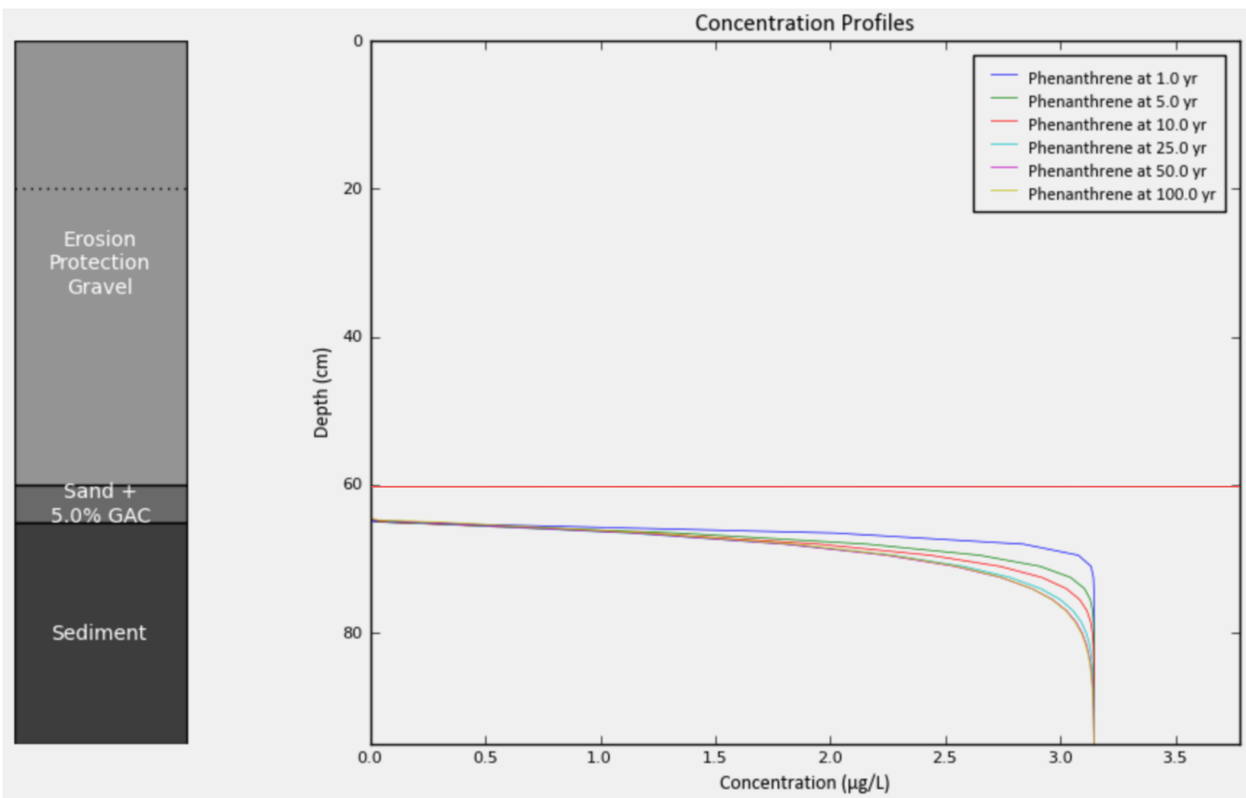

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
1e−4
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr

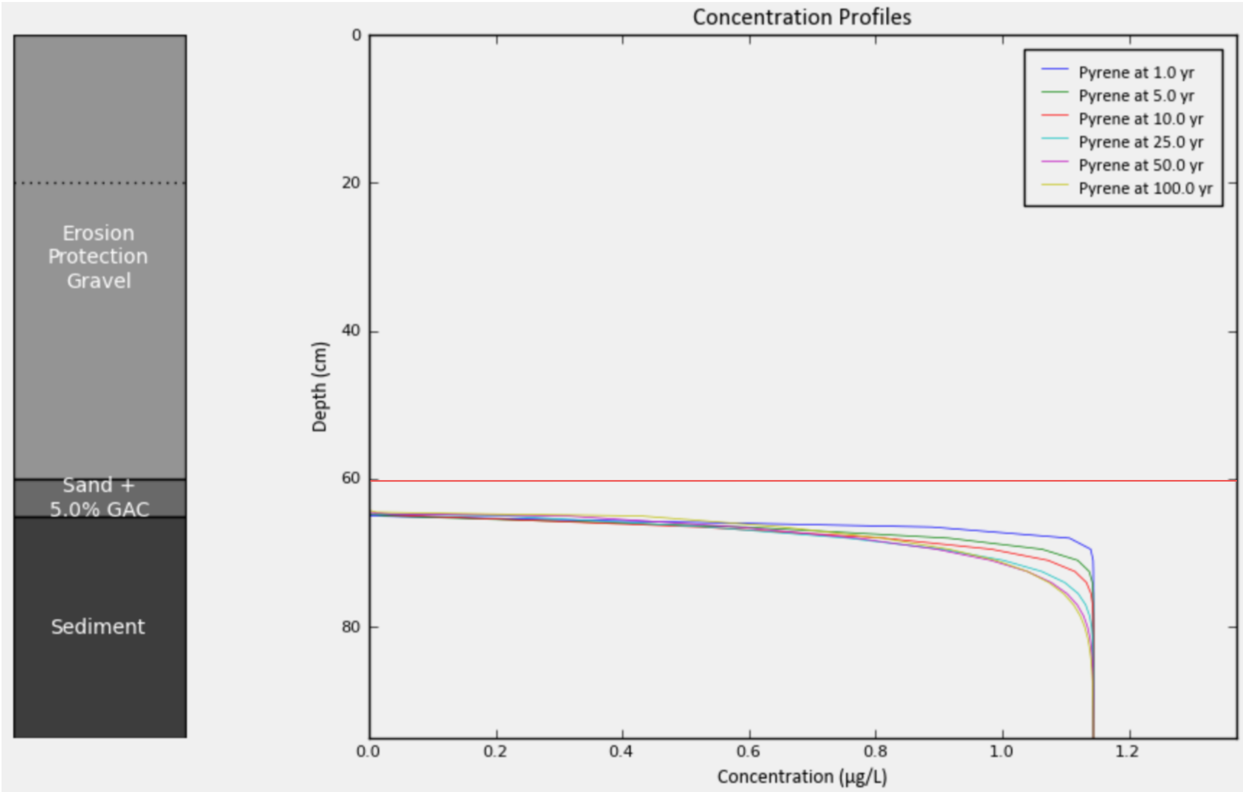

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr

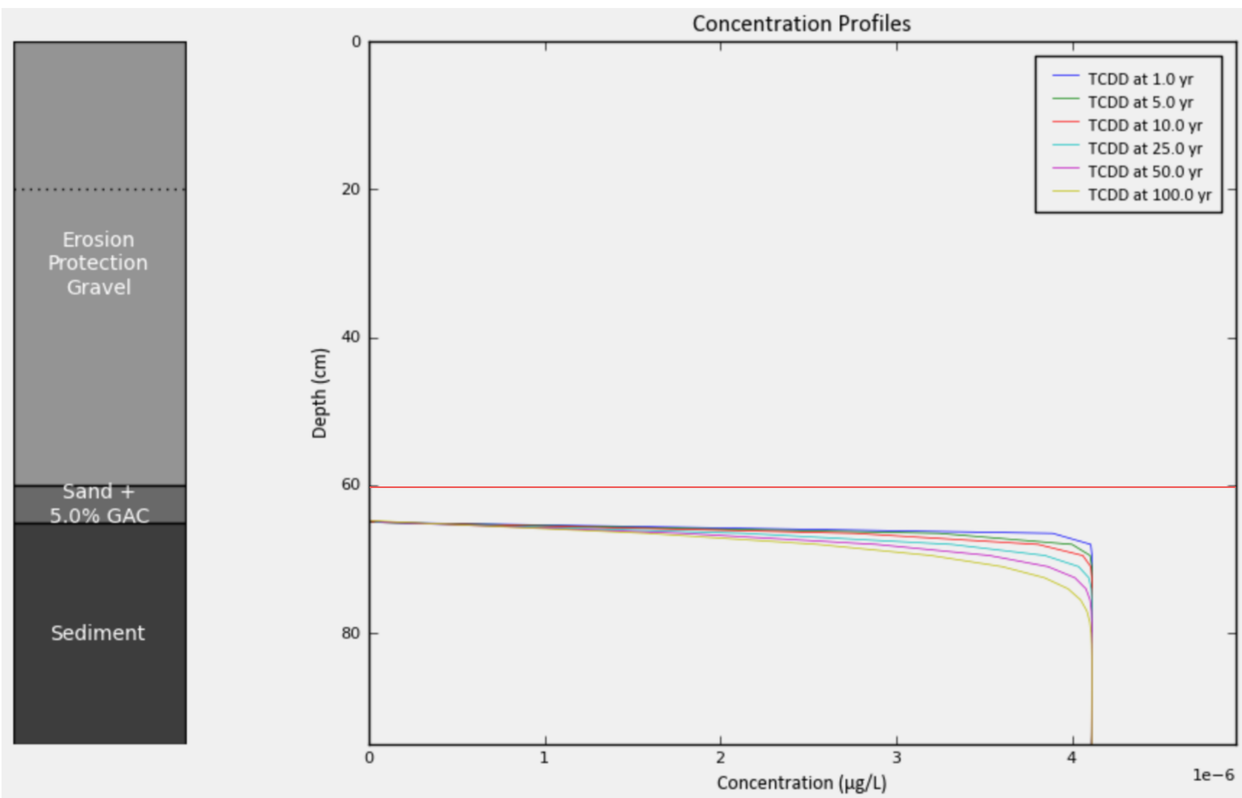

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr

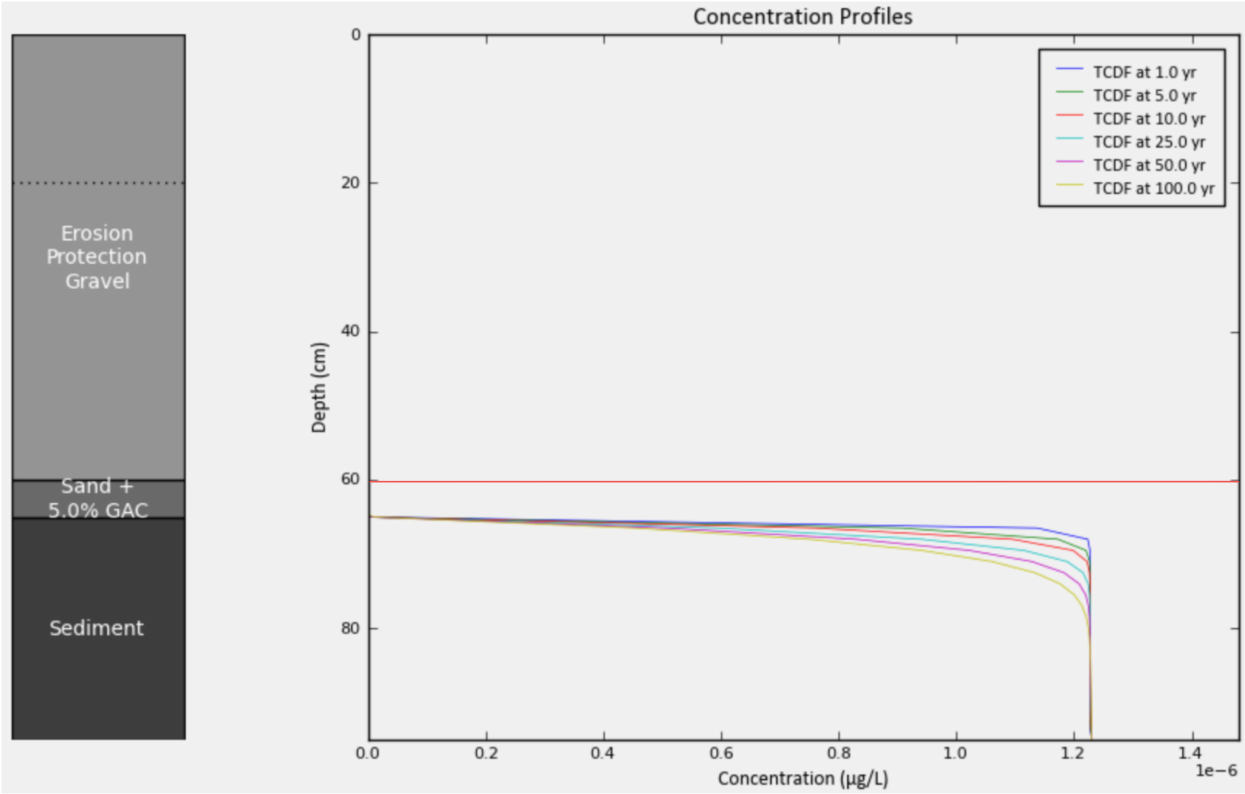

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−8
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr

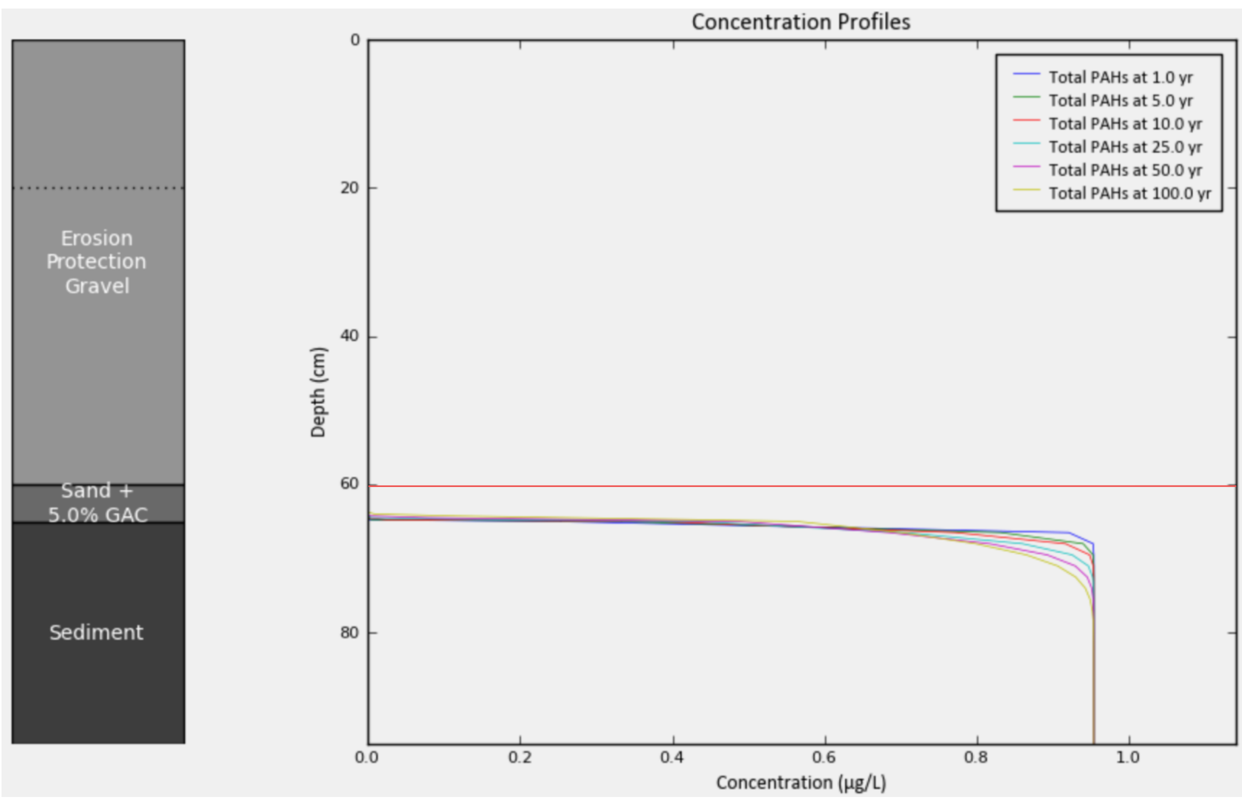

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr

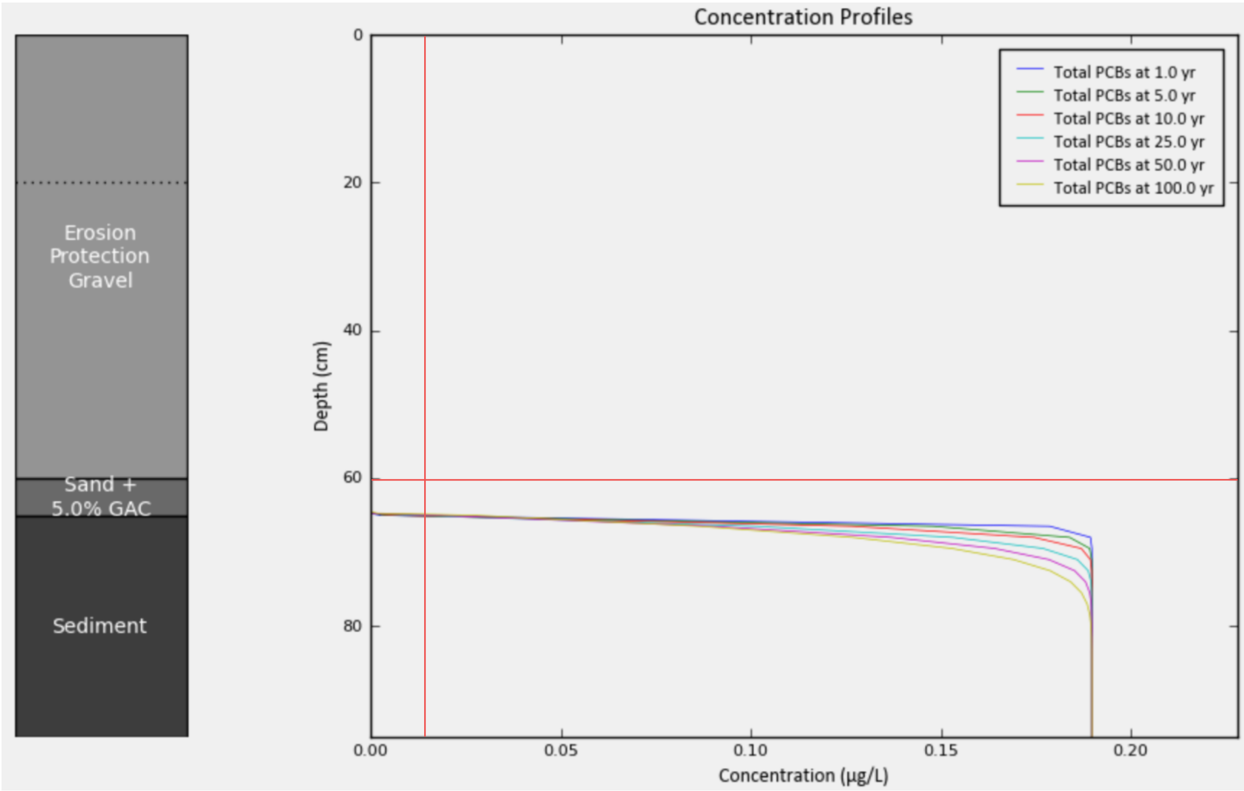

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr

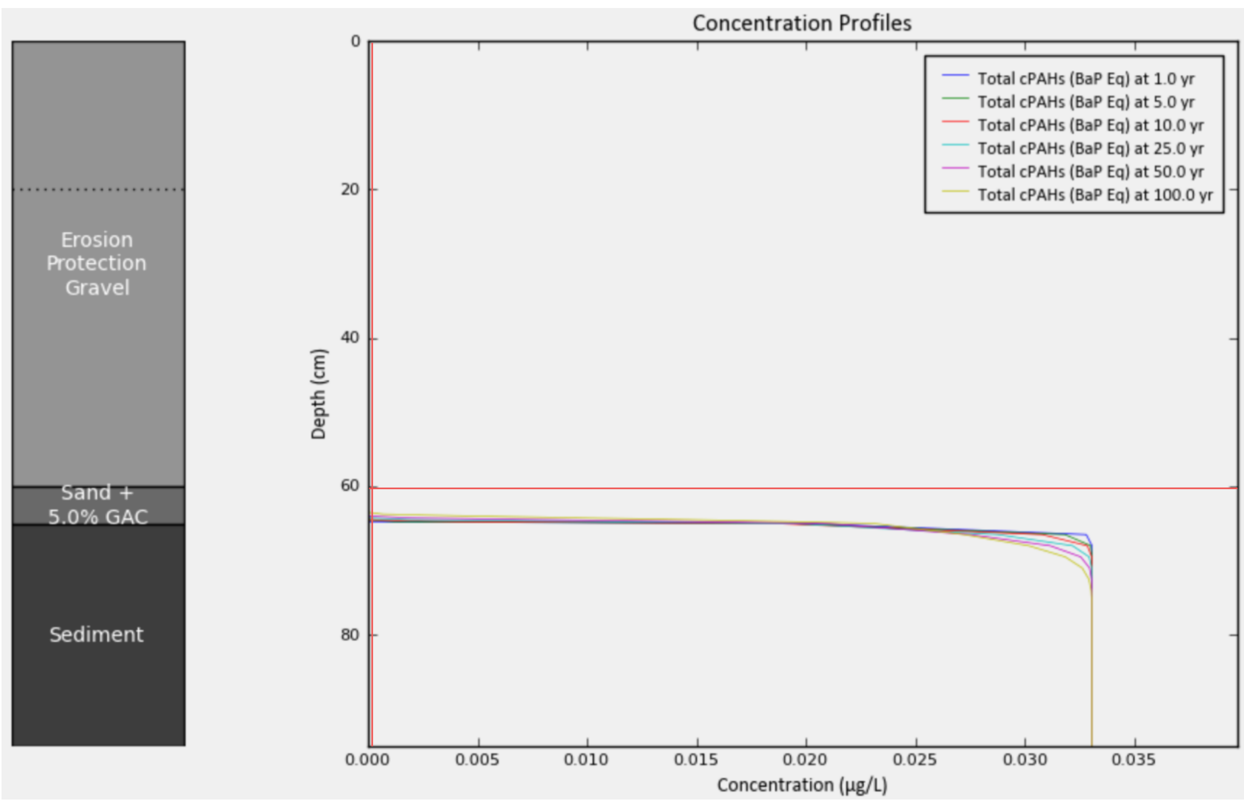

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr


Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr

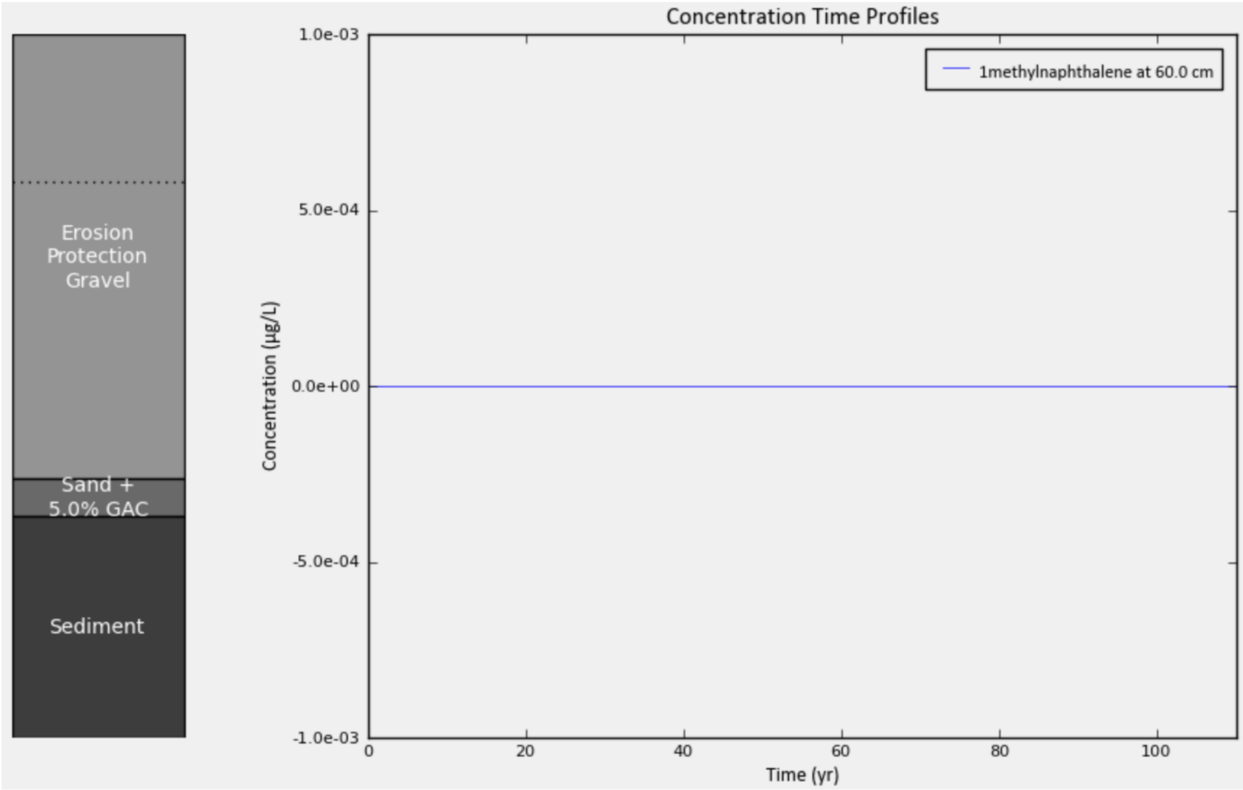

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

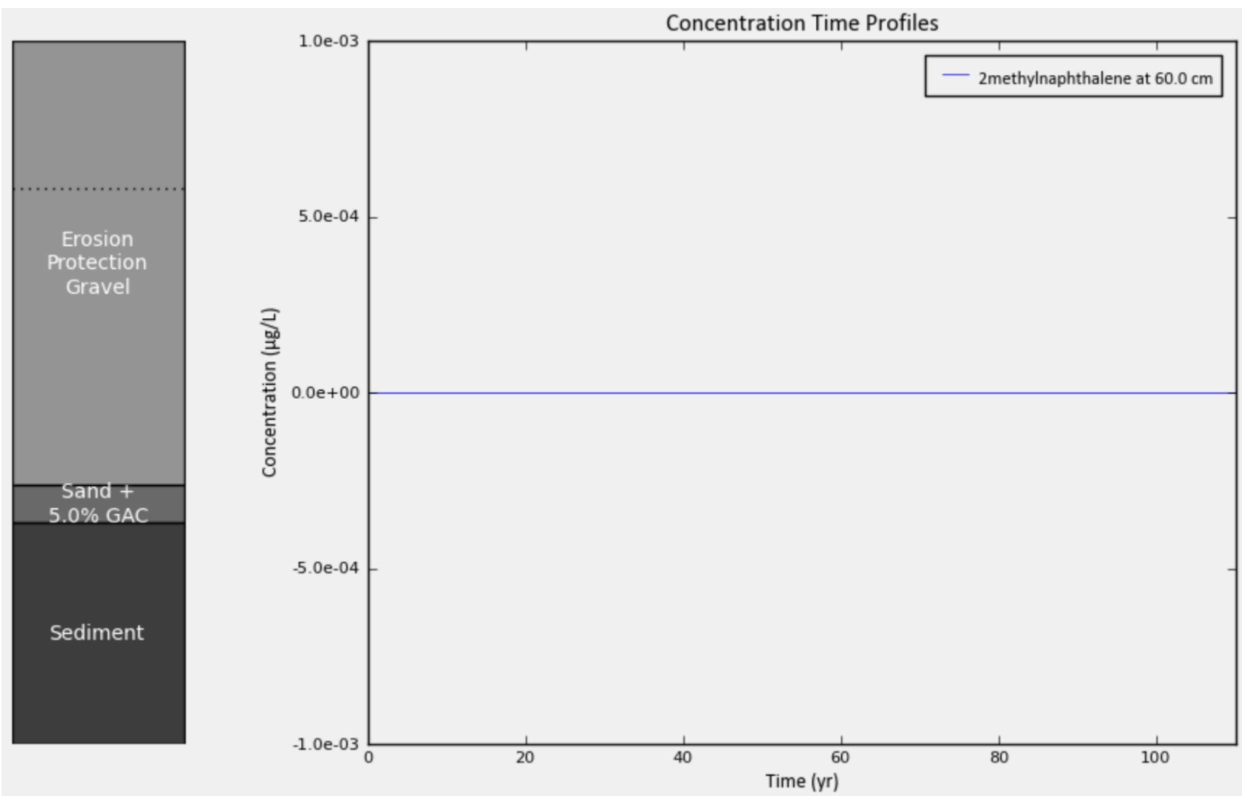

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

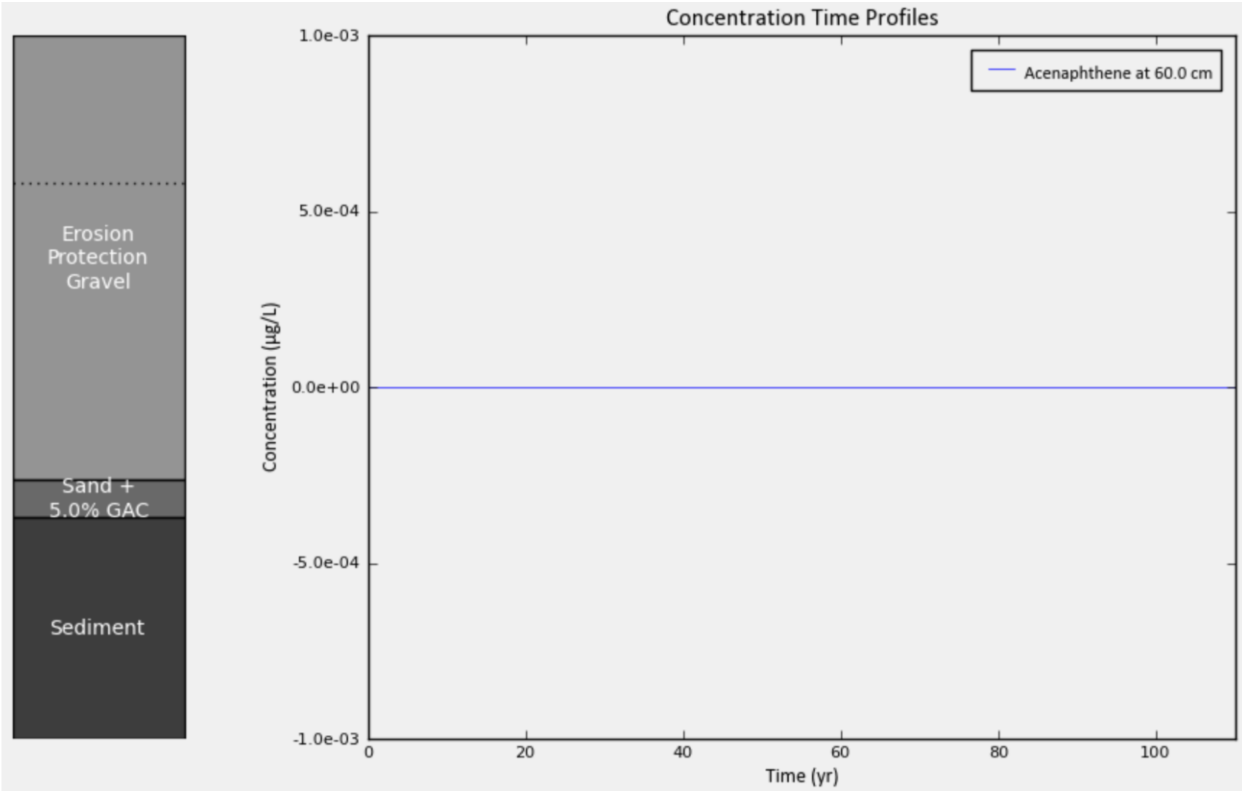

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr

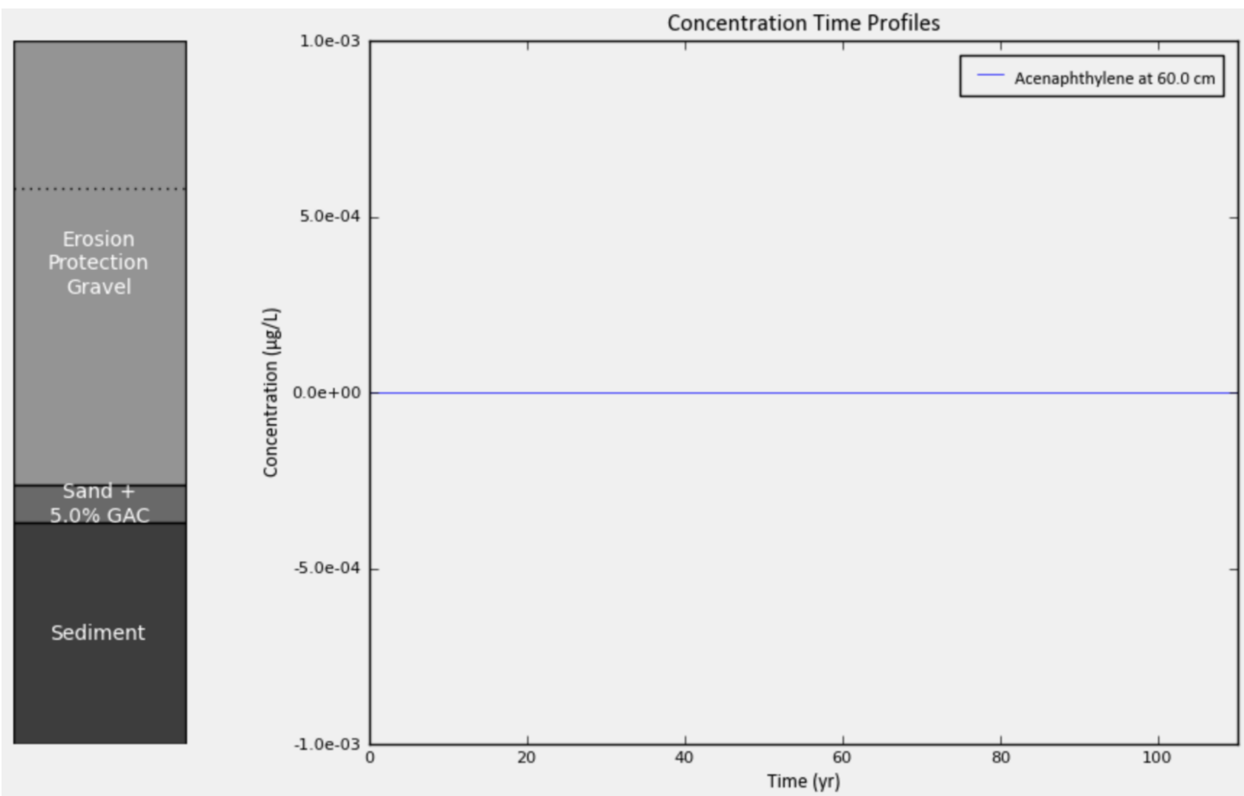

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr

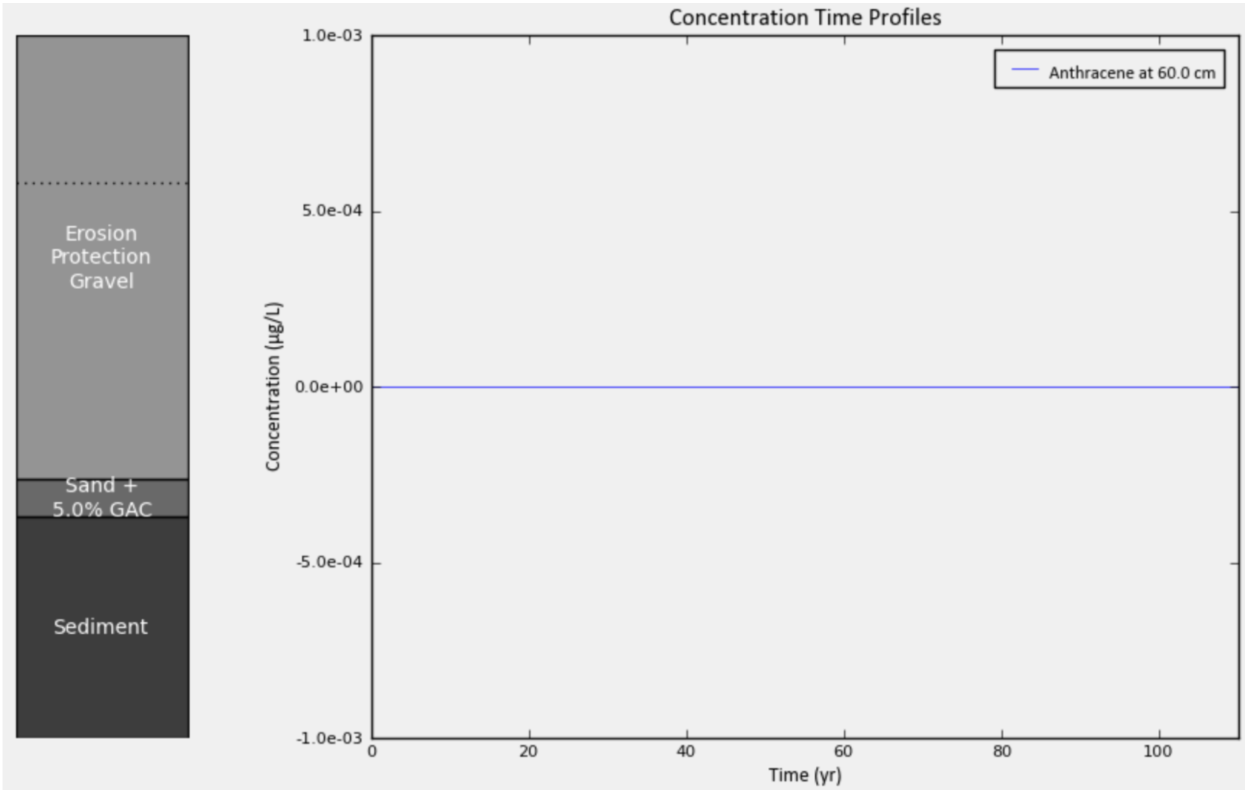
Porewater Concentration – Time

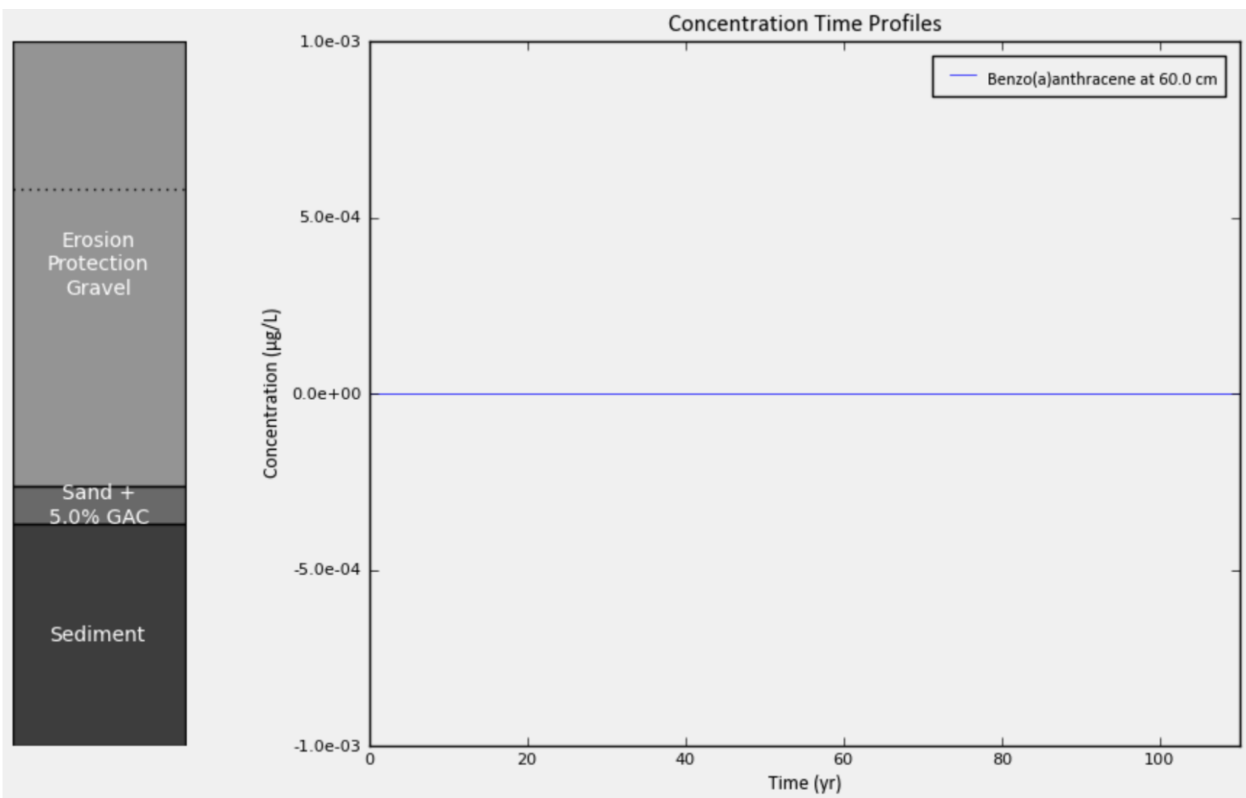


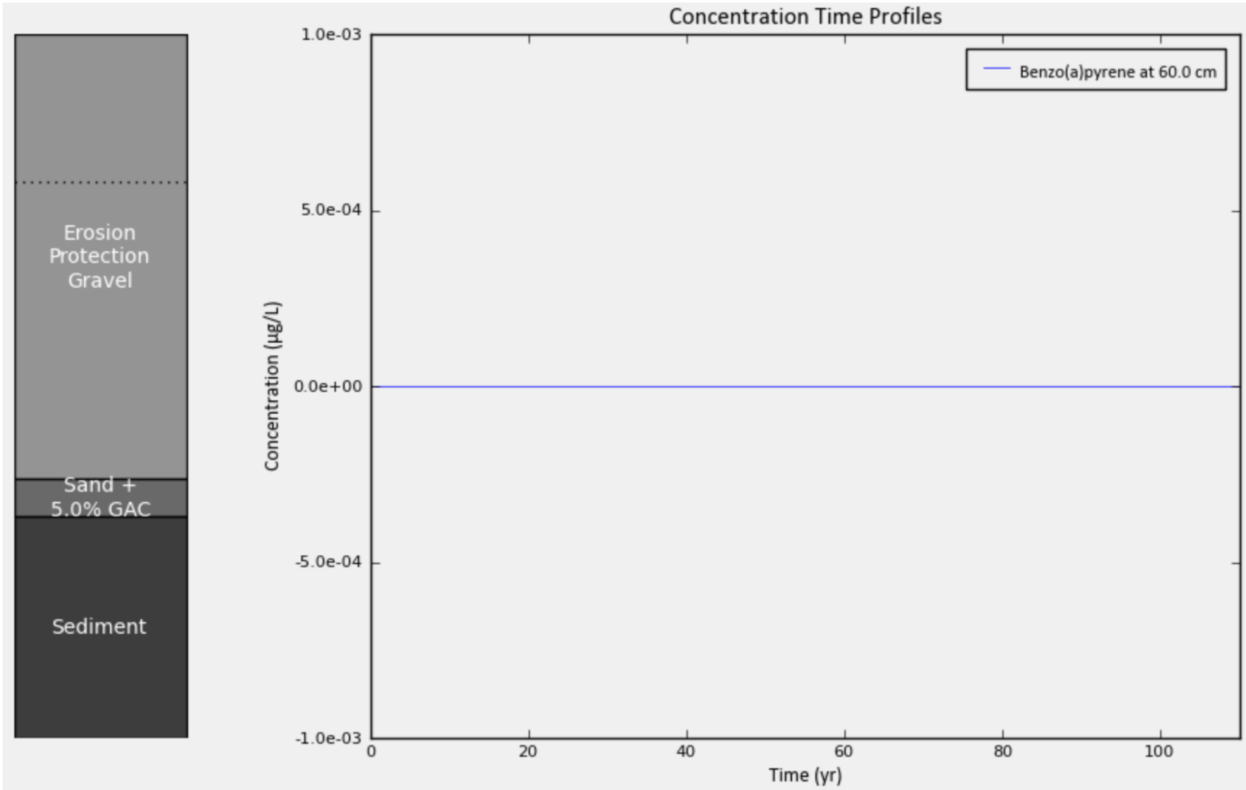


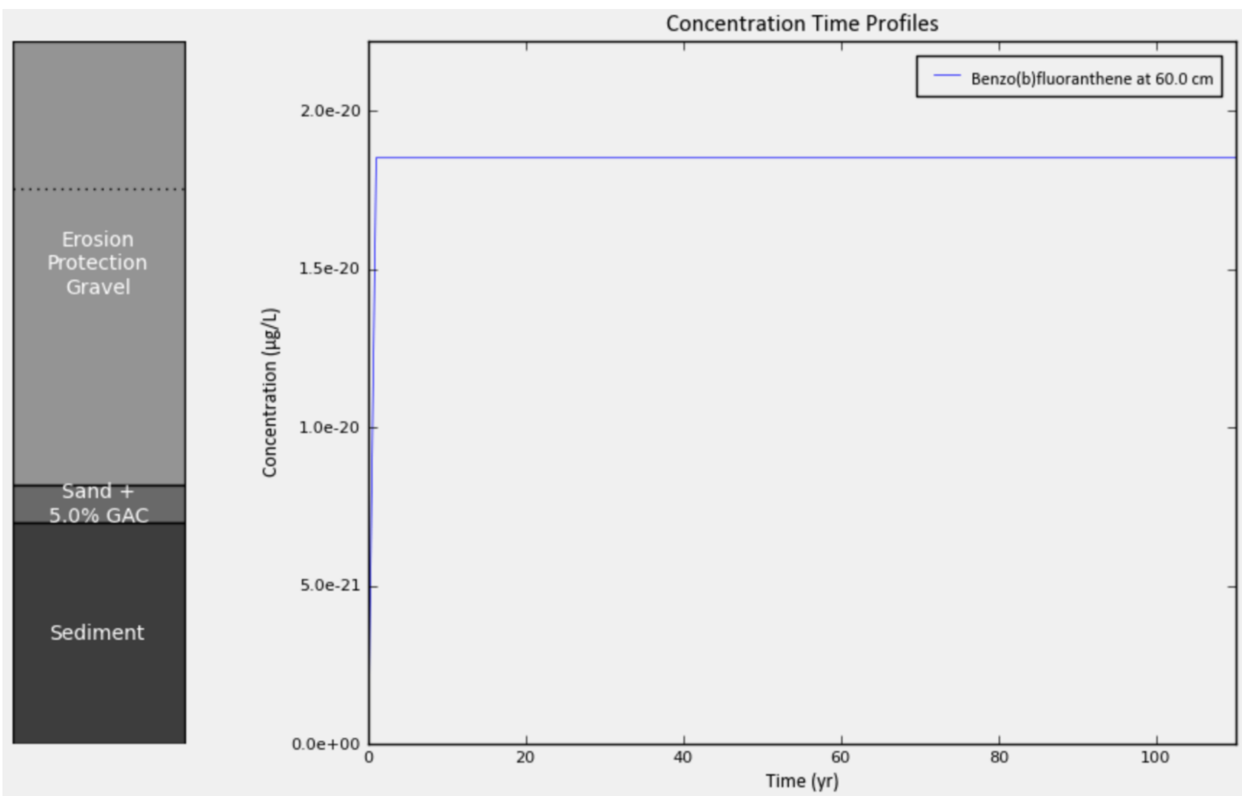

Concentration Time Profiles
Acenaphthene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

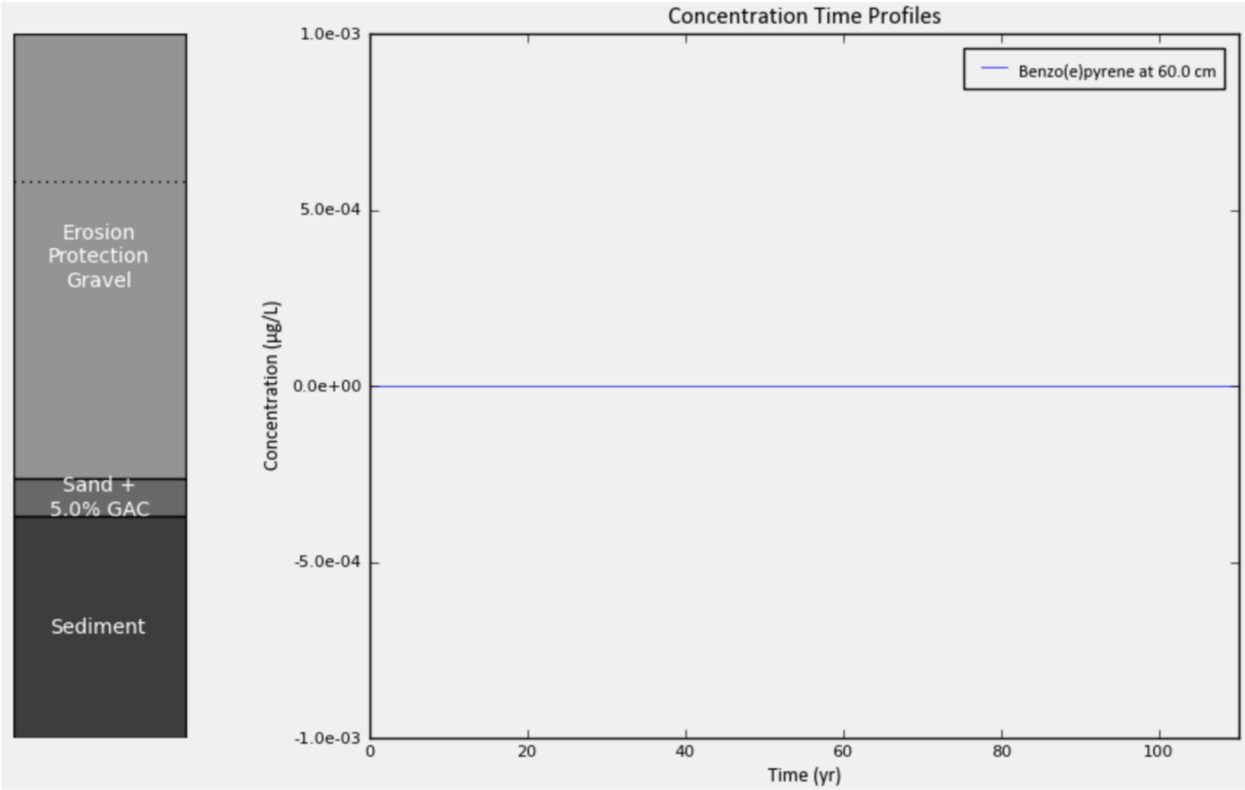

Concentration Time Profiles
Acenaphthylene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

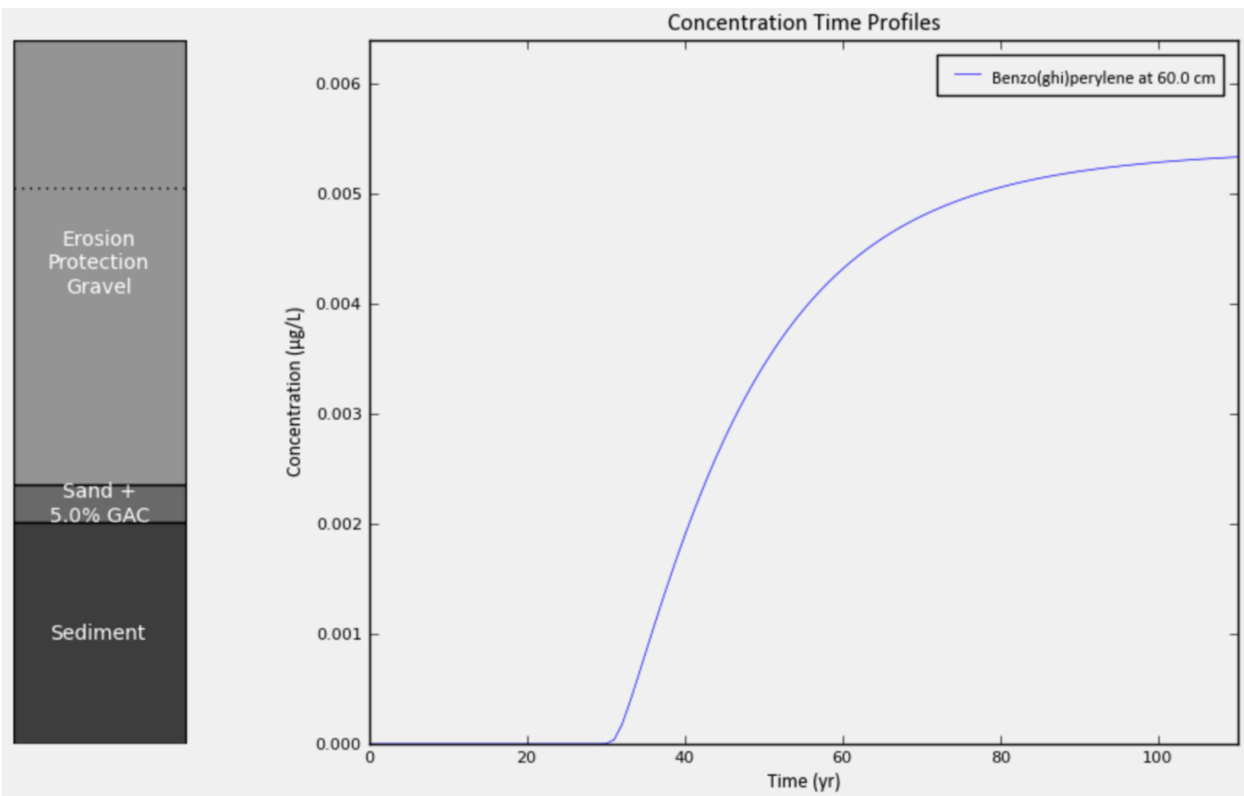

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

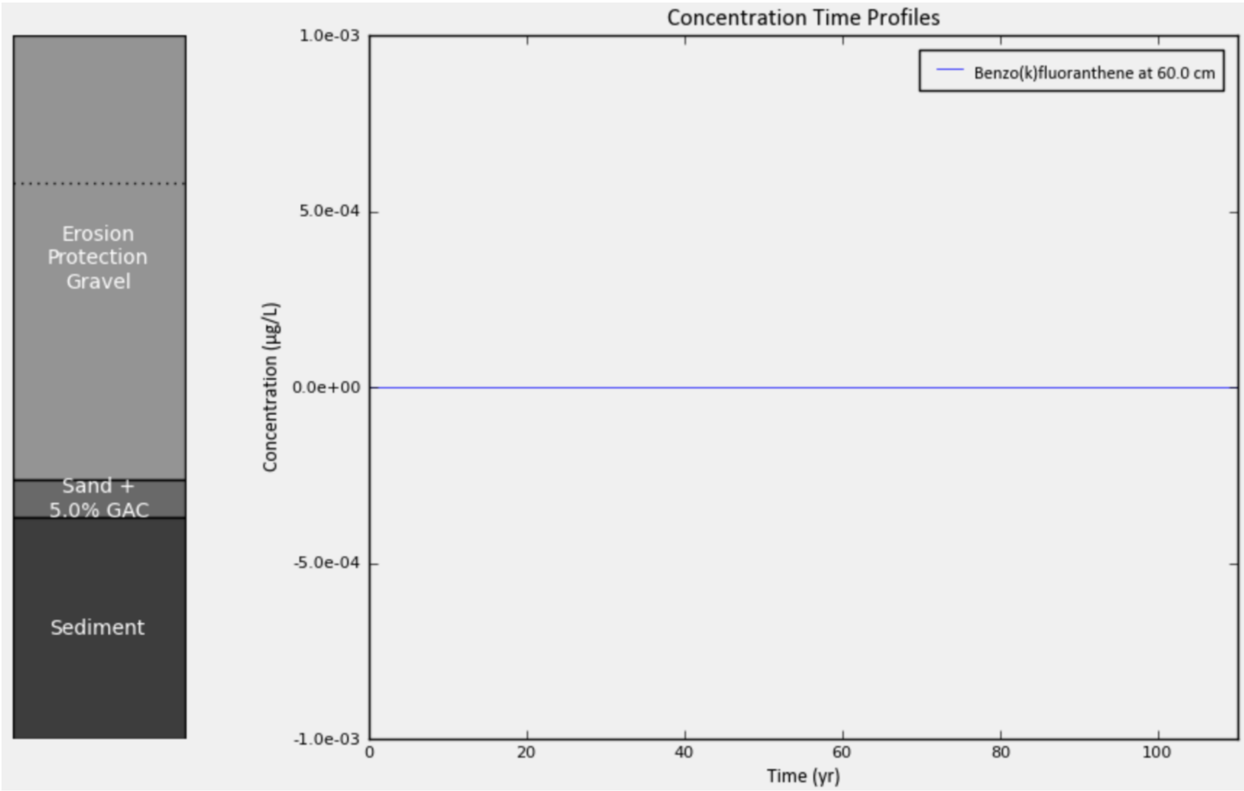

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

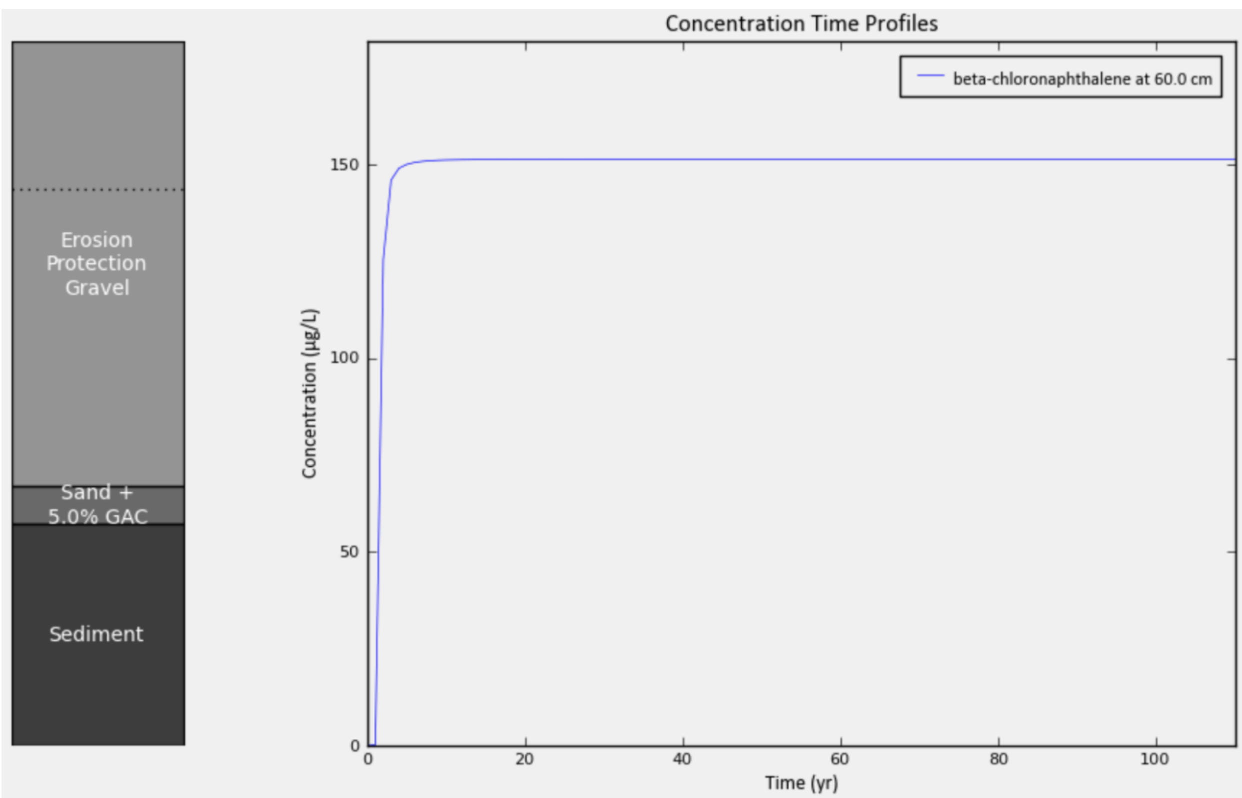

Concentration Time Profiles
Benzo(a)pyrene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

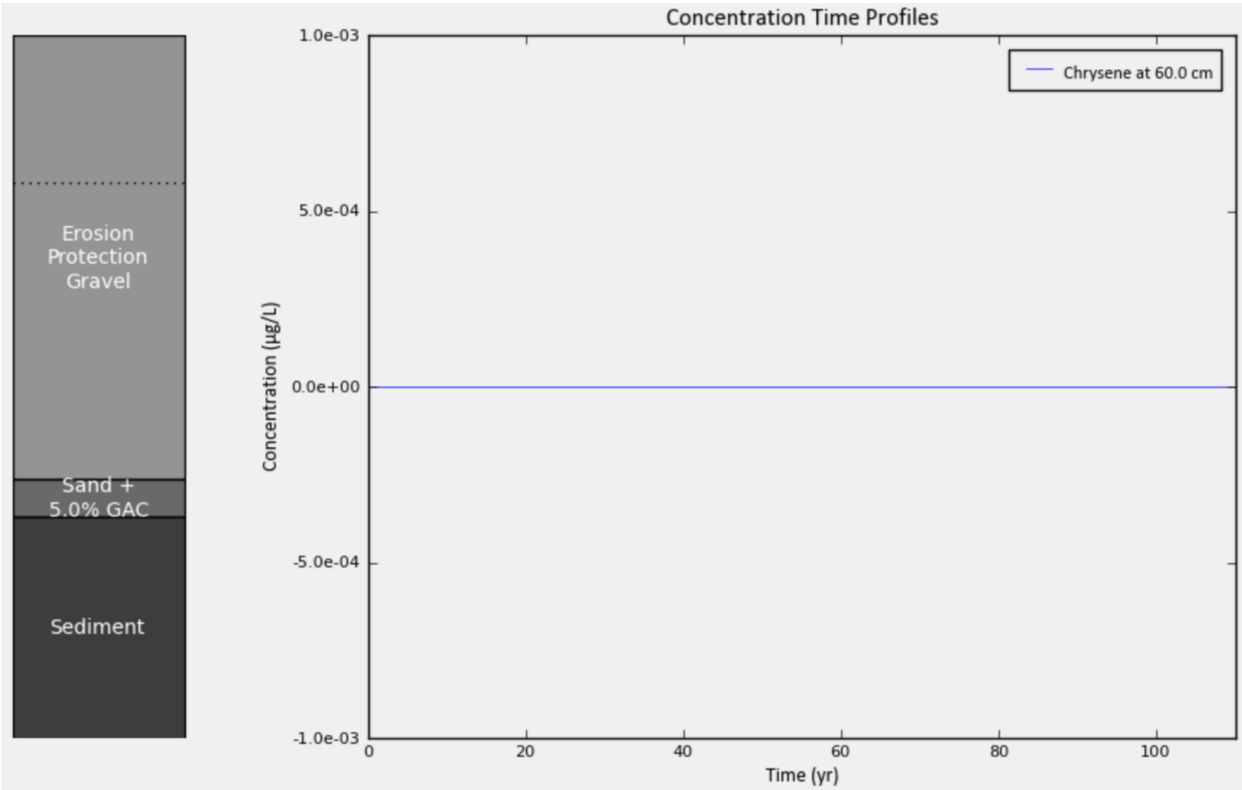

Concentration Time Profiles
Benzo(b)fluoranthene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
2.0e-20
1.5e-20
1.0e-20
5.0e-21
0.0e+00
0
20
40
60
80
100
Time (yr)

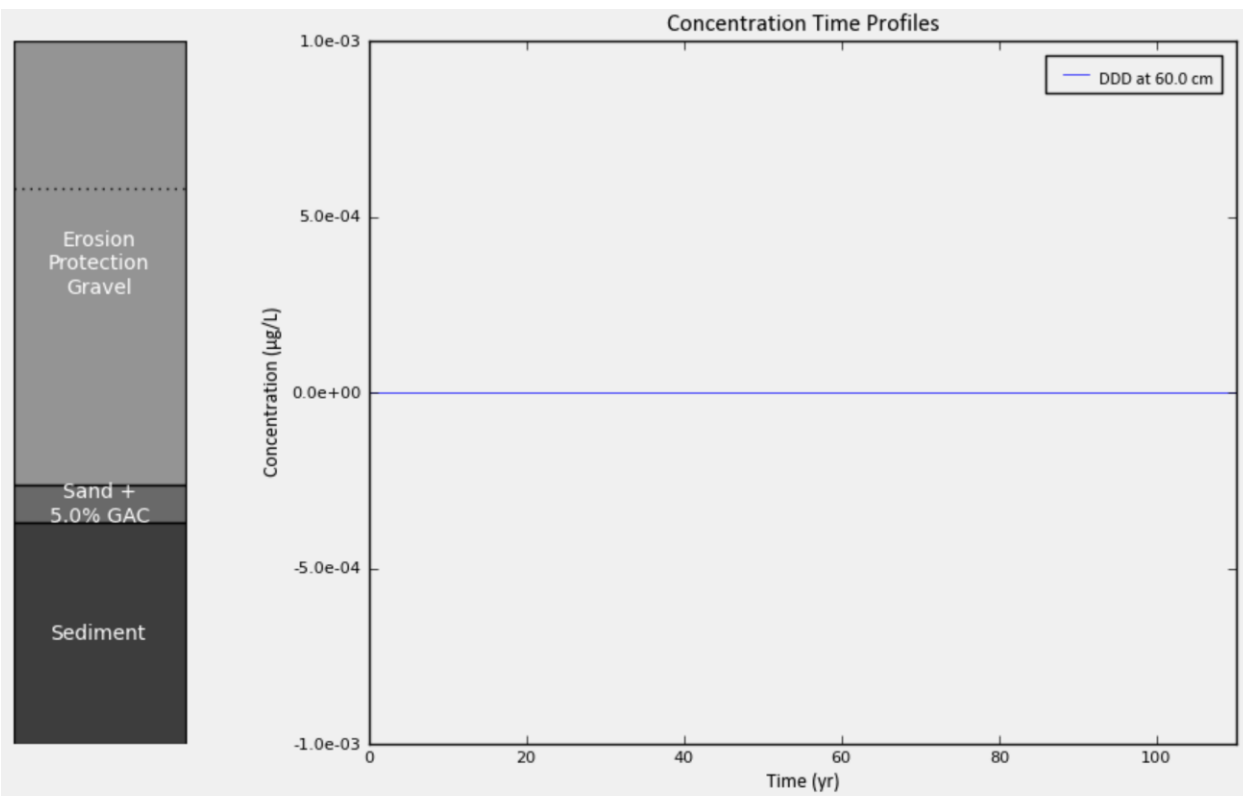

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(e)pyrene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

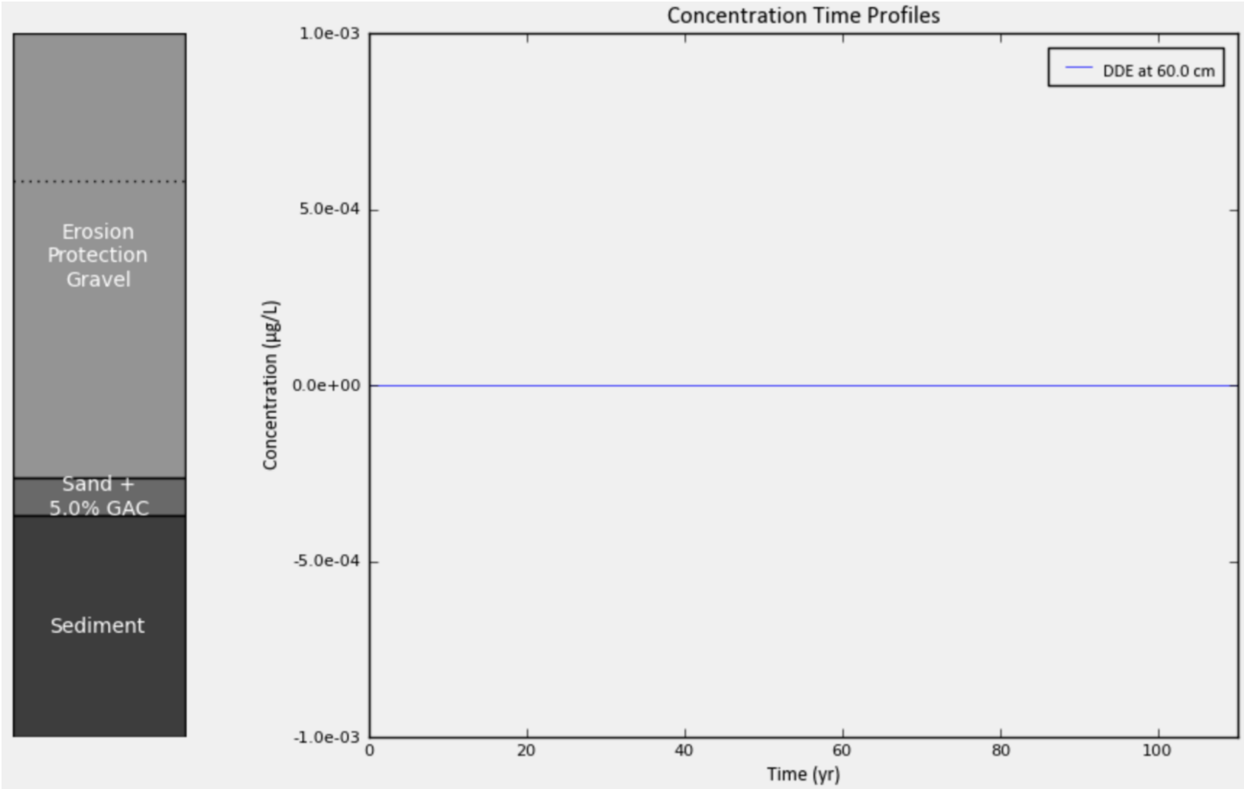

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(ghi)perylene at 60.0 cm
Concentration (µg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
20
40
60
80
100
Time (yr)

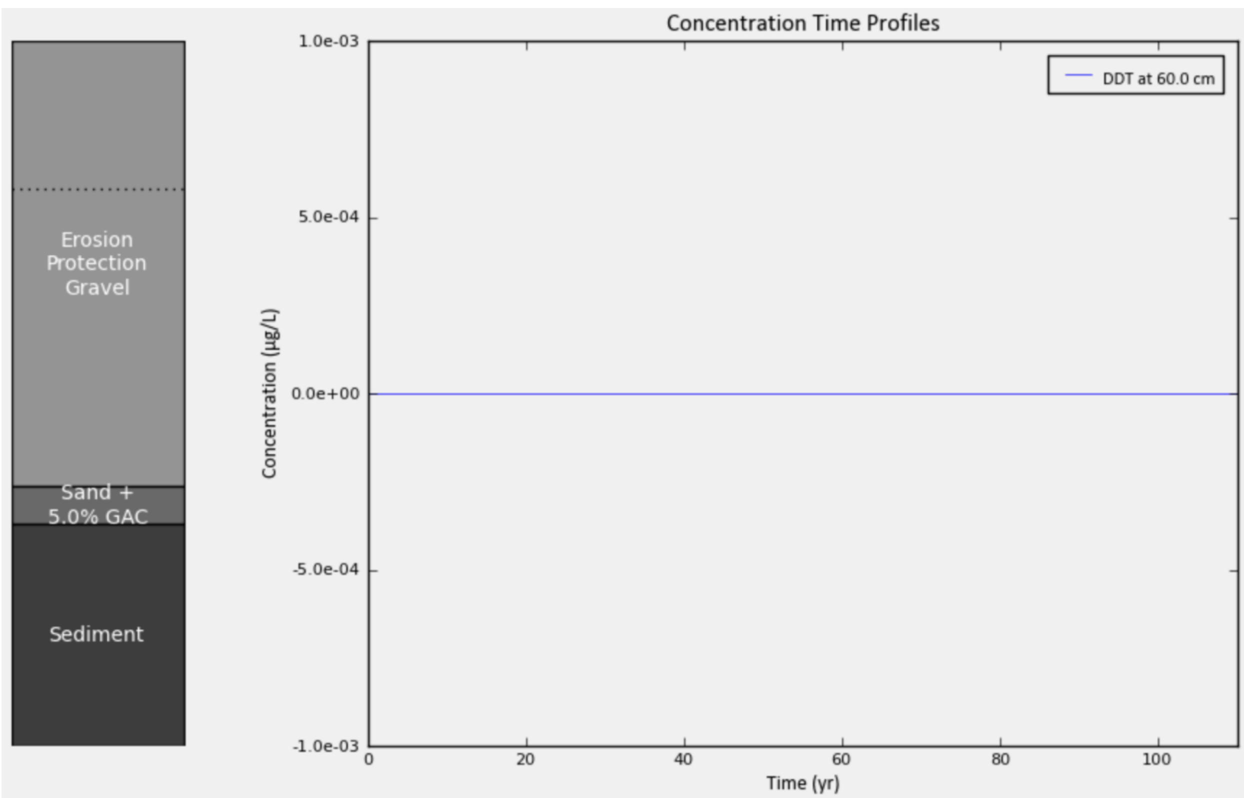

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

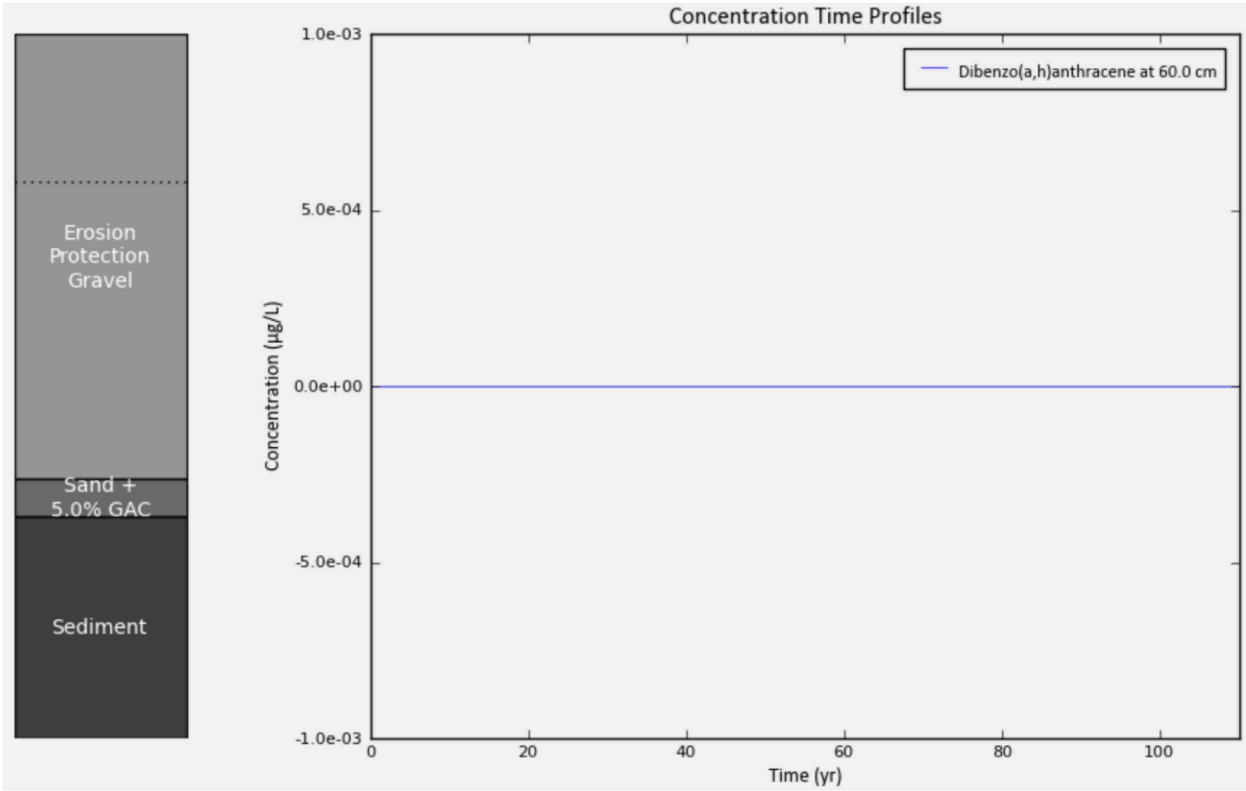

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 60.0 cm
Concentration (µg/L)
150
100
50
0
0
20
40
60
80
100
Time (yr)

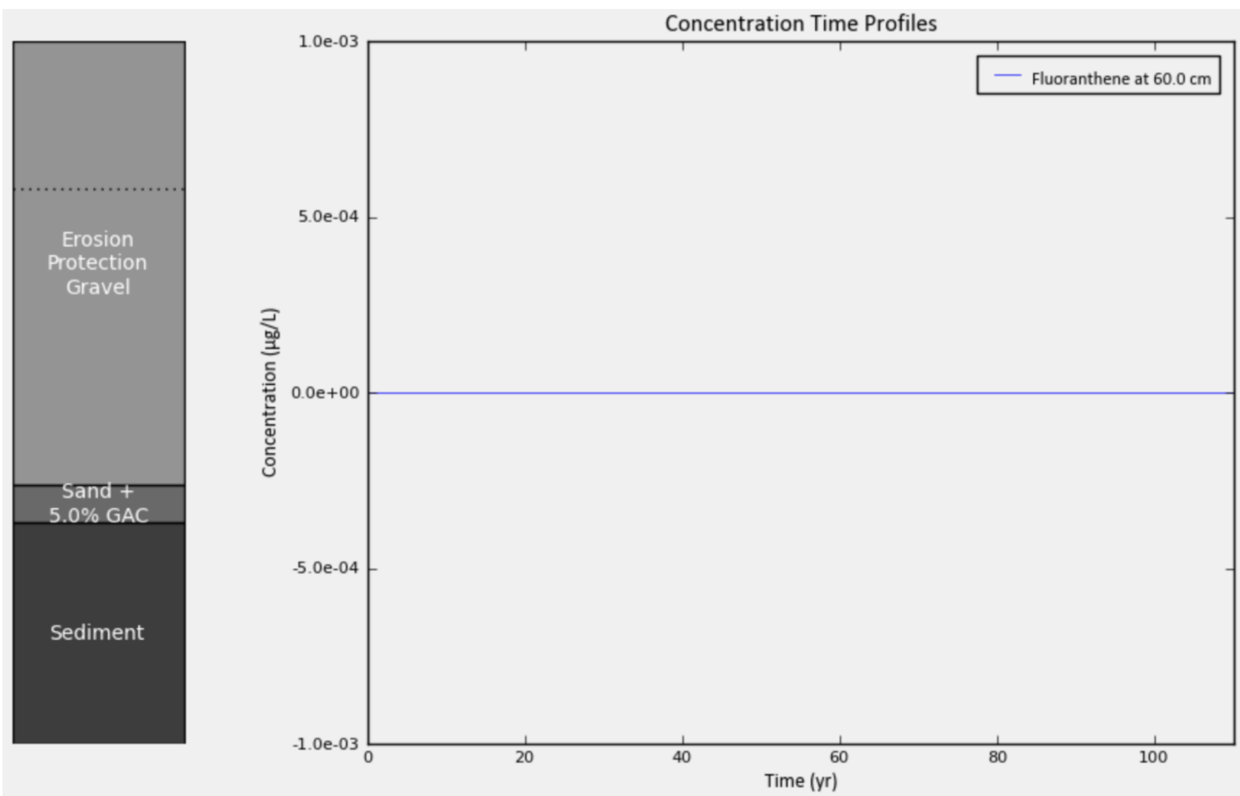

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
Chrysene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

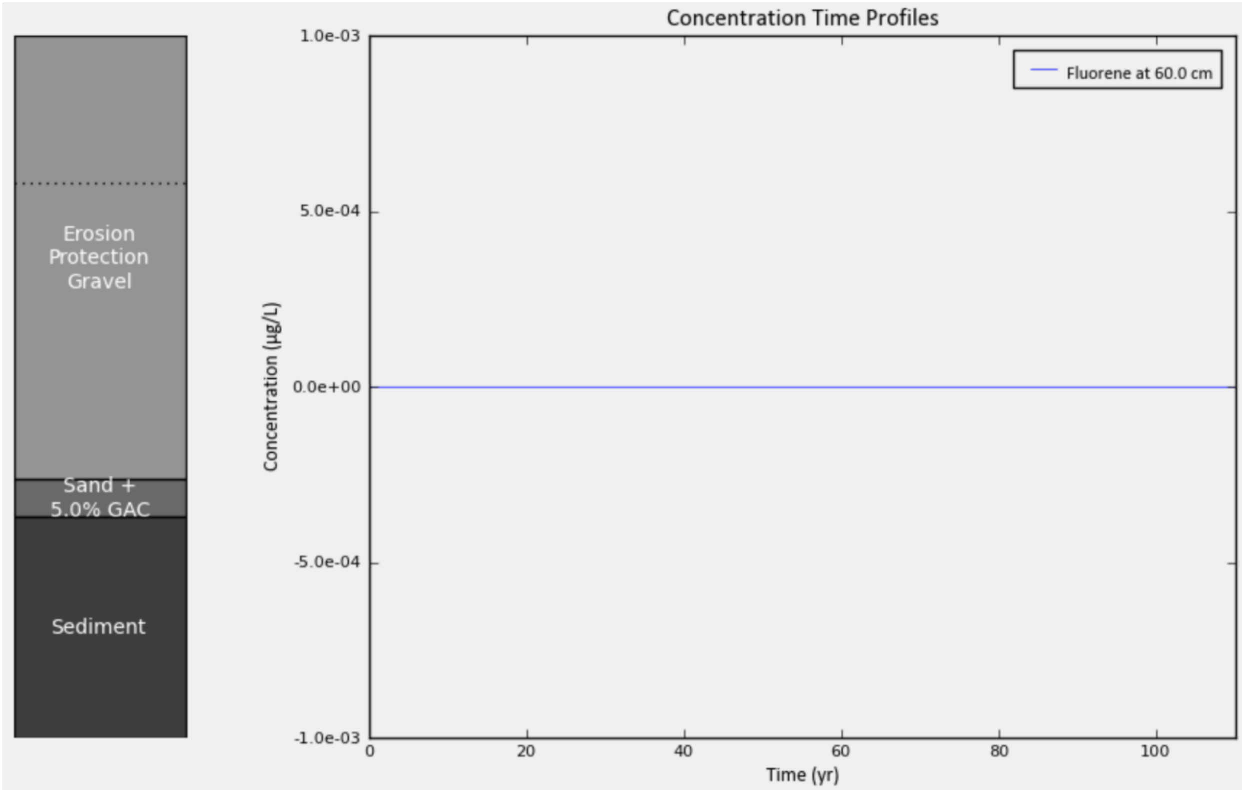

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
DDD at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

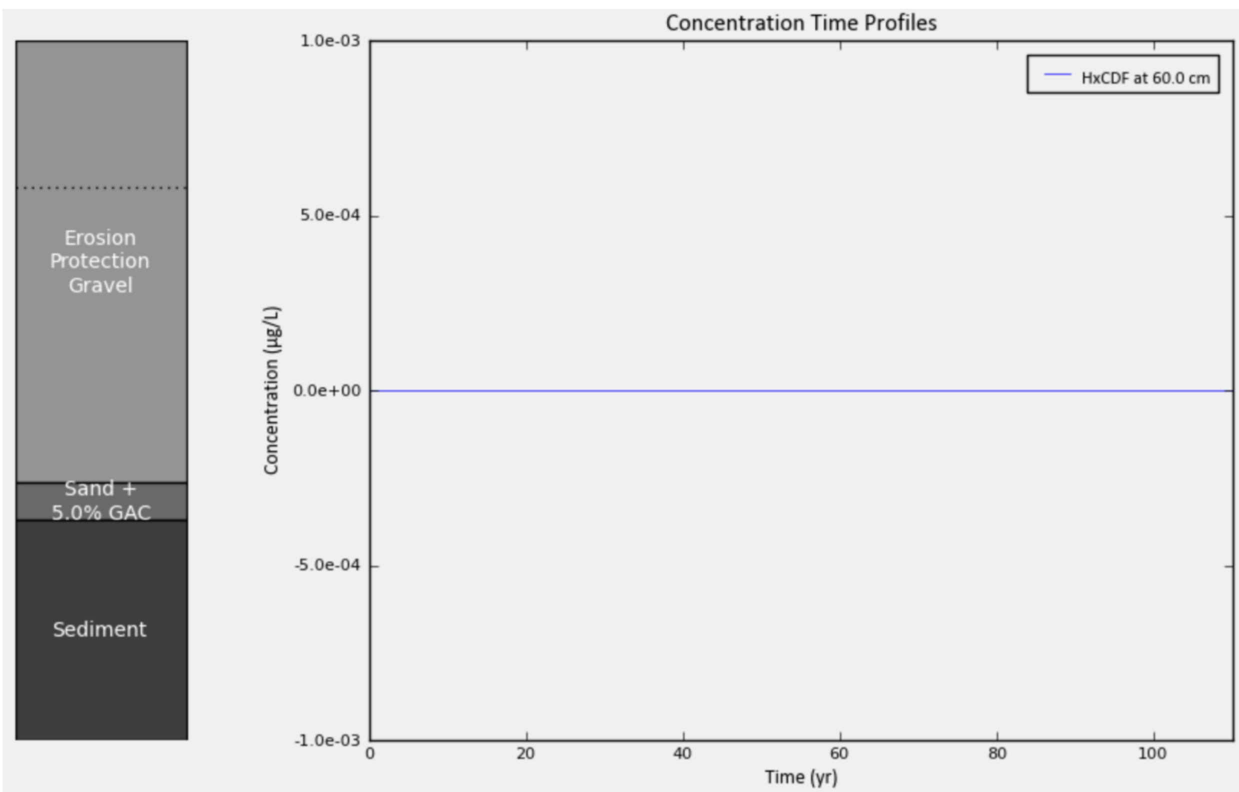

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDE at 60.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

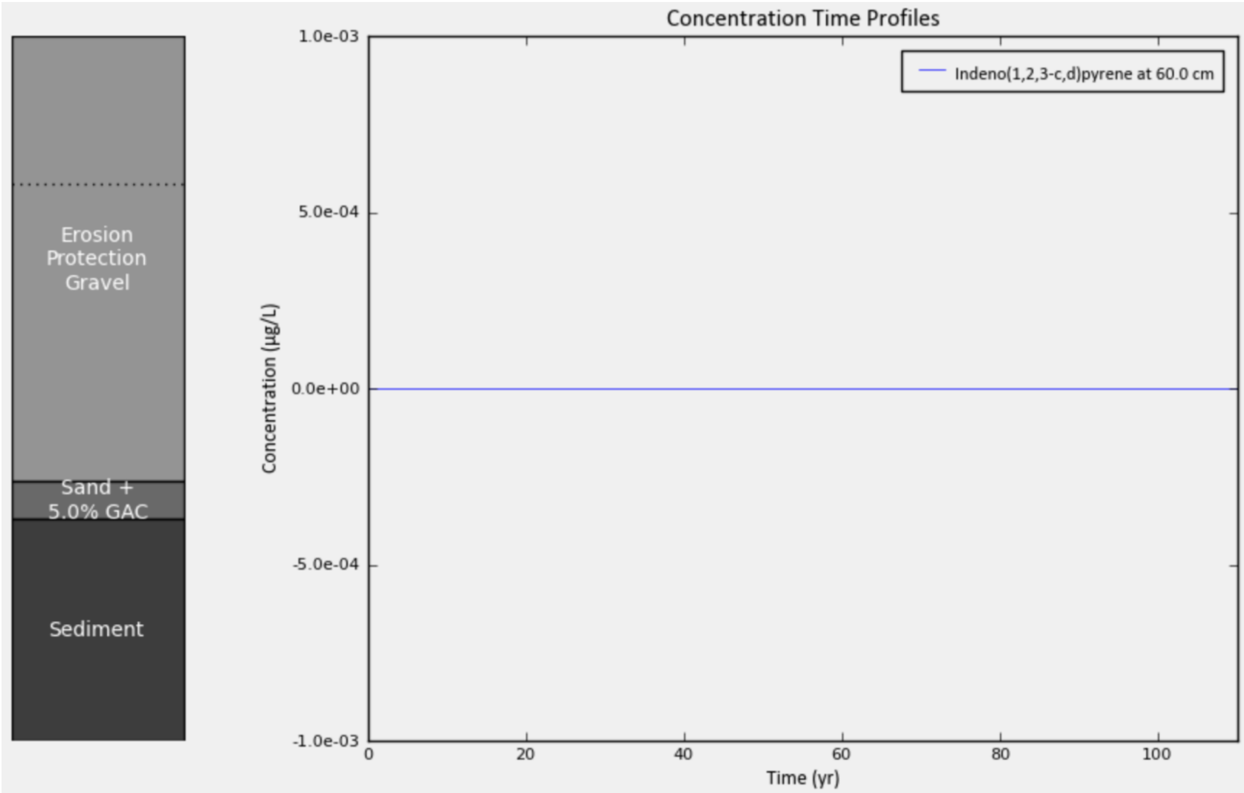

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDT at 60.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

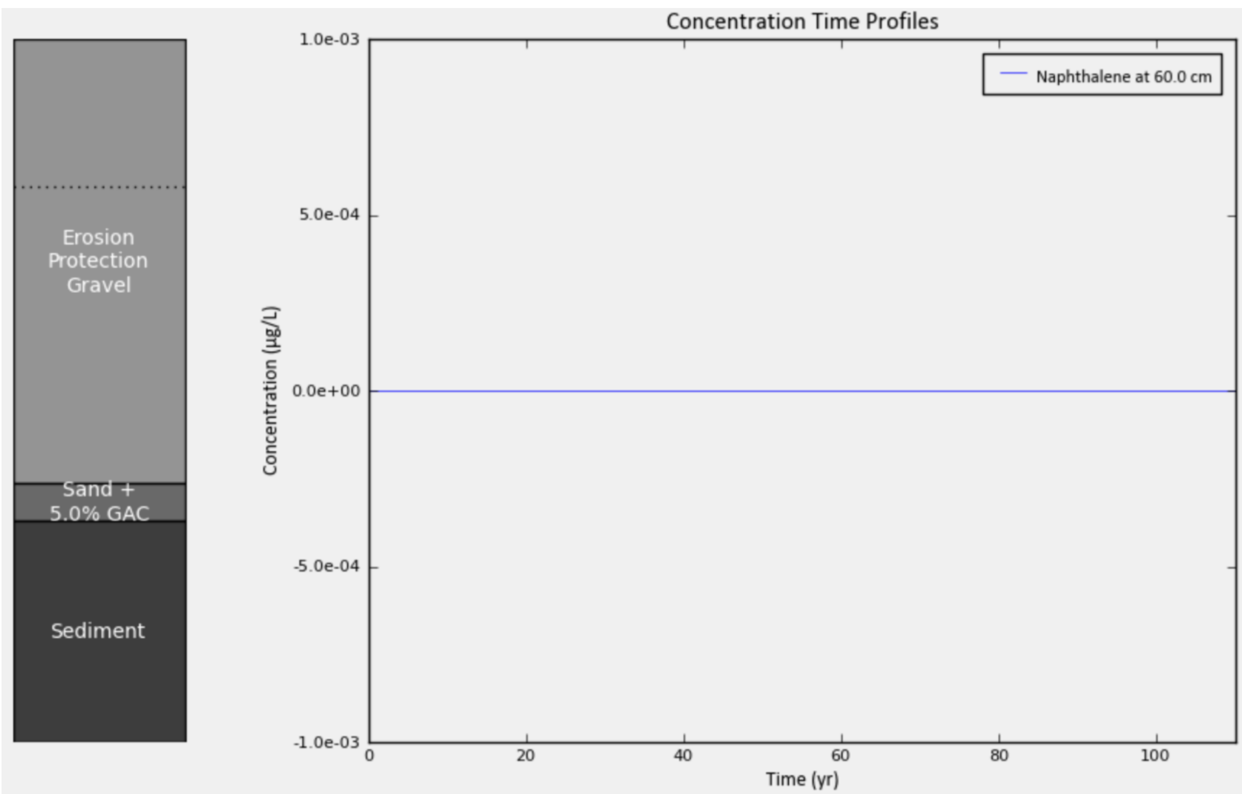

Concentration Time Profiles
Dibenzo(a,h)anthracene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

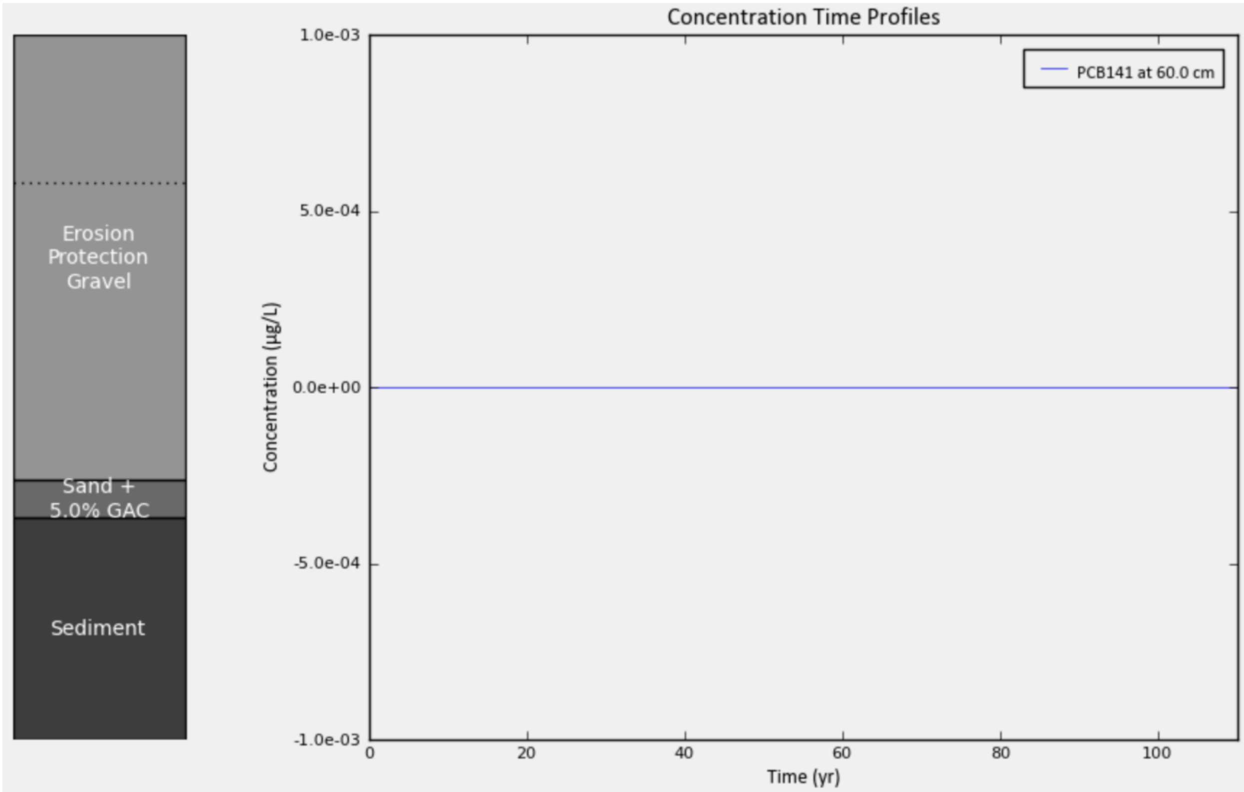

Concentration Time Profiles
Fluoranthene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

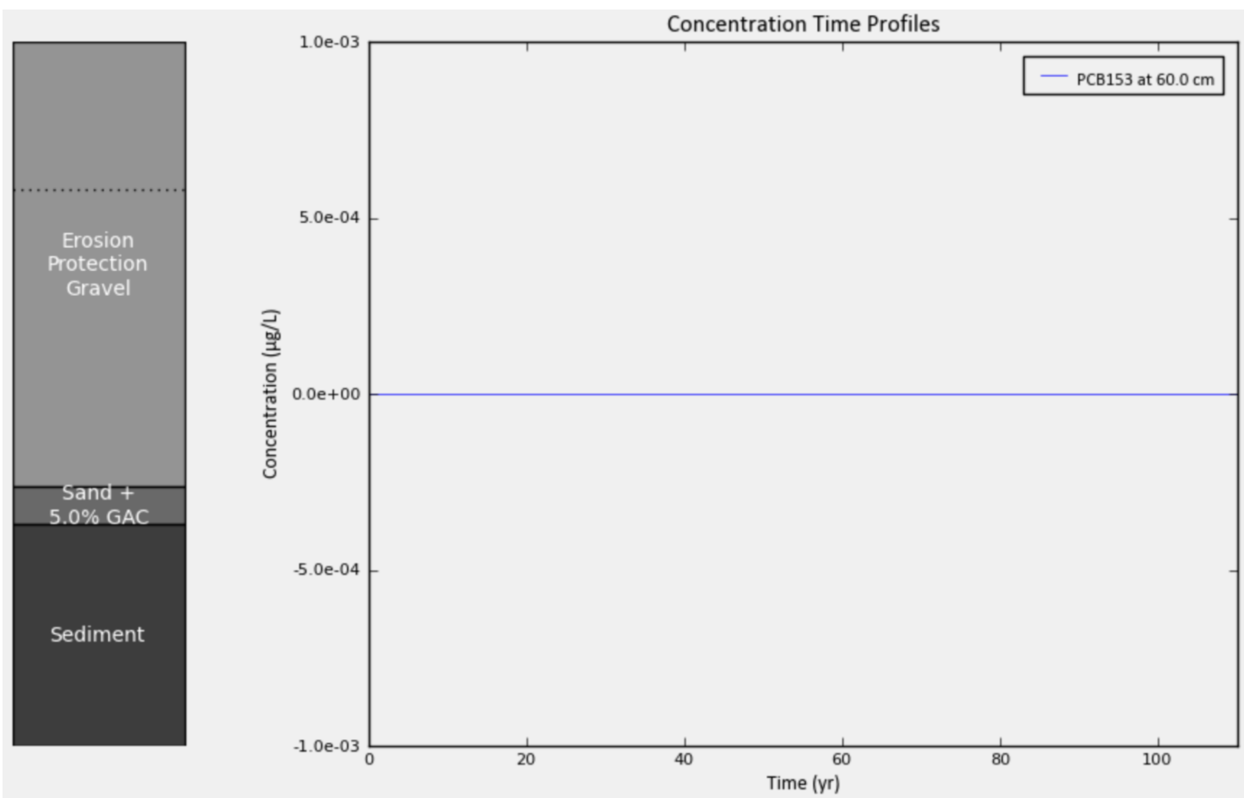

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluorene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

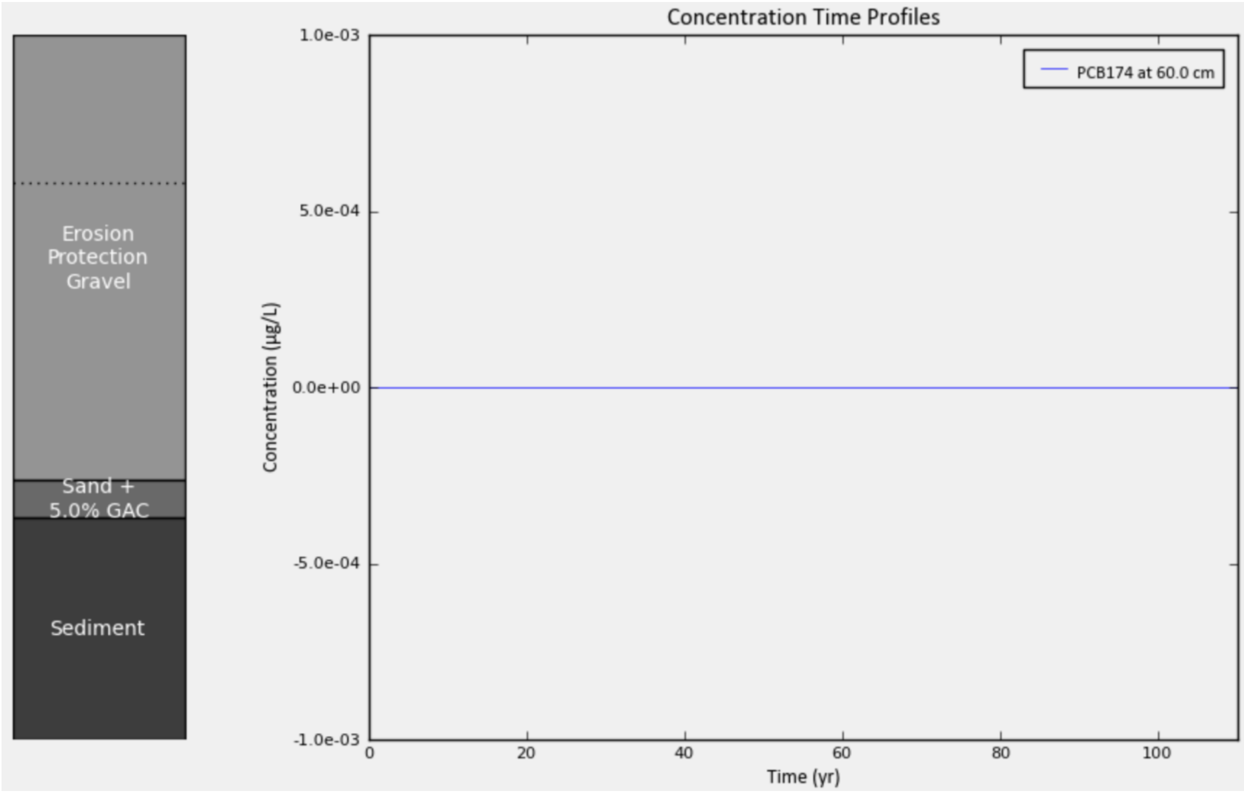

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
HxCDF at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

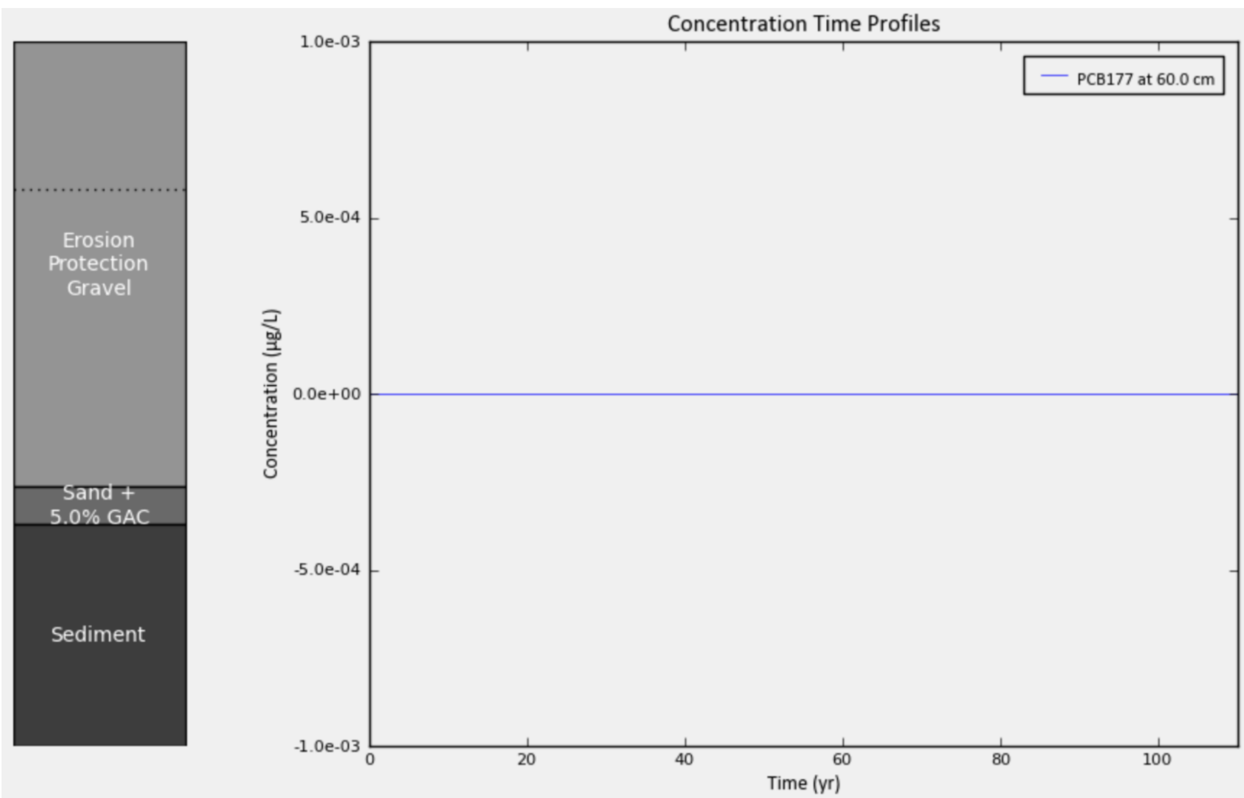

Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

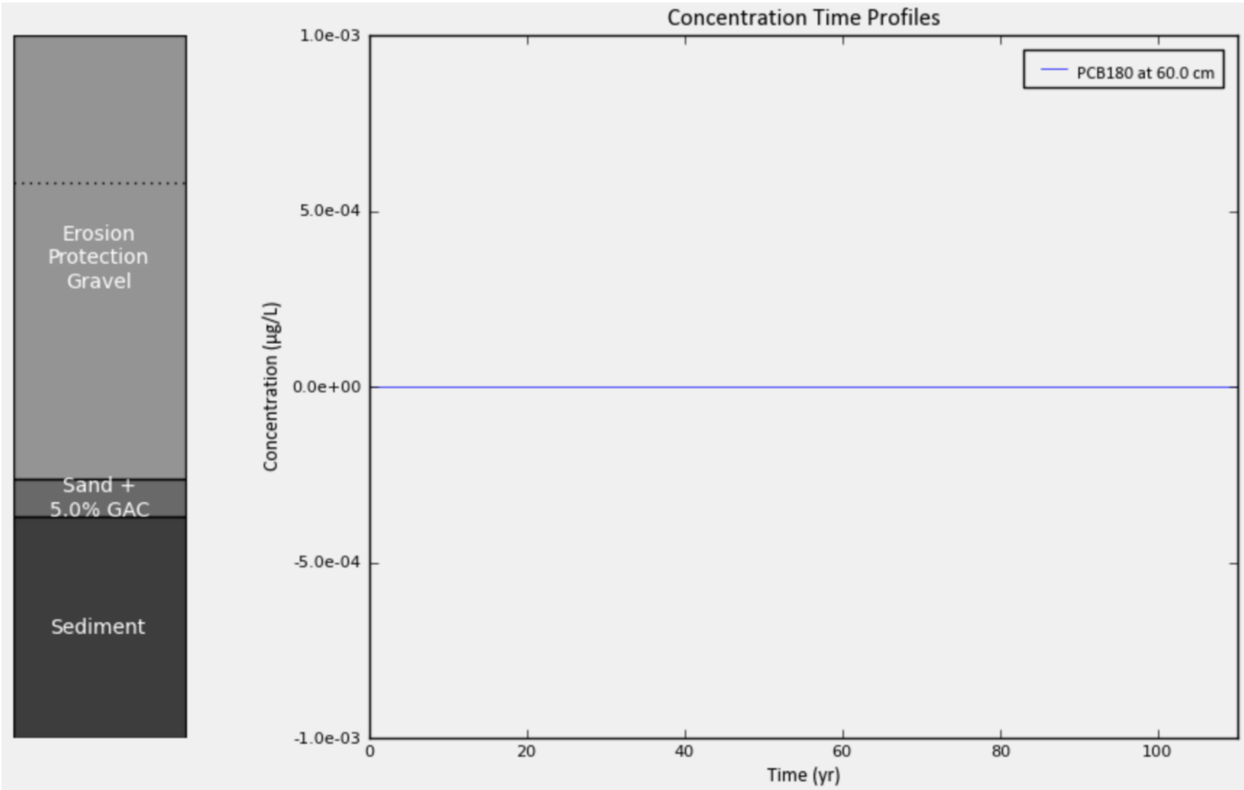

Concentration Time Profiles
Naphthalene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

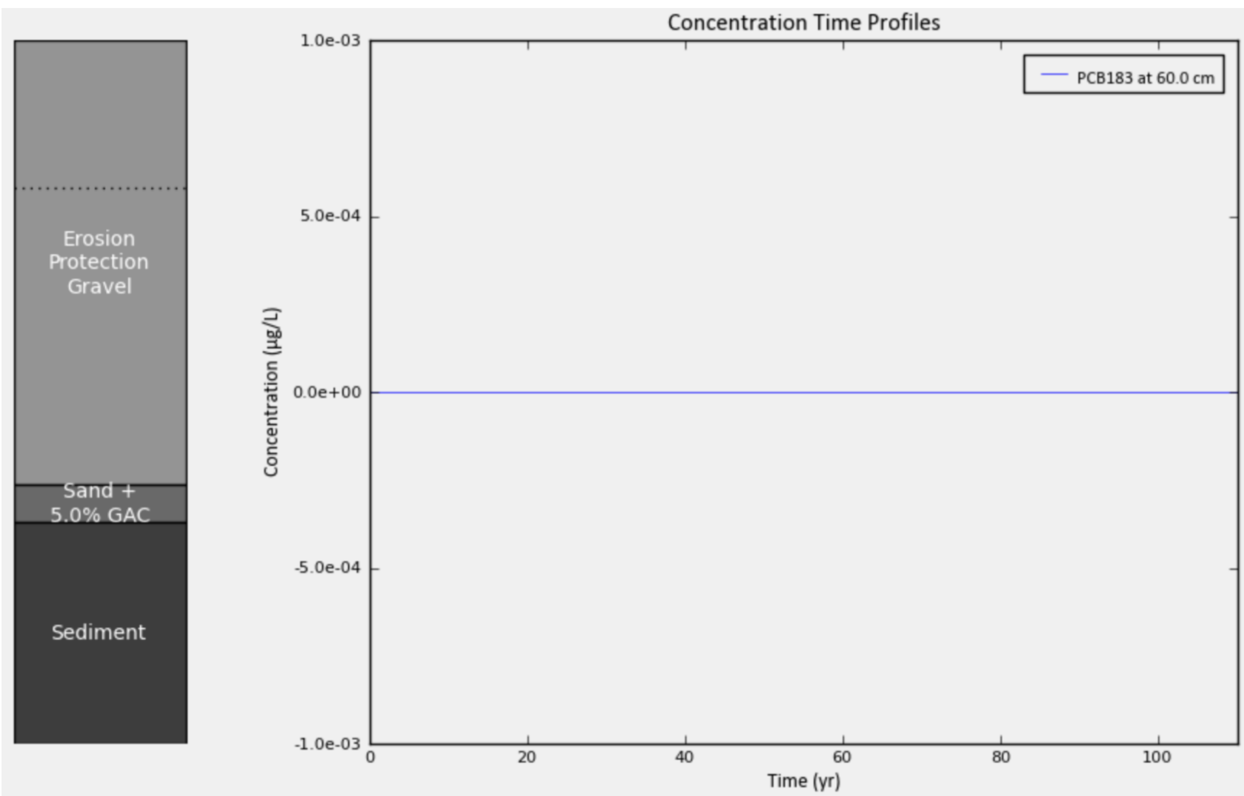

Concentration Time Profiles
PCB141 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

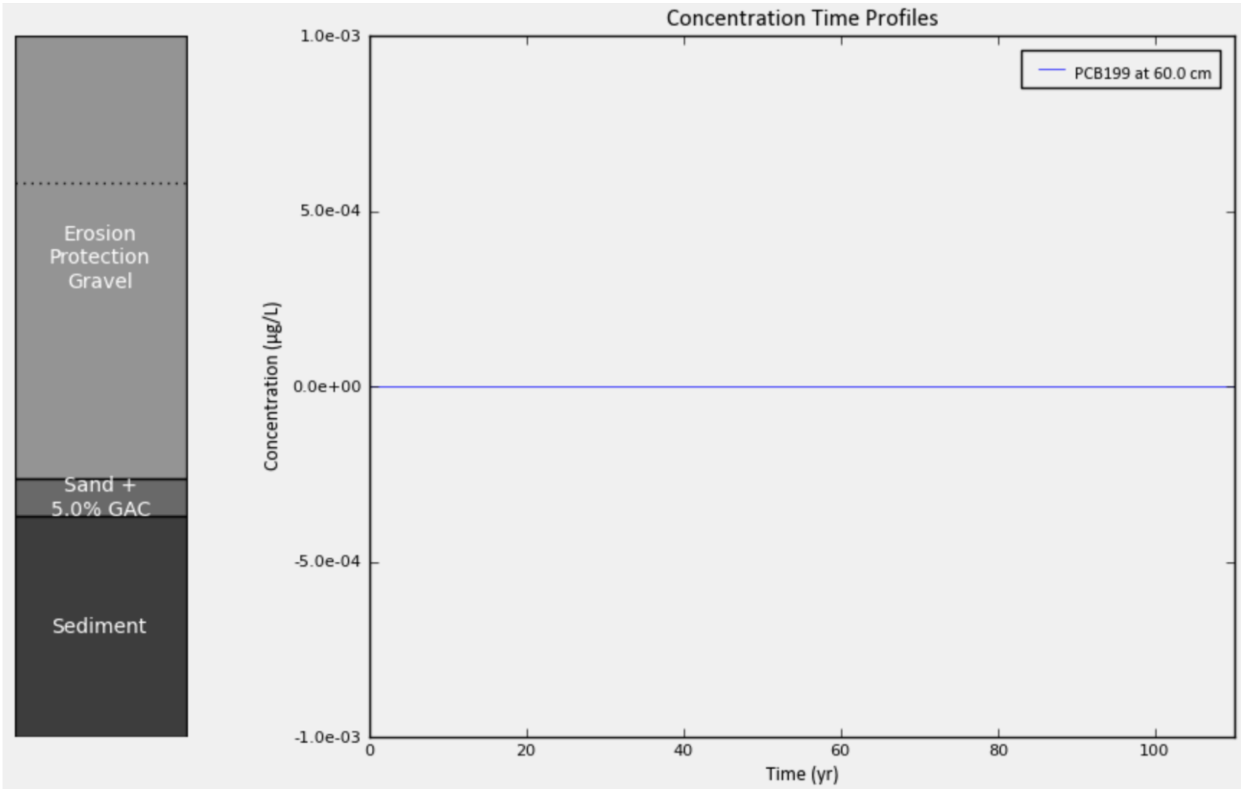

Concentration Time Profiles
PCB153 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB174 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

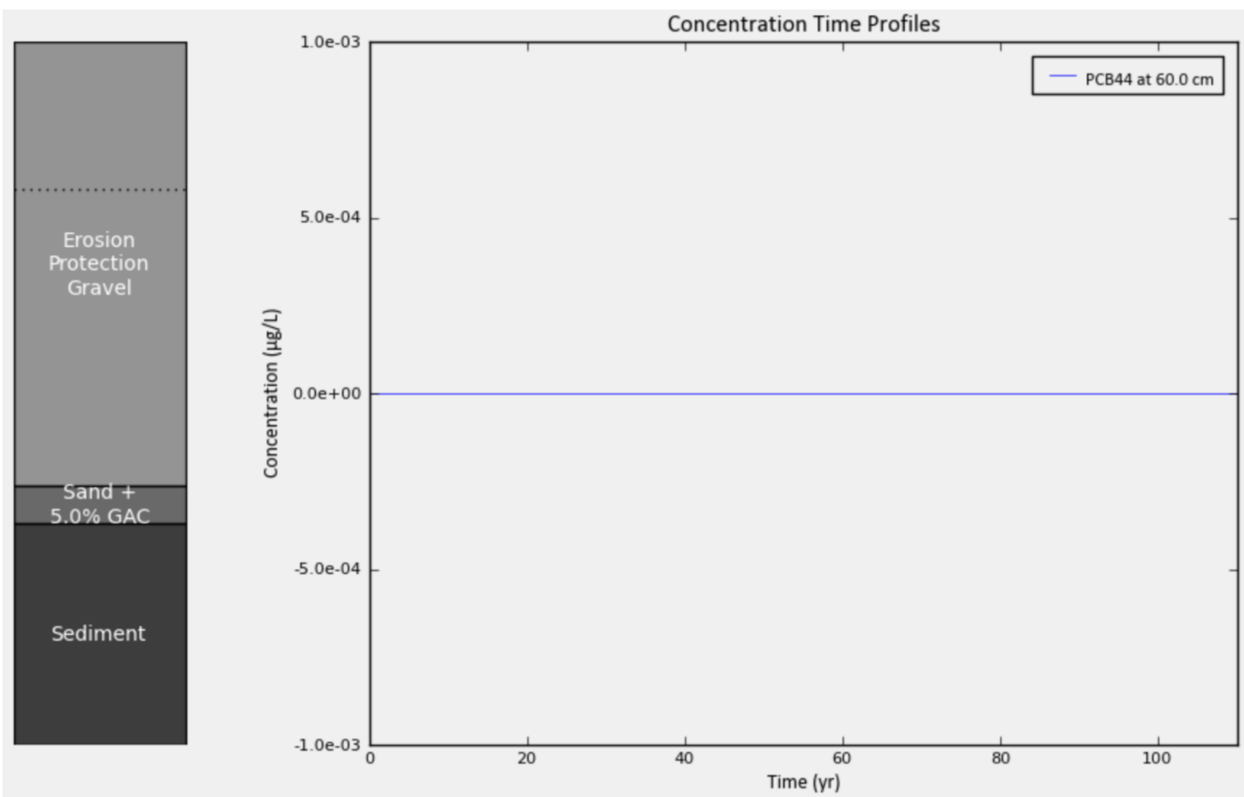

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB177 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
PCB180 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

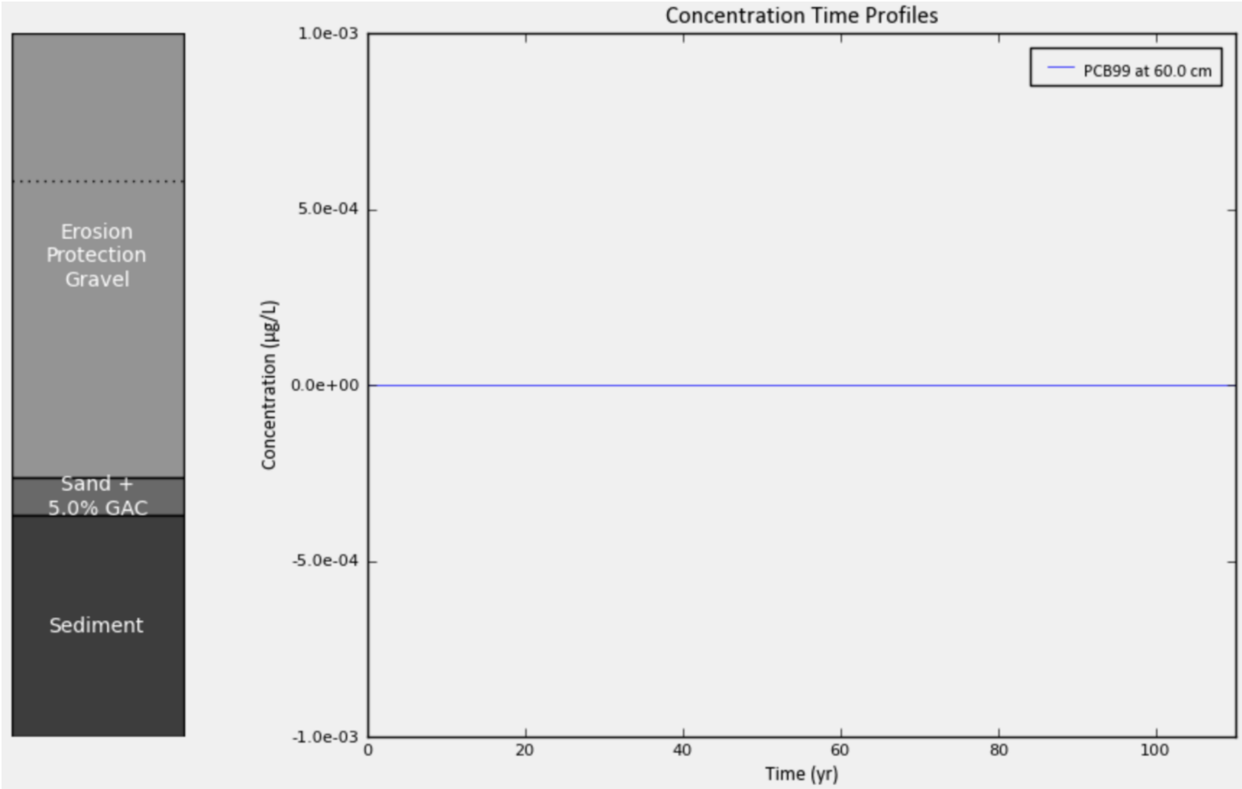

Concentration Time Profiles
PCB183 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100



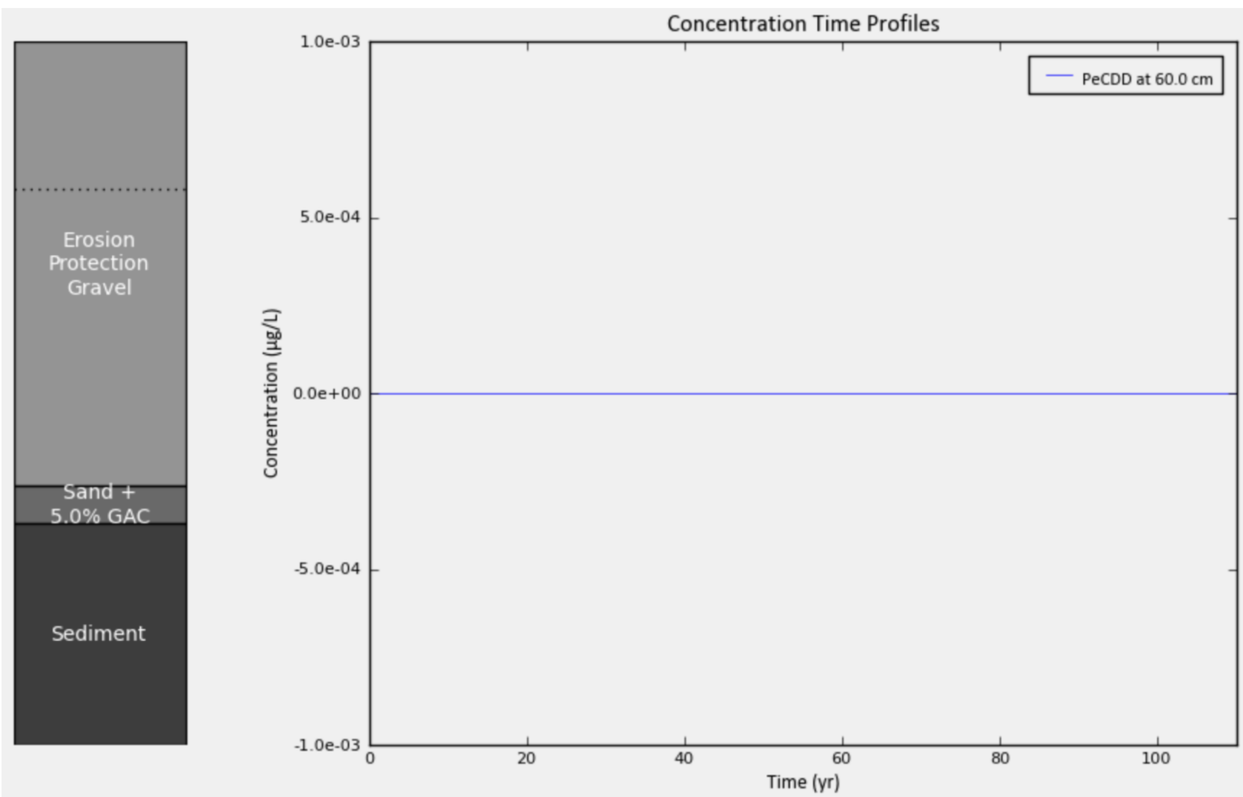
Concentration Time Profiles
PCB199 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)



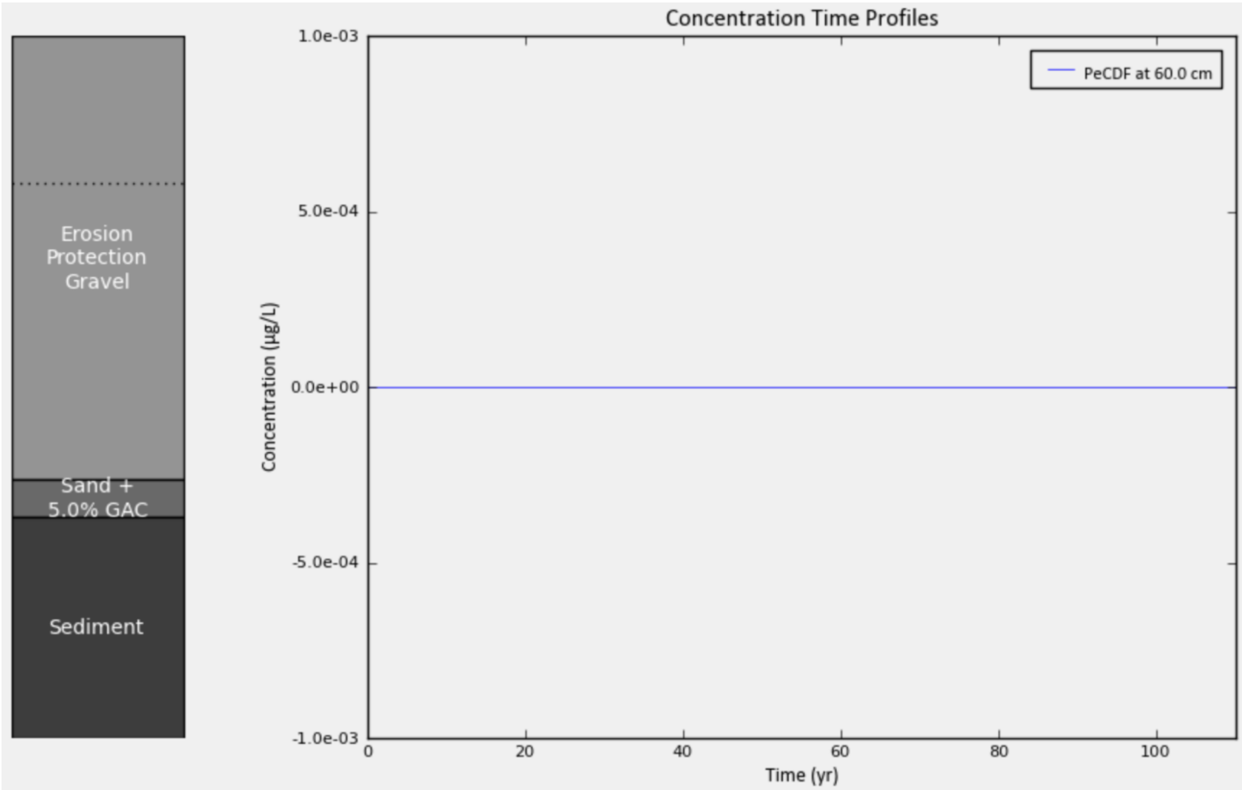
Concentration Time Profiles
PCB44 at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

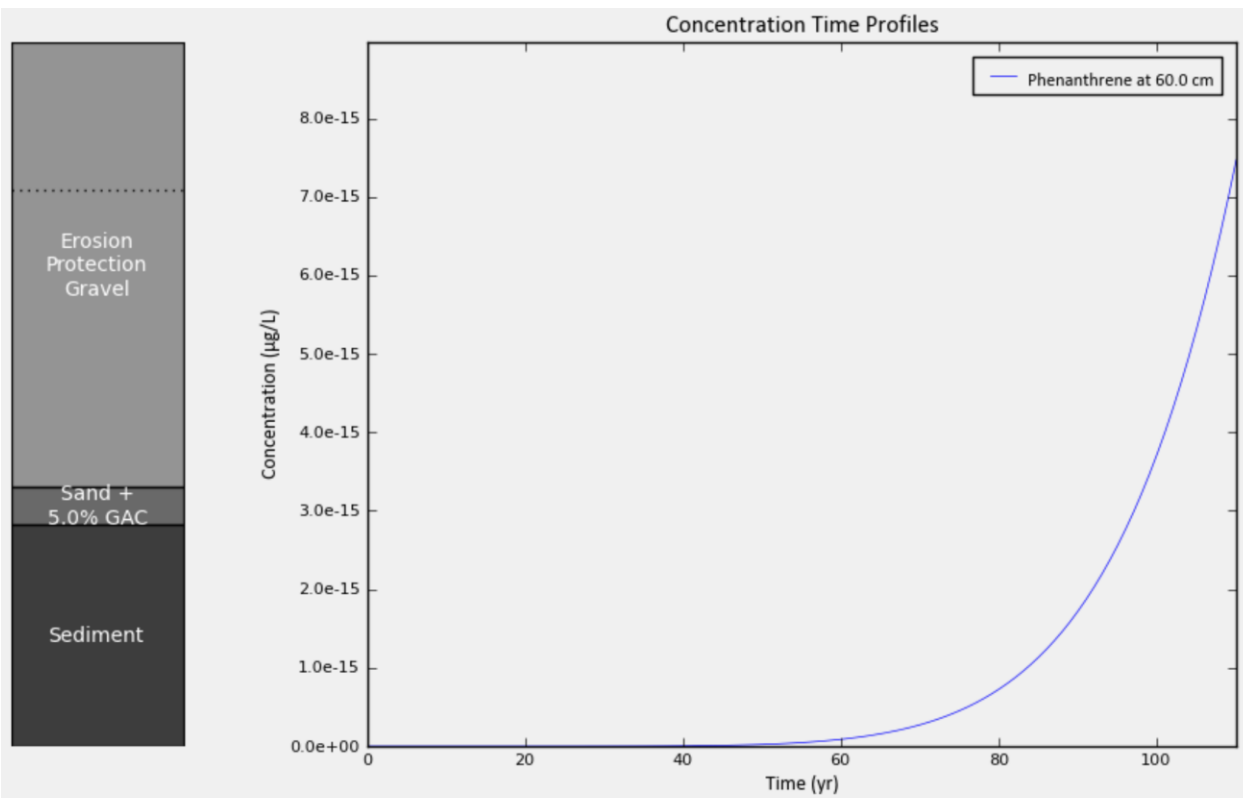


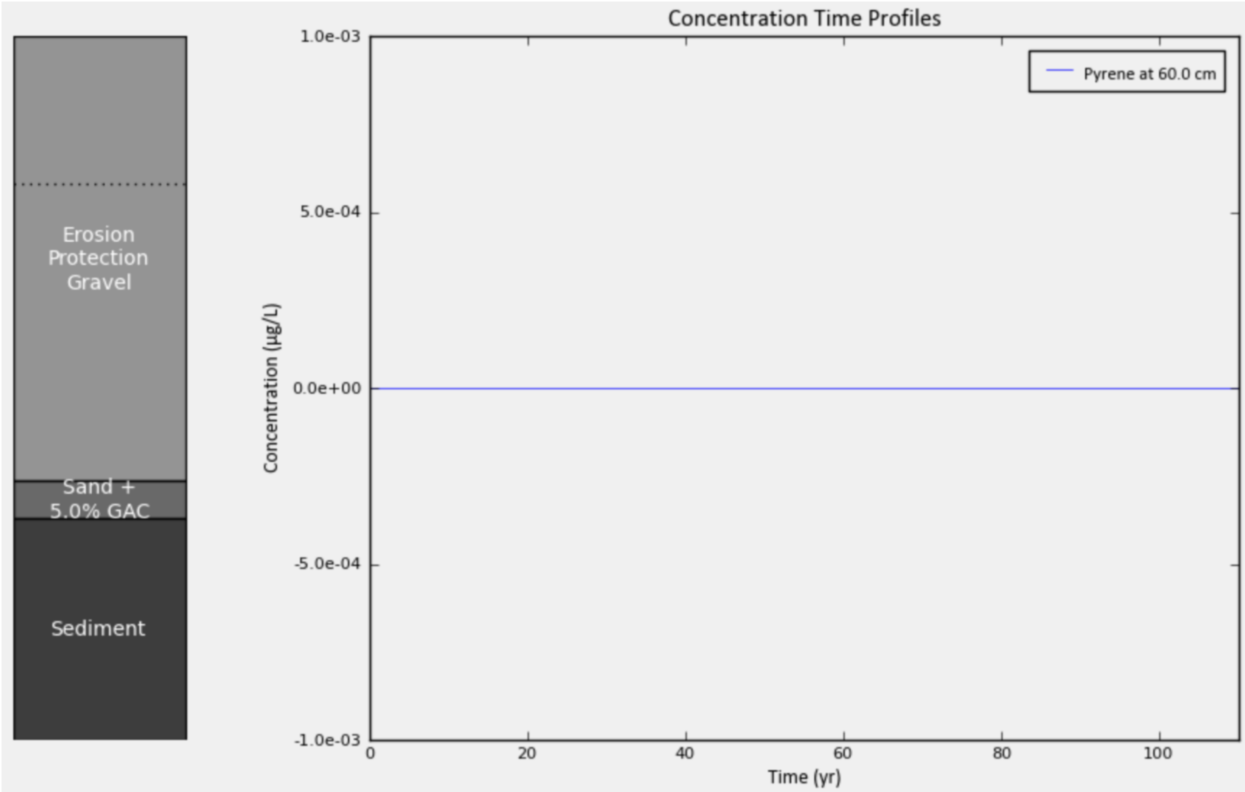
Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB99 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

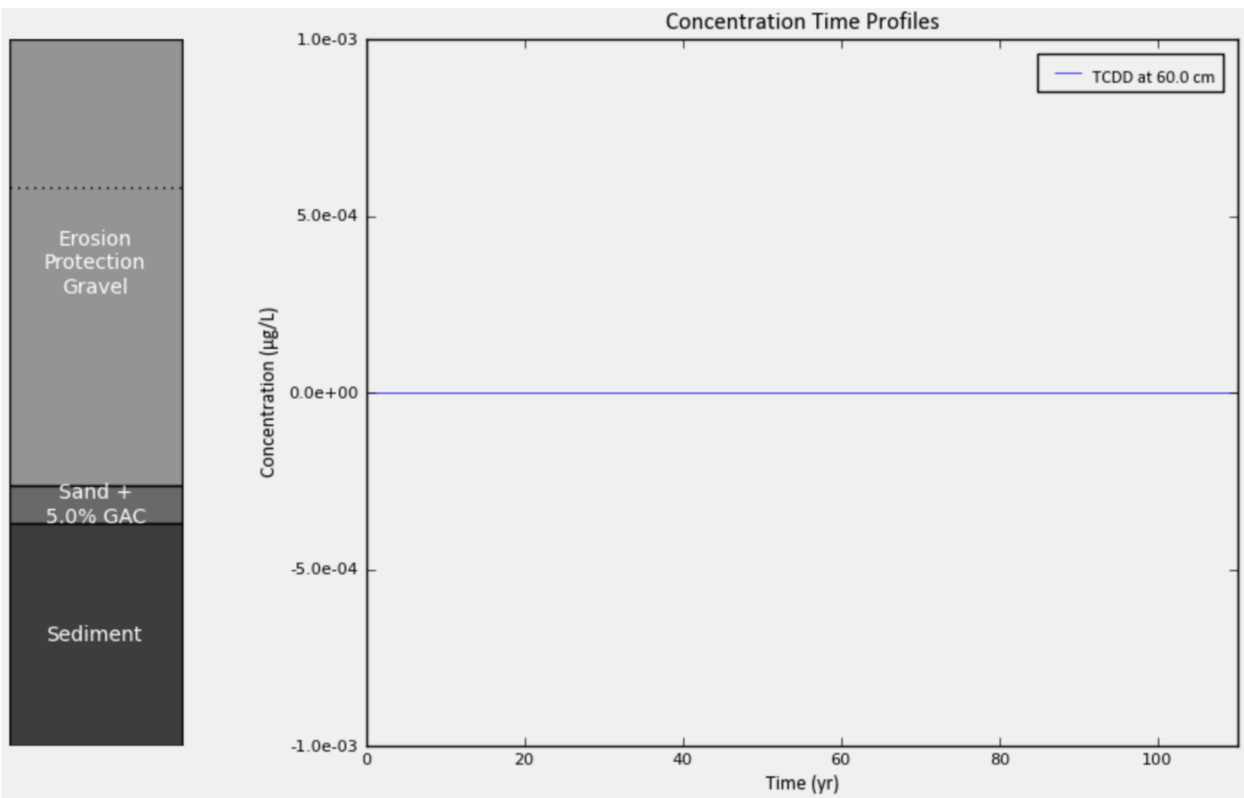


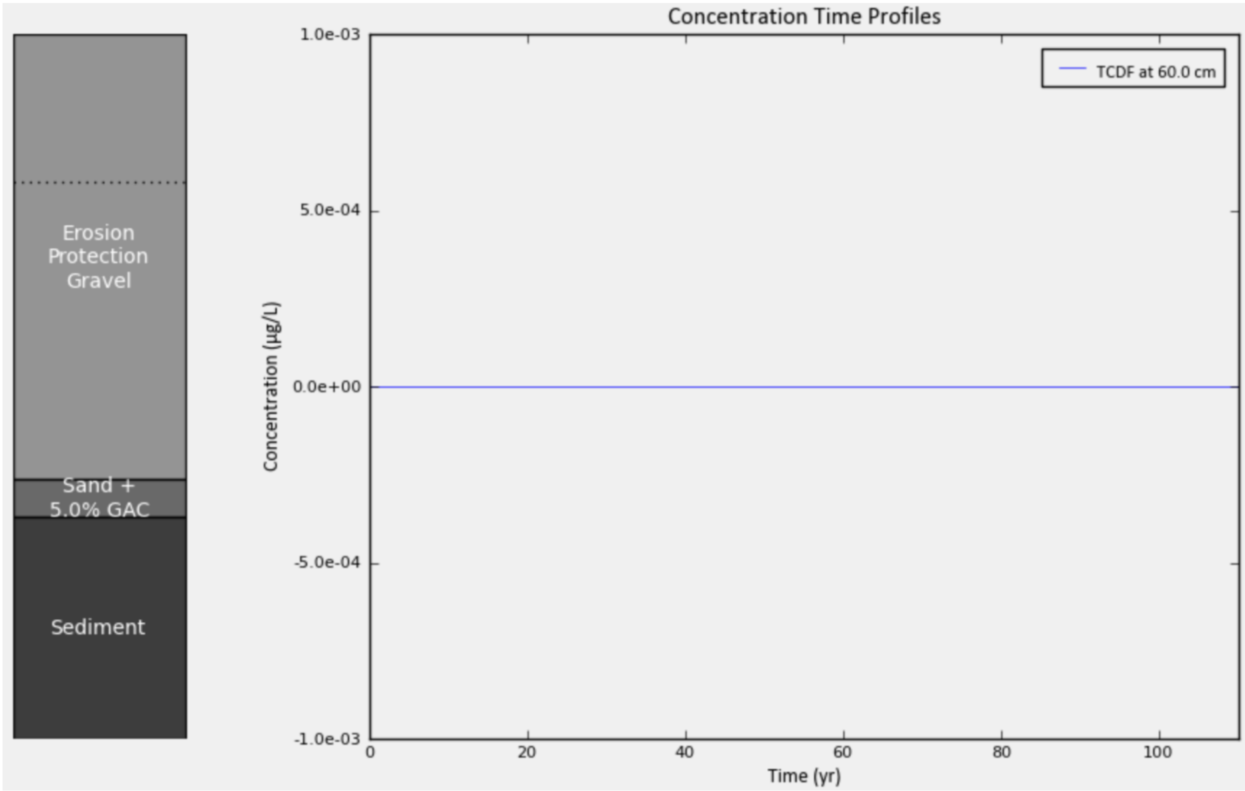
Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PeCDD at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

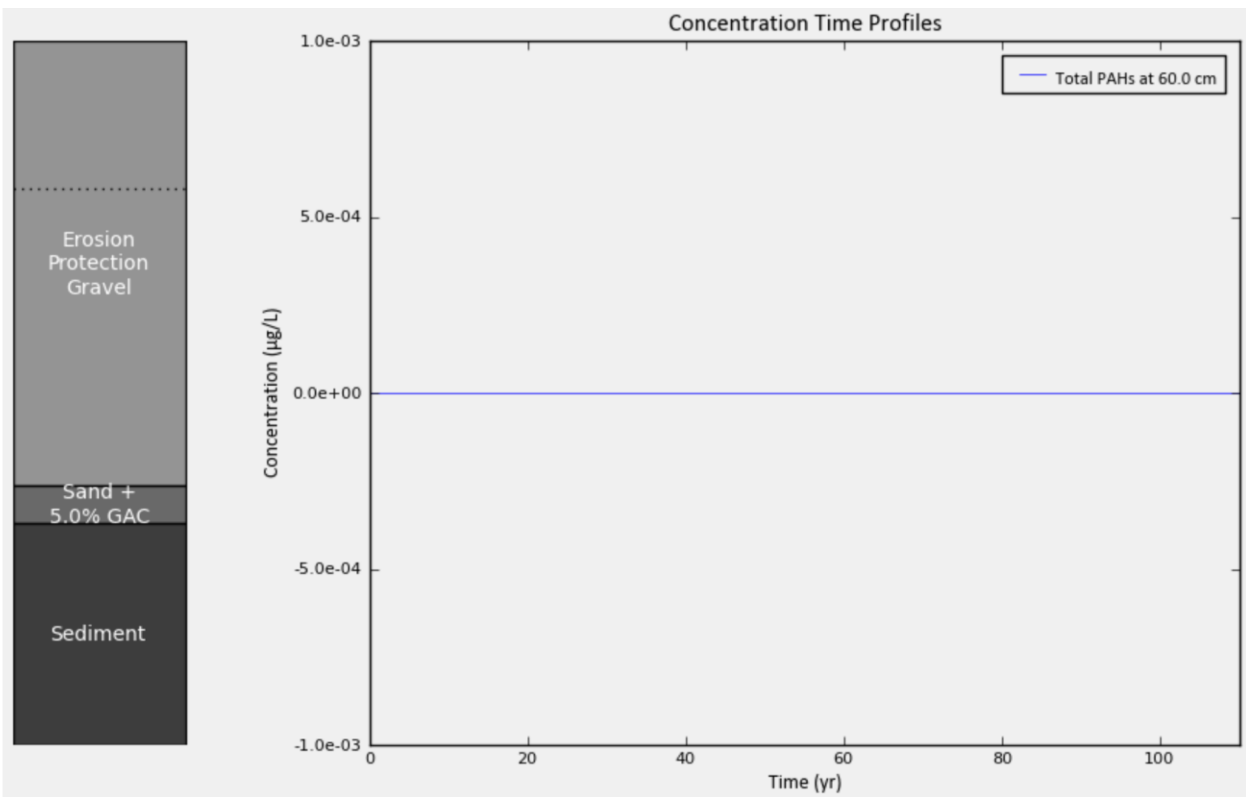

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PeCDF at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

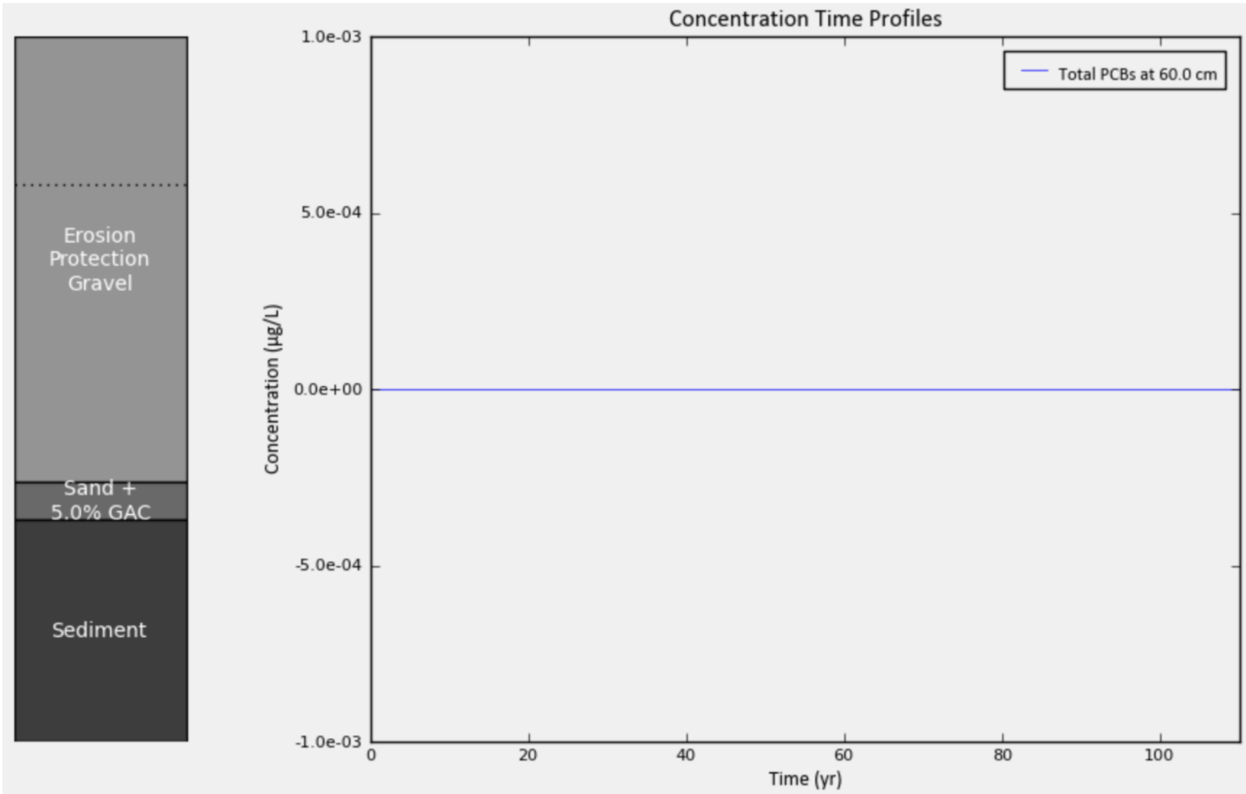

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Phenanthrene at 60.0 cm
Concentration (µg/L)
8.0e-15
7.0e-15
6.0e-15
5.0e-15
4.0e-15
3.0e-15
2.0e-15
1.0e-15
0.0e+00
0
20
40
60
80
100
Time (yr)

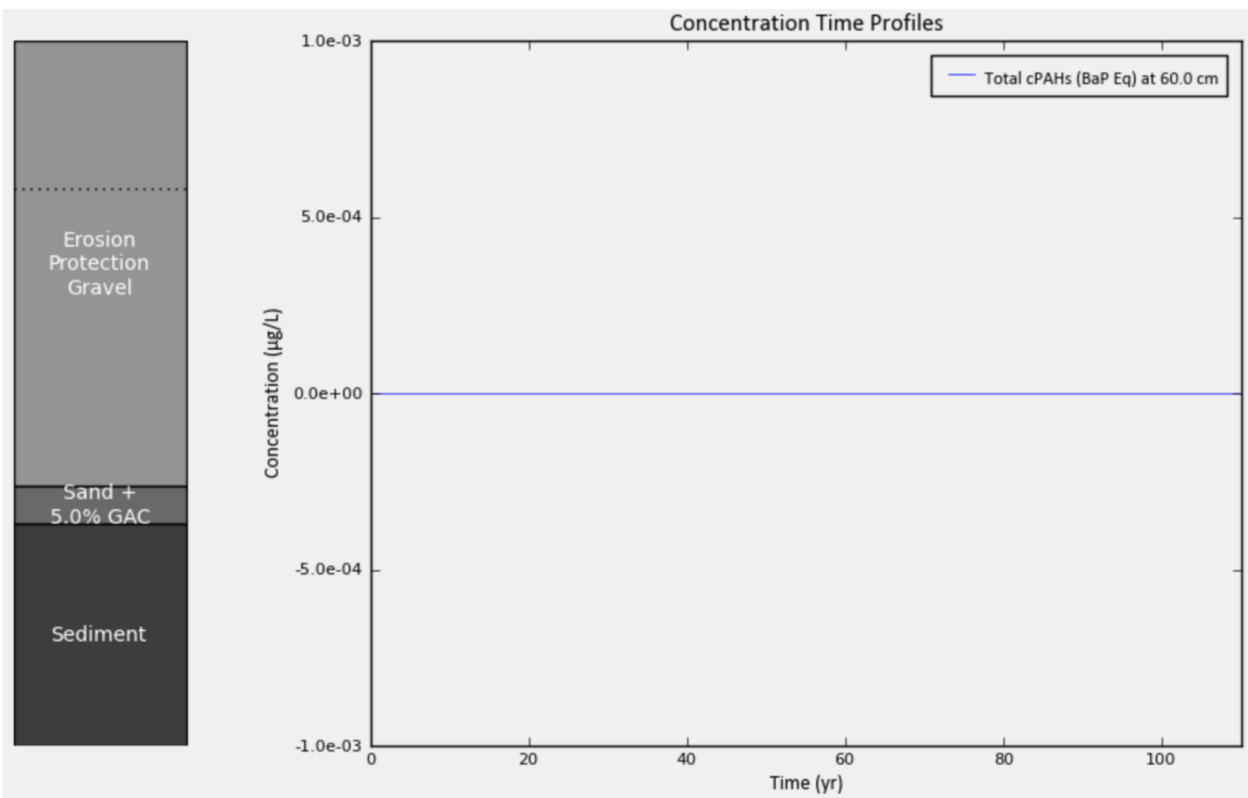

Concentration Time Profiles
Pyrene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100


Concentration Time Profiles
TCDD at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100


Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDF at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

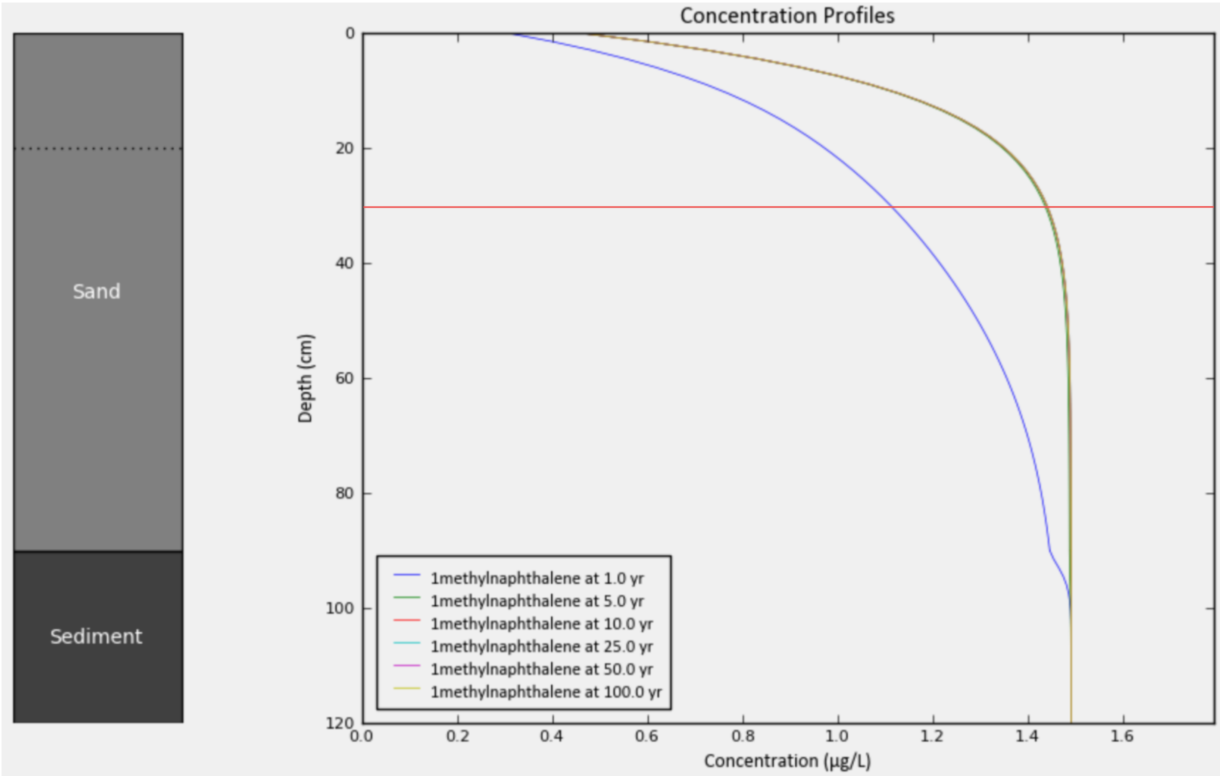

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PAHs at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

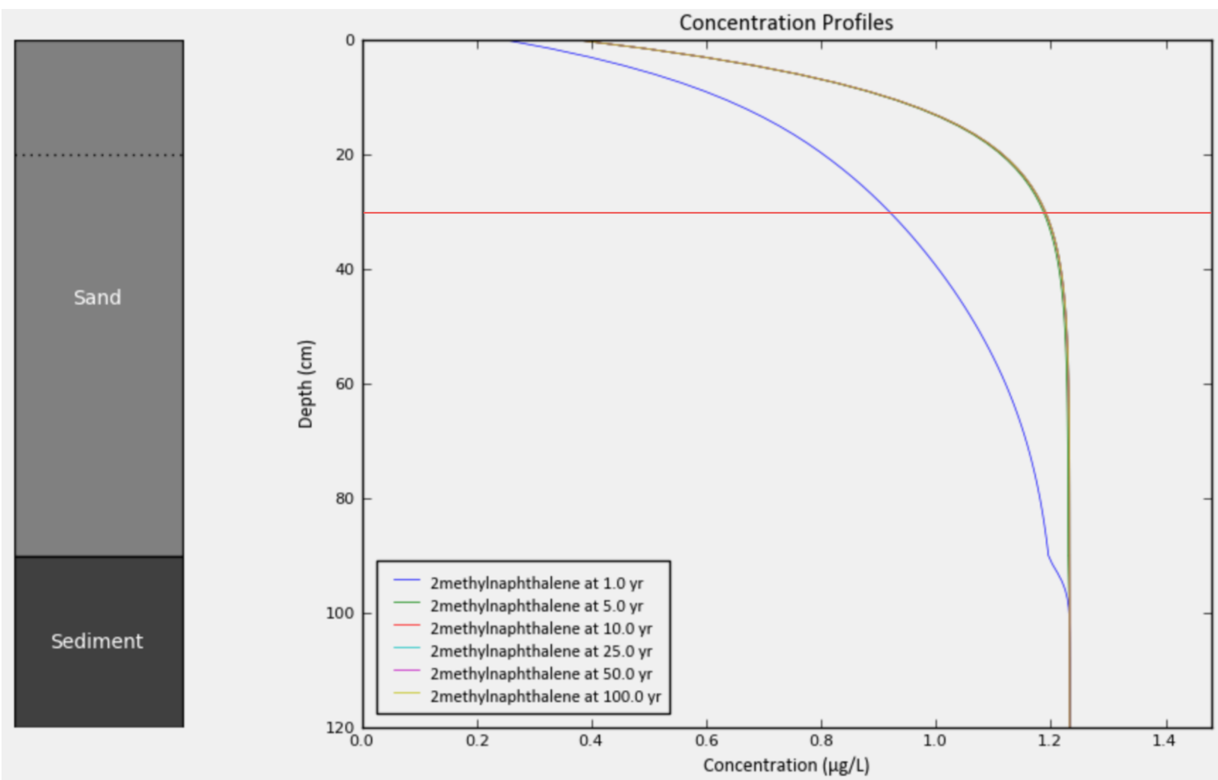

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PCBs at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

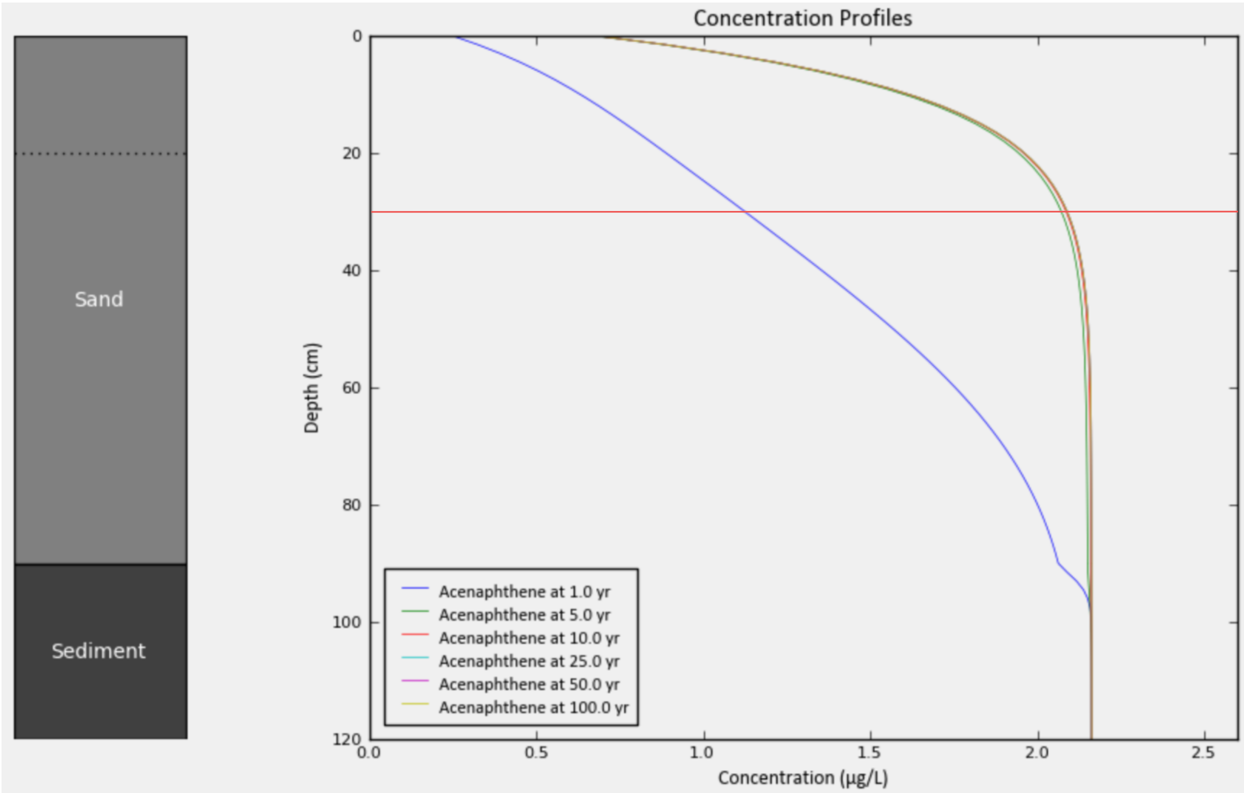

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

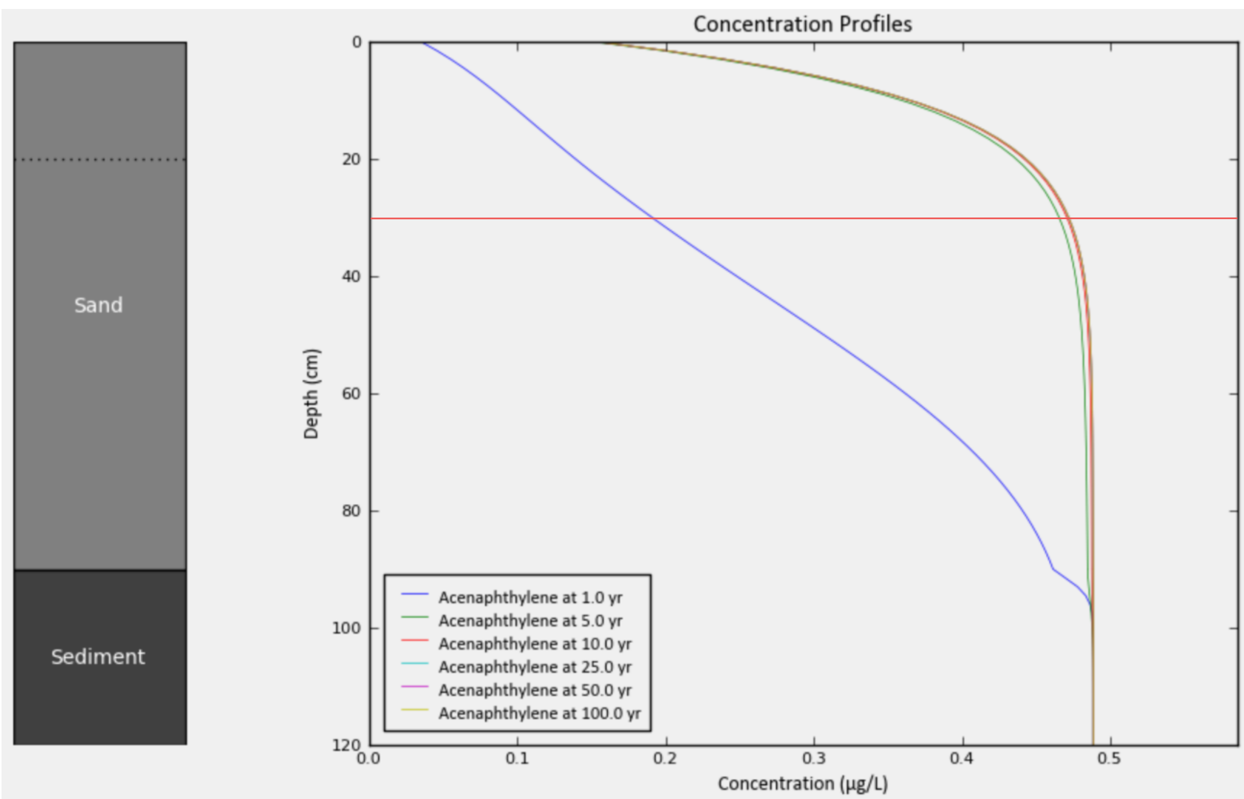
Cap Alternative 3: 90 cm of unamended sand

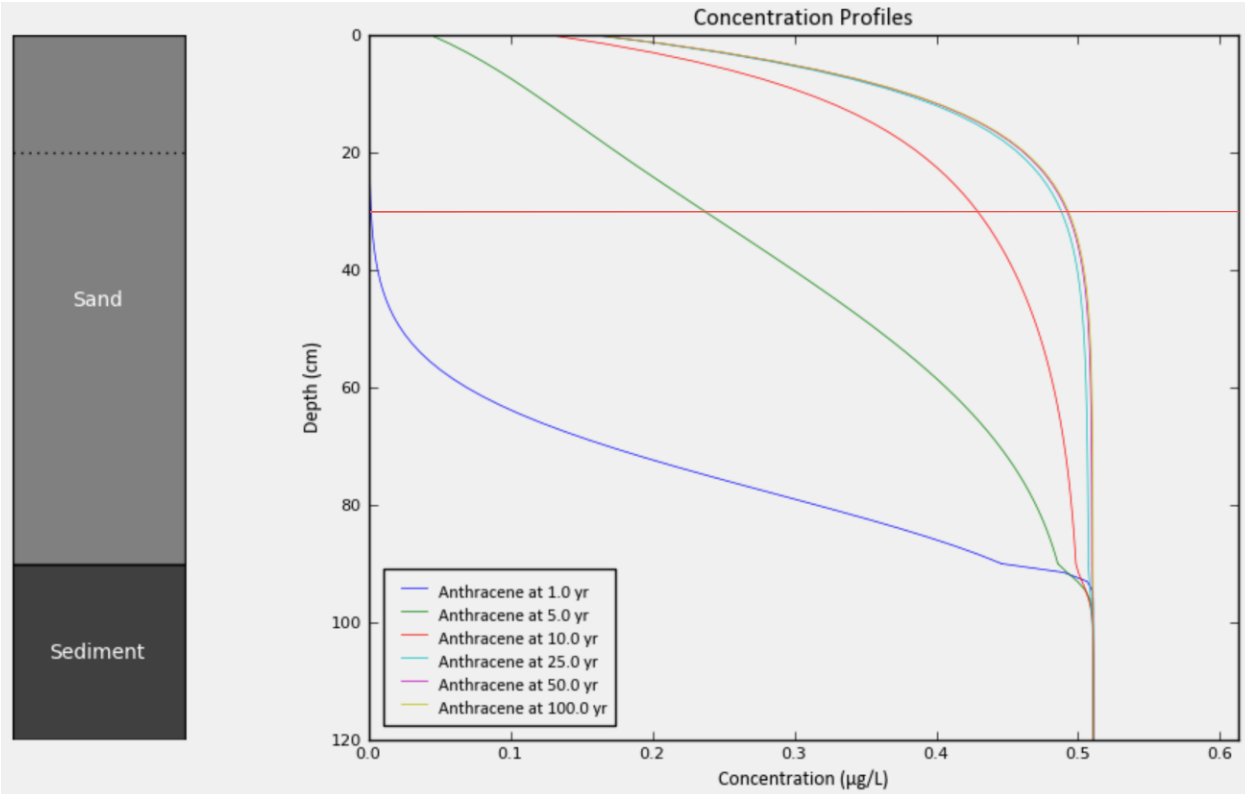
Porewater Concentration – Depth

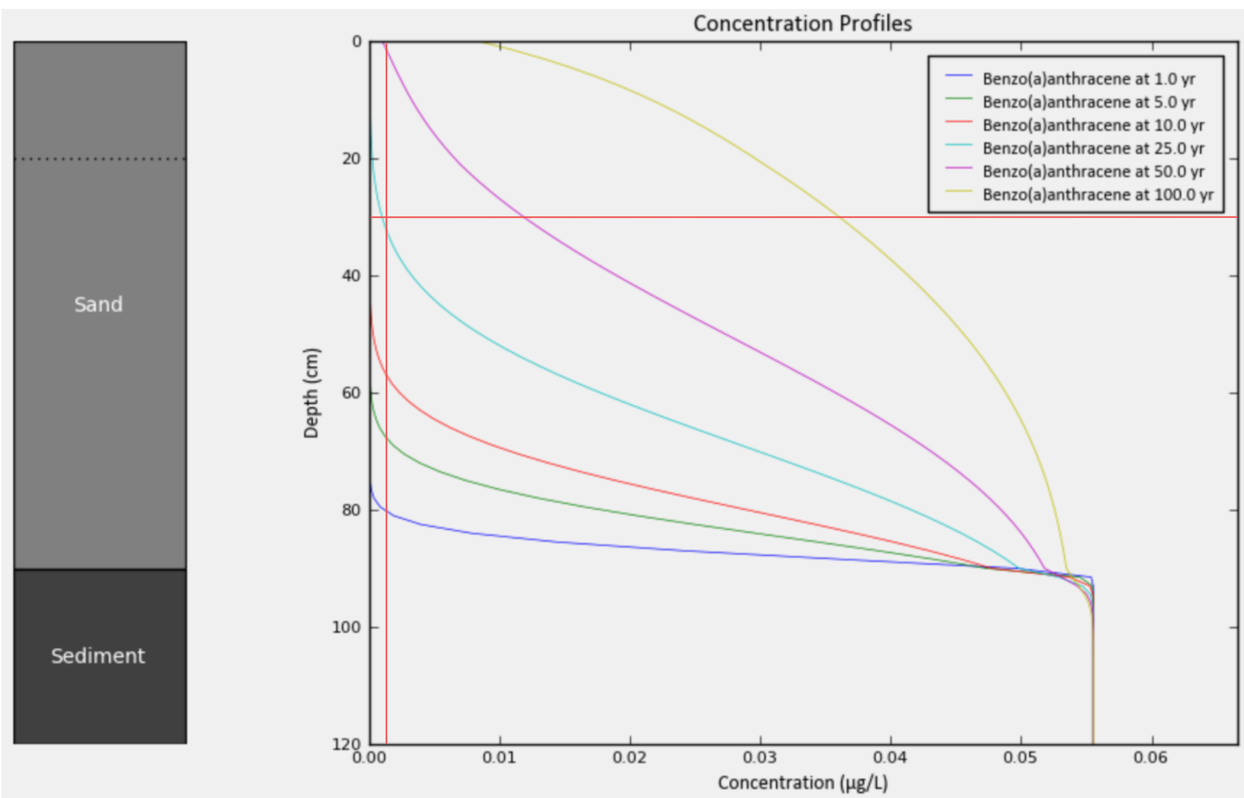


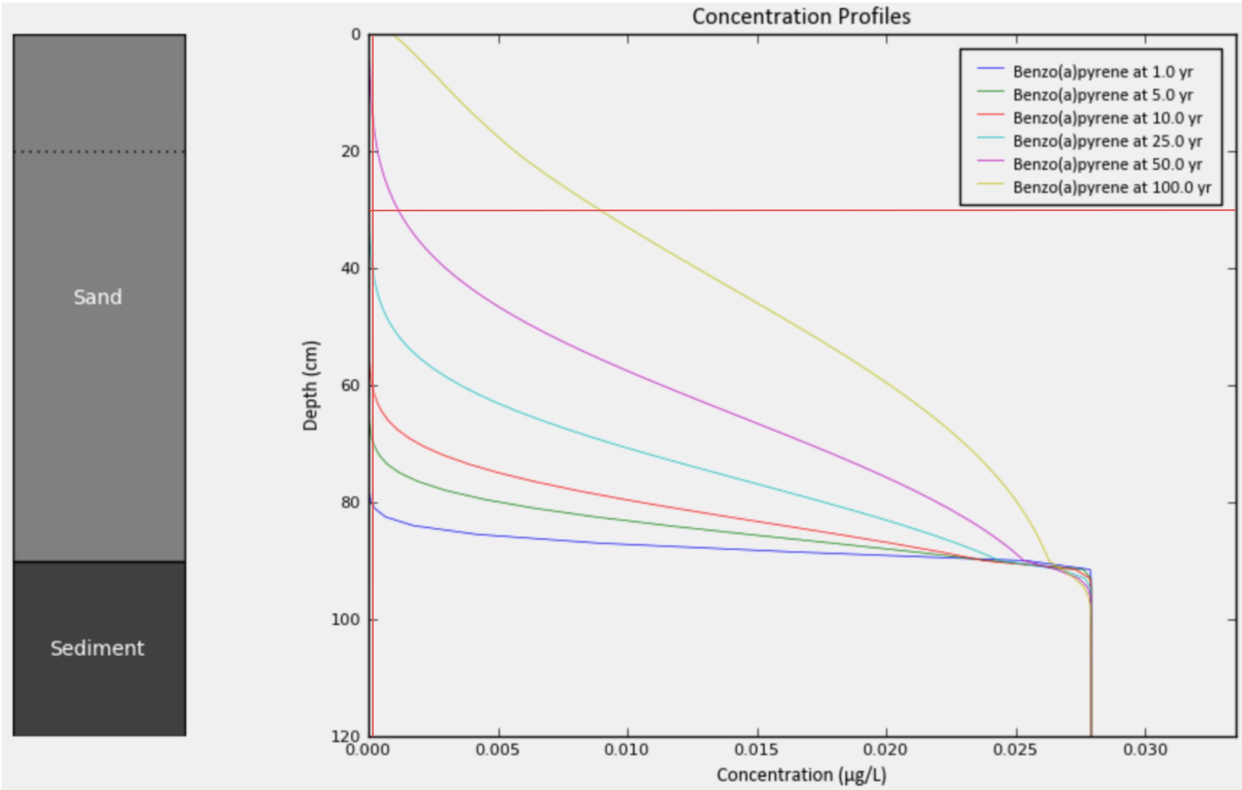


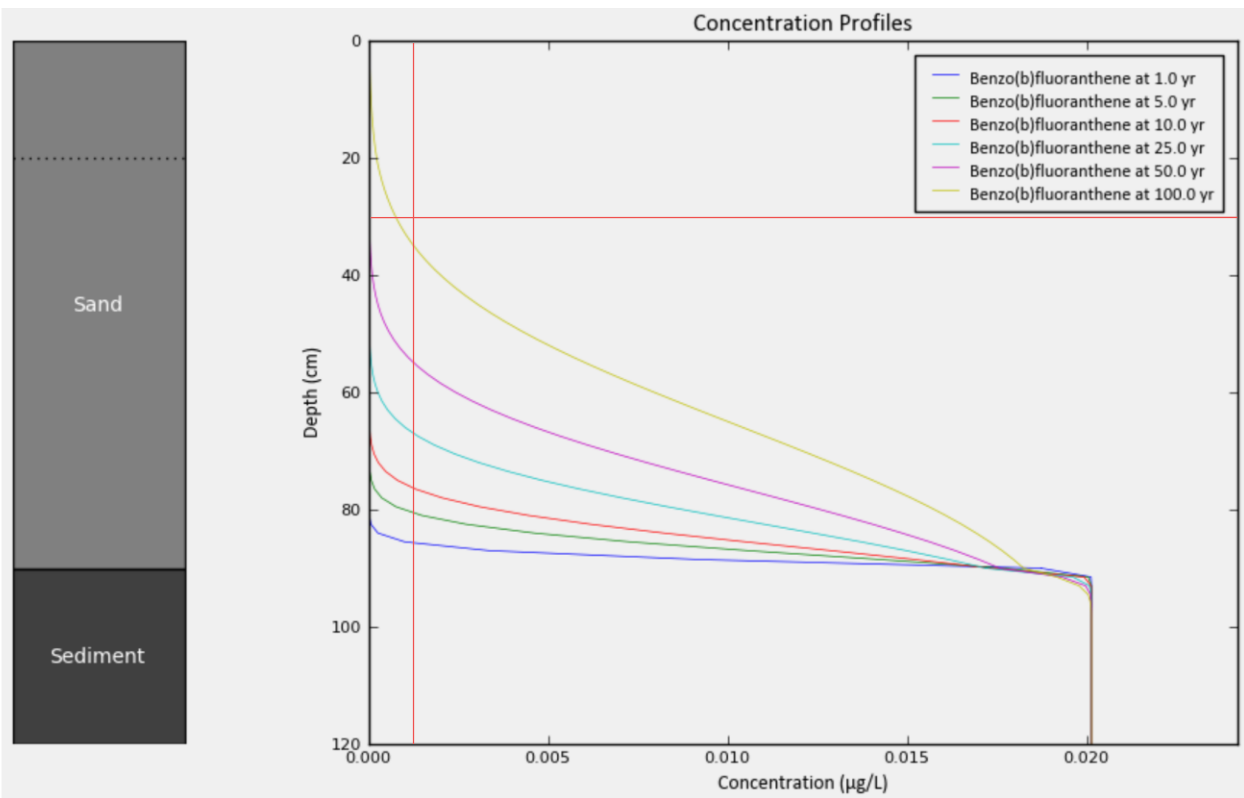

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0
0.5
1.0
1.5
2.0
2.5
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

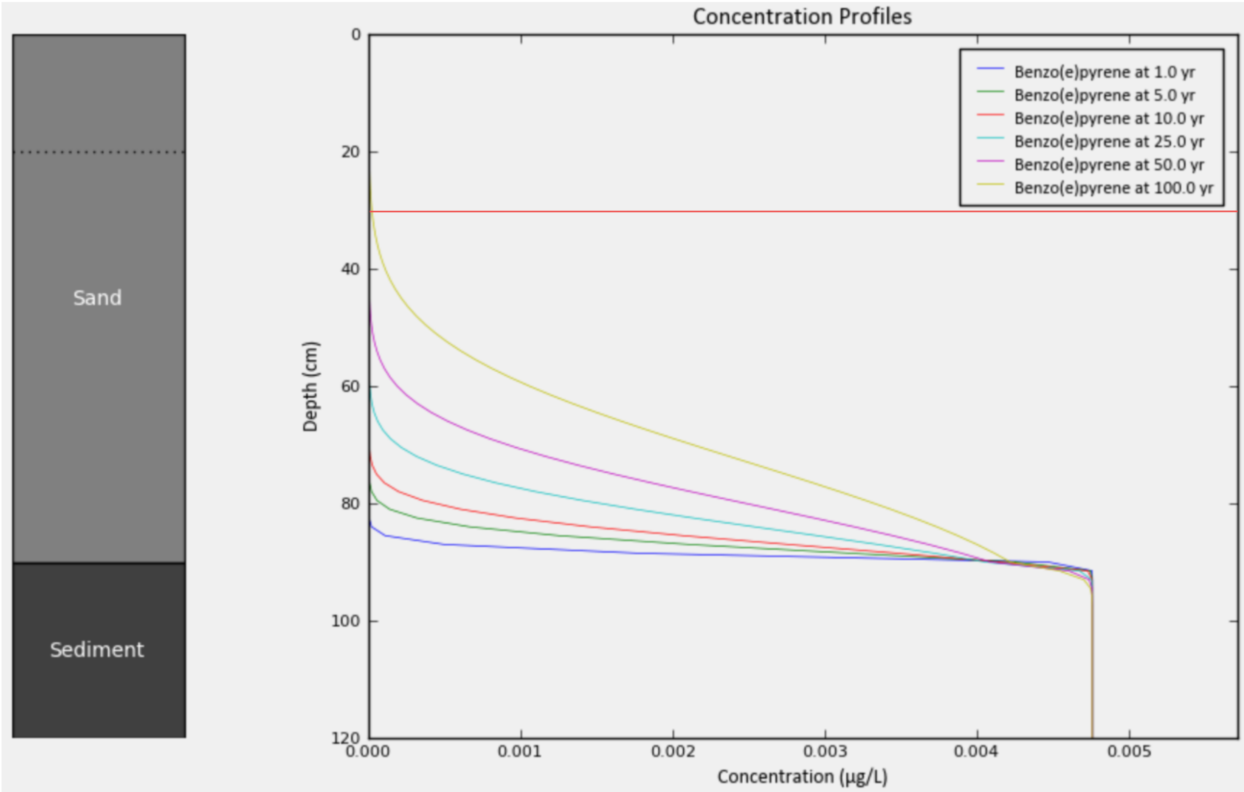

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0
0.1
0.2
0.3
0.4
0.5
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

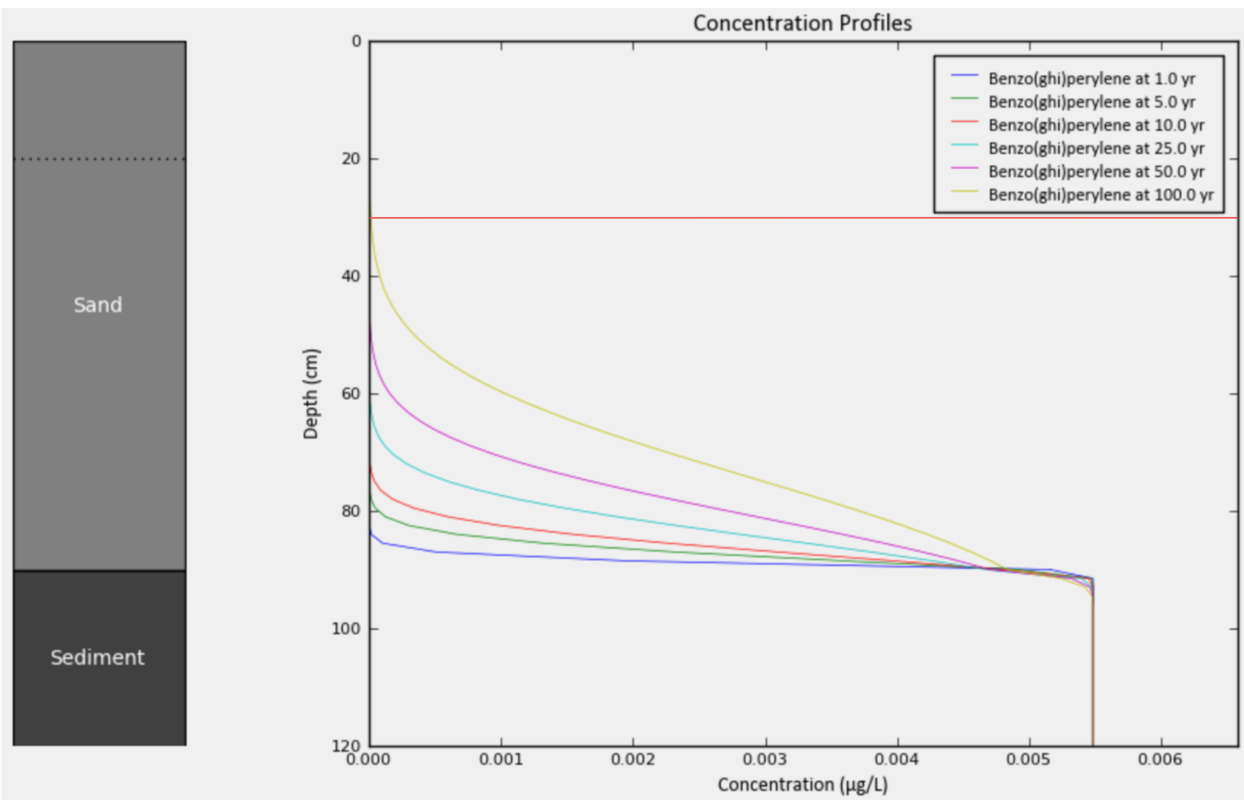

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

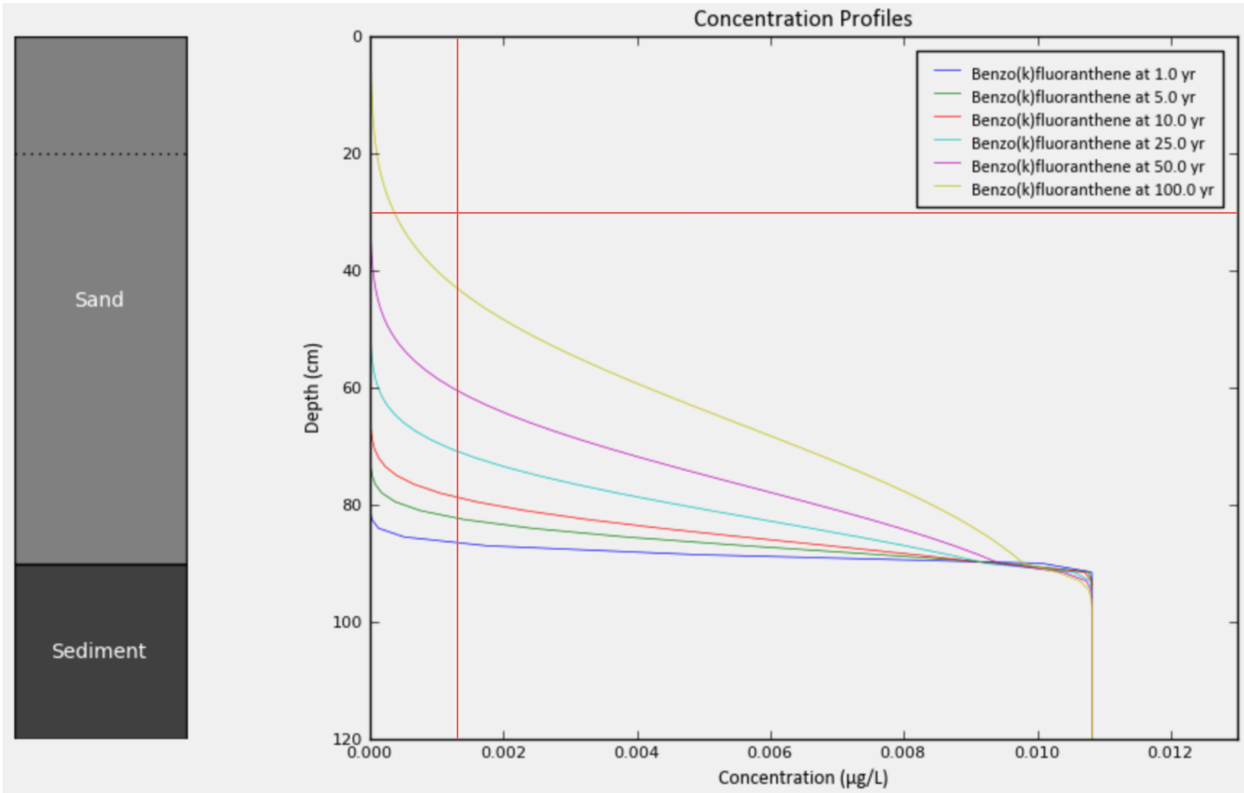

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

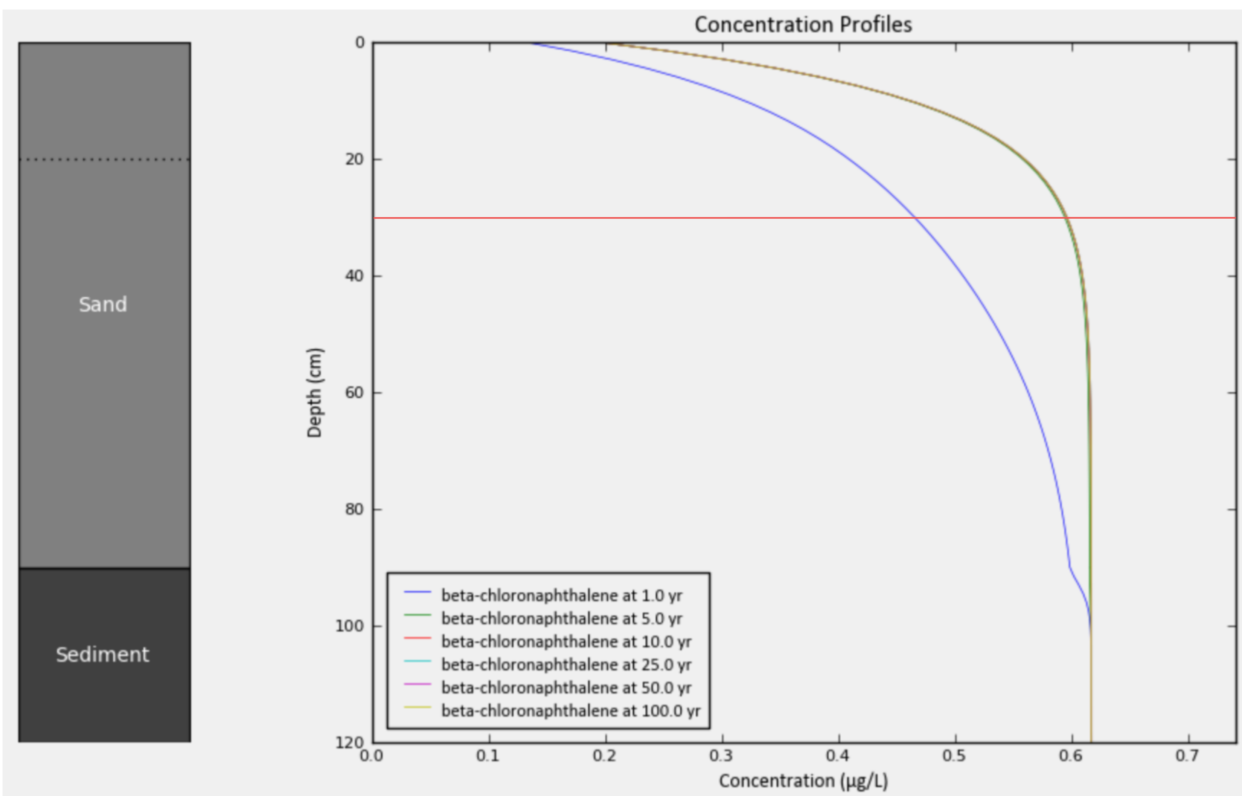

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr
0
20
40
60
80
100
120
0.000
0.005
0.010
0.015
0.020
0.025
0.030

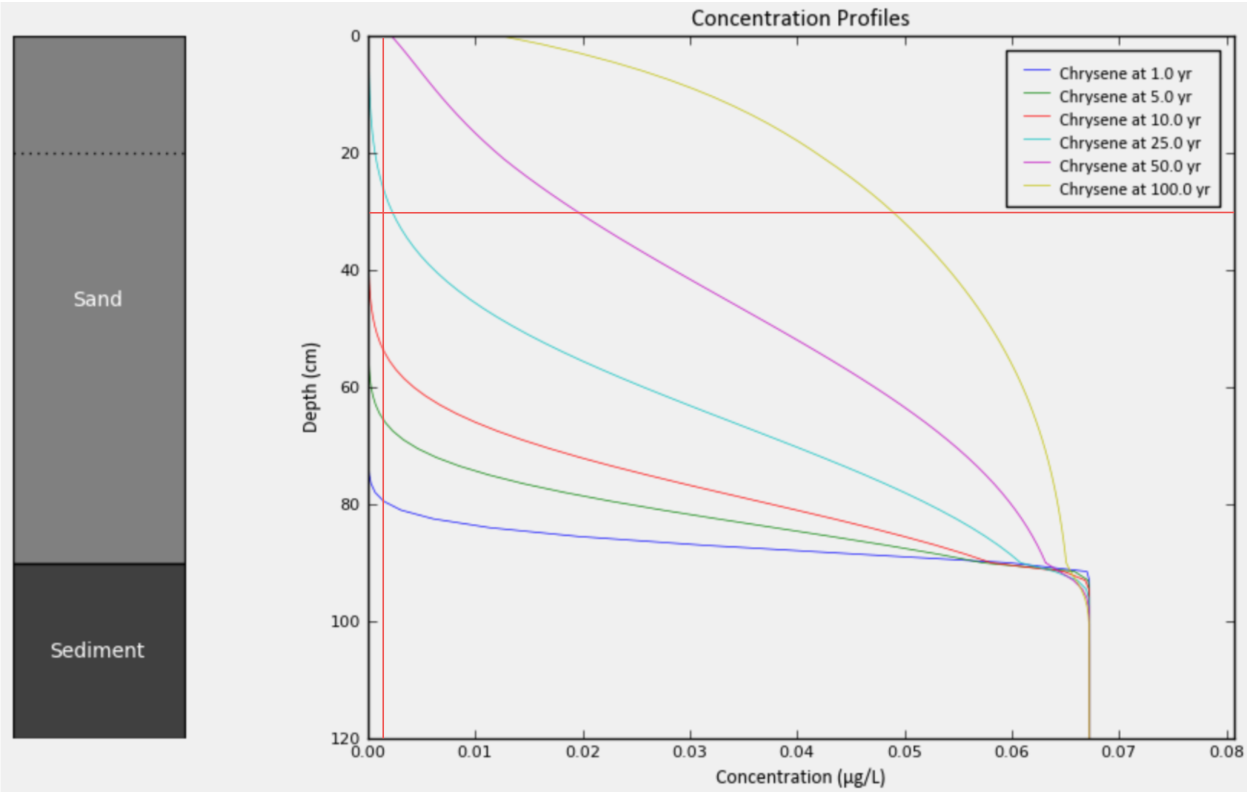

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr
0
20
40
60
80
100
120
0.000
0.005
0.010
0.015
0.020

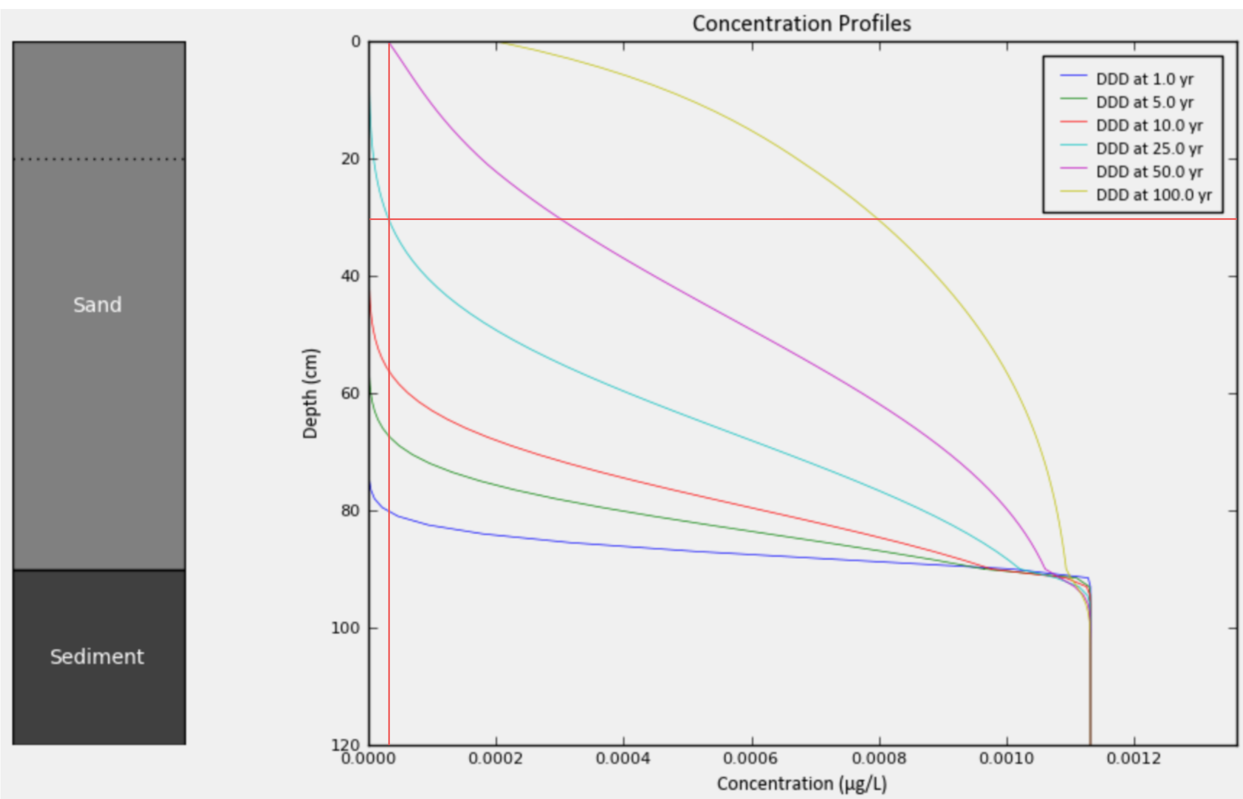

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

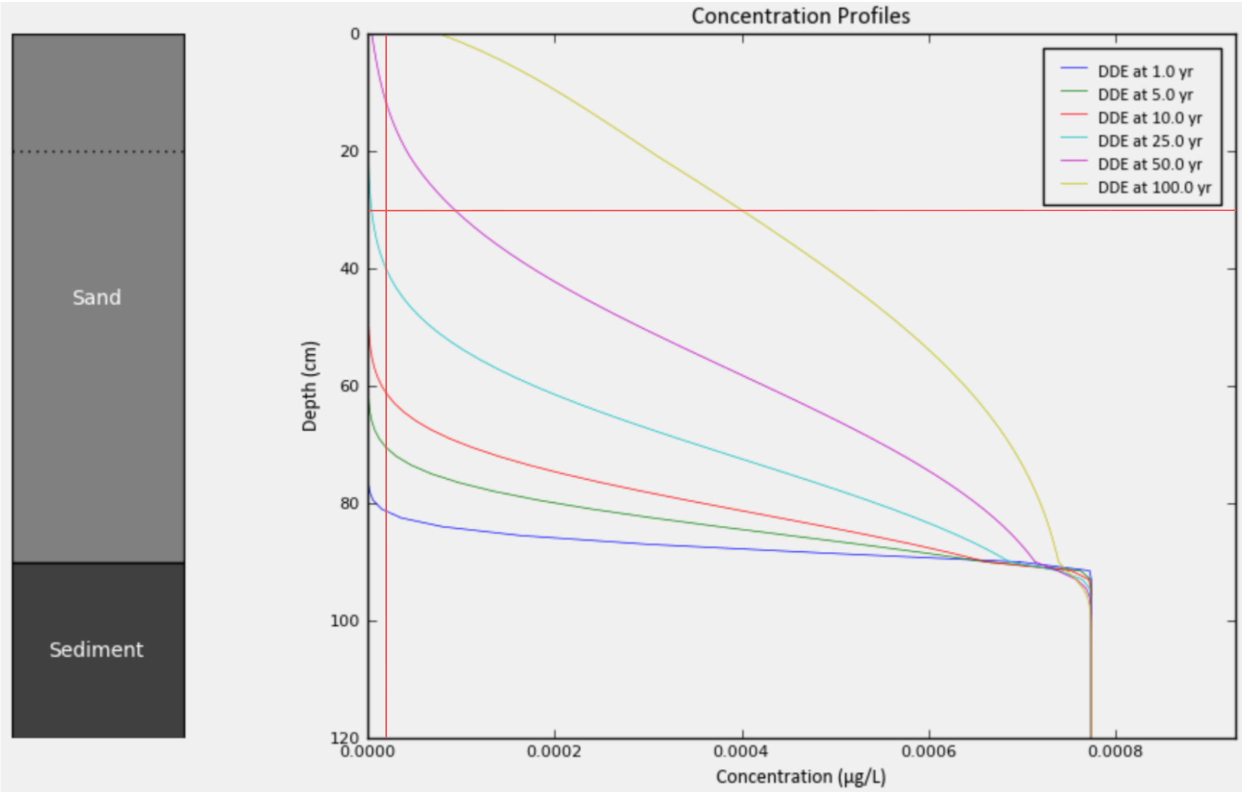

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

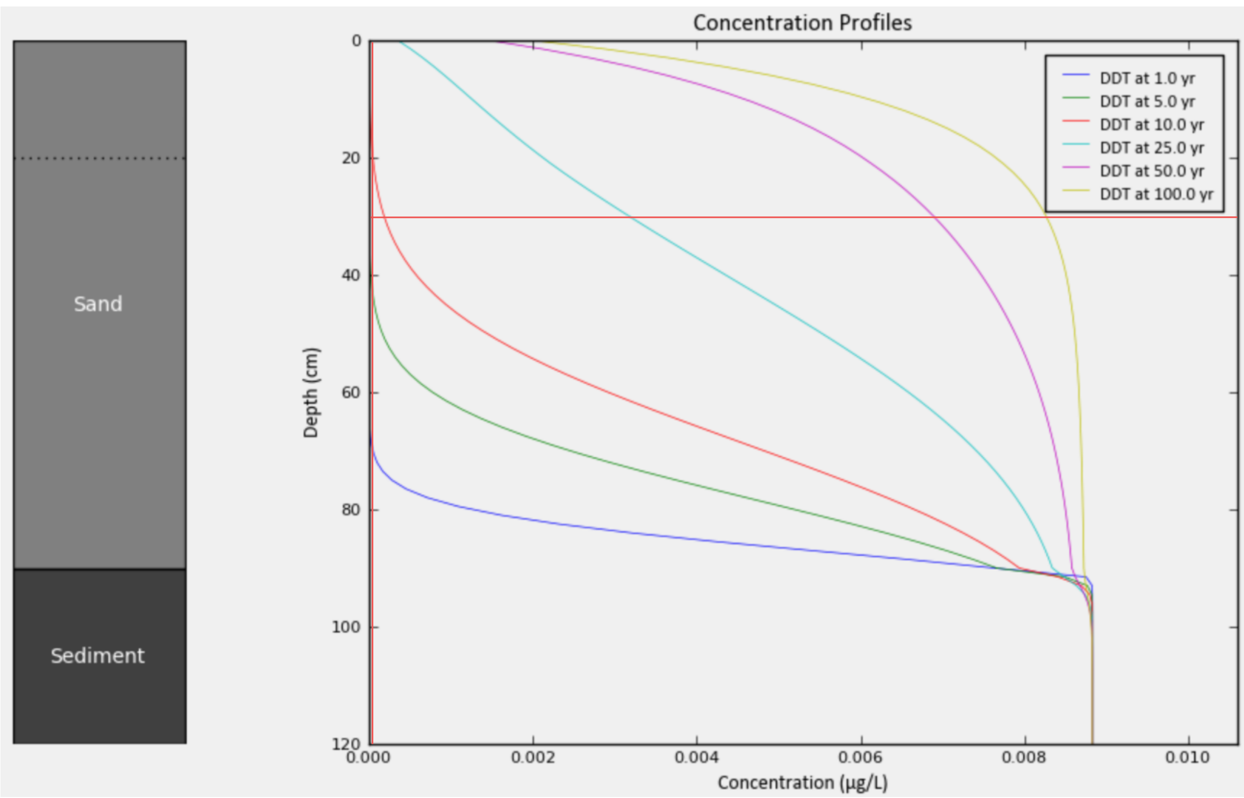

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr

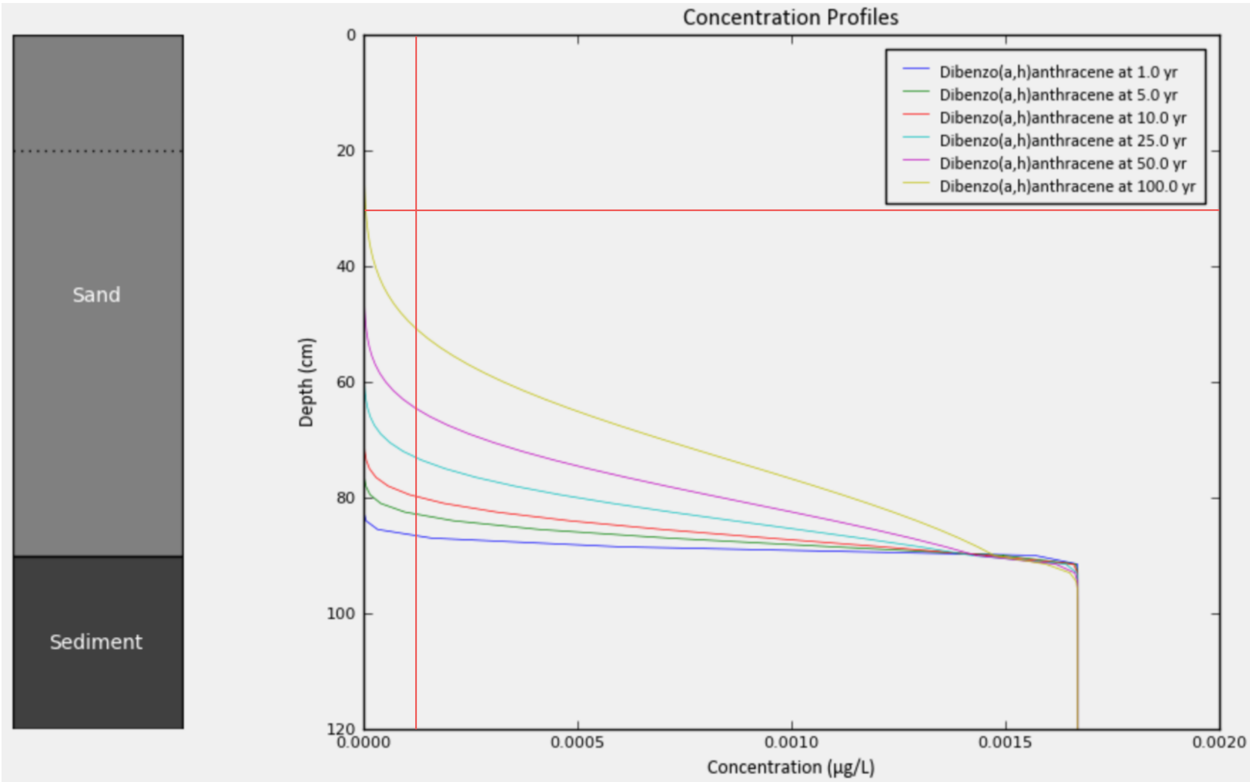

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr

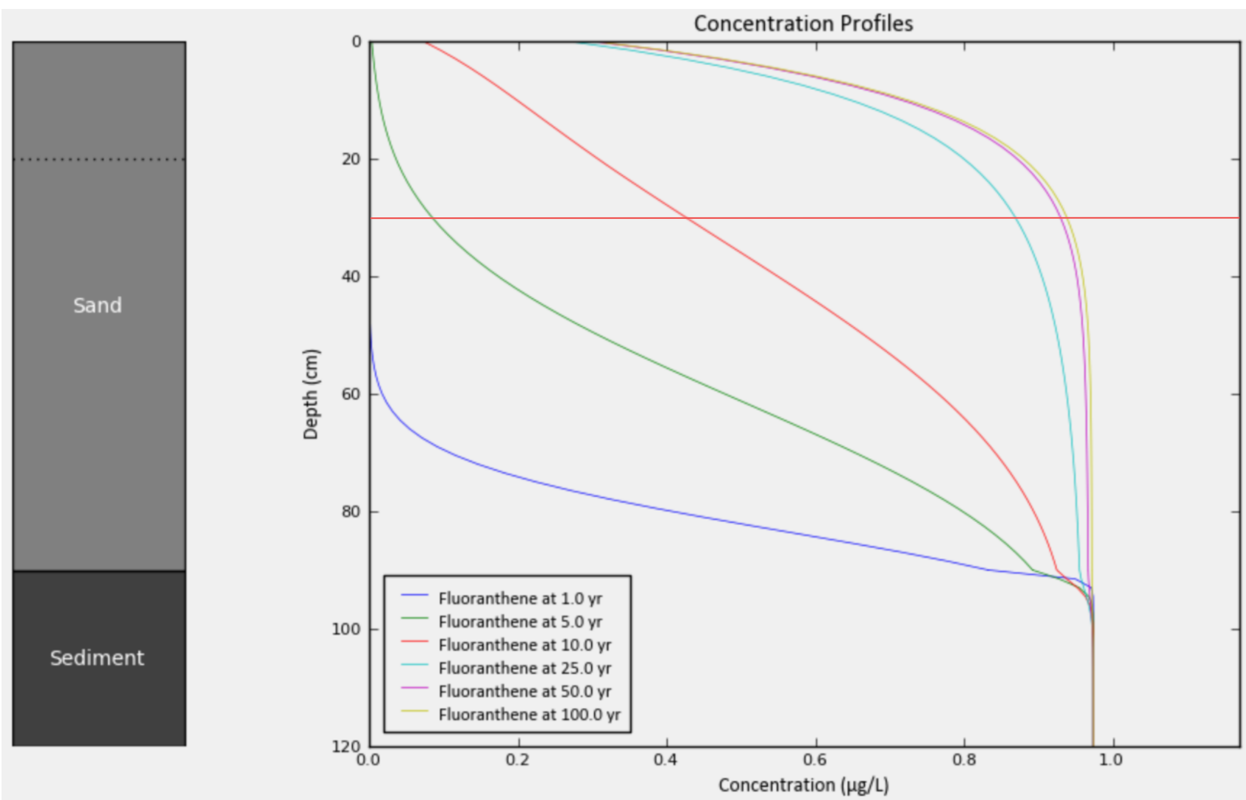

Sand
Sediment
Concentration Profiles
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

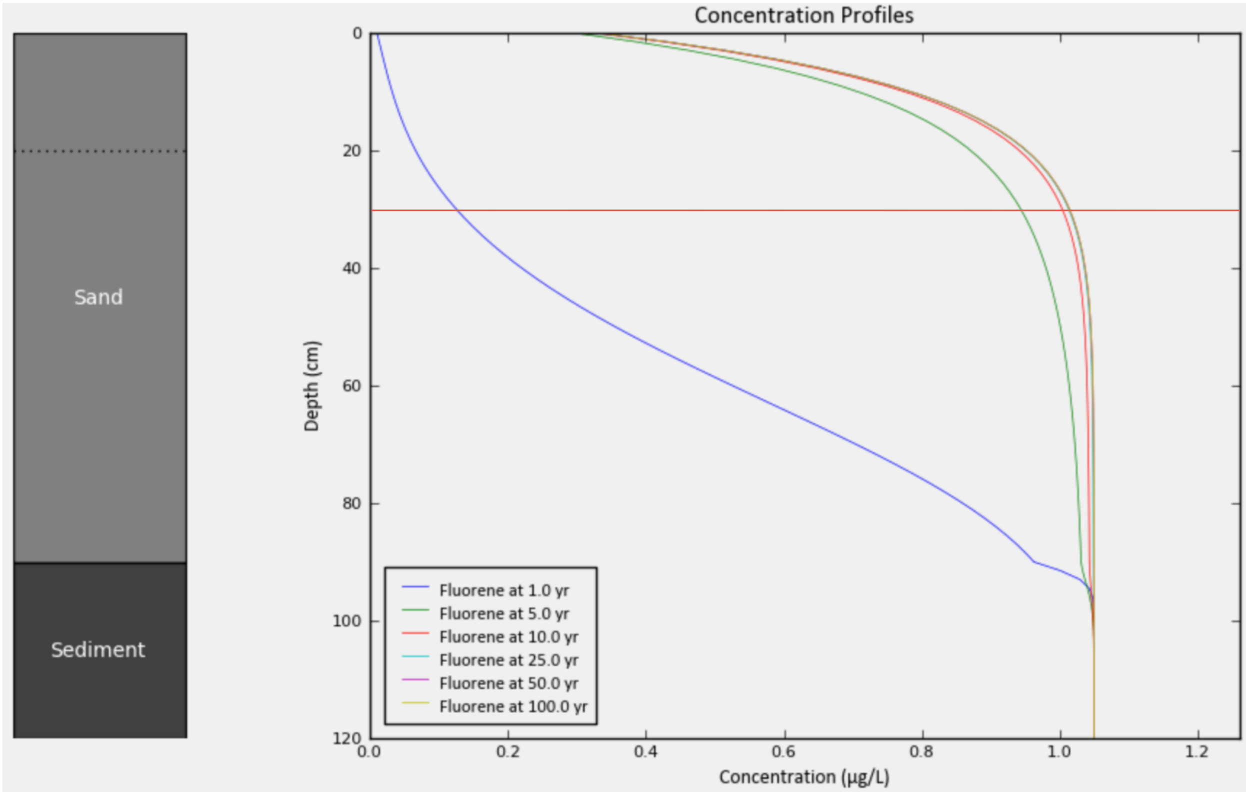

Sand
Sediment
Concentration Profiles
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012

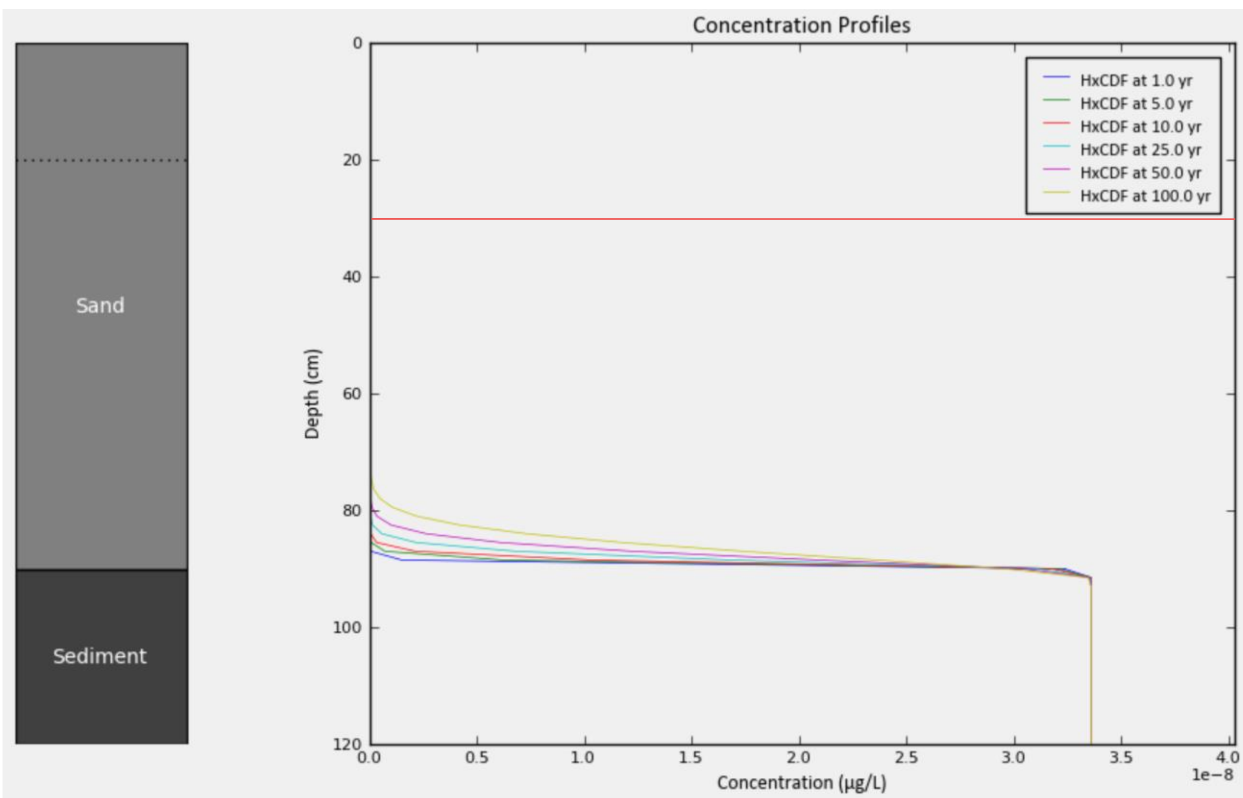

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
0
20
40
60
80
100
120
0.0000
0.0002
0.0004
0.0006
0.0008

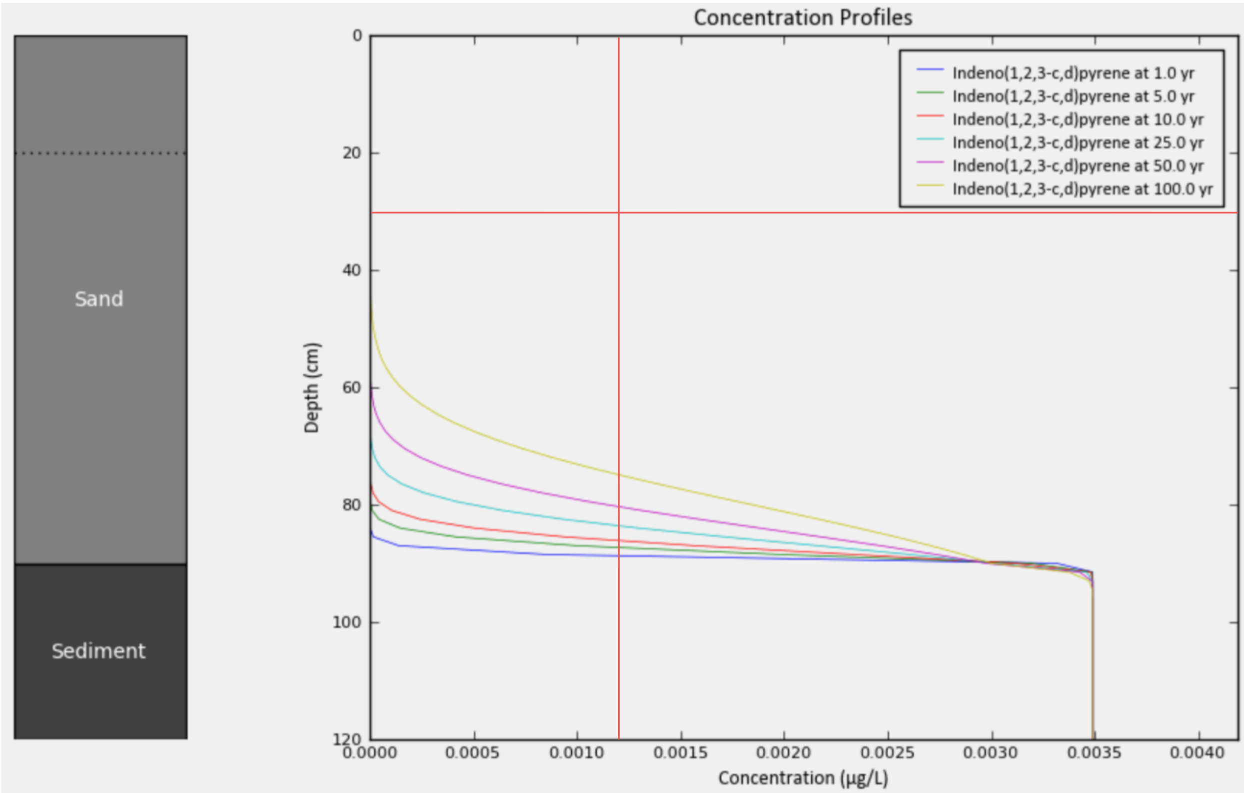

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
0
20
40
60
80
100
120
0.000
0.002
0.004
0.006
0.008
0.010

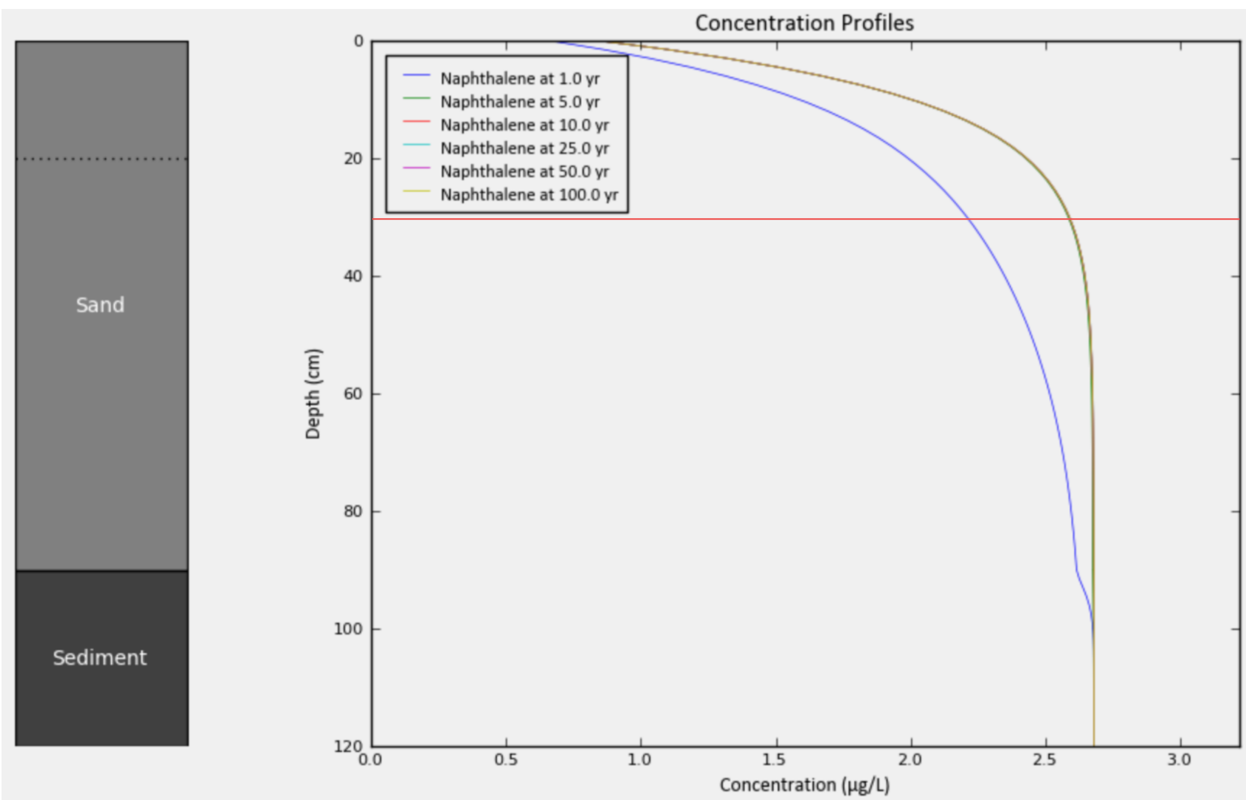

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
0
20
40
60
80
100
120
0.0000
0.0005
0.0010
0.0015
0.0020

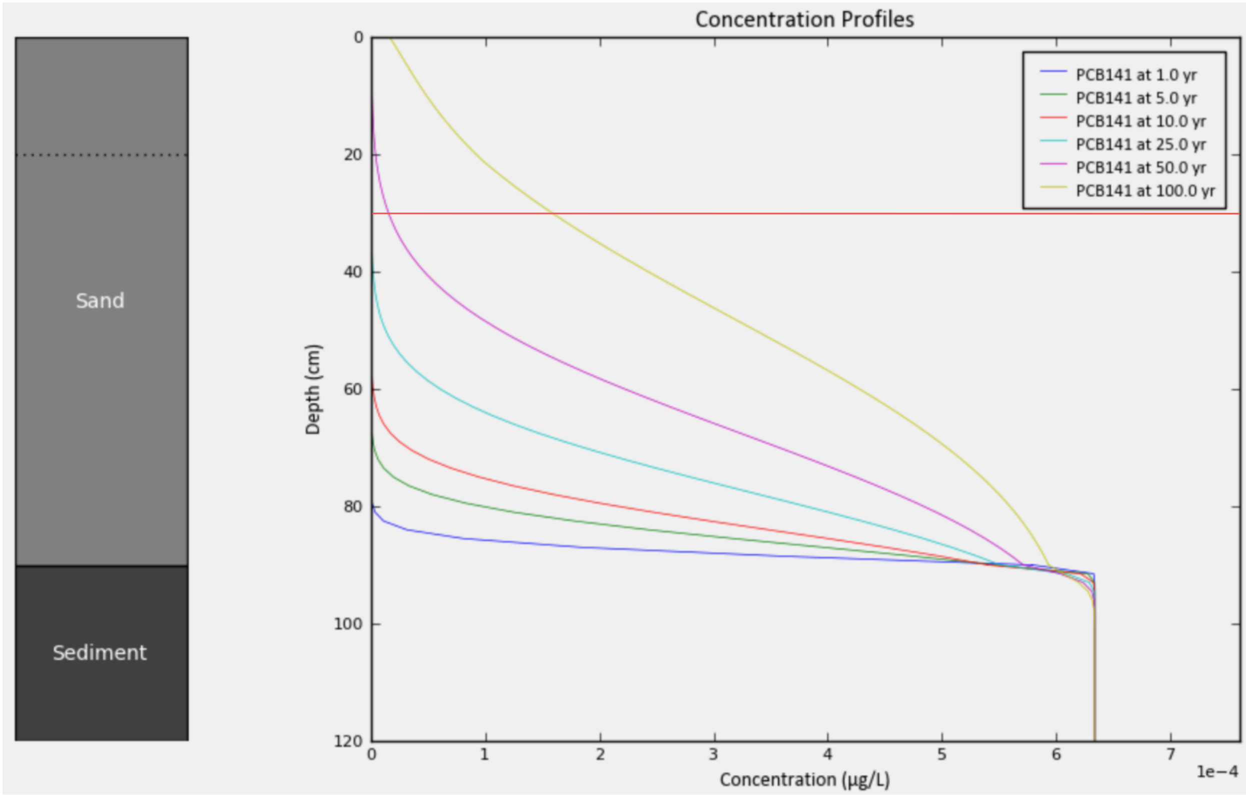

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
1.0

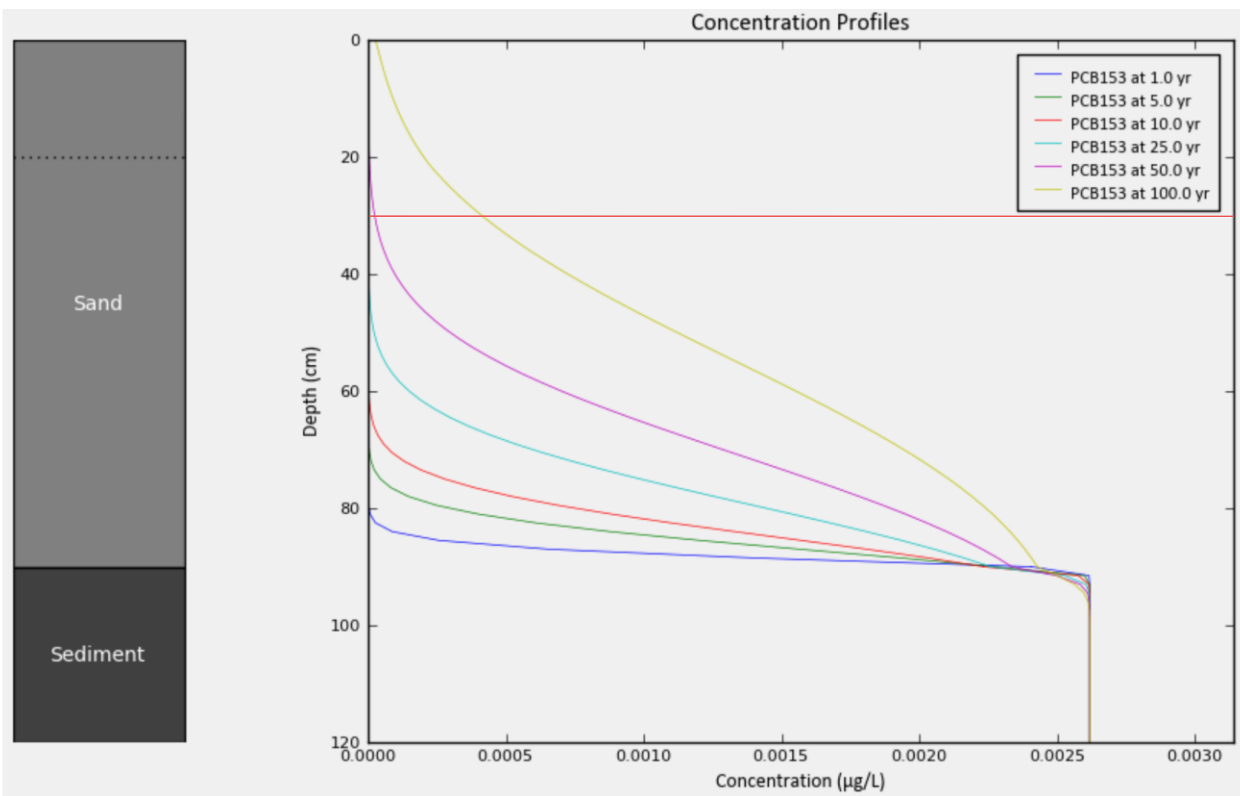

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr

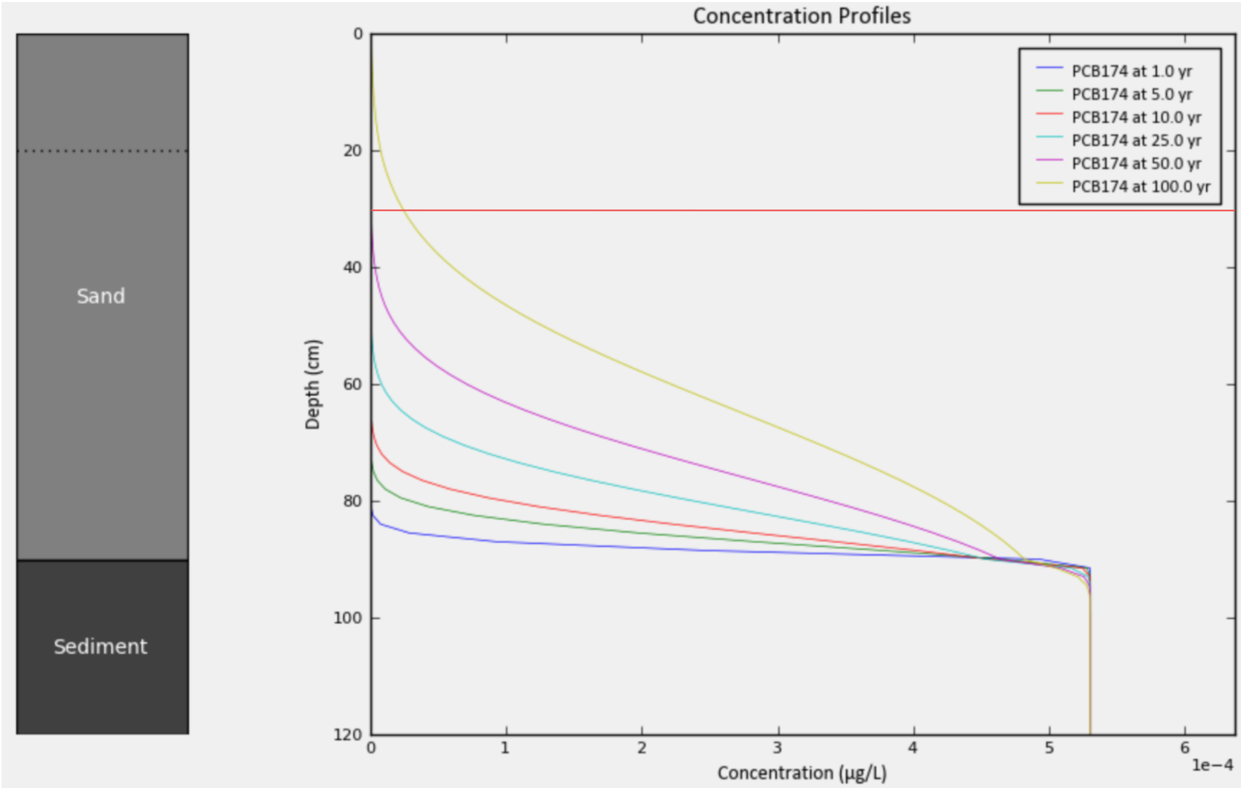

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−8
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr

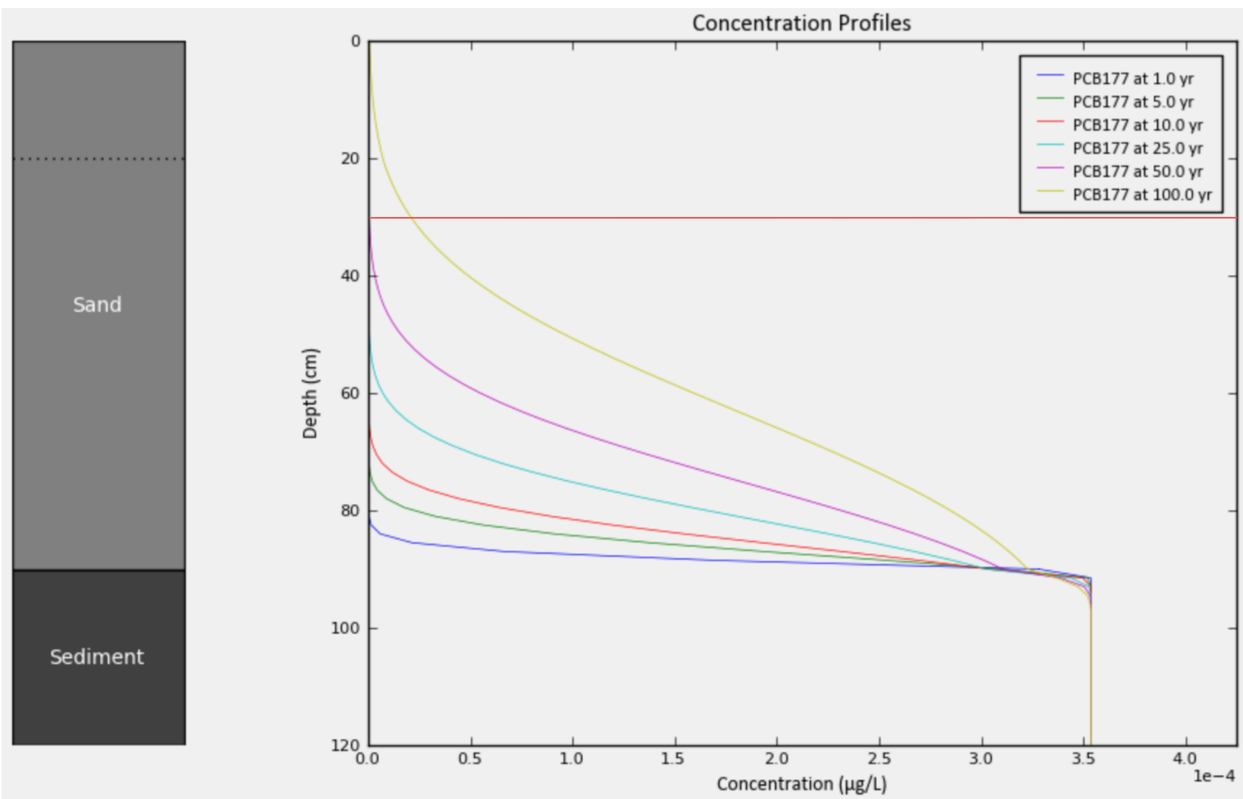

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr

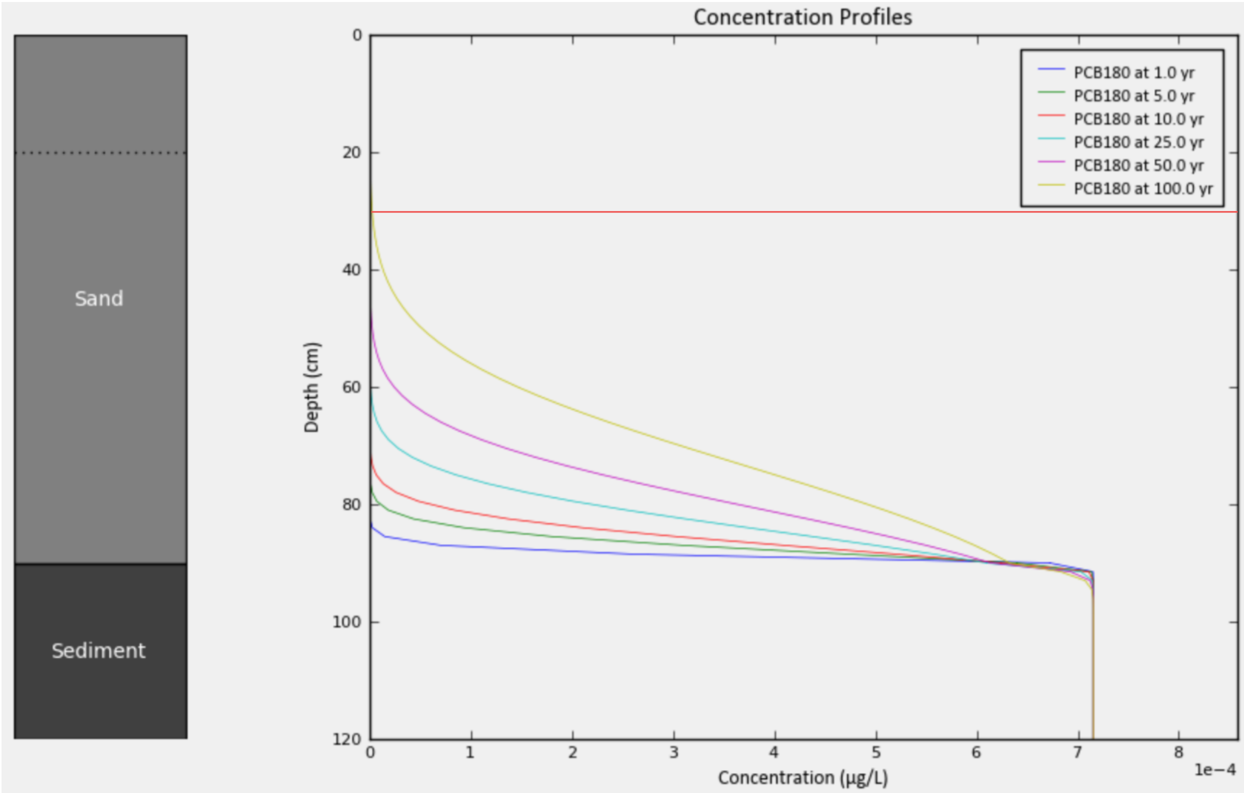

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr

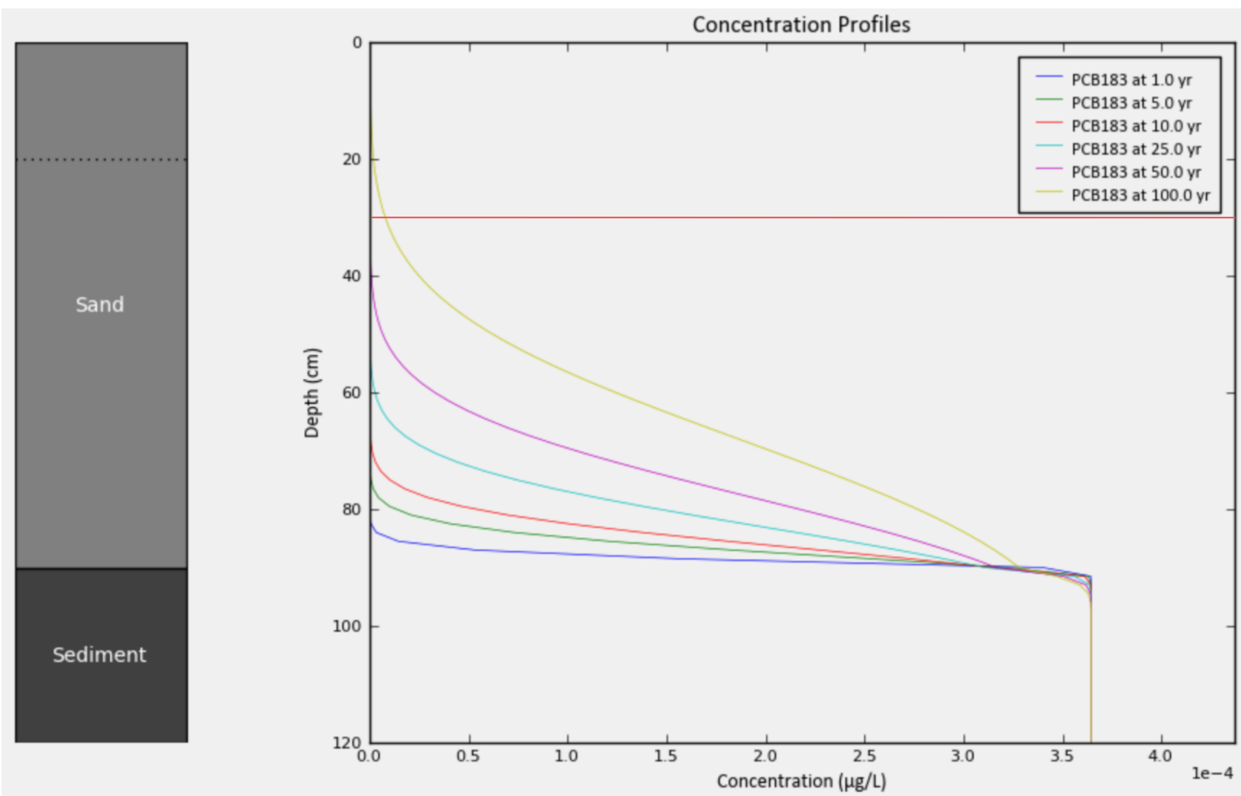

Sand
Sediment
Concentration Profiles
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

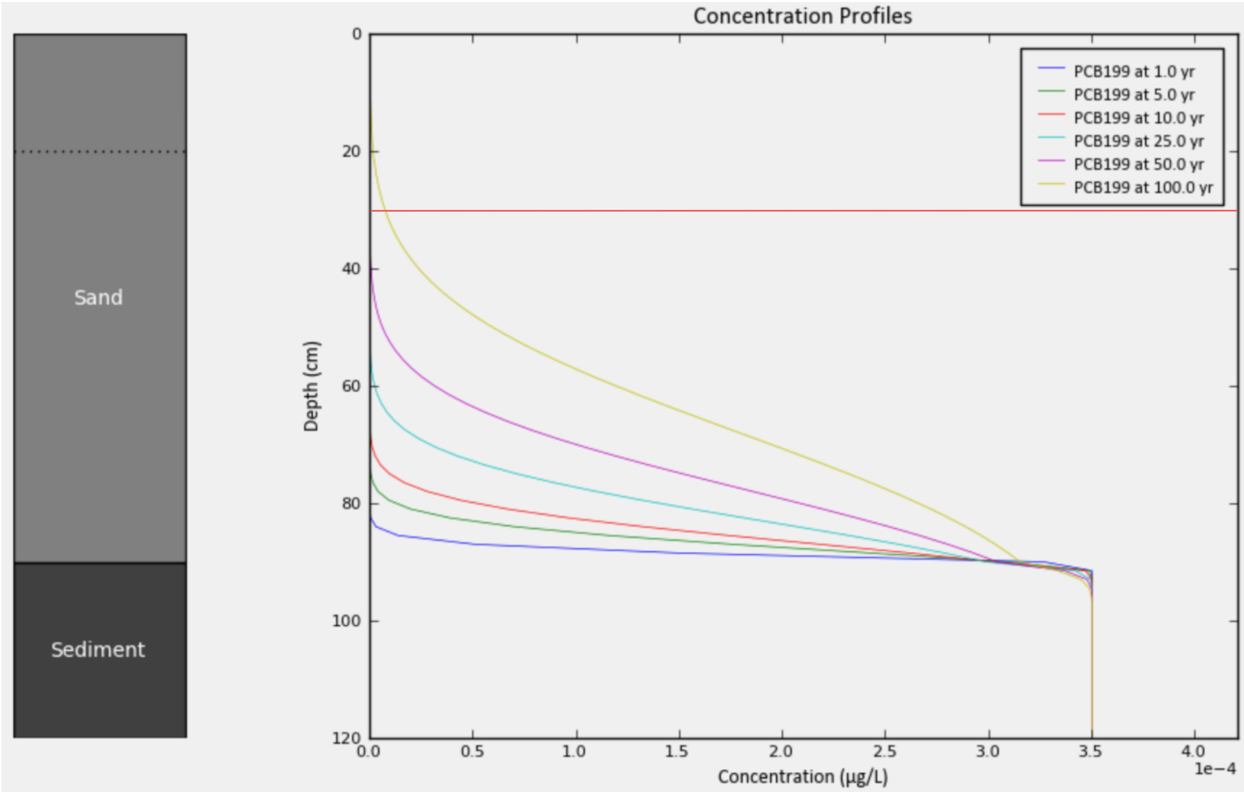

Sand
Sediment
Concentration Profiles
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr
Depth (cm)
Concentration (µg/L)

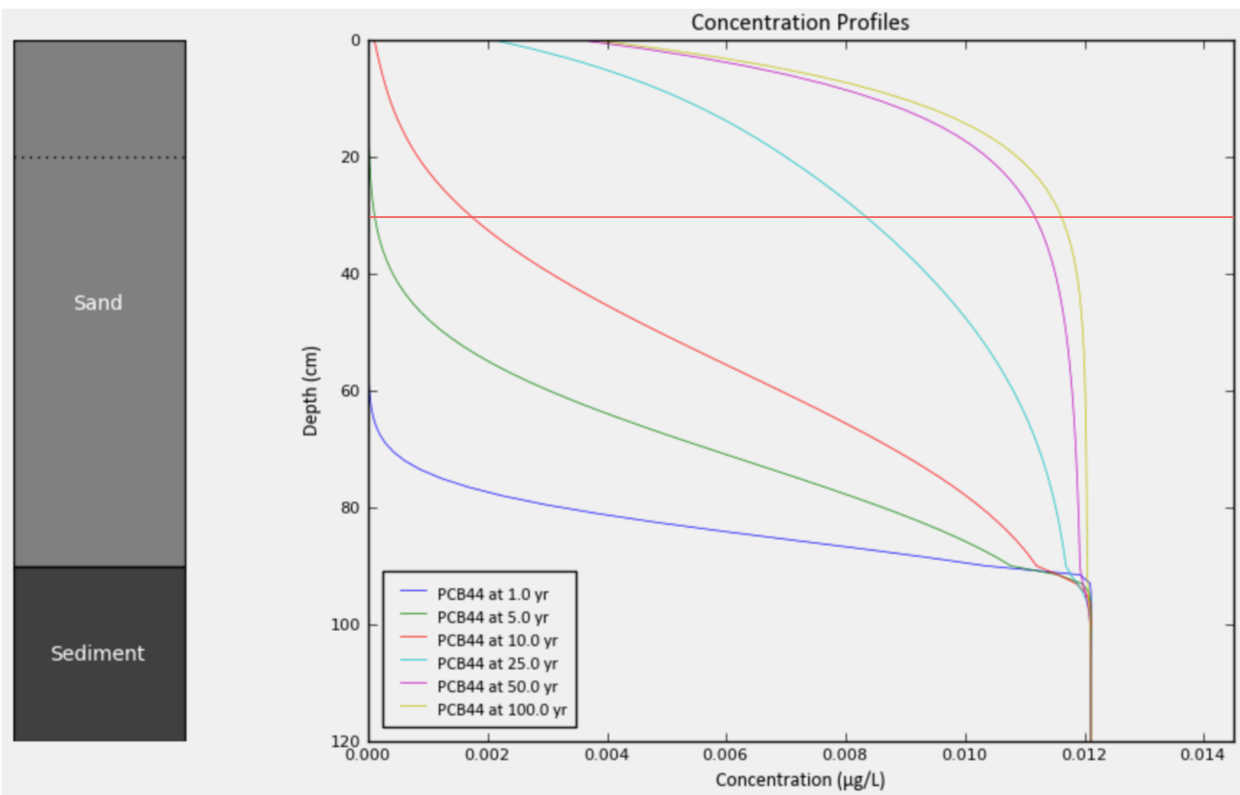

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr

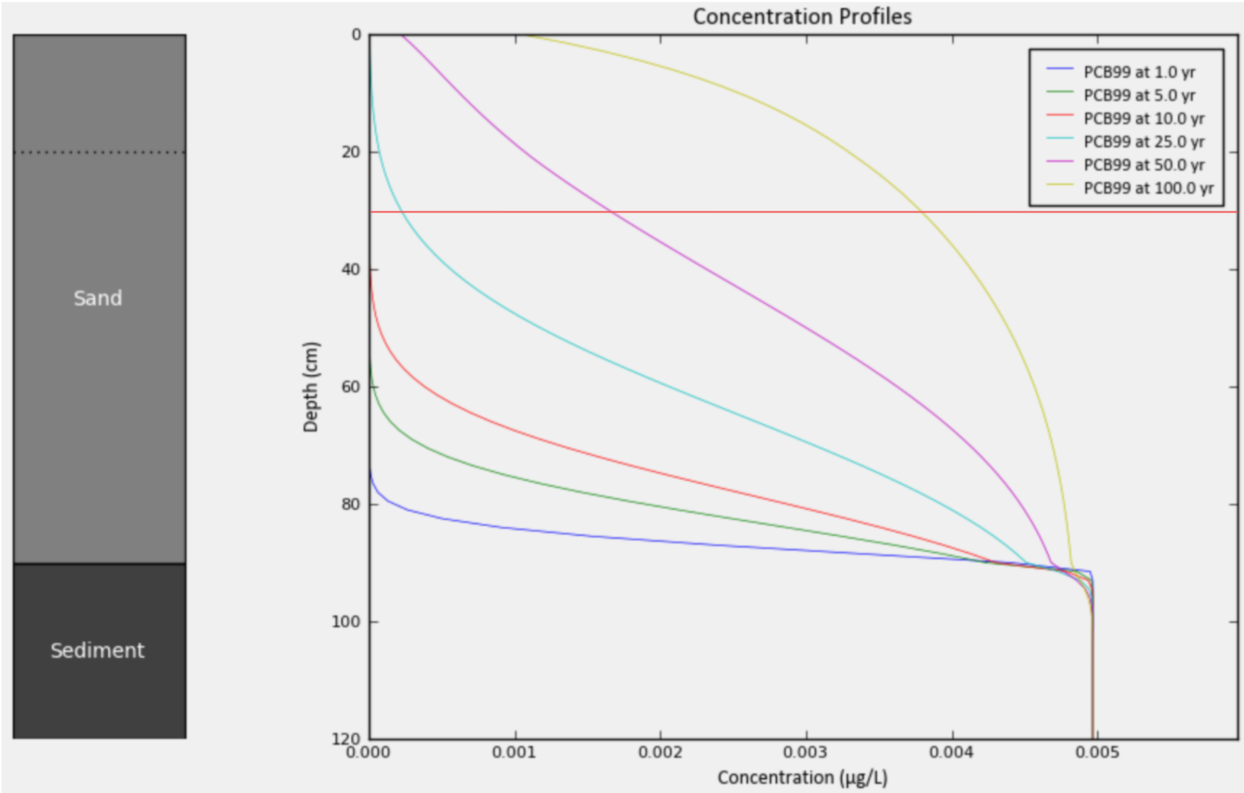

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr

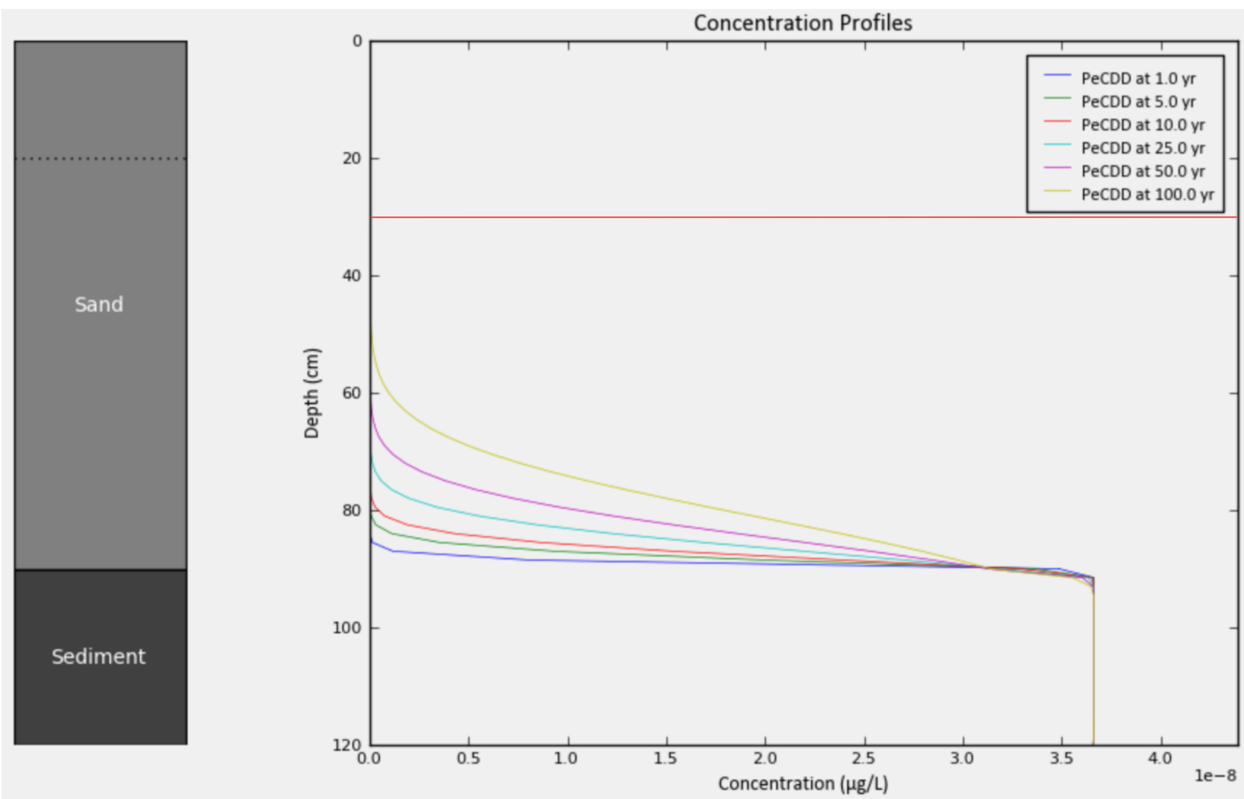

Sand
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

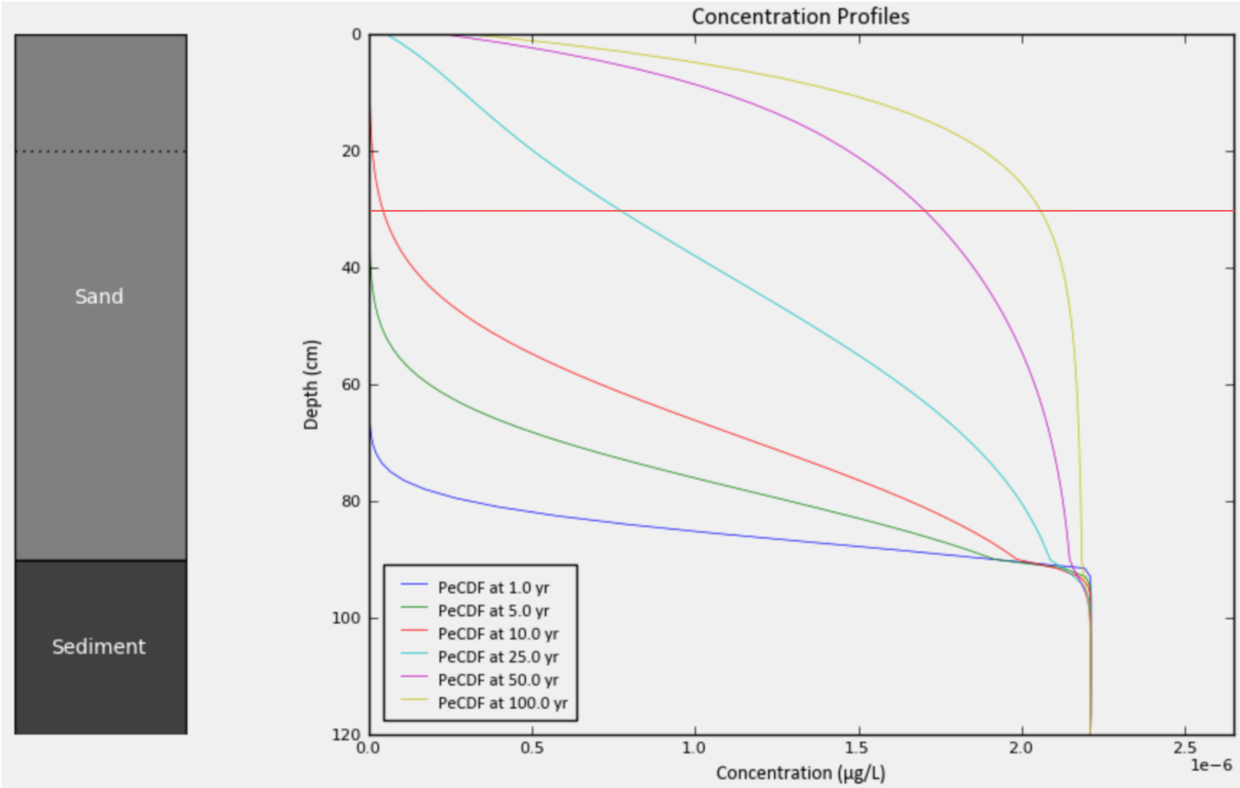

Sand
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4


Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr

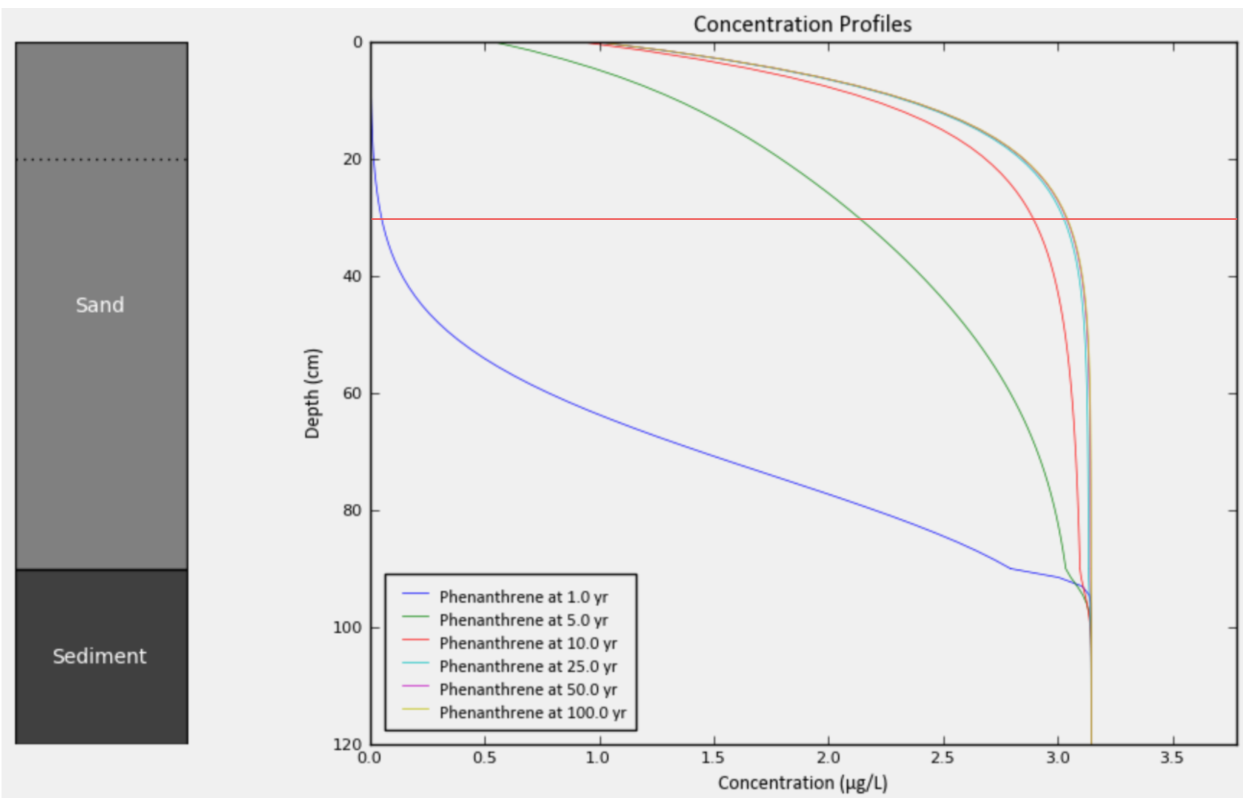

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr


Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
0
20
40
60
80
100
120
0.000
0.001
0.002
0.003
0.004
0.005

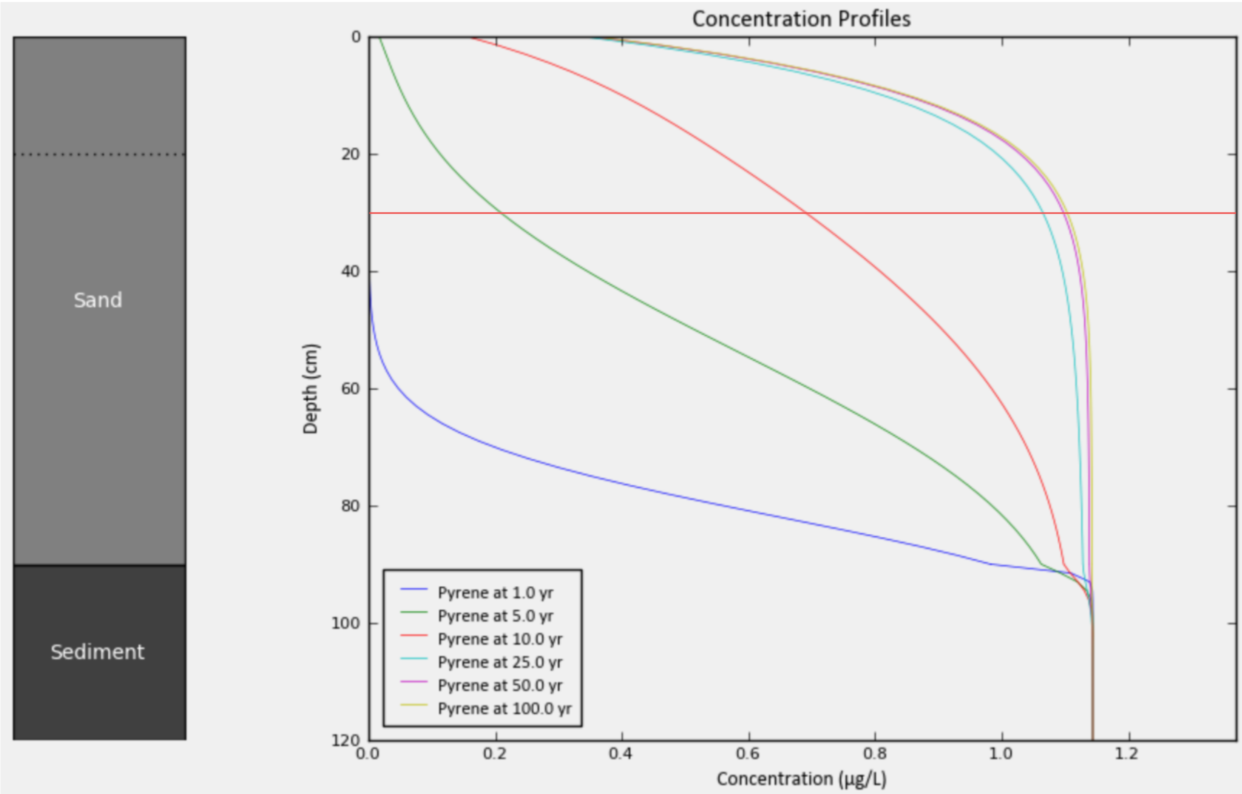

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
0
20
40
60
80
100
120
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−8

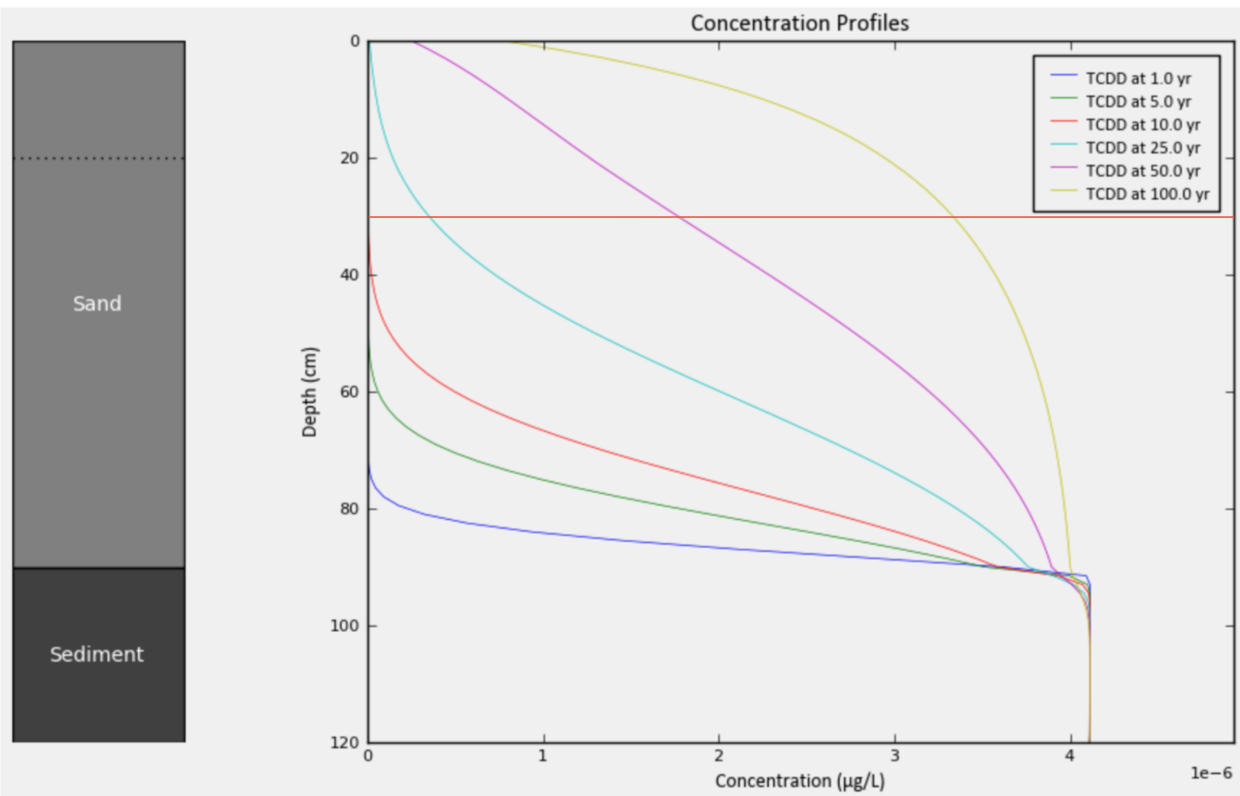


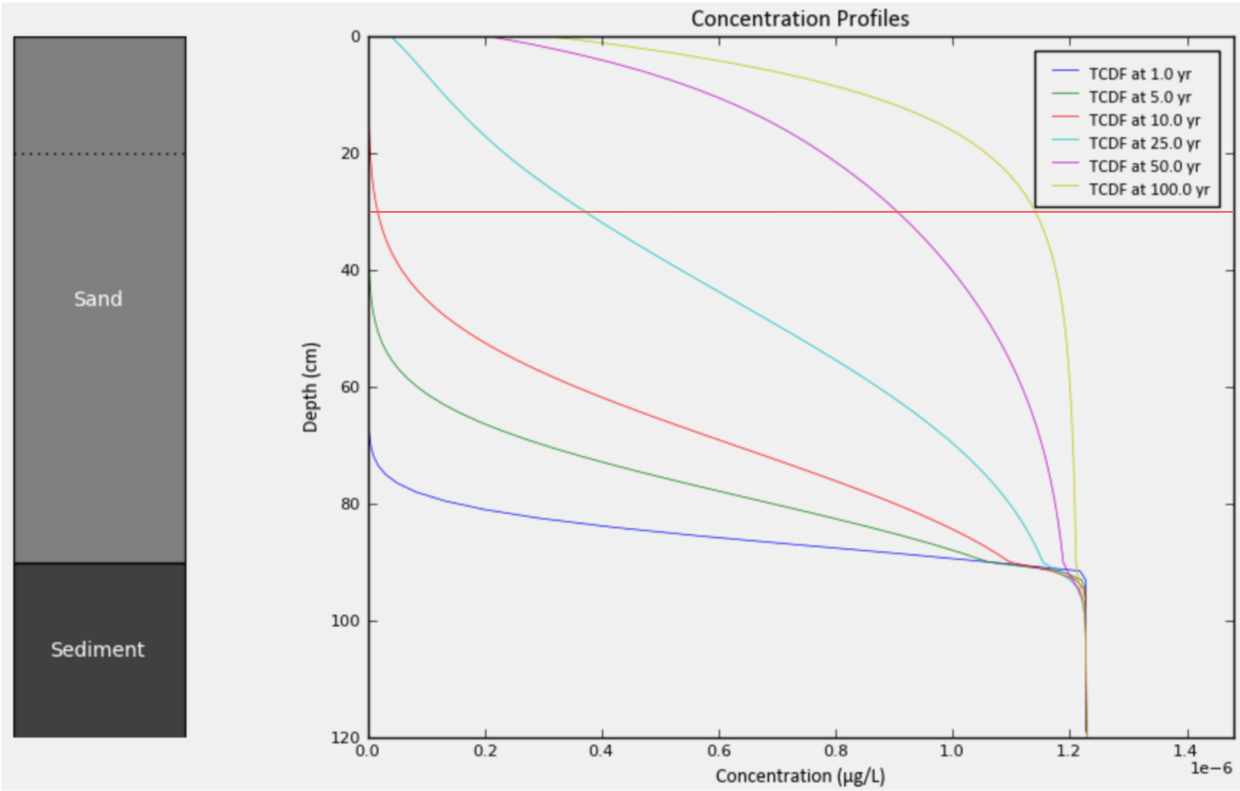
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
1e−6
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr

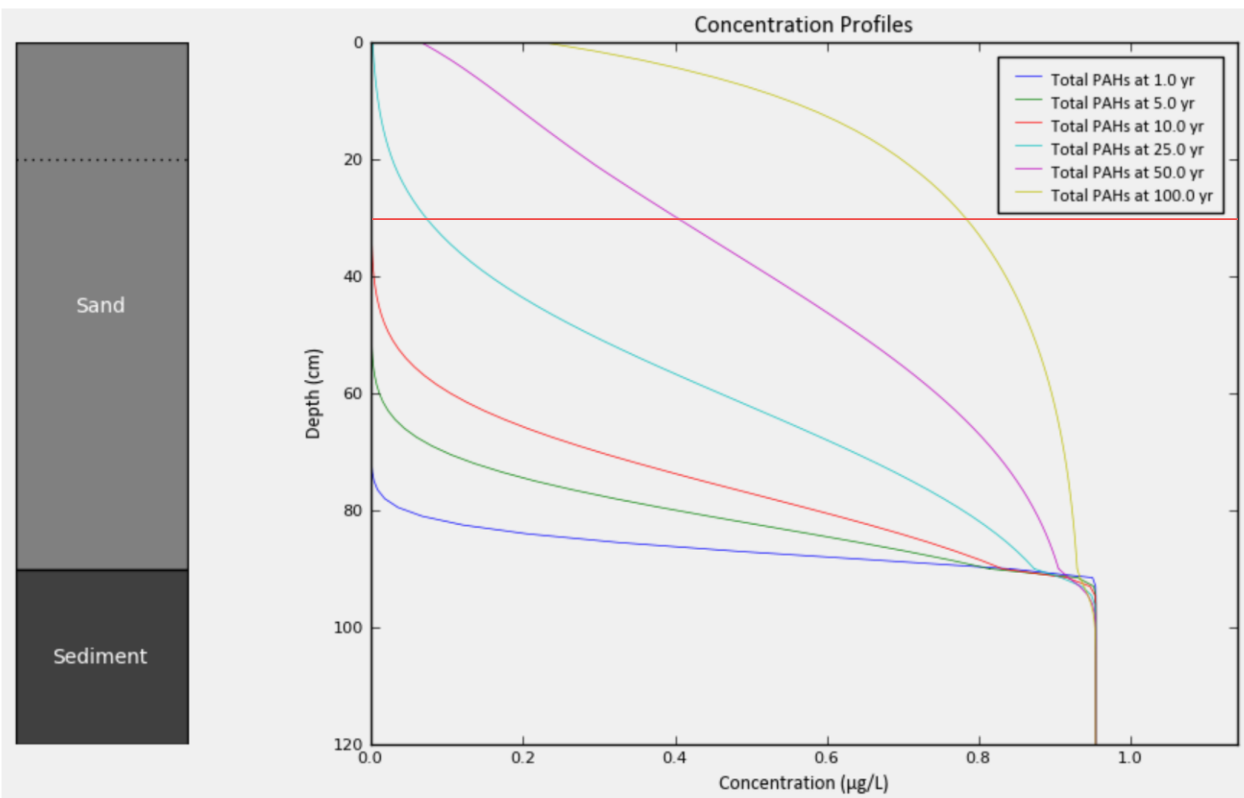


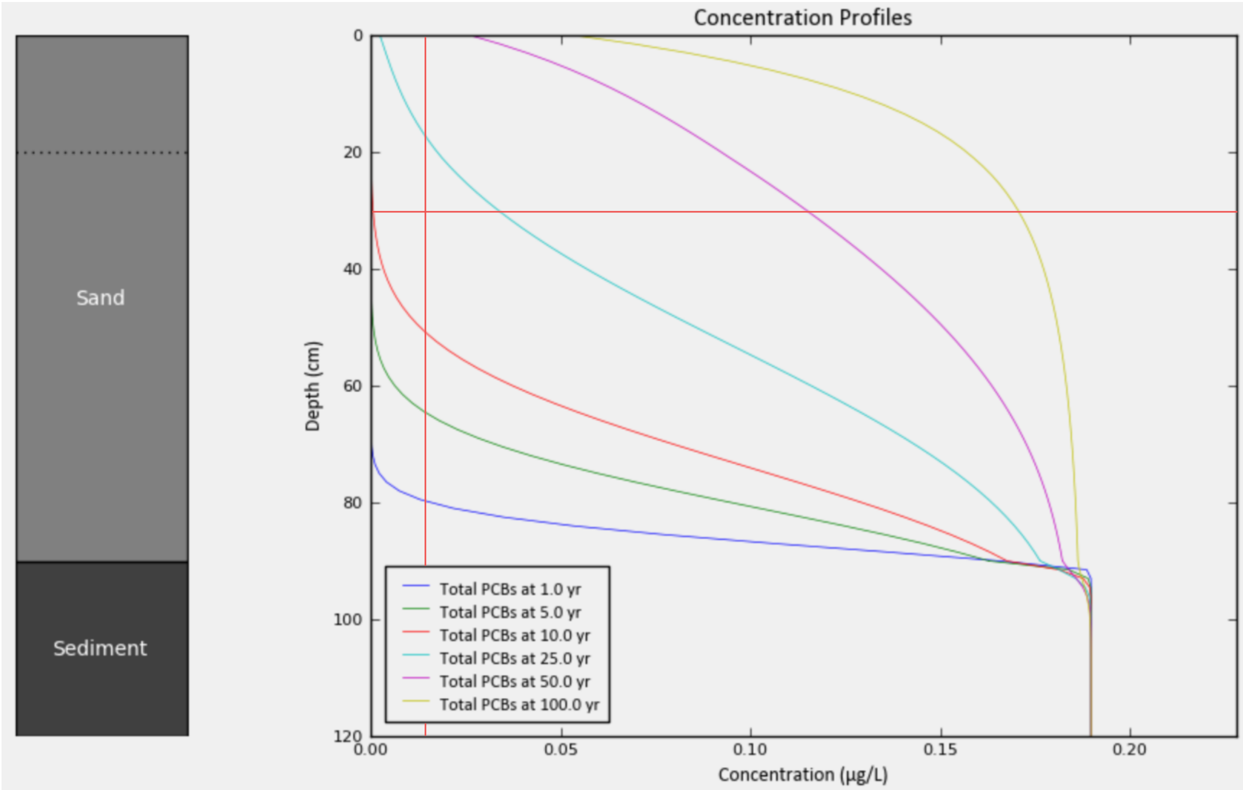
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr

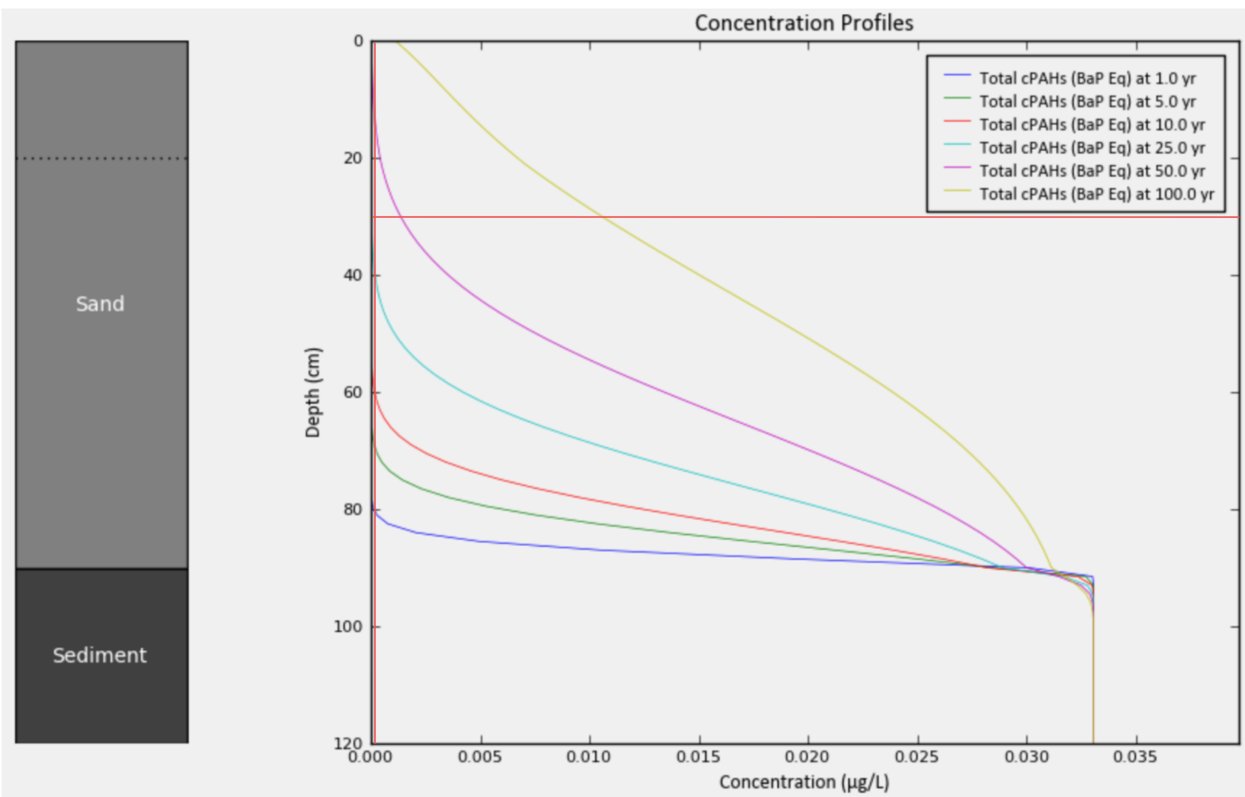

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr


Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
1e−6
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr

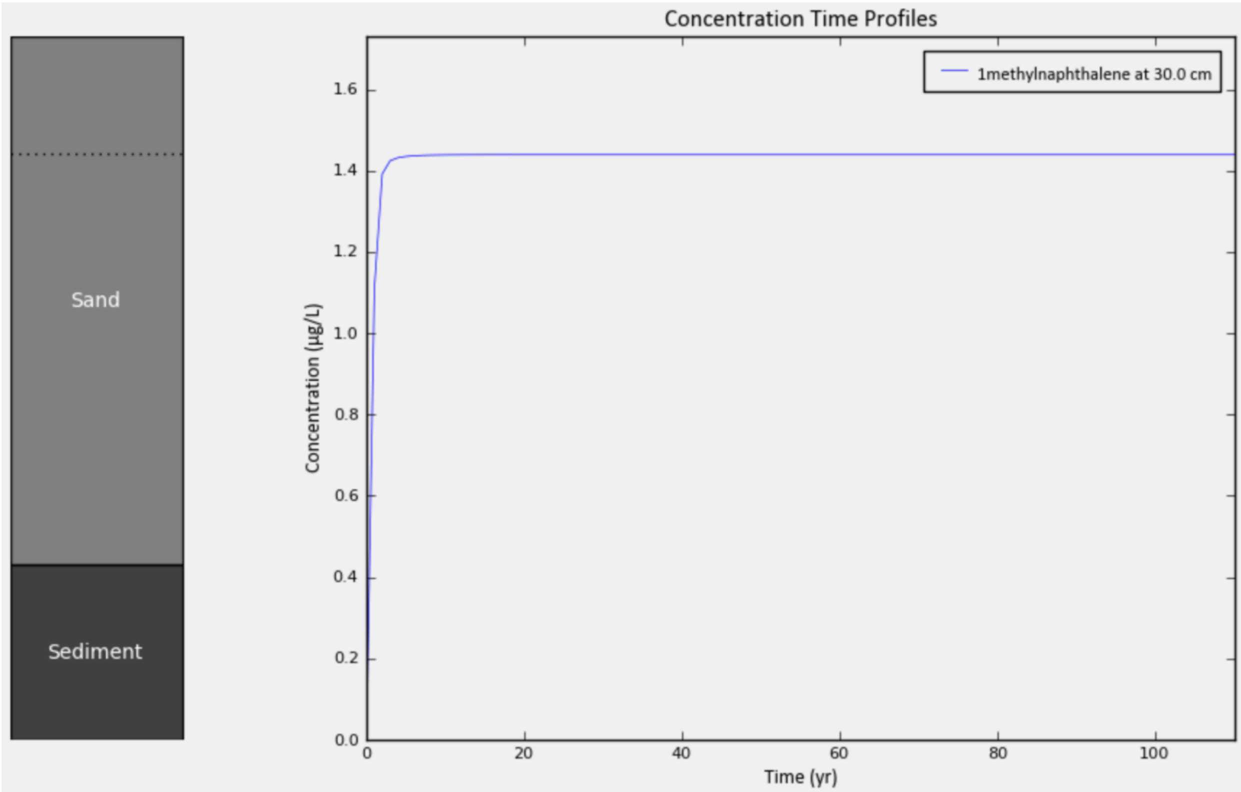

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

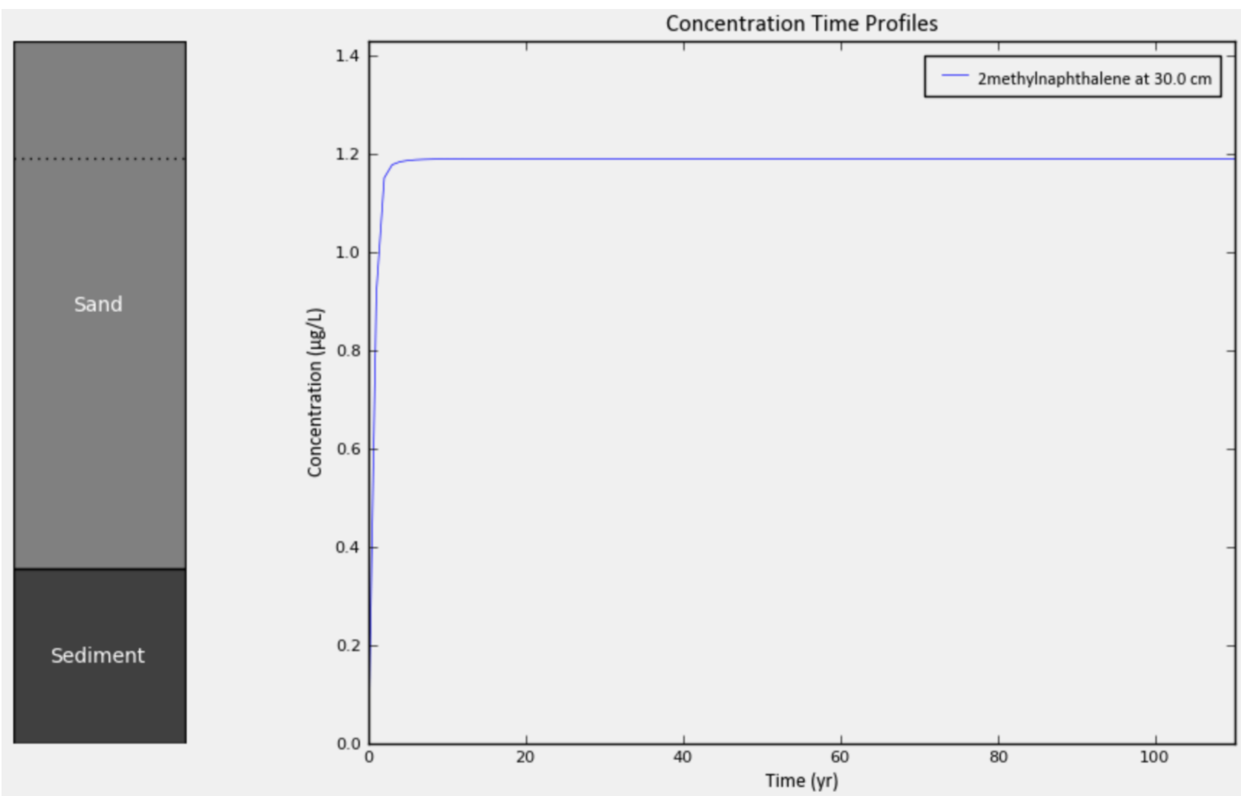

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

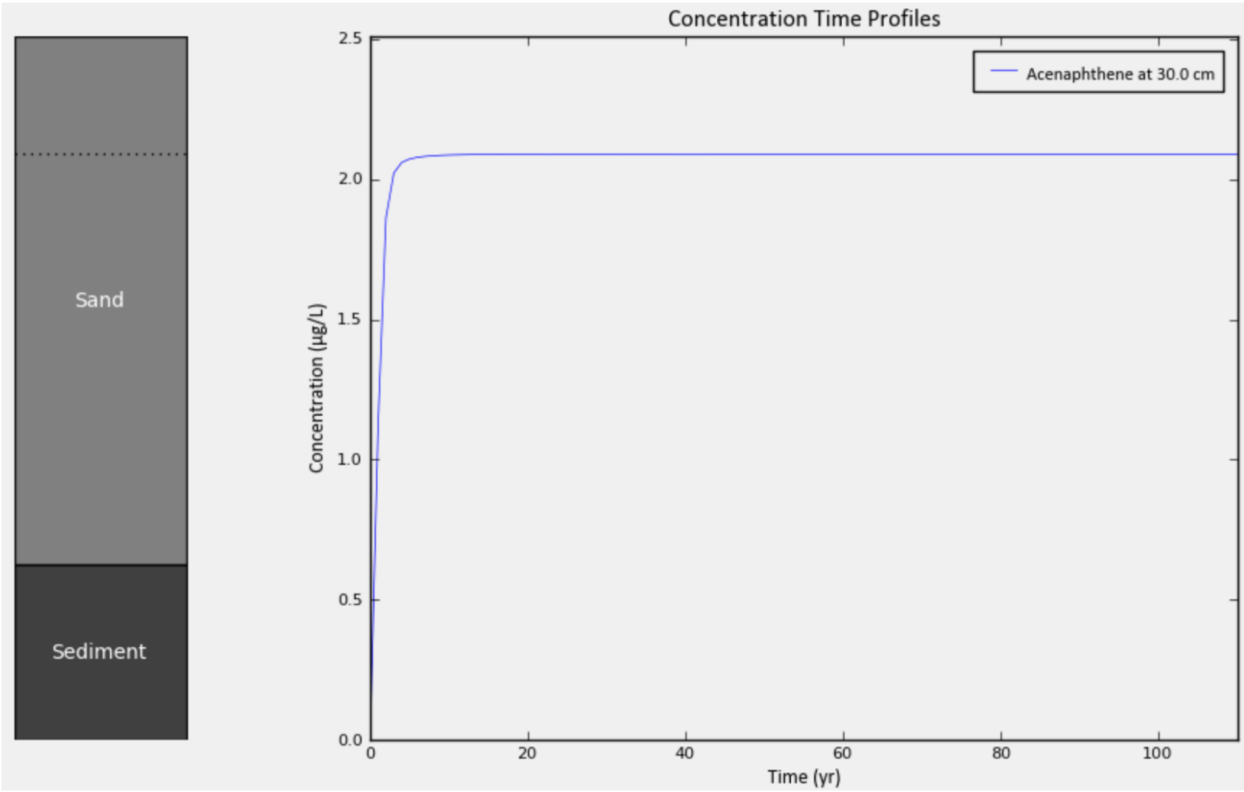

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr

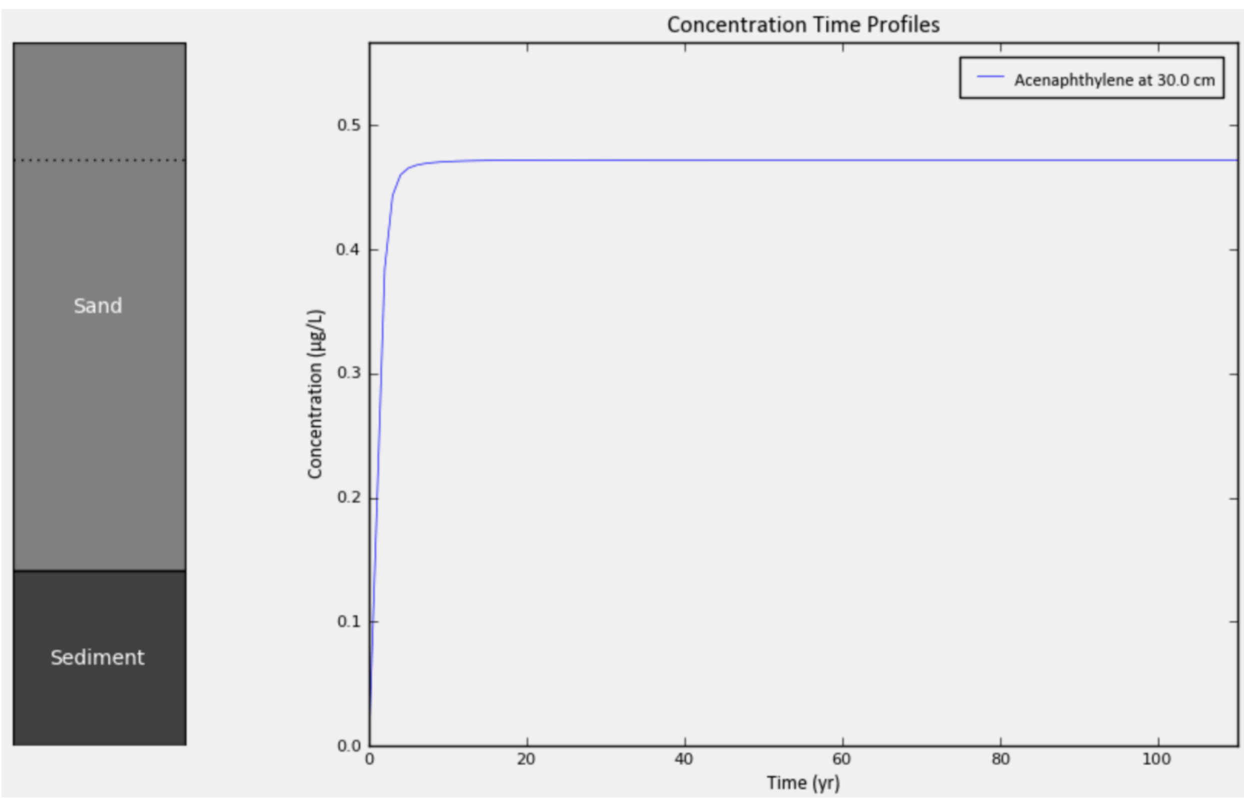

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr

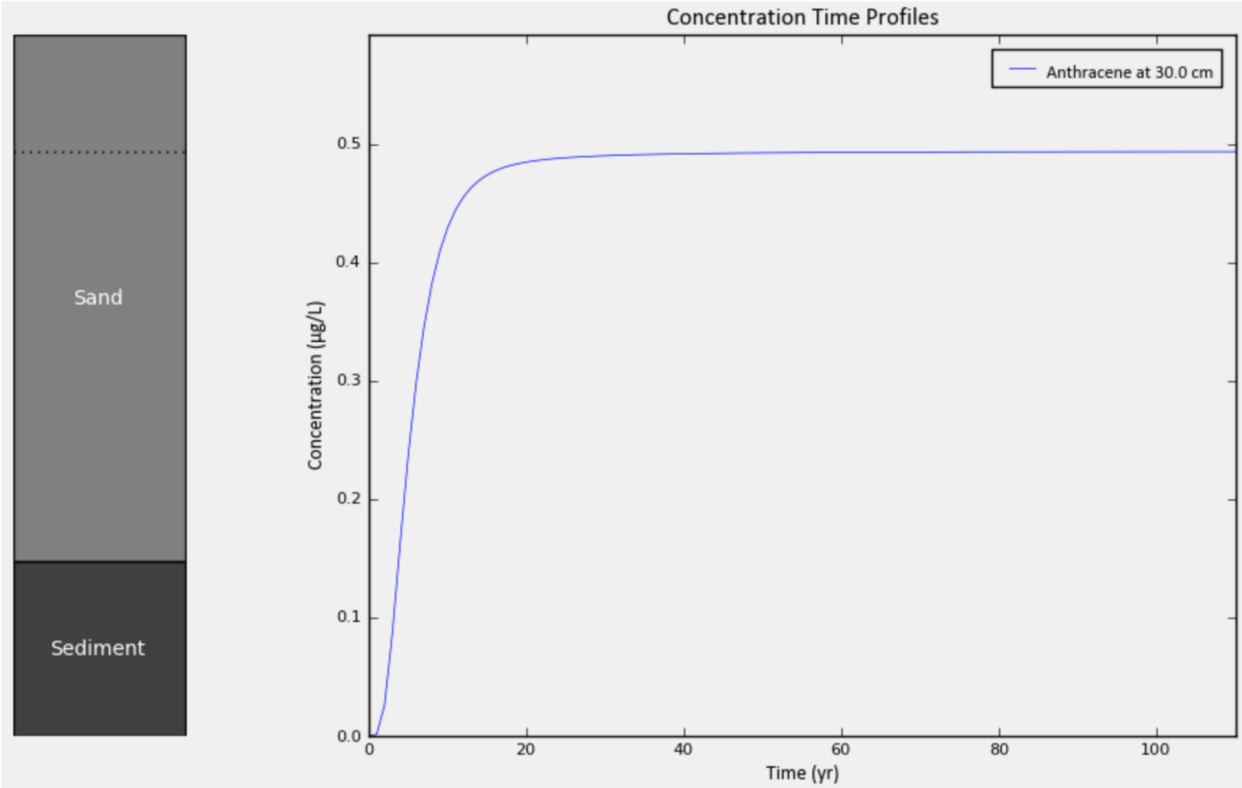
Porewater Concentration – Time

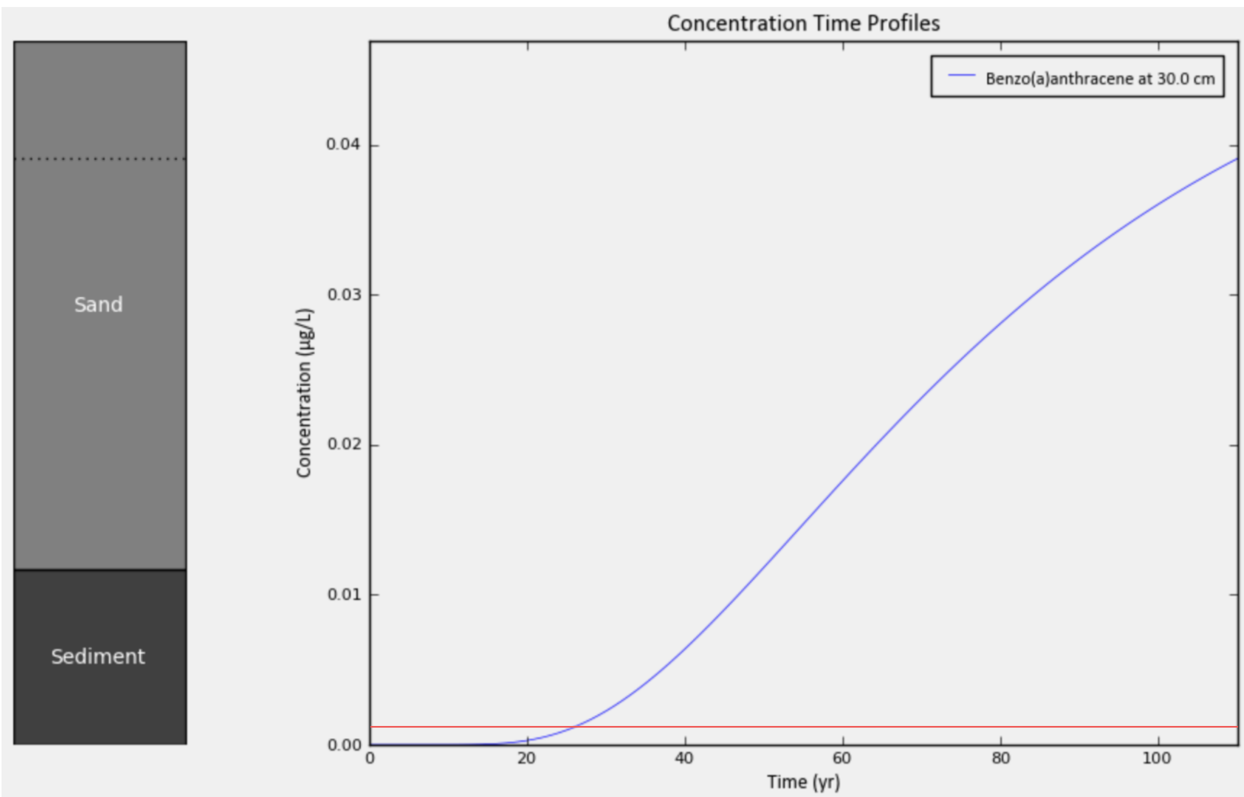


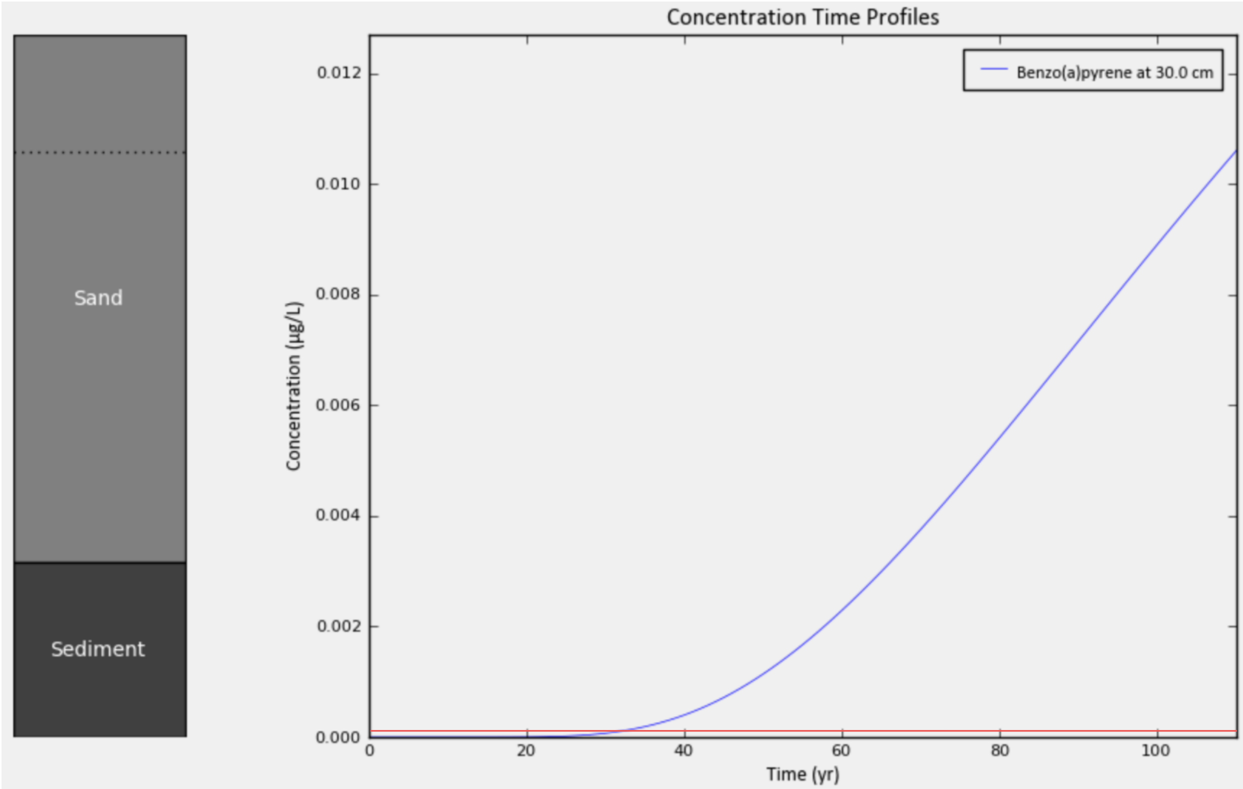


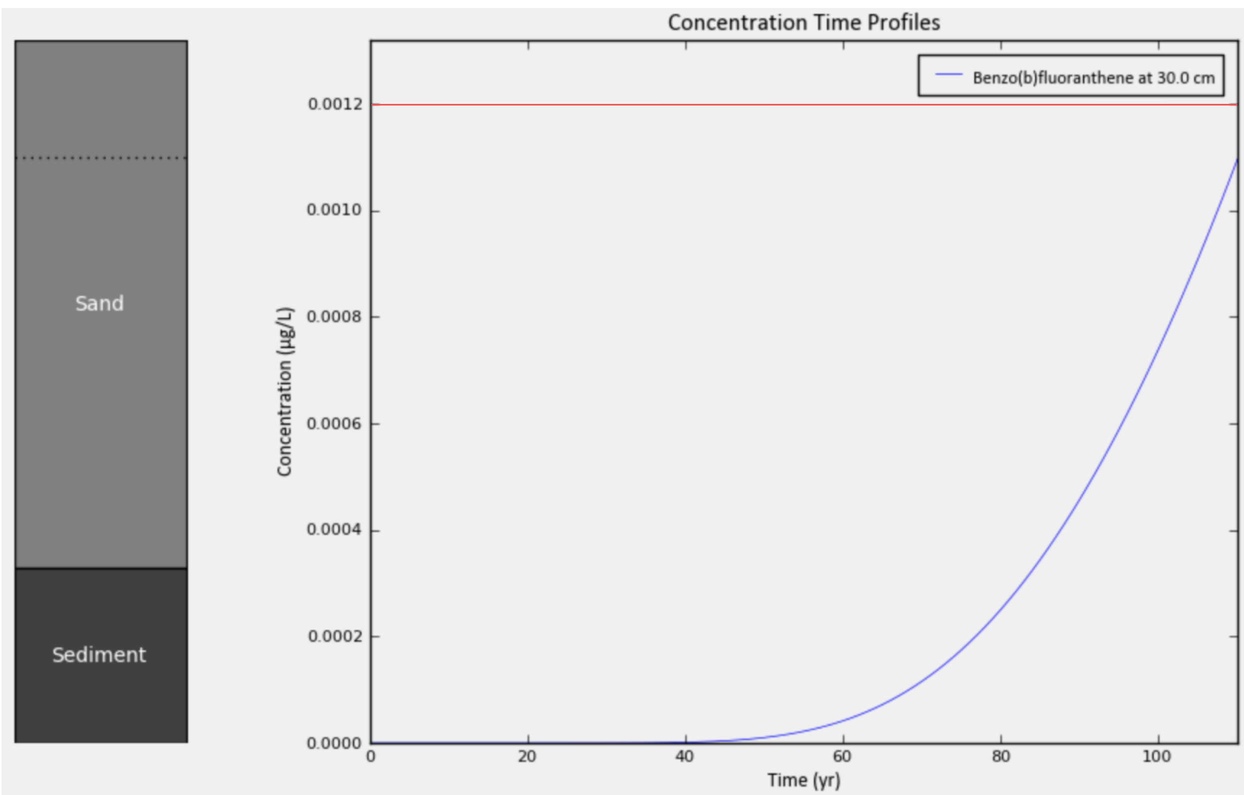

Concentration Time Profiles
Sand
Sediment
Acenaphthene at 30.0 cm
Concentration (μg/L)
Time (yr)
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100

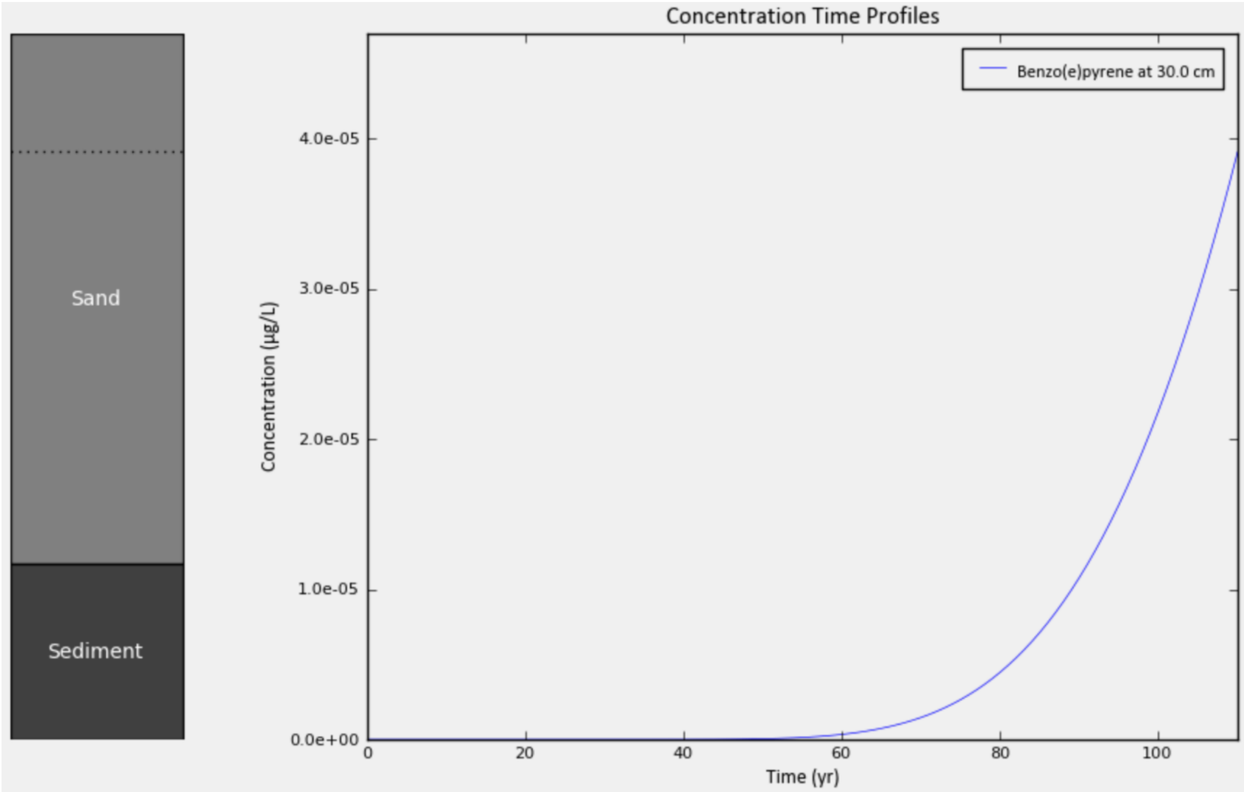

Concentration Time Profiles
Sand
Sediment
Acenaphthylene at 30.0 cm
Concentration (μg/L)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100

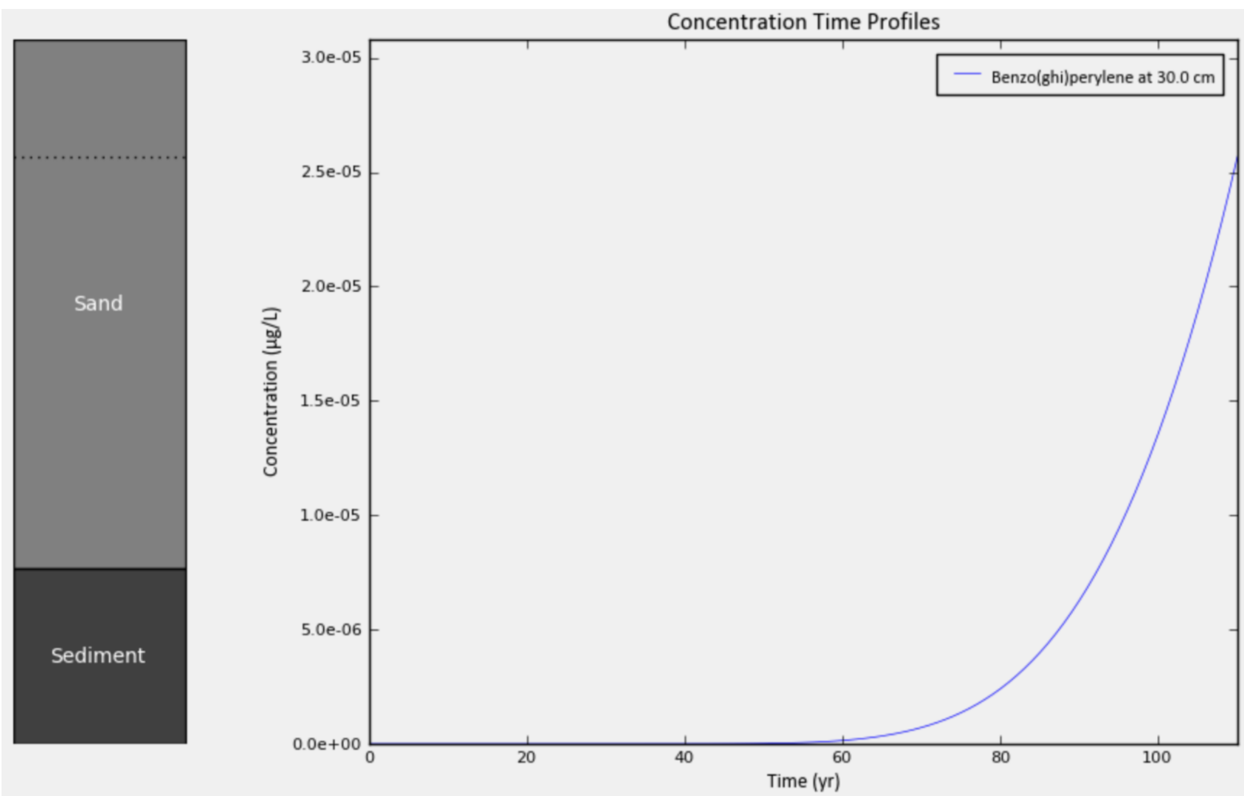

Sand
Sediment
Concentration Time Profiles
Anthracene at 30.0 cm
Concentration (µg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100
Time (yr)

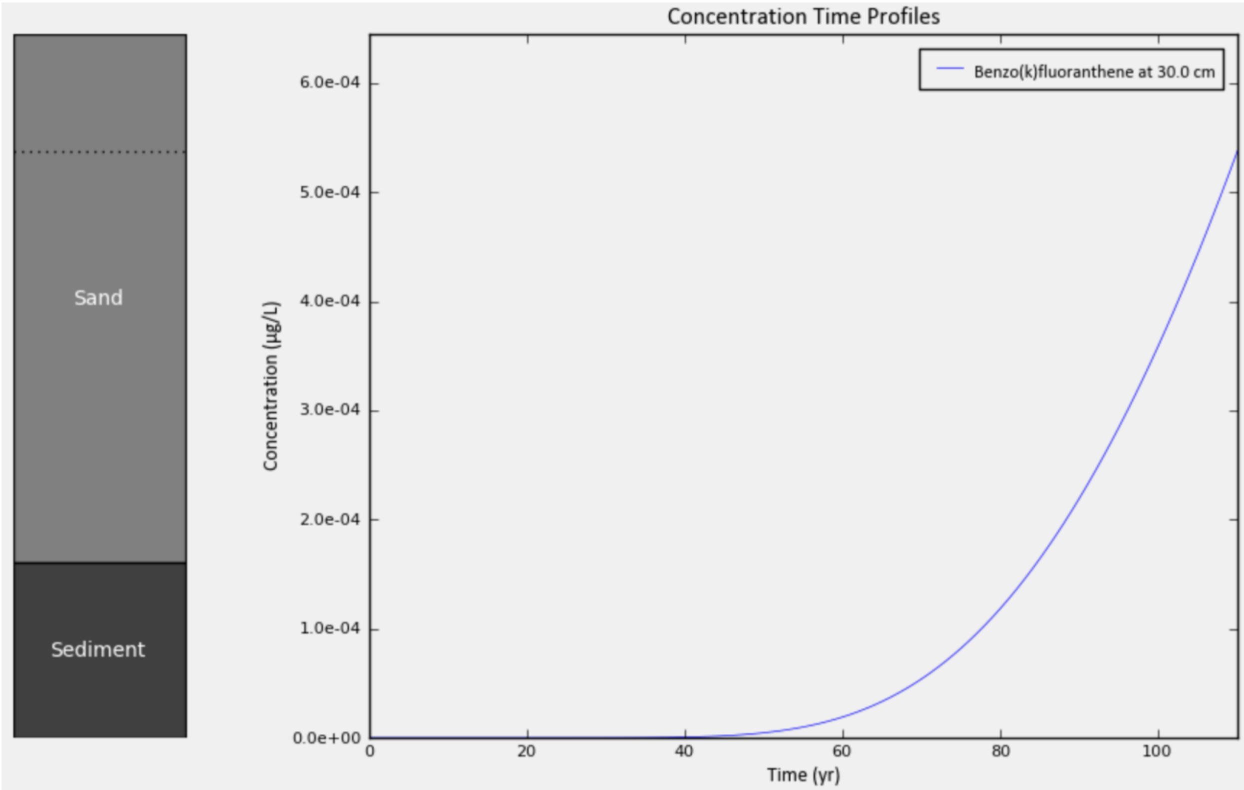

Sand
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 30.0 cm
Concentration (µg/L)
0.00
0.01
0.02
0.03
0.04
0
20
40
60
80
100
Time (yr)

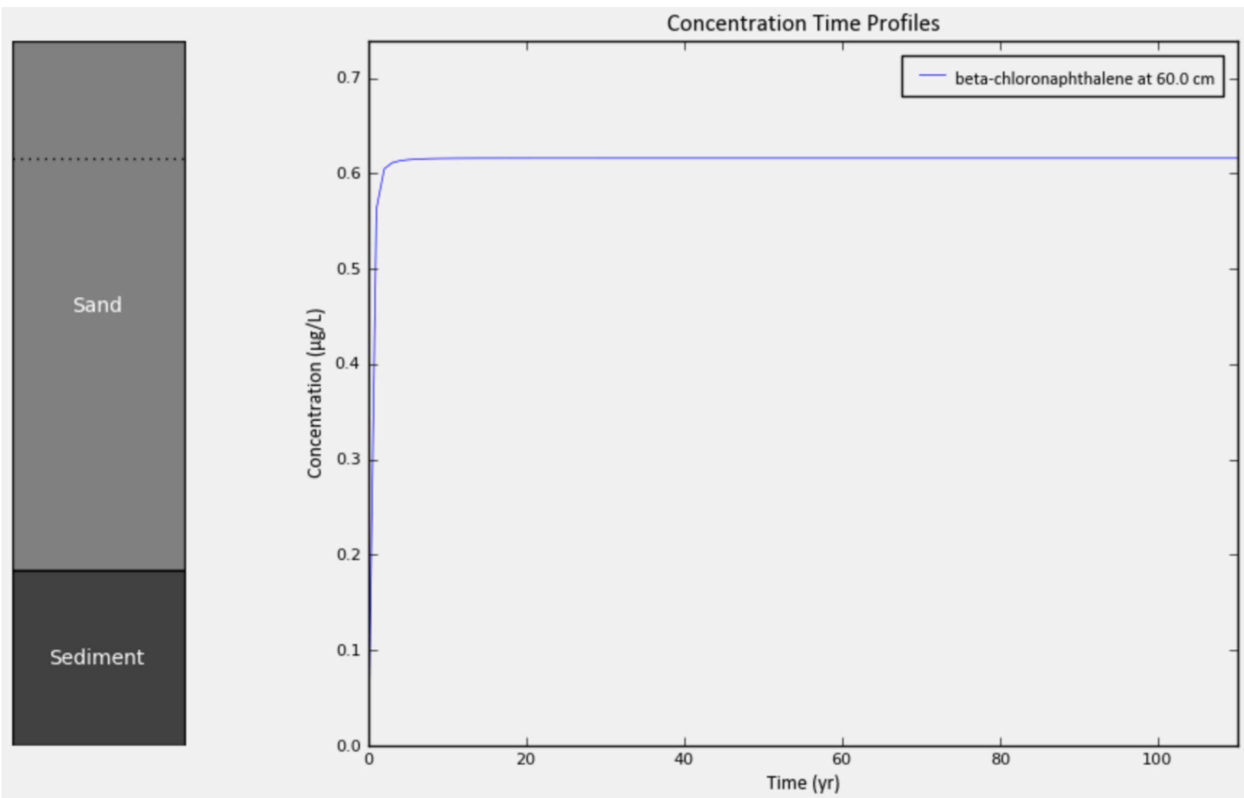

Sand
Sediment
Concentration Time Profiles
Benzo(a)pyrene at 30.0 cm
Concentration (µg/L)
Time (yr)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0
20
40
60
80
100

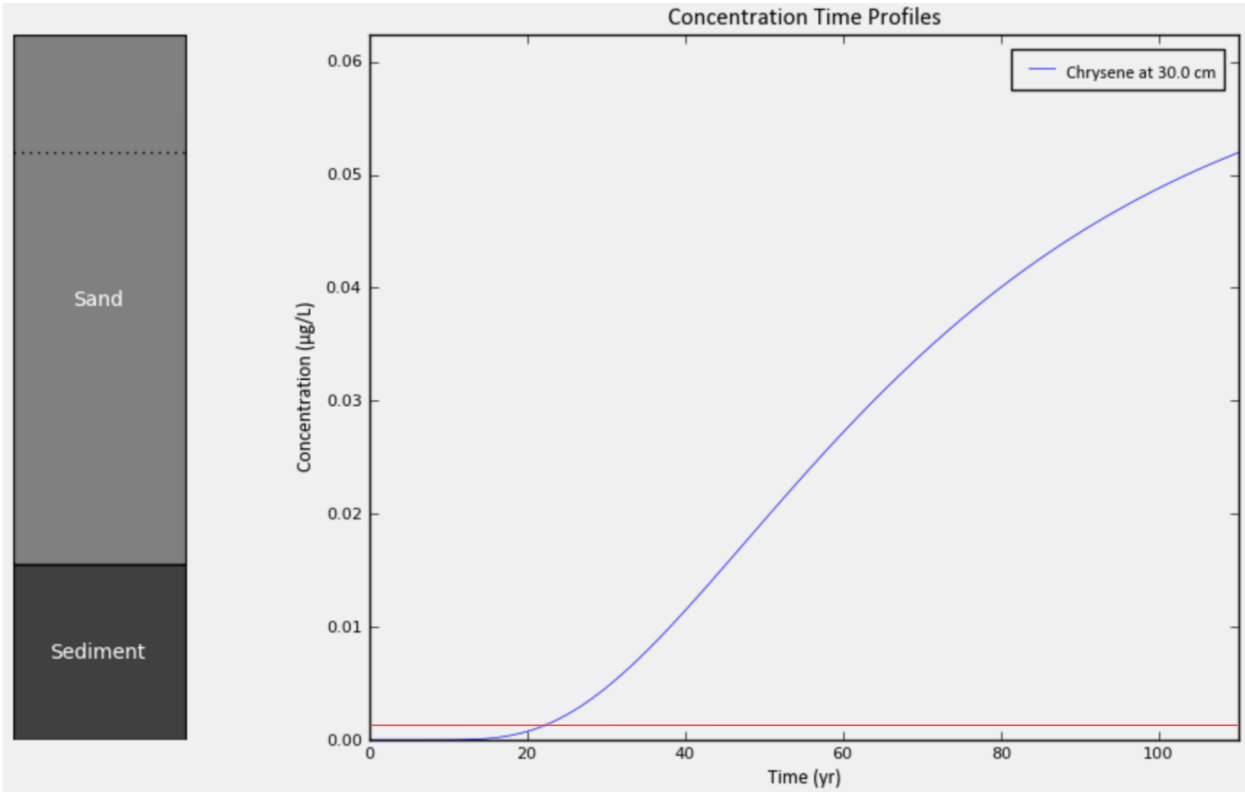

Sand
Sediment
Concentration Time Profiles
Benzo(b)fluoranthene at 30.0 cm
Concentration (µg/L)
Time (yr)
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012
0
20
40
60
80
100

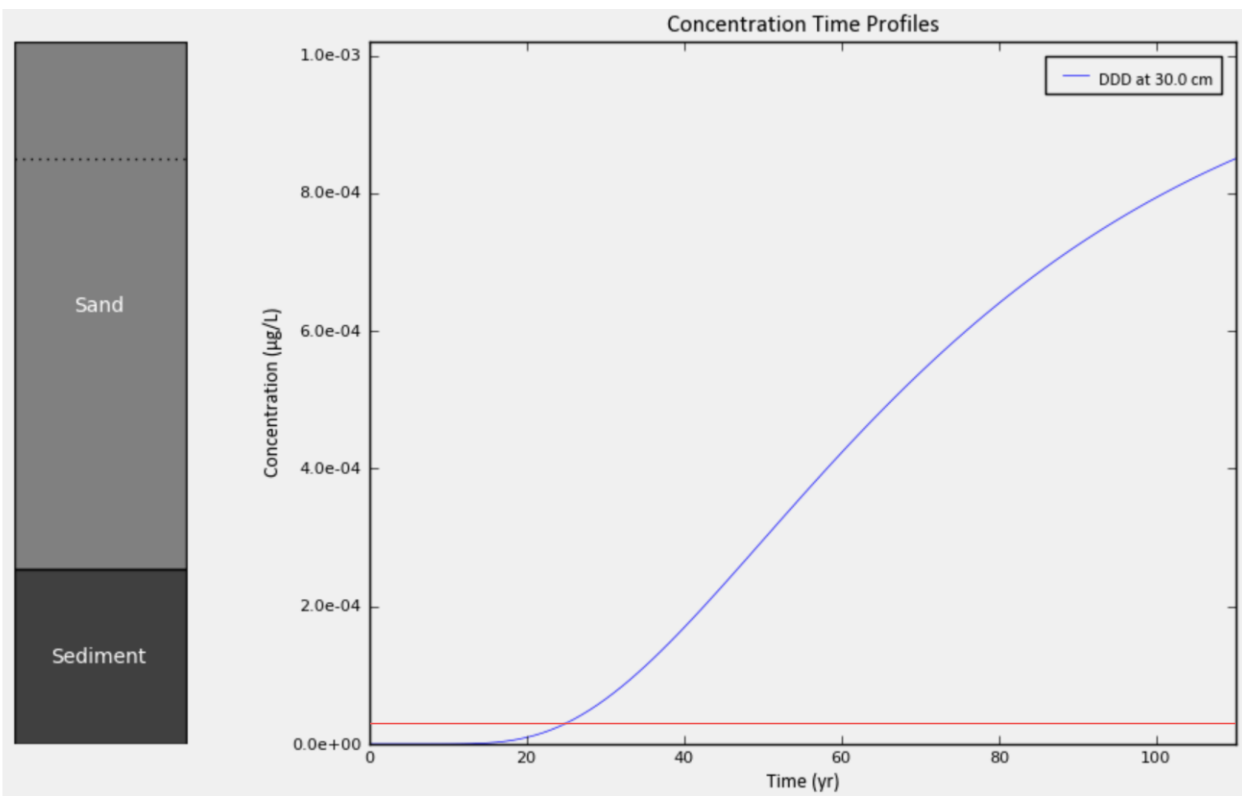

Concentration Time Profiles
Sand
Sediment
Benzo(e)pyrene at 30.0 cm
Concentration (µg/L)
4.0e-05
3.0e-05
2.0e-05
1.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

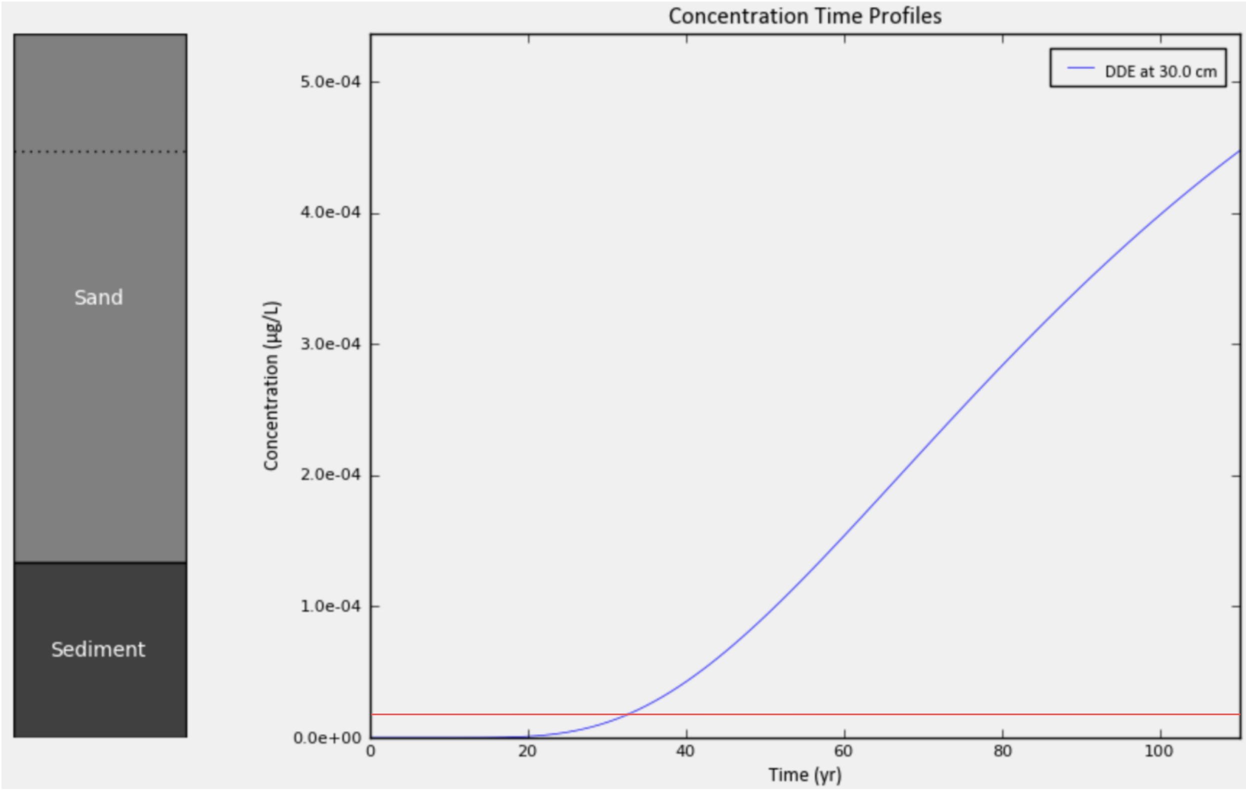

Concentration Time Profiles
Sand
Sediment
Benzo(ghi)perylene at 30.0 cm
Concentration (µg/L)
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

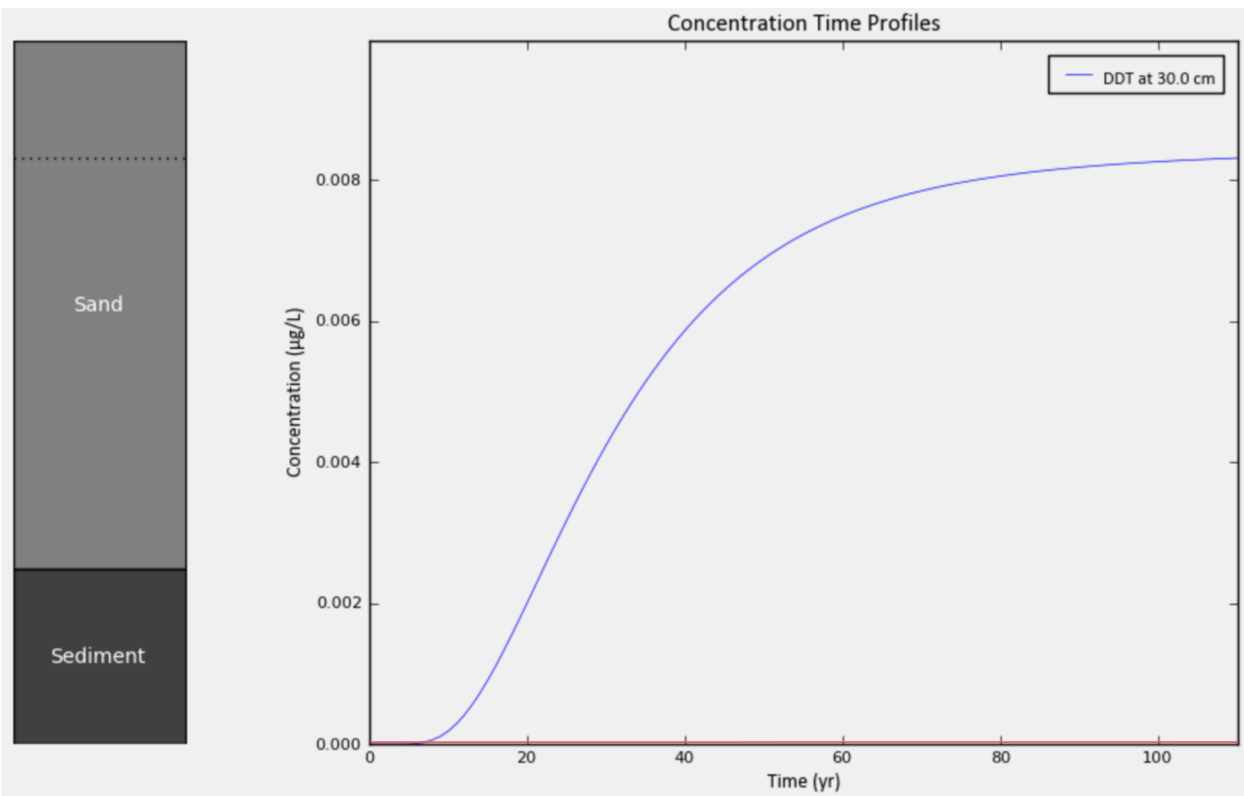

Concentration Time Profiles
Sand
Sediment
Benzo(k)fluoranthene at 30.0 cm
Concentration (µg/L)
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

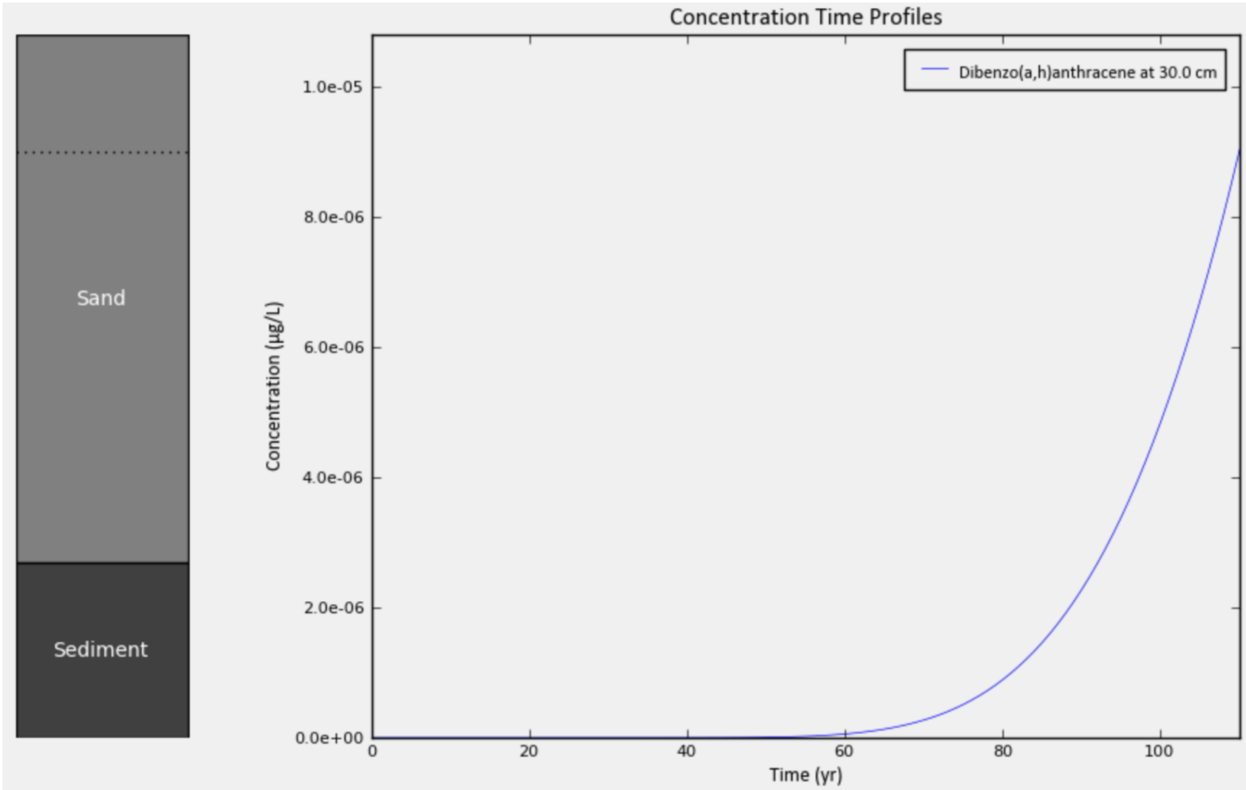

Concentration Time Profiles
Sand
Sediment
beta-chloronaphthalene at 60.0 cm
Concentration (µg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
Time (yr)

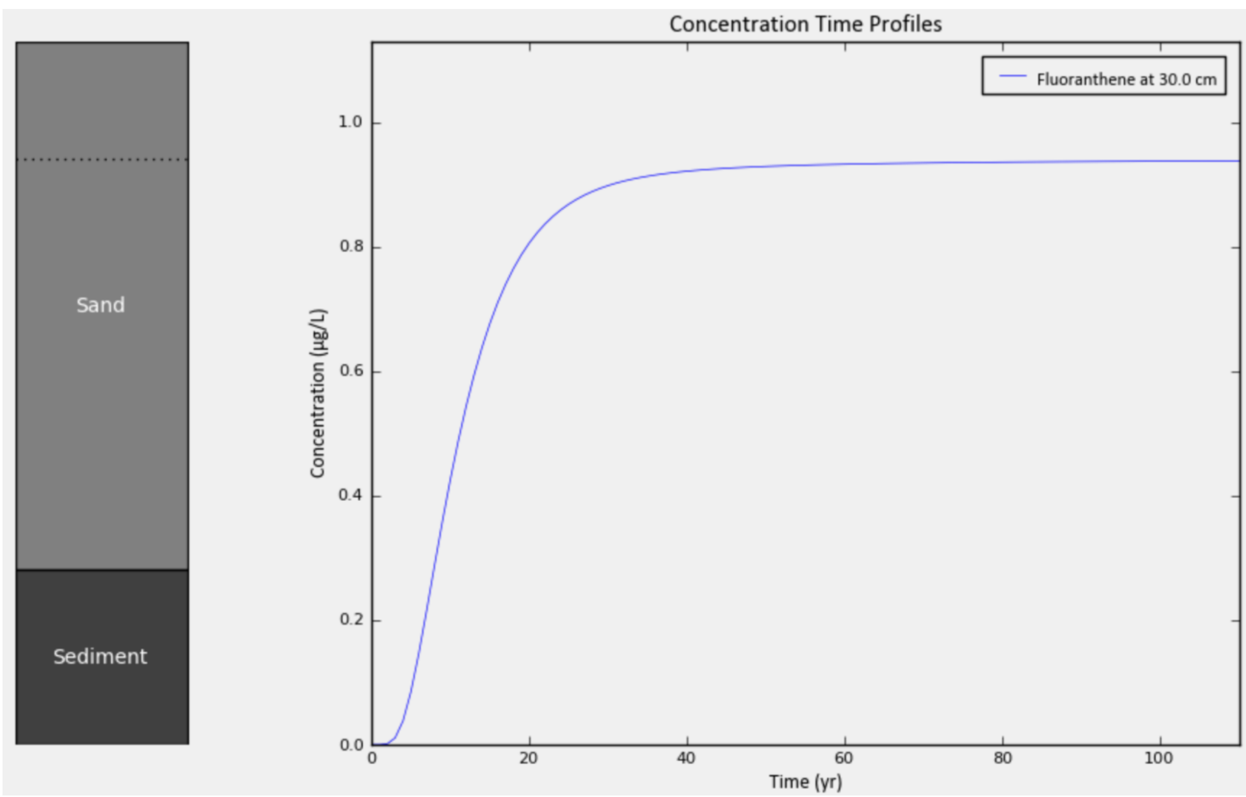

Sand
Sediment
Concentration Time Profiles
Chrysene at 30.0 cm
Concentration (µg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
Time (yr)

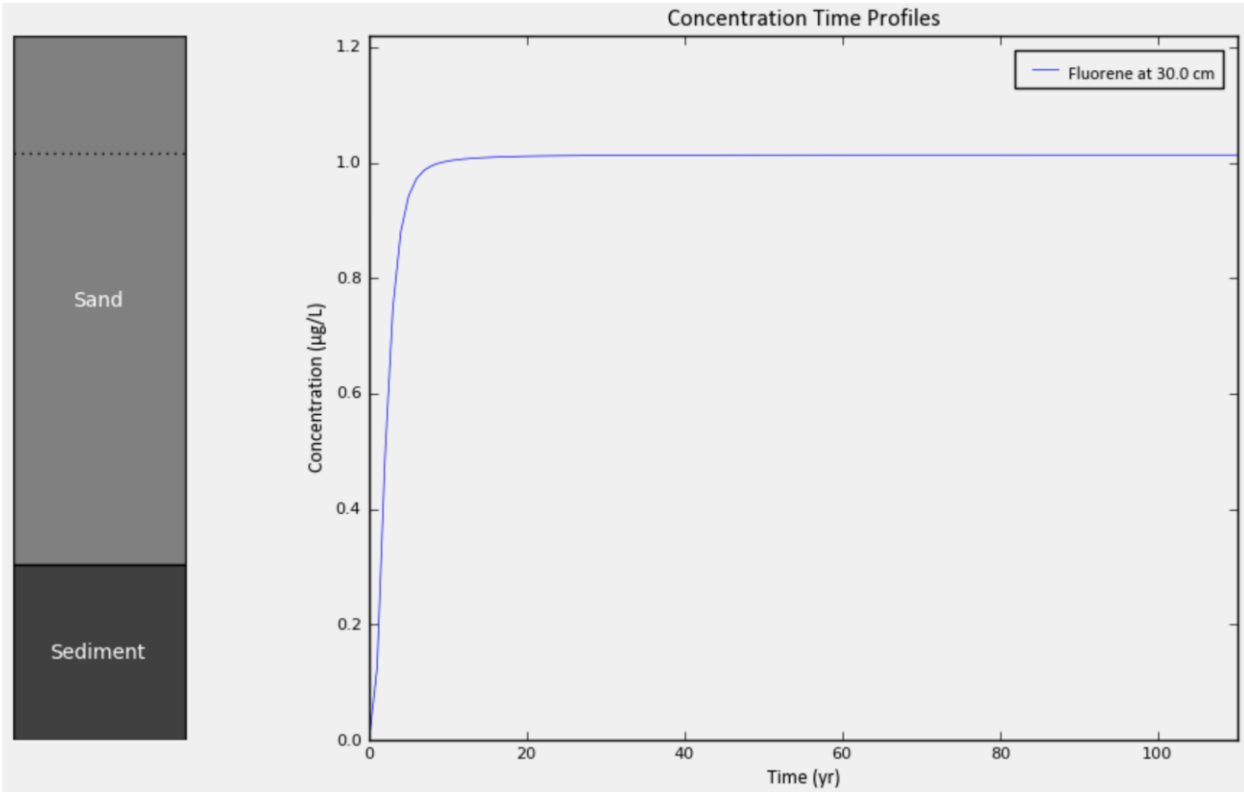

Sand
Sediment
Concentration Time Profiles
DDD at 30.0 cm
Concentration (µg/L)
1.0e-03
8.0e-04
6.0e-04
4.0e-04
2.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

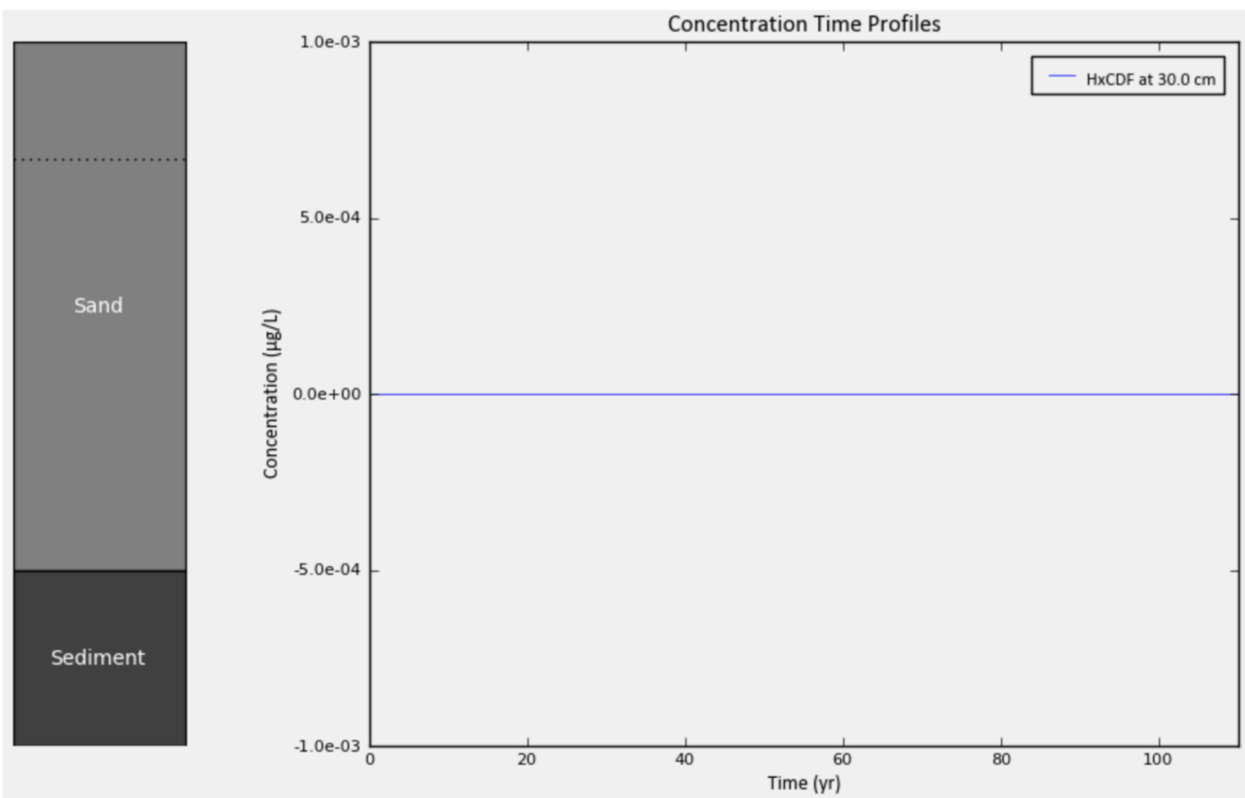

Concentration Time Profiles
DDE at 30.0 cm
Sand
Sediment
Concentration (µg/L)
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

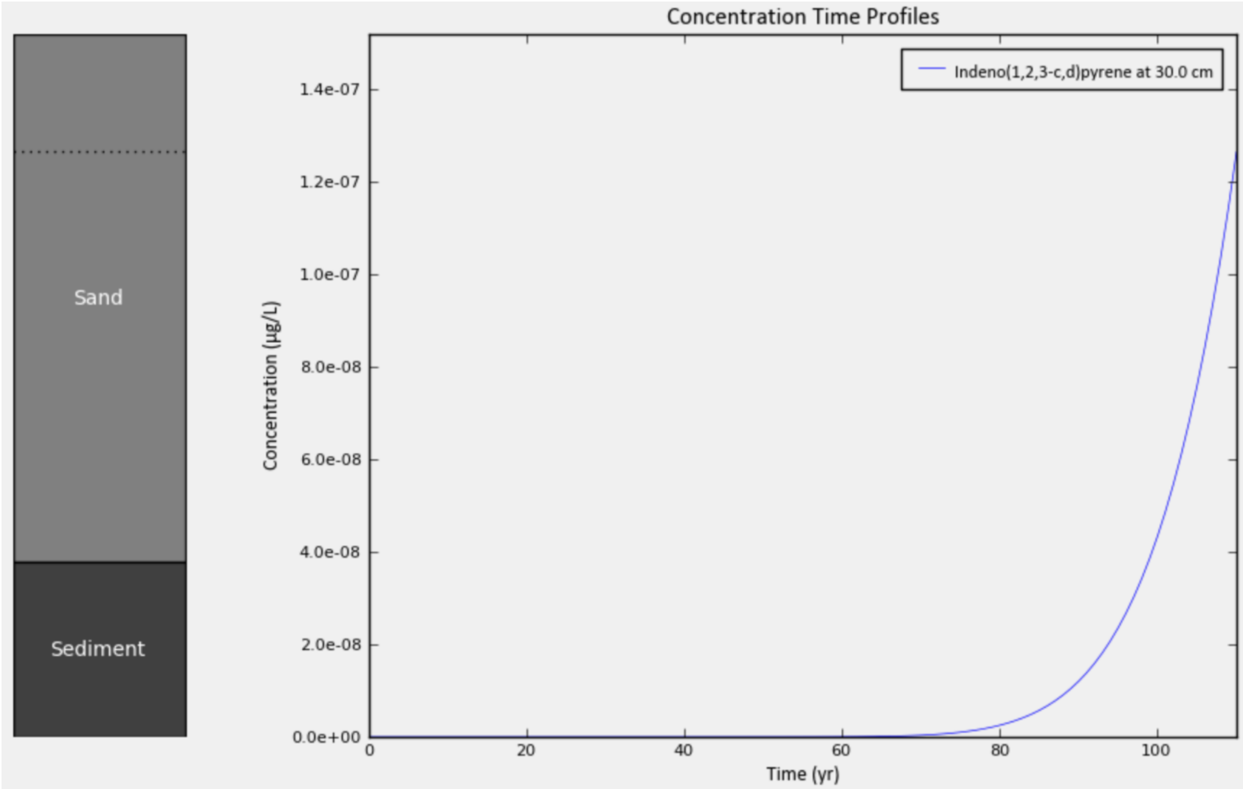

Concentration Time Profiles
DDT at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Dibenzo(a,h)anthracene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

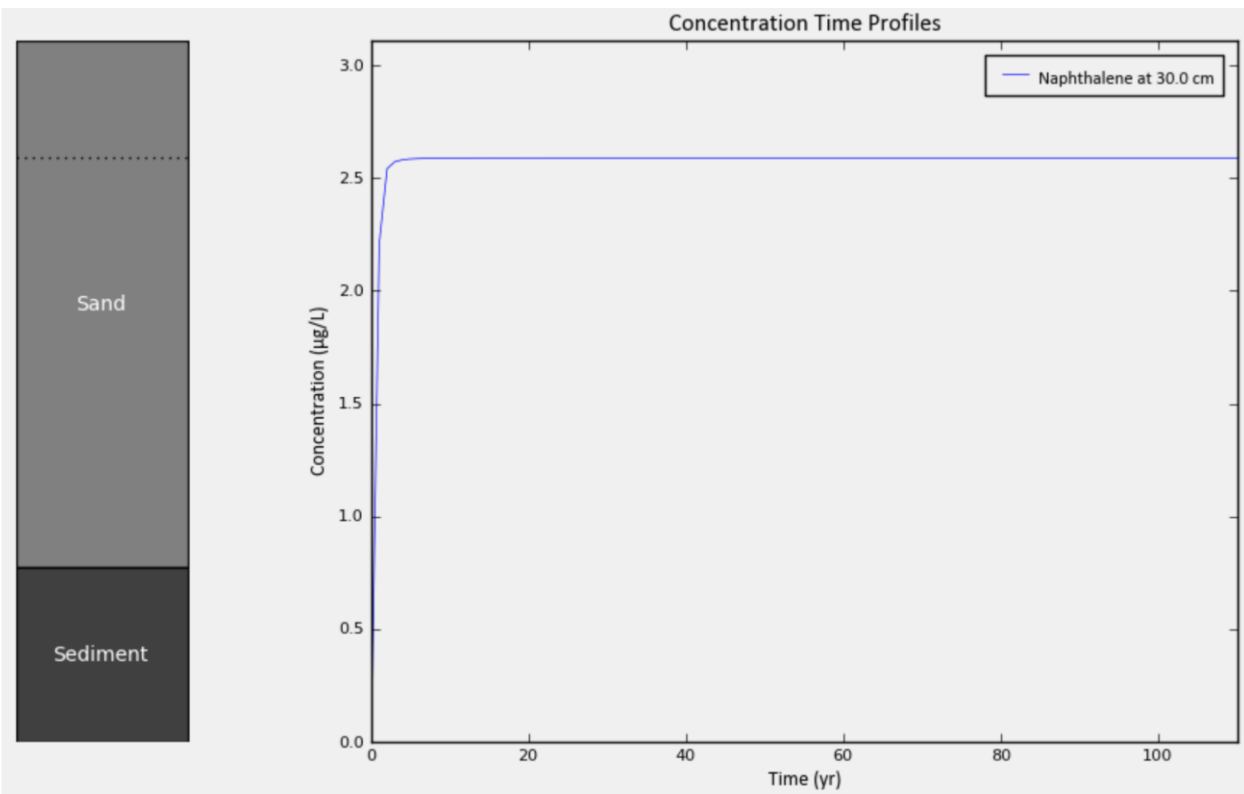

Concentration Time Profiles
Fluoranthene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Fluorene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
20
40
60
80
100

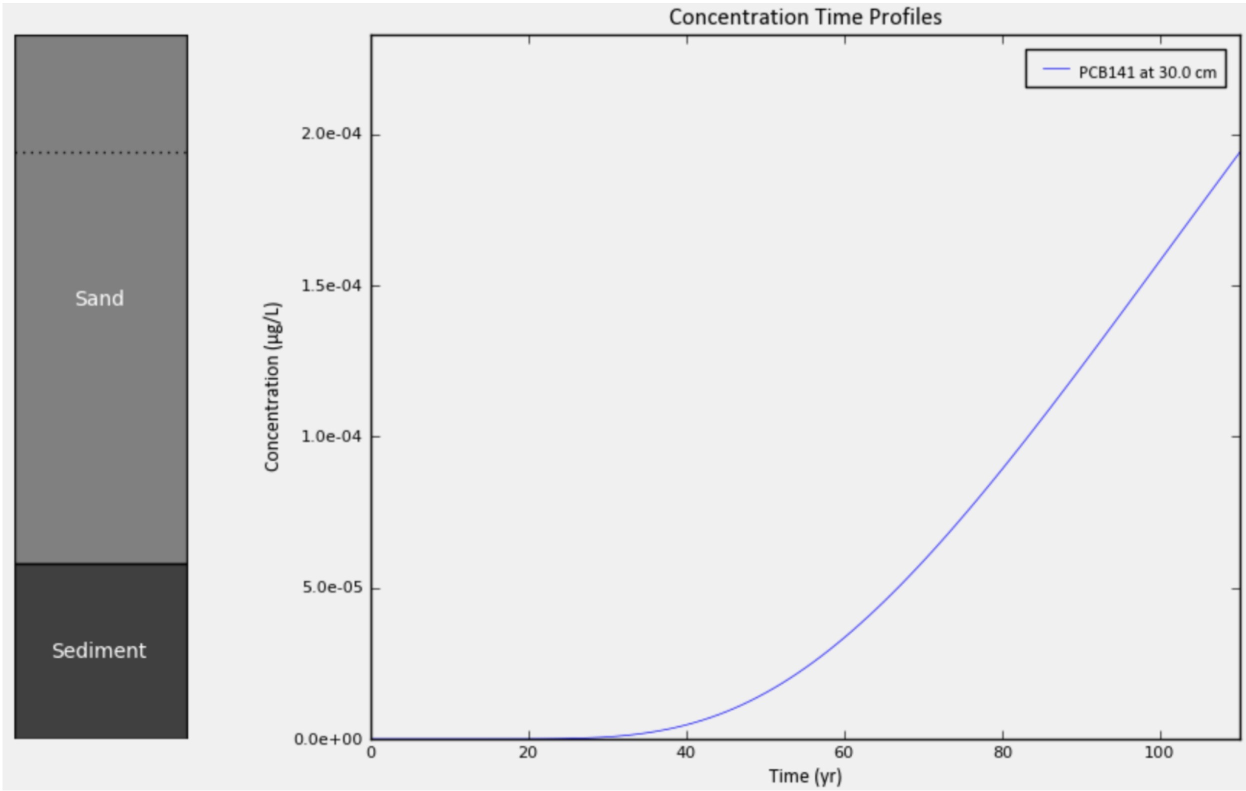

Concentration Time Profiles
HxCDF at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

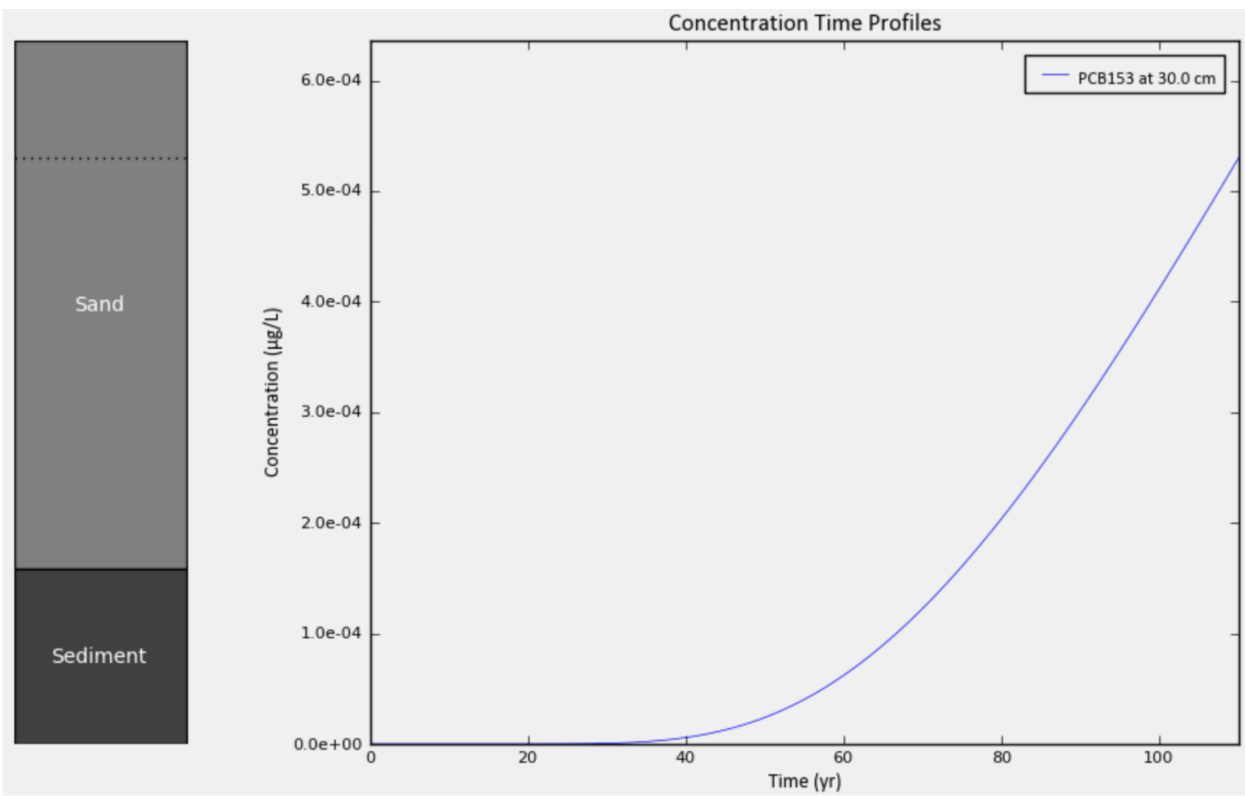


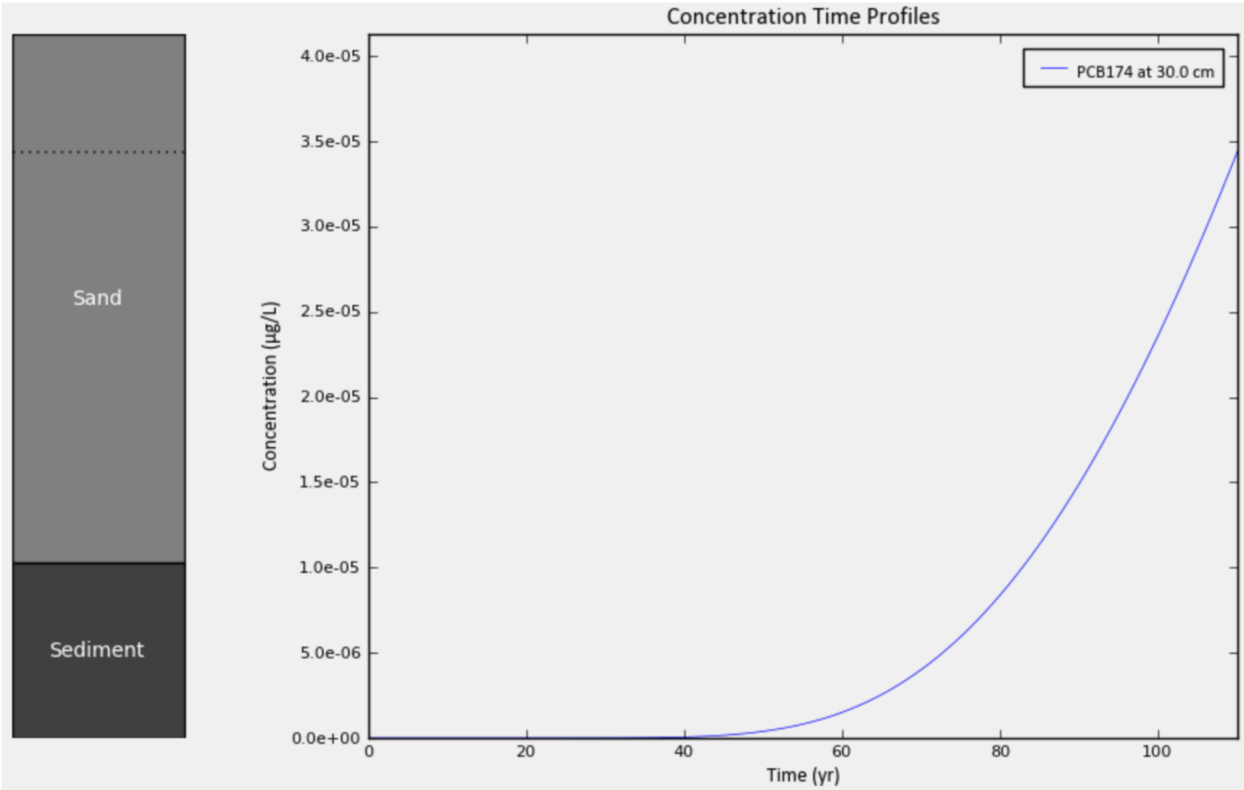
Sand
Sediment
Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 30.0 cm
Concentration (μg/L)
1.4e-07
1.2e-07
1.0e-07
8.0e-08
6.0e-08
4.0e-08
2.0e-08
0.0e+00
0
20
40
60
80
100
Time (yr)

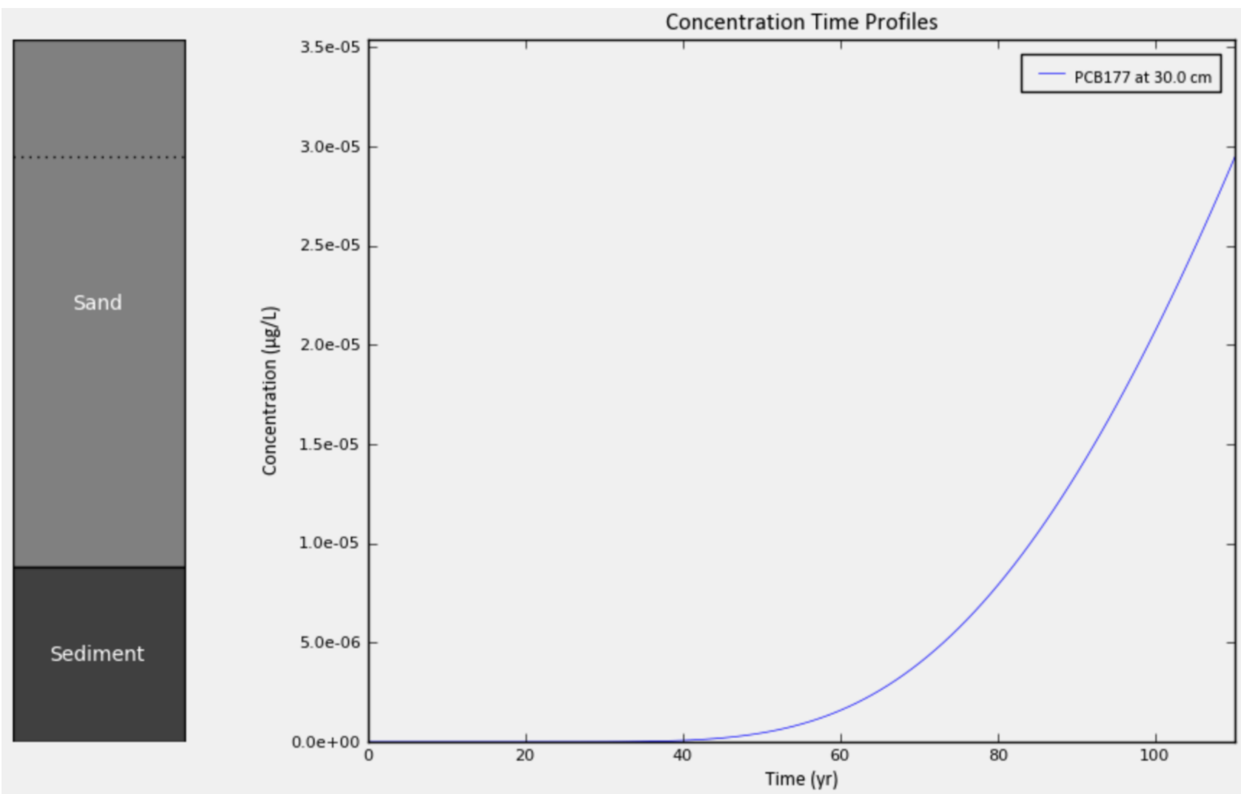


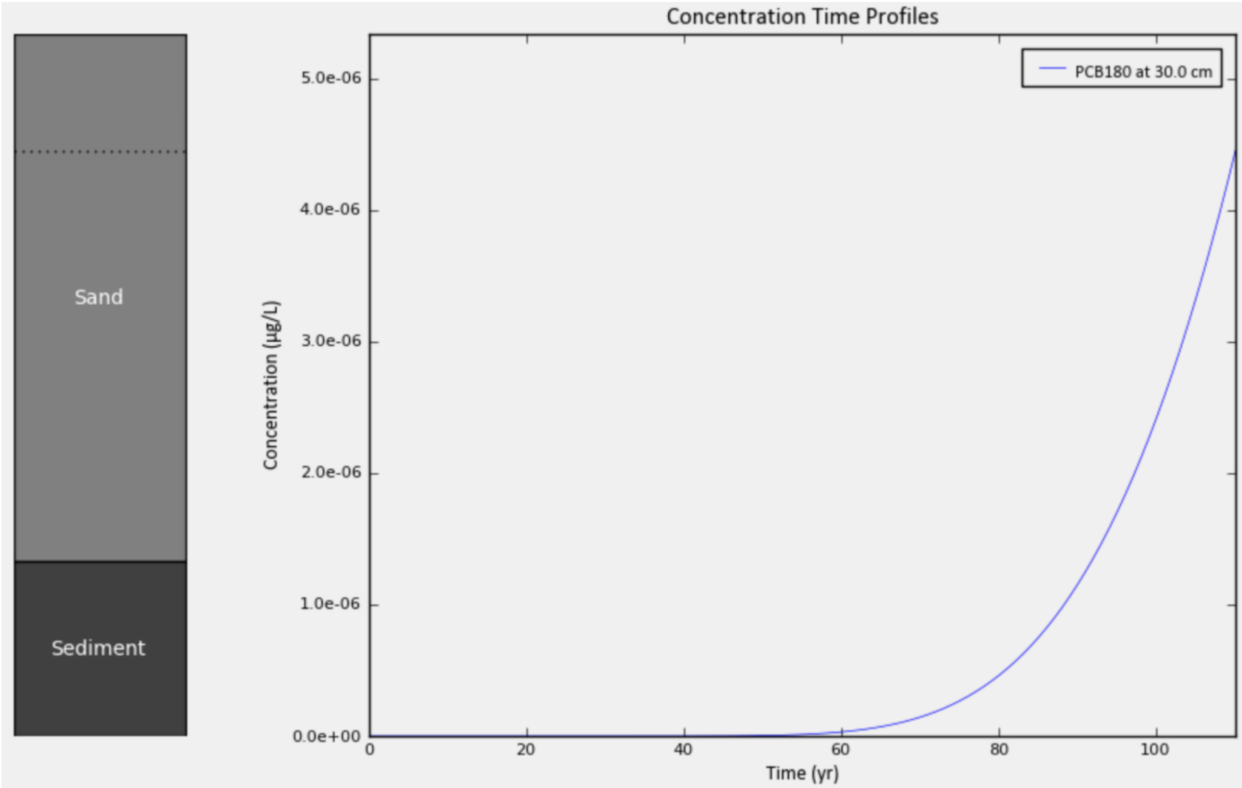
Sand
Sediment
Concentration Time Profiles
Naphthalene at 30.0 cm
Concentration (μg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)

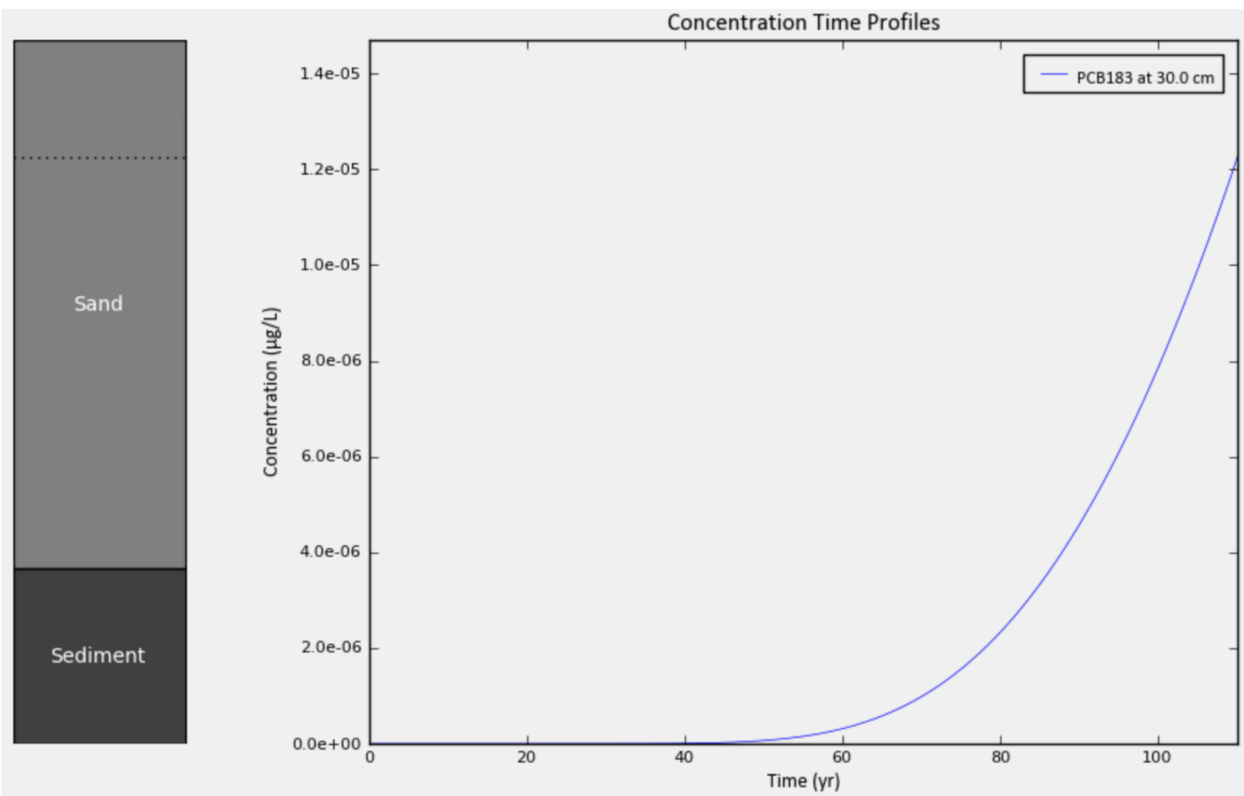

Concentration Time Profiles
PCB141 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

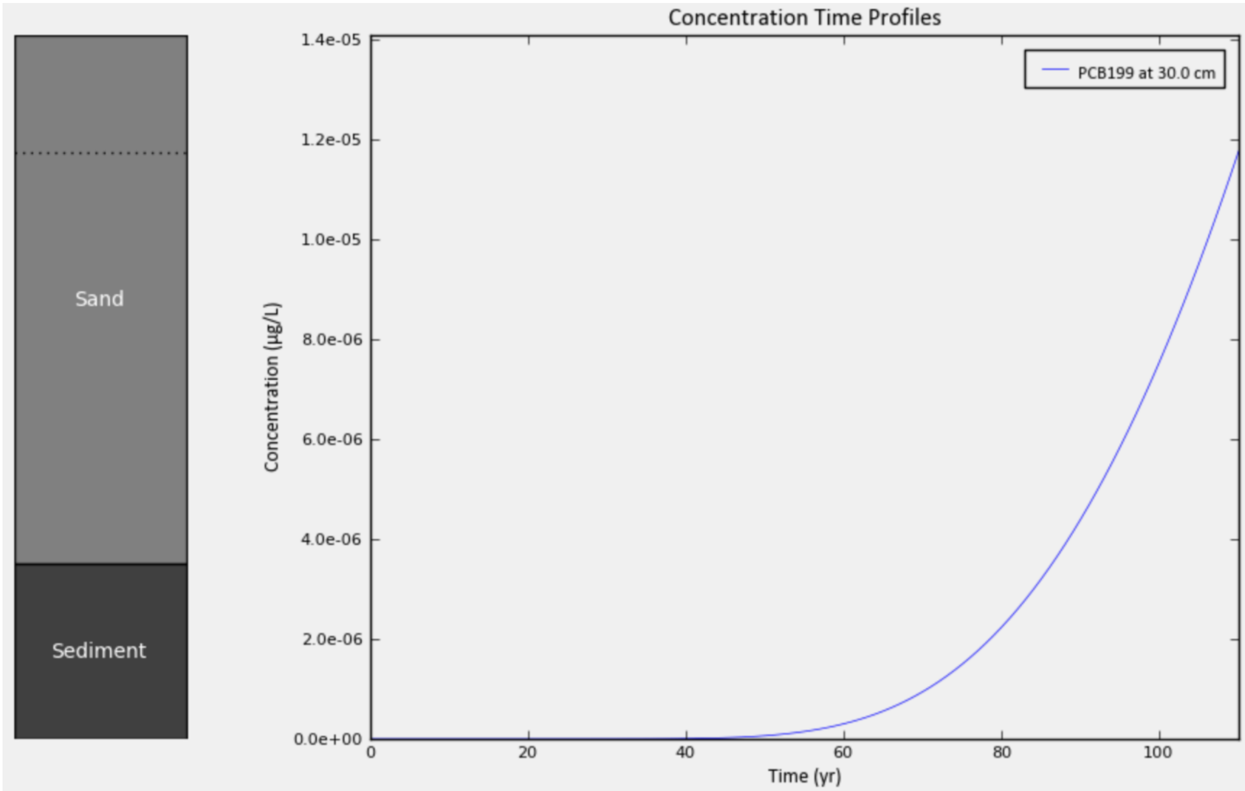

Concentration Time Profiles
PCB153 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

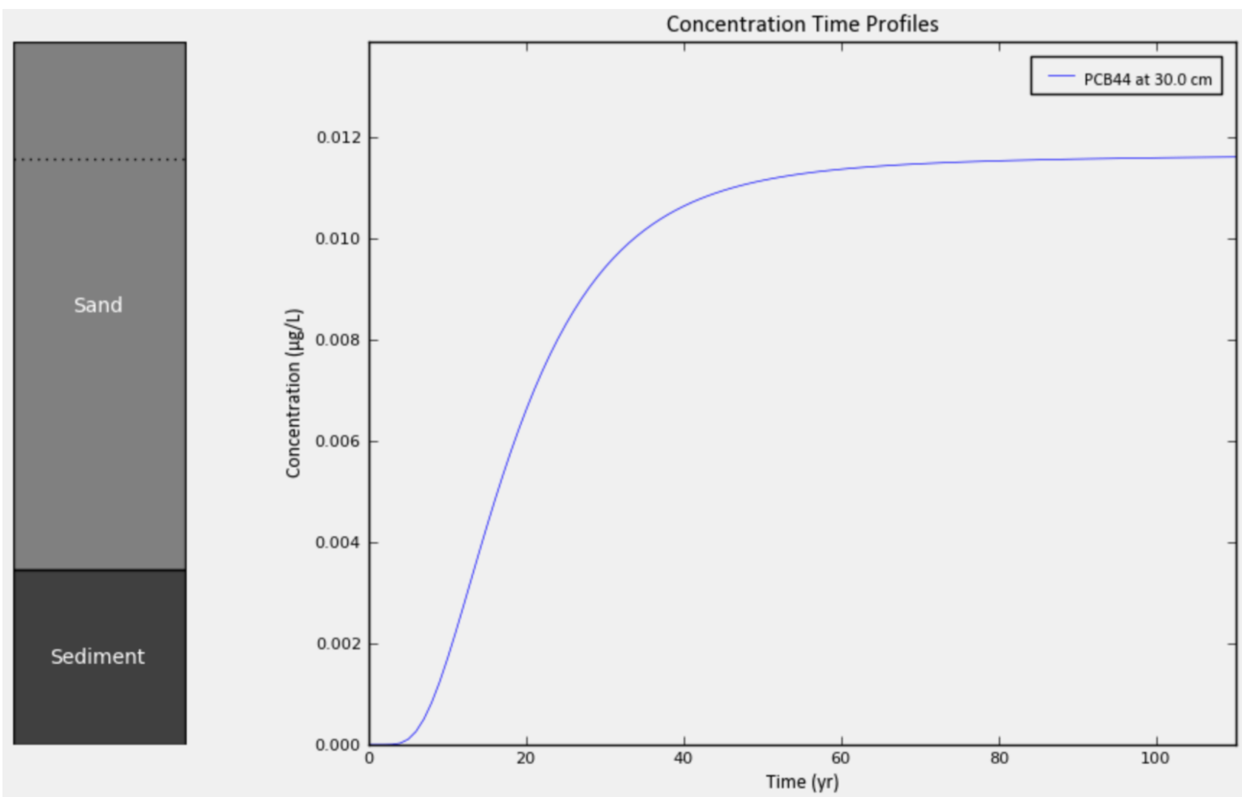

Concentration Time Profiles
PCB174 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
4.0e-05
3.5e-05
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100

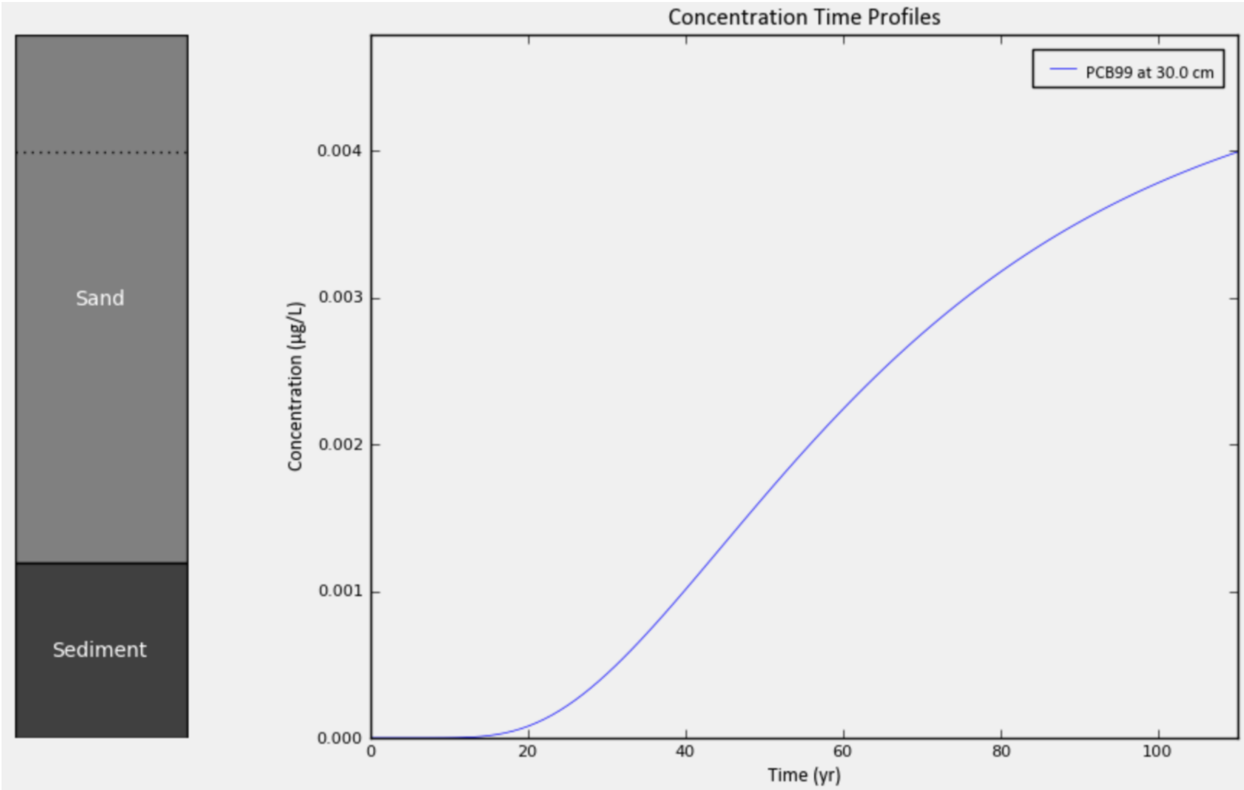

Concentration Time Profiles
PCB177 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
3.5e-05
3.0e-05
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100

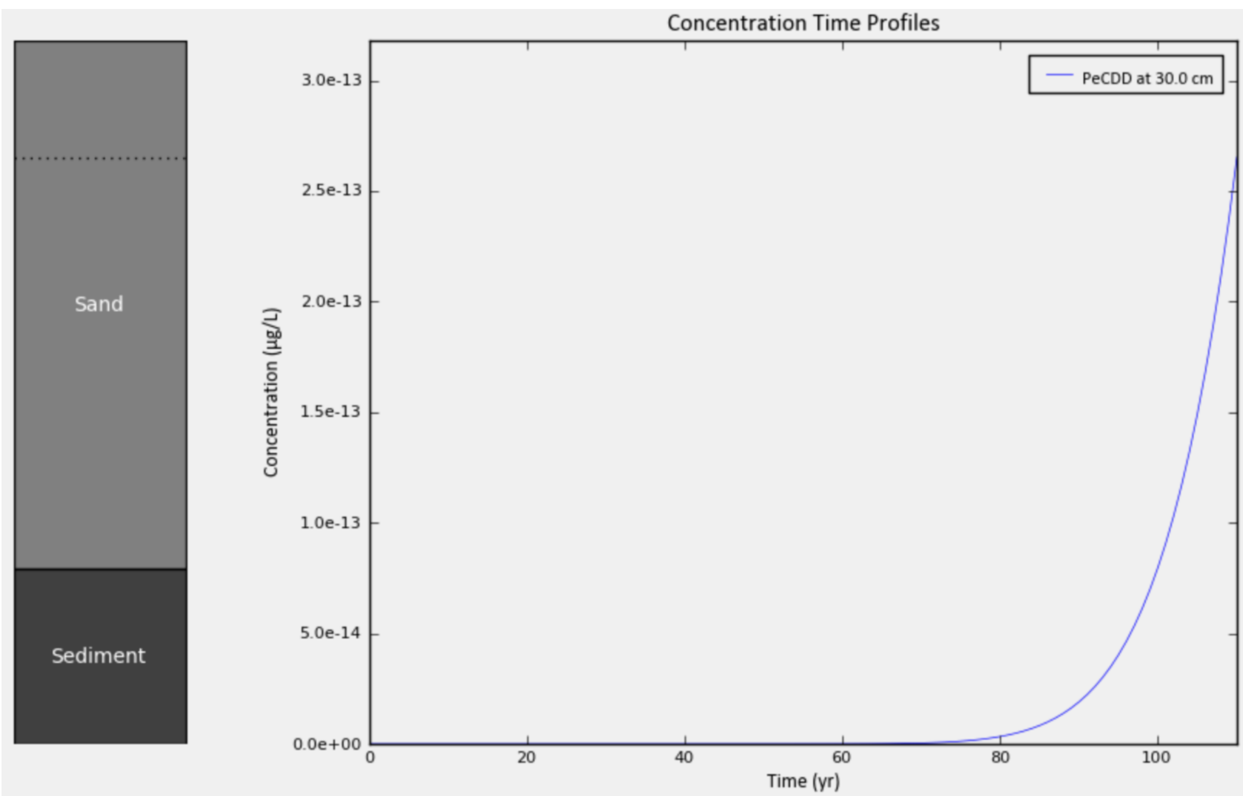

Concentration Time Profiles
PCB180 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
5.0e-06
4.0e-06
3.0e-06
2.0e-06
1.0e-06
0.0e+00
0
20
40
60
80
100

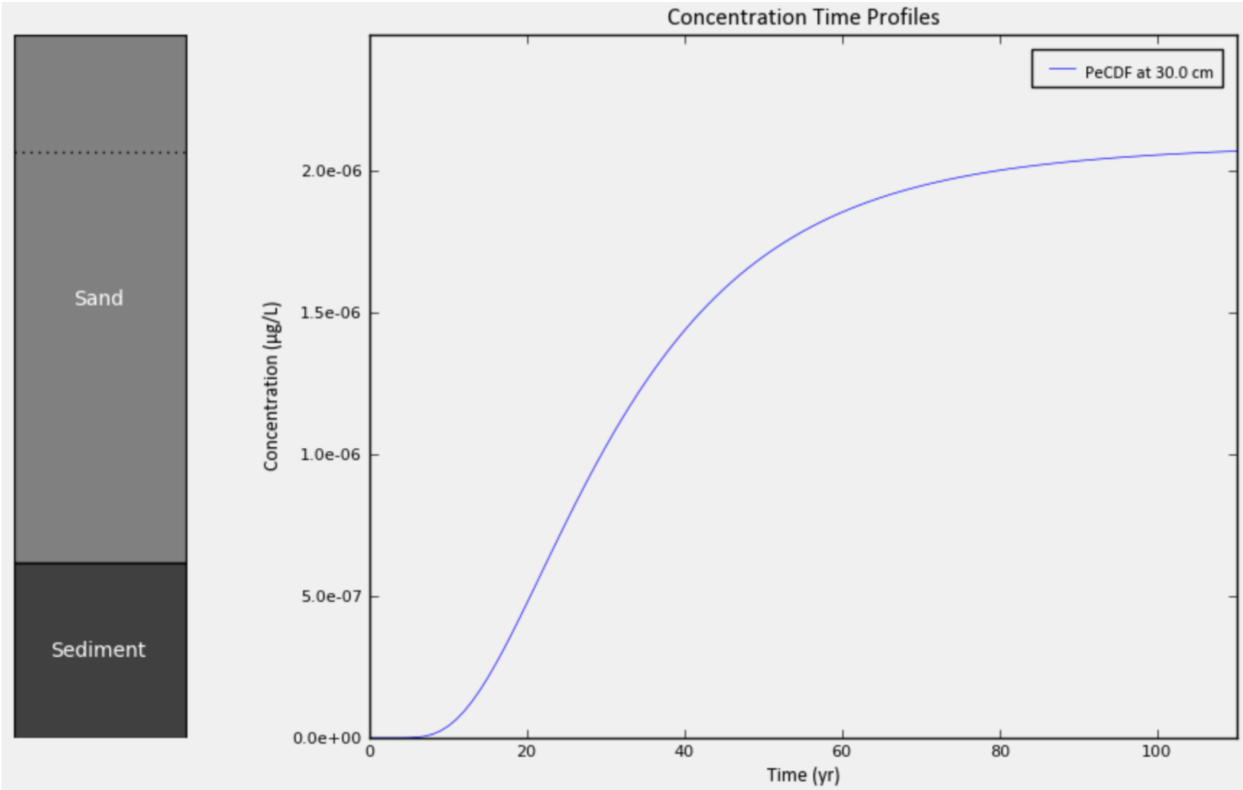

Concentration Time Profiles
PCB183 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
1.4e-05
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100

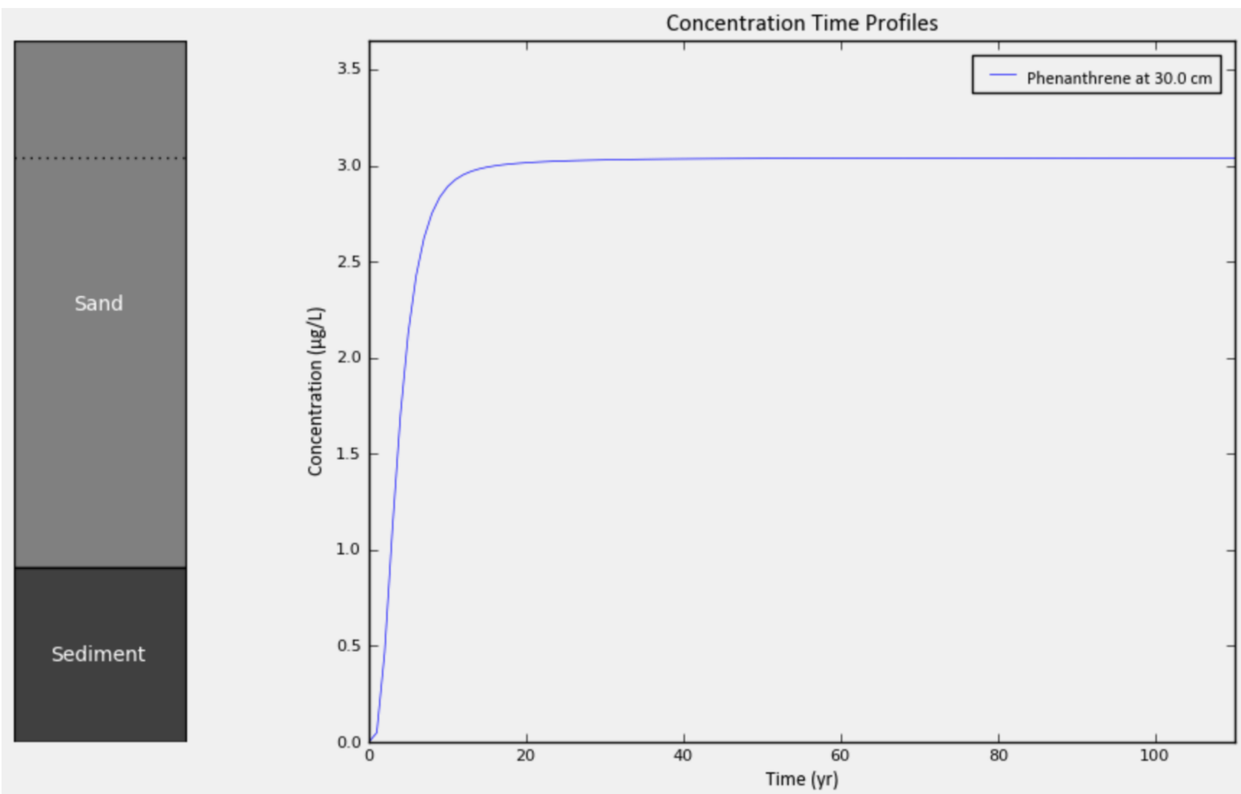

Concentration Time Profiles
PCB199 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
1.4e-05
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100

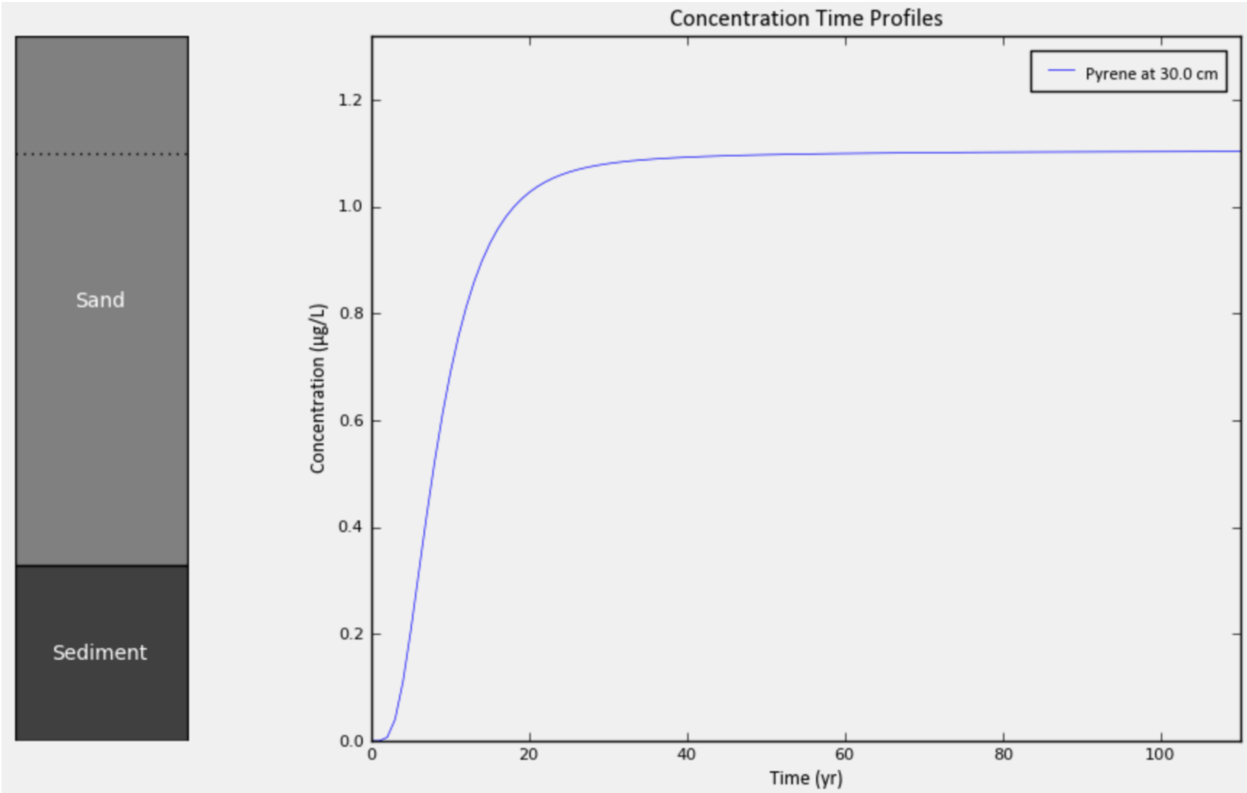

Concentration Time Profiles
PCB44 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100

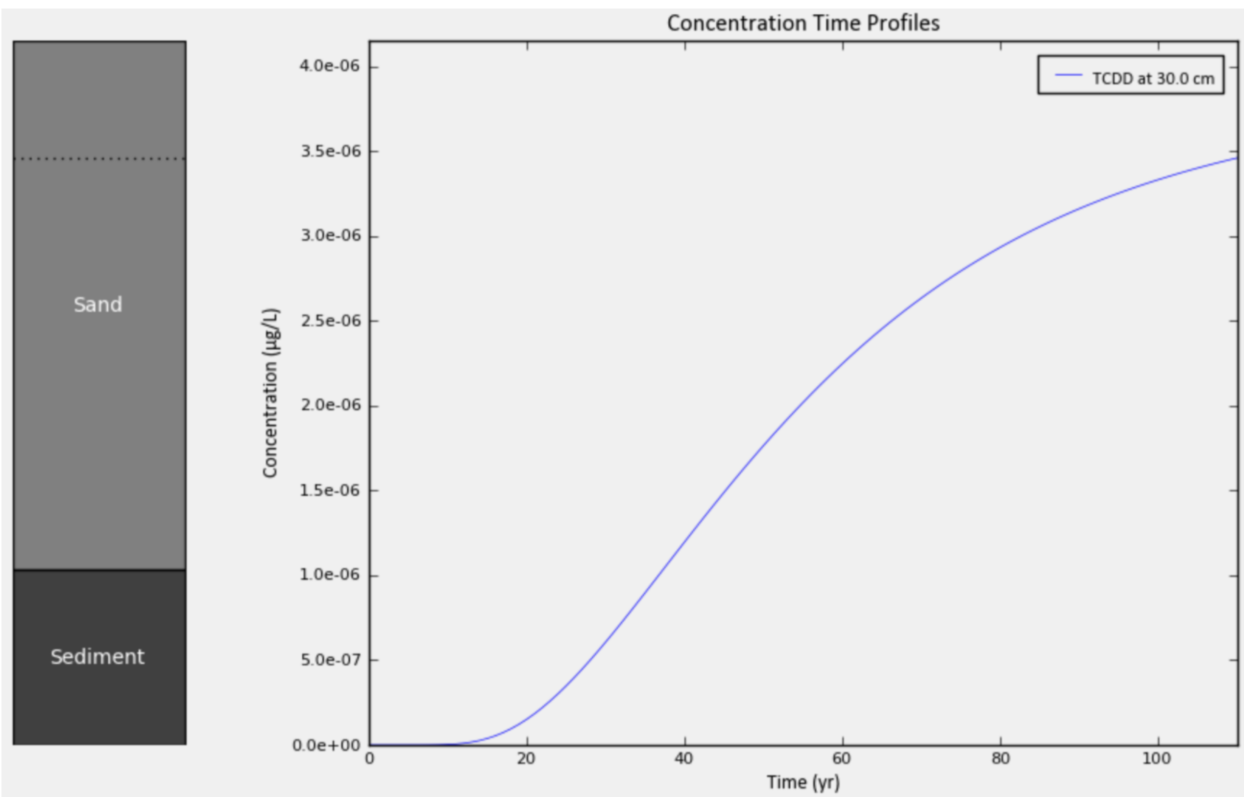

Concentration Time Profiles
PCB99 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.000
0.001
0.002
0.003
0.004
0
20
40
60
80
100
Time (yr)

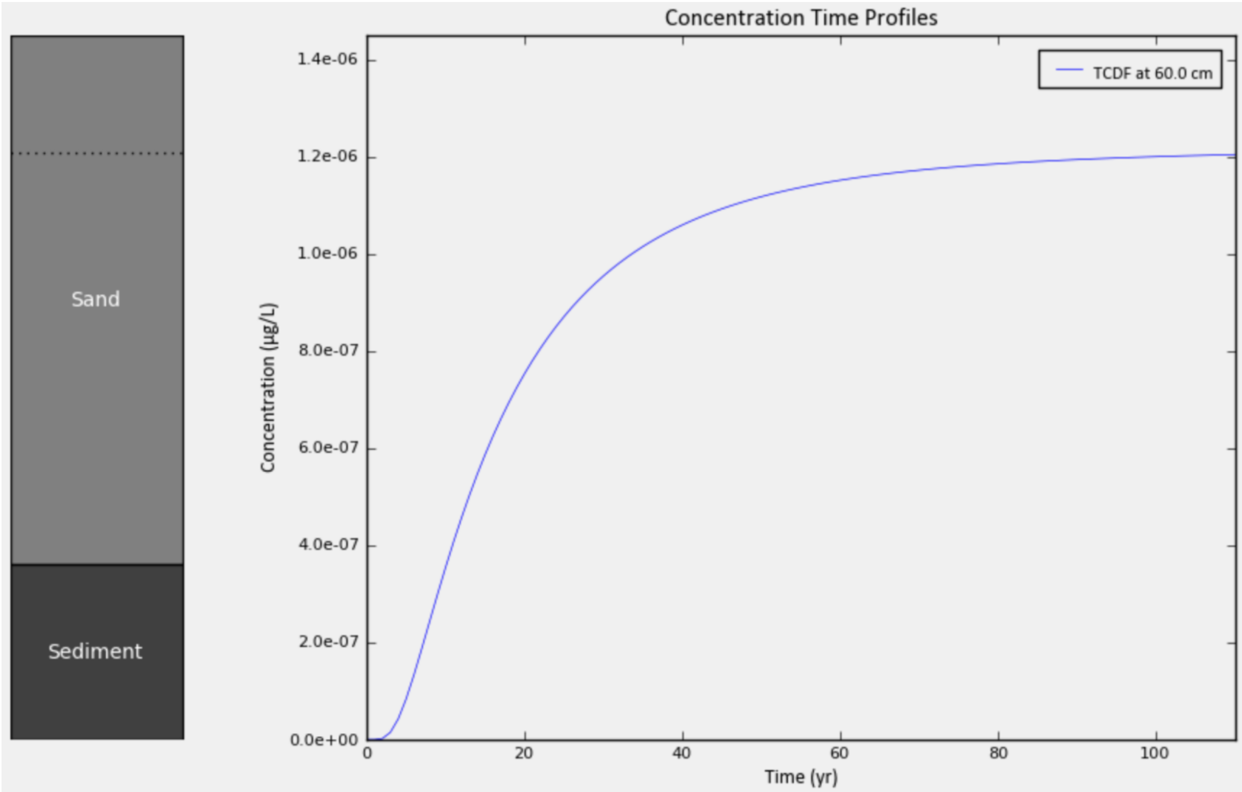

Concentration Time Profiles
PeCDD at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0e+00
5.0e-14
1.0e-13
1.5e-13
2.0e-13
2.5e-13
3.0e-13
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
PeCDF at 30.0 cm
Sand
Sediment
Concentration (µg/L)
2.0e-06
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

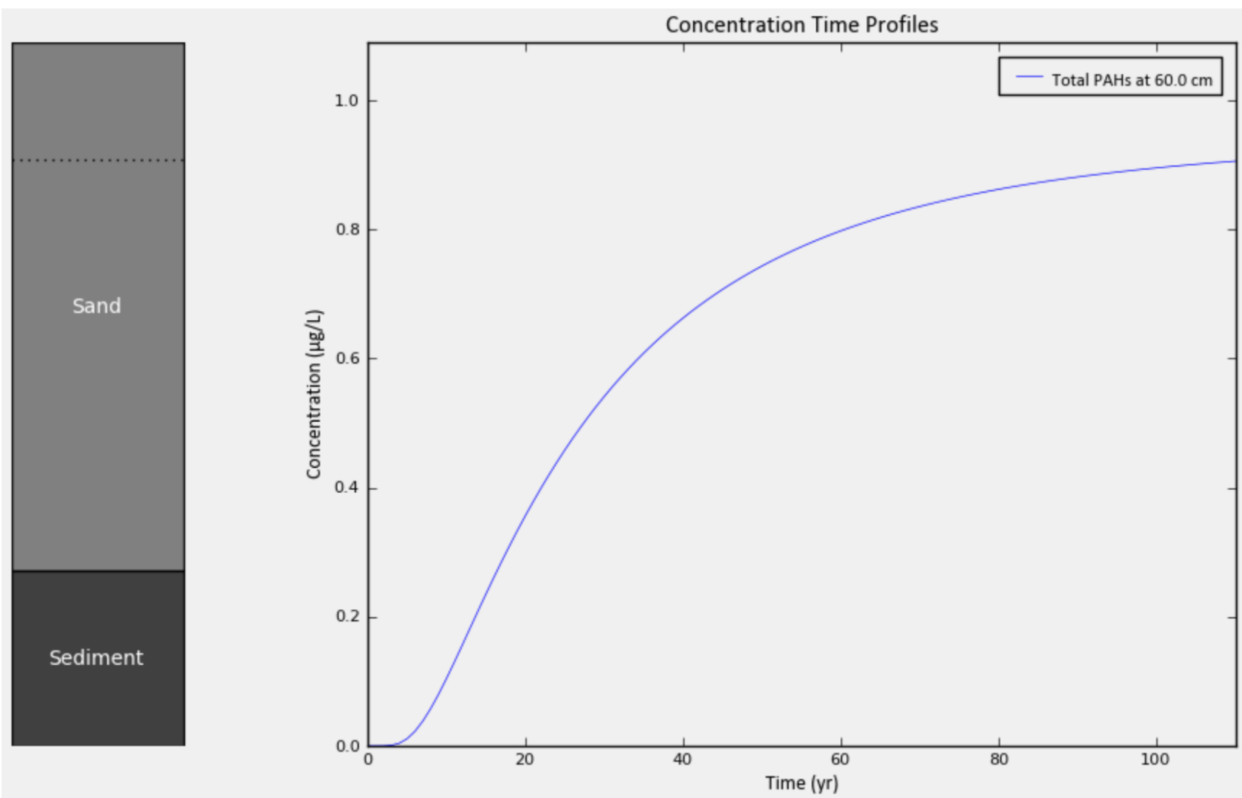

Concentration Time Profiles
Phenanthrene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand
Sediment
Pyrene at 30.0 cm
Concentration (µg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
20
40
60
80
100
Time (yr)

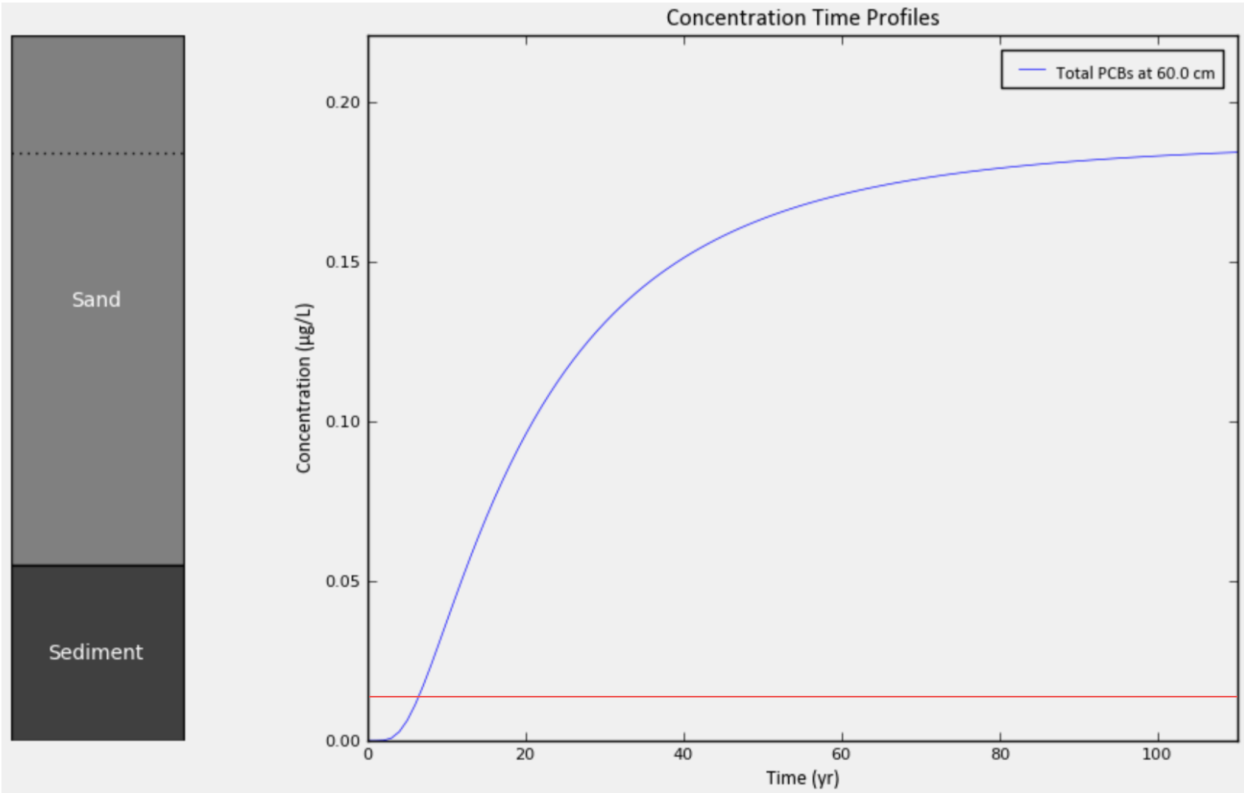

Concentration Time Profiles
Sand
Sediment
TCDD at 30.0 cm
Concentration (µg/L)
0.0e+00
5.0e-07
1.0e-06
1.5e-06
2.0e-06
2.5e-06
3.0e-06
3.5e-06
4.0e-06
0
20
40
60
80
100
Time (yr)



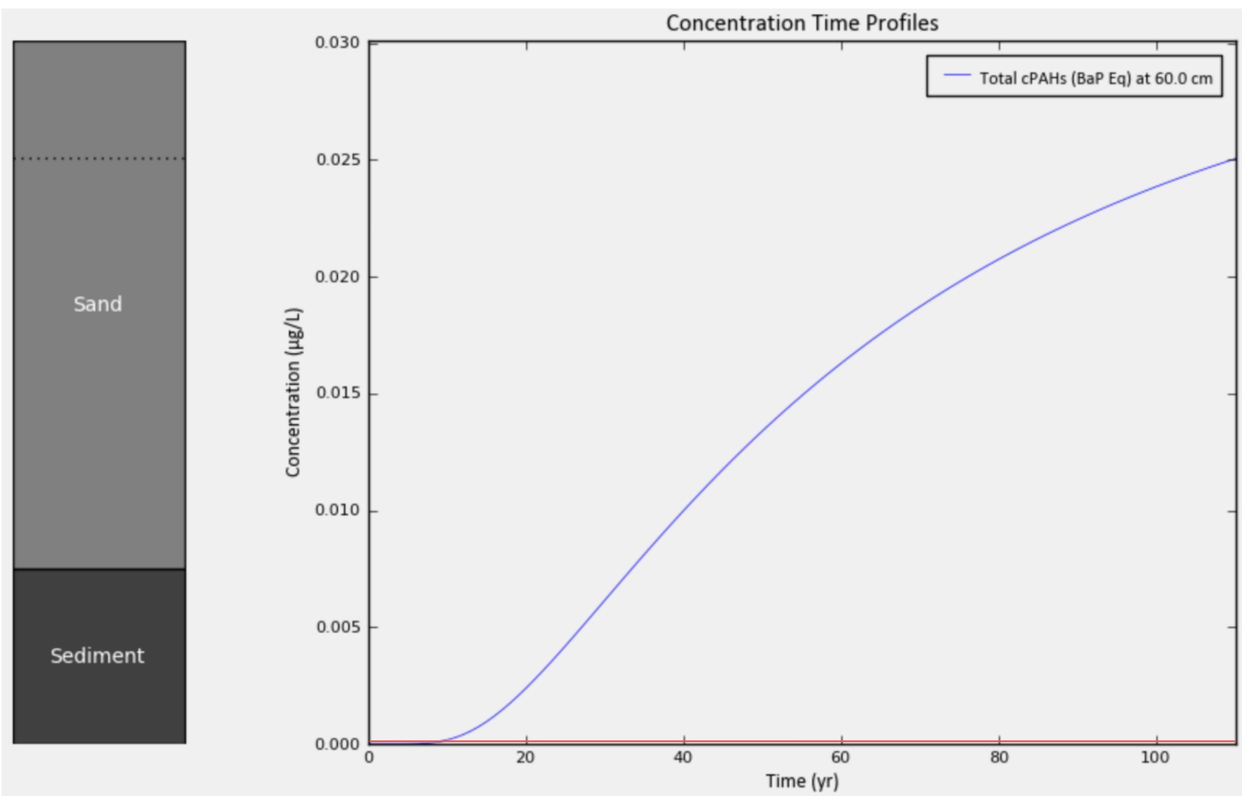
Concentration Time Profiles
Sand
Sediment
TCDF at 60.0 cm
Concentration (µg/L)
1.4e-06
1.2e-06
1.0e-06
8.0e-07
6.0e-07
4.0e-07
2.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)



Concentration Time Profiles
Sand
Sediment
Total PAHs at 60.0 cm
Concentration (µg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Time (yr)



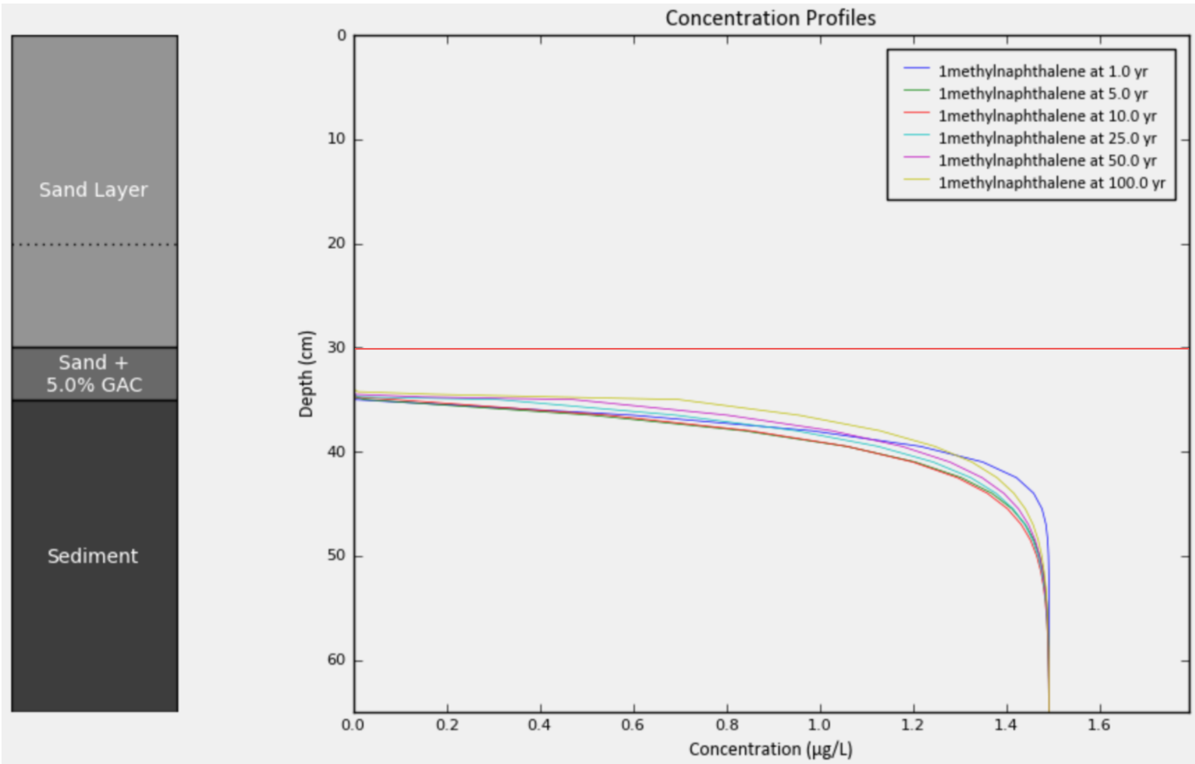
Concentration Time Profiles
Sand
Sediment
Total PCBs at 60.0 cm
Concentration (µg/L)
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
Time (yr)

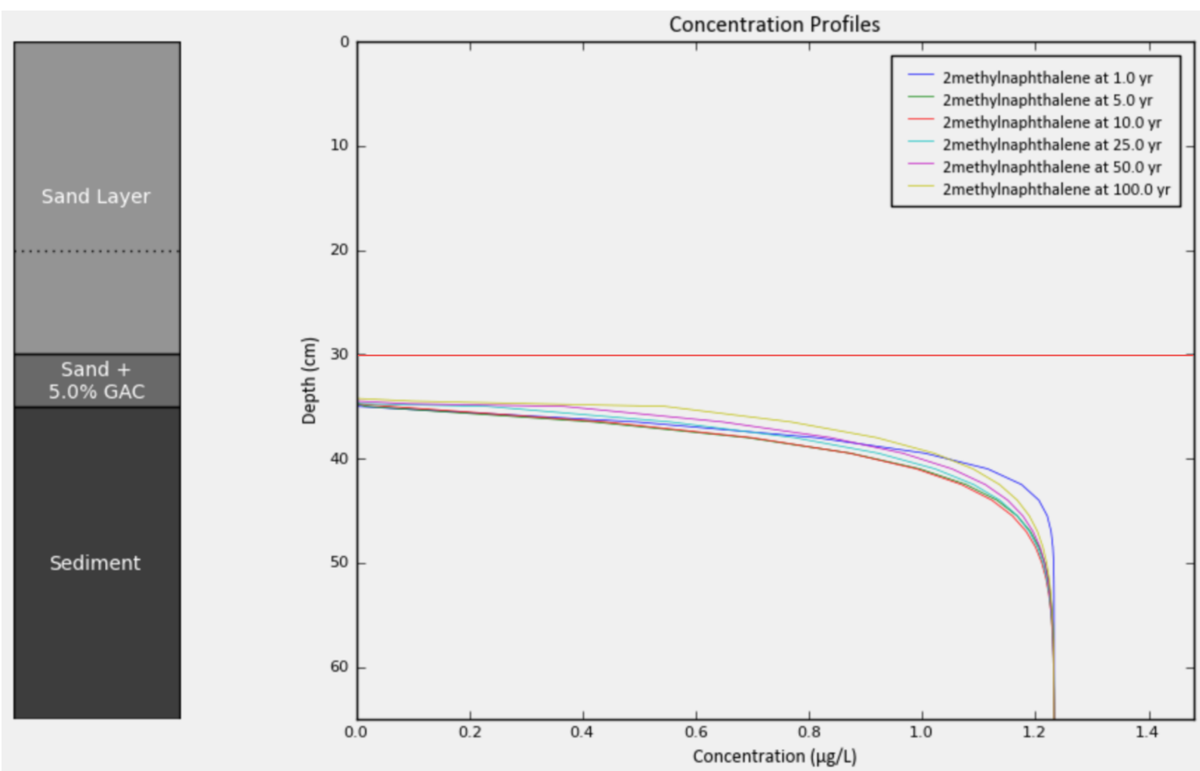


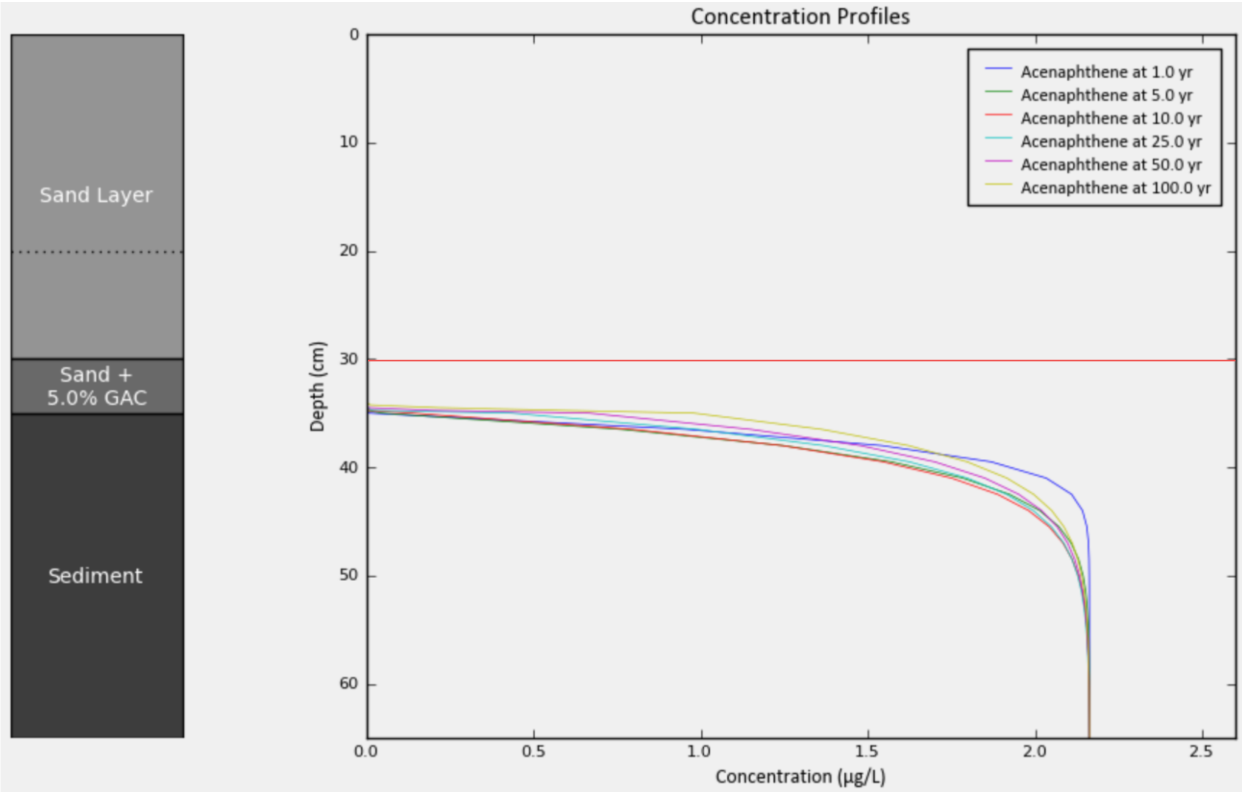
Concentration Time Profiles
Sand
Sediment
Total cPAHs (BaP Eq) at 60.0 cm
Concentration (µg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
Time (yr)

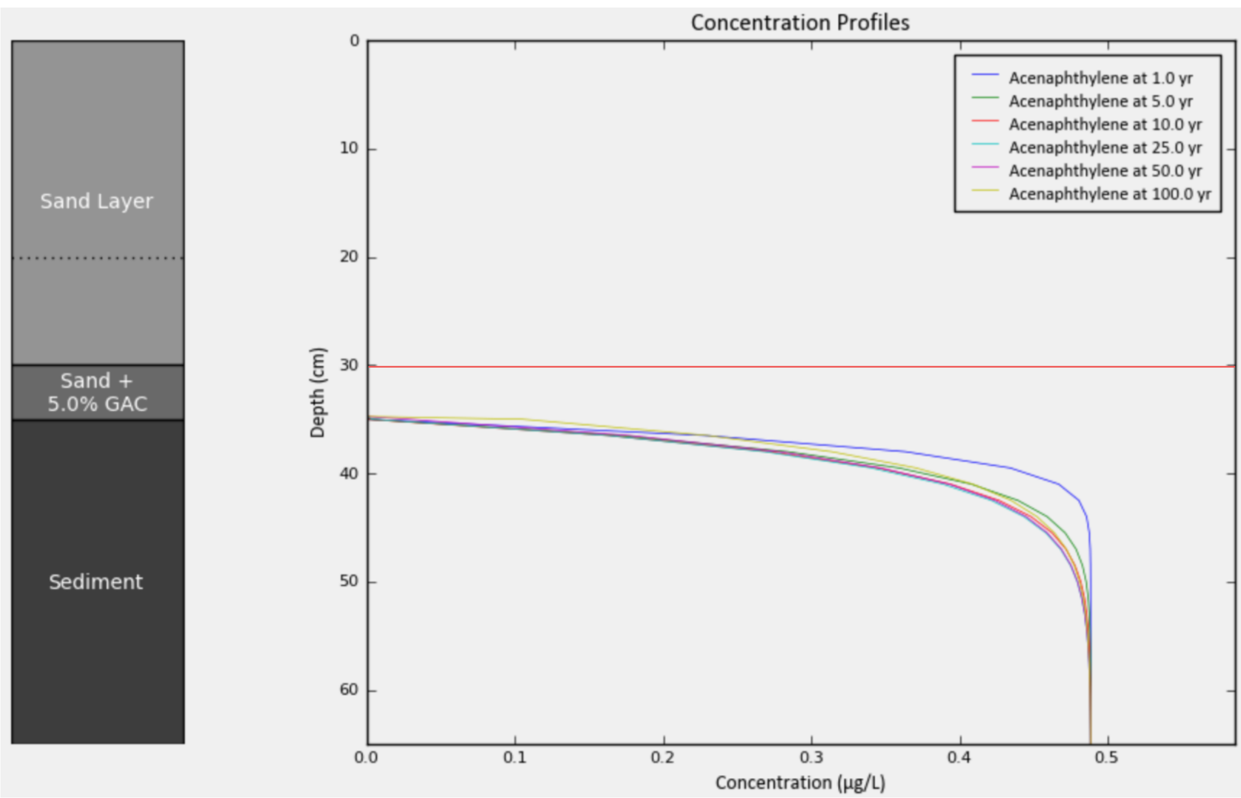
Cap Alternative 4: 5 cm of 5.0% GAC amended sand with 30 cm unamended sand layer

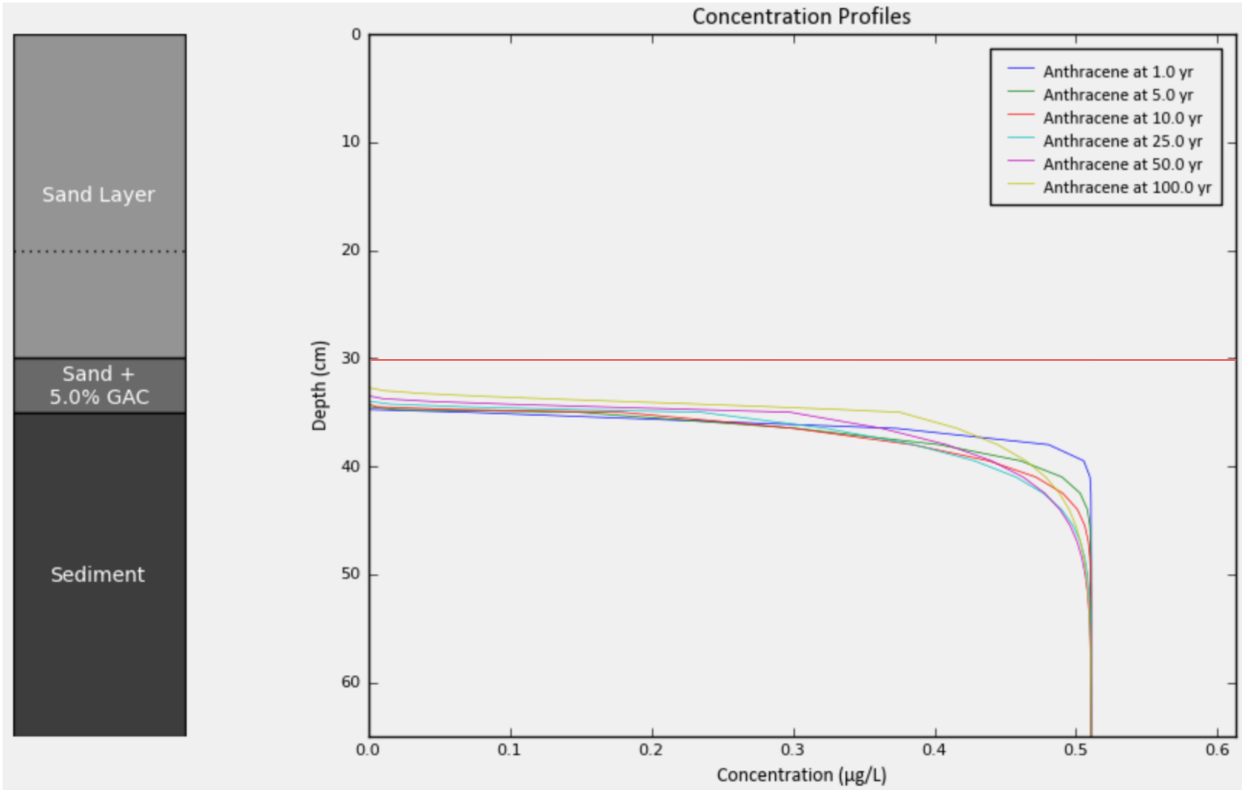
Porewater Concentration – Depth

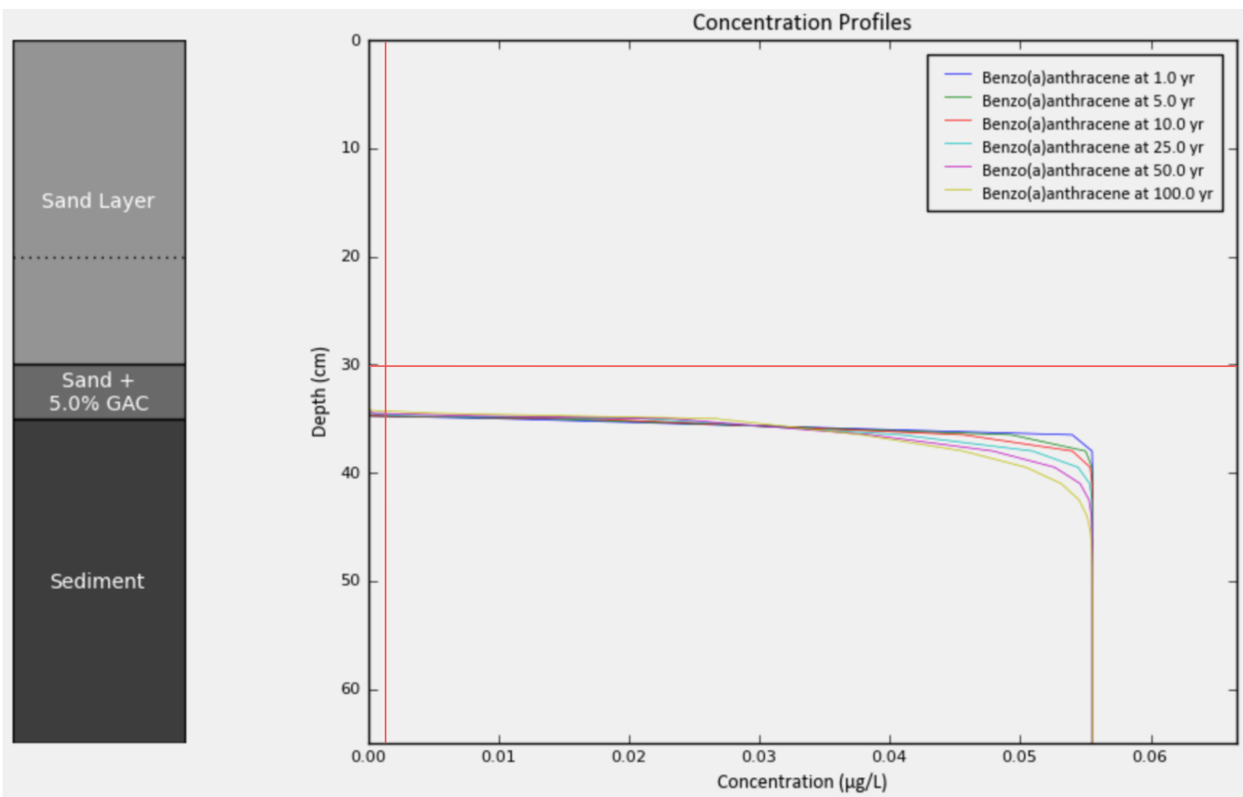


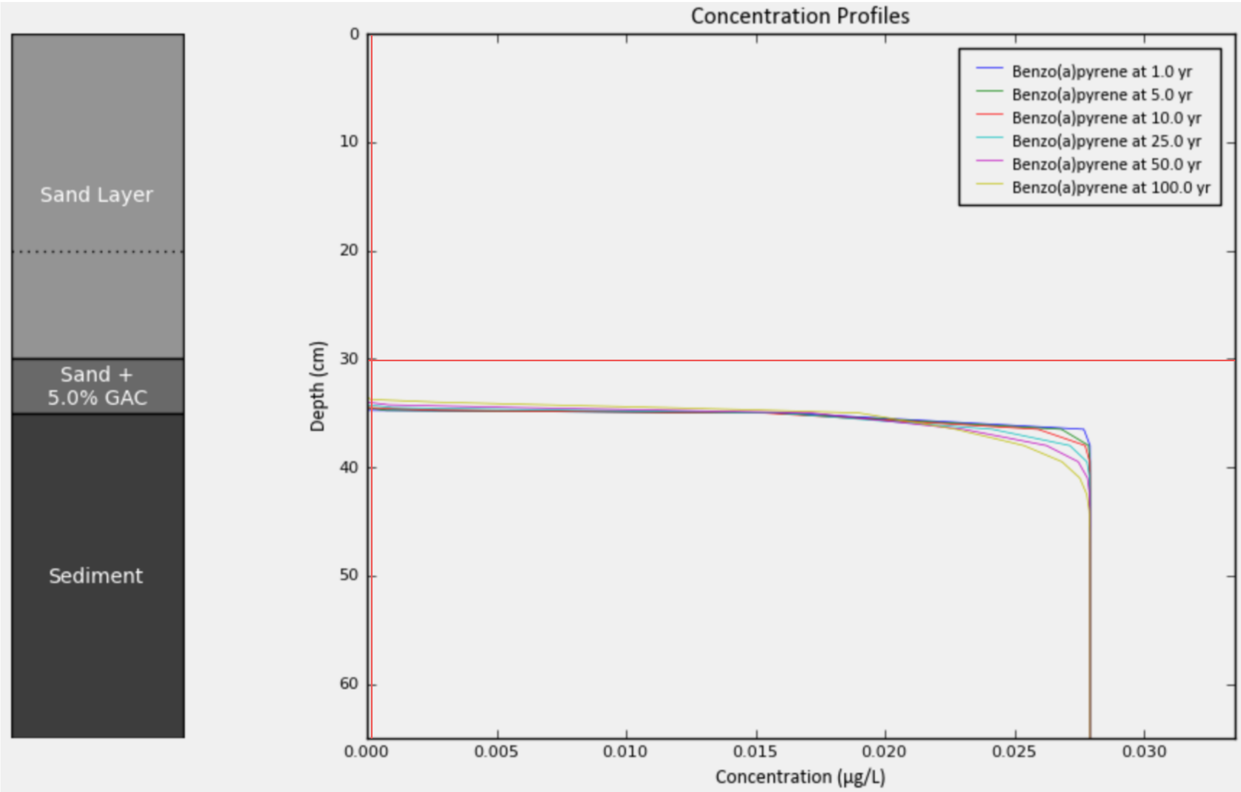



Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0
2.5
Concentration (µg/L)

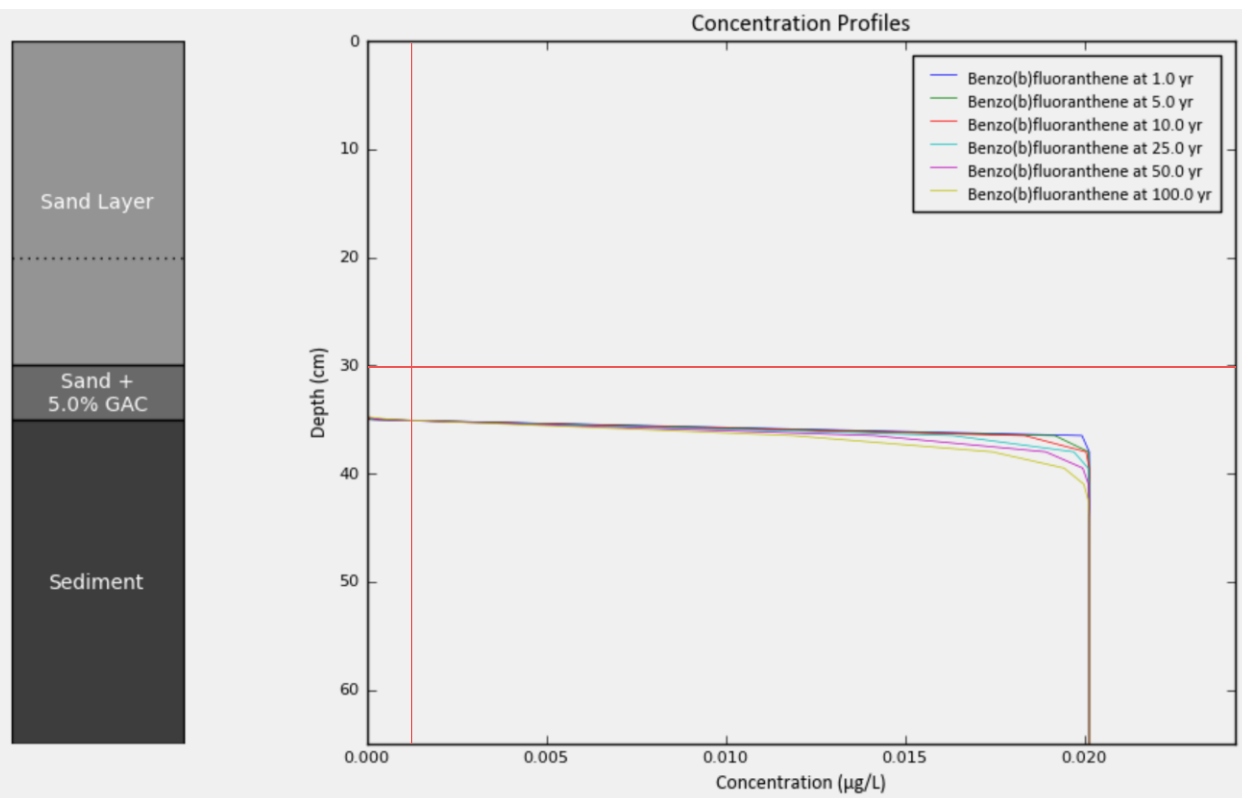

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.1
0.2
0.3
0.4
0.5
Concentration (µg/L)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

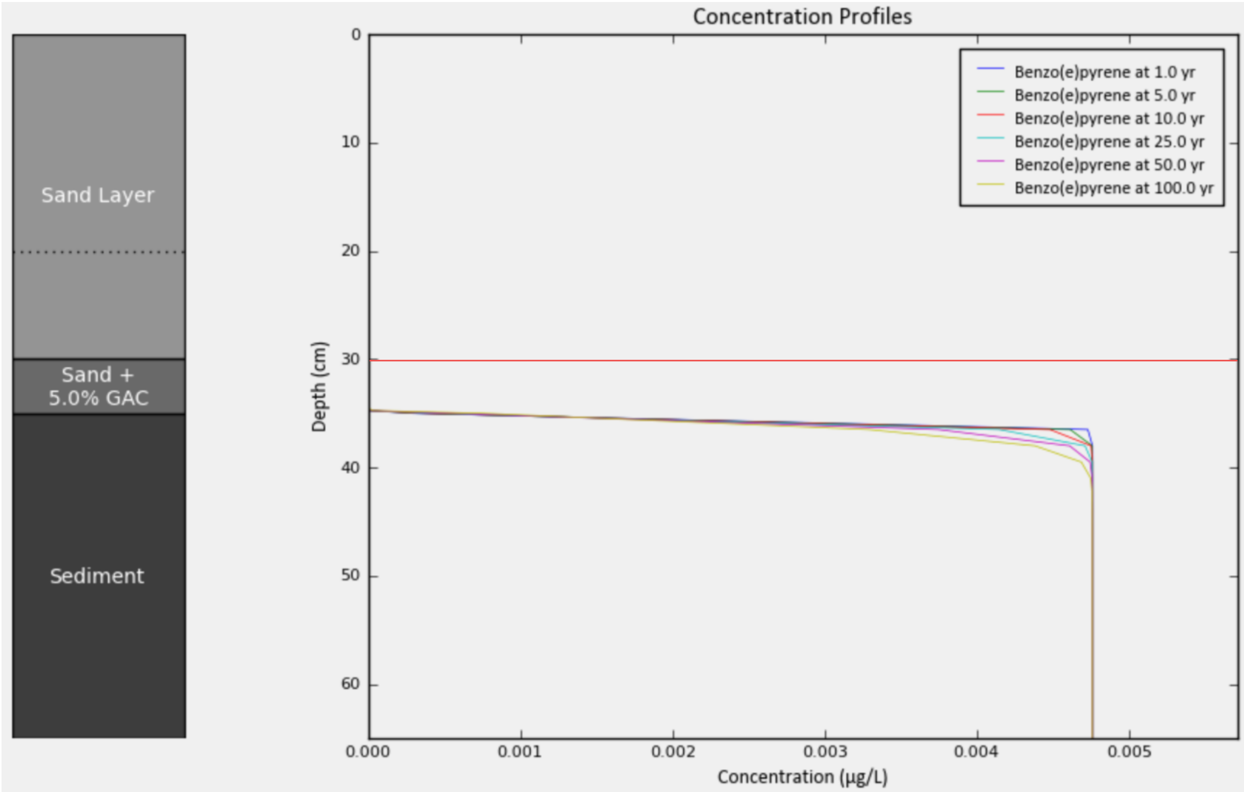

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

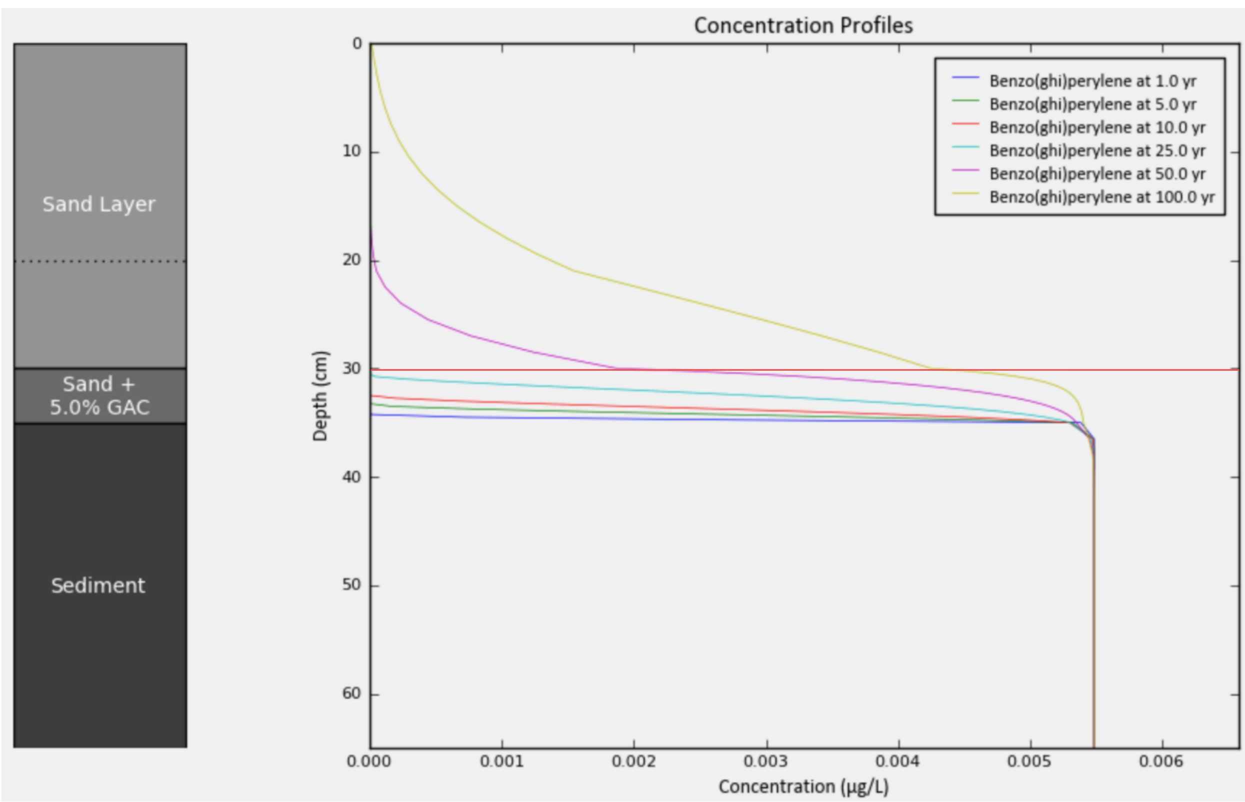


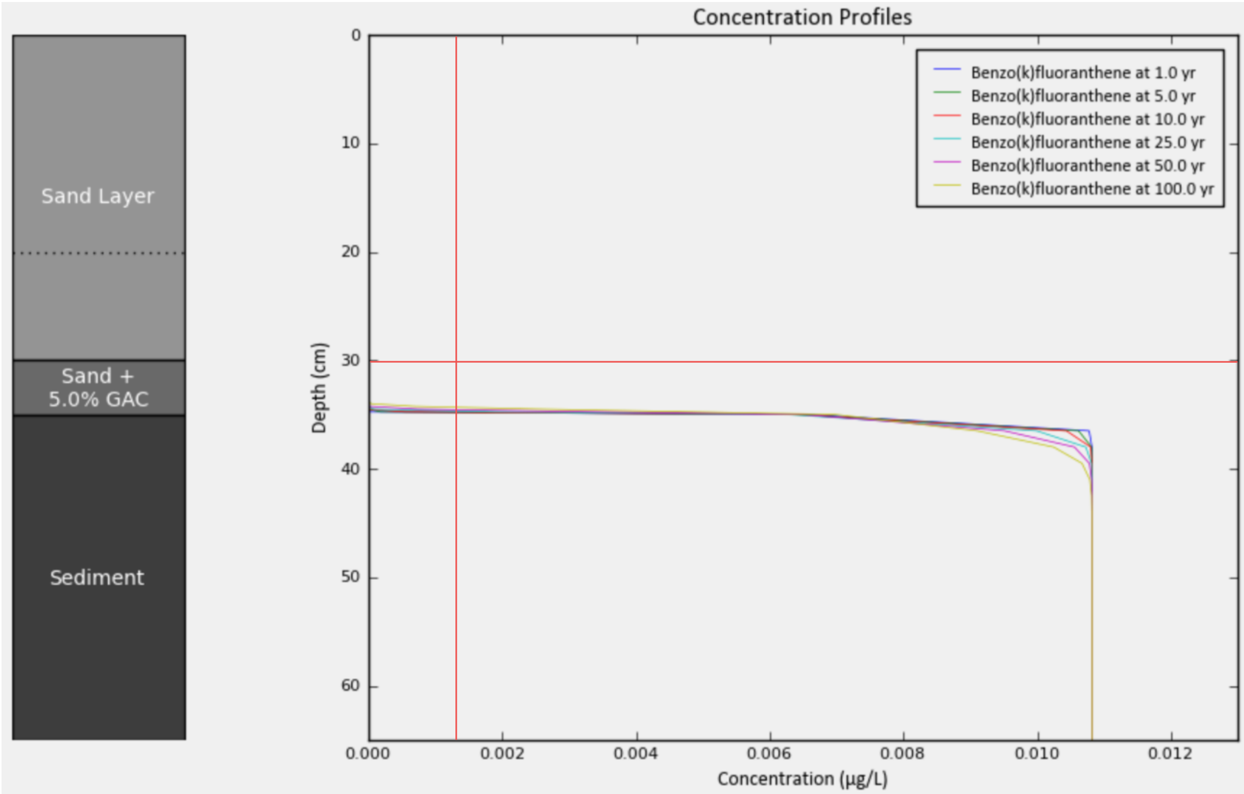
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.000
0.005
0.010
0.015
0.020
0.025
0.030

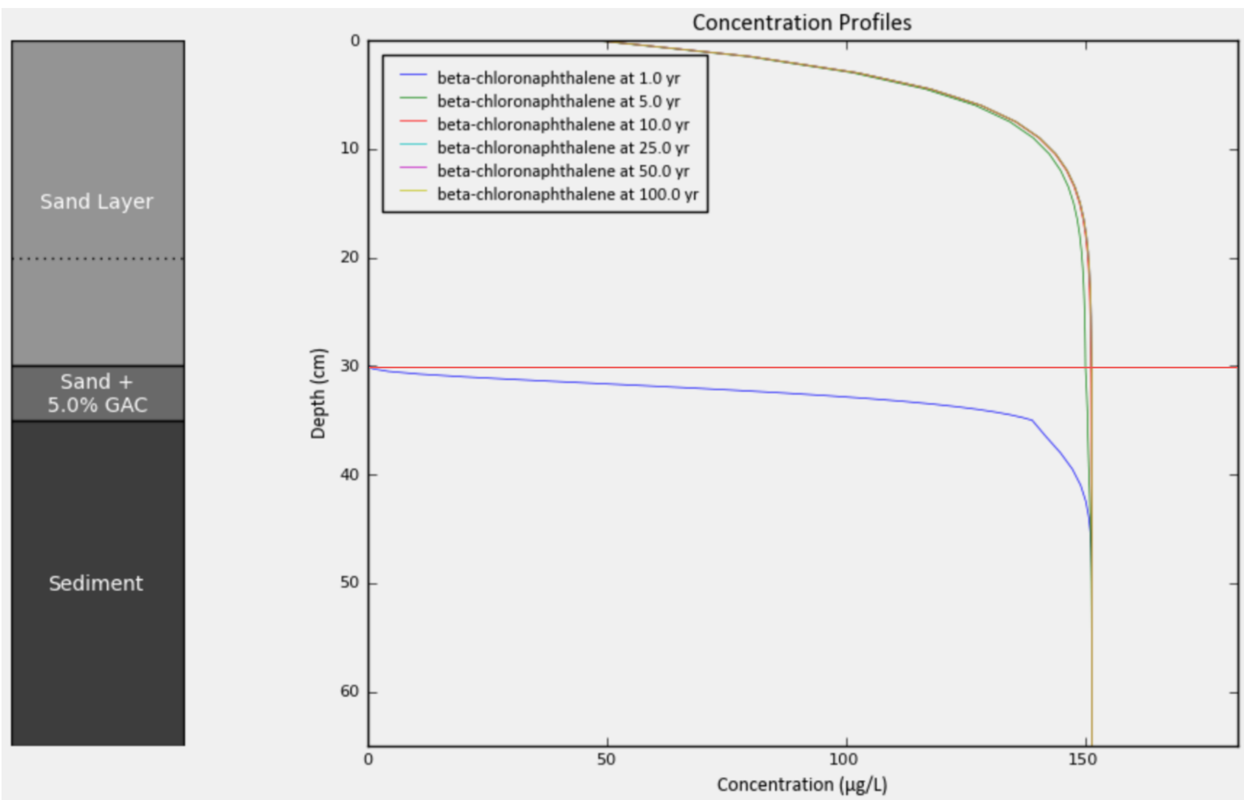


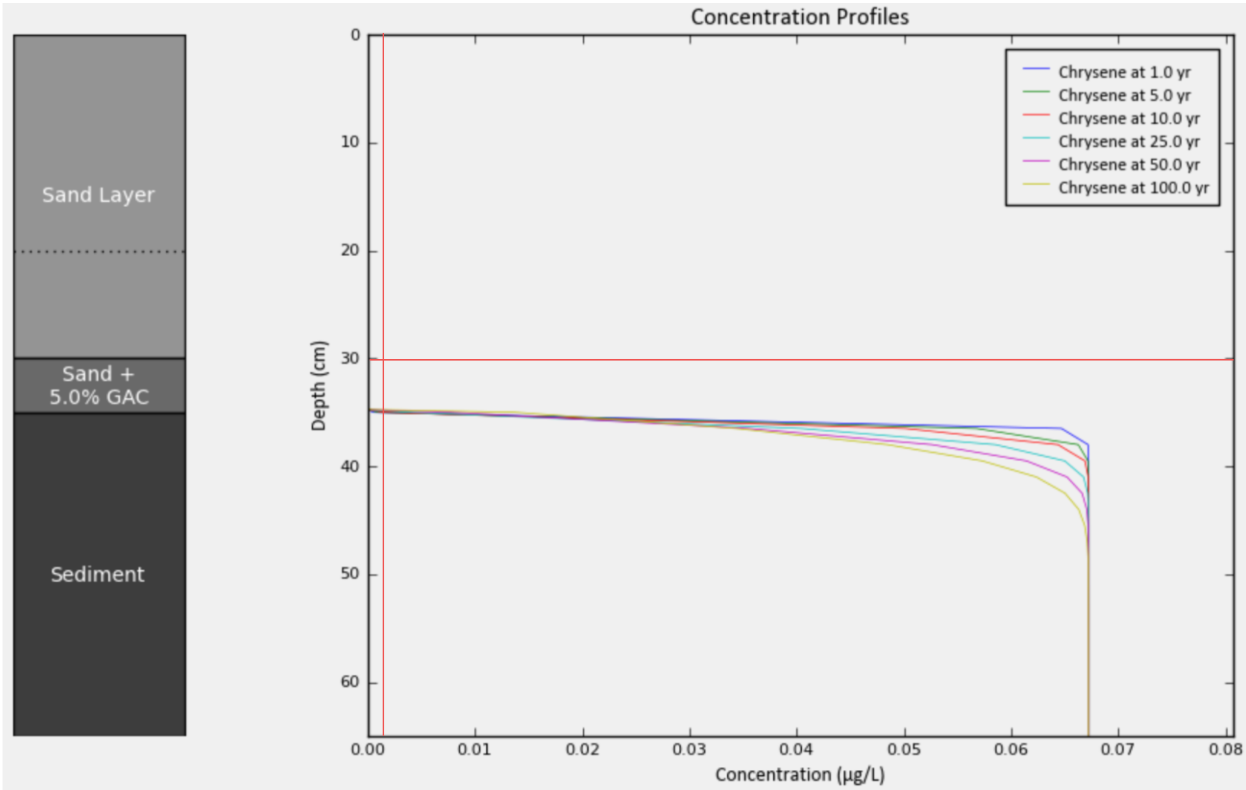
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.000
0.005
0.010
0.015
0.020

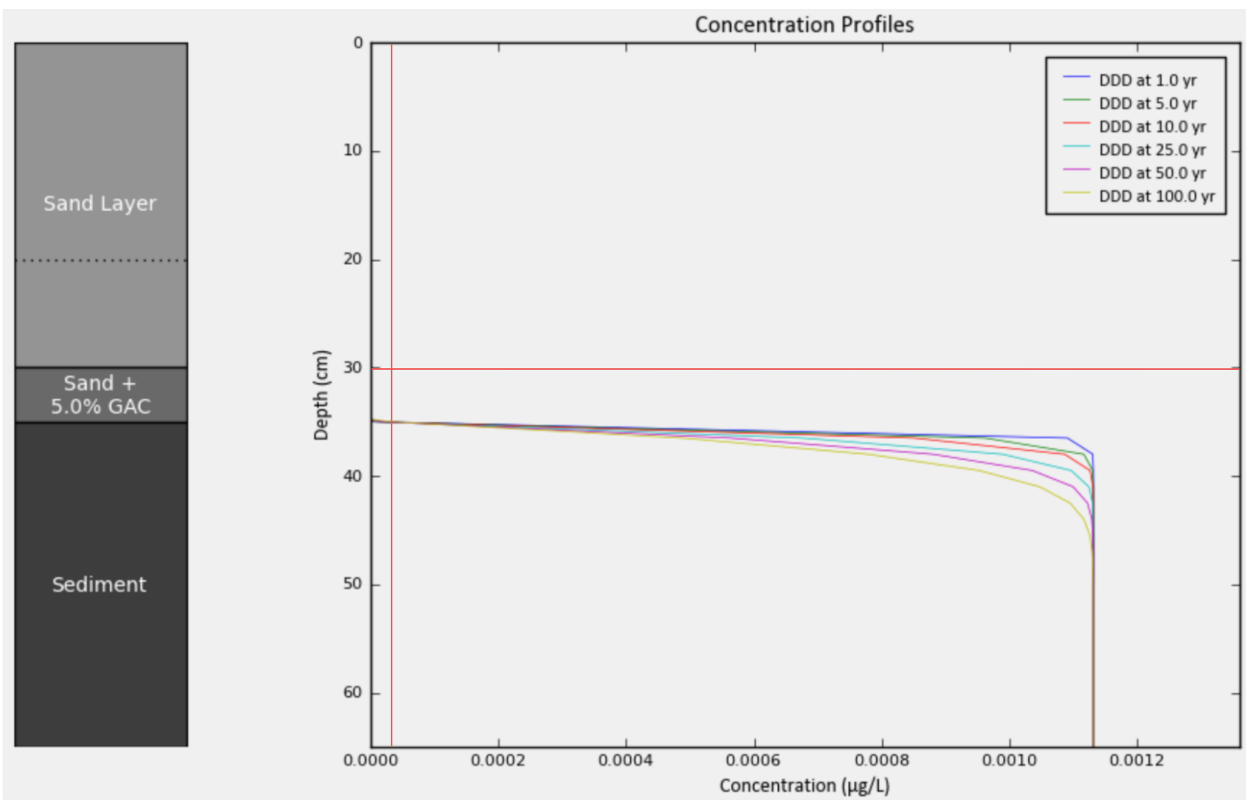

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

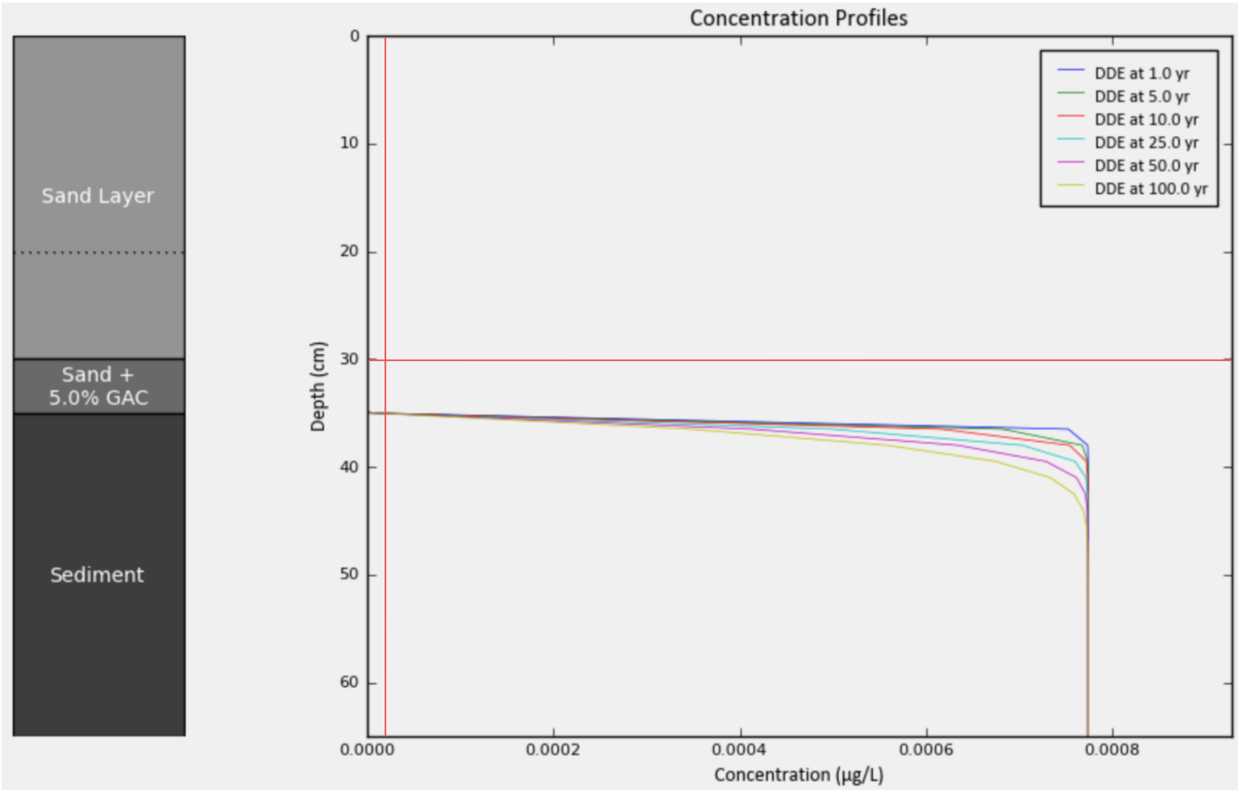

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

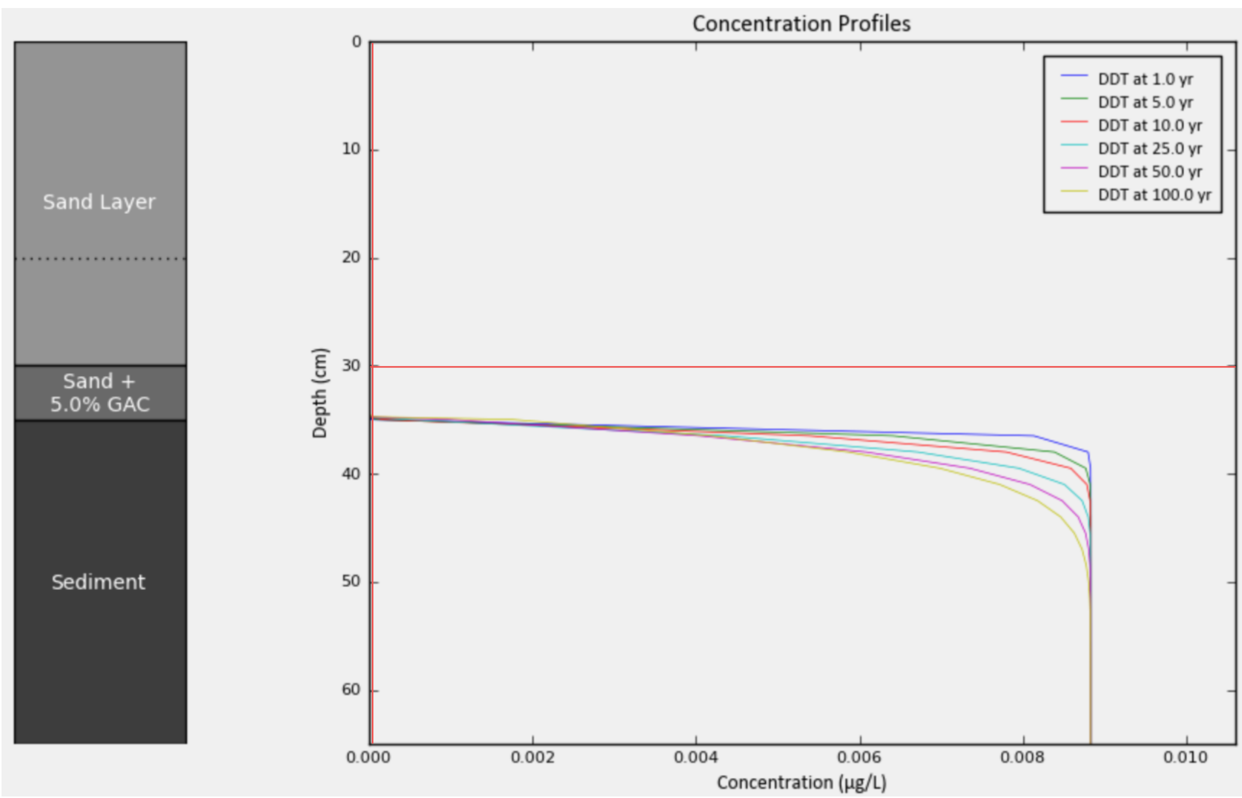

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0
10
20
30
40
50
60

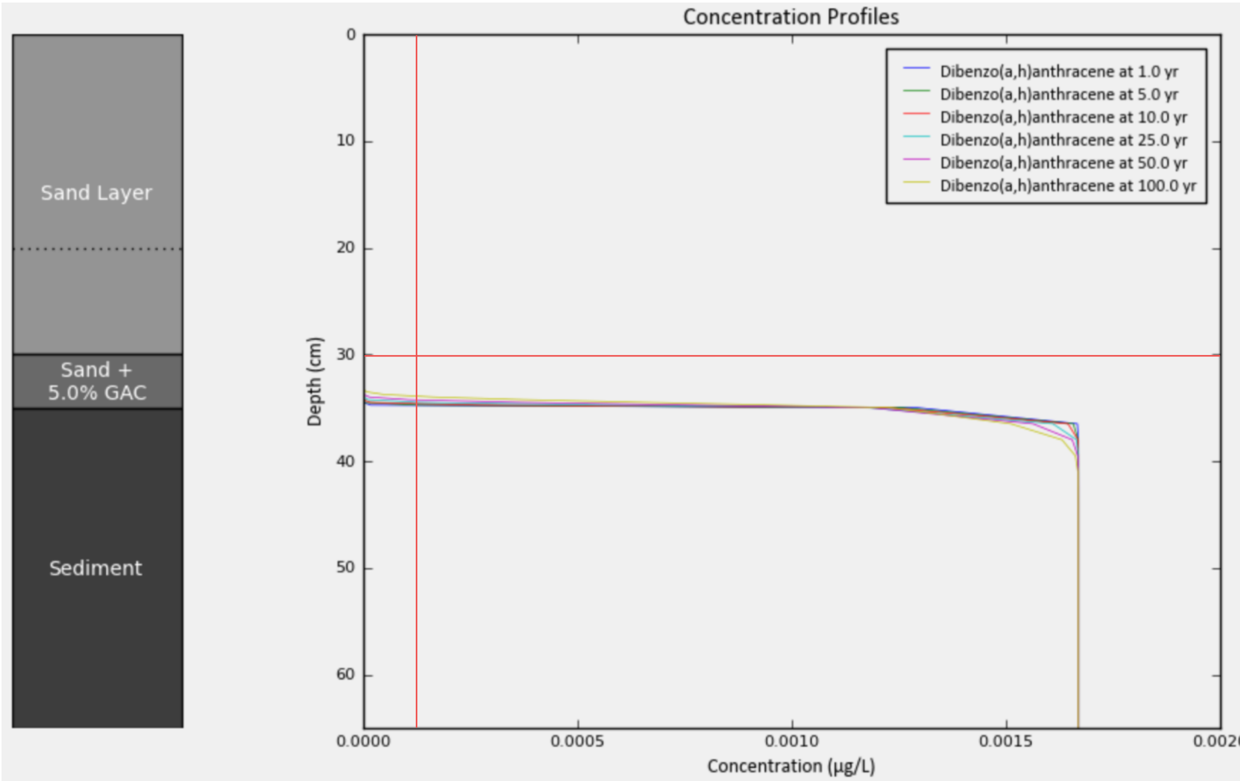

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr
0
50
100
150
0
10
20
30
40
50
60

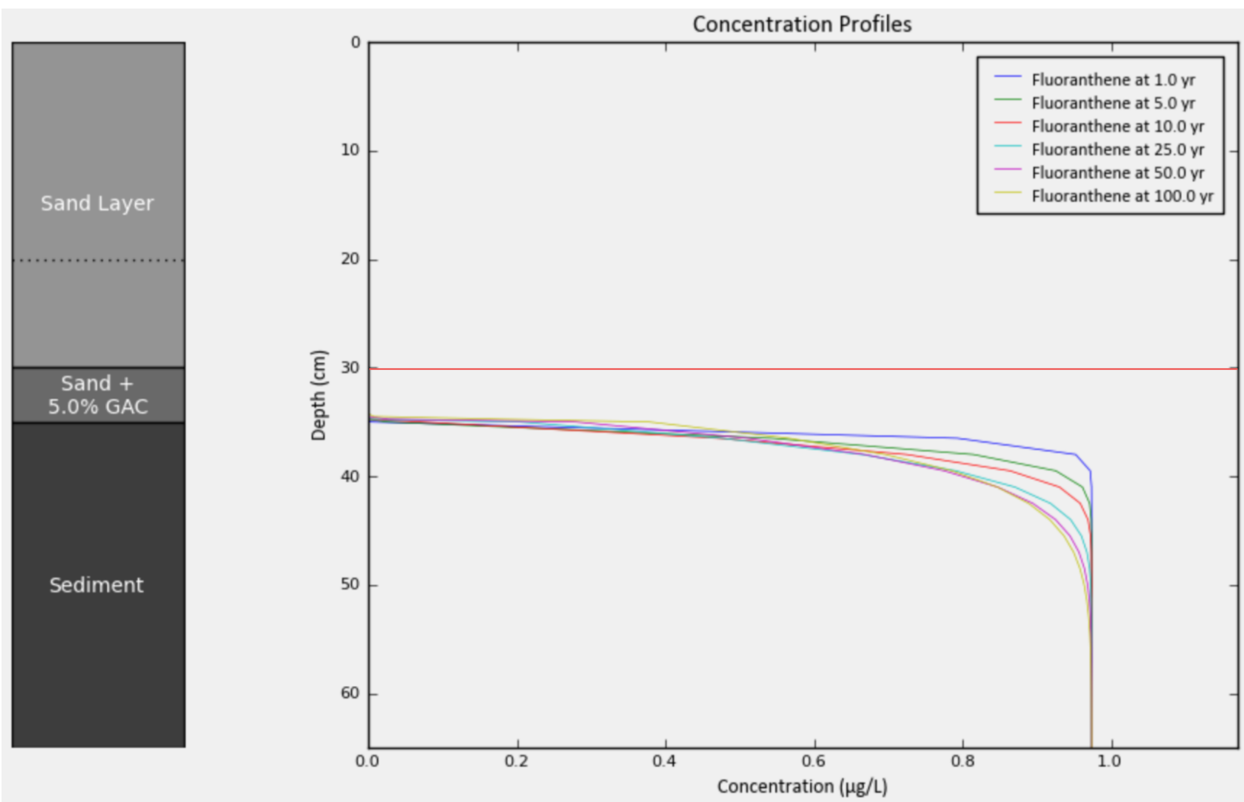

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
Depth (cm)
Concentration (µg/L)

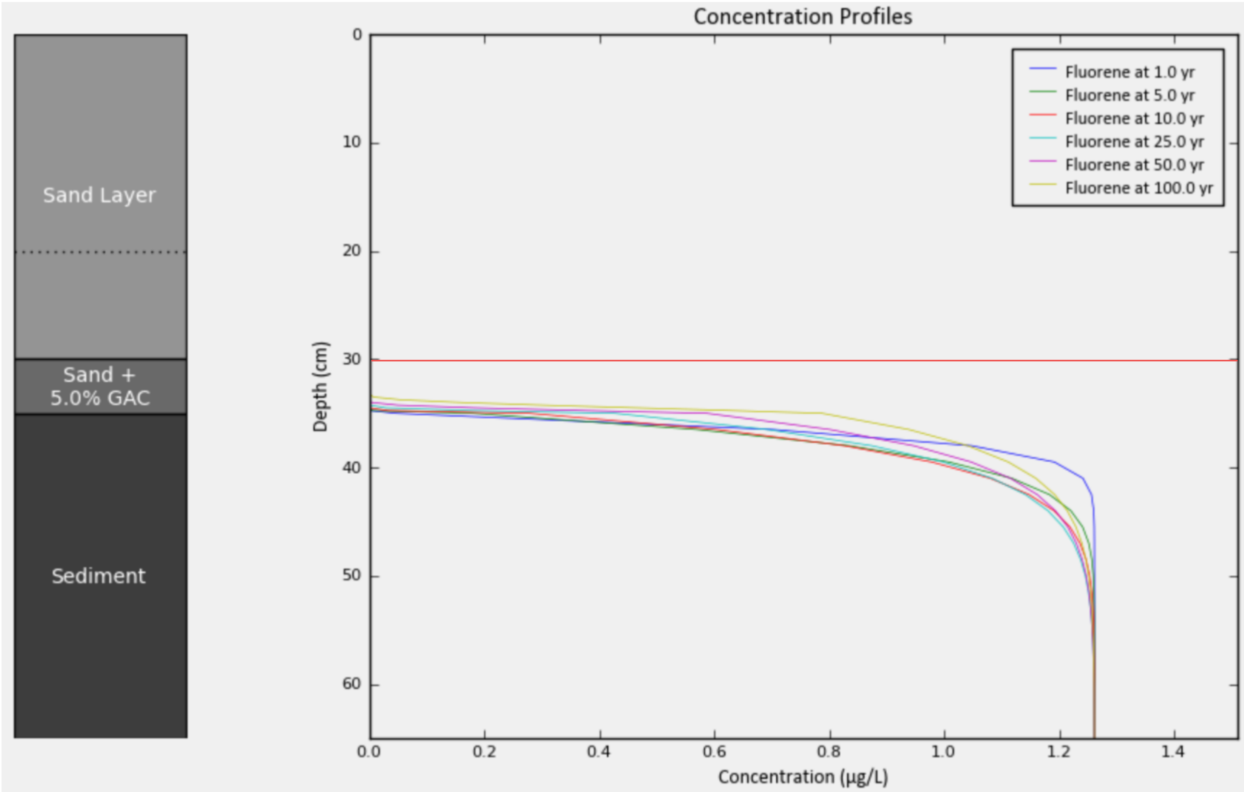

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
Depth (cm)
Concentration (µg/L)

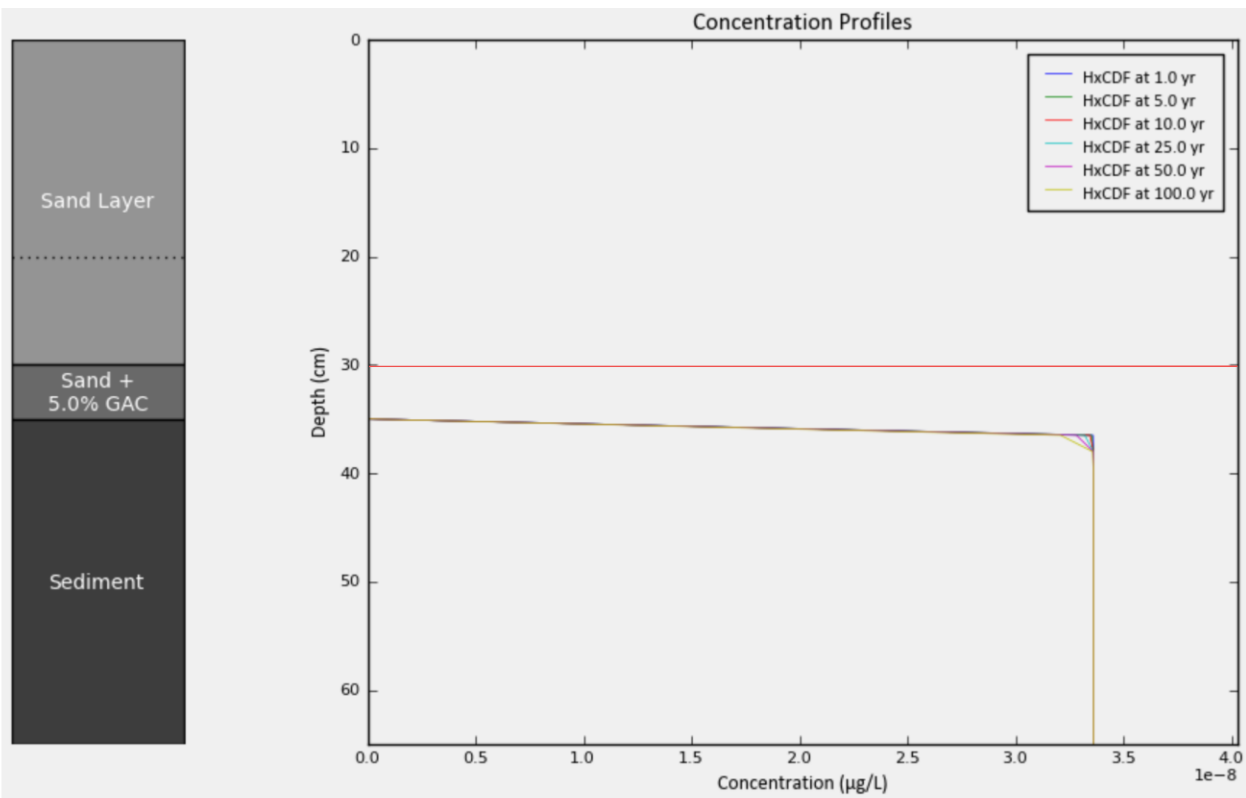

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0000
0.0002
0.0004
0.0006
0.0008
Concentration (µg/L)

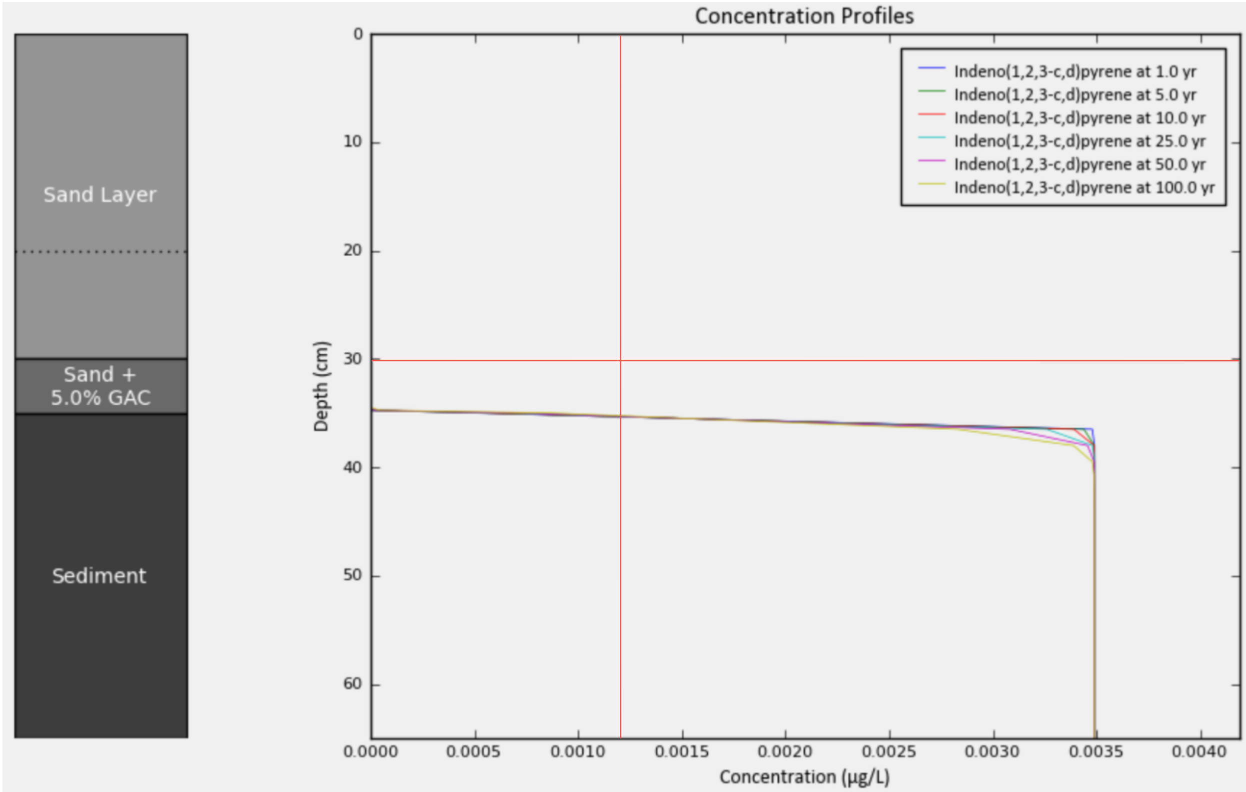

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.000
0.002
0.004
0.006
0.008
0.010
Concentration (µg/L)

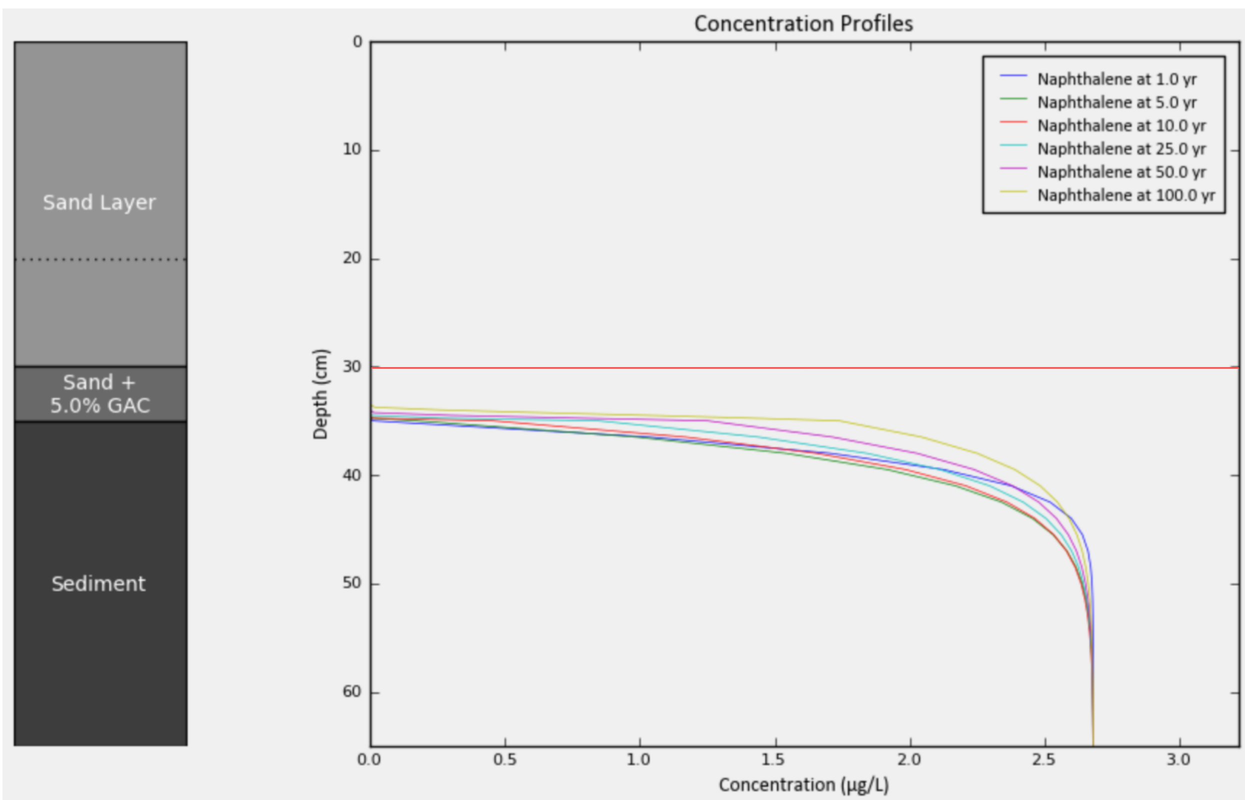

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0000
0.0005
0.0010
0.0015
0.0020
Concentration (μg/L)

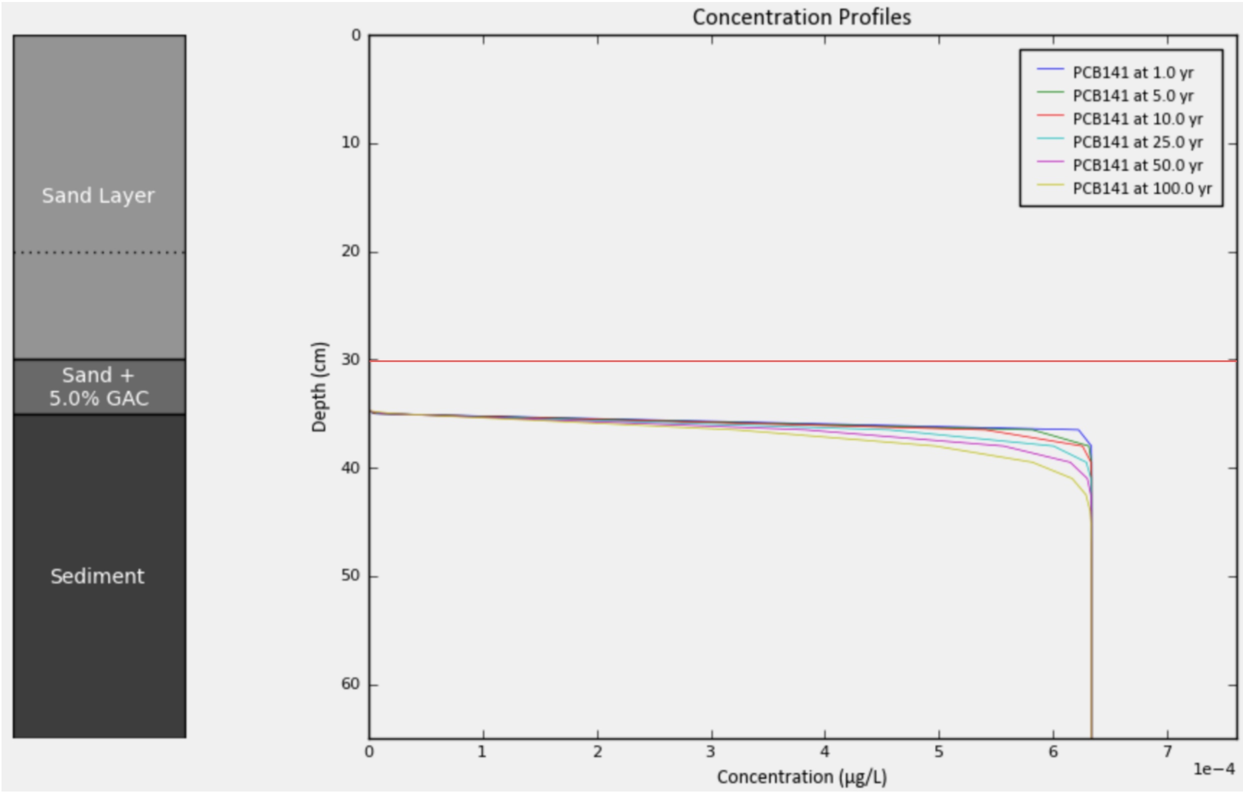

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.2
0.4
0.6
0.8
1.0
Concentration (μg/L)

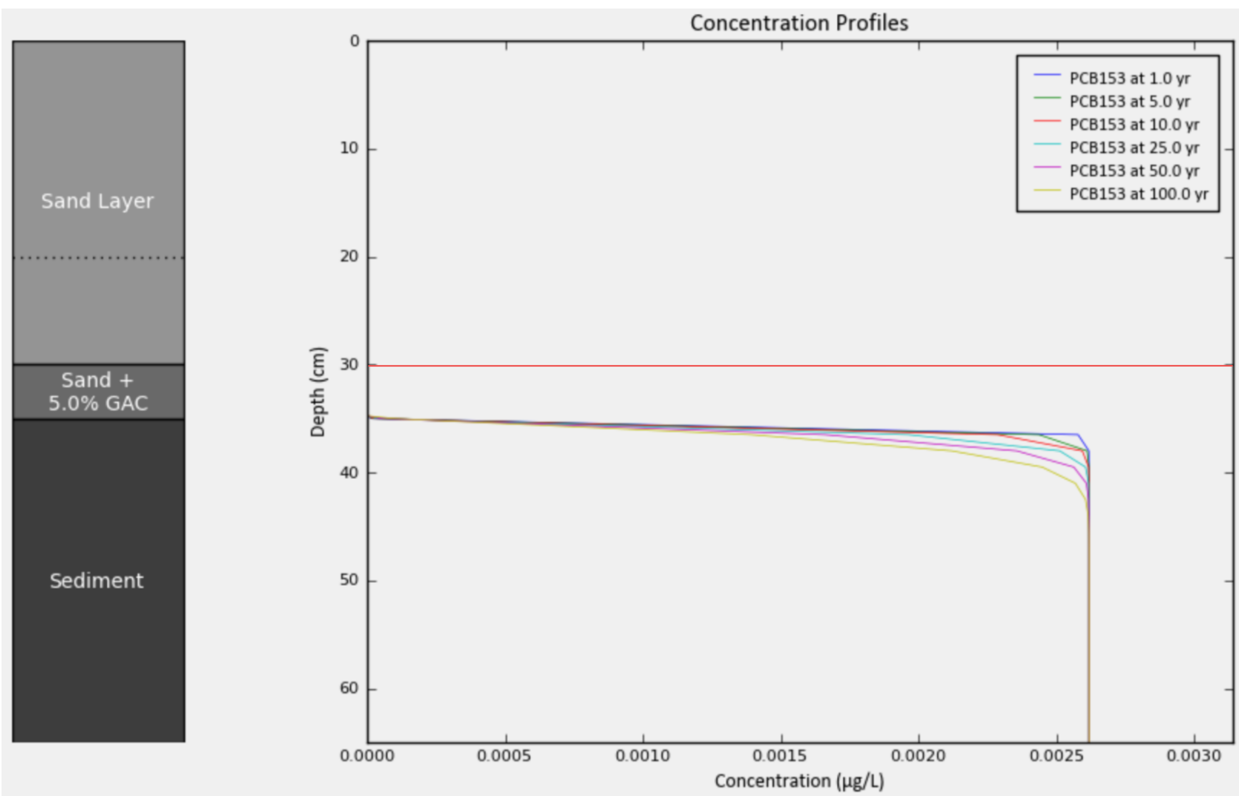

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

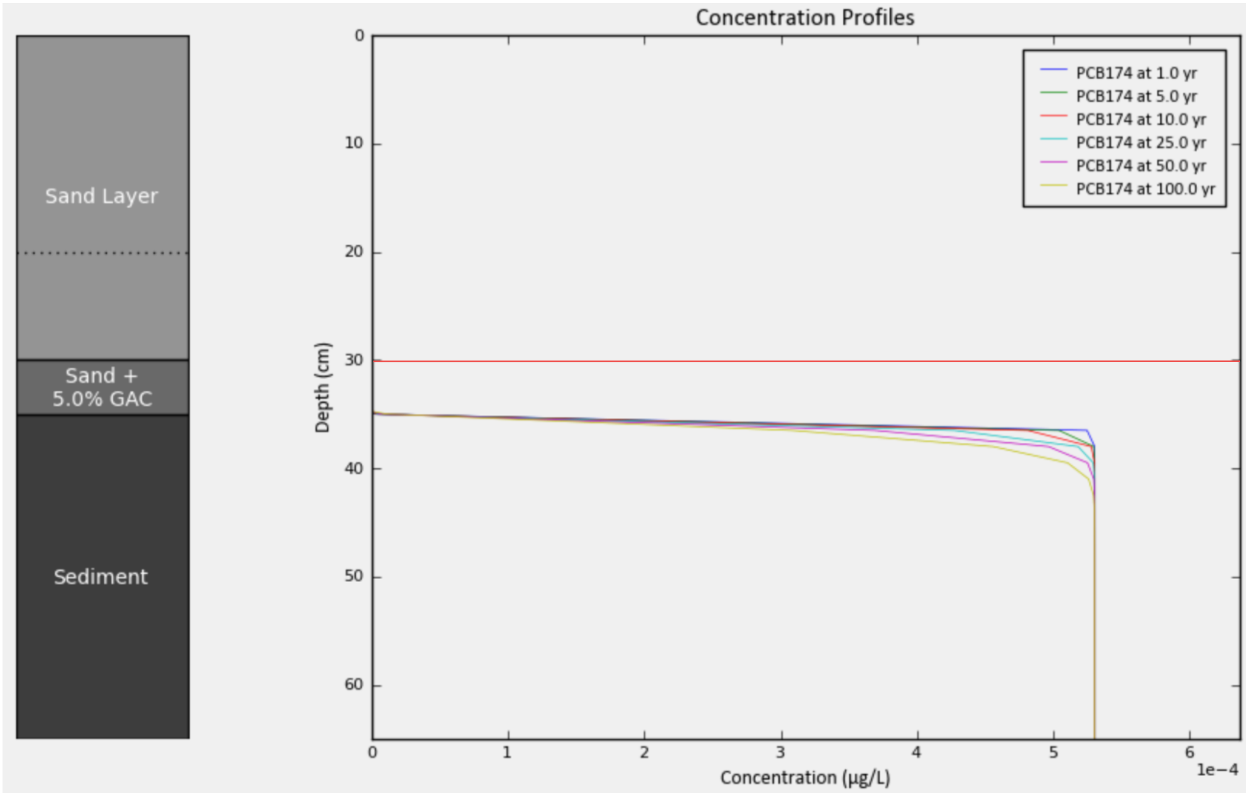

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−8


Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr

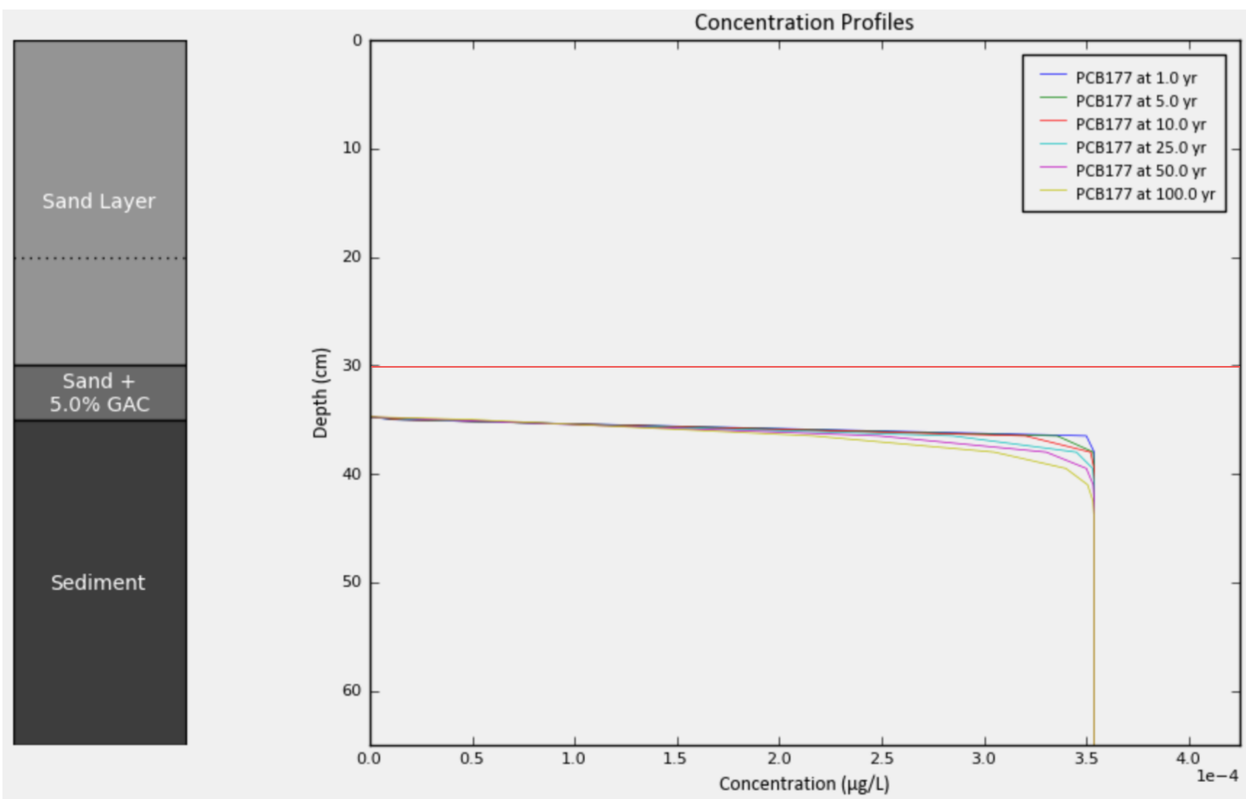

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

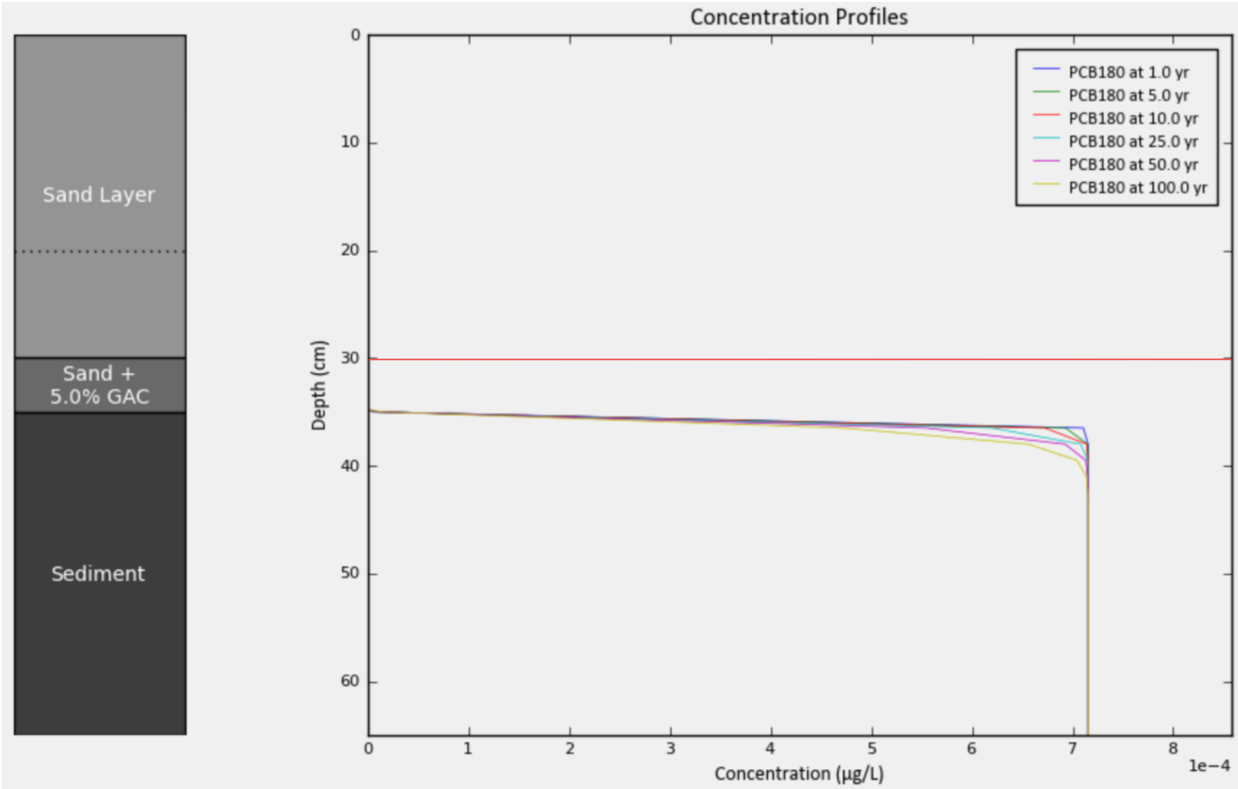

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr
Depth (cm)
Concentration (μg/L)

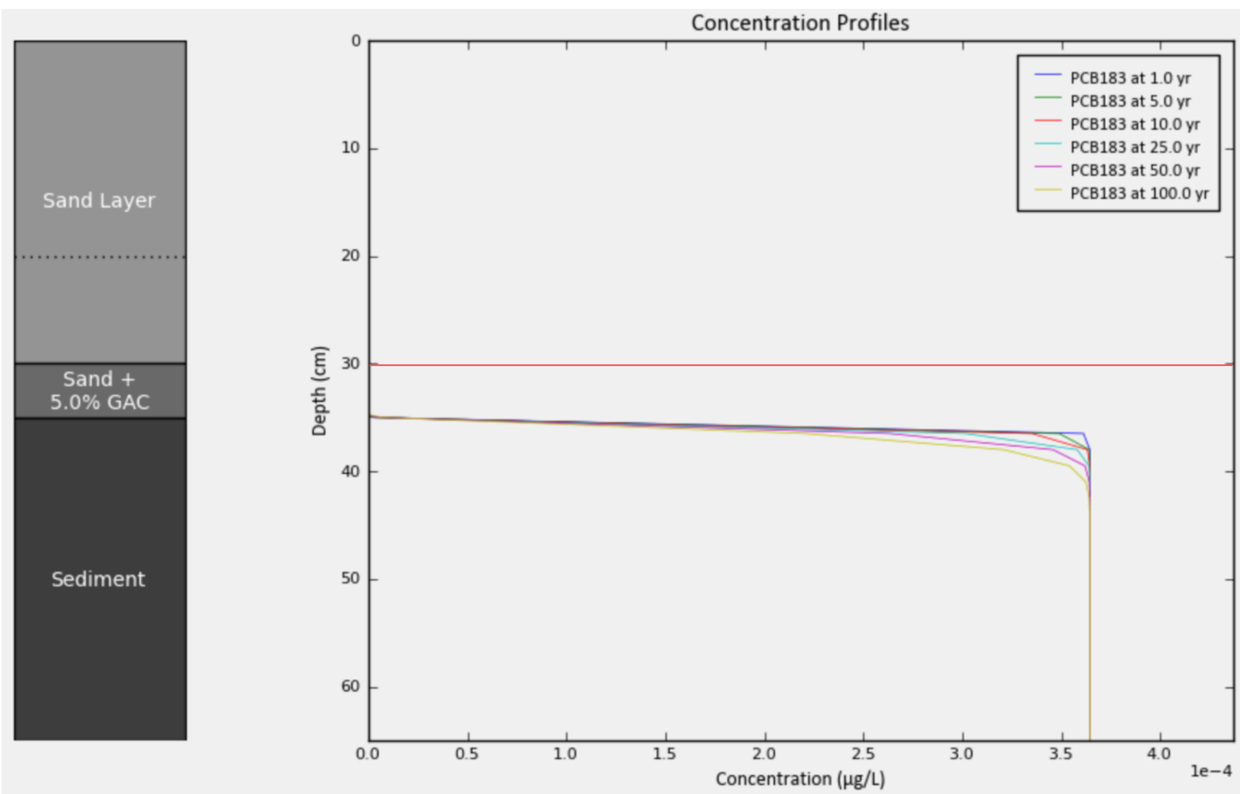


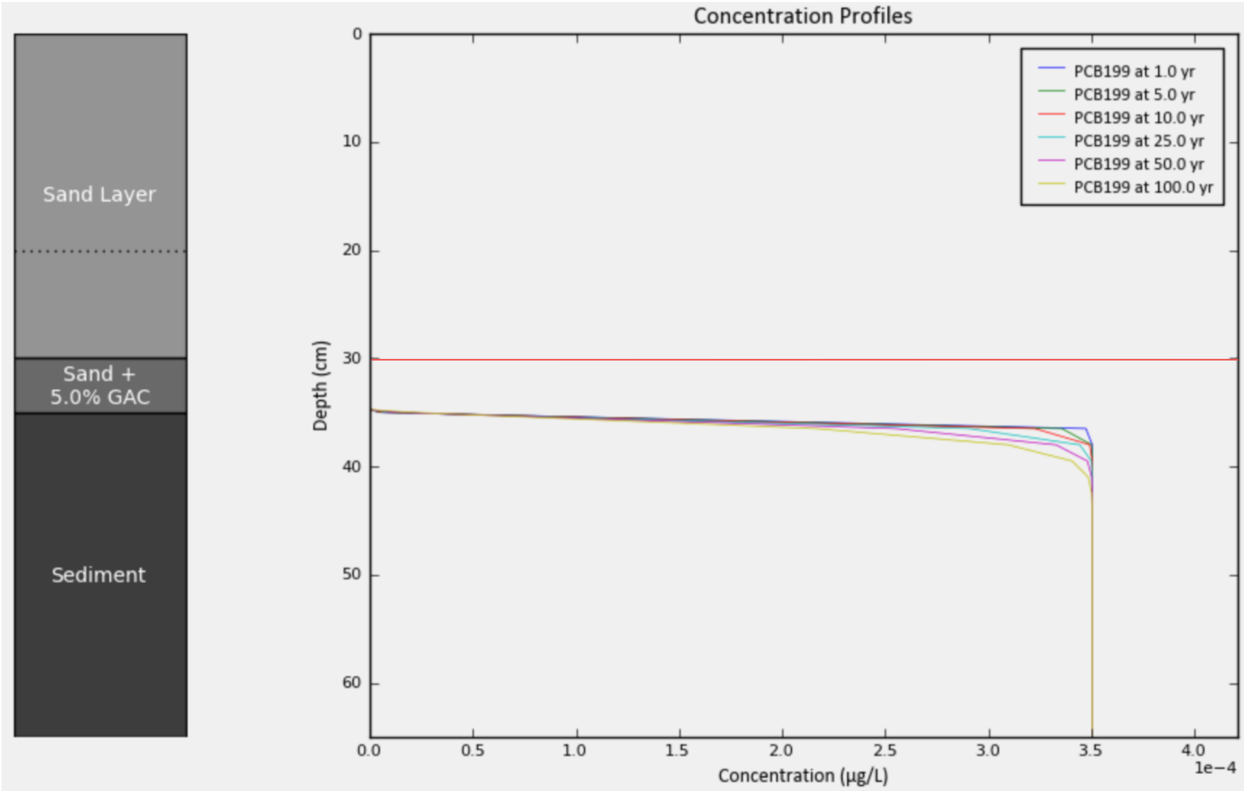
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

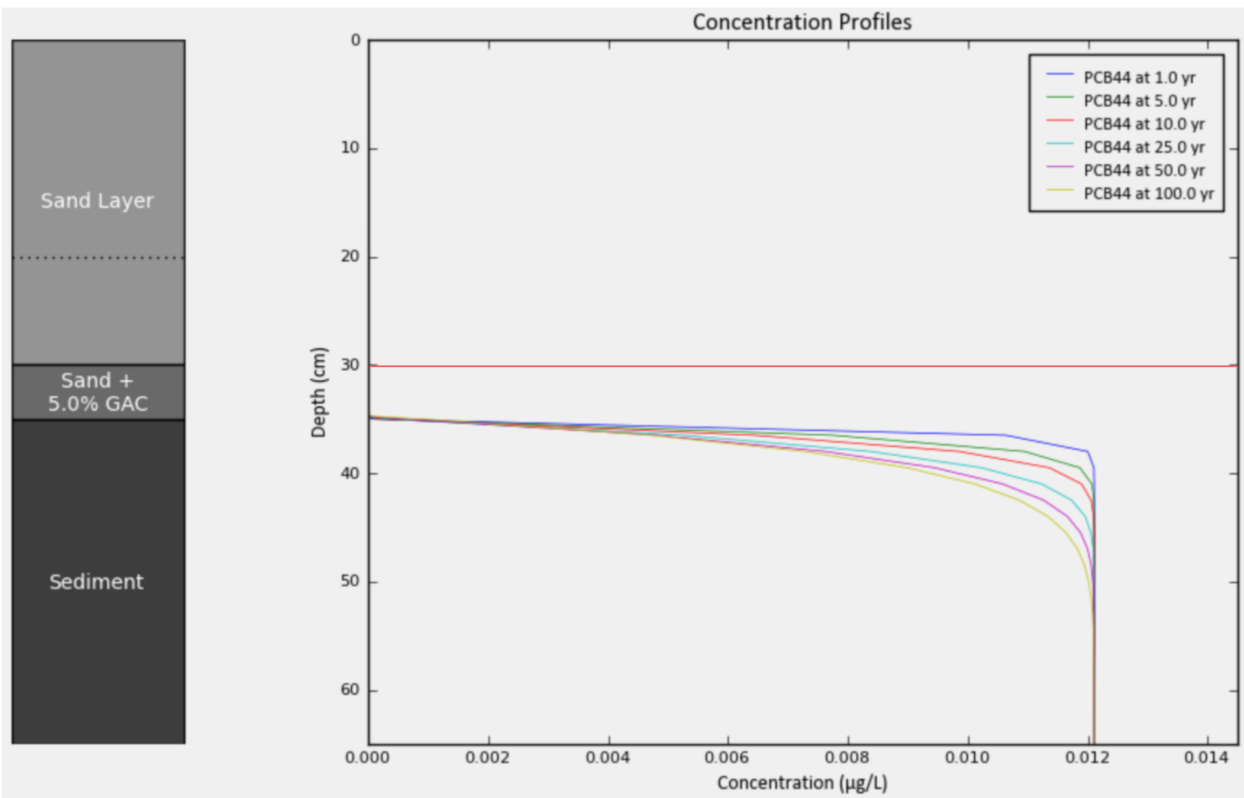


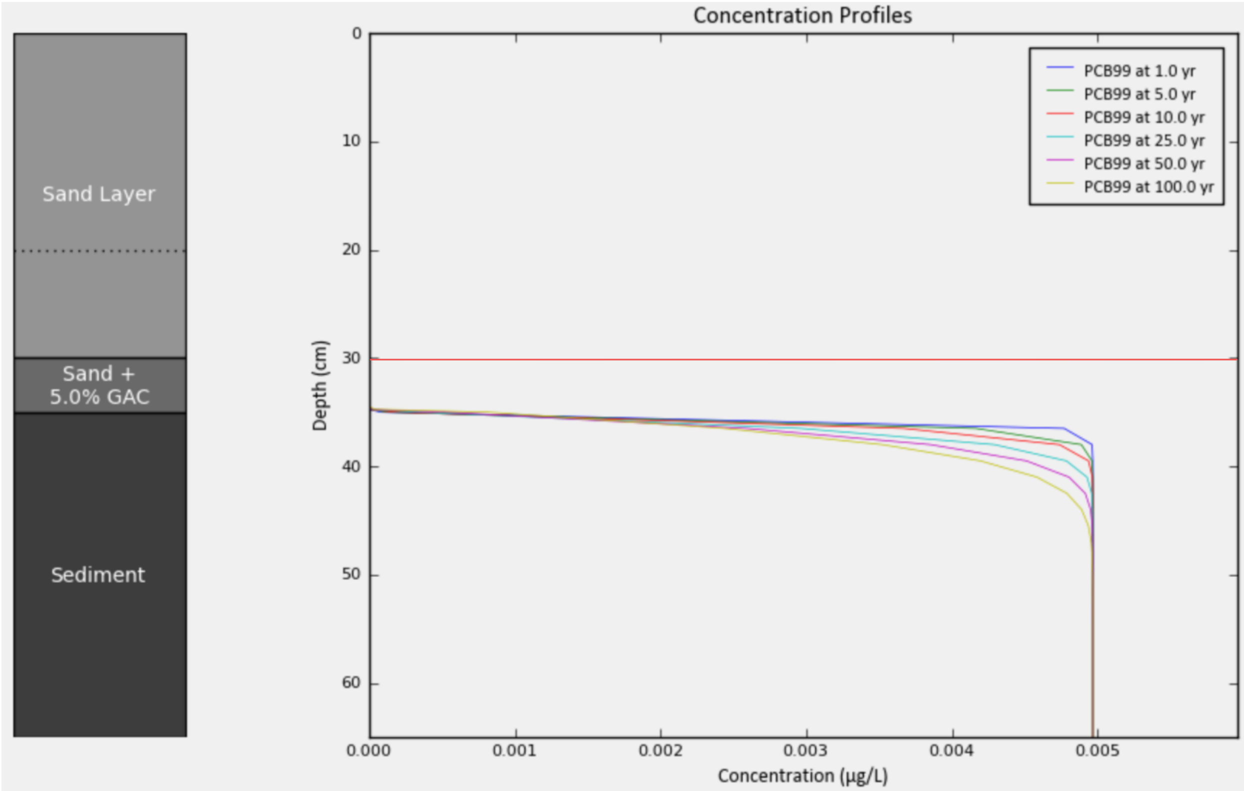
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

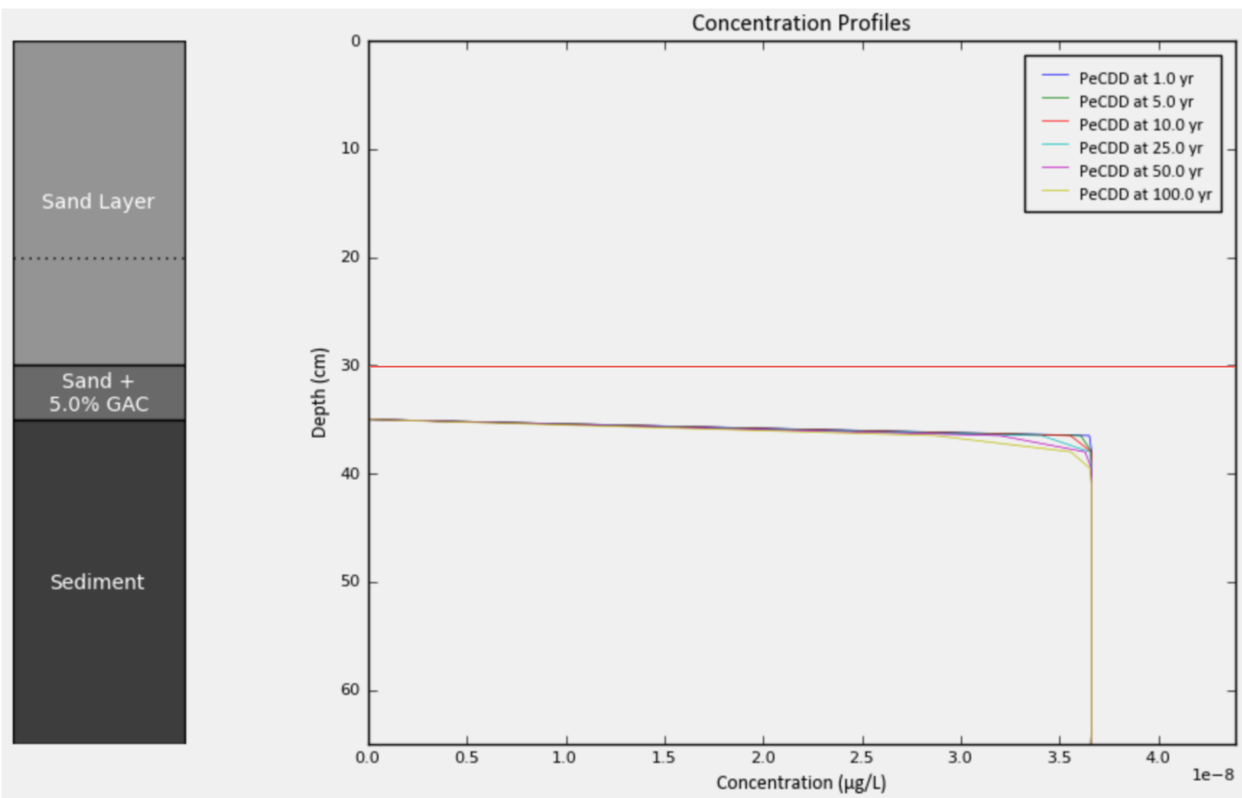

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

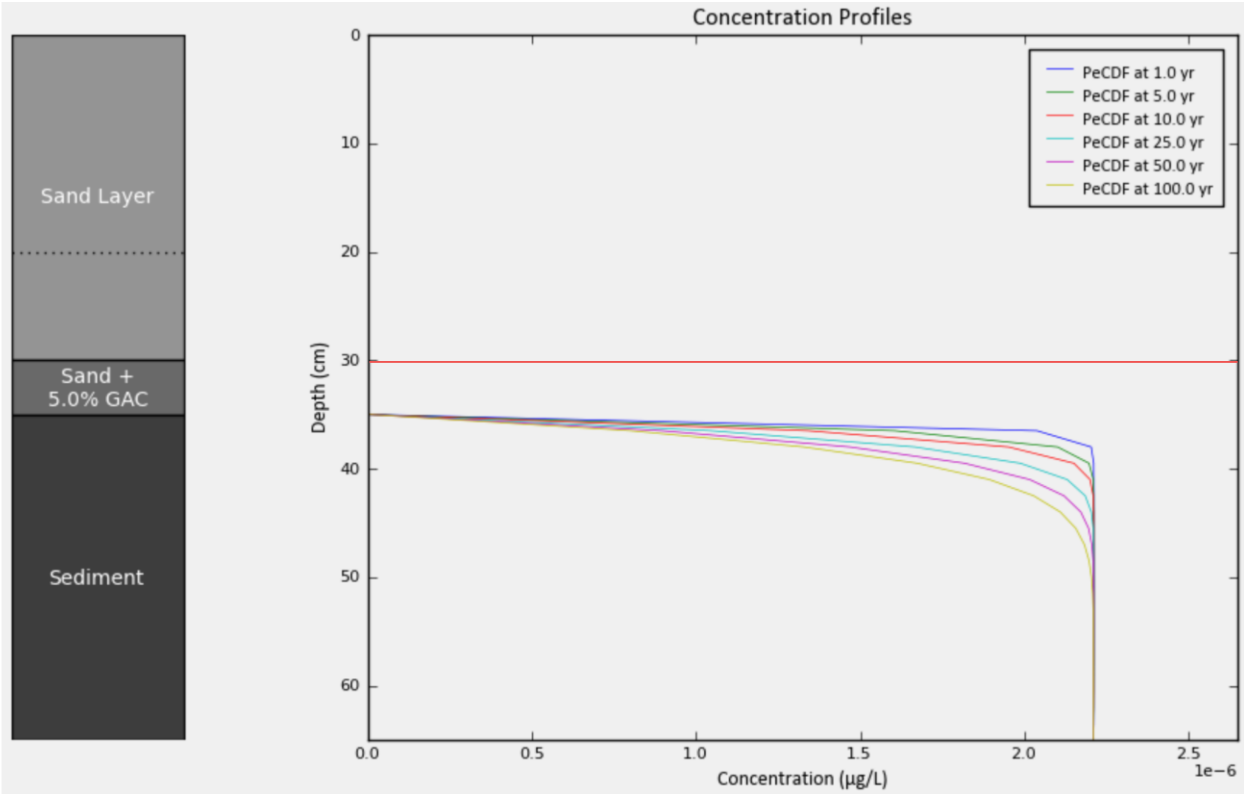

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

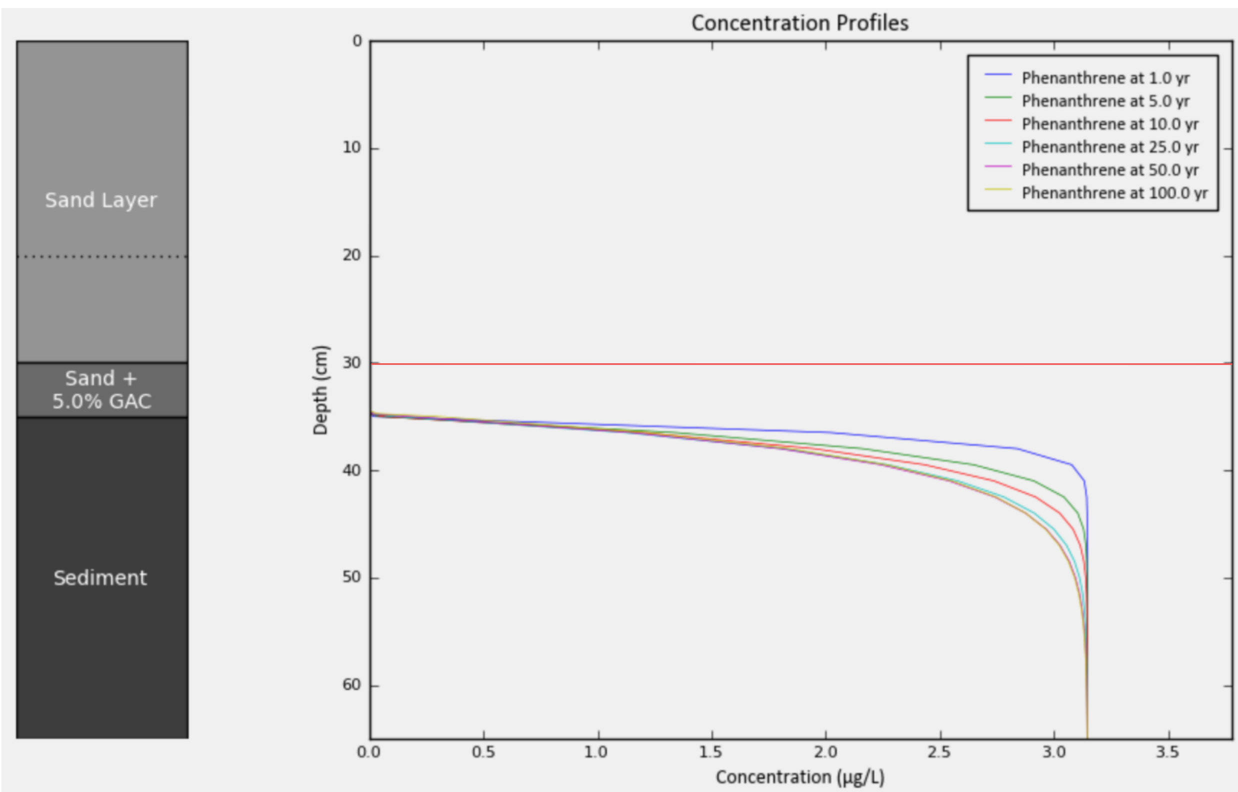

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr

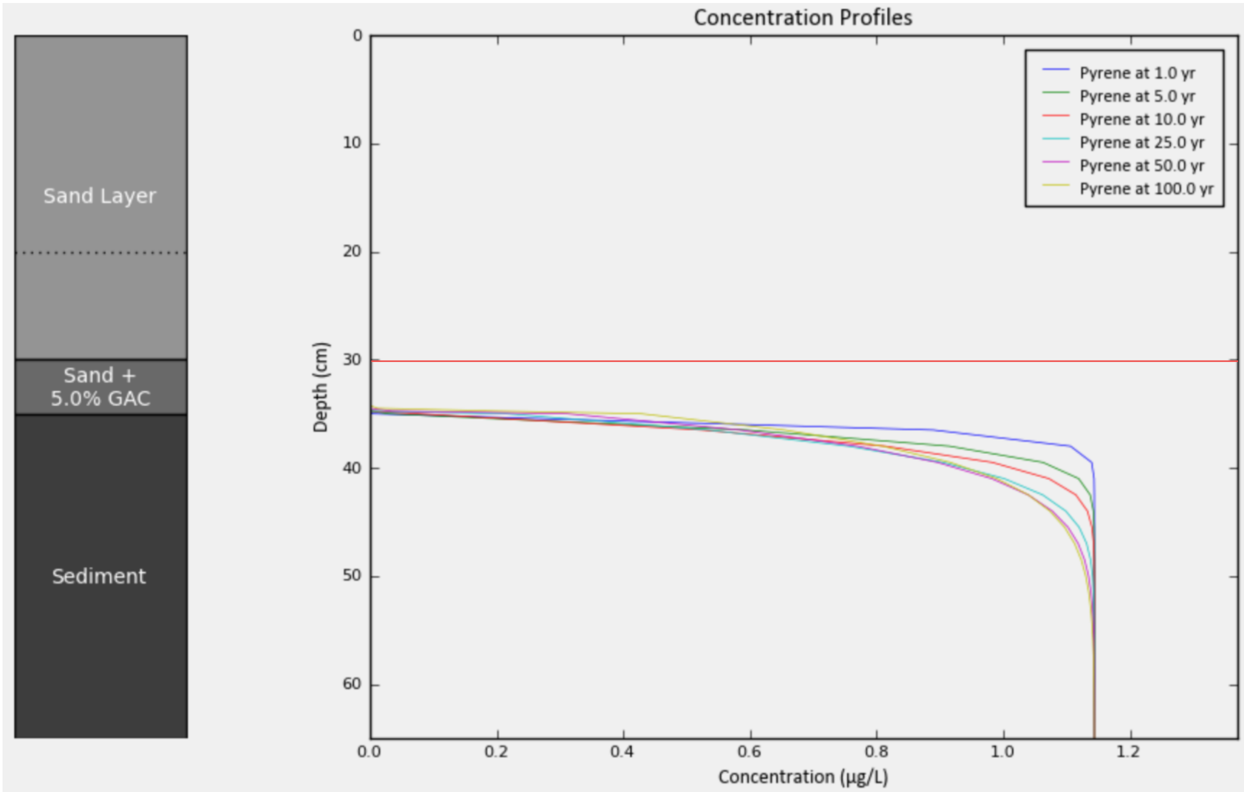

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr

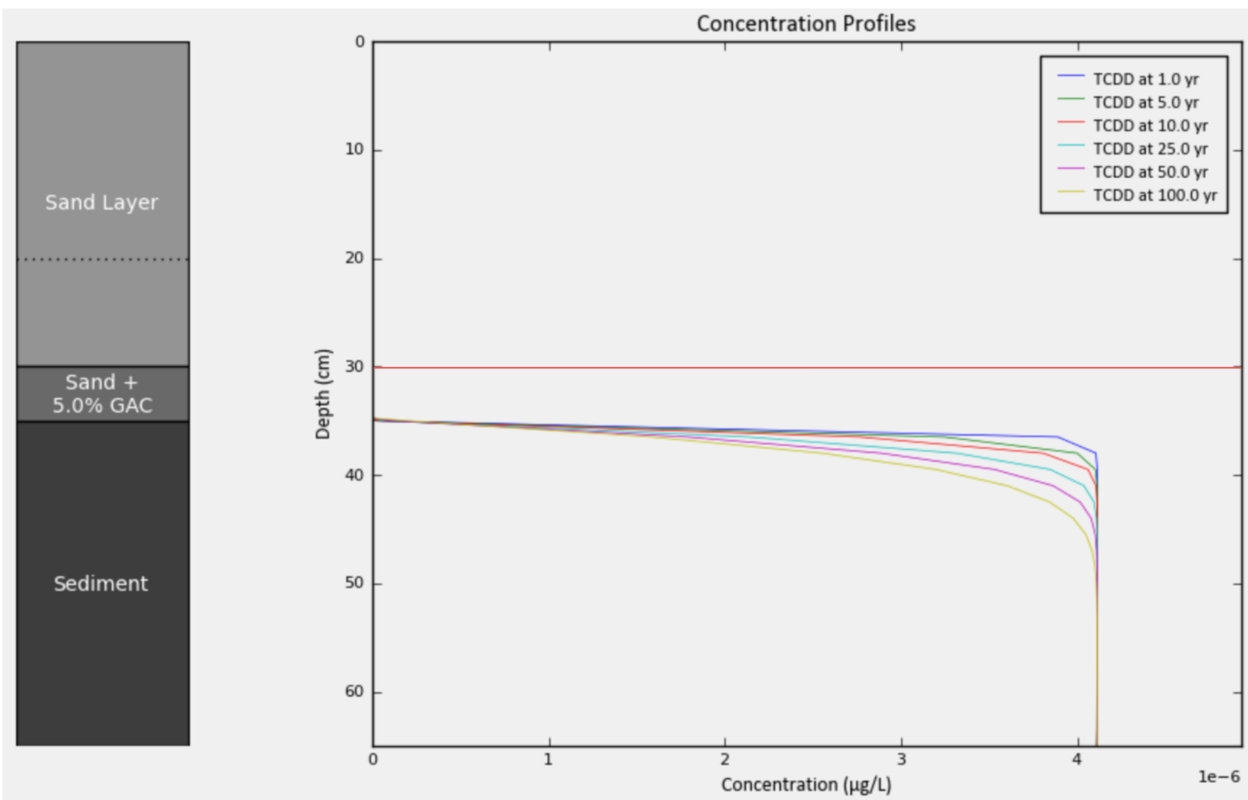

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
0
10
20
30
40
50
60
0.000
0.001
0.002
0.003
0.004
0.005

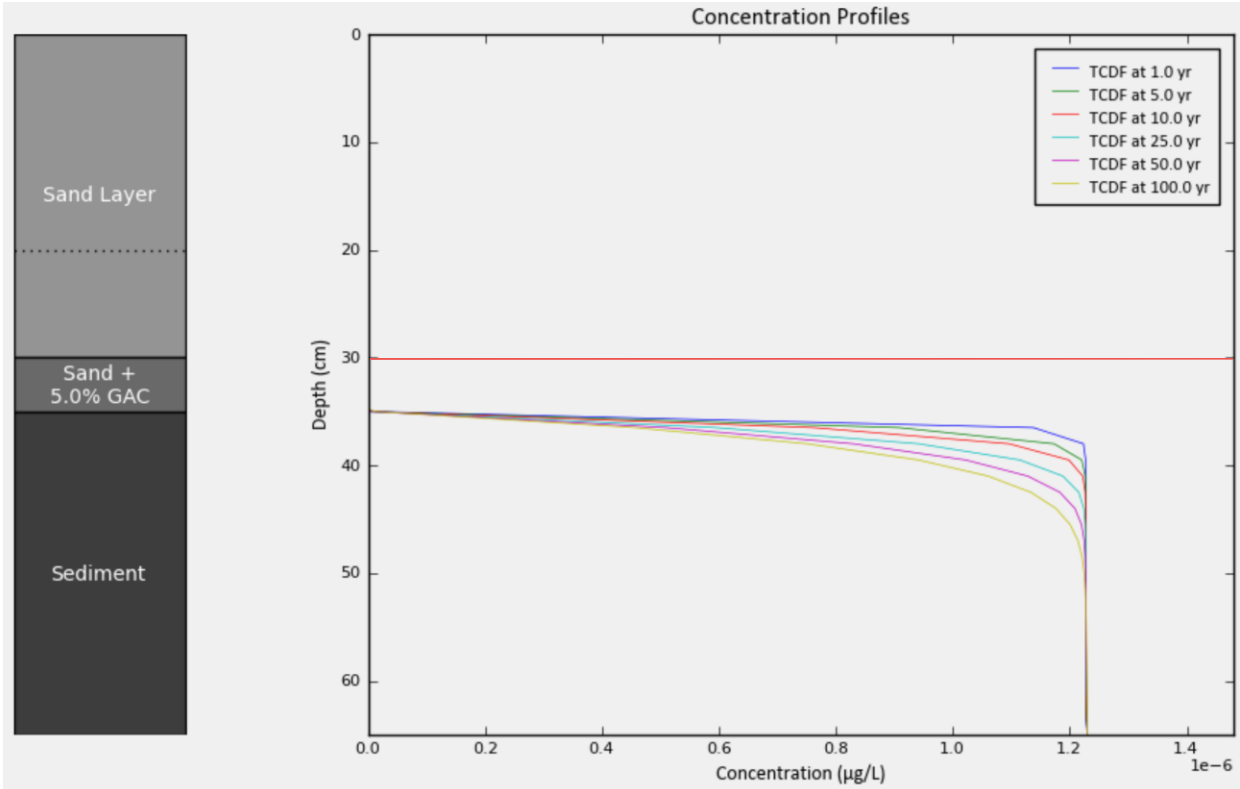

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−8

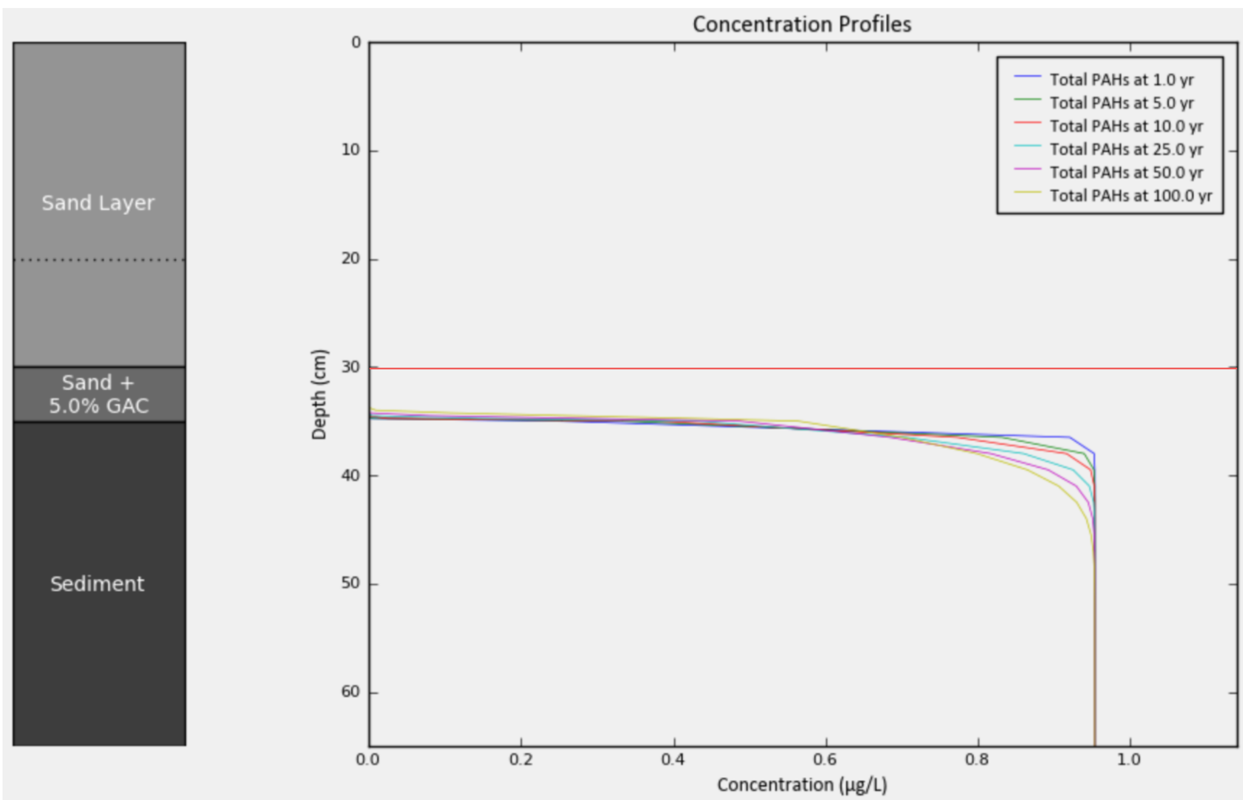

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−6

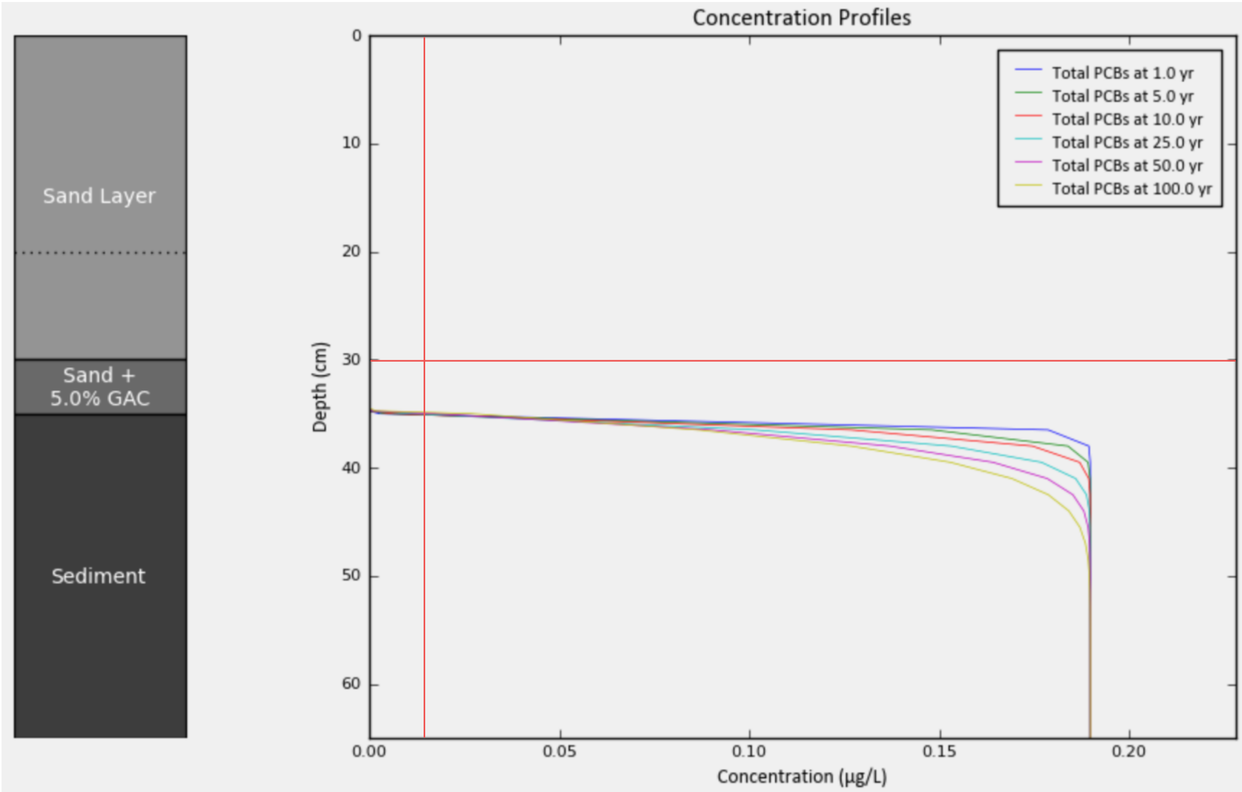

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr
Depth (cm)
Concentration (µg/L)

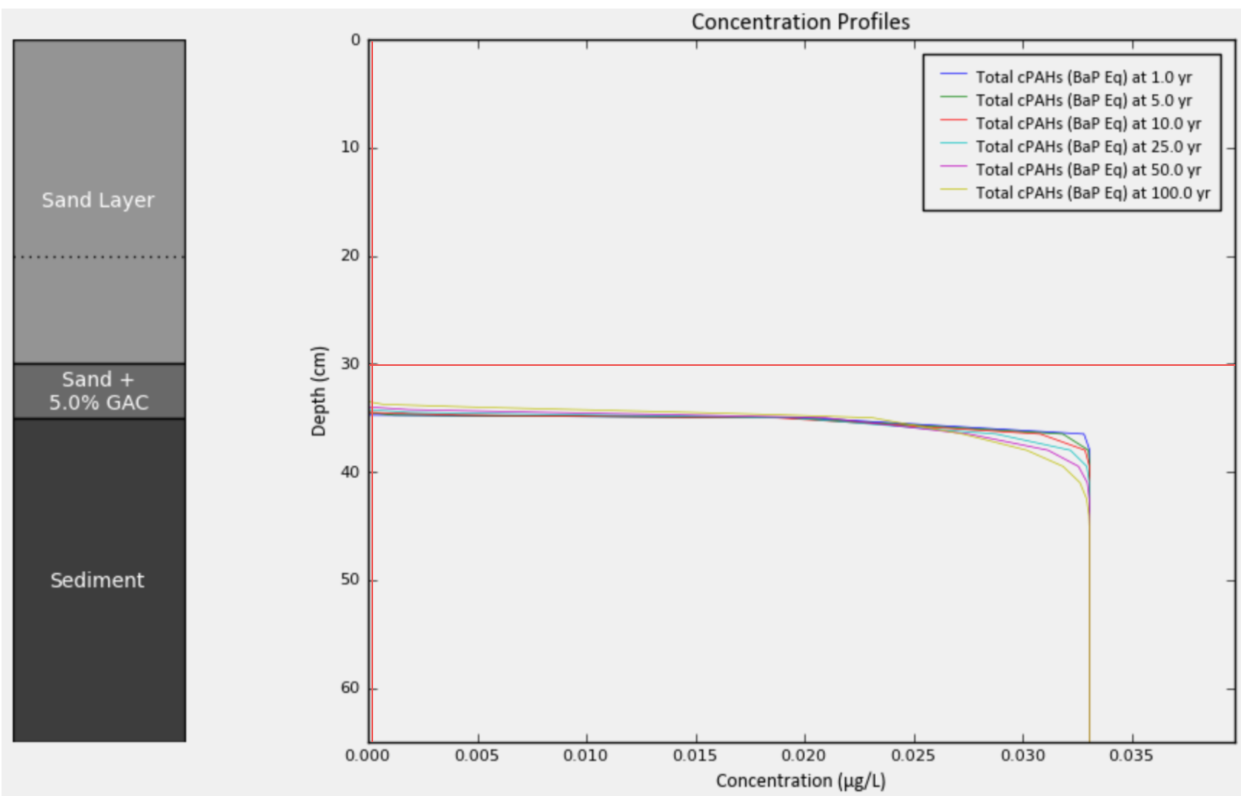

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Concentration (μg/L)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0
1
2
3
4
Concentration (μg/L)
1e−6

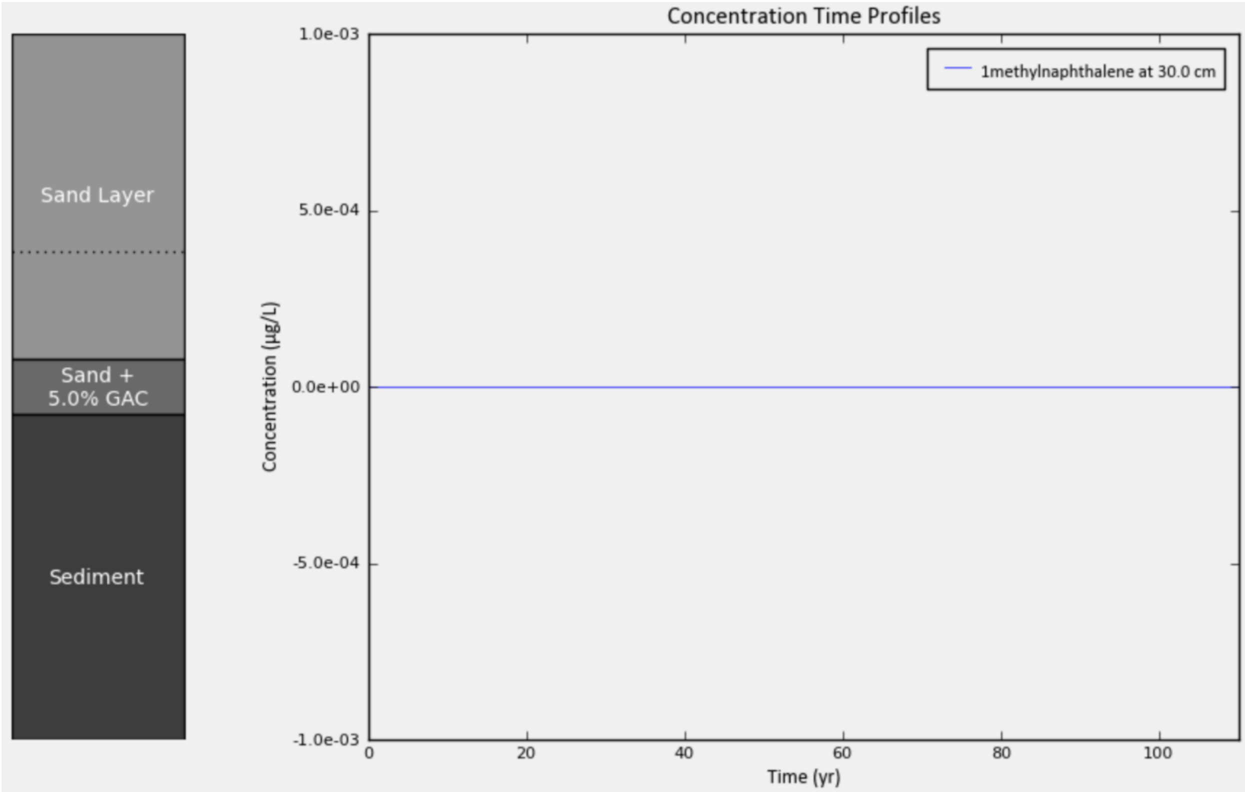

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

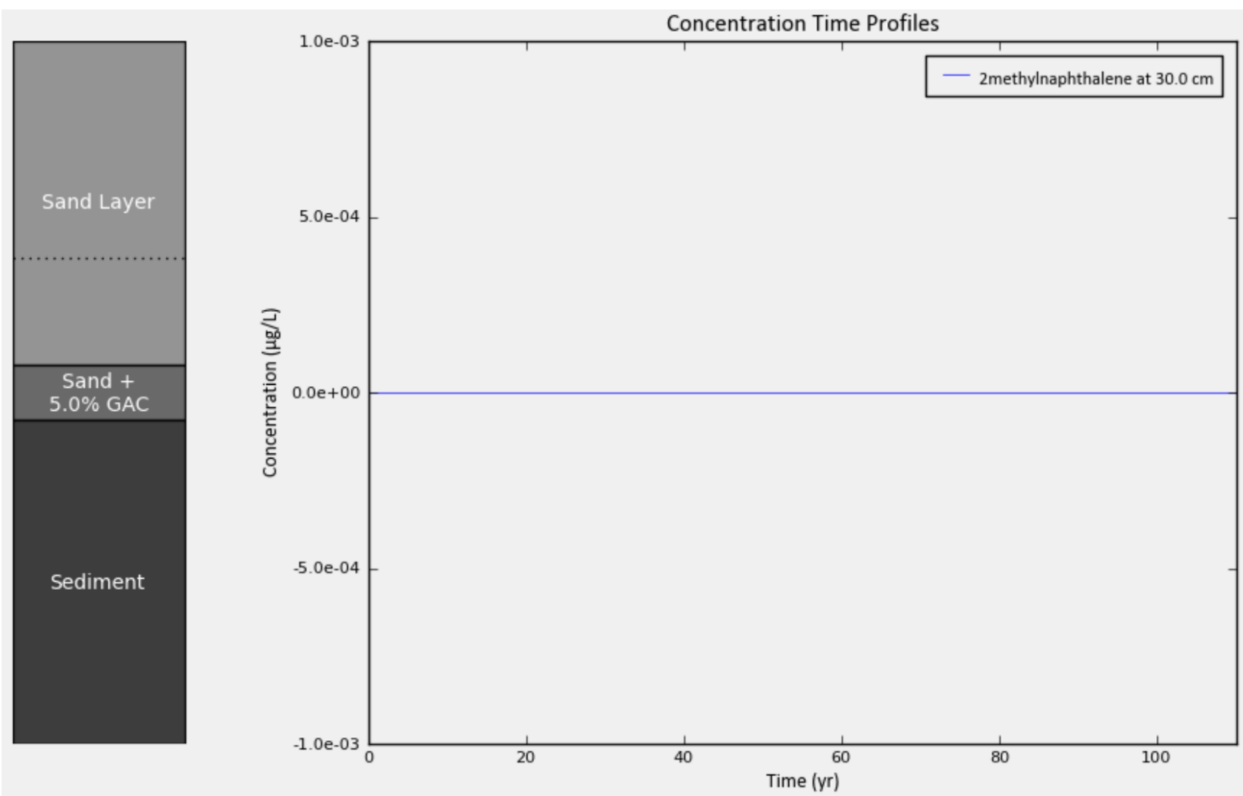

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

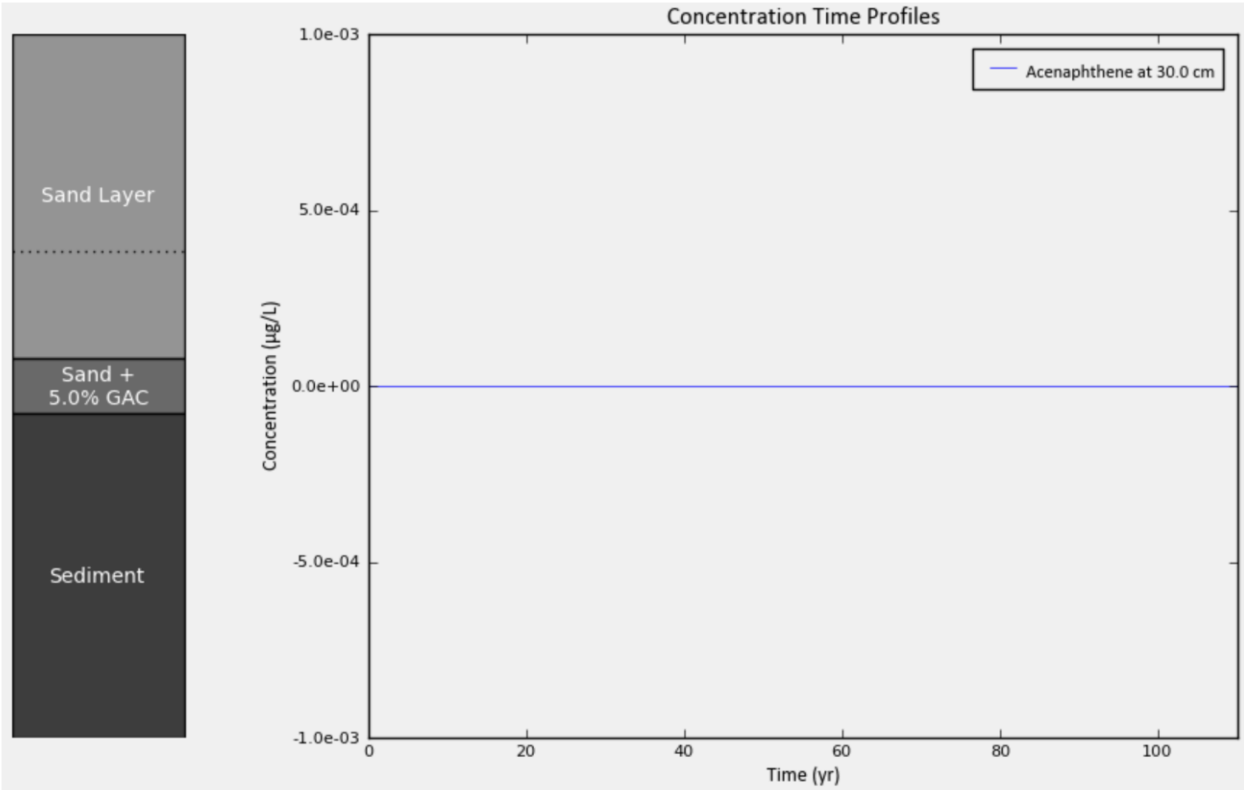

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr
0
10
20
30
40
50
60
0.00
0.05
0.10
0.15
0.20

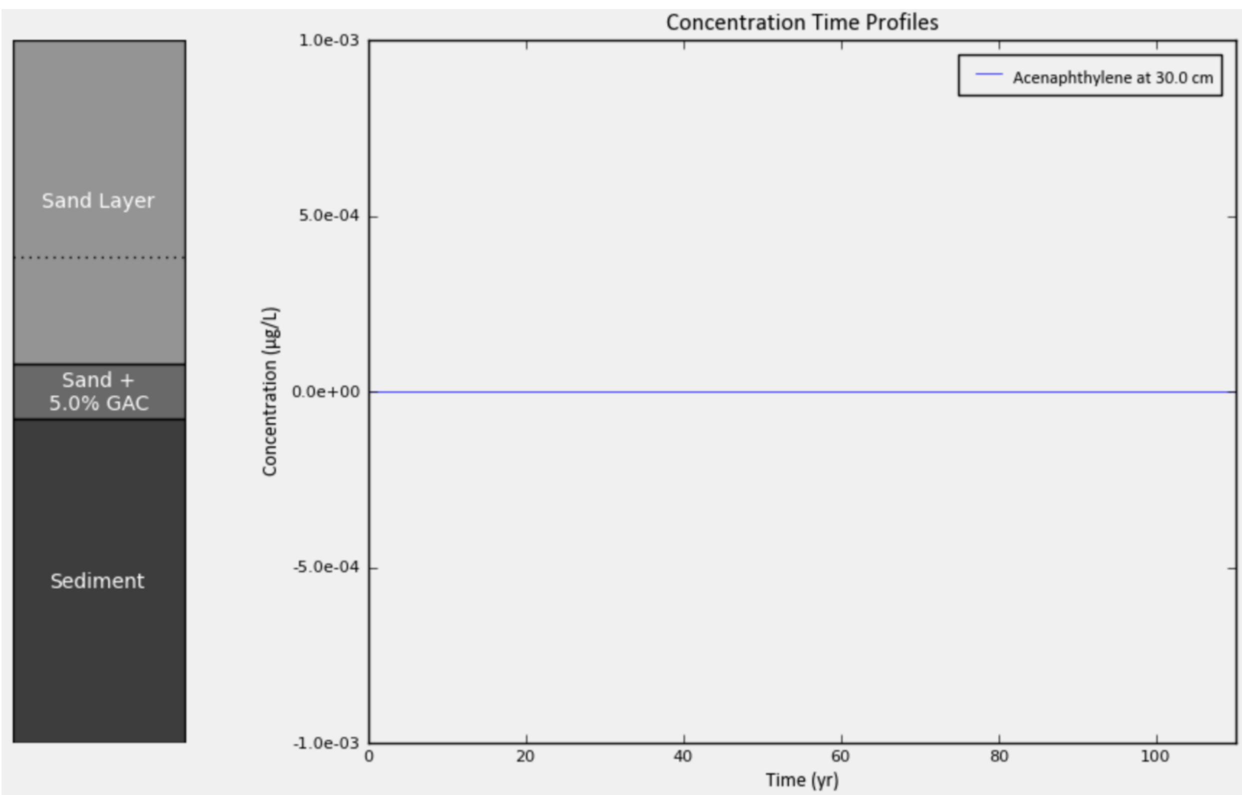

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr
0
10
20
30
40
50
60
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035

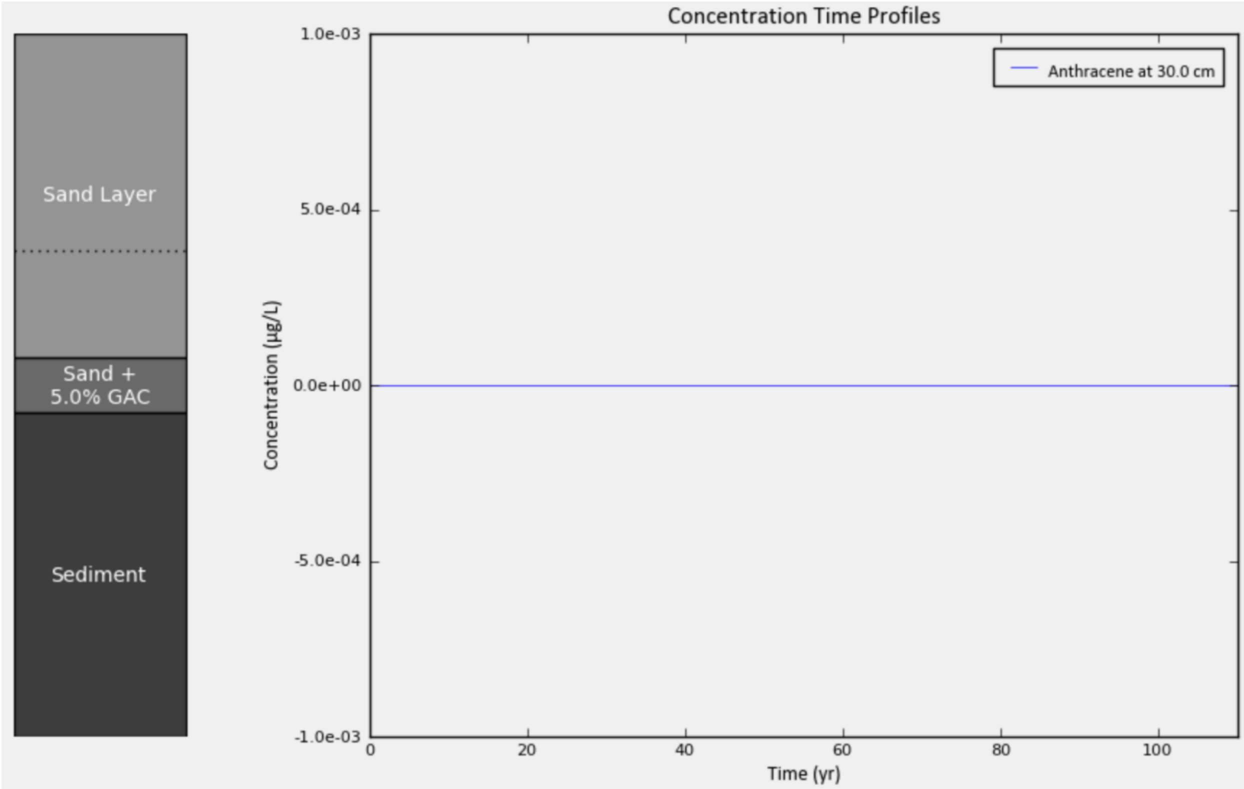
Porewater Concentration – Time

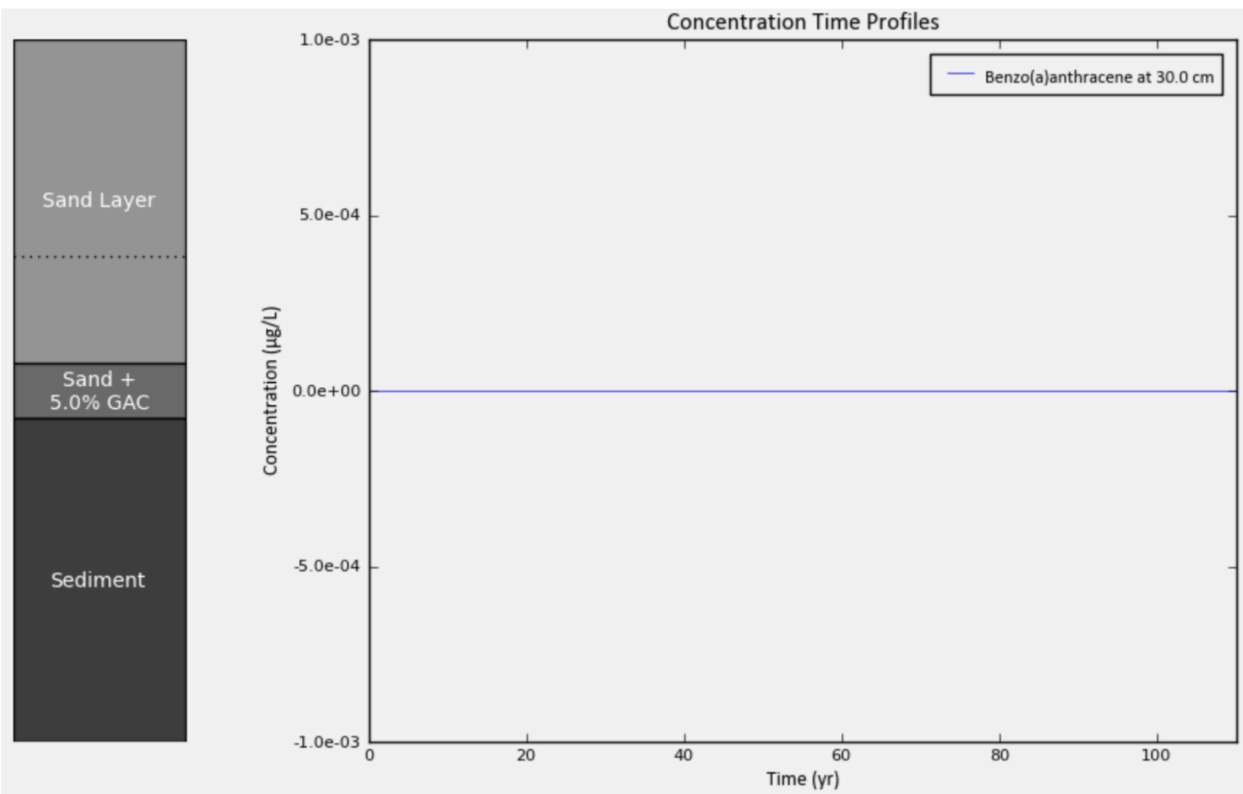


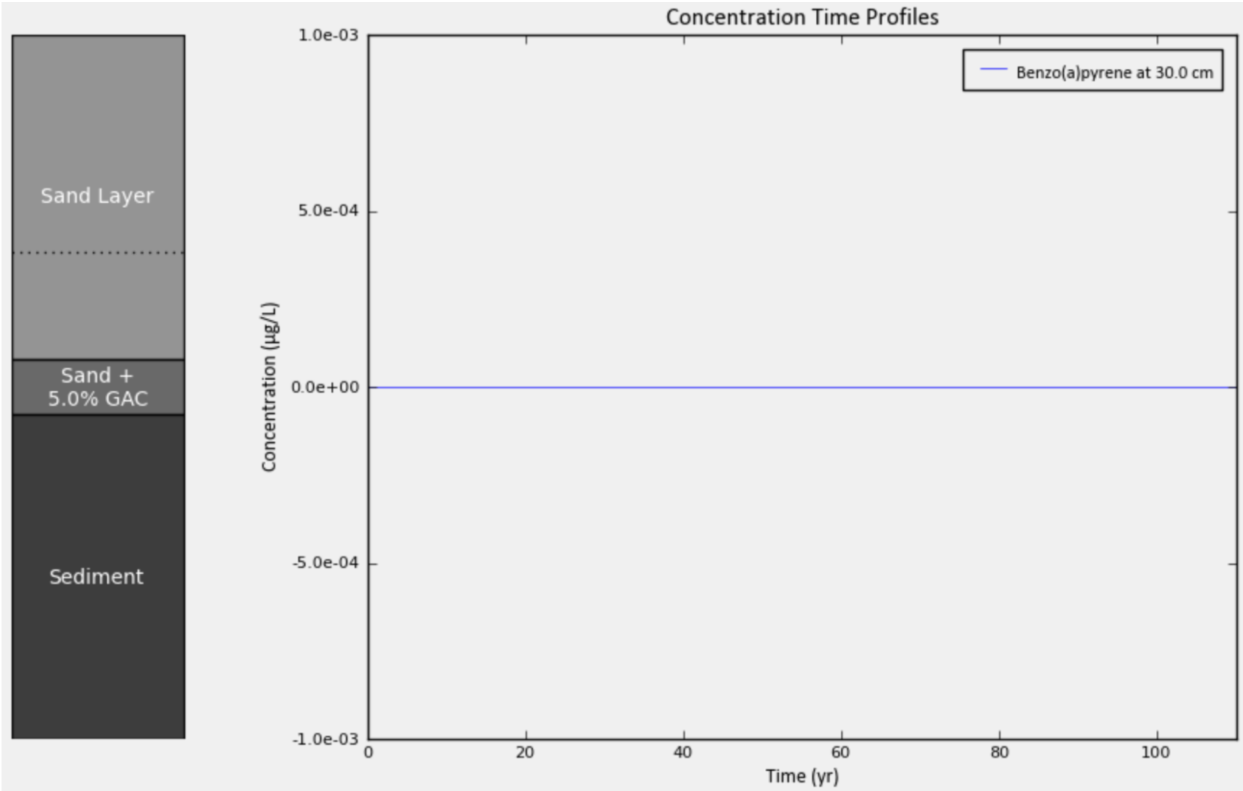


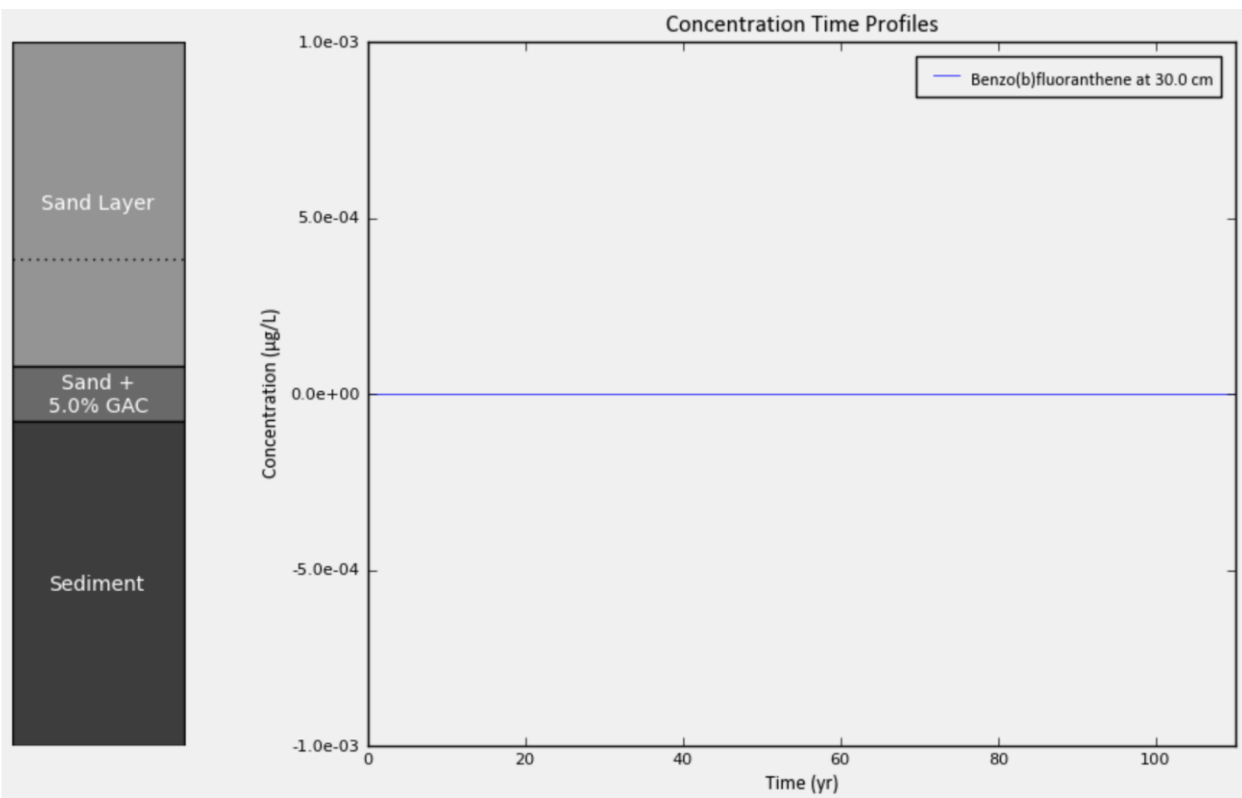

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

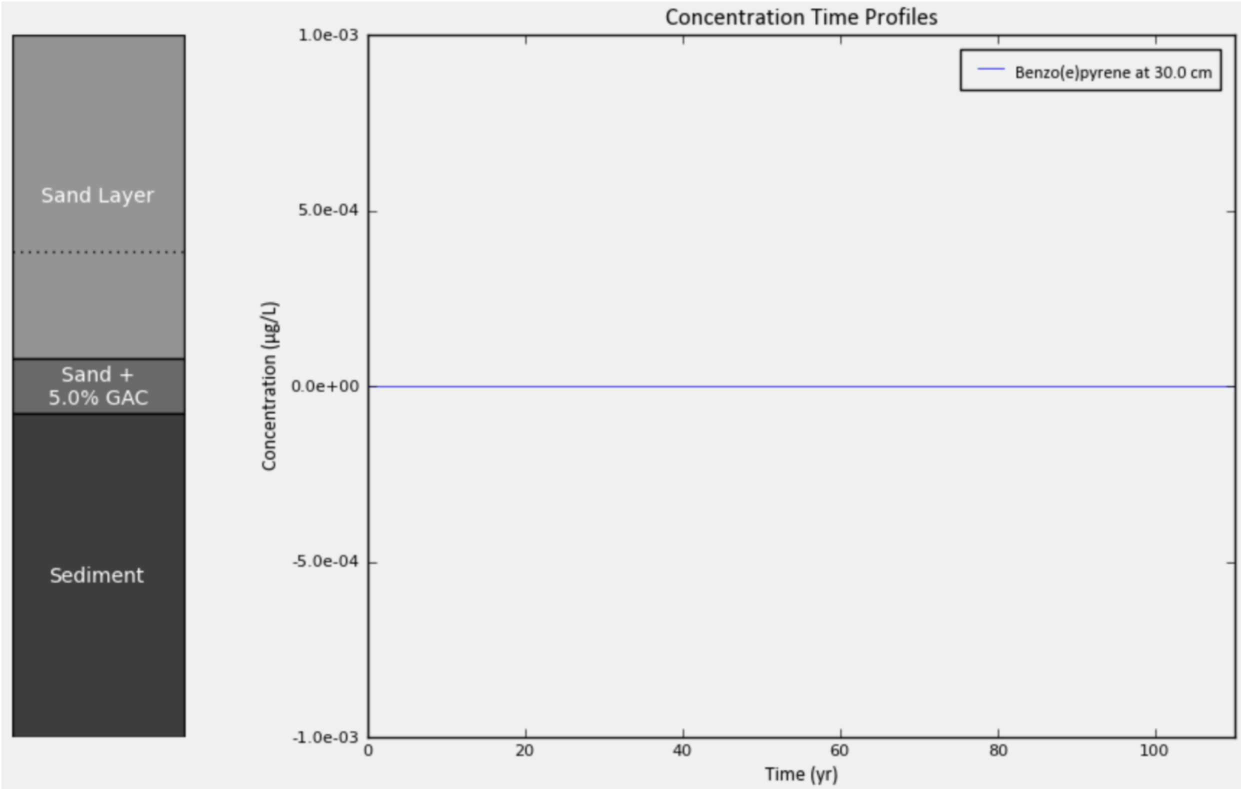

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthylene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Anthracene at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

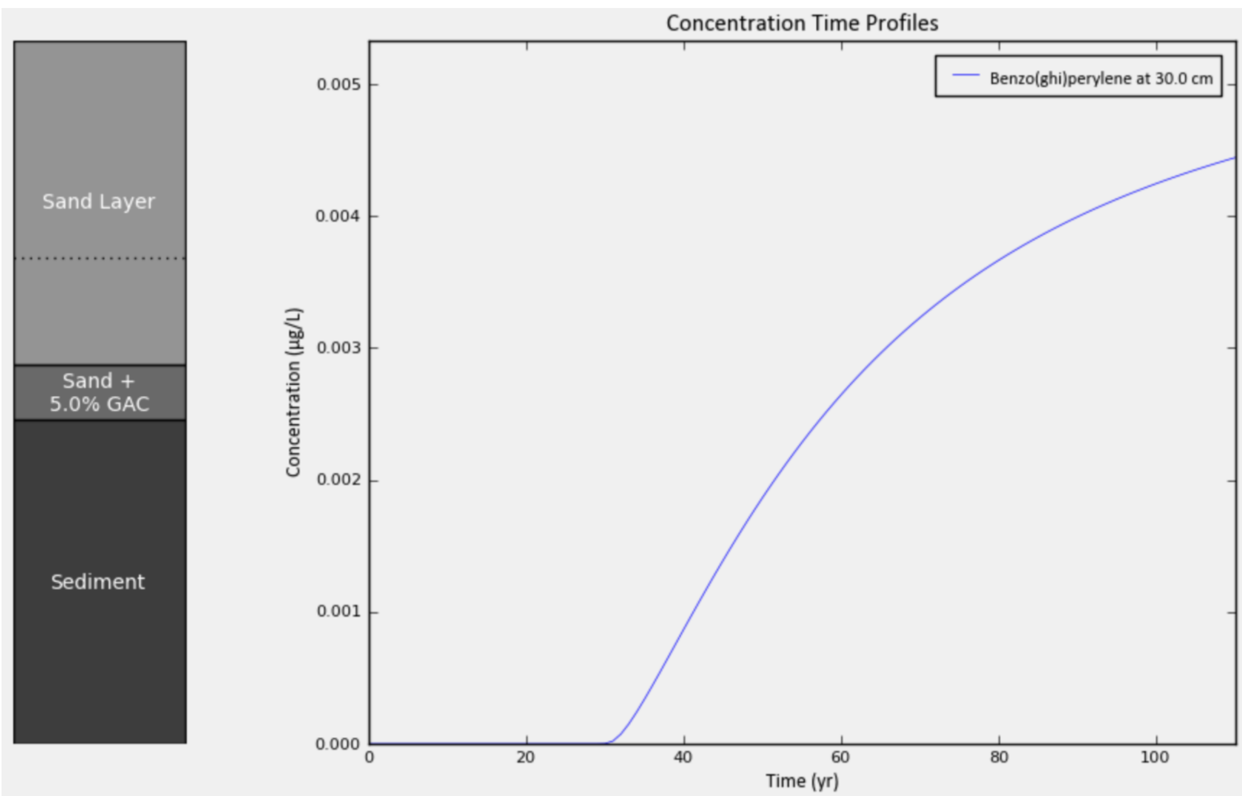

Concentration Time Profiles
Benzo(a)anthracene at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(a)pyrene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

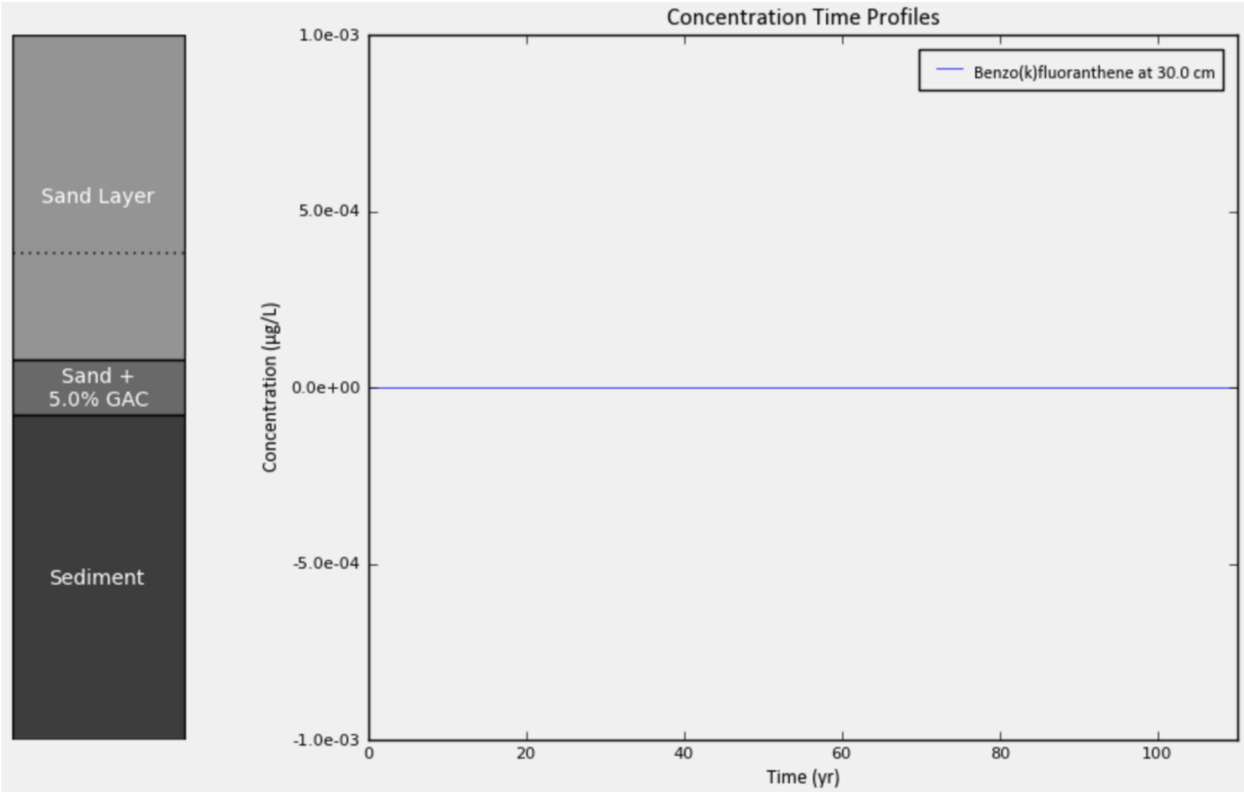

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(b)fluoranthene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

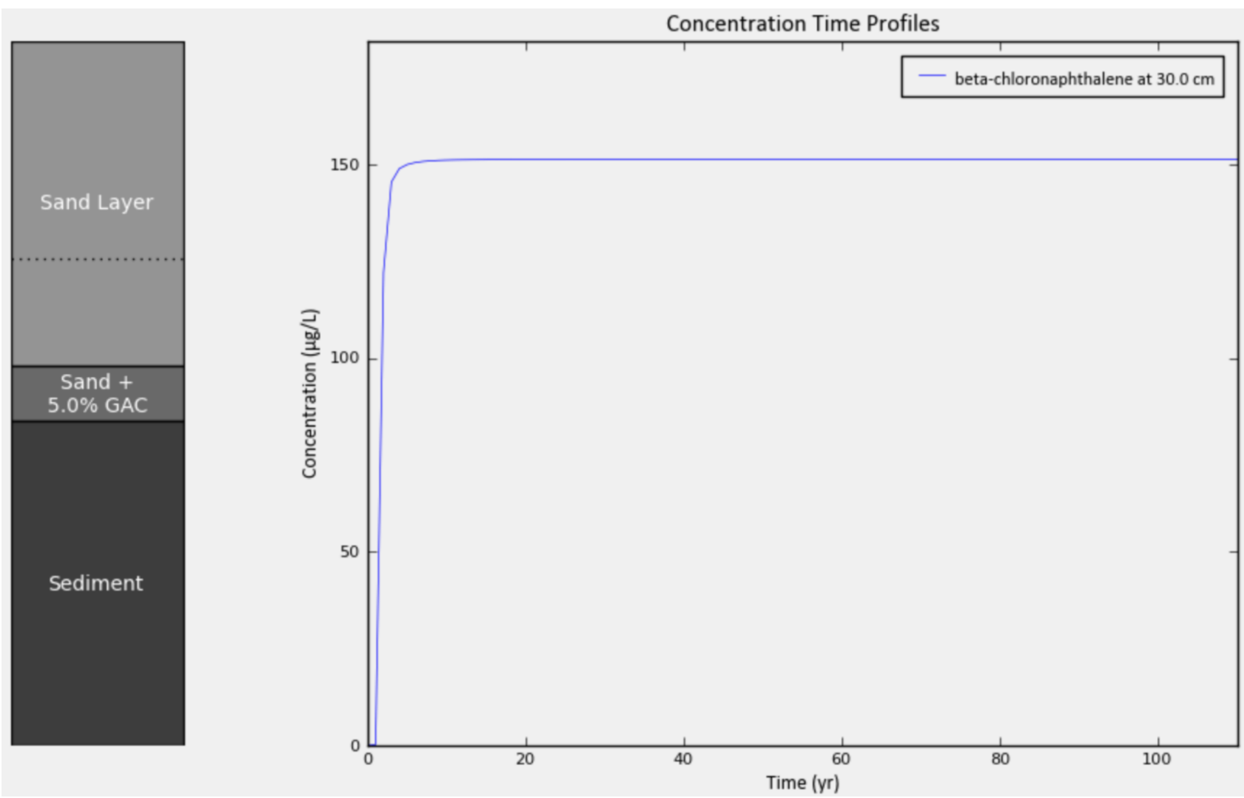


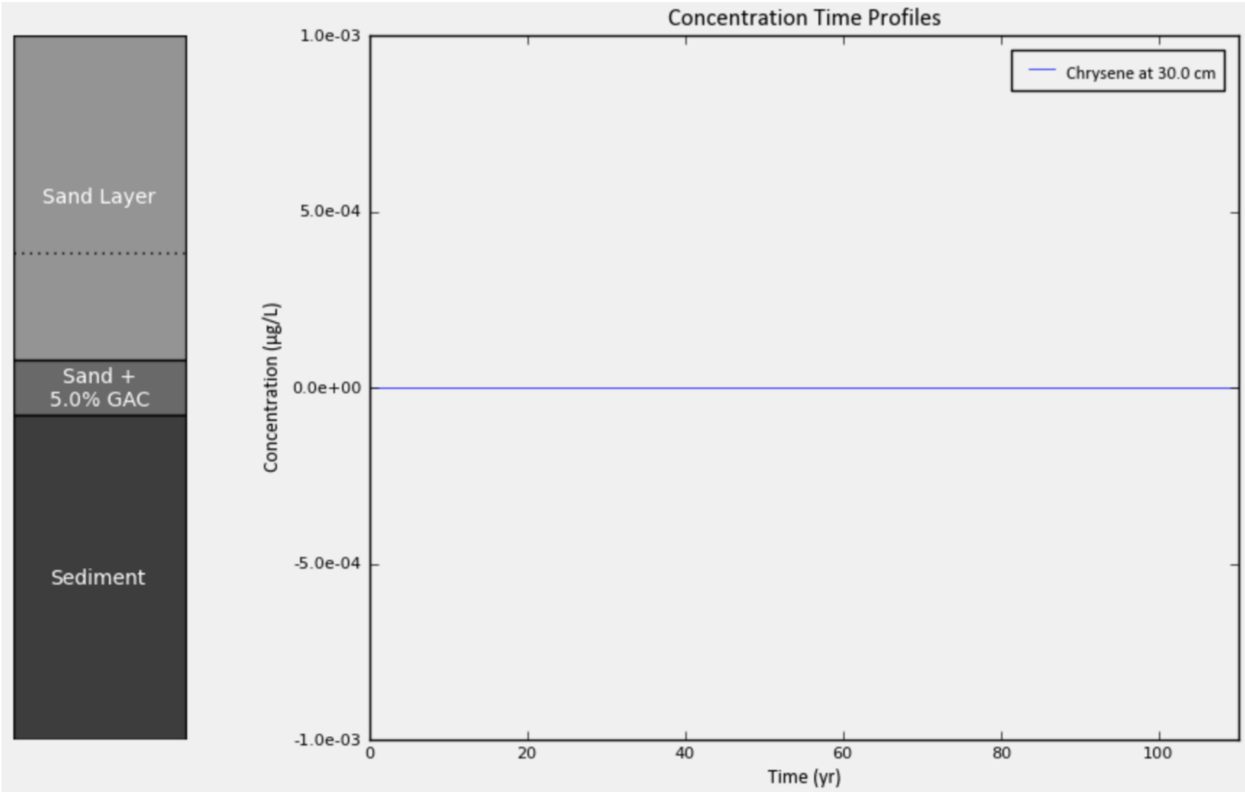
Concentration Time Profiles
Benzo(e)pyrene at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)



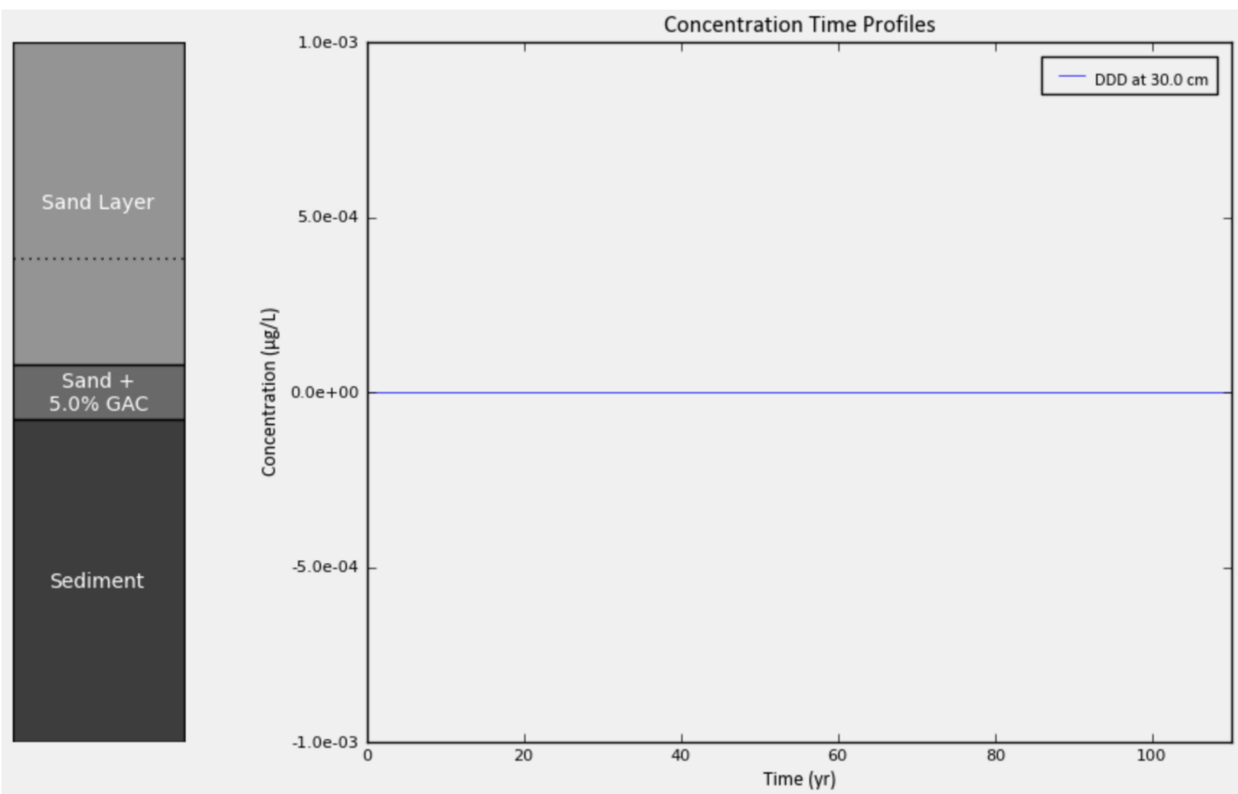
Concentration Time Profiles
Benzo(ghi)perylene at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
0.005
0.004
0.003
0.002
0.001
0.000
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 30.0 cm
Concentration (µg/L)
Time (yr)

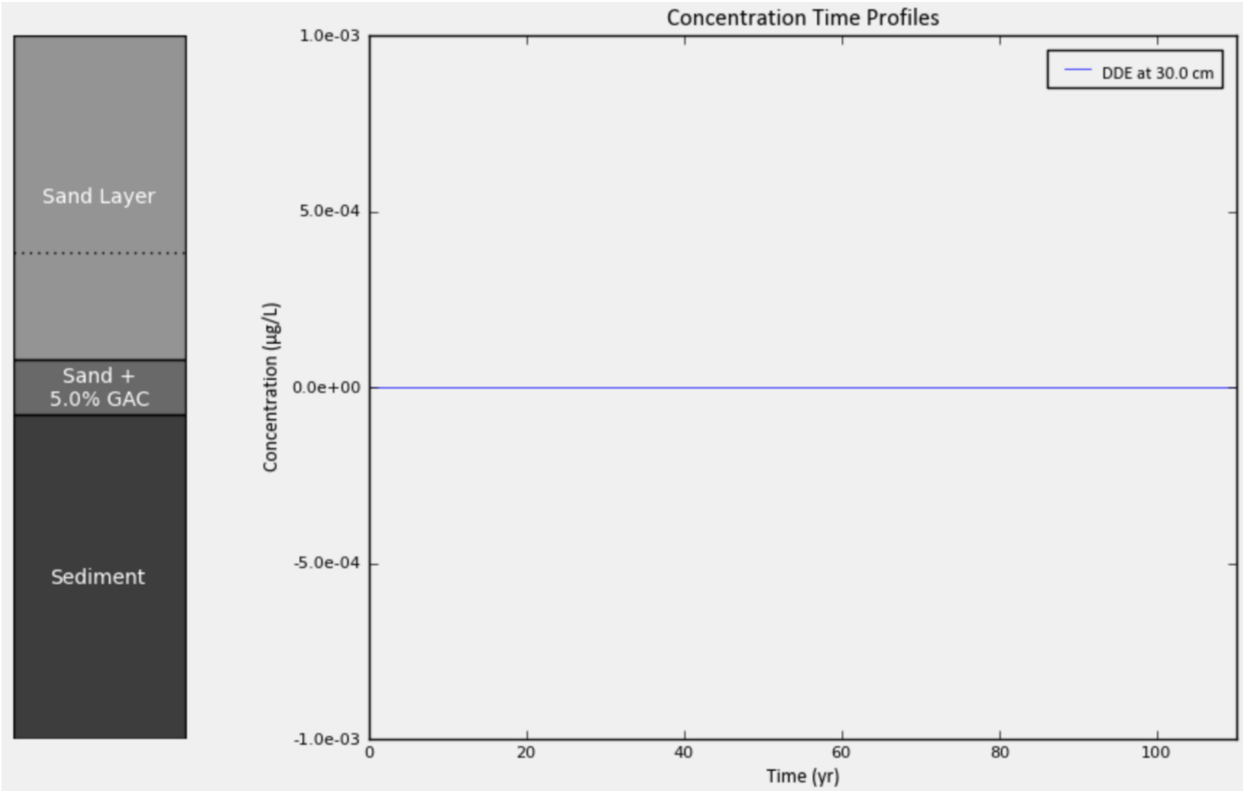

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 30.0 cm
Concentration (µg/L)
Time (yr)

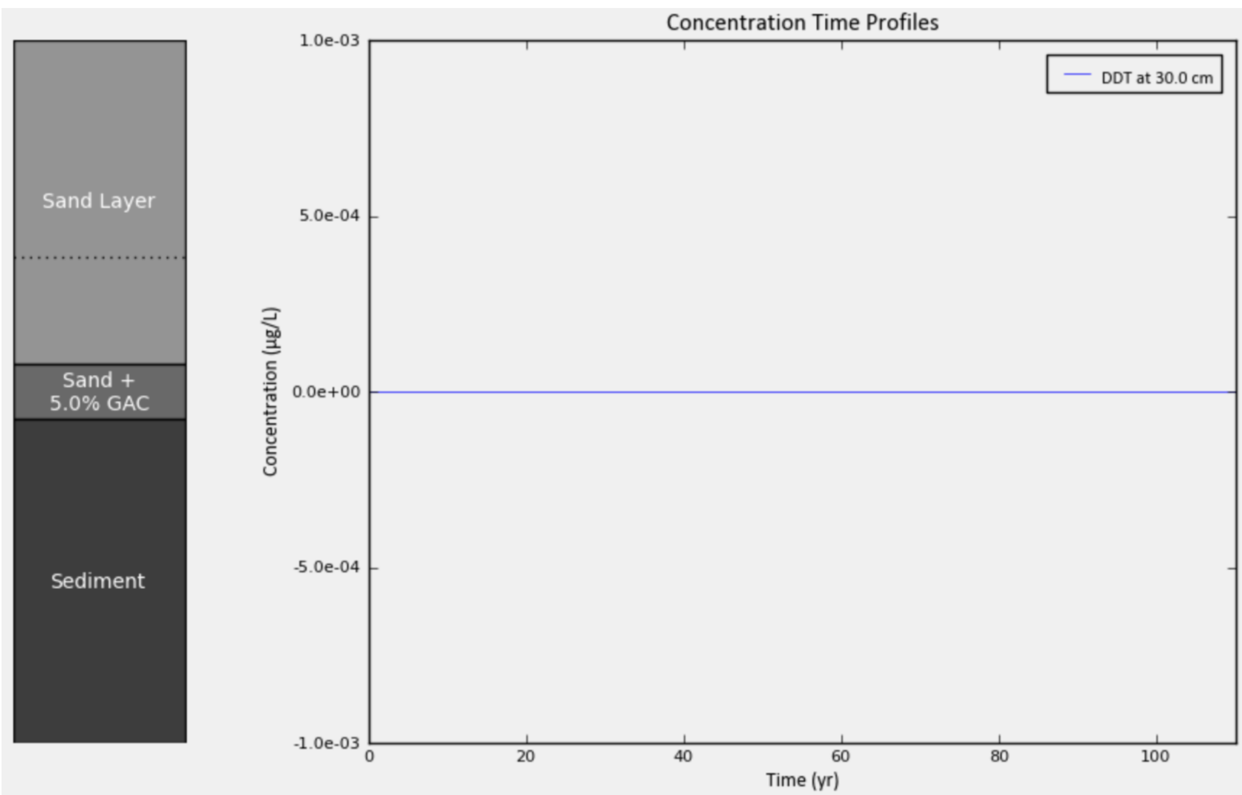


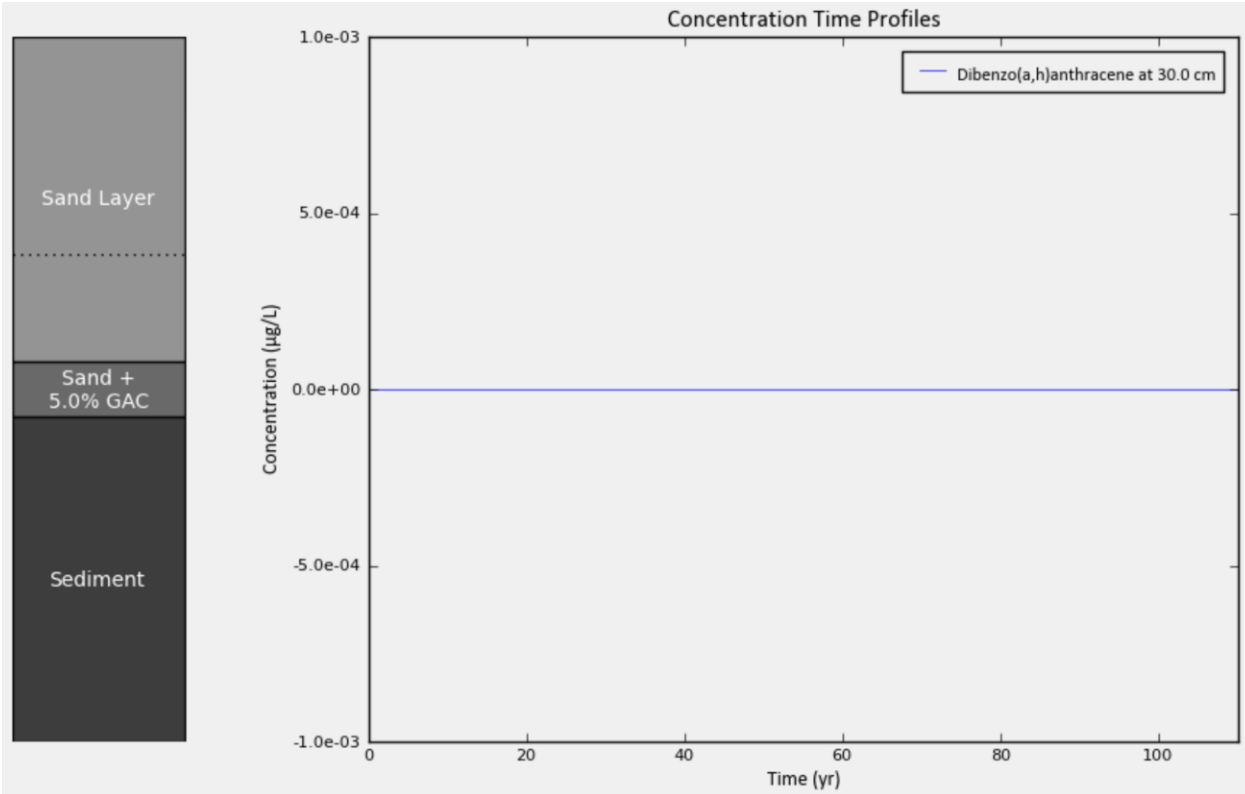
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Chrysene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

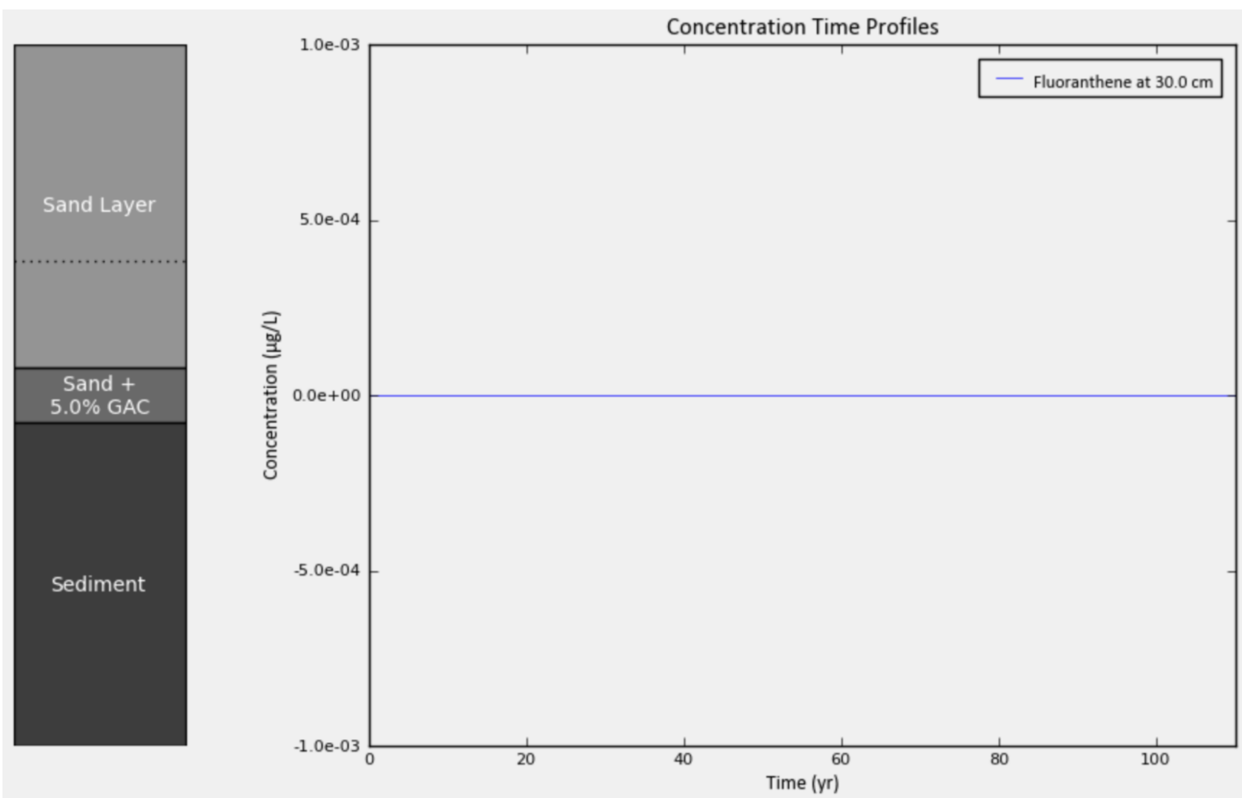


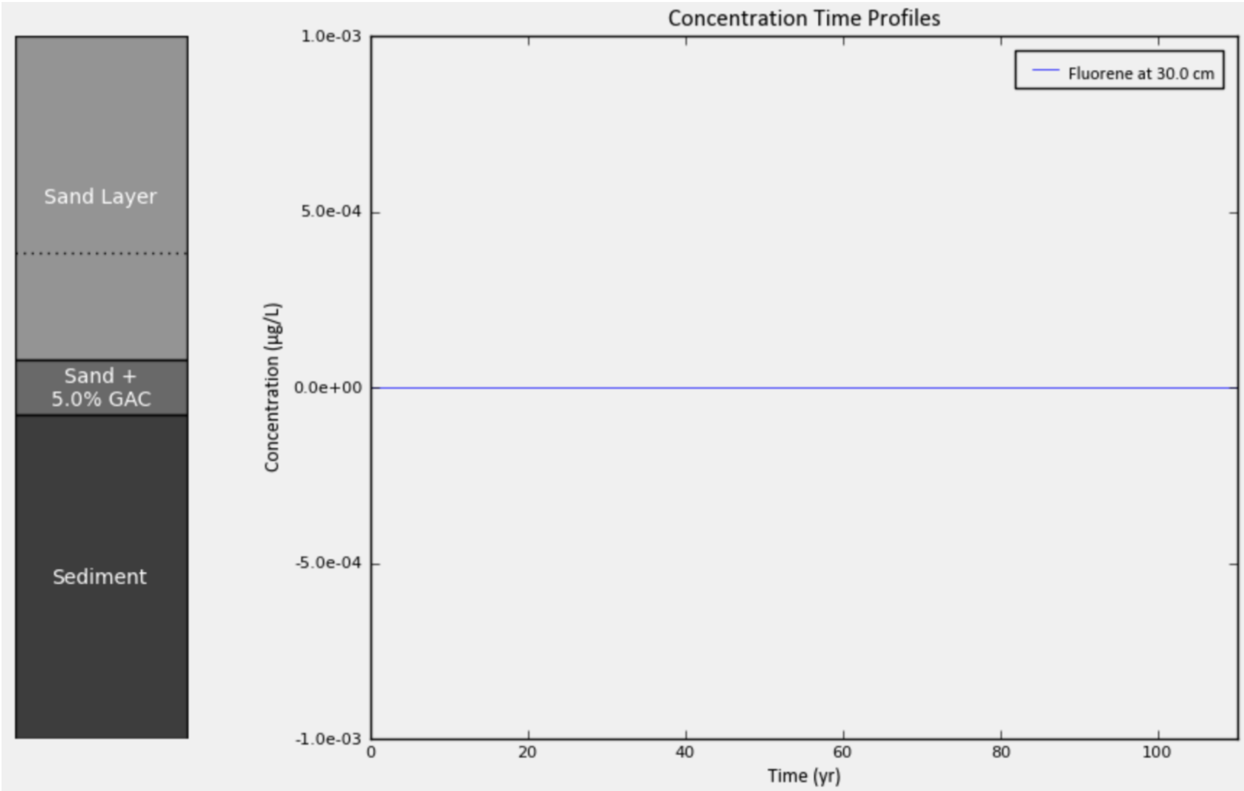
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDD at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

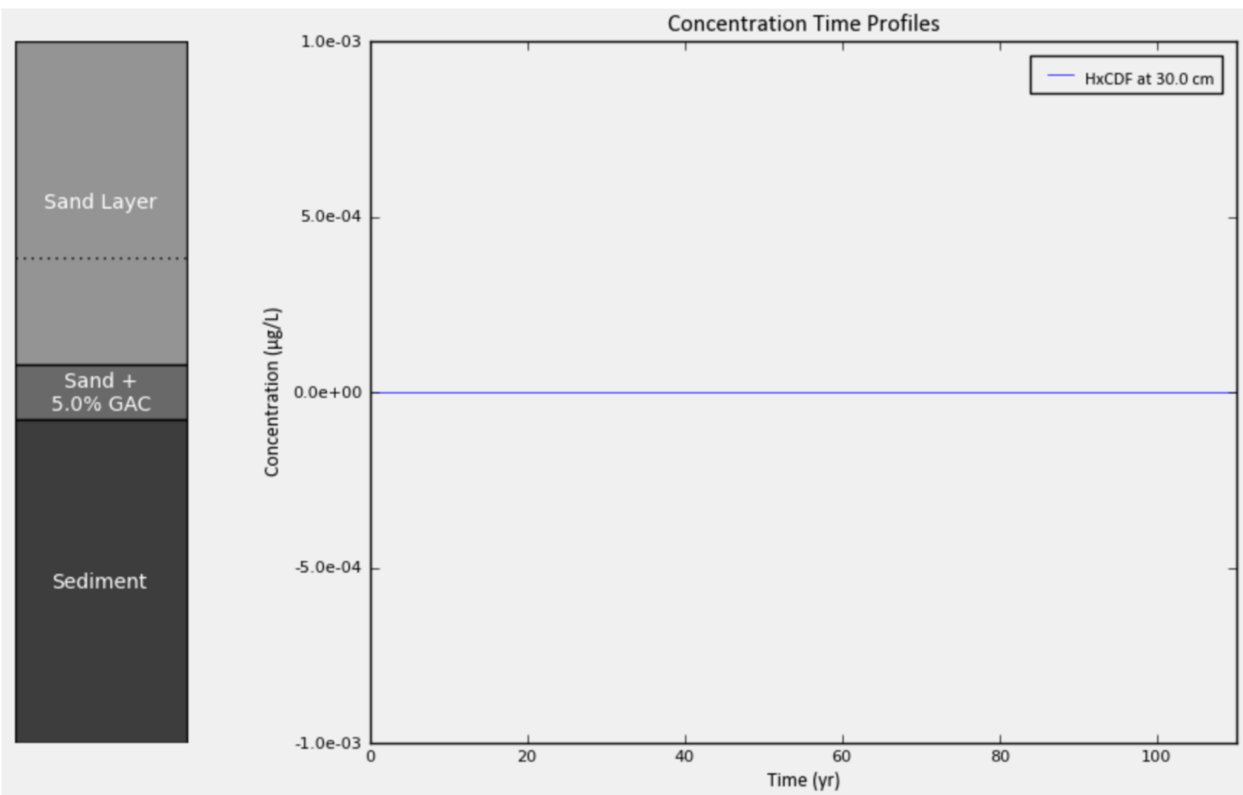

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDE at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

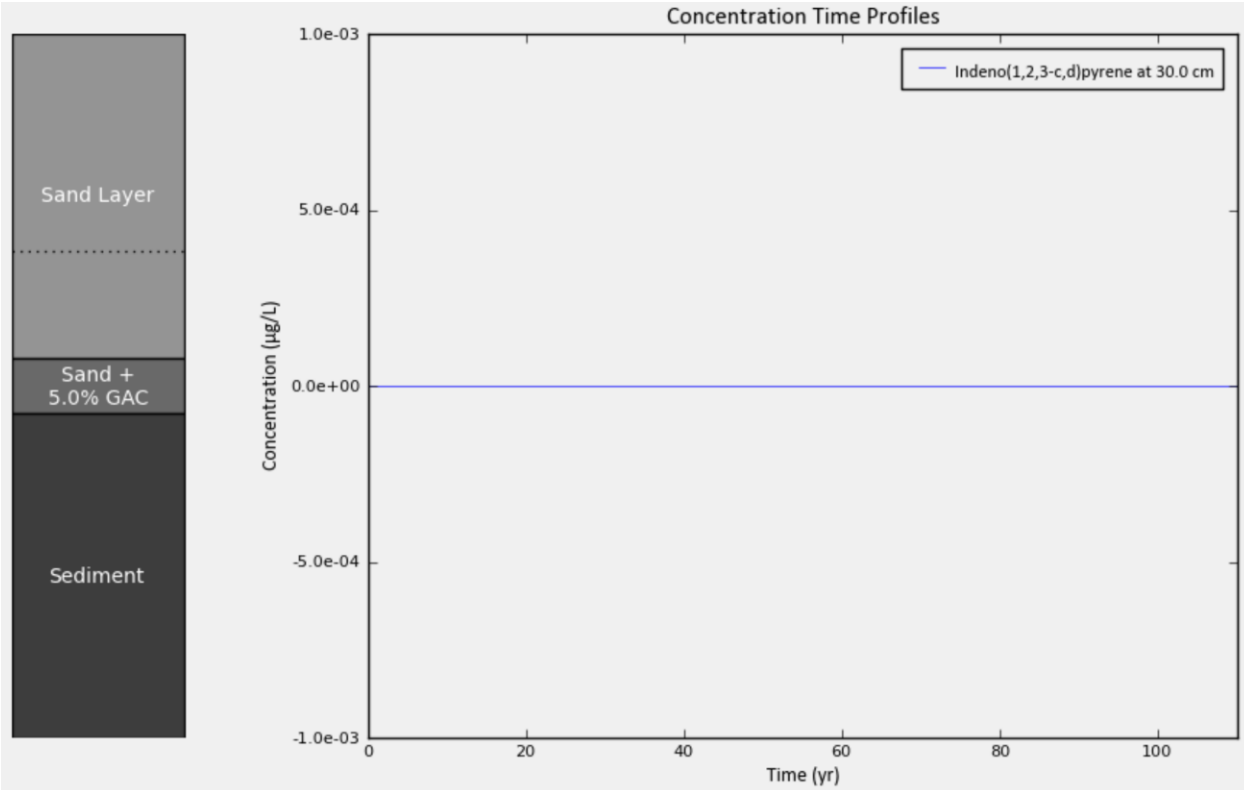

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDT at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

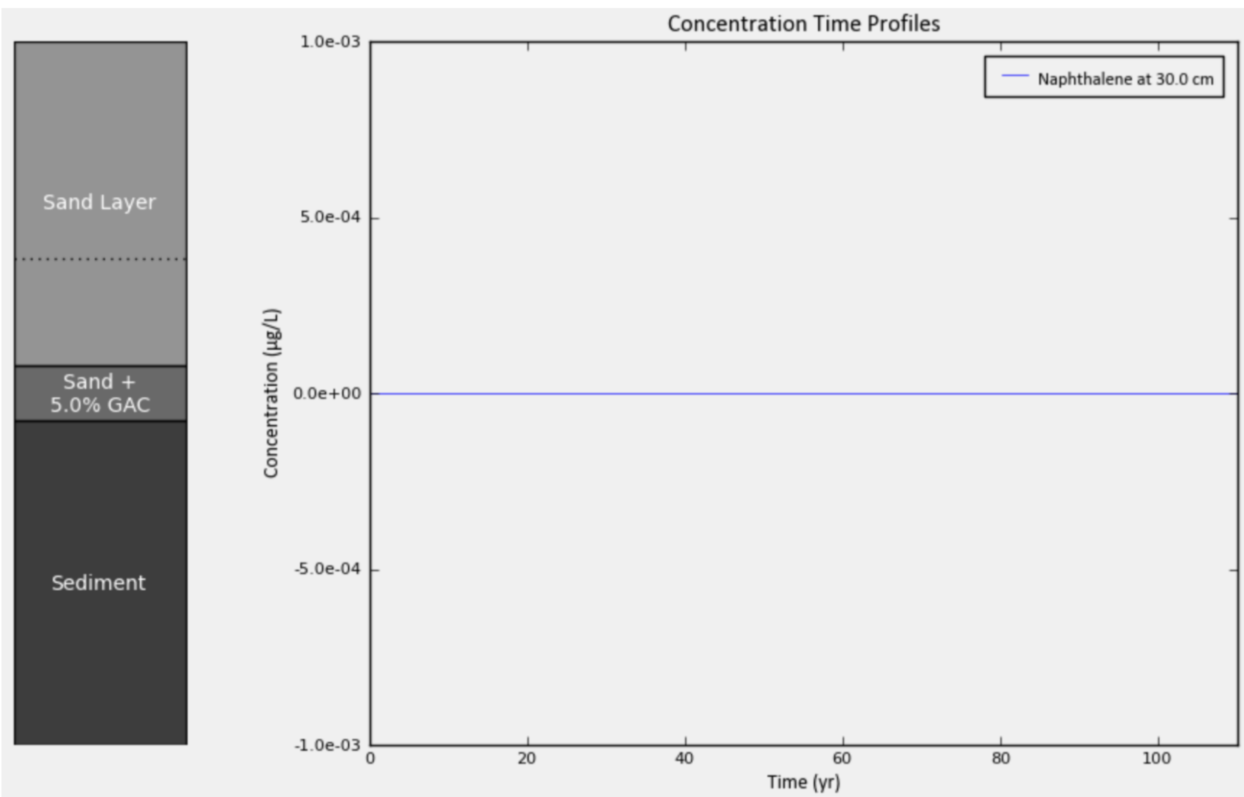

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Dibenzo(a,h)anthracene at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

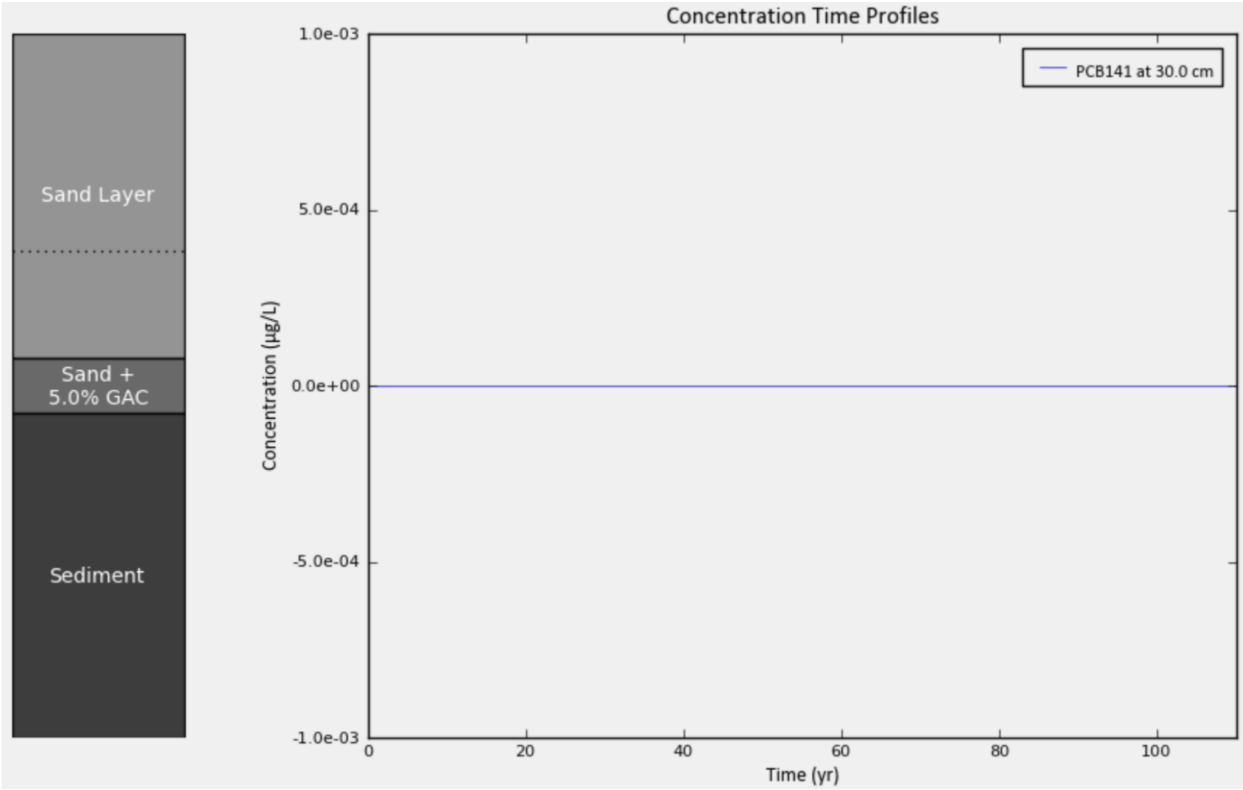

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluoranthene at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

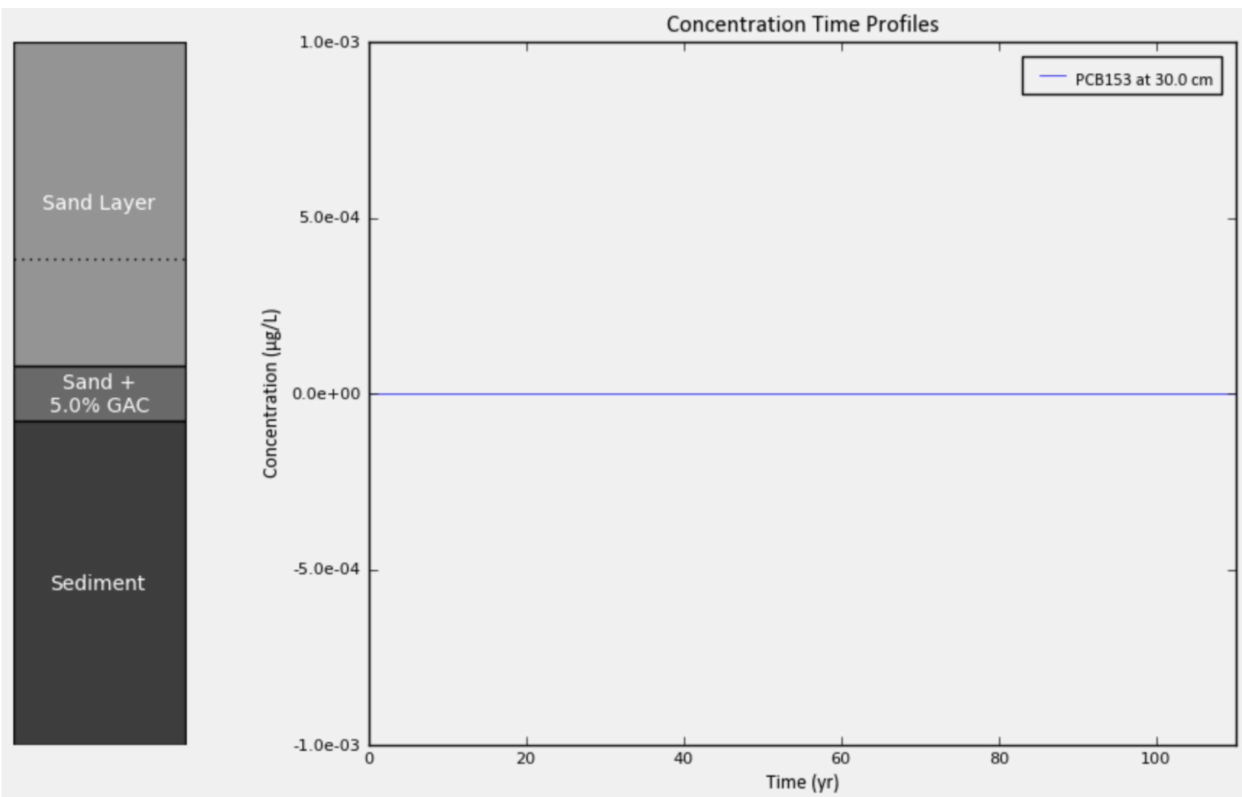

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluorene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

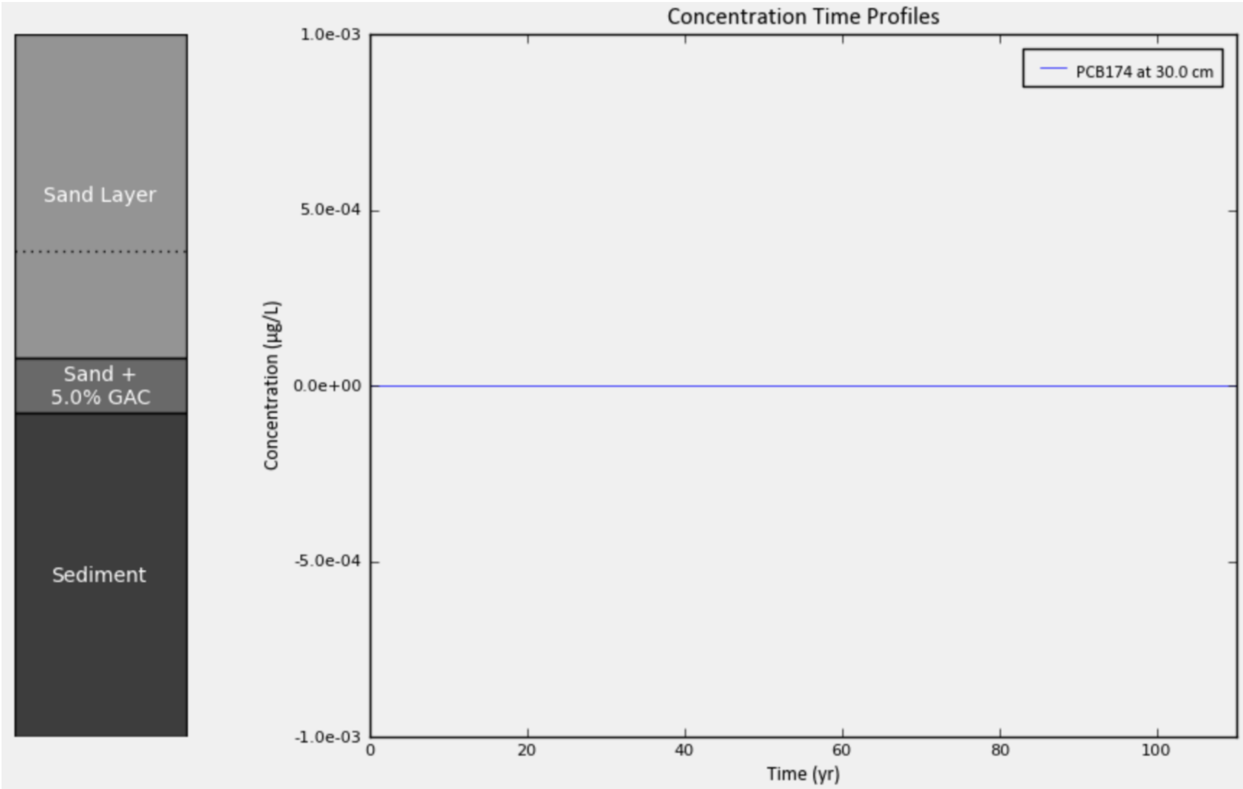

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
HxCDF at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

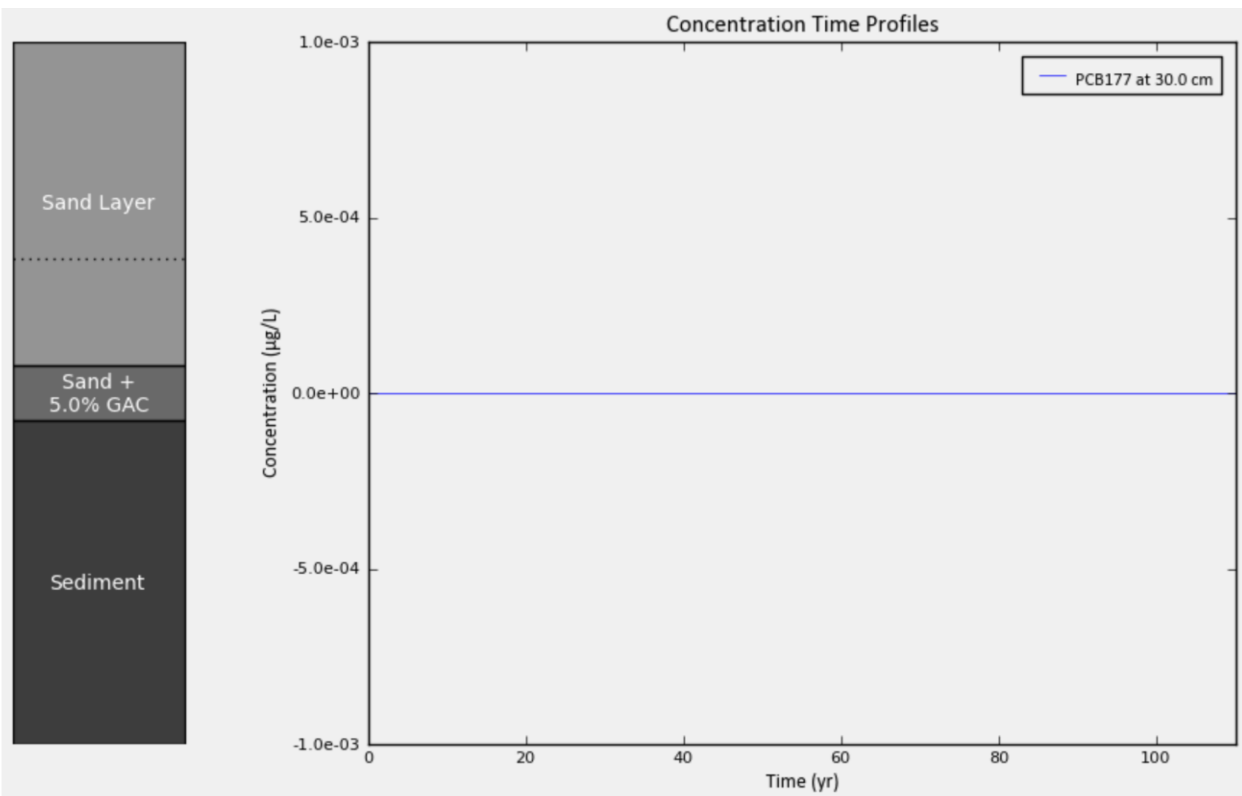

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

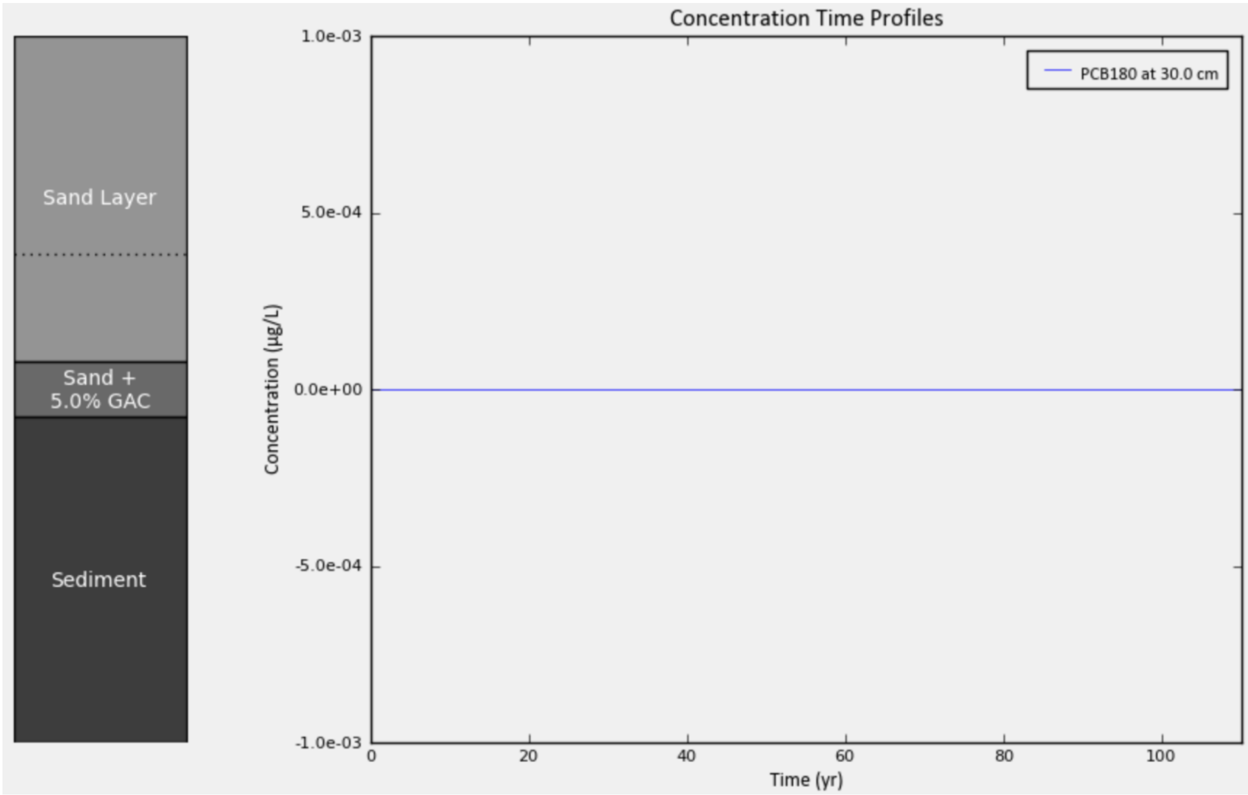

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Naphthalene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

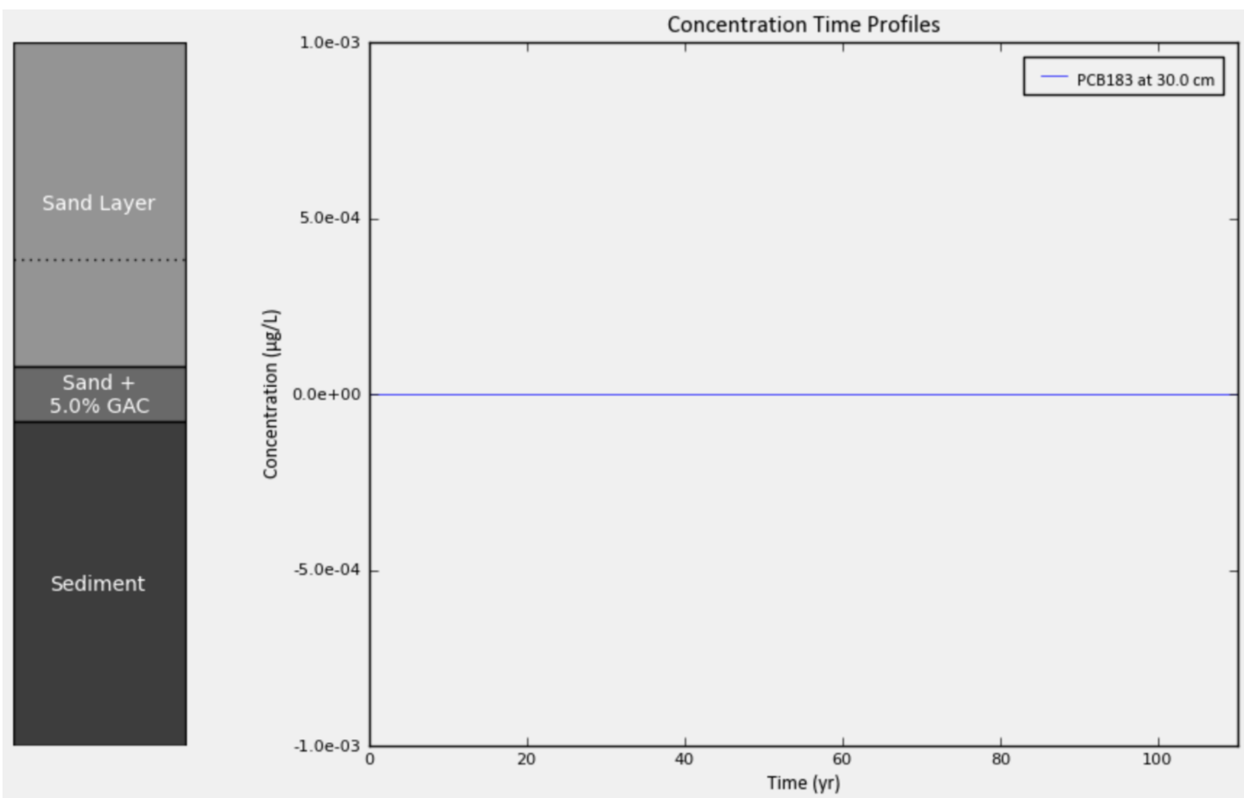

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB141 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

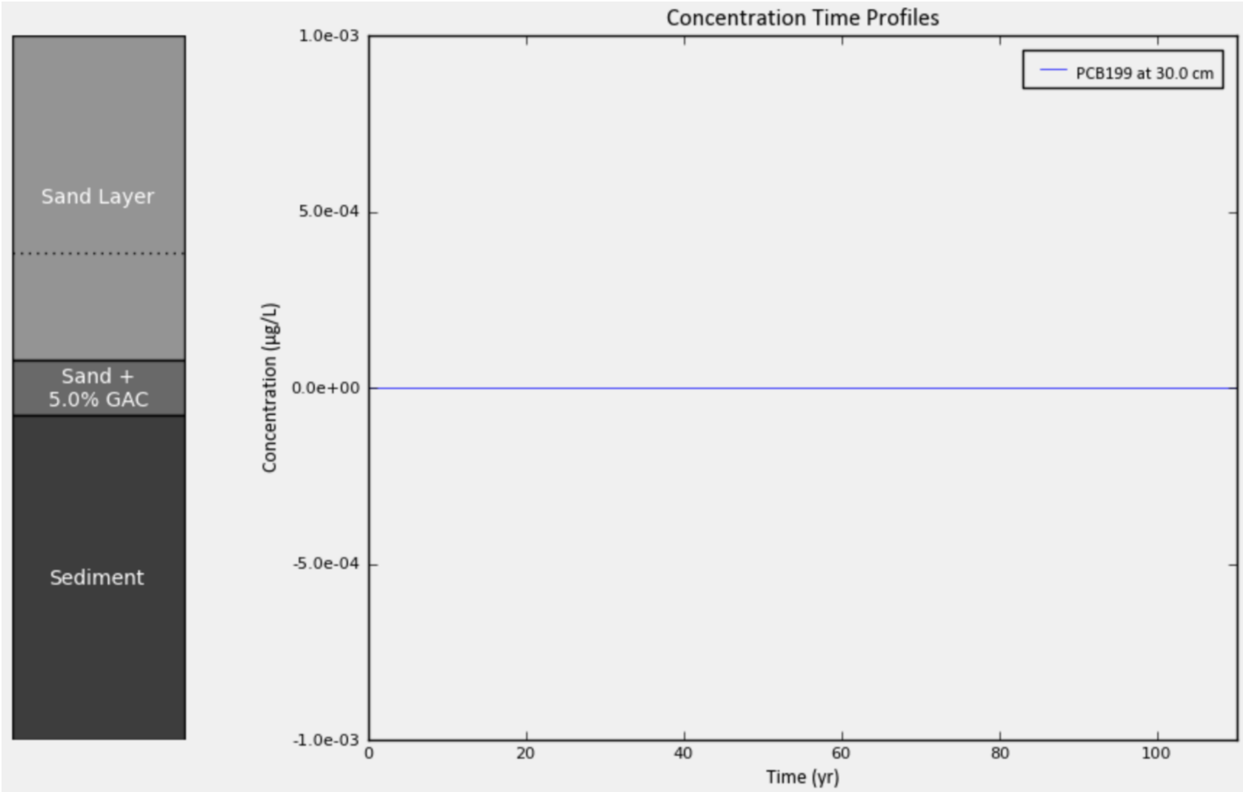

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB153 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

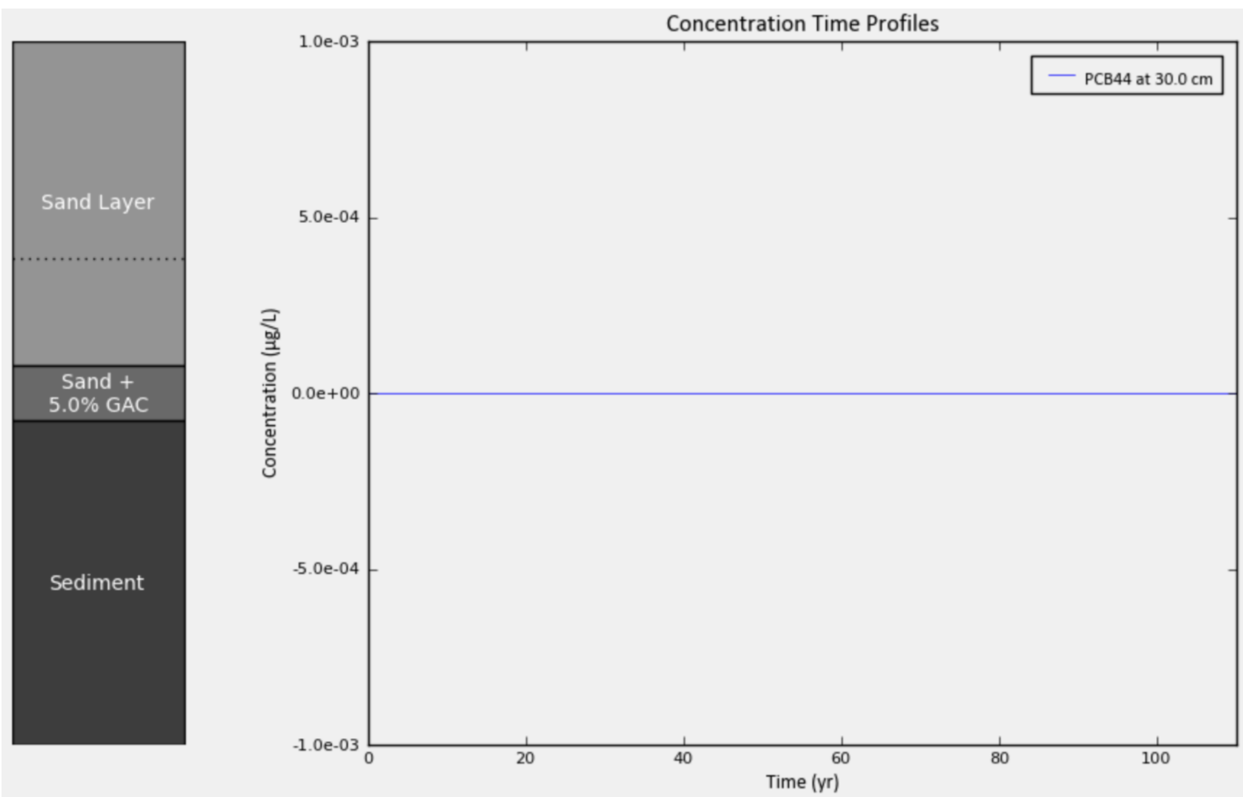

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB174 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

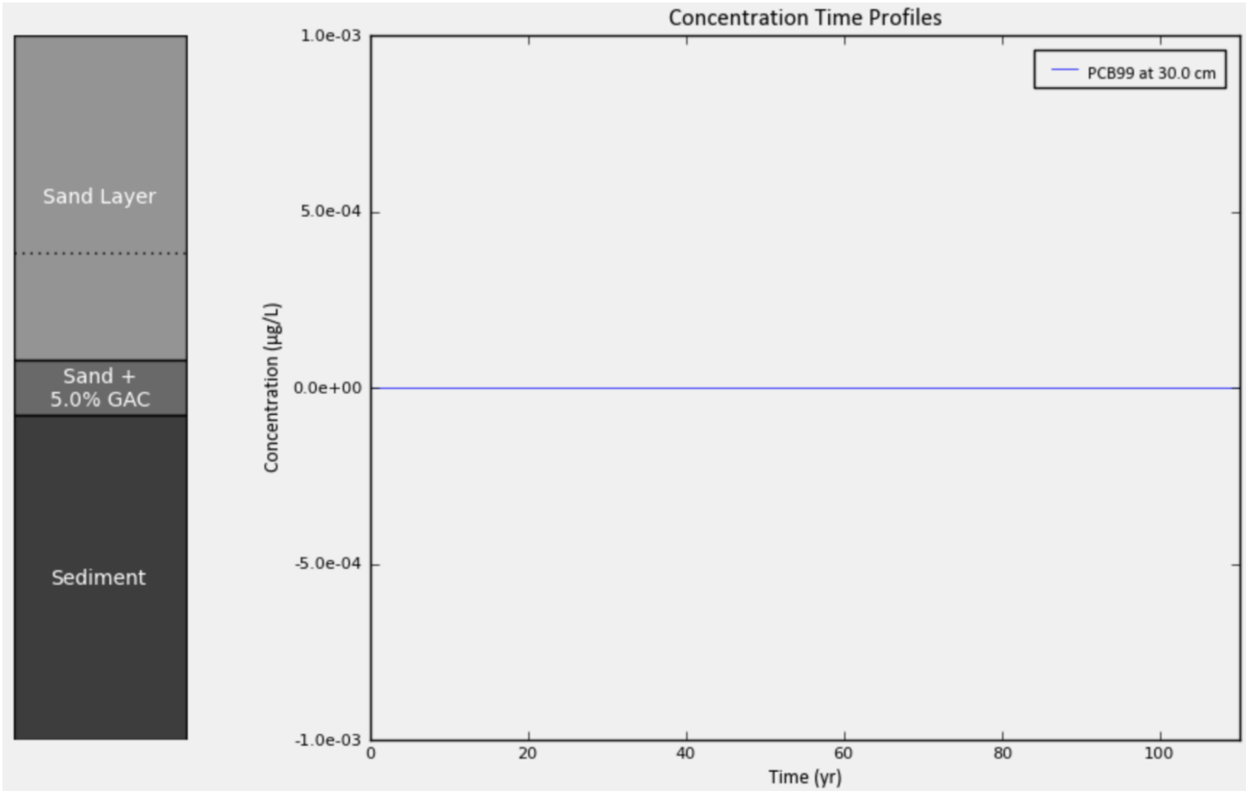

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB177 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

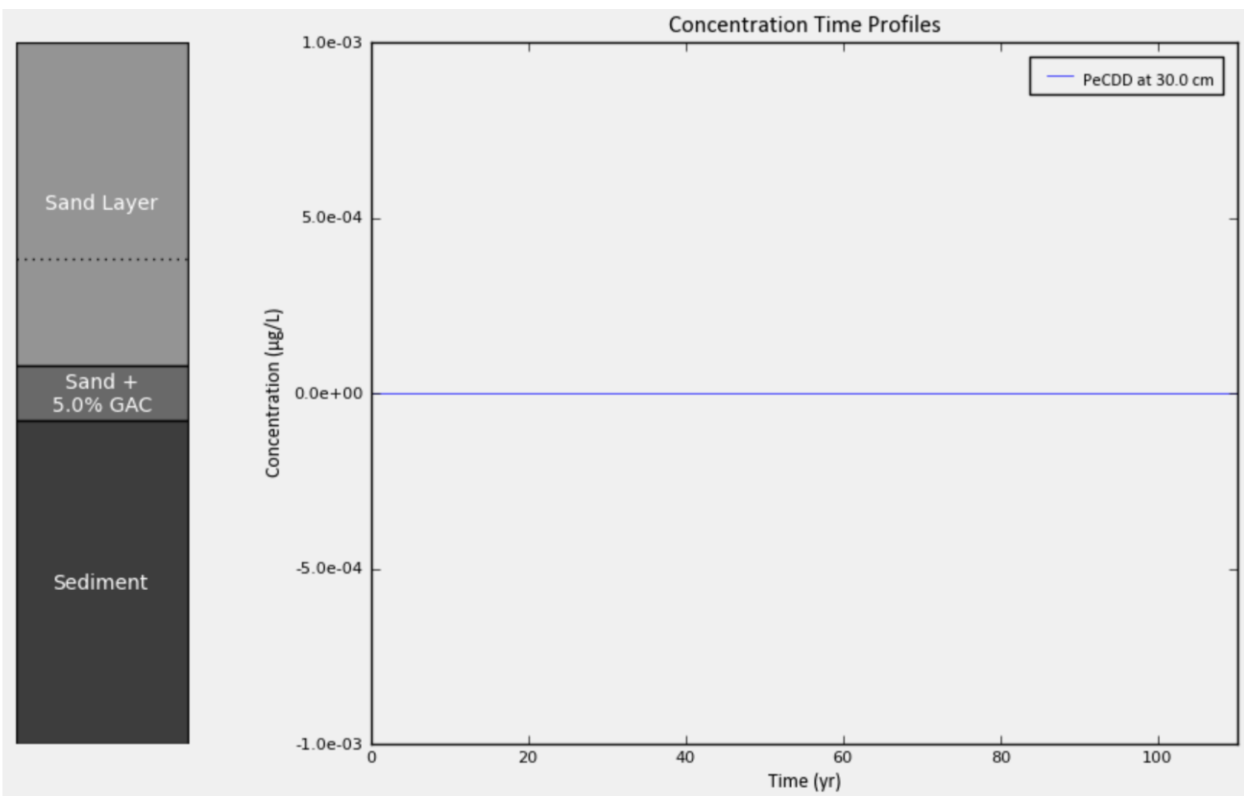

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB180 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

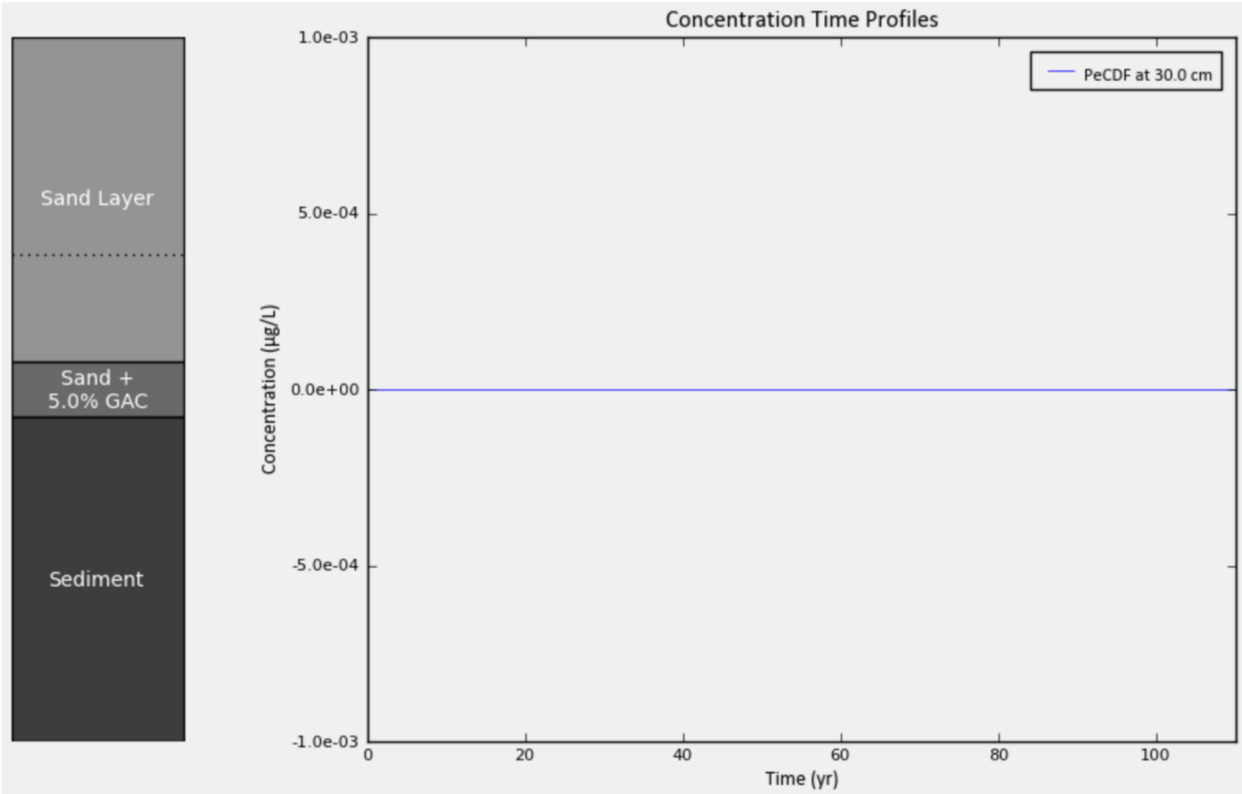

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB183 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

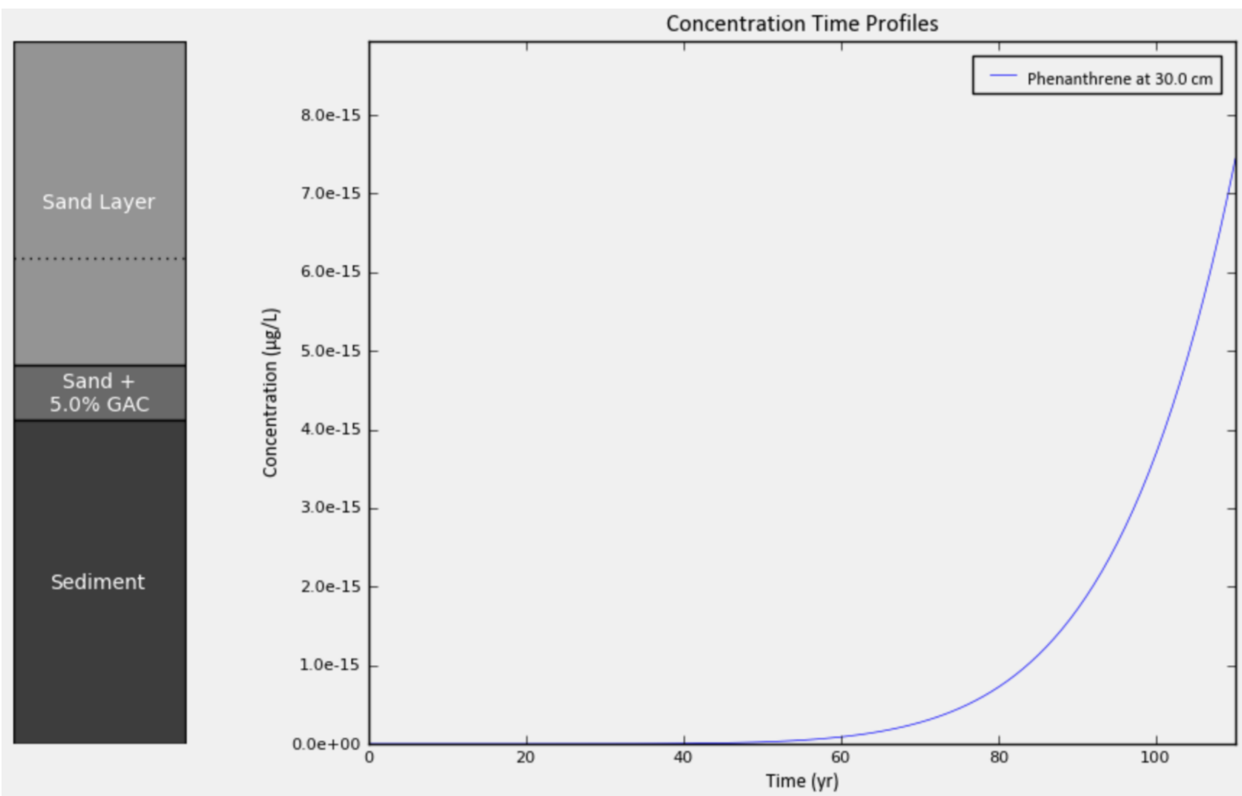

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB199 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

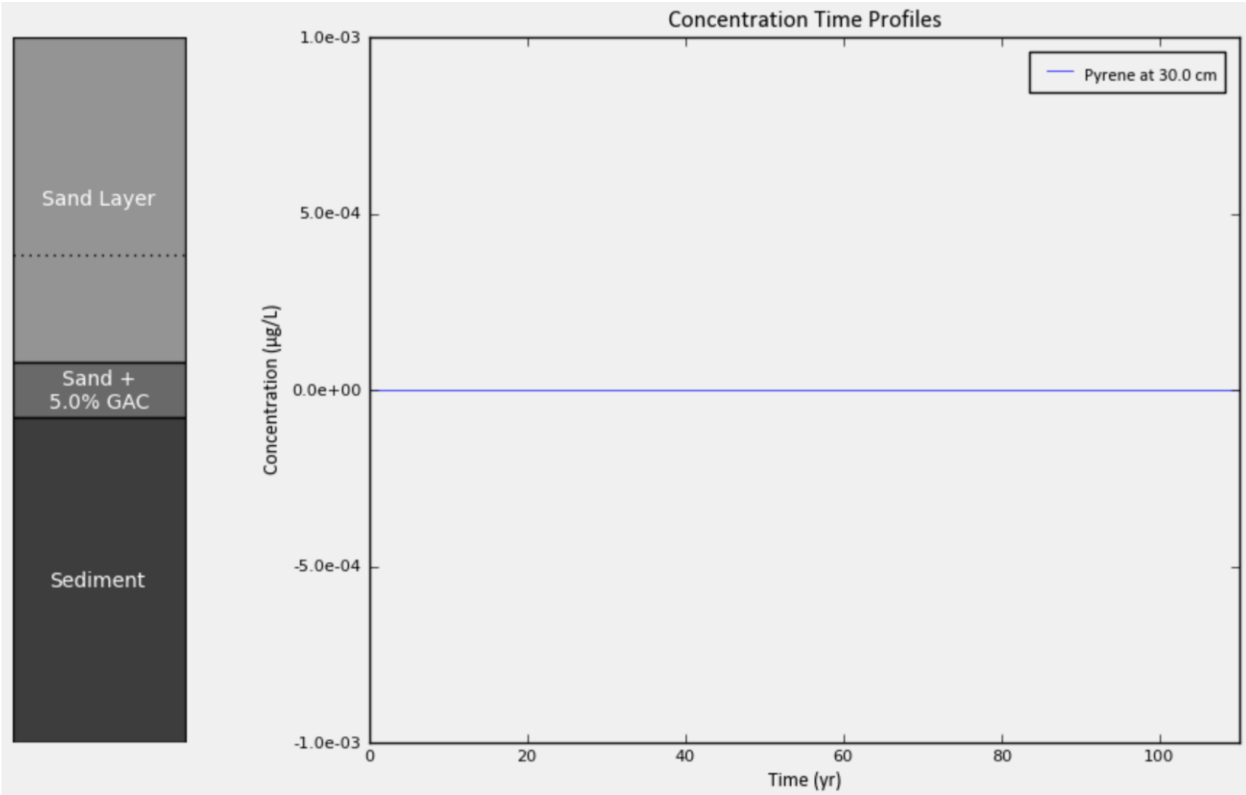

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB44 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

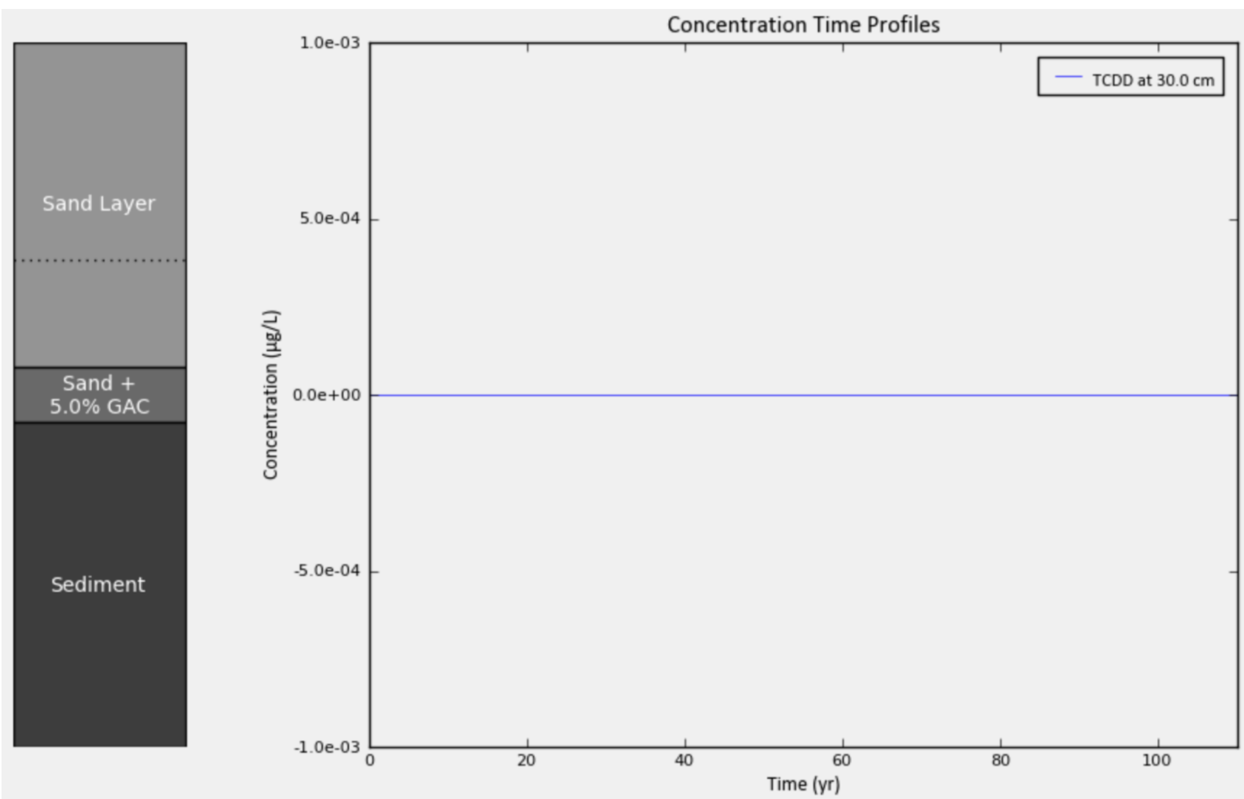

Concentration Time Profiles
PCB99 at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

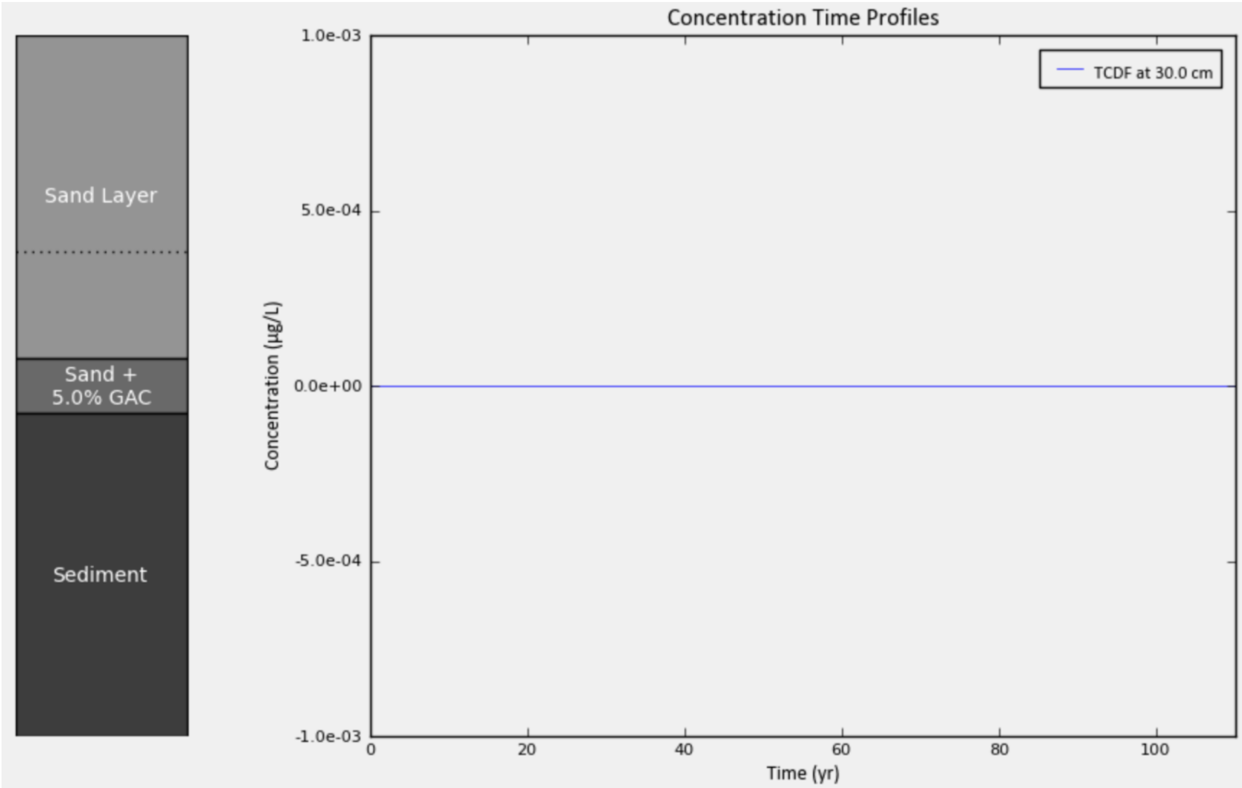

Concentration Time Profiles
PeCDD at 30.0 cm
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

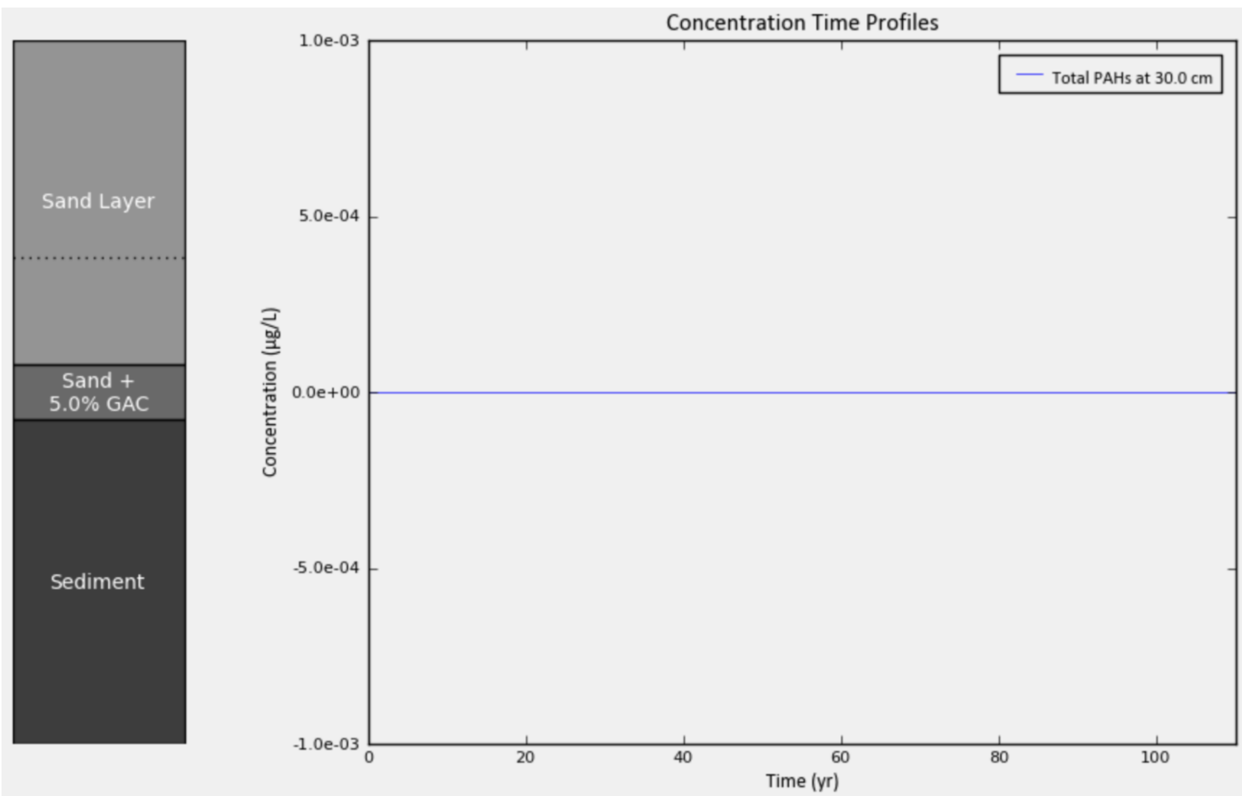

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PeCDF at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

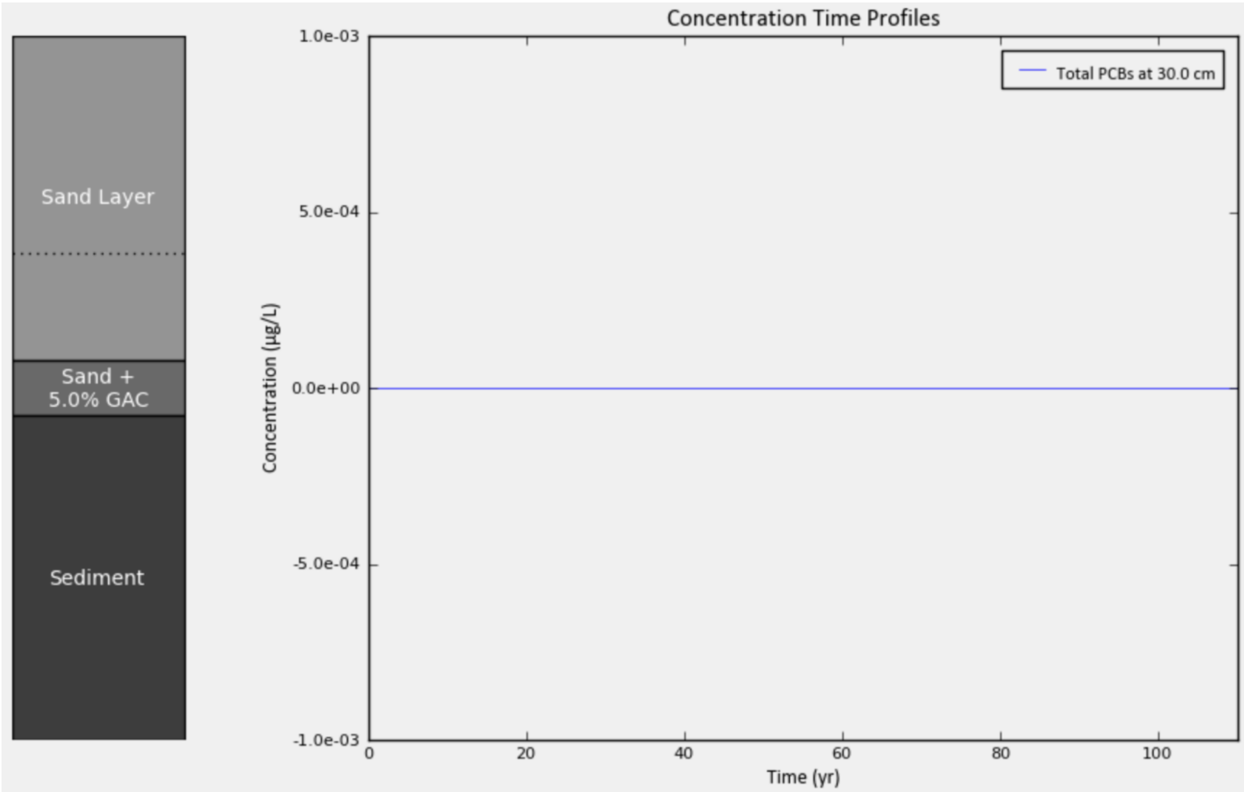

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Phenanthrene at 30.0 cm
8.0e-15
7.0e-15
6.0e-15
5.0e-15
4.0e-15
3.0e-15
2.0e-15
1.0e-15
0.0e+00
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Pyrene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDD at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDF at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PAHs at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PCBs at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

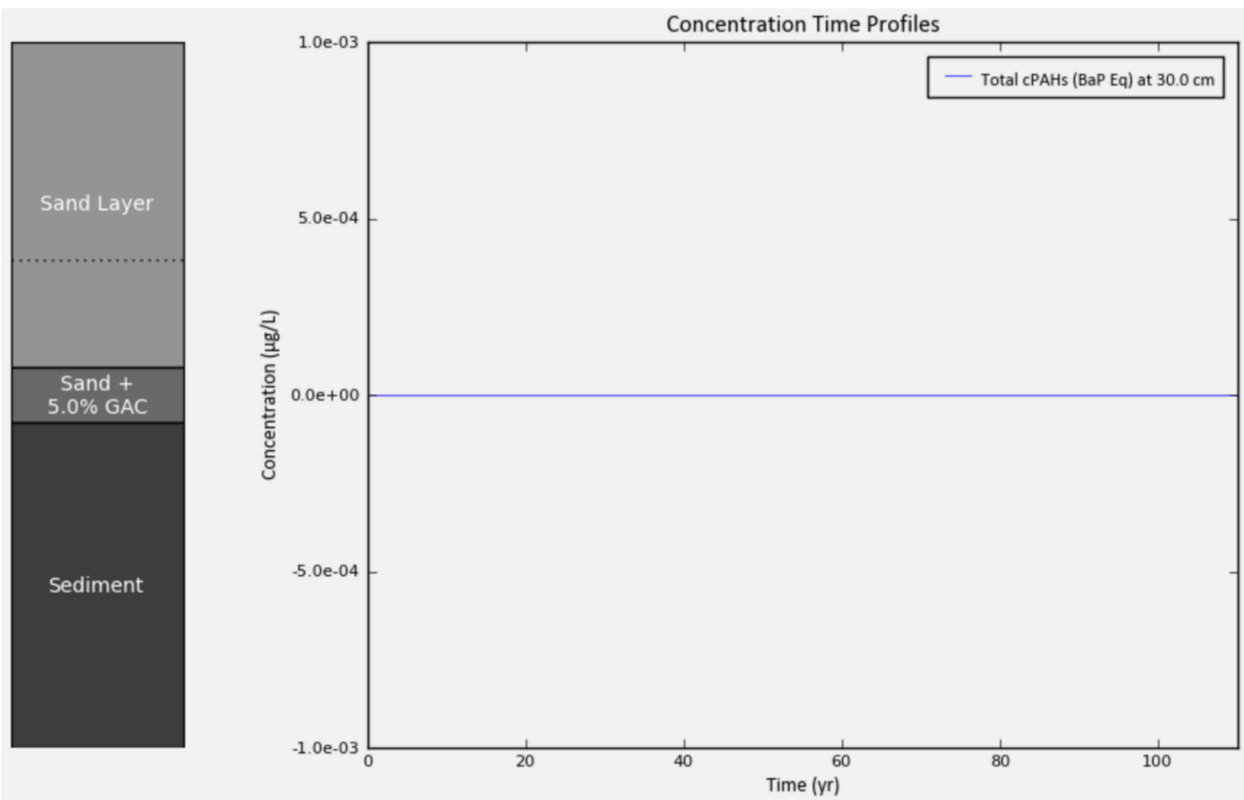
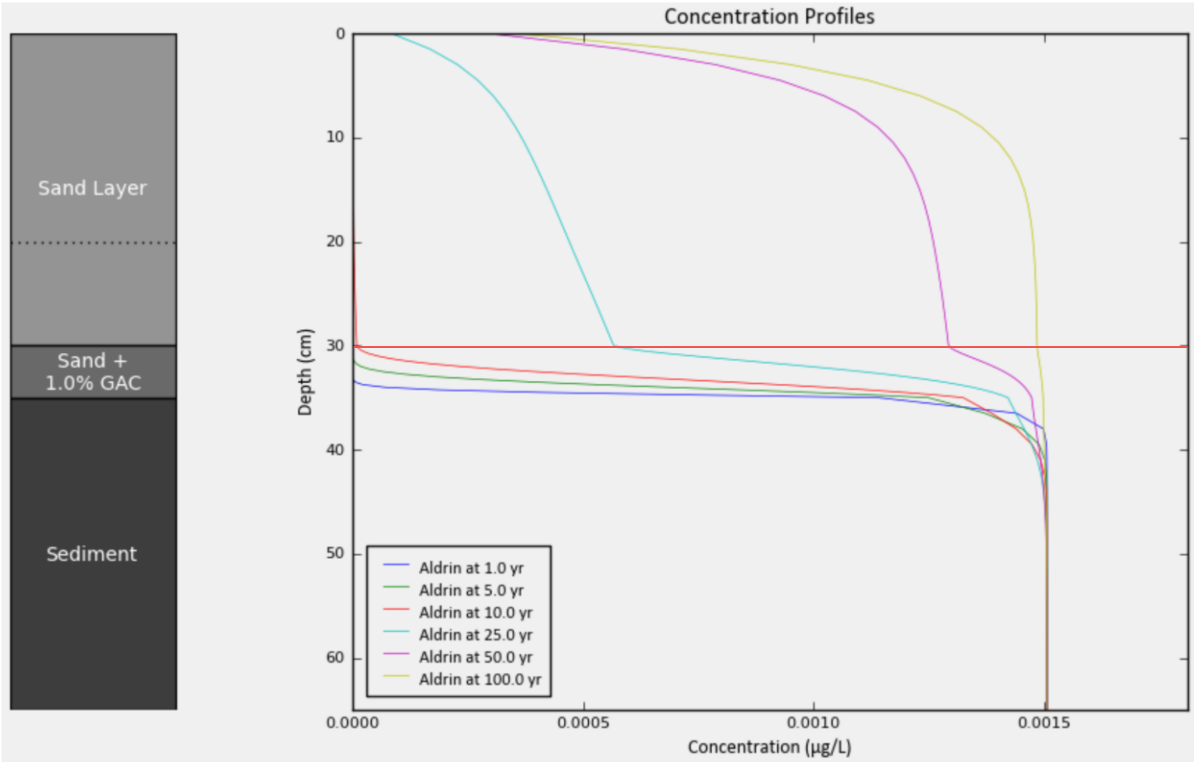
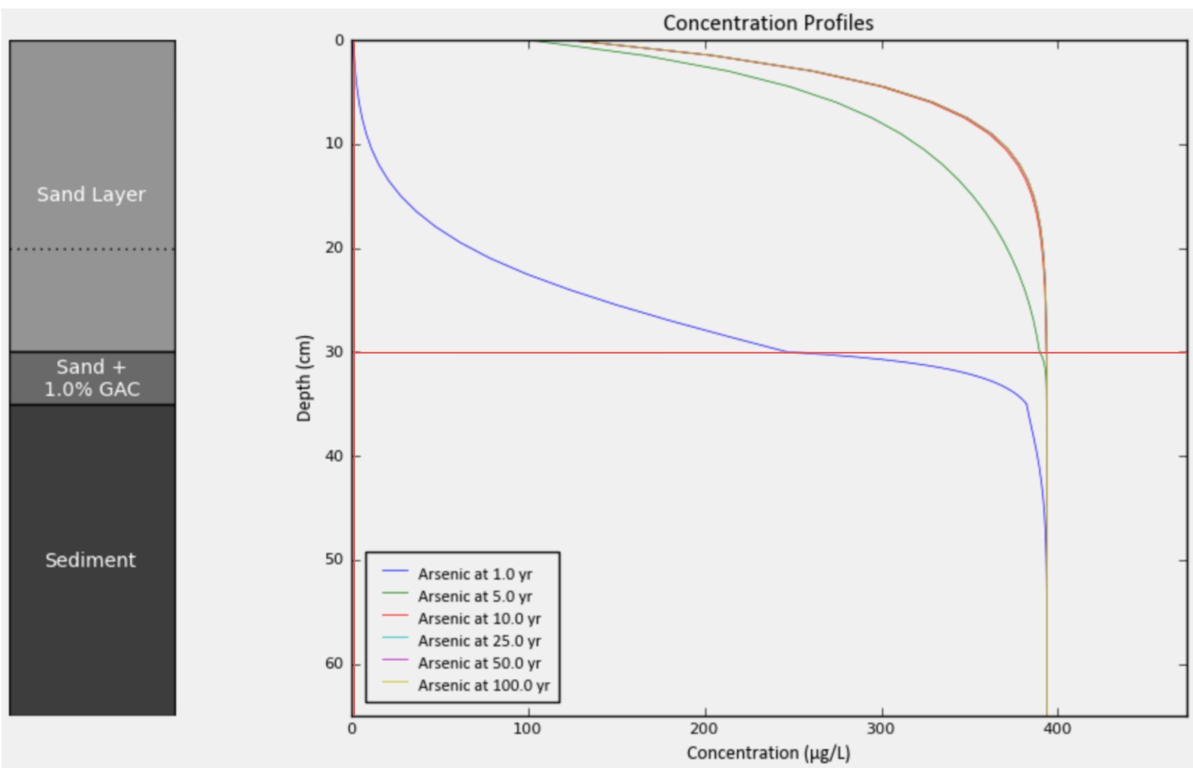
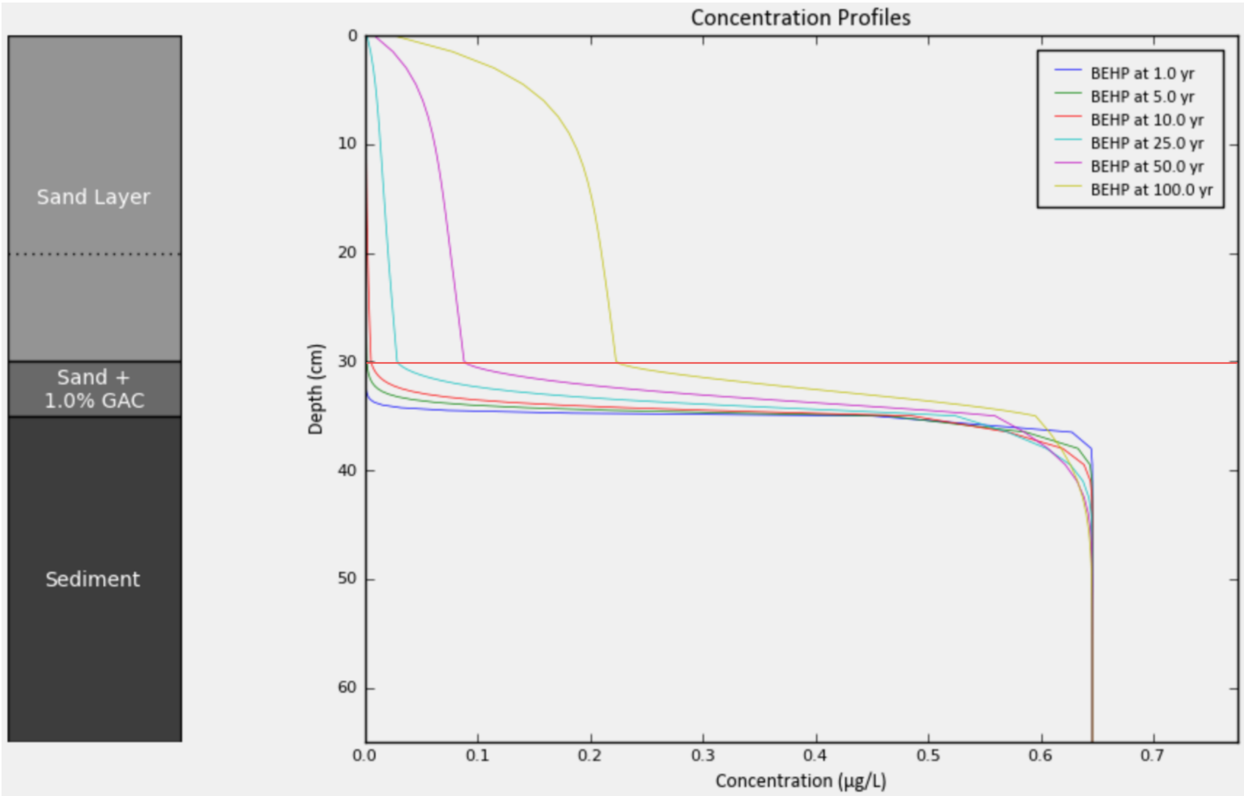

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

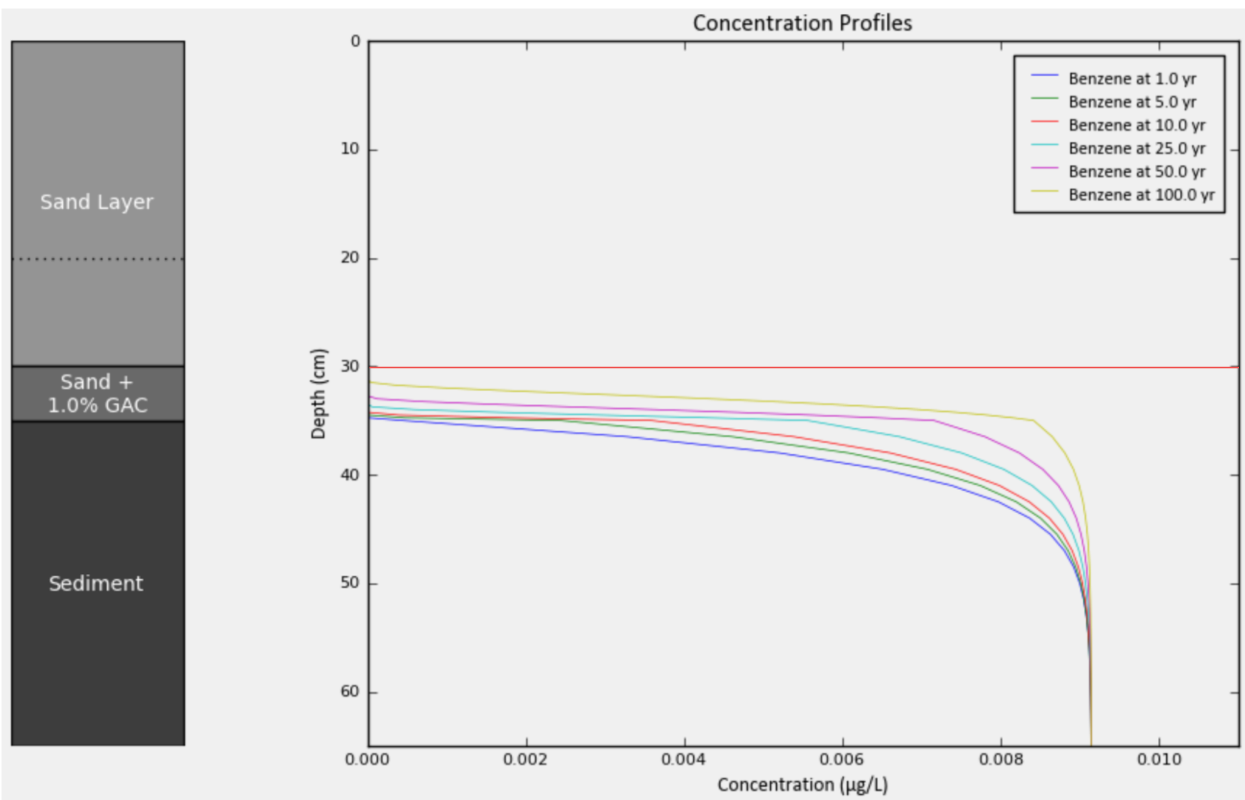
Table 17 COC Sensitivity Analysis: 5 cm of 1.0% GAC amended sand with 30 cm unamended sand layer

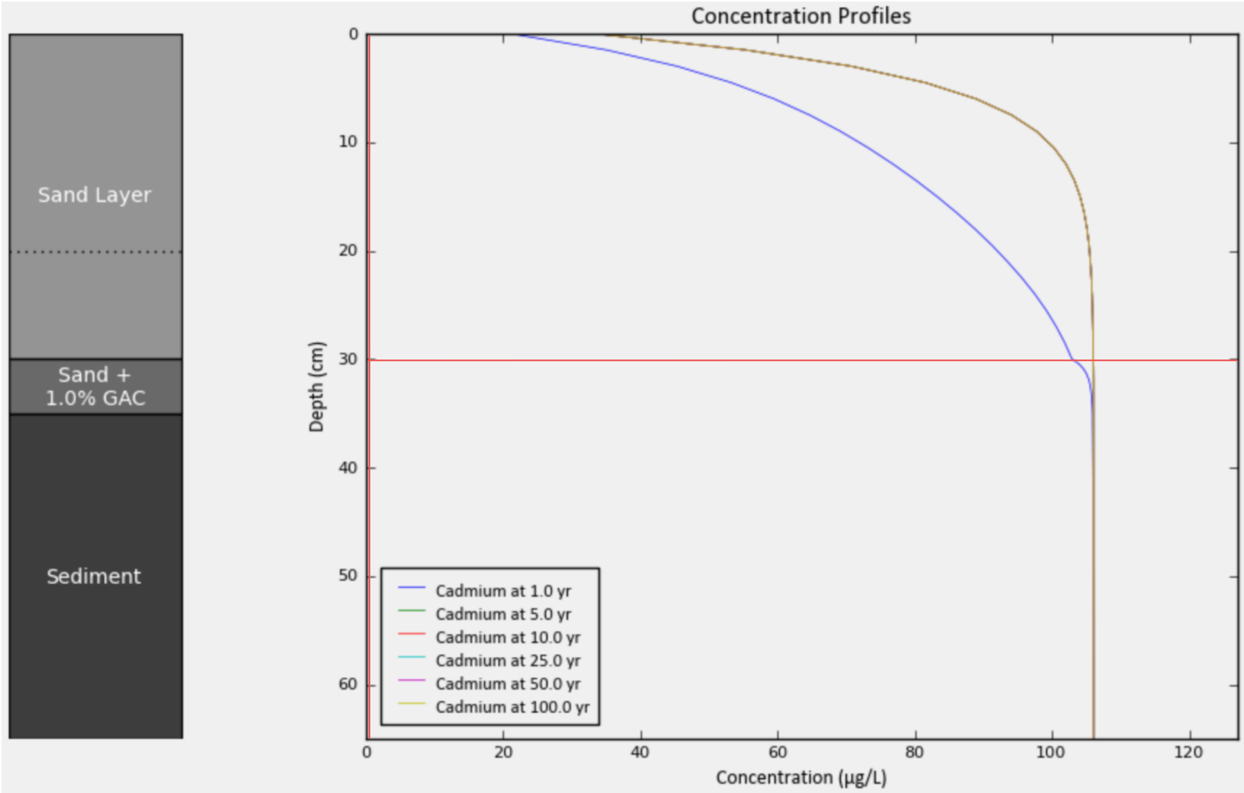
Porewater Concentration – Depth

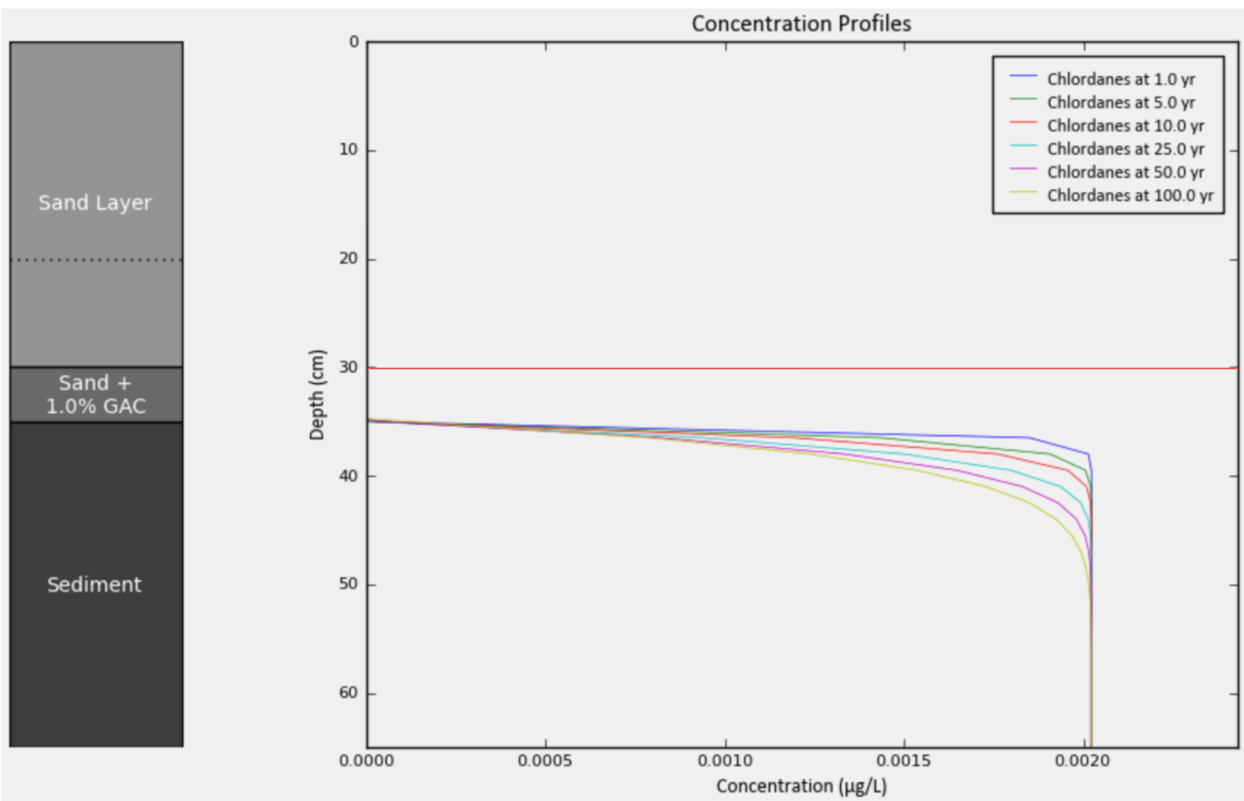


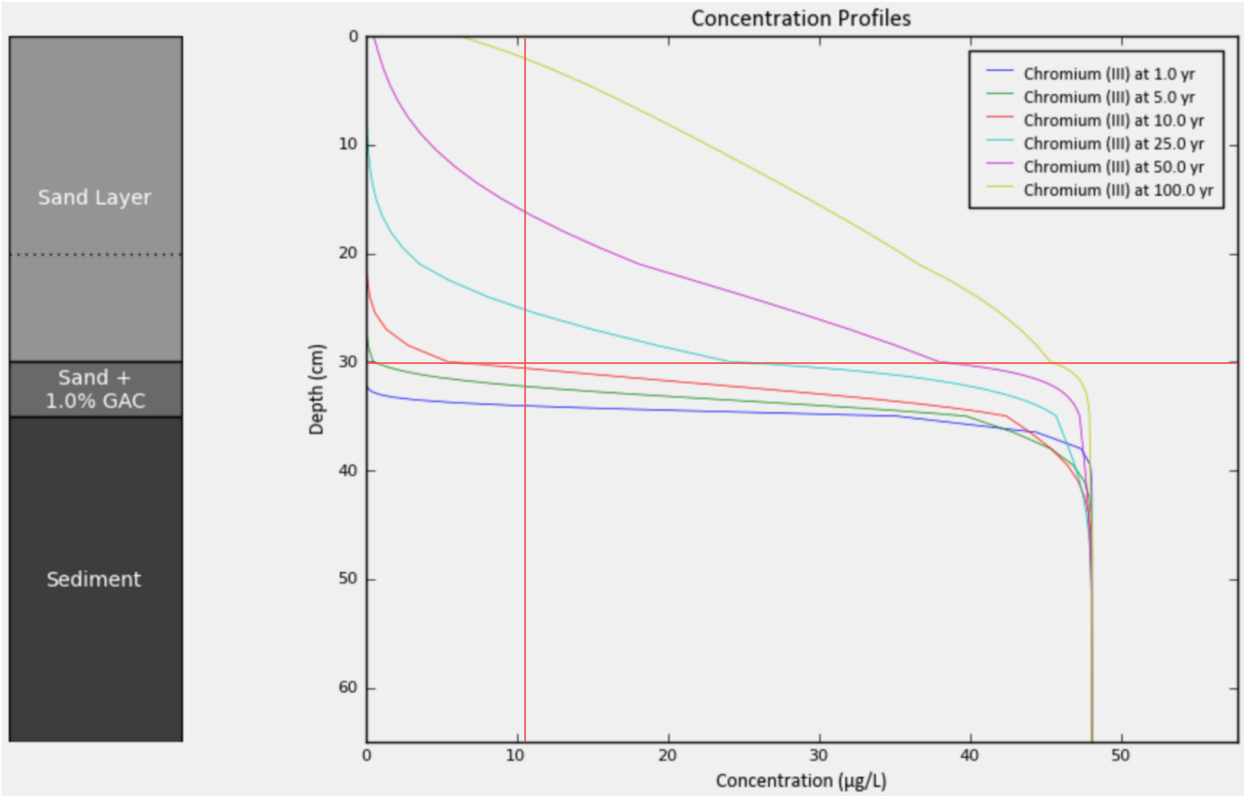


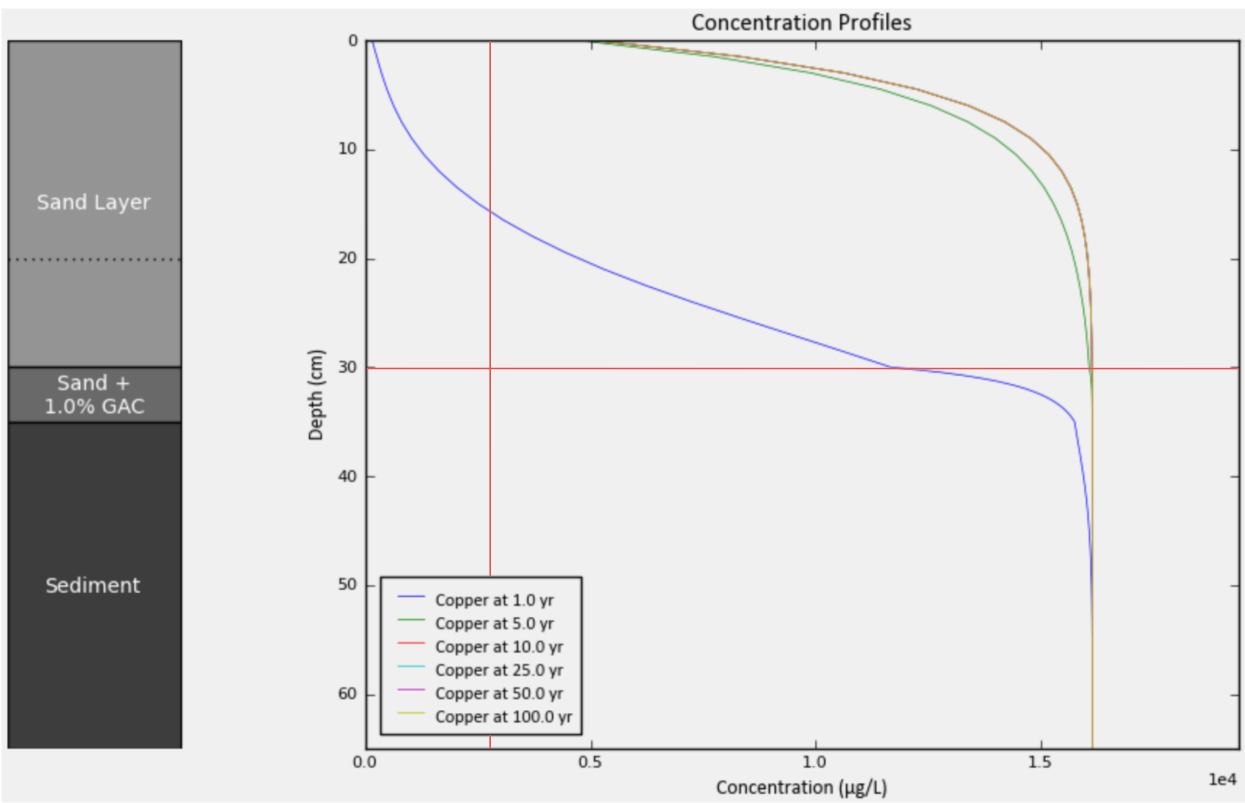

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
BEHP at 1.0 yr
BEHP at 5.0 yr
BEHP at 10.0 yr
BEHP at 25.0 yr
BEHP at 50.0 yr
BEHP at 100.0 yr

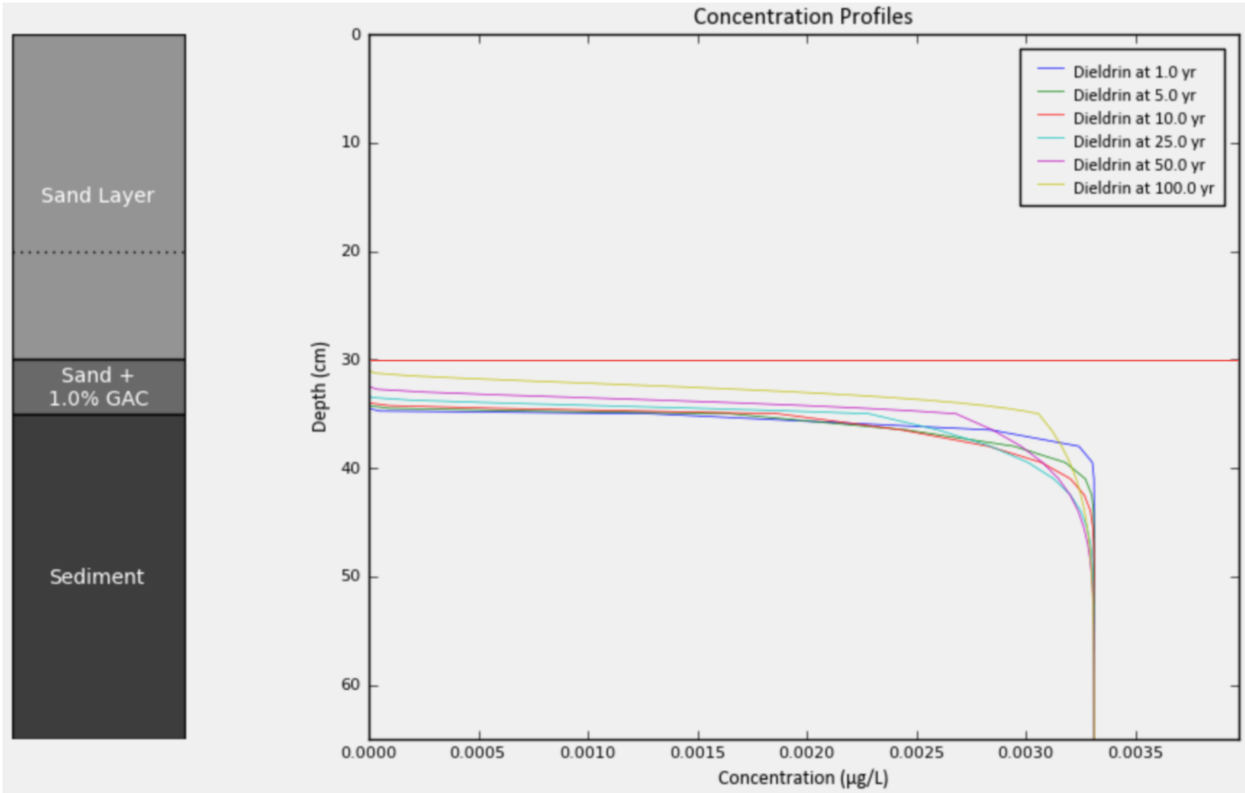

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Benzene at 1.0 yr
Benzene at 5.0 yr
Benzene at 10.0 yr
Benzene at 25.0 yr
Benzene at 50.0 yr
Benzene at 100.0 yr

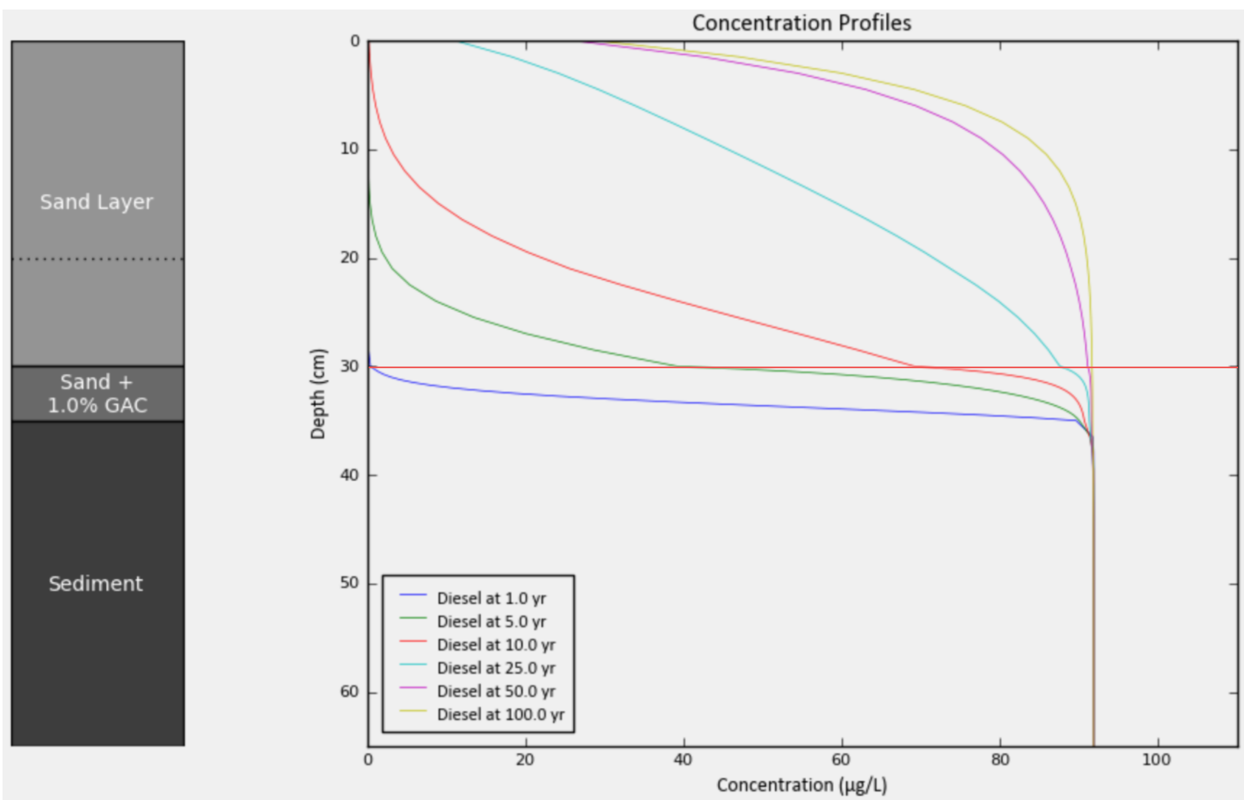

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Cadmium at 1.0 yr
Cadmium at 5.0 yr
Cadmium at 10.0 yr
Cadmium at 25.0 yr
Cadmium at 50.0 yr
Cadmium at 100.0 yr

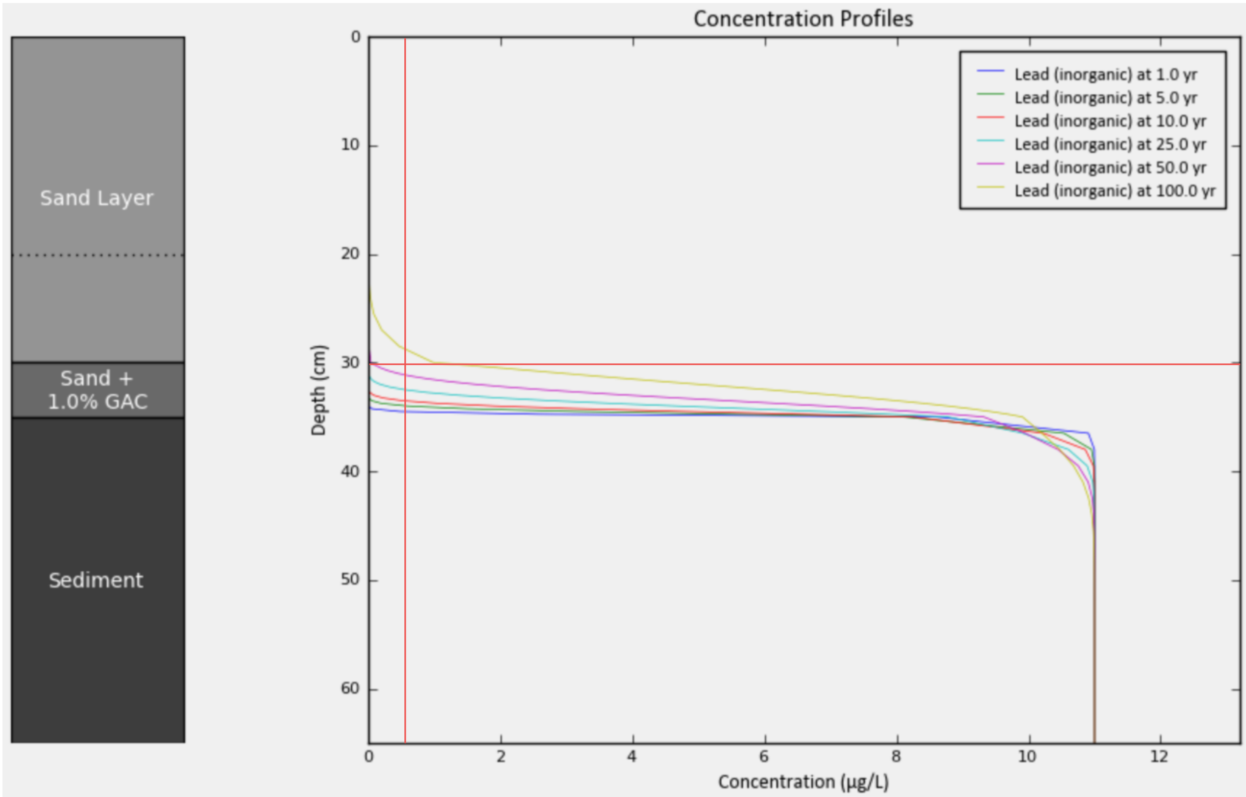

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Chlordanes at 1.0 yr
Chlordanes at 5.0 yr
Chlordanes at 10.0 yr
Chlordanes at 25.0 yr
Chlordanes at 50.0 yr
Chlordanes at 100.0 yr

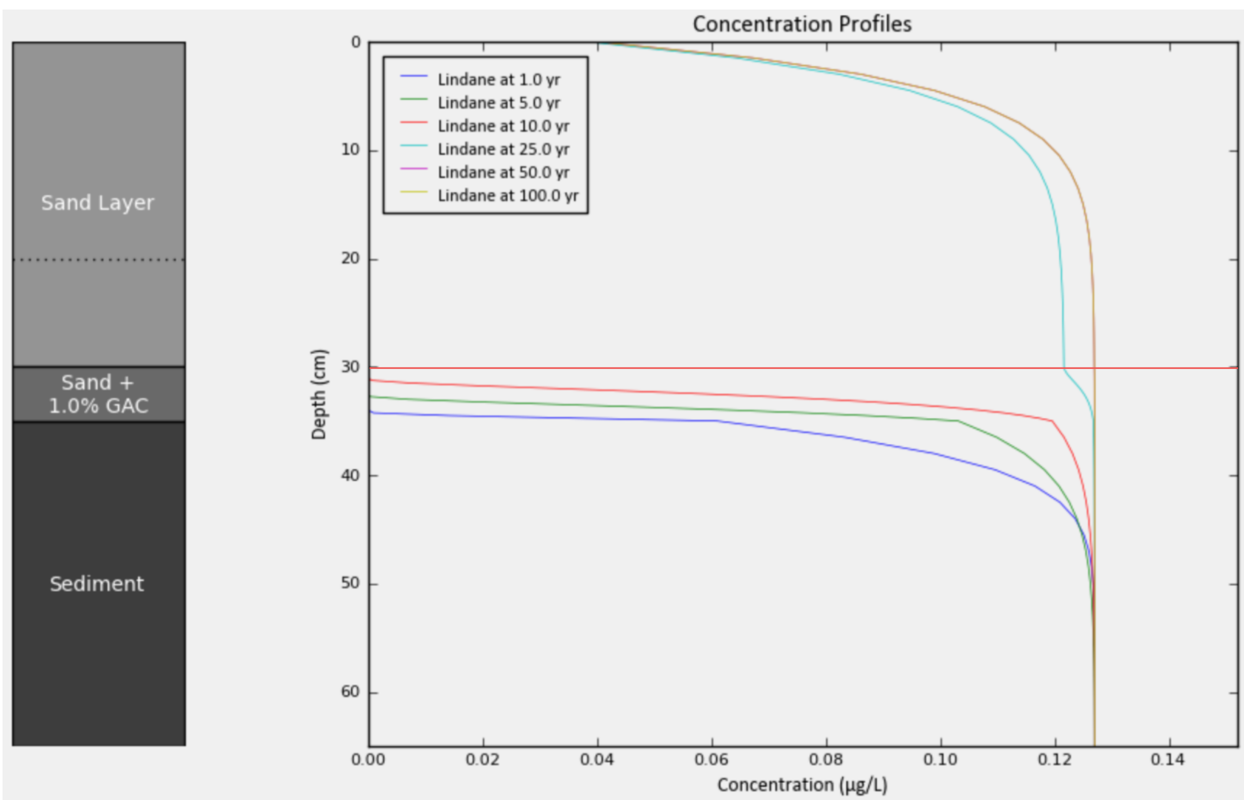

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Chromium (III) at 1.0 yr
Chromium (III) at 5.0 yr
Chromium (III) at 10.0 yr
Chromium (III) at 25.0 yr
Chromium (III) at 50.0 yr
Chromium (III) at 100.0 yr

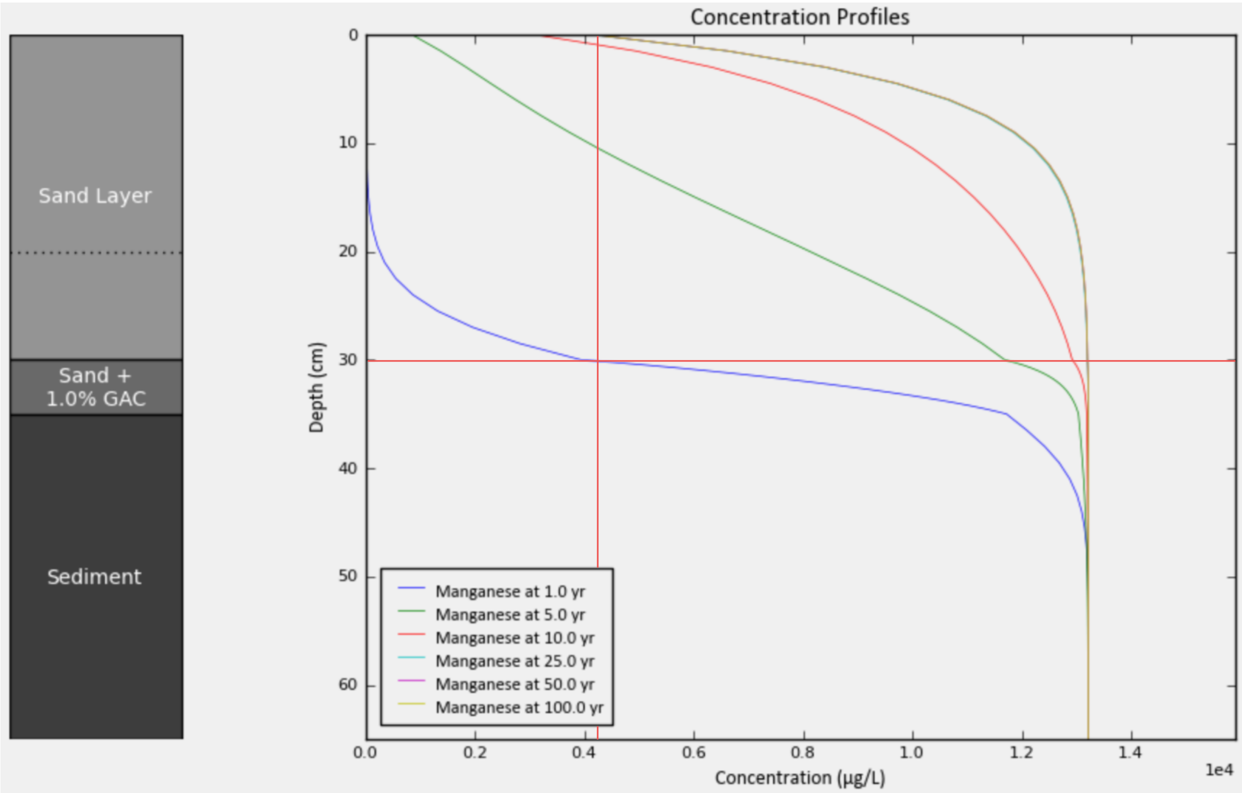

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e4
Copper at 1.0 yr
Copper at 5.0 yr
Copper at 10.0 yr
Copper at 25.0 yr
Copper at 50.0 yr
Copper at 100.0 yr

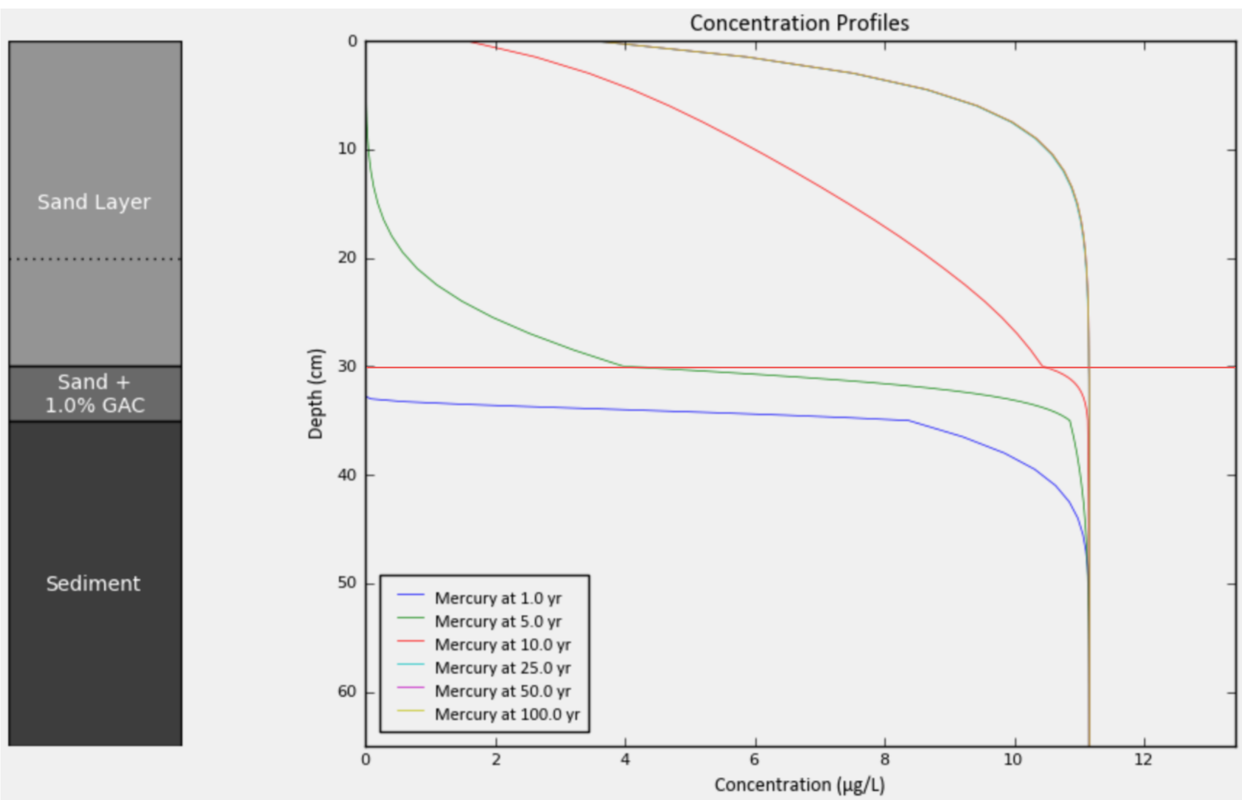

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Dieldrin at 1.0 yr
Dieldrin at 5.0 yr
Dieldrin at 10.0 yr
Dieldrin at 25.0 yr
Dieldrin at 50.0 yr
Dieldrin at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035

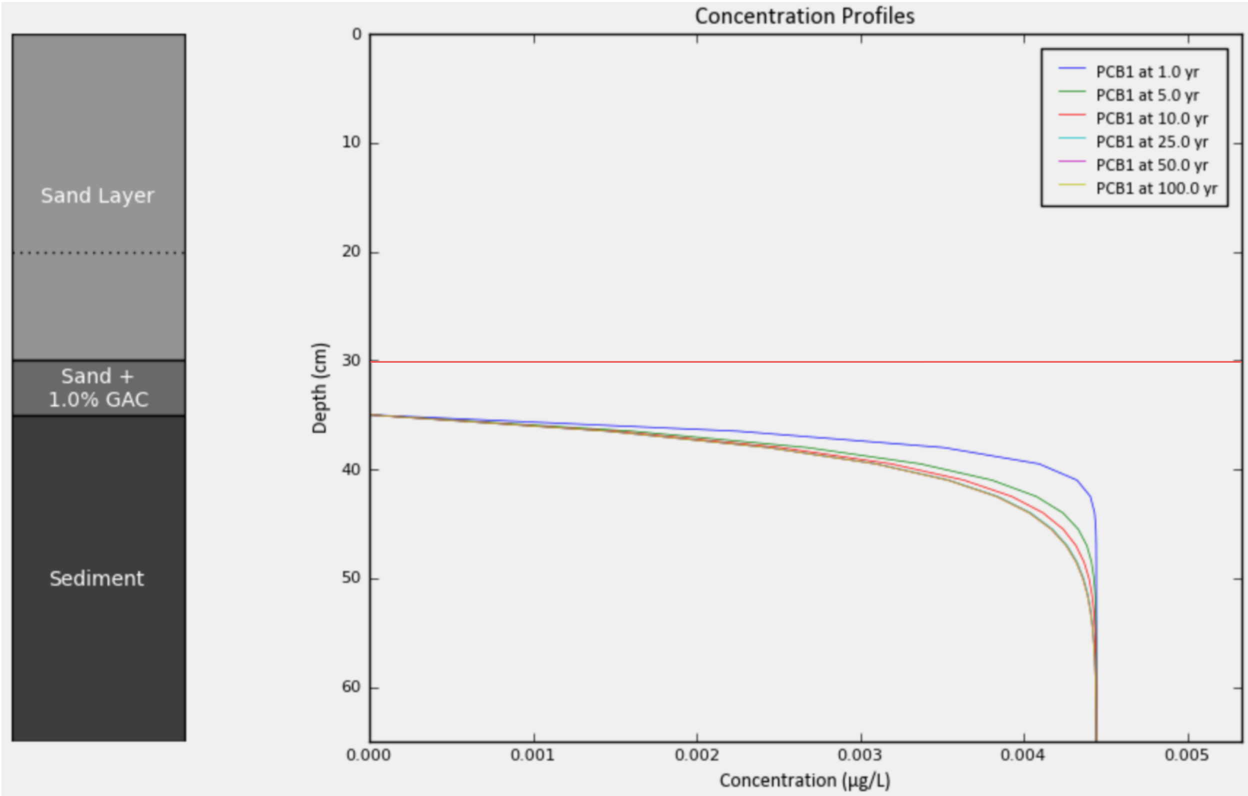

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Diesel at 1.0 yr
Diesel at 5.0 yr
Diesel at 10.0 yr
Diesel at 25.0 yr
Diesel at 50.0 yr
Diesel at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0
20
40
60
80
100

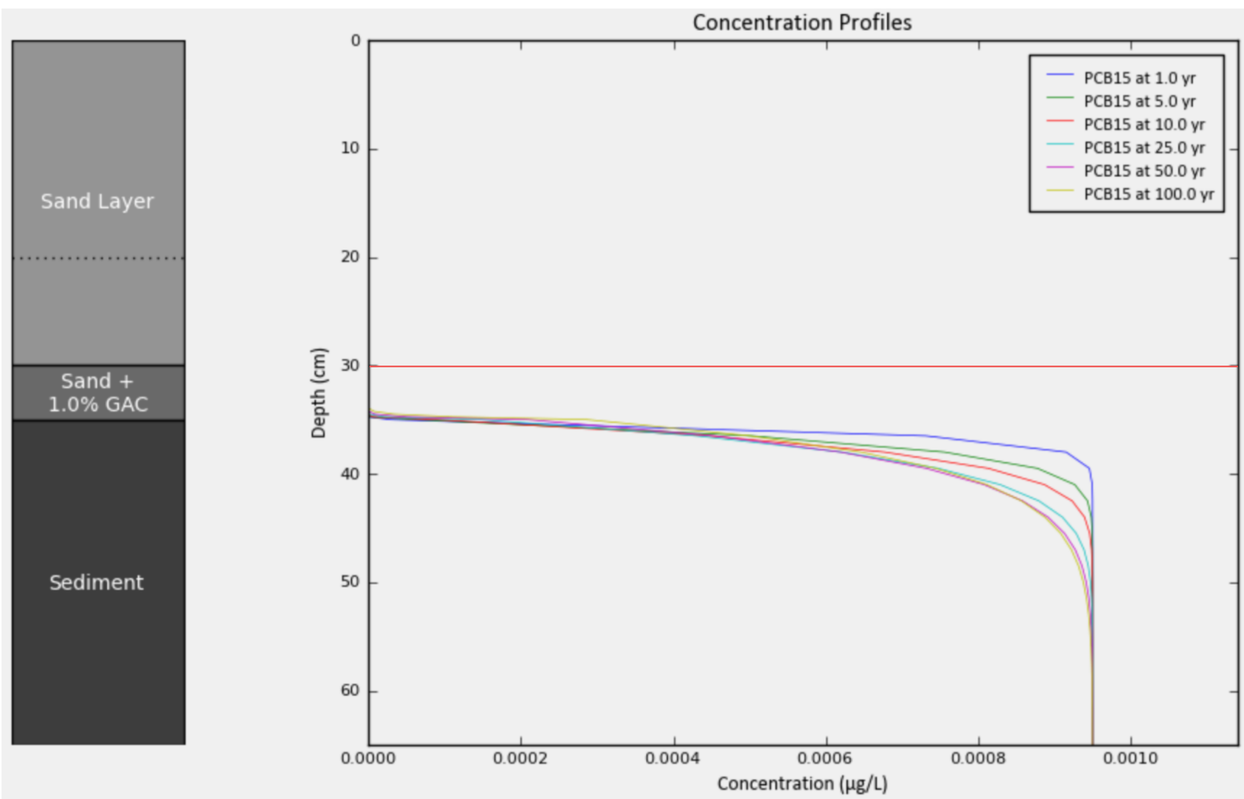

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Lead (inorganic) at 1.0 yr
Lead (inorganic) at 5.0 yr
Lead (inorganic) at 10.0 yr
Lead (inorganic) at 25.0 yr
Lead (inorganic) at 50.0 yr
Lead (inorganic) at 100.0 yr
Depth (cm)
Concentration (µg/L)

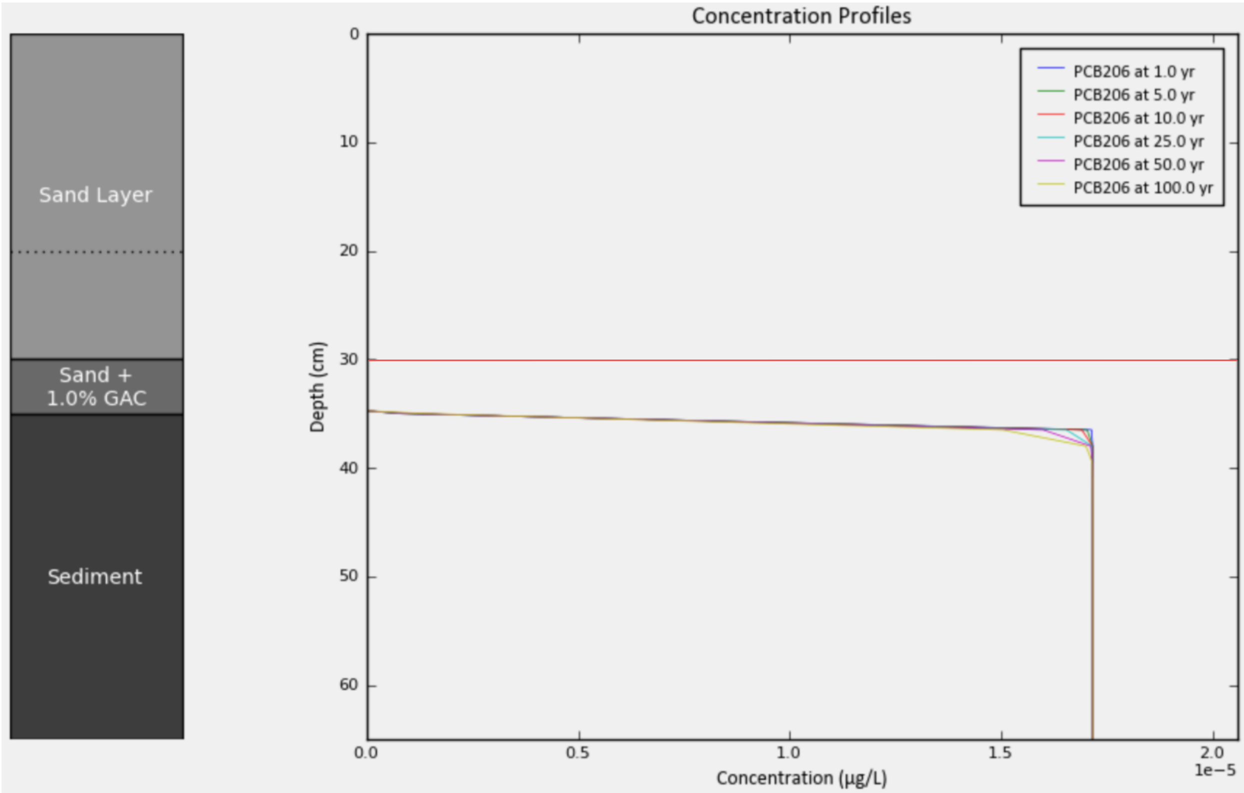

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Lindane at 1.0 yr
Lindane at 5.0 yr
Lindane at 10.0 yr
Lindane at 25.0 yr
Lindane at 50.0 yr
Lindane at 100.0 yr
Depth (cm)
Concentration (µg/L)

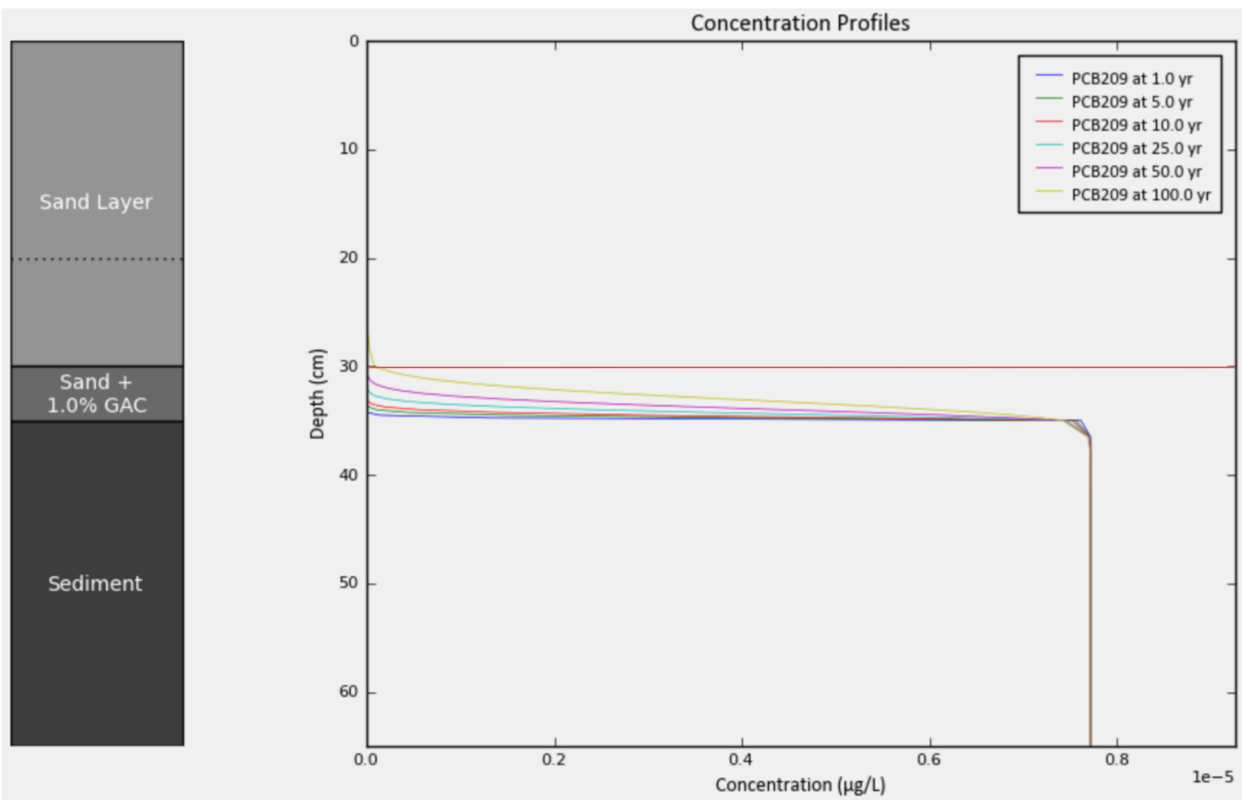

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e4
Manganese at 1.0 yr
Manganese at 5.0 yr
Manganese at 10.0 yr
Manganese at 25.0 yr
Manganese at 50.0 yr
Manganese at 100.0 yr

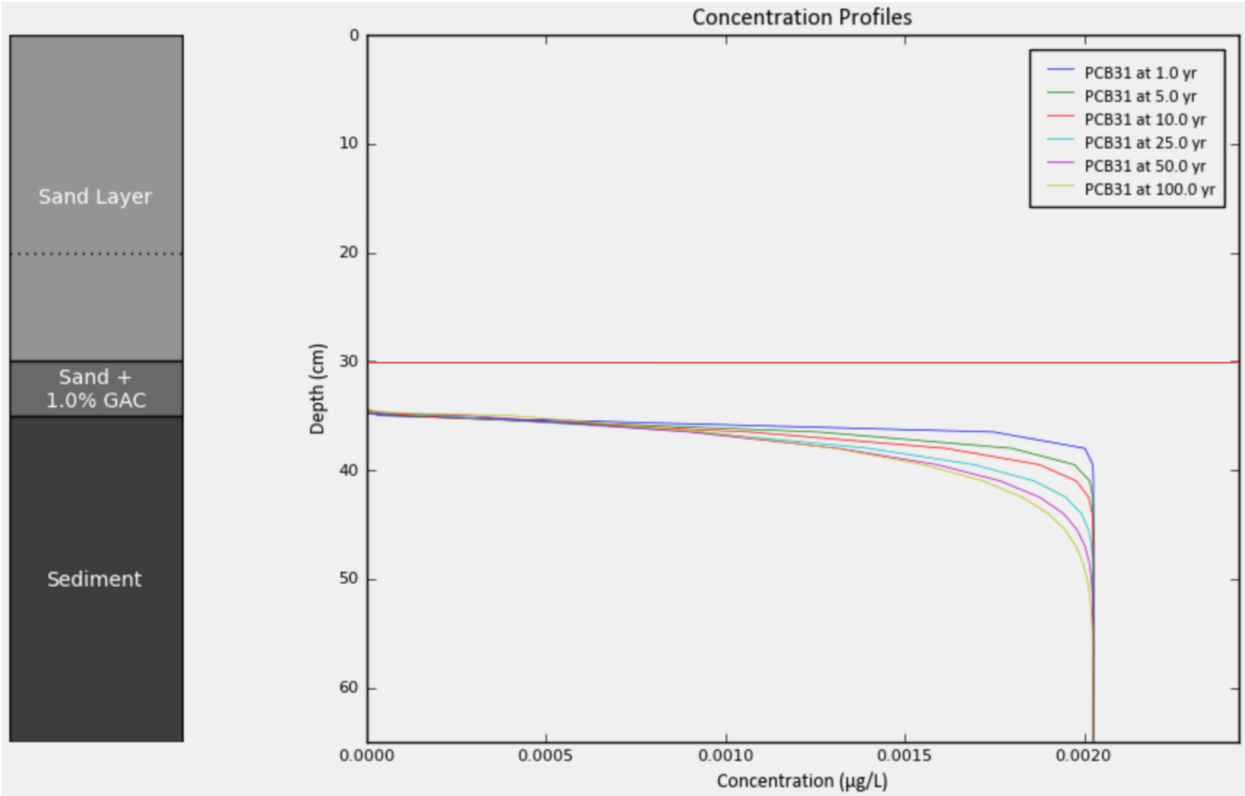

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Mercury at 1.0 yr
Mercury at 5.0 yr
Mercury at 10.0 yr
Mercury at 25.0 yr
Mercury at 50.0 yr
Mercury at 100.0 yr

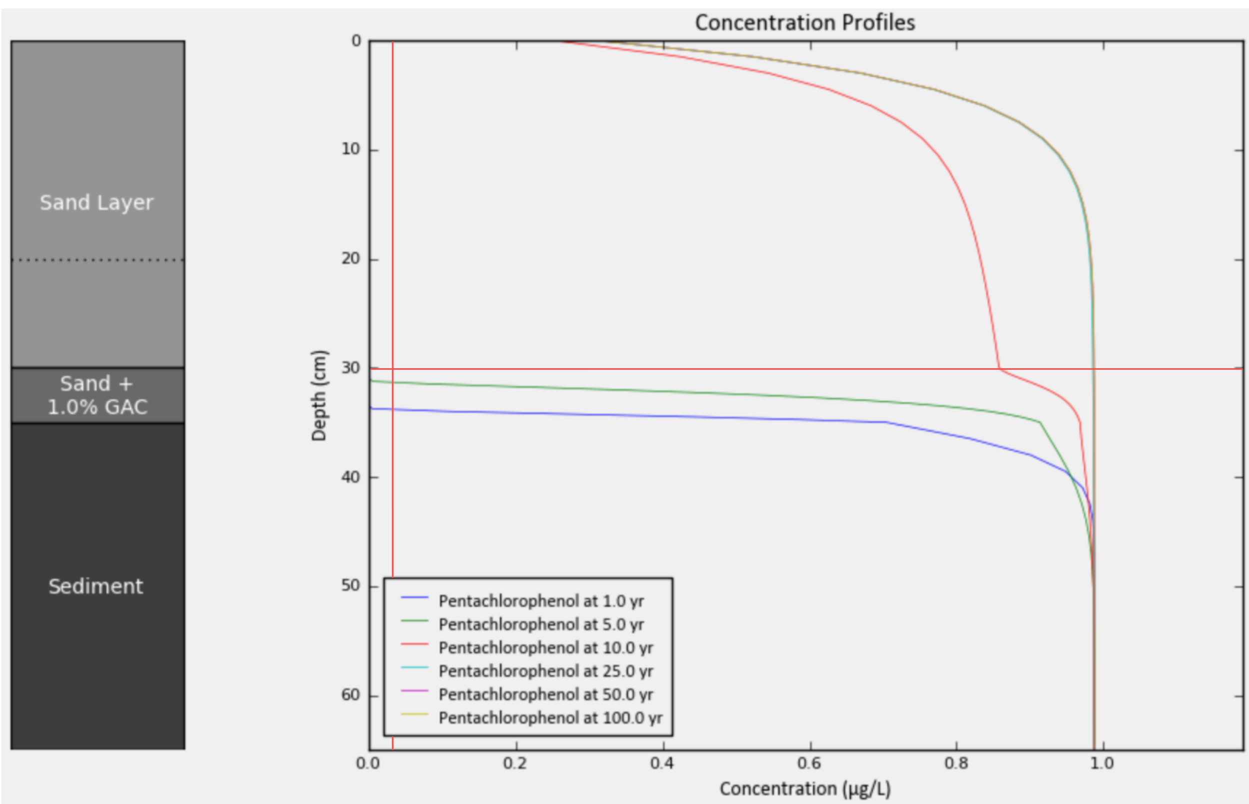

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
PCB1 at 1.0 yr
PCB1 at 5.0 yr
PCB1 at 10.0 yr
PCB1 at 25.0 yr
PCB1 at 50.0 yr
PCB1 at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.000
0.001
0.002
0.003
0.004
0.005

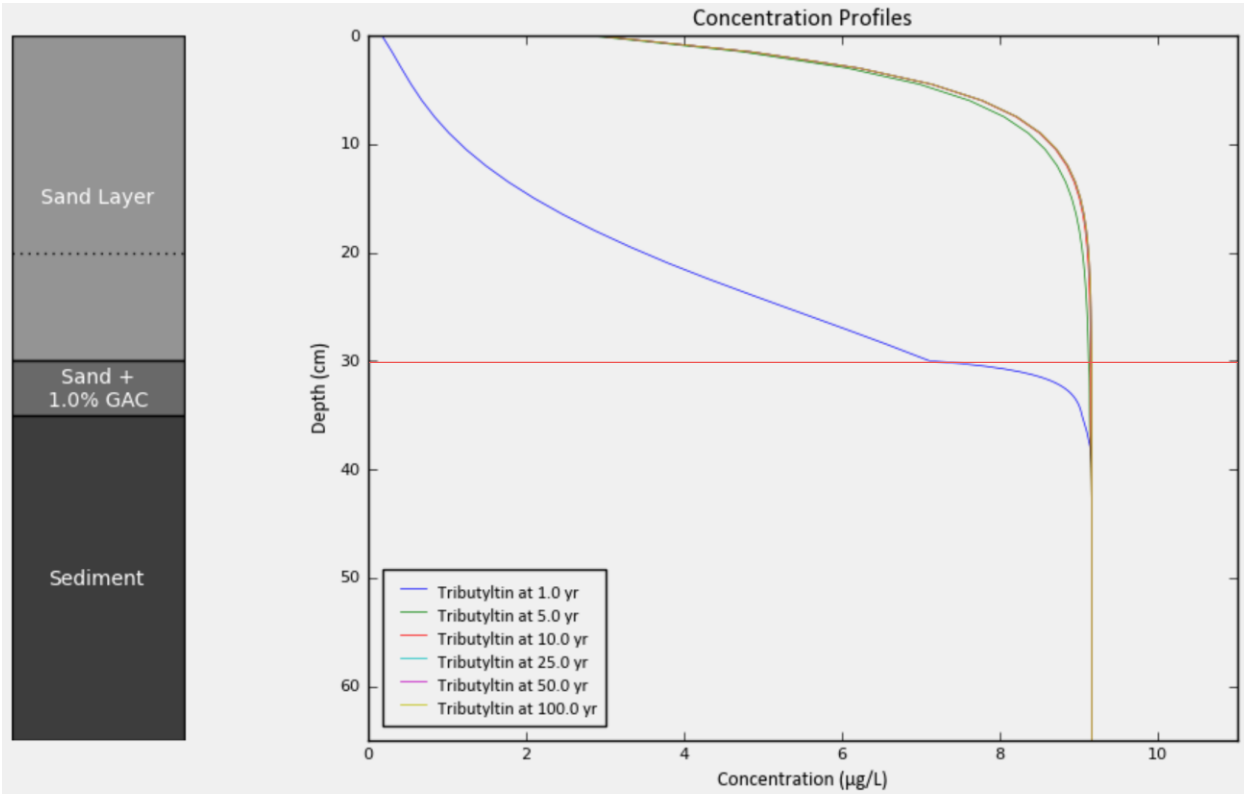

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
PCB15 at 1.0 yr
PCB15 at 5.0 yr
PCB15 at 10.0 yr
PCB15 at 25.0 yr
PCB15 at 50.0 yr
PCB15 at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010

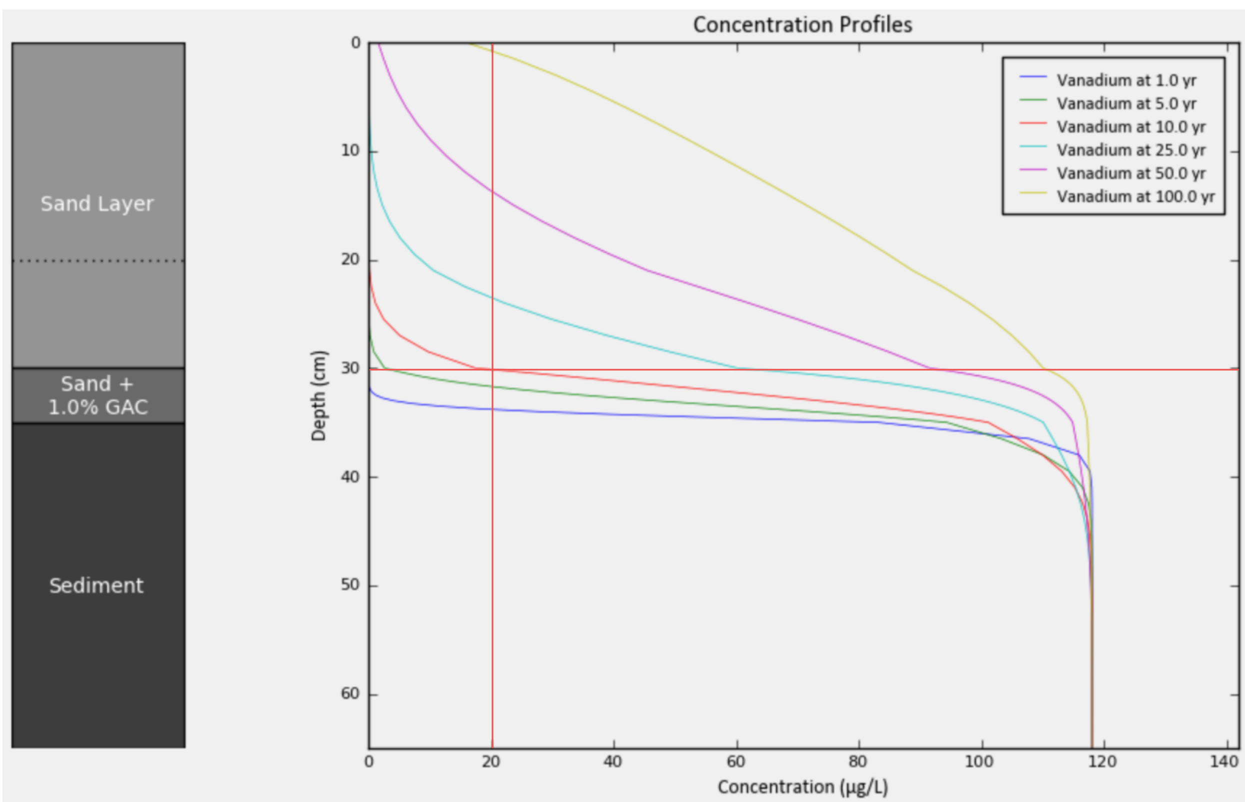

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
PCB206 at 1.0 yr
PCB206 at 5.0 yr
PCB206 at 10.0 yr
PCB206 at 25.0 yr
PCB206 at 50.0 yr
PCB206 at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0
1e−5
Concentration (μg/L)

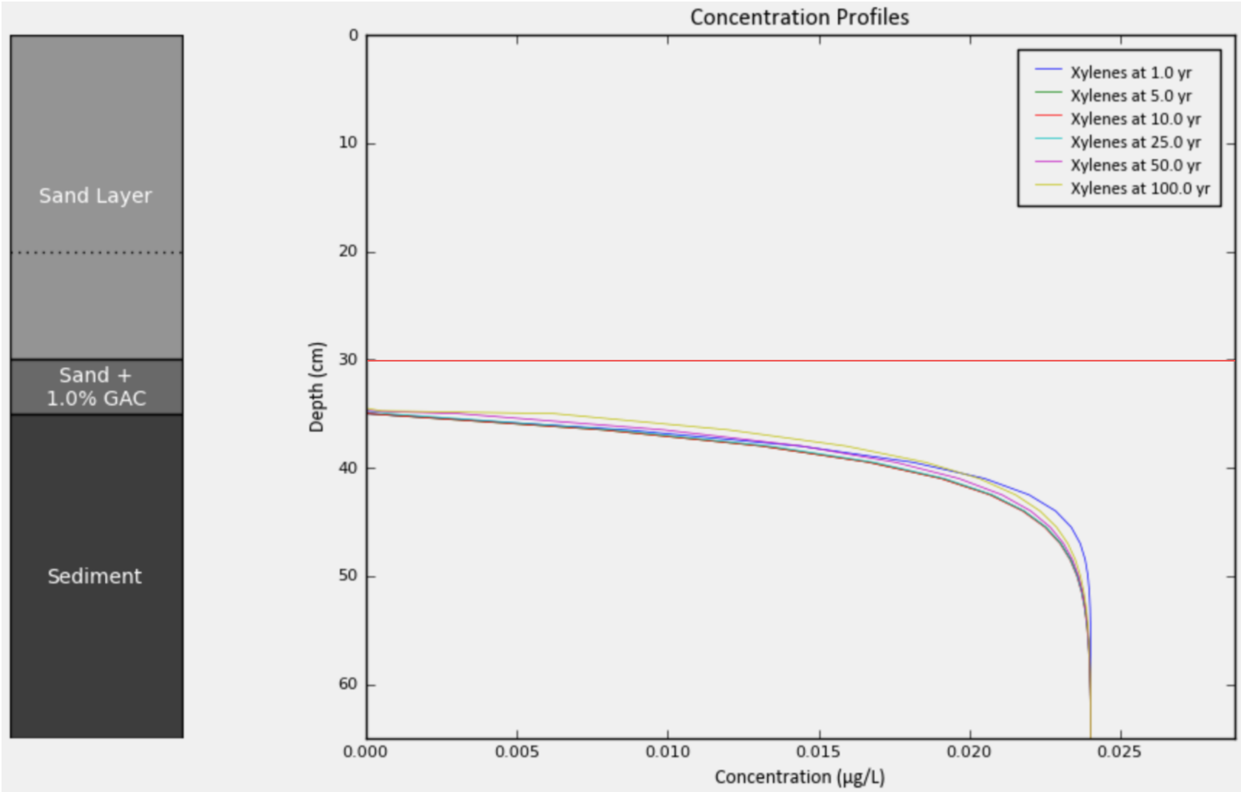

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
PCB209 at 1.0 yr
PCB209 at 5.0 yr
PCB209 at 10.0 yr
PCB209 at 25.0 yr
PCB209 at 50.0 yr
PCB209 at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
0.0
0.2
0.4
0.6
0.8
1e−5
Concentration (μg/L)

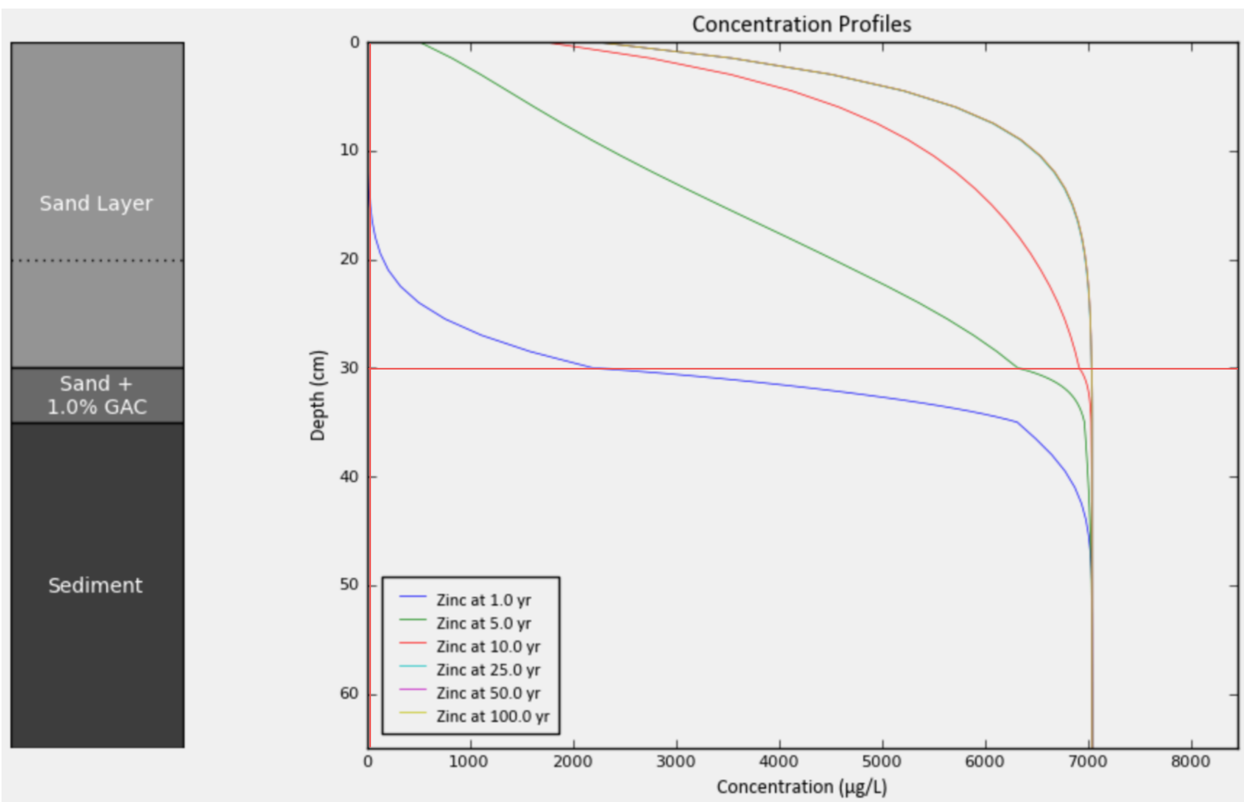

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
PCB31 at 1.0 yr
PCB31 at 5.0 yr
PCB31 at 10.0 yr
PCB31 at 25.0 yr
PCB31 at 50.0 yr
PCB31 at 100.0 yr


Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Pentachlorophenol at 1.0 yr
Pentachlorophenol at 5.0 yr
Pentachlorophenol at 10.0 yr
Pentachlorophenol at 25.0 yr
Pentachlorophenol at 50.0 yr
Pentachlorophenol at 100.0 yr

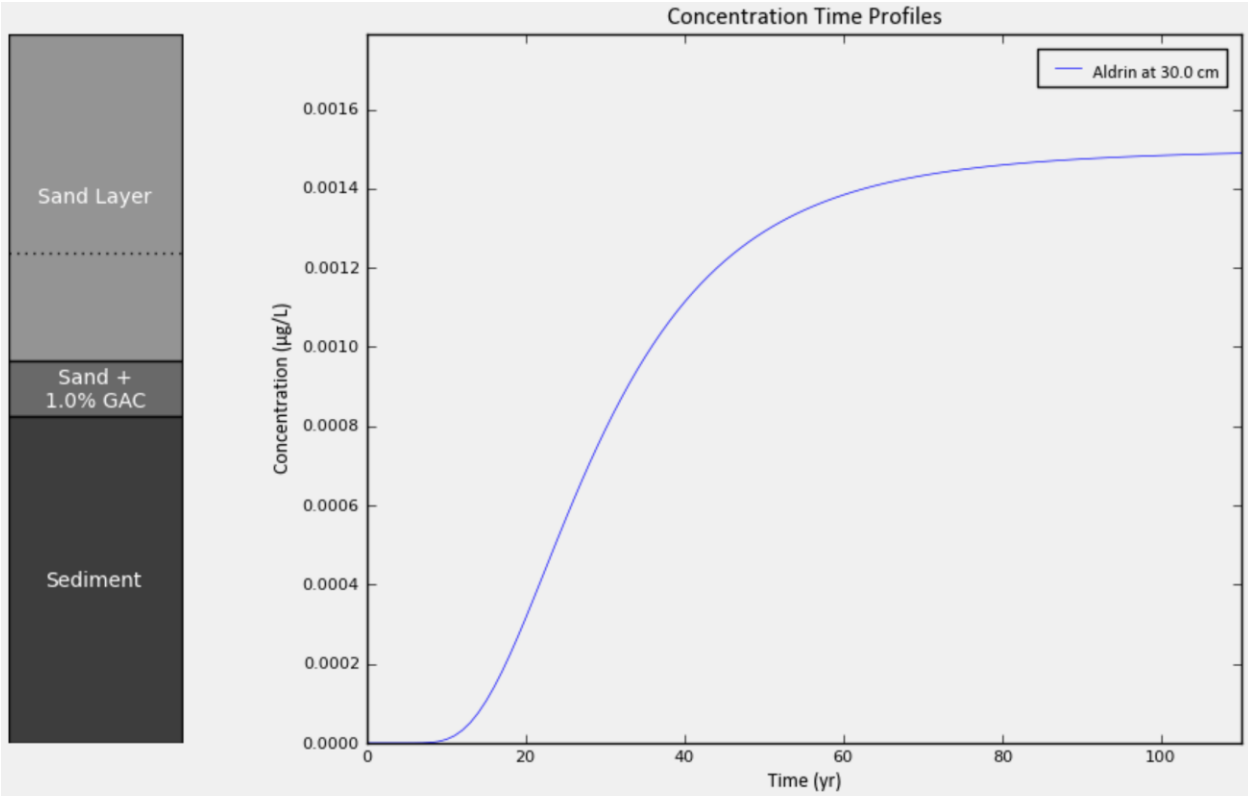

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Tributyltin at 1.0 yr
Tributyltin at 5.0 yr
Tributyltin at 10.0 yr
Tributyltin at 25.0 yr
Tributyltin at 50.0 yr
Tributyltin at 100.0 yr

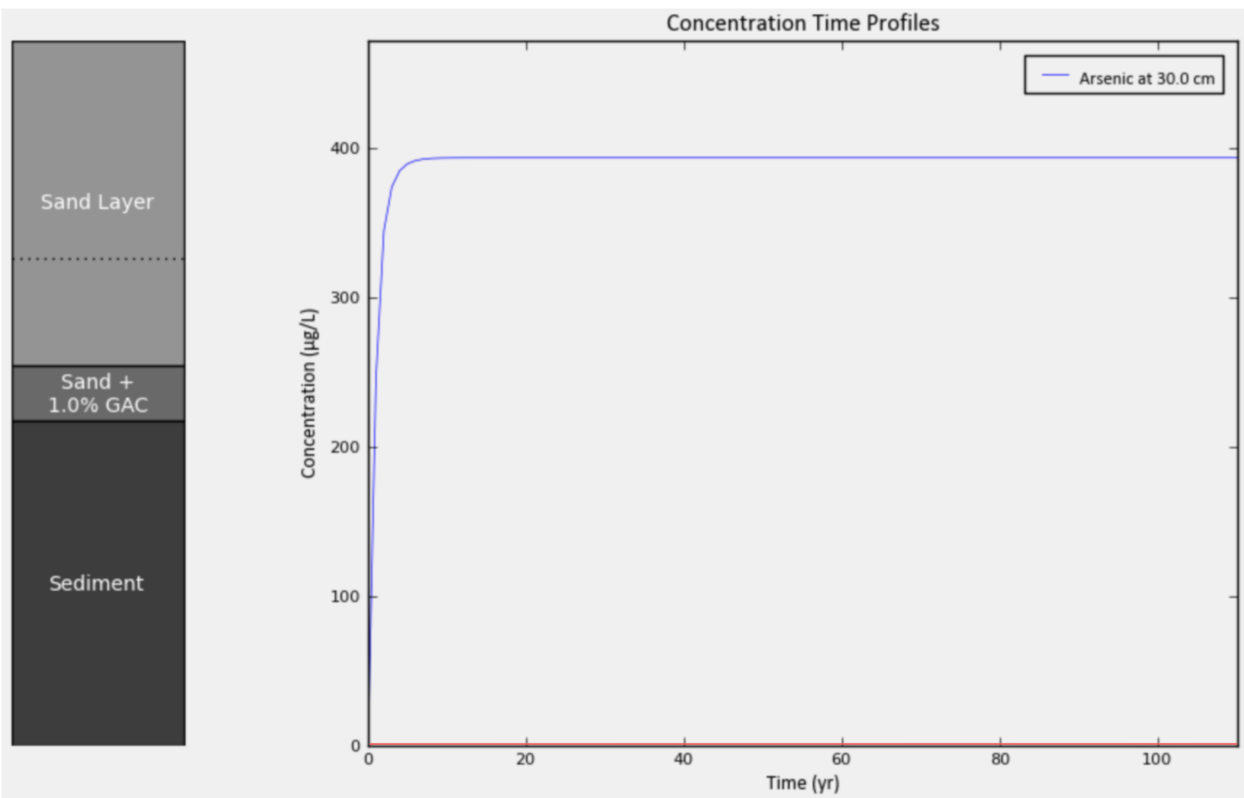

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Vanadium at 1.0 yr
Vanadium at 5.0 yr
Vanadium at 10.0 yr
Vanadium at 25.0 yr
Vanadium at 50.0 yr
Vanadium at 100.0 yr

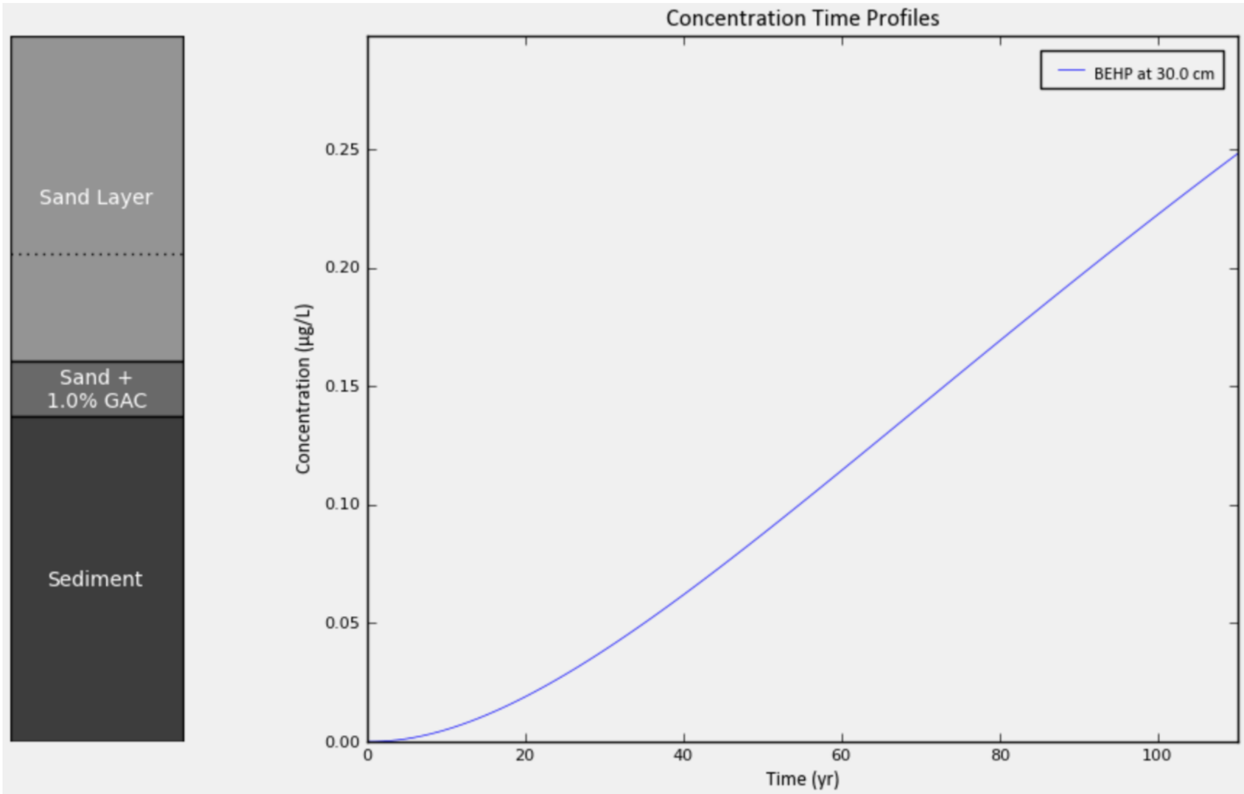

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Xylenes at 1.0 yr
Xylenes at 5.0 yr
Xylenes at 10.0 yr
Xylenes at 25.0 yr
Xylenes at 50.0 yr
Xylenes at 100.0 yr
0
10
20
30
40
50
60
0.000
0.005
0.010
0.015
0.020
0.025

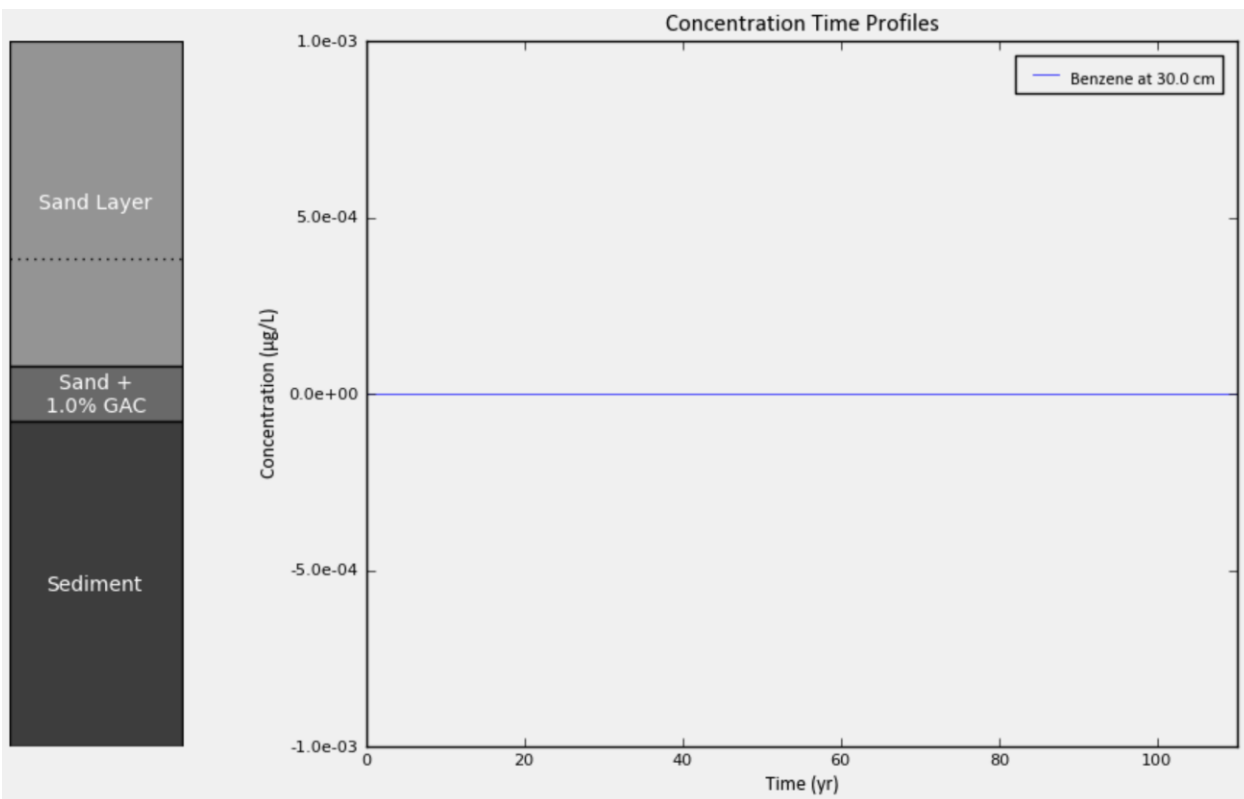

Concentration Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Zinc at 1.0 yr
Zinc at 5.0 yr
Zinc at 10.0 yr
Zinc at 25.0 yr
Zinc at 50.0 yr
Zinc at 100.0 yr
0
10
20
30
40
50
60
0
1000
2000
3000
4000
5000
6000
7000
8000

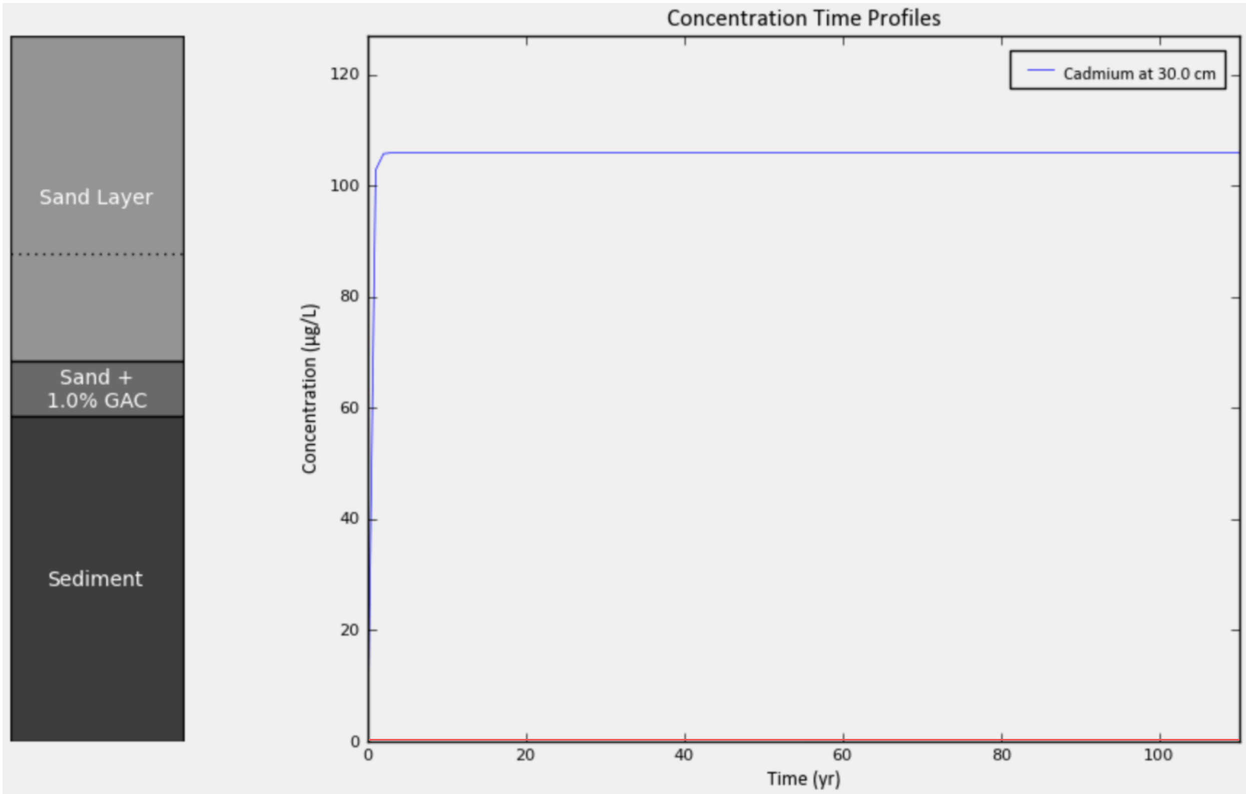
Porewater Concentration – Time

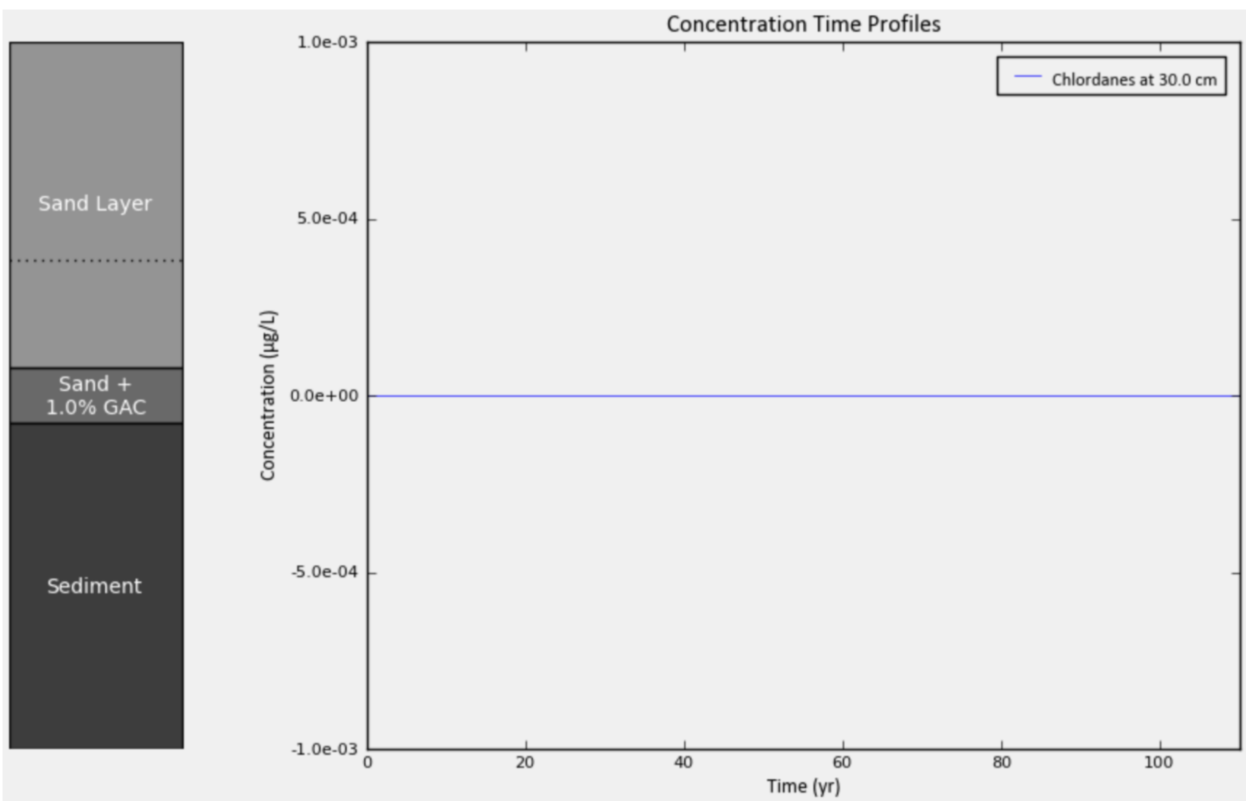


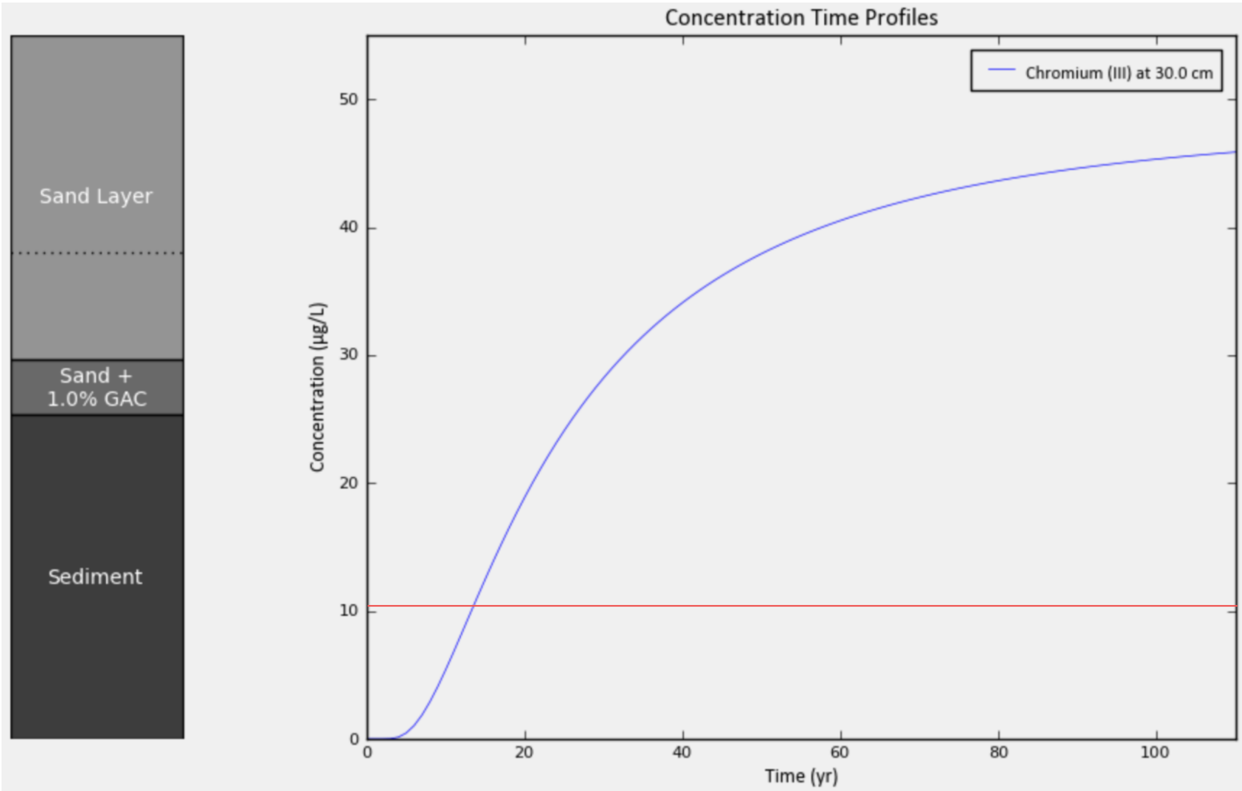


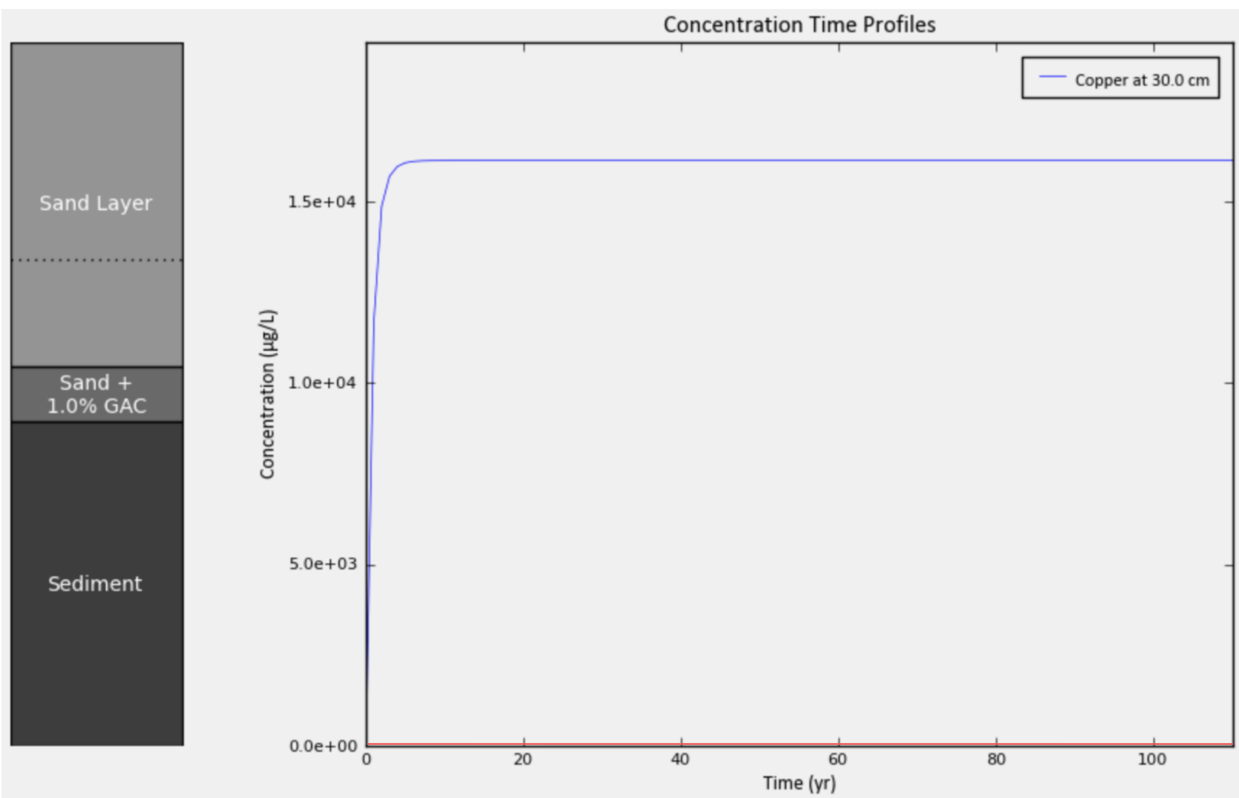

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
BEHP at 30.0 cm
Concentration (µg/L)
0.25
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
Time (yr)

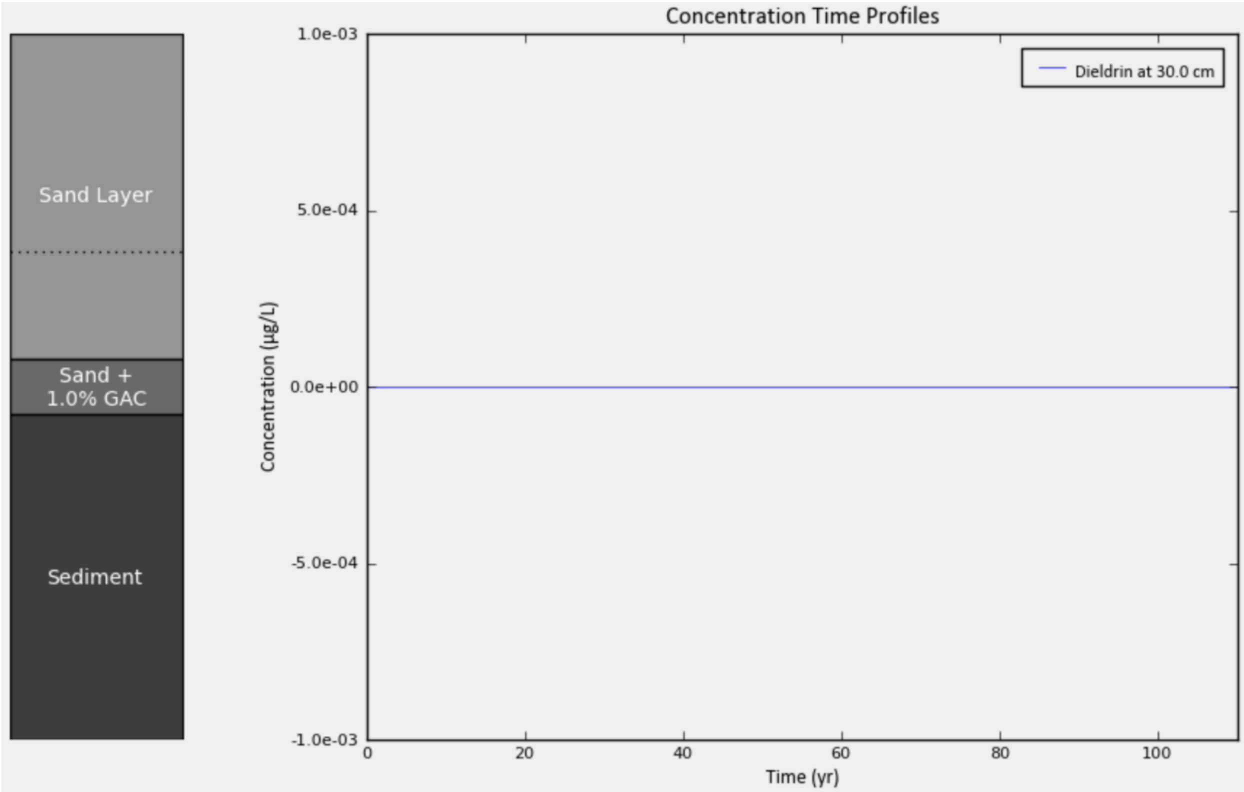

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
Benzene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

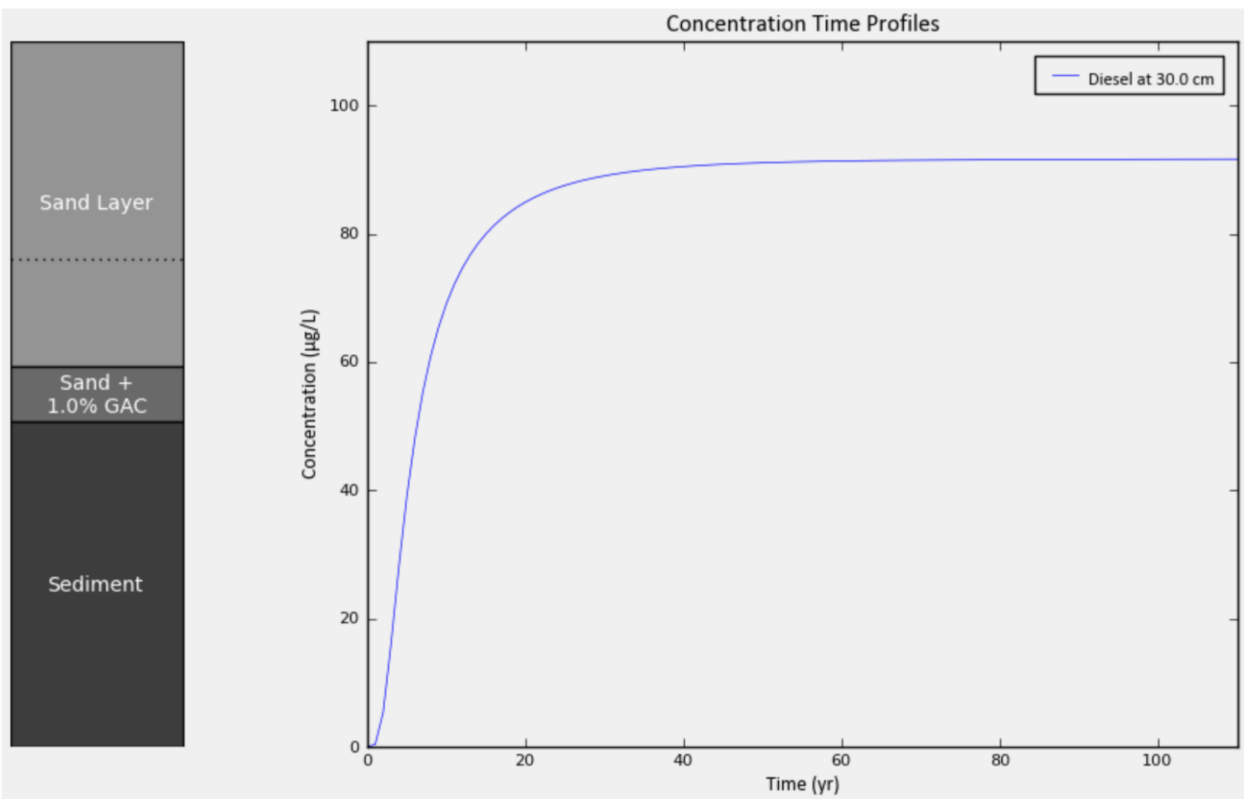

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Cadmium at 30.0 cm
Concentration (µg/L)
Time (yr)
0
20
40
60
80
100
120
0
20
40
60
80
100

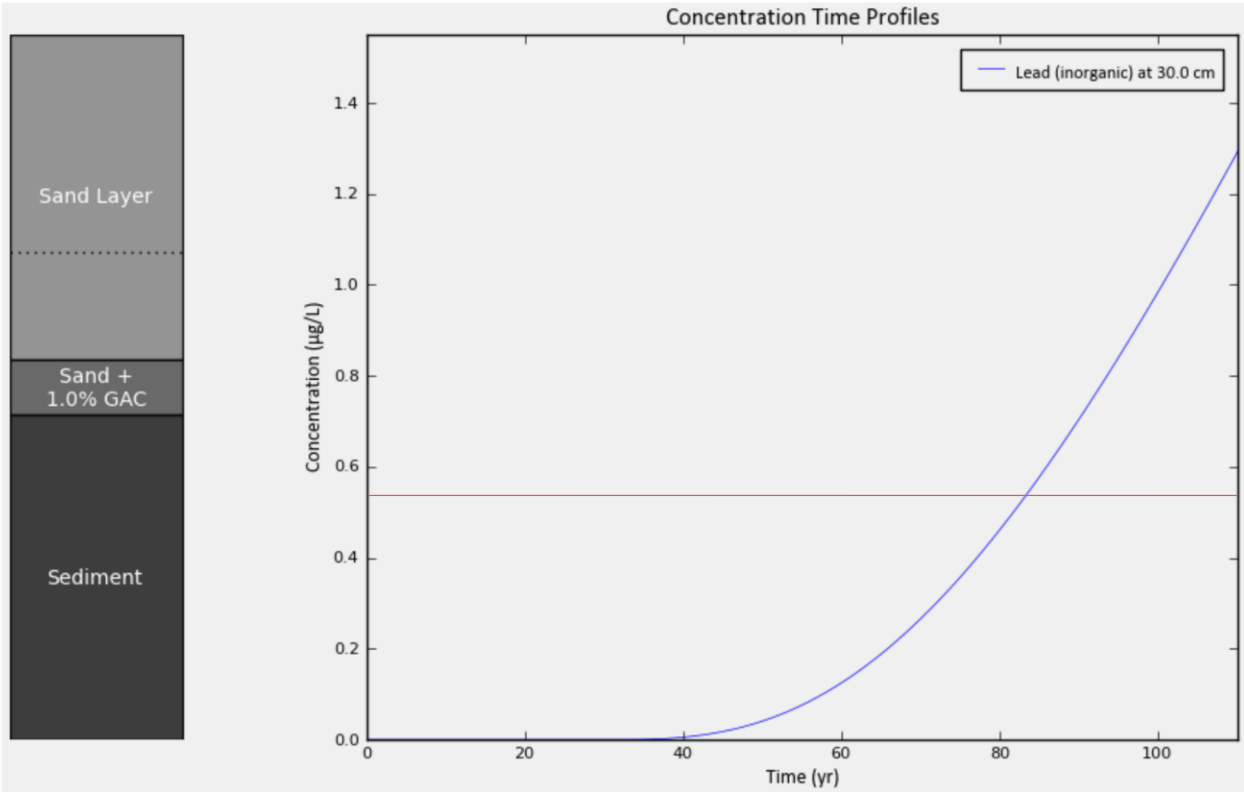

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Chlordanes at 30.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

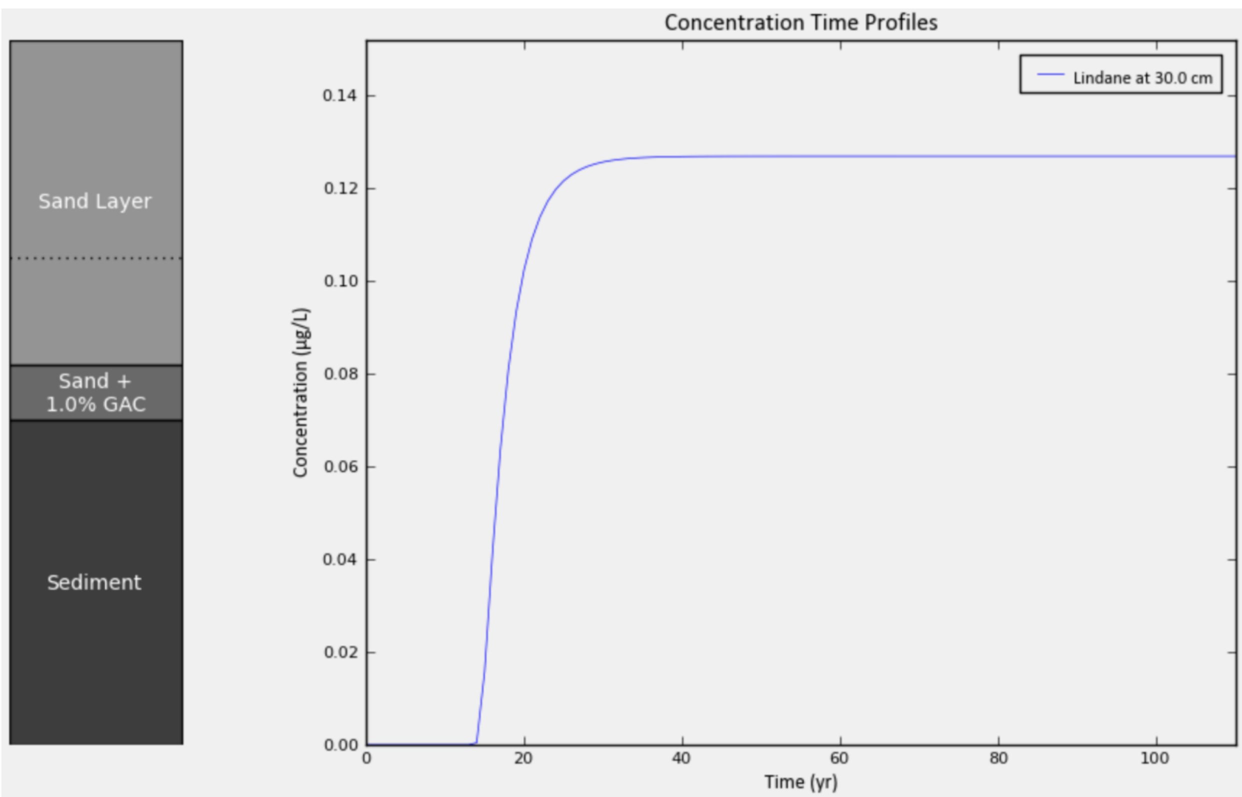

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Chromium (III) at 30.0 cm
Concentration (µg/L)
Time (yr)
0
10
20
30
40
50
0
20
40
60
80
100

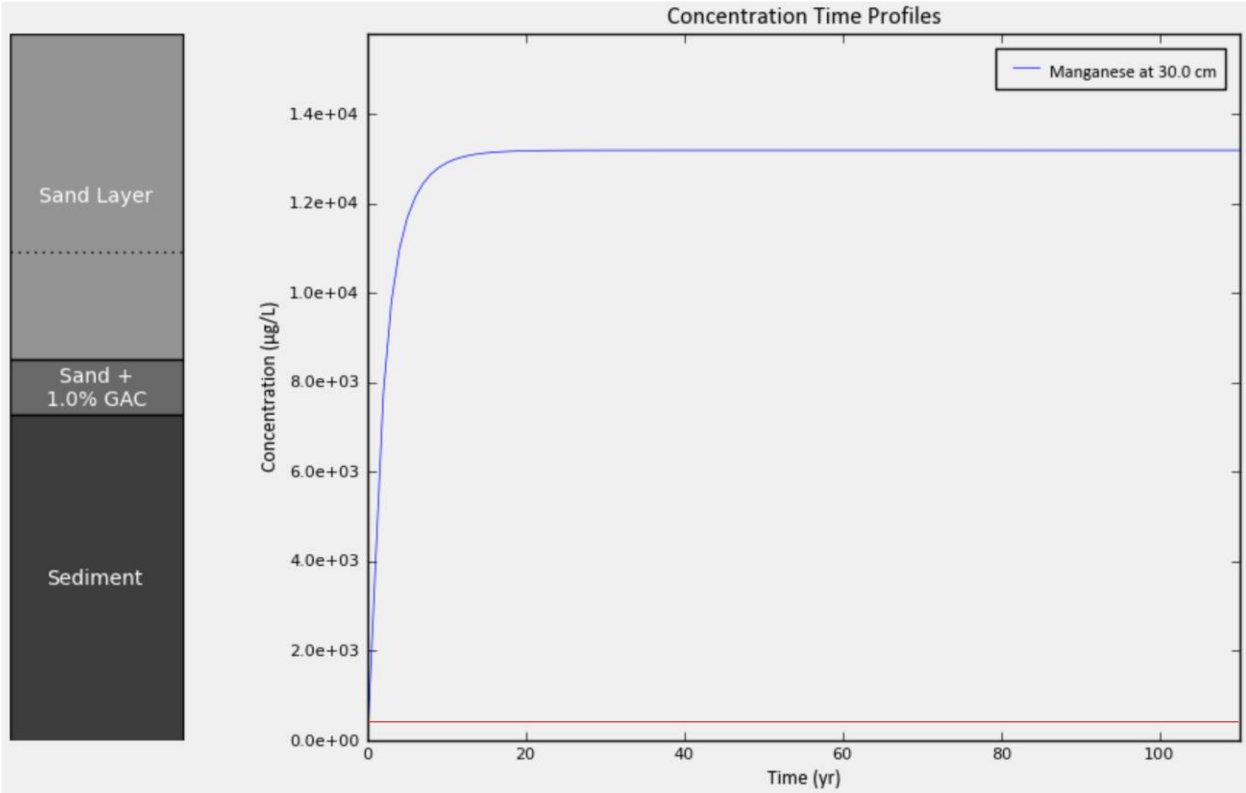

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Copper at 30.0 cm
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e+03
1.0e+04
1.5e+04
0
20
40
60
80
100

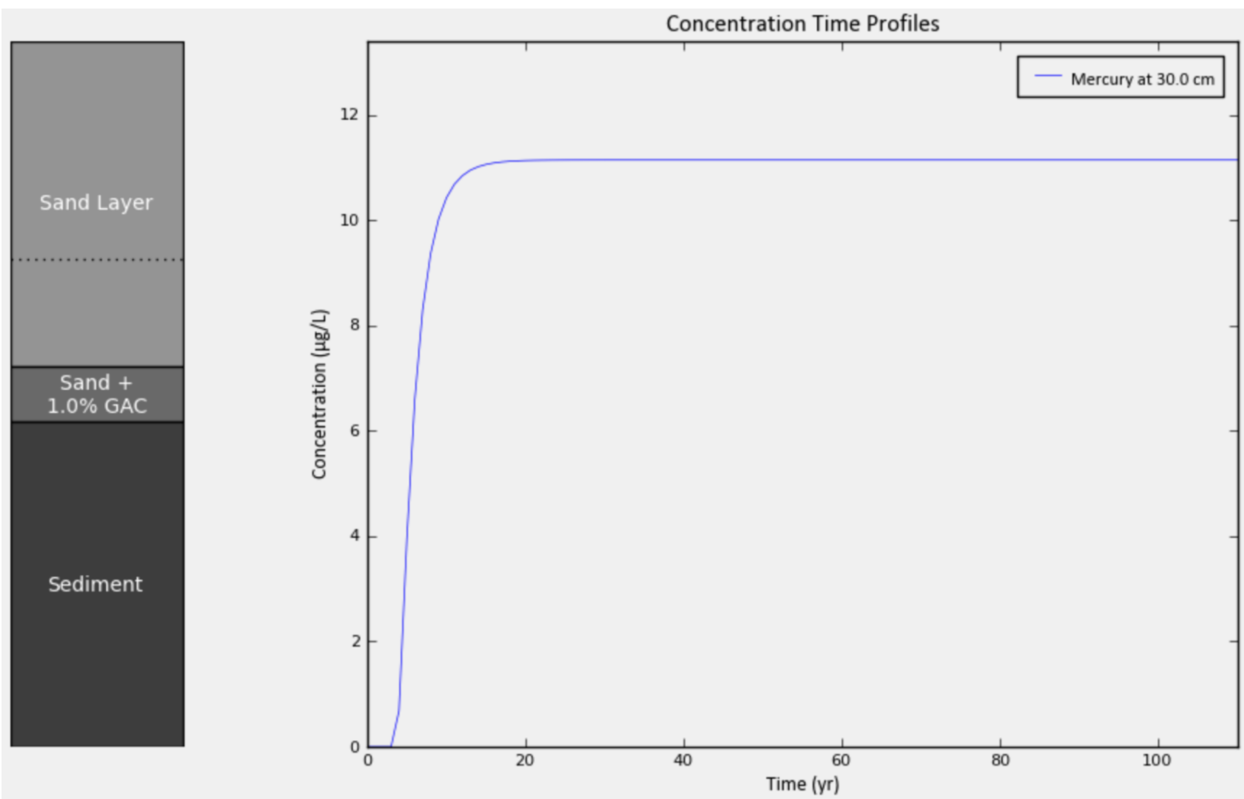

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
Dieldrin at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

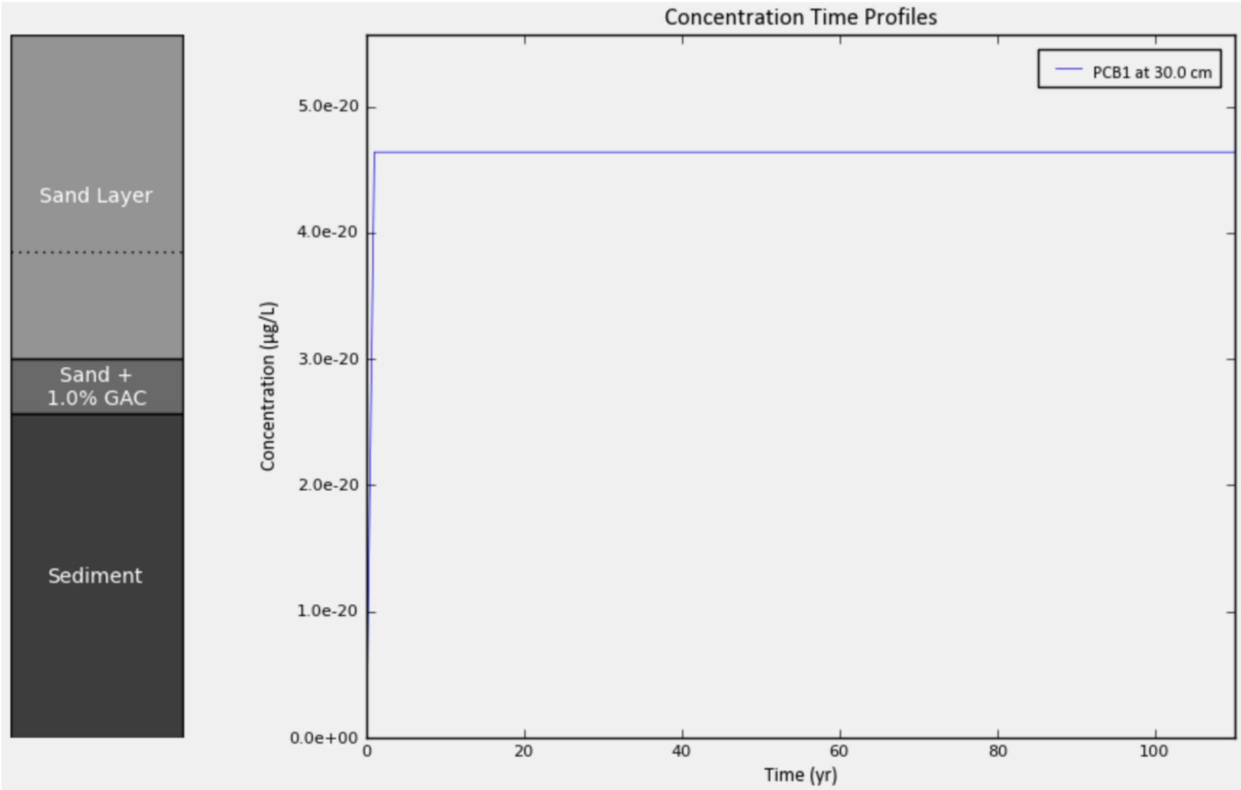

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
Diesel at 30.0 cm
Concentration (µg/L)
100
80
60
40
20
0
20
40
60
80
100
Time (yr)

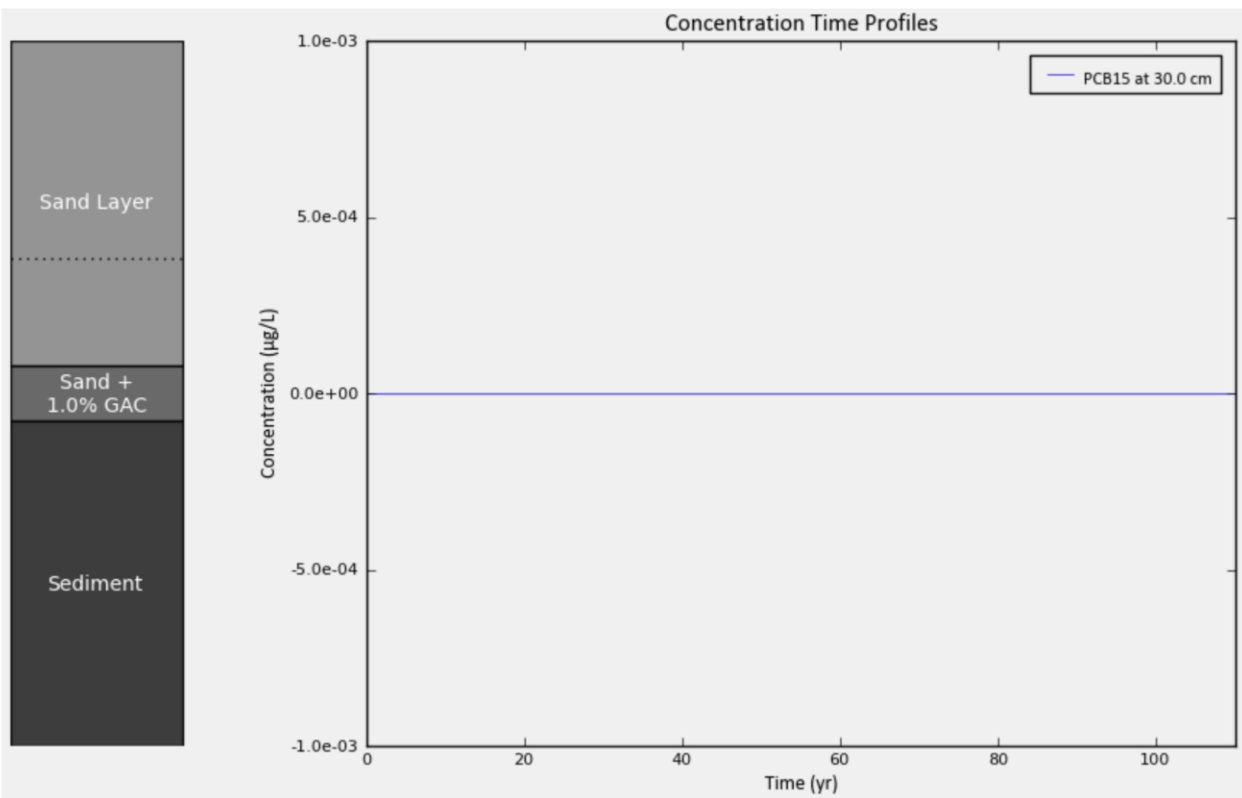

Concentration Time Profiles
Lead (inorganic) at 30.0 cm
Sand Layer
Sand +
1.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
20
40
60
80
100

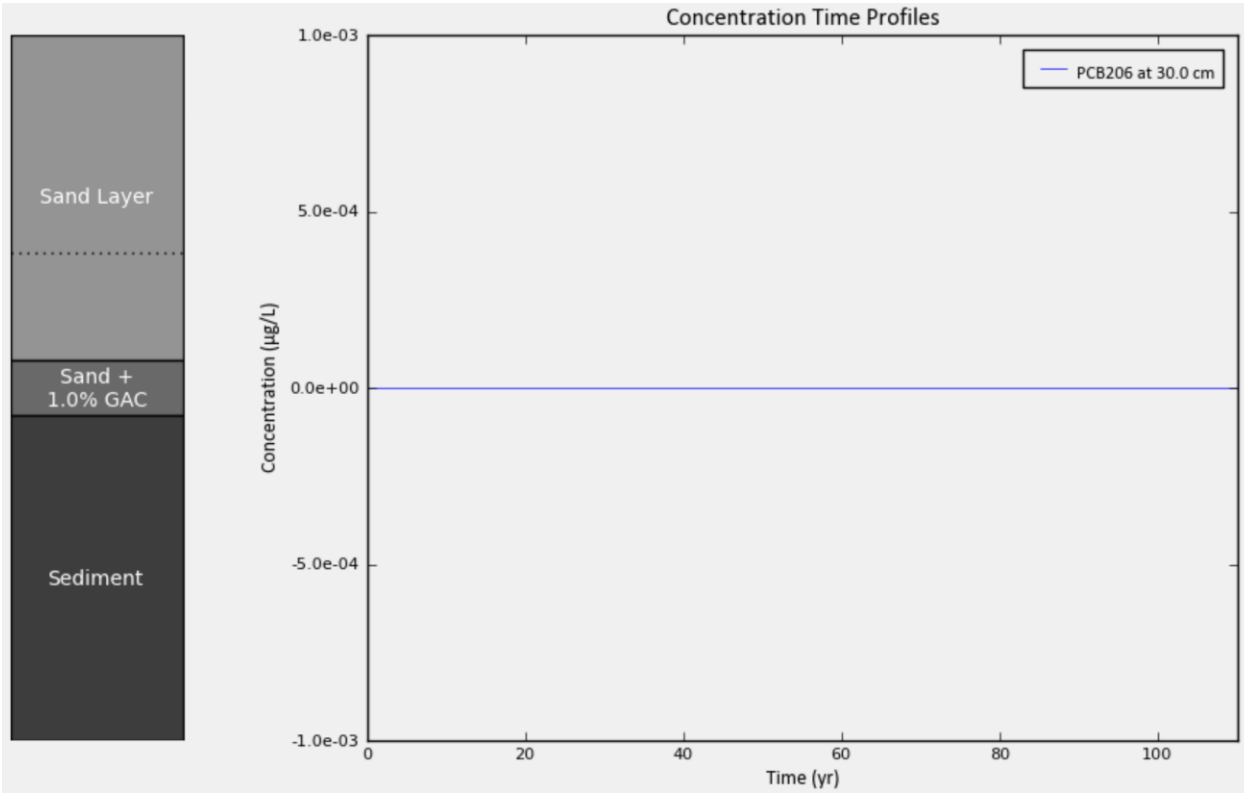

Concentration Time Profiles
Lindane at 30.0 cm
Sand Layer
Sand +
1.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
20
40
60
80
100

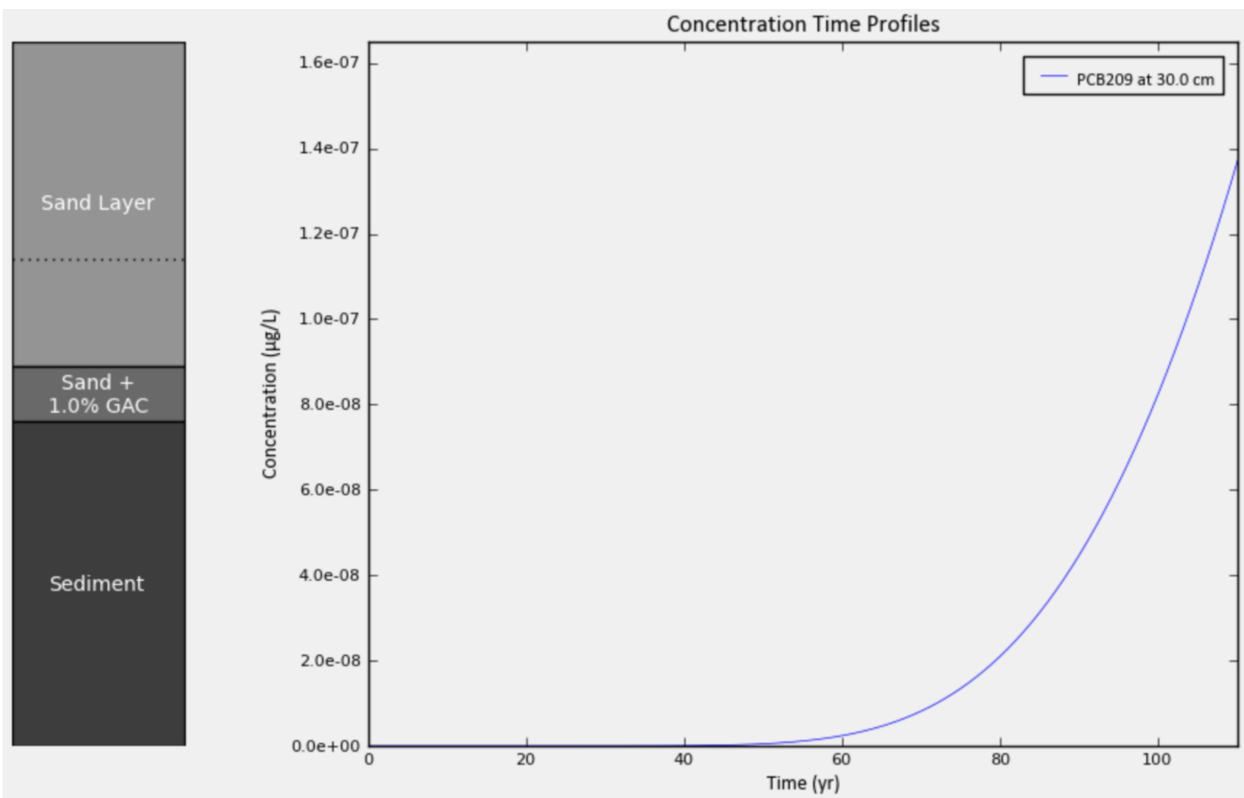

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Manganese at 30.0 cm
Concentration (µg/L)
1.4e+04
1.2e+04
1.0e+04
8.0e+03
6.0e+03
4.0e+03
2.0e+03
0.0e+00
0
20
40
60
80
100
Time (yr)

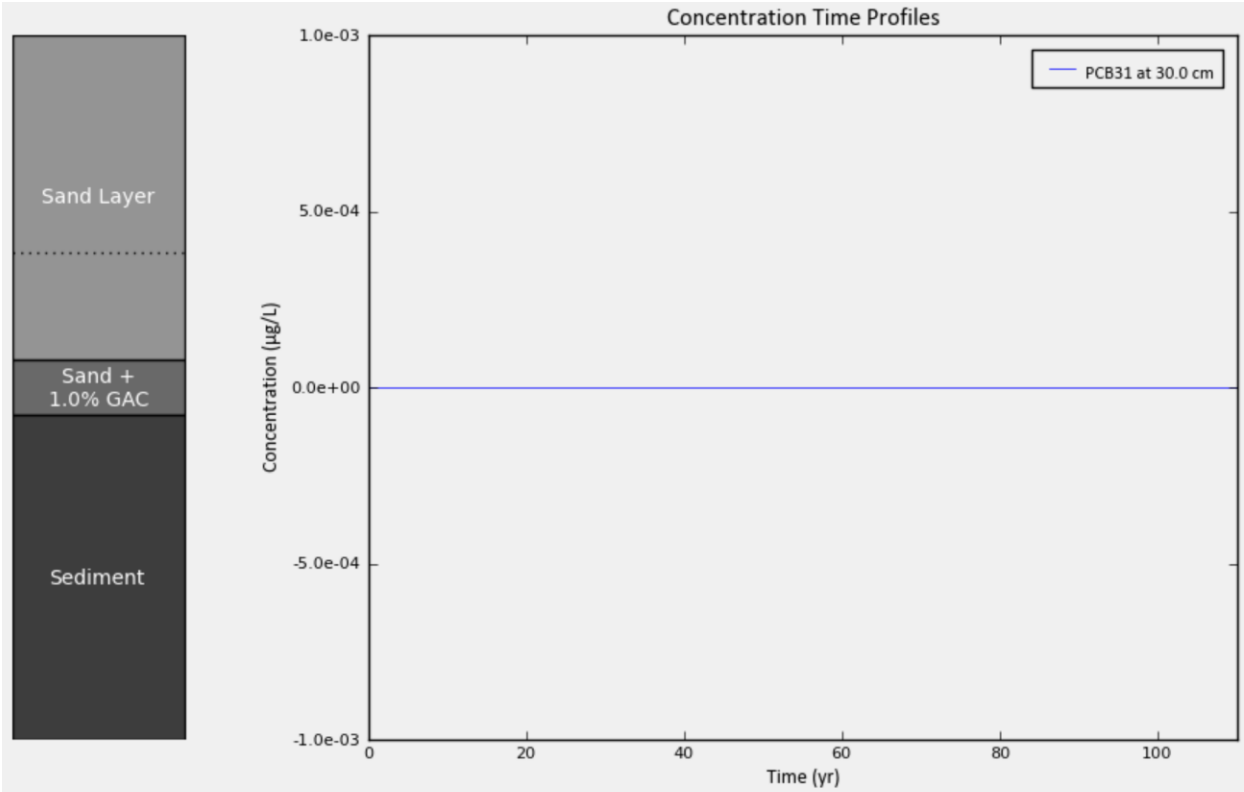

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Mercury at 30.0 cm
Concentration (µg/L)
12
10
8
6
4
2
0
0
20
40
60
80
100
Time (yr)

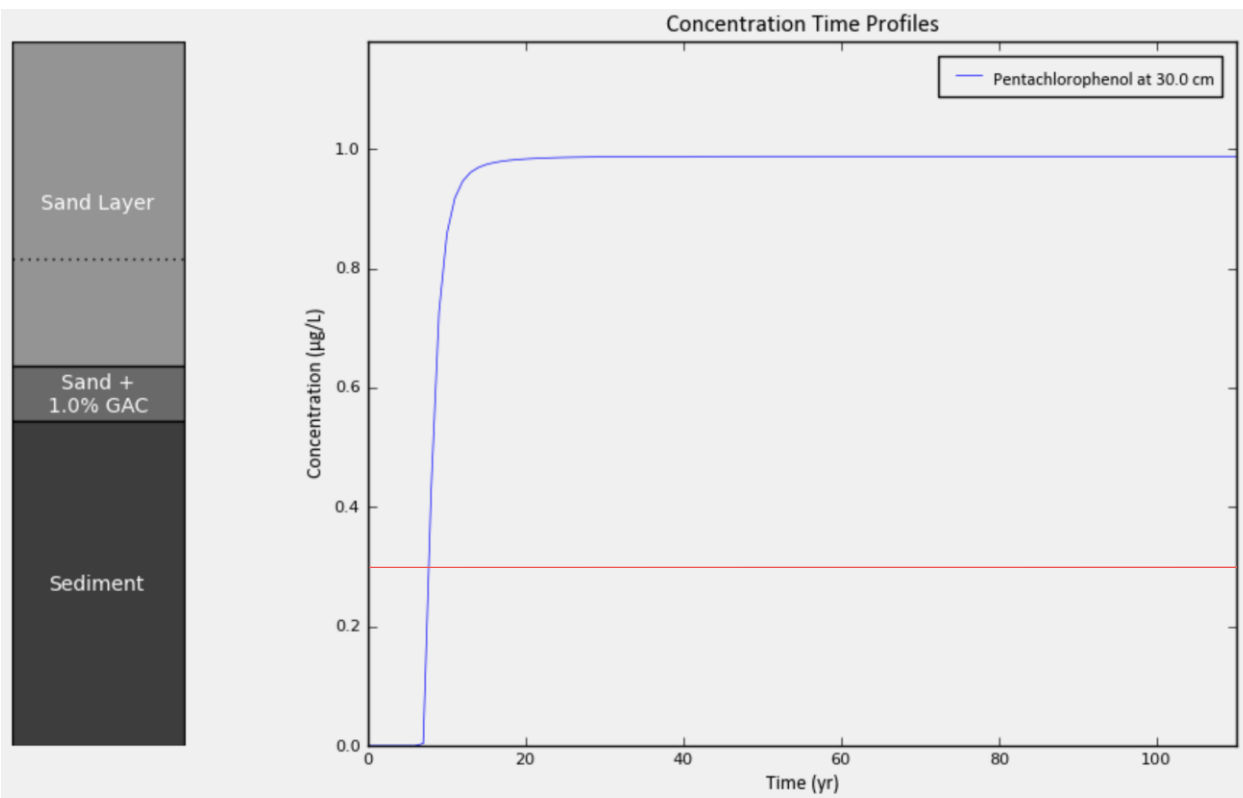

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
PCB1 at 30.0 cm
Concentration (µg/L)
5.0e-20
4.0e-20
3.0e-20
2.0e-20
1.0e-20
0.0e+00
0
20
40
60
80
100
Time (yr)

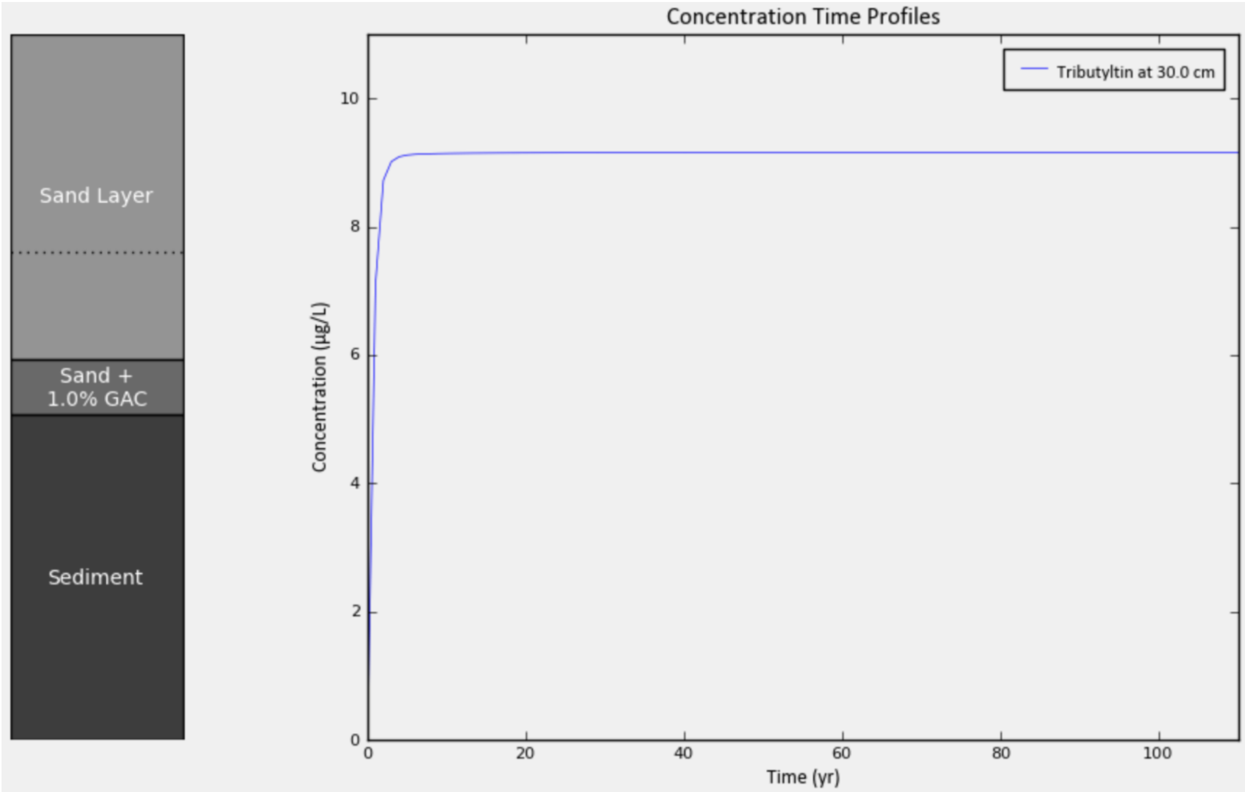

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
PCB15 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

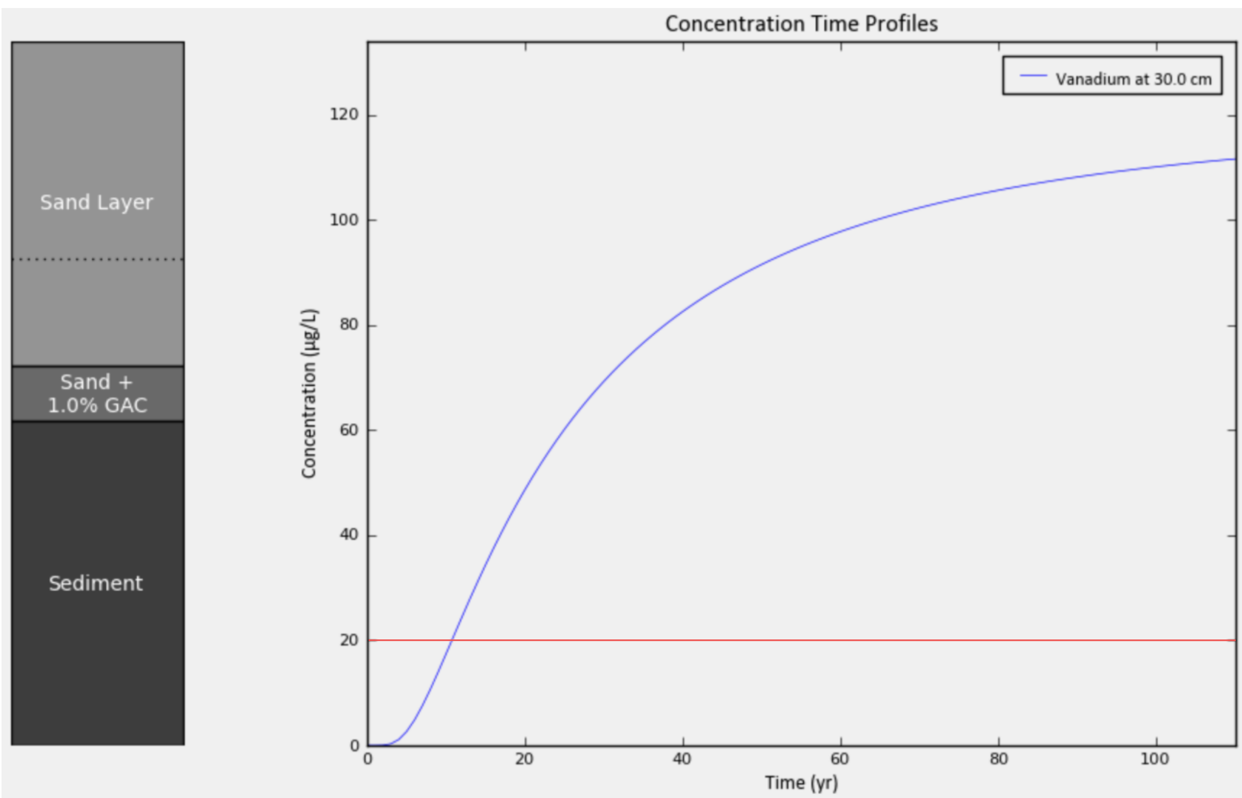

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
PCB206 at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

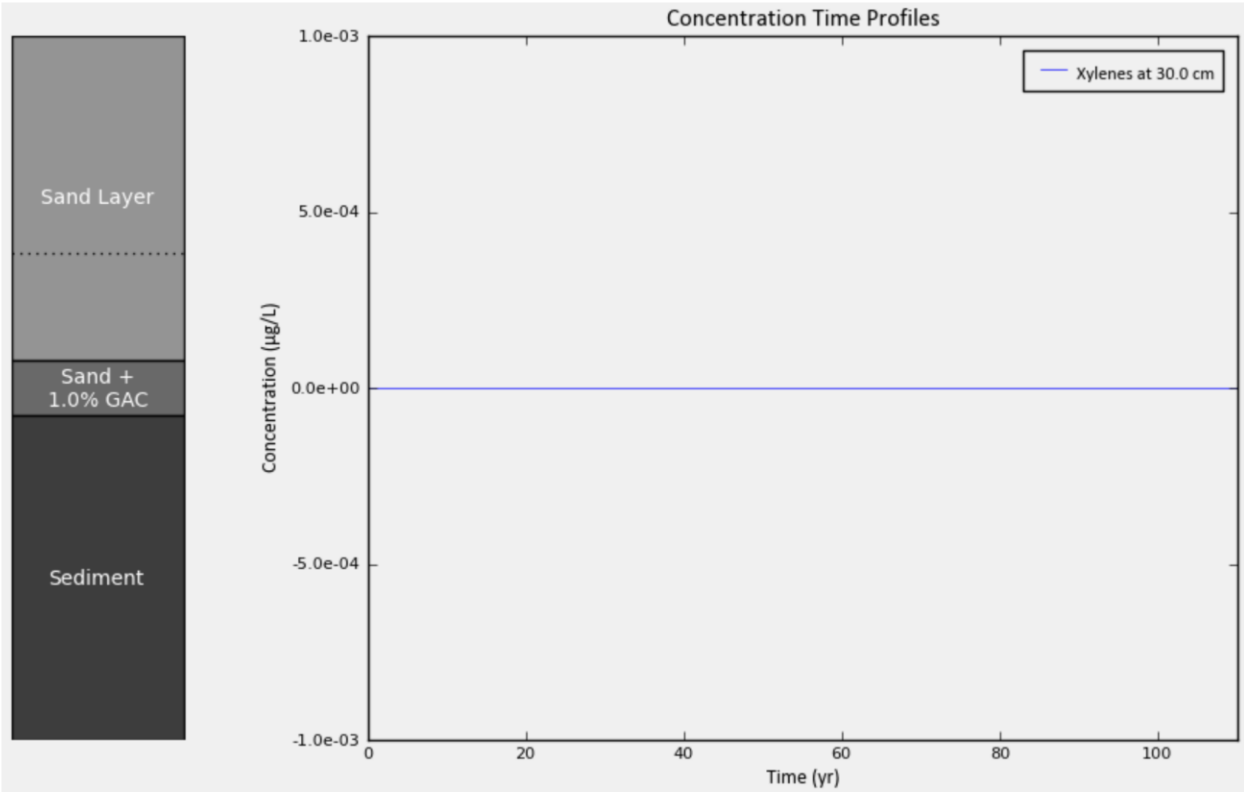

Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
PCB209 at 30.0 cm
Concentration (μg/L)
1.6e-07
1.4e-07
1.2e-07
1.0e-07
8.0e-08
6.0e-08
4.0e-08
2.0e-08
0.0e+00
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
PCB31 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Pentachlorophenol at 30.0 cm
Concentration (µg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Tributyltin at 30.0 cm
Concentration (µg/L)
Time (yr)
0
2
4
6
8
10
20
40
60
80
100


Concentration Time Profiles
Sand Layer
Sand +
1.0% GAC
Sediment
Vanadium at 30.0 cm
Concentration (µg/L)
Time (yr)
0
20
40
60
80
100
120


Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
Xylenes at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

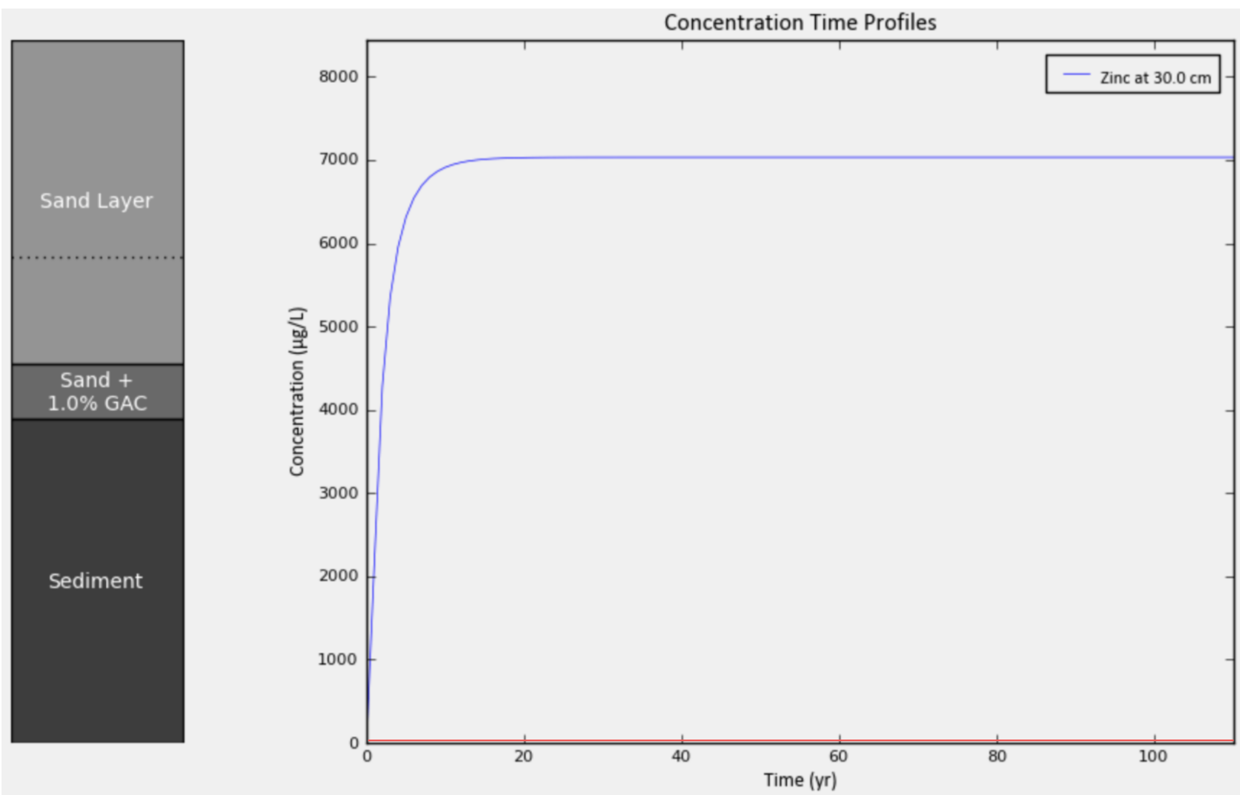
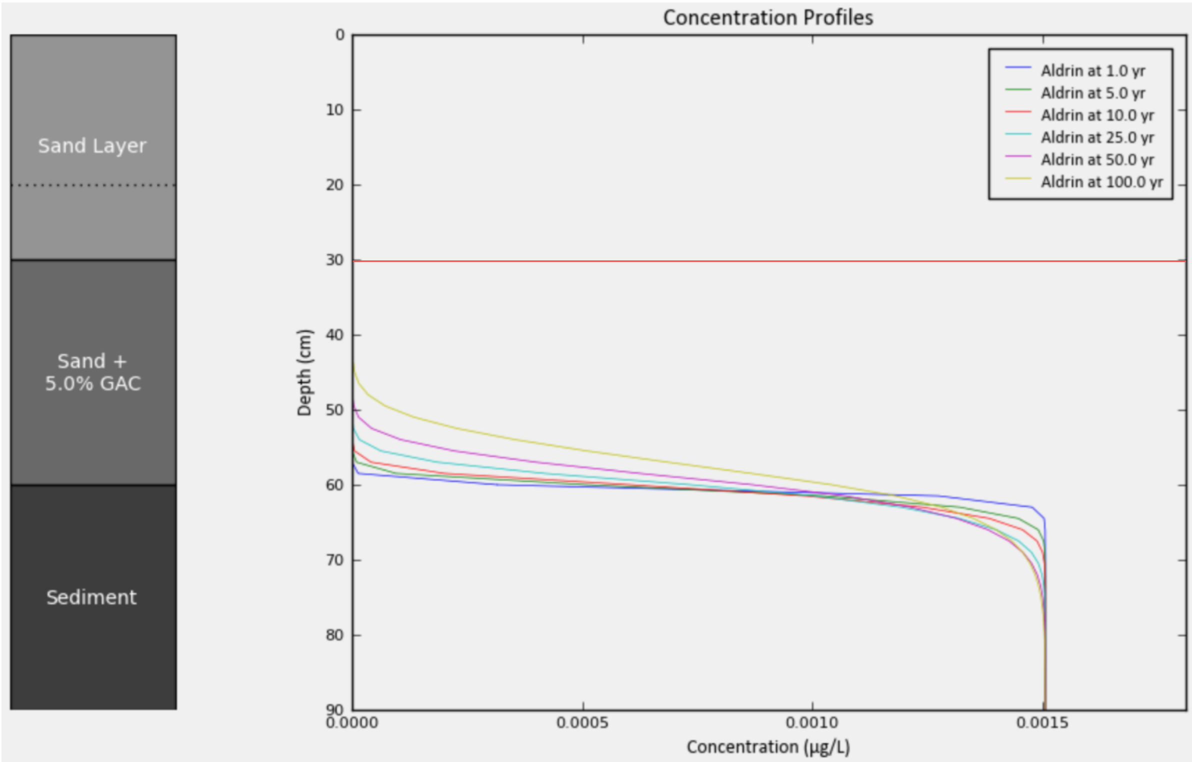
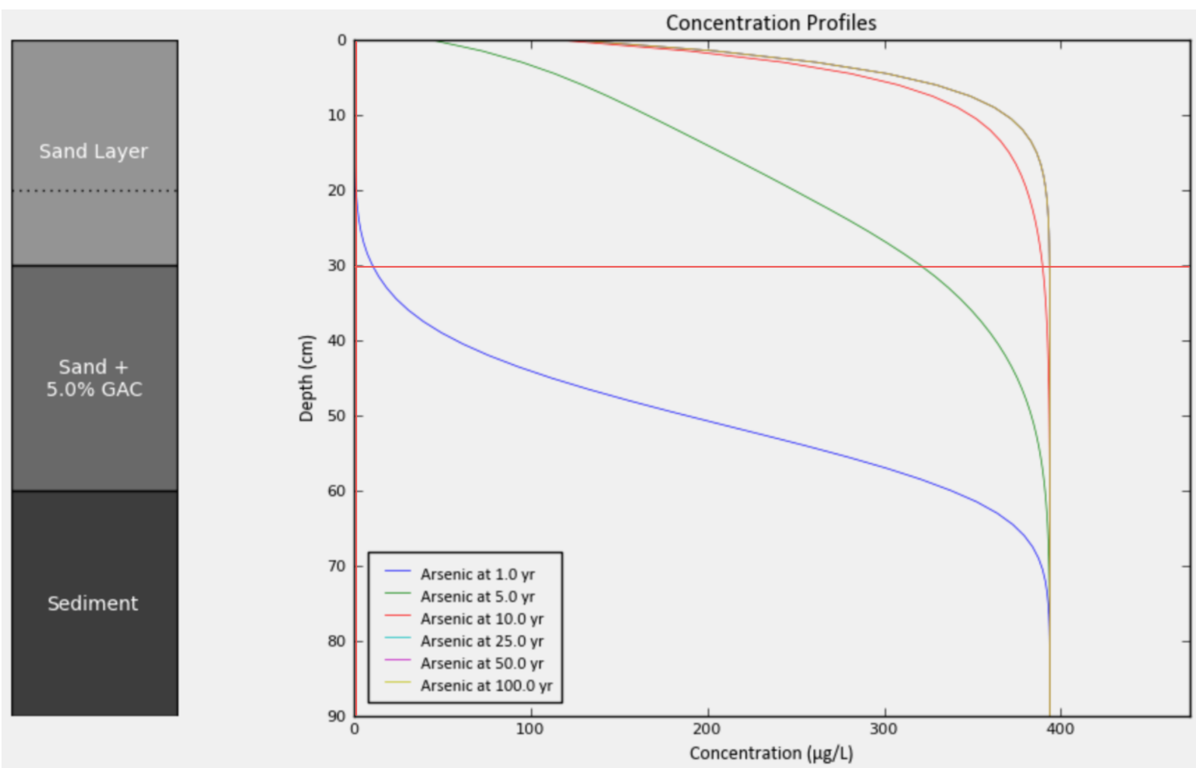
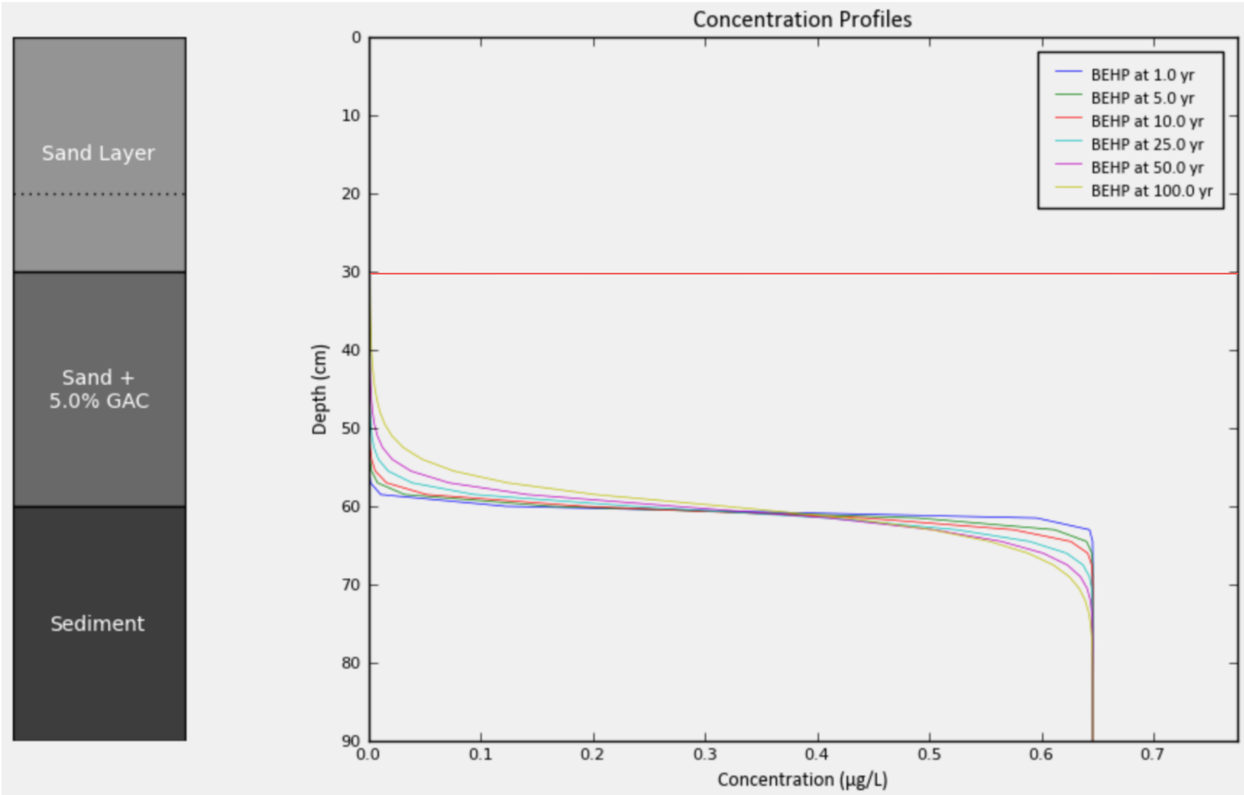

Sand Layer
Sand +
1.0% GAC
Sediment
Concentration Time Profiles
Zinc at 30.0 cm
8000
7000
6000
5000
4000
3000
2000
1000
0
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

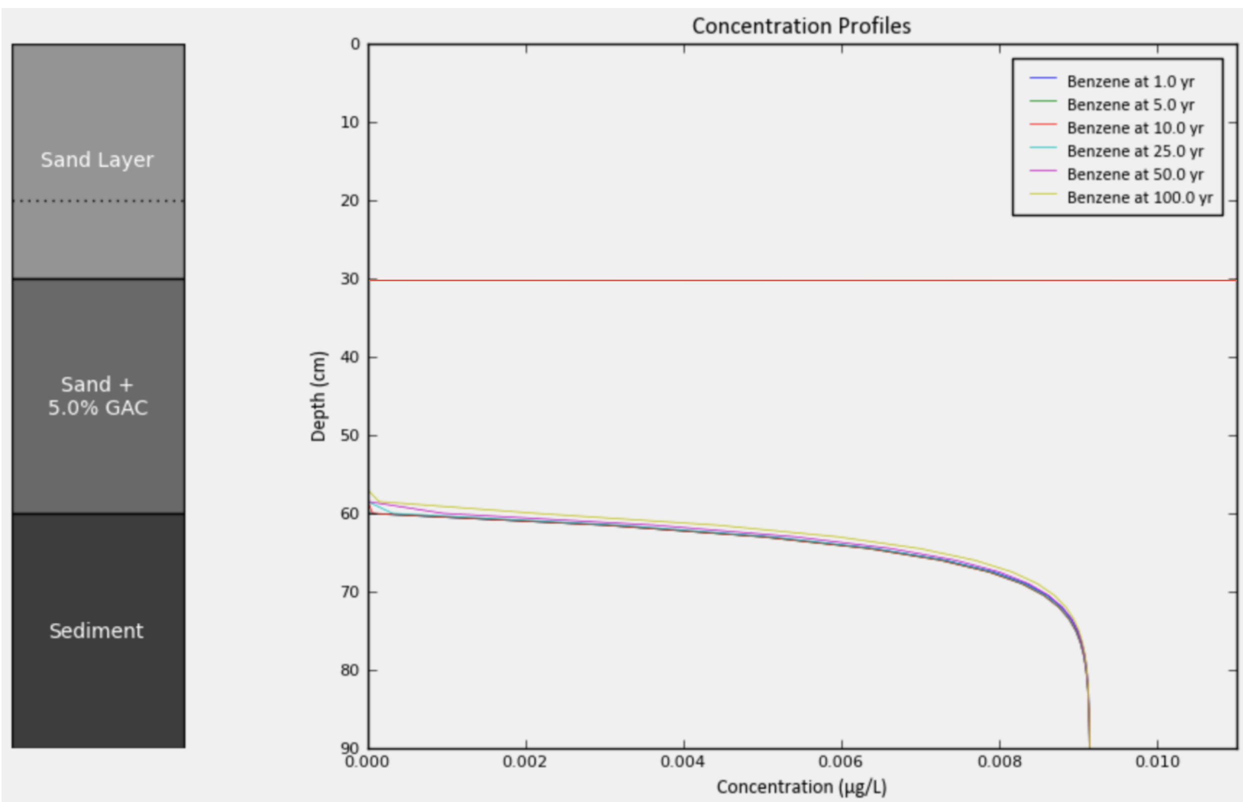
Table 17 COC Sensitivity Analysis: 30 cm of 5.0% GAC amended sand with 30 cm unamended sand layer

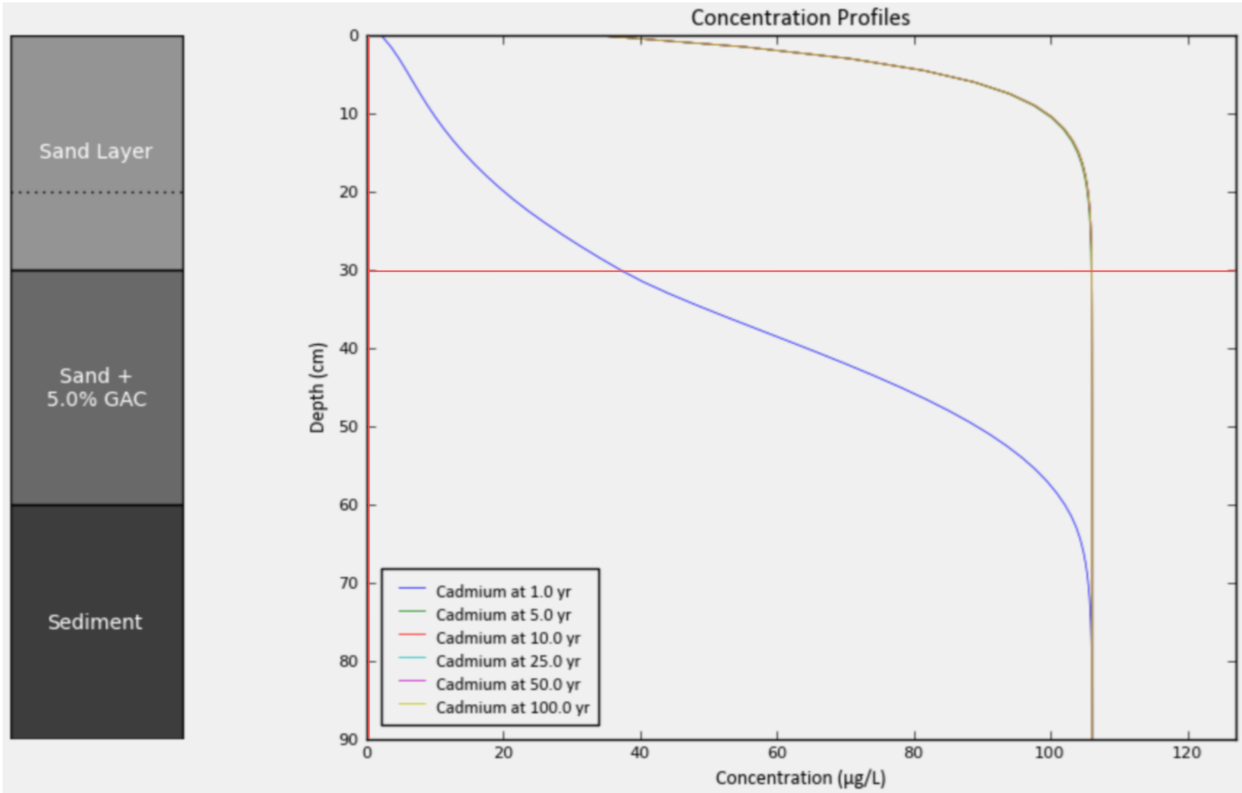
Porewater Concentration – Depth

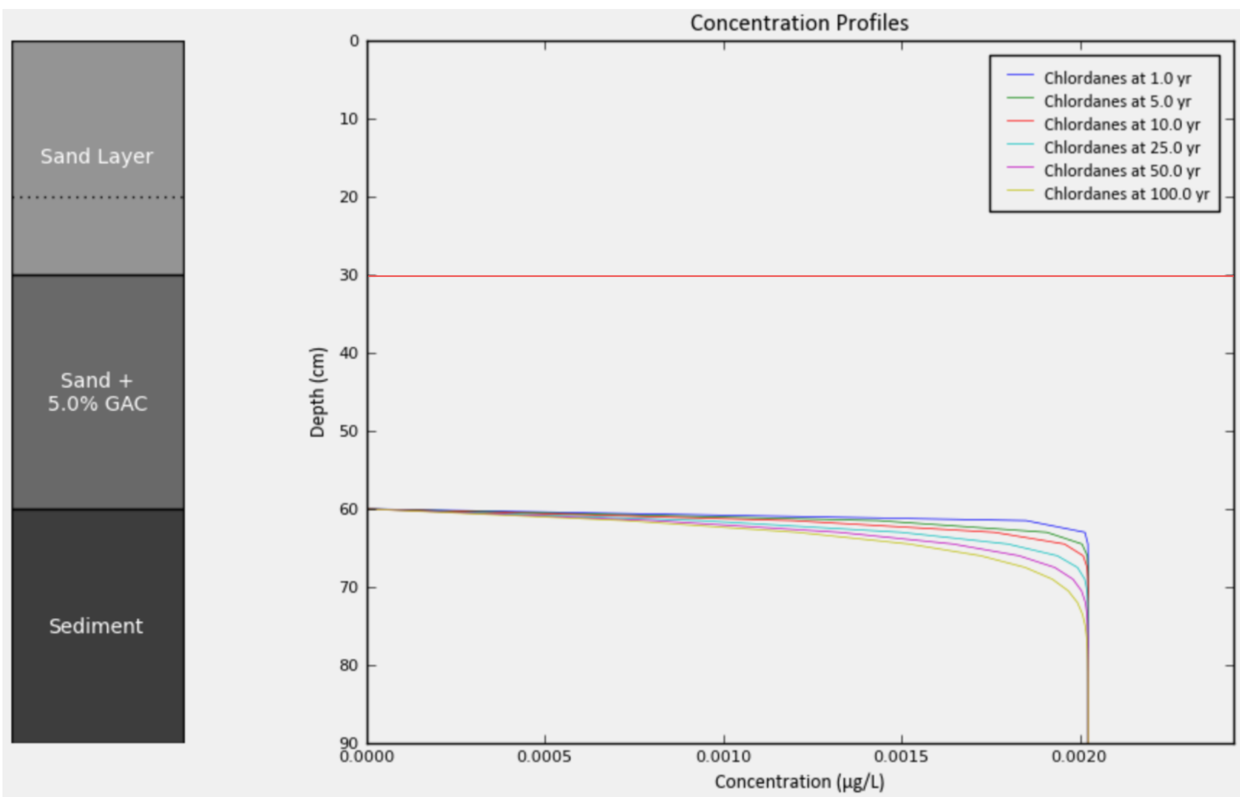


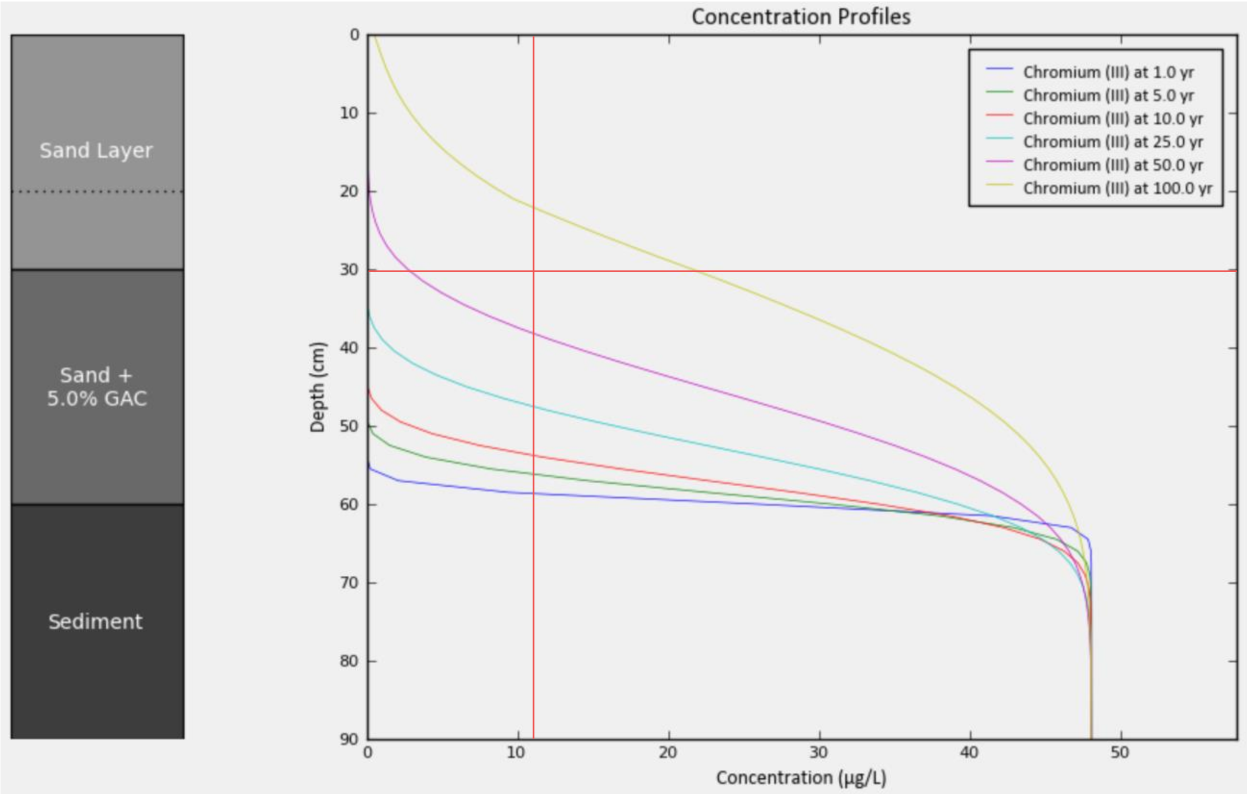


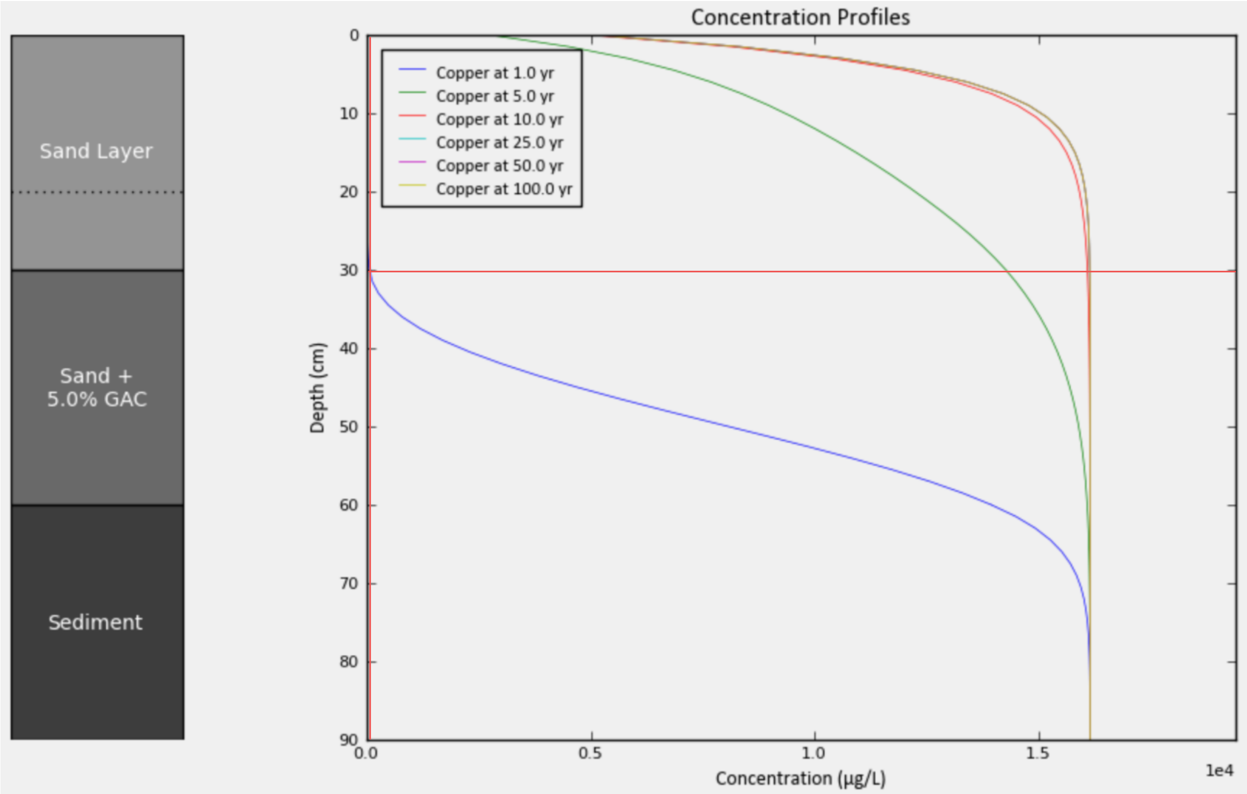

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
BEHP at 1.0 yr
BEHP at 5.0 yr
BEHP at 10.0 yr
BEHP at 25.0 yr
BEHP at 50.0 yr
BEHP at 100.0 yr
0
10
20
30
40
50
60
70
80
90
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

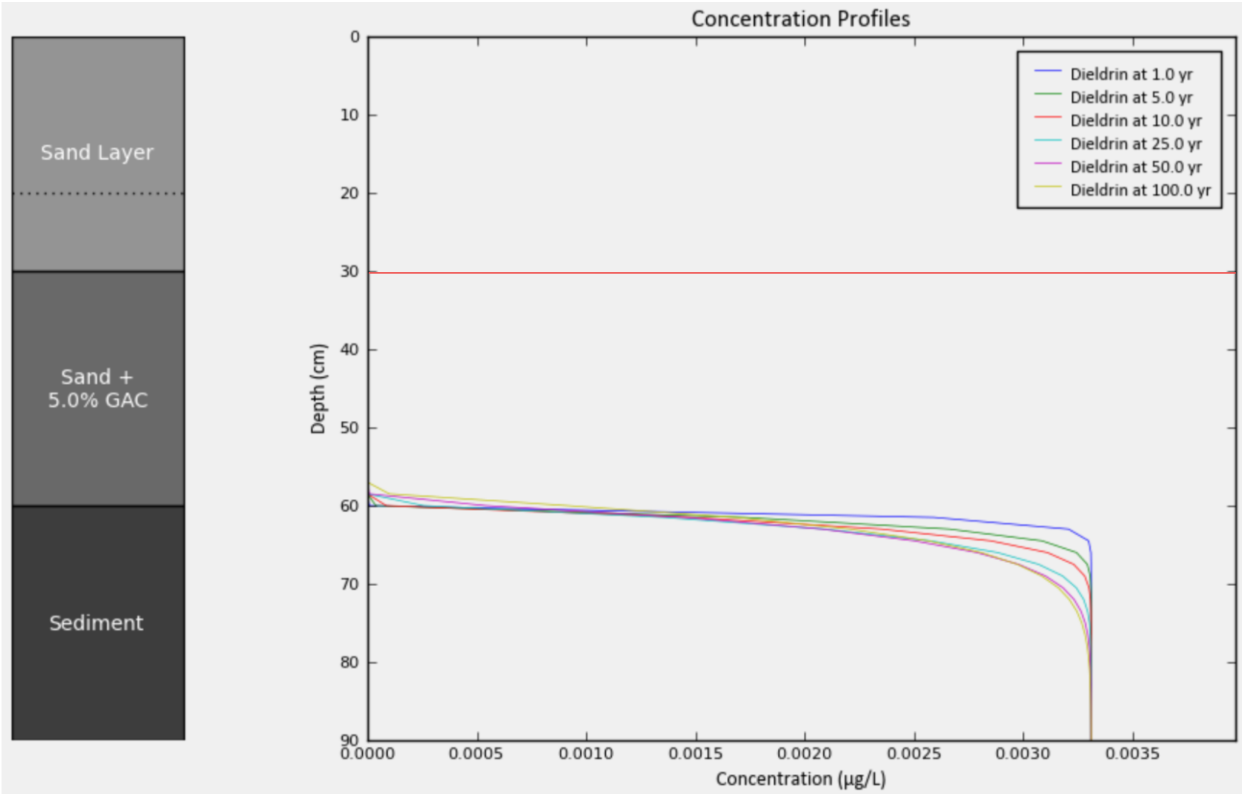

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzene at 1.0 yr
Benzene at 5.0 yr
Benzene at 10.0 yr
Benzene at 25.0 yr
Benzene at 50.0 yr
Benzene at 100.0 yr
0
10
20
30
40
50
60
70
80
90
0.000
0.002
0.004
0.006
0.008
0.010

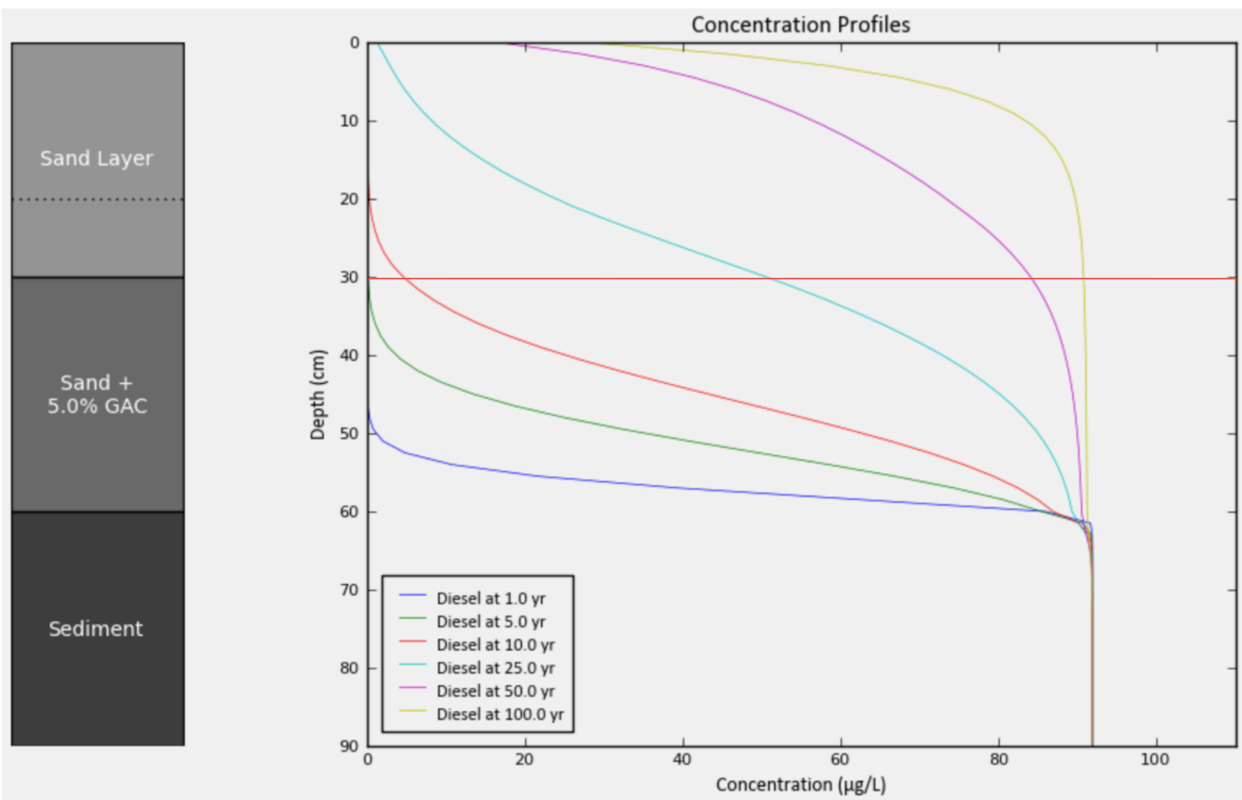

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Cadmium at 1.0 yr
Cadmium at 5.0 yr
Cadmium at 10.0 yr
Cadmium at 25.0 yr
Cadmium at 50.0 yr
Cadmium at 100.0 yr

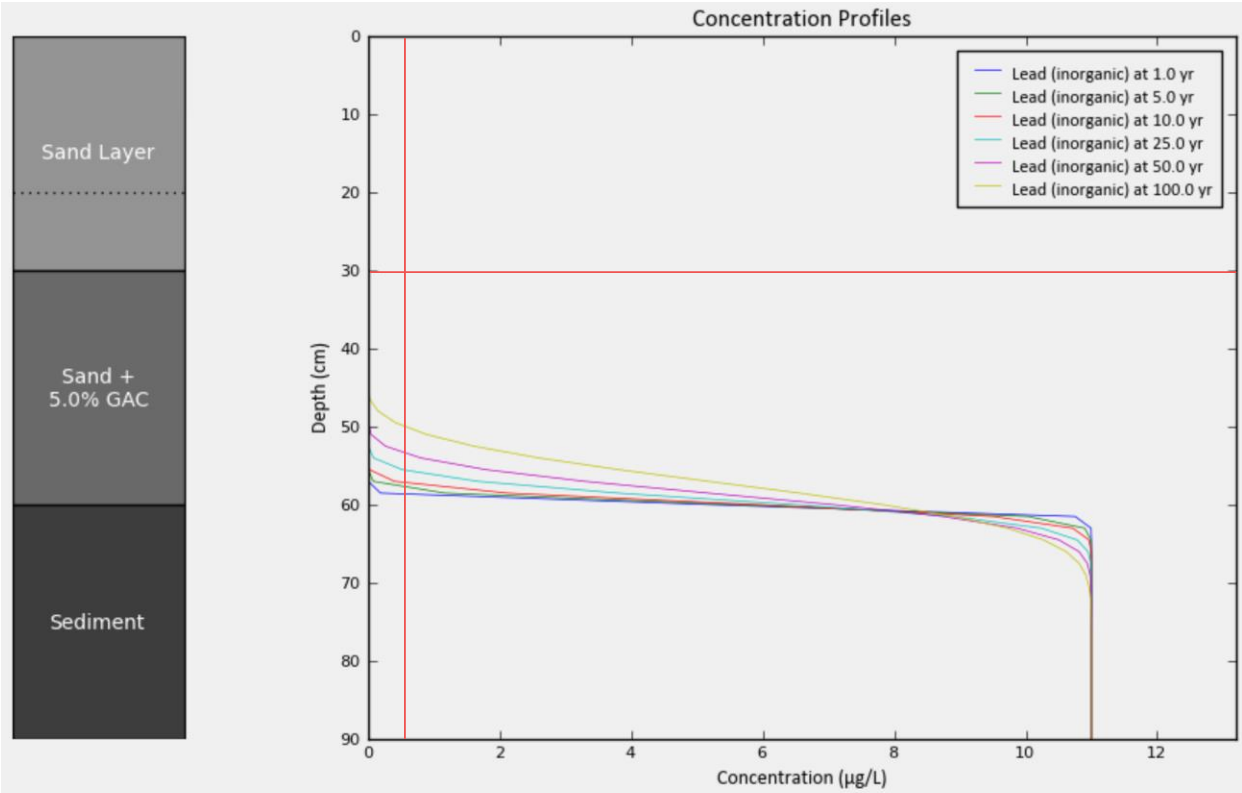

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Chlordanes at 1.0 yr
Chlordanes at 5.0 yr
Chlordanes at 10.0 yr
Chlordanes at 25.0 yr
Chlordanes at 50.0 yr
Chlordanes at 100.0 yr

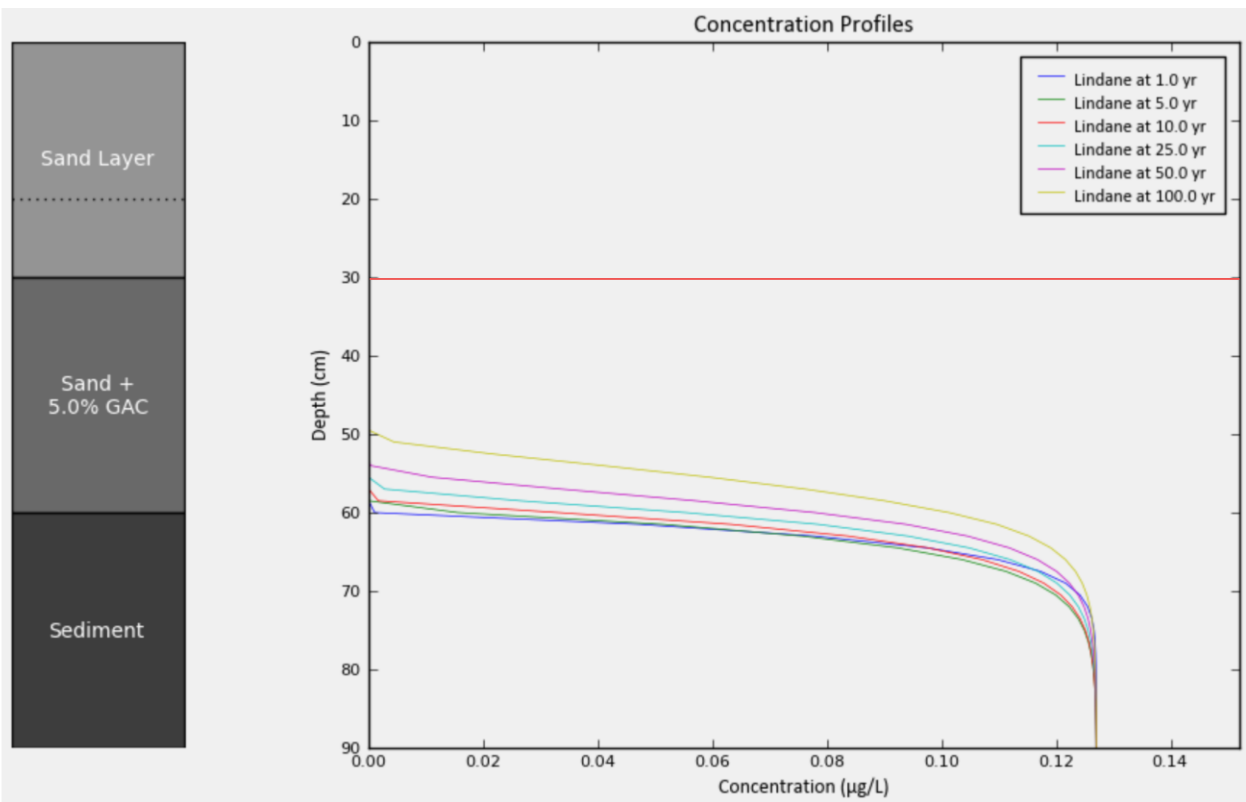

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Chromium (III) at 1.0 yr
Chromium (III) at 5.0 yr
Chromium (III) at 10.0 yr
Chromium (III) at 25.0 yr
Chromium (III) at 50.0 yr
Chromium (III) at 100.0 yr
Depth (cm)
Concentration (μg/L)

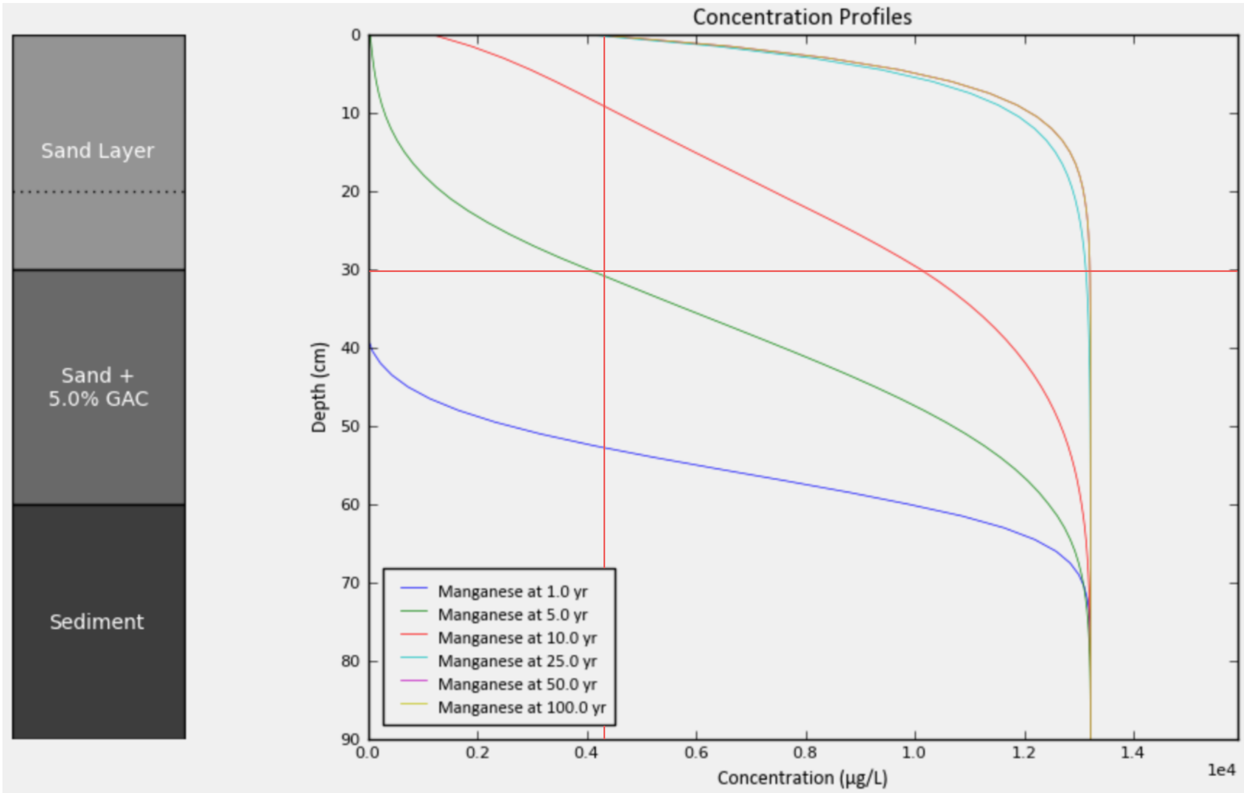

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Copper at 1.0 yr
Copper at 5.0 yr
Copper at 10.0 yr
Copper at 25.0 yr
Copper at 50.0 yr
Copper at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e4

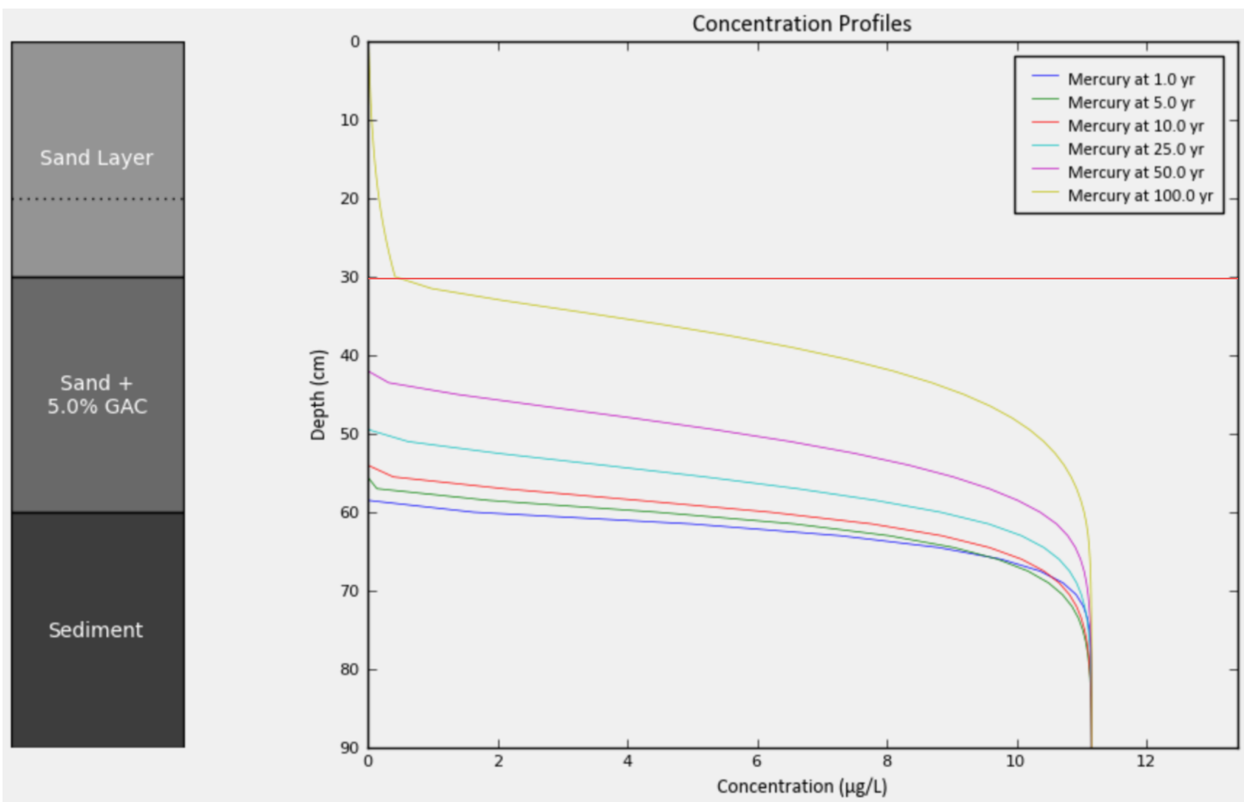

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Dieldrin at 1.0 yr
Dieldrin at 5.0 yr
Dieldrin at 10.0 yr
Dieldrin at 25.0 yr
Dieldrin at 50.0 yr
Dieldrin at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
70
80
90
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035

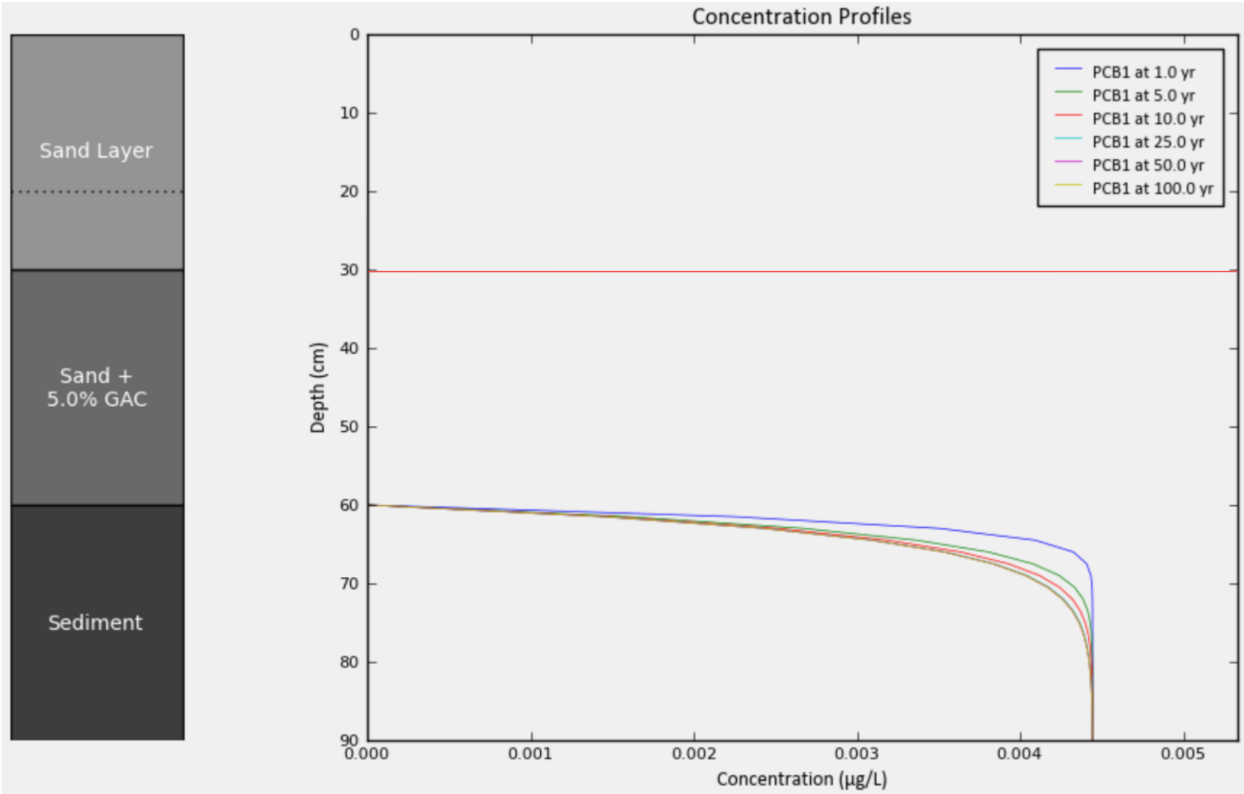

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Diesel at 1.0 yr
Diesel at 5.0 yr
Diesel at 10.0 yr
Diesel at 25.0 yr
Diesel at 50.0 yr
Diesel at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Lead (inorganic) at 1.0 yr
Lead (inorganic) at 5.0 yr
Lead (inorganic) at 10.0 yr
Lead (inorganic) at 25.0 yr
Lead (inorganic) at 50.0 yr
Lead (inorganic) at 100.0 yr
Depth (cm)
Concentration (μg/L)

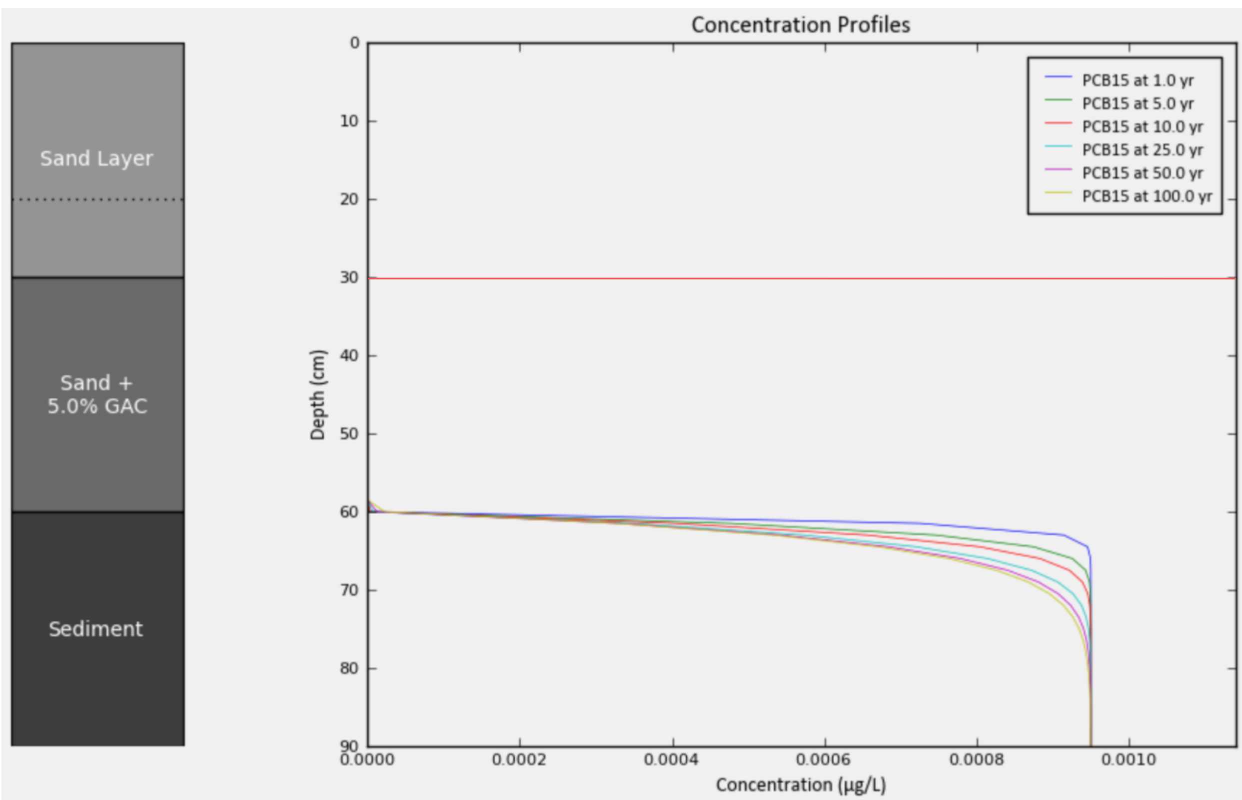

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Lindane at 1.0 yr
Lindane at 5.0 yr
Lindane at 10.0 yr
Lindane at 25.0 yr
Lindane at 50.0 yr
Lindane at 100.0 yr
Depth (cm)
Concentration (μg/L)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e4
Manganese at 1.0 yr
Manganese at 5.0 yr
Manganese at 10.0 yr
Manganese at 25.0 yr
Manganese at 50.0 yr
Manganese at 100.0 yr

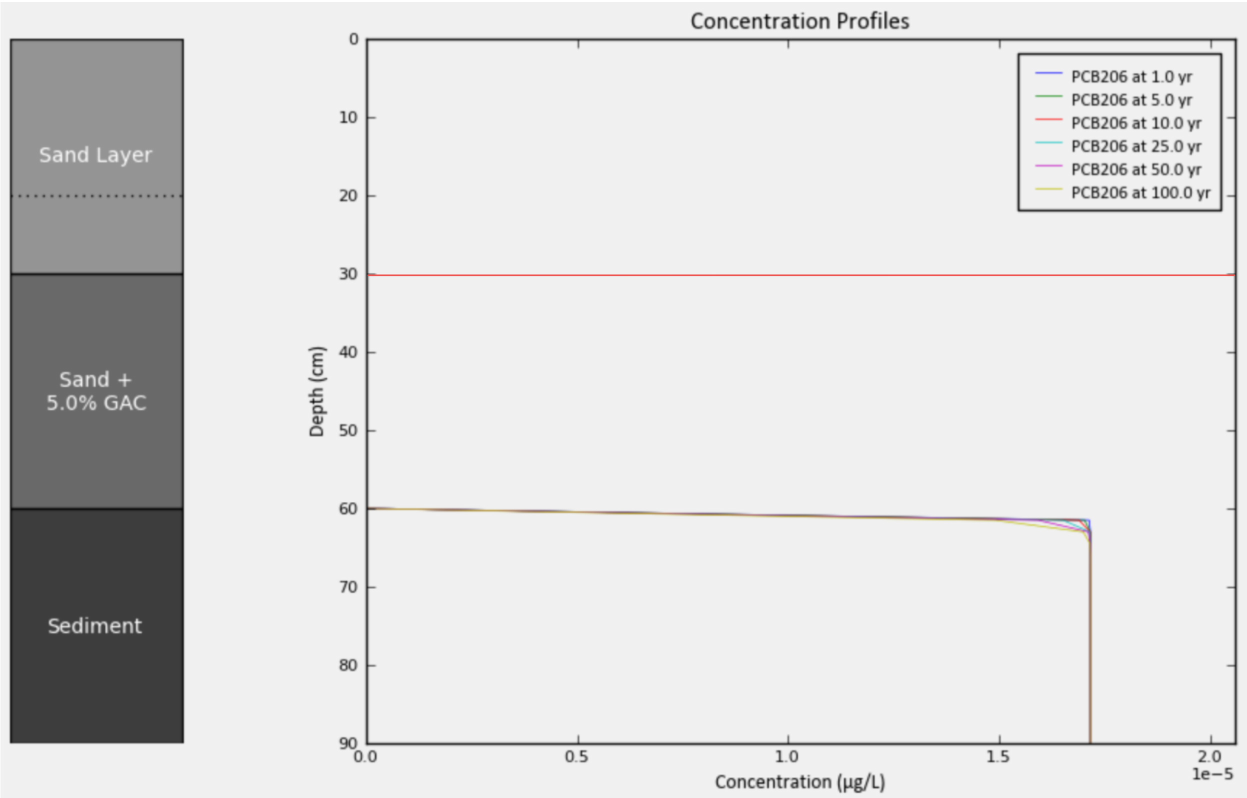

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Mercury at 1.0 yr
Mercury at 5.0 yr
Mercury at 10.0 yr
Mercury at 25.0 yr
Mercury at 50.0 yr
Mercury at 100.0 yr

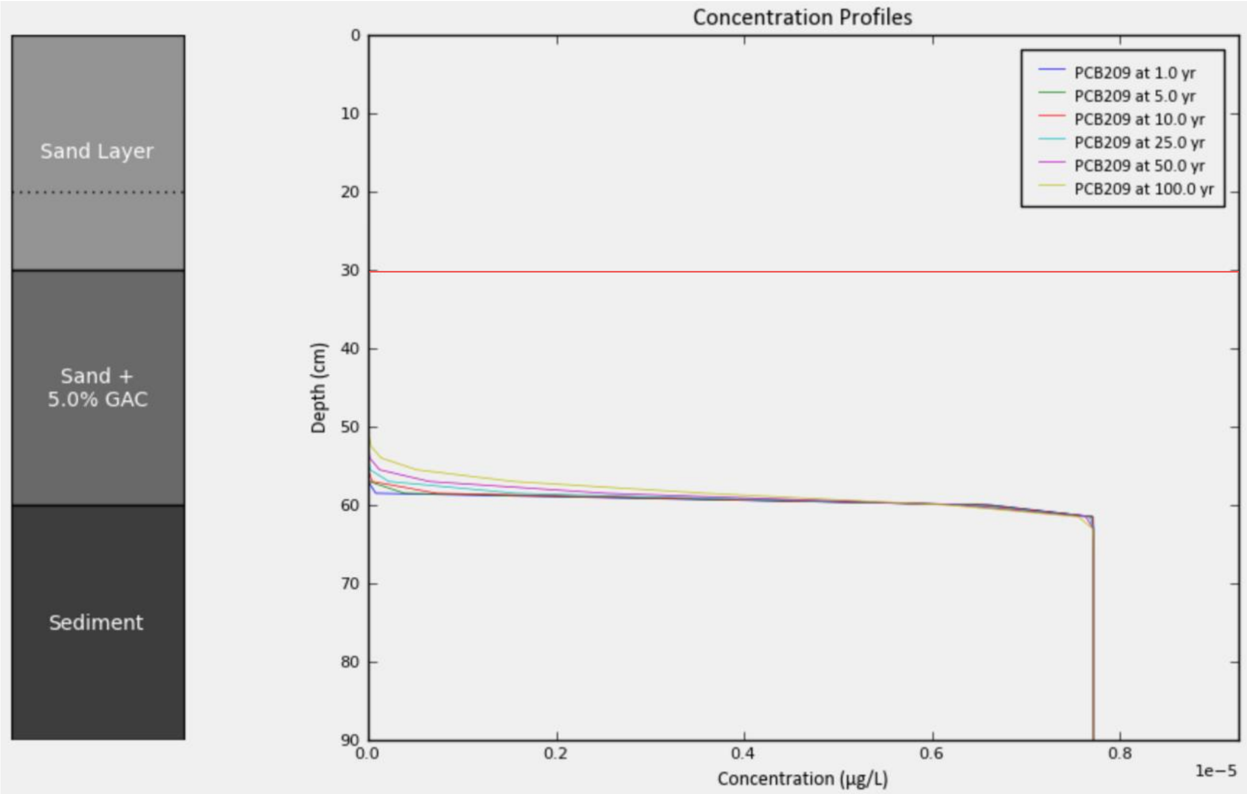


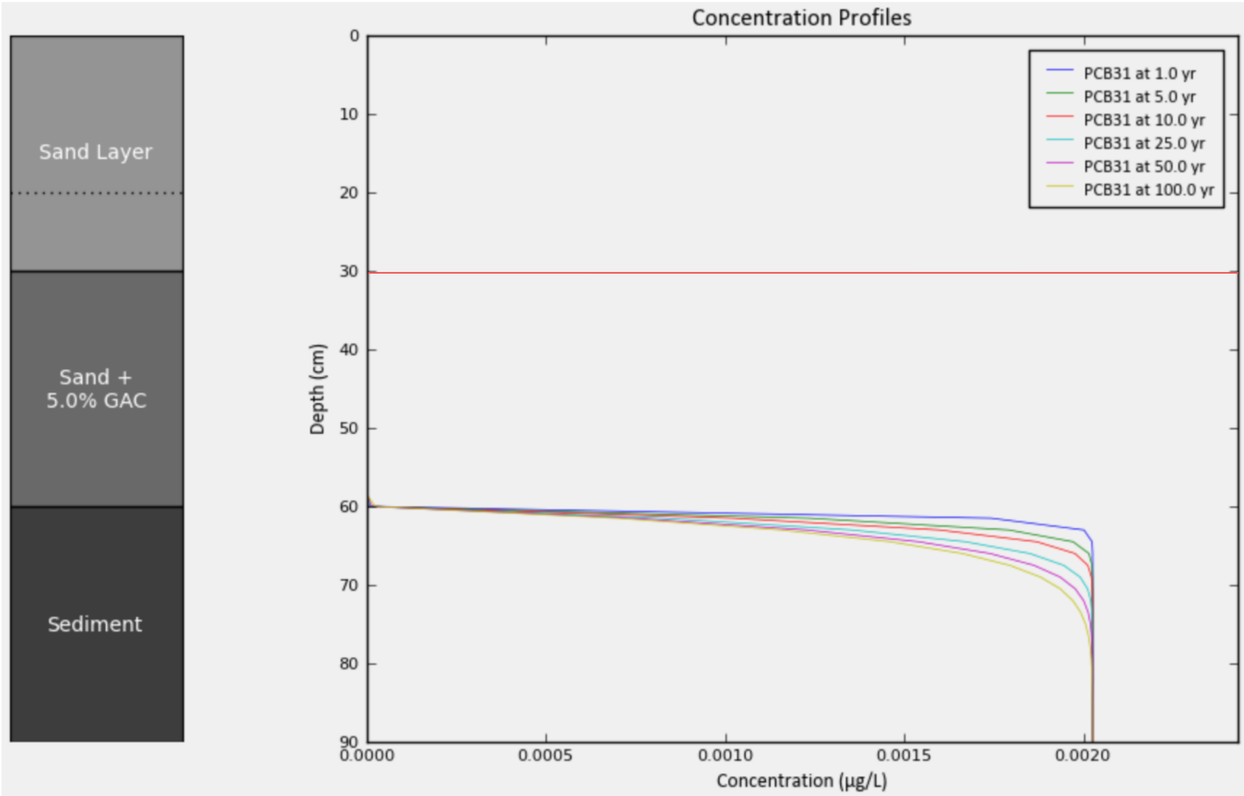
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB1 at 1.0 yr
PCB1 at 5.0 yr
PCB1 at 10.0 yr
PCB1 at 25.0 yr
PCB1 at 50.0 yr
PCB1 at 100.0 yr
Depth (cm)
Concentration (µg/L)

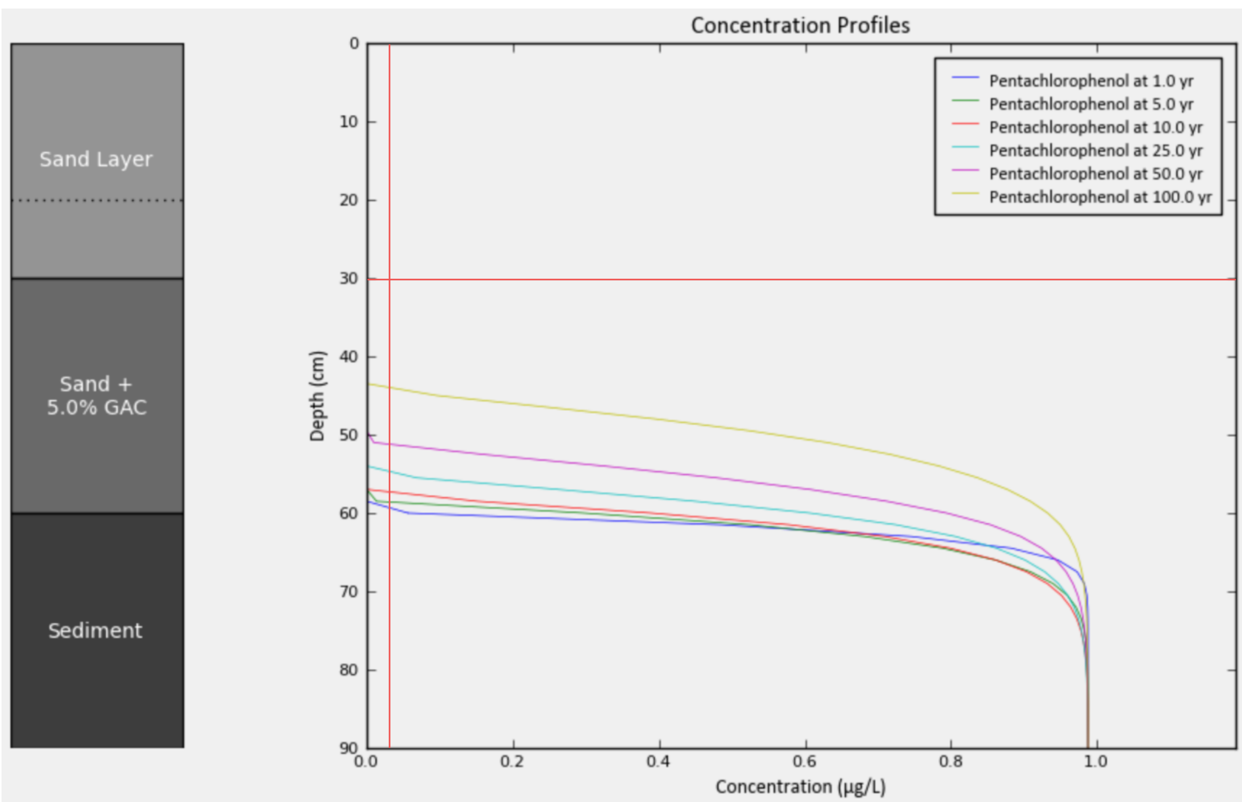


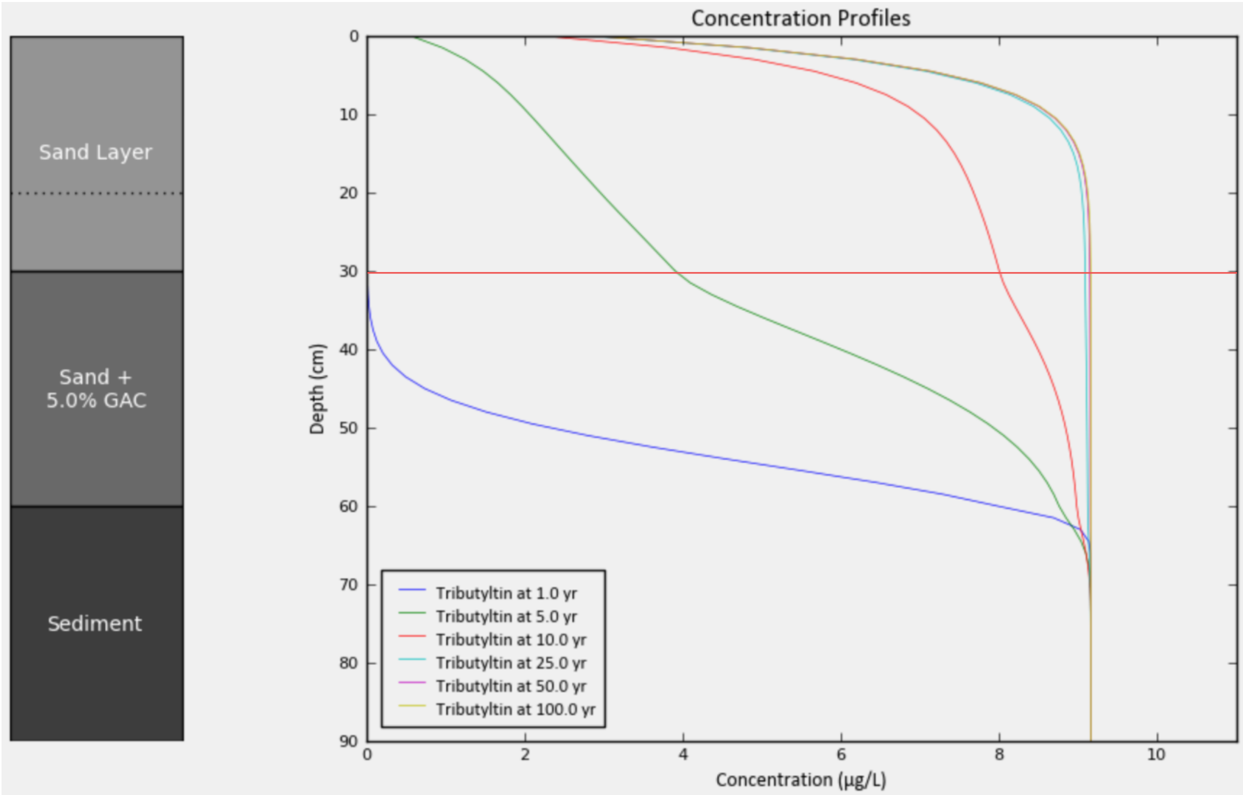
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB15 at 1.0 yr
PCB15 at 5.0 yr
PCB15 at 10.0 yr
PCB15 at 25.0 yr
PCB15 at 50.0 yr
PCB15 at 100.0 yr
Depth (cm)
Concentration (µg/L)

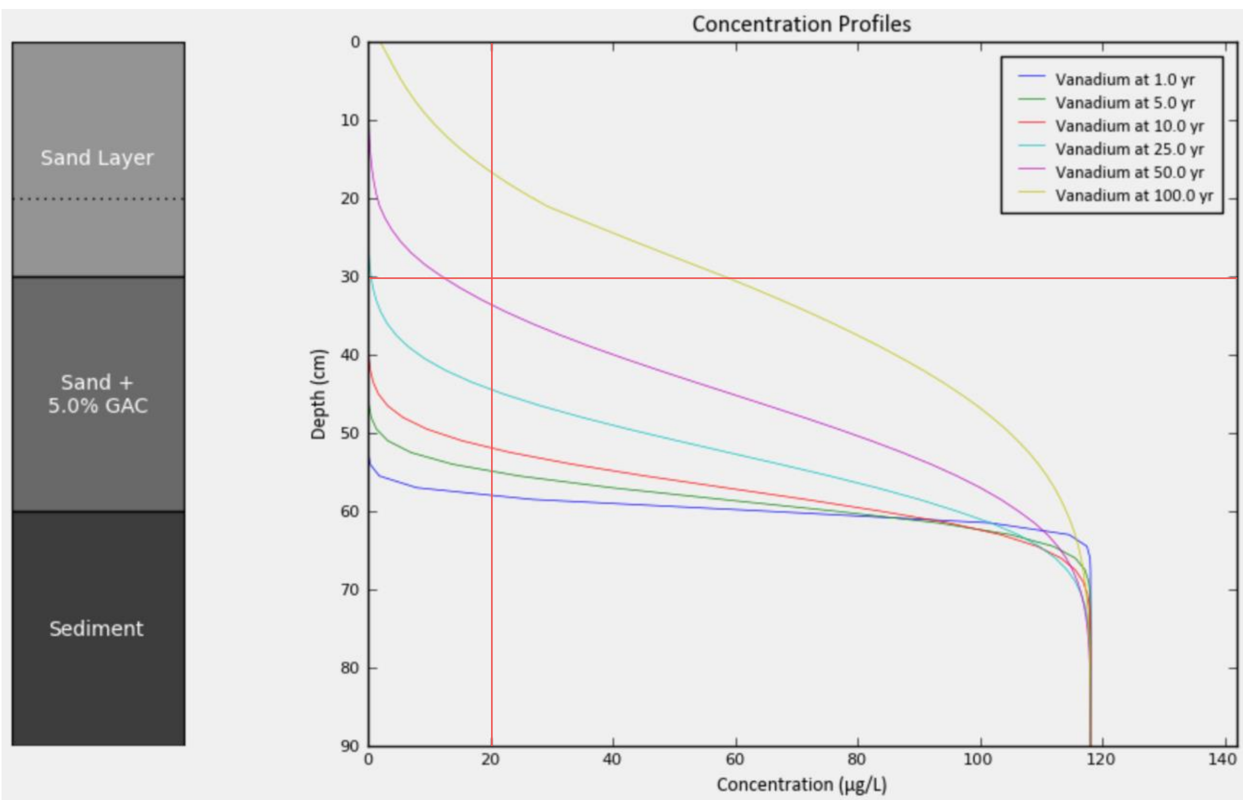

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB206 at 1.0 yr
PCB206 at 5.0 yr
PCB206 at 10.0 yr
PCB206 at 25.0 yr
PCB206 at 50.0 yr
PCB206 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−5

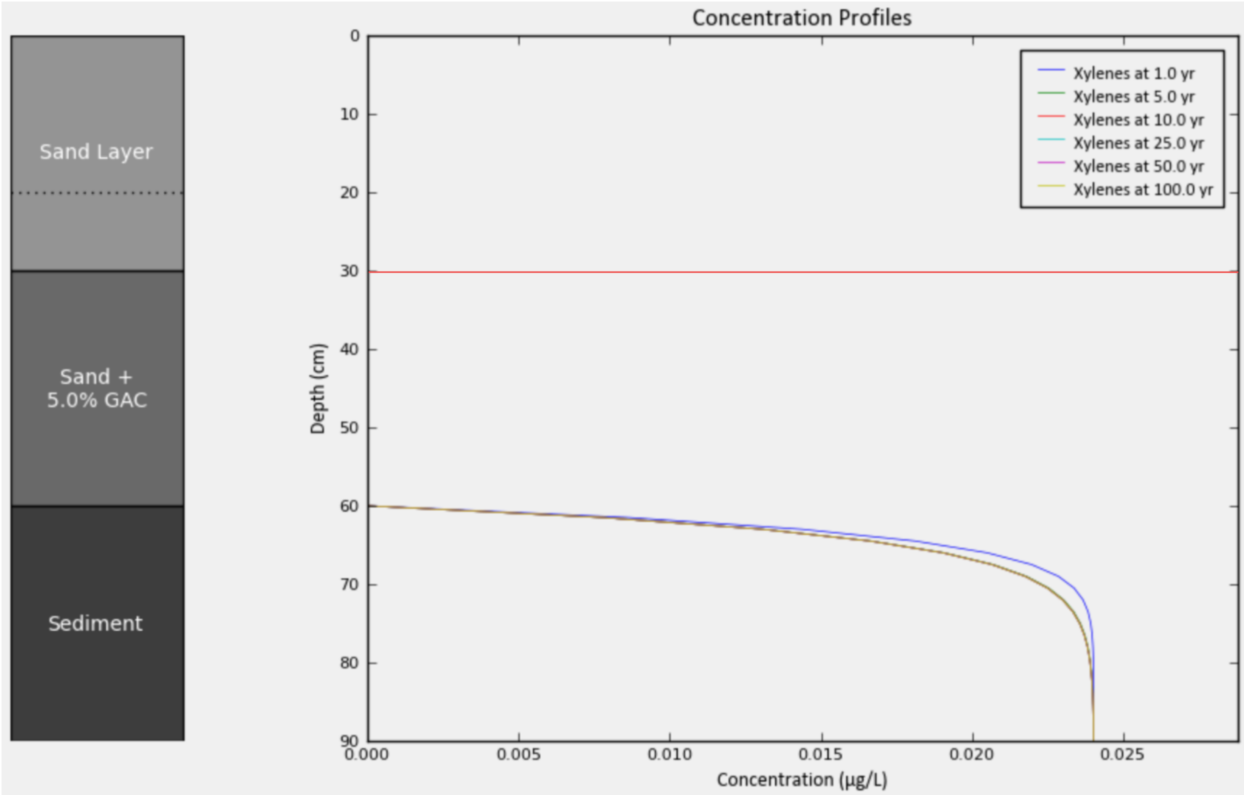

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB209 at 1.0 yr
PCB209 at 5.0 yr
PCB209 at 10.0 yr
PCB209 at 25.0 yr
PCB209 at 50.0 yr
PCB209 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−5

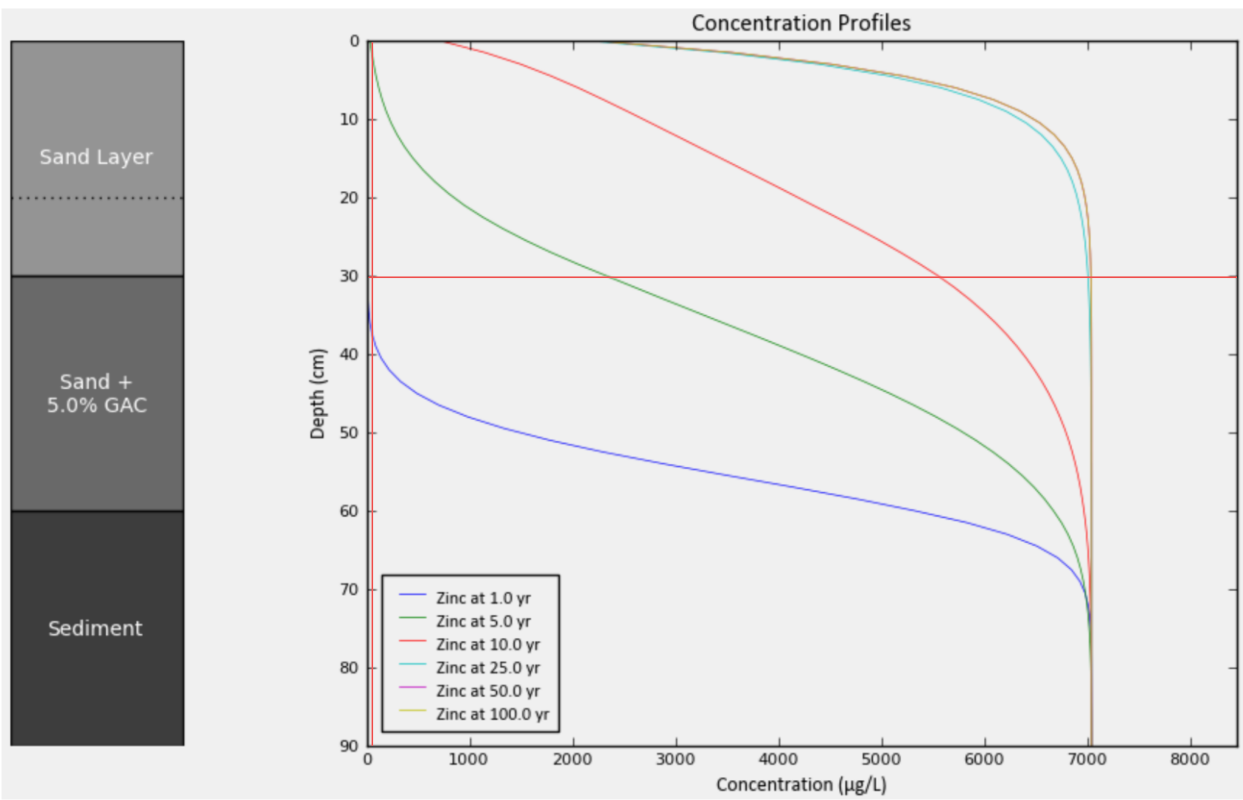

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
PCB31 at 1.0 yr
PCB31 at 5.0 yr
PCB31 at 10.0 yr
PCB31 at 25.0 yr
PCB31 at 50.0 yr
PCB31 at 100.0 yr


Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Pentachlorophenol at 1.0 yr
Pentachlorophenol at 5.0 yr
Pentachlorophenol at 10.0 yr
Pentachlorophenol at 25.0 yr
Pentachlorophenol at 50.0 yr
Pentachlorophenol at 100.0 yr

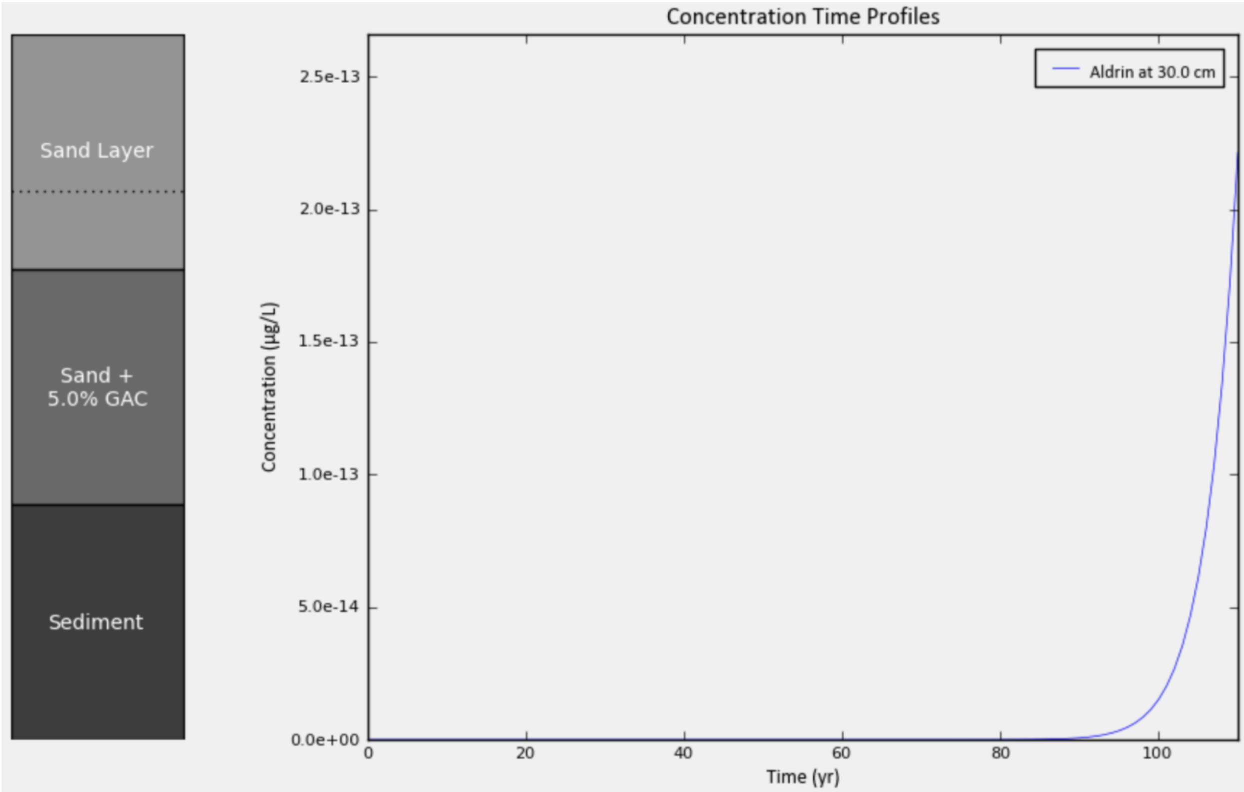

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Tributyltin at 1.0 yr
Tributyltin at 5.0 yr
Tributyltin at 10.0 yr
Tributyltin at 25.0 yr
Tributyltin at 50.0 yr
Tributyltin at 100.0 yr

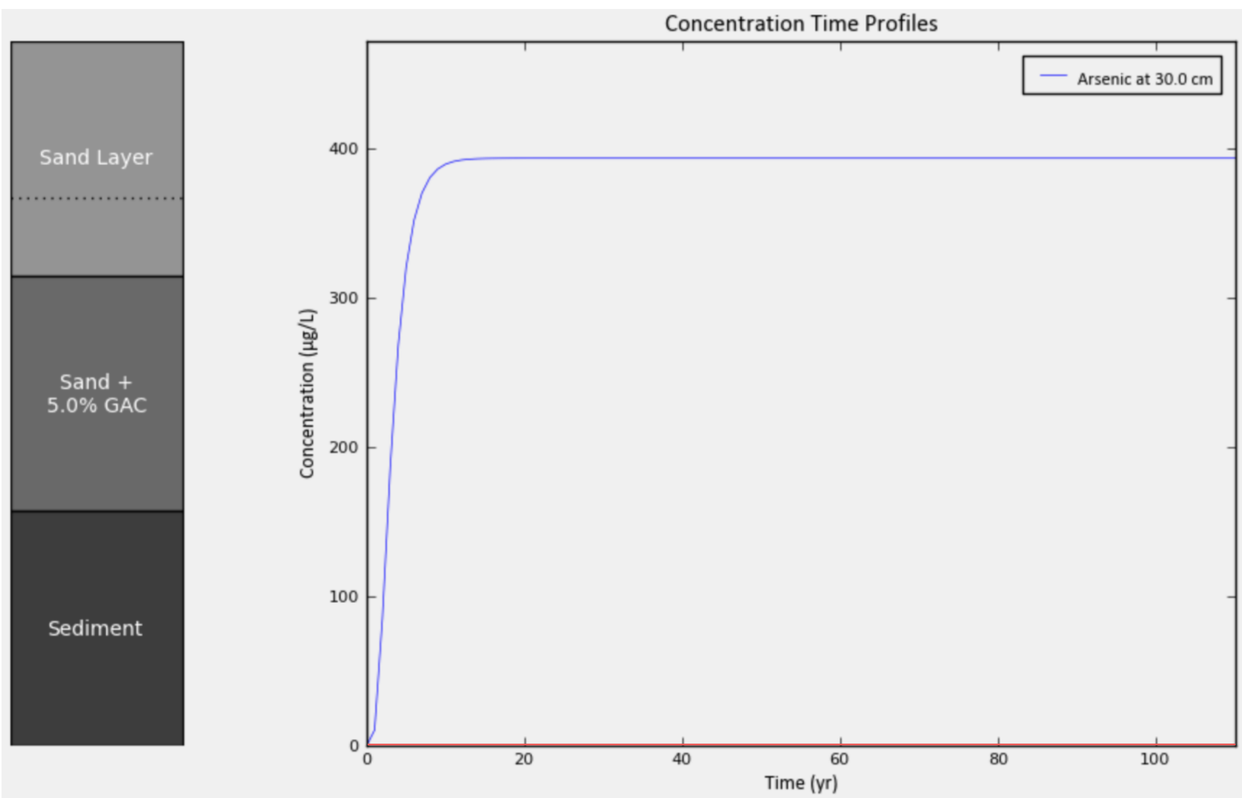

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Vanadium at 1.0 yr
Vanadium at 5.0 yr
Vanadium at 10.0 yr
Vanadium at 25.0 yr
Vanadium at 50.0 yr
Vanadium at 100.0 yr

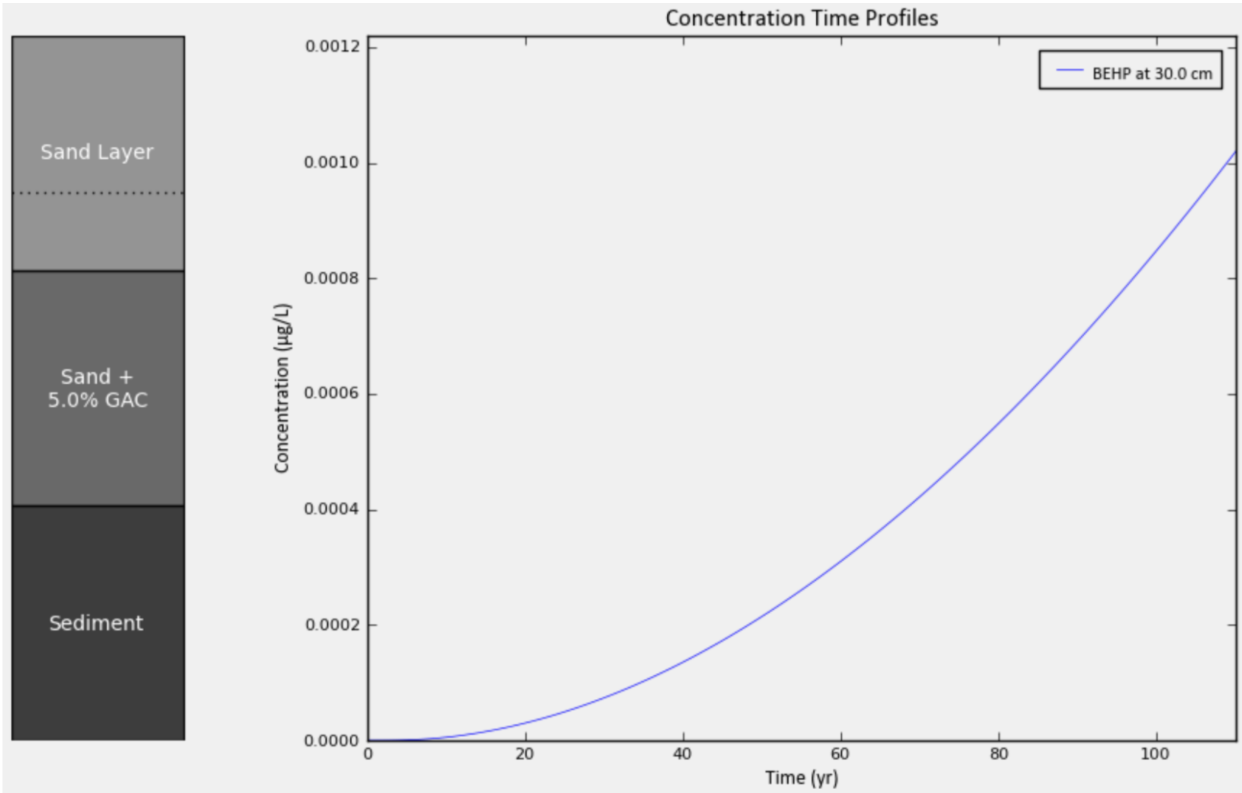

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Xylenes at 1.0 yr
Xylenes at 5.0 yr
Xylenes at 10.0 yr
Xylenes at 25.0 yr
Xylenes at 50.0 yr
Xylenes at 100.0 yr

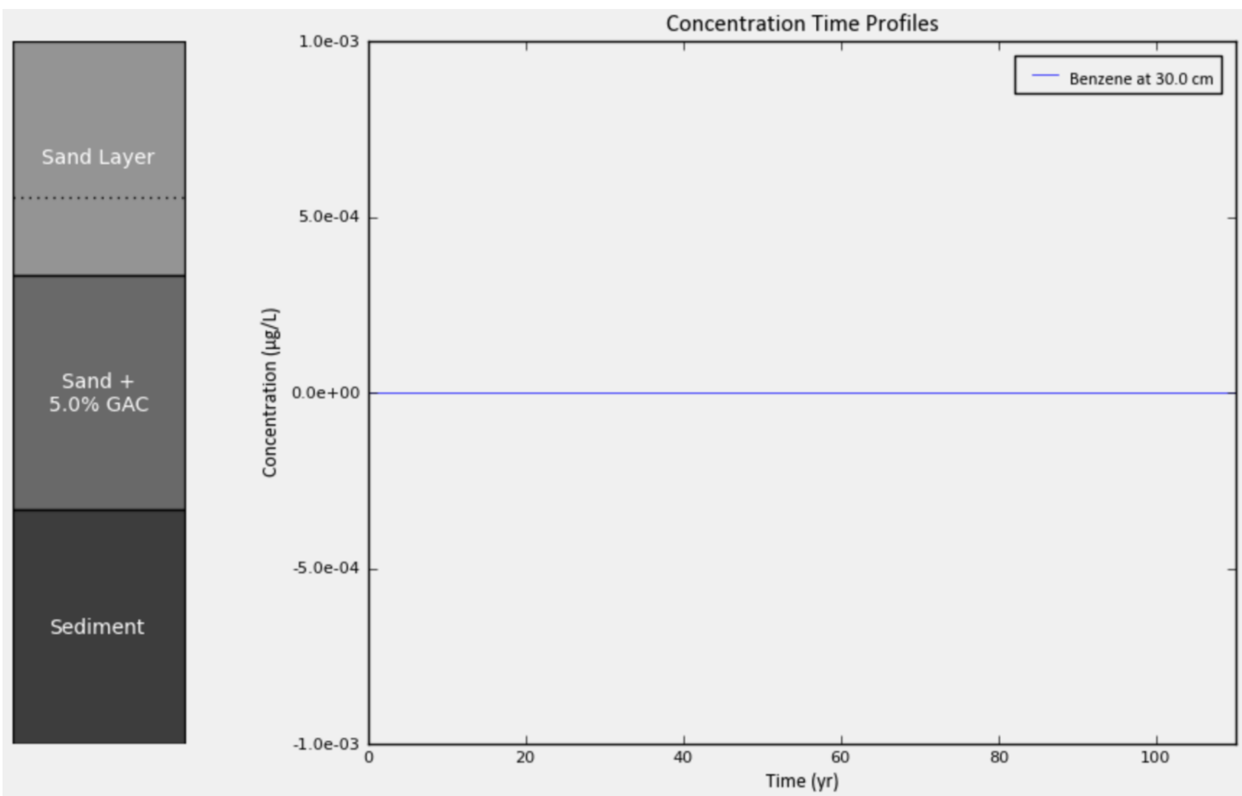

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Zinc at 1.0 yr
Zinc at 5.0 yr
Zinc at 10.0 yr
Zinc at 25.0 yr
Zinc at 50.0 yr
Zinc at 100.0 yr

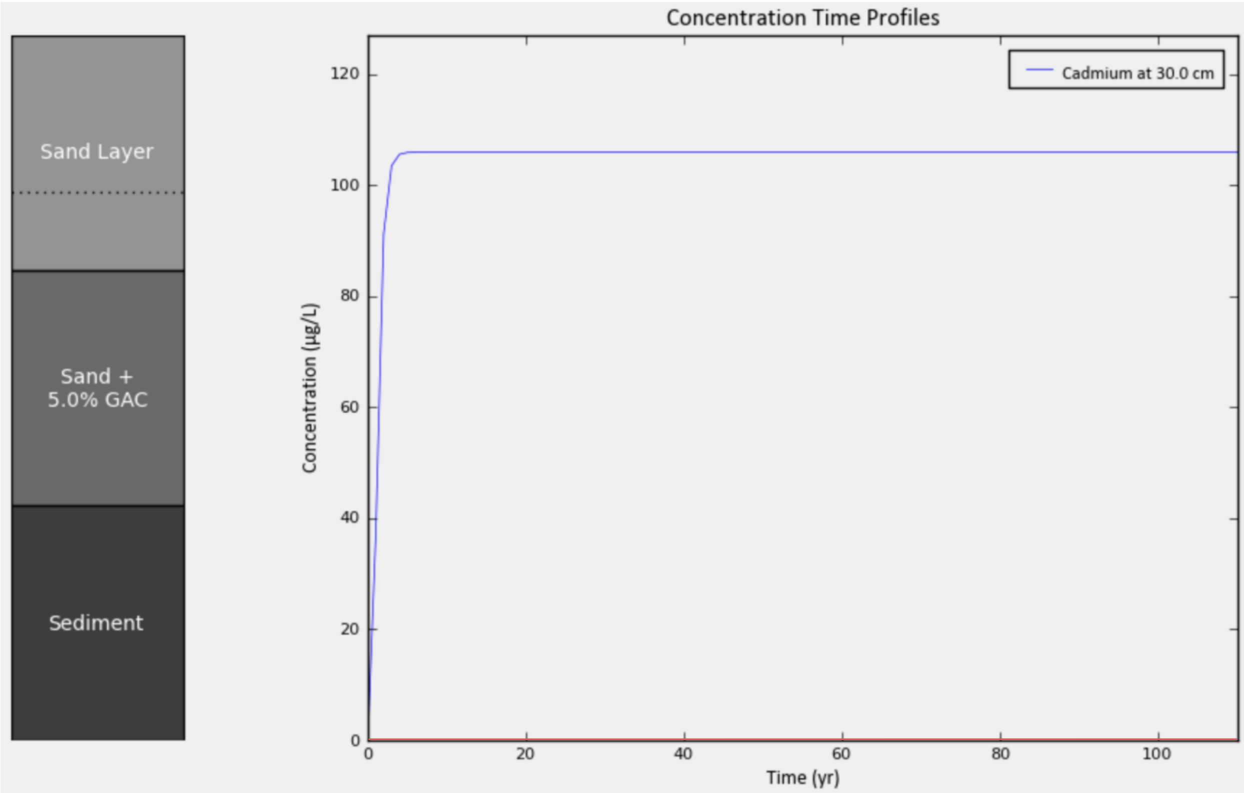
Porewater Concentration – Time

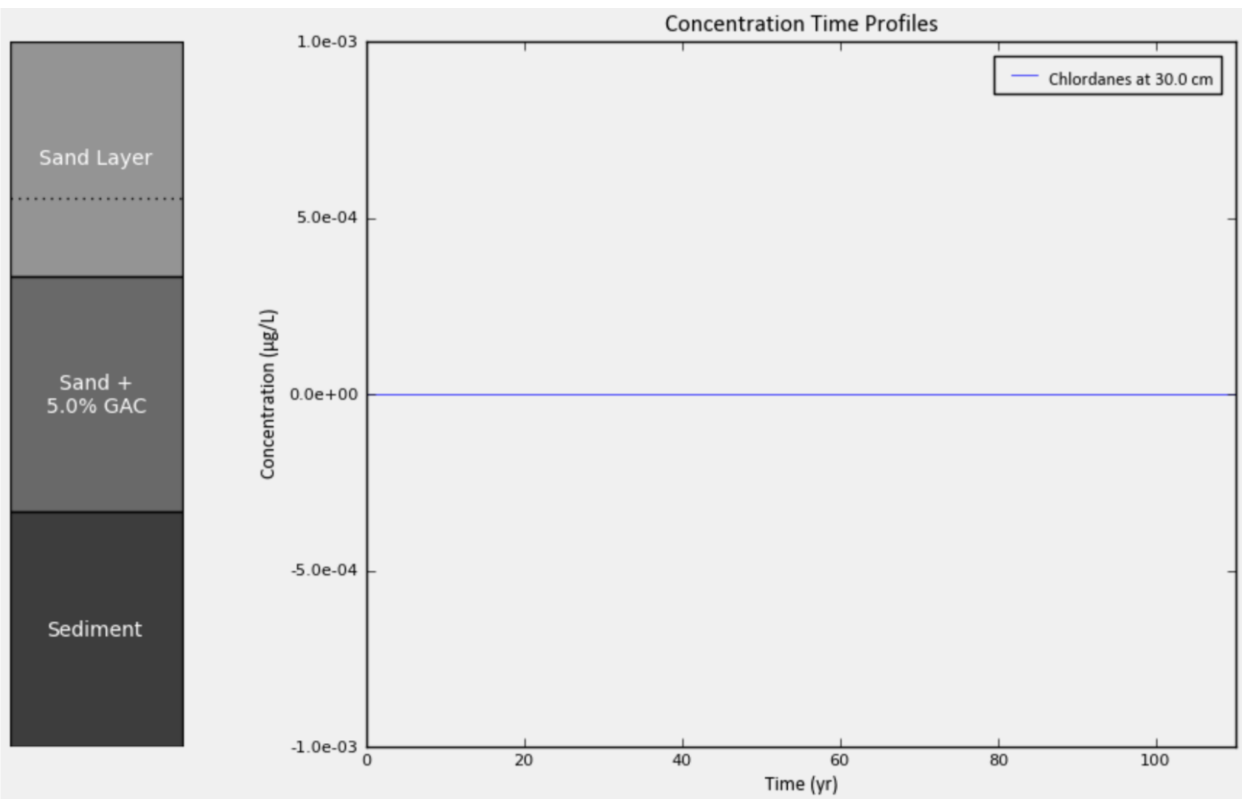


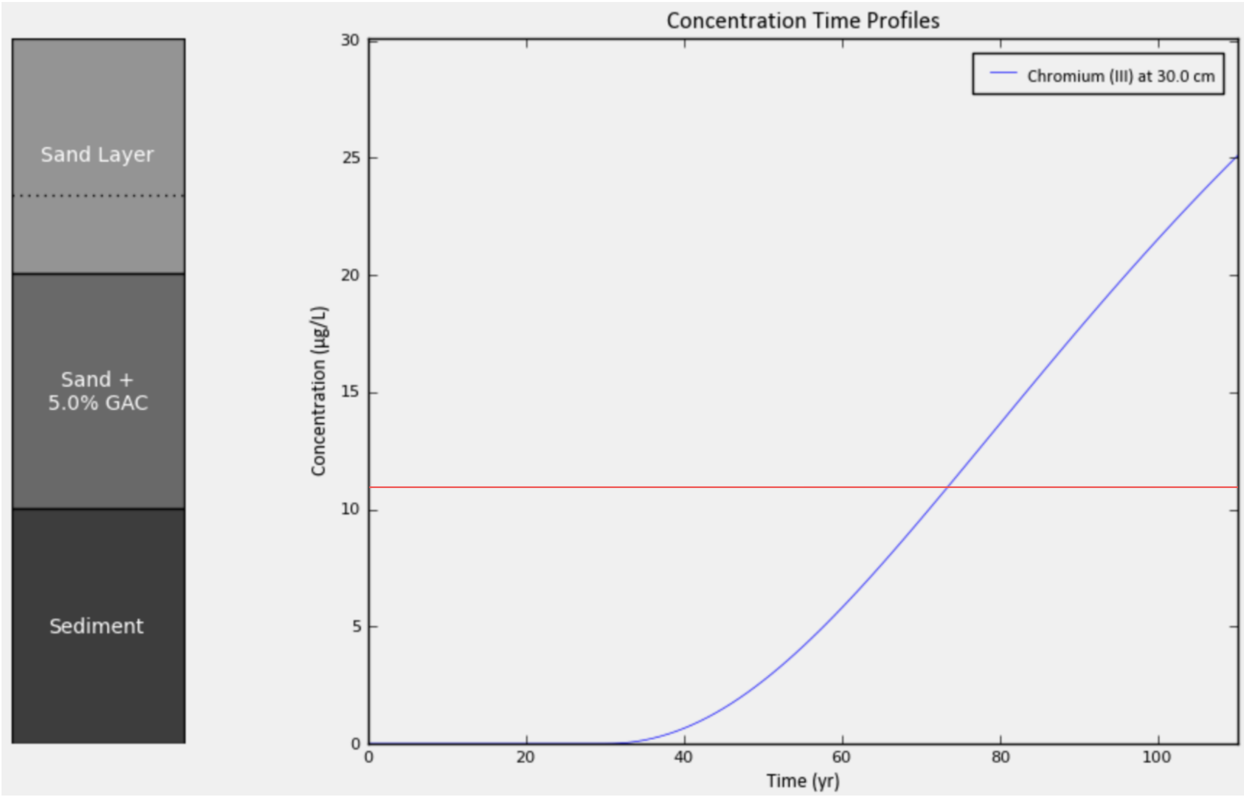


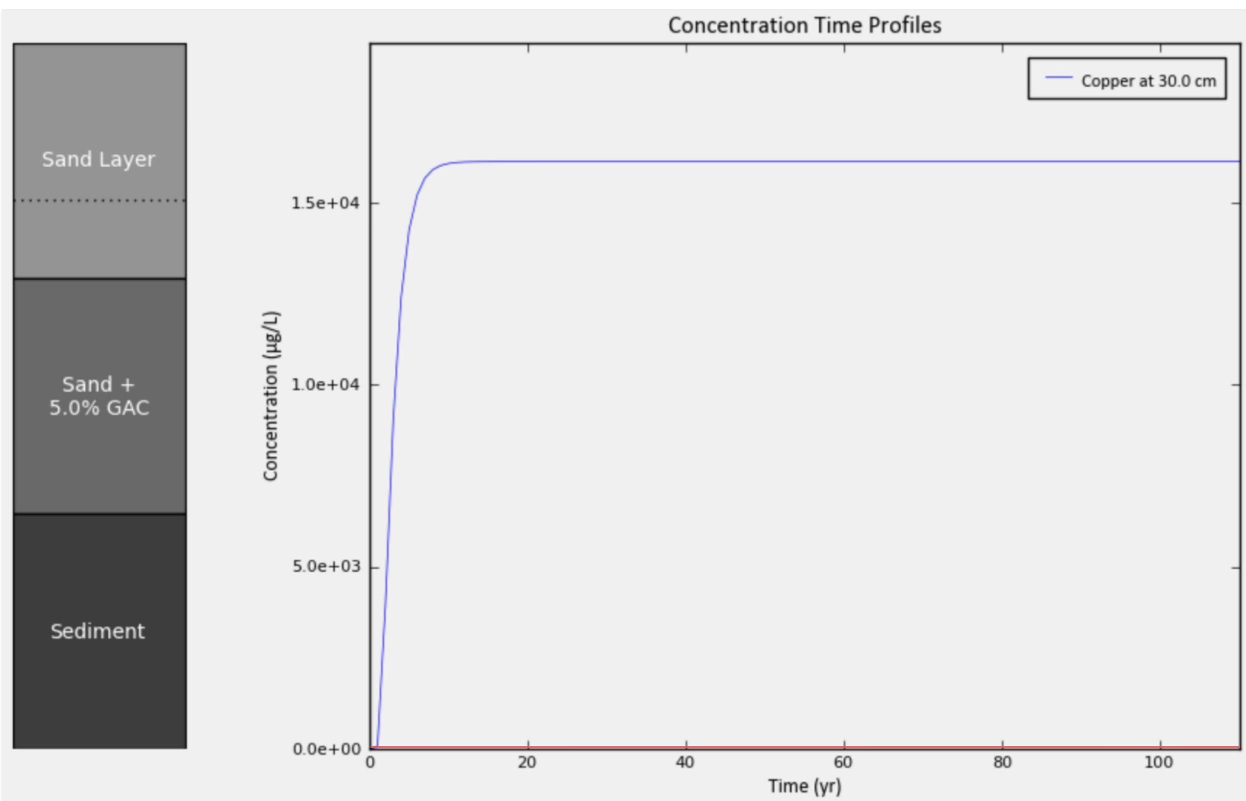

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
BEHP at 30.0 cm
Concentration (µg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
0
20
40
60
80
100
Time (yr)

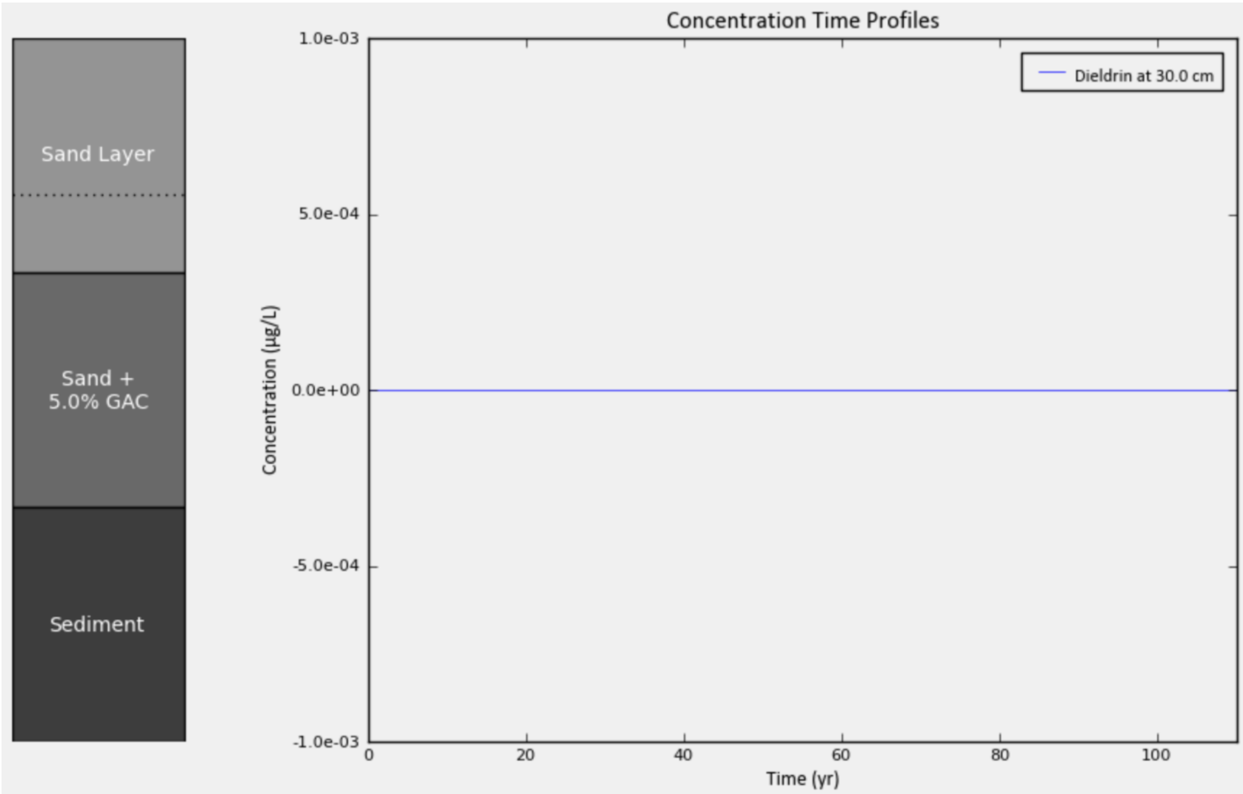

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Benzene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Cadmium at 30.0 cm
Concentration (µg/L)
Time (yr)
0
20
40
60
80
100
120

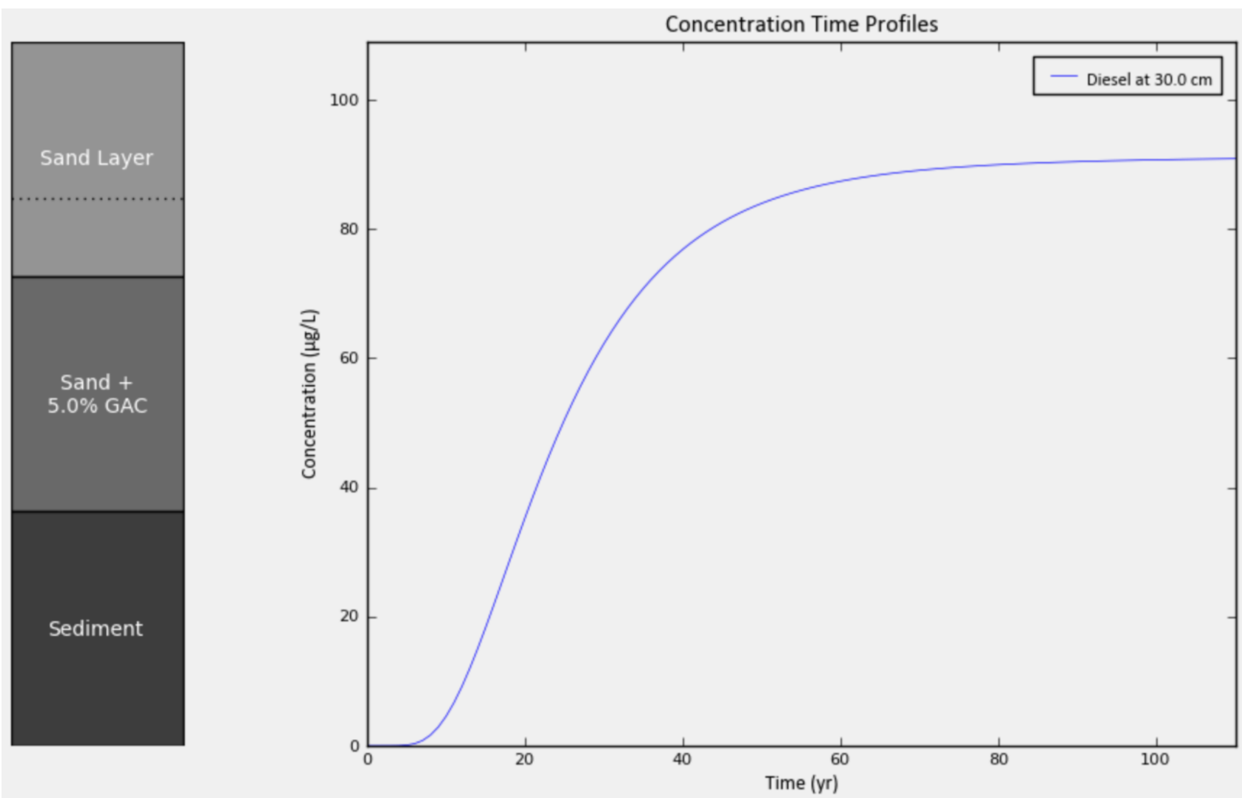

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Chlordanes at 30.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Chromium (III) at 30.0 cm
Concentration (µg/L)
Time (yr)
0
5
10
15
20
25
30
0
20
40
60
80
100

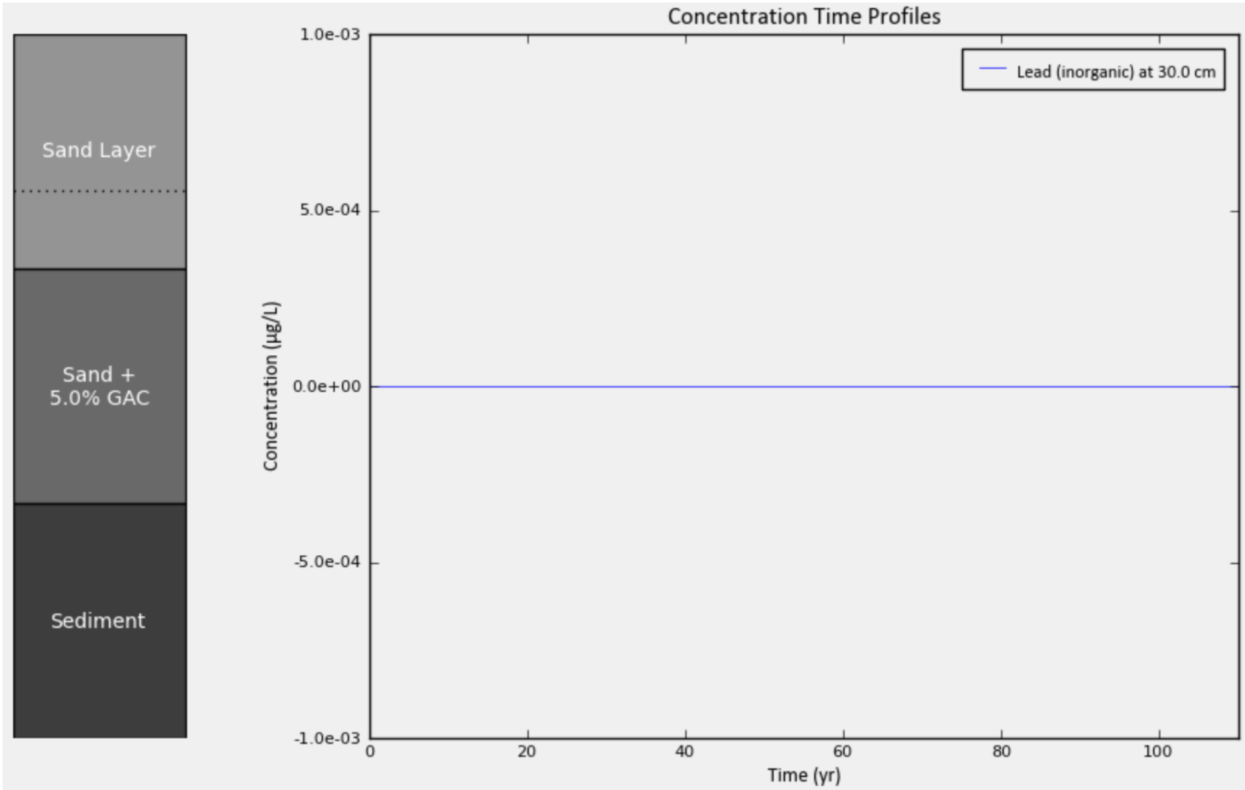

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Copper at 30.0 cm
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e+03
1.0e+04
1.5e+04
0
20
40
60
80
100

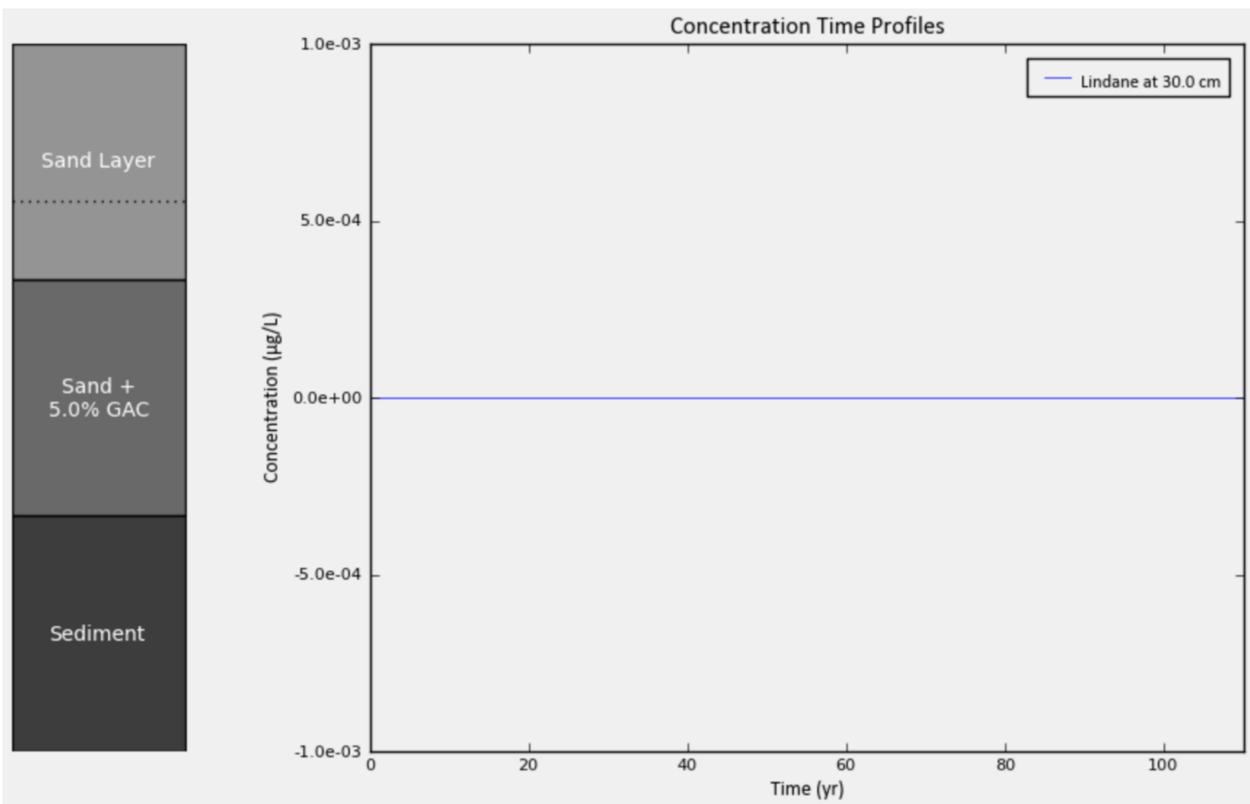


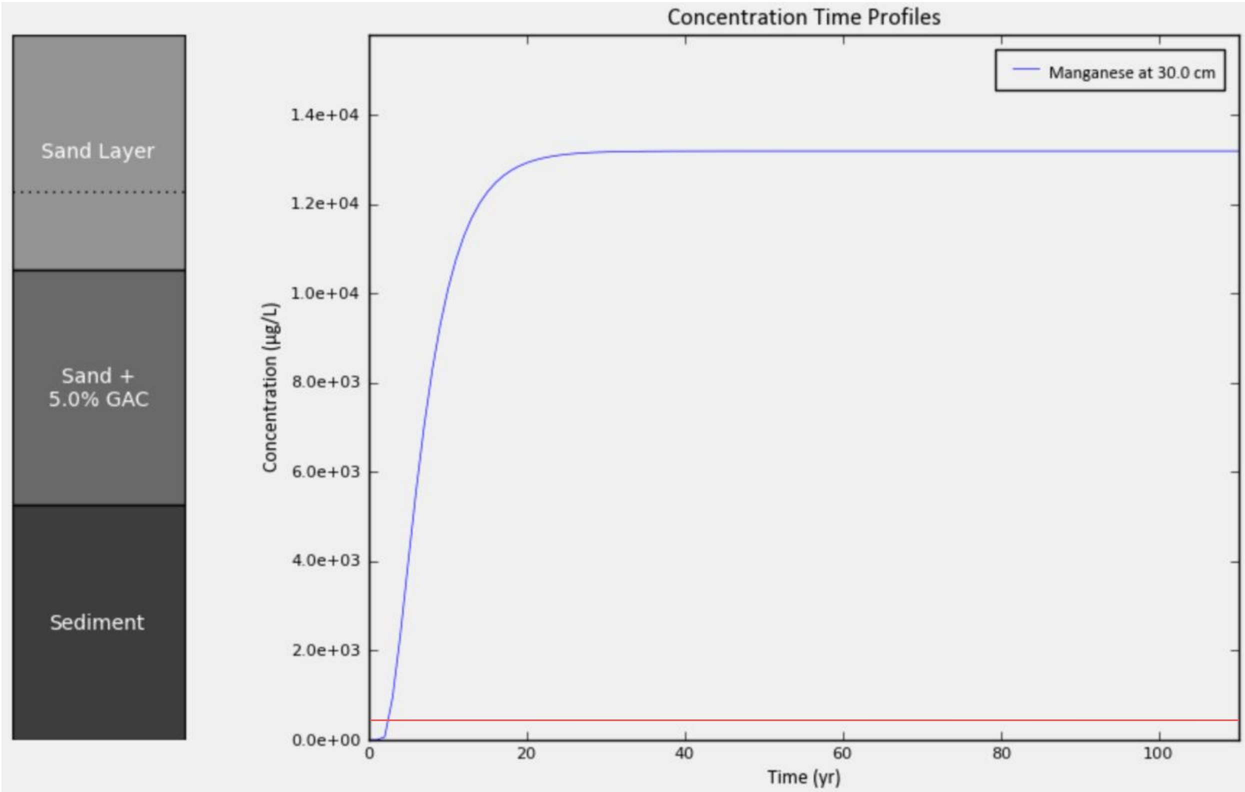
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Dieldrin at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

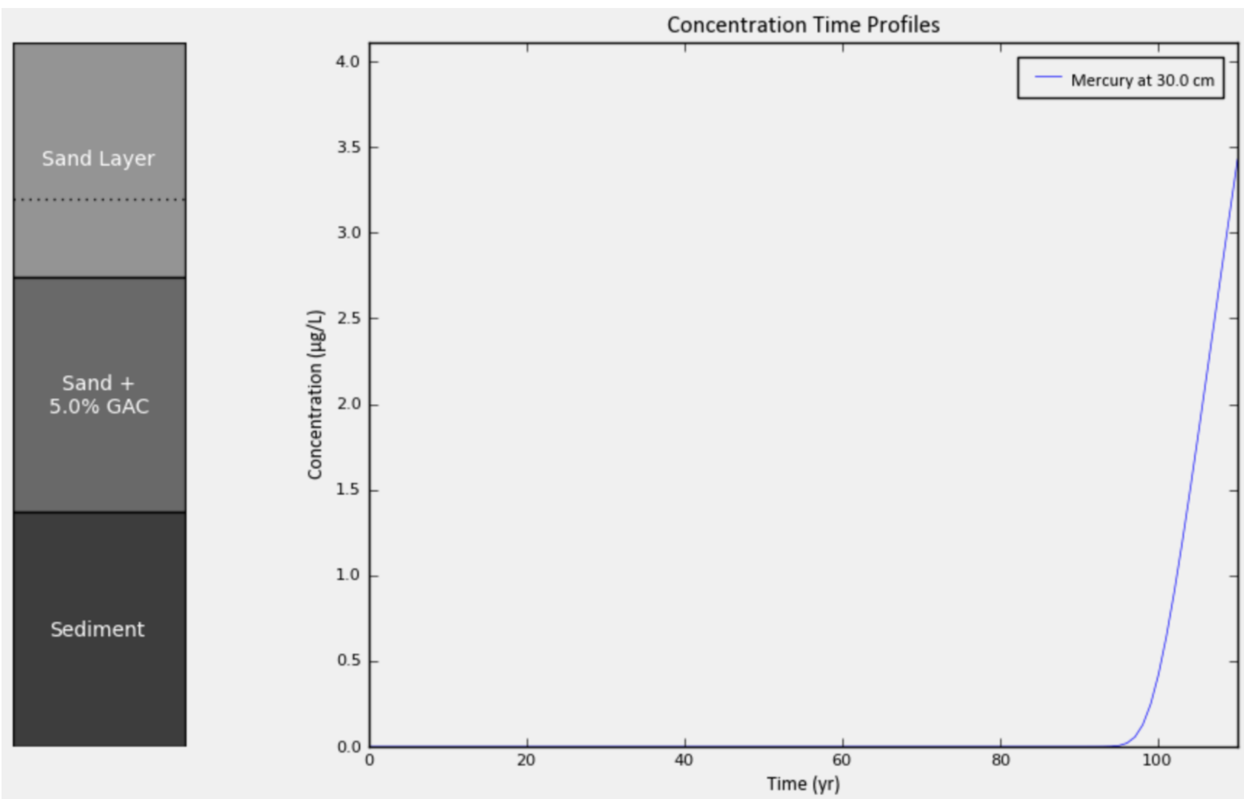


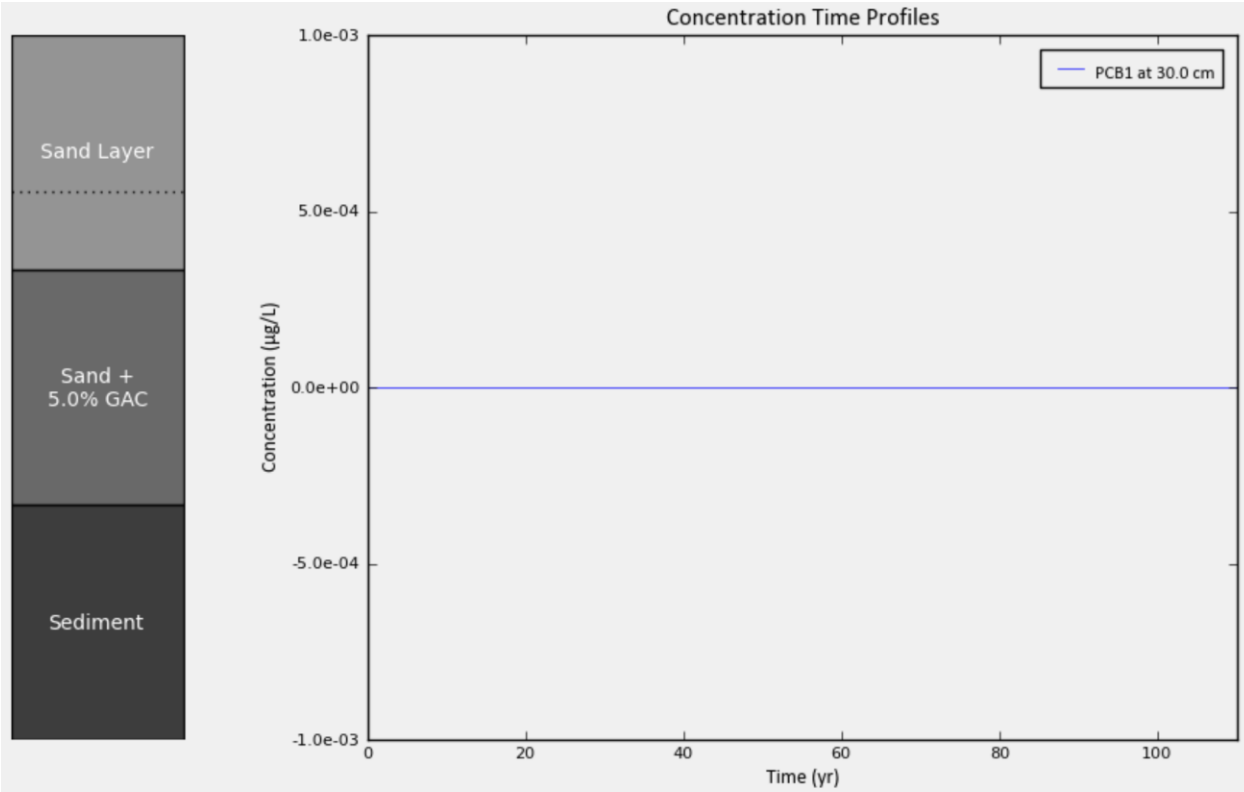
Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Diesel at 30.0 cm
100
80
60
40
20
0
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

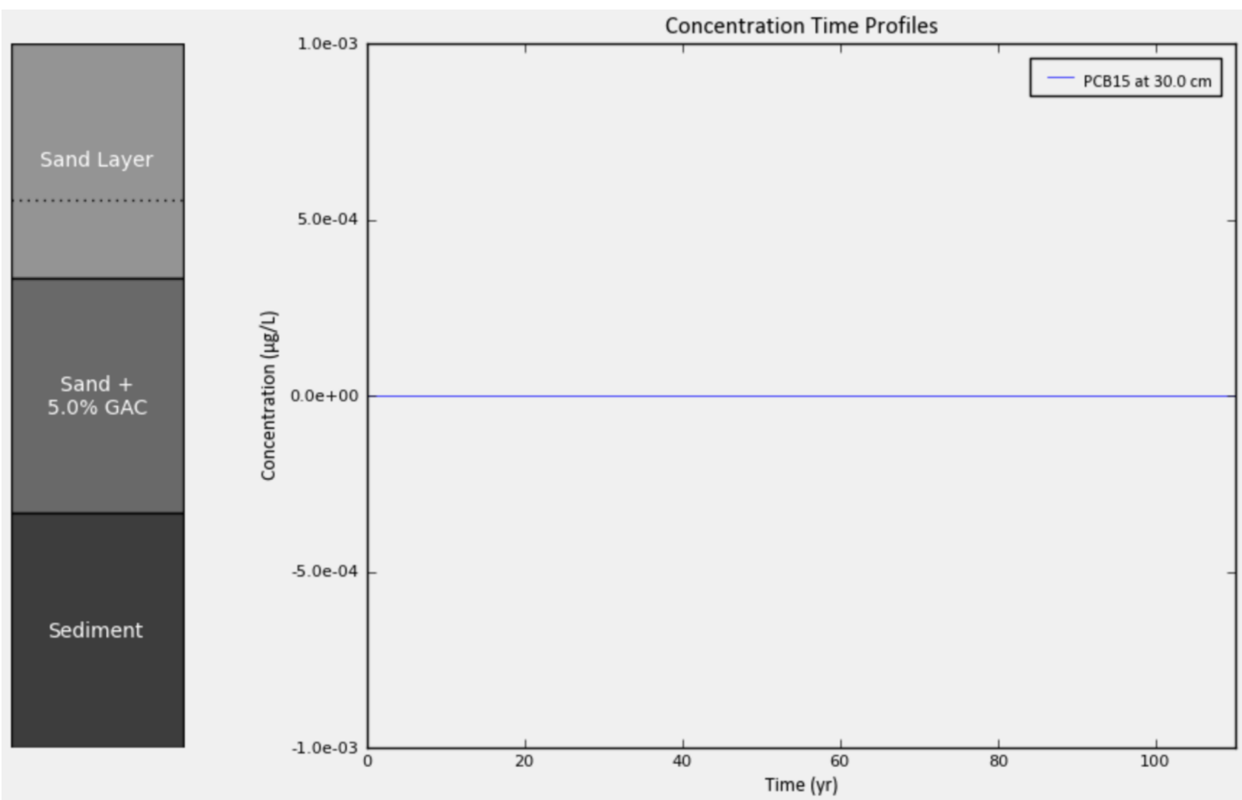

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Lead (inorganic) at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

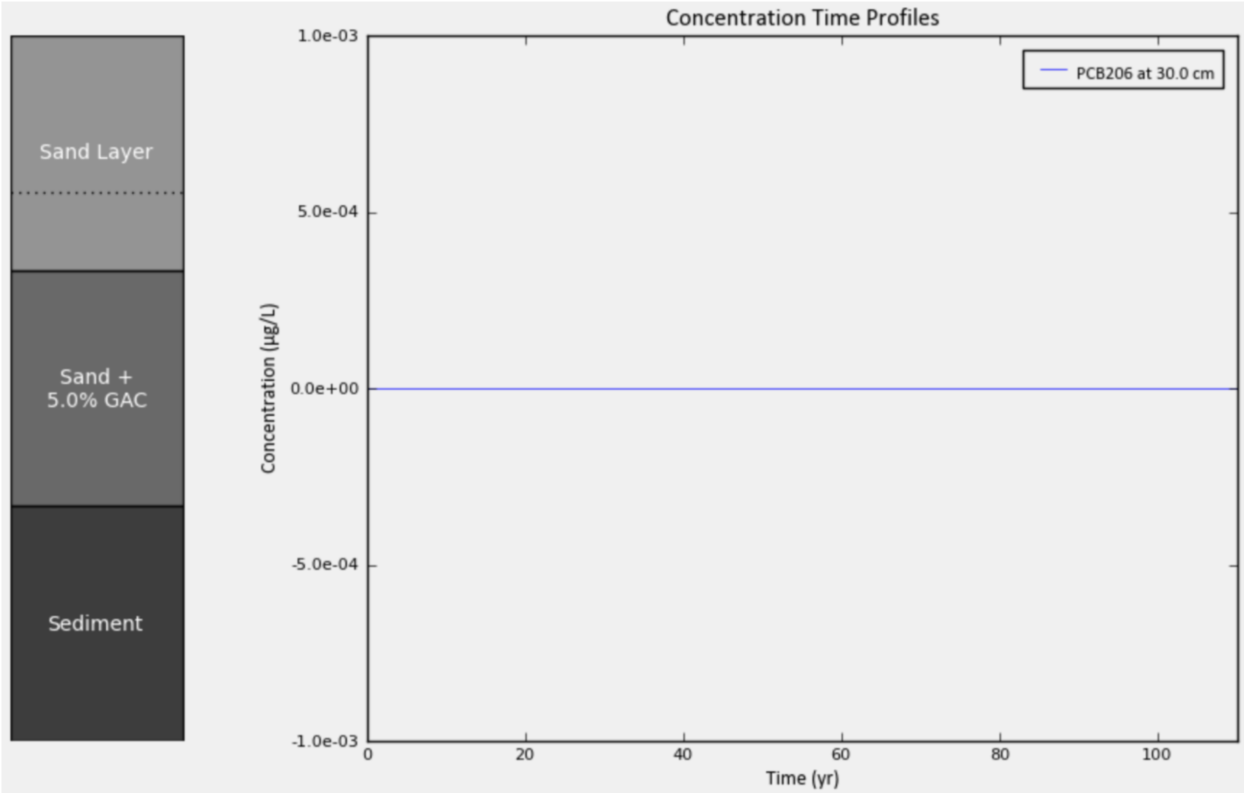

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Lindane at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

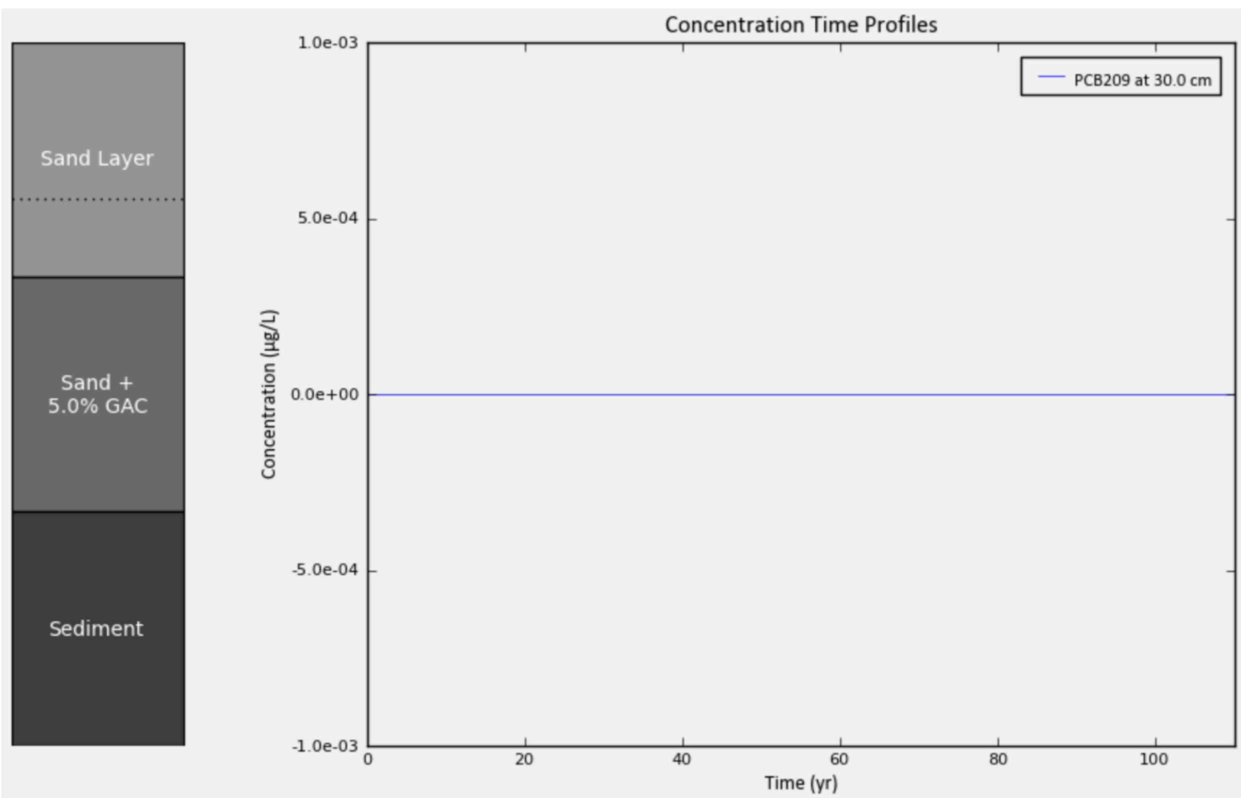

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Manganese at 30.0 cm
Concentration (µg/L)
1.4e+04
1.2e+04
1.0e+04
8.0e+03
6.0e+03
4.0e+03
2.0e+03
0.0e+00
0
20
40
60
80
100
Time (yr)

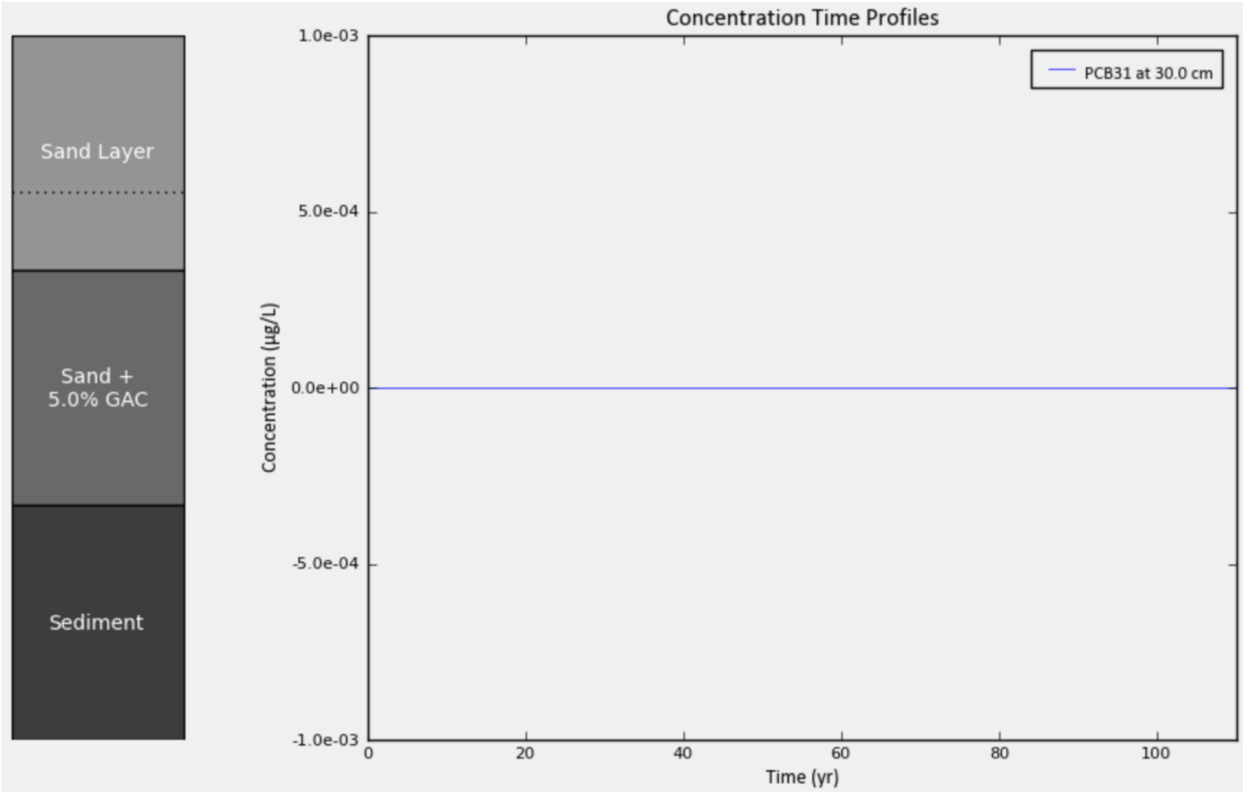

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Mercury at 30.0 cm
Concentration (µg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)

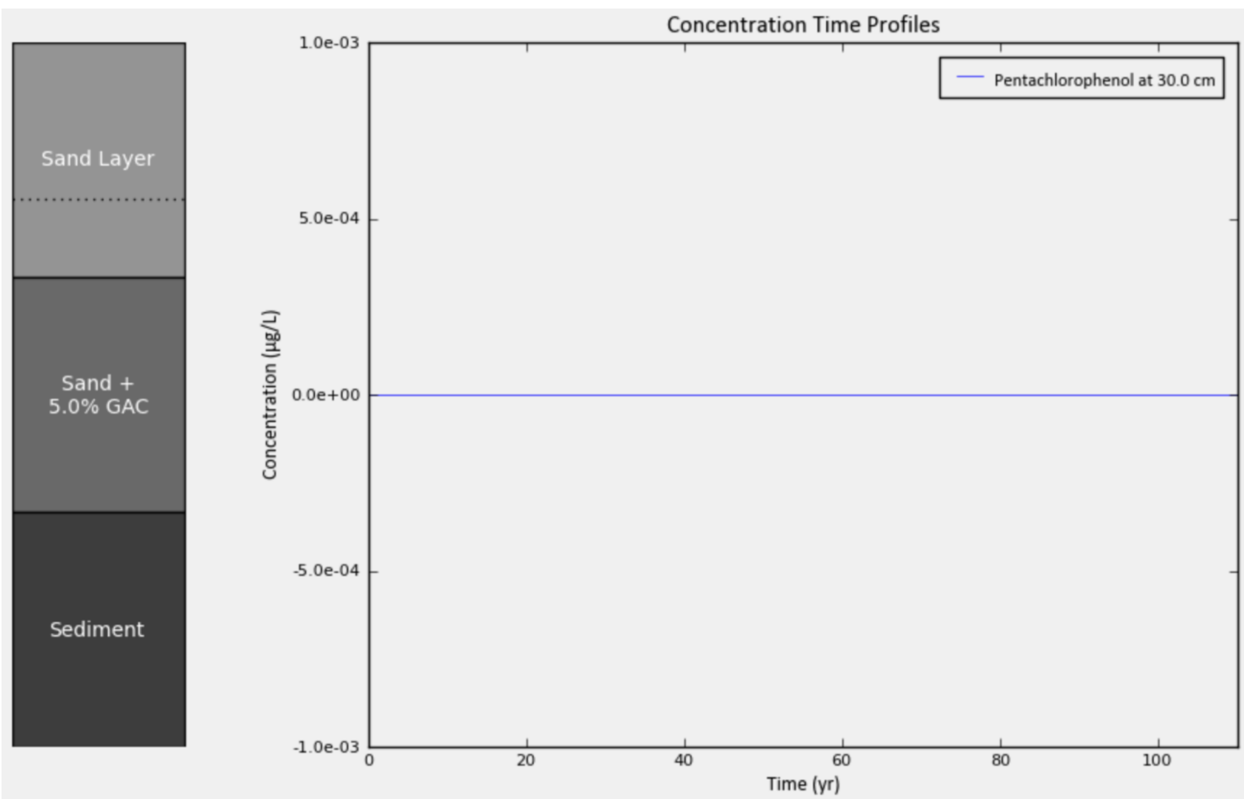

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB1 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

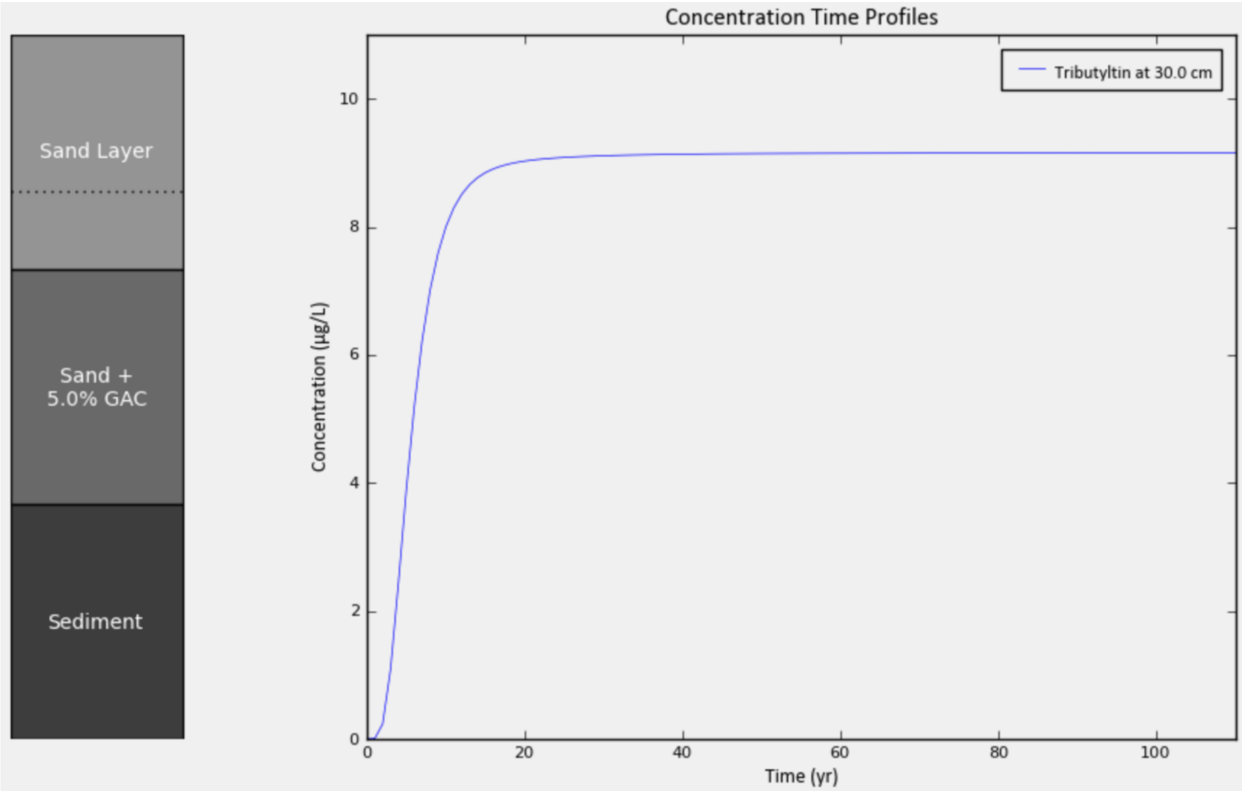

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB15 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

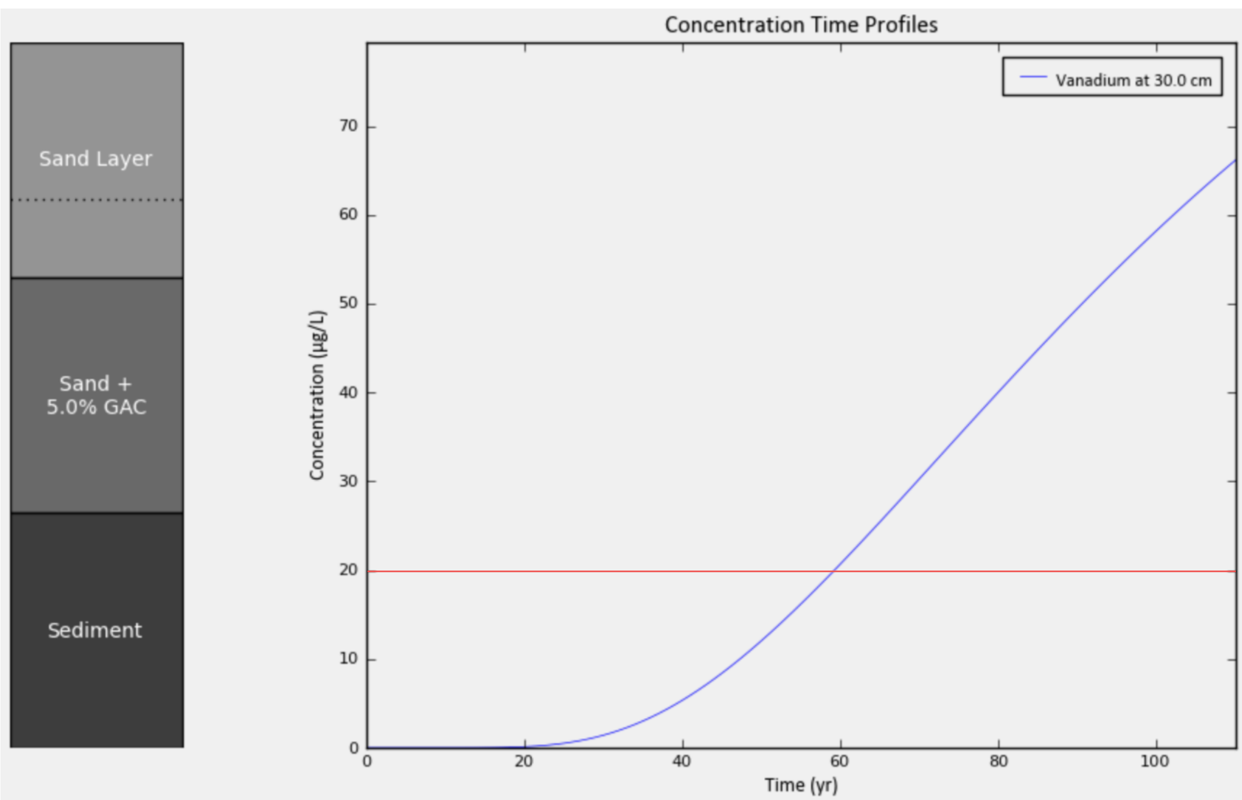

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB206 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

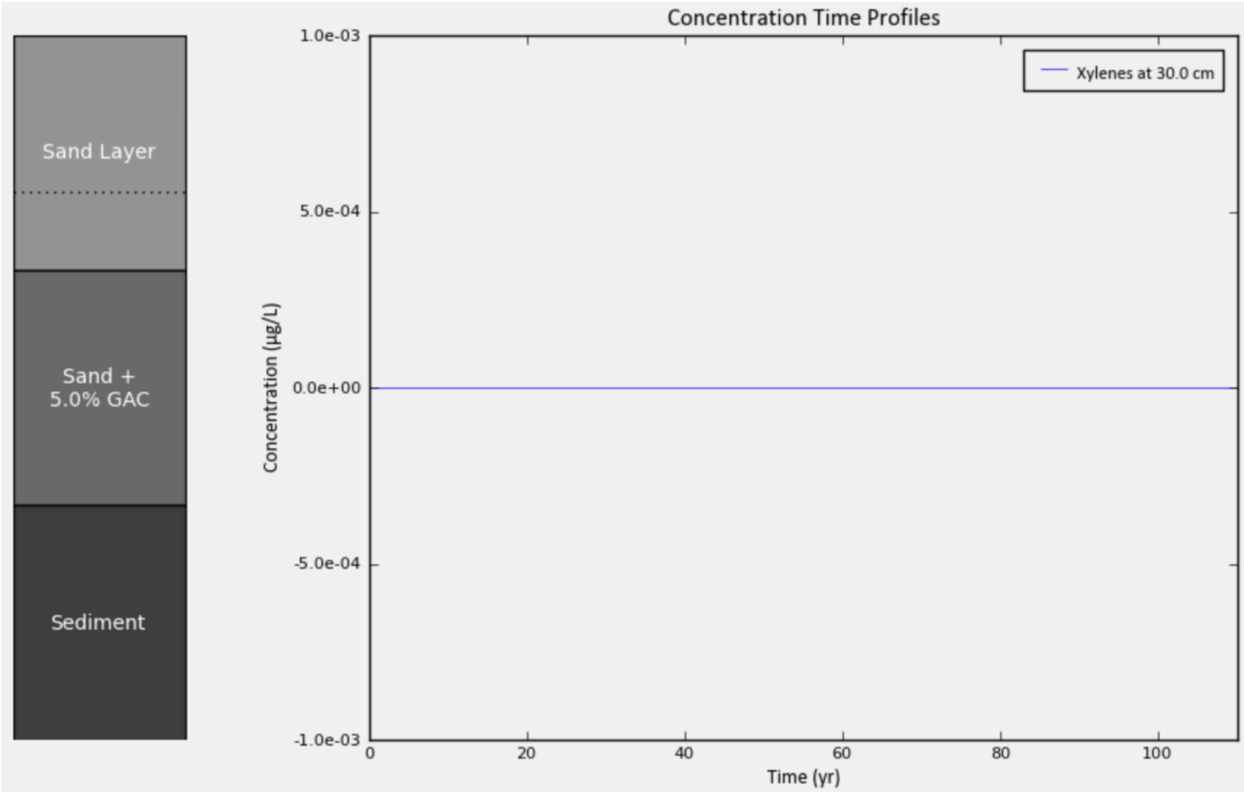

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB209 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

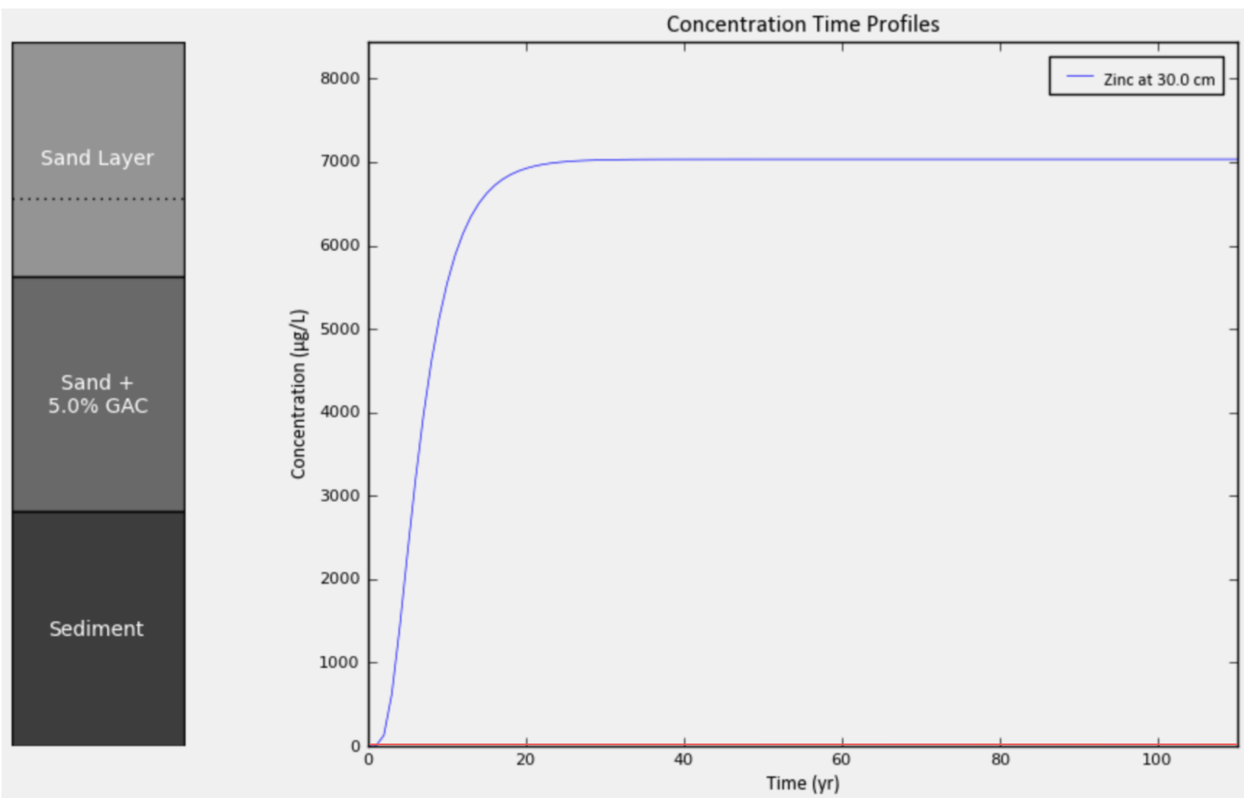

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
PCB31 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Pentachlorophenol at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Tributyltin at 30.0 cm
Concentration (µg/L)
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Vanadium at 30.0 cm
Concentration (µg/L)
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Xylenes at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Zinc at 30.0 cm
Concentration (µg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
Time (yr)

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