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NORTHEAST WASTE MANAGEMENT OFFICIALS' ASSOCIATION

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Quality Site Assessments & Investigations Using the Conceptual Site Model Approach

PART II: SITE INVESTIGATION

Testing the Conceptual Site Model

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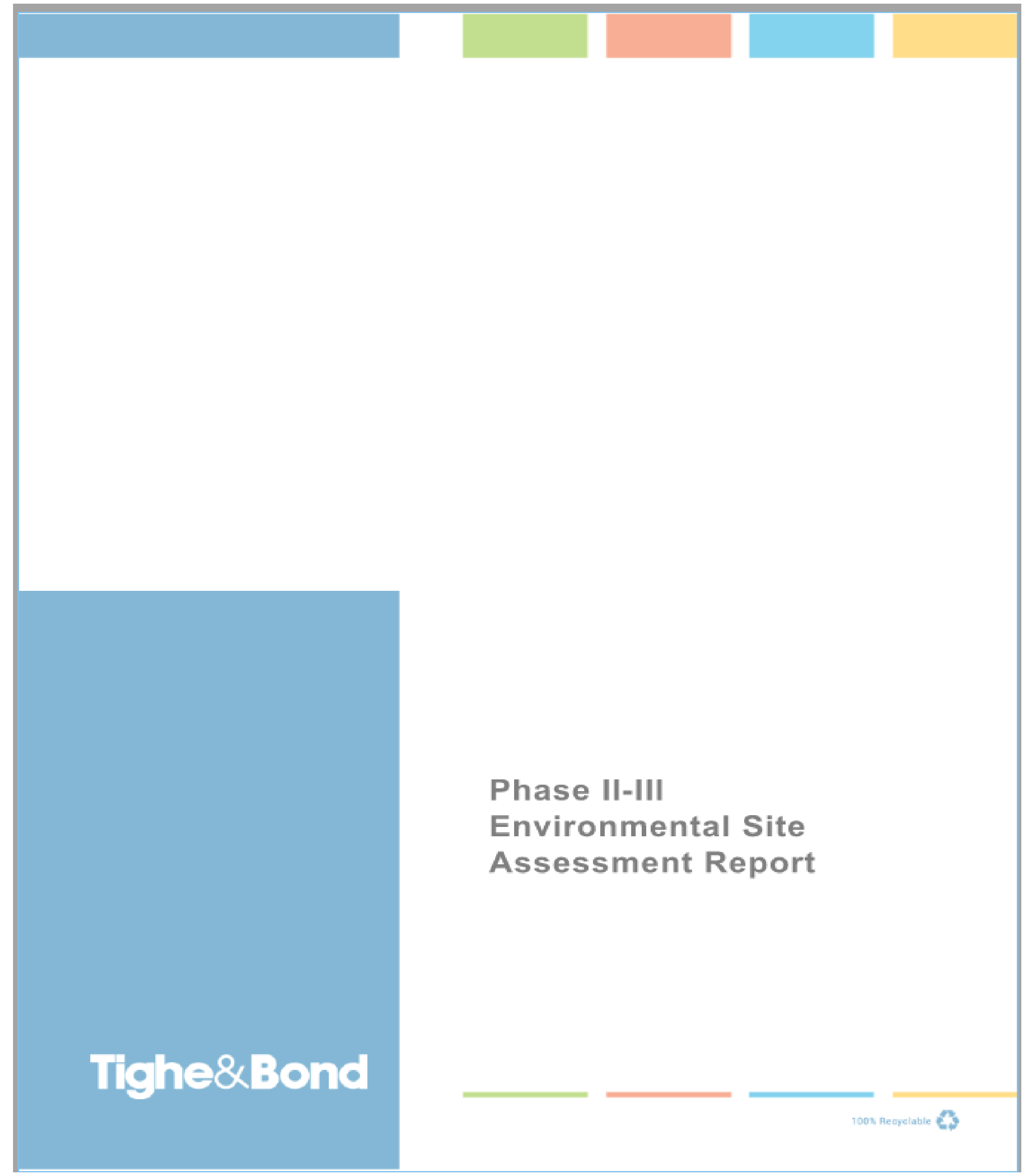
Tighe&Bond

SITE INVESTIGATION WORK PLAN

Conceptual Site Model

INTRODUCTION

- Developing the Site Investigation Workplan
- Exposure routes
- Data needs
- Soil
- Groundwater
- Sediment and surface water
- Air/vapor intrusion
- Other considerations
- Data quality objectives



SITE INVESTIGATION WORK PLAN - CSM

Develop the Initial CSM

"A CSM is a representation of an environmental system that is used as a tool for explaining to others the basis and rationale for the site investigation and the conclusions drawn about the environmental conditions at a site. A CSM incorporates information about a chemical's release, fate, transport mechanisms and pathways and any potential receptors…" Source: *CT SCGD, Published 2007, Revised 2010*

The CSM is a Dynamic Framework For:

- Defining the purpose of the investigation
- Identifying and addressing data gaps and managing uncertainty
- Eliminating or controlling contaminant sources
- Developing and conducting response action strategies
- Evaluating whether response actions have achieved desired endpoints

SITE INVESTIGATION WORK PLAN - CSM

Develop the Initial CSM (cont'd)

- **Summarize Known and Hypothesized Information - Visual, Descriptive**
  - Location of RECs, AOCs, Releases, etc.
  - On-site features or processes that could exacerbate RECs, AOCs, etc.
    - Infrastructure details
  - Identify/hypothesize contaminants of concern
  - Evaluate anticipated contaminant behavior in the environment
    - Mobility, density, volatility, biodegradability
  - Geology
  - Groundwater flow direction
  - Surface Runoff Patterns
  - Hypothesize extent of contamination
    - Vertical and horizontal extent
  - Nearby sensitive receptors (potable/supply wells, indoor air, reservoirs, endangered species)

SITE INVESTIGATION WORK PLAN - CSM

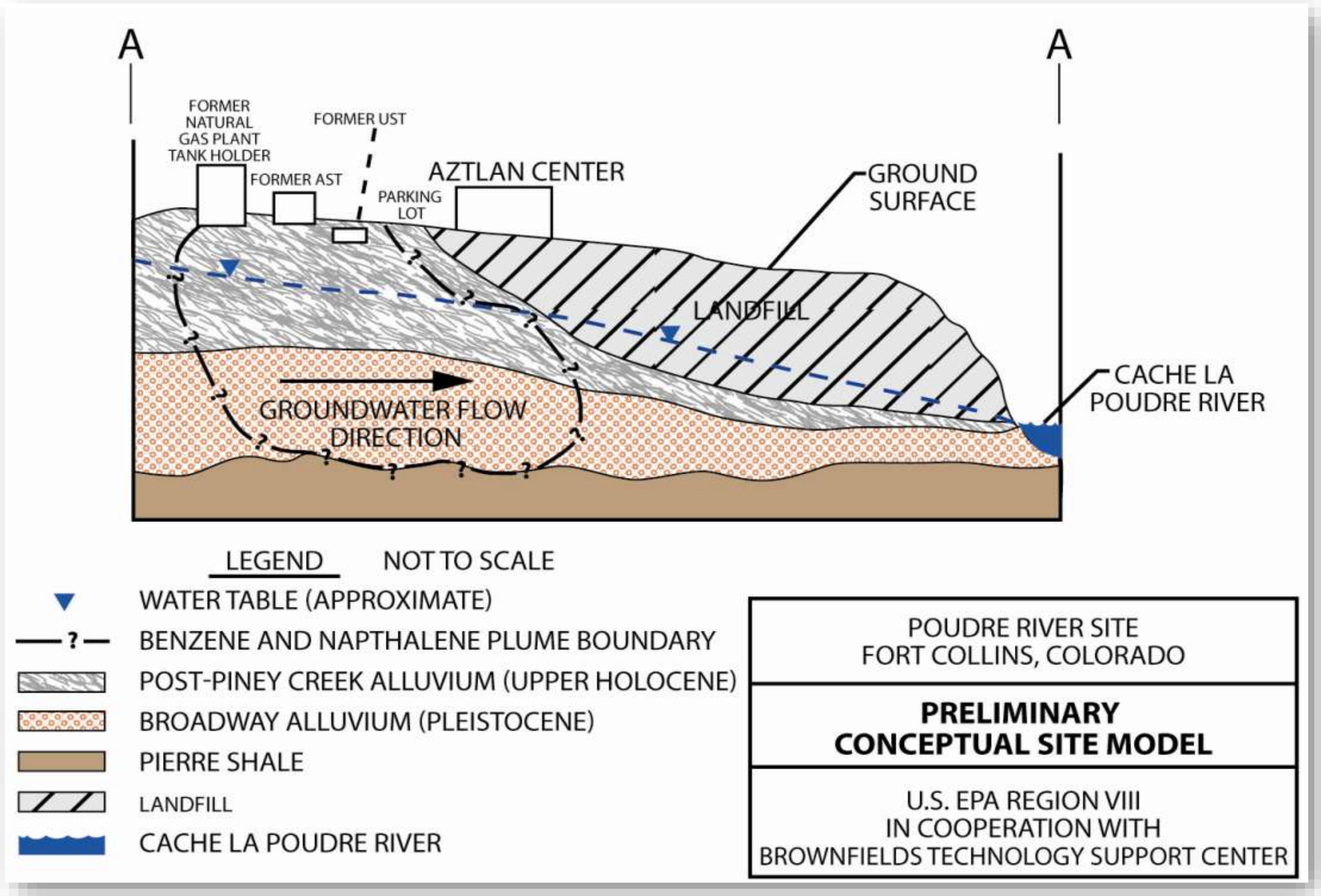
Develop the Initial CSM (cont'd)

TABLE 4-1
CONCEPTUAL SITE MODEL
Phase II/III ESA

AOC	LOCATION	DESCRIPTION	COCs	PREVIOUS SAMPLE LOCATIONS
AOC-1 **(2) Casting Furnaces**	**Building:** 1 **Location:** Basement	The eastern half of the mill was used as a brass casting shop with two furnaces believed to have been water cooled with water from the River that was piped or diverted in a raceway that ran along the northern side of . The two furnaces were observed in the basement filled with potential casting sand and concrete. According to the Phase I ESA from 1996, the brass alloy typically manufactured in mills of this type were primarily made of copper and zinc, with added amounts of lead and tin and trace amounts of cadmium and selenium. Metal particles made airborne during the brass casting process would have accumulated in the dust observed throughout the former manufacturing areas of the building. Metal particles and dusts may also have been washed into the basement during cooling and into the basement floor drains.	PAHs, PCBs, Metals	N/A
AOC-2 **Basement Trenches and Sumps (multiple locations)**	**Building:** 1 **Location:** Basement	An extensive network of trench drains, cleanouts, and sumps is present in the basement beneath most of Building 1. The drain system runs parallel to the former casting furnaces and around several tanks observed in the northern portion of the basement. Most of the trenches appear to be full of sand and/or ash. Significant black staining was observed in many areas of the concrete floor surrounding the trenches. The depth of the trenches and final discharge points of the system could not be determined at the time of this report. Piping was observed within some trench areas with black staining visible around pipe protrusions. The discharge locations of the drains, pits, and sumps were similarly not determined during 2006 Phase I and Phase II environmental assessments. According to the Phase I ESA from 1996, wastewater generated at the site reportedly discharged directly to the River prior to construction of the municipal sanitary sewer system.	VOCs, PAHs, ETPH, PCBs, Metals	N/A
	Building: 2 **Location:** Basement	A trench was observed within the concrete floor below Unit A-1. The trench was covered by steel plates. Holes and gaps in the steel plates allowed for limited observations of the underlying trenches, which were observed to be full of residual ash and/or dust. Staining to the concrete floor was observed around the trench area.	VOCs, PAHs, ETPH, PCBs, Metals	N/A
AOC-3 **Ash Reclamation Areas (multiple locations)**	**Building:** 1 **Location:** Basement	During this Phase I ESA, the former ash reclamation areas were still covered by steel plates and could not be thoroughly observed. According to the 2006 Phase I, the narrow southern portion of the basement was reportedly used for ash reclamation. Ash was reclaimed in several pits, approximately three feet wide by 20 feet long and six feet deep and were also referred to by SEI as "jigs". The jigs were covered by steel plates at the time of the 1996 Phase I ESA by .	PAHs, Metals	N/A
	Building: 2 **Location:** Basement	Several areas of piled ash were observed in the southwest corner of the basement below Unit A-1 ( ). Residual ash was observed throughout the basement area. According to 1996 Phase I ESA, an ash reclamation area was formerly located in this area. Ash from the furnaces reportedly contained metal slag and oxide metal from the melt, including zinc oxide dust. The foundation of the ash reclamation building contains pits known as jigs used to wash away the fine dust and ash leaving re-meltable slag and ash for recovery in the bottom of the pits. Lead, cadmium, and selenium were likely present in the ash within from the reclamation process.	PAHs, Metals	N/A

SITE INVESTIGATION WORK PLAN - CSM

Develop the Initial CSM (cont'd)



Source: USEPA ***Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model***

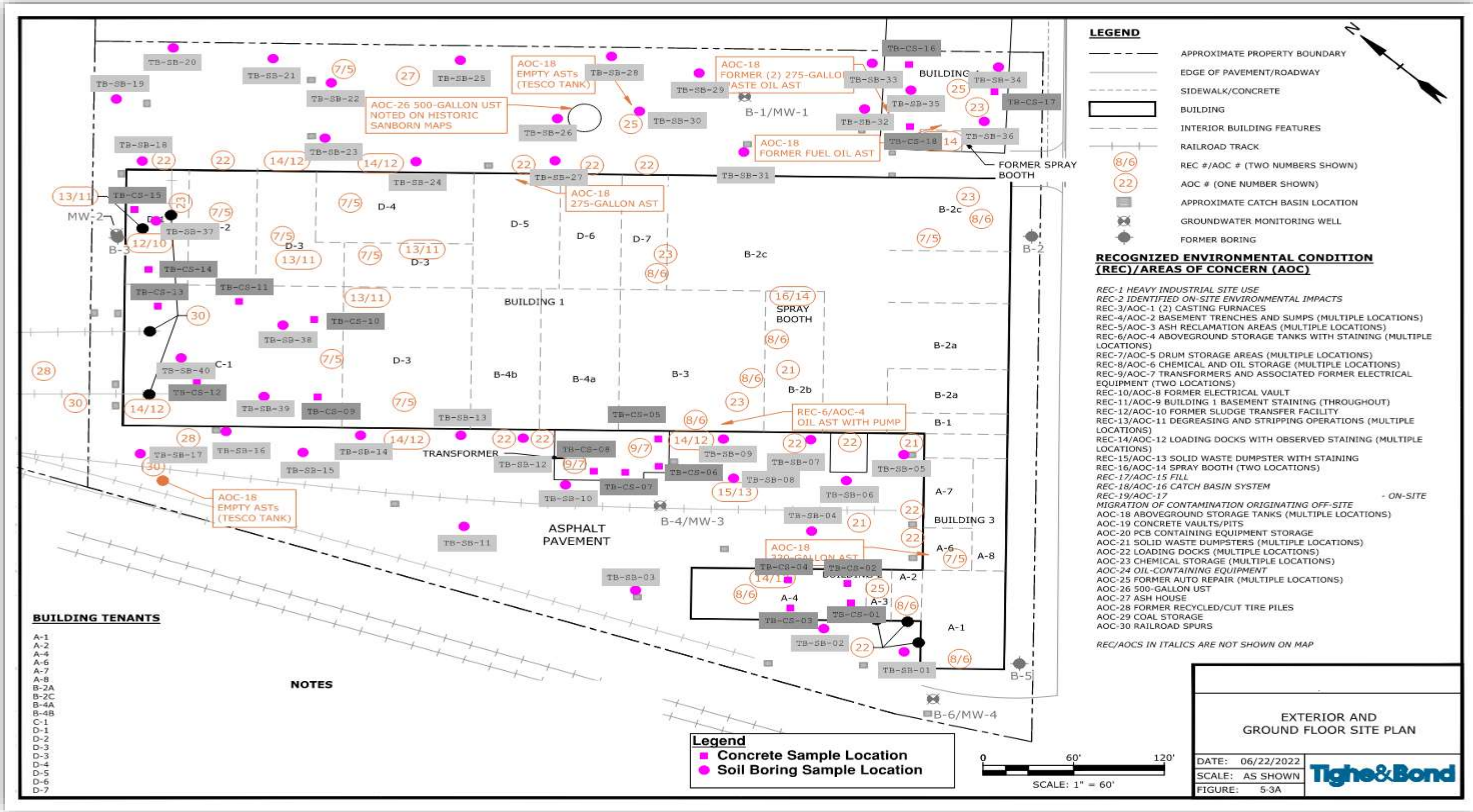
SITE INVESTIGATION WORK PLAN - CSM

Develop a Work Plan Based on the CSM

- **Start with the End in Mind**
  - Connect the source areas to receptors
  - Identify potential site uses and exposure pathways requiring evaluation
  - Evaluate/build on existing data
  - Design a workplan that provides useful data for risk characterization
- **Consult Quality Assurance Plans and Standard Operating Procedures**
  - Regional EPA Quality Assurance Project Plan (QAPP) Procedures - Brownfields
  - State governmental guidance documents (eg. CT Reasonable Confidence Protocols, CT Laboratory Quality Assurance and Quality Control Guidance Document)
  - Industry or company-specific Standard Operating Procedures (SOPs) (decontamination procedures, Health and Safety Plan (HASP), engineering controls)
- **Develop an Initial Site Sketch**
  - Existing physical site features identified in the CSM
  - Receptors (potable/supply wells, indoor air, surface waters)
  - Proposed sample, boring, monitoring well locations
  - "Scope and detail should correspond with the release(s) and site conditions"

SITE INVESTIGATION WORK PLAN - CSM

Develop a Work Plan Based on the CSM (cont'd)



SITE INVESTIGATION WORK PLAN - CSM

Develop a Work Plan Based on the CSM (cont'd)

TABLE 5-5
SOIL SAMPLING RATIONALE
Phase II/III ESA

Soil Boring ID	PURPOSE	GENERAL TARGET DEPTH	TARGET SAMPLE DEPTH(S)	SAMPLE MEDIA			PROPOSED NUMBER OF SAMPLES AND ANALYSES											
				Soil / Sediment	Water	Porous Media	VOCs (EPA 8260B)	TCLP/SPLP VOCS (EPA 8260B/1312)	SVOCs (EPA 8270D)	TCLP/SPLP SVOCs (EPA 8270D)	CT ETPH	RSR Metals (EPA 6010C/7471B)	TCLP/SPLP RSR Metals (EPA 1312 6010C/7471B)	Total Cyanide (EPA Method 9012)	Amenable Cyanide (EPA 4500 CNCG)	PCBs (EPA 8082/3540C)	1,4-Dioxane (EPA 8270)
TB-SB-01	Assessment of potential releases associated with AOC-6, AOC-15, and AOC-22.	0-15 ftbg; Boring depth designed to evaluate the presence and thickness of fill.	Interval exhibiting the greatest degree of impacts above the observed water table.	1			1		1		1	1				1	
TB-SB-02	Assessment of potential releases associated with AOC-15.			1			1		1		1	1				1	
TB-SB-03	Assessment of potential releases associated with AOC-15, AOC-16, and AOC-30.			1			1		1		1	1				1	
TB-SB-04	Assessment of potential releases associated with AOC-15 and AOC-30.			1			1		1		1	1				1	
TB-SB-05	Assessment of potential releases associated with AOC-15, AOC-16, AOC-21, and AOC-22.			1			1				1						
TB-SB-06	Assessment of potential releases associated with AOC-15, AOC-21, and AOC-22.			1			1		1		1	1				1	
TB-SB-07				1			1				1						
TB-SB-08	Assessment of potential releases associated with AOC-13 and AOC-15.			1			1		1		1	1				1	
TB-SB-09	Assessment of potential releases associated with AOC-12 and AOC-15.			1			1		1		1	1				1	
TB-SB-10	Assessment of potential releases associated with AOC-7, AOC-15, and AOC-30.			1			1		1		1	1				1	

NOTES:

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SITE INVESTIGATION WORK PLAN - CSM

Develop a Work Plan Based on the CSM (cont'd)

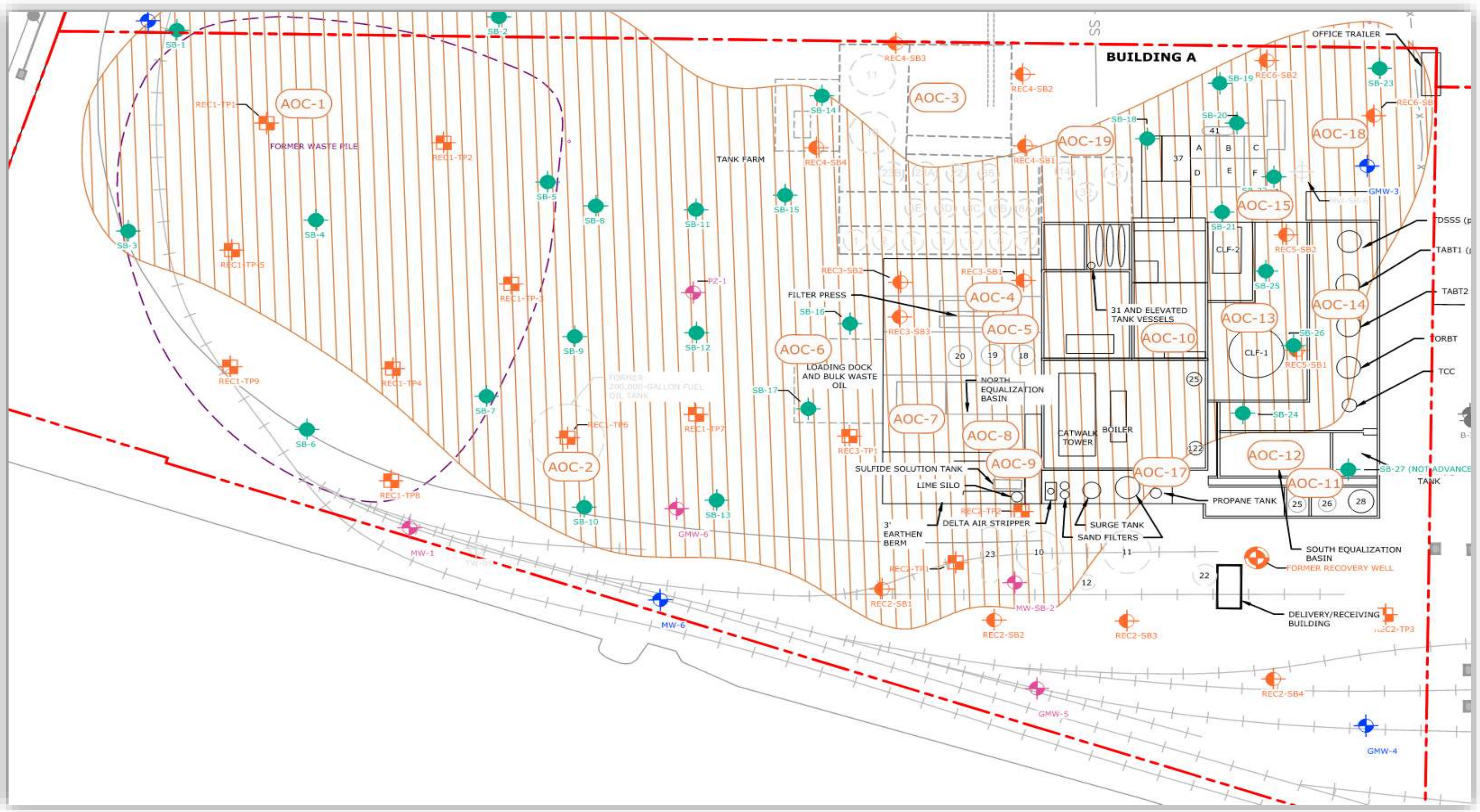
– **Consider Potential Anthropogenic Influences**
  - Potential groundwater mounding from
  - Septic/stormwater infiltration
  - Abandoned building foundations and footings
  - Preferential pathways from utility gravel beds
  - Cutting and filling
  - Historical fill

– **Identify Analyses Required**
  - Data sensitivity and risk characterization needs
  - Microscopy analysis (lead, asbestos)

Analysis	Matrix/Method	Container	Preservative	Holding Time
Porous Media and Soil Samples				
VOCs	Concrete/Soil/5035/ 8260/1312	4-oz. glass jar, (1) methanol VOA, (2) Water VOA	Cool to 4° ± 2° C	Submit to lab within 48-hours of collection. 14-days
SVOCs	Concrete/Soil/8270C /1312	4-oz. glass jar	Cool to 4° ± 2° C	14-days
ETPH	Concrete/Soil CTDEEP Method/1312	4-oz. glass jar	Cool to 4° ± 2° C	14-days
PCBs	Concrete/Soil/3540/ 8082/1312	4-oz glass jar	Cool to 4° ± 2° C	14-days to extraction. 40-days from extraction to analysis. Up to one-year for samples frozen within 48-hours of collection.
Cyanide	Concrete/Soil/9010C /1312	4-oz. glass jar	Cool to 4° ± 2° C	14-days
CT 15 Metals	Concrete/Soil/6000/ 7000/1312	4-oz. glass jar	Cool to 4° ± 2° C	6-months and 28-days for Hg. 14-days for SPLP/TCLP extraction
Pesticides	Concrete/Soil/8081B	8-oz. amber glass jar	None	14-days
Herbicides	Concrete/Soil/8151A	8-oz. amber glass jar	None	14-days
Groundwater Samples				
VOCs	GW/8260	(3) 40-ml/VOA vials	HCL, Cool to 4° ± 2° C	14-days
SVOCs	GW/8270C	(2) 1,000-ml/amber	Cool to 4° ± 2° C	7-days
ETPH	GW/CTDEEP Method	1,000-ml/amber	Cool to 4° ± 2° C	7-days

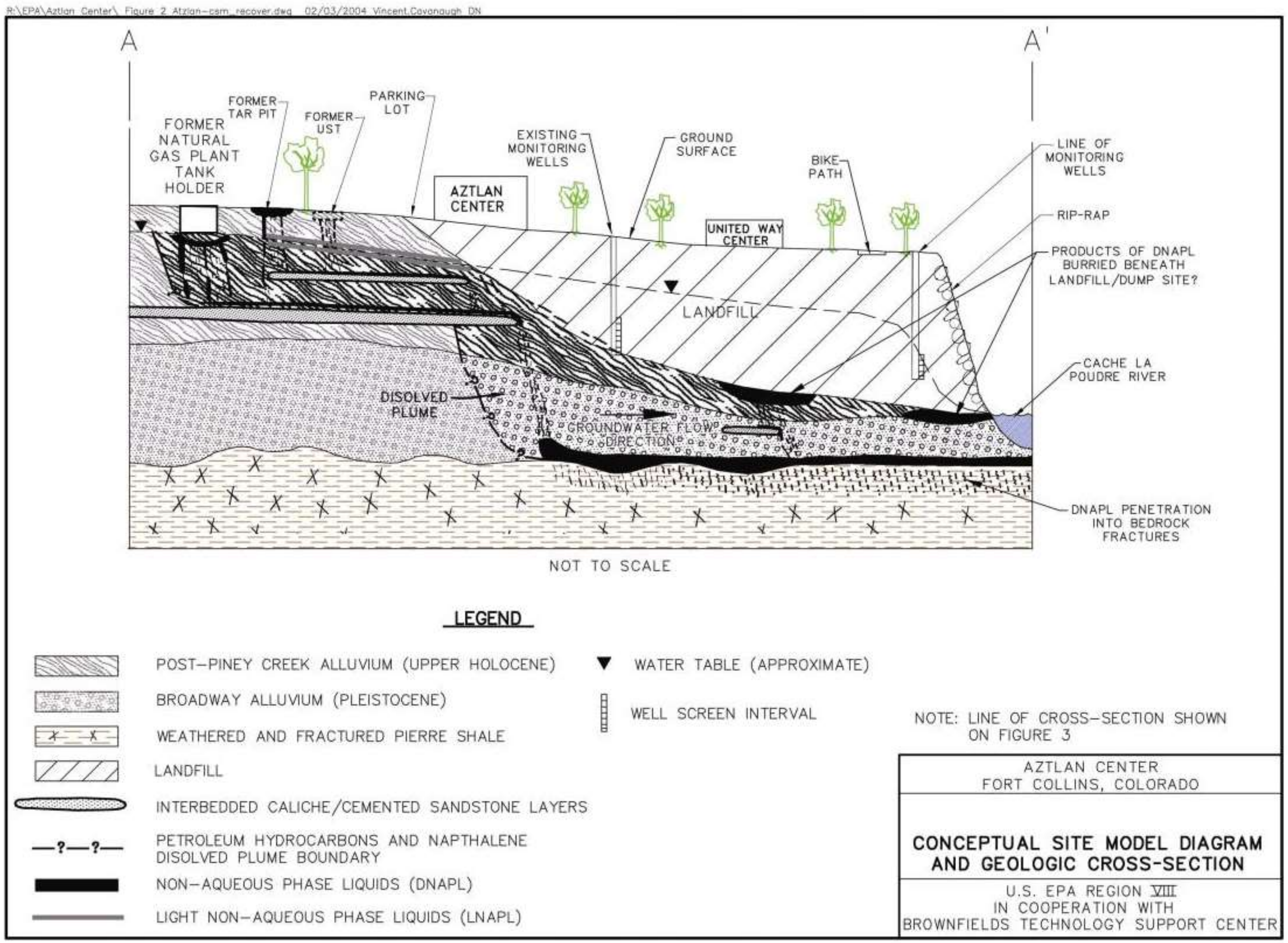
SITE INVESTIGATION WORK PLAN - CSM

Develop a Work Plan Based on the CSM (cont'd)



SITE INVESTIGATION WORK PLAN - CSM

Redeveloping the CSM



Source: USEPA *Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model*

TESTING THE CSM

Potential Exposure Pathways

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Exposure Pathway

An *exposure pathway* is the link between a contaminant source and a receptor (U.S. EPA).

E.g., Groundwater, drinking water, indoor air, surficial soil

Exposure Route

An *exposure route* is the way a chemical enters an organism upon contact (U.S. EPA)

E.g., Ingestion, inhalation, dermal absorption

TESTING THE CSM

Potential Exposure Pathways

Air Pathways

- Outdoor/ambient air
- Indoor Air (vapor intrusion)

Groundwater Pathways

- Direct Consumption (drinking, cooking)
- Dermal Absorption (bathing)
- Inhalation (bathing)

Soil Pathways

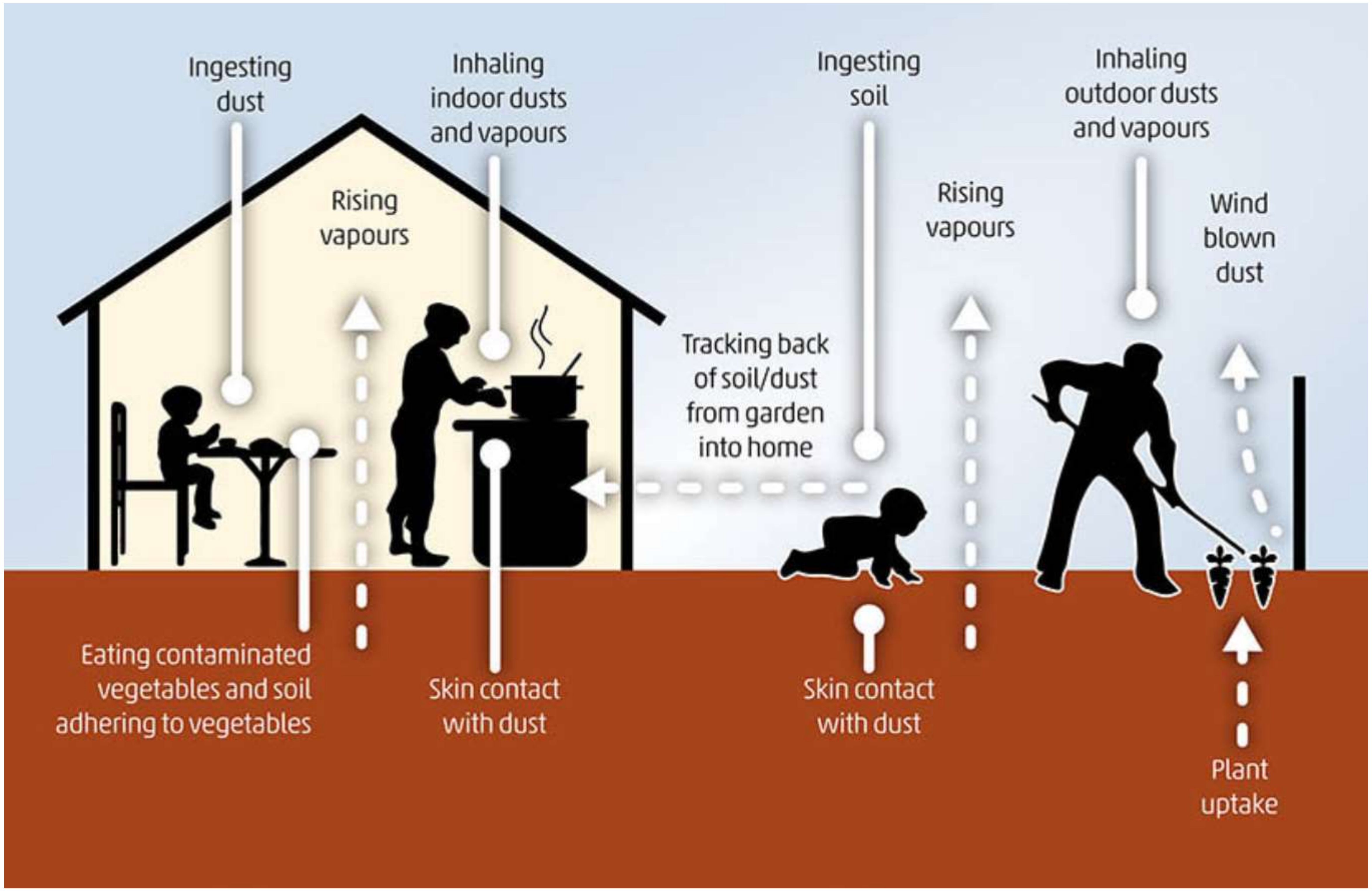
- Dermal Absorption (recreation)
- Incidental Ingestion (construction)
- Inhalation of Particles (construction)
- Produce (agriculture/gardening)
- Soil Gas (vapor intrusion)

Surface Water Pathways

- Dermal Absorption (recreation)
- Incidental Ingestion (recreation)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Soil



Source: ***United Nations Environmental Assembly:*** **Chapter 4. Environmental, health and socio-economic impacts of soil pollution**

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Soil Exposure Pathway

- Direct contact with soil is the primary concern
- Exposure pathways are categorized based on soil contaminant accessibility to receptors
- Exposure routes include dermal absorption, incidental ingestion, dust inhalation

Surficial Soil

- Considered “accessible” in most cases (top 3 feet)
- Typically residential activities (passive recreation, gardening, home produce)
- Majority of ecological exposures are in the top 2 feet

Soil “at Depth”

- Considered “potentially accessible” or “inaccessible” (below 15 feet)
- Typically associated with construction activities (excavations, utility work)
- Can become “surficial” soil if cutting/filling occurs in the future

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Soil Exposure Pathway Assessment

Soil Sampling

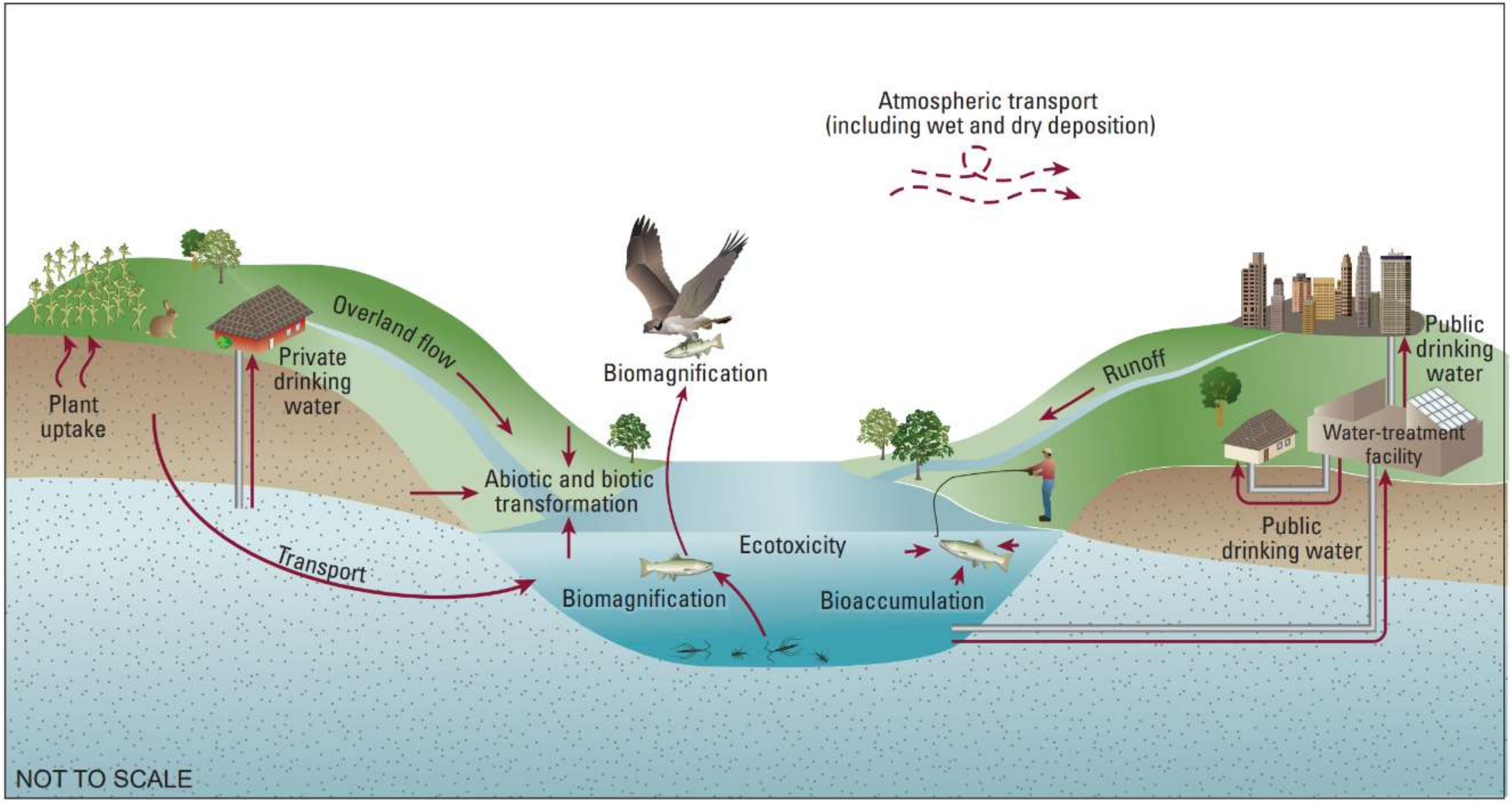
- Hand tools for surficial soil
- Soil borings for deep assessment
  - Geoprobe is economical, but compression can cause uncertainty in sample depths
  - Hollow-stem auger is slower, but gives more precise sample depths
- Field screening techniques available (TPH, total VOCs)
  - Guides assessment (vertical, horizontal) and analytical sample selection
- Match sample depths to exposure pathways (e.g. 0-2 feet, > 15 feet)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Soil Exposure Pathway Assessment (cont'd)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Groundwater



Source: *USEPA:* **Improving Understanding and Coordination of Science Activities for Per- and Polyfluoroalkyl Substances (PFAS) in the Chesapeake Bay Watershed**

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Groundwater Exposure Pathway

- Direct consumption
  - Private wells
  - Municipal supply wells
  - Facility potable/supply wells
  - Future exposures (Potentially Productive Aquifers)
- Vapor Intrusion
  - Within proximity to buildings
  - Average groundwater depth < 15 feet
- Recreational and Ecological
  - Potential discharge to surface water bodies

Always check state regulations!

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Groundwater Pathway Assessment

- Consider characteristics of contaminant(s) being assessed
  - Well screen intersects top of water table (NAPL)
  - Well screened at confining layers (DNAPL)
  - Assess bedrock as needed
  - Well placement near buildings
  - Sample potable/supply wells directly
- Monitoring well network (source area, mid-plume, edge of plume)
  - Contaminant mobility
  - Anticipated groundwater flow direction
- Quality Assurance
  - Develop monitoring wells (reduce turbidity)
  - Bailer or low-flow sampling
  - Sample integrity: keep samples cool, meet analytical method holding times

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

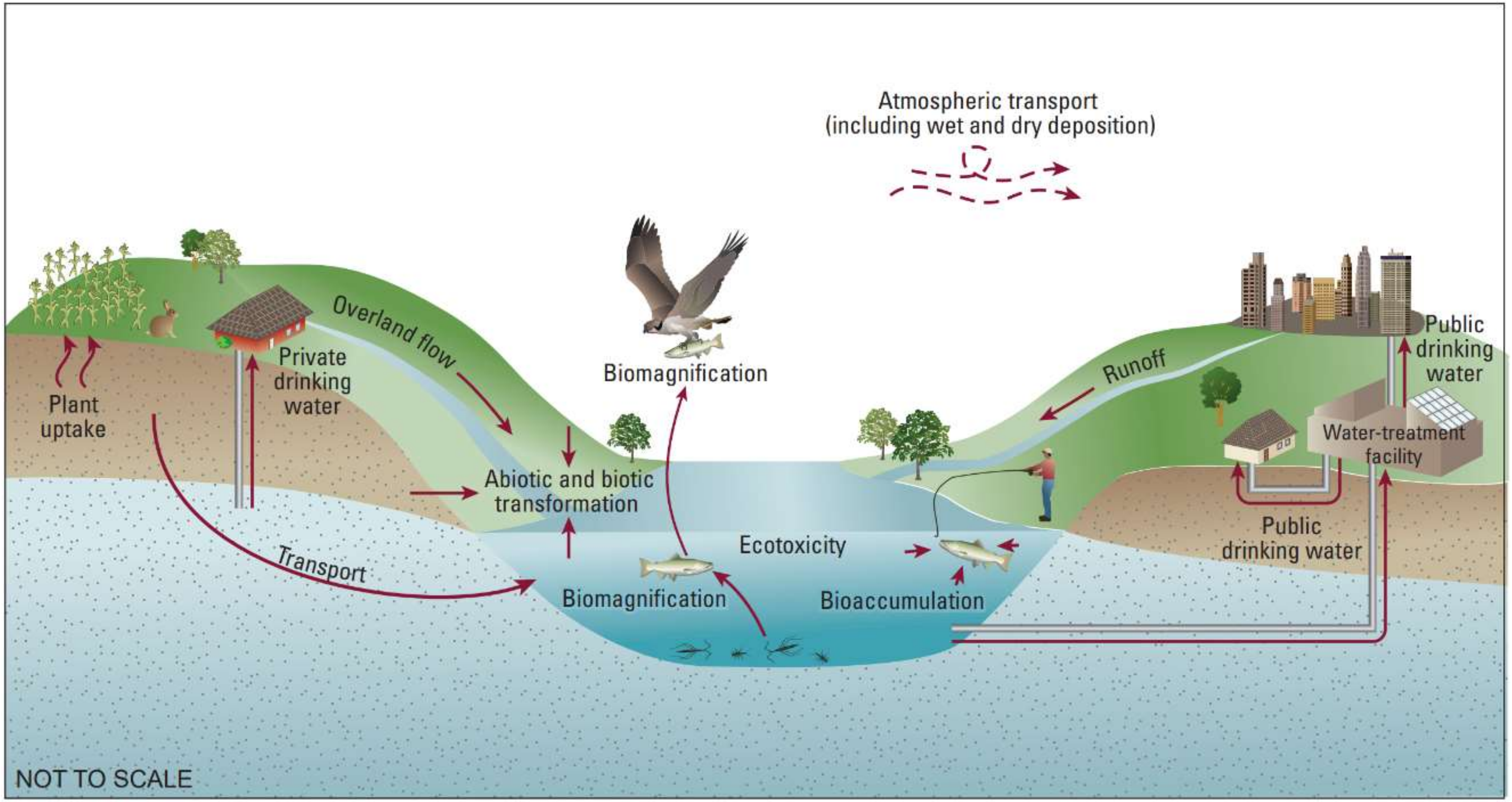
Groundwater Pathway Assessment (cont'd)

Source: ***Pine-Environmental:*** Copyright © 2019 Pine. All Rights Reserved.designed by port80

- Pump rate (100-400 milliliters per min), depth to water, temperature, dissolved oxygen, specific conductance, pH, oxidation reduction potential (ORP), and turbidity

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Sediment and Surface Water



Source: *USEPA:* **Improving Understanding and Coordination of Science Activities for Per- and Polyfluoroalkyl Substances (PFAS) in the Chesapeake Bay Watershed**

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Sediment and Surface Water Exposure Pathway

- Recreational and Ecological
  - Potential discharge to hydraulically connected water bodies
  - Bioaccumulation

- Direct consumption
  - Private wells
  - Municipal supply wells
  - Facility potable/supply wells
  - Future exposures (Potentially Productive Aquifers)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Sediment and Surface Water Exposure Assessment

- Sediment
  - Hand tools: scoops, dredgers, coring devices
  - Consider sediment transport
  - Solids versus suspended sediment

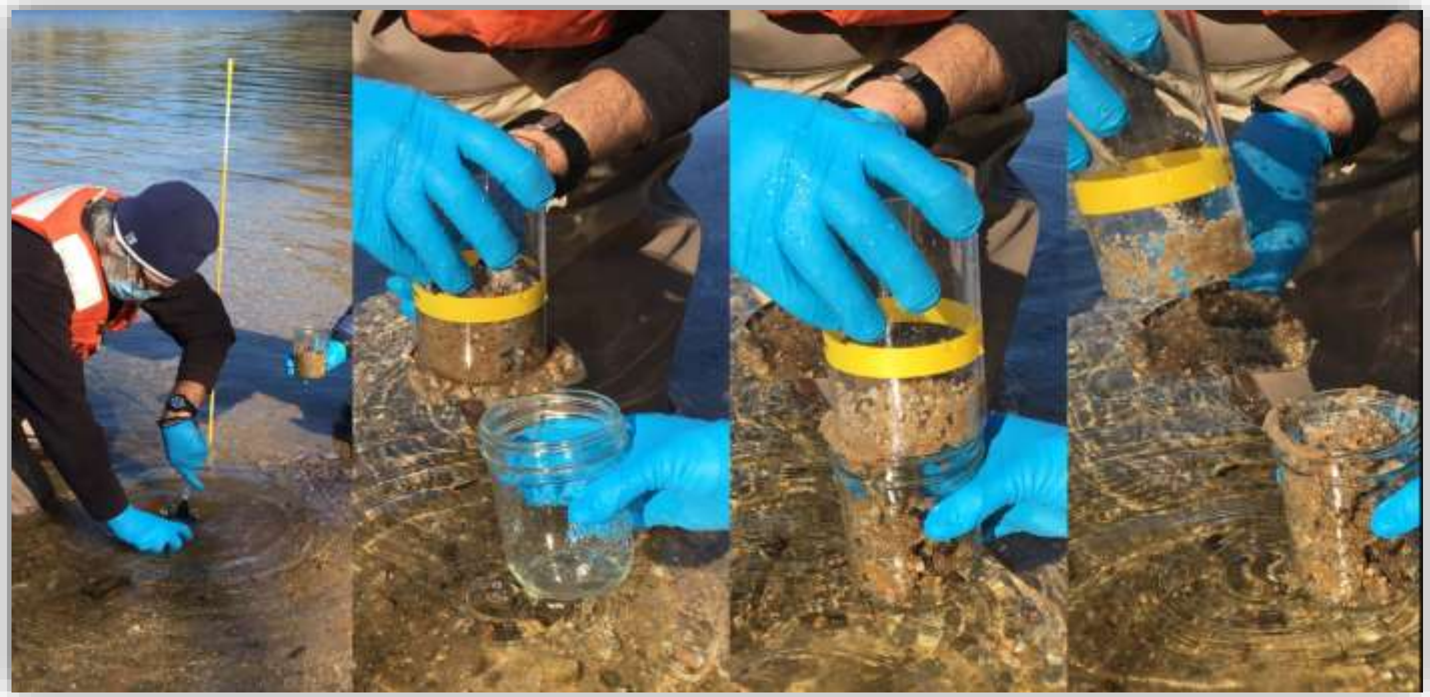
- Surface Water
  - Direct fill containers or use of telescopic scoops, pumps
  - Goal is to collect a representative sample of the waterbody

SOPs for media sampling are available from the EPA.

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Sediment and Surface Water Exposure Assessment (cont'd)

Source: ***Ocean Surveys:*** Grab sampling Fig. 1

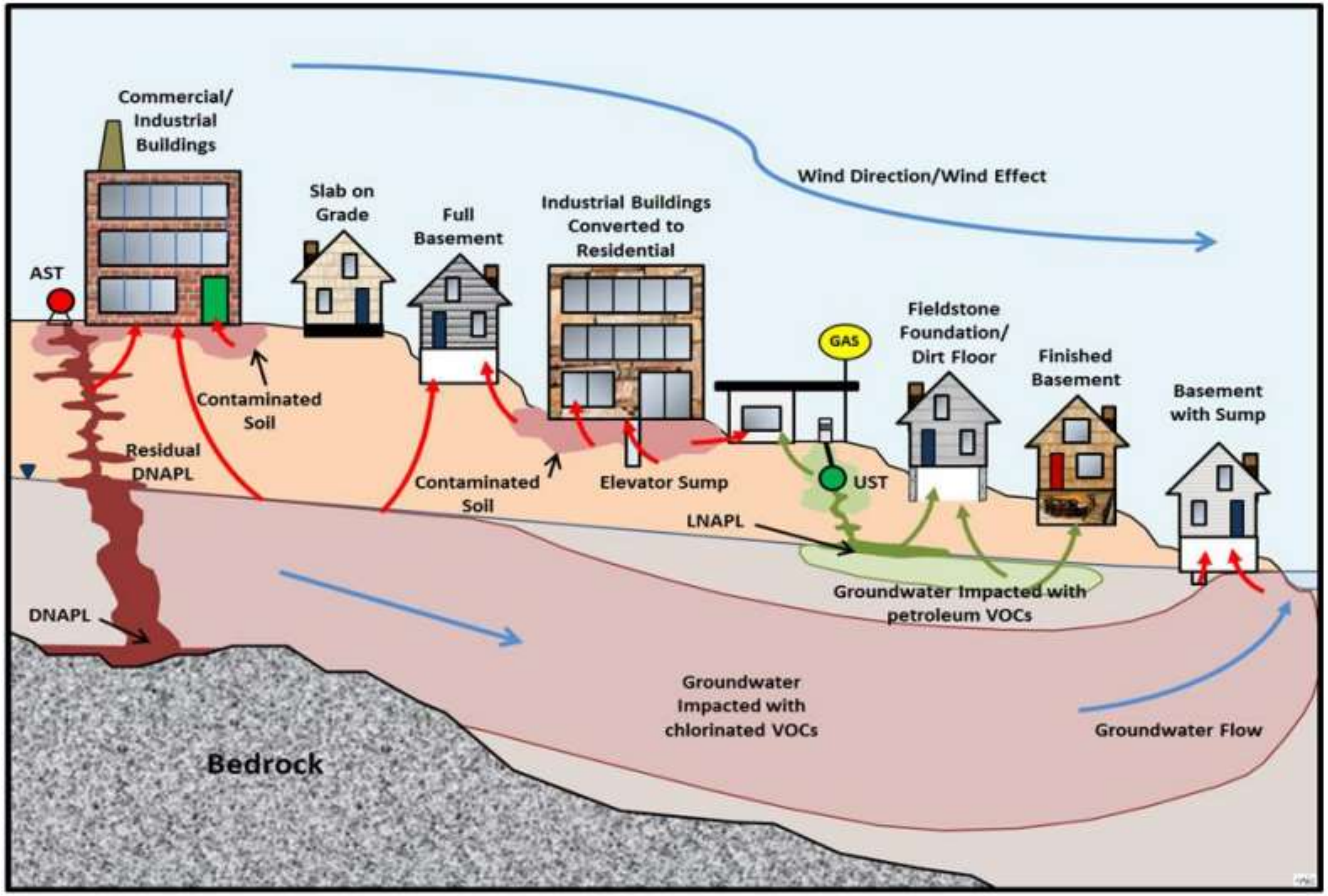


Source: ***USGS:*** Public Domain

Source: ***USGS:*** Public Domain

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Air



Source: MassDEP *Vapor Intrusion Guidance: Site Assessment, Mitigation and Closure Policy #WSC-16-435*

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Air Exposure Pathway

- Volatile substances
- Vapor intrusion is often the primary concern
- Begins with soil and groundwater assessment
- Sub-slab soil gas assessment

Soil Vapors

- Assess generally within proximity to a building
- LNAPL/DNAPL sources near building

Groundwater Vapors

- Monitoring well generally within proximity to a building
- Groundwater < 15 feet below ground on average
- Evaluate direct exposure pathways (e.g. bathing)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Air Exposure Pathway Assessment

Sub-Slab Soil Gas Sampling

– Concentrations are variable over short distances

– "Air-Tight" is important (water dams, counter-sunk vapor pins, helium shrouds)

– Applicable thresholds indicate need for indoor air sampling

Indoor Air Sampling

– Remove confounding sources (notify ahead of time)

– Create "representative" environment (open windows in summer, closed in winter)

– Applicable thresholds indicate need for risk characterization

Considerations

– Seasonality ("winter" conditions: indoors 10F > outdoor temperature)

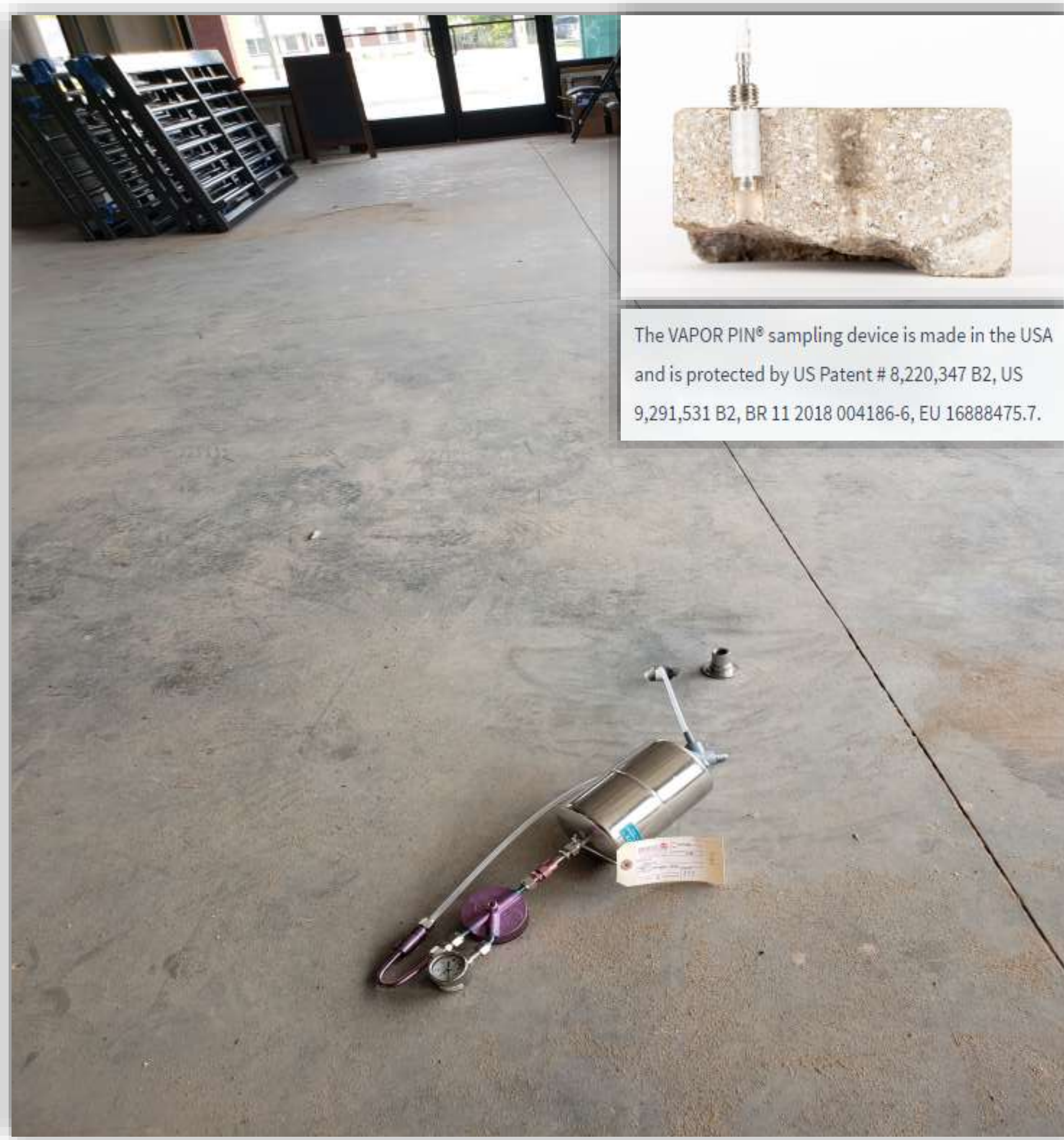
– Preferential pathways/concentration gradient (heating/cooling air movement in building)

– "Other" sources - heated water from contaminated private well

– Confounding indoor sources (moth balls, brake/carburetor cleaners)

TESTING THE CSM – POTENTIAL EXPOSURE PATHWAYS

Air Exposure Pathway Assessment (cont'd)



TESTING THE CSM – OTHER CONSIDERATIONS

Start with the End in Mind

- Presence/absence determination
- Risk characterization (long-term exposure)
- Groundwater / Surface Water Interactions
  - Groundwater “discharges” and “recharges” surface water seasonally
- Continually update CSM with new data

DATA QUALITY OBJECTIVES

Definition: Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of the data needed from a particular activity to support specific decisions.

Standard: DQOs must be in conformance with professional standards and agency requirements and consistent with known information about the site.

DQOs are the starting point in designing a sampling program: matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data meets project requirements**.**

General DQOs include the following:

- To produce an accurate description of site conditions.
- To allow an objective assessment of exposure pathways and risks to receptors.
- To evaluate the risk to human health and the environmental in accordance with current regulatory standards (e.g. detection limits must be sufficiently low to compare to the regulation or state that governs the sampled media.

DATA QUALITY OBJECTIVES

General DQOs (cont'd)

- To establish long-term trends in contaminant levels to support future site management decisions.
- To evaluate the effectiveness of a treatment system or other remedial strategy.
  - Long-term groundwater monitoring (LTM) is a common remedial alternative for many sites.
    - Verify reductions in concentrations, on-going natural attenuation processes are reducing the plume, and plume attenuation rates.

DQO Soil Example

- Determine the presence/absence of contaminants of concern in soil, and
- Further delineate the extend of known areas of soil contamination

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Questions?

CASE STUDY
CT Site Testing the CSM

- CSM hypothesizes zinc impacted sediment has migrated and deposited on the site from off-site sources.

- Primary exposure routes include direct contact with sediment and/or surface water.

- Receptors include groundwater and surface water bodies, no known use of groundwater at the site or within the area.

- Data needs, in this case evaluate existing data in the context of the proposed CSM.

- Specifically evaluate soil and groundwater quality in the context of the CSM. Establish DQOs

CASE STUDY

CT Site Testing the CSM

- Is zinc truly in groundwater?
- DQO - obtain representative groundwater samples.
- Redevelop wells and collect new samples, total and dissolved.
- Evaluate effects of sample turbidity on zinc concentrations.
- Conclusion, zinc confirmed to be present in groundwater at concentrations of concern.

CASE STUDY

CT Site Testing the CSM

– Zinc soil correlations, DQO - samples locations vs. former stream channels (horizontal).

CASE STUDY

CT Site Testing the CSM

– Zinc soil correlations, DQO - zinc soil concentrations and site geology, fill vs. native alluvium (vertical profile).

Zinc in Soil (mg/Kg)

Purple	>2,500
Pink	1,000-2,500
Orange	400-1,000
Yellow	100-400
Green	<100

Sample ID	Date Sampled	Consultant	Bottom Depth of Boring	Sample Depth	Zinc (mg/Kg)	SPLP Zinc (mg/L)	Soil Correlations
CT DEEP RSRs				Res Dec	20,000	NA	
				I/C DEC	610,000	NA	
				GB PMC	NA	50	
TB-TP-12	8/31/2016	Tighe & Bond		5-7'	41.8	-	
TB-TP-12	8/31/2016	Tighe & Bond		10-11'	1,330	0.074	10-11' Black coarse sand and fine gravel, very organic, twigs observed, string and rubber belt at 10' Cu = 3,210 mg/kg, Pb = 79.7 mg/kg
TB-TP-13	8/31/2016	Tighe & Bond		1-3'	88.8	-	
TB-TP-13	8/31/2016	Tighe & Bond		4-6'	88.3	0.056	
TB-TP-13	8/31/2016	Tighe & Bond		10'	186	-	
TB-TP-14	8/31/2016	Tighe & Bond		1-2'	49.1	-	
TB-TP-14	8/31/2016	Tighe & Bond		2-5'	57.6	ND<0.010	
TB-TP-14	8/31/2016	Tighe & Bond		14'	54	-	
DUP-1	8/31/2016	Tighe & Bond		2-5'	45.3	-	
TB-TP-15	9/6/2016	Tighe & Bond		10'	25.5		

CASE STUDY
Updated CSM

– Area properties (in orange) are historic industrial operations (zinc used heavily on some).