
Contaminant Pathways Evaluations for Upland Confined Placement:

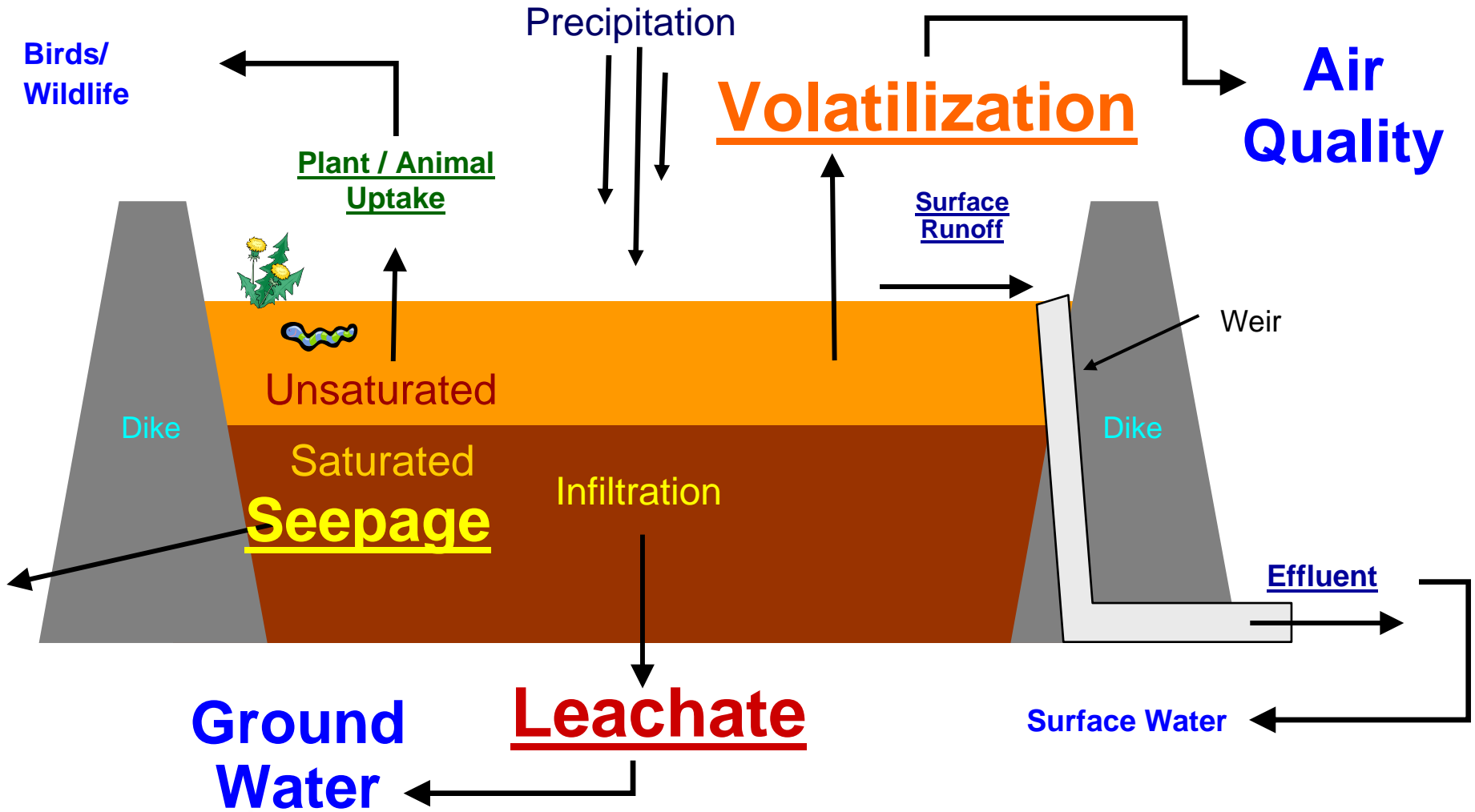
Leachate and Volatilization

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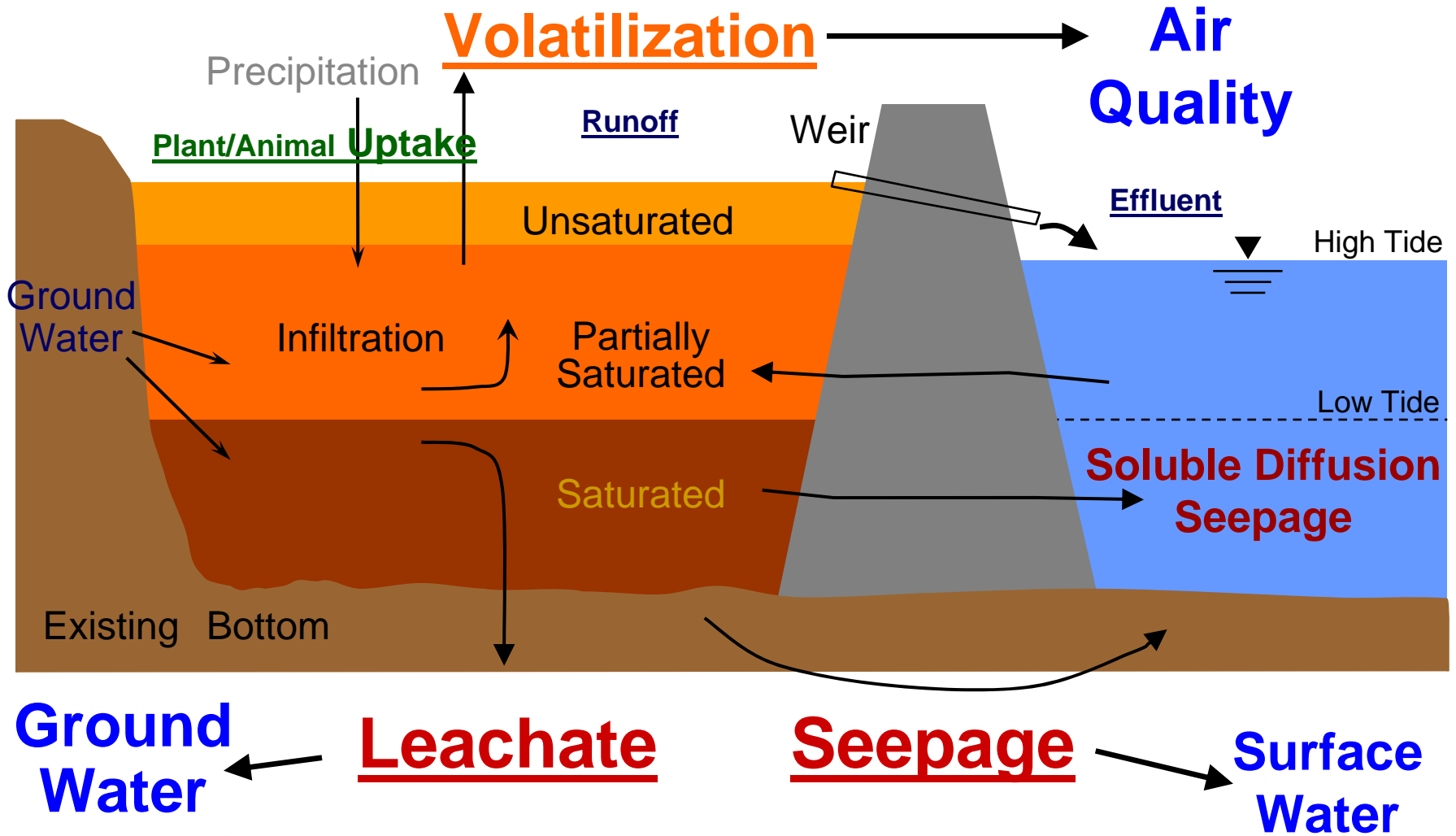
Keywords: CDFs, Contaminant Pathways, Testing, Leachate



Conceptual Model - Contaminant Pathways



Nearshore CDF Contaminant Migration Pathways



CDF Pathway End Points

- **Leachate**

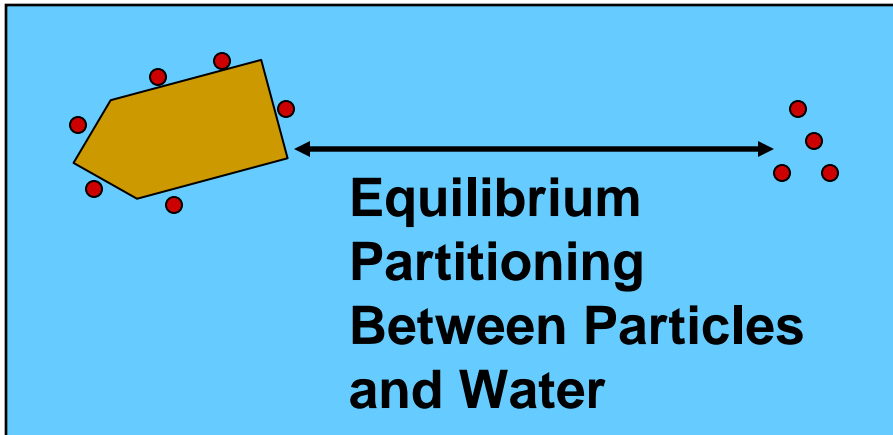
- Applicable GW Standards for freshwater sediments after factoring in attenuation
- Applicable Surface Water Standards for marine sediments after factoring in attenuation

- **Volatiles**

- OSHA Human Exposure Standards after factoring in dispersion
- Health-Based Air Concentrations for acceptable level of risk after factoring in dispersion



Tier II - Screening



Leachate

Volatile Emissions (Henry's Law)

Leaching from saturated, reduced geochemical environment

Volatilization from Flooded and Exposed dredged material for On-site and Off-site exposures

Spreadsheet developed to support the UTM proposed screening

Microsoft Excel - UTMHR4.xls

R219 = =IF(Q219="NA", "NA", (IF(Q219 = 1,Q219,Q219*65/(Data!\$B\$29))))

	Input	Input	Input	SCREENING CRITERIA							
	Actual Bulk Sediment Conc. (mg/kg)	Carrier Water Conc. (ug/l)	Back-ground Conc. (ug/l)	Effluent Marine Chronic Criteria C _u (ug/l)	Runoff Marine Chronic Criteria C _u (ug/l)	Leachate Marine Chronic Criteria C _u (ug/l)	Volatilization Reference Dose (mg/kg-d)	Plant Applicable Screening Criteria (mg/kg)	Animal Applicable Screening Criteria (mg/kg)	Molecule Weigh (g/mole)	
Metals											
95	Aluminum			200.0000	200.0000	200.0000	1.40E-07	NA	NA	2	
96	Antimony			6.0000	6.0000	6.0000	4.00E-04	37	NA	12	
97	Arsenic	0.8800	26.0000	0.0000	50.0000	50.0000	NA	NA	NA	7	
98	Boron	35.4000			2000.0000	2000.0000	2000.0000	NA	29	13	
99	Barium	0.6200			4.0000	4.0000	4.0000	NA	24	110	
100	Cadmium	1.1000	9.3000	0.0000	5.0000	5.0000	5.0000	8.00E-04	NA	21	
101	Chromium	25.2000	50.0000	0.0000	100.0000	100.0000	100.0000	5.70E-07	NA	5	
102	Cobalt	5.2000			NA	NA	NA	NA	NA	9	
103	Copper	54.5000	3.8000	0.0000	1300.0000	1300.0000	1300.0000	NA	NA	6	
104	Lead	50.6000	9.3000	0.0000	0.0000	0.0000	0.0000	NA	NA	20	
105	Mercury	0.1500	0.0250	0.0000	0.2000	0.2000	0.2000	6.60E-05	NA	20	
106	Nickel	14.5000	8.3000	0.0000	NA	NA	NA	NA	NA	5	
107	Phosphorus		0.1000	0.0000	0.1000	0.1000	0.1000	NA	NA	3	
108	Selenium		71.0000	0.0000	5.0000	5.0000	5.0000	1.00E-00	189	7	
109	Silver				100.0000	100.0000	100.0000	5.00E-05	NA	10	
110	Thallium				0.5000	0.5000	0.5000	0.00E-05	NA	20	
111	Tin				NA	NA	NA	NA	NA	111	
112	Vanadium	37.2000			NA	NA	NA	NA	5.42264	9	
113	Zinc	143.0000	86.0000	0.0000	5000.0000	5000.0000	5000.0000	NA	13.01456	6	
114											
115	PAHs										
116	1,2-Dimethylbenzene	1.5000			0.0000	0.0000	0.0000	NA	NA	NA	



Leachate Tier III

- **Sediment-Specific Exposure Testing and Evaluations**
- **Laboratory Determination of Sediment Chemical Properties for Contaminant Transport**
 - Partitioning coefficient as a function of salinity
 - Leachable fraction
 - Clay and organic fractions of foundation soils
 - Hard carbon analysis
 - Attenuation
- **Models for Mixing, Attenuation and Dispersion**
- **Comparisons with End Points**
- **Results of all Tier III tests can be used in Risk Assessments**



Leachate to Groundwater

Sequential Batch Leach Test (SBLT) for Freshwater Sediments



“Pancake” Column Leach Test (PCLT) for Marine/Brackish Sediments



Selection of Test Procedure

- **Freshwater Dredged Material: Batch Testing**

Generally yields well-behaved contaminant desorption isotherm or single point K_D if clustered concentration data result.

- **Saline Dredged Material: Column Testing**

Salt elution from saline dredged materials results in colloid release to leachate that cannot be quantitatively described by batch test results because of the effects of leachate shear velocity.



Batch Test Procedures

- 1. Load sediment in a 4:1 water-to- sediment ratio under anaerobic (nitrogen atmosphere) conditions (for unoxidized dredged materials).**
- 2. Shake for 24 hours, centrifuge, and filter leachate.**
- 3. Add water to sediment to make up that removed. Repeat steps 1 and 2.**
- 4. Repeat procedure for at least four cycles.**



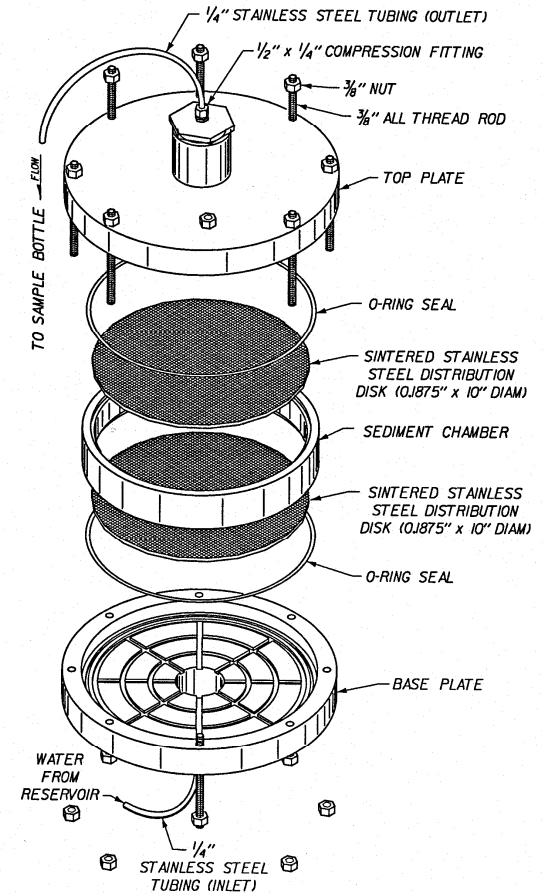
Column Test Procedures

- **Laboratory-scale physical model of contaminant elution from dredged material**
- **Thin layer column to maximize the number of pore volumes eluted**
- **Testing conducted in up-flow mode**
- **Pore water velocity limited to 1×10^{-5} cm/sec**
- **Elution of 30 pore volumes recommended**



Column Test Apparatus

- Thin layer column for maximizing number of pore volumes eluted
- Improved flow control and delivery
- Column is 25.4 cm in diameter
- Details on column design and operation available in guidance documents



Leachate Pathway Assessment

- **Quality**
 - Partitioning
 - Leachable Fraction
- **Quantity**
 - Consolidation Analysis
 - Permeability
 - Pore Pressure Gradient
- **Dilution Attenuation Factor**
 - Diffusion
 - Degradation
 - Volatilization
 - Irreversible exchange with solids
- **Receptor**
 - Groundwater Supply for Freshwater
 - Benthic Zone Receptor for Saline Waters
- **Transport**
 - Advection
 - Diffusion
- **Groundwater Modeling**
 - Vadose Zone TN
 - Saturated Zone TN
 - MultiMed / IWEM
 - GMS



Vadose Zone Transport Considerations

- **Vadose Zone Properties**

- Quantity of fine-grained materials, oxides, sulfides, and organic matter
- Thickness
- Porosity
- Partitioning relationship

- **CDF Design**

- Thickness
- Permeability
- Climate
- Dredged material characteristics



Saturated Zone Transport Considerations

- **Groundwater Velocity**
 - Increases diffusion and dilution
 - Decreases the time to reach receptor
- **Receptor Locations**
 - Upgradient or off-center limits exposure
 - Distance increases diffusion and dilution
- **Aquifer Thickness increases diffusion and dilution**
- **Aquifer Heterogeneity**
 - Increases short-circuiting
 - Decreases diffusion and dilution
- **Retardation Capacity**
 - Function of the quantity of fine-grained materials, oxides, sulfides, and organic matter in the aquifer
 - Reduces the long-term exposure



Leachate Controls

- **Liners and Drains**
 - Geomembranes
 - Clay for coarse-grained materials
- **Amendments**
 - Stabilizing agents
 - Adsorbing or precipitating agents such as activated carbon to control organics or apatite to control certain metals

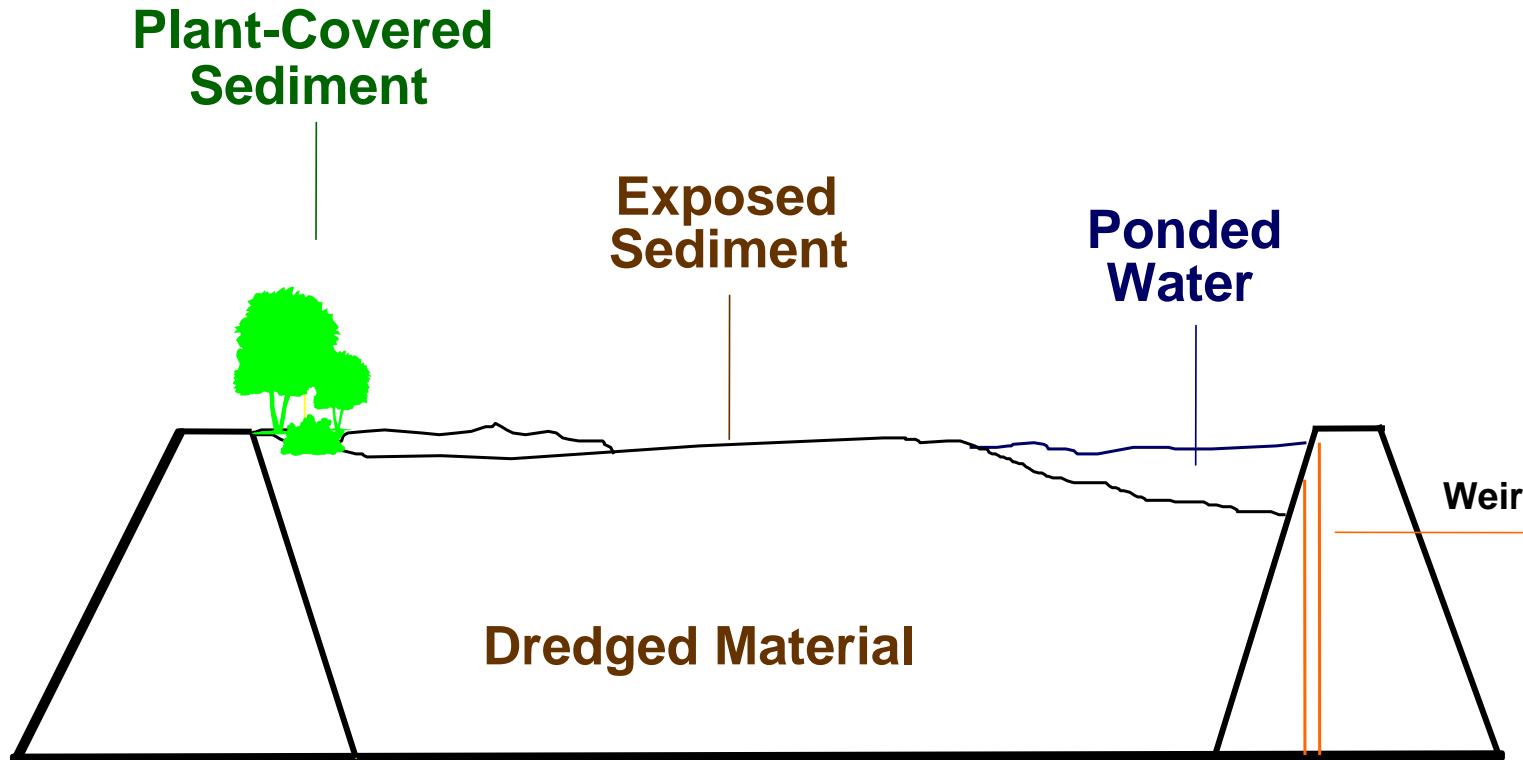


Volatilization Tier III

- **Sediment-Specific Exposure Testing and Evaluations**
- **Laboratory Determination of Sediment Chemical Properties for Contaminant Transport**
 - Partitioning coefficient
 - Henry's law constant
 - Diffusivity in air
 - Air and water side mass transfer coefficients
- **Models for Dispersion**
- **Comparisons with End Points**
- **Results of all Tier III tests can be used in Risk Assessments**



Volatile Emission Regimes



Evaluation of Volatile Losses

- **Laboratory Procedures to Quantify Volatile Losses in the Field**
 - Determine partitioning characteristics
 - Determine mass transfer coefficients
- **Predictive Models to Describe the Loss of Volatile Organic Compounds from Dredging and Disposal Sites**

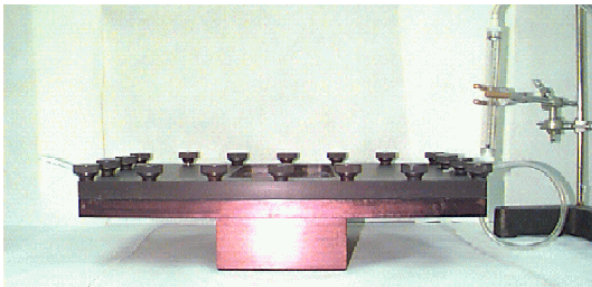
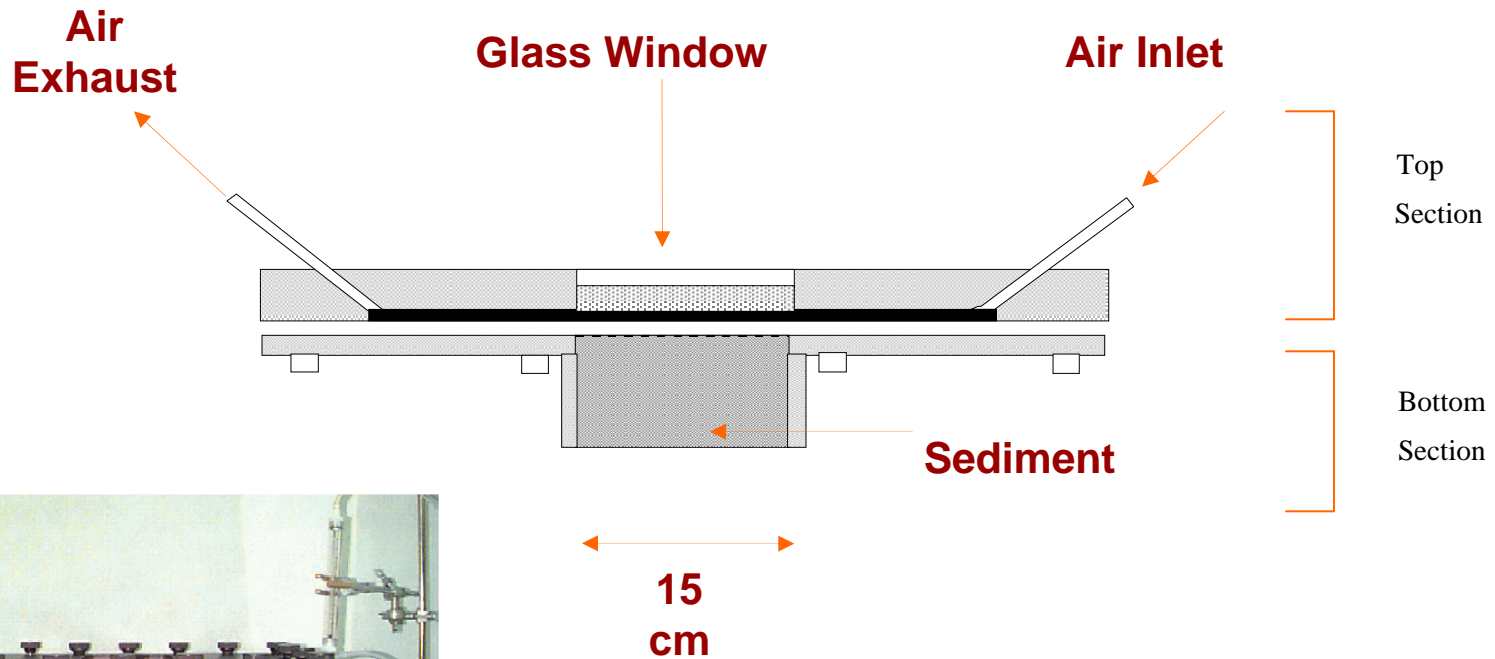


Volatilization Parameters

- **Sediment Physical Characteristics**
 - Moisture content, porosity, aging, oil and grease concentration
- **Contaminant Chemical Properties**
 - Henry's Law constant, diffusion coefficient, partitioning coefficient, vapor pressure, sediment contaminant concentrations
- **Environmental Variables**
 - Relative air humidity, temperature, wind
 - Mechanical movement (mixing) of the sediment



Flux Chamber Used for Quantifying Volatile Emissions in a Laboratory Setting



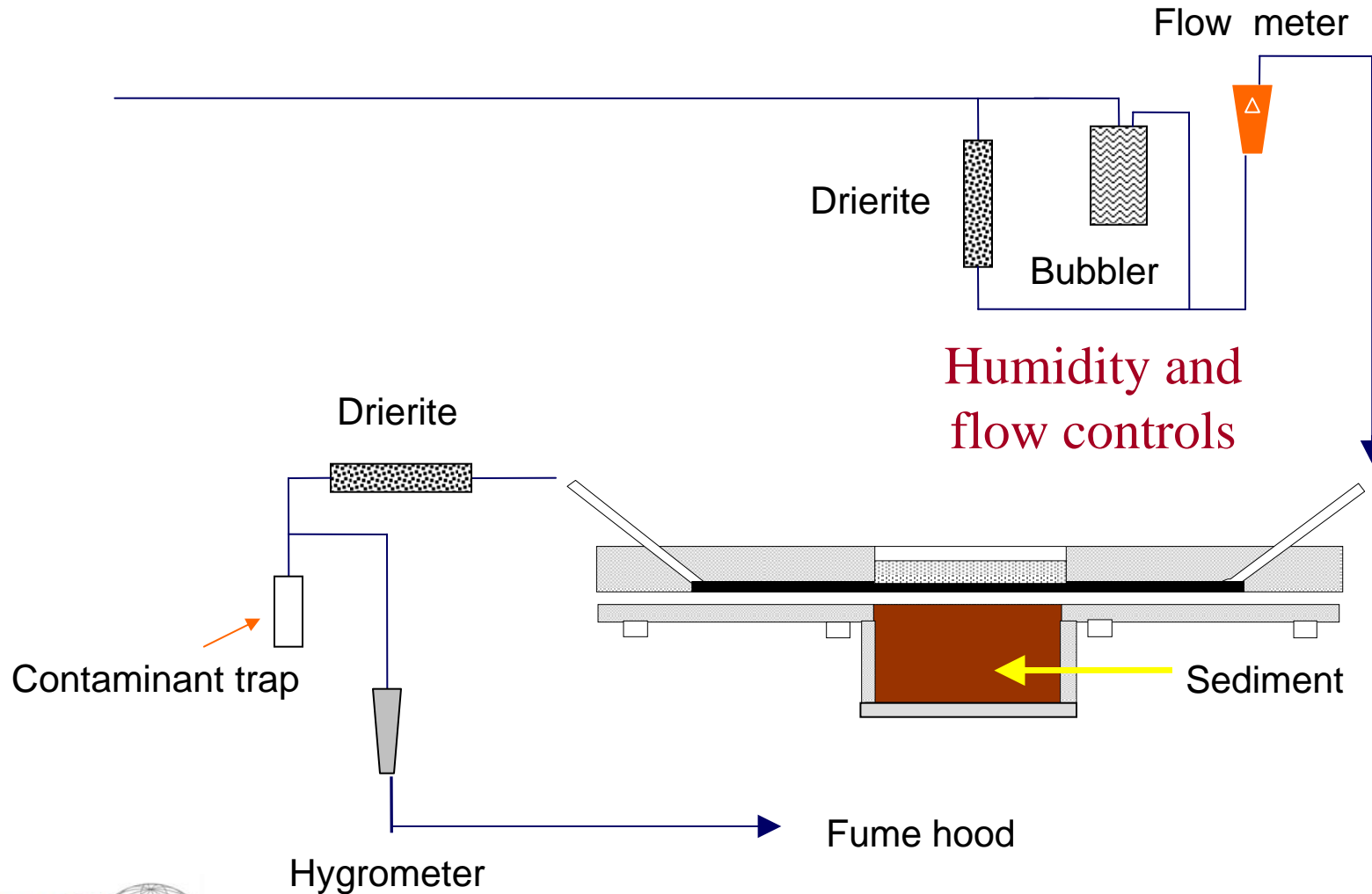
Equipment

VOC Flux Chamber (Description)

- **Two-piece construction of anodized aluminum**
- **Bottom section**
 - Sediment chamber-25 cm x 15 cm x 10 cm deep
- **Top portion**
 - Designed with channels to distribute airflow uniformly across sediment surface
 - Fitted with glass window to allow visual monitoring of sediment surface
- **Chamber is sealed with an O-ring and threaded fasteners to produce an airtight fit**



Laboratory Experimental Design



Equipment

- **Air Supply – laboratory “house” air or compressed gas cylinder; vacuum pump**
- **Sampling Traps - contaminant-specific air sampling tubes (Supelco, Inc.)**
- **Flow Meter (able to handle flows > 1 L/min)**
- **Tygon tubing**
- ***Humidity Meter (for in-line monitoring)**
- ***Water Bubbler (air humidity adjustment)**
 - * optional (dependent upon sampling conditions)



Sediment Preparation

- **Core or grab samples should completely fill storage containers (cores not removed need to be immediately sealed)**
 - Volume of sample is dependent upon compounds of interest
- **Refrigerate samples**
- **Thoroughly homogenize samples prior to sediment analysis and volatile emissions testing**



Test Protocol (Laboratory)

- **Carrier Air – “house” air; compressed gas of sufficient purity, or vacuum pump**
- **Flow rate - 1.7 L/min**
- **Trapping Material - dependent upon contaminants of interest**
- **Humidity - controlled via water bubbler**
- **Sampling Regime - dependent upon contaminant concentrations, trapping material and retention capacity, experimental conditions (i.e., soil moisture)**



Example Sampling Protocol

- **Sampling times / intervals:**

- **6, 24, 48, 72 hours, 5, 7, 10, and 14 days**

- Sample continuously (replace trap at each sample interval making sample intervals anywhere from 6 to 96 hours each)
- Sampling length dependent on contaminant concentrations and analytical detection limits

- **Experimental conditions:**

- Initiate experiment with field moist sediment and apply dry air over sediment surface (14-day experiment)
- Apply humid air over sediment surface for 7 days
- Rework sediment and repeat with dry air



Field Apparatus



Field Measurements



Flux Calculations

- Contaminant flux is calculated by determining the total mass of material captured in a given time interval using the equation:

$$N_A(t) = \Delta m / \Delta t / A_c$$

Δm = mass (mg) of compound collected on the trap in time Δt (hr)

A_c = area the sediment-air interface, m² (0.0375)

$N_A(t)$ is expressed in mg/m²/hr



Air Quality Models

Gaussian Models --

Computes contaminant concentration at a point (X, Y, Z) downwind from a source at an elevation H above the ground by simple dispersion equation.

Web Models, SCREEN3 or CTSCREEN

Suite of More Sophisticated Models Available for Complex Terrains from EPA --

AERMOD or ISCLT3

<http://www.epa.gov/scram001/dispersionindex.htm>



Volatilization Controls

- **Activated Carbon Applications**
 - CDF pond
 - Slurry
- **Capping**
 - Prevent exposed condition by maintaining pond
 - Cover dredged material with clean material



Questions?

