NJDEP Alternative Remediation Standards

Effectively Integrating and Accounting for Site-Specific Conditions in Managing Environmental Risk at NJDEP SRP Sites

Overview - Alternative Remediation Standards

- Alternative Remediation Standards (ARSs) – Direct Contact Pathway
  - Ingestion-Dermal
    - Lead Contaminated Sites
    - Recreational Land Use
  - Inhalation
    - VOCs – depth & organic content
    - Particulates
    - Recreational Land Use
- ARSs - Impact to Groundwater Pathway
  - Soil-Water Partition Equation
  - Dilution Attenuation Factor
  - SPLP
  - Immobile Chemicals
  - Sesoil / ATD123
  - Soil and GW Evaluation - VOCs, Metals, SVOCs
- Capping to Satisfy Impact to Groundwater Pathway
- Vapor Intrusion - Alternative Screening Levels for Groundwater

Things to KIM when Selecting Standards

- Standards vs. Criteria vs. Screening Levels
- Present and Future Land Use
- Receptors & Exposure pathways – ARSs are Pathway Specific
- Background, Offsite, and Diffuse Anthropogenic Pollution
- ARS development should follow the CSM
- Cost-benefit of developing ARSs vs default standards remediation
- Forms and other documentation required by NJDEP for ARSs

NJDEP Standards, Criteria,& Screening Values

- NJAC 7:26D – Remediation Standards
  - Direct Contact Soil Remediation Standards
  - Impact to Groundwater (IGW) Soil Standards (Default or Site-Specific)
  - Groundwater Quality Standards (GWQS) (NJAC 7:9C)
  - Surface Water Quality Standards (SWQS) (NJAC 7:9B)
- EE TG – Ecological Screening Criteria – Sediment/Surface Water
- Protocol for Addressing EPH Guidance
- NJDEP Chromium Soil Cleanup Criteria (2010) – Soil, Groundwater
- VI TG Screening Levels - Groundwater, Soil Gas, Indoor Air
- Vanadium - USEPA Regional Soil Screening Level of 390 mg/kg
- LNAPL Guidance / Sheen Policy

NJDEP Soil Remediation Standards

NJDEP Soil Remediation Standards (SRSs) – NJAC 7:26D

- Residential (Res) and Non-Residential (NR) Direct Contact (DC) SRS
  - Ingestion-Dermal Criteria (Equations and Assumptions - Appendix 2)
  - Inhalation Criteria (Equations and Assumptions – Appendix 3)
  - Practical Quantification Limit (PQL)
- DC SRS is more stringent of ingest.-dermal or inhalation criterion, assuming non-limiting PQL
- **Table 1A** - Res DC criteria, PQLs, and SRSs; **Table 1 B** - NR DC criteria, PQLs, and SRSs
- Impact to Groundwater (IGW) SRS developed on a site-specific basis per NJAC 7:26D-1.1(b)
  - Develop IGW ARS using one of NJDEP methods; or
  - Default IGW Soil Screening Levels (IGWSSLs) - Table 1 of Soil-Water Partition Equation (SWPE) Guidance

Regulatory Basis for Developing of Soil ARSs

NJAC 7:26D-7.3, basis for the development/request of alternative remediation standard may include:

1. New chemical toxicity data;
2. New risk assessment models or methods;
3. Alternate land use planned for Site;
4. Site specific conditions supporting modification of input parameters for SRSs
5. Conditions which require cleanup to a level more stringent than SRS

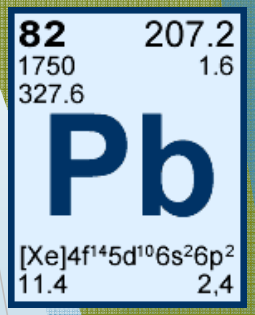
Development of ARSs

- Ingestion-Dermal DC – NJAC 7:26D, Appendix 4
- Inhalation DC – NJAC 7:26D, Appendix 5
- Impact to Groundwater – various NJDEP IGW Guidance Documents

ARSs are exposure pathway specific. Need to determine which COCs and pathways are risk/cost drivers and strategically evaluate ARS options. Make sure that any ARS you develop is protective for all pathways/receptors (i.e., HH ingestion-dermal, HH inhalation, IGW, and ecological).

Direct Contact Soil ARSs – Ingestion-Dermal

Lead Contaminated Sites



- Requires NJDEP Pre-Approval
- Res ARSs may be developed using *Integrated Exposure Uptake Biokinetic Model for Lead in Children* (IEUBK - EPA, 1994) and site data for lead in soil & dust.
- NR ARSs may be developed using input parameters in *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil* (USEPA, 1996).
- ARSs for lead may be developed for recreational land use using non-continuous exposure (all ages) identified in *Assessing Intermittent or Variable Exposures at Lead Sites* (USEPA, 2003)

Direct Contact Soil ARSs – Ingestion-Dermal

Recreational Land Use

- Requires NJDEP Pre-Approval
- ARS based on site-specific land use scenarios effecting how and how long people use a recreational site.
- Two types of recreational land use:

  Active - sports playing fields and playgrounds

  Passive - walking or bike trails.
- Approval of an ARS for recreational land is contingent on the use of proper institutional controls (ICs) to ensure the future use of the site for the proposed recreational purpose.

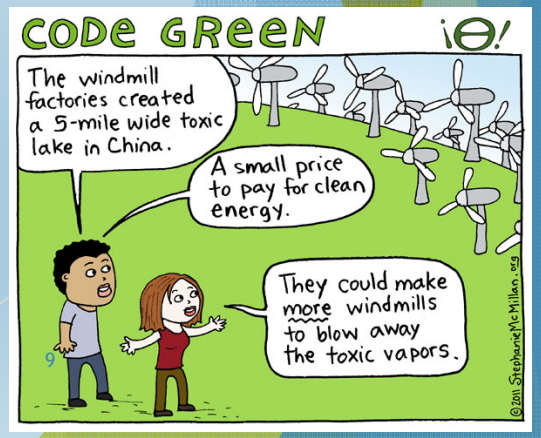
Direct Contact Soil ARSs – Inhalation

VOCs – Adjusting Depth Range of Contamination

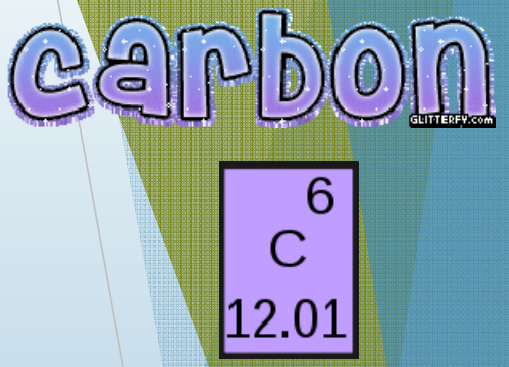
- **Theory:** Finite COC depth (bottom) reduces Volatilization Factor (VF)
- Model Default – Infinite Depth of COCs
- Does not Require NJDEP Pre-Approval
- IC not required when depth range of COCs begins at surface, but is required when depth range of COCs begins below the ground surface.

Method for Developing

1. Determine depth range of contamination via sampling & analysis per N.J.A.C. 7:26E-4.
2. Use observed depth range of contamination in the Jury Model (EMSOFT Package) to derive a site-specific VF
3. Substitute calculated VF into Equations 1 or 2 N.J.A.C. 7:26D, Appendix 2, to calculate an inhalation ARS.



Direct Contact Soil ARSs – Inhalation



VOCs – Adjusting the Organic Carbon Content of Soil

- **Theory:** Increased organic carbon fraction reduces volatilization flux.
- Does not require Department Pre-Approval
- IC is not required when adjusting the Organic Carbon Content (OCC)

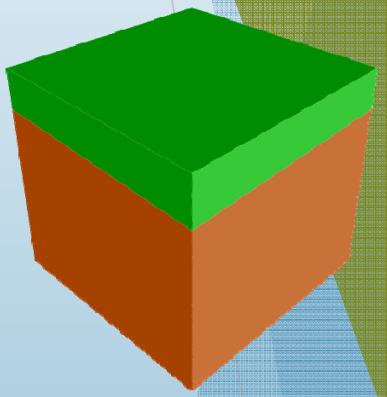
Method for Developing

1. Collect 3 samples (min) from different locations in each AOC. Can't be collected from areas with total VOCs > 1,000 ppm.
2. Analyze samples for soil OCC using the Lloyd Kahn Method.
3. Use the average soil OCC as the foc in the App. 2, Eq. 5 to calculate Kd.
4. Substitute Kd into App. 2, Eq. 4 to calculate Apparent Diffusivity (DA).
5. Substitute DA into App. 2, Eq. 3 to calculate a site-specific VF.
6. Substitute the site-specific VF into App. 3, Eqs 1 or 2 to calculate inhalation ARS.

Direct Contact Soil ARSs – Inhalation

Particulates – Adjusting Fraction of Vegetative Cover

- **Theory:** Increase in vegetative cover decreases emission of particulates
- Residential Sites Only
- Does not require NJDEP Pre-Approval
- IC required for ARS based on vegetative cover condition of Site



Method for Developing

1. Measure amount of vegetative cover fraction (V) on the site. Acceptable vegetative cover are areas of continuous grass with no exposed ground.
2. Substitute the measured V into Equation 11, Appendix 2 to calculate the particulate emission factor (PEF).
3. Substitute the PEF into Equation 9 or 10 of Appendix 2 to calculate the particulate contaminant carcinogenic or noncarcinogenic inhalation ARS.

DC Soil ARSs – Inhalation - Particulates

Particulates – Adjusting Truck Trips Per Day

- **Theory**: Less Traffic Stirs Up Less Dust
- Non-Residential Sites Only
- Does not require NJDEP Pre-Approval
- IC required based on number of vehicles used in calculation.

Method for Developing

1. Determine daily traffic count (TC) for an unpaved area by dividing the weekly total number of vehicles by the number of days of site operation that week.
2. Substitute TC into Eq. 20, App. 2 to calculate the particulate emission rate for site traffic (ER-traffic).
3. Substitute ERtraffic into Eq. 19, App.2 to calculate the particulate emission factor (PEF).
4. Substitute PEF in Eq. 18, App. 2 to calculate the exposure dose calculation (DOSE).
5. Substitute DOSE into Eq. 14 or 15, App. 2 to calculate the COC carcinogenic or noncarcinogenic inhalation ARS.

Direct Contact Soil ARSs – Inhalation

Recreational Land Use

- Requires NJDEP Pre-Approval
- ARS based on site-specific land use scenarios effecting how and how long people use a recreational site.
- Two types of recreational land use:

  Active - sports playing fields and playgrounds

  Passive - walking or bike trails.
- Approval of an ARS for recreational land is contingent on the use of proper institutional controls (ICs) to ensure the future use of the site for the proposed recreational purpose.

Impact to Groundwater ARS

- Per NJAC 7:26D-1.1(b), Must develop IGW-ARS (or utilize Default IGWSSLs).
- Generally, IGW ARS should be evaluated/developed if COC > IGWSSL, unless :
  - cost of remediation to IGWSSL is less than cost to develop IGW ARS; or
  - DC standard (default or ARS) or other relevant cleanup standard is more stringent than default IGWSSL.
- IGWSSLs calculated using SWPE; derived via back calculation using GWQSs and NJDEP standard assumptions.
- Guidance for developing IGW ARS currently provided in numerous, separate documents; NJDEP currently combining into one comprehensive document.

Dilution Attenuation Factor	Soil Water Partition Equation
Synthetic Precipitation & Leaching Procedure	Immobile Chemicals
Site Soil and GW Data Evaluation	Sesoil & Sesoil/ATD123

Impact to GW ARSs – Soil-Water Partition Eq.

Theory/Application: COCs exist in three phases in the environment. SWPE calculates amount of COC that can remain in unsaturated soil such that corresponding GW COC conc < health-based GWQC.

Use Recommended:

- Site-specific DAF > default value
- Organic contaminants, site-specific soil organic content (foc) > default value

Required : SPLP is used to calculate a site-specific soil-water partition coefficient (Kd)

- Not Applicable for AOCs where total VOC contamination exceeds 1,000 mg/kg.

Calculation/Methods: Modified EPA Soil Screen Level S/W Partition Equation (EPA 1996). Three calculation spreadsheets dependent on input variable modified: DAF, foc, or Kd.

Guidance – Development of Impact to Groundwater Soil Remediation Standards using the Soil-Water Partition Equation (Version 2.0; November 2013)

Assumptions: Default site conditions/assumptions for calculation of IGWSSLs - refer to Section VI of Guidance. Chemical property inputs (http://www.nj.gov/dep/srp/guidance/rs/chemproperties.pdf);

Reporting: Spreadsheet at www.nj.gov/dep/srp/guidance/rs/partition_equation.xls Submit copy of completed spreadsheets and all input parameters values utilized to determine site-specific IGW ARS to NJDEP.

Impact to GW ARSs – Soil-Water Partition Eq.

Four input variables may be modified in SWPE:

- **Fraction Organic Carbon (foc)**
  - Collect minimum of 3 representative soil samples, analyze samples for organic carbon using Lloyd Kahn method
  - Substitute average organic carbon as foc in Eq. 1a; if organic carbon varies > order of magnitude, use lowest value
- **Soil-Water Partition Coefficient (Kd)**
  - Collect and analyze samples per the SPLP Guidance
  - Use SPLP Spreadsheet to derive a site-specific Kd
  - Substitute site-specific Kd into Eq. 1b
- **Dilution-Attenuation Factor (DAF)**
  - Develop a site-specific DAF per the DAF Guidance
  - Substitute site-specific DAF into Eq. 1a (organics) or 1b (inorganics, or site specific Kd)
- **Ionizable Phenols - Koc for Soil pH**
  - Collect minimum of 3 representative soil samples, measure soil pH in each sample
  - Use soil pH for each sample to determine corresponding Kocs from Table 2
  - Use Kocs to calculate IGW ARSs using Eq. 1a, average if ARSs vary by less than OOM

Eq. 1A

$$IGWSRS = C_{gw}\left\{(K_{oc}f_{oc}) + \frac{\theta_w + \theta_a H'}{\rho_b}\right\}DAF$$

Eq. 1B

$$IGWSRS = C_{gw}\left\{(K_d) + \frac{\theta_w + \theta_a H'}{\rho_b}\right\}DAF$$

$IGWSRS$ = Impact-to-ground water soil remediation standard (mg/kg)
C_{gw} = Ground Water Quality Criterion (mg/L)
f_{oc} = organic carbon content of soil (kg/kg)
K_{oc}=soil organic carbon-water partition coefficient (L/kg)
K_d = soil-water partition coefficient (L/kg)
θ_w = water-filled soil porosity (L_{water}/L_{soil})
θ_a = air-filled soil porosity (L_{air}/L_{soil})
H' = Henry's law constant (dimensionless)
ρ_b = dry soil bulk density (kg/L)
DAF = dilution-attenuation factor

Impact to GW ARSs – DAF Guidance

Theory/Application: Infiltration containing leached COCs recharges an aquifer. The amount of dilution and resulting ground water COC concentration is calculated via the dilution-attenuation factor (*DAF*).

Calculation/Methods: Calculate site-specific DAF and substitute into the Soil-Water Partition Equation when calculating an IGW ARS.

Guidance: Development of a Dilution-Attenuation Factor for the Impact to Groundwater Pathway (Version 2.0; November 2013)

Assumptions: NJDEP standard inputs for calculation of default DAF (20) is included in Appendix A of guidance;

Reporting: Spreadsheet at http://www.nj.gov/dep/srp/guidance/rs/daf_calc.xls; Submit completed spreadsheet and all input parameters values to NJDEP.

Impact to GW ARSs – DAF Guidance

Four input variables may be modified in DAF Equation:

1. **Length of AOC, parallel to GW flow (L):**
   - only effective when length is large enough to cause mixing zone depth > thickness of aquifer
   - site-specific L must be utilized when calculating a site-specific DAF
   - Default NJDEP input for L = 100 feet
2. **Infiltration Rate (I):**
   - Consultation with NJDEP required for use of site-specific infiltration rate
   - Default NJDEP input for I = 11 inches/year
3. **Hydraulic Conductivity (K) and Gradient (i):**
   - Determine K and L per NJDEP GW Technical Guidance
   - DAF has linear relationship to both K and I
   - Default NJDEP inputs – K=142 ft/day; I = 0.003
4. **Aquifer Thickness (da):**
   - Thickness to be measured in field or determined using NJGS or USGS data
   - Default NJDEP input for da = 3.5 meters (11.5 feet)

$$DAF = 1 + \frac{Kid}{IL}$$

where

i = gradient (m/m)
d = mixing zone depth (m), calculated below (Equation 2)
I = infiltration rate (m/yr)
L = length of area of concern parallel to ground water flow (m)
K = aquifer hydraulic conductivity (m/yr)

Impact to GW ARSs – SPLP

Theory/Application – Simulates leaching of COC via infiltration using an extraction fluid. COC concentration in leachate is compared to COC-specific leachate criteria (DAF x GWQC).

Use Recommended:

Most beneficial for developing IGW ARSs for inorganics & low mobility organics (Koc > 20,000 L/kg). Consider collecting additional sample for SPLP to obviate remobilizations.

Calculation/Methods - SW-846 Method 1312 – Analysis of both leachate (mg/L) and total COC concentration in sample. SPLP utilized to derive: (1) Site Kd for use in SWPE; and (2) Site IGW ARSs . Evaluation of results using one of three methods.

Guidance – Development of Site-Specific Impact to Ground Water Soil Remediation Standards using the Synthetic Precipitation Leaching Procedure (Version 3.0; November 2013)

Assumptions: Default Leachate Criteria for Class II Groundwater Class II Groundwater (Appendix B)

Reporting: Spreadsheet at http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls. Numerous additional parameters required for reporting for each sample for SPLP.

Impact to GW ARSs – SPLP

SPLP Methodology:

1. Collect minimum of 3 samples from each AOC. Collect samples representing the range of COC detections (up to and including highest detection). Approximately 120 grams (4-5 oz) of sample is needed for SVOC and Metals SPLP analysis.
2. For VOCs do not homogenize sample, but collect separate, yet like samples for in encores. Make sure to collect additional sample for moisture and pH.
3. Submit samples for analysis of total COCs and SPLP COCs, pH, and moisture (all included in SPLP package for most labs).
4. Determine Site Leachate Criteria (LC): (1) **Default, health-based LC** (GWQC x 20); of (2) **Site-Specific LC based on Site-specific DAF** (GWQC x ss-DAF). LC cannot be greater than water solubility of COC.
5. Calculate Field Leachate Criteria (FLCs) for each sample using the NJDEP SPLP calculator. Spreadsheet also calculates site-specific Kd values which can be substituted into the SWPE for developing IGW SRSs.
6. Compare FLCs to LCs to determine IGW ARSs via any or all of three evaluation options. NJDEP Spreadsheet performs evaluation via all three options.

Impact to GW ARSs – SPLP

1. Tabular Evaluation
   - Tabulate total COC concentrations in ascending order with respective field leachate concentrations (FLCs).
   - Compare sorted FLCs versus LC:
     - If all FLCs < LC, IGW is the highest total COC concentration
     - Otherwise ARS is the highest total COC concentration whose corresponding FLC < LC

Sample Number	Total Contaminant Concentration in Soil C_T (mg/kg)	Contaminant Field Leachate Concentration C_L (µg/L)	Leachate Criterion LC (µg/L)
Sample 1	5	900	2600
Sample 2	10	1200	2600
Sample 3	30	2280	2600
Sample 4	**50**	**1680**	**2600**
Sample 5	75	2700	2600

Sample Number	Total Contaminant Concentration in Soil C_T (mg/kg)	Contaminant Field Leachate Concentration C_L (µg/L)	Leachate Criterion LC (µg/L)
Sample 1	5	900	1950
Sample 2	**10**	**1200**	**1950**
Sample 3	30	2280	1950
Sample 4	50	1680	1950
Sample 5	75	2700	1950

Impact to GW ARSs – SPLP

2. Calculate Site-Specific Kd and substitute into SWPE
   - Use total COC concentration and respective FLC to calculate sample-specific Kds using Eq. 1.
   - Average sample-specific Kds if vary by less than an order of magnitude, If they vary by more than order of magnitude, use lowest sample-specific Kd
   - Substitute the calaculated Kd into Eq. 3 to calculate IGW ARS

Eq. 1 $$K_d = \frac{(C_T M_S - C_{SPLP} V_L)/M_S}{C_{SPLP}}$$

K_d = is the soil-water partition coefficient (L/kg)
C_T = the total concentration of the contaminant in the SPLP soil sample (mg/kg)
M_S = the total weight of the soil sample submitted for SPLP analysis (~0.1 kg for inorganic chemicals and semivolatiles, or ~0.025 kg for volatiles)
C_{SPLP} = the concentration of contaminant in the SPLP leachate (mg/L)
V_L = the volume of the SPLP leachate (~2 L for inorganic chemicals and semivolatiles, or ~0.5 L for volatiles)

Eq. 3 $$IGWSRS = LC\left\{[K_d] + \frac{\theta_w + \theta_a H'}{\rho_b}\right\}$$

$IGWSRS$ = Impact to Groundwater Soil Remediation Standard (mg/kg)
LC = Leachate criterion (mg/L)
K_d = is the average, or lowest, calculated sample specific soil-water partition coefficient (L/kg)
θ_w = the volume fraction of water in the original soil sample (0.23)
θ_a = the volume fraction of air in the original water sample (0.18)
H' = the dimensionless Henry's law constant for the contaminant of interest
ρ_b = the dry soil bulk density (1.5 kg/L)

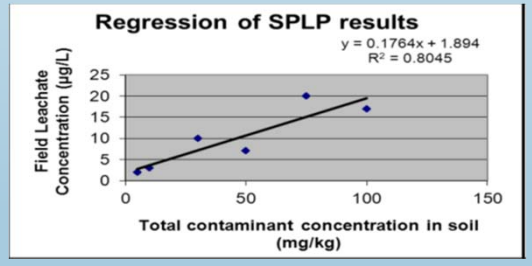
Impact to GW ARSs – SPLP

3. Linear Regression
    1. Plot total COC concentrations on x-axis
    2. Plot respective FLCs on y-axis
    3. Determine if data passes linear correlation test ($r^2 > 0.7$):
    4. Calculate IGW ARS using Equation 4

Sample Number	Contaminant Concentration in Soil C_T (mg/kg)	Contaminant Field Leachate Concentration C_L (µg/L)	Leachate Criterion LC (µg/L)
Sample 1	5	2	10
Sample 2	10	3	10
Sample 3	30	10	10
Sample 4	50	7	10
Sample 5	75	20	10
Sample 6	100	17	10

Eq. 4

$$IGWSRS = \frac{LC - b}{m}$$



IGWSRS = (10µg/L-1.89µg/L)/0.176(µg/L)/(mg/kg)=46 mg/kg

Impact to GW ARSs – Immobile Chemicals

Theory/Application : "Immobile chemicals" become resistant to desorption from soil with increased contact. Over time these chemicals can become irreversibly adsorbed to unsaturated soil and do not pose a threat to GW if adequate "clean zone" of soil exists above the water table. Typically immobile chemical conditions should be evaluated after the RI is complete, but RI should include strategic sampling that will help support a determination if conditions are applicable.

Aluminum	Copper	Lead	Vanadium	Aldrin
B(a)A	B(a)P	B(b)F	B(g,h,i)P	B(k)F
BEHP	Butyl Benzyl Pth	Di-n-Butyl Pth	Chlordane	Chrysene
DDD	DDE	DDT	**D(a,h)A**	DOP
Fluoranthene	Heptachlor	Hept Epoxide	HexClBenzene	HC-1,3-butadiene
HC-C pentadiene	I(1,2,3-cd)Pyrene	Methoxyclor	Pyrene	Toxaphene
		PCBs		

Reporting: Submit the following to demonstrate Immobile conditions:

- Soil Boring Logs
- All soil analytical results (including those in two foot clean zone)
- Table Comparing analytical results with the Site-Specific Impact to GW Soil Remediation Criteria; and
- Discussion and support documentation (as needed) relative to site/soil conditions in guidance.

Impact to GW ARSs – Immobile Chemicals

Guidance: Evaluation of Immobile Chemicals for the Impact to Groundwater Pathway (June 2008)

Methods: Demonstration of Immobile Conditions:

1. Immobile Chemical is listed in NJDEP Guidance; and
2. Clean (< IGWSSL) zone exists between contamination and water table; and
3. None of the following site conditions exist:
   - COC was discharged as mixture that could affect mobility of COC;
   - Co-solvent is present that could affect mobility of COC;
   - Soil (or fill material) texture at the site is more course than sandy loam;
   - Soil pH has been altered by release of acids or bases (caustics); or
   - The COC is present at levels indicative of free or residual product.

Impact to Groundwater ARSs – SESOIL / AT123D Modeling

SESOIL Model

- Groundwater is *not* impacted
- Clean or "buffer" zone exists between impacted soil and groundwater
- Used to demonstrate concentrations in soil will not lead to groundwater concentrations above the GWQS

SESOIL/AT123D Model

- Groundwater is already impacted
- Both soil and groundwater impacted
- Used to demonstrate that contaminant concentrations will not lead to unacceptable groundwater impacts (extent or duration of current impacts)

Impact to Groundwater ARSs – SESOIL

Method – Contaminant transport in the vadose zone

- SESOIL model evaluates soil concentration distribution to generate depth-dependent IGW ARSs distribution, rather than a single number.

1. Confirm site conditions do not adversely impact GW; or
2. Develop site specific criterion for response action.
   - If either 1 or 2, then no further action required for IGW pathway (no monitoring, no engineering/institutional controls)

Application

- Contaminant has low mobility
  - not eligible for “immobile contaminant” option
  - failed SPLP test
- Contaminant has high mobility
  - limited in distribution and/or
  - present at low concentrations

Impact to Groundwater ARSs – SESOIL/AT123D

Method – Contaminant transport in vadose zone & via groundwater

- Estimate the time required for attenuation of contaminant concentration via transport to and through contaminated aquifer. GOAL is to demonstrate the soil and gw **impacts will not:**
  1. enlarge the current groundwater plume, ***or***
  2. extend the estimated time period.
- Model predicts COC concentration at two compliance points – predicted over 10' interval

Application

- AOC cannot have impervious cap - leverages infiltration/recharge and volatilization rates
- Highly contaminated soil (e.g., NAPL) remediated in accordance with applicable regs
- Soil and GW impacts have been delineated – horizontally & vertically
- Overburden, unconfined aquifer – not able to model flow through bedrock
- Must complete/conduct receptor evaluation

Impact to Groundwater ARSs – SESOIL/AT123D

Data

- COC concentrations in soil and groundwater **must be delineated**
  - Soil concentration distribution (highest concentration used for sublayers not sampled)
  - GW plume extent and estimated time period (CEA parameters)
- Default values in model for weather parameters and chemical properties of COC
  - Site-specific, measured Kd value can be used (from soil with highest COC concentration)
  - For ionizable organics, measure soil pH (min of 3) to select appropriate Koc value
- **REQUIRED site-specific soil data**
  - For each distinct soil layer (including aquifer, if using AT123D), average from a minimum of 3 samples
  - Soil texture using particle size distribution, including silt and clay fractions (e.g., sieve analysis with hydrometer analysis of fines)
  - Soil organic carbon – recommended Lloyd Khan method
- Aquifer parameters, use MNA guidance to determine site-specific:
  - Hydraulic conductivity
  - Hydraulic gradient
  - Effective porosity (use default in model guidance or site-specific)
  - Bulk density (use default in model guidance or site-specific)

Impact to Groundwater ARSs – SESOIL/AT123D

Reporting

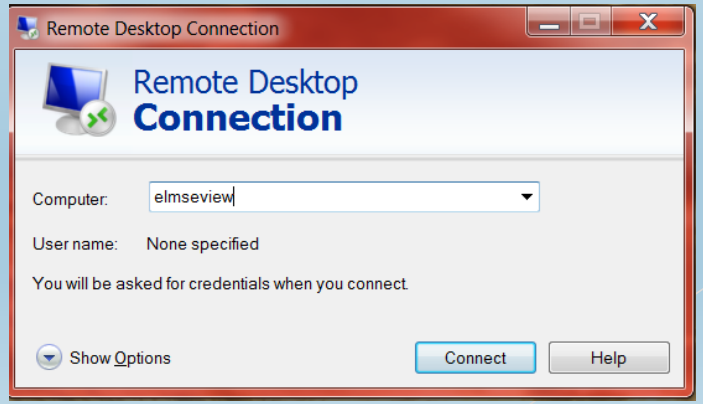
- Short writeup, describe/present all input parameters, and provide copies of graphical outputs from the model

Guidance

- SESOIL (Dec. 2008): http://www.nj.gov/dep/srp/guidance/rs/sesoil.pdf
- AT123D (May 2014): http://www.nj.gov/dep/srp/guidance/rs/at123d_guidance.pdf

ELM Access: elmseview

Use ELM login password



IGW ARSs – Soil & GW Data Eval.– SVOC/Metals

Theory: Certain site conditions and observed GW quality can be used to determine if metals or SVOCs in soil are impacting GW quality. If the highest concentration of soil COCs is present at the water table and no IGW is observed, no remediation for the impact to ground water pathway is required.

Use Recommended:

Likely most applicable to legacy sites after RI is substantially complete.

Guidance: Site Soil and Groundwater Analytical Data Evaluation – Metals and SVOC Contamination (6/2009).

Methods: Conditions that must be met to demonstrate IGW Pathway not a concern:

- Soil contamination has been fully delineated to SS IGW Soil Remediation Criteria per NJAC 7:26E-4.1;
- Highest COC concentrations identified at water table (old releases, subsurface releases); and
- Minimum of two groundwater sampling events (≤ 30 days apart), biased toward highest COCs in soil

Reporting:

- Scaled Map depicting locations of all soil and groundwater samples;
- GW summary table: sample ID, collection date, analytical results, sample depth, depth of water table;
- Boring logs;
- Description of GW sampling methodology; and
- Historical description of discharge including data and volume of discharge, if known.

IGW ARSs – Soil & GW Data Eval. - VOCs

VOCs from Discharges of Petroleum Mixtures

Theory/Application: For VOCs resulting from discharges of petroleum, GW monitoring can be used as an indicator that petroleum COCs in soil have attenuated to concentrations < IGW.

Use Recommended:

Most applicable to: (1) legacy petroleum UST Sites with complete soil and GW RI; and (2) Sites where removal of soil COCs was impracticable during UST removal and MNA monitoring has been completed.

Reporting: NJDEP Submission Requirements:

- A scaled map indicating the locations of all soil samples (post-ex & delineation samples), and monitoring wells;
- Historical soil sample summary table: sample ID, date collected, sample depth, and analytical results;
- Historical GW sample summary table: MW ID, sampling date, depth to GW, GW elevation, analytical results;
- Graphs for each MW depicting: (1) depth to water and (2) contaminant concentrations vs. time over all water table depth intervals - data must not indicate correlation between depth to water and COC concentrations;
- A discussion and map (if not previously provided) of the location of any potential receptors relative to the ground water COC plume;
- If ground water contamination remains, proposed or updated CEA accordance with NJAC 7:26E; and
- A discussion of the decreasing trends in ground water COC concentrations consistent with MNA guidance.

IGW ARSs – Soil and GW Data Eval. - VOCs

Guidance: Site Soil and Groundwater Analytical Data Evaluation – VOC including MTBE and TBA Derived from Discharges of Petroleum Mixtures (June 2009).

Methods: Conditions for NFA for unsaturated soil COCs following MNA for GW:

- Soil contamination has been delineated to the IGW Soil Remediation Criteria per NJAC 7:26E-4.1;
- Soil contamination exceeding GW SRS has been treated/removed to extent practicable;
- Highest soil contamination remaining is located between seasonal high and low of water table;
- Free and residual product has been removed, pursuant to N.J.A.C. 7:26E-6.1(d);
- Ground water contamination has been delineated to the ground water remediation standards;
- COCs detected in ground water ≤ GWQS or relatively low concentations and decreasing trends - decreasing contaminant trends can not be related to water table fluctuation;
- Demonstrated lack of receptor risk (supply wells, vapor intrusion, subsurface utilities, ecological);
- Established Classification Exception Area, if applicable; and
- Any soil contamination > most-restrictive direct contact SRS (default or ARS) has been remediated.

Capping to satisfy Impact to GW pathway

Theory/Application: Inorganics and SVOCs are primarily mobilized via recharge via infiltration. For these chemicals, impermeable caps can be used to satisfy the soil IGW pathway.

Inorganics and SVOCs are defined as having Henry's law constants less than 10-5 atm m-3 mol-1 or vapor pressures less than 1 mm Hg at 25°C . Listed in Table 1 of Guidance.

Guidance: Capping of Inorganic and Semi volatile Contaminants For The Impact to Ground Water Pathway (Version 1, March 2014)

Methods:

- Sites capped to satisfy IGW require an IC and EC and an approved Remedial Action Permit for Soils.
- Impermeable caps include: asphalt, concrete, building slabs, engineered clay caps, or other appropriately designed impermeable caps.
- New or existing caps must be impermeable to rain water. Cracks or other damage or deterioration must be repaired or sealed in order to prevent infiltration.
- The cap should extend far enough beyond the boundaries of the contaminated area to prevent infiltrating water at the edges from reaching the contaminated zone.
- No free or residual product under cap
- If all GW COCs < GWQS & minimum 2 foot clean zone (ie, soil COC concentrations < IGW ARS) above the seasonal high water table, no groundwater monitoring is required
- Where GW COC concentrations > GWQS, periodic monitoring of the ground water is required to ensure that additional contamination does not occur.

Other Options for ARSs (Other than Soil)

Groundwater

- Background investigation per NJDEP Groundwater Technical Guidance & NJAC 7:26E-3.8
- Determination of off-site contribution per NJDEP Groundwater Technical Guidance & NJAC 7:26E-3.8
- Reclassification of groundwater (Class III) per NJAC 7:9C-1.10
- Technical Impracticability Waiver

Surface Water

- Modification of water quality effluent limitations per NJAC 7:9B 1.8 or 1.9 - includes background determination and cases where effluent is of better quality than existing receiving water quality
- Reclassify specific segments of surface water bodies for less restrictive uses per NJAC 7:9B 1.10

Ecological Screening Criteria

- Complete Ecological Risk Assessment (steps 3-8 ERAGS) & develop Ecological Risk-Based Remediation Goals pursuant to EE TG and NJAC 7:26E-4.8
- Background, Diffuse-Anthropogenic Contamination, and Off-Site Contribution Determinations per EE TG

Vapor Intrusion

- Modification of select input parameters to Johnson & Ettinger Model per updated (September 2016) NJDEP Instructions for J&E Model – VI Technical Guidance Web Page.

Alternative Screening Levels - VI

- Can develop Site-Specific Screening Levels for Groundwater for VI.
- NJDEP modified versions (NJ-GW-SCREEN and NJ-GW-ADV) of the USEPA J&E Model Spreadsheets: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm
- Guidance spreadsheets: http://www.nj.gov/dep/srp/guidance/vaporintrusion/njje.htm
- Only site-specific parameters that can be adjusted are: soil texture and depth to GW
  - Soil texture must be determined via sample collection and analysis per VI TG (8/2016). Median soil texture must be utilized as input parameter.
  - Standard values for soil properties for each soil texture are built into the spreadsheet database. Substitution of values for soil moisture, soil bulk density, and soil porosity is not allowed.
  - Alternate depth to GW values may be entered directly into spreadsheets (default= 10 ft.)
- Multiplying factors for calculated screening levels:
  - For hydrocarbons*, a multiplication factor of ten may be applied to the calculated screening level to allow for contaminant degradation.
  - Methylene chloride, trichloroethene, and vinyl chloride must have an adjustment factor applied to calculated screening as they are considered mutagens by EPA: MECl = 0.40; TCE = 0.72; VC = 0.29.

* benzene, ethyl benzene, toluene, xylene, naphthalene, 2-methylnaphthalene, styrene, 1,3-butadiene, hexane, and cyclohexane