STATE OF DELAWARE

Technical Guidance for Evaluating the Soil to Groundwater Pathway under the Hazardous Substance Cleanup Act (HSCA)

FINAL

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DEFINITIONS

All statutory and regulatory HSCA definitions apply to this document. Please refer to the statute or regulations for the appropriate definition. In addition, the following definitions of terms apply to this document:

"Conceptual Site Model" or "CSM" means a graphical or written model describing what is known or hypothesized about the subject site.

"Contains" means the presence of a hazardous substance within the sampled environmental media which results in an analytical value above the laboratory method detection limit. This includes any qualified values.

"Delineate" means describing or marking out the horizontal and vertical extent of a contaminated area of soil or groundwater through environmental samples, maps, figures, written descriptions, computerized mathematical modeling, or other visual representations of data collected.

"Demonstrate" means to show the existence or truth of something by evidence or to provide sufficient documentation to validate a claim.

"Saturated Soil" means the soil horizon which all pore spaces are filled with water. **This is also inclusive of soil that is seasonally or tidally saturated**.

"Unsaturated Soil" or "Vadose Zone" means the soil horizon which the pore spaces contain water and air. **This is not inclusive of soil that is seasonally or tidally saturated.**

ACRONYMS

The following are acronyms used in this document:

bgs	below ground surface
CSM	Conceptual Site Model
DF	Dilution Factor
DNREC	Department of Natural Resources and Environmental Control
HSCA	Hazardous Substance Cleanup Act
MCL	Maximum Contaminant Level
NAPL	non-aqueous phase liquids
NPL	National Priority List
PID	photo ionization detector
PO	Project Officer
RI	Remedial Investigation
RS	Remediation Section
SAP	Sampling and Analysis Plan
SOILgw GV	Soil to Groundwater Generic Value
SOILgw SS	Soil to Groundwater Site Specific Value
SPLP	synthetic precipitation leaching potential
SSG	Soil Screening Guidance
TW RSL	Tap Water Regional Screening Level
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

The Department of Natural Resources and Environmental Control (DNREC) Remediation Section (RS) developed this technical guidance to outline the steps that need to be followed to evaluate the soil to groundwater pathway of certain hazardous substances. This document establishes best practices when detections of hazardous substances threaten to contaminate the groundwater resources of Delaware. These detections are evaluated during environmental investigations conducted under the Hazardous Substance Cleanup Act (HSCA).

1.1 STATEMENT OF PURPOSE

The technical guidance presents a process for evaluating the soil to groundwater pathway and identifying conditions in which the pathway will not require additional evaluation. This document also describes strategies to delineate the vertical and horizontal extent of the soil contamination that poses a threat to groundwater and only applies to facilities being evaluated under HSCA. The goal of this document is to:

- Establish procedures to identify, evaluate, characterize, and address hazardous substances that may leach from soil to groundwater,
- Establish soil to groundwater generic values ($SOIL_{gw}$ GV) to identify areas within soil that may require additional evaluation, to investigate the potential risks to groundwater from soil, to delineate soils that may require potential remediation,
- Establish procedures for calculating site-specific soil to, and groundwater values ($SOIL_{gw}$ SS) to provide an alternative method to evaluate the potential site-specific risks to groundwater.

1.2 AUTHORITY

The evaluation of the soil to groundwater pathway is required under 7 DE Admin. Code 1375 and this evaluation shall be included in the Remedial Investigation (RI) Report. The regulations require the completion of a HSCA investigation that is inclusive of the soil to groundwater pathway. The soil to groundwater pathway is a part of "the nature and extent of a release," and this pathway is a "specific condition that may require remediation". Certain hazardous substances pose a direct contact risk, an inhalation risk, and can potentially contaminate groundwater. Contaminated groundwater can move to downgradient receptors and pose unacceptable risks.

1.3 APPLICABILITY

The information and procedures presented in this technical guidance document are the best practices to achieve regulatory compliance. Adherence to these practices will allow DNREC-RS staff to effectively review regulatory submissions to arrive at better decisions.

2.0 SOIL TO GROUNDWATER PATHWAY

A complete soil to groundwater exposure pathway occurs when hazardous substances are released to soil, migrate through the vadose zone, and come into contact with the saturated zone either through direct releases to the subsurface or migration of surface releases via infiltration and percolation (Šimunek & van Genuchten, 2016). The ultimate fate and transport of the contamination are affected by certain soil properties and contaminant specific properties (Whiteaker & Valdez, 2022). In addition, vadose zone migration is often times enhanced through groundwater fluctuations due to seasonality and the effects of certain groundwater quality parameters such as pH, oxygen-reduction potential, and specific electrical conductance (Abanyie, et al., 2023). The collection of unsaturated and, in some cases, saturated soil samples for analysis of hazardous substances that can leach to groundwater is essential for the complete evaluation of the following; the conceptual site model (CSM), fate and transport analysis, and the evaluation of risk.

2.1 PREVIOUS GUIDANCE

The United States Environmental Protection Agency (USEPA) published a Soil Screening Guidance (SSG) in 1996 and the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. These documents assist Superfund project managers in addressing the soil to groundwater pathway at Federal National Priority List (NPL) sites. This document has been in continual use since 1996 with minor updates and amendments. While the USEPA SSG is generally applicable to facilities investigated under Federal cleanup programs, the use of the SSG in the HSCA program is also acceptable.

2.2 PATHWAY OF CONCERN

The soil to groundwater pathway is a specific condition at environmental remediation sites that could require remediation. The complete evaluation of this pathway will assist in preventing the following at facilities contaminated with specific hazardous substances:

- Persistent groundwater plumes that migrate off of a property where a HSCA facility is located and create unacceptable risks to both on-site and neighboring receptors.
- Groundwater plumes that migrate into fractured bedrock (Piedmont) or into deeper semi-confined or confined aquifers (Coastal Plain).
- Potential vapor intrusion risks into existing building(s) on the property, existing building(s) off property, or any future buildings.
- Human health risks associated with contaminated groundwater diffusely discharging into sediment pore water and surface water.
- The need for any long-term monitoring of groundwater plumes.

2.3 CONTAMINANTS COVERED UNDER THE DOCUMENT

All hazardous substances have the potential to be evaluated for the soil to groundwater pathway. To help in this evaluation, DNREC-RS has calculated soil to groundwater generic values ($SOIL_{gw}$ GV) for certain hazardous substances. A listing of the hazardous substances with calculated $SOIL_{gw}$ GV is located in **Table 1** at the end of this document. Those hazardous substances that do not have a calculated $SOIL_{gw}$ GV are not exempt from the evaluation. Instead, based on regional, area-wide, and site-specific conditions, these hazardous substances may also be required in an evaluation of this pathway under HSCA. Please consult with your DNREC-RS Project Officer (PO) to determine if evaluation of additional substances will be necessary at individual sites.

3.0 SOIL TO GROUNDWATER VALUES

To determine if concentrations of certain hazardous substances detected at a facility have the potential to contaminate groundwater above risk based screening levels or maximum contaminant levels (MCLs), generic soil to groundwater values have been calculated. The following section provides a discussion of how the statewide $SOIL_{gw}$ GVs used in this document are calculated. The $SOIL_{gw}$ GVs are similar to HSCA screening levels. $SOIL_{gw}$ GVs are values used to determine if the soil concentrations detected at a facility will require a more extensive soil to groundwater pathway evaluation in reporting submitted to the Department. The $SOIL_{gw}$ GV only applies to unsaturated soils. Soil samples collected in saturated conditions must use a site-specific $SOIL_{gw}$ value (or $SOIL_{gw}$ SS). If any soil concentrations at the facility exceeds the $SOIL_{gw}$ value (generic or site-specific) for the selected hazardous substances, the facility requires additional evaluation of the soil to groundwater pathway. This evaluation needs to be documented in writing in the RI report submitted to the Department. If there are regional, facility, and site-specific conditions that require a different evaluation of hazardous substances, an alternate method to determine if soil is a threat to contaminate groundwater may be performed, such as using a synthetic precipitation leaching potential (SPLP) or EPA Method 1312.

3.1 CALCULATION OF THE SOIL$_{gw}$ GV FOR ORGANICS

To calculate a generic value for the soil to groundwater pathway for organic compounds, the formula from the USEPA's 1996 SSG was adapted for this document. The formula was simplified and uses default values. The calculation relies on a target groundwater concentration to derive a numeric value in soil. Since all groundwater in the state is assumed to be available for use as drinking water, the target leachate concentration will be based on a drinking water value. If the compound has a published maximum contaminant level (MCL) for drinking water, that value is used. If no MCL exists, the tap water regional screening value (TW RSL) is used. The TW RSL is based on the HSCA SL, but increased by one order of magnitude (TR=1E-05 instead of TR=1E-06 or hazard quotient equal to 1) The formula is below:

$$SOILgw\ GV = Cw\ \cdot \{(Koc\ \cdot foc) + \ \theta w/\rho b\}$$

Where:

SOIL$_{gw}$ GV = Soil to groundwater generic value (mg/kg)

C_w = target soil leachate concentration (mg/L)

  C_w = Delaware MCL x DF or

  C_w = adjusted TW RSL x DF

DF = Dilution Factor (unitless)

K_{oc} = Soil organic carbon-water partition coefficient (L/kg)

f_{oc} = Organic carbon content of soil (kg/kg)

θ_w = Water filled soil porosity (Lwater/Lsoil)

P_b = Soil bulk density (kg/L)

The soil Koc is a compound specific value, and **Table 1** provides references from which the value used in the calculation was derived. The dilution factor (DF) is a Department selected general dilution factor constant. The organic carbon content of the soil (f_{oc}), the water filled soil porosity (θ_w), and the soil bulk density (P_b) are default values adapted from the USEPA's SSG (1996) and its proposed updates (Whiteaker & Valdez, 2023). For the calculation of a site-specific soil to groundwater value, these defaults may be changed using site-specific data and information collected during the course of the evaluation or investigation.

DF = 100 (unitless)
f_{oc} = 0.002 (kg/kg)
θ_w = 0.43 (Lwater/Lsoil)
P_b = 1.5 kg/L

The calculated SOILgw GV for organic hazardous substances is presented in **Table 1** of this document.

3.2 CALCULATION OF THE $SOIL_{gw}$ GV FOR INORGANICS

Since inorganic compounds are not affected by the organic carbon content of the soil (f_{oc}), this value is removed from the calculation. The organic carbon partition coefficient (K_{oc}) is replaced with the dissociation constant or K_d value. The formula is below:

$$SOILgw\ GV = TV * \left(Kd + \frac{\theta w}{\rho b}\right) * DF$$

Where:
$SOIL_{gw}$ GV = Soil to groundwater generic value (mg/kg)
TV = target soil leachate concentration (mg/L) Delaware MCL or adjusted TW RSL
K_d = Dissociation Constant (L/kg)
θ_w = Water filled soil porosity (Lwater/Lsoil)
P_b = Soil bulk density (kg/L)
DF = Dilution Factor (unitless)

The default values used in **Section 3.1** remain consistent. The calculated $SOIL_{gw}$ GV and reference for the dissociation constant used for inorganic hazardous substances is presented in **Table 1** of this document.

3.3 CALCULATION OF THE $SOIL_{gw}$ SS

An alternate method for a soil to groundwater evaluation is to calculate site-specific soil to groundwater ($SOIL_{gw}$ SS) values. These values can be used to:

- Allow users to substitute a site-specific K_{oc}, K_d, or dilution attenuation factor (DAF) values for a more accurate representation of soil leaching rates of the subject site.
- Evaluate saturated site soils.
- To provide greater detail in delineating soil contamination contributing to groundwater and potentially surface water contamination.
- To target areas that may require remediation.

A value can also be calculated using formulas from the USEPA's SSG document or using the formula presented in **Section 3.1** for organics or **Section 3.2** for inorganics. If using the formulas from **Section 3.1** or **Section 3.2**, users will replace certain values with site-specific values derived from data collected from the facility. Any calculation of a $SOIL_{gw}$ SS shall be presented in reporting to DNREC-RS and provide a detailed rationale for the site-specific values used in the calculations. This evaluation shall demonstrate that the selected site-specific values are appropriate for the subject site.

The Department will also accept other alternate approaches to a calculation of a $SOIL_{gw}$ SS. These approaches will also be made on a site-by-site basis. The use of generic values does not preclude the use of site-specific values, or vice versa. This approach will allow for a more flexible soil to groundwater evaluation.

4.0 PATHWAY EVALUATION

The technical guidance presented below offers a path to determine if soil is contaminated with hazardous substances that pose a threat to groundwater. The process is visualized in **Figure 1: The Soil to Groundwater Pathway Analysis Flow Diagram.**

4.1 PRIMARY DETERMINATION

When completing a soil to groundwater pathway evaluation, quantitative soil analytical data is needed to compare the collected site data to the calculated soil to groundwater values. This comparison allows a quick review to determine whether additional investigation is needed at a site. The data comparison can also be used to determine if a soil to groundwater evaluation is no longer necessary at a facility/site or operable unit. If the collected site data contains limited detections of contaminants in soil or groundwater, the site may qualify for an early screen out of the soil to groundwater pathway (See Oval 1 of **Figure 1**). The determination of the limited detections evaluation needs to be made in conjunction with the DNREC-RS PO.

A site needs both soil *and* groundwater analytical data to fully evaluate the pathway. If no soil samples collected during an investigation exceed a SOILgw GV or SOILgw SS value and sampled groundwater contains[1] no hazardous substances that have a calculated SOILgw value (either generic or site-specific), the pathway will be considered closed, and no further evaluation of this pathway is needed (See Box 1 & 2 of **Figure 1**). If there are any exceedances of the soil to groundwater values and the site groundwater contains hazardous substances, additional investigation will need to be completed to characterize the site (See Box 3 of **Figure 1**).

If site soils do not contain hazardous substances above the SOILgw GV or SOILgw SS value but the groundwater contains hazardous substances, the following questions need to be answered:

- Are there any potential off-property or off-facility groundwater plumes that can be demonstrated (See Oval 2 of **Figure 1**)?
- Are <u>all</u> potential source areas at the site characterized in both soil and groundwater (See Box 3 of **Figure 1**)?

[1] Please refer to the definitions section

The procedures to determine if off property/facility groundwater plumes are affecting the site are found in **Section 4.2.2**. If the property/facility groundwater plume is determined to be affecting the neighboring property or properties, an evaluation of the potential risks posed by the plume is required to be made. If all exposure pathways are closed, the soil to water evaluation is complete. However, if potential risks are identified from exposure to groundwater, this groundwater plume typically requires further evaluation of the source and potential sources. After the soil to groundwater evaluation is completed for the property or parcels, the Department will determine whether additional investigation may be required for the groundwater plume migrating onto the neighboring property or parcels (See Box 4 of **Figure 1**). The table below illustrates the potential groundwater risks associated with permitted wells by DNREC Division of Water.

Potential Risk to Permitted Wells

Well Type	Ingestion Risk	Dermal Adsorption Risk	Inhalation Risk
Public Well	Y	Y	P
Domestic Well	Y	Y	P
Observation Well	N/A	P	P
Monitoring Well	N/A	P	P
Agricultural Well	P	P	P
Irrigation Well	N/A	Y	P
Dewatering Well	N/A	P	P
Closed-loop Geothermal	N/A	N/A	N/A

Y = Pathway open
N/A = No pathway/pathway closed
P = Potential pathway, can be mitigated with permit restrictions
Note: All permitted wells listed have the potential to have drilling restrictions due to production of soil cuttings and drilling water that could be contaminated.

4.2 DATA EVALUATION

This section presents an iterative process that evaluates whether both soil and groundwater are characterized in accordance with 7 DE Admin. Code 1375.

If the contaminants identified at the facility are found to be above the SOILgw GV or SOILgw SS values, those contaminants shall be retained for the soil to groundwater evaluation. If all source areas or potential sources are not fully evaluated, additional data must be collected (See Box 5 of **Figure 1**). The CSM needs to confirm that existing analytical data is located in proximity to suspected releases. The locations of the exceedances of the SOILgw GV or SOILgw SS values should be plotted on a figure of the facility to determine areas that could require additional data collection. The evaluation should be a "worst case scenario" and be biased toward the area of likely release or elevated concentrations of hazardous substances[2] (for example: adsorptive clay layers). This can include any field screening data, such as photo ionization detector (PID) reading. Geologic cross sections and soil iso-concentrations maps are recommended to visualize these data.

Saturated soil should be avoided during the investigation; however, soil samples collected in the saturated zone can be used for the evaluation if the groundwater elevation at the facility is close to ground surface. For the purposes of this document, less than five (5) feet below ground surface (bgs) is considered 'close to the surface'. Please consult with you DNREC-RS PO with assistance in this determination.

To complete the delineation of the source area, any proposed soil investigation needs to be presented in an approved Sampling and Analysis Plan (SAP) for the facility. The number of soil borings, number of soil samples, the rationale for placement of the borings, and any site contingencies that may hinder the soil investigation need to be included in

[2] Please be advised that biased investigation samples may not be used in risk assessments. The biased samples are critical to delineate soil concentrations but can skew data used in a risk assessment. This needs to be highlighted in the SAP and discussed in the Risk Assessment reporting.

the SAP including the required analyses. During this time, the data quality objectives (DQOs) are investigative, and the SAP shall reflect this fact. The DNREC screening lab may be used to screen soils for the contaminants covered under this document, especially for the absence of these compounds. However, representative quantitative analytical results are needed to delineate the nature and extent of the contamination in soil that potentially threatens groundwater.

Since many of the hazardous substances with a SOILgw GV are volatiles, the use of a PID fitted with a 10.6 eV lamp, an 11.7 eV lamp, or both should be used (depending on the type of volatile). Other field instruments and high resolution tools may also be deployed to detect hazardous substances in soil. All of these field screening methods are recommended to be used to complete the following:

- Qualitatively determine areas that are not affected by releases or suspected releases,
- To direct discrete sampling of the soil column at desired depths to collect soil samples to be sent to laboratory to derive appropriate quantitative analytical results,
- To locate potential areas of non-aqueous phase liquids (NAPL).

Other factors such as age of release, past facility activities, soil depths, confining layer(s), chemical interactions, and building footprints or other physical sub-surface barriers need to be considered when using discrete soil analytical values for this evaluation. All SAPs submitted to DNREC-RS shall reflect these considerations. The evaluation should be inclusive of all release and potential exposure points identified at the facility. Since these samples generally follow soil investigation DQOs, their use in risk assessment might be limited. A review of the site-specific SAP and discussions with the DNREC-RS PO is recommended (See Oval 3 of **Figure 1**). Use of statistical tests to determine a mean soil concentration across exposure units, areas of concern, or operable units is not appropriate for a soil to groundwater pathway evaluation.

4.2.1 SOIL DATA

After all of the soil analytical samples are collected, the results can be compared to the soil to groundwater generic value or a calculated SOILgw SS value. If the values do not exceed the selected soil to groundwater value for the contaminants covered under this document, the soil to groundwater pathway is closed and no further evaluation is necessary.

If there are soil concentrations that exceed the SOILgw GV (or calculated SOILgw SS values) but there are no detectable concentrations of the contaminants in the facility's groundwater. This may indicate that the volume of soil contaminated with the hazardous substances evaluated is negligible, or the release is not readily leaching to groundwater. For this evaluation to be complete, the location of groundwater monitoring wells, depth of the soil samples, and additional boring data will need to be reviewed to ensure the soil exceedance of the soil-to-groundwater pathway is highly localized (See **Section 4.4** on Remedial Investigation Reporting). Additional quarterly rounds of groundwater samples from wells in close proximity to the exceedance is also necessary to demonstrate the SOILgw GV (or a calculated SOILgw SS values) exceedance is not contaminating groundwater at the site. This data needs to be collected during the remedial investigation and presented in reporting (See Box 6 of **Figure 1**).

If site soils are not contributing to the underlying groundwater contaminant plume, the soil to groundwater pathway is incomplete. However, when both soil and groundwater contamination are present at the site, the contamination present at the site has the potential to present unacceptable groundwater risks in the future and existing institutional and engineering controls currently in place should be sufficient to address these risks. The site may qualify for a Conditional No Further Action (CNFA) or if present or future controls are effective at removing the risks, these controls shall be documented in a deed notice.

4.2.2 GROUNDWATER DATA

The evaluation of an off property or off facility groundwater plume is an option to determine if an upgradient or ambient groundwater plume is affecting the site you are evaluating. This determination requires multiple rounds of groundwater data and an evaluation of contaminant concentrations. The evaluation can use the following:

- A review of DNREC databases for neighboring sites. The upgradient site should be established through groundwater flow directions from both the neighboring facility and the facility being evaluated. Upgradient contaminant concentrations have to be migrating toward the site under evaluation. All data used to make this evaluation has to be presented in reporting to DNREC. This includes maps, figures, data tables, and any other information used to complete this demonstration.
- Existing groundwater monitoring wells at the site. If an upgradient groundwater plume affects the site under evaluation, the groundwater concentration will decline as the groundwater moves across the site. Upgradient wells will have higher concentrations than downgradient wells. This evaluation requires monitoring over time to make this determination. Please consult with your DNREC PO to determine number of samples and length of monitoring.
- For ambient conditions, relative concentrations of groundwater at monitoring wells shall have a consistent concentration. This can be demonstrated by statistical analysis of contaminant concentrations over time and can also include surface water data for certain sites.

If the determinations above cannot be made, it will be assumed the site under evaluation is the source of the groundwater plume and that there is completed soil to groundwater pathway.

4.3 SOIL DELINEATION

The delineation of soils containing hazardous substances that threaten to contaminate groundwater will identify areas within the subsurface that will require remedial action to document and reduce the mass loading of soil contamination to groundwater. The soil delineation will be documented in the RI and will consider the following:

- Number of soil exceedances above the SOILgw GV, the SOILgw SS, or other calculated level.
- Horizontal and vertical extent of those exceedances.
- Estimated volume of the soil exceeding the selected soil to groundwater values and calculation of soil cleanup values to reduce the risk to groundwater.

For delineation, soil analytical values less than or equal to the SOILgw GV or SOILgw SS can be used to delineate the soil mass contaminated with the contaminants that have potential to leach contamination to groundwater. Vertical delineation may rely on contaminant specific properties along with subsurface conditions that may affect soil deeper within the column. The default values used to calculate generic values can be changed to site-specific levels. Documentation of the values used in the calculations of the SOILgw SS must be presented in the RI reporting to the Department. The delineation data is used to determine the following about the site (See Box 7 of **Figure 1**):

- The delineated site soils that are <u>and</u> that are not contributing to the groundwater plume.
- Whether the loading of hazardous substances from soil to groundwater presents potential risks to the following:
  - o Downgradient water supplies
  - o Surface Water (Ecological and Human Health)
  - o Vapor Intrusion

If the soil to groundwater pathway is complete and the characterized soils, groundwater, or both at the site are contributing to an unacceptable risk(s) as determined through a risk assessment, a remedial action must be performed.

4.4 REMEDIAL INVESTIGATION REPORTING

The results of the soil delineation should be presented in the RI and contain the following elements to document delineation of the soil to groundwater pathway:

- An evaluation of all data used in the evaluation including high resolution tool output, field screening methods, calibration logs of field instruments, lab screening data, and explanation on how this information was used to delineate soil;
- An analytical data table showing the number of soil borings, sample IDs, and all sample results including any non-detects (ND or U-qualified values);
- A figure or map outlining delineated soil areas above the SOILgw GV, the SOILgw SS, or other approved levels;
- A narrative of the soil findings and the calculation of approximate soil volume exceeding the generic values, site-specific values, or other approved levels;
- A discussion of any changes made to the SAP and how they affected the delineation effort; and
- A discussion of the next steps of the evaluation. This may include no further evaluation, an explanation of why the pathway presents no risk or is an acceptable risk, or the remedial efforts needed to address the pathway.

5.0 CONCLUSIONS

This technical guidance will assist in determining the best course of action for soil contaminated by hazardous substances with a propensity to leach to groundwater at facilities based upon their site-specific conditions. The calculated soil to groundwater values, meant to protect human health and the environment, were developed in accordance with 7 DE Admin. Code

1375. The steps and procedures presented in this document highlight the best practices for the identification, delineation, and evaluation of certain hazardous substances in soils that pose the greatest threat of leaching to groundwater.

6.0 REFERENCES

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FIGURE 1:

THE SOIL TO GROUNDWATER PATHWAY ANALYSIS FLOW DIAGRAM

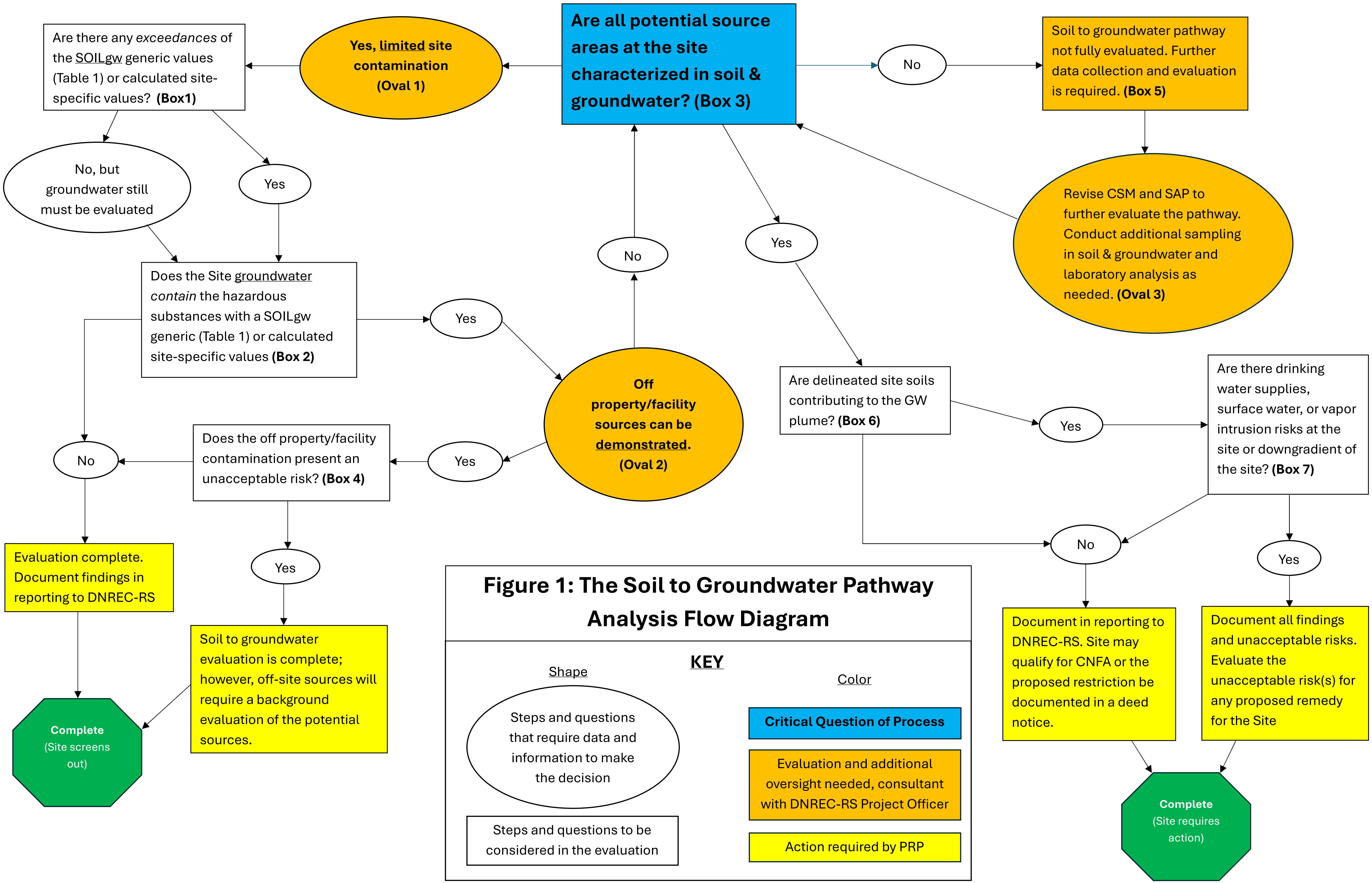

Figure 1: The Soil to Groundwater Pathway Analysis Flow Diagram

TABLE 1:

SOILGW GENERIC VALUES FOR SELECT HAZARDOUS SUBSTANCES UNDER HSCA

Table 1: $SOIL_{gw}$ Generic values for select hazardous substances under HSCA

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
Acenaphthene	83-32-9	4900	b		0.53	530
Acetone	67-64-1	0.31	b		18	520
Acetophenone	98-86-2	170	b		1.9	120
Acrolein	107-02-8	0.56	b		0.000042	0.001
Acrylonitrile	107-13-1	11	b		0.00052	0.02
Aldrin	309-00-2	48000	b		0.0000092	0.09
Aluminum	7429-90-5	9.9	b		20	20000
Anthracene	120-12-7	21000	b		1.8	7600
Antimony (metallic)	7440-36-0	45	b	0.006		27
Arsenic, Inorganic	7440-38-2	29	b	0.01		29
Atrazine	1912-24-9	130	b	0.003		0.16
Barium	7440-39-3	41	b	2		8300
Benzaldehyde	100-52-7	11.1	f		0.19	5.9
Benzene	71-43-2	62	a	0.005		0.21
Benzidine	92-87-5	530000	b		0.0000011	0.12
Benz[a]anthracene	56-55-3	350000	b		0.0003	21
Benzo[a]pyrene	50-32-8	910000	b	0.0002		36
Benzo[b]fluoranthene	205-99-2	550000	b		0.0025	280
Benzo[k]fluoranthene	207-08-9	4400000	b		0.025	22000
Beryllium and compounds	7440-41-7	790	b	0.004		320
Biphenyl, 1,1'-	92-52-4	1700	b		0.00083	0.31
Bis(2-chloro-1-methylethyl) ether	108-60-1	62	b		0.71	29
Bis(2-chloroethoxy)methane	111-91-1	61	b		0.059	2.4
Bis(2-chloroethyl)ether	111-44-4	76	b		0.00014	0.006
Bis(2-ethylhexyl)phthalate	117-81-7	87000	b	0.006		100
Bromochloromethane	74-97-5	27	b		0.83	28
Bromodichloromethane	75-27-4	93	b	0.08		3.8

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
Bromoform	75-25-2	126	a	0.08		4.3
Bromomethane	74-83-9	170	b		0.0075	0.47
Butyl Alcohol, t-	75-65-0	2	d		1.5	44
Butyl Benzyl Phthalate	85-68-7	34000	b		0.16	1100
Cadmium	7440-43-9	75	b	0.005		38
Caprolactam	105-60-2	6	d		9.9	300
Carbon Disulfide	75-15-0	300	b		0.81	72
Carbon Tetrachloride	56-23-5	152	a	0.005		0.30
Chlordane (alpha or cis-)	5103-71-9	11600	h		0.0036	8.5
Chlordane (gamma or trans-)	5103-74-2	1995262	h		0.001	400
Chloroaniline, p-	106-47-8	460	b		0.0037	0.45
Chlorobenzene	108-90-7	224	a	0.1		7.3
Chloroform	67-66-3	53	a	0.08		3.1
Chloromethane (Methyl Chloride)	74-87-3	6	a		0.19	5.7
Chlorophenol, 2-	95-57-8	400	b		0.091	10
Chromium(VI)	18540-29-9	19	b		0.0035	6.8
Chromium, Total	7440-47-3	3225	g	0.1		32000
~Chloronaphthalene, Beta-	91-58-7	8500	b		0.75	1300
Chrysene	218-01-9	490000	b		0.25	25000
Cobalt	7440-48-4	440	i		0.006	260
Copper	7440-50-8	430	b	1.3		56000
Cresol, o-	95-48-7	22	b		0.93	31
Cresol, p-	106-44-5	49	b		0.37	14
Cresol, p-chloro-m-	59-50-7	780	b		1.4	260
Cumene (Isopropylbenzene)	98-82-8	2800	b		0.45	260
Cyanazine	21725-46-2	199	b		0.00088	0.06
Cyanide (CN-)	57-12-5	9.9	b	0.2		200
Cyclohexane	110-82-7	479	b		12	1500
DDD, p,p`- (DDD)	72-54-8	44000	b		0.00032	2.8

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
DDE, p,p'-	72-55-9	87000	b		0.00046	8.0
DDT	50-29-3	240000	b		0.0023	110
Dibenz[a,h]anthracene	53-70-3	1800000	b		0.00025	90
Dibenzofuran	132-64-9	10233	b		0.0079	16
Dibromo-3-chloropropane, 1,2-	96-12-8	140	b	0.0002		0.01
Dibromochloromethane	124-48-1	83	b	0.08		3.6
Dibromoethane, 1,2- (EDB)	106-93-4	54	b	0.00005		0.002
Dibutyl Phthalate	84-74-2	1600	b		0.9	310
Dichlorobenzene, 1,2-	95-50-1	379	a	0.6		63
Dichlorobenzene, 1,4-	106-46-7	616	a	0.075		11
Dichlorobenzidine, 3,3'-	91-94-1	22000	b		0.0013	5.8
Dichlorodifluoromethane	75-71-8	360	b		0.02	2.0
Dichloroethane, 1,1-	75-34-3	52	b		0.028	2.8
Dichloroethane, 1,2-	107-06-2	38	a	0.005		0.18
Dichloroethylene, 1,1-	75-35-4	65	a	0.007		0.29
Dichloroethylene, cis-1,2-	156-59-2	49	b	0.07		2.7
Dichloroethylene, trans-1,2-	156-60-5	38	a	0.1		3.6
Dichlorophenol, 2,4-	120-83-2	160	b		0.046	2.8
Dichloropropane, 1,2-	78-87-5	47	b	0.005	0.0082	0.31
Dichloropropene, 1,3-	542-75-6	27	b		0.0047	0.16
Dieldrin	60-57-1	11000	b		0.000018	0.04
Diethyl Phthalate	84-66-2	81	b		15	670
Dimethylphenol, 2,4-	105-67-9	130	b		0.36	20
Dinitro-o-cresol, 4,6-	534-52-1	116	d		0.0015	0.078
Dinitrophenol, 2,4-	51-28-5	0.79	b		0.039	1.1
Dinitrotoluene, 2,4-	121-14-2	51	b		0.0024	0.09
Dinitrotoluene, 2,6-	606-20-2	74	b		0.00049	0.02
Dinitrotoluene, Technical grade	25321-14-6	82.4	d		0.001	0.05
Dioxane, 1,4-	123-91-1	7.8	b		0.0046	0.14

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
Diphenylhydrazine, 1,2-	122-66-7	660	b		0.00078	0.13
Endosulfan	115-29-7	2000	b		0.1	43
Endosulfan Sulfate	1031-07-8	2300	b		0.11	54
Endrin	72-20-8	11000	b	0.002		4.5
Ethylbenzene	100-41-4	220	b	0.7		51
Ethyl Chloride	75-00-3	42	b		8.3	310
Fluoranthene	206-44-0	49000	b		0.8	7900
~Fluorene	86-73-7	7900	b		0.29	470
Formaldehyde	50-00-0	3.6	b		0.0039	0.11
Heptachlor	76-44-8	6800	b	0.0004		0.56
Heptachlor Epoxide	1024-57-3	21000	b	0.0002		0.85
Hexachlorobenzene	118-74-1	3800	b	0.001		0.79
Hexachlorobutadiene	87-68-3	4700	b		0.0014	1.4
Hexachlorocyclohexane, Alpha-	319-84-6	1800	b		0.000072	0.03
Hexachlorocyclohexane, Beta-	319-85-7	2300	b		0.00025	0.12
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9	1400	b	0.0002		0.06
Hexachlorocyclopentadiene	77-47-4	7200	b	0.05		73
Hexachloroethane	67-72-1	2200	b		0.0033	1.5
Hexanone, 2-	591-78-6	54	b		0.038	1.5
Indeno[1,2,3-cd]pyrene	193-39-5	31000000	b		0.0025	16000
Isophorone	78-59-1	31	b		0.78	27
Lead and Compounds	7439-92-1	900	b	0.015		1400
Manganese	7439-96-5	65	b		0.43	2800
Mercury (elemental)	7439-97-6	52	b	0.002		10
Methoxychlor	72-43-5	63000	b	0.04		510
Methyl Acetate	79-20-9	30	b		20	690
Methyl Ethyl Ketone (2-Butanone)	78-93-3	32	b		5.6	200
Methyl Isobutyl Ketone (MIBK)	108-10-1	11	c		6.3	190

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
Methylnaphthalene, 2-	91-57-6	16000	b		0.036	120
Methyl tert-Butyl Ether (MTBE)	1634-04-4	12	b	0.01		0.31
Methylene Chloride	75-09-2	16	b	0.005		0.16
Naphthalene	91-20-3	950	b		0.0012	0.26
Nickel Soluble Salts	7440-02-0	65	b	0.1		650
Nitroaniline, 2-	88-74-4	27	b		0.19	6.5
Nitroaniline, 4-	100-01-6	15	b		0.038	1.2
Nitrobenzene	98-95-3	130	b		0.0014	0.08
Nitroso-di-N-propylamine, N-	621-64-7	11	b		0.00011	0.003
Nitrosodimethylamine, N-	62-75-9	8.5	b		0.0000011	0.00003
Nitrosodiphenylamine, N-	86-30-6	580	b		0.12	17
Octyl Phthalate, di-N-	117-84-0	9.8E+08	b		0.2	39000000
Pentachlorophenol	87-86-5	20000	b	0.001		2000
Phenanthrene	85-01-8	38000	b		0.12	920
Phenol	108-95-2	22	b		5.8	190
~Aroclor 1016	12674-11-2	110000	b		0.0014	31
~Aroclor 1221	11104-28-2	1900	b		0.000047	0.02
~Aroclor 1232	11141-16-5	1500	b		0.000047	0.02
~Aroclor 1242	53469-21-9	48000	b		0.000078	0.75
~Aroclor 1248	12672-29-6	190000	b		0.000078	3.0
~Aroclor 1254	11097-69-1	810000	b		0.000078	13
~Aroclor 1260	11096-82-5	1800000	b		0.000078	28
Polychlorinated Biphenyls (Total PCBs)	1336-36-3	78100	b	0.0005	0.00044	7.8
Pyrene	129-00-0	68000	b		0.12	1600
Selenium	7782-49-2	5	b	0.05		26
Silver	7440-22-4	8.3	b		0.094	81
Styrene	100-42-5	912	a	0.1		21
Tetrachlorobenzene, 1,2,4,5-	95-94-3	1800	b		0.00017	0.07
Tetrachloroethane, 1,1,2,2-	79-34-5	79	a		0.00076	0.03

Analyte	CAS No.	K_{oc} or K_d L/kg	Ref	DE MCL mg/L	TW RSL mg/L	$SOIL_{gw}$ Generic Value mg/kg
Tetrachloroethylene (PCE)	127-18-4	265	a	0.001		0.08
Tetrachlorophenol, 2,3,4,6-	58-90-2	6200	b		0.24	300
Thallium (Soluble Salts)	7440-28-0	71	b	0.002		14
Toluene	108-88-3	130	b	1		55
Toxaphene	8001-35-2	1500	b	0.003		1.0
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1	1200	b		10	2700
Trichlorobenzene, 1,2,3-	87-61-6	1622	e		0.007	2.5
Trichlorobenzene, 1,2,4-	120-82-1	1500	b	0.07		23
Trichloroethane, 1,1,1-	71-55-6	135	a	0.2		11
Trichloroethane, 1,1,2-	79-00-5	75	a	0.005		0.22
Trichloroethylene (TCE)	79-01-6	94	a	0.001		0.05
Trichlorofluoromethane	75-69-4	130	b		5.2	280
Trichlorophenol, 2,4,5-	95-95-4	2400	b		1.2	610
Trichlorophenol, 2,4,6-	88-06-2	1100	b		0.012	3.0
Trimethylbenzene, 1,2,4-	95-63-6	2200	b		0.056	26
Trimethylbenzene, 1,3,5-	108-67-8	660	b		0.006	1.0
Vanadium and Compounds	7440-62-2	1000	b		0.086	8600
Vinyl Chloride	75-01-4	19	a	0.001		0.03
Total Xylenes	1330-20-7	350	b	10		990
Zinc and Compounds	7440-66-6	62	b		6.0	37000

Equation for $SOIL_{gw}$ Screning Value (Organics)

$$SOIL_{gw}GV = (TV \times DF)*((K_{oc} \times f_{oc}) + \theta_w/\rho_b)$$

Equation for $SOIL_{gw}$ Screning Value (Inorganics)

$$SOIL_{gw}GV = TV*(K_d + \theta_w/\rho_b)*DF$$

Target Value (TV) = MCL or Tap Water RSL

Where:		unit	
f_{oc}	0.002		From USEPA SSG (1996)
porosity (θ_w)	0.43		From USEPA SSG (1996)
bulk density (ρ_b)	1.5	kg/L	From USEPA SSG (1996)
DF	100		Default

Koc or Kd Reference
a: EPA Document on Soil to Groundwater evaluation under CERCLA (1993)
b: Table 5a or 5b of Pa Code 250 (2023)
c: EPA Toxicological Review of Methyl Isobutyl Ketone (2003)
d: NJDEP Chemical Properties for Calculation of Impact to Groundwater (2019)
e: ATSDR Toxicological Profile for Trichlorobenzene (2014)
f: USEPA Provisional Peer-Reviewed Toxicity Values for Benzaldehyde (2015)
g: Hassan, S.M. and Garrison, A.W. (1996) Distribution of chromium species between soil and porewater.
Chemical Speciation and Bioavilability. (Kd value is the median of the highest and lowest derived values for Chromium III)
h: USEPA Toxicological Review of Chlordane, Technical (1997)
i: Shappard, S., Long J., Sanipelli, B. and Sohlenius G (2009). Solid/liquid partition coefficients (Kd) for selected
soils and sediments at Forsmark and Laxemar-Simpevarp. Svensk Kärnbränslehantering AB. SKB Rapport R-09-27.
(Lowest derived Co value)