BEST PRACTICES FOR DEVELOPMENT AND USE OF DATA SCREENING VALUES AND CLEAN-UP OBJECTIVES
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Civil/Environmental Engineer

- Over 13 years’ experience in the environmental industry
- Registered civil/environmental engineer
- Manages the chemistry group at Trihydro
- Her primary responsibilities include:
  - Providing technical support for projects in data defensibility
  - Data quality
  - Managing complex site investigations and remediation projects
Why are Screening Values and Clean-Up Levels Important?

**Laboratory**
- Client Expectations
- Choosing Methodology
- Repeat Work
- Forecasting Future Regulatory Requirements

**Consultant/Responsible Party**
- Protection of Human Health and the Environment
- Property Reuse
- Meeting Project Objectives
- Risk Mitigation
- Spending Resources to Address Highest Risks

**Regulatory Agencies**
- Protection of Human Health and the Environment
- Public Scrutiny
- Public Protection
- Property Reuse
- Risk Mitigation
- Spending Resources to Address Highest Risks
Common Questions

- What are the differences between a screening level and clean-up objective?
- How are screening levels developed?
- Who develops screening levels?
- Why are there so many screening value sources?
- Which of the multiple sources should I use?
- What if the laboratory cannot meet the screening levels?
- What if my existing data doesn’t meet the screening levels?
- What happens if I exceed a screening level?
## What is the Difference Between a Screening Level and Clean-up Objective?

<table>
<thead>
<tr>
<th>SCREENING LEVEL</th>
<th>CLEAN-UP OBJECTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used in the first steps of an evaluation to determine pathways and develop a Chemical of Potential Concern and Chemical of Concern List.</td>
<td>Used in the corrective action phase of an investigation.</td>
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<tr>
<td>Very important part of Site Investigations, Sampling Plans, and Quality Assurance Plans.</td>
<td>Developed as a Site Specific approved value that the site must meet to obtain closure or no further action.</td>
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<tr>
<td>Developed with consideration for uncertainty.</td>
<td>Site specific risk values are assumed or calculated.</td>
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<tr>
<td>Designed to be overly protective of the media and receptors.</td>
<td>Typically are higher than screening levels.</td>
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<td>Used as final steps for clean-up.</td>
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How are Screening Levels Developed?

Research to determine chemical toxicity → Each chemical is assigned a carcinogenic risk → Risk values go through nine steps of review and research
### How Screening Levels Are Developed

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<th>Key</th>
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<th>Key</th>
<th>RFD (mg/kg-day)</th>
<th>Key</th>
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**Key**: I = IRIS; P = PPRTV; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #27); H = HEAST; J = New Jersey; O = EPA Office of Water; F = See FAQ; RBA applied (See User Guide for Arsenic notice); c = cancer; *= where: n SL < 100x c SL; **= where n SL < 10x c SL; n = noncancer; m = Concentration may exceed.
How Screening Levels are Calculated

Human Health

• Carcinogenic
  • Ingestion

\[
SL_{\text{res-soil-ca}} = \frac{\text{TR} \times AT_r \left(\frac{365 \text{ days}}{\text{year}} \times LT (70 \text{ years})\right)}{\text{CSF}_0 \left(\frac{\text{mg}}{\text{Kg} \times \text{day}}\right)^{-1} \times \text{IFS}_{\text{adj}} \left(\frac{36750 \text{ mg}}{\text{Kg}}\right) \times \left(\frac{10^{-6} \text{Kg}}{\text{mg}}\right)}
\]

where:

\[
\text{IFS}_{\text{adj}} = \frac{\text{EF}_{\text{ressc}} \left(\frac{350 \text{ days}}{\text{year}}\right) \times ED_c (6 \text{ years}) \times IRS_c (200 \text{ mg/day})}{BM_c (15 \text{ Kg})} + \frac{\text{EF}_{\text{ressa}} \left(\frac{350 \text{ days}}{\text{year}}\right) \times ED_r - ED_c (20 \text{ years}) \times IRS_a (100 \text{ mg/day})}{BM_a (80 \text{ Kg})}
\]

Note the duration

Note that both a child and adult are considered
How Screening Levels are Calculated

**Human Health**

- **Noncarcinogenic-child**
  - Ingestion

\[
SL_{\text{res-soil-nc-ing-c}} (\text{mg/kg}) = \frac{THQ \times AT_r \left( \frac{365 \text{ days}}{\text{year}} \right) \times ED_c (6 \text{ years}) \times BW_c (15 \text{ Kg})}{EF_r \left( \frac{350 \text{ days}}{\text{year}} \right) \times ED_c (6 \text{ year}) \times \frac{1}{RfD_o \left( \frac{\text{mg}}{\text{Kg-day}} \right)} \times IRS_c \left( \frac{200 \text{ mg}}{\text{day}} \right) \times 10^{-6} \text{Kg} \div 1 \text{mg}}
\]

- **Total**

\[
SL_{\text{res-soil-nc-tot-c}} (\text{mg/kg}) = \frac{1}{\frac{1}{SL_{\text{res-soil-nc-ing-c}}} + \frac{1}{SL_{\text{res-soil-nc-der-c}}} + \frac{1}{SL_{\text{res-soil-nc-inh-c}}}}
\]
Migration to Groundwater

\[
SSL (\text{mg/kg}) = C_w \left( \frac{\text{mg}}{\text{L}} \right) \times \text{DAF} \times \left( K_d \left( \frac{\text{L}}{\text{kg}} \right) + \frac{\left( \theta_w \left( \frac{\text{L}}{\text{L}} \right) + \theta_a \left( \frac{\text{L}}{\text{L}} \right) \times H' \right)}{\rho_b \left( \frac{1.5 \text{ kg}}{\text{L}} \right)} \right)
\]

where:

\[
\theta_a \left( \frac{\text{L}}{\text{L}} \right) = n \left( \frac{\text{L}}{\text{L}} \right) - n \left( \frac{\text{L}}{\text{L}} \right) \left( \frac{0.3 \text{L}}{\text{L}} \right);
\]

\[
n \left( \frac{\text{L}}{\text{L}} \right) = 1 - \left( \frac{\rho_b \left( \frac{1.5 \text{ kg}}{\text{L}} \right)}{\rho_s \left( \frac{2.65 \text{ kg}}{\text{L}} \right)} \right) \text{ and }
\]

\[
K_d \left( \frac{\text{L}}{\text{kg}} \right) = K_{oc} \left( \frac{\text{L}}{\text{kg}} \right) \times f_{oc} (0.002 \text{ unitless})
\]
HOW SCREENING LEVELS ARE CALCULATED

DIFFERENT KINDS OF SCREENING LEVELS

Human Health
- Dermal
- Ingestion
- Inhalation
- Adult / Child
- Residential / Industrial
- Trespasser / Construction
- Soil
- Groundwater
- Air

Migration to Groundwater
- Dermal
- Ingestion
- Inhalation
- Soil
- Risk Based
- MCL

Ecological
- Dermal
- Ingestion
- Inhalation
- Plants
- Invertebrates
- Animals
- Soil
- Sediment
- Surface Water

Carcinogenic/Non-Carcinogenic Constituents
### Risk Level

- **Carcinogens**
- Combined risk $< 1 \times 10^{-6}$
- 1 in a million increased risk for developing cancer
- Lifetime average daily dose (weighted child/adult)

### Hazard Quotient (HQ)

- **Non-Carcinogens**
- Combined Risk HQ $< 1$
- Average daily dose over time of exposure (i.e. child)

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Some chemicals can have both cancer and non-cancer effects.
Who Develops Screening Levels?

- States
- Regions
- EPA
- Site Specific
- Regulatory Agencies
Regional Screening Levels

- Considered the Gold Standard
- Harmonized from EPA regions 3, 6, and 9 in 2008
- Receptor Specific (residential/industrial)
- Soil and Groundwater do not consider Vapor Intrusion
- Not depth specific (surface/subsurface soils)
- Based on a “typical” Site Conceptual Model
- Provide information for Site Specific Calculations
- Are updated approximately every 6 months
- June 2015 is the most recent
### Regional Screening Levels – Summary Table

See FAQ #27: H = HEAST; J = New Jersey; O = EPA Office of Water; F = See FAQ; E = Environmental Criteria and Assessment Office; S = see user guide Section 5; L = see user guide on lead; M = mutagen; V = volatile; R = SL < 100X c SL; ** = where n SL < 10X c SL; n = noncancer; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide); SSL values are based on DAF=1

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>CAS No.</th>
<th>Resident Soil (mg/kg) key</th>
<th>Industrial Soil (mg/kg) key</th>
<th>Resident Air (ug/m³) key</th>
<th>Industrial Air (ug/m³) key</th>
<th>Tapwater (ug/L) key</th>
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<td>Aldicarb</td>
<td>118-06-3</td>
<td>6.3E+00  n</td>
<td>8.2E+01  n</td>
<td>2.0E+00  n</td>
<td>3.0E+00  n</td>
<td>7.5E-04  n</td>
<td>4.9E-04  n</td>
<td>n</td>
</tr>
<tr>
<td>Aldicarb Sulfone</td>
<td>1646-88-4</td>
<td>6.3E+00  n</td>
<td>8.2E+01  n</td>
<td>2.0E+00  n</td>
<td>3.0E+00  n</td>
<td>7.5E-04  n</td>
<td>4.9E-04  n</td>
<td>n</td>
</tr>
<tr>
<td>Aldicarb sulfonate</td>
<td>1646-87-3</td>
<td>6.3E+00  n</td>
<td>8.2E+01  n</td>
<td>2.0E+00  n</td>
<td>3.0E+00  n</td>
<td>7.5E-04  n</td>
<td>4.9E-04  n</td>
<td>n</td>
</tr>
<tr>
<td>Alizarin</td>
<td>309-00-2</td>
<td>3.9E-02  c''</td>
<td>1.8E-01  c'</td>
<td>5.7E-04  c</td>
<td>2.5E-03  c</td>
<td>9.2E-04  c'</td>
<td>1.5E-04  c'</td>
<td>n</td>
</tr>
<tr>
<td>Allyl</td>
<td>74223-64-6</td>
<td>1.0E+03  n</td>
<td>2.1E+04  n</td>
<td>4.5E-02  c</td>
<td>4.5E-02  c</td>
<td>4.5E-02  c</td>
<td>1.9E-01  n</td>
<td>n</td>
</tr>
<tr>
<td>Allyl Alcohol</td>
<td>817-19-6</td>
<td>1.0E+03  n</td>
<td>2.1E+04  n</td>
<td>4.5E-02  c</td>
<td>4.5E-02  c</td>
<td>4.5E-02  c</td>
<td>1.9E-01  n</td>
<td>n</td>
</tr>
</tbody>
</table>
Regional Screening Levels

Soil and Groundwater Screening Levels are a Combination of Ingestion, Dermal and Inhalation Pathways

\[
SL_{res-soil-nc-tot-c} (\text{mg/kg}) = \frac{1}{SL_{res-soil-nc-ing-c}} + \frac{1}{SL_{res-soil-nc-der-c}} + \frac{1}{SL_{res-soil-nc-inh-c}}
\]
Ecological Screening

Ecological Benchmark Tool

Screening ecological benchmarks are used to identify chemical concentrations in environmental media that are at or below thresholds for effects to ecological receptors. The Environmental Sciences Division of Oak Ridge National Laboratory developed and compiled a comprehensive set of ecotoxicological screening benchmarks for surface water, sediment, and surface soil applicable to a range of aquatic organisms, soil invertebrates, and terrestrial plants. These benchmarks, or updates, are performed in collaboration with The Institute for Environmental Modeling at the University of Tennessee and the Bechtel Jacobs Corp., are provided as a searchable database. Links to supporting technical reports from which the benchmarks were obtained are also provided.

The RAIS maintains links to several EPA Ecological Risk Assessment Guidance documents.

Soil Choices

Dutch Intervention Soil Screening Benchmark
- Dutch HC50 Soil Screening Benchmark
- Dutch Target Soil Screening Benchmark
- Eco-SSL Avian Soil Screening Benchmark
- Eco-SSL Inverts Soil Screening Benchmark
- Eco-SSL Mammalian Soil Screening Benchmark
- Eco-SSL Plants Soil Screening Benchmark
- EPA R6 Earthworms Surface Soil Screening Benchmark
- EPA R6 Plants Surface Soil Screening Benchmark
- ORNL Invertebrates Soil Screening Benchmark

Soil Choices

- Eco-SSL Inverts Soil Screening Benchmark
- Eco-SSL Mammalian Soil Screening Benchmark
- Eco-SSL Plants Soil Screening Benchmark
- EPA R6 Earthworms Surface Soil Screening Benchmark
- EPA R6 Plants Surface Soil Screening Benchmark
- ORNL Invertebrates Soil Screening Benchmark
- ORNL Microbes Soil Screening Benchmark
- ORNL Plants Screening Benchmark
- SO EPA R4 Soil Screening Benchmark
- SO EPA R5 ESL Soil Screening Benchmark
What About Background?

Geochemical and Mineralogical Data for Soils of the Conterminous United States
CHOOSING WHICH SCREENING LEVELS TO USE

Site Specific and Background

Federal

State

Regional

Calculated
Compare Result to Screening Level

If ≥ than action is required

If < than no action is required
OPTIONS IF YOU CAN’T MEET THE SCREENING LEVEL

Statistical Design  
Risk Assessment  
Calculate Clean-Up Objectives  
Re-analyze using Different Methods

Remediate and Resample  
Establish Background  
Eliminate Pathways

Top soil w/ twigs  
Clay

Leaching
Lessons Learned

- Understand where the screening levels are coming from and what is needed to have a successful project
- Obtain established screening levels prior to starting work
- Compare screening levels to the laboratory’s reporting limits and method detection limits prior to analyses
- Choose the best method for their matrix and data requirements
- Choose if reporting limits or method detection limits (MDL) are best for the site (are there concerns with using an MDL?)
- Explain/understand how dilutions, matrix interference, blank contamination, and other field and laboratory issues may effect their results (as appropriate)
- Explain/understand laboratory, regulatory agents, clients, and consultants about the variability in laboratory data results (as appropriate)
Example Comparison Table

<table>
<thead>
<tr>
<th>Analyte</th>
<th>CAS Number</th>
<th>Residential Screening Level (mg/kg)</th>
<th>Industrial Screening Level (mg/kg)</th>
<th>Migration to GW Screening Level (mg/kg)</th>
<th>Achievable Laboratory Limits</th>
<th>Residential Soil Limit Determination</th>
<th>Industrial Soil Limit Determination</th>
<th>Soil Limit Determination (Migration to GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-Dioxane</td>
<td>123-91-1</td>
<td>4.9</td>
<td>17</td>
<td>0.00014</td>
<td>0.5</td>
<td>0.0681</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
</tr>
<tr>
<td>2,2-Dichloropropane</td>
<td>594-20-7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>0.005</td>
<td>0.00044</td>
<td>--</td>
<td>--</td>
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<tr>
<td>2-Chlorotoluene</td>
<td>95-49-8</td>
<td>1600</td>
<td>20000</td>
<td>0.17</td>
<td>0.005</td>
<td>0.00051</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
</tr>
<tr>
<td>4-Chlorotoluene</td>
<td>108-43-4</td>
<td>1600</td>
<td>20000</td>
<td>0.18</td>
<td>0.005</td>
<td>0.00078</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
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<tr>
<td>4-Methyl-2-pentanone (MIBK)</td>
<td>108-10-1</td>
<td>5300</td>
<td>53000</td>
<td>0.23</td>
<td>0.02</td>
<td>0.00436</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
</tr>
<tr>
<td>Acetone</td>
<td>67-64-1</td>
<td>61000</td>
<td>630000</td>
<td>2.4</td>
<td>0.02</td>
<td>0.00538</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
</tr>
<tr>
<td>Benzene</td>
<td>71-43-2</td>
<td>1.1</td>
<td>5.4</td>
<td>0.0002</td>
<td>0.005</td>
<td>0.00047</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
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<tr>
<td>Bromobenzene</td>
<td>108-86-1</td>
<td>300</td>
<td>1800</td>
<td>0.036</td>
<td>0.005</td>
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<td>RL below RSL</td>
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<tr>
<td>Bromochloromethane</td>
<td>74-97-5</td>
<td>160</td>
<td>680</td>
<td>0.021</td>
<td>0.005</td>
<td>0.0003</td>
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<td>RL below RSL</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>75-27-4</td>
<td>0.27</td>
<td>1.4</td>
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<td>RSL below MDL</td>
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<td>Bromoform</td>
<td>75-25-2</td>
<td>62</td>
<td>220</td>
<td>0.0021</td>
<td>0.005</td>
<td>0.00023</td>
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<td>Bromomethane</td>
<td>74-83-9</td>
<td>7.3</td>
<td>32</td>
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<td>0.01</td>
<td>0.0005</td>
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<td>MDL below RSL</td>
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<td>Carbon Disulfide</td>
<td>75-15-0</td>
<td>820</td>
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<td>0.005</td>
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<td>RL below RSL</td>
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<tr>
<td>Carbon Tetrachloride</td>
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<td>0.61</td>
<td>3.0</td>
<td>0.00015</td>
<td>0.005</td>
<td>0.00063</td>
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<td>RSL below MDL</td>
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<td>Chlorobenzene</td>
<td>108-90-7</td>
<td>290</td>
<td>1400</td>
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<td>0.005</td>
<td>0.00054</td>
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<td>RL below RSL</td>
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<tr>
<td>Chloroethane</td>
<td>75-00-3</td>
<td>15000</td>
<td>61000</td>
<td>5.9</td>
<td>0.01</td>
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<td>Chloroform</td>
<td>67-66-3</td>
<td>0.29</td>
<td>1.5</td>
<td>0.000053</td>
<td>0.01</td>
<td>0.00029</td>
<td>RL below RSL</td>
<td>RSL below MDL</td>
</tr>
<tr>
<td>Chloromethane</td>
<td>74-87-3</td>
<td>120</td>
<td>500</td>
<td>0.049</td>
<td>0.01</td>
<td>0.00077</td>
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<td>RL below RSL</td>
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<td>cis-1,2-Dichloroethene</td>
<td>156-59-2</td>
<td>160</td>
<td>20000</td>
<td>0.0082</td>
<td>0.0025</td>
<td>0.00056</td>
<td>RL below RSL</td>
<td>RL below RSL</td>
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</tbody>
</table>
RESULT: PREMISE

VERIFIED
Invest in site-specific data to calculate site-specific standards rather than adopting generic screening standards as cleanup objectives.
Summary

- The laboratory cannot always meet screening levels since they are established using toxicological results not actual instrumentation.

- Regulatory agencies develop screening levels to be extremely conservative.

- Failure of a screening level is cut and dry at the exact number and may trigger additional investigation and remediation if above the limit.

- Be realistic if a screening level cannot be met.

- Look at multiple screening levels and options to determine what is best for the site and where to get the most benefit for the time and money spent.
References and Acknowledgements

Dr. Charlie DeWolf, PHD, Trihydro Corporation
Shannon Thompson, P.E., Trihydro Corporation
Allison Riffel, P.E., Trihydro Corporation
