



When Worlds Collide

Integrating Soil and Groundwater Studies When Remediating and Risk
Managing Upstream Oil and Gas Sites

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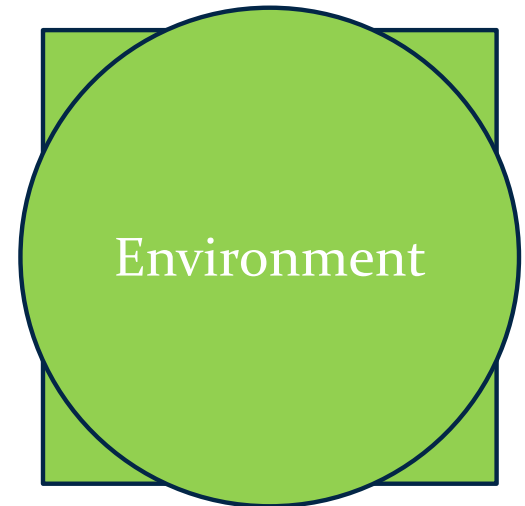
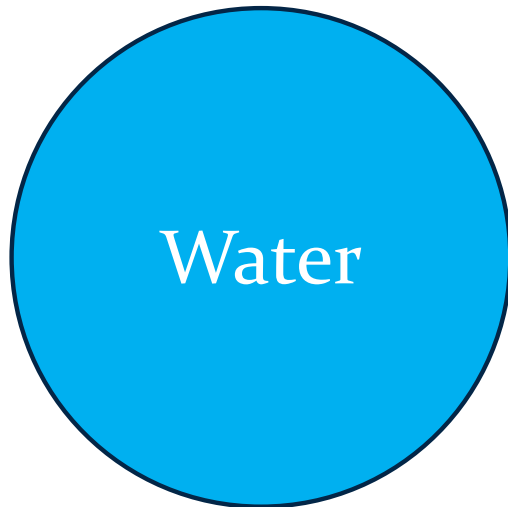
Waterline: What We're About

- Environmental and hydrogeology consulting company
- 50 staff in Alberta and BC
- Focused on producing high quality, cost-effective solutions
- Frequently collaborate with soil/rec and other specialty companies
- Technology and efficiency-focused company with in-house web apps that have automated data visualization, interpretation, and reporting tasks

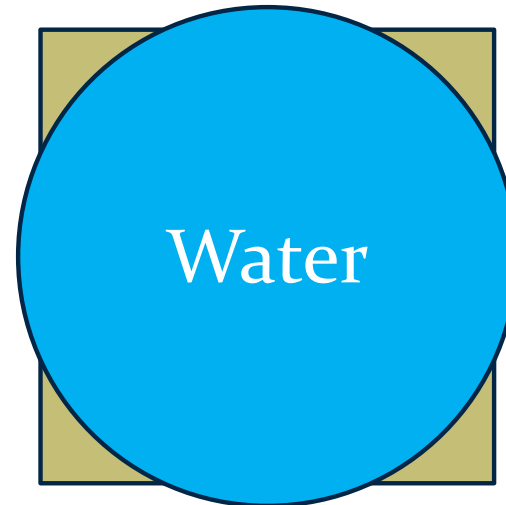
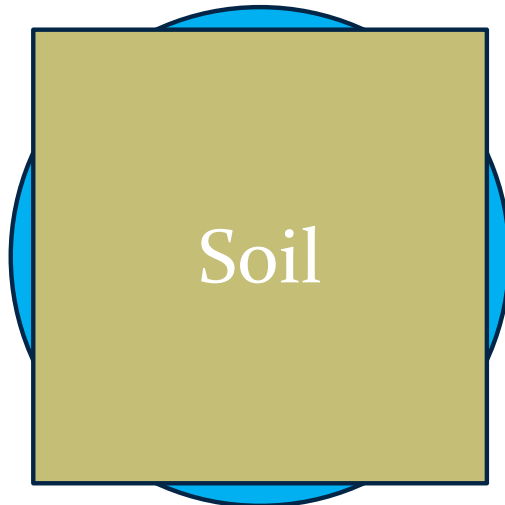
Attendee List: Good mix of consultants, oil and gas environmental advisors, regulators, colleges, laboratories



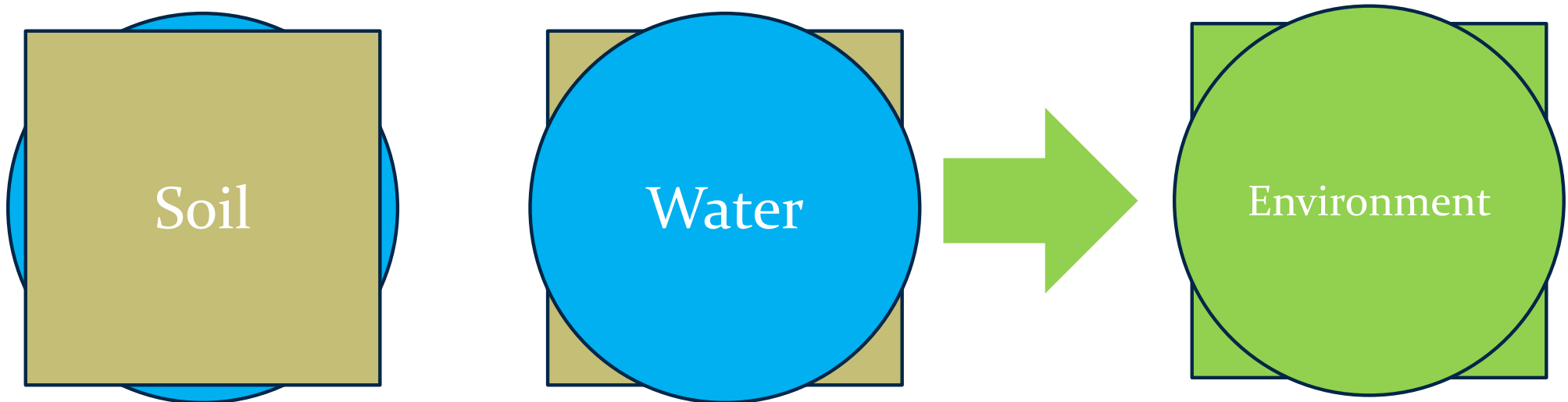
What Should We Be Focusing On?



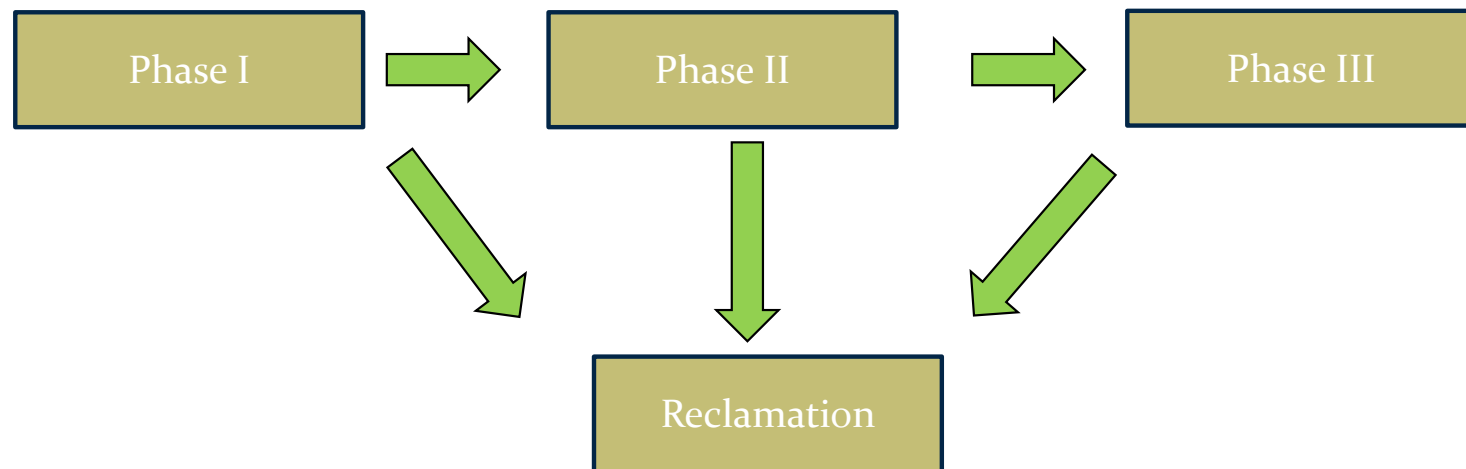
We Gravitate Towards What We're Familiar With (Regulators and Practitioners Alike)



So How Do We Improve Our Practice?

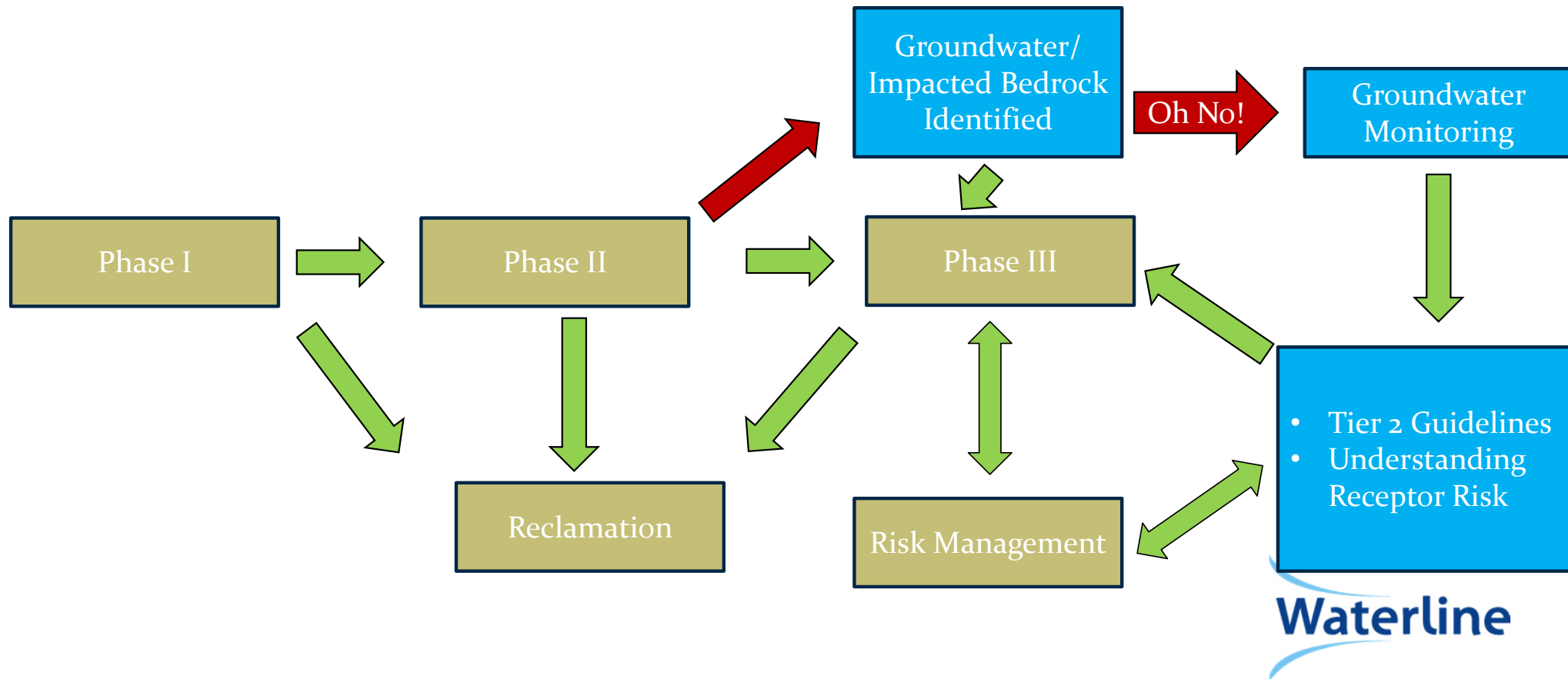


Remediation/Reclamation Workflow: The Path to a Reclamation Certificate



- Largely completed by practitioners with a soil focus

A Wrench in the Workflow: Groundwater



A Change in Workflow: Regulatory Perspective and Focus

Historical Regs and Guidance (Still Applicable)	New Regs and Guidance Since 2016
<ul style="list-style-type: none">• Soil Monitoring Directive (Soil)• Soil Management Programs (Soil)• Air Monitoring Directive (Soil)• Groundwater Monitoring for Sour Gas Plants (GW)• Code of Practice for Compressors (GW)• Water Act for Remediation (GW)	<ul style="list-style-type: none">• Alberta Risk Management Plan Guide• Exposure Control Guide• Alberta Environmental Assessment Standard• CSU letter requests• Remediation Action Plan Guide (AEP regulated sites, not AER regulated sites)
<ul style="list-style-type: none">• Prescriptive• Short-term focused	<ul style="list-style-type: none">• Often more groundwater/risk management focused• More open-ended• Longer-term thinking• Increased complexity

AER Regulatory Mechanisms

- AEP to AER file transfer and risk ranking in 2013 supported by Waterline
- Inventory of non-approval contaminated sites to answer basic questions:
 - How many upstream contaminated sites are there? What's the environmental liability? Is a plan in place?

Assigning
Potential
Problem
Sites
(SSLAs)

Risk/
Remediation
Action Plans
(RAPs)

Record of
Site
Condition
(ROSC)
Ranking

Well Site Assessment, Remediation, and Reclamation

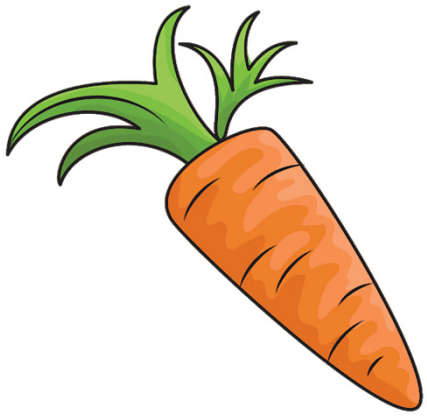


Exhibit A: The Regulatory
Carrot Approach

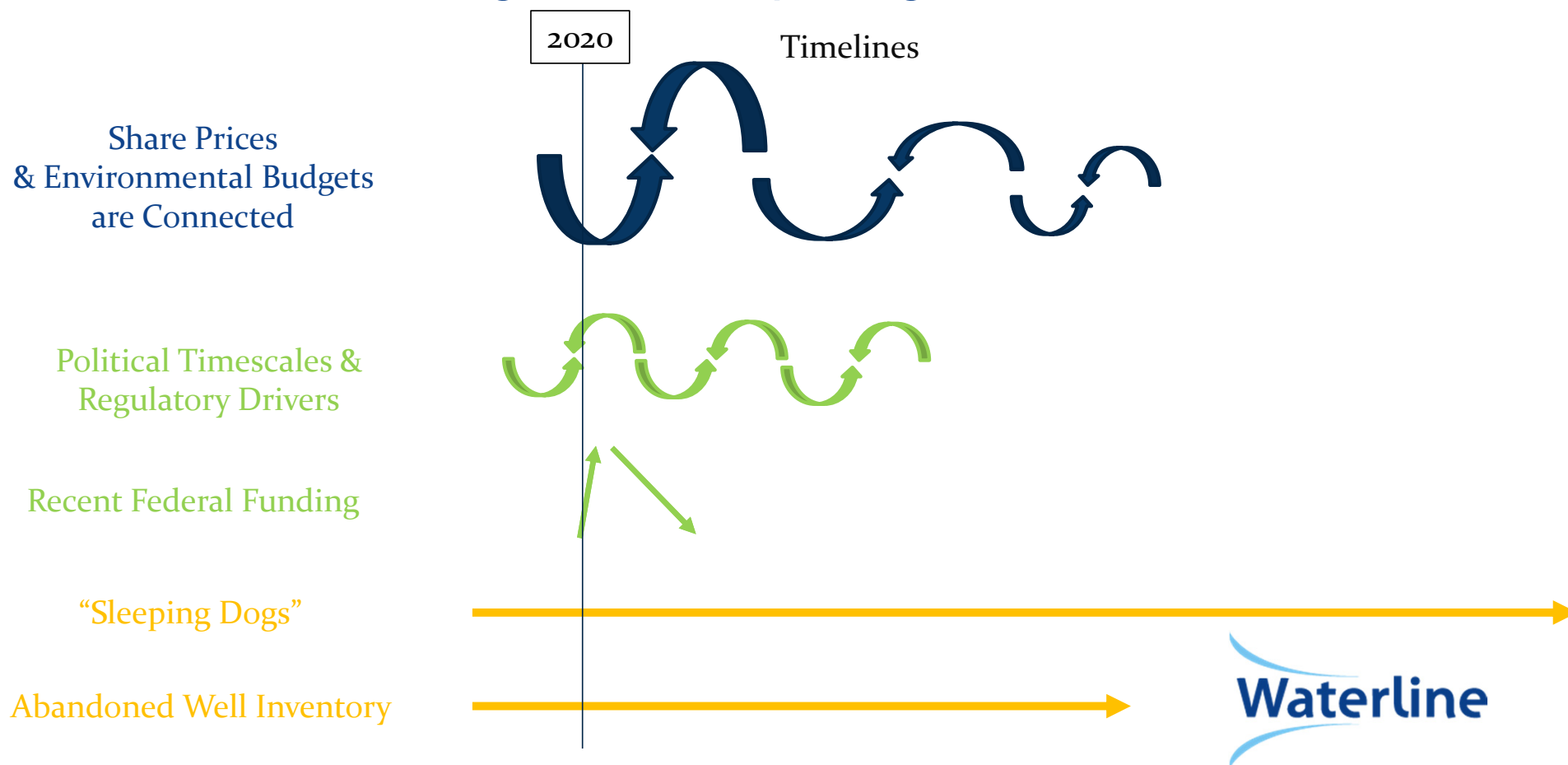
- Corporate-level motivation to reduce environmental liability by reclaiming as many well sites as possible
- Relatively predictable outcomes
- Regulatory rewards
- Not the same regulatory “carrots” for sites that require long-term risk management approaches

A Change in Workflow: Waking up the Sleeping Dogs

- The typical wellsite rem/rec approach doesn't address the sleeping dogs (sites that are going to continue to have environmental issues 10s to 100s of years from now)
- Who is going to be responsible for the sleeping dogs 10s to 100s of years from now?
- What is the long-term plan for sites with high liability that aren't easy wins?



It's All About the Timing and Competing Priorities...




How Do We Adapt and Provide Value?



Play to
Our
Strengths



Collaborate

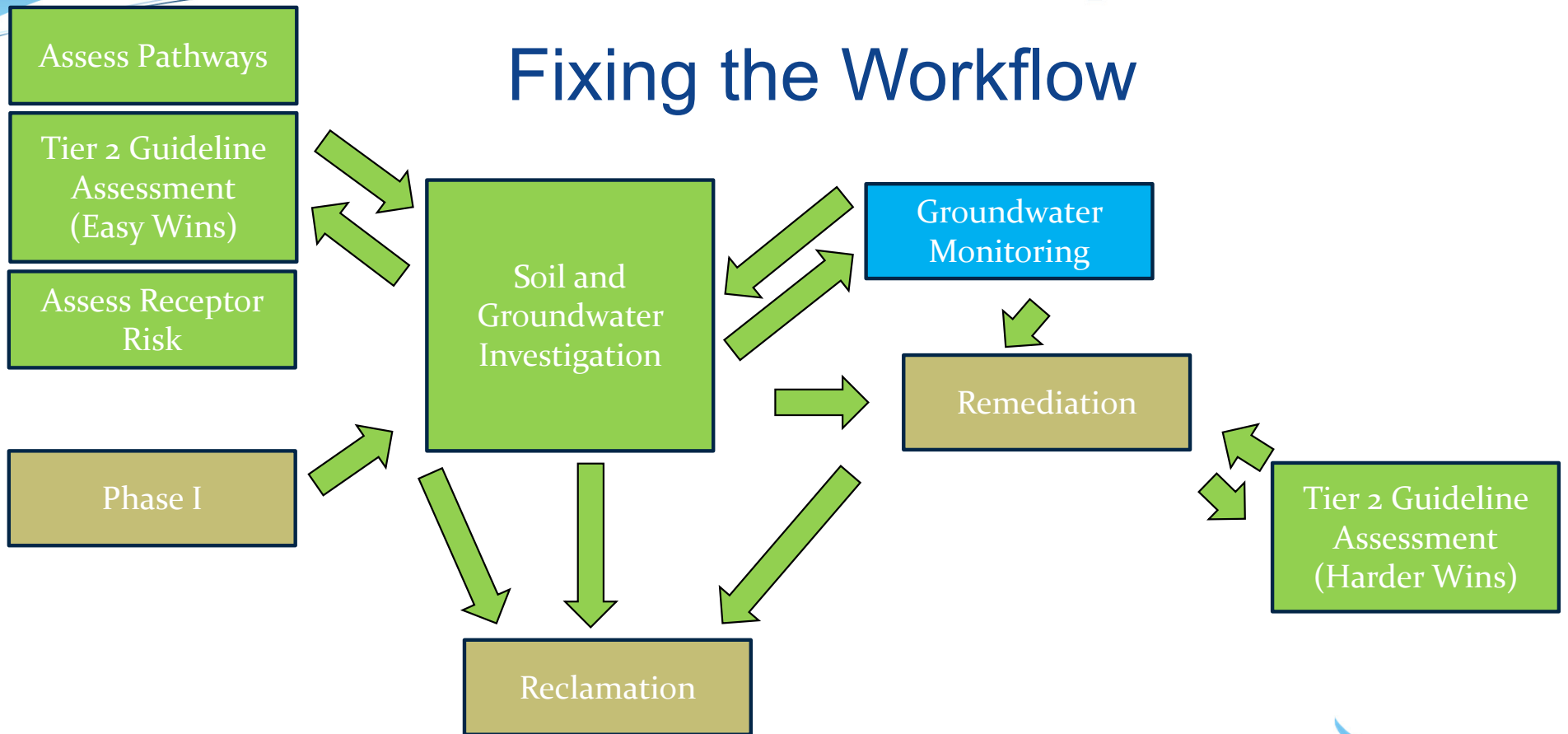


Embrace
Tier 2
Guidelines

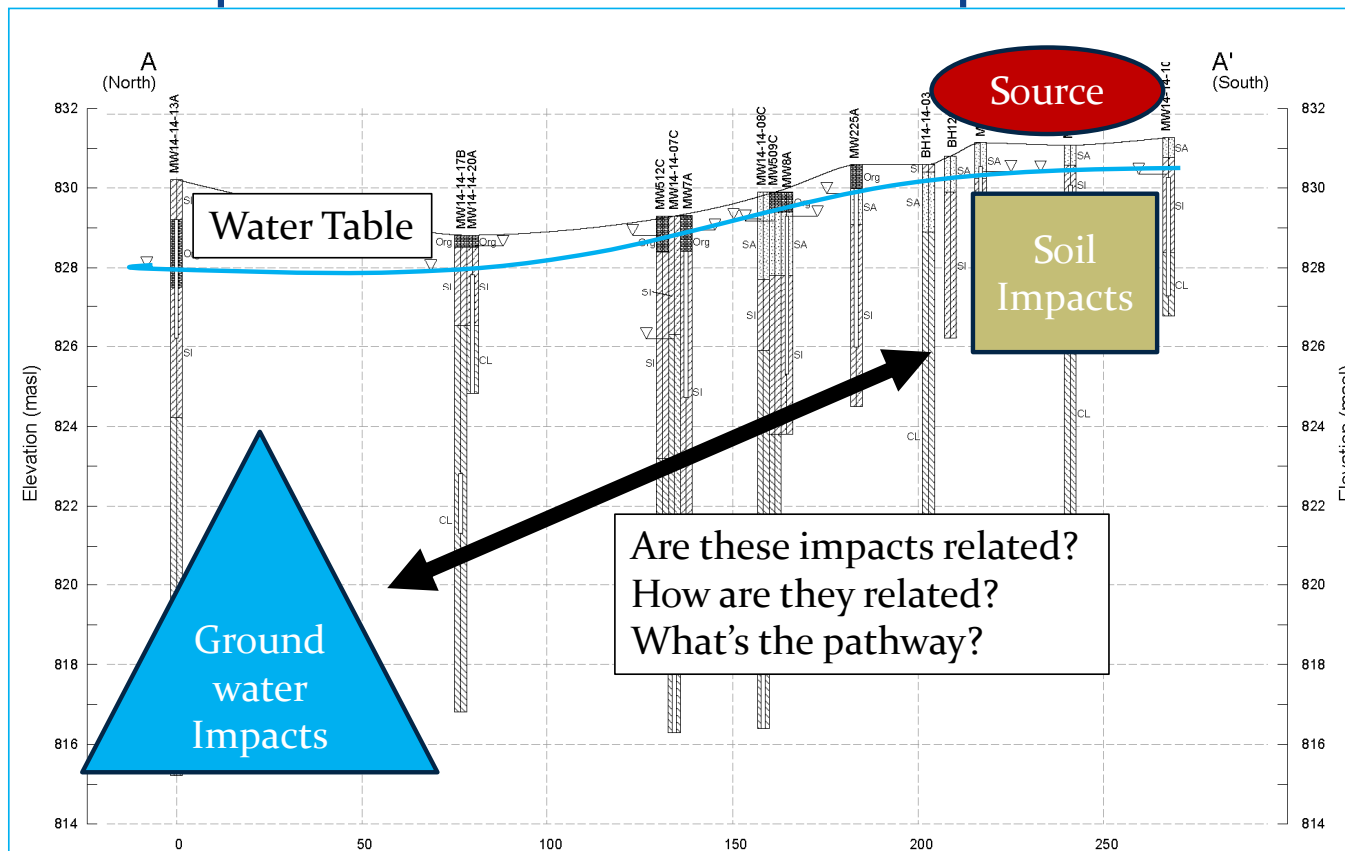


Plan Ahead and
Improve Workflow

Fixing the Workflow

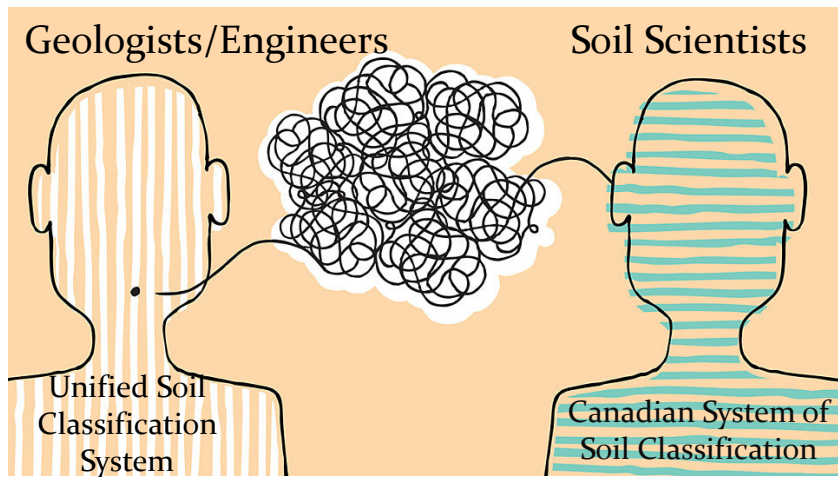


Assessing Pathways & Conceptual Site Model Development



Soil/Geological Classification Systems

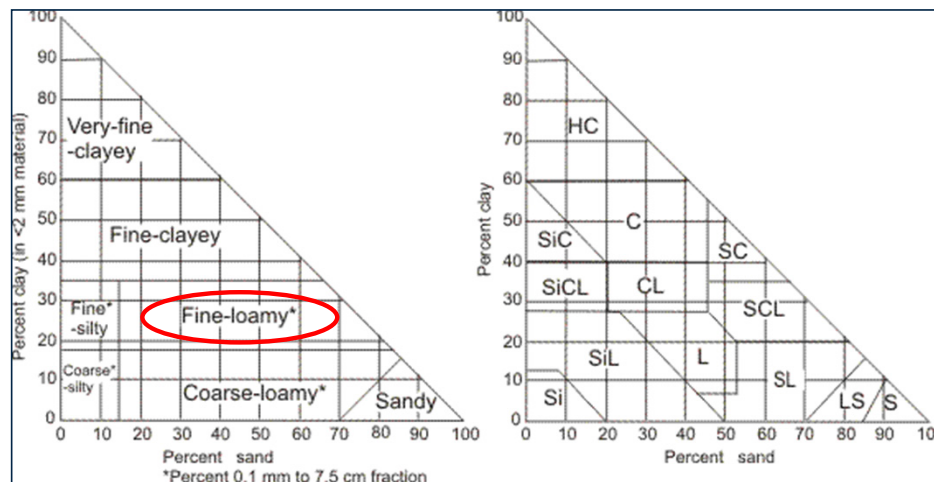
We are not speaking the same language



- What is the boundary between soil and geology?
 - Is it 1 metre below ground level?
 - Is the CSSC getting used at depths greater than what it was intended for?
 - Should the Unified Soil Classification System not be used for topsoil?

Soil Classification Systems

- Canadian System of Soil Classification has its limitations as investigations get deeper
- How to account for gravel, cobbles, boulders, and bedrock?
- Loam classification



Source: Ag Canada http://sis.agr.gc.ca/cansis/taxa/cssc3/chpt14_a.html

Improving Workflow: Soil/Geological Classification Systems

- Laboratory grain-size analysis is helpful to calibrate observations
- Consider using the Unified Soil Classification System at depth
 - Percentage based
 - Less exceptions (e.g., loam classifications)
 - Easier to assess receptor risk to domestic use aquifers and freshwater resources (personal preference?)
 - Has descriptors that are useful for identifying the water table (more later)



Bedrock Identification: Common Pitfalls

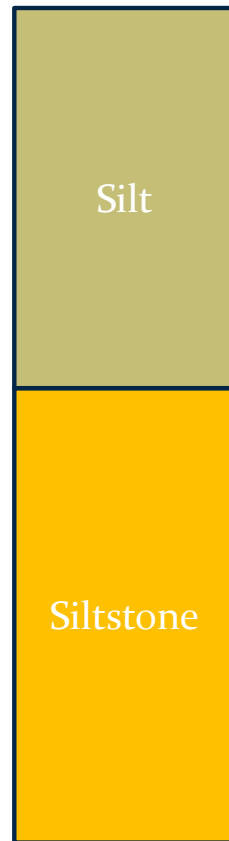
Geofantasy
Example 1



Geofantasy
Example 2

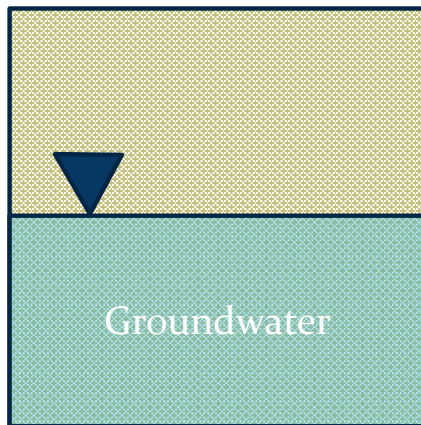


Reality



- Can be a tendency in consulting to not interpret and only present observations
- Often need to use multiple lines of evidence to determine presence/absence of bedrock (prep is key!)
- Geological logging is the foundation of site conceptual models

Water Table Identification in Low Hydraulic Conductivity Settings



- If groundwater is identified, then it must be assessed according to regs
- In most of Alberta, we have low hydraulic conductivity clay
- Wells are often dry shortly after installation in fine-grained overburden and siltstone and excavations may not fill up with water, even if they are below the water table
- How do we identify the water table?

Water Table Identification in Low Hydraulic Conductivity Settings

Do Your Homework

- Use available information from previous assessments and on-site measurements before drilling
- Leave monitoring wells to the last part of the field work
- Rely on drillers but not for their opinion on water table (they drill a lot of holes but don't get to do the follow-up groundwater monitoring)

Water Table Identification in Clay

Unified Soil Classification Indicators

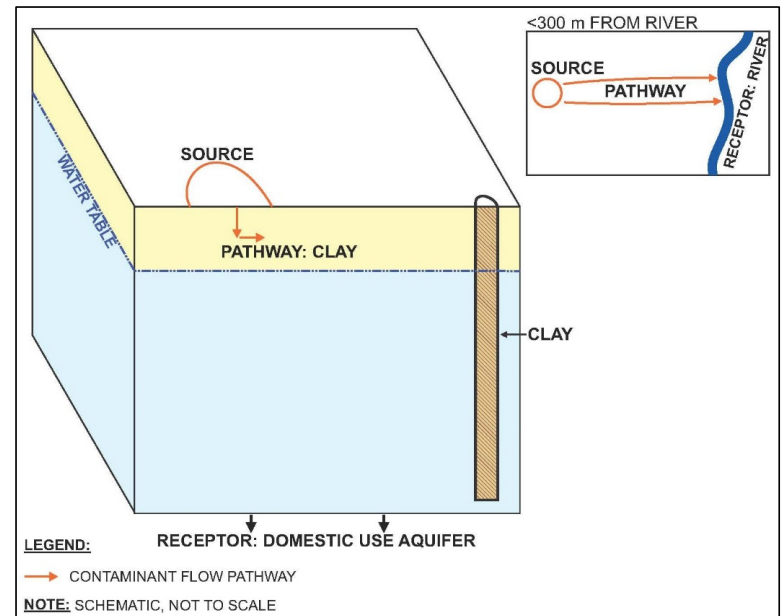
- Change in plasticity (rolls up as a snake)
- Change in softness (soft = water, hard = no water)
- Grey colour (consistent)

Two out of three indicators are likely indicative of the water table



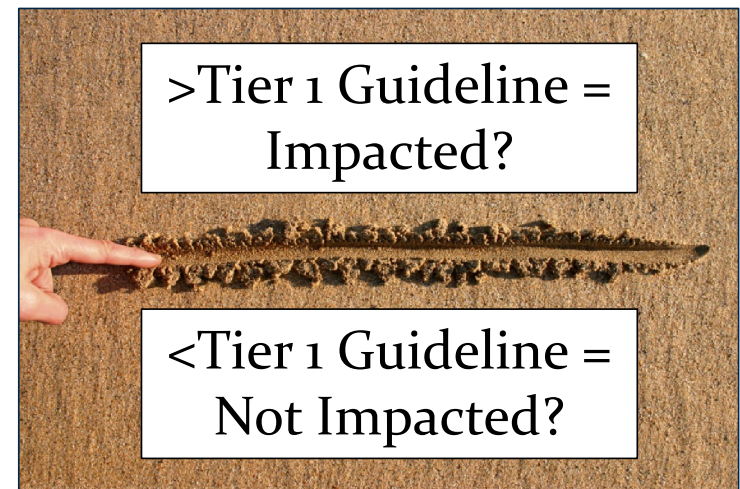
Assessing Pathways to Satisfy Regulatory Drivers

- Understanding geological pathways is the foundation of conceptual site model development
 - Consider using the Unified Soil Classification System
 - Grain size analysis is our friend
 - Geological interpretation with multiple lines of evidence is essential
 - Correctly identifying the absence or presence of groundwater is a regulatory requirement and essential for understanding pathways



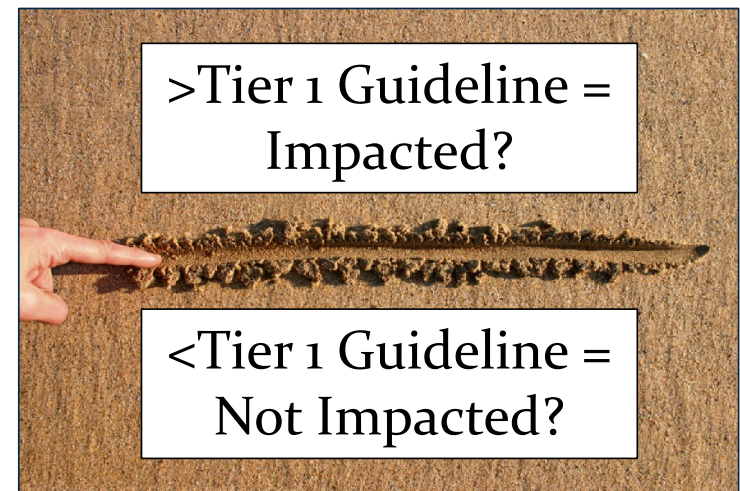
Fixing the Work Flow: Tier 2 Guideline Modifications (Easy Wins)

- Tier 1 guidelines are often being applied when there are easy Tier 2 wins that could be considered with minimal additional effort and cost
- Why use guidelines that are protective of receptors that don't exist?
- Tier 1 guidelines are based on conservative assumptions in generic conditions (e.g., 10 m from a surface water body; 500 year, continuous source, etc.)



Fixing the Work Flow: Tier 2 Guideline Modifications (Easy Wins)

- Benefits are cost savings but also environmental (conservation of soil, long-term legacy of needlessly landfilling soil, decreased fossil fuel use from trucking)
- Don't remediate unless it's to Tier 2 guidelines, plan ahead!



Get into a New Routine: Tier 1/2 Guideline Modifications (Easy Wins)

- Easy Win Tier 1/2 Guideline Exclusions
 - Distance to freshwater aquatic life water bodies (>300 m downgradient, >100 m cross- and up-gradient)
 - Protection of potable water pathway exclusions
 - Subsoil guidelines for hydrocarbons in soil and groundwater
 - PHC F2 and F3 in soil guideline adjustments for management limits in natural land use areas



Get Into a New Routine: Tier 2 Guideline Adjustments for Hydrocarbon and Salinity Parameters (Big Wins)

- Tier 2 adjustments using site-specific data
 - Uses same assumptions as Tier 1 guidelines except considers site-specific information
 - Low cost, easy to discuss with regulators
 - Successfully applied for PAHs, salinity, hydrocarbons at difficult sites



Get Into a New Routine: Tier 2 Guideline Adjustments for Hydrocarbon and Salinity Parameters (Big Wins)

- Protection of Potable Water and Freshwater Aquatic Life Pathways
 - Alternative, low-cost transport modelling
 - Groundwater-surface water interactions assessments
 - Ecological risk assessments (less certain outcomes)



Fixing the Workflow: Assessing Receptor Risk

- Knowledge of pathways is essential to assessing receptor risk
- Using the incremental Tier 2 approach described above, regulator questions about receptor risk are already answered before they ask!
- Using Tier 2 guidelines is a win-win: Cost savings and scientifically defensible outcomes



Setting Up For Success

- We should all be taking a holistic approach to managing environmental issues
- Understanding geological pathways is a must
- Tier 2 guideline exclusions and adjustments can be considered in a staged, incremental manner to optimize resources
- Collaborative, integrated solutions create positive outcomes





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