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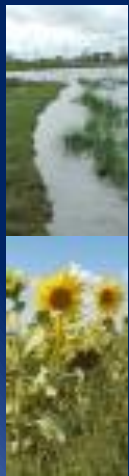
# **Remediation Case Studies for Salt Impacted Sites using Recently Release SST V3.0 – learnings and potential pitfalls**

**REMTECH 2021 (Game On!)**

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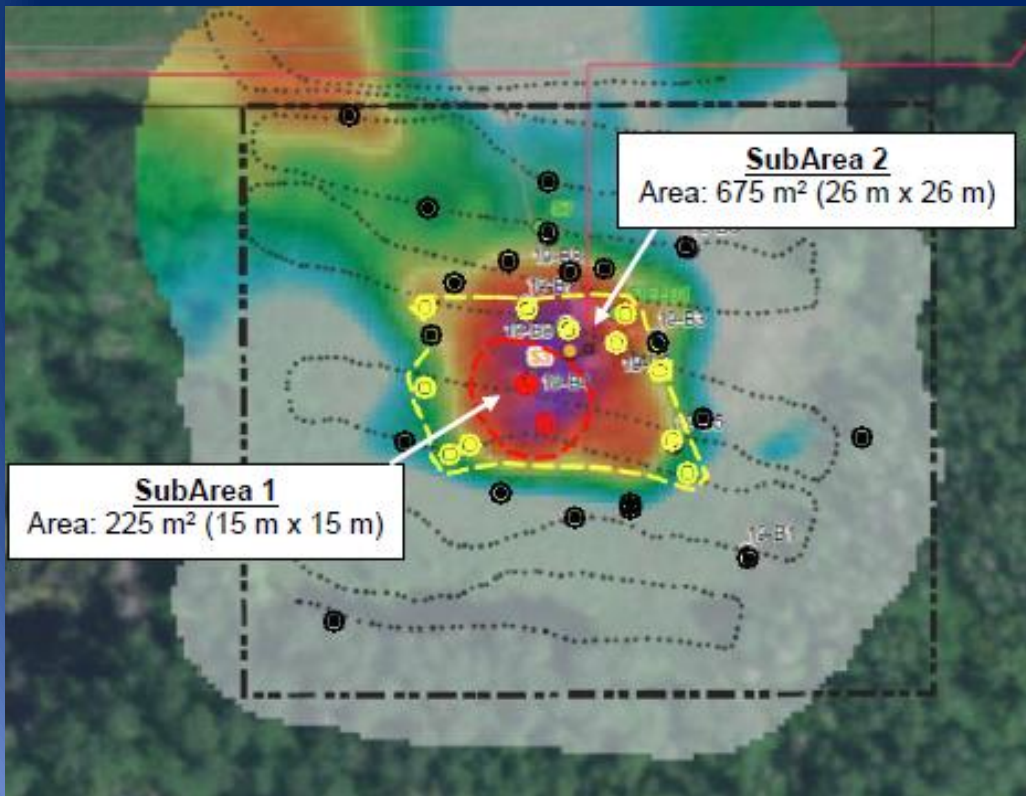
# Introduction

- This presentation will discuss remediation of salt impacted sites using SST V3.0 derived guidelines. Case studies for a simple and complex site will be reviewed, highlighting some of the learnings that were identified during these programs in both the planning and execution of these remediations.



# Case Study #1

- The first case study is a former wellsite with identified Tier 1 salinity and soidicity exceedances within the rooting zone, as well as elevated subsoil chloride, SAR, and sodium identified in the subsoil.
- No co-contamination was identified at the site during previous assessments.



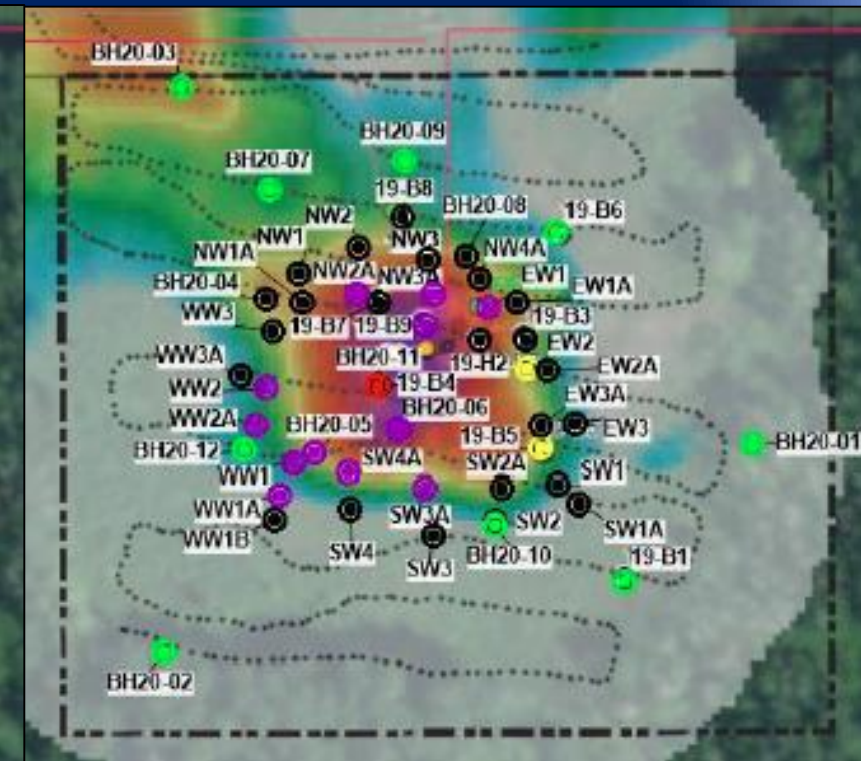
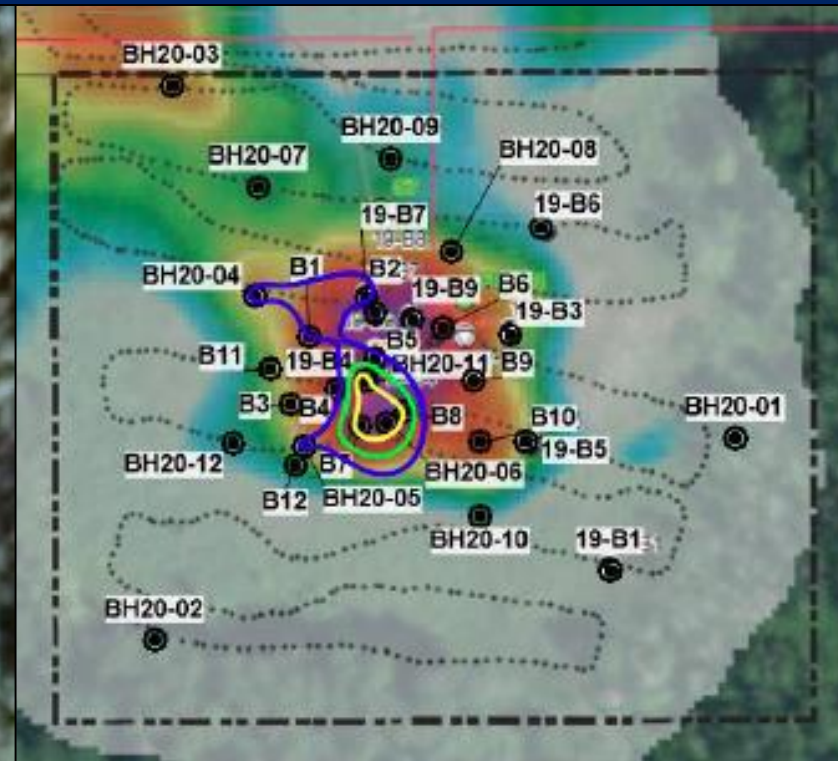
# Remediation Areas

- A pre-remediation drilling assessment is recommended to be completed prior to an excavation to allow for refining the areas, submitting samples for landfill analysis, obtaining confirmatory samples, and sampling potential backfill sources.
- Impacts identified during pre-remediation drilling or confirmatory sampling during a remediation may define or change the APECs that in turn could alter the SST SubAreas.



# Pre-Remedial Drilling

- Pre-remedial Phase 2 assessment was completed to further refine the extents of the rooting zone Tier 1 EC and SAR impacts, subsoil salinity areas, as well as vertically delineate salinity impacts and obtain further background results for the SST model.



# Backfill Considerations

- **Evaluation of backfill sources should be completed during the pre-planning phase of a program. Regardless of the source of the backfill soil texture, salinity, sodicity, and saturation percentage are critical inputs for SST guidelines.**
  1. **Backfill soil quality (within applicable guidelines)**
  2. **Soil texture, salinity, sodicity, and saturation percentage for suitable backfill**
  3. **Location of the backfill source**
  4. **Preparation and reclamation work required for using source for backfill**
  5. **Potential for trucking backfill on a backhaul if located at or near landfill**

## Backfill Options

- Preliminary backfill options can be completed at a desktop level to determine how different backfill options may have an effect on the derived SST guidelines.
- For the 1.0 to 1.5 m root zone depth interval, some SubAreas require remediation to more stringent criteria to provide a buffer that accounts for future upward migration of subsoil ( $>1.5$  m depth) salinity impacts into the rooting zone as per SST protocols.

# Backfill Options

- The SST allows for different backfill soil properties to be entered for the Excavate and Backfill Root Zone (EBRZ) scenario. If a site is in the preliminary stages without a confirmed backfill source, potential backfill options can be evaluated.

Example: Backfill Option 1 (Standard)

SubArea	Tier 2 Subsoil Chloride SRG (mg/kg Chloride) (Top of Impact Considered for Guideline calculation noted in brackets)				Depth of Exceedances (m)
	EBRZ/URZ	FAL	DUA	IW and LW	
1	1,100 (2)	11,000 (no dig)	12,000 (no dig) Management Limit = 7,000	Excluded from calculations (GW >6m)	No exceedances
2	420 (1.5)	710 (no dig)	830 (no dig)	Excluded from calculations (GW >6m)	No Exceedances

Example: Backfill Option 2 (Increase EC and SAR)

SubArea	Tier 2 Subsoil Chloride SRG (mg/kg Chloride) (Top of Impact Considered for Guideline calculation noted in brackets)				Depth of Exceedances (m)
	EBRZ/URZ	FAL	DUA	IW and LW	
1	870 (2.0)	11,000 (1.5)	2,300 (1.5)	Excluded from calculations (GW >6m)	No exceedances
2	620 (1.5)	710 (1.5)	830 (1.5)	Excluded from calculations (GW >6m)	No Exceedances



# Backfill Options

- This allows for comparison of backfill options that may be available and could even result in a reduced total excavation volume with associated cost savings.

Example: Backfill Option 1 (Standard)

SubArea	Tier 2 Subsoil Chloride SRG (mg/kg Chloride) (Top of Impact Considered for Guideline calculation noted in brackets)				Depth of Exceedances (m)
	EBRZ/URZ	FAL	DUA	IW and LW	
1	1,100 (2)	11,000 (no dig)	12,000 (no dig) Management Limit = 7,000	Excluded from calculations (GW >6m)	No exceedances
2	420 (1.5)	710 (no dig)	830 (no dig)	Excluded from calculations (GW >6m)	No Exceedances

Example: Backfill Option 3 (Standard EC/SAR 10% increase in Sat. %)

SubArea	Tier 2 Subsoil Chloride SRG (mg/kg Chloride) (Top of Impact Considered for Guideline calculation noted in brackets)				Depth of Exceedances (m)
	EBRZ/URZ	FAL	DUA	IW and LW	
1	1,100 (1.5)	11,000 (1.5)	2,300 (1.5)	Excluded from calculations (GW >6m)	No exceedances
2	960 (1.5)	710 (1.5)	830 (1.5)	Excluded from calculations (GW >6m)	No Exceedances

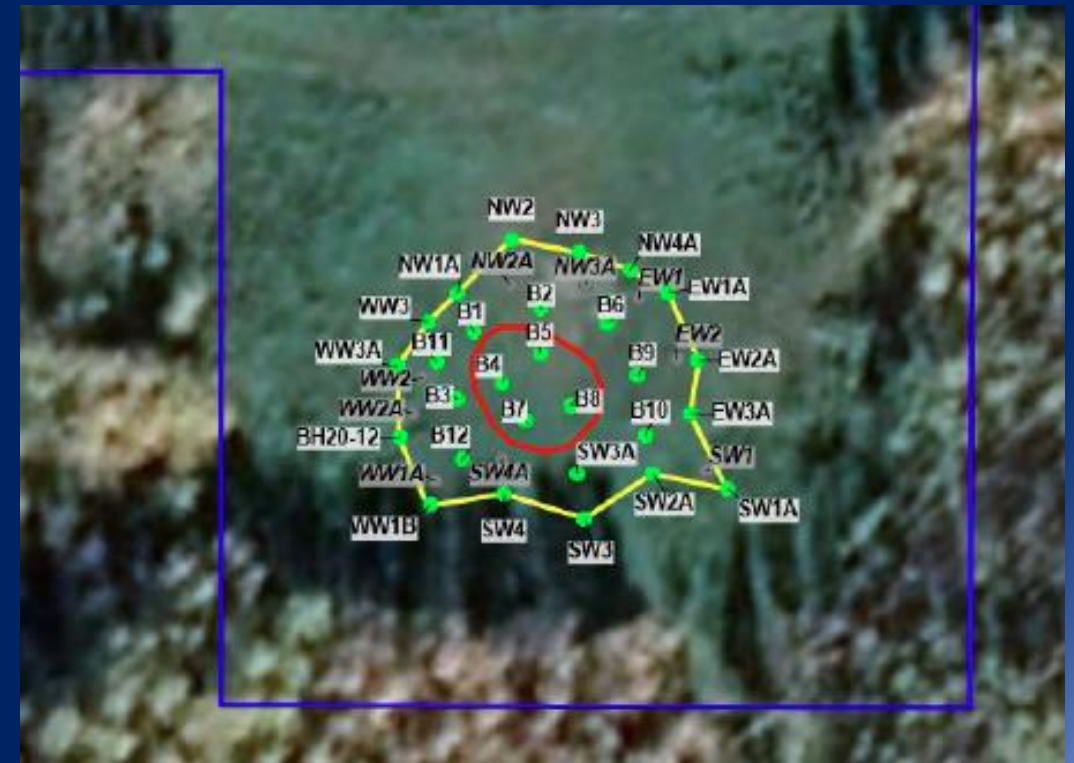
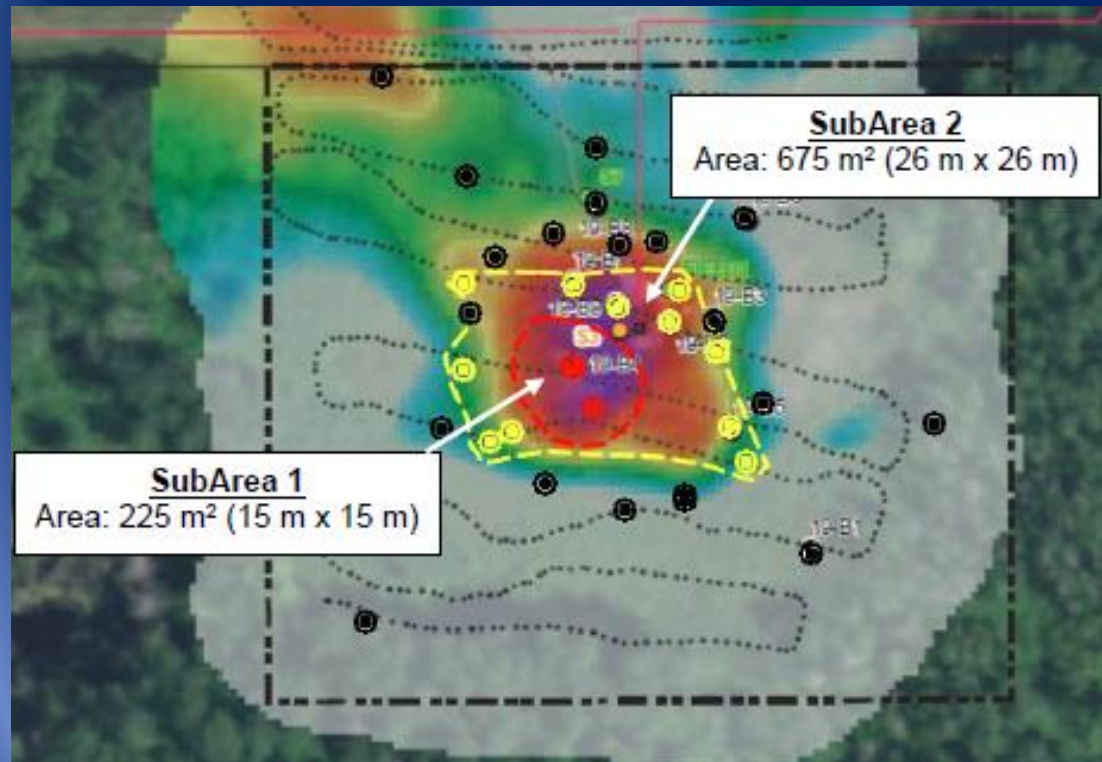
# Backfill Quality

- By analyzing backfill sources beforehand guidelines can be refined for consideration of the selected backfill source.
- Backfill quality regardless must meet SST requirements in terms of chemistry and texture should be reasonably close to background areas at the site.



## Conditions That Trigger SST Re-run

- An SST rerun may be required, and if so it is expected that changes in SubArea dimensions and measured concentrations would not be expected to trigger an AER review of the SST assessment.
- It should be expected that contaminant SubAreas could change in shape and volume with pre-remediation drilling or during confirmatory sampling.



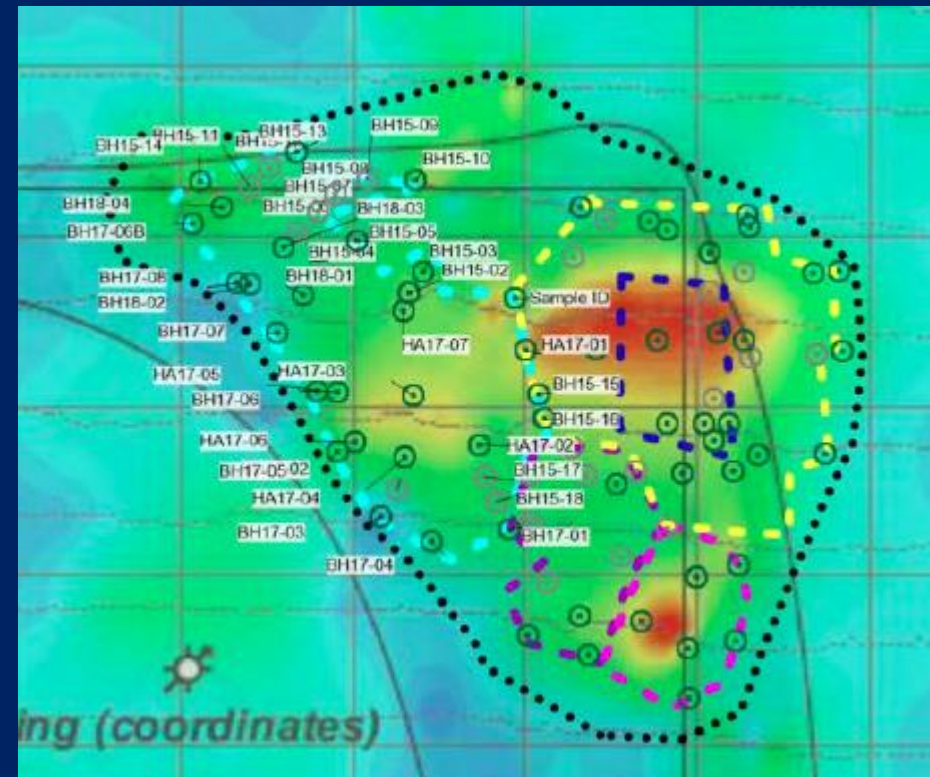
# Backfill Preparation

- Once confirmatory results are obtained at the walls and base of the excavation preparation for backfill can be completed.



## Case Study #2

- The second case study is a former wellsite with identified Tier 1 salinity and soidicity exceedances within the root zone, elevated subsoil chloride, SAR and sodium concentrations.
- Additionally, this site has co-contamination in the salinity impacted areas with Tier 1 metals and Tier 2 hydrocarbon impacts.



# SubArea Soil Remediation Guidelines

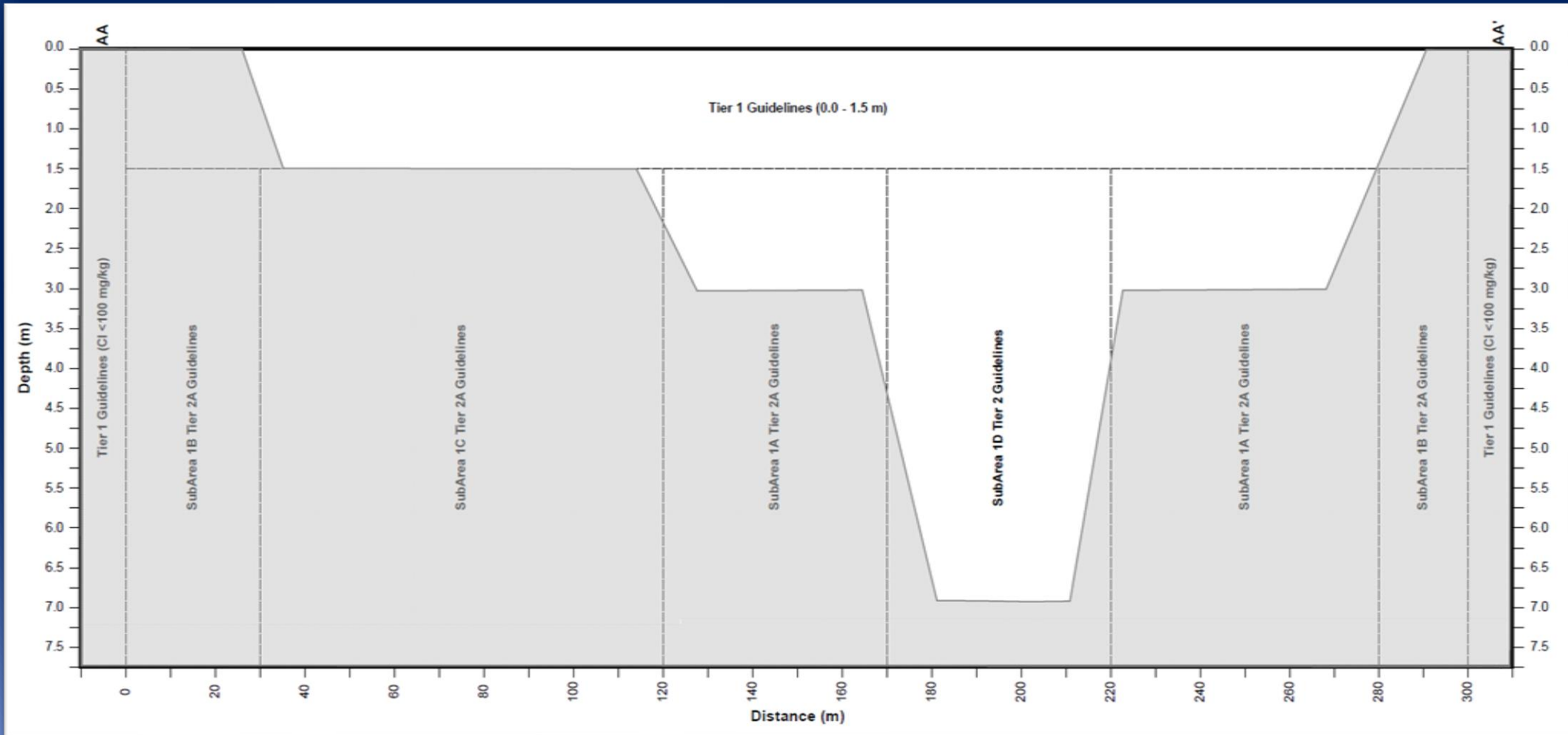
- All areas of the remediation will have applicable guidelines (Tier 1 and/or Tier 2), that will require confirmatory analysis.
- Subsoil salinity guidelines for the base of a SubArea will be the Tier 2 SST guidelines derived for that SubArea.
- Subsoil salinity guidelines for the walls of a SubArea will be the adjacent SubArea guideline.





# SubArea Soil Remediation Guidelines

- Subsoil salinity guidelines for the walls of a SubArea will be the adjacent SubArea guideline (e.g., SubArea 1D wall guideline will be the SubArea 1A base guideline).





## Co-Contamination with Salt Impacts

- Initially when evaluating a site, it is important to understand if there are areas that are co-contaminated with salt impacts (e.g., metals, hydrocarbons) that exceed applicable guidelines (Tier 1 or Tier 2).



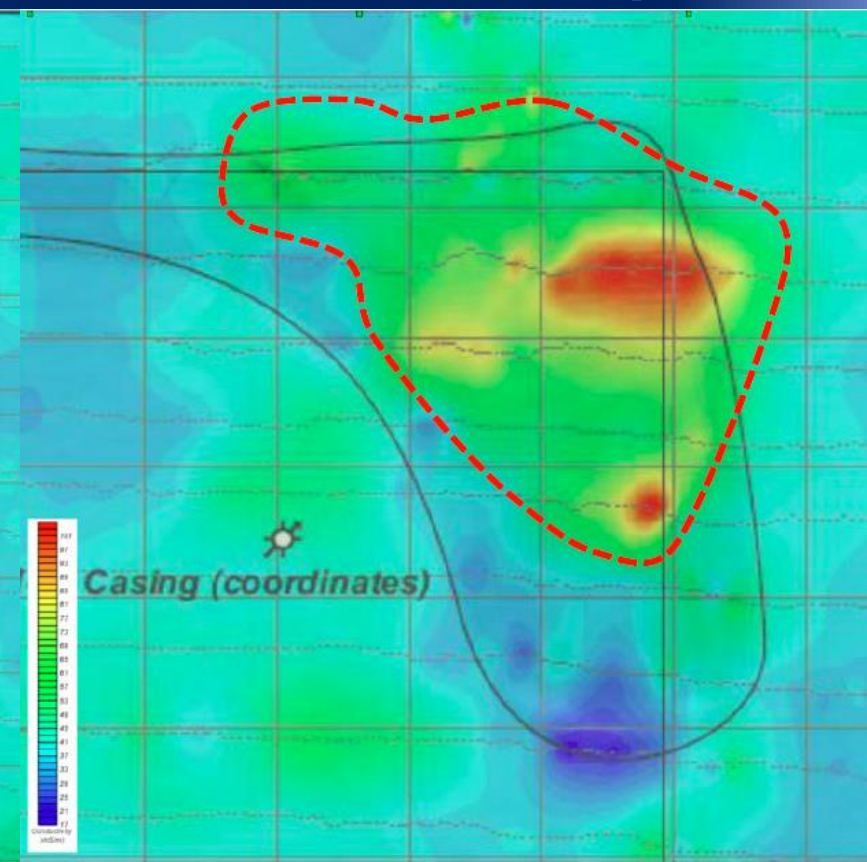
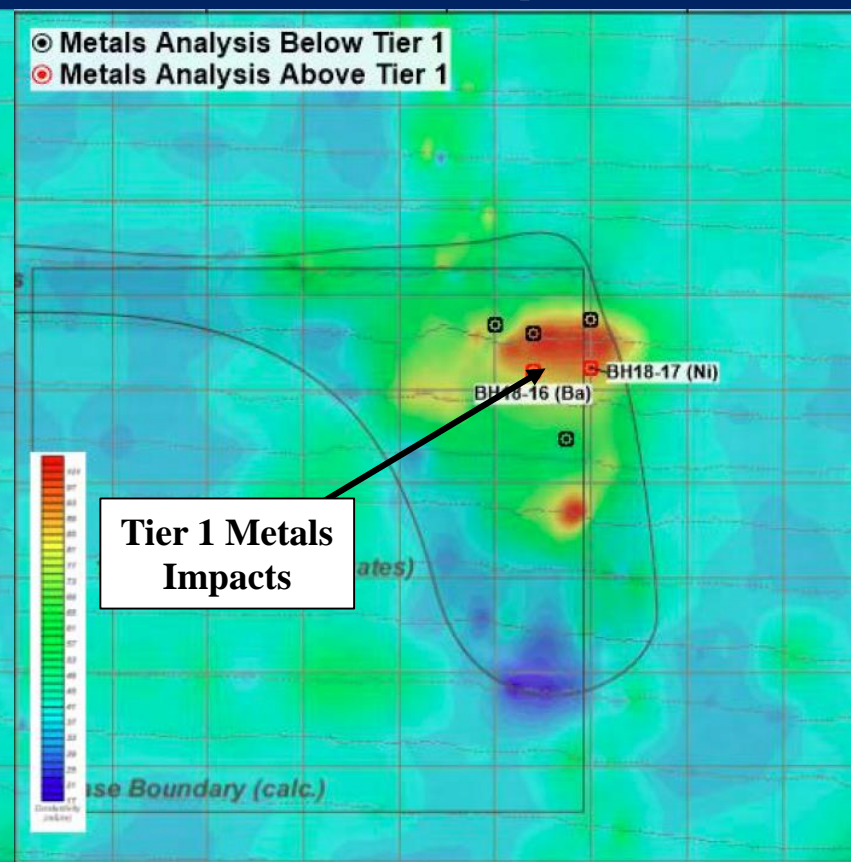
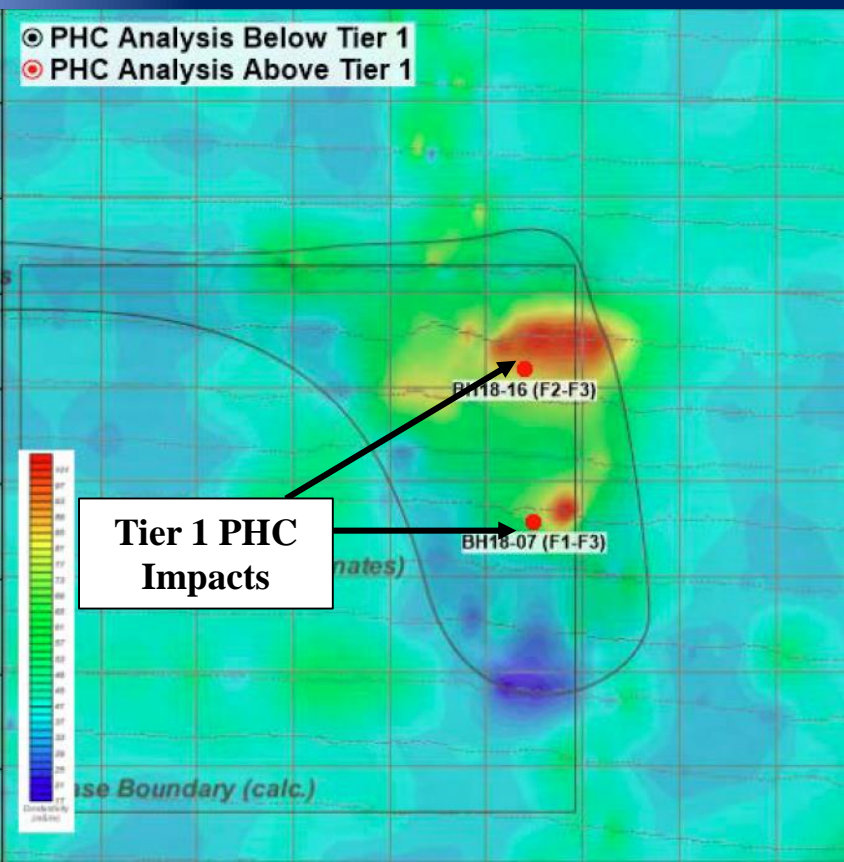
# Co-Contamination with Salt Impacts

- Case study site #2 had hydrocarbon and metals impacts within the Tier 1 salinity and sodicity rooting zone impact area.
- This will have an effect on the spatial impact areas, but also determine the top and bottom of respective impact areas.

Tier 1 Hydrocarbon Impacts

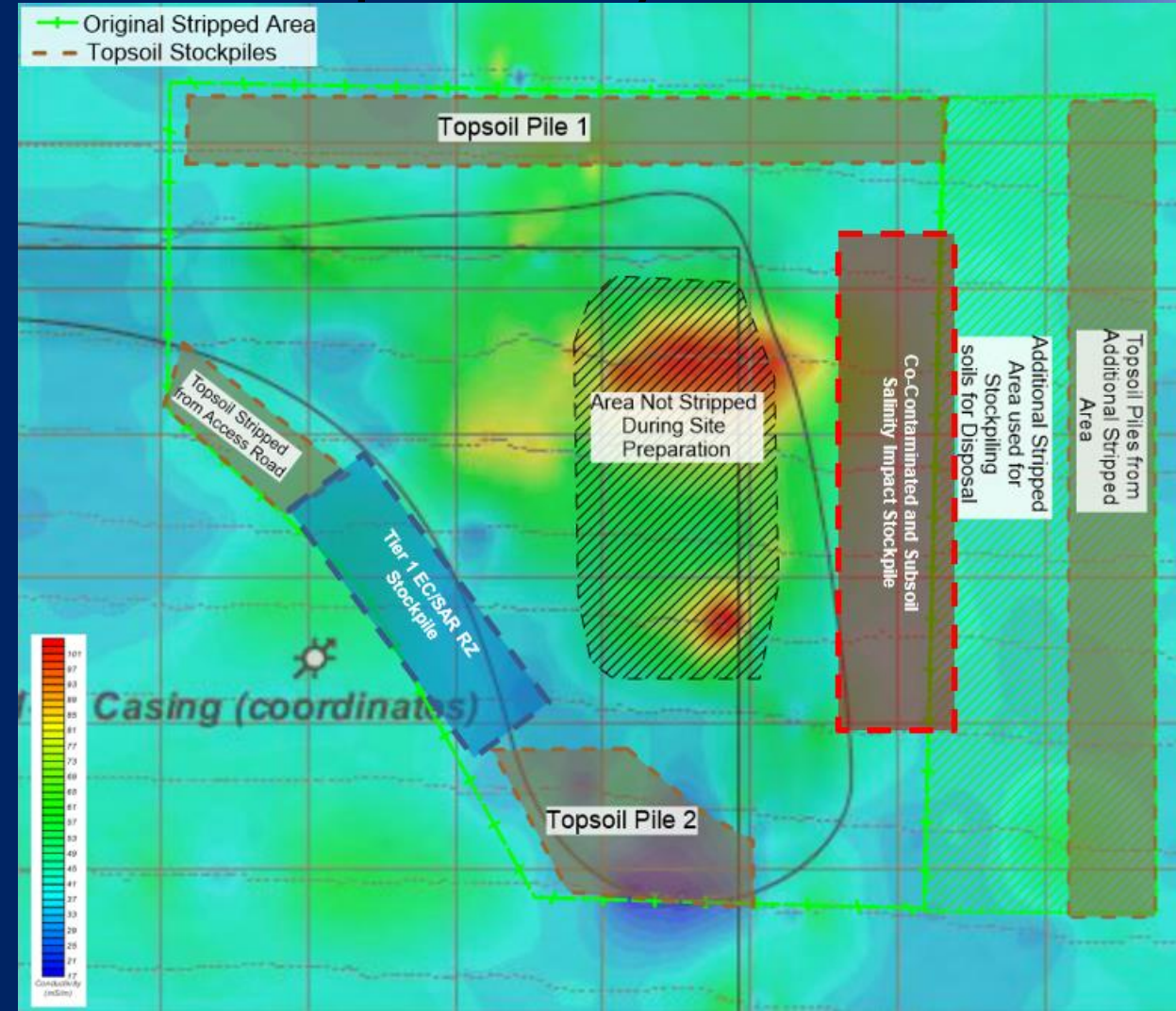
Tier 1 Metals Impacts

Tier 1 EC and SAR RZ Impacts



# Waste Management

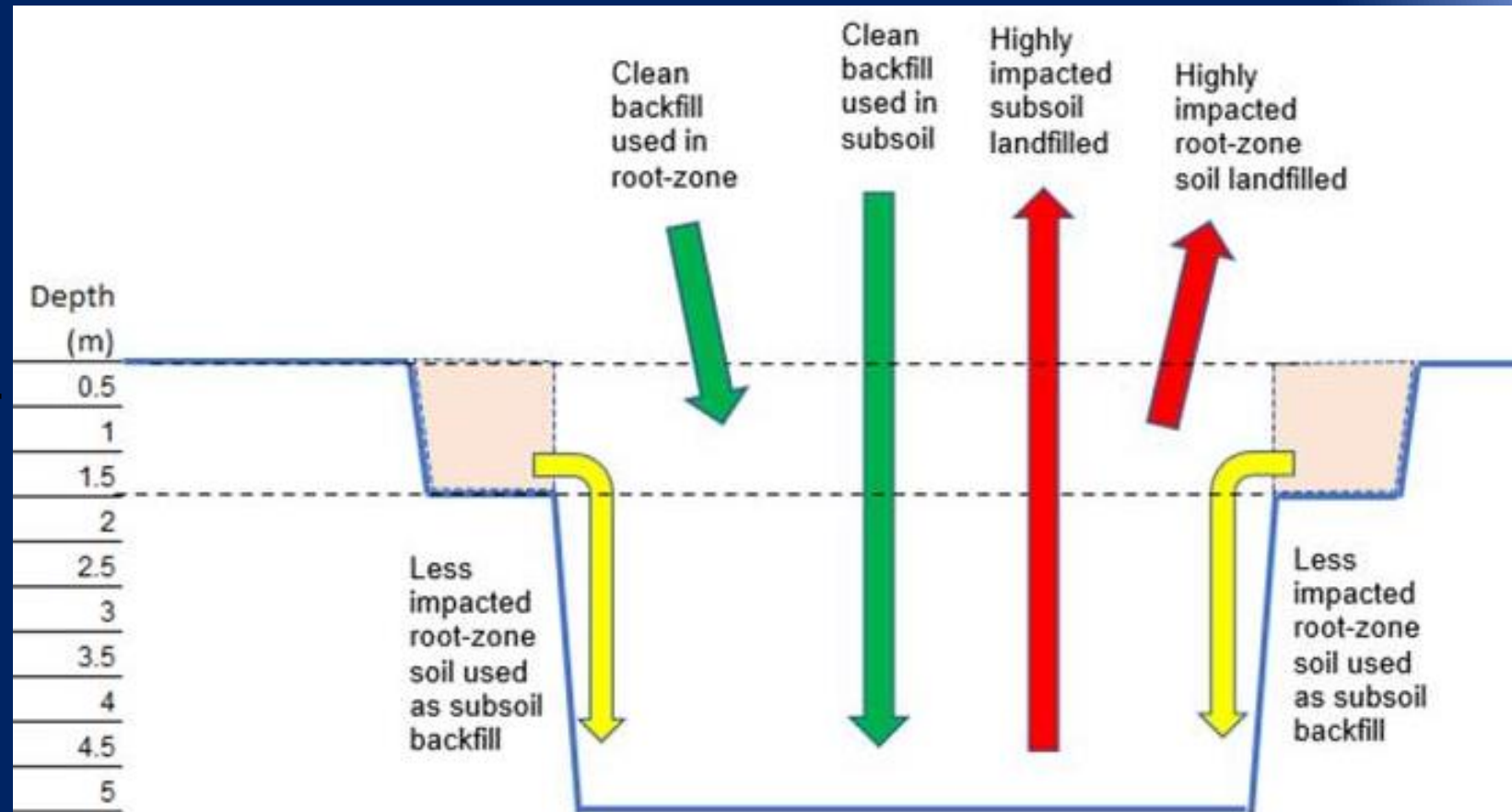
- Soil that is co-contaminated will likely require landfill disposal. Important to clearly define subareas where this will apply and ensure that soil is efficiently stockpiled and not to be potentially re-used in other sub areas of the excavation.



# Waste Management

- **Low level salinity impacted soil without other co-contaminants exceeding applicable guidelines (Tier 1 or Tier 2) could potentially be re-used as backfill in areas where the depth exceeds the rooting zone (>1.5 m).**

- **Low level salinity impacted soil can only be re-used in areas where previously higher concentrations were present.**



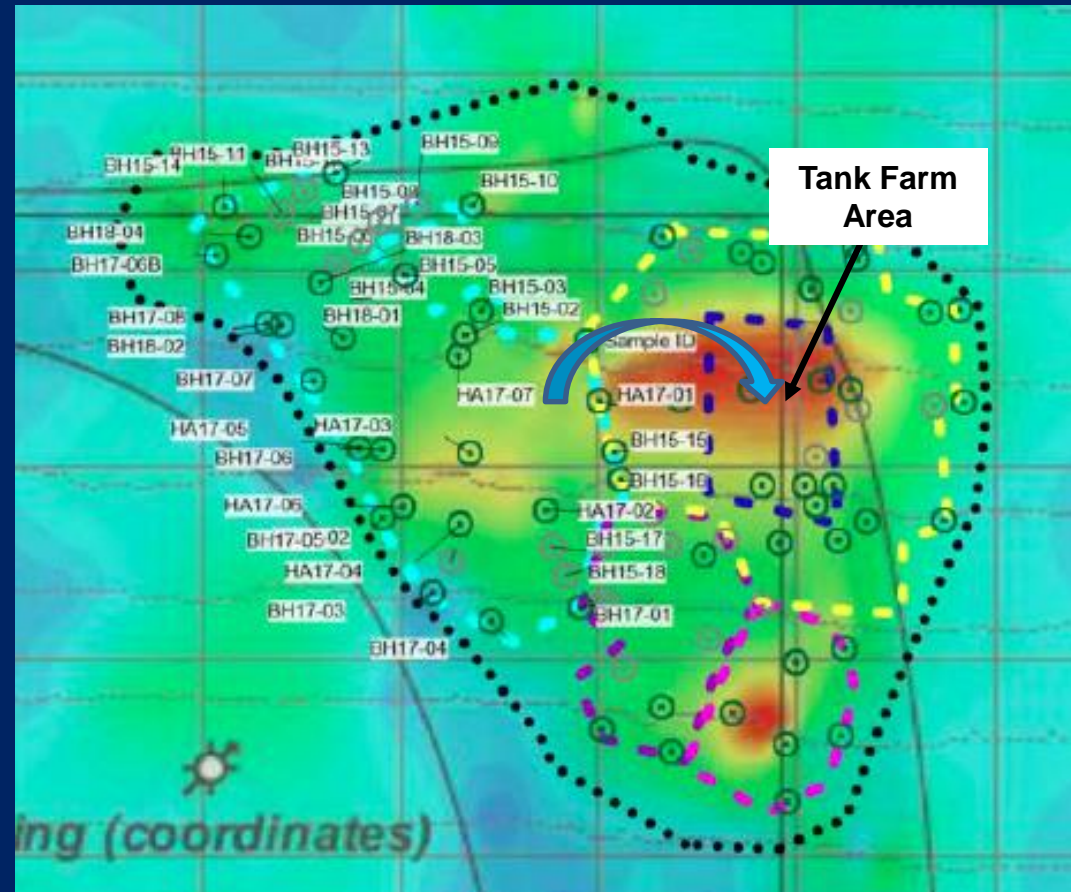
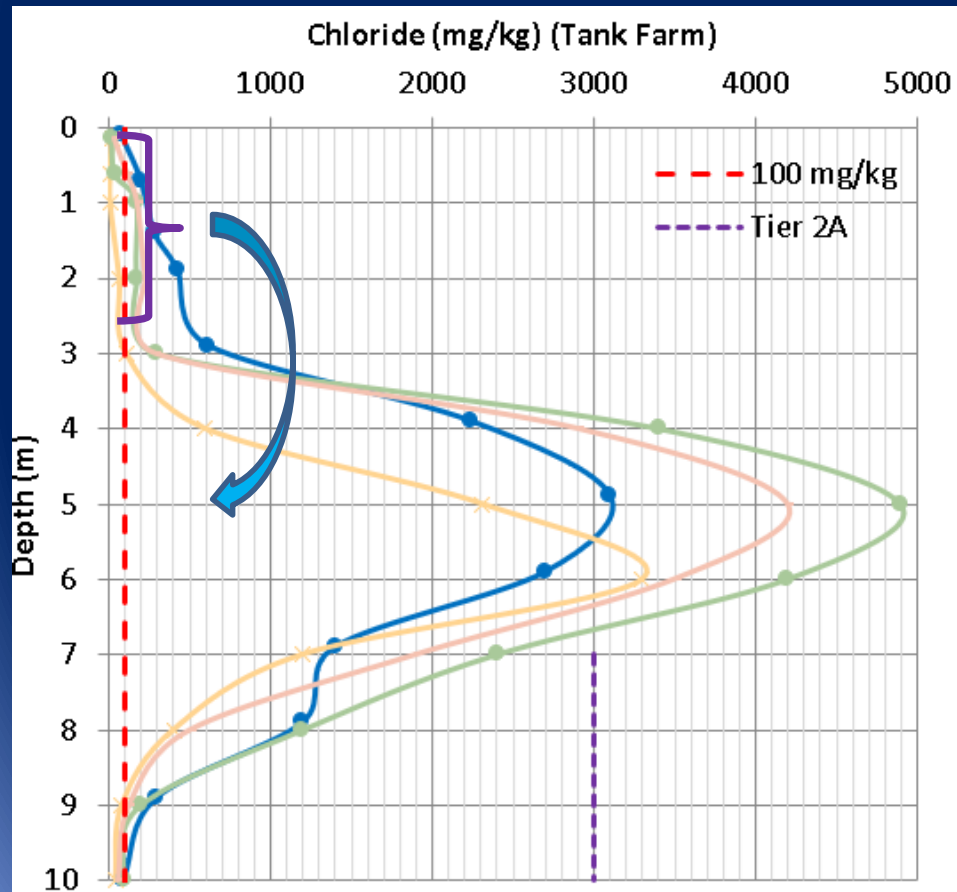
# Waste Management

- Low level salinity and sodicity impacted soils could be used as backfill in areas where higher impacts were previously observed (by location and depth), providing no Tier 1 exceedances for other parameters (e.g., metals, hydrocarbons) are present.



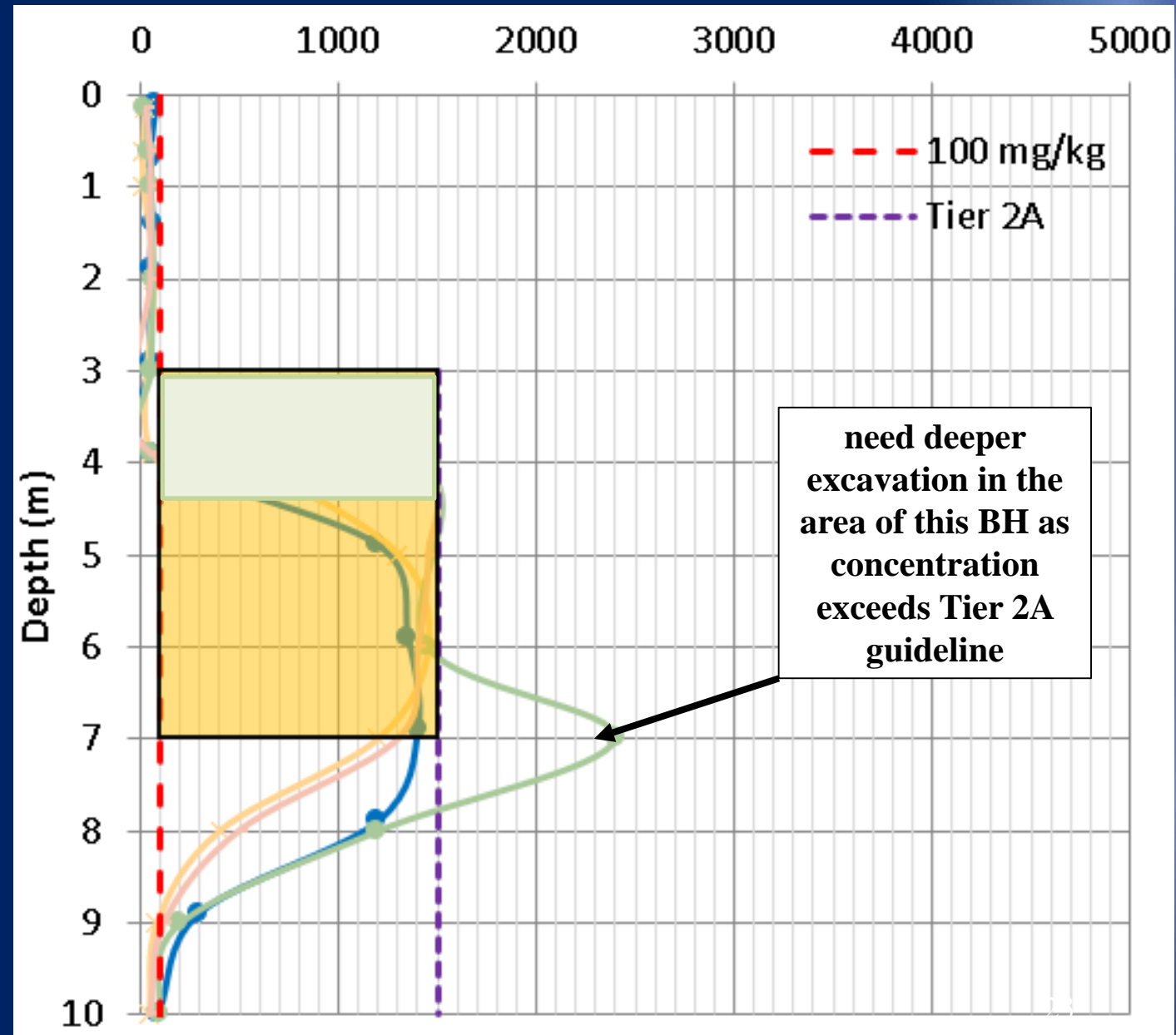
# Reuse of Impacted Soils

- Tank farm area – deep chloride impacts (7 m) up to 5,000 mg/kg
- Overlying soil from 0.0–2.5 m re-used as backfill within this area where greater impacts previously observed. **SST must be re-run with top of impact to account for the re-used low impact backfill.**



# 'Hot Spot' Impacted Soils

- SST guideline derived for this SubArea is 1,500 mg/kg. It addresses most boreholes with the exception of one borehole representative of a 'hot spot'. Rather than re-running the SST guidelines to account for this one borehole guideline exceedance, one could dig down that area to obtain confirmatory samples less than the 1,500 mg/kg guideline.



# Reuse of Impacted Soils

- **Calculations required...**
  - **Recalculate guidelines with SST**
    - Iterative – what depth interval can the tank farm be backfilled with impacted soil from: 1) shallow tank farm soils; and, 2) Low level salinity and sodicity impacted root zone
    - **Don't forget subsoil Na/SAR guidelines in SST V3.0**
  - **Volume calculations**
    - Side slope considerations – how much void space is available that covers a specific depth range
    - Compaction requirements
  - **Mixing considerations of backfill**
    - Use upper bound statistic (95<sup>th</sup> percentile; max) – easiest and less risk of regulatory challenge as more conservative
    - Do not mix in clean (unimpacted) soil with impacted material
    - Do not mix heavily impacted with low level impacted material



# Reuse of Impacted Soils

- **Cost Implications**
  - Total site volume sent to landfill was reduced by ~35% (\$800k total remediation program cost – saved approximately \$220k in landfill, backfill, and trucking costs)
- **Costs increases can result due to,**
  - larger workspace area requirements and landowner damages reimbursement (loss of crop)
  - Materials handling
    - Critical that there is good stockpile material segregation and tracking
    - Efficient and safe use of workspace
  - Additional costs were approximately \$60k
- **Net savings – ~\$160k or ~20% of total project budget**
  - Percentage saved will vary considerably between sites
  - pre-analysis and planning is key



**The End**

**Questions?**

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