Equilibrium Environmental Inc

Subsoil Salinity Tool (SST)

Technical Manual

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Presentation Overview

- SST Version History

- Version 3.0 Technical Manual Topics (examples)
  - Chloride transport and 'Principle of Superposition'
  - Effect of deeper water table on upward migration
  - Lateral transport and SubArea complexities
  - Sodium transport
  - Saturation percentage / texture correlations
  - Guideline implementation

- SST FAQ (Frequently Asked Questions)

- SST Courses

SST Version History

- **2009 Initial version and updates through Ver 2.5**
  - **Beta versions, courses commenced in late 2009**
- **2010: Version 2.5.1 released**
  - **First ‘official’ version**
- **2011: Version 2.5.2 released**
  - **Interface upgrades, some technical / modeling upgrades**
- **2014: Version 2.5.3 released**
  - **Interface upgrades, some technical / modeling upgrades**
- **Nov 2020: Version 3.0 released**
  - **Interface upgrades**
  - **MAJOR technical / modeling upgrades**
  - **Minor bug-fixes and speed/security update in July 2021**

- **Help files / user manuals accompanied each version**
  - **Increasing need over time for more detailed ‘Technical Manual’**

Chloride Transport: Principle of Superposition

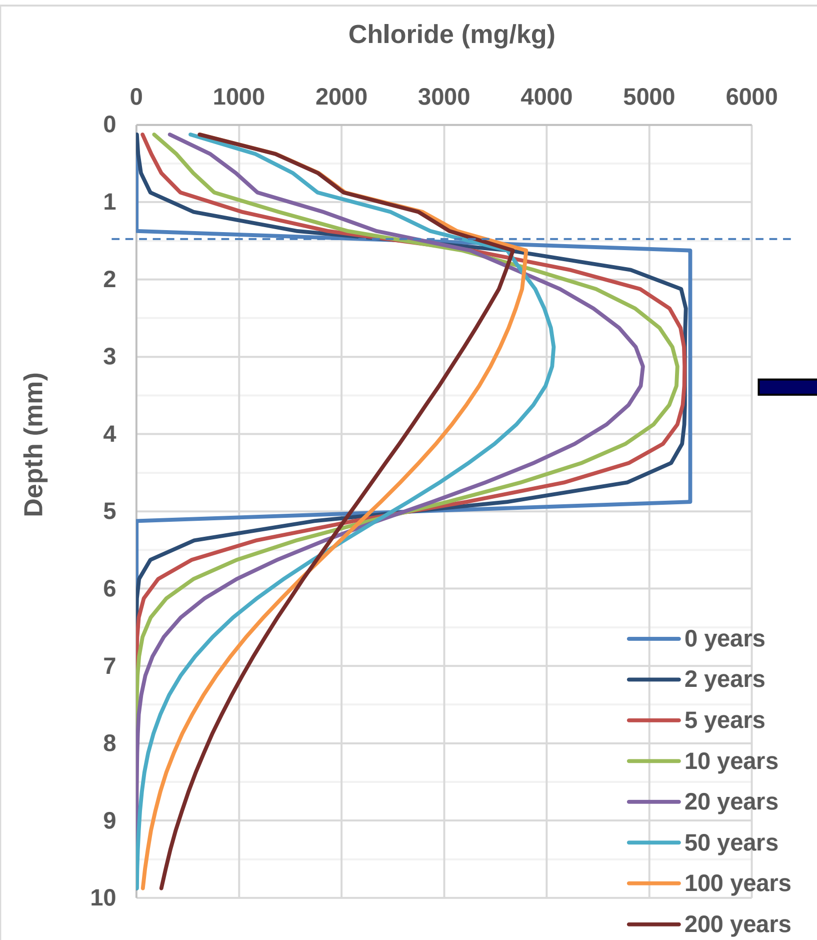
- **Key concept to allow SST to be runnable in ‘real time’**
  - **Each LeachM model scenario takes many hours to run**
  - **<u>HUGE</u> number of combinations / variables / factors**
  - **Without this technique, we’d probably still be doing the modeling…**

- **Allows more complex problems to be analyzed by breaking into smaller pieces, and then adding up the results**

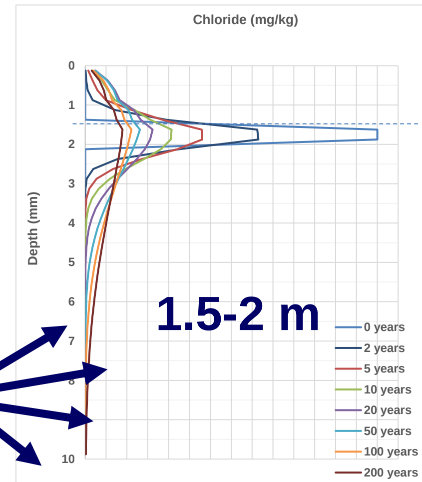
‘Divide and Conquer!’

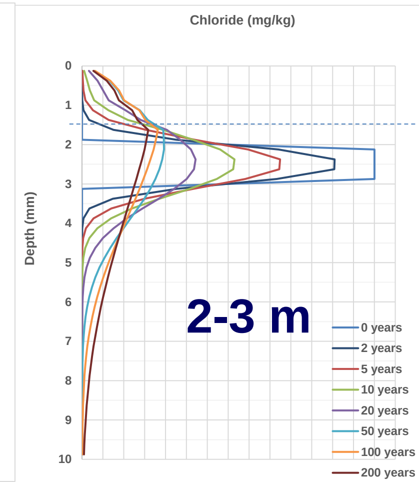
Chloride Transport: Principal of Superposition

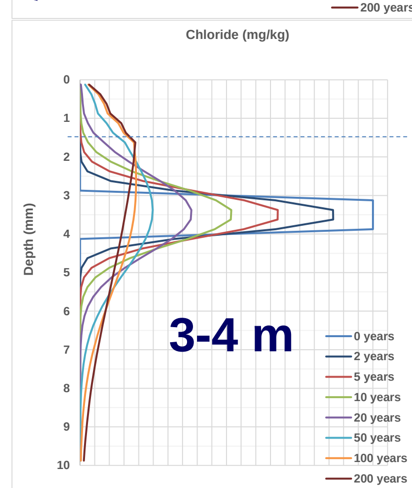
- **Discussion of vertical modeling of chloride in SST**
  - **Example of 1.5-5 m impact depth transporting over 200 years**
  - **Initial profile modelled by breaking into smaller pieces and adding**

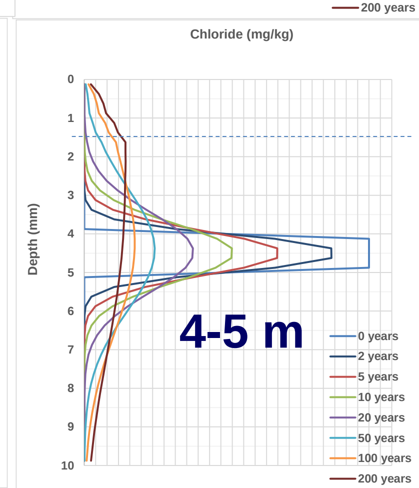


Break 1.5-5 m impacts into:









Water Table Depth vs Upward Transport

- **Additional modeling performed in Ver 3.0 with deeper water tables to evaluate effects on upward chloride migration**
  - **Previous version had upward migration based on ~2 m water table**

- **Deeper water tables have reduced risk of upward moisture and salt transport**
  - **Based on reduced diffusion through unsaturated soils**
  - **Via increased ‘tortuosity’**

- **Effects analyzed via extensive new modelling in LeachM**
  - **Influenced by soil ‘Campbells Parameters’ for fine and coarse soil**
  - **Describes how ‘grabby’ soil is for moisture**

- **Important to quantify distribution of water content based on water table depth**
  - **Expressed as ‘relative saturation’**

Unsaturated soils relatively 'drier' for coarse vs fine

Relative saturation: Fine soils

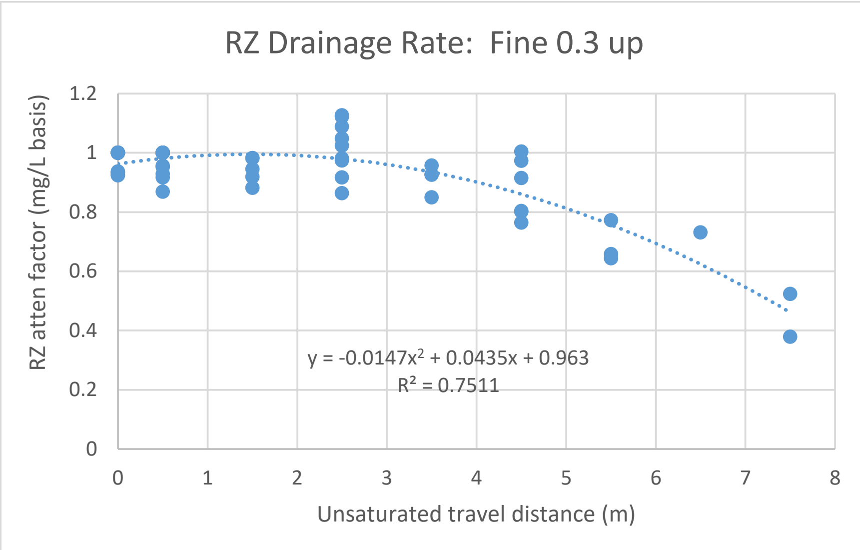
Depth slice (m)	Water Table (m) 2	3	4	5	6	7	8	9	10	11	12	13	14	15
1-1.5	0.81	0.77	0.74	0.73	0.72	0.71	0.71	0.70	0.70	0.70	0.70	0.70	0.70	0.70
1.5-2 m	0.88	0.82	0.78	0.76	0.74	0.73	0.73	0.72	0.72	0.72	0.72	0.72	0.71	0.71
2-3 m	1.00	0.90	0.84	0.81	0.78	0.77	0.76	0.75	0.74	0.74	0.74	0.73	0.73	0.73
3-4 m	1.00	1.00	0.92	0.87	0.84	0.81	0.80	0.79	0.78	0.77	0.76	0.76	0.75	0.75
4-5 m	1.00	1.00	1.00	0.94	0.89	0.86	0.84	0.82	0.81	0.80	0.79	0.78	0.78	0.77
5-6 m	1.00	1.00	1.00	1.00	0.95	0.91	0.88	0.86	0.84	0.83	0.82	0.81	0.80	0.79
6-7 m	1.00	1.00	1.00	1.00	1.00	0.95	0.92	0.89	0.87	0.86	0.84	0.83	0.82	0.81
7-8 m	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.93	0.90	0.88	0.87	0.85	0.84	0.83
8-9 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.94	0.91	0.89	0.88	0.87	0.85
9-10 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.94	0.92	0.90	0.89	0.88
10-11 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.95	0.93	0.91	0.90
11-12 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.95	0.93	0.92
12-13 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.94
13-14 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96
14-15 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98

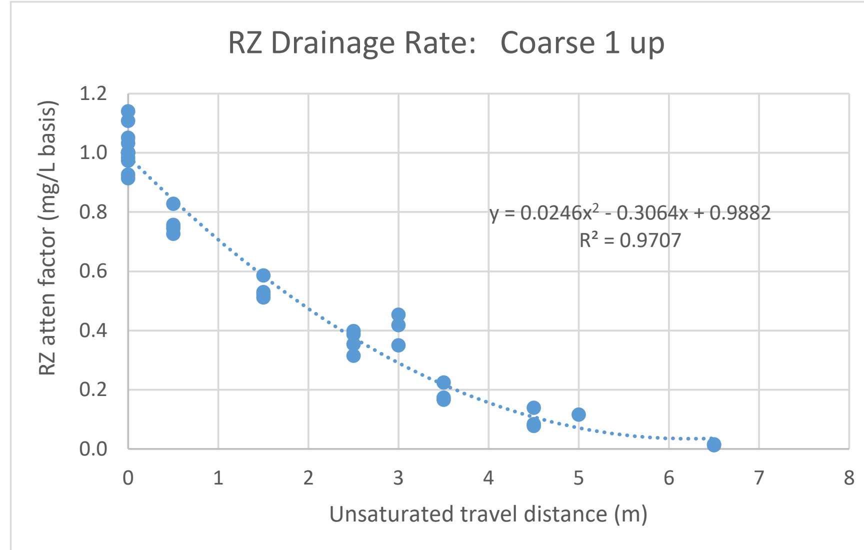
Relative saturation: Coarse soils

Depth slice (m)	Water Table (m) 2	3	4	5	6	7	8	9	10	11	12	13	14	15
1-1.5	0.65	0.58	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
1.5-2 m	0.79	0.67	0.63	0.61	0.60	0.59	0.59	0.58	0.58	0.58	0.58	0.57	0.57	0.57
2-3 m	1.00	0.81	0.73	0.69	0.66	0.64	0.63	0.62	0.62	0.61	0.61	0.60	0.60	0.59
3-4 m	1.00	1.00	0.87	0.79	0.75	0.72	0.69	0.68	0.66	0.65	0.64	0.64	0.63	0.63
4-5 m	1.00	1.00	1.00	0.90	0.83	0.79	0.75	0.73	0.71	0.70	0.68	0.67	0.66	0.66
5-6 m	1.00	1.00	1.00	1.00	0.92	0.86	0.82	0.78	0.76	0.74	0.72	0.71	0.70	0.69
6-7 m	1.00	1.00	1.00	1.00	1.00	0.93	0.88	0.84	0.81	0.78	0.76	0.75	0.73	0.72
7-8 m	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.89	0.86	0.83	0.80	0.78	0.77	0.75
8-9 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90	0.87	0.84	0.82	0.80	0.78
9-10 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.91	0.88	0.85	0.83	0.81
10-11 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.92	0.89	0.87	0.84
11-12 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.93	0.90	0.88
12-13 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.93	0.91
13-14 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.94
14-15 m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97

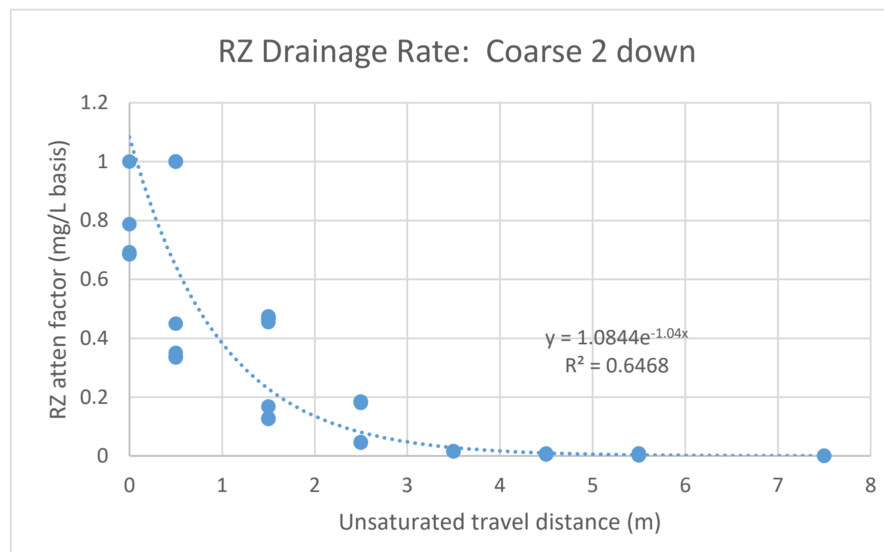
Water Table Depth vs Upward Transport

- **Empirical attenuation factors for root-zone transport measured over large number of LeachM model runs**





- **Net effect: Higher root-zone guidelines with deeper water table**
  - **particularly when coarse soils, recharge conditions→**

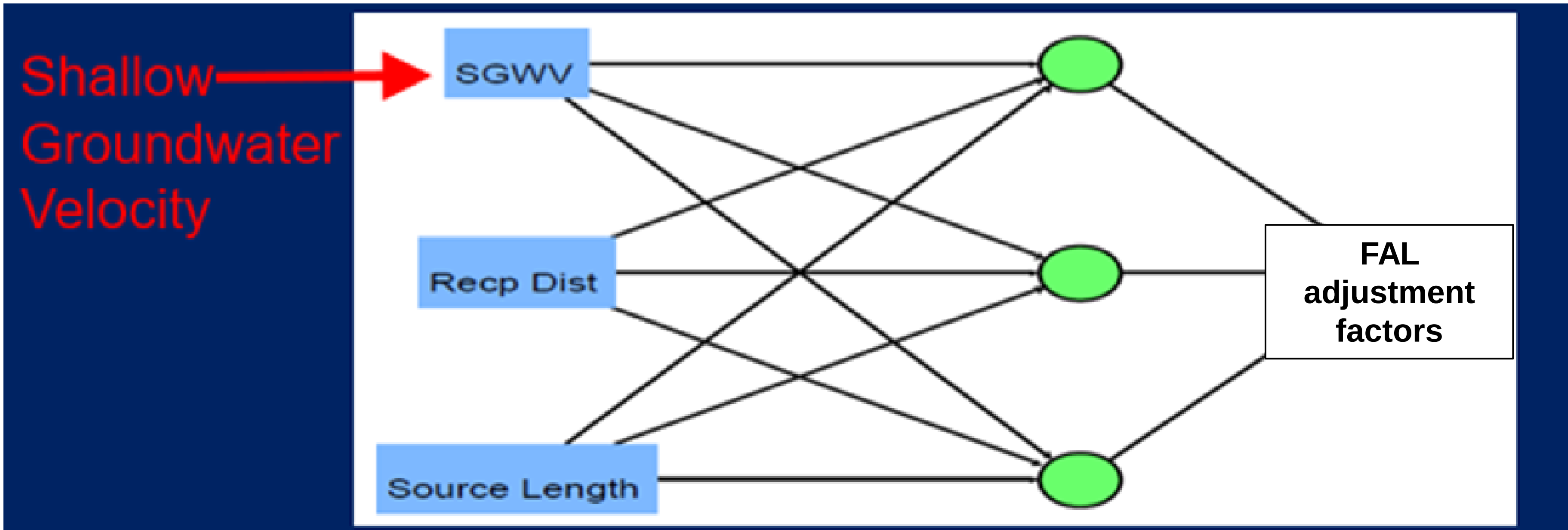


Lateral Transport and Subarea Complexity

- ‘Buffer’ concept combined with ability to handle multiple subareas at once is a major upgrade in Version 3.0
  - Allows estimation of cumulative loading on receptors
- In some cases, this cumulative risk estimation is more conservative than others
  - Particularly for aquatic life receptors in close proximity to impacts with multiple subareas
- Neural network approach was implemented in Version 3.0 to remove some of the excess conservatism for cases with multiple subareas in close proximity to FAL receptors
  - Technical manual provides additional documentation of some details of the neural network and its influence

Lateral Transport and Subarea Complexity

- **Simplified schematic of neural network implementation**



$$E\{Y\} = \beta_0 + \beta_1 X_1 + \cdots + \beta_{p-1} X_{p-1}$$

Sodium Transport: Cation Calculations

- Additional modeling for sodium was performed for Version 3.0 using LeachC
  - Allows cation exchange effects to be modelled

- Background concentrations of other cations (calcium, magnesium) also important
  - Influences sodium transport via cation exchange

- Sodium and (calcium plus magnesium) concentrations can be calculated based solely on EC and SAR
  - Assumes potassium is relatively negligible
  - Most direct to calculate in meq/L units first
  - Can then convert to mg/kg using sat% if needed

Sodium Transport: Cation Calculations

SAR definition

$$SAR = \frac{Na}{\sqrt{\frac{(Ca+Mg)}{2}}}$$

all meq/L units

EC vs Cations regression

$$EC = \frac{(Na+Ca+Mg)}{12}$$

Solve for Sodium

(a mess…. needs quadratic equation)

$$Na = -\frac{SAR^2}{4} + \frac{\sqrt{SAR^4 + 96 \times EC \times SAR^2}}{4}$$

Now solve for Calcium+Magnesium

(whew – easier…)

$$Ca{+}Mg = (12 \times EC) - Na$$

Example background info:

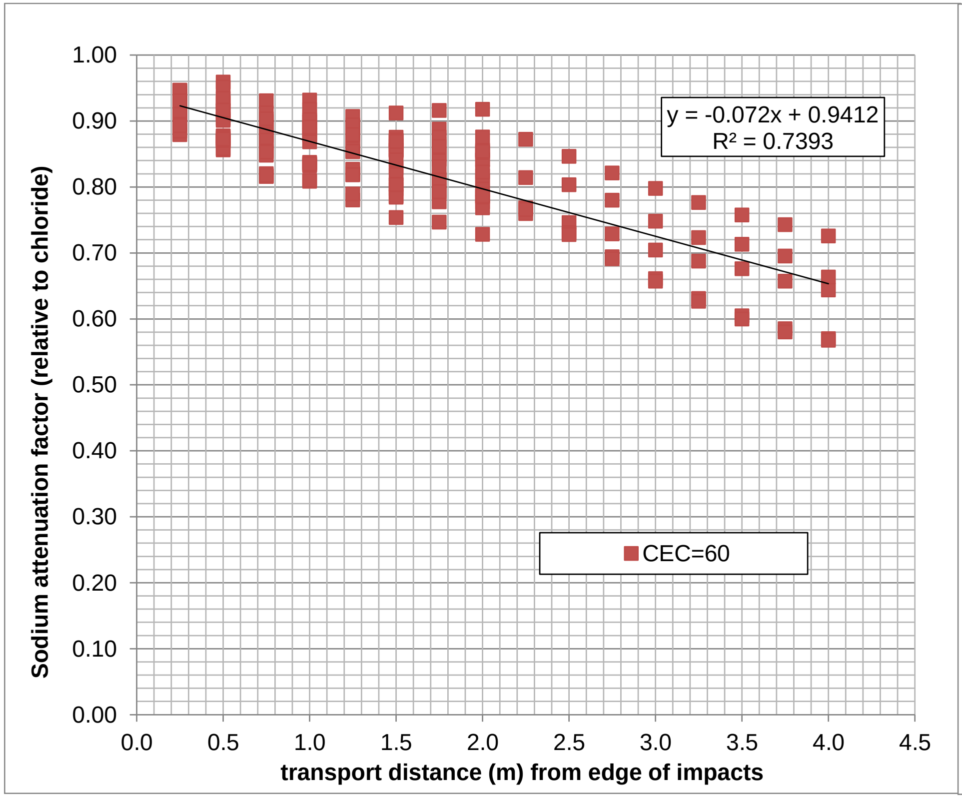
Given: EC=1.8 dS/m, SAR=4.8

Calculated: Na=11.03 meq/L, Ca+Mg = 10.57 meq/L

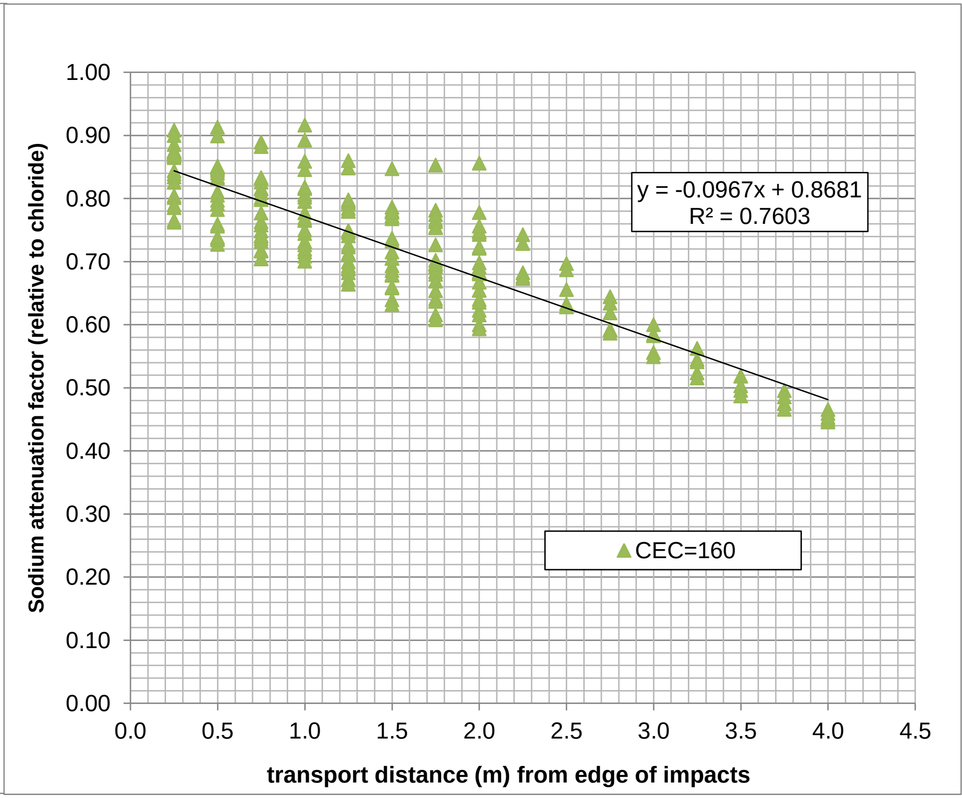
Sodium Transport: Modelling

- **Upward sodium transport into RZ modelled similar to chloride**
  - with additional adjustment factors due to cation exchange effects
- **Additional sodium attenuation relative to chloride calculated based on soil texture and upward transport distance**
  - More attenuation for higher transport distance
  - More attention for fine soils (higher Cation Exchange Capacity) than coarse

Coarse

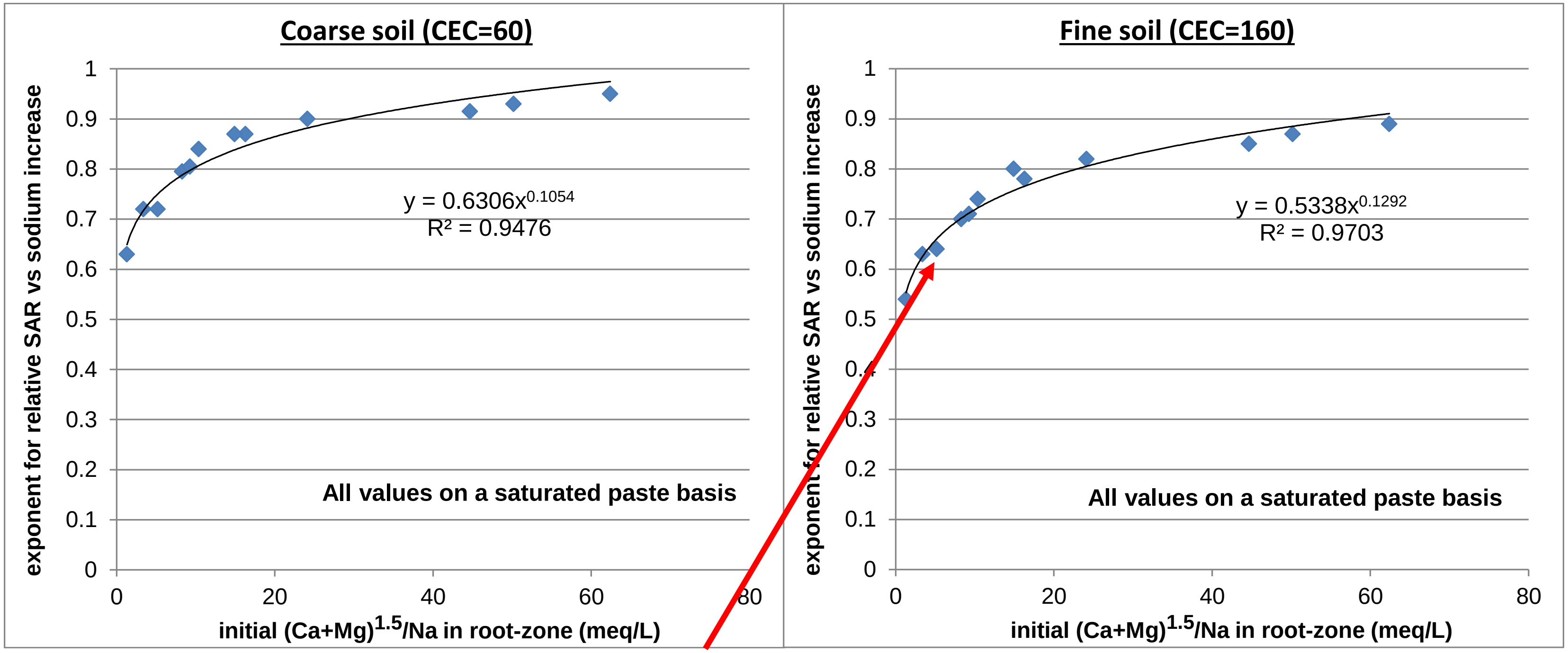


Fine



Sodium Transport: Modelling

- **Root-zone cation exchange influences upward sodium transport**
- **Relative increase in SAR is lower than increase in sodium**
  - **Release of calcium and magnesium in root-zone (buffering effect)**
- **Extensive LeachC modeling showed complex regressions relating initial RZ cation status and future RZ risk**
  - **Effects more pronounced at low initial Ca+Mg concentrations in RZ**



Example: Sodium in root-zone needs to increase by 3-fold to cause a 2-fold increase in SAR here. Net result: Increased Na guideline.

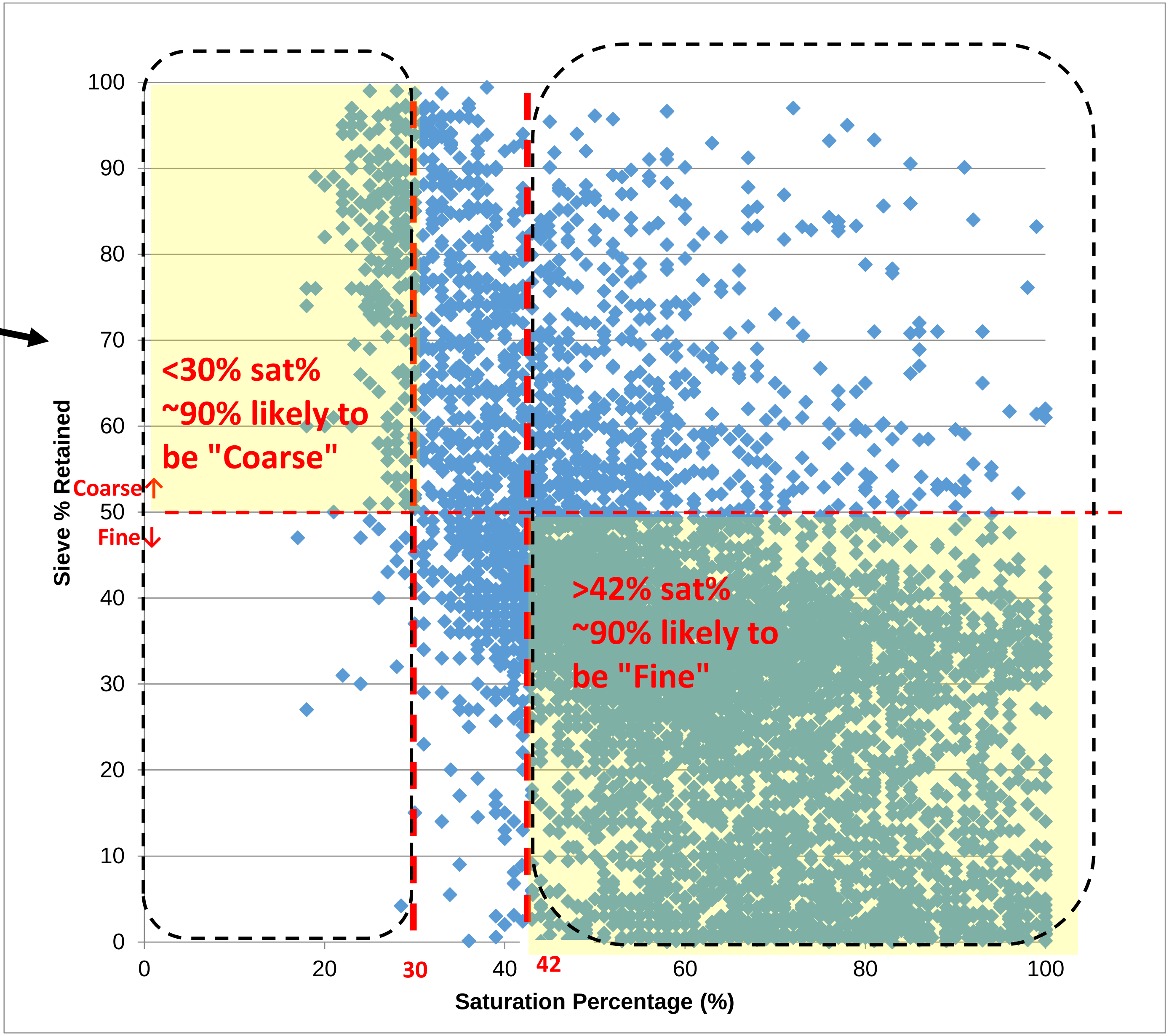
Saturation % / Texture Correlations

- **Technical manual shows final results for PTAC-supported research for saturation percentage / sieve correlations**
  - **Expansion of previous work from 2014 on sat% vs clay content**
- **Saturation percentage data provides additional ‘free’ insight into soil texture**
  - **Improves confidence and robustness in modelling parameters used in SST**
  - **Insight into both texture by hydrometer (clay content) and sieve (fine vs coarse)**
- **Newest work includes substantially larger database**
  - **Expanded to include sieve data**
- **Generates sat% thresholds that can predict fine vs coarse soil with high levels of confidence**

Saturation % / Texture correlations

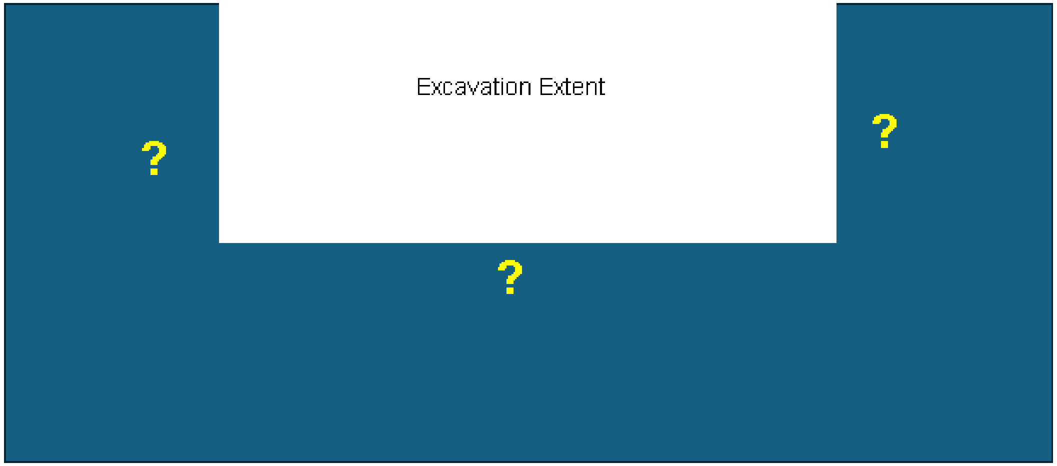
- **Saturation % thresholds of <30% (coarse) >42% (fine) for texture by sieve**

- **Similar updated saturation % thresholds of <32% (low) >46% (mid-high) for clay content by hydrometer**



Guideline Implementation

- SST process does not stop at guideline generation
  - Also needs implementation in ‘real life’
- Implementation during confirmatory sampling important
  - Sometimes simple, but can get complex in a hurry
- Especially with multiple subareas, root-zone scenarios, excavation depths, etc.
  - Additional guidance provided for multiple scenarios of varying complexity



SST Frequently Asked Questions (FAQ)

- **A way to engage with SST user community and discuss important topics / questions**
- **Process:**
  - **Send questions to SSTInfo@eqm.ca**
  - **Selected questions are announced on EEI LinkedIn page**
  - **Question and Answer provided on FAQ page:**
    https://www.eqm.ca/faq
- **Answers to key questions will also involve regulatory vetting**

SST Course

3.5-Day Full Certification Course [ON-LINE]

Spring 2025 April 8-11, 2025

Milestone!

Will be 50th full certification course since 2009, and more than 700 individual certifications!

For further information:

Visit our webpage at www.eqm.ca

Or contact SSTinfo@eqm.ca

Or visit our LinkedIn page

Acknowledgements

- Alberta Environment and Protected Areas
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  - Technical Champion for manual: Shawn Glessing (Cenovus)

Thank you!

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