

Practical Use of MEND Report 2.21.4

Design, Construction, and Performance Monitoring of Cover Systems for Waste Rock and Tailings



Natural Resources
Canada

Ressources naturelles
Canada

Canada

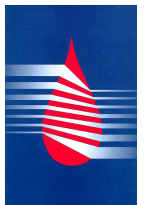
Acknowledgements



- **MEND**
 - **Gilles Tremblay**
 - **Charlene Hogan**

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- **Original Manual Developed at the University of Saskatchewan (DRAFT)**
 - **Dr. Lee Barbour**
 - **Dr. Michel Aubertin**
 - **Dr. Ernest Yanful**
 - **Dr. Ward Wilson**
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 - **Dr. Lee Barbour**
 - **Dr. Michel Aubertin**
 - **Dr. Craig Nichol**
 - **Numerous Other Individuals!**
 - **Permission by Companies to use Case Studies**



Organization of Manual

Volume 1: Summary

Volume 2: Theory and Background

**Volume 3: Site Characterization, Conceptual
Cover System Design, *Approach to
Numerical Modelling***

**Volume 4: Field *Performance Monitoring*,
Sustainable Performance of Cover
Systems**

Volume 5: *Case Studies*



Intended Audience for Manual?

- **Manual *Intended* for *Mine Operators* or Individuals wanting to know more about the *Process***
- **Manual was *NOT* meant as a *Step-by-Step Guide* for *Cover System Design***
- **Manual can be used to *Highlight “State-of-the-Art” Areas of Cover System System Design, or Areas where Mistakes are Commonly Encountered***



Purpose of Modelling

- **Interpretation**
 - **Understand a mechanism or process**
 - **To prove a hypothesis.....To train our thinking**
 - **To make sense of monitoring data**
- **Design**
 - **Evaluation of relative performance of alternatives**
- **Prediction**
 - **To make a final prediction of future behaviour or impact**

Geo-Slope International Ltd., 2004. "Vadose Zone Modelling with Vadose/W"

Chapter 2: "Numerical Modelling: What, Why, How (Lee Barbour)"

Barbour and Krahn, 2004. "Modelling – Prediction or Process?"

Geotechnical News, in Review



Modelling

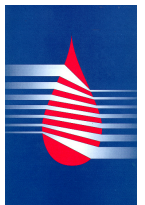
- **Key Advantage of Modelling:**
 - **Ability to *Enhance Judgment***
 - ***NOT* the Ability to *Enhance Predictive Capabilities***
 - **Modelling is about *“Process”* not *“Prediction”***
 - ***“The attraction of ... modelling is that it combines the subtlety of human judgment with the power of the digital computer.” (Anderson and Woessner 1992)***

Geo-Slope International Ltd., 2004. “Vadose Zone Modelling with Vadose/W”


Chapter 2: “Numerical Modelling: What, Why, How (Lee Barbour)







Barbour and Krahn, 2004. “Modelling – Prediction or Process?”

Geotechnical News, in Review




Enhancing Judgment






5 Day Forecast from  Environment Canada

Wednesday	Wednesday night	Thursday	Friday	Saturday	Sunday
					
Sunny	Clear	Sunny	Sunny	Sunny	Sunny
High 33°C	Low 24°C	High 33°C	Low 24°C	Low 24°C	Low 24°C
		High 33°C	High 33°C	High 33°C	High 32°C

**Darwin, NT
Australia**

5 Day Forecast from  Environment Canada

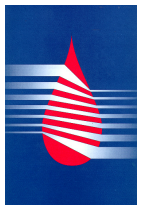
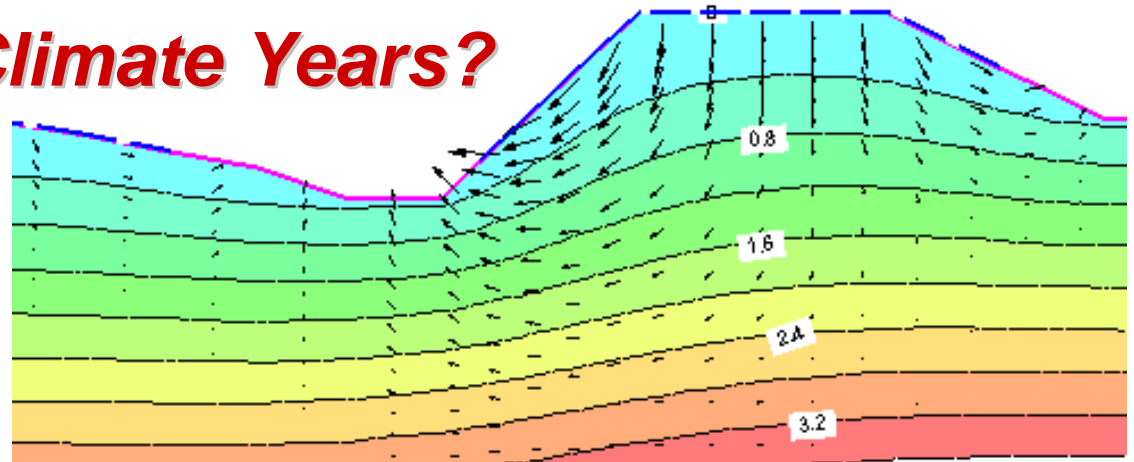
**Yellowknife
NWT
Canada**

Tuesday night	Wednesday	Thursday	Friday	Saturday
				
Periods of snow	Periods of snow	Sunny	Sunny	Sunny
Low -22°C	High -20°C	Low -23°C	Low -34°C	Low -30°C
		High -19°C	High -28°C	High -25°C

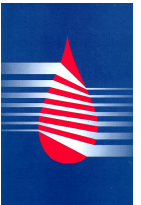
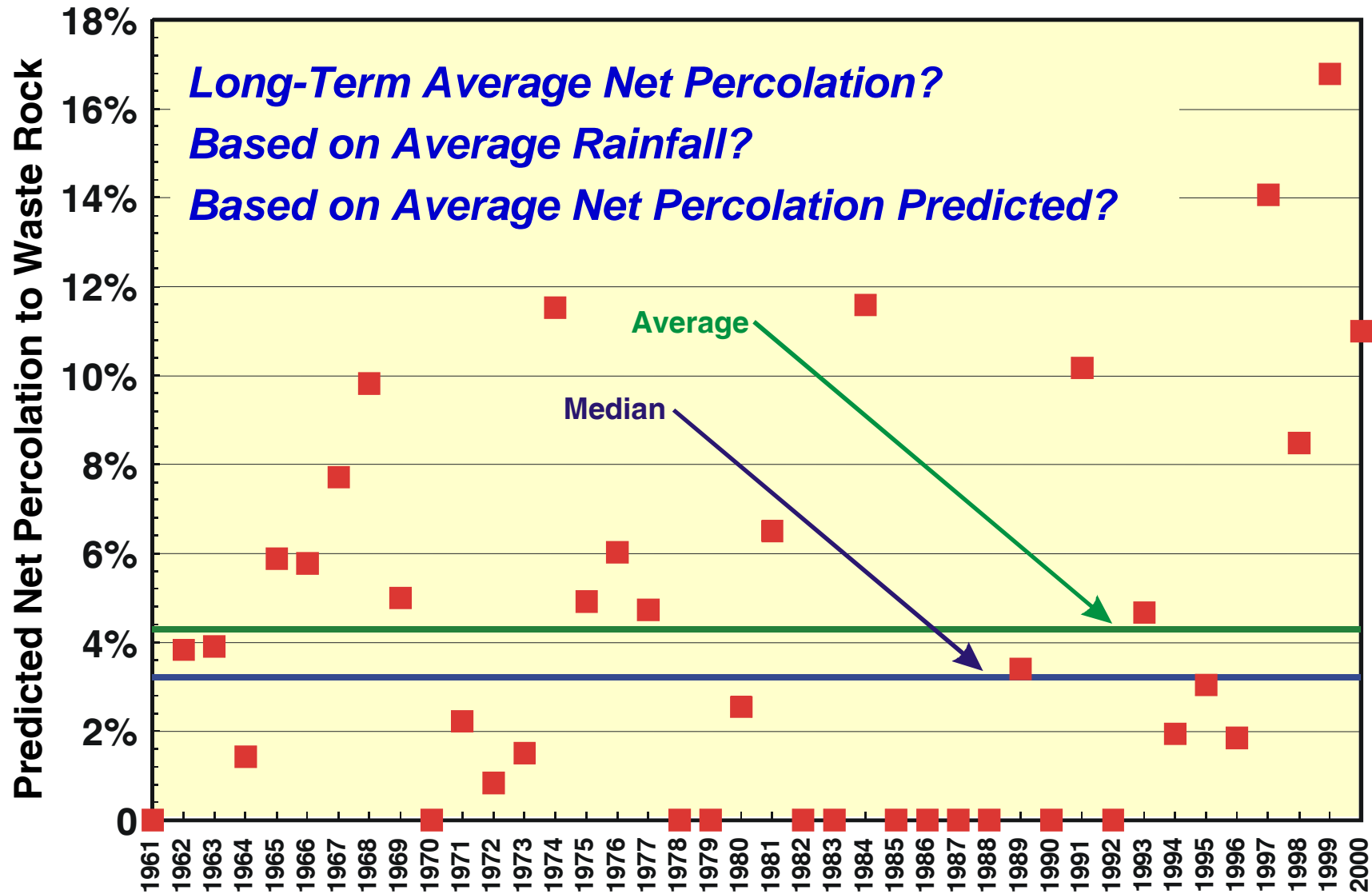


Modelling Input?

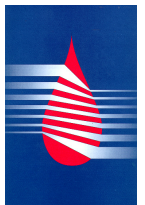
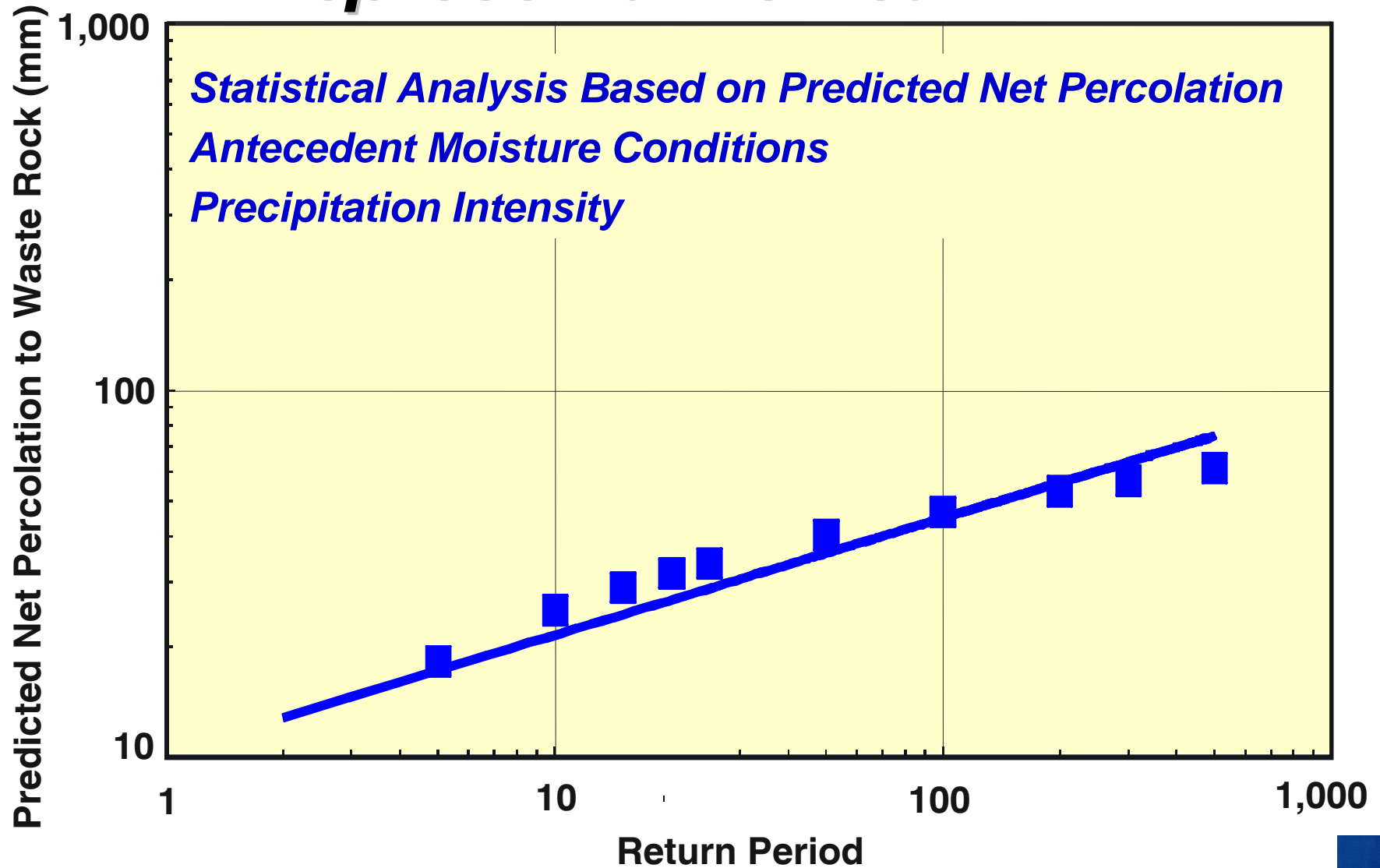
- **Initial Conditions**
- **Material Properties**
- **Boundary Conditions**
 - **Lower Boundary Conditions**
 - **Upper Boundary Conditions...Focus on *Precipitation***
- **Representative Climate Years?**
 - **Wet?**
 - **Dry?**
 - **Average?**



Representative Year?

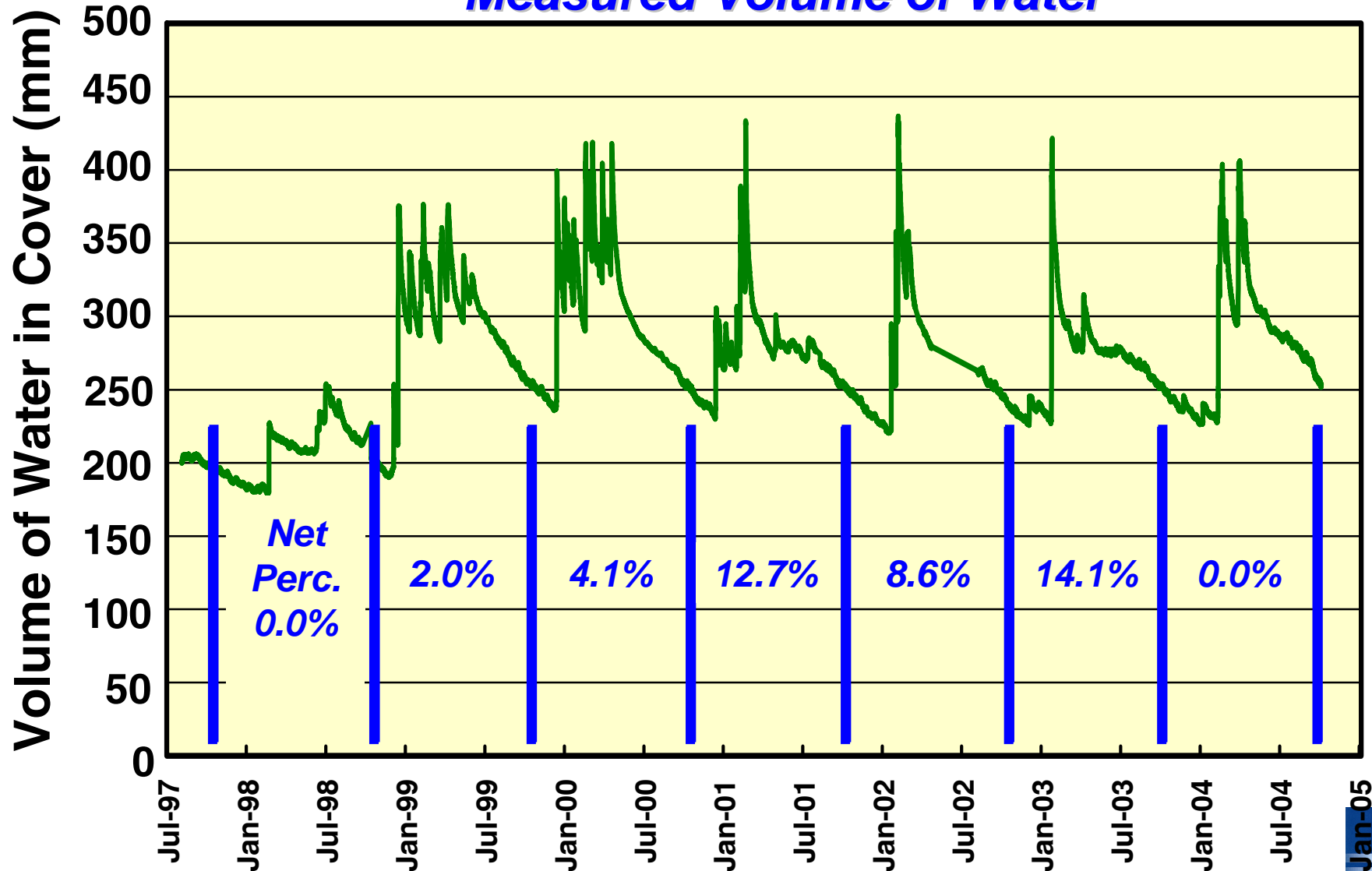


Representative Year?



Mt. Whaleback

Measured Volume of Water



Kimberley Operations

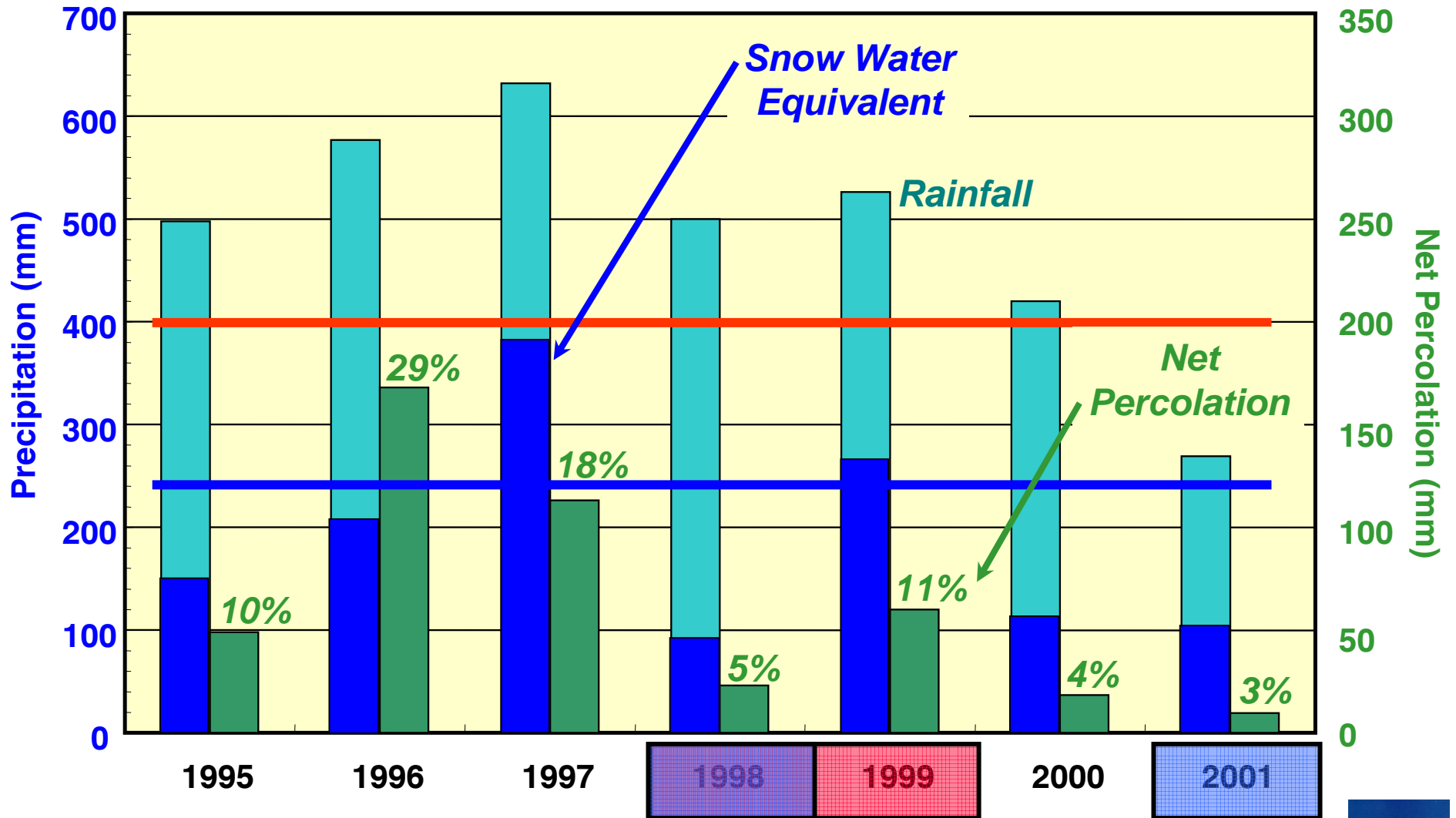
- **Site has annual moisture deficit**
- **Site experiences hot dry summers**



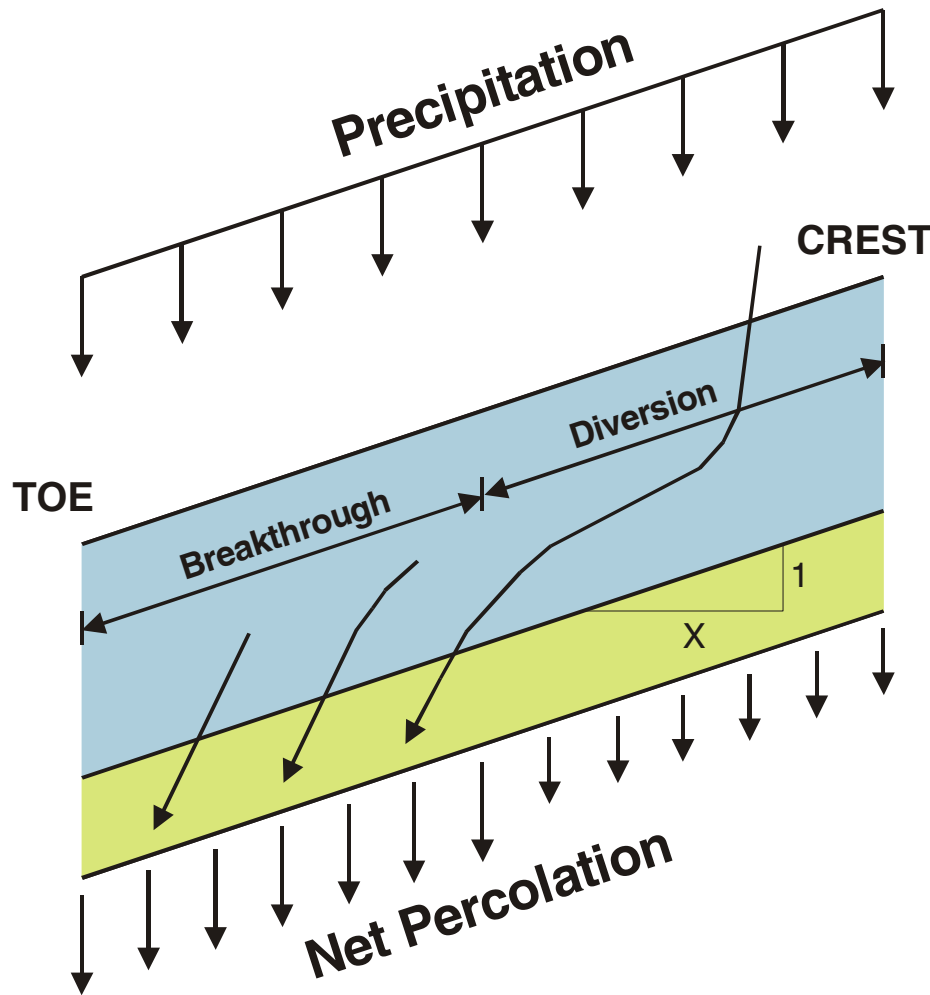
- **Humid fall and winter**
- **Spring freshet contributes significantly to flow in surface drainage courses**



Kimberley Operations



General Behavior – 2D Cover Systems

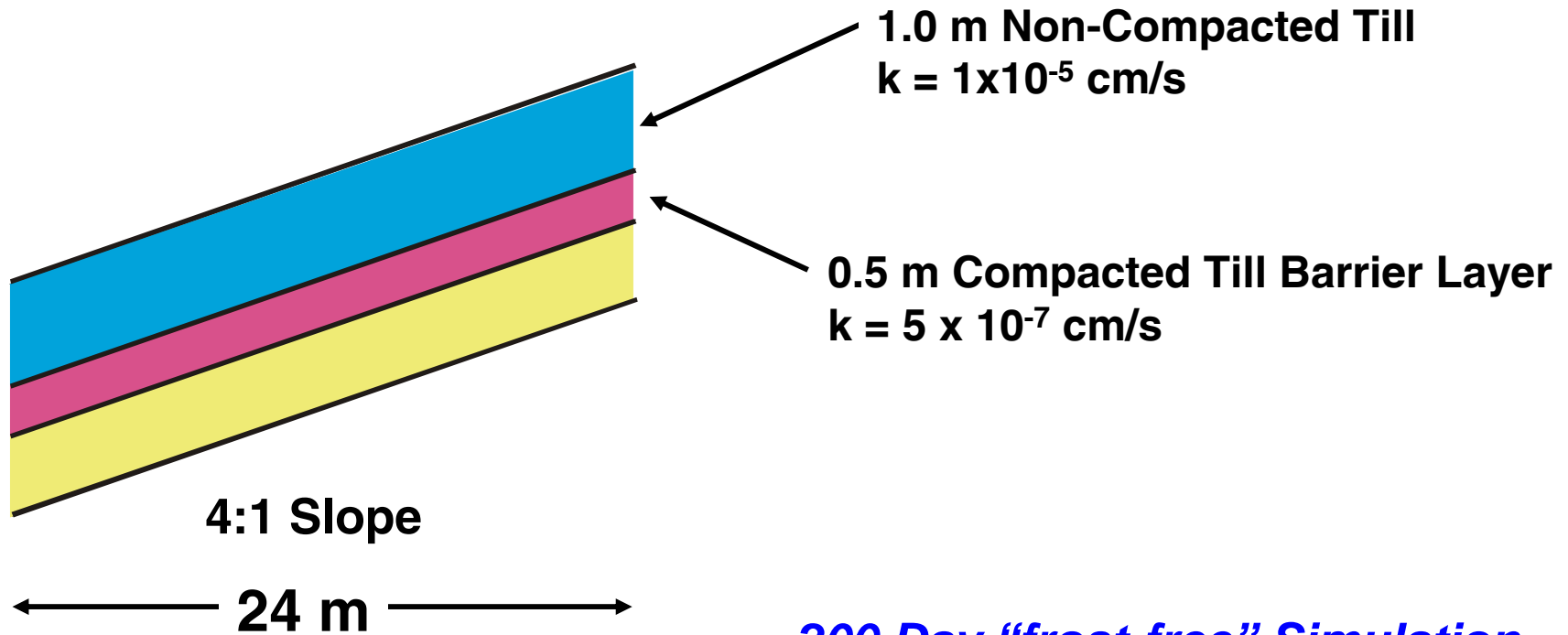


Lower Slope	Upper Slope
Increased Net Percolation	Low Net Percolation
Higher Degree of Saturation	Decreased Degree of Saturation
Lower Oxygen Ingress	Higher Oxygen Ingress

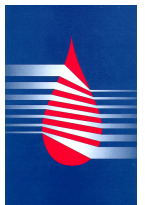
Vegetation?



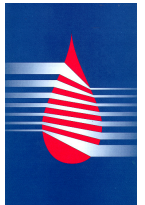
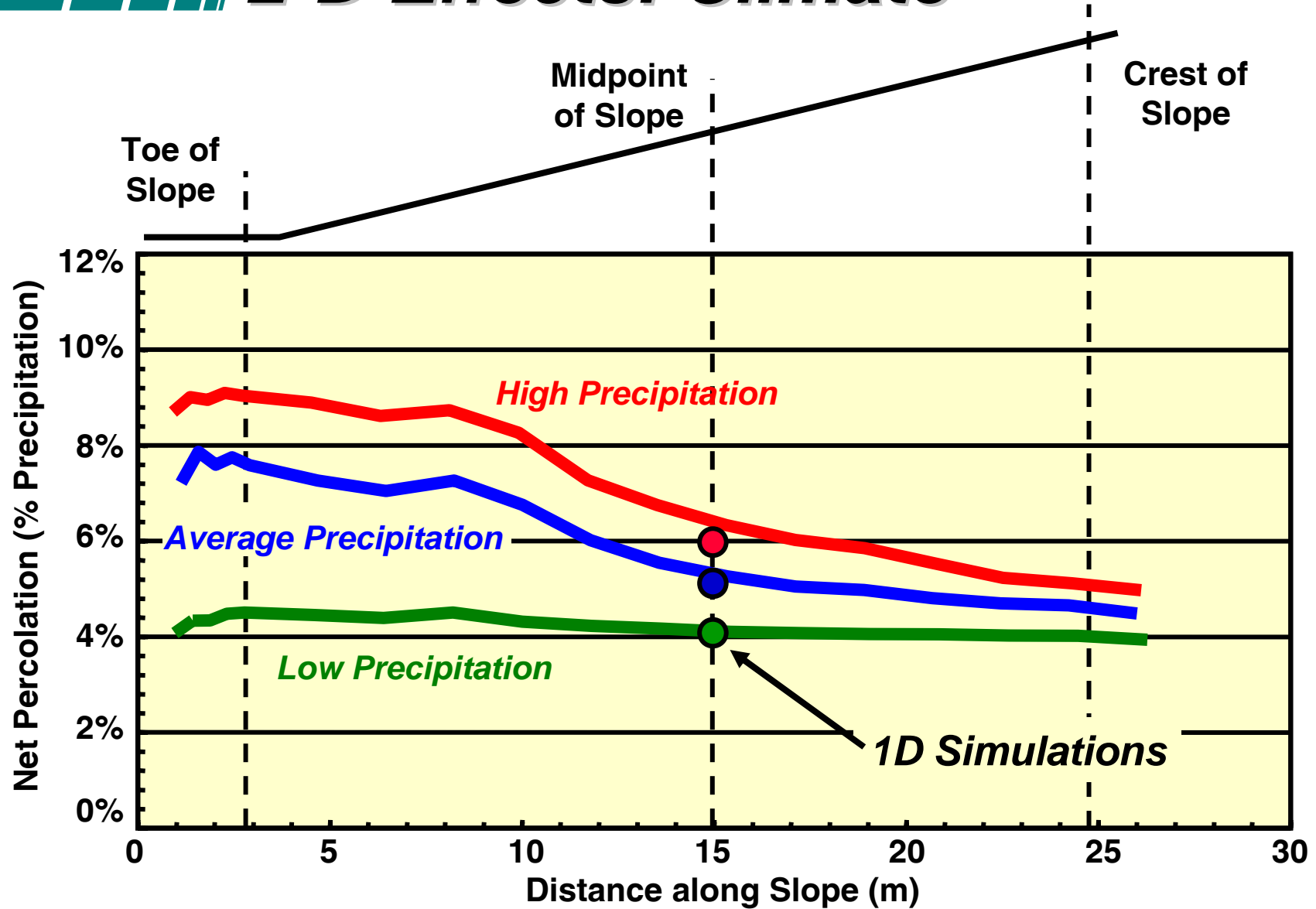
2-D Effects: Climate



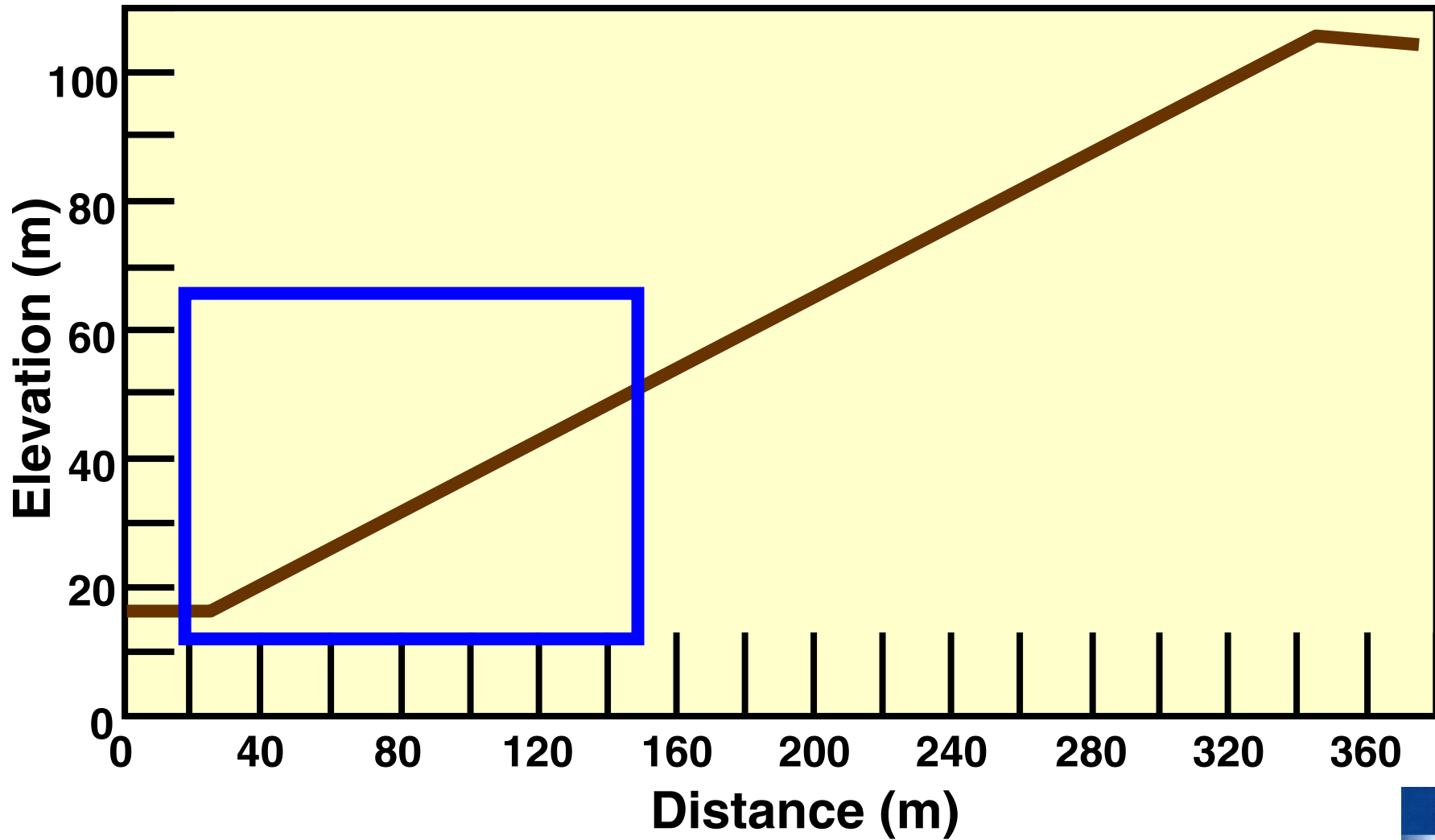
*200 Day “frost-free” Simulation
typical of a British Columbia
mine site*



2-D Effects: Climate

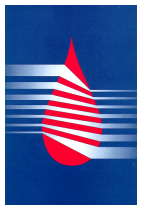
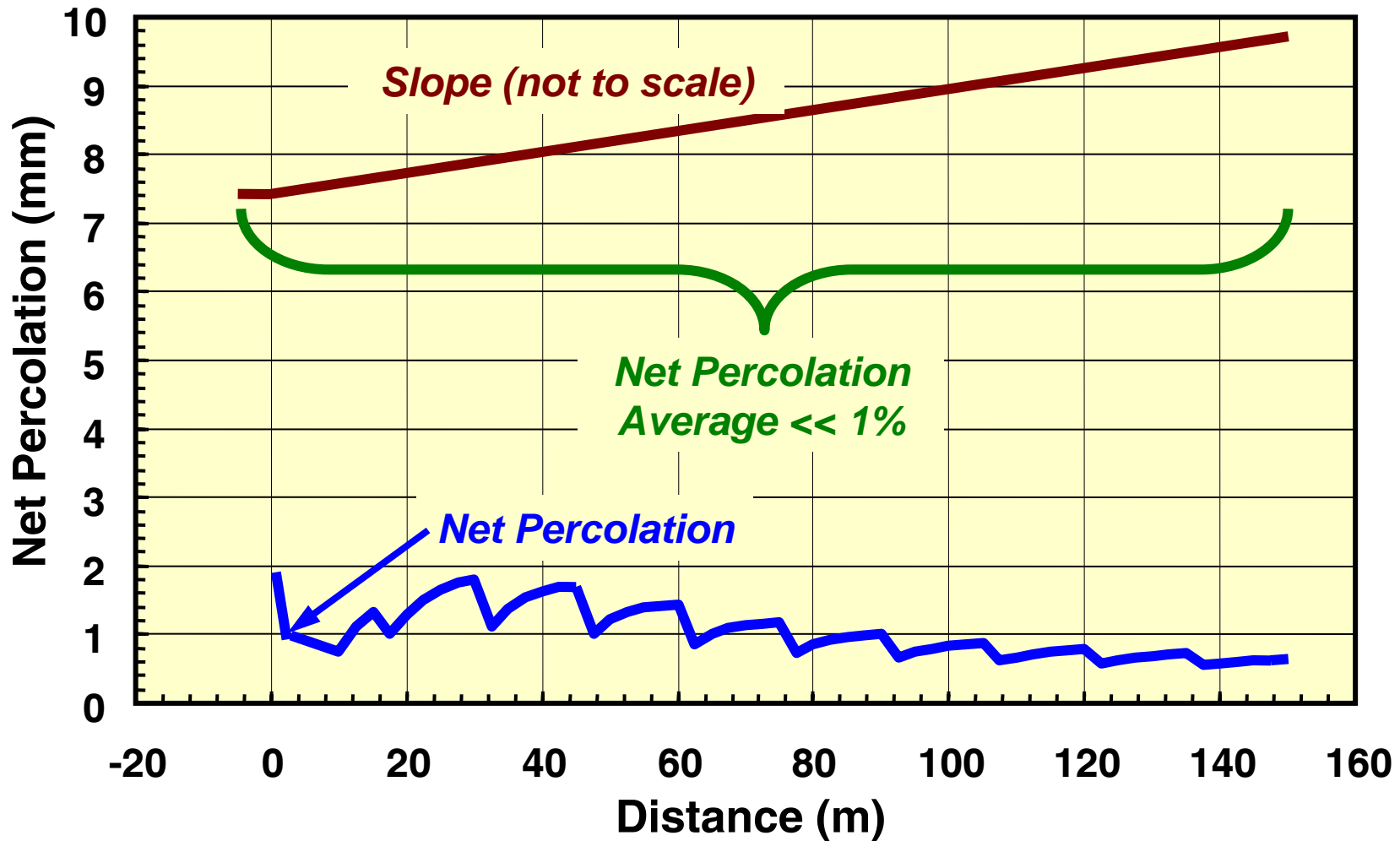


2-D Effects: Slope Length

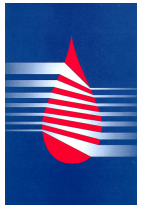
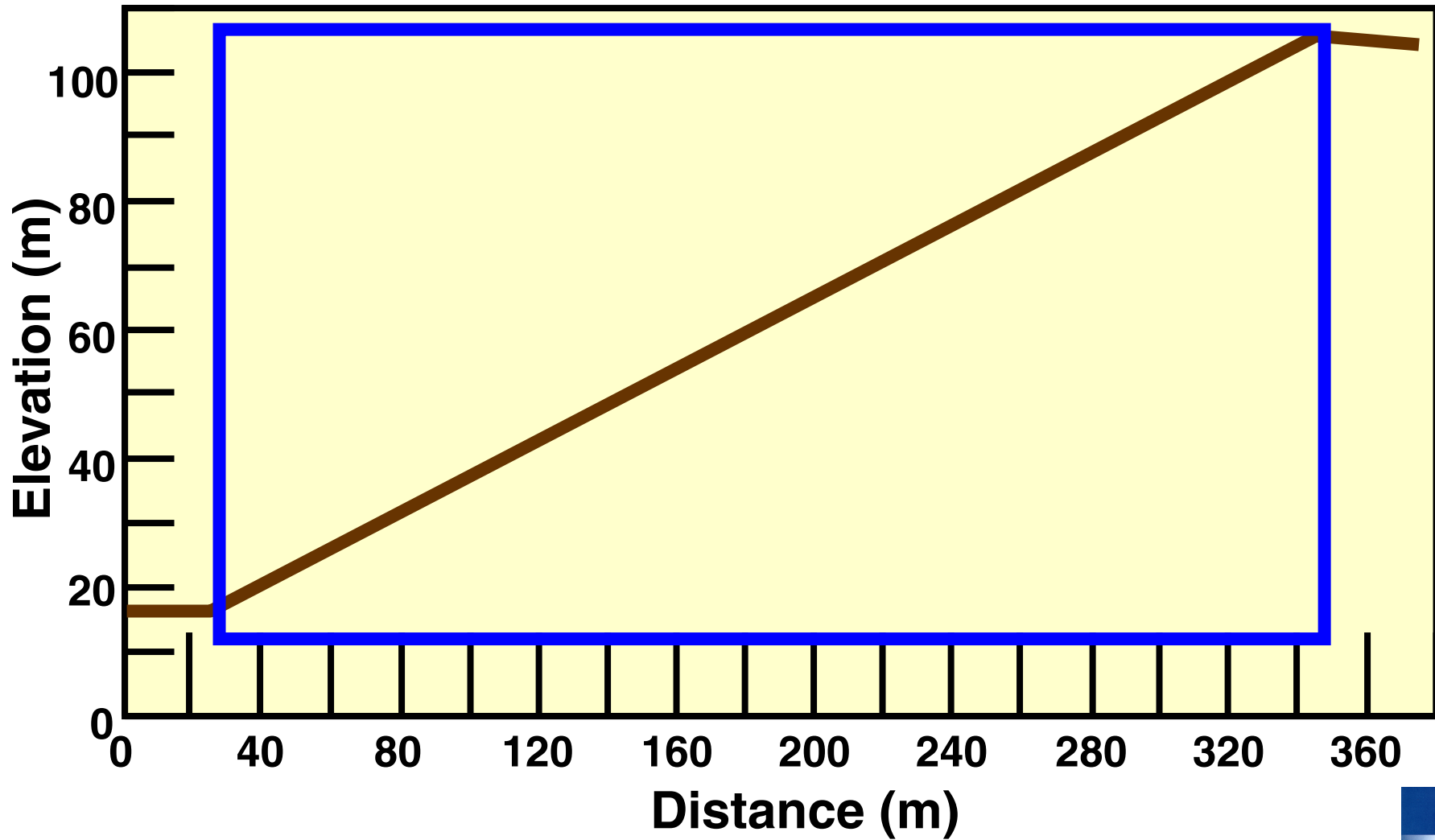


2-D Effects: Slope Length

2-D Effects from Upper Slope not Included

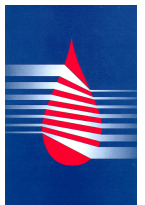
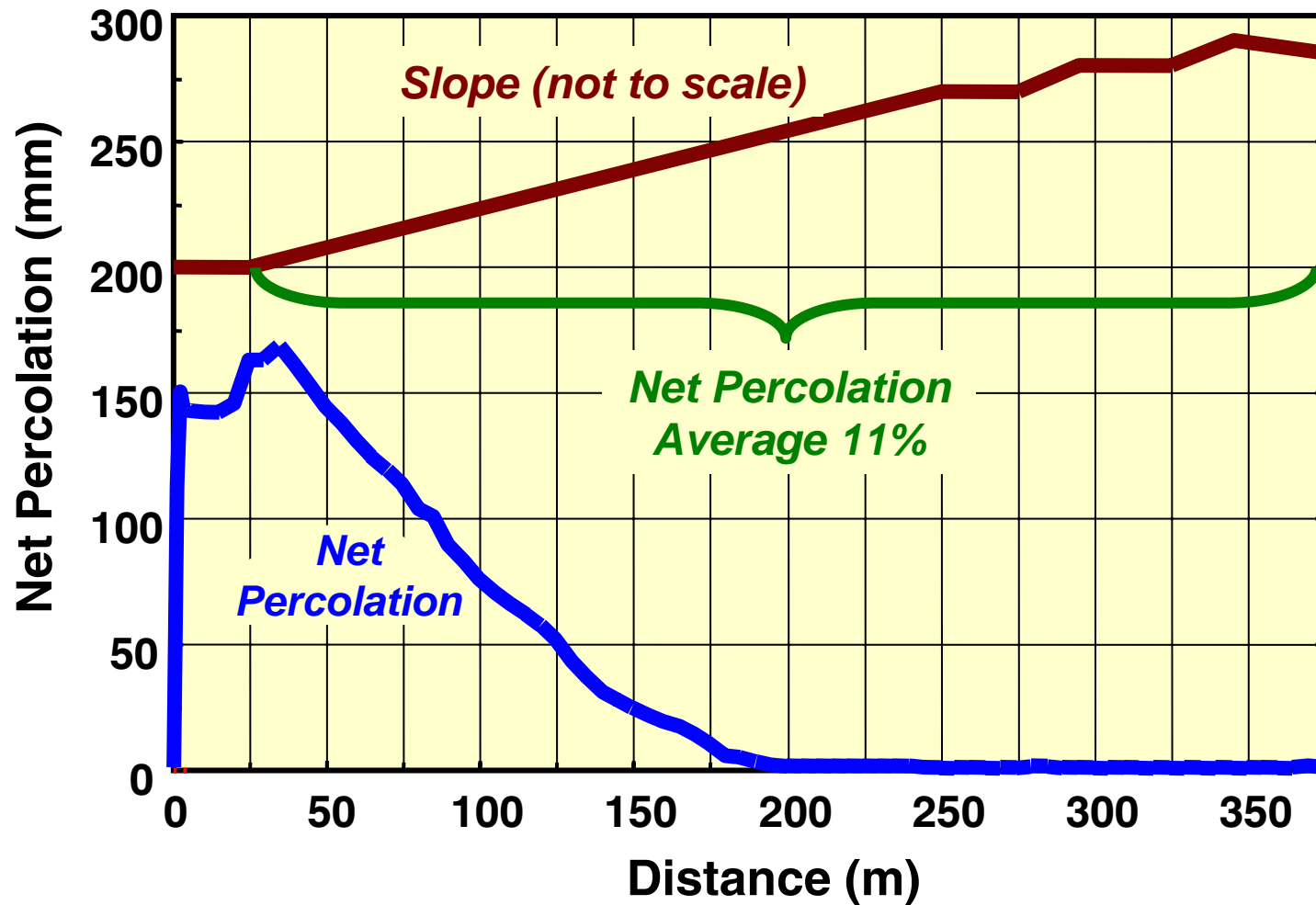


2-D Effects: Slope Length



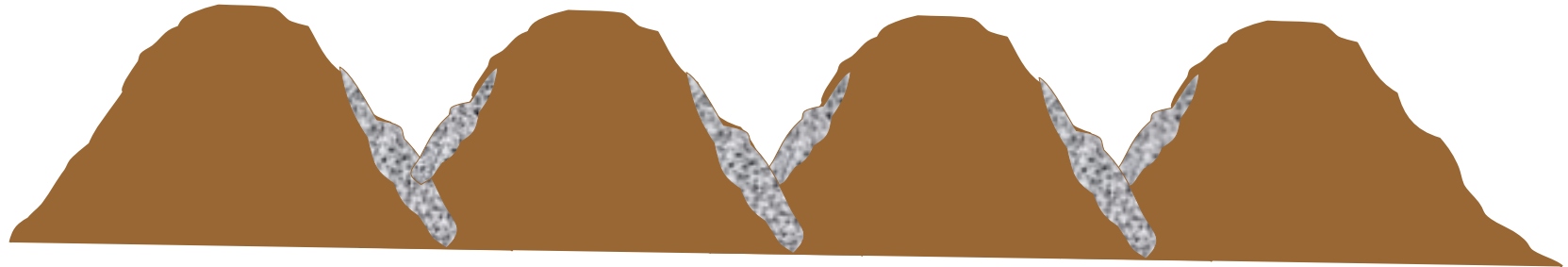
2-D Effects: Slope Length

Entire Slope Considered in Analysis



Construction and QA/QC

**Potential Coarse
“Rubble” Zone**

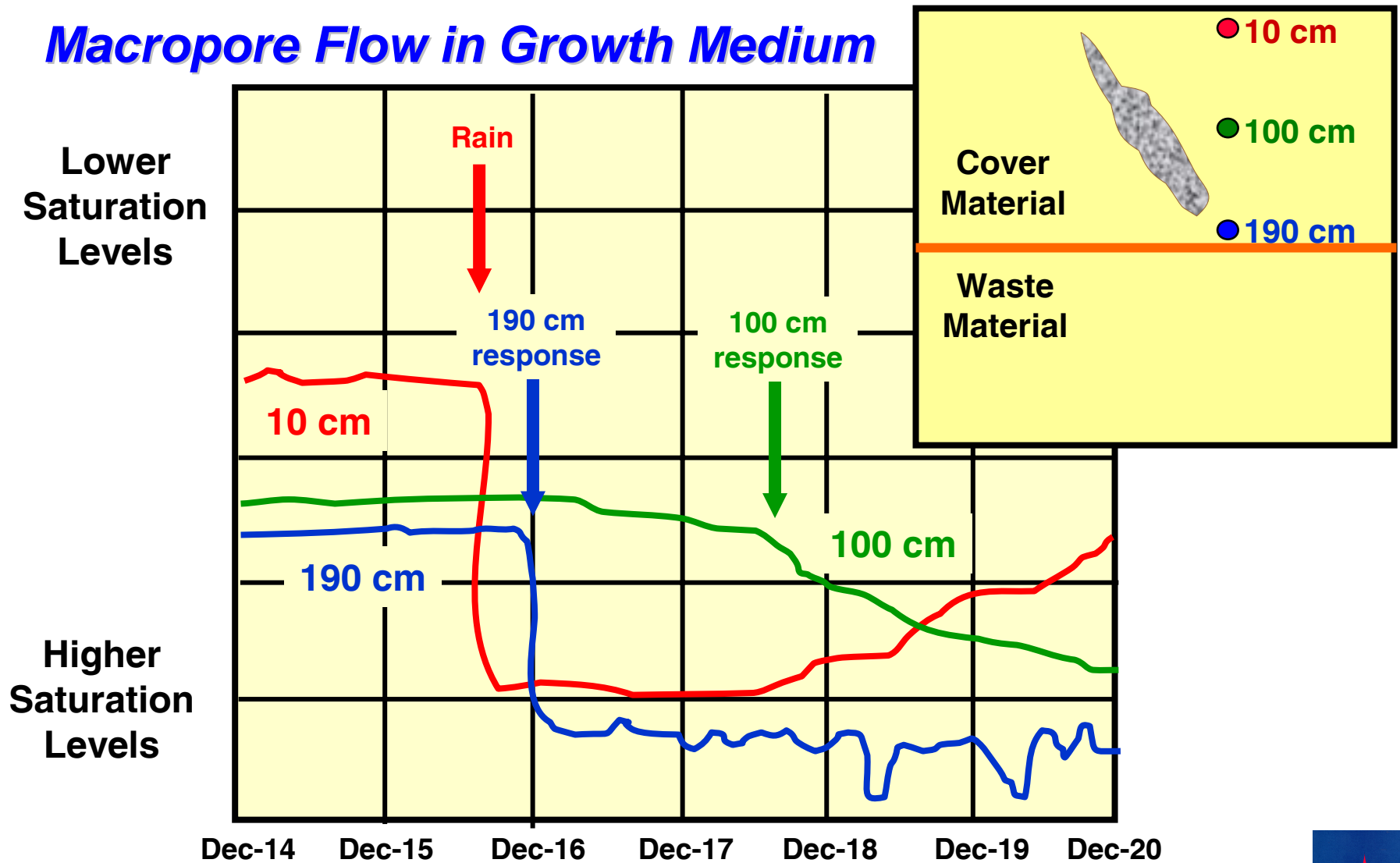


Near Surface Preferential Flow

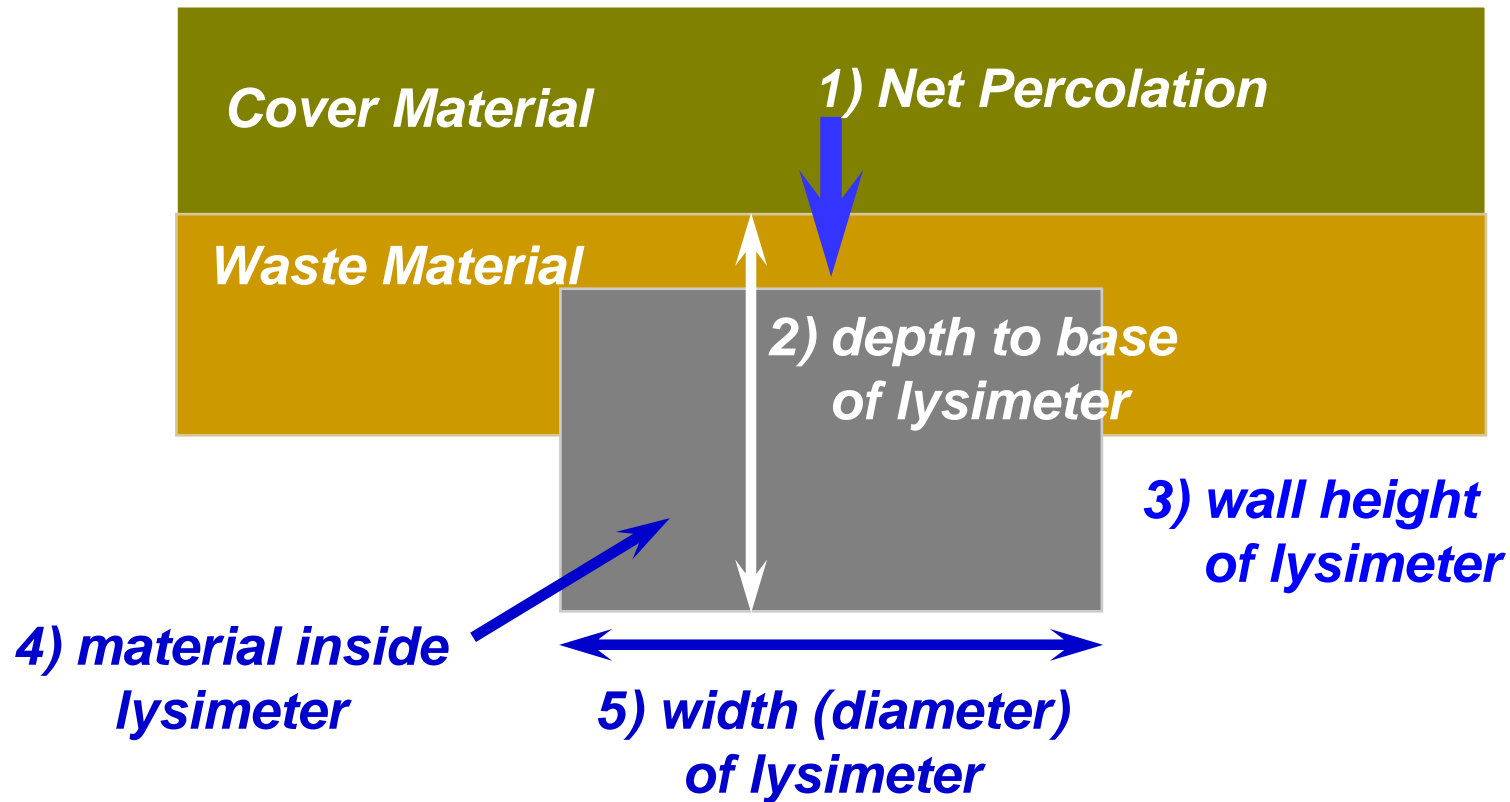


Construction QA/QC

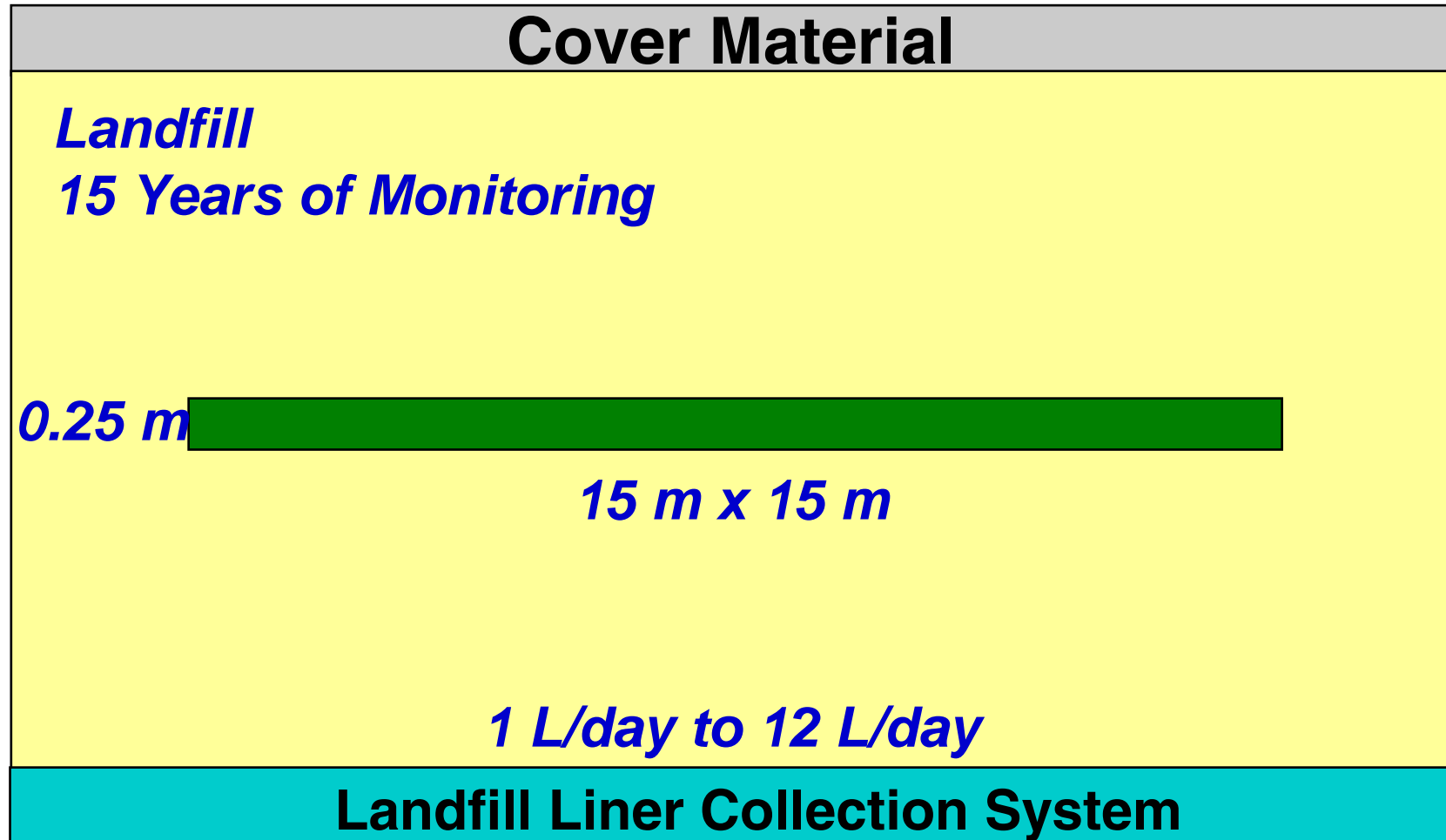
Macropore Flow in Growth Medium



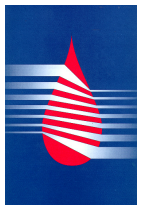
Lysimeter Design



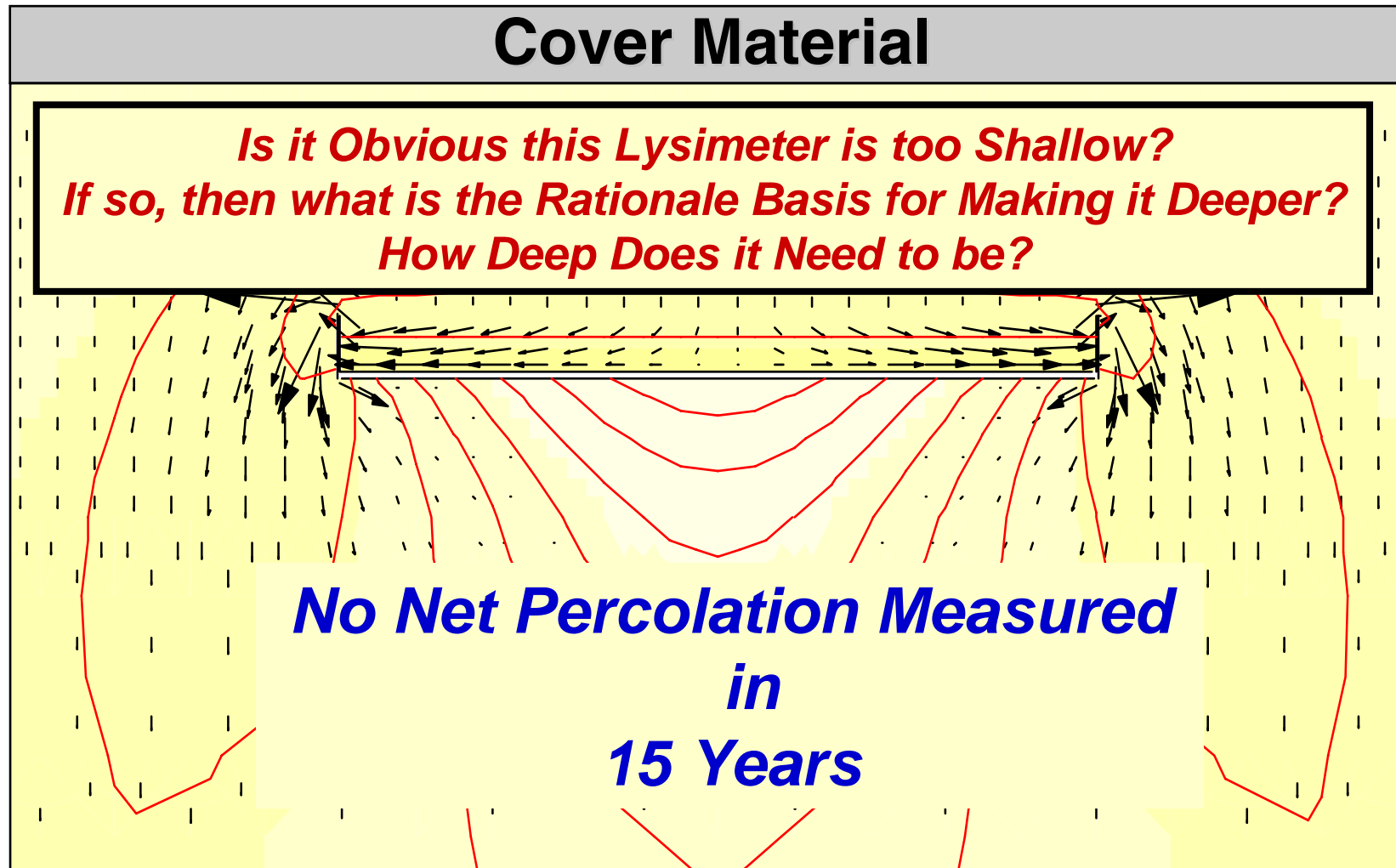
Increase Lateral Surface Area?



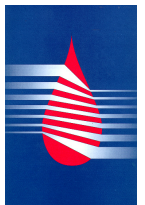
(Barone et al., 1999)



Increase Lateral Surface Area?



(Barone et al., 1999)



Macro Scale Manual

“Macro Scale Cover Performance Monitoring and the Application of the Observational Method for Evaluating Long Term Engineered Landscape Performance / Cover System Design”

Volume 1: Introduction and Background

(Designing Cover Systems as Watersheds)

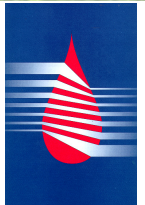
Volume 2: Watershed-Scale Monitoring Methods

Volume 3: Cover System Evolution with Time

A Single Case Study will be

“Woven”

into all of the Volumes

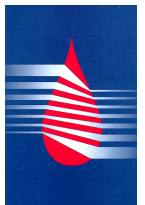


Micro to Macro Scale??



- *It is the major building block of landscapes*
- *Majority of questions asked about landscape performance can be addressed at the watershed scale*
- *It can encompass the range of target ecosites desired for the particular reclamation material*
- *It allows for “real” measurement of balances and patterns*
- *It demands thought about interactions*
- *It is manageable*

Source: Clara Qualizza, Syncrude Canada Ltd.



Watershed Monitoring Objective

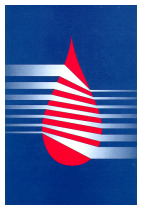


- **Identify Optimal Reclamation Methods, Thereby Reducing Liability**

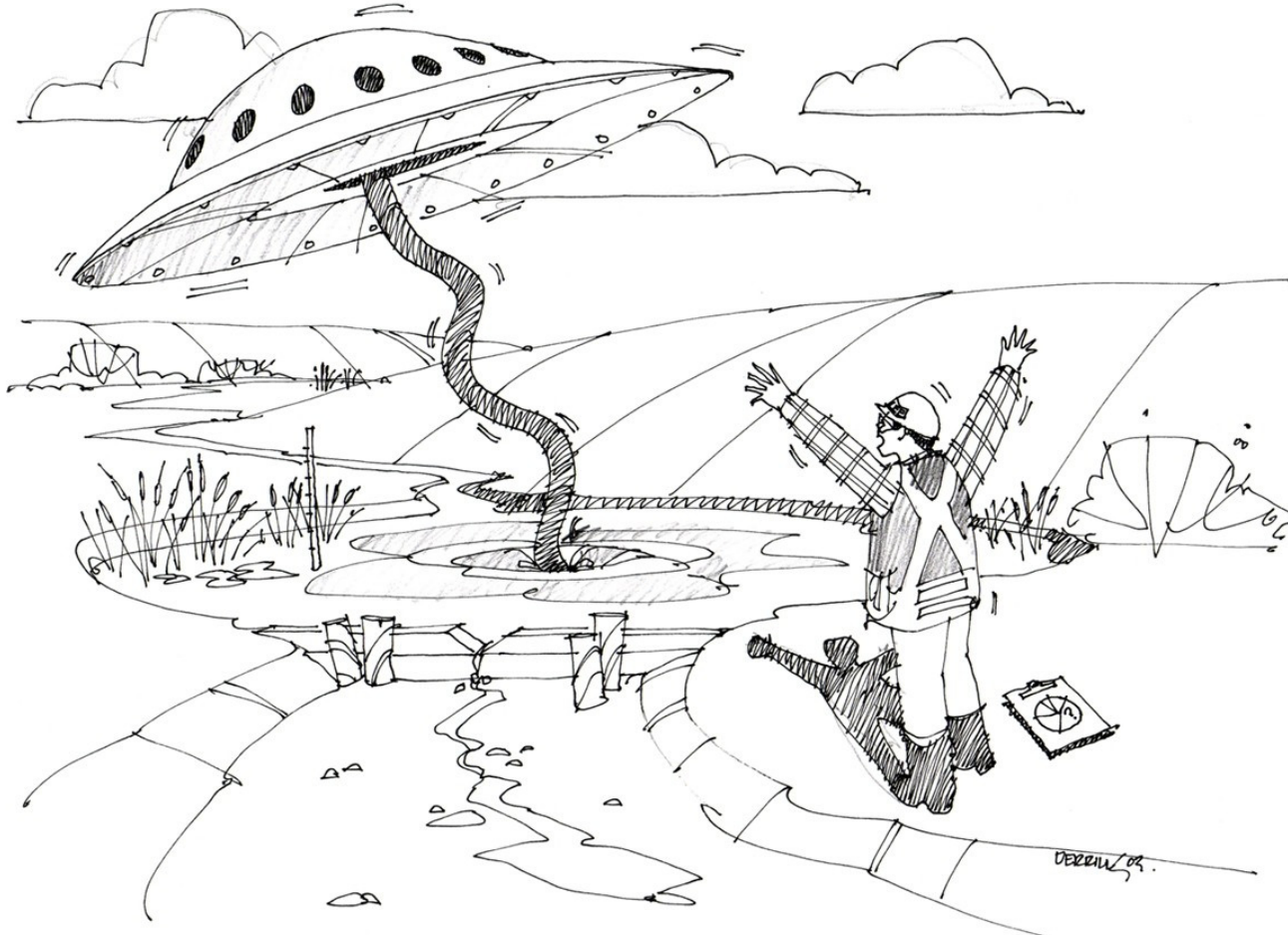


- **Develop a Credible “Biography” and Projection of Landscapes**

Source: Clara Qualizza, Syncrude Canada Ltd.



Need a Water Balance!!!!



Suddenly Lee Discovered why He's Never Quite been able to Balance the Water Budget

Source: Gord McKenna

