Climate Change for Engineers: How to Consider Future Unknowns in the Context of Design Today

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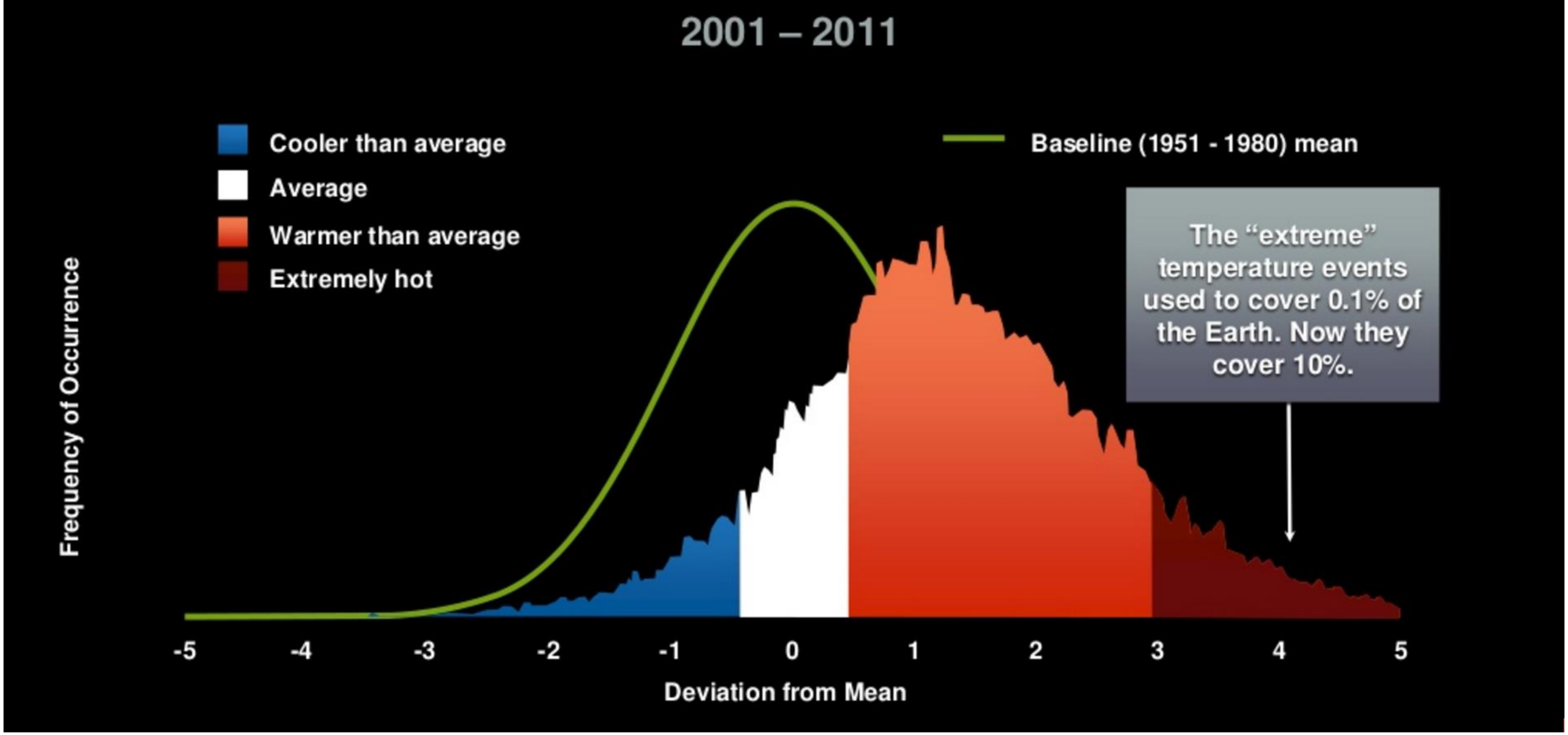
Specialists in Geochemistry and Unsaturated Zone Hydrology

The Future

Moving into a future of extremes not reflected in recent experience. Key is increase in frequency of occurrence



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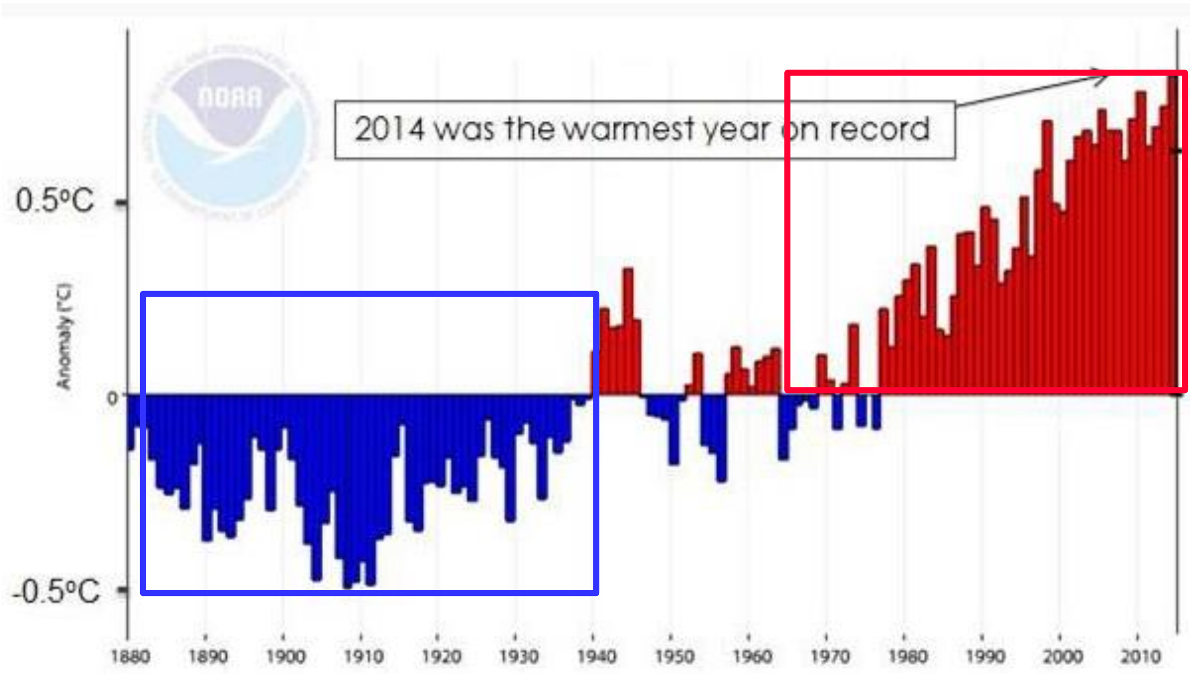
Climate Cycles: Temperature (Canada)



Cool Period vs warm period.

- The average is a moving number its not fixed (strong consideration for the time period)
- No year experienced an "average" temperature
  - It is "normal" for temperatures to be above or below average that is the nature of a cycle

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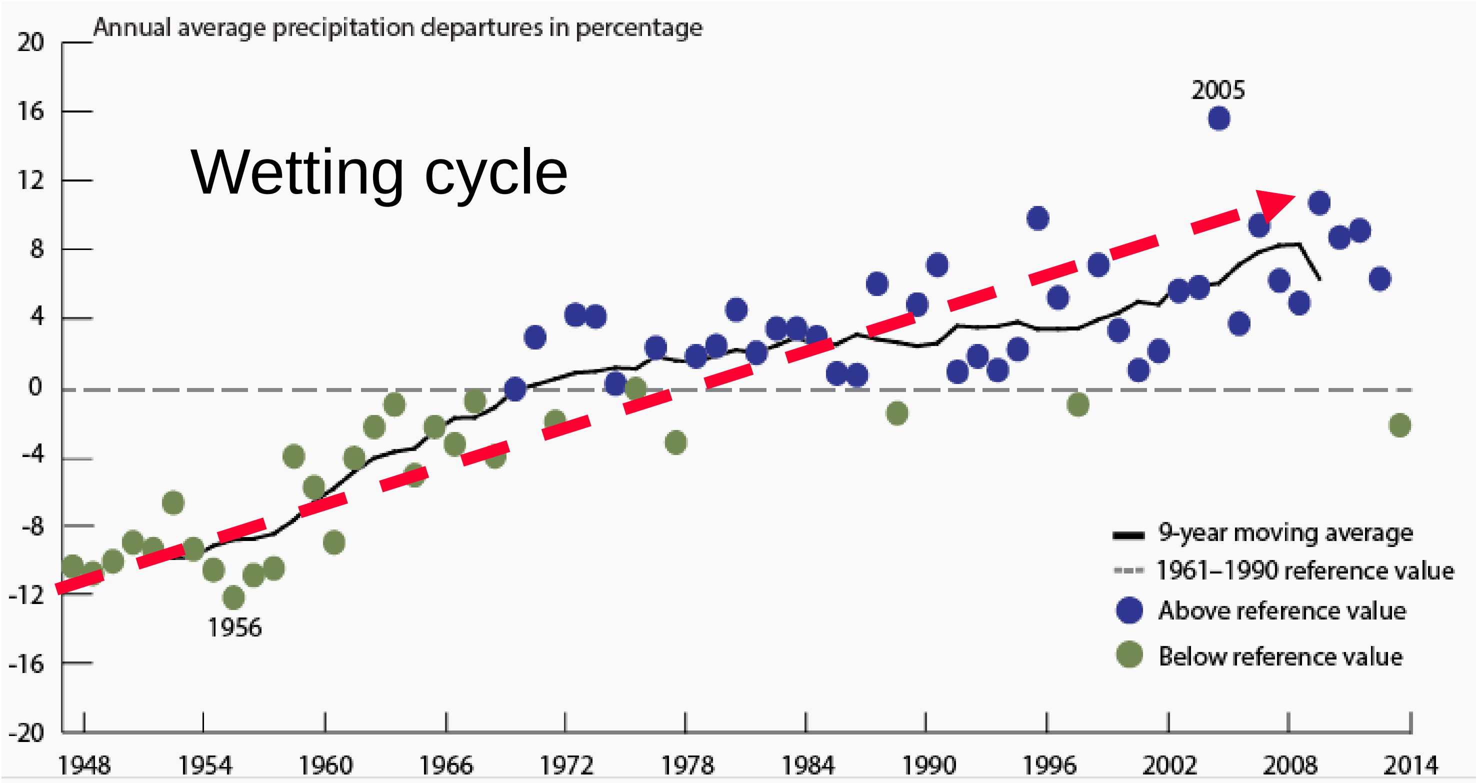
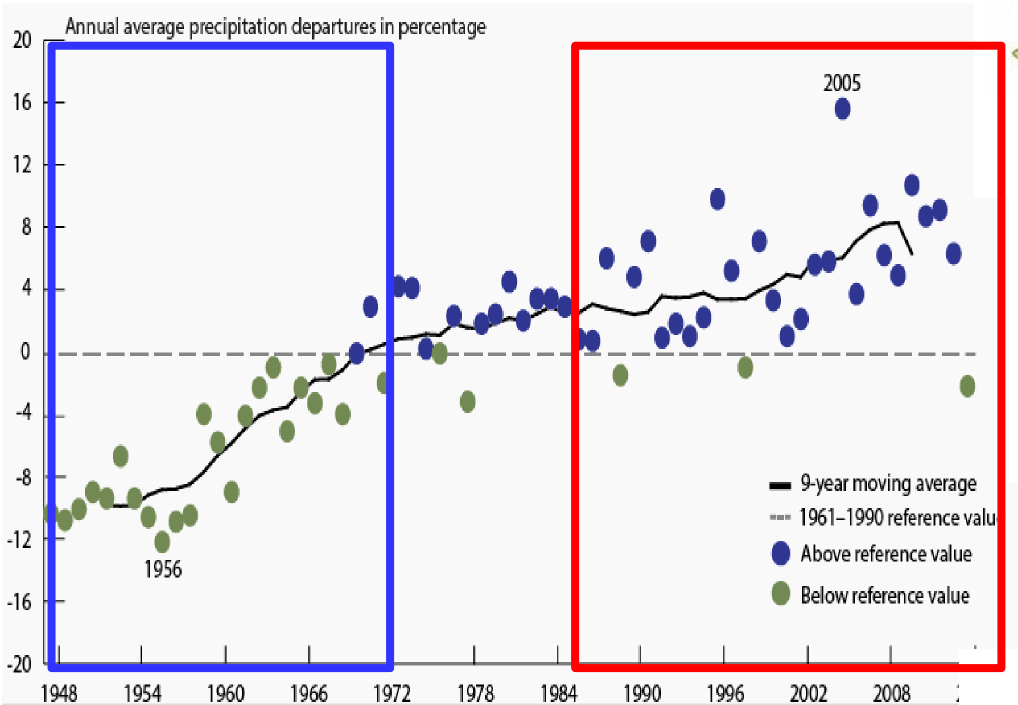
Climate Cycles: Precipitation (Canada)

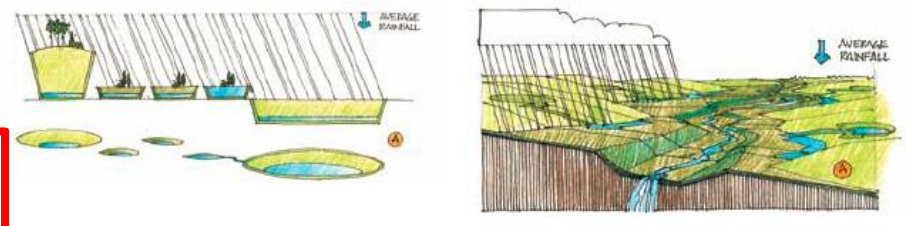


Cumulative departure from the mean is a good way to plot data to spot a trend from long term data, position in a cycle and the magnitude of change

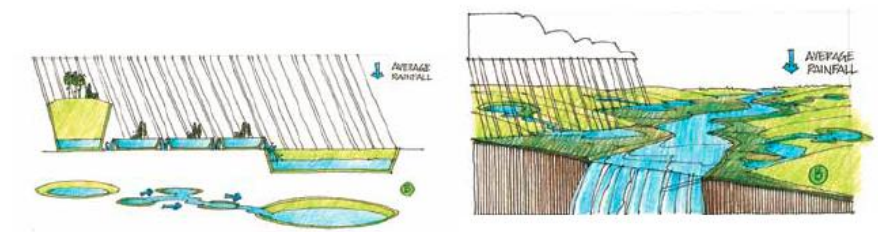
From engineering risk perspective



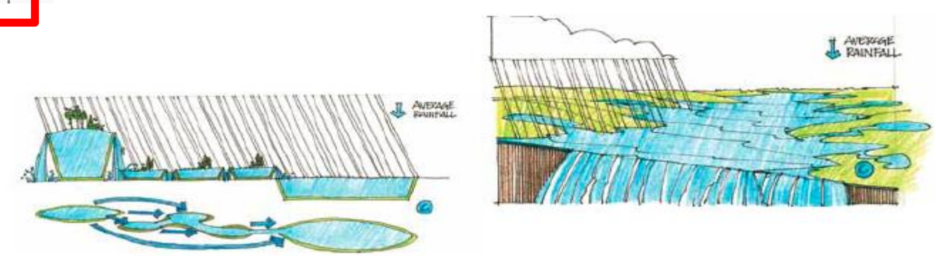
Past: Precipitation Deficit



Present: Precipitation Surplus



Future: Magnitude increase?



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Black Box Design Challenges

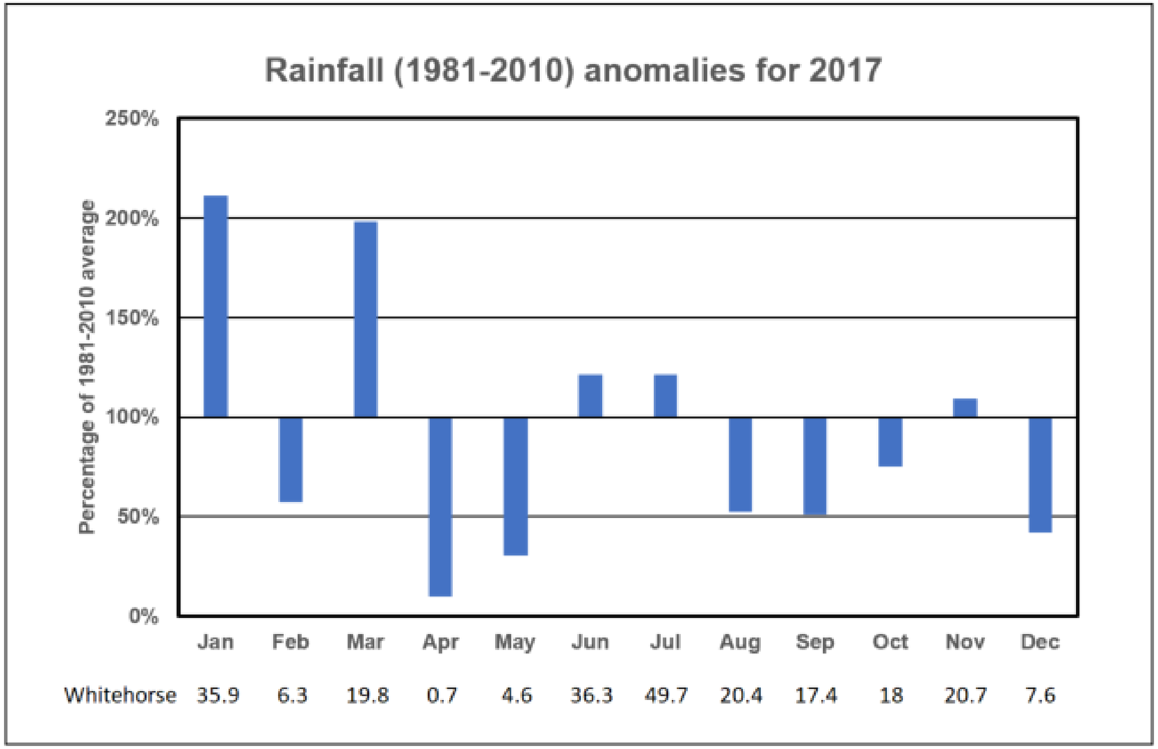
Annual Mean Temperature = 10°C

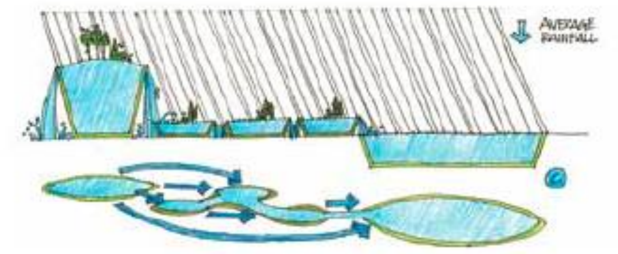
Annual Average Precipitation = 1200 mm

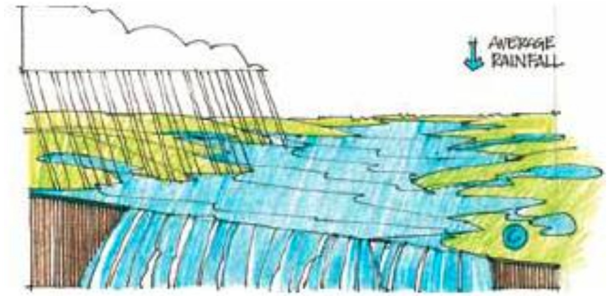
- If we are using a black box, we need to know the validity of the data we are feeding into it
  - Use of annual climate averages masks underlying seasonality and dominant processes
- Consider the risk and appropriateness of diving into quantitative modelling using this framework as a starting point

Seasonality

Average mean rainfall: +10-15%, but if this is occurring in few months, magnifying extreme events. January 2017 had >200% average precipitation!







Annual changes on their own not likely suitable basis to quantify risk

Climate Risk Framework

- Appropriate climate framework leads to more realistic engineering performance expectations
- Framework for considering climate change in engineering planning as risk management tool for decision making.

$$\boldsymbol{Risk} = \textbf{Likelihood of Occurrence} \times \textbf{Consequence}$$

An FMEA is an

Excellent Tool / Framework

to

Enhance / Facilitate

Discussion of climate change

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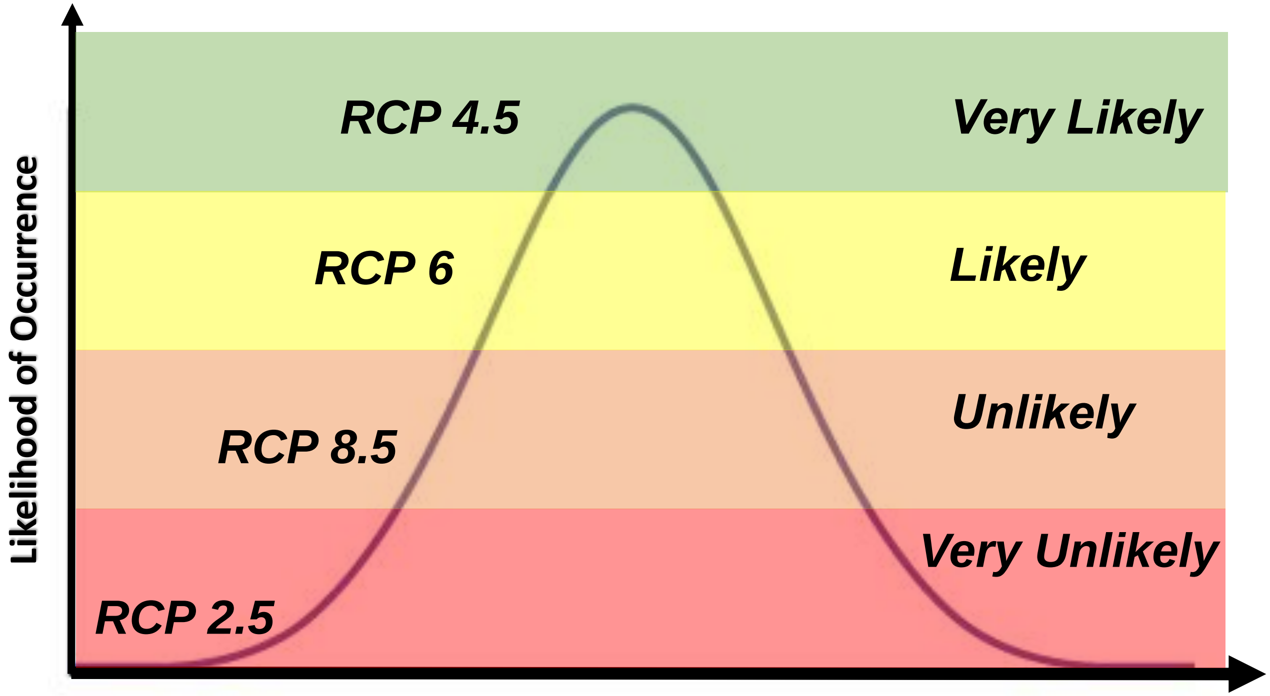
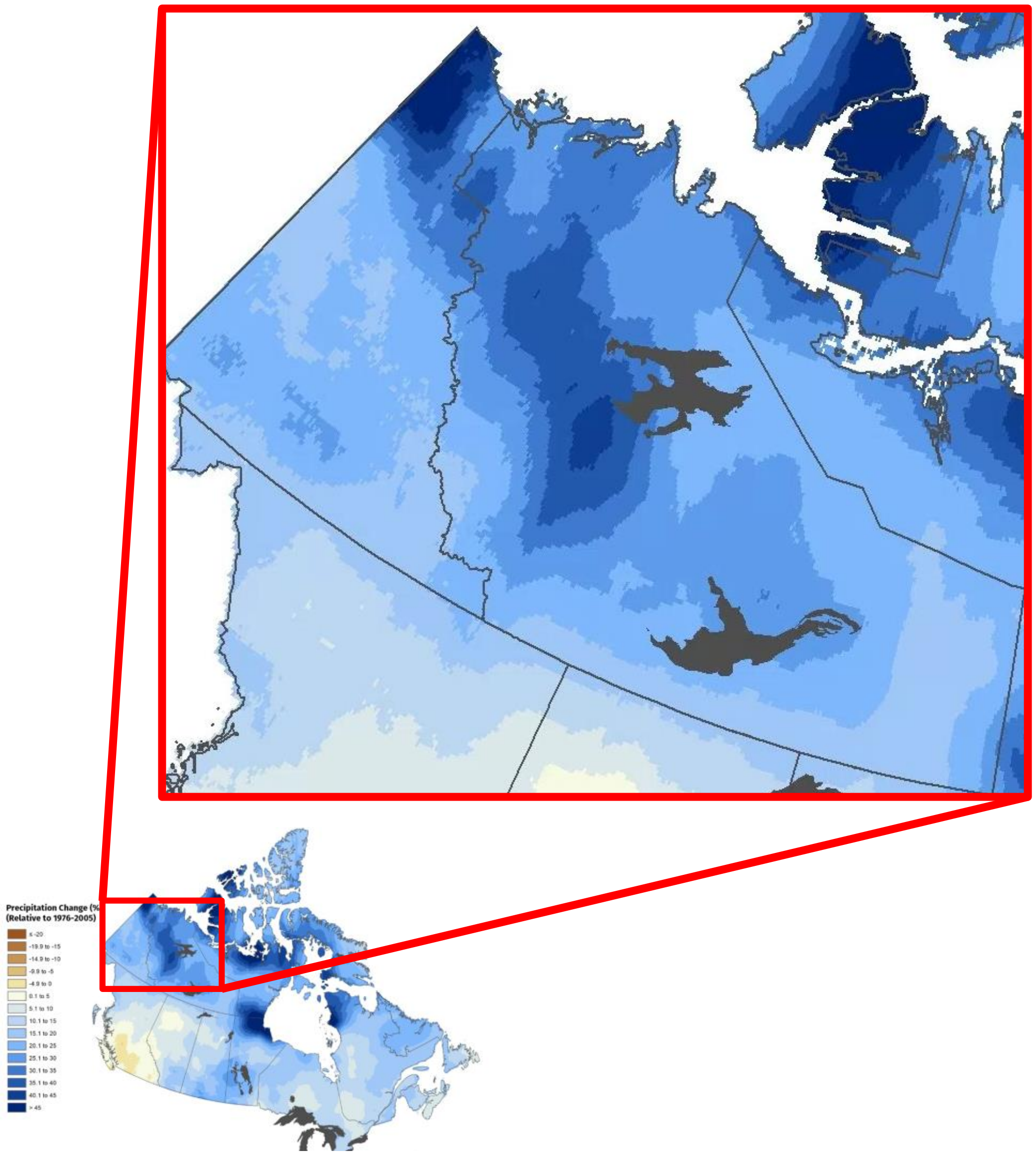
Likelihood of Occurrence

- IPCC does not provide RCP probability.
- Need to Rank RCP's based on project risk profile



Likelihood is project/time specific - depends on the accepted risk profile

Precipitation Increase



- Under RCP4.5 precipitation is expected to increase up to 25% over the next century.
- This will cause an increase in runoff and net percolation.
- What will we do with this increase in precipitation?
  - Design?

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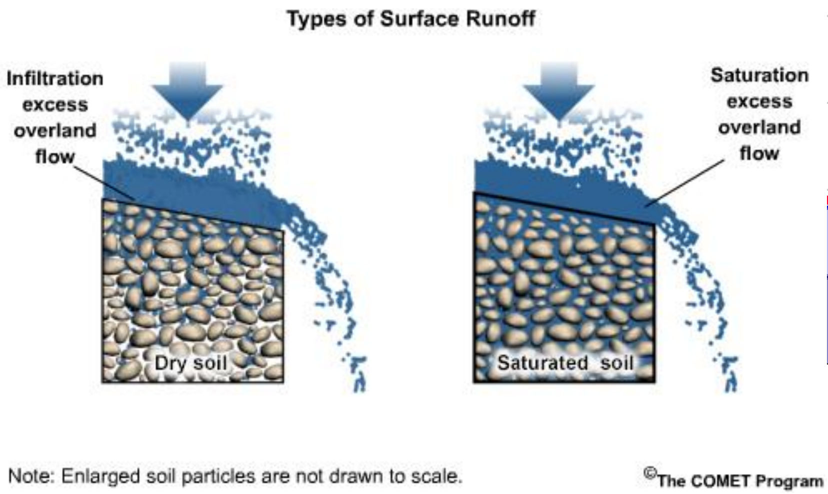
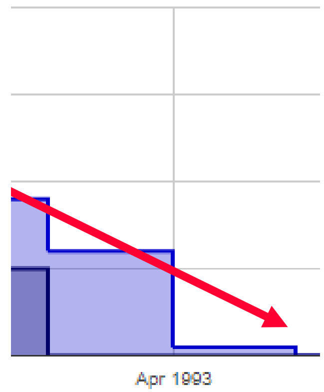
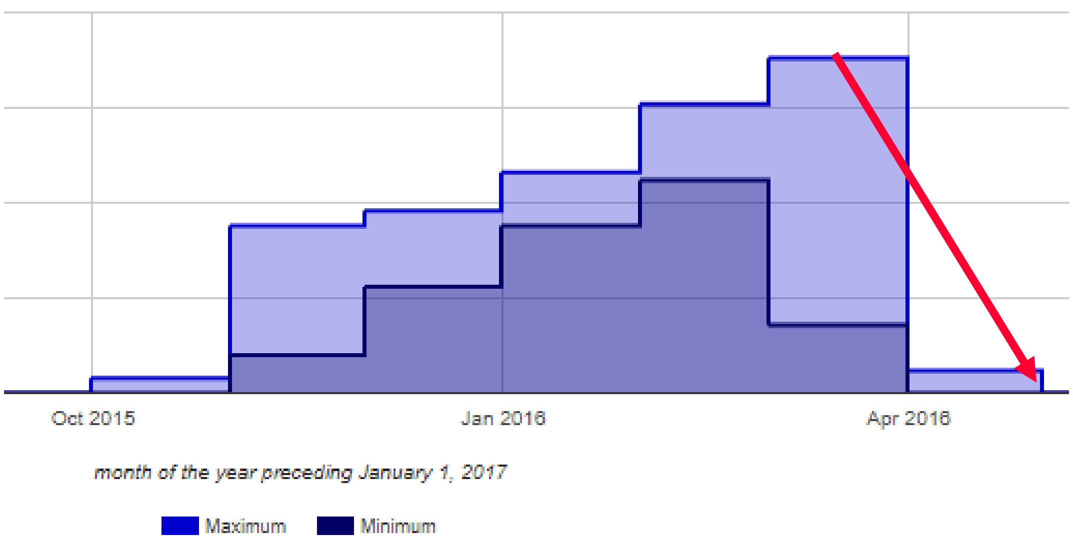
Snow on Ground







- Increase in temperature causing rapid snow melt in spring.
- Increasing magnitude of runoff.
- How will you handle the increase in runoff?

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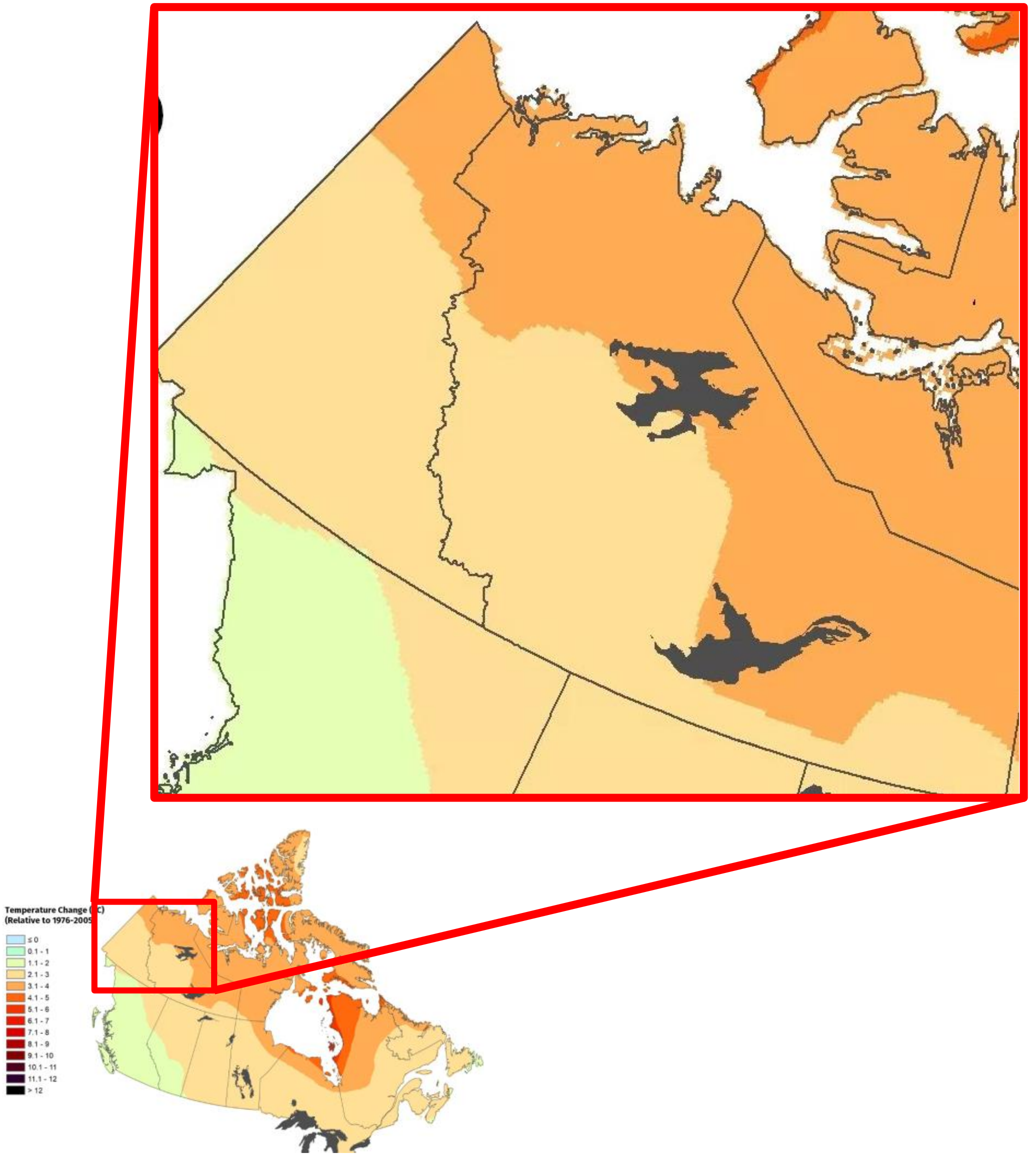
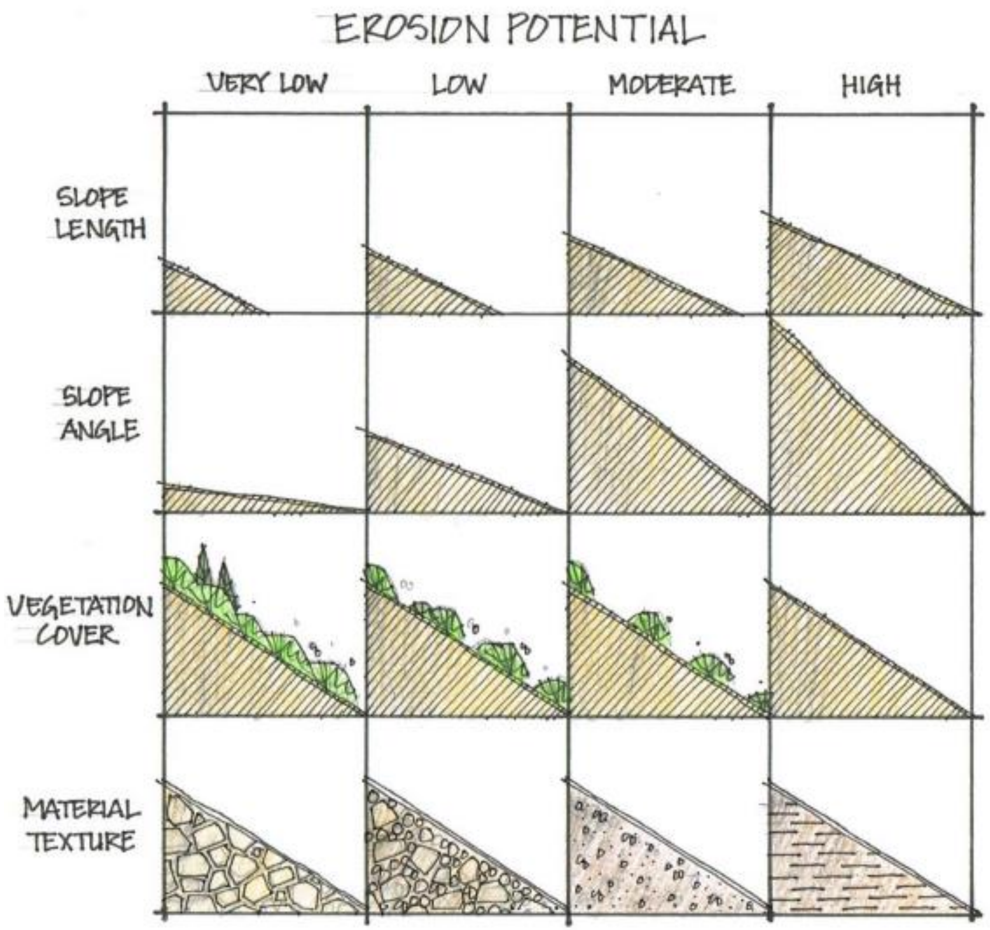
Temperature Increase

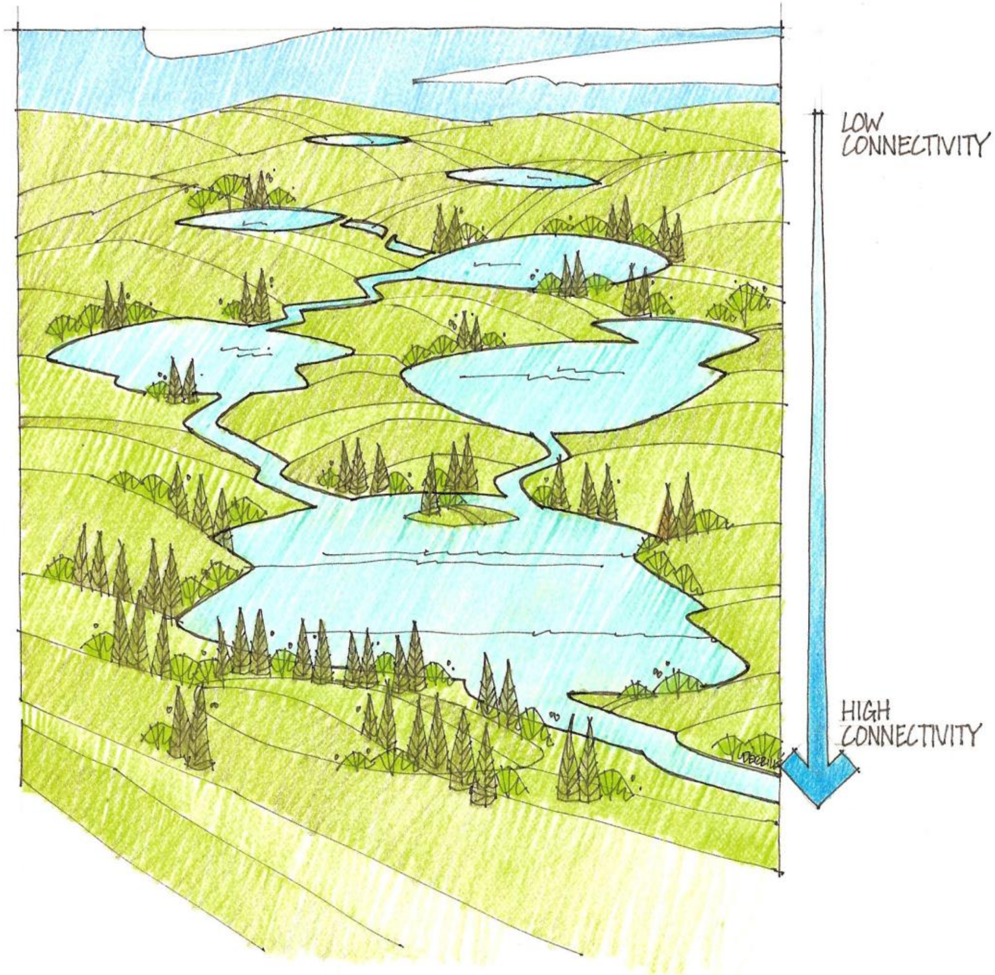


Permafrost Degradation



- Warmer temps → permanent thawing of permafrost.
- Resulting in unconsolidated, erosional soil.
- Where will this eroded soil go? What will be left?
  - Design slopes?

Water Considerations for the North



- Non stationarity in:
  - water balance
  - hydraulic connectivity
- Assumptions today may not hold true in the future for:
  - Landform Performance
  - Landscape integration / performance

Results on Cover System Design

- Overall, northern Canada will be within a ‘Hot Spot’ for climate change.
- Therefore, a resilient cover system design must be developed by thinking about tomorrow.
  - Materials today vs. tomorrow.
  - Change in water balance (PPT, RO, PET)
    - Water quality
    - Treatment volumes + max flow.

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Supporting:

- Rainbow of Hope for Children,
- Habitat for Humanity Initiative – El Salvador

Habitat for Humanity®

Rainbow of HOPE for Children

Supporting:

- Mine Overlay Site Testing Facility – University of Saskatchewan, Canada
- Centre for Minerals Environmental Research (New Zealand)