Analysis of Surface Water Quality at Seven Legacy Uranium Mines in Saskatchewan

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Engineering a better future for our planet and its people.

Our Vision

We create sustainable solutions that connect people, data and technology to design, deliver and operate the most complex projects.

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The Saskatchewan Research Council (SRC) is one of Canada's leading providers of applied research, development and demonstration (RD&D) and technology commercialization. We are a Treasury Board Crown Corporation in the Province of Saskatchewan, and serve clients across Saskatchewan and the world in four main areas:

- Energy
- Environment
- Mining and Minerals
- Agriculture and Biotechnology

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Background

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Project CLEANS (**CLE**anup of **A**bandoned **N**orthern **S**ites)

- 37 cold-war era legacy uranium mine and mill sites
  - Gunnar Mine and Mill
  - Lorado Mill
  - 35 “Satellite Sites”
- Managed by SRC on behalf of SK Ministry of Energy & Resources
- Goal: Ensure the sites are safe, secure, and stable for transfer into the province’s Institutional Control Program

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Outline

- Background
  (Introduce the Sites)
- Problem/Challenges
- Approach/Methodology
- Outcome
- Questions/Discussion

N.L ABC Mine

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The Seven Sites

- Abandoned uranium mines that were operational between the 1950s to 1970s located near Uranium City
- Ore was processed off site
- No tailings present at the sites
- SK Ministry of Environment is the main regulator
- Remediation completed at six sites

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Previous Remediation Activities

- Closure of mine openings
- Gamma shield soil cover
- Perimeter fence around unstable underground mine working
- Collection and burial of legacy debris
- Slope regrading

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Additional Context

- Region historically impacted by mining activities
- Remote and seldom accessed by the public
- Traditional land use (hunting, fishing, etc.) should be considered
- Protection of human health and safety has been the main driver, but environmental considerations cannot be ignored

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Problem/Challenges

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Problem/Challenges

- SRC has completed several years of surface water monitoring program at these sites
- A preliminary review of this data identified the need for further critical analyses in the following areas:
  - Water quality exceedances
  - Insufficient understanding of contaminant sources
  - Accessing the underground water quality
  - Potential risk to human health receptors
  - Development of site-specific objective is costly
  - Available resources vs. scale/complexity of the site

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Approaches/Methodology

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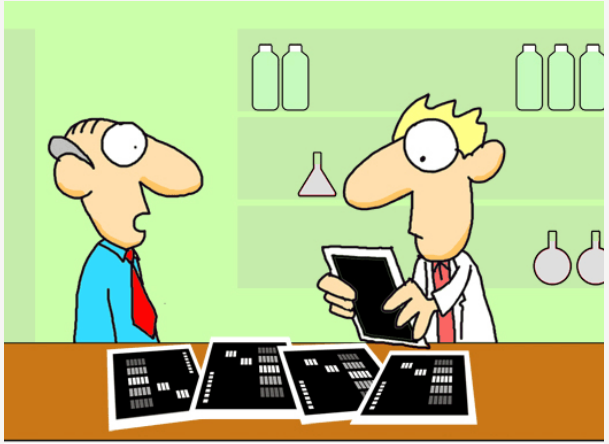
Approaches – Data Screening and Statistic Summary

- Type of Water Course
- Identify areas of high gamma radiation
- Identify background sample locations
- Remove outliers
- Identify maximum and 95 percentile
- Statistic Summary



"Data don't make any sense,
we will have to resort to statistics."

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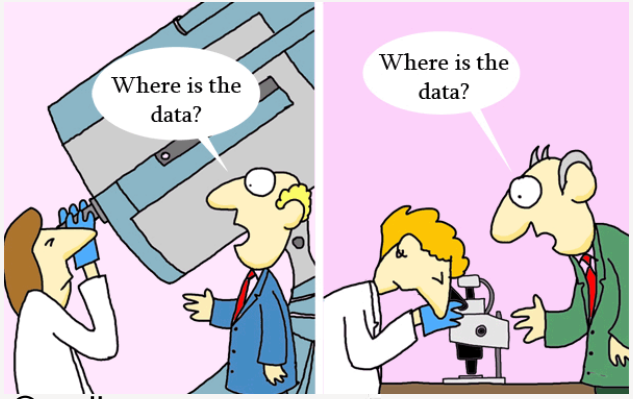
Approaches – Data Review

- Compare with applicable regulatory criteria
- Review and Refine SOPC list
- Retain chemicals as Substance of of Potential Concerns in refined date set that contains:
  - the maximum concentration exceeds Tier 2 SEQS
  - the maximum concentration exceeds background concentrations
  - the chemical is related to site activities



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Approaches – Data Interpretation

- Further Statistic Summary of the exceedances
- Compare upstream and downstream data
- Determine whether exceedances are presented at downstream locations
- Calculate potential loading to receiving environment
- Determine surfacewater concentration trend
- Calculate CCME water quality index for various areas of the Site
- Data gap and a remedial plan

CCME Water Quality Index (WQI)

- The WQI incorporates the following three elements of water quality data:
  1. *Scope* – the number of parameters whose guidelines are not met
  2. *Frequency* – the number of time these guidelines are not met
  3. *Amplitude* – the amount by which these guidelines are not met
- These elements are combined as the summation of the three vectors to produce a single value between 0 and 100 that describes the water quality for a given location (CCME, 2017).

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CCME Water Quality Index (WQI) – Sample output

Sampling Stations	WQI for Potable Water[a]	WQI for Aquatic Life[a]	WQI for Livestock Watering[b]
Upstream			
Jean Lake, upstream from the mine site (Cayzor 2)	97 – Excellent	85 – Good	100 – Excellent
Pond/creek sampling stations upstream from the mine site (Cayzor 6, 8)	95 – Excellent	92 – Good	100 – Excellent
Main Site Area			
Runoff or pooled water at or adjacent to the main site area (Cayzor 4, 5, 7)	60 – Marginal	49 – Marginal	89 – Good
Jean Lake, adjacent to the main site area (Cayzor 1)	85 – Good	78 – Fair	95 – Excellent
Downstream			
Jean Lake, downstream from the mine site (Cayzor 3)	100 – Excellent	96 – Excellent	100 – Excellent

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Cayzor

Evidence	Yes/No[1]	Comments
Exceedances of human receptor criteria (potable water)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
Exceedances of ecological receptor criteria (protection of aquatic life)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
CCME WQI upstream water quality "fair" or better[2]	Yes	"Good" with respect to aquatic life, and "excellent with respect to potable water
CCME WQI downstream water quality "fair" or better[2]	Yes	"Excellent" with respect to all criteria examined
CCME WQI receiving environment adjacent to site water quality "fair" or better[2]	Yes	"Fair" with respect to aquatic life, and "good" with respect to potable water
CCME WQI onsite runoff and/or pooled water quality "fair" or better[2]	No	"Marginal" with respect to aquatic life and potable water – skewed by water quality in pooled water (Cayzor 4). Not considered source of drinking water or significant aquatic habitat.
Downstream water quality significantly poorer than upstream water quality	No	No statistical difference in priority SOPC concentrations (uranium and radium 226)
SOPC source is likely related to the site	Yes	Significant upstream sources are not suspected, however trenching and exploration activities are known to have occurred along the stream that feeds Jean Lake (GSC, 1971).
Priority SOPC concentrations in the receiving environment, stable, decreasing or indeterminate	Yes	Uranium – stable Radium 226 – stable in the receiving environment near the site, indeterminate downstream

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Rix-Smitty

Evidence	Yes/No[1]	Comment
Exceedances of human receptor criteria (potable water)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
Exceedances of ecological receptor criteria (protection of aquatic life)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
CCME WQI upstream water quality "fair" or better[2]	Yes	"Excellent" with respect to all criteria examined
CCME WQI downstream water quality "fair" or better[2]	Yes	"Good" with respect to the protection of aquatic life and "excellent" with respect to potable water.
CCME WQI receiving environment adjacent to site water quality "fair" or better[2]	N/A	Although there are sample stations located in the former beaver pond downstream of the Zone-62 Adit, only the station in Emu Lake (at the outlet) was considered to be representative of the receiving environment downstream of the site.
CCME WQI onsite runoff or pooled water quality "fair" or better[2]	No	Drainage from Zone-62 Adit is "poor" with respect to the protection of aquatic life and "marginal" with respect to potable water. Other runoff/pooled water onsite is "fair" with respect to the protection of aquatic life and "good" with respect to potable water.
Downstream water quality significantly poorer than upstream water quality	Yes	There was a statistically significant difference in concentration of priority SOPCs (uranium and radium-226) upstream (Boom Lake) and downstream (Emu Lake) of the site.
SOPC source is likely related to the site	Yes	Significant upstream SOPC sources are not suspected, and the comparison of upstream and downstream concentration suggests that the site is contributing to an increase in chemical concentrations.
Priority SOPC concentrations in the receiving environment, stable, decreasing or indeterminate	Yes	Uranium – Stable downstream of the site in Emu Lake Radium-226 – no trend downstream of the site in Emu Lake

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Outcome

- A multiple line of evidence approach
- Able to identify potential risk to human health
- Determined that no significant remedial actions are needed
- Collaborative approach between client and consultant was helpful
  - SRC able to provide the context, while SNC-Lavalin able to provide technical expertise
  - Regulators and client able to understand the significance of findings
- Site conditions of six sites accepted by Ministry of Environment
- Rix-Smitty under risk assessment

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Acknowledgement

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Questions?

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INTEGRITY	*We do the right thing, no matter what, and are accountable for our actions.*
COLLABORATION	*We work together and embrace each other's unique contribution to deliver amazing results for all.*
INNOVATION	*We redefine engineering by thinking boldly, proudly and differently.*

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