Saskatchewan Research Council

Planning Radiological Risk Mitigation for Remediation of Abandoned Uranium Mines

Elizaveta Petelina, M.Sc., MSEM, EP, PAg

David Sanscartier Ph.D., P.Eng.

Alexey Klyashtorin Ph.D.

RemTech 2019, Banff, Alberta, Oct 16-18, 2019

The Saskatchewan Research Council (SRC) is a provider of applied research, development and demonstration and technology commercialization. We are a provincially-owned corporation in Saskatchewan and serve clients world-wide in four main areas:

- Environment
- Mining
- Energy
- Agriculture and biotechnology

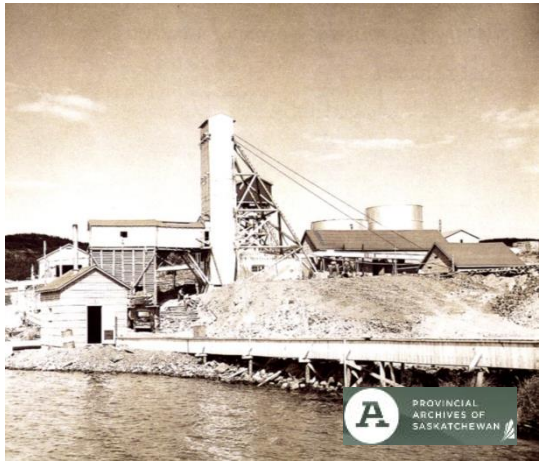
Objective

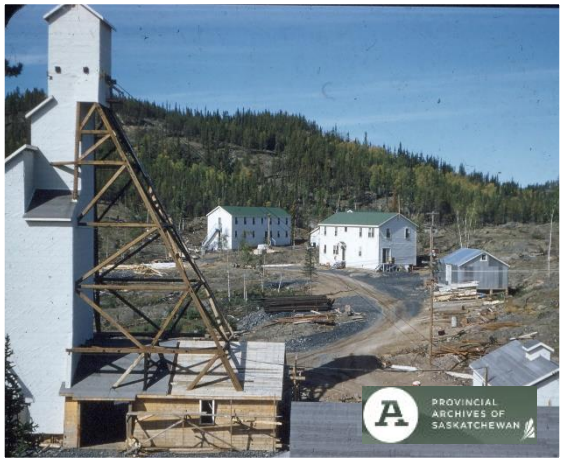
Present the remediation and risk assessment approach used for planning remediation of radiological-impacted remote uranium legacy mines

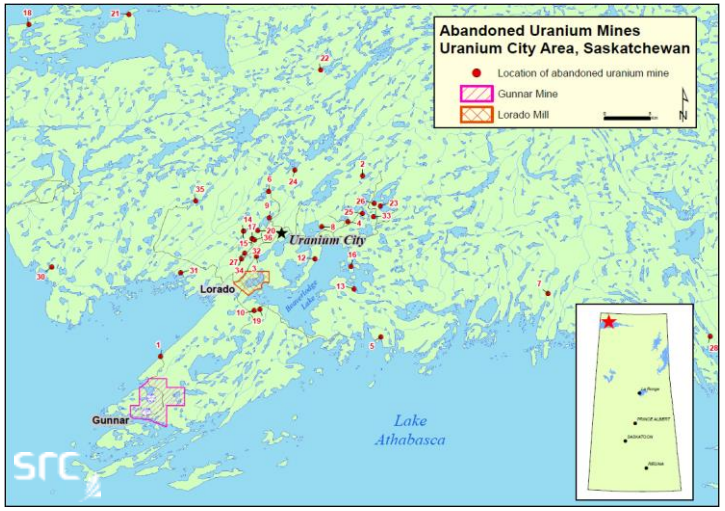
Project CLEANS

Cleanup of Abandoned Northern Sites

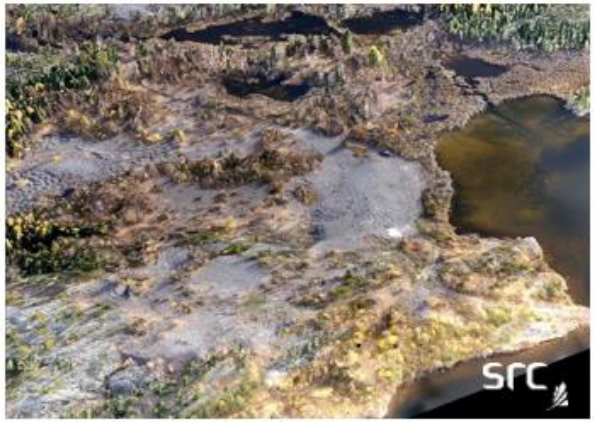
- Started in 2007
- Managed by SRC on behalf of SK Ministry of Energy and Resources
- 37 Sites (36 abandoned mine sites and 2 closed mills)
- Northern shore of Lake Athabasca near Uranium City







3 Satellite Site Case Studies

	Cayzor Uranium Mine	Rix-Athabasca Uranium Mines – Smitty Mine	Nesbitt-Labine Uranium Mines – Eagle Mine
Historical Photos			
Recent Photos			

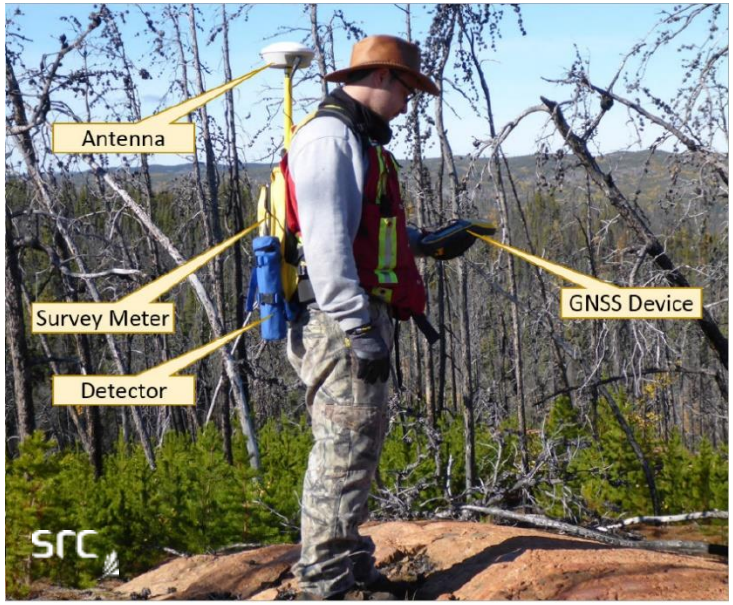
Methodology

Remediation Objectives

- Objective 1: 1 µSv/h above background on average per hectare
- Objective 2: 2.5 µSv/h above background per 2x2 m spot

Gamma Surveys

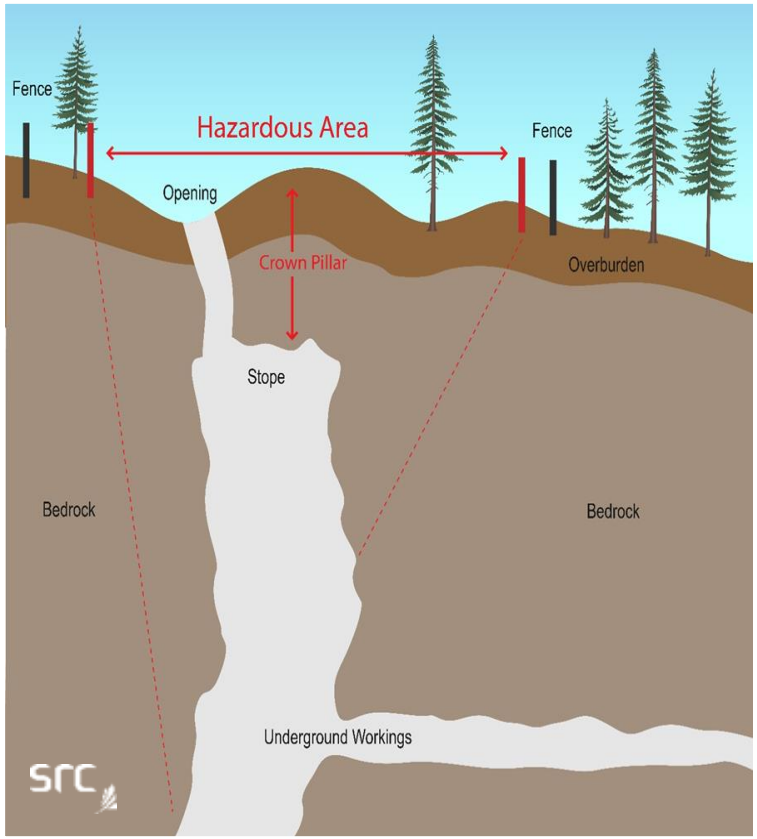
- 2-inch NaI detector with GPS
- 1 m above the ground
- Data processed with ArcGIS
- 2x2 m regularized data used for analysis



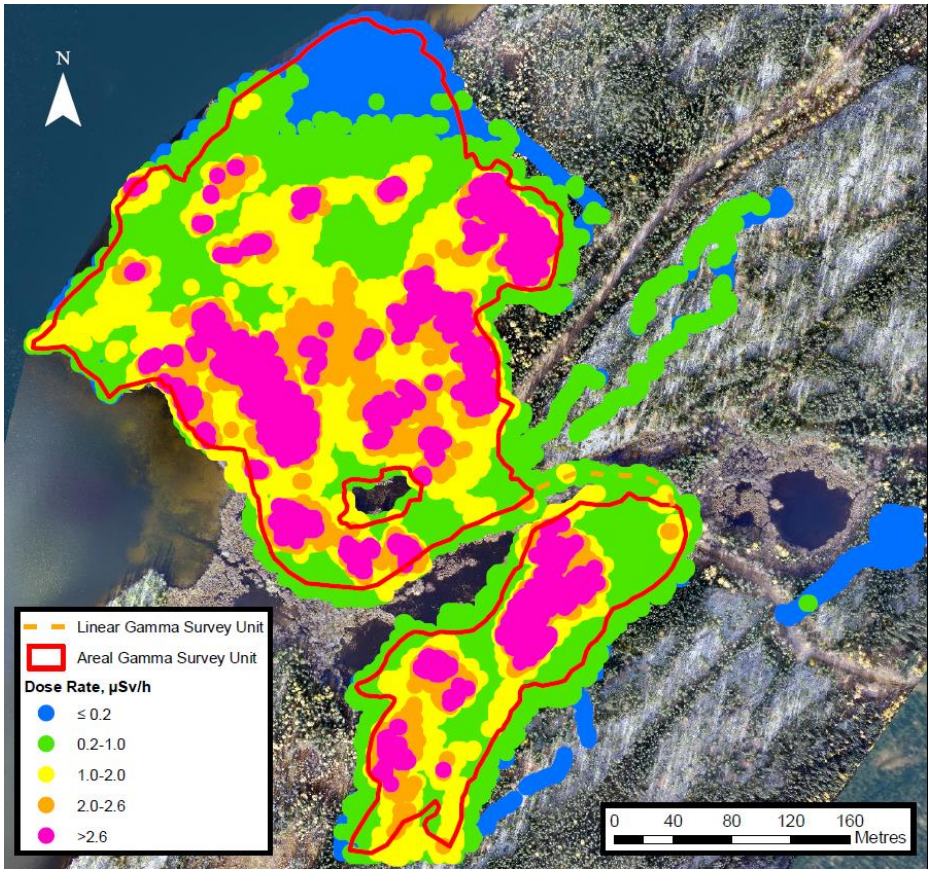
Remediation Approach

- 30 cm soil cover installed on most of the hot spots except:
  - Fenced areas
  - Steep slopes, trenches, exposed bedrocks
- Risk assessment if objectives not achieved: modelling with ArcGIS to estimate gamma levels after remediation:
  - Assuming 30 cm soil cover (reduction by 2 per 10 cm lift)
  - Excluding fenced areas

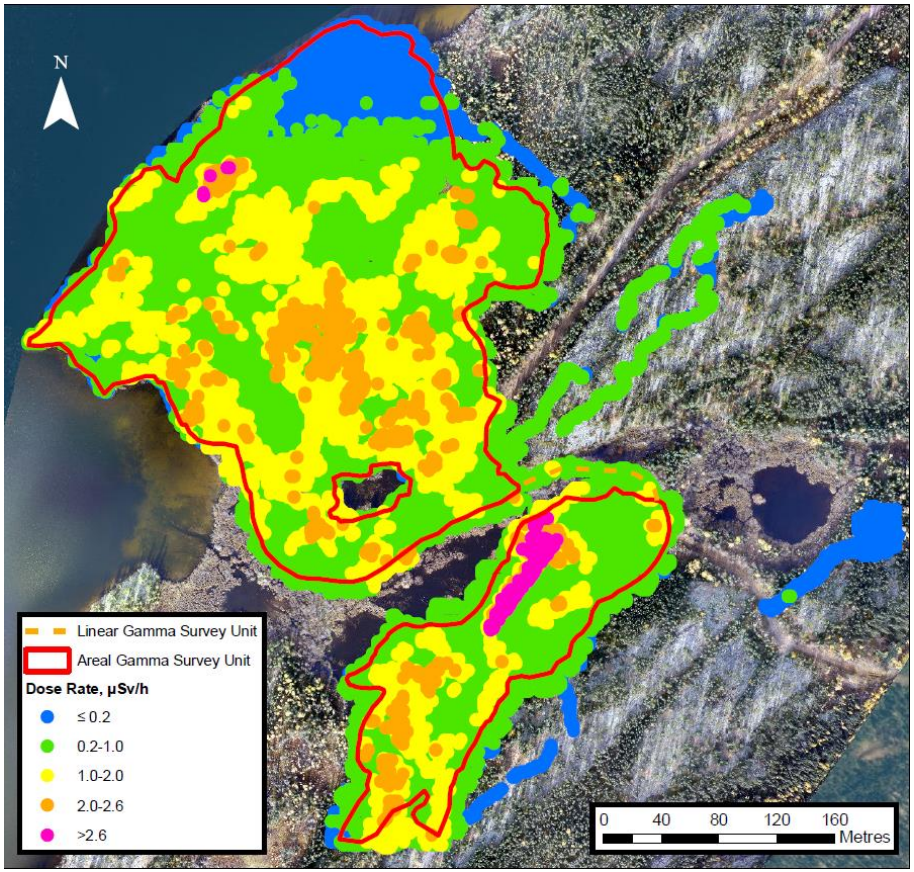
Perimeter fence around hazardous underground areas



Cayzor Spot Gamma Dose Rates



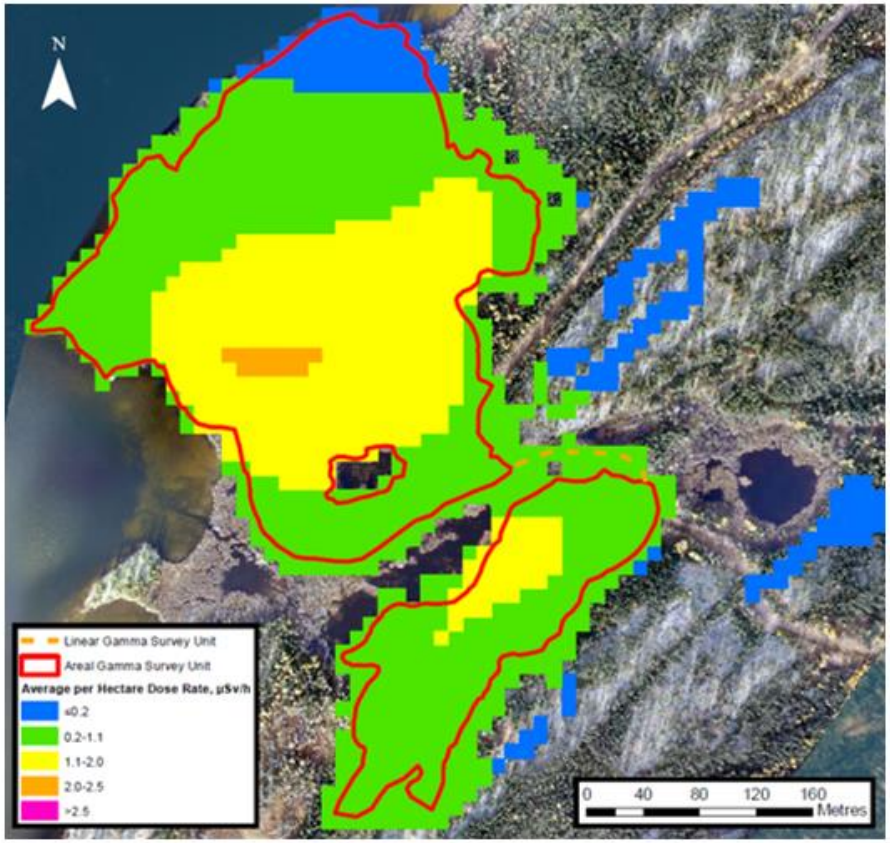
Before Remediation (actual data)



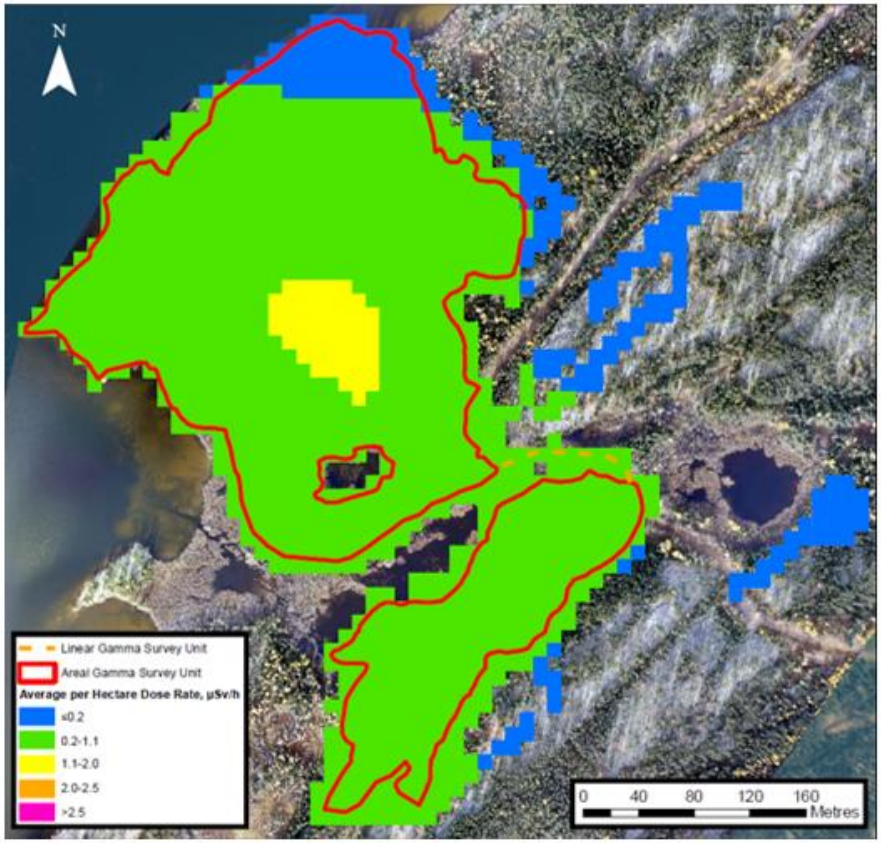
After Remediation (modelled data)

Objective Not Achieved => Risk Assessment

Cayzor Average per Hectare Gamma Dose Rates



Before Remediation (actual data)



After Remediation (modelled data)

Objective Not Achieved => Risk Assessment

Site Specific Gamma Dose Rates Before & After Remediation

Site	Obj. 1, (µSv/h)	Obj. 2, (µSv/h)	Remed. Stage	Site Dose Rates (µSv/h)	Objective 1		Objective 2		
					Average Dose Rate per ha (µSv/h)	Achieved	Total Hot Spot Area (ha)	Average Hot Spot Dose Rate (µSv/h)	Achieved
Cayzor	1.1	2.6	Before	0.1 – 9.4 (1.3)	0.1 – 2.1 (0.8)	No	2.0 (19%)	2.5	No
			After	0.1 – 9.4 (0.8)	0.1 – 1.3 (0.6)	No	0.2 (2%)	2.1	No
NL Eagle	1.2	2.7	Before	0.04 – 10.6 (0.5)	0.1 – 1.0 (0.3)	Yes	0.5 (5%)	2.4	No
			After	0.04 – 4.8 (0.3)	0.1 – 0.5 (0.2)	Yes	0.02 (0.2%)	1.3	No
Rix-Smitty	1.1	2.6	Before	0.1 – 11.4 (1.0)	0.1 – 2.0 (0.6)	No	0.9 (11%)	2.8	No
			After	0.1 – 2.6 (0.5)	0.1 – 0.7 (0.3)	Yes	None	1.0	Yes

Post Remediation Conditions

Smitty

- Objective 1: Achieved in full
- Objective 2: Achieved in full (all hot spots either covered or fenced)

Eagle

- Objective 1: Achieved in full
- Objective 2: Not achieved in full, but total hot spot area decreased from 0.5 to 0.02 ha

Cayzor

- Objective 1: Not achieved in full, but 30% reduction of average gamma dose rates over a hectare
- Objective 2: Not achieved in full, but total hot spot area decreased from 2 to 0.2 ha

Radiological Risk Assessment Method

Applied Radiation Dose Limits:

- 1 mSv/a – Radiation Dose Limit for Public (Canadian Nuclear Safety Commission, 2017)
- 0.3 mSv/a – Recommended Value for Control of Public Exposure to be protective for people visiting a few sites (NORM, Health Canada, 2011)

Four Exposure Scenarios for Public Exposure

Scenario	Exposure Area	Exposure Time	Average Dose Rate (DR)
1	Entire Site	Maximum Current Land Use (as per the land use surveys)	Site Average DR
2	Hot Spot Area	Maximum Current Land Use (as per the land use surveys)	Hot Spot Average DR
3	Entire Site	Permissible Land Use (10 days per year = 240 h/a)	Site Average DR
4	Hot Spot Area	Permissible Land Use (10 days per year = 240 h/a)	Hot Spot Average DR

Risk Assessment Results

Site	Before Remediation					After Remediation				
	Incremental Dose Current Site Condition mSv/a				Remediation required	Incremental Dose Modelled Data mSv/a				Remediation required
Scenario	1	2	3	4		1	2	3	4	
Cayzor	0.01	0.03	0.31	0.60	Yes	0.01	N/A*	0.19	N/A*	No
NL Eagle	0.02	0.08	0.12	0.58	Yes	0.01	N/A*	0.07	N/A*	No
Rix Smitty	0.01	0.02	0.24	0.67	Yes	N/A	N/A	N/A	N/A	No

*** - unrealistic scenario**

After Remediation Dose Rates < 0.3 mSv/a even under the conservative scenarios

Conclusion

- Proposed remediation approach resulted in significant improvement of site radiological conditions
- Risk assessment results showed that the remediation adequately mitigated the radiation risks even if the objectives are not achieved

Thank you
Questions?

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Elizaveta.Petelina@src.sk.ca
david.sanscartier@src.sk.ca

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