



▶ Protection against Radon in Saskatchewan's Uranium Mines and Mills

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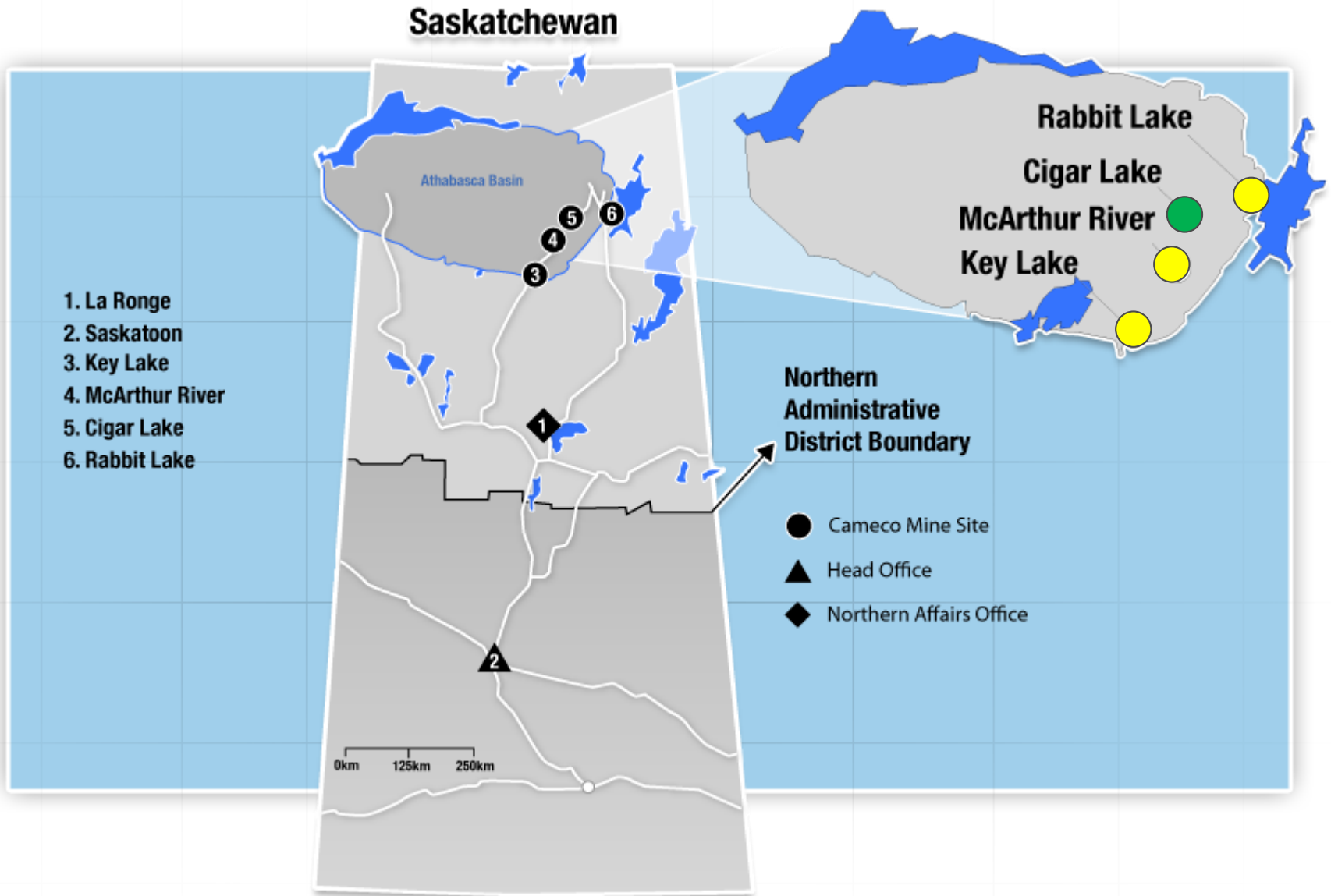


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► Protection against Radon in Saskatchewan's Uranium Mines

- **Cameco Overview**
- **Size and Scale of Radon Hazards**
 - How radon enters the mine
 - Mining Methods
- **Controls**
 - Ventilation
 - Code of Practice
- **Radon Monitoring**
 - Area
 - Personal

► Uranium Mines & Mills in SK



▶ Cameco Overview

- **Cameco's underground mines are high grade deposits**
 - World average of 0.1%
 - Rabbit Lake ~ 1% U₃O₈
 - McArthur River ~ 16% U₃O₈
 - Cigar Lake ~ 16% U₃O₈
- **High ore grades equate to high source terms of radiation, relative to the uranium industry**



Cigar Lake



McArthur River



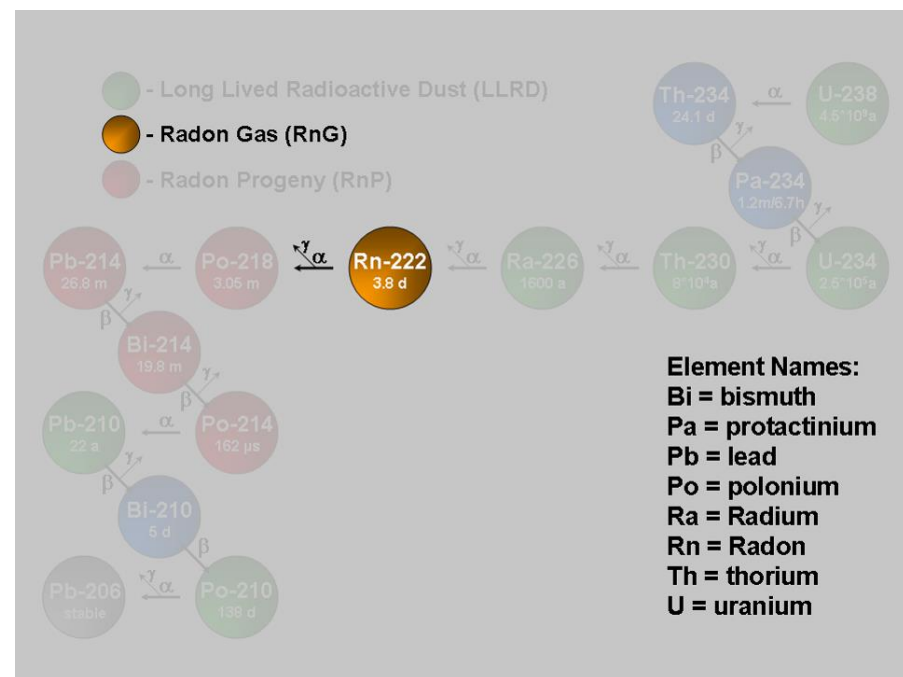
Rabbit Lake



Key Lake

▶ Radon Gas vs. Radon Progeny

- Radon Progeny is the health hazard. Radon is the source
 - Radon gas generated by breakdown of uranium
 - ◆ Measured in Bq/m^3
 - ◆ Mostly exhaled
 - RnP is a direct indication of the health risk
 - ◆ Measured in WL
 - ◆ Retained in the lung



▶ Radon Hazards

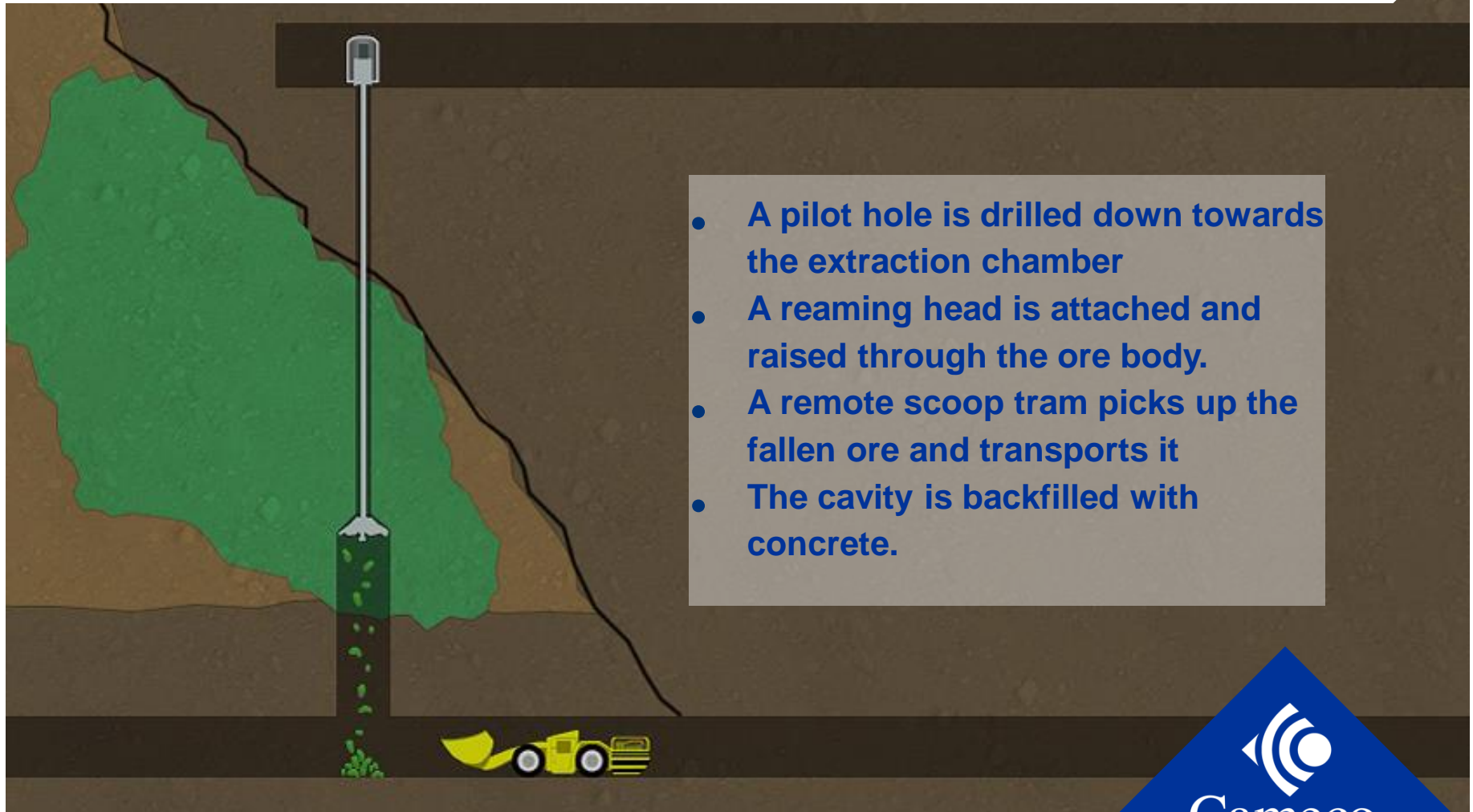
How Radon Gas (RnG) Enters the mine



▶ Mining Methods

McArthur River – Raisebore Mining

- In high grade, don't allow tunnels to enter the ore body

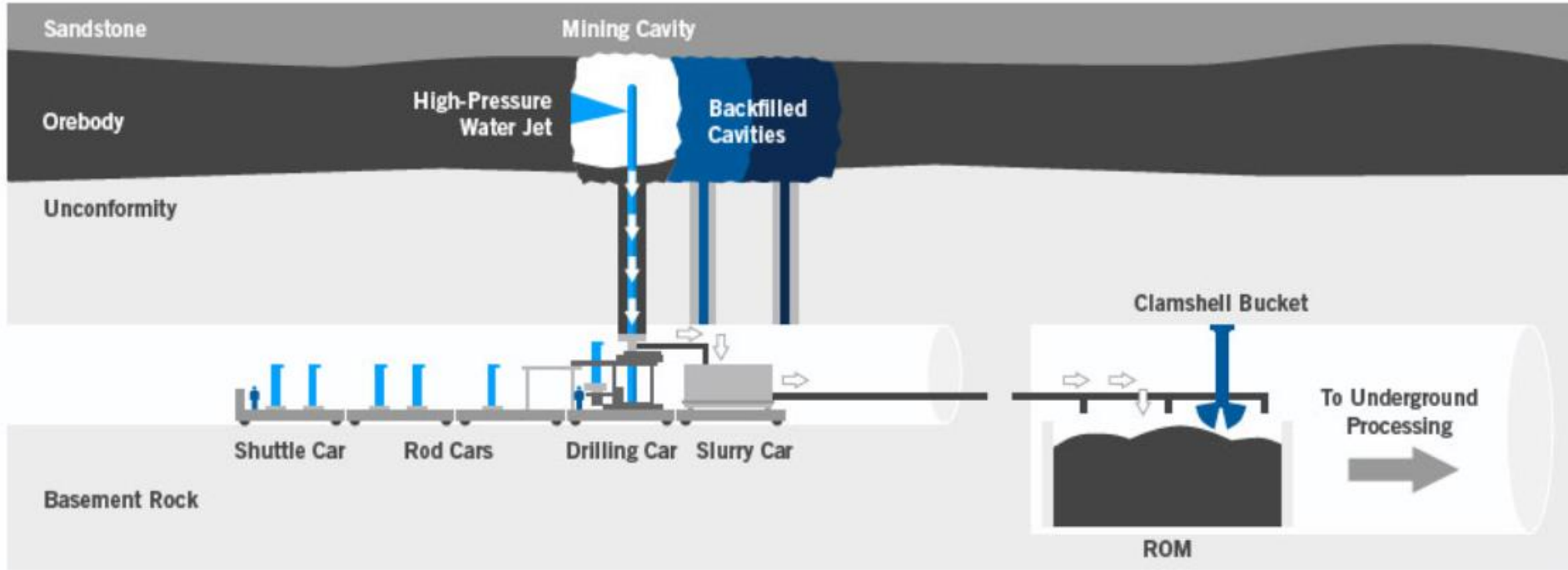


▶ Mining Methods



Mining Methods

Cigar Lake – Jet Boring System



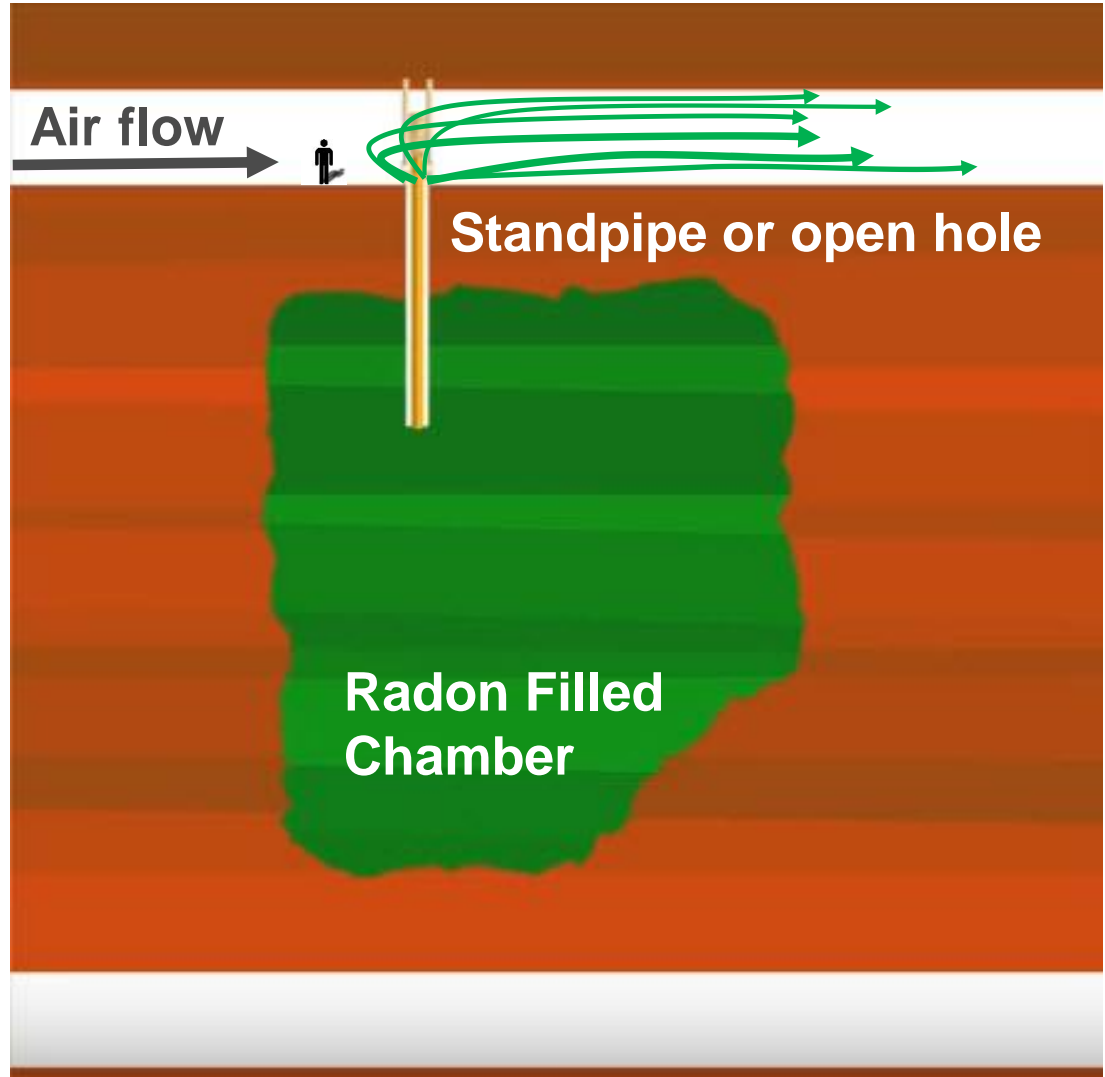
► Cigar Lake – Jet Boring System



▶ Hazards – Sources and Controls

Areas of Elevated Radon Progeny (RnP)

- Upcasting
- Backfilling



Hazards – Sources and Controls

Areas of Elevated Radon Progeny (RnP)

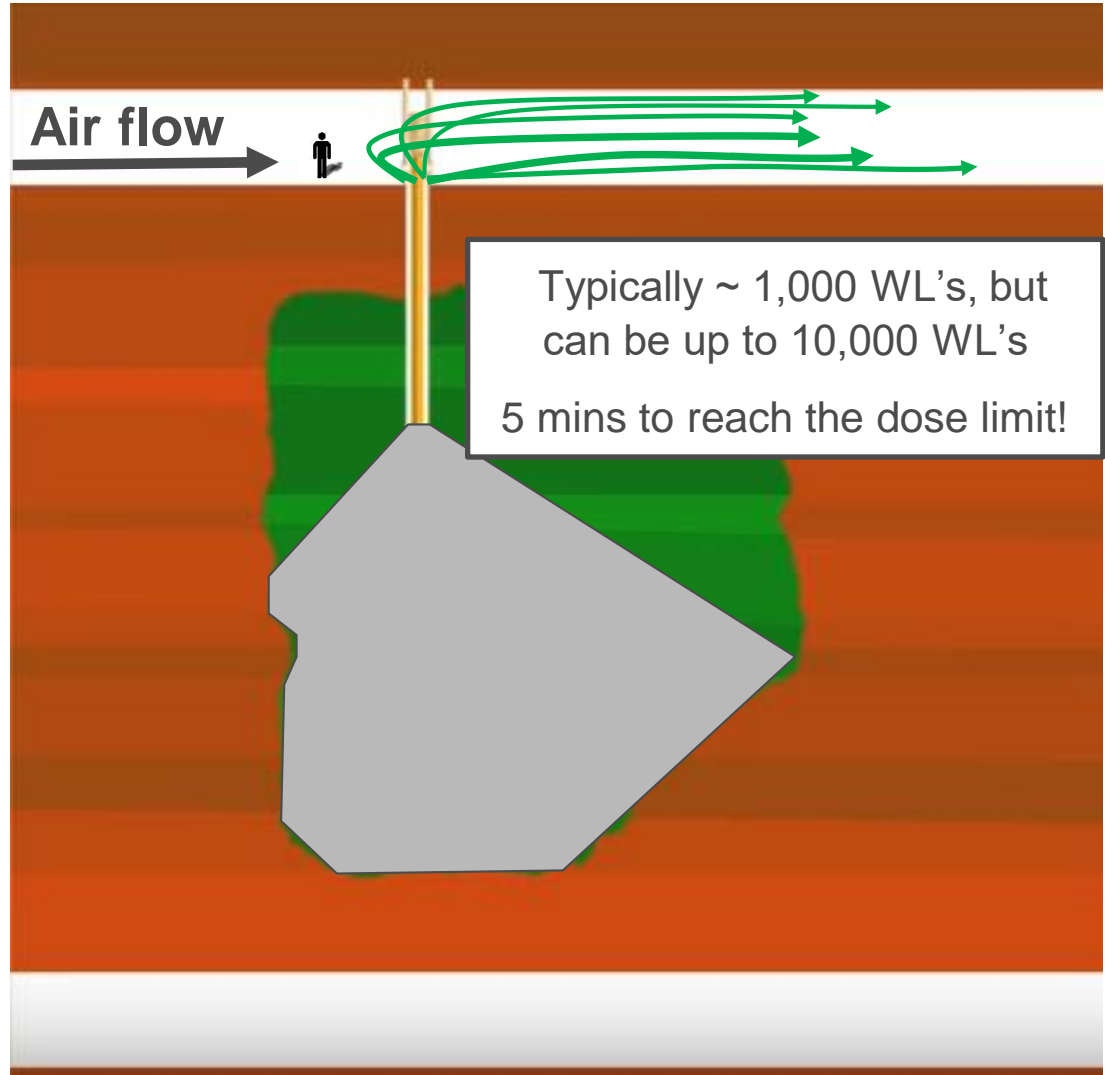
- Upcasting
- Backfilling

Reminder on Working Levels

1 WL = 3,700 Bq/m³
in EQ

1 WLM = Exposure to
1 WL for 170 Hours

Dose Limit = 4 WLM
= 20 mSv



▶ Controls for Radon



Ground freezing is used for geologic stability and controlling ground water inflows. It also aids in controlling radon entering the mine

▶ Ventilation

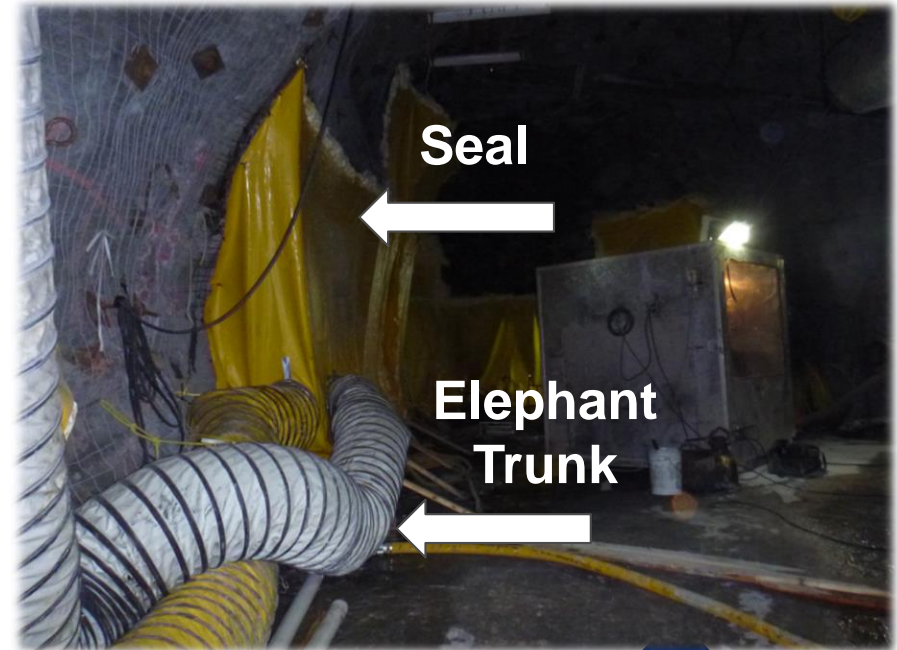
Primary

- One-pass ventilation
- ~ 600,000-900,000 CFM intake/exhaust
- ~ 20,000 CFM in a drift



Secondary

- Containment of sources
- Point source capture of sumps etc.



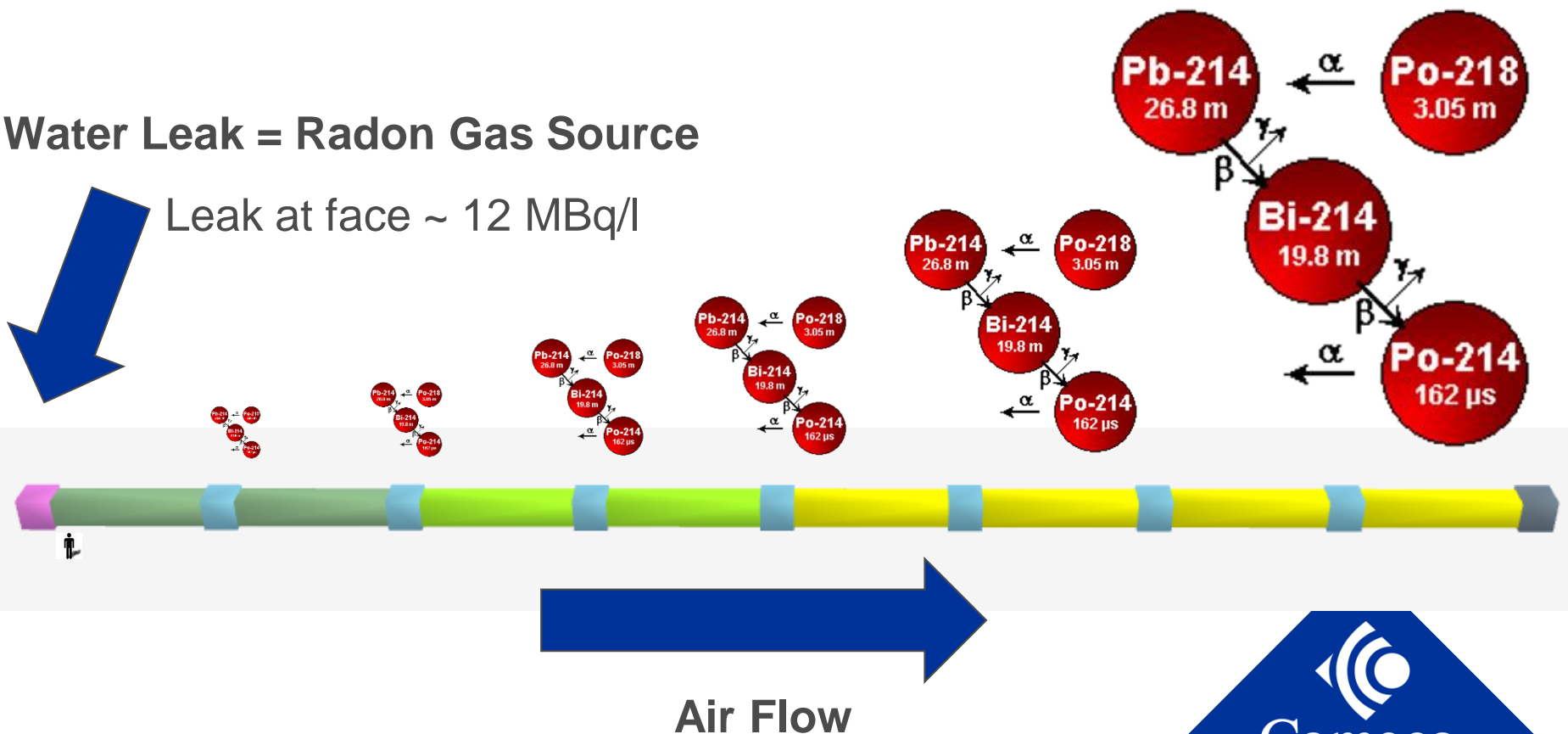
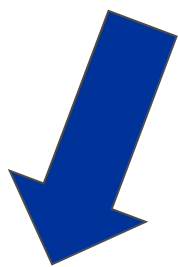
Ventilation

Air Movement Controls Radon Progeny (RnP) Levels

- The working level increases when the air “ages” as it moves along the mine
- Air flows from “Clean” to “Dirty”


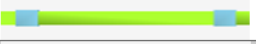

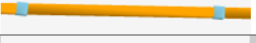

Water Leak = Radon Gas Source

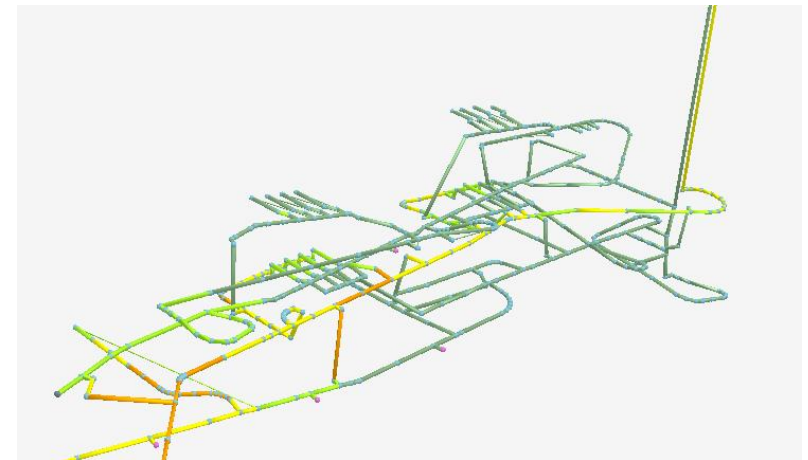
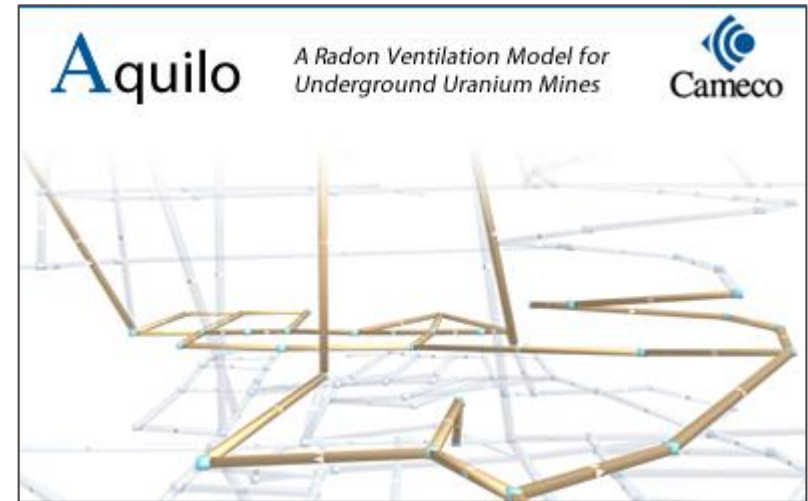
Leak at face ~ 12 MBq/l



Aquilo

- Aquilo is 3-D wire/node modelling software that uses grab sample and ventilation data to predict levels of Rn and RnP in underground mines.
- Full mine layouts can be evaluated for elevated radiological conditions.

	Color	RnP Level (WL)
Dark Green		0 to 0.10
Light Green		0.10 to 0.25
Yellow		0.25 to 0.50
Orange		0.50 to 1.00
Red		> 1.00



▶ Continuous Rn Progeny Monitor










- Continuous RnP Monitors sample every 10 minutes
- Provide real time conditions in the area



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Radiation Protection Program

• C

	Continue normal operations.
 	Investigate cause and correct if possible or contact shifter. After 4 hours, contact radiation department to investigate.
	Investigate cause and correct if possible or contact shifter. After 2 hours, contact radiation department to investigate.
 	Stop routine work, inform shifter and the radiation department, and investigate / correct the cause. Restrict access and leave area within 1 hour if problem cannot be corrected.
	Leave area immediately, restrict access, then contact shifter and the radiation department to investigate.

Prism
Measures Radon
Progeny



Level	RnP Level	Time Limit
	0 – 0.1 WL	None
 	0.1 – 0.25 WL	4 Hours
	0.25 - 0.50 WL	2
 	0.50 – 1 WL	1
	> 1 WL	0

radiation**



▶ Personal Alpha Dosimeters



- PADS monitor the RnP exposure of underground workers.
- Worn and analyzed monthly.

Engineering Monitoring

Daily Area Grab Sampling

- RnP routinely sampled by Rad Techs
- 8,759 U/G samples at McA in 2017
- 4,985 U/G samples at Cigar in 2018

Rn Gas

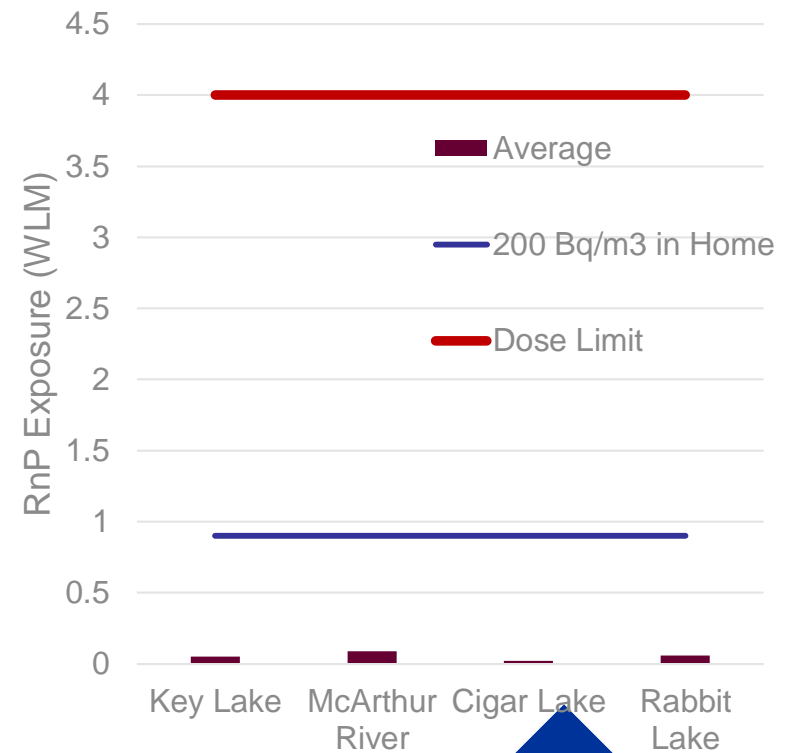
RnP

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▶ Conclusion

- Exposure to radon is well controlled even in high grade uranium mines
- Worker doses far below limits

	2017 Average RnP Exposures (WLM)	Max RnP Measurement Recorded
Key Lake	0.05 WLM	3.5 WL's
McArthur River	0.09 WLM	895 WL's
Cigar Lake	0.02 WLM	209 WL's
Rabbit Lake	0.06 WLM	65 WL's





▶ Questions

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