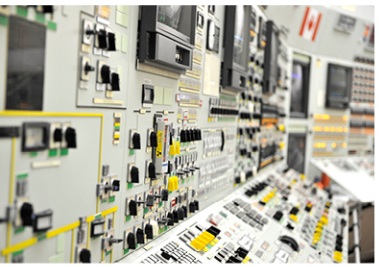
Bruce Power's Use of Technology to Achieve ALARA Objectives

January 8th, 2018

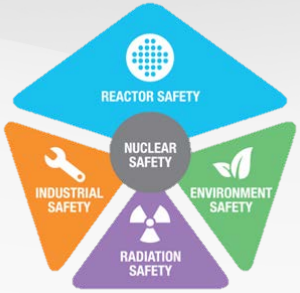



Colin Pritchard

Bruce Power™

Innovation at work

Overview of Bruce Power



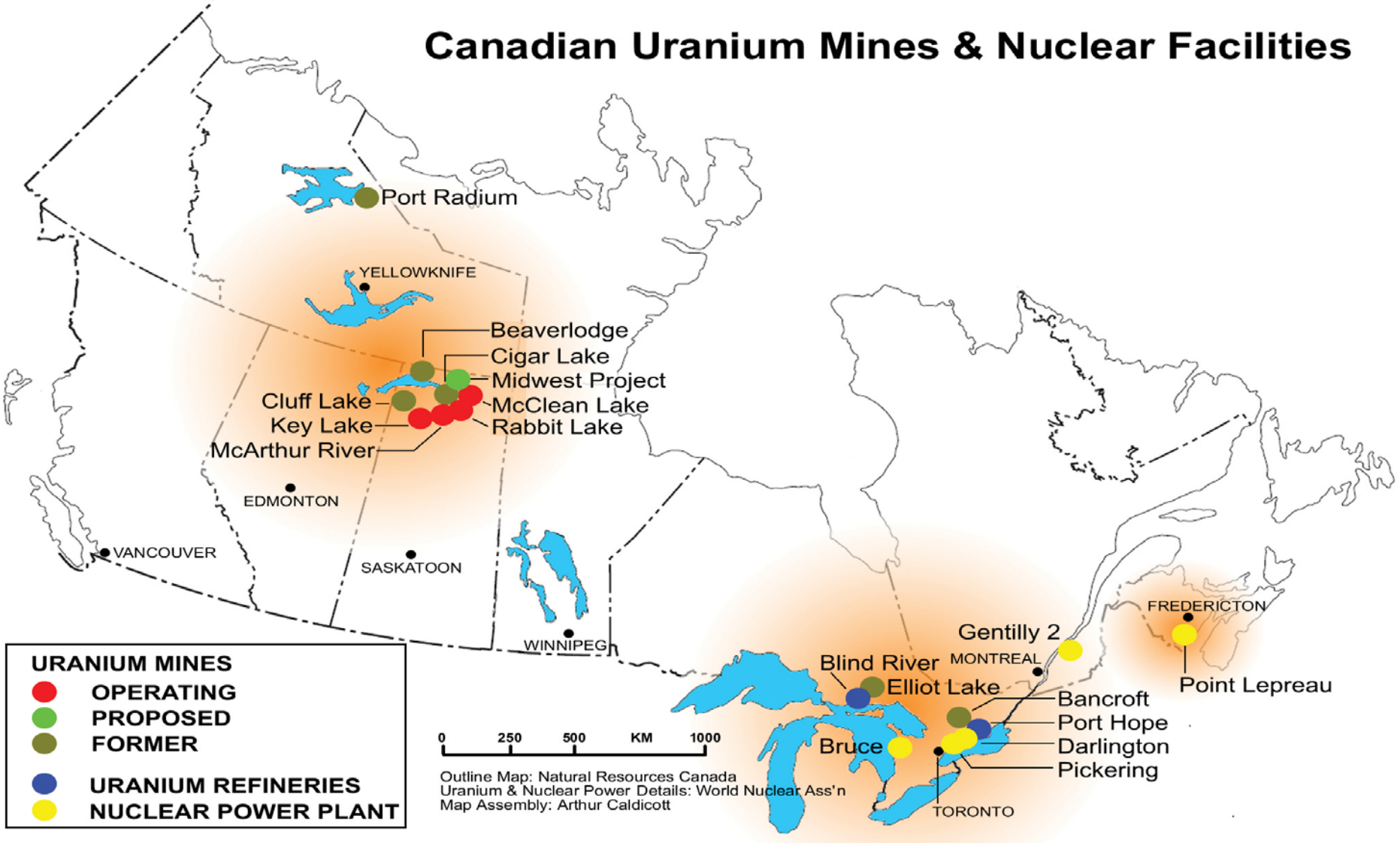
- Nuclear Safety is our core value
- Largest Nuclear Power site in the world, publicly owned but privately operated
- Bruce Power is Ontario's largest independent power producer, setting power production records in each of last four years
- Multiple units setting long-run records for continuous operation. Unit 8 set record January 2nd at 581 days, next outage is Sept 2018.

Overview of Bruce Power

Bruce Power L.P.

The Issuer	• Canada's only private nuclear generator
Ownership	• ~97% owned by OMERS[1] and TransCanada[2] • ~3% owned by unions and employees
Bruce Power Facility	• 8 reactors on a 2,300 acre site leased from OPG • 2 physically separate stations (Bruce A and Bruce B)
Installed Capacity	• ~6,300 MW
Technology	• Reactors employ proven CANDU technology
Regulatory Body	• Canadian Nuclear Safety Commission (CNSC)
Implementation Agreement	• Long-term agreement with the IESO expiring in 2064 • Fixed price (subject to escalation and periodic adjustments) for all electricity generation

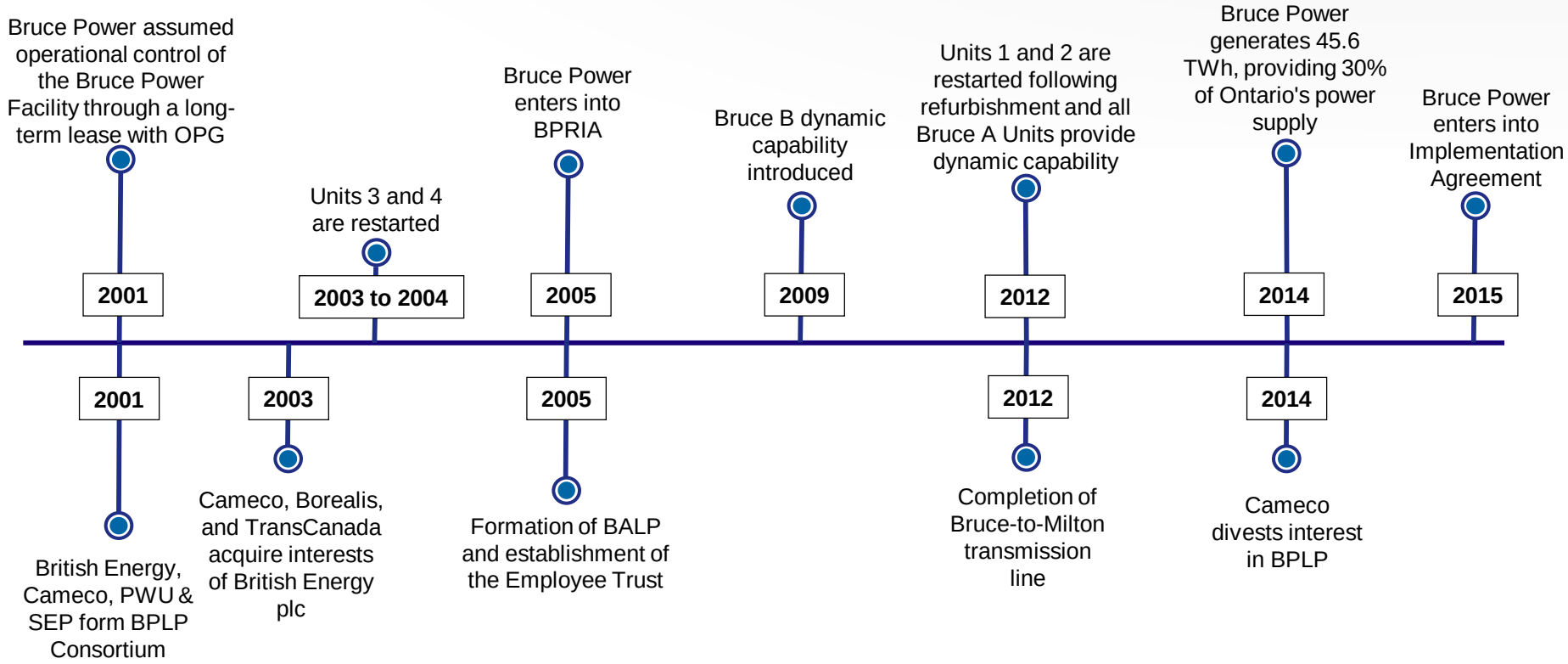
Canadian Uranium Mines & Nuclear Facilities



Bruce Power™
Innovation at work

History of Bruce Power

Bruce Power began operating the facility in 2001; upon completion of the refurbishment of Units 1 and 2 in 2012, all 8 reactors were operational for the first time since 1995.

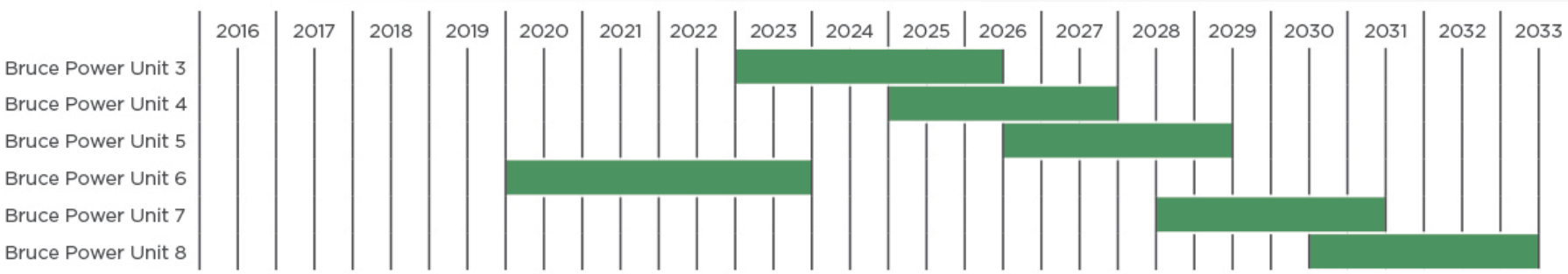


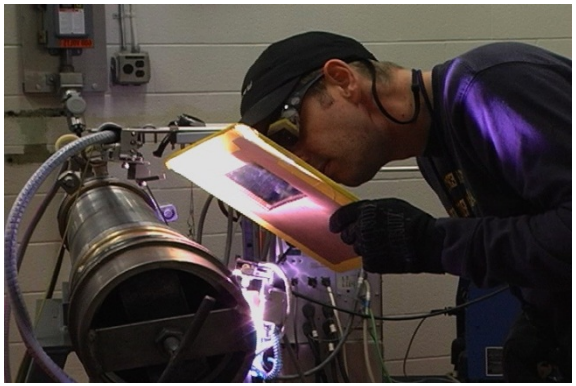
Bruce Power
Innovation at work

Bruce Power Life-Extension

- Bruce Power will continue to play an important role in achieving Ontario's long term climate change goals through the life extension of Bruce Units 3-8.
- There will be a $13 billion private investment program in six of its units over 20 years, extending their life another 40 years.
- This will help Ontario and Canada meet their carbon-reduction goals, as their focus shifts to a clean energy system.

Life Extension Schedule

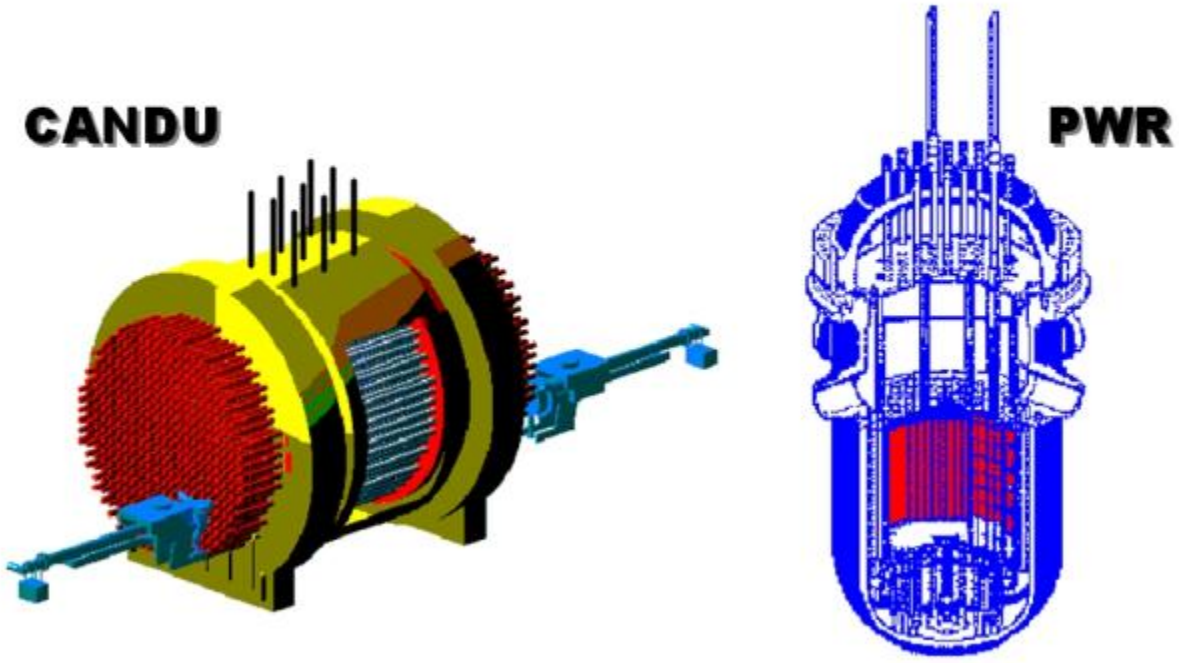


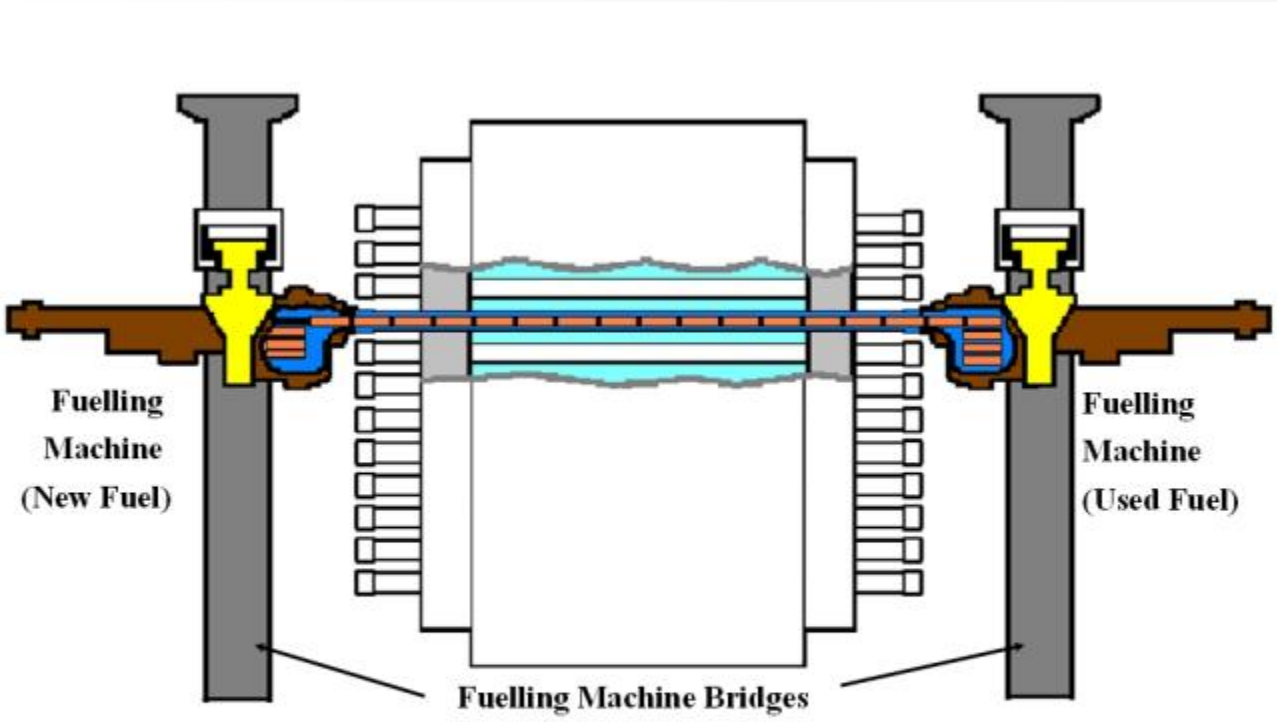


Bruce Power™
Innovation at work

CANDU Design

Reactors with Equal Power Output





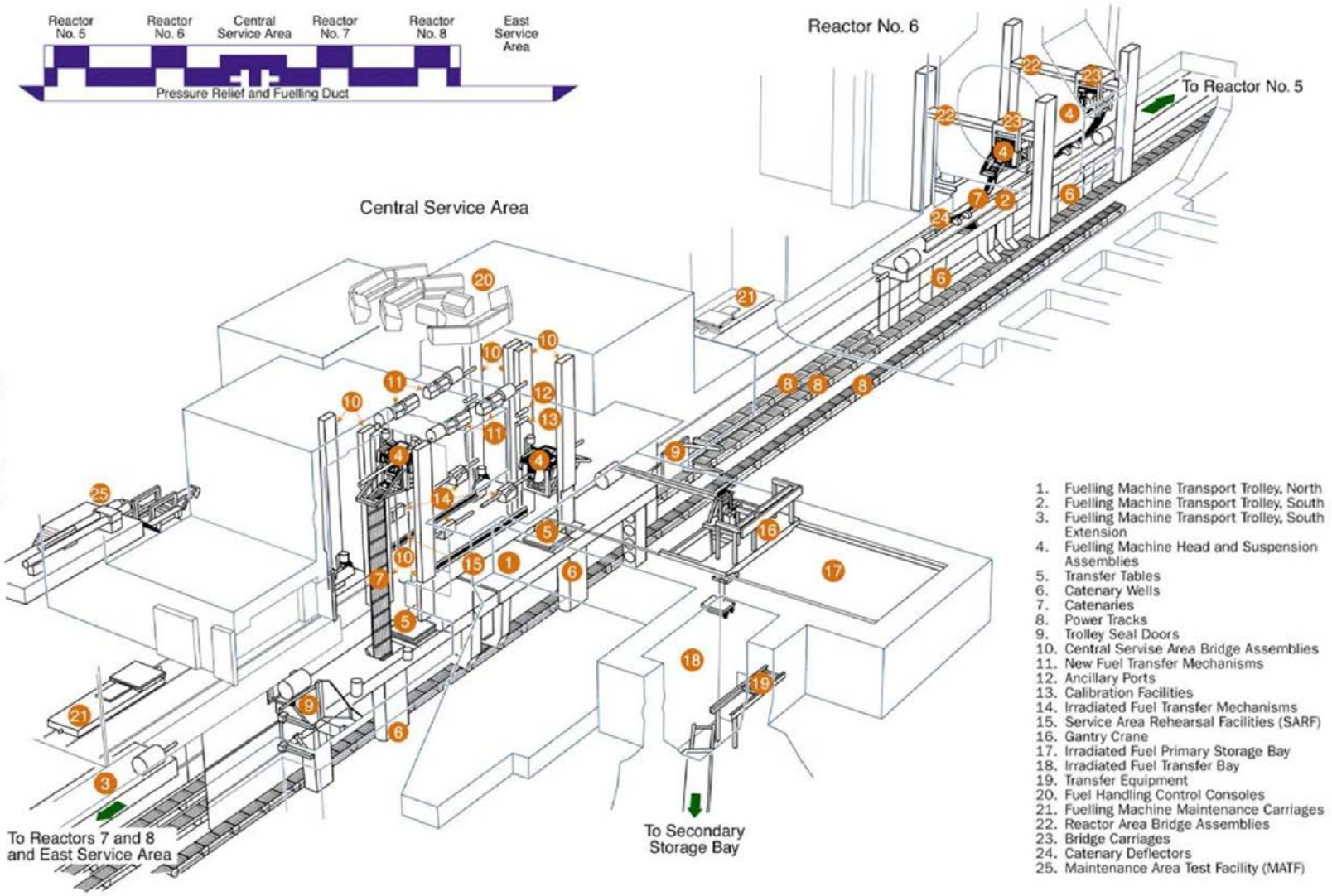
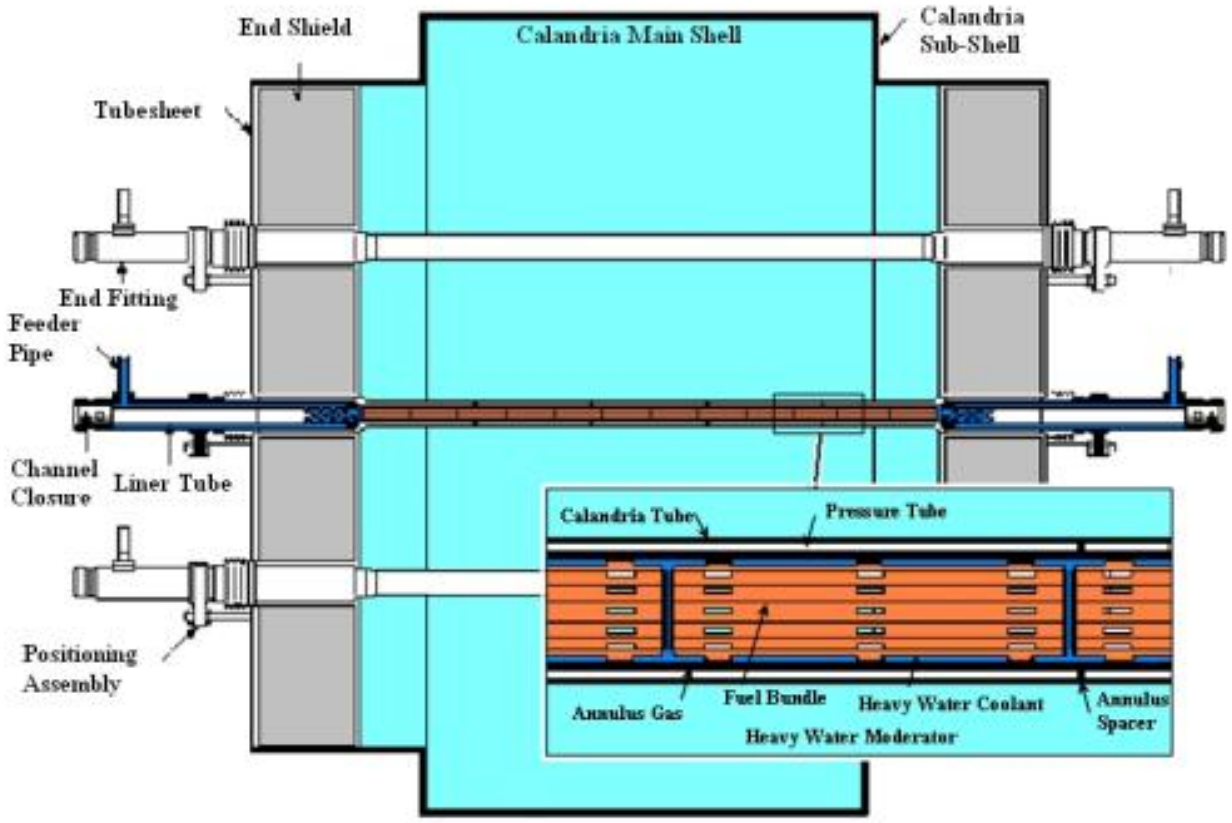
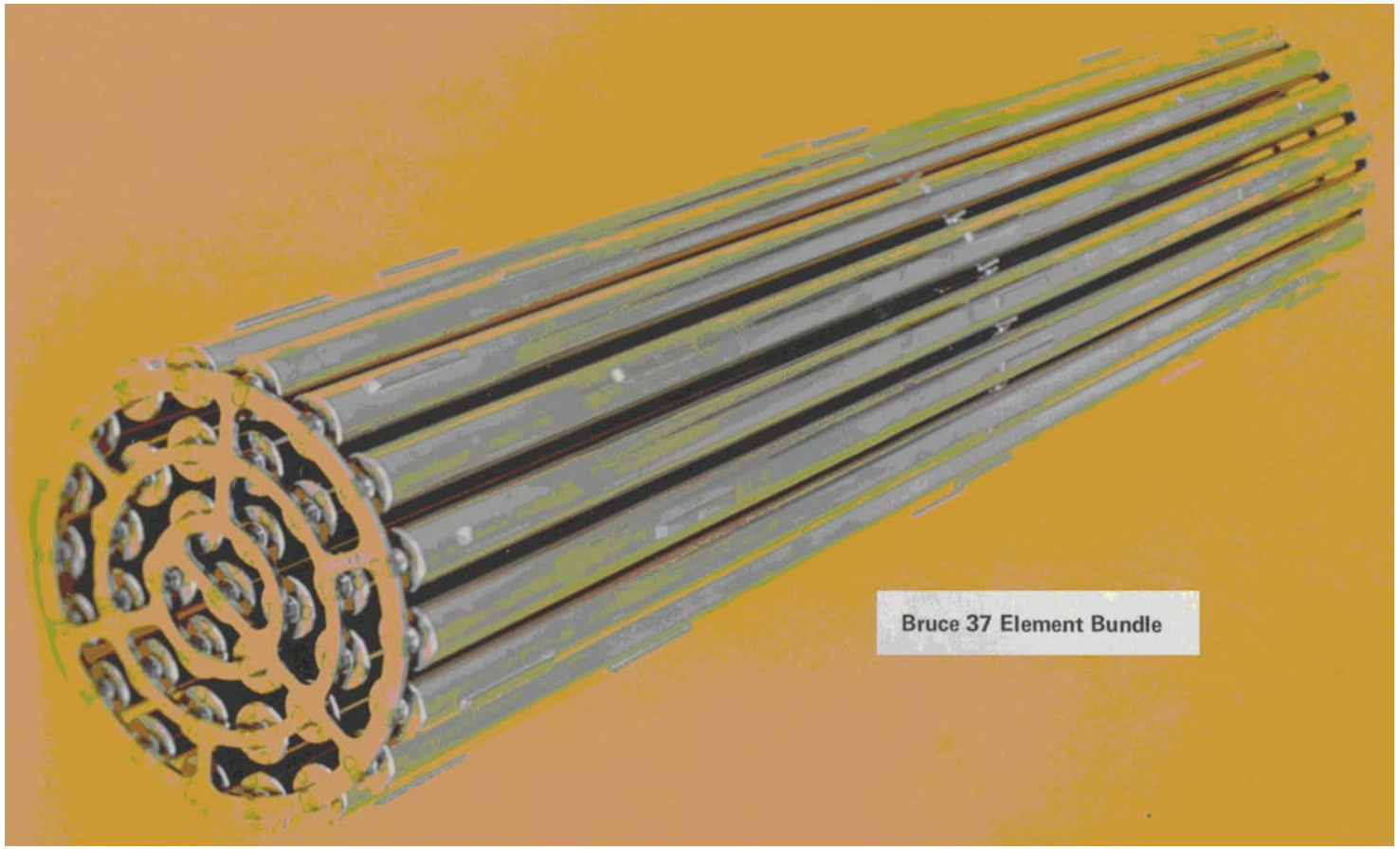
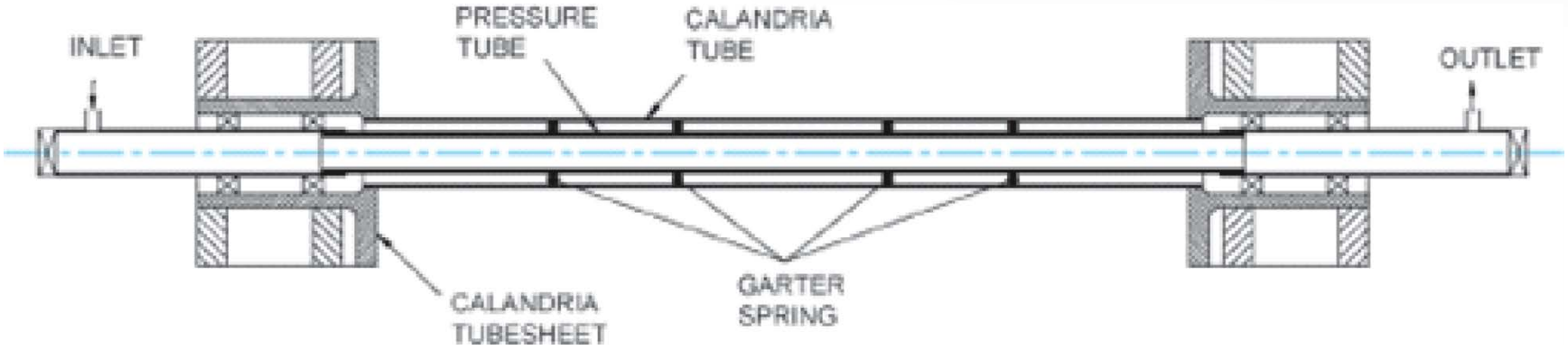


Figure 10-3
Fuel Handling System

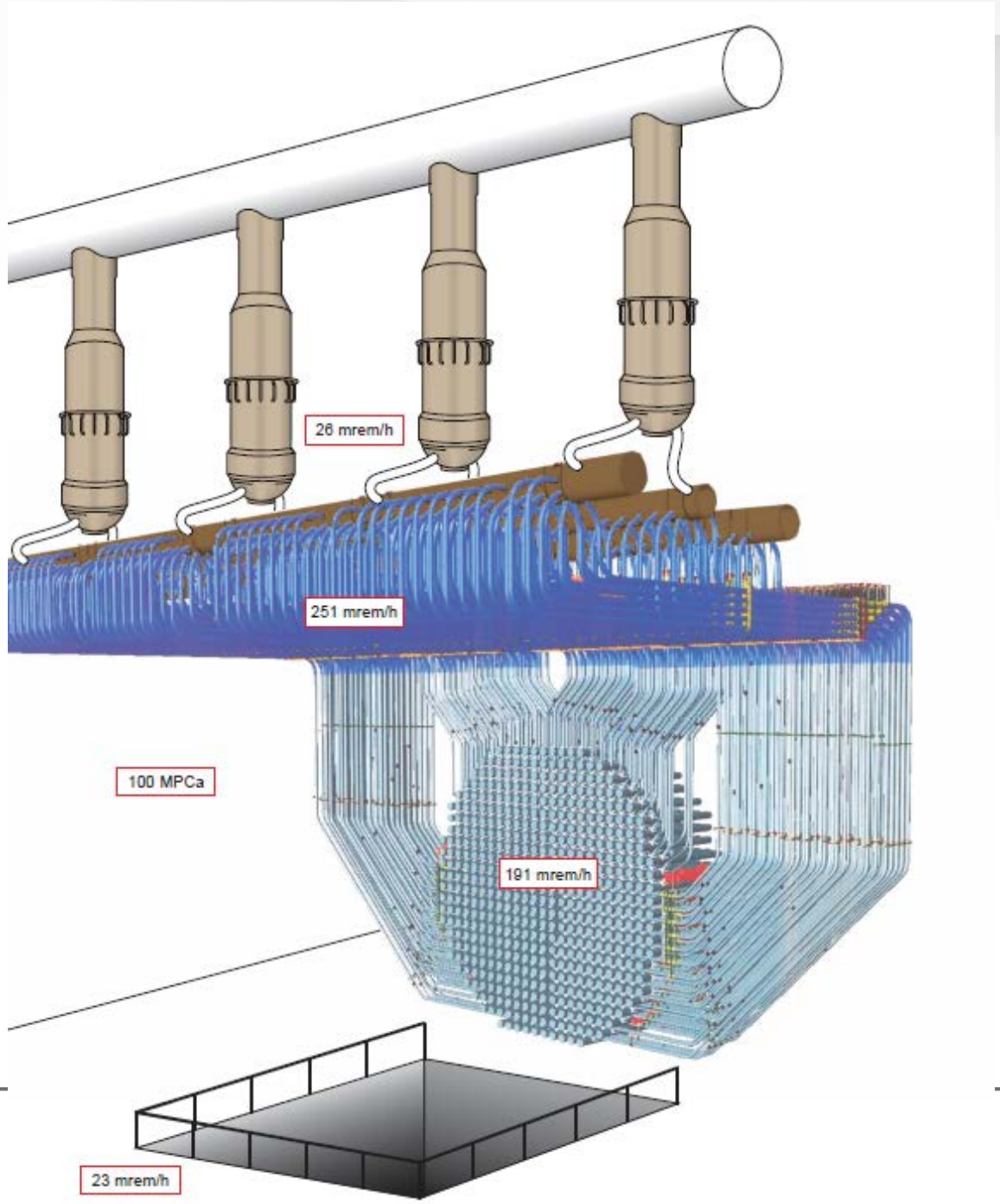



Bruce 37 Element Bundle



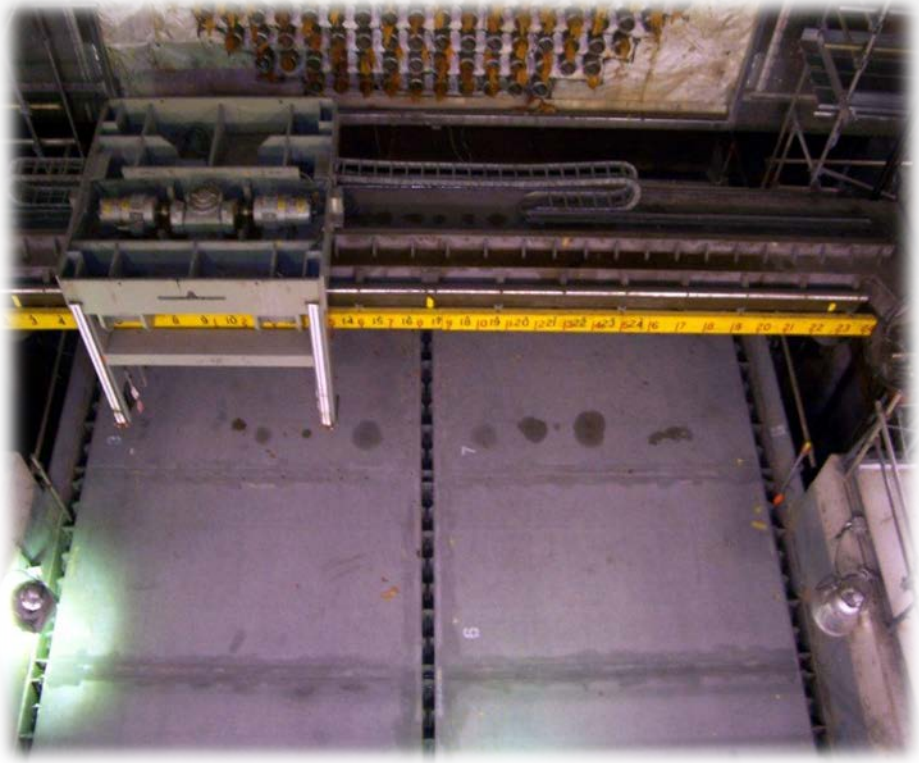
Lead In / Lead Out Scope

- Transition from operations to construction
  - Defuel the reactor
  - Drain & dry moderator & primary heat transport systems
  - Install & remove the bulkheads (containment isolation)
  - Establish layup requirements
  - Return unit to service once construction complete


26 mrem/h
251 mrem/h
100 MPCa
191 mrem/h
23 mrem/h

Bulkhead Installation & Removal Scope

- Material procurement and fabrication of bulkheads
- Installation/ Removal of bulkheads

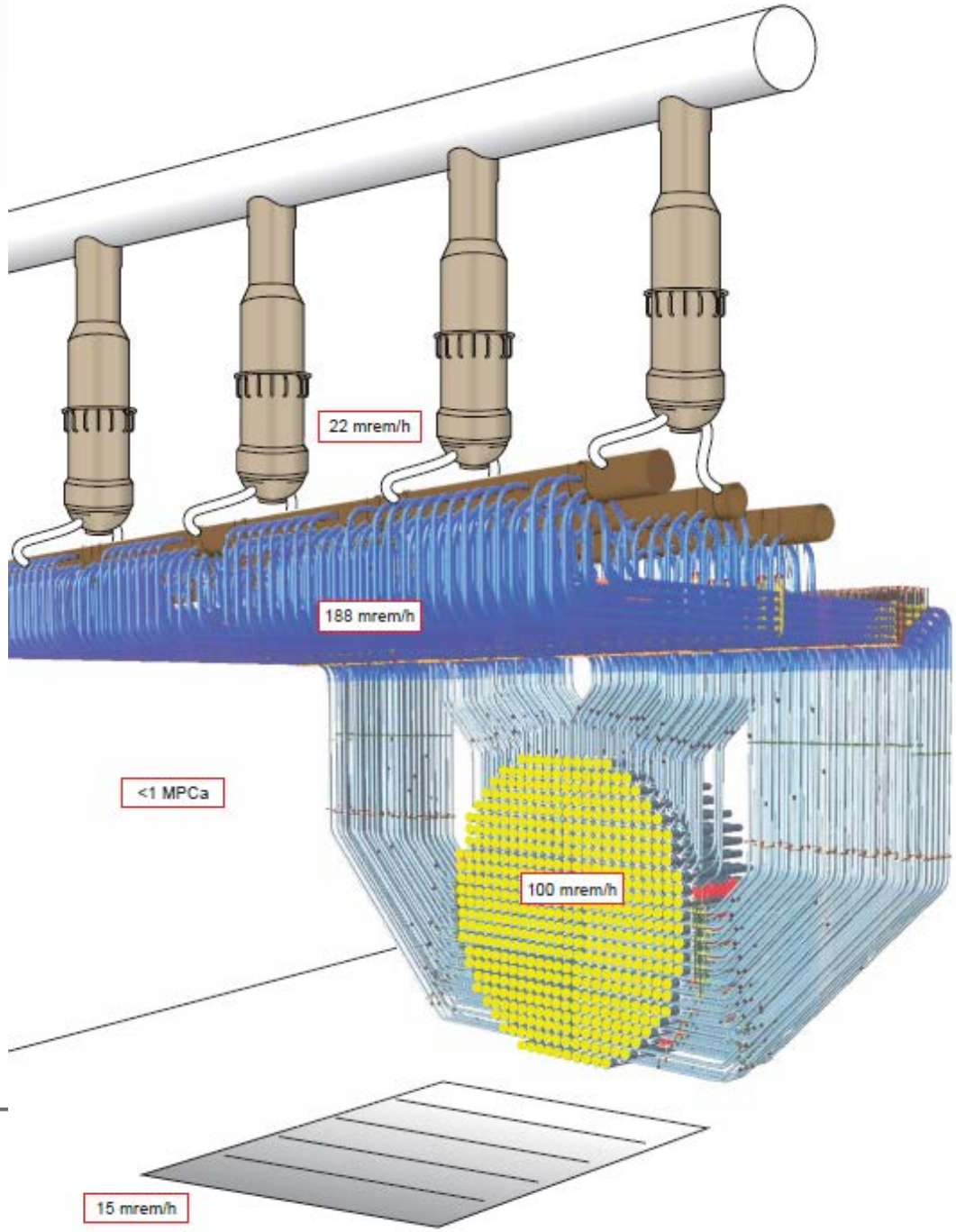


Bulk Head Shielding

- Continued Operation of U5 requires spent fuel transfers under Unit 6.
- Typically requires vault evacuation due to very high dose rates; At 10 feet away: Gamma ~1600 rem/hr, Neutron ~1.6 rem/hr.
- At two fuel runs per day equates to 3-4 hours lost critical path productivity per day.
- Over ~30 months equates to $140M loss potential
- Detailed shielding design with extensive MCNP models

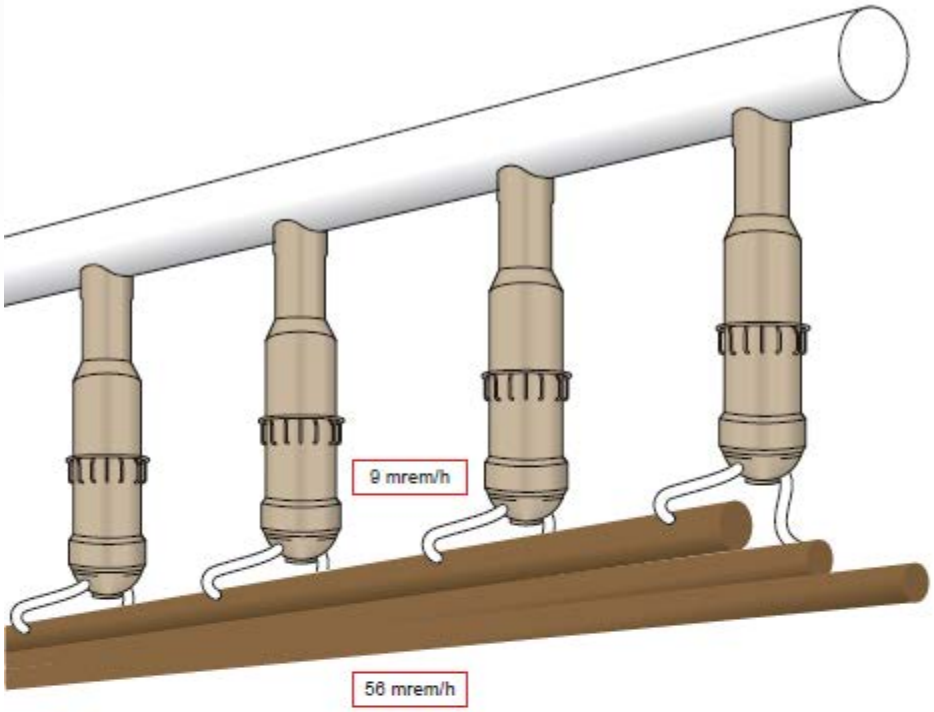
MCNP Summary

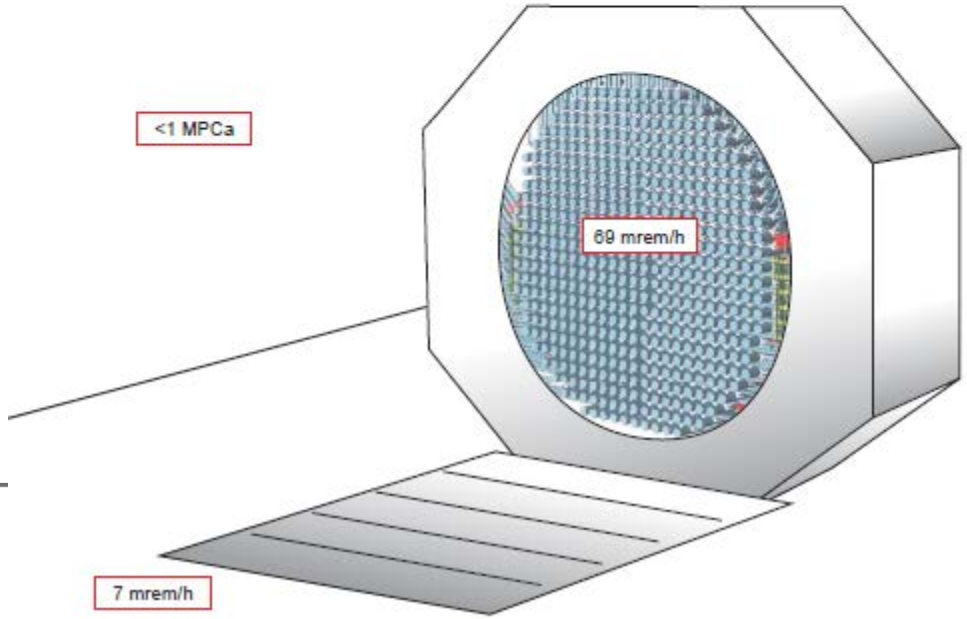
SOURCE	8”Steel-2” Poly/Boron-2” Steel (No Delay)	4”steel/2”Gd-ATH/8”steel			4”Steel-2” Poly/Boron-8” Steel (No Delay)	4”Steel - 1”HDPE-1” B4C -1”Std Silflex Gd Poly -7”Steel (No Delay)	4”Steel-3” Poly/Boron-7” Steel (No Delay)	4”Steel-3” Poly/Boron-7” Steel (No Delay) PLUS Intra bulkhead shield of 1” Steel + 3” Poly/Boron
		NO DELAY	1 HOUR DELAY	2 HOUR DELAY				
GAMMA	238 mRem/h	49 mRem/h	29 mRem/h	20 mRem/h	54 mRem/h	97 mRem/h	100 mRem/h	37 mRem/h
NEUTRON	34 mRem/h	64 mRem/h	36 mRem/h	21 mRem/h	30 mRem/h	62 mRem/h	9 mRem/h	0.9 mRem/h


22 mrem/h
188 mrem/h
<1 MPCa
100 mrem/h
15 mrem/h

Feeder Program Scope

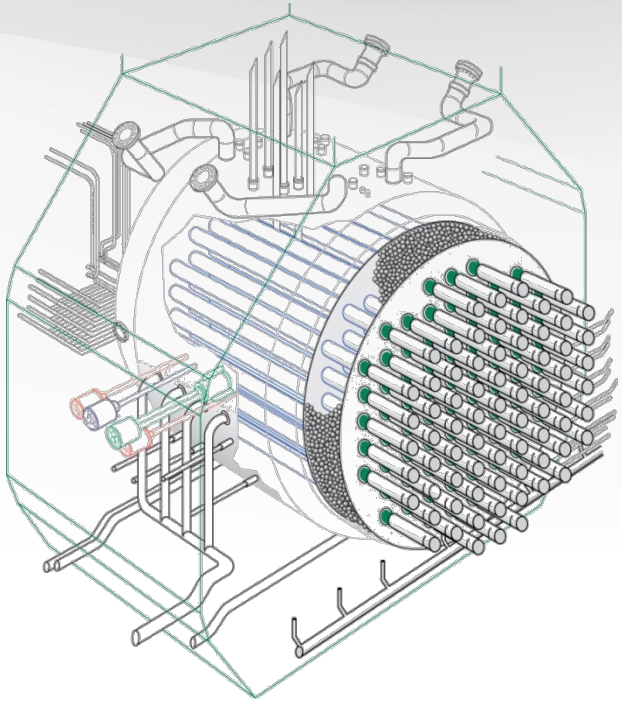
- Feeder cabinet & feeder removals
- Upper feeder installation
- Lower feeder installation


9 mrem/h
56 mrem/h


<1 MPCa
69 mrem/h
7 mrem/h

Detube / Retube Scope

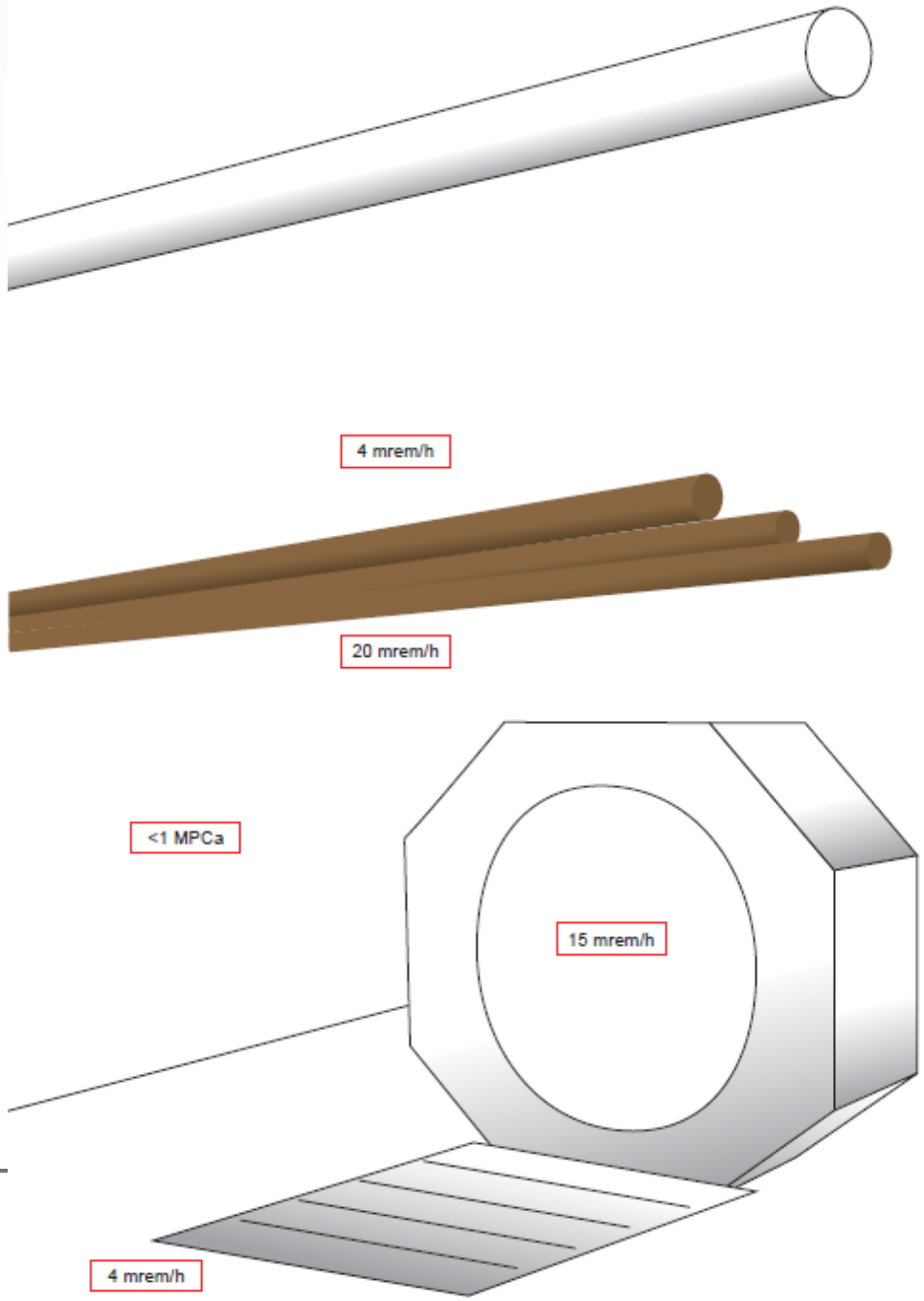
- Safely remove & replace all 480 fuel channels & calandria tubes while meeting all relevant regulations, standards & codes
- Procure all reactor components & tooling to perform the work
- Train staff to execute the work

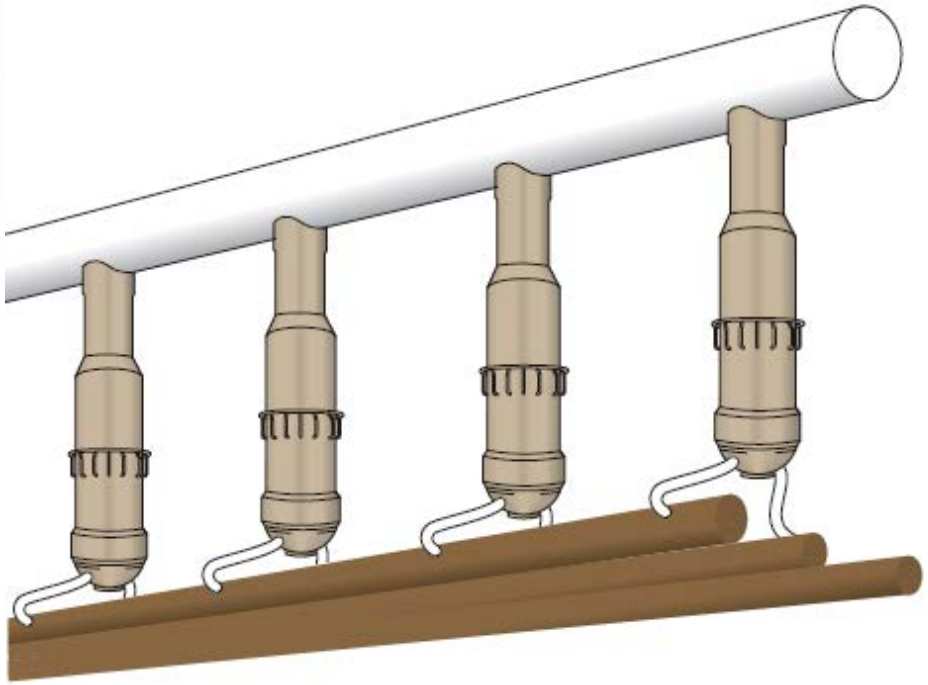


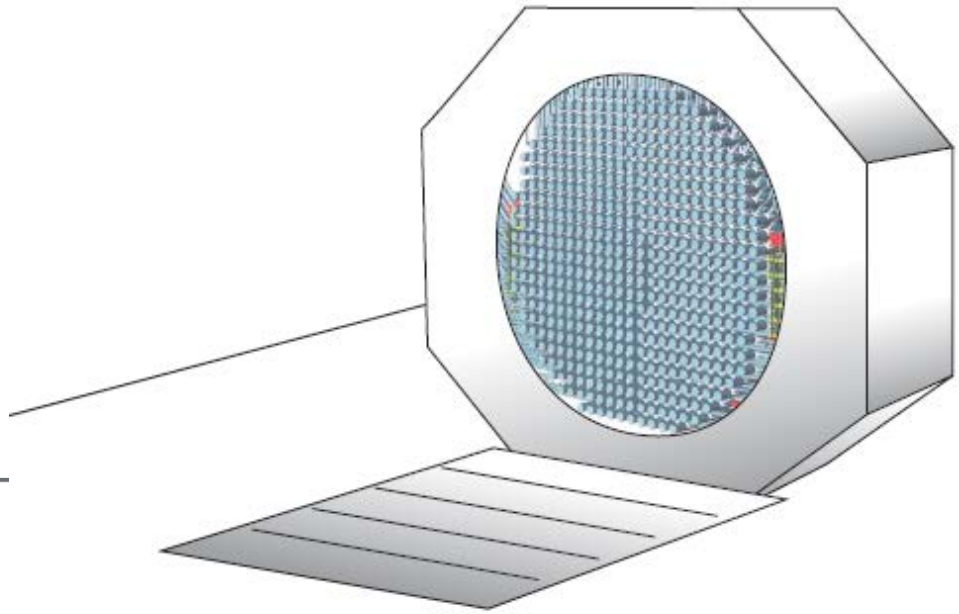
Contingencies:

- OPEX from Unit 1 and Pt Lepreau
  - Loss of Control of Garter Springs
  - Mostly Zircaloy with some Inconel
  - Significantly different Hazards
- Needs a remote solution….robotics
  - Versatile attachments
    - Gamma meters, cameras etc

Robotics/

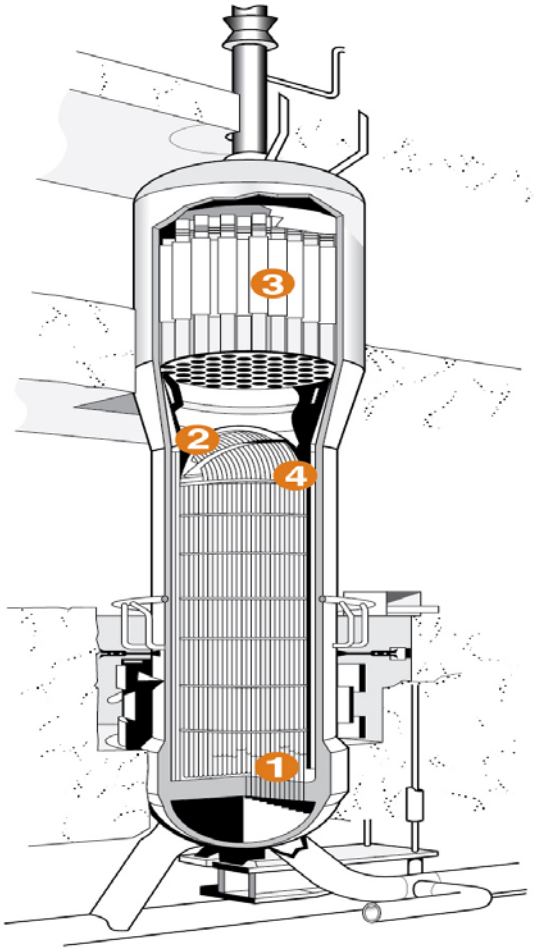

4 mrem/h
20 mrem/h
<1 MPCa
15 mrem/h
4 mrem/h

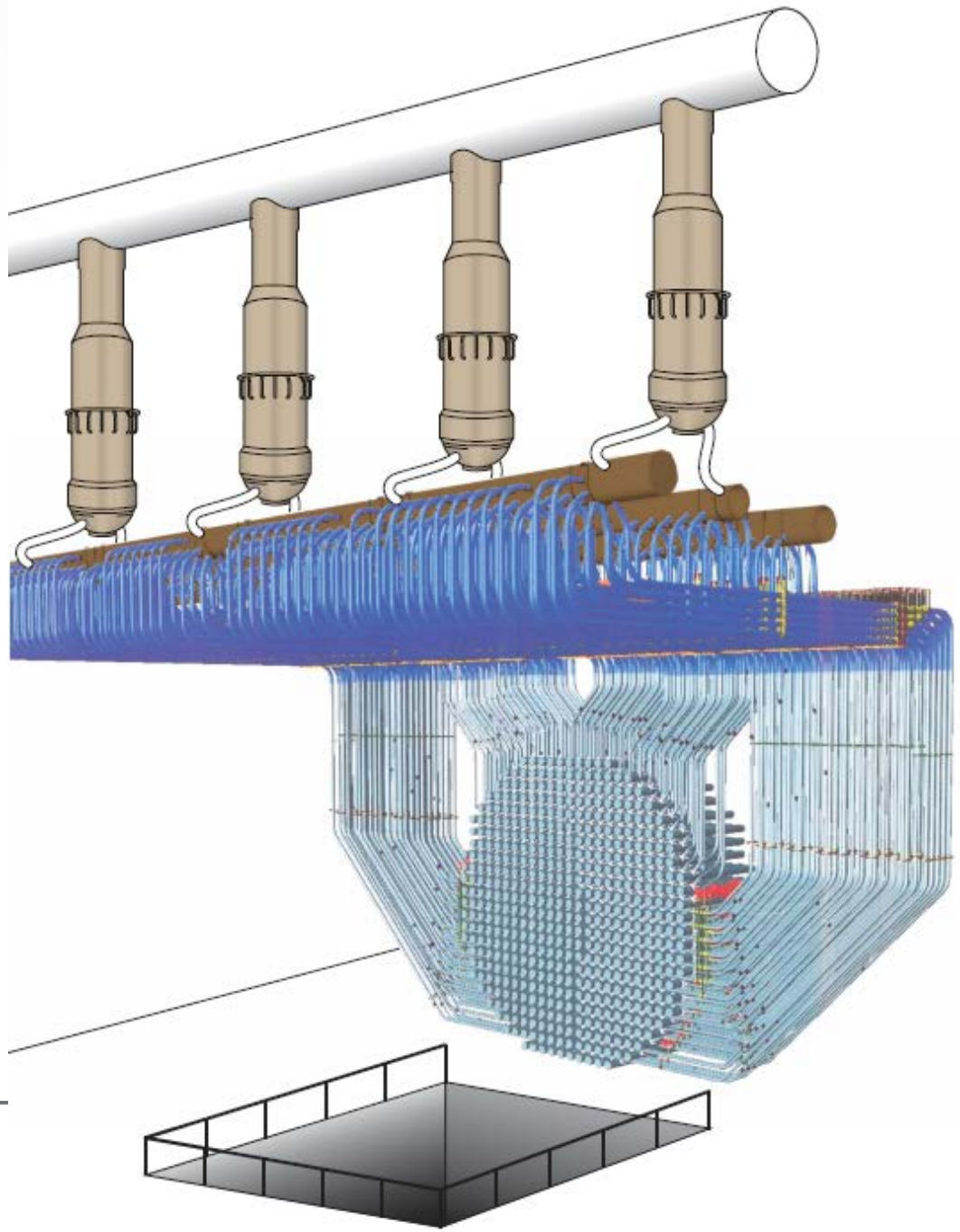




Steam Generator Replacement Scope

- Specify, design & buy replacement steam generator cartridges
- Prepare modifications for affected interfacing systems
- Create openings in the reactor building & steam drum enclosure roofs to facilitate steam drum & steam generator removal
- Remove, temporarily relocate & subsequently reinstall other defined interfering components
- Remove, inspect, refurbish & reinstall steam drum portions of steam generator assemblies
- Remove & replace steam generator cartridges
- Inspect and disposition of results



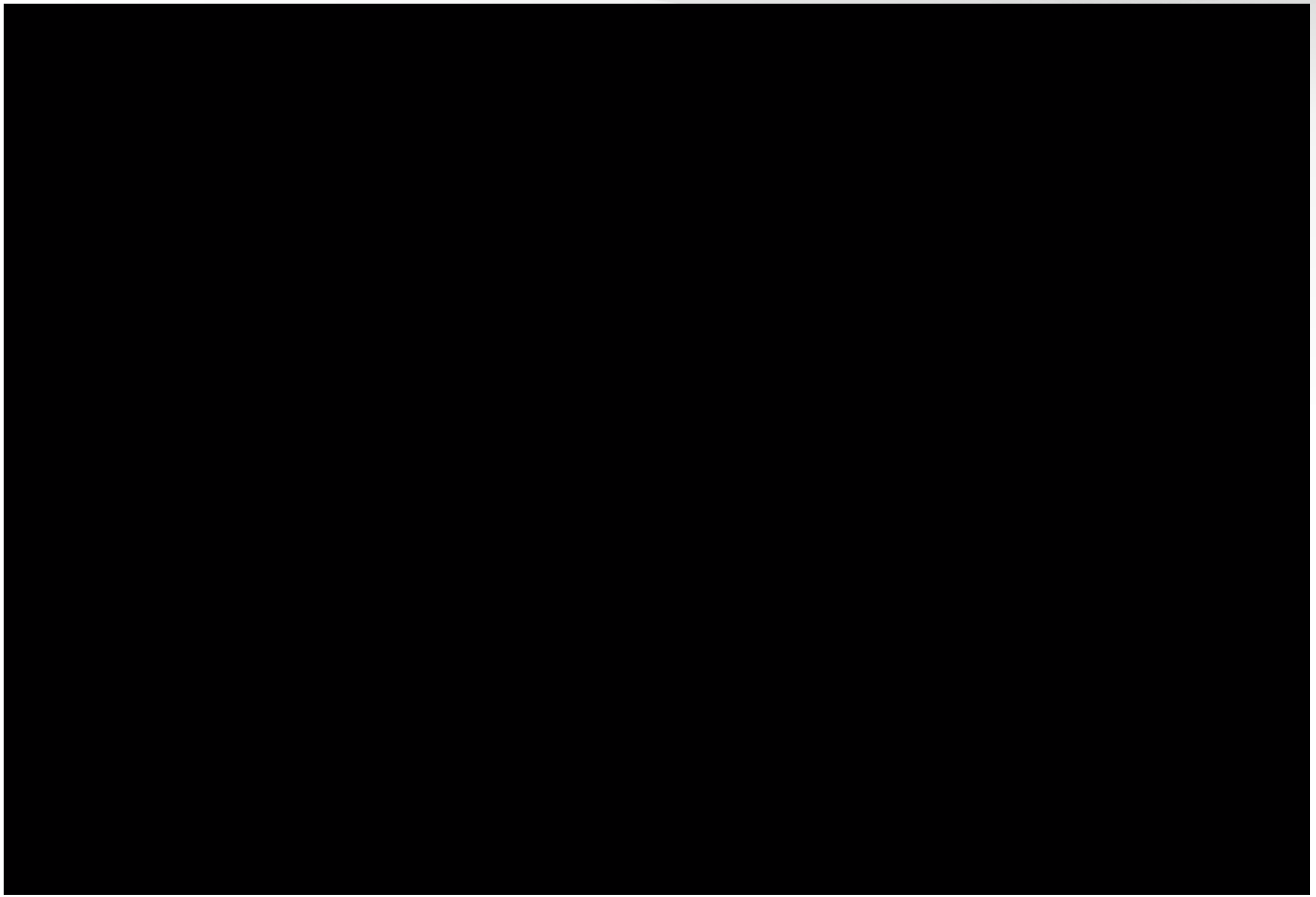


Bruce Power™

Innovation at work

Innovations

- New camera systems and New Communications systems
  - Integrated to allow a wireless call from inside containment to anyone outside with live-time video feed to solve problems in real time
- Virtual reality system for “touring” actual work areas with zero exposures before work starts
  - Integrated into Initial training for new trades staff
- Use of drones with high resolution cameras for visual inspections
  - Eliminates scaffolding, saves space and time



Questions?