Dose Considerations for a Site Boundary for Surface Operations at a Deep Geological Repository

Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities

Toronto, Ontario

September 11-14, 2011

Dr Erik Kremer
Senior Engineer, Repository Safety

NWMO
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Presentation Overview

- Study Objective
  - Develop a method for determining the minimum Site Boundary required to ensure public dose remains below regulatory limits
- Contents
  - Context of the Study
  - Study Objectives
  - Reference Assumptions
  - Scope of the Study
  - Hypothetical Public Dose Consequences
  - Summary
- Study Conclusion
  - Based on the reference assumptions, current conceptual design, and methodology in this study, radiological consequences would not require setting a site boundary

Context of the Study

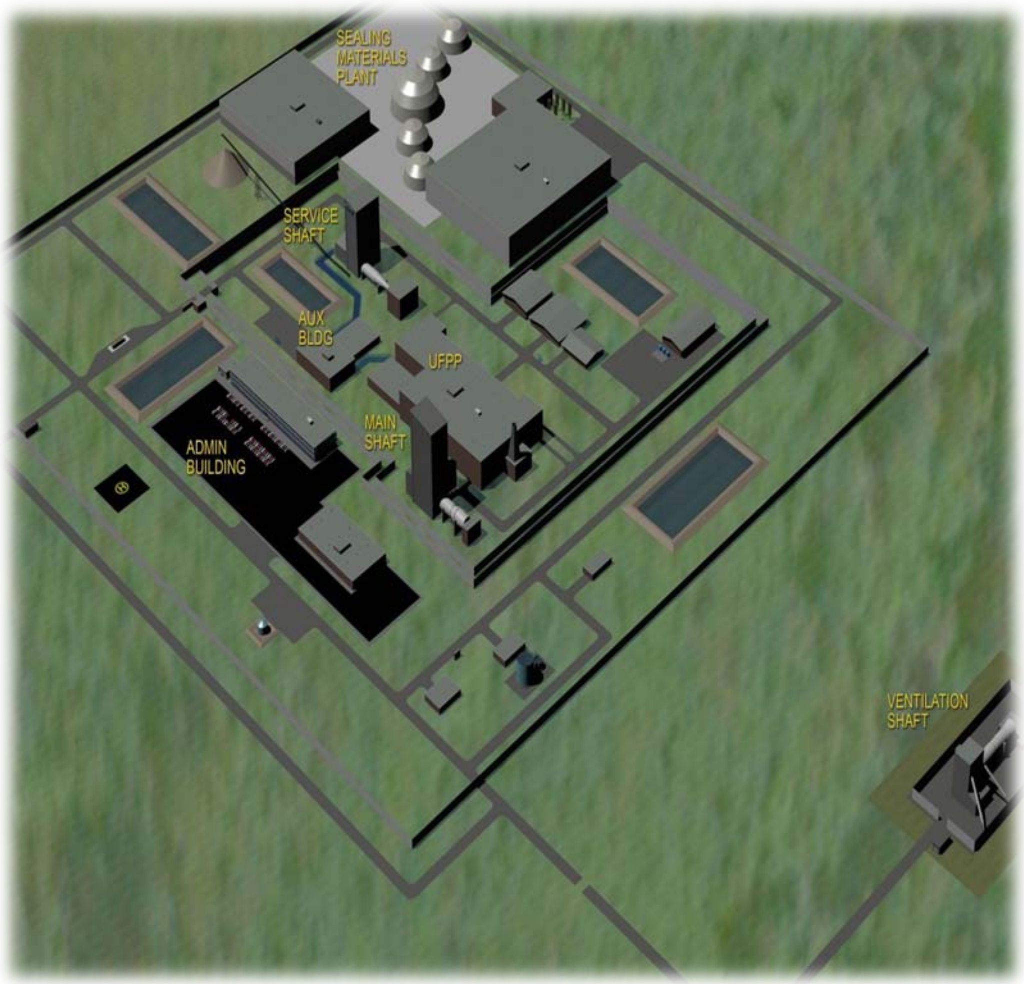
The Deep Geological Repository (DGR) will be a self-contained complex.

Surface facilities will include a Protected Area, containing all handling and storage of used nuclear fuel.

Irradiated Fuel Transportation Casks (IFTCs) will be received at the Used Fuel Packaging Plant (UFPP).

Each IFTC carries two used fuel modules, containing 192 used fuel bundles in total.

At the UFPP, used fuel will be transferred from IFTCs to Used Fuel Containers (UFCs); UFCs will then be transferred underground for placement in the repository.



Study Objectives

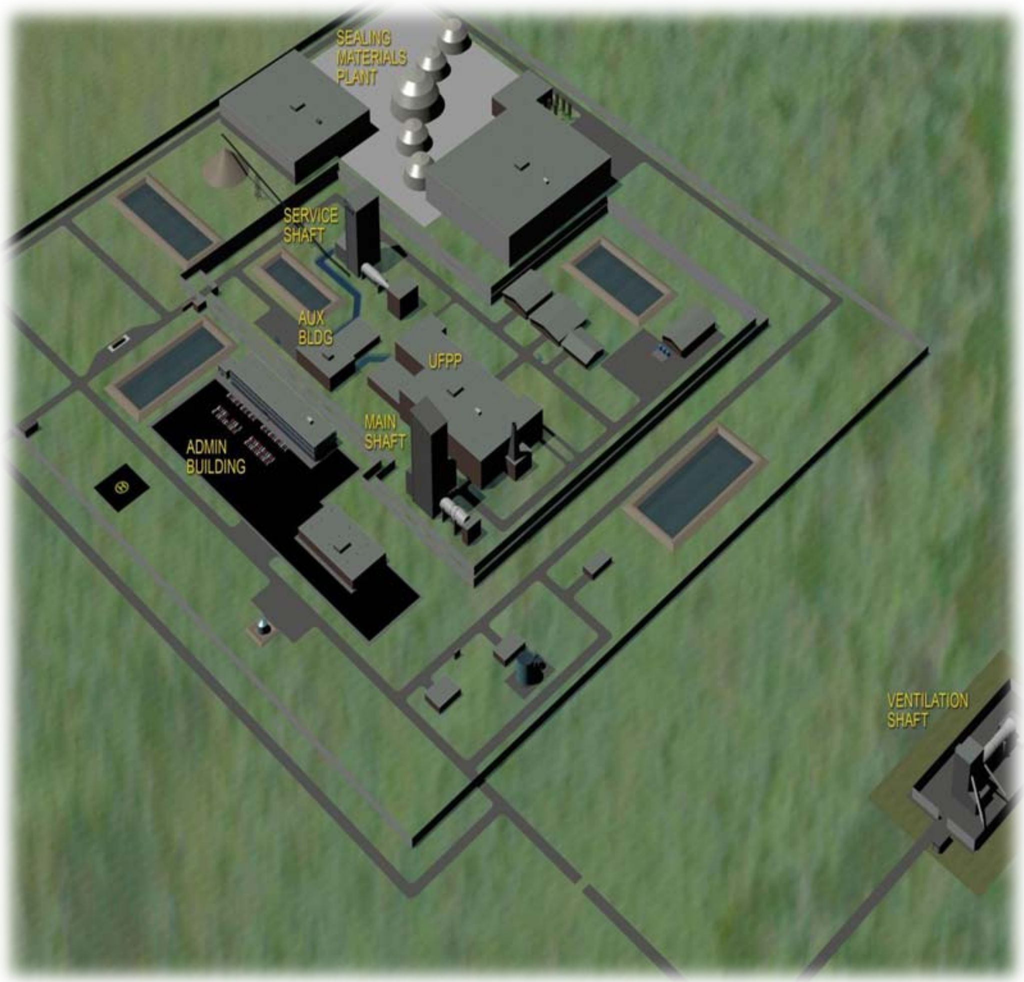
Develop a method for determining the minimum Site Boundary required to ensure public dose remains below regulatory limits

Define assumptions characterising

- Nuclide release rates
  - Surface contamination
  - Corrosion
  - Fuel sheath defects
- Conditions within IFTCs
- Used fuel handling at the UFPP
- UFPP containment efficiency

Define appropriate parameters for

- Environmental dispersion
- Biosphere pathways
- Human receptor characteristics



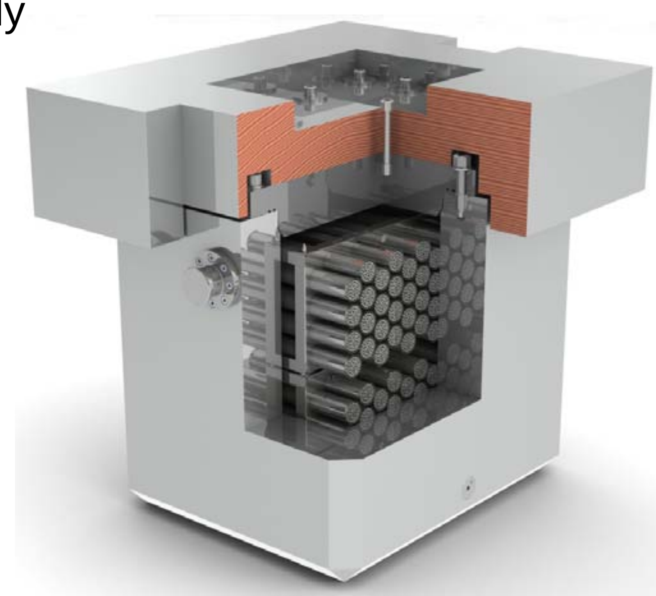
Reference Assumptions

Used Nuclear Fuel

- Standard 37-element CANDU® fuel bundle
- 30 years out-of-reactor

Irradiated Fuel Transportation Casks

- IFTCs contain 2 modules each
- 625 IFTCs will be received annually



Used Fuel Containers

- UFCs contain 3 fuel baskets each
- Baskets contain 120 bundles each
- 333 UFCs will be filled and placed in the repository annually

Reference Assumptions

Biosphere

Pathway analyses and receptor modelling were performed as outlined in guidelines N288.1 and N288.2 of the Canadian Standards Association

Assumed a representative meteorology

DGR was conservatively assumed to be situated within farming lands, near a small lake

Scope of the Study

Consider the Operational Phase of the DGR

- Base Case: 3.6 million used CANDU® fuel bundles delivered over 30 years
- Operating capacity of 120,000 bundles per year

Define Normal Operating conditions

- Based on the current conceptual DGR design
- Use conservative assumptions

Identify Anticipated Operational Occurrences (AOOs), non-typical but possible

- Maximum frequency of expected occurrence = at least once every 100 years

Propose Design Basis Accidents (DBAs), with bounding radiological impact

- Maximum frequency of expected occurrence = at least once every 10,000 years

Hypothetical Public Dose Consequences

<u>Normal Operations</u>

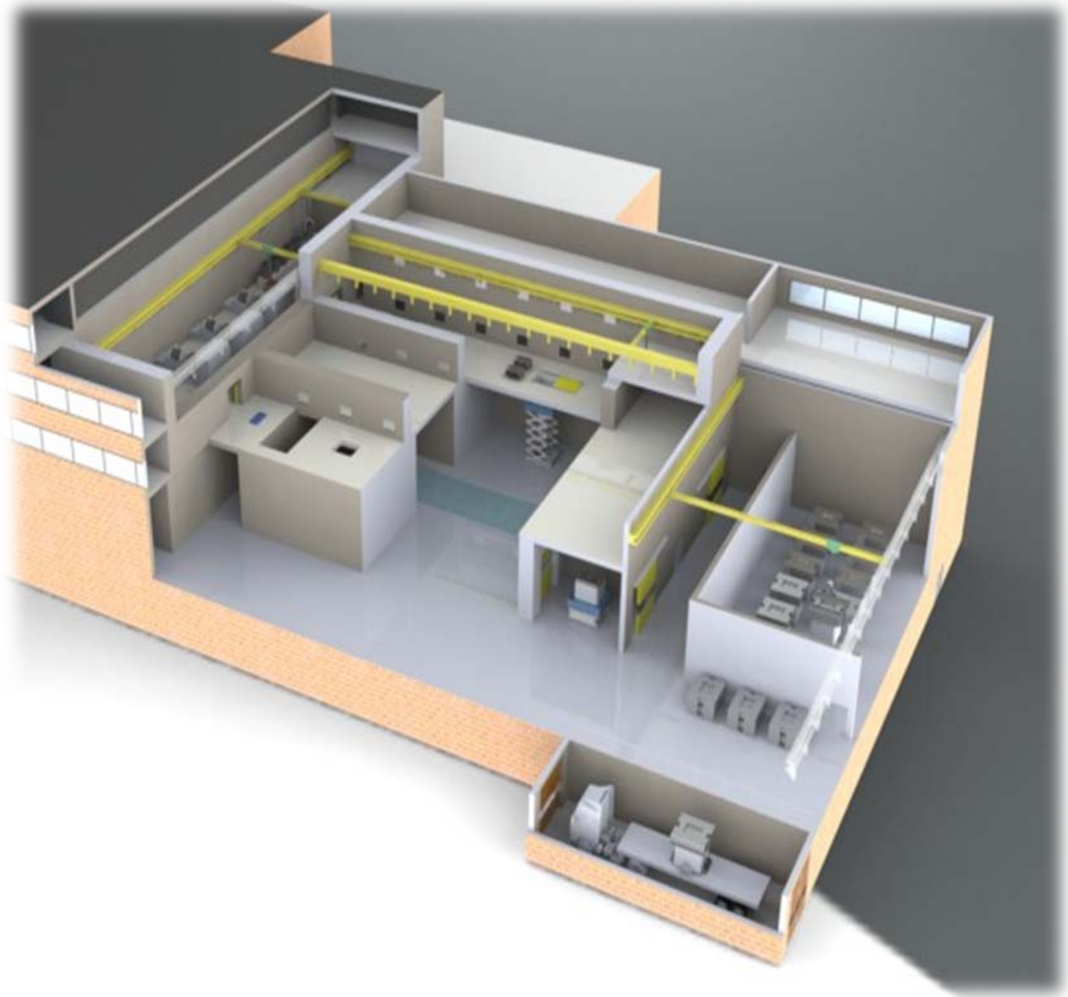
Design Performance
- Interior of IFTCs are dry
- IFTCs spend 2 days in transit
- 1% of fuel bundles contain a defect
- 4 fuel modules in module handling cell
- 4 fuel baskets in fuel handling cell

<u>Anticipated Operational Occurrences</u>

Scenario 1
- IFTCs spend 14 days in transit
- 5% of fuel bundles contain a defect
- 8 fuel modules in module handling cell
- 8 fuel baskets in fuel handling cell

Scenario 2
- Scenario 1 +
- Interior of IFTCs are wet

Scenario 3
- Scenario 1 +
- HEPA filter failure, undetected for 7 days



Hypothetical Public Dose Consequences

Normal Operations

Design Performance

- Interior of IFTCs are dry
- IFTCs spend 2 days in transit
- 1% of fuel bundles contain a defect
- 4 fuel modules in module handling cell
- 4 fuel baskets in fuel handling cell

Anticipated Operational Occurrences

Scenario 1

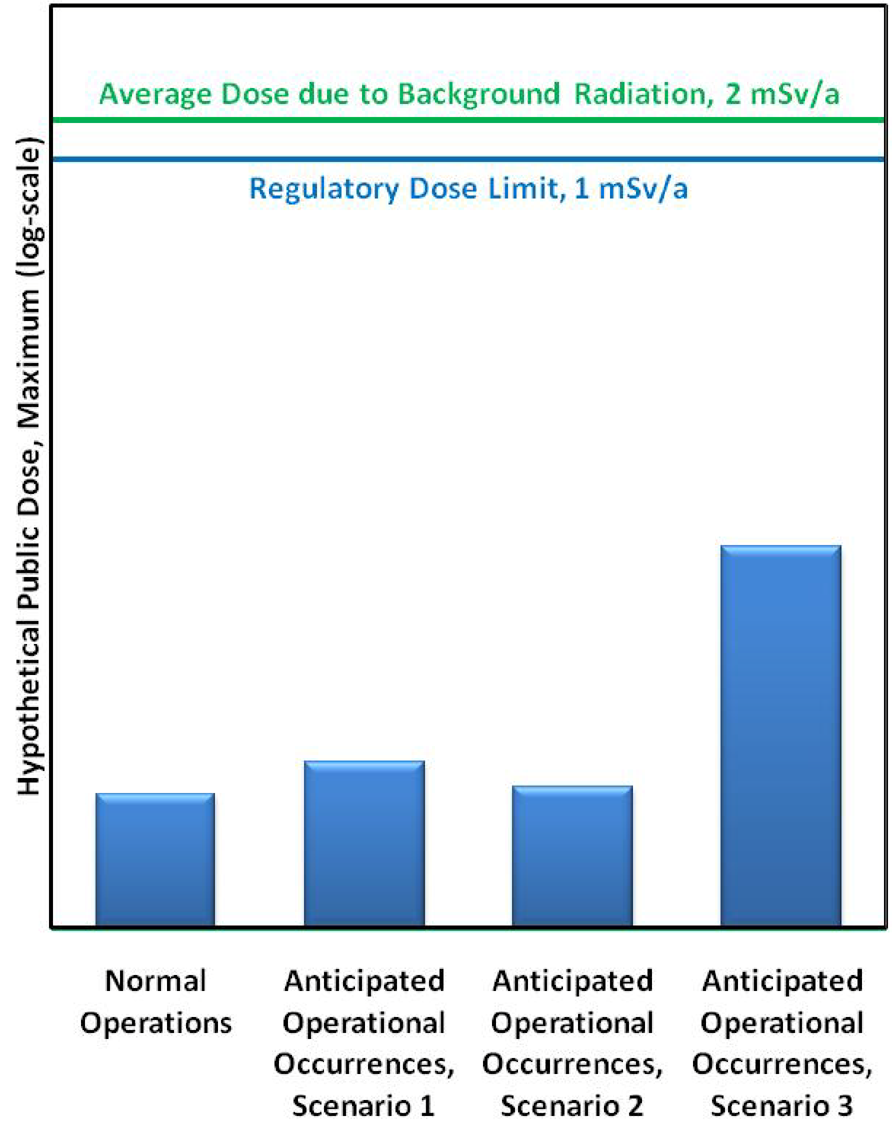
- IFTCs spend 14 days in transit
- 5% of fuel bundles contain a defect
- 8 fuel modules in module handling cell
- 8 fuel baskets in fuel handling cell

Scenario 2

- Scenario 1 +
- Interior of IFTCs are wet

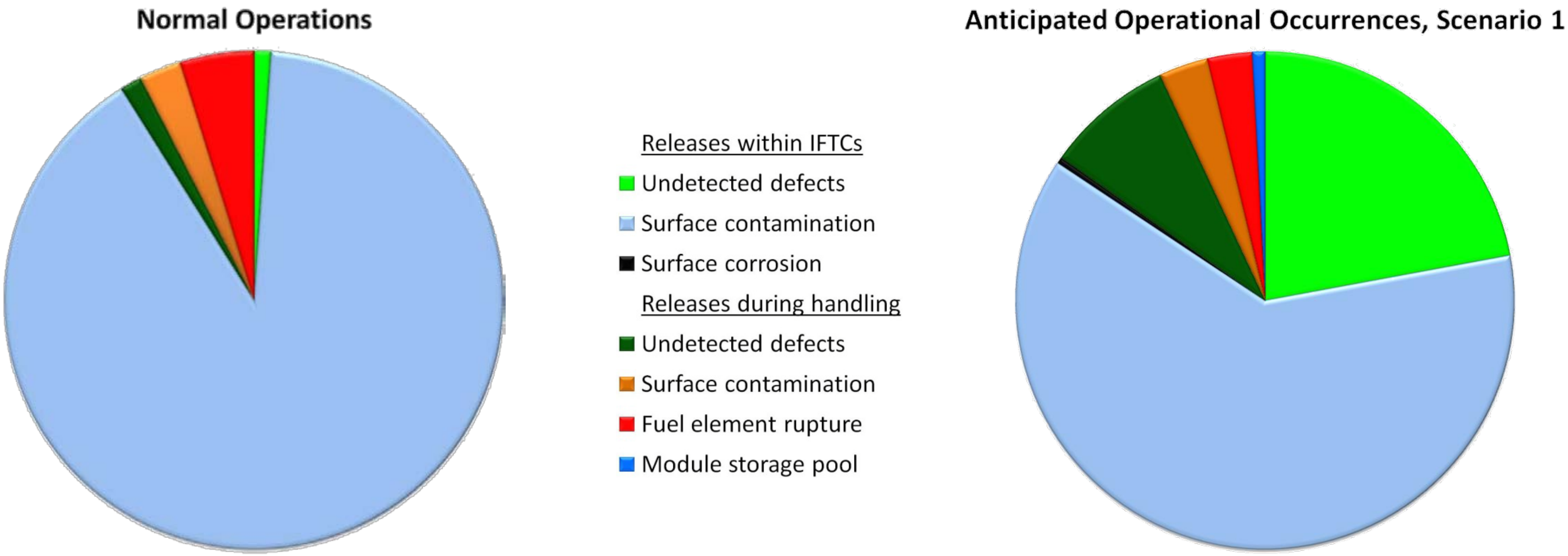
Scenario 3

- Scenario 1 +
- HEPA filter failure, undetected for 7 days



Hypothetical Public Dose Consequences

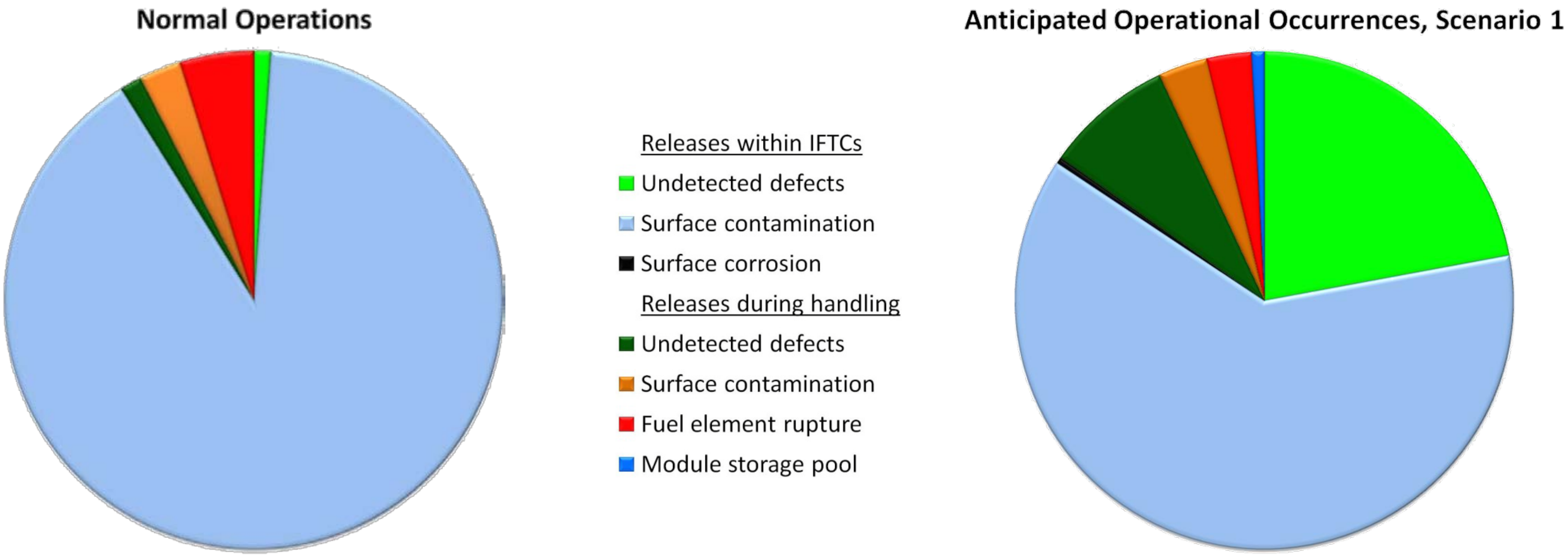
Estimating emissions due to each step in the fuel handling sequence allows assessment of their individual contributions to chronic dose.



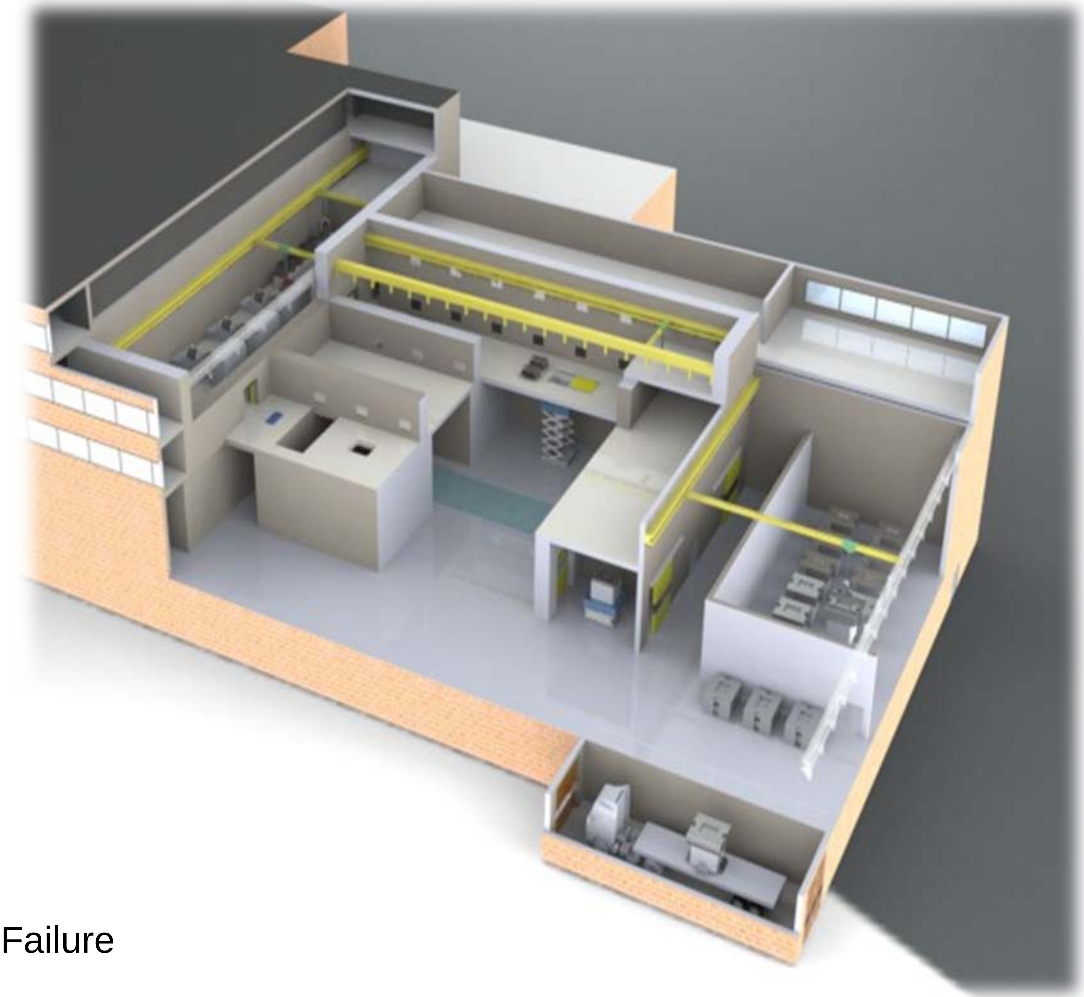
Hypothetical Public Dose Consequences

Iterations of assessment and review can lead to

- better estimates of emissions, improved understanding of emission sources,
- gauging relative impacts of design parameters, improving design to reduce emissions
- guidance for implementing the ALARA principle (As Low As Reasonably Achievable)
- defining check points and benchmarks for monitoring programs



Hypothetical Public Dose Consequences



Design Basis Accidents

Scissor Lift Failure

- IFTC drops, containing 2 fuel modules
- 10% of fuel elements breach
- Produces mixture of radioactive gas and particles
- HEPA filter operates as designed:
  - 99.97% of particles retained
  - Gases escape
- Without HEPA filtration:
  - All particles and gases escape

Module Crane Failure

- Fuel module drops on second fuel module
  - Impacts 2 fuel modules
  - Consequences same as Scissor Lift Failure

Hypothetical Public Dose Consequences

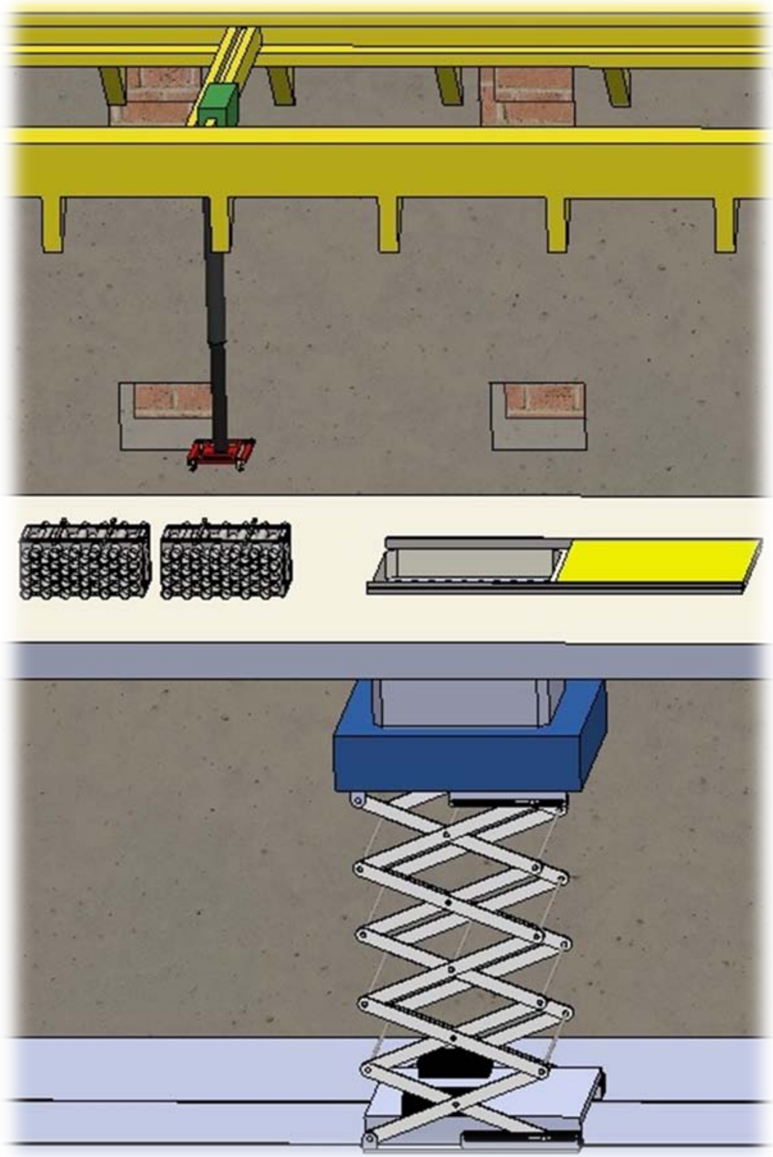
<u>Design Basis Accidents</u>

Scissor Lift Failure

- IFTC drops, containing 2 fuel modules
- 10% of fuel elements breach
- Produces mixture of radioactive gas and particles
- HEPA filter operates as designed:
  - 99.97% of particles retained
  - Gases escape
- Without HEPA filtration:
  - All particles and gases escape

Module Crane Failure

- Fuel module drops on second fuel module
  - Impacts 2 fuel modules
  - Consequences same as Scissor Lift Failure



Hypothetical Public Dose Consequences

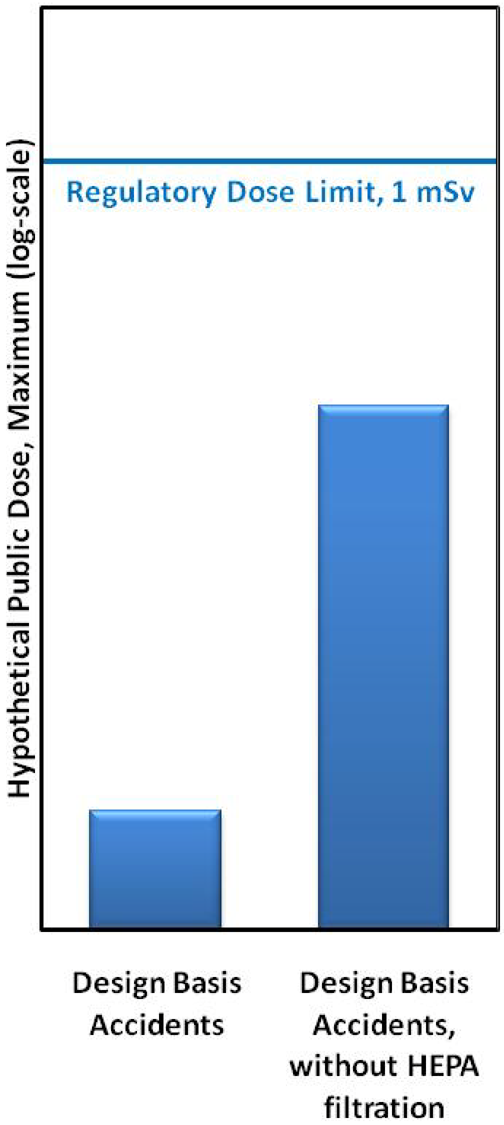
<u>Design Basis Accidents</u>

Scissor Lift Failure

- IFTC drops, containing 2 fuel modules
- 10% of fuel elements breach
- Produces mixture of radioactive gas and particles
- HEPA filter operates as designed:
  - 99.97% of particles retained
  - Gases escape
- Without HEPA filtration:
  - All particles and gases escape

Module Crane Failure

- Fuel module drops on second fuel module
  - Impacts 2 fuel modules
  - Consequences same as Scissor Lift Failure



Summary

- Environmental pathway analyses and receptor modelling were performed as outlined in guidelines N288.1 and N288.2 of the Canadian Standards Association
- Methodology developed based on conservative assumptions
  - Hypothetical emissions due to normal operations and AOOs result in a public dose well below the regulatory dose limit
  - Hypothetical Design Basis Accidents, both with and without concurrent HEPA filter failure, result in a public dose well below the regulatory dose limit
  - Based on the reference assumptions, current conceptual design, and methodology in this study, radiological consequences would not require setting a site boundary
  - A site boundary could be set for non-radiological reasons

Acknowledgements

» Dr Nava Garisto and her team at SENES Consulting performed the pathway analyses and receptor modelling for this project.

» Jorge Villagran derived source terms for similar earlier assessments – this project has benefited substantially from his work.