Joint Waste Owner Conceptual Designs

Overview Documentation

Overview of Joint Waste Owners' Conceptual Design Work Related to Nuclear Fuel Waste Act

May 2004

Based on a presentation given to the NWMO Assessment Team, January 21, 2004, by Frank King, Director, Nuclear Waste Engineering and Technology, Ontario Power Generation

Purpose of Presentation

- To describe the work, related to the Nuclear Fuel Waste Act, conducted by the Joint Waste Owners (OPG, HQ, NBP, AECL)

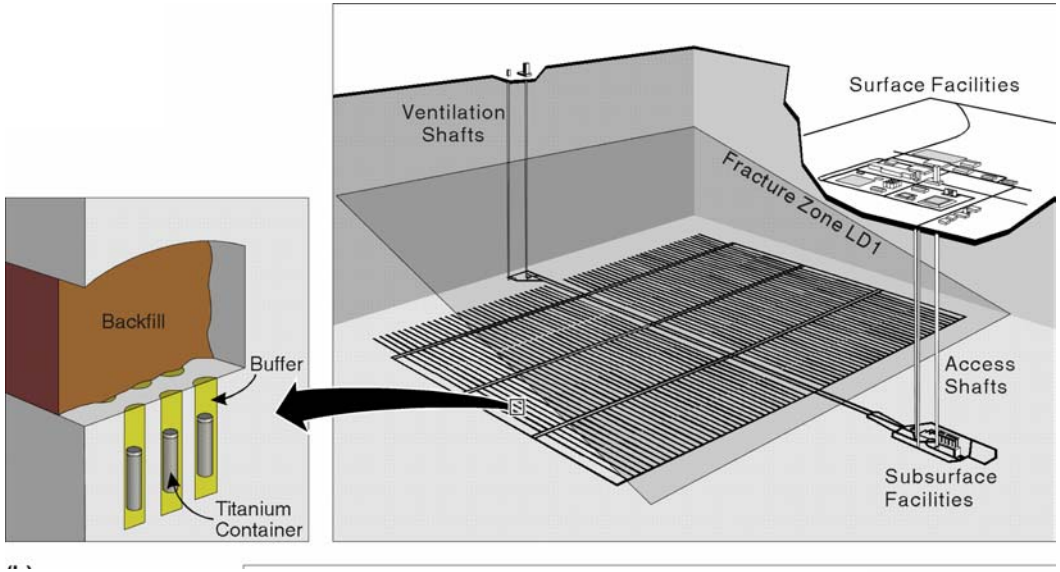
Work Initiated by JWO

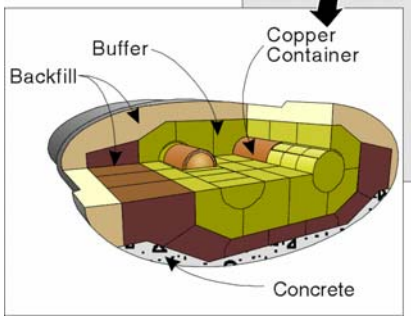
- Developed typical conceptual designs and associated cost estimates for deep geologic disposal, centralized storage and storage at reactor sites, including associated transportation systems for centralized facilities
- Options other than those listed in the Nuclear Fuel Waste Act not considered
- Work conducted in 2001–2003

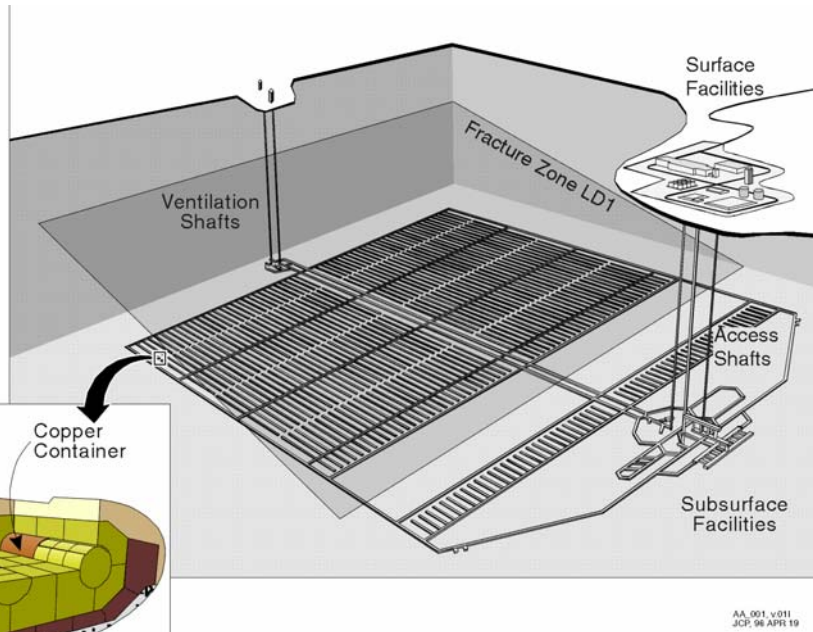
Geologic Disposal in Canadian Shield

- Update of conceptual design developed by AECL in period 1980–1994, together with corresponding cost estimate
- Work performed by CTECH (RWE Nukem + Canatom / SNC–Lavalin)

AECL Concept



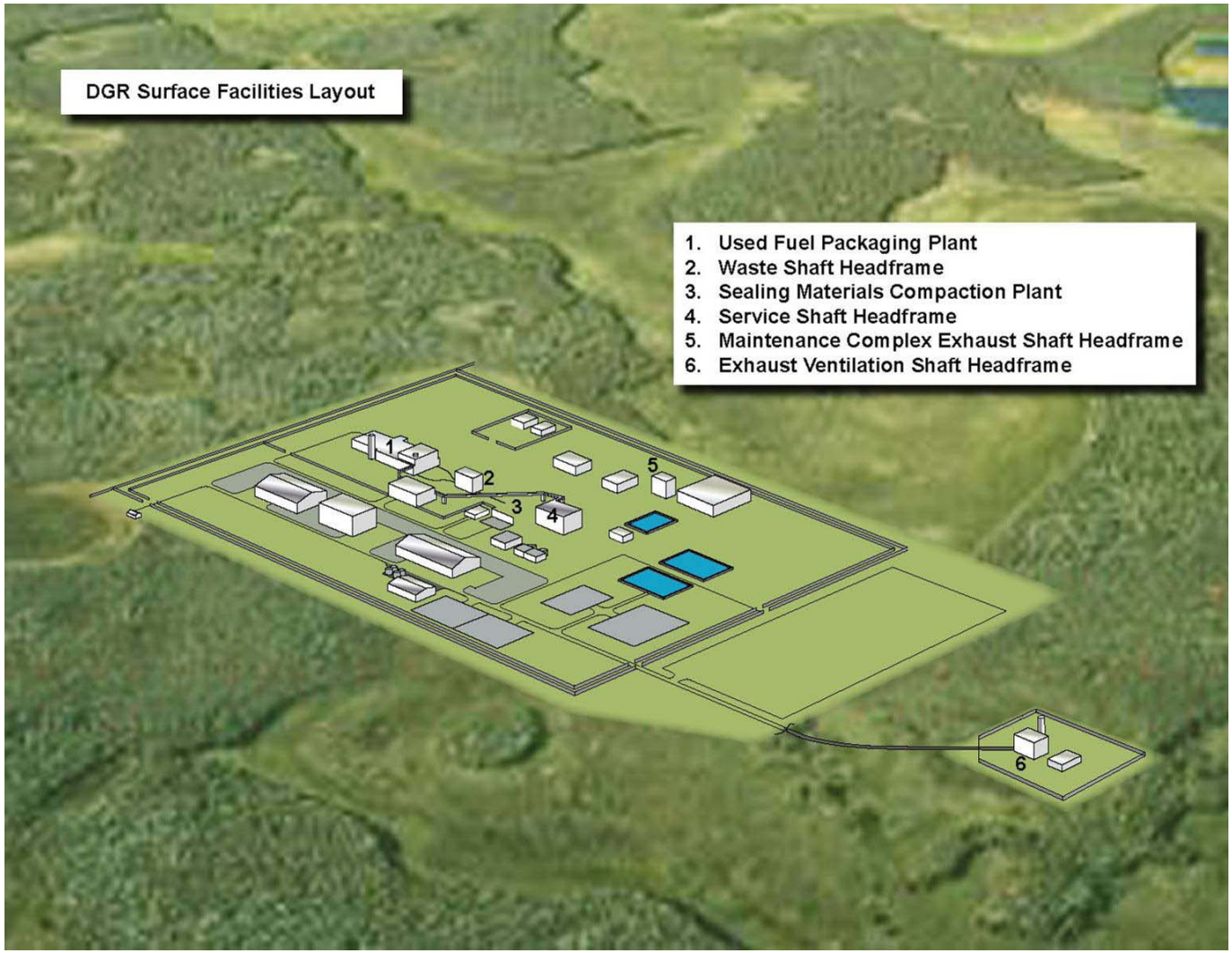




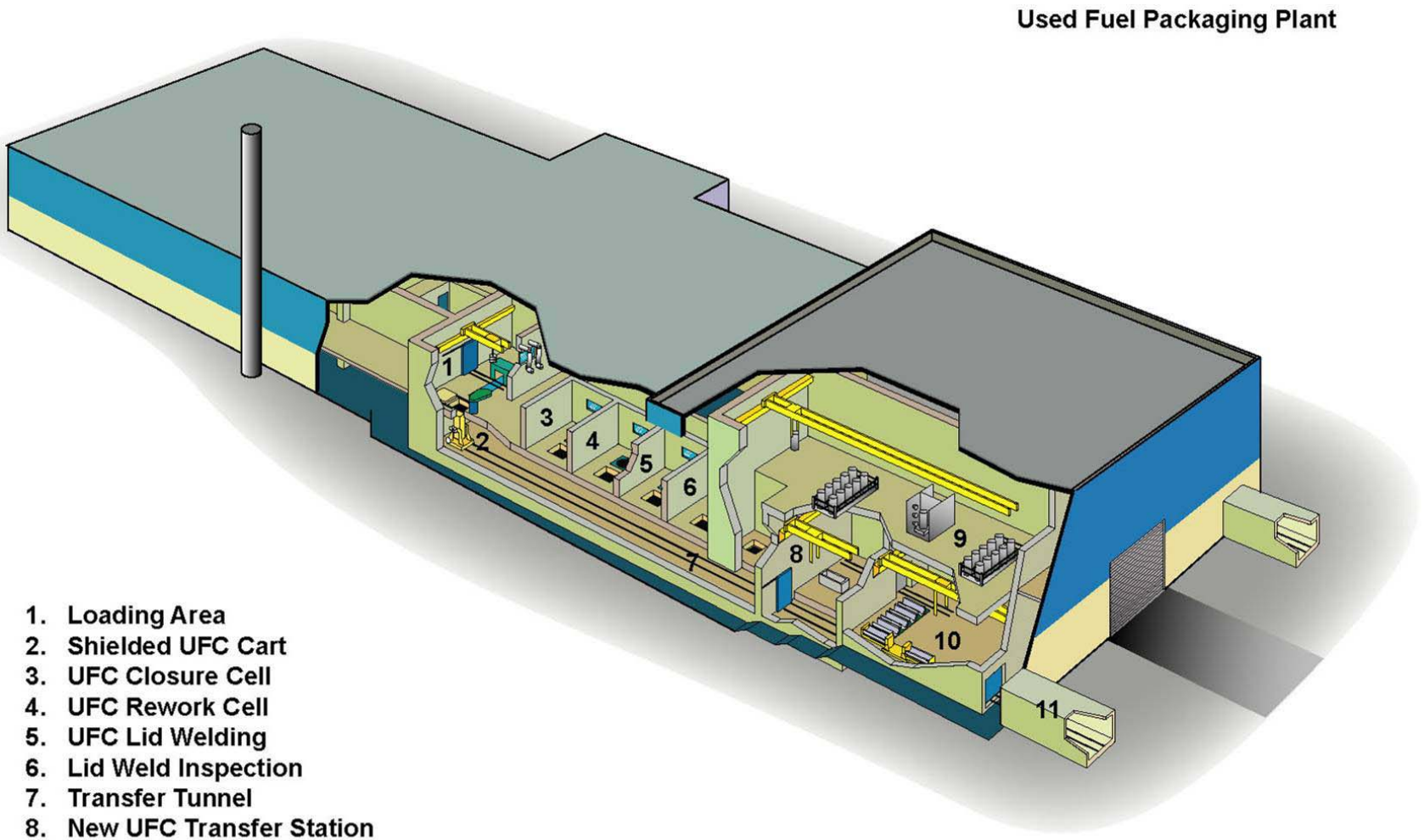
Major Changes to AECL Concept

- Now 3.6M fuel bundles vs AECL's 10.1M bundles
- Reference fuel age changed from 10 to 30 years
- Change in container design:
  - titanium to copper outer shell
  - glass beads to steel inner vessel
  - 72 bundle to 324 bundle
- In-room emplacement option engineered and costed
- Extended monitoring period prior to closure

Deep Geologic Repository (DGR) Surface Facilities

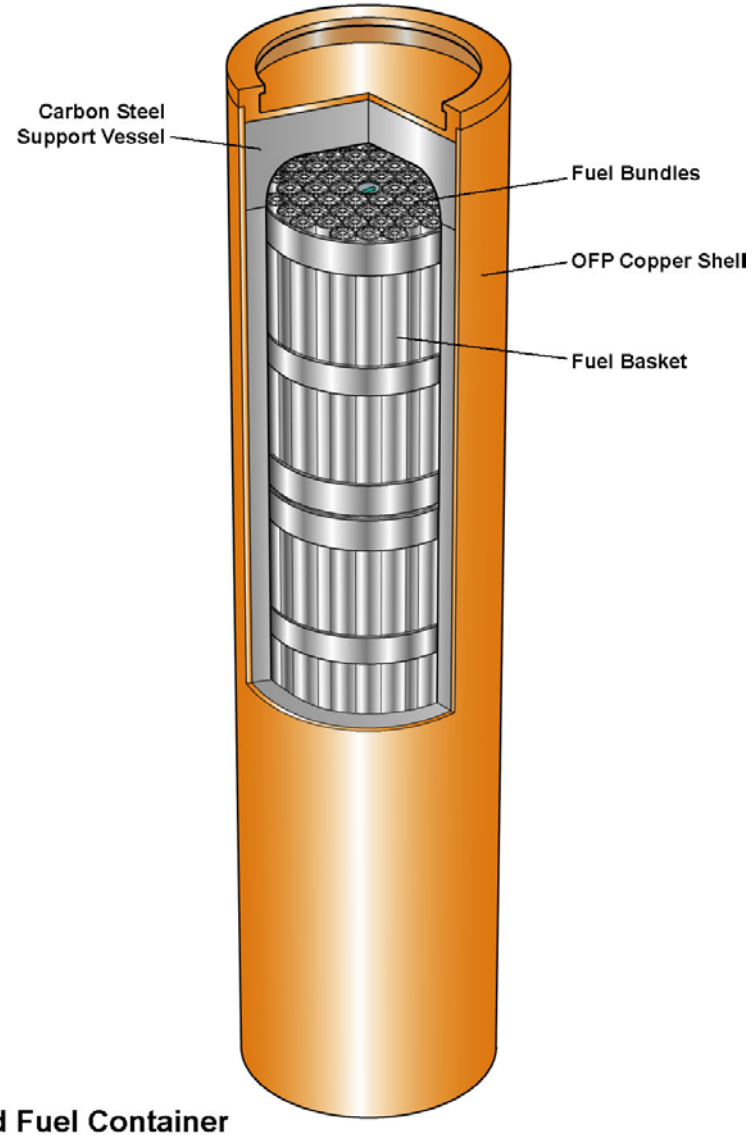


Used Fuel Packaging Plant

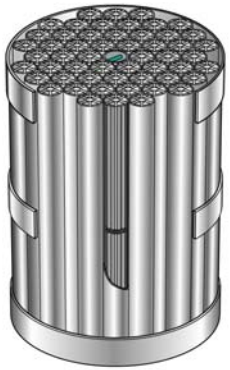


1. Loading Area
2. Shielded UFC Cart
3. UFC Closure Cell
4. UFC Rework Cell
5. UFC Lid Welding
6. Lid Weld Inspection
7. Transfer Tunnel
8. New UFC Transfer Station
9. UFC Decontamination
10. UFC Jacketing Area
11. UFC Export Tunnel

Disposal Container and Fuel Basket

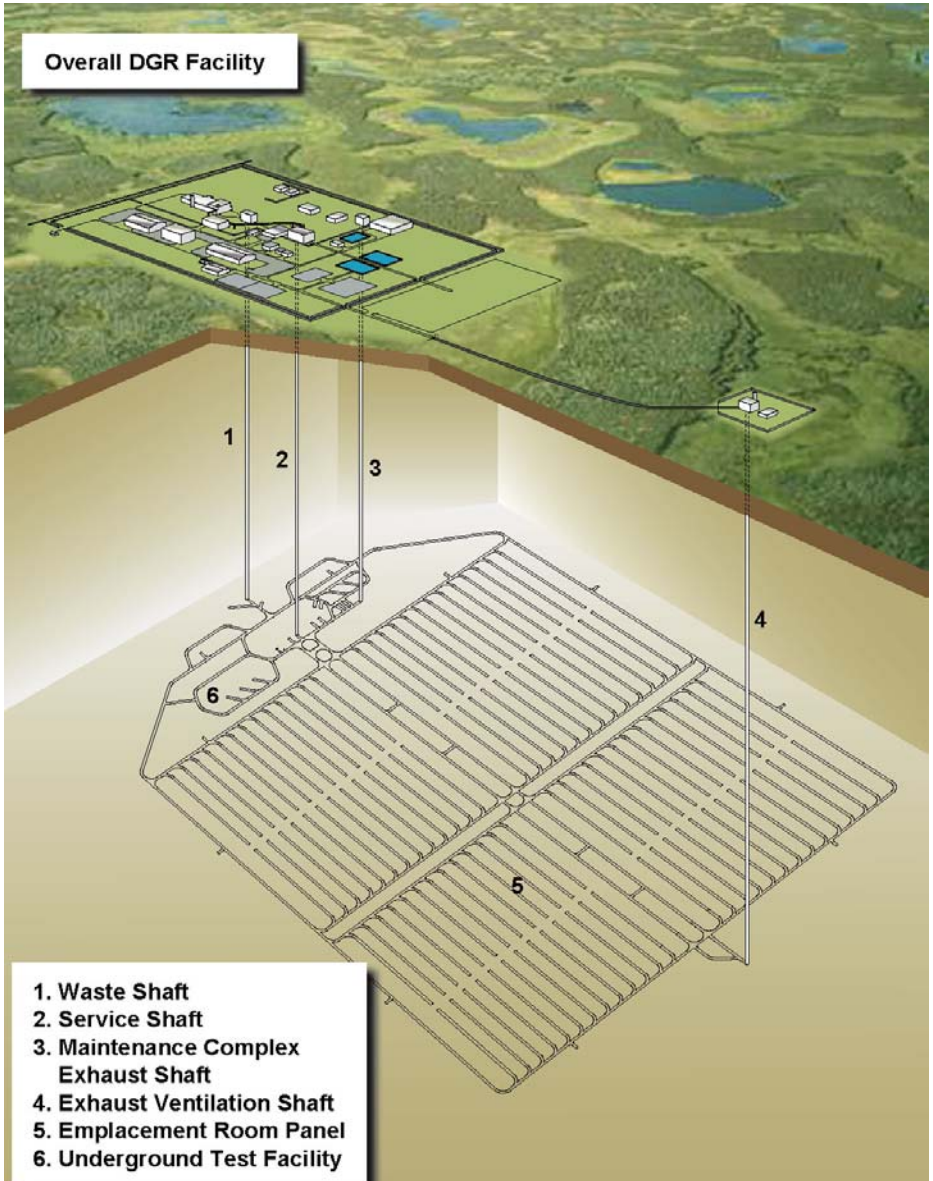


Used Fuel Container

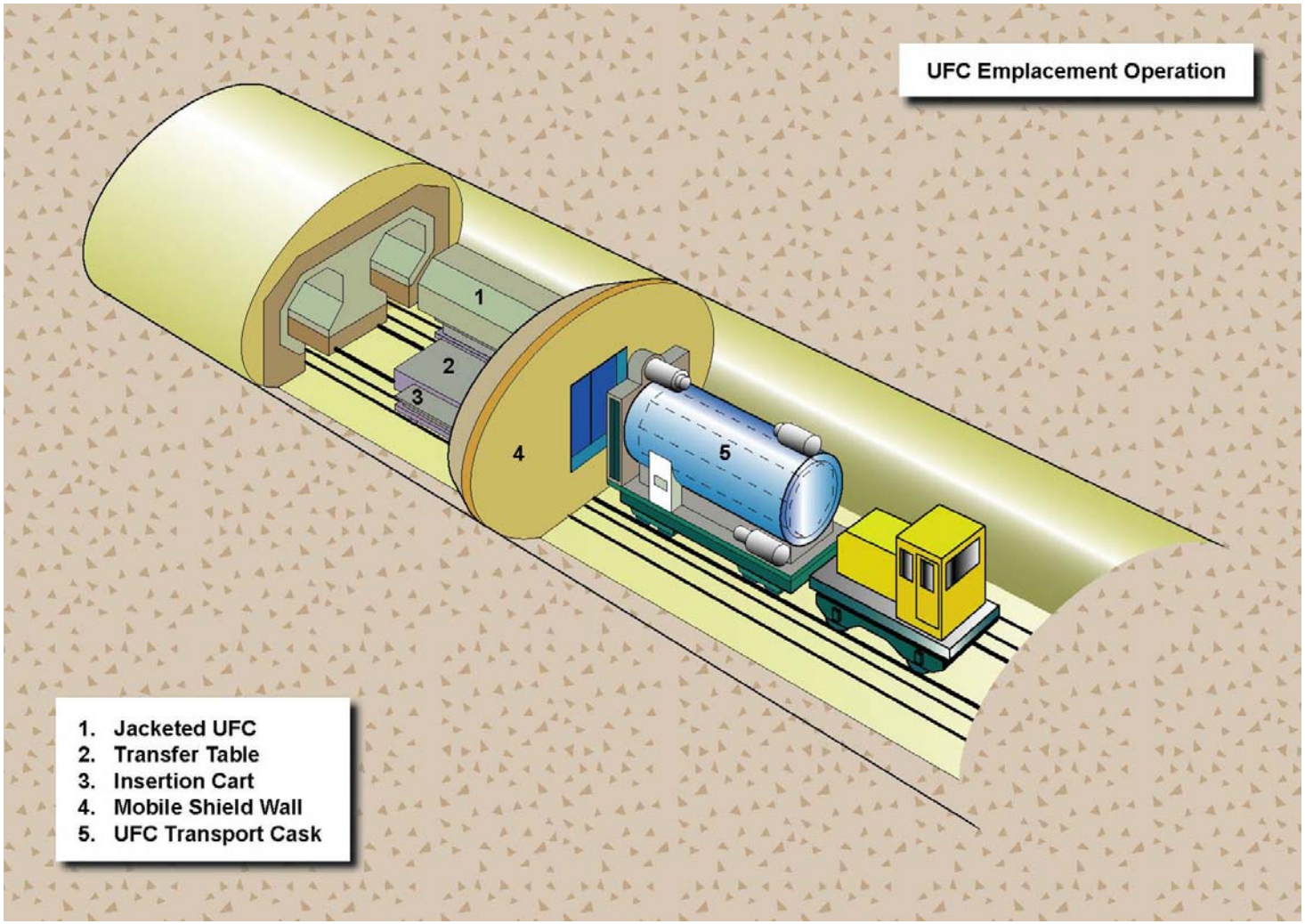


108-bundle Basket
for the Used Fuel Container

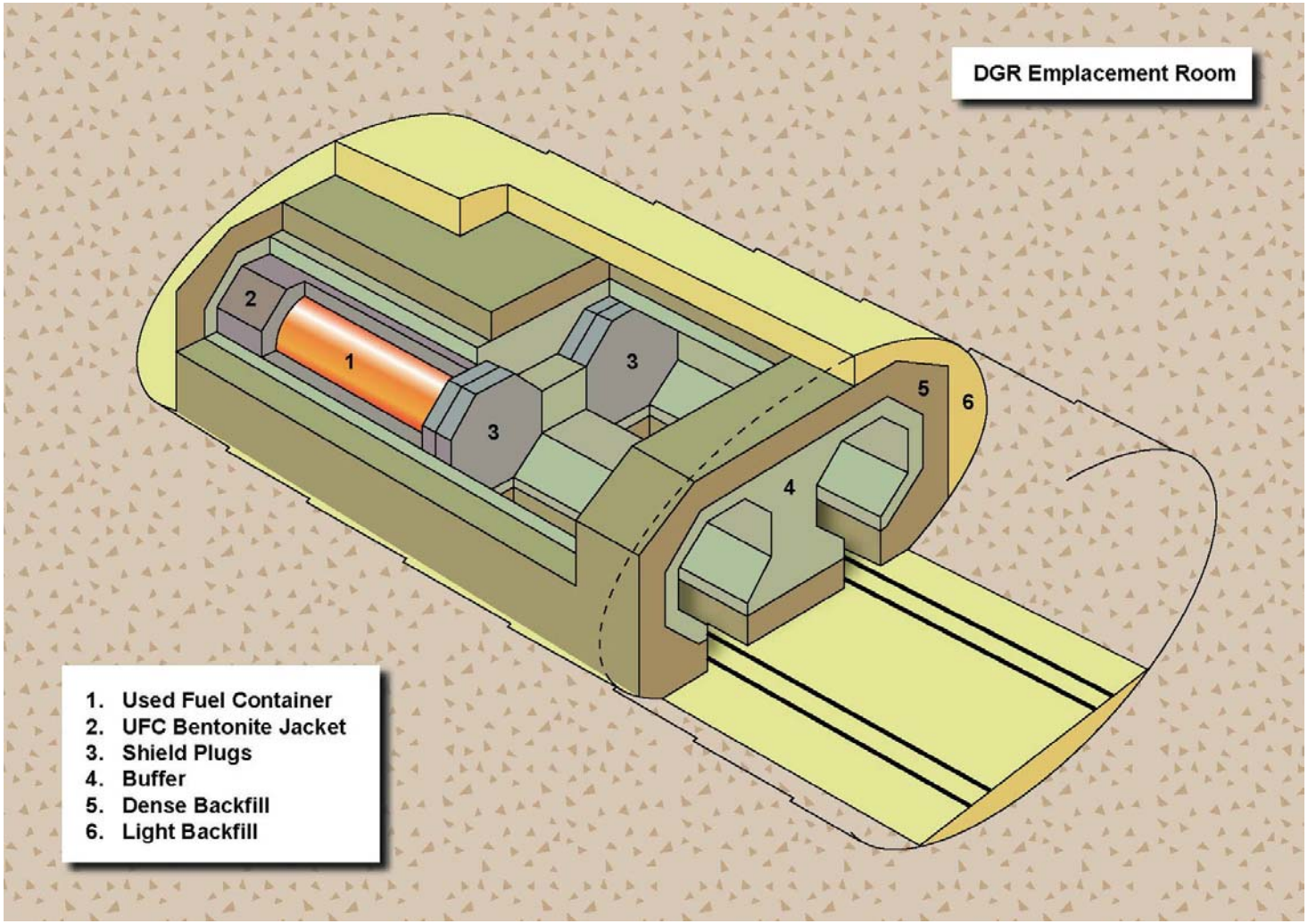
DGR Underground Layout



Emplacement Operation



Repository Emplacement Room

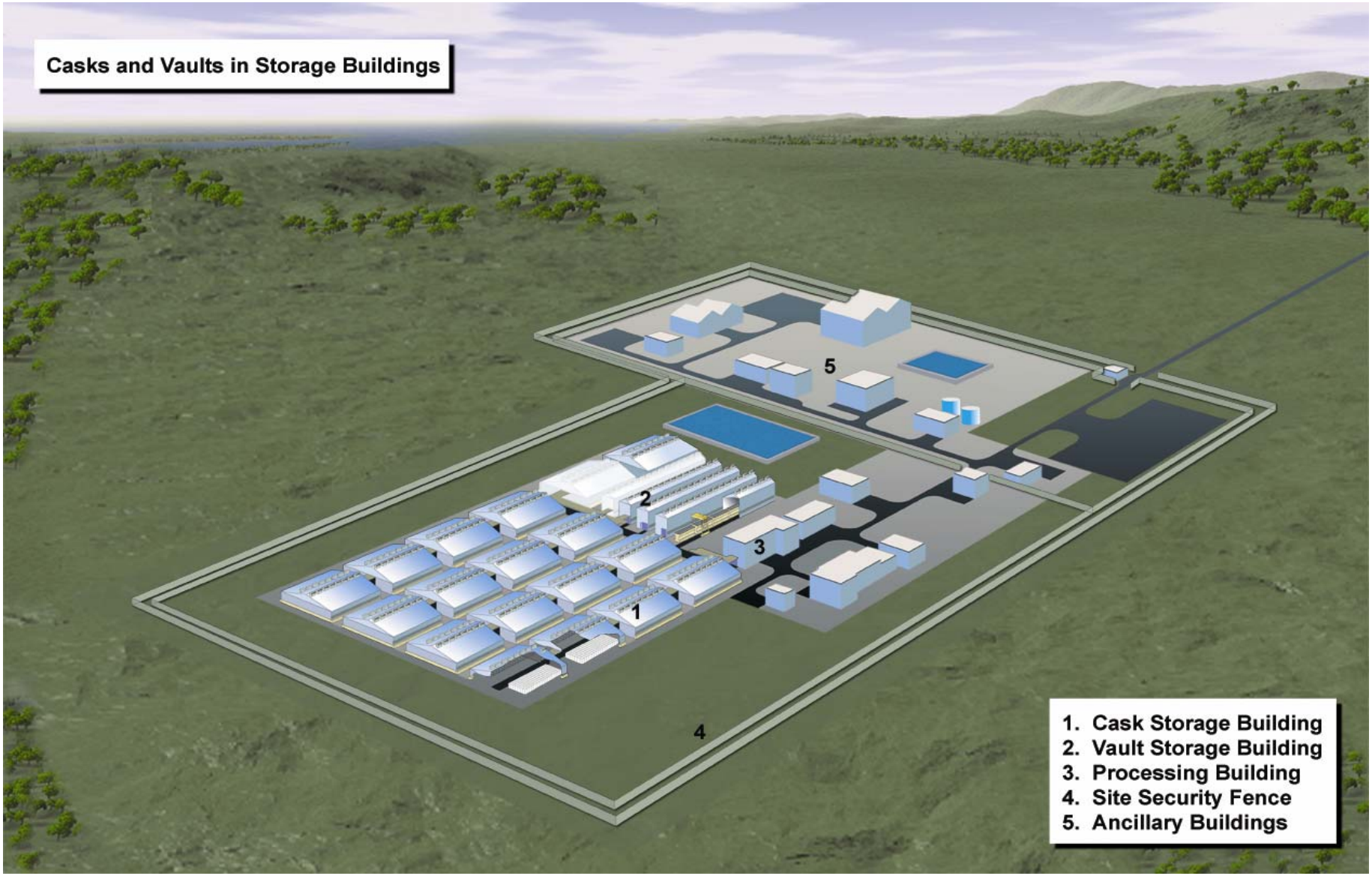


Centralized Extended Storage (CES)

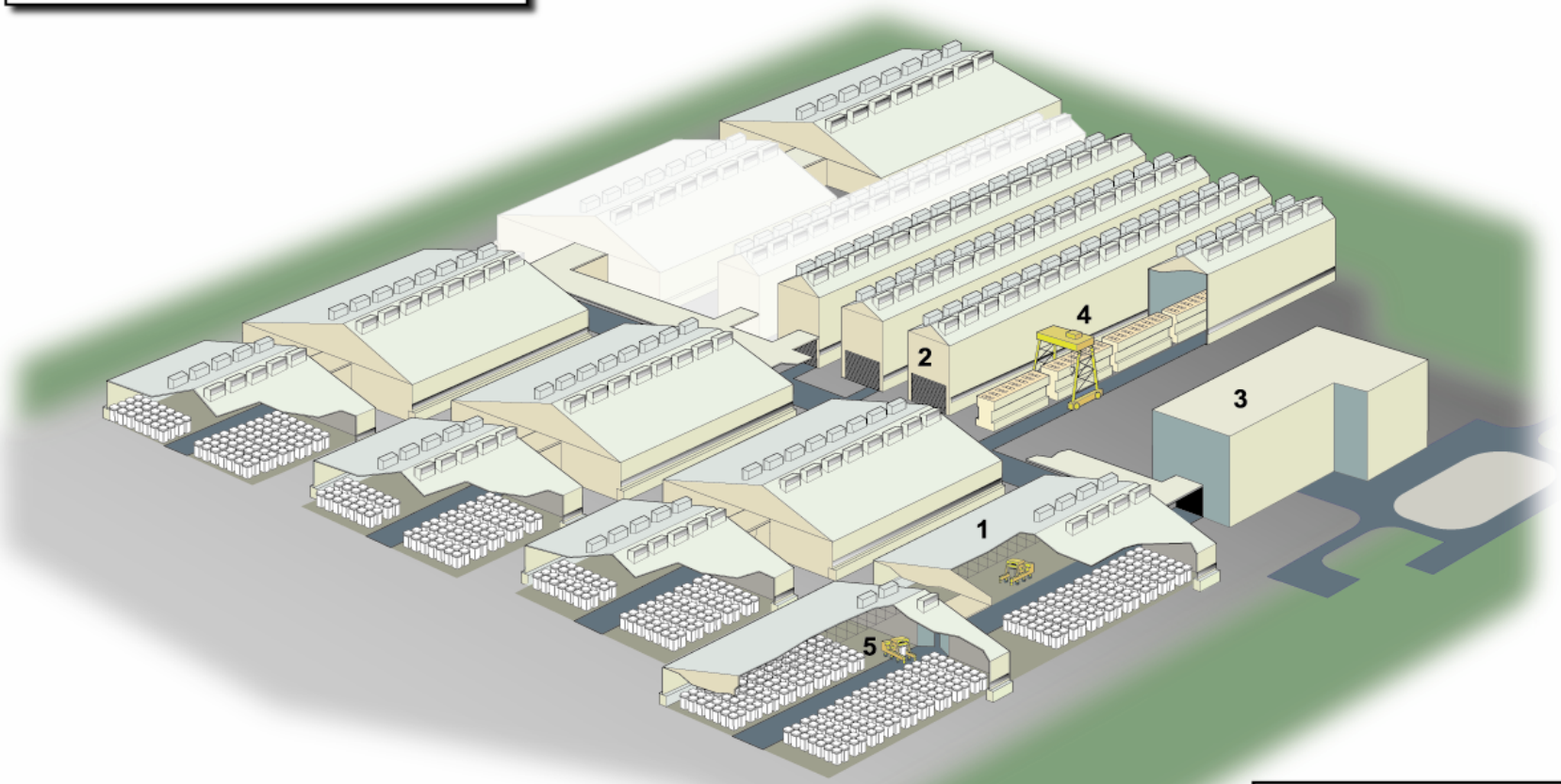
- Conceptual designs and cost estimates prepared for two above-ground and two below-ground options (typical)
- Work performed by CTECH (RWE Nukem + Canatom / SNC–Lavalin) (different team)

CES Key Assumptions

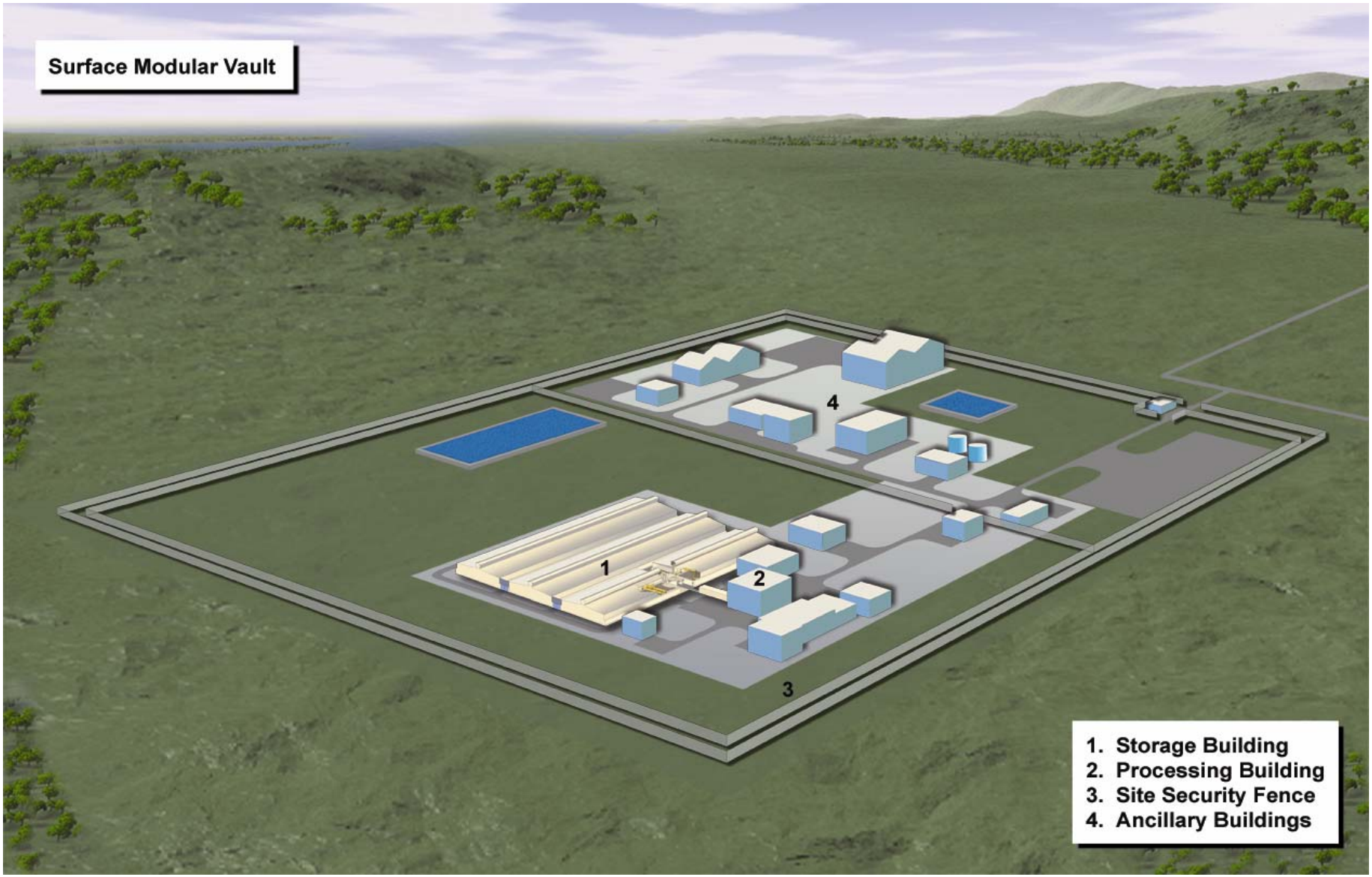
- Only one centralized storage site
- Storage assumed to be perpetual
- Only dry storage considered


Casks and Vaults in Storage Buildings
1
2
3
4
5
1. Cask Storage Building
2. Vault Storage Building
3. Processing Building
4. Site Security Fence
5. Ancillary Buildings

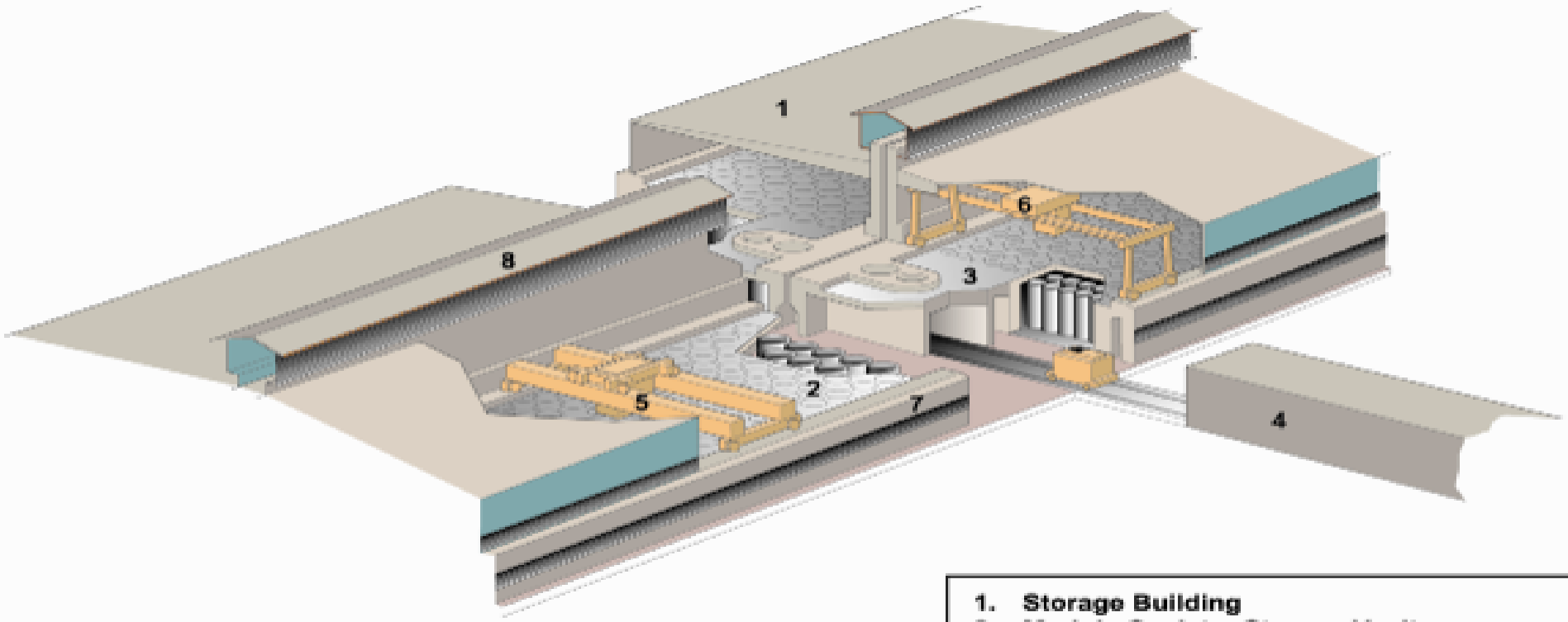
Casks and Vaults in Storage Buildings
Enlarged View of Storage Complex



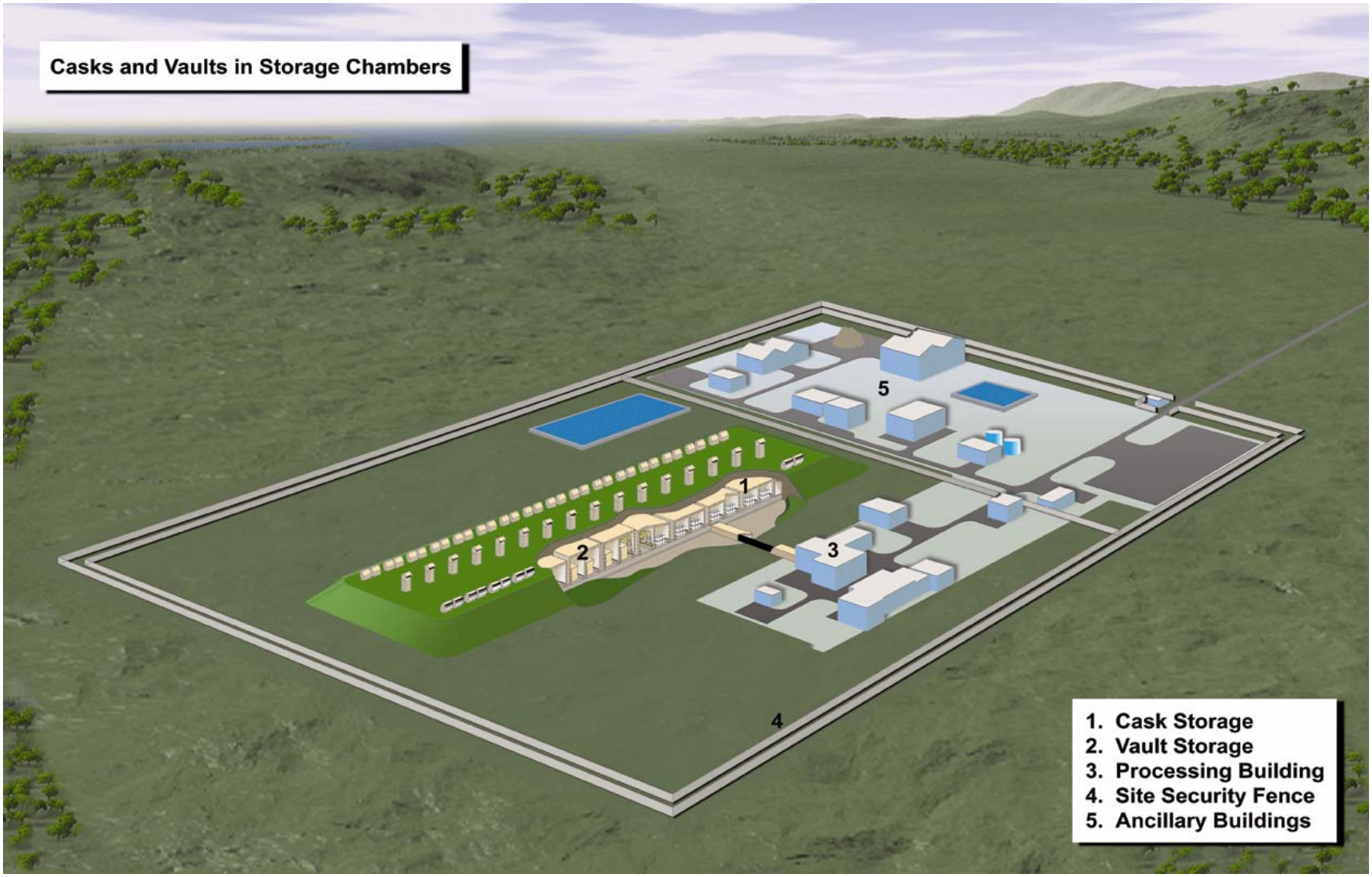
1. Cask Storage
2. Vault Storage
3. Processing Building
4. Vault Gantry Crane
5. Cask Transporter


Surface Modular Vault
4
1
2
3
1. Storage Building
2. Processing Building
3. Site Security Fence
4. Ancillary Buildings

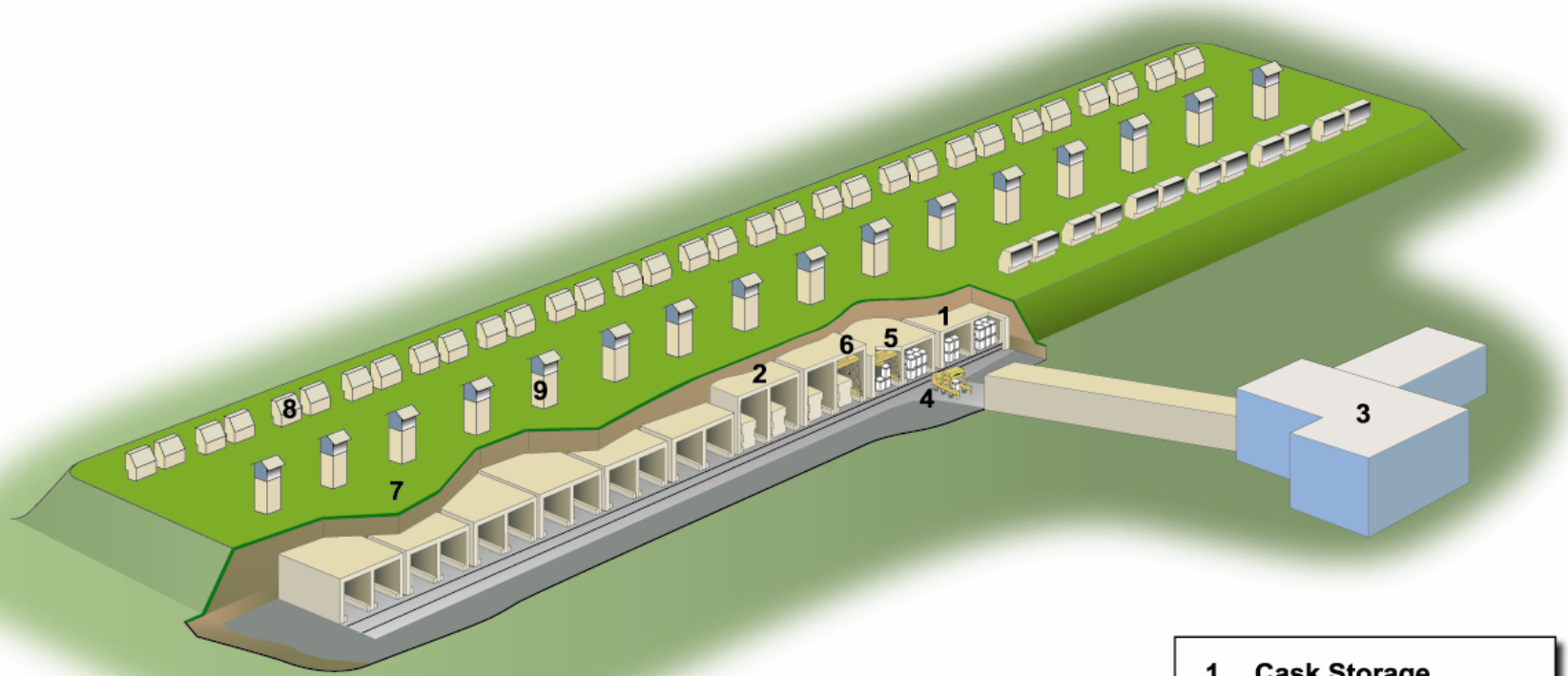
Surface Modular Vault
Enlarged View of Storage Complex



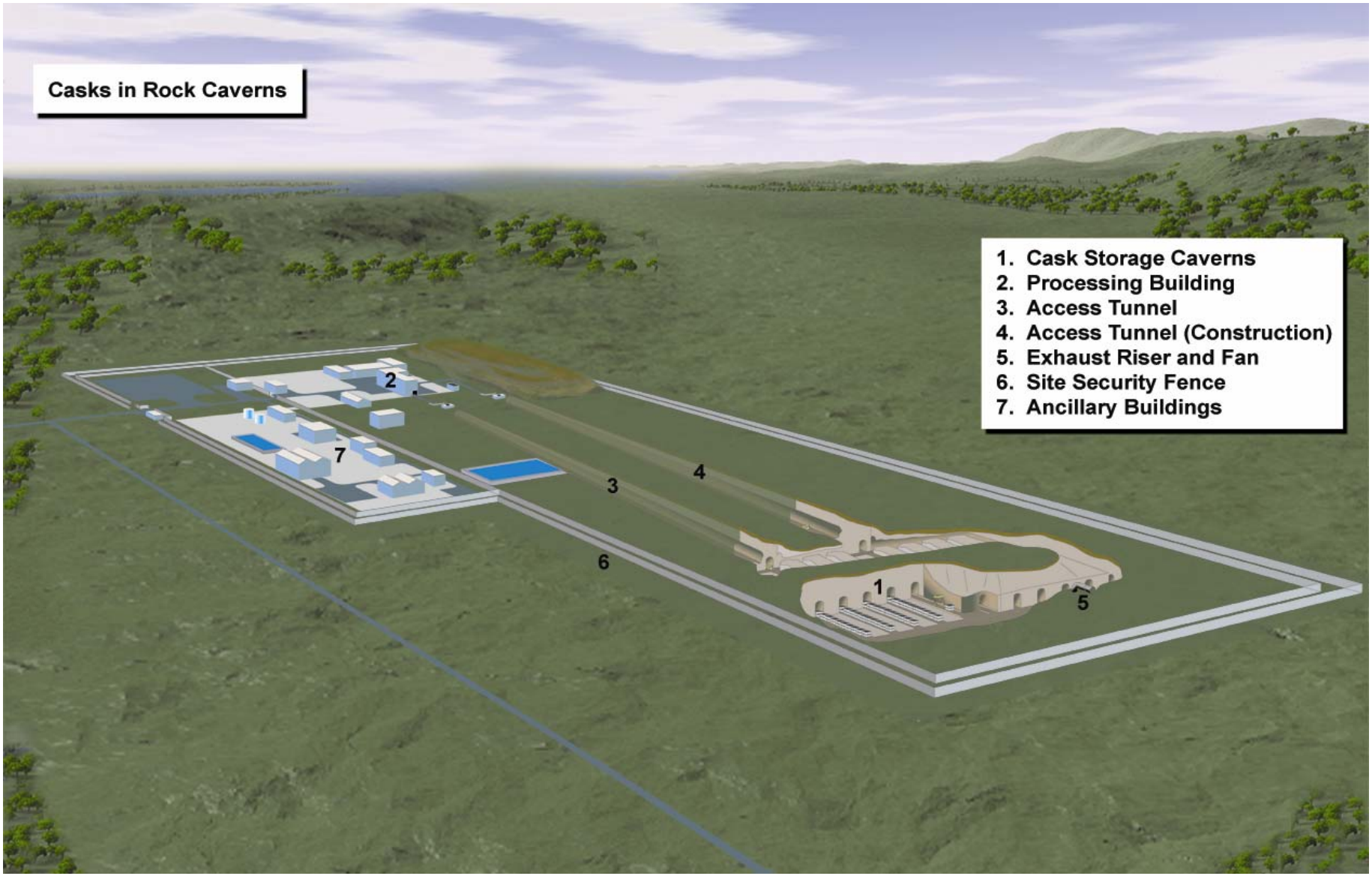
1. Storage Building
2. Module Canister Storage Vault
3. Basket Storage Vault
4. Transfer Route from Processing Building
5. Canister Handling Machine
6. Basket Transfer Gantry Crane
7. Ventilation Inlet
8. Ventilation Exhaust


Casks and Vaults in Storage Chambers
1
2
3
4
5
1. Cask Storage
2. Vault Storage
3. Processing Building
4. Site Security Fence
5. Ancillary Buildings

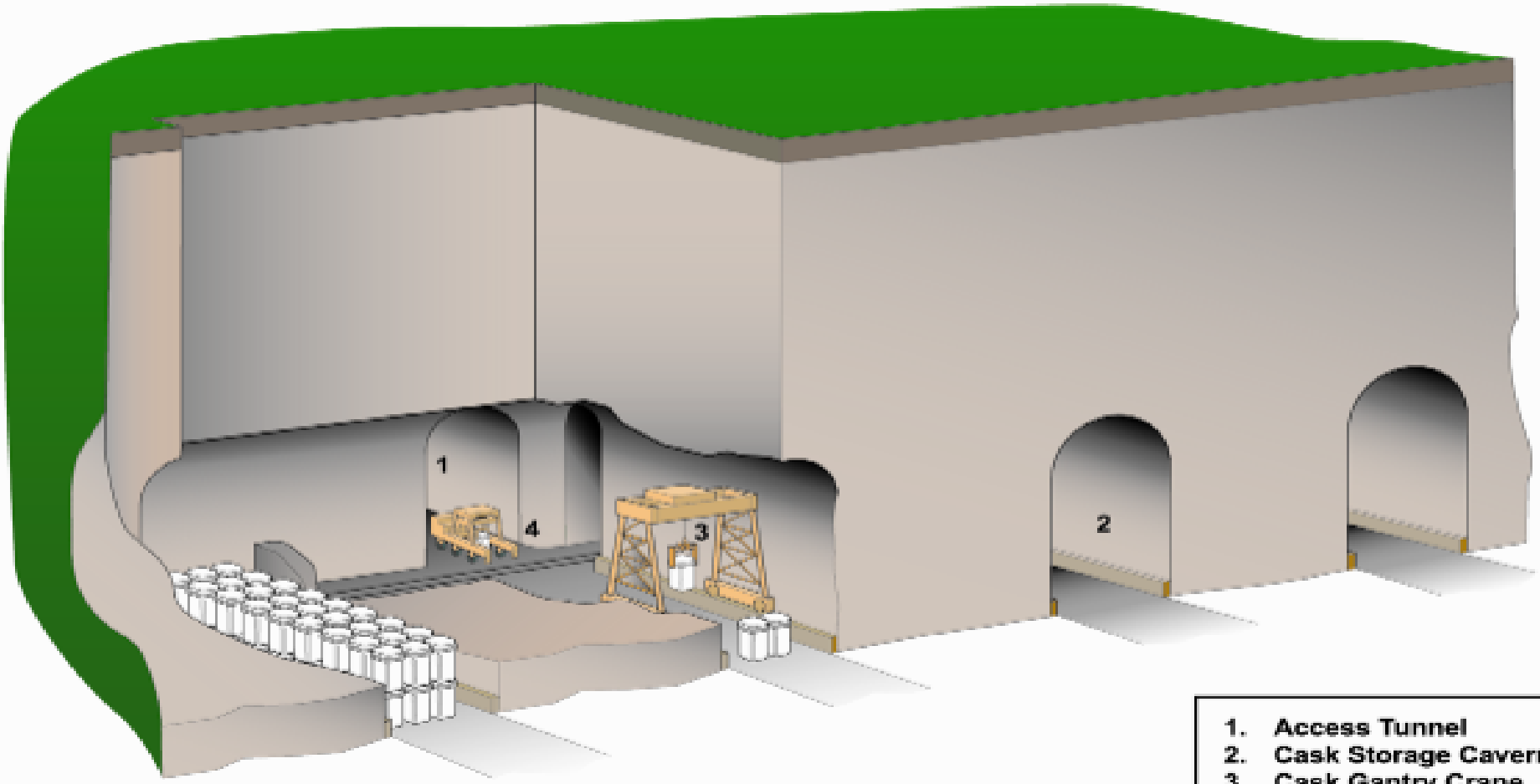
Casks and Vaults in Storage Chambers
Enlarged View of Storage Complex



1. Cask Storage
2. Vault Storage
3. Processing Building
4. Cask Transporter
5. Cask Gantry Crane
6. Vault Gantry Crane
7. Earthen Cover
8. Ventilation Inlet
9. Ventilation Exhaust


Casks in Rock Caverns
1. Cask Storage Caverns
2. Processing Building
3. Access Tunnel
4. Access Tunnel (Construction)
5. Exhaust Riser and Fan
6. Site Security Fence
7. Ancillary Buildings
1
2
3
4
5
6
7

Casks in Rock Caverns
Enlarged View of Storage Complex



1. Access Tunnel
2. Cask Storage Cavern
3. Cask Gantry Crane
4. Cask Transporter

Reactor-Site Extended Storage (RES)

- Assumes no used fuel is transported
- Work performed by CTECH as part of Centralized Extended Storage contract
- Designs and costs are scaled down from Centralized Extended Storage equivalents

Existing Used Fuel Storage Practice

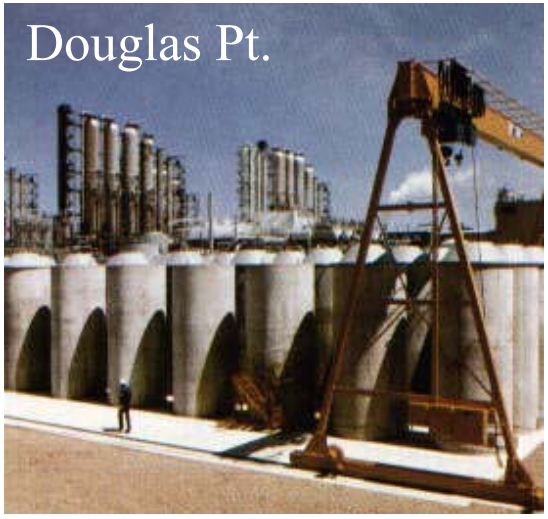
- Used nuclear fuel currently stored at reactor sites
- Initial storage in wet bays, followed by transfer to dry storage facilities
- OPG – dry storage containers in storage buildings
- Hydro-Québec: outside vaults
- New Brunswick Power and AECL: outside silos

OPG (Pickering, Western, Darlington)

Hydro-Québec

New Brunswick Power

Atomic Energy of Canada Limited



Reactor-Site Extended Storage – OPG Fuel

- Design 1: casks in storage buildings (repeat of existing practice)
- Design 2: casks in buried concrete chambers
- Design 3: surface modular vault
- Same designs at each site

Reactor-Site Extended Storage – HQ Fuel

- Design 1: outside vaults (repeat of existing practice)
- Design 2: vaults in buried concrete chambers
- Design 3: surface modular vault

Reactor-Site Extended Storage – NBP Fuel

- Design 1: outside silos (repeat of existing practice)
- Design 2: vaults in buried concrete chambers
- Design 3: surface modular vault

Reactor-Site Extended Storage – AECL Fuel

- Chalk River: outside silos, silos in buildings and silos in buried concrete chambers
- Douglas Point: fuel stored with OPG fuel at Bruce
- Gentilly–1: fuel stored with HQ fuel at Gentilly
- Whiteshell: outside silos, silos in buildings and silos in buried concrete chambers

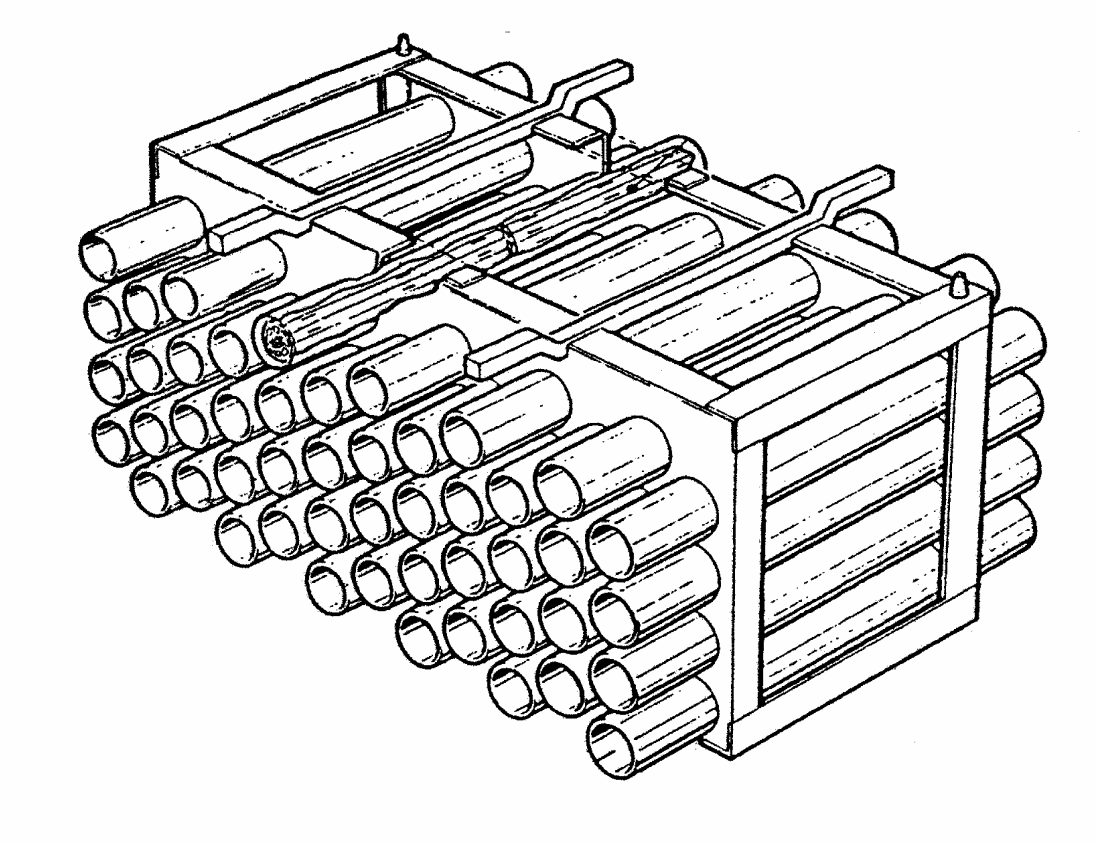
Used Fuel Transportation

- Three options developed: all road, mostly rail, mostly water
- Centralized sites (DGR and CES) assumed to be in Ontario for logistics and costing calculations
- Work performed by Cogema Logistics

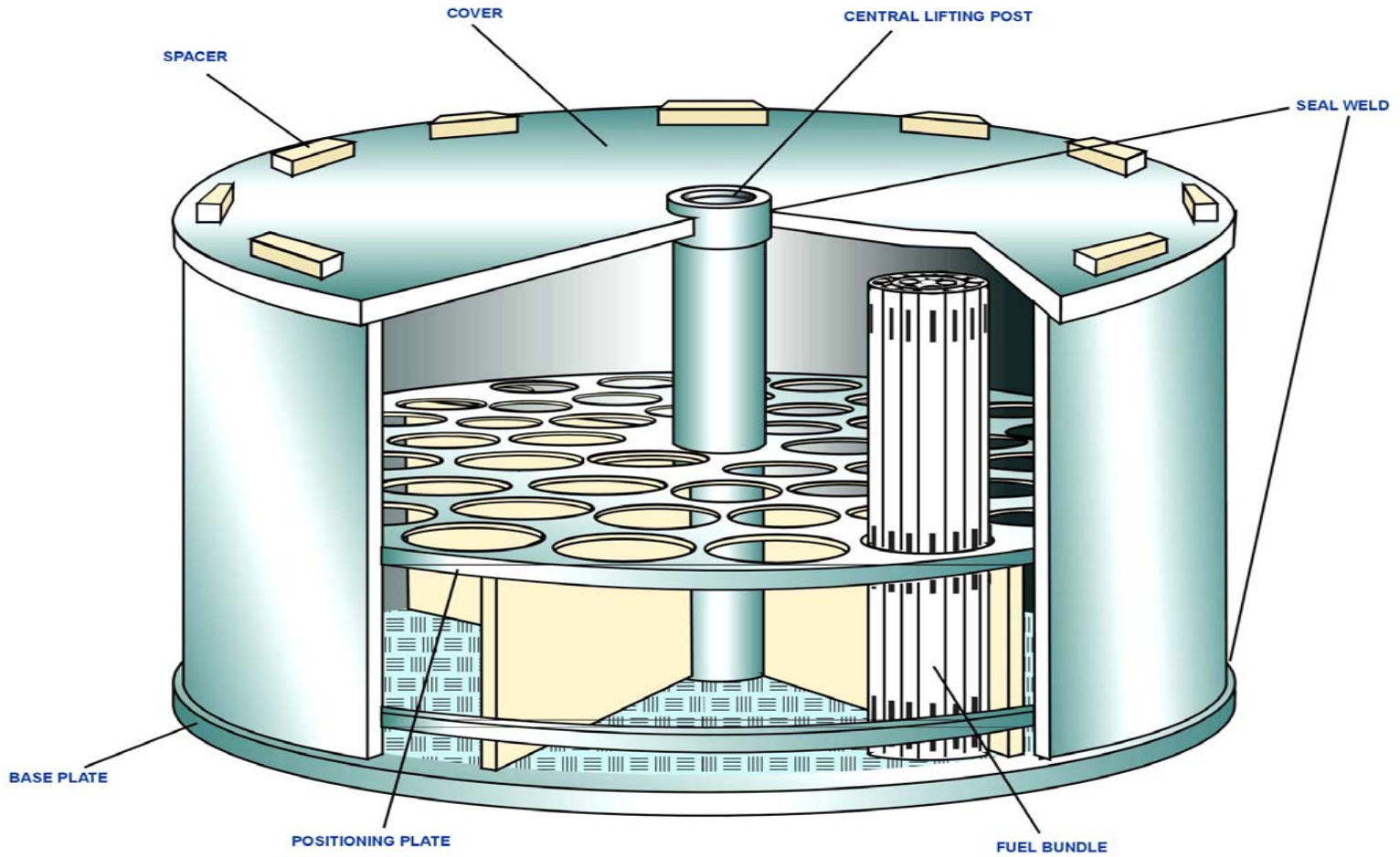
Transportability of Current Containers

- OPG storage modules are transportable
- OPG DSCs are only transportable by rail or water. Long-distance road transportation is impractical due to size and weight considerations
- AECL/HQ/NBP fuel will be in transportable baskets. Adequacy of current baskets under review

OPG Fuel Module

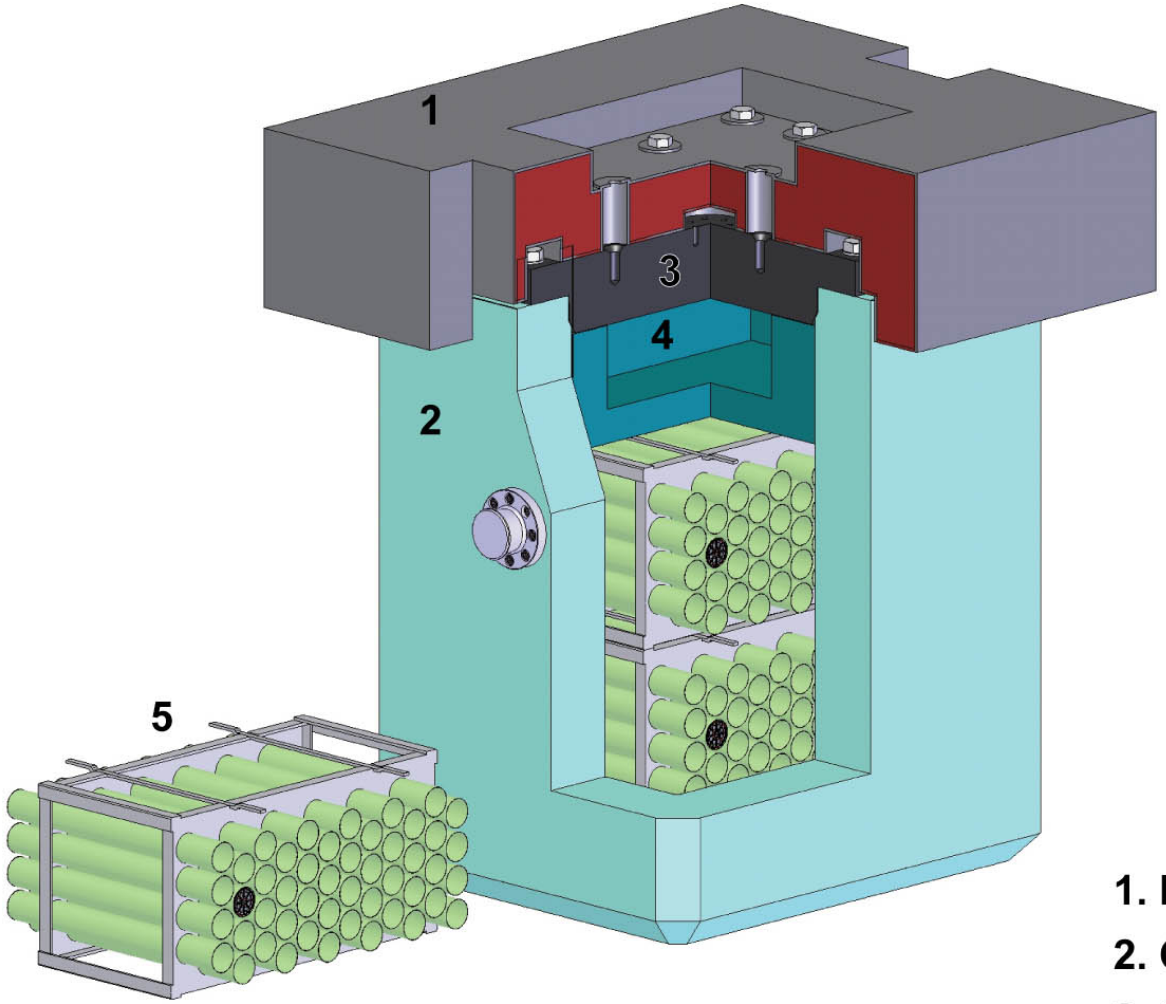


AECL/HQ/NBP Basket



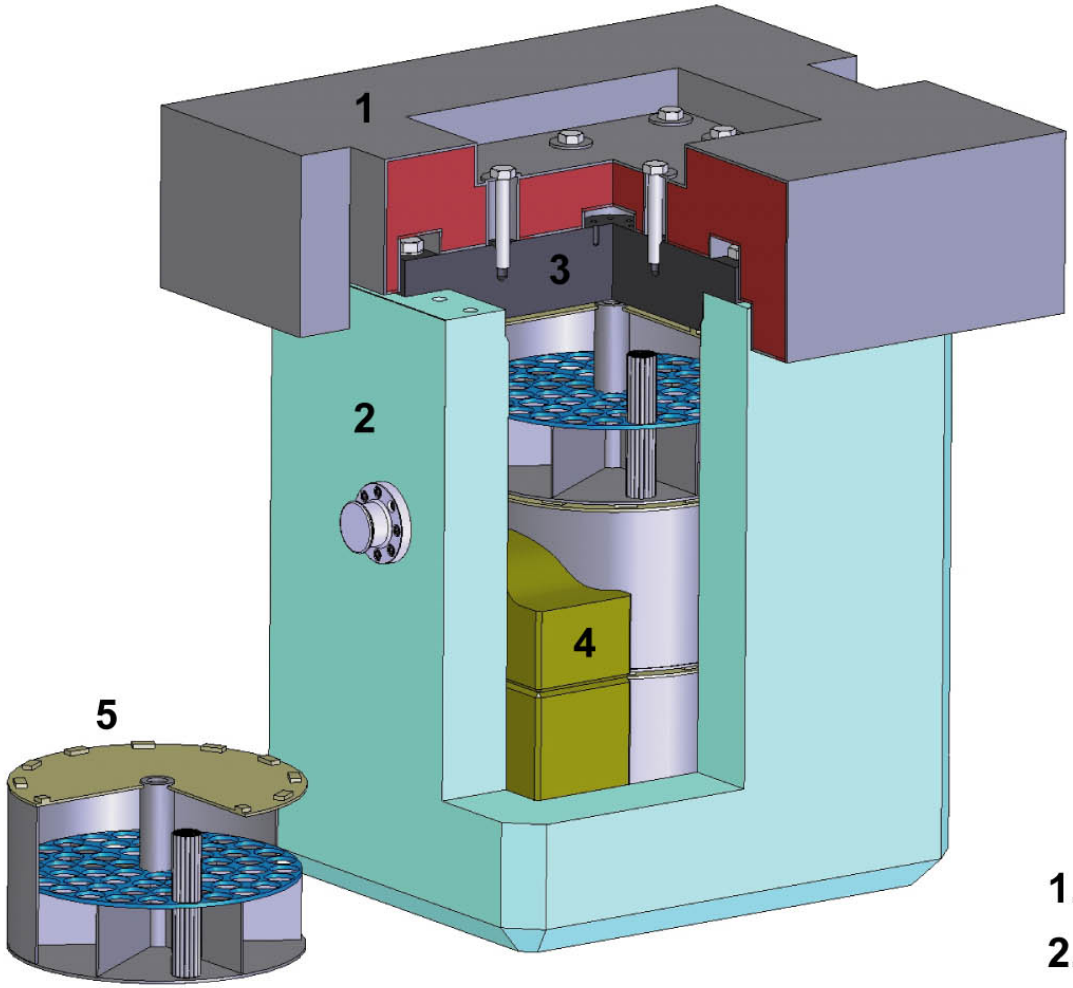
IRRADIATED FUEL DRY-STORAGE BASKET (60 bundles capacity)

Transportation Cask IFTC/BM with Modules



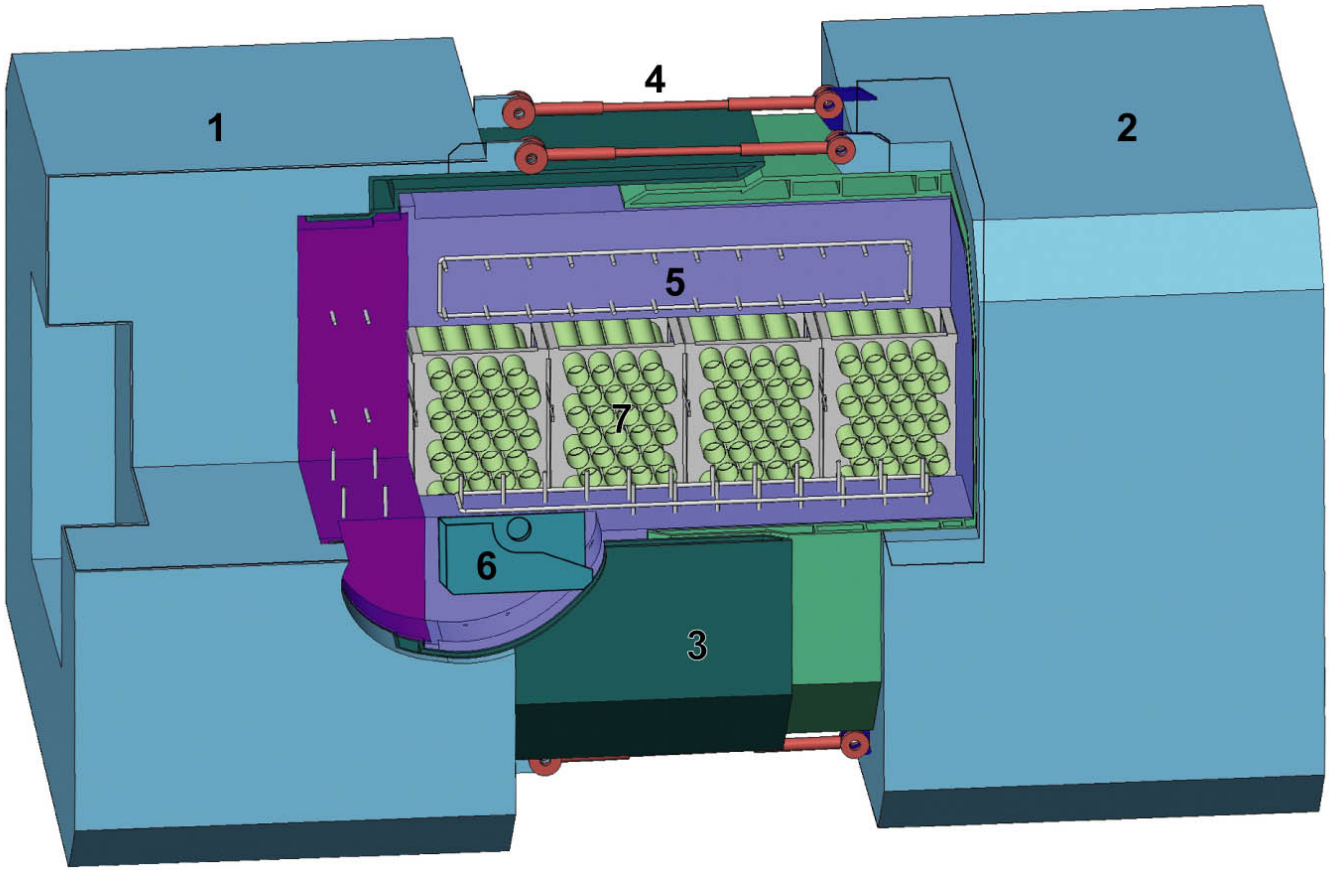
1. Impact Limiter
2. Cask Body
3. Cask Lid
4. Spacer
5. Module

Transportation Cask IFTC/BM with Baskets



1. Impact Limiter
2. Cask Body
3. Cask Lid
4. Spacer
5. Basket

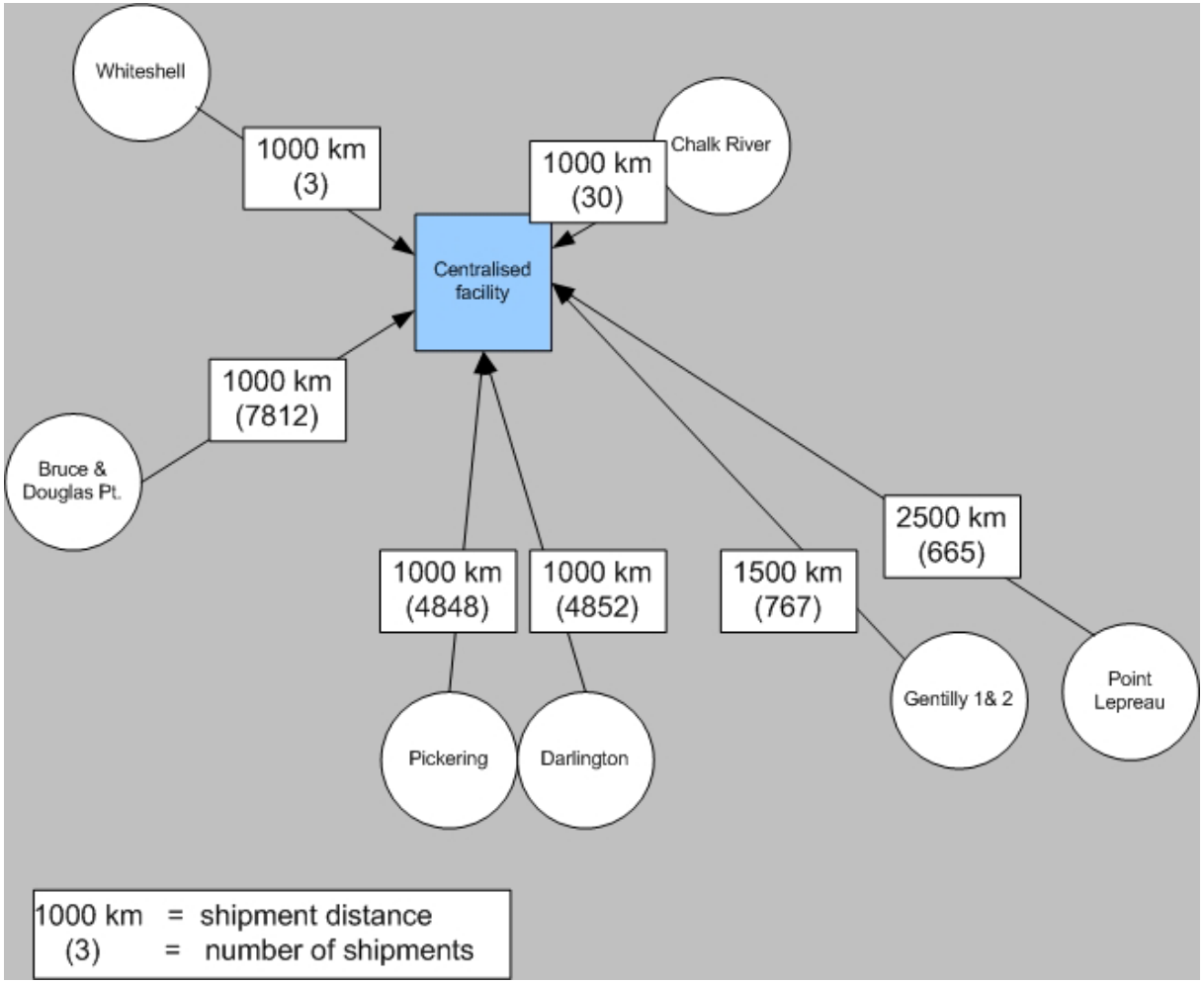
Dry Storage Container Transportation Package



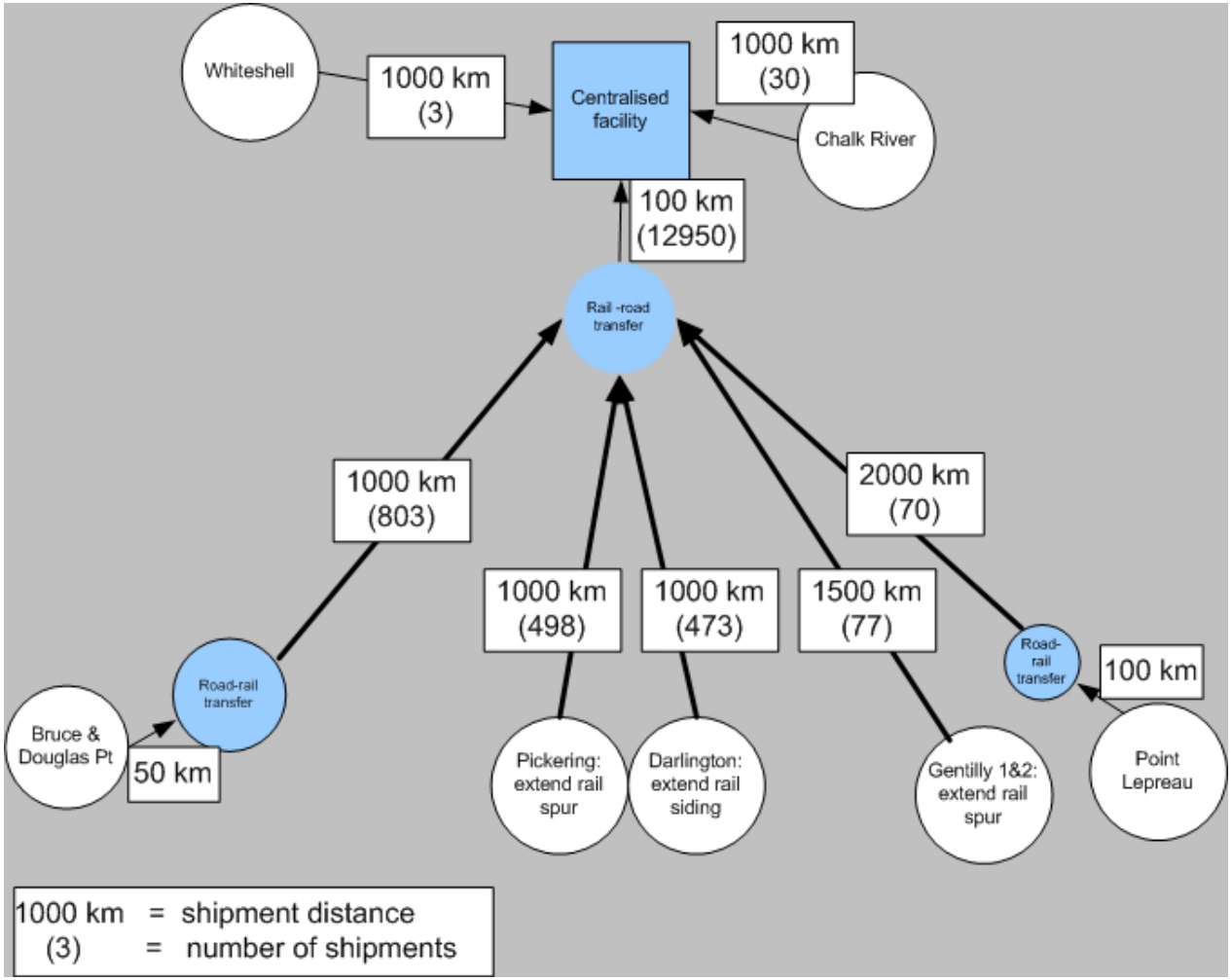
1. Top Impact Limiter
2. Bottom Impact Limiter
3. Side Armour
4. Wire Rope Attachments
5. DSC
6. DSC Lift Plate
7. Fuel Modules (4)

Nuclear Sites in Canada

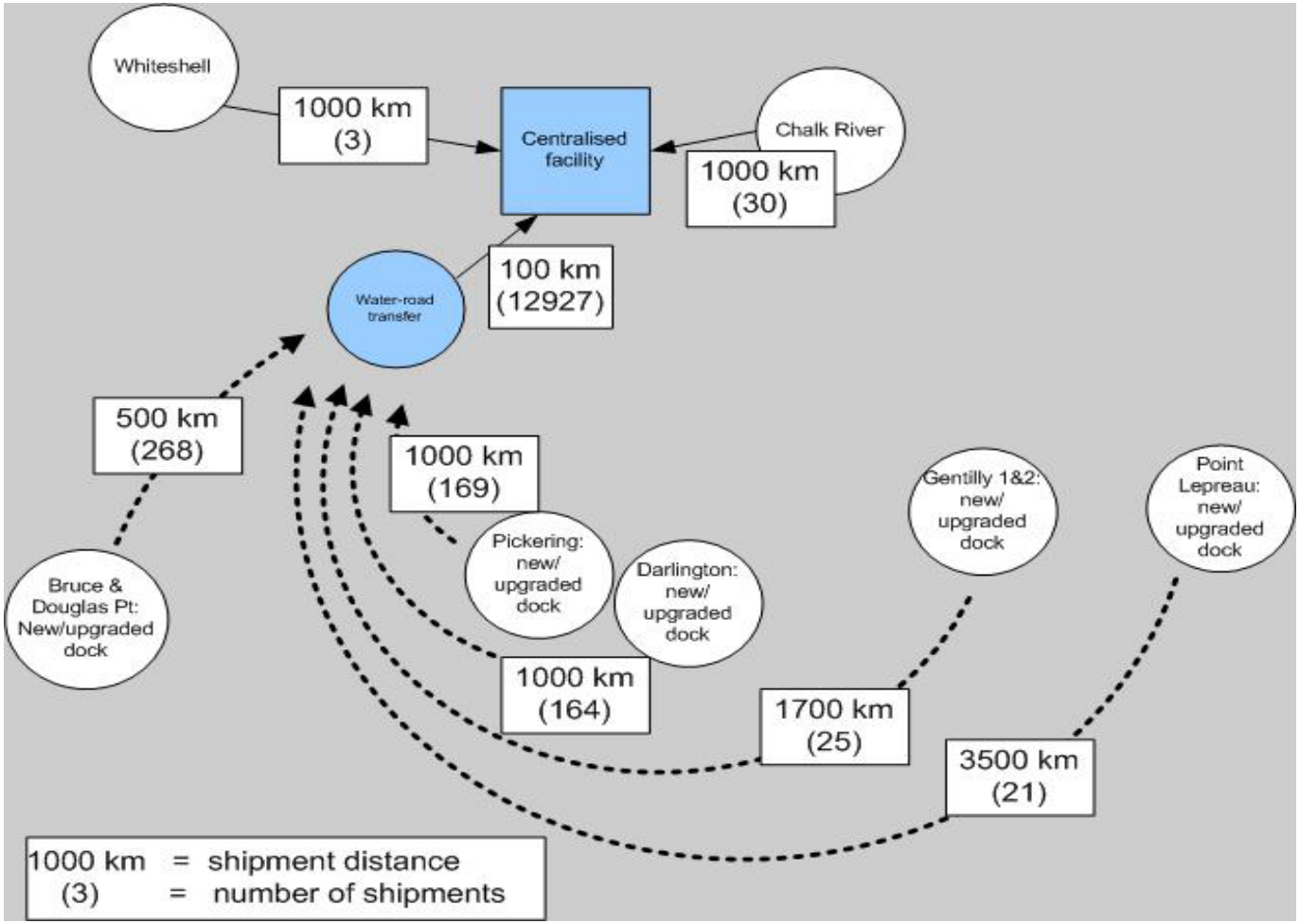
Road Transportation System



Mostly Rail Transportation System

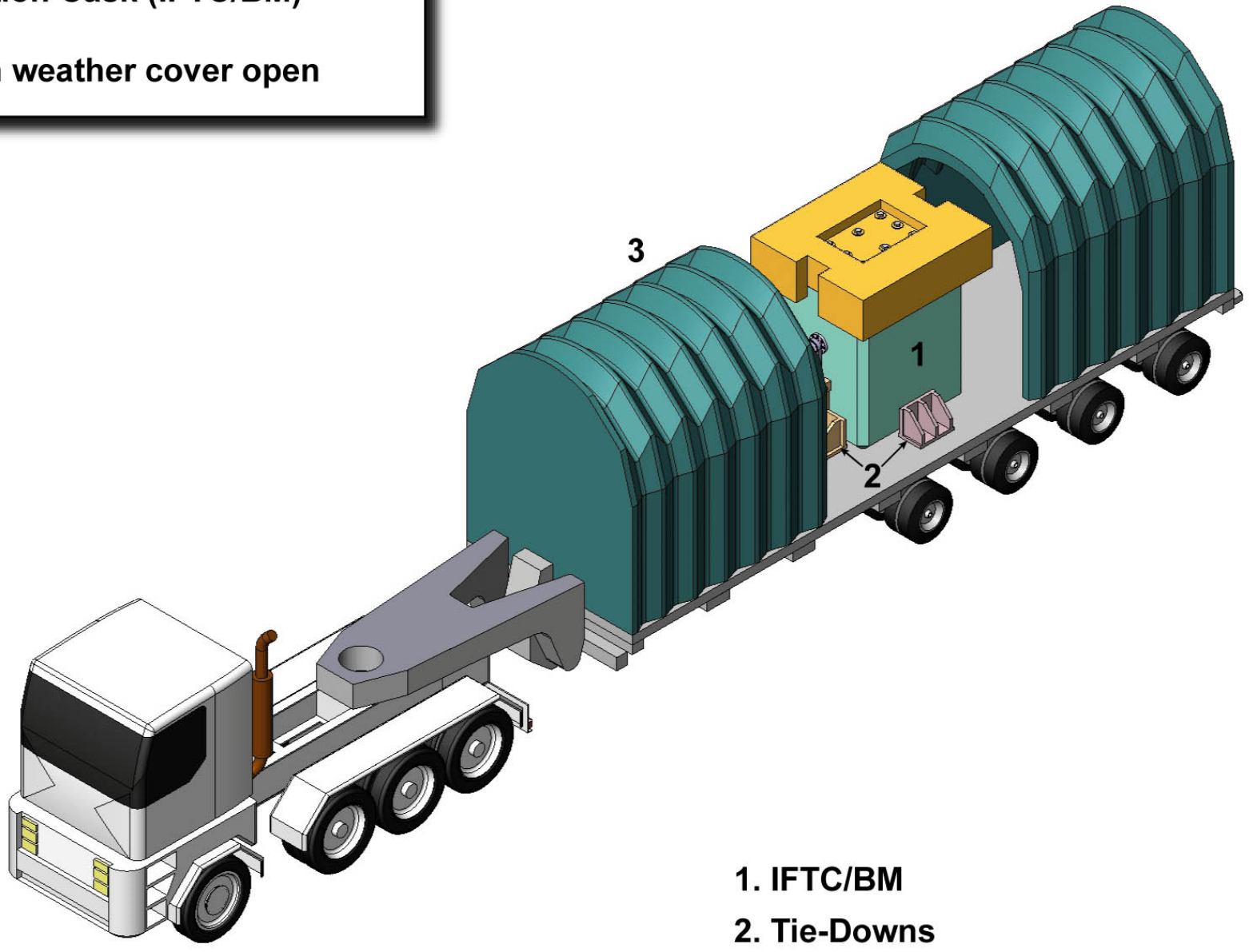


Mostly Water Transportation System



Road Transportation of Road-weight Transportation Cask (IFTC/BM)

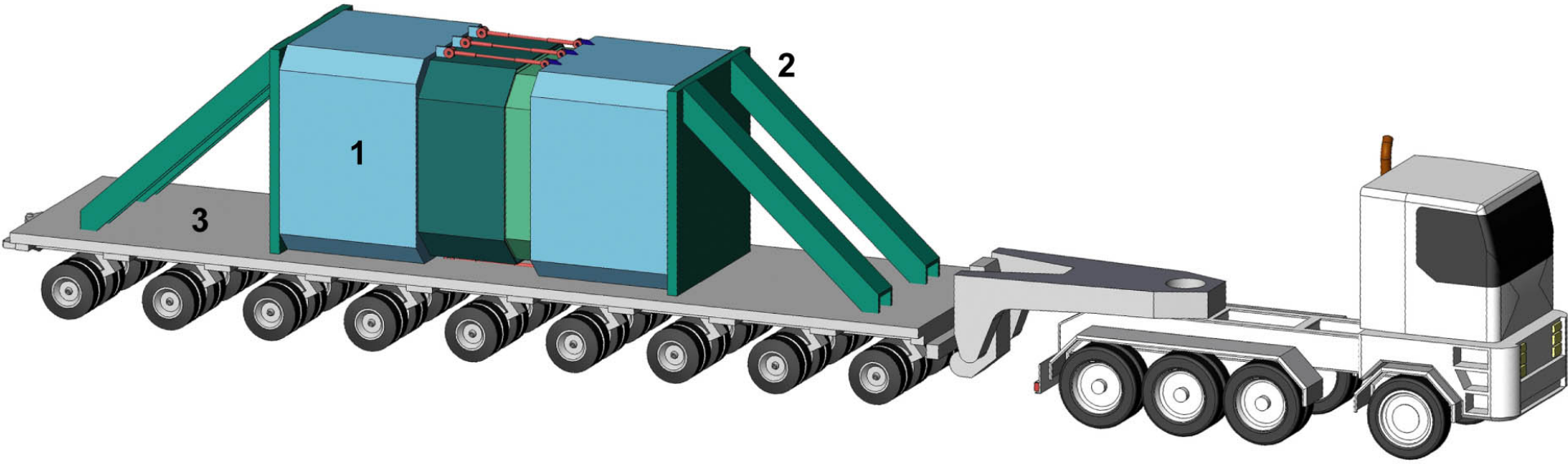
Shown with weather cover open



1. IFTC/BM
2. Tie-Downs
3. Weather Cover

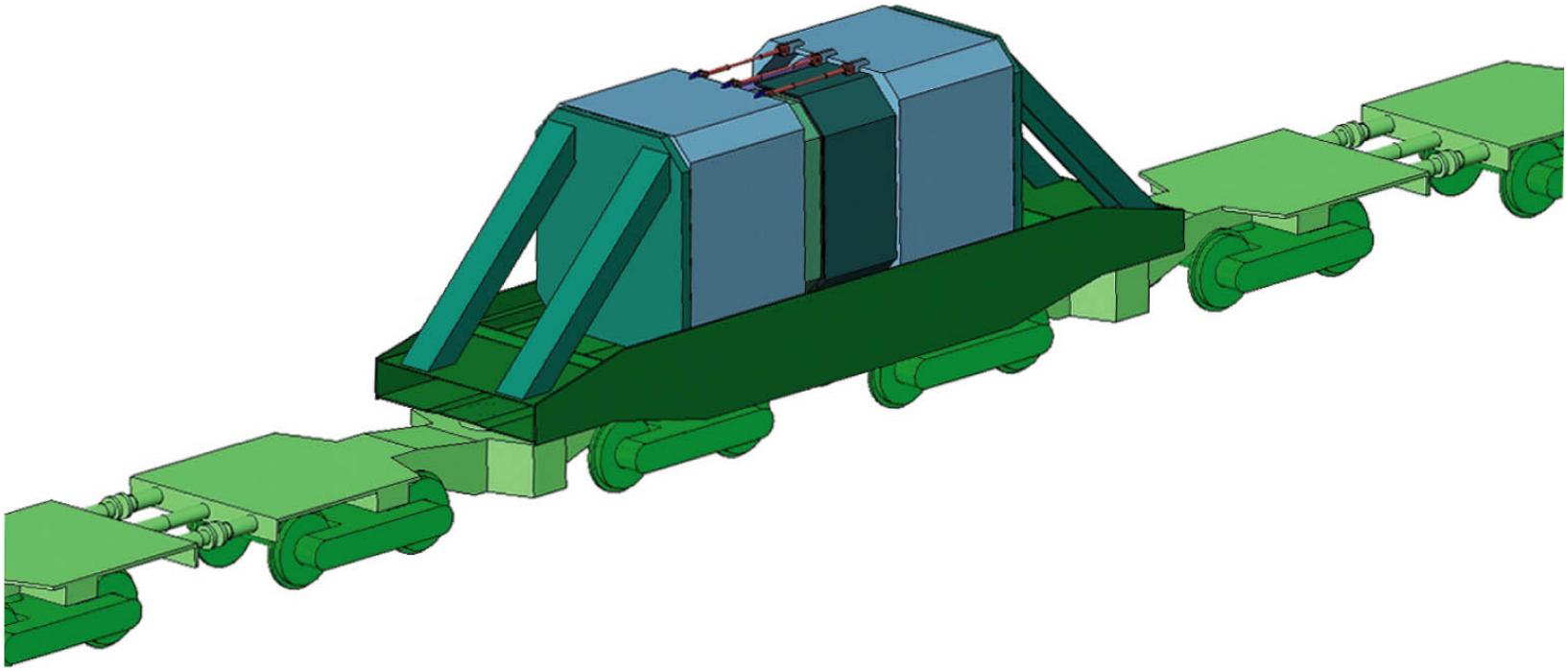
(labelling for transportation not shown

Road Transportation of Dry Storage Container Transportation Package



1. DSCTP
2. Beams and Clamping Mechanisms (side beams not shown)
3. 9-Axle Trailer (weather cover and labelling for transportation not shown)

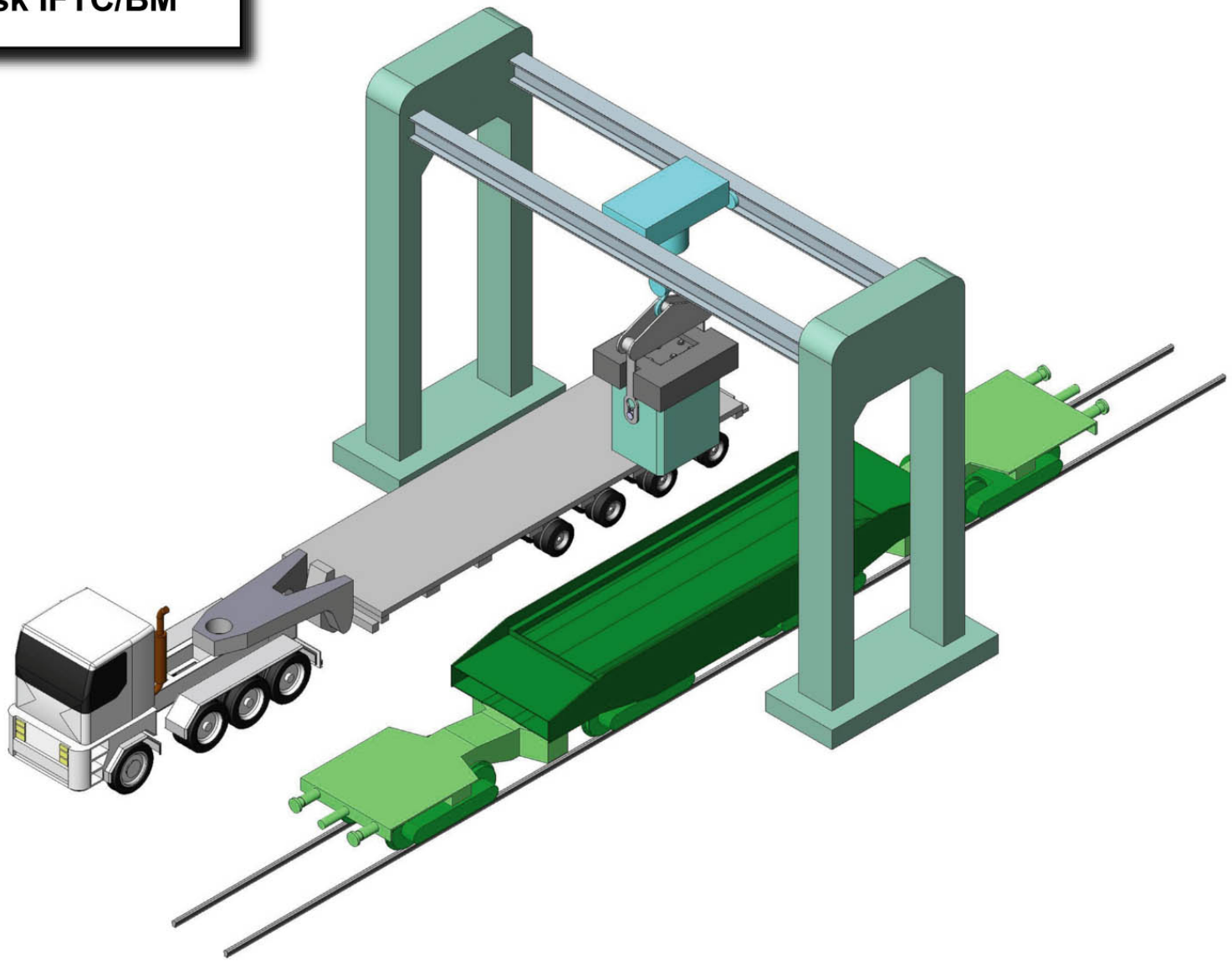
Rail Transportation of Dry Storage Transportation Package



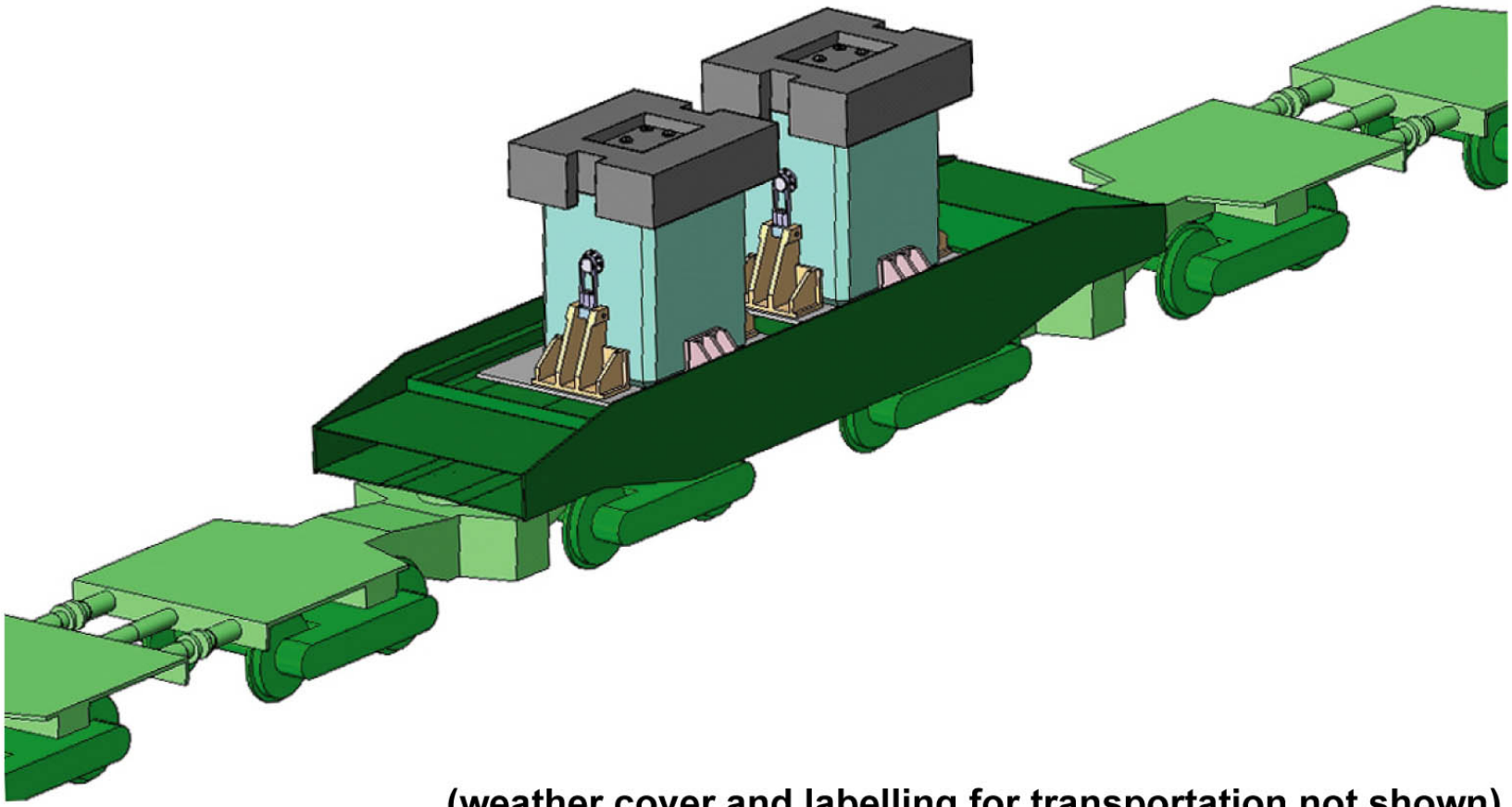
(weather cover and labelling for transportation not shown)

Intermodal Transfer:

Road-to-Rail Transfer of Transportation Cask IFTC/BM

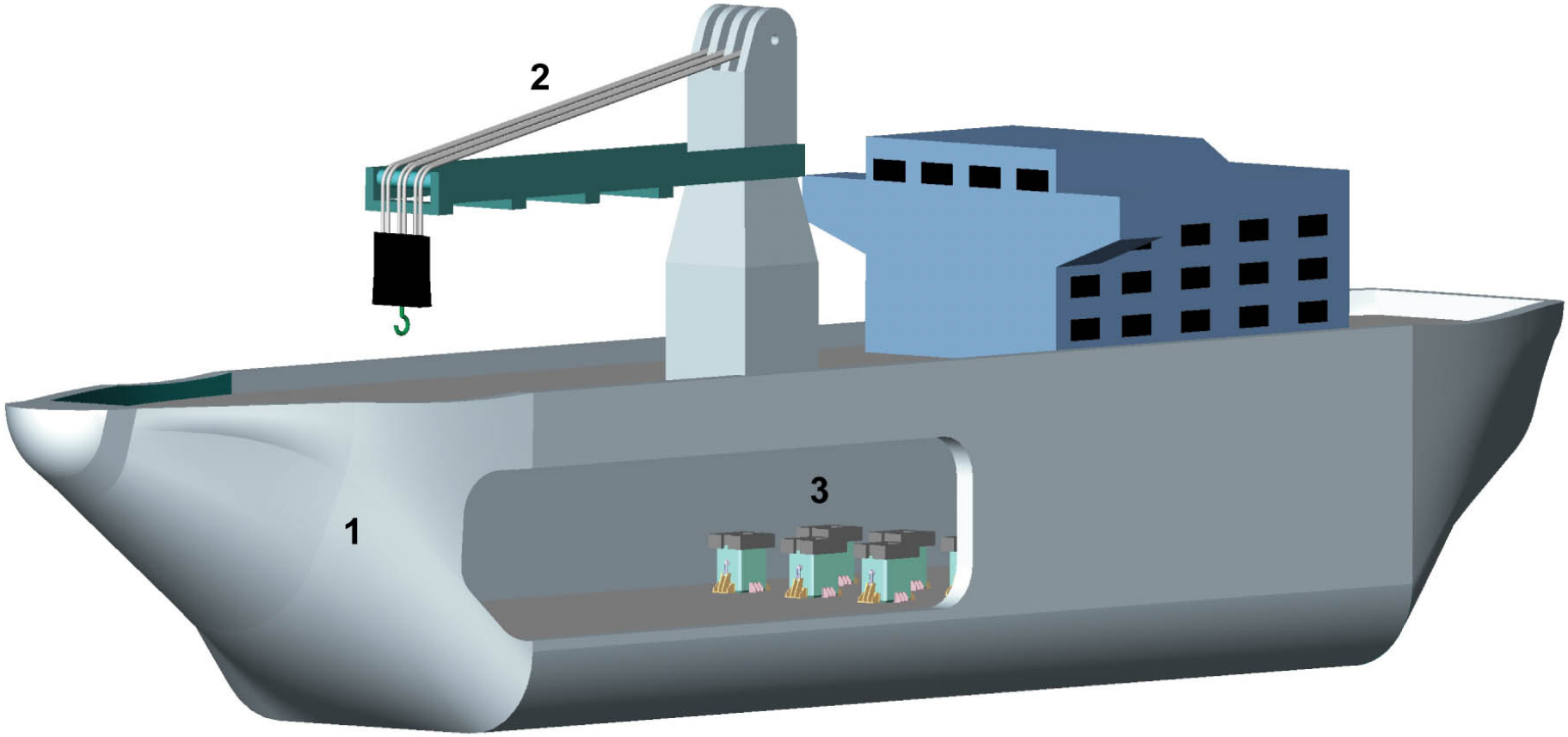


Rail Transportation of Transportation Cask IFTC/BM



(weather cover and labelling for transportation not shown)

Water Transportation of Transportation Cask IFTC/BM



1. Vessel meeting INF Code requirements
2. Self-geared
3. IFTC/BM Casks shown in hold

Published Reports (in CD format)

- Conceptual Design and Cost Estimate Reports:
  - Deep Geologic Repository (DGR)
  - Centralized Extended Storage (CES)
  - Reactor Site Extended Storage (RES)
  - Transportation (TRANS)

Cost Estimate Summary

- Cost Estimate Summary Reports submitted to NWMO:
  - Interim Storage + DGR + TRANS
  - Interim Storage + CES + TRANS
  - Interim Storage + RES
- Costs: actual in 2002$ and PV in 2004$

Deep Geologic Repository Costs

Fuel Bundles (millions)/ Station Life (Years)	Estimated Cost*				
	Interim Storage and Retrieval 2002 M$	Road Transportation 2002 M$	Disposal 2002 M$	Total 2002 M$	Total PV Jan 2004 M$
3.0/30	2,054	815	11,487	14,356	5,529
3.7/40	2,380	954	12,882	16,216	6,157
4.4/50	2,706	1,091	14,208	18,005	6,763

* From July 1, 2006 onwards

Centralized Extended Storage Costs

Alternative	Fuel Bundles (Millions)/ Station Life (Years)	Estimated Cost*				
		Interim Storage and Retrieval 2002 M$	Rail** Transportation 2002 M$	Central Storage 2002 M$	Total 2002 M$	Total PV Jan 2004 M$
CVSB (Casks & Vaults in Storage Buildings)	3.0/30	1,398	997	11,448	13,843	2,761
	3.7/40	1,633	1,162	12,903	15,698	3,140
	4.4/50	1,868	1,322	14,248	17,438	3,507
SMV (Surface Modular Vaults)	3.0/30	1,667	997	14,930	17,594	3,337
	3.7/40	1,964	1,162	16,860	19,986	3,803
	4.4/50	2,262	1,322	18,645	22,229	4,252
CVST (Casks & Vaults in Shallow Trenches)	3.0/30	1,398	997	14,076	16,471	3,154
	3.7/40	1,633	1,162	15,890	18,685	3,584
	4.4/50	1,868	1,322	17,568	20,758	3,999
CRC (Casks in Rock Caverns)	3.0/30	1,398	997	12,698	15,093	3,017
	3.7/40	1,633	1,162	14,314	17,109	3,427
	4.4/50	1,868	1,322	15,809	18,999	3,823

*From July 1, 2006 onwards. **Rail allows transportation of loaded DSCs

Reactor Site Extended Storage Costs

- 21 reactor-site extended storage scenarios logically grouped into three alternatives for each of 7 sites as follows:
  - Current technology (CSB) – including Casks in Storage Buildings (CSB) and Silos and Vaults (VLTS)
  - New above ground technology (SMV) – including Surface Modular Vaults (SMV) and Silos in Storage Buildings (SSB) and,
  - New below ground technology (CST) – including Casks in Shallow Trenches (CST), Silos in Shallow Trenches (SST), and Vaults in Shallow Trenches (VST).

Reactor Site Extended Storage Costs

Alternative Grouping	Fuel Bundles (Millions)/ Station Life (Years)	Estimated Cost*			
		Interim Storage 2002 M$	Reactor-Site Storage 2002 M$	Total 2002 M$	Total PV Jan 2004 M$
Current Technology (CSB)	3.0/30	1,782	13,880	15,662	1,958
	3.7/40	1,994	15,643	17,637	2,324
	4.4/50	2,207	17,269	19,476	2,682
New Above Ground Technology (SMV)	3.0/30	1,091	21,491	22,582	3,809
	3.7/40	1,304	24,404	25,708	4,422
	4.4/50	1,517	27,084	28,601	4,999
New Below Ground Technology (CST)	3.0/30	1,085	17,957	19,042	3,071
	3.7/40	1,297	20,302	21,599	3,561
	4.4/50	1,510	22,463	23,973	4,026

*From July 1, 2006 onwards