Used Fuel Disposition Campaign

Repository Cost Estimates

Tom Severynse
Savannah River National Laboratory

UFD Working Group Meeting
June 11, 2015

Cost Estimates for 16 Generic Concepts

16 Disposal Concepts

Mode	Media	Emplacement	Features	Package Size	Basis
Enclosed	Crystalline	Vertical borehole		4P	SKB (2011)
	Argillaceous	Horizontal in-line	Steel drift liner	4P	ANDRA (2005)
		Horizontal In-line	Self-shielded package	12P	NAGRA (2002,2003)
	Salt	Horizontal in-drift		4P, 12P, 21P, DPC	SRNL (2011)
Open	Hard Rock (e.g., Crystalline)	Horizontal In-line	Unsaturated	12P, 21P, DPC	YM concept
		Horizontal In-line	Saturated	12P, 21P, DPC	Open, backfill at closure
	Argillaceous	Horizontal In-line	Saturated	12P, 21P, DPC	Open, backfill at closure

Estimate Basis

- **Receipt/emplacement rate: 3,000 MT/year**
- **Same assumptions as 2012 study (FCRD-UFD-2012-000211)**
  - Schedule

• *Preconceptual/conceptual design*	*~ 10 years*
• *Preliminary design*	*2 years*
• *Final design*	*4 years*
• *Construction & Startup*	*7 years*
• *Operations*	*47 years*
• *Ventilation (for "open" modes)*	*100 years*
• *Closure*	*10-12 years*
• *Post-closure*	*50 years*

  - Surface infrastructure includes remote handling area and hot cell for transfer of fuel from shipping cask to waste overpack
  - No bare fuel handling

Summary Waste Package Inventory

Concept	Package Capacity (PWR/BWR)	140,000 MT Repository		Disposal Overpack Material
		Total Waste Packages	Annual Waste Packages [A]	
Crystalline (enclosed)	4/9	82,583	1,667	Cu and/or low-alloy steel
Argillaceous (enclosed)	4/9	82,583	1,667	Low-alloy steel
	12/21	28,792	556	
Salt (enclosed)	4/9	82,583	1,667	Low-alloy steel
	12/21	28,792	556	
	21/44	16,157	318	
	DPC	~10,000	209 [B]	
Hard rock unsaturated (open)	12/21	28,792	556	Corrosion resistant
	21/44	16,157	318	
	DPC	~10,000	209	
Hard rock saturated (open)	12/21	28,792	556	Corrosion resistant
	21/44	16,157	318	
	DPC	~10,000	209	
Argillaceous (open)	12/21	28,792	556	Corrosion resistant

Package and Drift Spacing Data

Case	Concept	Package Spacing (m)	Drift/Boring Spacing (m)	Excavation	
				Length, m	Volume, m^3
1	Crystalline (enclosed, 4-PWR)	10	20	1,600,000	35,000,000
2	Argillaceous (enclosed, 4-PWR)	10	30	1,300,000	35,000,000
3	Argillaceous (enclosed, 12-PWR)	10	60	1,100,000	36,000,000
4	Salt (enclosed, 4-PWR)	10	20	970,000	23,000,000
5	Salt (enclosed, 12-PWR)	20	25	700,000	17,000,000
6	Salt (enclosed, 21-PWR)	30	30	440,000	11,000,000
7	Salt (enclosed, DPC)	30	35	400,000	10,000,000
8	Hard rock unsaturated (open, 12-PWR)	5	81	190,000	5,000,000
9	Hard rock unsaturated (open, 21-PWR)	5	81	110,000	3,100,000
10	Hard rock unsaturated (open, DPC)	10	81	140,000	5,000,000
11	Hard rock saturated (open, 12-PWR)	10	81	190,000	5,000,000
12	Hard rock saturated (open, 21-PWR)	10	81	110,000	3,100,000
13	Hard rock saturated (open, DPC)	20	81	140,000	3,600,000
14	Argillaceous (open, 12-PWR)	10	70	490,000	12,000,000
15	Argillaceous (open, 21-PWR)	10	70	530,000	12,000,000
16	Argillaceous (open, DPC)	20	70	500,000	12,000,000

Length, volume of excavation vary by an order of magnitude

Package and Layout Data

Case	Media/Mode	Size	Total # Packages	Packages/year	Overpack Material (Thickness, cm) Inner /Outer	Total Drift Length, km	Total Area, km^2
1	Crystalline/enclosed	4/9	82,583	1,757	Cu (2)/CS (4)	1,600	15.4
2	Argillaceous/enclosed	4/9	82,583	1,757	CS (5)	1,300	28
3	Argillaceous/enclosed	12/21	28,792	556	CS (15)	1,100	19.6
4	Salt/enclosed	4/9	82,583	1,757	CS (5)	950	14
5	Salt/enclosed	12/21	28,792	556	CS (5)	700	14
6	Salt/enclosed	21/44	16,157	344	CS (5)	440	14
7	Salt/enclosed	DPC	10,000	209	CS (7)	400	14
8	Unsaturated Hard Rock/open	12/21	28,792	556	SS (3)/Alloy-22 (2)	190	13.5
9	Unsaturated Hard Rock/open	21/44	16,157	344	SS (5)/Alloy-22 (2)	110	6.7
10	Unsaturated Hard Rock/open	DPC	10,000	209	SS (5)/Alloy-22 (2)	140	10
11	Saturated Hard Rock/open	12/21	28,792	556	SS (3)/Alloy-22 (2)	190	43.5
12	Saturated Hard Rock/open	21/44	16,157	344	SS (5)/Alloy-22 (2)	110	25.2
13	Saturated Hard Rock/open	DPC	10,000	209	SS (5)/Alloy-22 (2)	140	21
14	Argillaceous/open	12/21	28,792	556	SS (3)/Alloy-22 (2)	490	43.5
15	Argillaceous/open	21/44	16,157	344	SS (5)/Alloy-22 (2)	530	25.2
16	Argillaceous/open	DPC	10,000	209	SS (5)/Alloy-22 (2)	500	21

Cost Estimate Basis

- **TPC includes Design, Construction, Startup**
  - Facility capital cost + 2 years of mining
  - Largest contributor is the remote handling/hot cell facilities
  - Assumes PA/SAR support is ~ 40%
  - Contingency is +30%, +100%
- **Operations**
  - Assumes 47 year duration
  - Mining rates per 2012 study
  - Labor escalated by 2.6% per year
  - Includes labor and material for backfill for “enclosed” modes
  - Contingency is +10%, +50%

Waste Packages

- Fabricated from plate of appropriate material and size
- Includes labor for rolling, welding, pre/post welding activities
- Unit cost per package:

Case	1	2	3	4	5	6	7	8,11,14	9,12,15	10,13,16
Unit Cost, $K	274	194	521	194	256	297	595	818	905	1,323

- Contingency is +5%, +30%
- Up to 30 – 40% of cost for corrosion resistant packages (e.g. Cases 8-16)

Closure

- Duration is 10 years
- Uses backfill material costs per 2012 escalated to 2015
- Includes capital project support @ 15% of TPC facilities over 10 years
- Contingency is +10%, +50%

Other Functions

- **Regulatory & Licensing**
  - Includes site screening, field studies, environmental assessments done by project team
  - Funds external support from EPA, NRC and state regulatory agencies
  - Majority of effort during site screening, characterization and construction/startup phases.
  - Relatively small contributor to cost: 2-3%
- **Monitoring**
  - Based on 2008 YMTSLCC of $21.7M per year for 1500 acre site
  - Scale based on area, and provide for Operations, Closure, Post-closure, and Ventilation periods
  - ~ 5% for enclosed, ~ 10% for open

Other Functions

- **Performance Confirmation**
  - Based on YM 2008 TSLCC of $28,600,000 per year
  - Activities defined in YM Performance Confirmation Plan (TDR-PCS-SE-00001)
  - Pro-rated based on area, for TPC and Operations activities
- **Program Integration**
  - Catch-all for program support
  - Continues through all phases
  - ≤ 5% of cost, lower for enclosed alternatives

Life Cycle Cost Range Summary ($,Bs)

Case #	Low	High
1	62,900	83,900
2	83,400	112,600
3	50,600	67,700
4	44,100	59,000
5	30,000	40,700
6	24,700	33,600
7	31,600	43,000
8	59,800	79,200
9	43,900	58,600
10	43,900	58,700
11	57,700	76,200
12	42,900	57,300
13	40,000	53,500
14	60,400	79,900
15	46,700	62,400
16	43,800	58,700

Cost Comparison: Case 9 vs. YM 2008 TSLCC

Functional Area	YM 2008 TSLCC	Case 9 Range
TPC	15.9	2.7 to 4.2
Operations	8.0	8.2 to 11.4
Closure	1.0	7.6 to 10.3
Waste Packages	12.5	15.3 to 19.0
Drip Shields	7.7	7.0 to 9.5
Regulatory & Licensing	1.0	1.5 to 2.1
Monitoring	1.1	3.0 to 4.1
Post Closure	2.8	2.8 to 3.8
Total	52.5	43.9 to 58.6