Idaho Cleanup Project

Calcine Disposition Project

Presented To: The NWTRB Meeting

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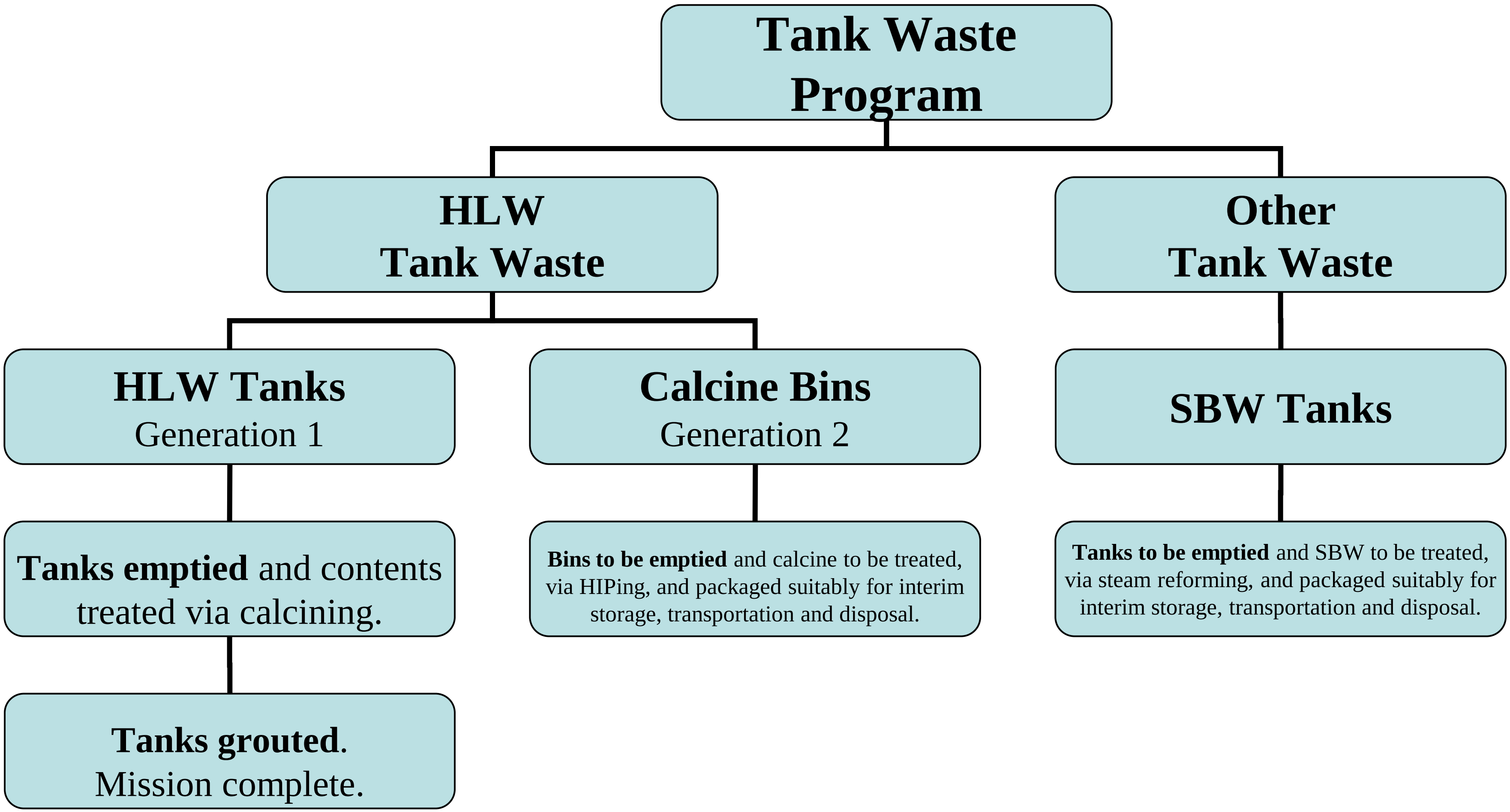
1.0 Background
1.1 INL Tank Waste Program

INL EM-Managed Tank Waste Program

1. HLW Tank Waste

2. Other Tank Waste

1.1.1 Tank Waste Program Elements



1.1.2 Tank Status

Time	3 – 18k gal	4 – 30k gal	11 – 300k gal	Liquid Total gal	Calcine Volume M^3	Curies	Makeup
Historic	3 used	4 used	10 used, 1 reserve	7,725,000	4,398	3.64E+07	HLW & SBW
Current	Not in use for HLW	Closed	4 in use (not for HLW), 7 closed	900,000	NA	5.00E+05	SBW

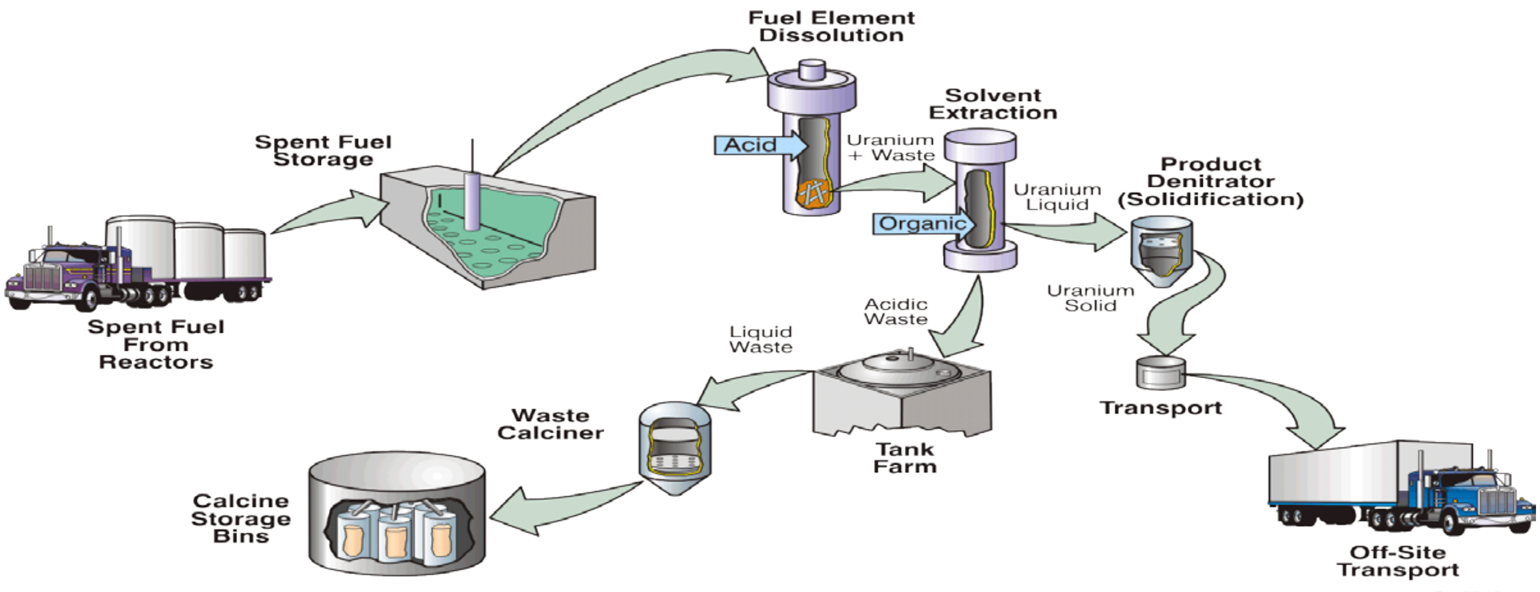
1.1.3 Typical composition of Tank Farm waste

Major Species	Units	Aluminum	Zirconium	Fluorinel	Electrolytic Stainless Steel	Sodium-Bearing Waste
Acid (H^+)	molar	0.81	1.40	1.50	2.2	1.28
Aluminum	molar	1.51	0.68	0.43	0.2	0.57
Boron	molar		0.19	0.15		0.017
Cadmium	molar			0.05		0.001
Chloride	mg/L			50		1,000
Chromium	molar		0.015	0.002	0.025	0.001
Fluoride	molar		3.2	2.10		0.04
Iron	molar	0.01	0.007	0.005	0.086	0.002
Mercury	molar	0.02				.0013
Nickel	molar				0.012	
Nitrate	molar	5.4	2.3	1.90	3.2	4.5
Potassium	molar		0.003	0.005		0.17
Sodium	molar	0.06	0.017	0.02		1.5
Tin	molar		0.005	0.003		
Zirconium	molar		0.41	0.31		0.03

1.2 Calcine
1.2.1 Calcine is Solidified First & Other Cycle Raffinates

Converted the liquid waste into a granular solid using a thermal process referred to as calcination

- Resulted in a 7 to 1 volume reduction
- Capable of being safely stored for several hundred years in 43 large shielded bins contained in six bin sets



1.2.2 Calcine Condition

Calcine contains hazardous waste constituents and is regulated by the State of Idaho under its RCRA authority and the associated Site Treatment Plan

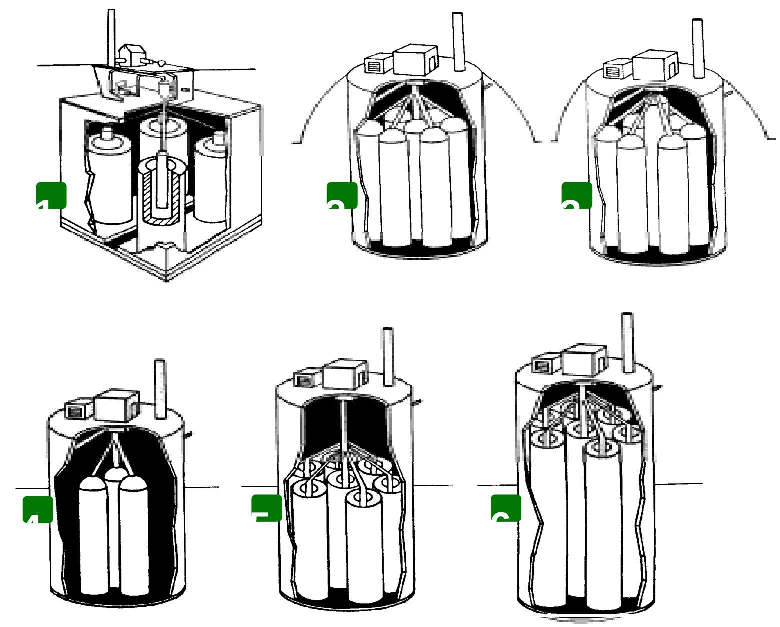
Currently stored in Bin Sets under a 10-year RCRA Part B Permit issued November 2006 (Compliance is based on a State-approved exemption from RCRA double containment requirement that requires periodic State approval to remain valid)

1.2.3 Calcine Generation History

Campaign		Parameters			
Begin	**End**	**Volume gal**	**Volume ft^3**	**Volume m^3**	**Curies**
Dec- 63	Mar - 81	4,081,000	77,300	2,189	
Aug - 82	May - 00	3,644,000	78,000	2,209	
Total		**7,725,000**	**155,300**	**4,398**	**3.64E+07**

1.2.4 Calcine Solids Storage Facility (CSSF)

Status	CSSF	Bins	Capacity (m^3)
In Use	1	12	227
	2	7	851
	3	7	1,130
	4	3	486
	5	7	1,010
	6	7	1,506
	Sub	**43**	**5,210**
Not in Use	7	7	1,784
	Total	**50**	**6,994**



1.3 HLW Site Summary* How Does the INL HLW Compare?

Site	Canisters (No)	Volume Glass (m3)	Mass Glass (MT)	% Mass Glass	Tanks (No) [4]
Hanford Site	14,500	15,700	44,000	77.08	177
INL - INTEC	**1,190**	**1,860**	**743**	**1.30**	**18**
INL - MFC (Ceramic matrix) [1]	109	61	153	0.27	0
Savannah River Site	5,978	4,240	11,600	20.32	51
West Valley Demonstration Project [2, 3]	280	200	585	1.02	2
Total	**22,057**	**22,061**	**57,081**	**100.00**	**248**

1 Canister number is the arithmetic mean of the range of 82 - 135.

2 Canister number is the arithmetic mean of the range of 260 - 300.

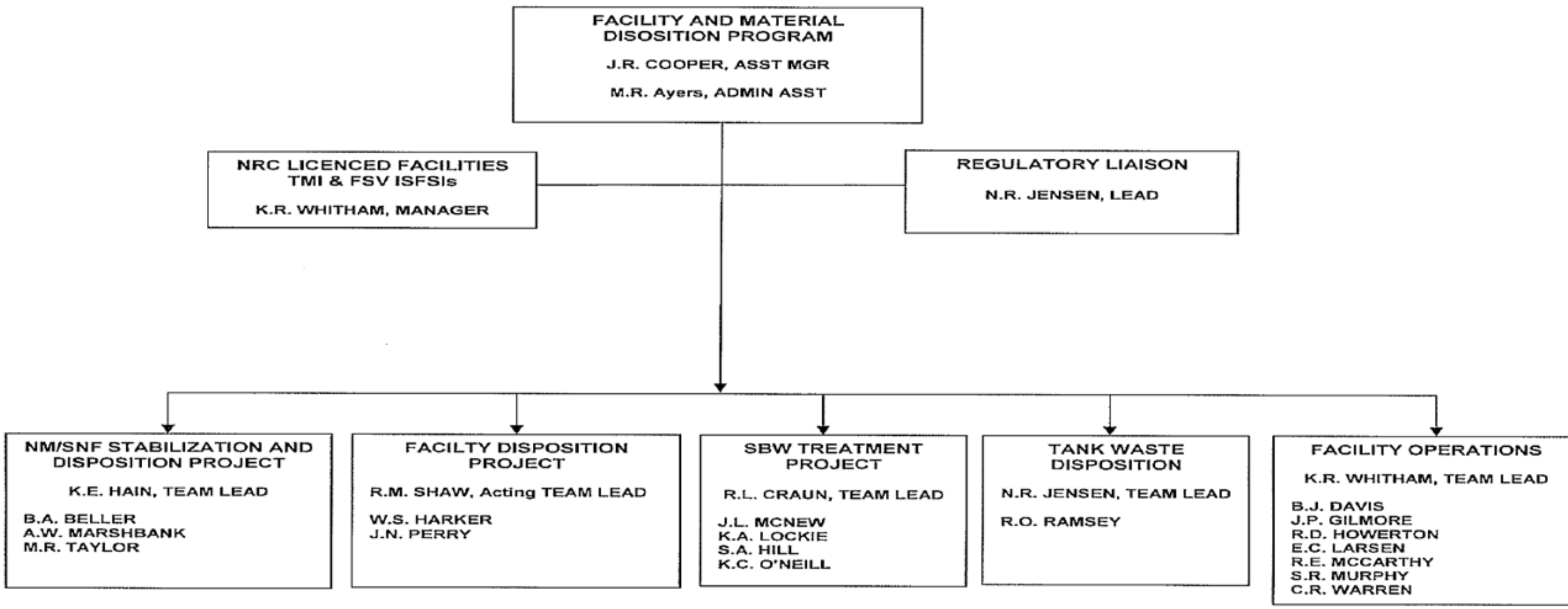
3. Mass of Glass is the arithmetic mean of the range of 540 - 630.

4. Source: The relevant site EISs.

* Source: Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada; DOE/EIS-0250; February 2002

2.0 Calcine Disposition Project

2.1 The DOE-ID Team



March 2010

2.2 INL's CDP Programmatic End Goals

1. Safe and efficient management of all materials within our custody.

2. Protection of the Snake River Aquifer.

3. Calcine shall be made road ready by a target date of 12/31/2035.

2.3 Project Scope

1. **Design and construct processing facility using IWTU to the maximum extent practical.**
2. **Retrieve and transport 4,400 cubic meters of calcine from current storage in the Calcine Solids Storage Facility (bin sets).**
3. **Treat calcine to eliminate RCRA characteristic wastes, if necessary.**
4. **Package resultant treated waste form in canisters** (10 or 15 ft tall by 2 foot diameter DOE standardized canister).
5. **Store resultant canisters pending shipment out of State.**
6. **Perform RCRA performance-based closure on existing HLW facilities and clean closure of new facilities (2005 ROD).**

2.4 Project Drivers

- **Predecessor Documents**
  - **Consent Order, December 9, 1991 (FFA CO)**
  - **Consent Order, April 3, 1992 (Notice of Noncompliance CO)**
  - **Court Order, June 28, 1993 (1st Court Order)**
- **Federal Facility Compliance Act of 1992**
- **Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement; DOE/EIS-02-3-F; April 1995** and associated RODs
- **Idaho Settlement Agreement, October 1995**
- **Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement; DOE/EIS-0287; September 2002** and associated RODs

2.5 Calcine Project Milestones

- **Critical Decision (CD)-0 (Approve Mission Need) was signed June 29, 2007**

- **An amended Record of Decision (ROD) selecting Hot Isostatic Pressing (HIP) treatment technology was issued by DOE on December 23, 2009, meeting the December 31, 2009, milestone in the Idaho Settlement Agreement (SA) and the Idaho Site Treatment Plan (STP)**

- **CD-1 (Approve Preliminary Baseline Range) must be approved by December 31, 2010 per the STP**

- **Remaining SA milestones include:**
  - Submittal of a RCRA Part B permit application no later than December 1, 2012
  - All Calcine will be road ready in compliance with the Settlement Agreement by December 31,2035

2.6 The Selection Process

- Evaluation of more than 20 alternatives down to 12 (INL HLW FEIS, September 2002)
- Direct disposal added as a principal dispositioning option (October 2003)
- Evaluation of 13 alternatives down to four (VE Session, March 2006)
- Direct disposal eliminated as a dispositioning option (November 2009)
- Evaluation of four alternatives down to the preferred option (VE Session, November 2009)
- Amended ROD signed December 23, 2009

2.6.1 Selection Value – Environmental

Under normal operations, none of the waste processing action alternatives analyzed in the EIS would result in large short-term or long-term impacts to human health or the environment.

None of the action alternatives result in appreciably different impacts on historic, cultural and natural resources.

Any of the waste treatment alternatives that place the calcine in a waste form suitable for disposition outside of the State of Idaho would be environmentally preferable compared to the “No Action” and “Continued Current Operations Alternatives”.

2.6.2 Selection Value – Cost

Estimated Range of CDP Treatment and Cost Parameters

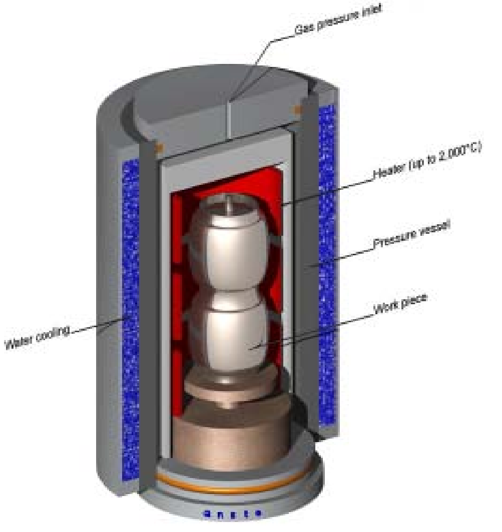
Parameters	**HIP without RCRA Treatment**		**HIP with RCRA Treatment**		**Direct Disposal**		**Vitrification with Separations**		**Vitrification without Separations**	
Canisters	2,900	3,300	3,700	4,600	6,700	7,300	750	2,200	11,100	13,300
Total Life-Cycle Cost ($M)	5,503	6,228	6,052	7,119	7,661	8,408	9,556	12,769	11,054	13,074
Cost Ratio	1.00	1.13	1.10	1.29	1.39	1.53	1.74	2.32	2.01	2.38

2.6.3 Selection Value – HIP Treatment Technology

- **HIP technology is a mature process developed over 50 years ago**
- **Established in US industry for 30 years**
  - Produces robust glass-ceramic waste form that meets performance requirements for borosilicate glass while also reducing volume
  - Results in large life-cycle cost savings through final disposition
  - HIP process is also suitable for future waste management missions

2.7 How it Works
2.7.1 Basic Hot Isostatic Pressing Process

- **HIP patented in the US by Romp in 1941.**
  - Battelle patented HIP process to diffusion bond nuclear fuel in 1964.
- **Technology consists of a pressure vessel containing an electrically heated furnace.**
- **Components are placed in a sealed can inside the furnace and isostatically pressed with argon gas to maximum density**
  - Temperatures to 2,550 degrees C
    - 1,050-1,200 degrees C required for calcine treatment
  - Pressures to 30,000 psi
    - 5,100-7,200 psi required for calcine treatment
- **Pressure vessels are built to stringent ASME codes, and include active and passive safety systems.**
  - HIP vessels experience less than 0.1% failure rate
    - HIP can isolates pressure vessel from contamination



2.7.2 Proof of Concept – Preliminary Test Data

- There are two major calcine types: alumina and zirconia
- Surrogate calcines were made containing a suite of RCRA metals in the amounts data show them to be present in true calcine
- A HIPing recipe was added to complex the metals
- Testing by: TCLP (Method 1311) and PCT (ASTM C1285)
- Tests were run on samples containing: 1) the baseline average constituency, 2) the maximum constituency, and 3) a transition sample between the two constituencies.

2.7.3 Data for Alumina Calcine

Table 3 Treated Transition and Maximum RCRA Alumina Calcine

	Transition RCRA		Maximum RCRA		
Can & HIP Conditions					
HIP Location	ANSTO	ANSTO	ANSTO	ANSTO	ANSTO
HIP Process Conditions (Temp/Press/Time)	1150°C/ 35MPa/ 2hrs	1150°C/ 35MPa/ 2hrs	1150°C/ 35MPa/ 2hrs	1150°C/ 35MPa/ 2hrs	1150°C/ 35MPa/ 2hrs
Waste loading					
Weight % Calcine	77%	77%	77%	77%	77%
Volume reduction					
Effective HIP volume reduction compared to as stored calcine	**61%**	**65%**	**61%**	**66%**	**65%**
Characterization					
PCT (EA Standard)	Pass	Archive	Pass	Pass	Archive
TCLP (UTS Standard)	Pass	Archive	Pass	Pass	Archive

2.7.4 Data for Zirconia Calcine

Table 6 Treated Maximum RCRA Zirconia Calcine

	Treated Maximum Zirconia Calcine							
Can & HIP Conditions	**Distillation**	**Distillation**	**Distillation**	**Archive**	**Fine grind**	**Coarse grind**	**Coarse grind**	**Distillation & coarse**
HIP location	ANSTO	ANSTO	ANSTO	ANSTO	ANSTO	ANSTO	ANSTO	ANSTO
HIP Process Conditions (Temp/Press/Time)	1150°C/35 MPa/2h	1150ºC/ 35MPa/ 2h	1150ºC/ 35MPa/ 2h	1150ºC/ 35MPa/ 2h	1150°C/35 MPa/2h	1175°C/35 MPa/2h	1175ºC/ 35MPa/ 2h	1175ºC/ 35MPa/ 2h
Waste Loading								
Weight % Calcine	60%	60%	60%	60%	60%	60%	60%	80%
Volume Reduction								
Effective HIP volume reduction of the calcine	**10%***	**17%**	**14%**	**17%**	**7%**	**10%***	**13%***	**33%***
Chemical Durability								
PCT (EA Standard)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
TCLP (UTS Standard)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail

** Smaller single convolution HIP cans were used that do not provide an accurate indication of achievable volume reduction*

2.7.5 HIP Technology Presents Certain Advantages over Vitrification

Comparison:	HIP	Vitrification (JHM)
Matrix:	glass-ceramic	borosilicate glass
Waste loading:	**60-90%**	**20-35%**
Durability (PCT-B):	10-100 x EA glass	10 x EA glass
Final volume:	**20-70% reduction**	**~100% increase**
(relative to untreated calcine)	(treat low – non-treat high)	
Temp:	1,050-1,200°C	1,150°C
Pressure:	5,100-7,200 psi	atmospheric
Off-gas/by product waste:	minimal	medium-high
Flexibility:		
• Calcine:	treat or super-compact	treat only
• Future mission:	diverse/flexible	limited/less flexible

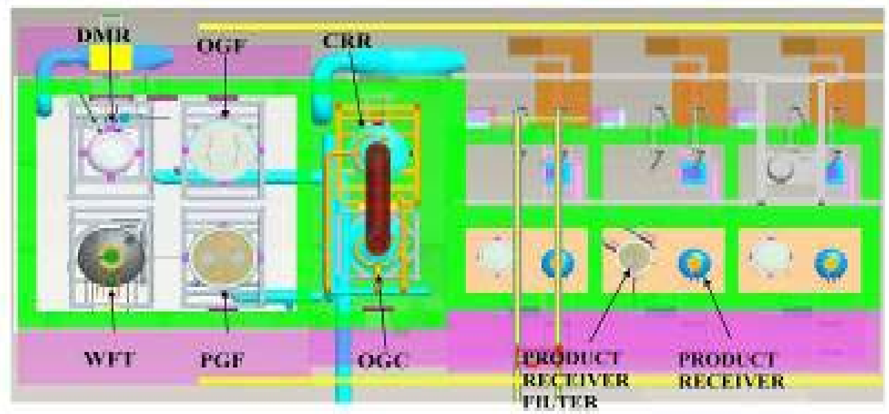
Cold calcine in glass-ceramic matrix

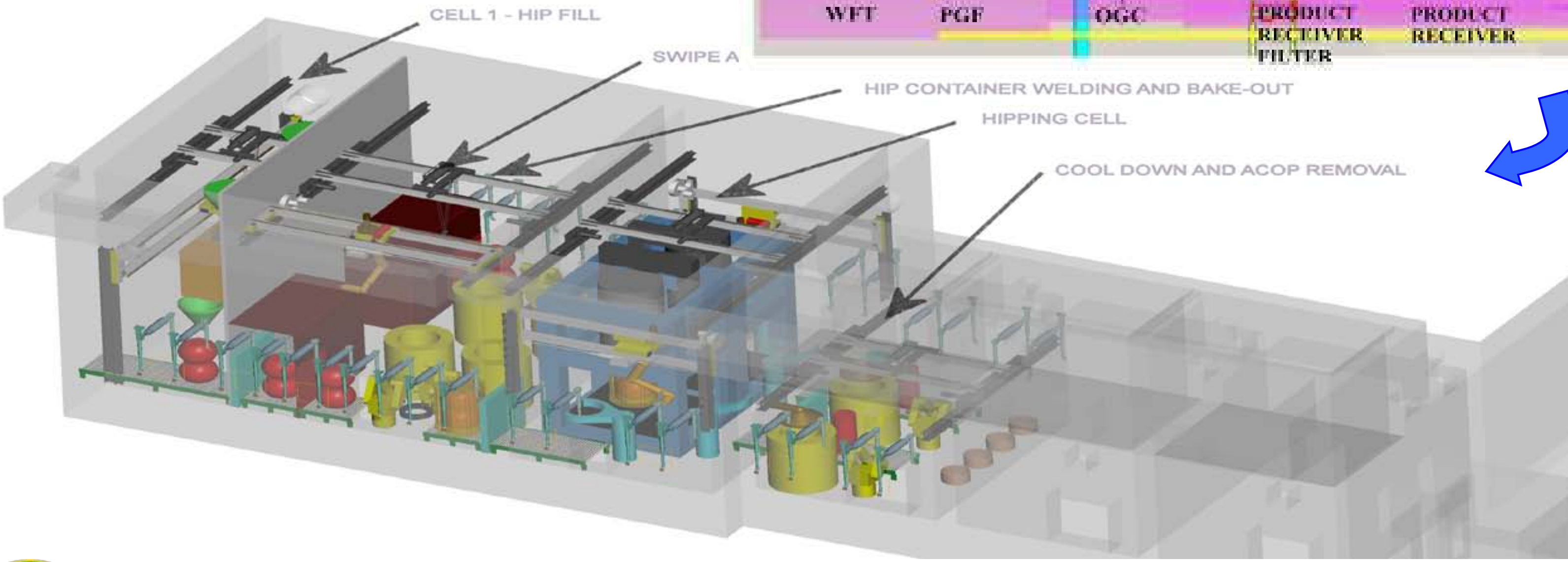
Direct SBW compaction (no additives)

Metal encapsulation of uneconomic feeds (Swedish SNF in copper shown)

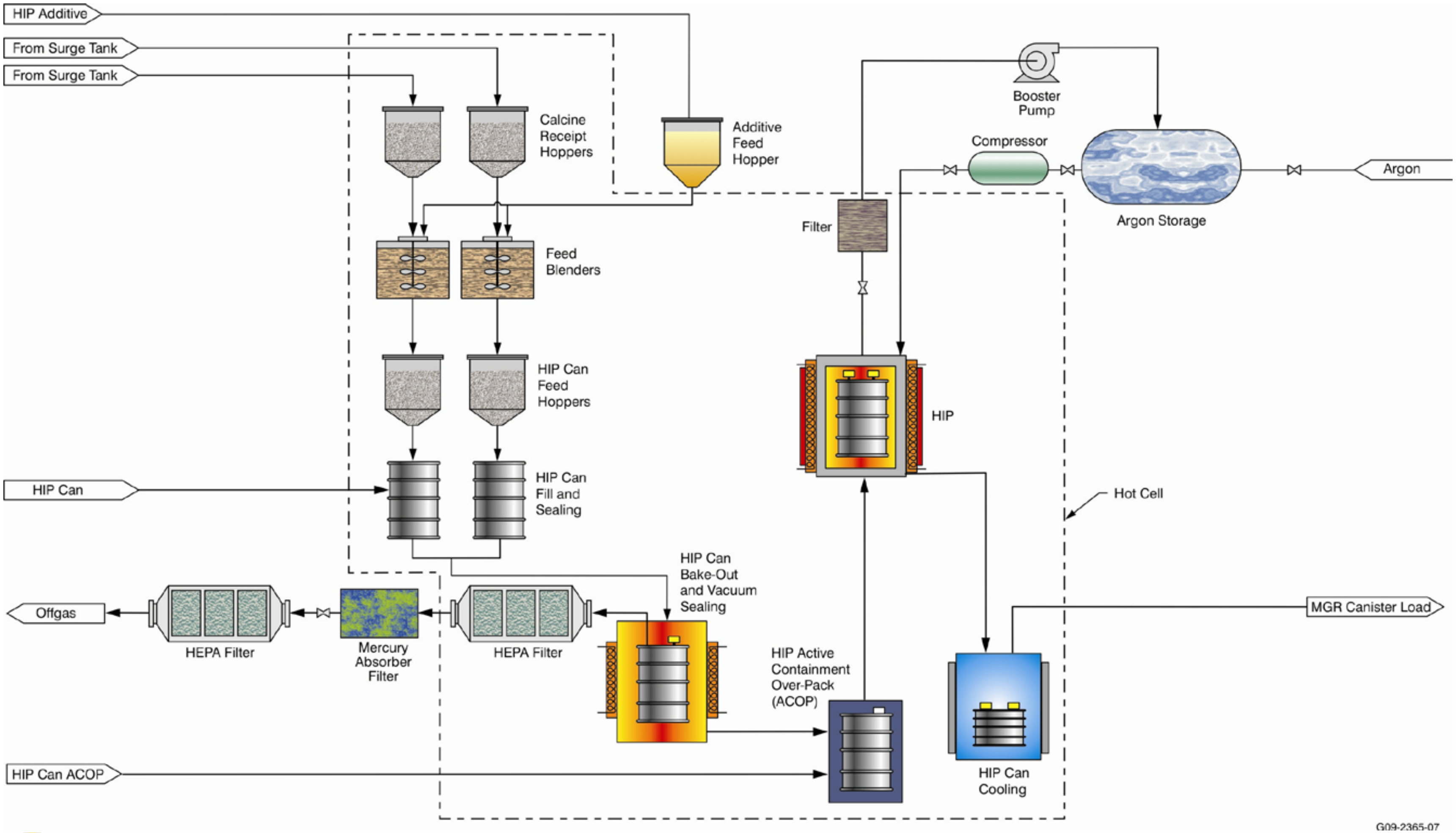
2.8 The Facility
2.8.1 IWTU Retrofit for Hot Isostatic Pressing of Calcine (Concept)

Objective: Upon completion of Sodium Bearing Waste mission, the Integrated Waste Treatment Unit will be retrofitted to the extent practical to treat calcine with HIP technology.

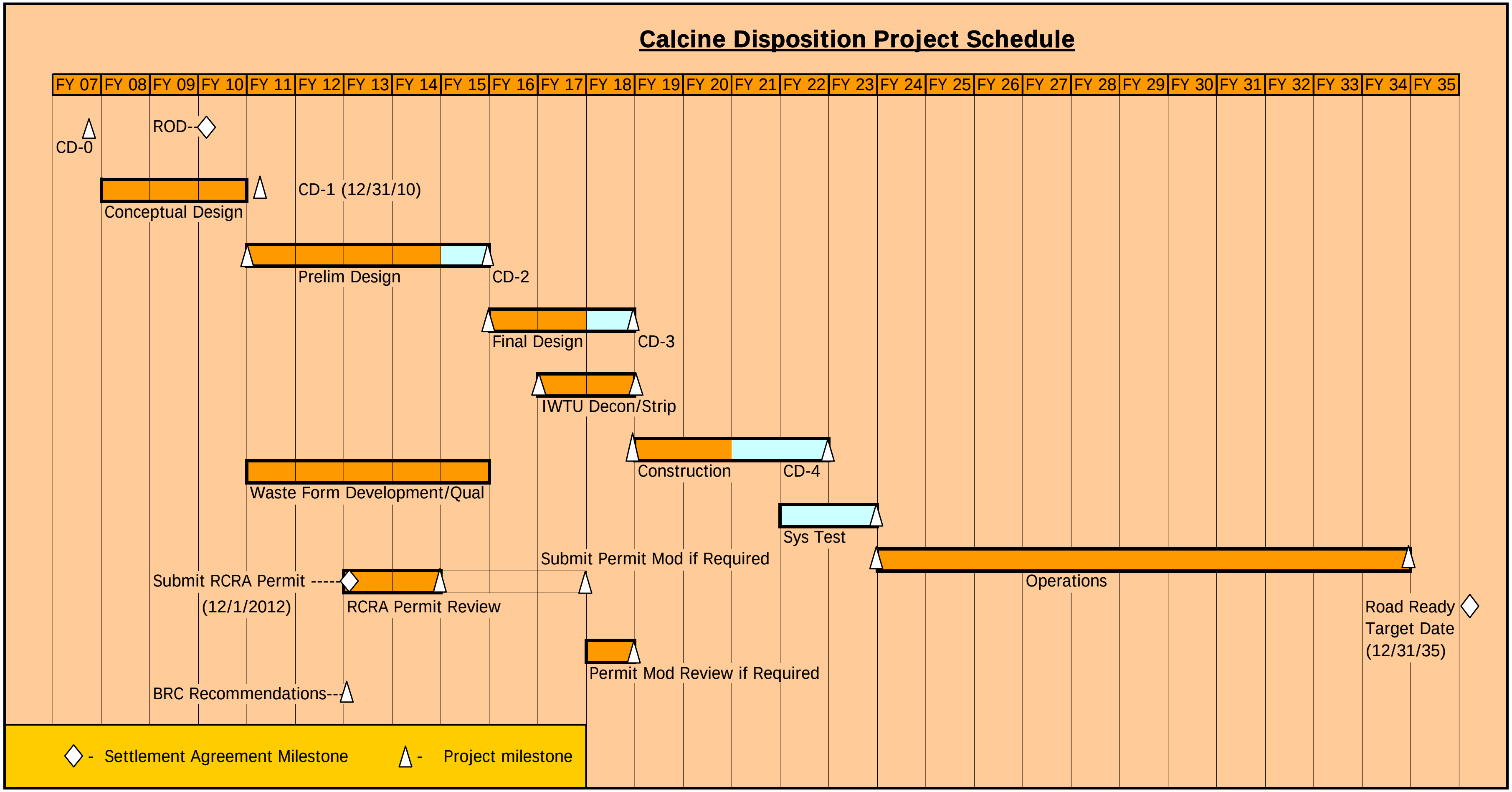




2.8.2 HIP Process Flow



2.8.3 CDP Critical Path



2.9 Challenges and Risk Management Response

Programmatic

Ch: Cost and schedule in a cost retrenching environment.

MR: Constant project monitoring & adjustments as necessary.

Technical

Ch: Maximizing loading efficiency; dust and fines; high heat environment; high radiation environment.

MR: Detailed design, lab-scale testing and full-scale mockups, modeling, and review.

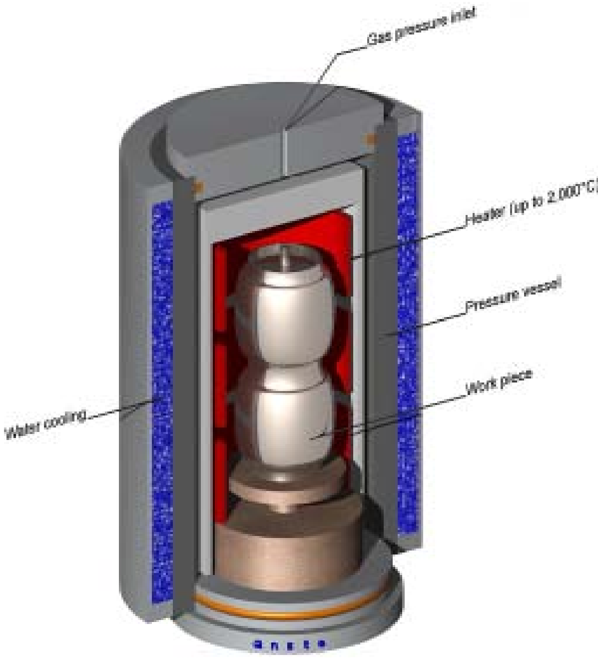
Strategic

Ch: Meeting treatment, packaging and receipt standards without an

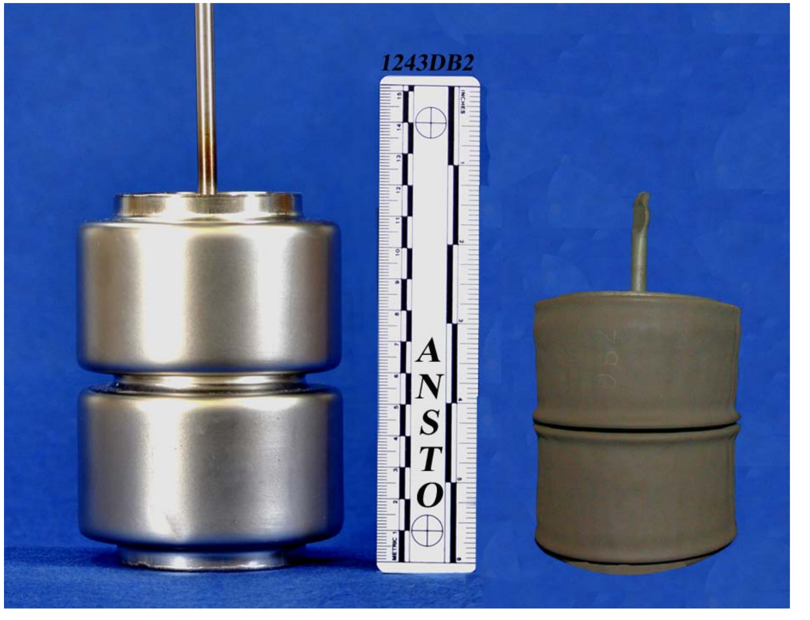
established repository.

MR: Tracking of Blue Ribbon Commission (BRC) findings and recommendations with interaction as appropriate. Develop waste form to meet most stringent standards (e.g., RCRA UTS LDR and WASRD)

2.10 The Result - Hot Isostatic Pressing (HIP)



HIP Schematic



HIP Demonstration

Backup Information

High Level Waste

- *HLW: The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combinations of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.*

Processing at the INL

- SNF processing at the INL: 1953 – 1991
- Calcination at the INL: 1963 - 2000