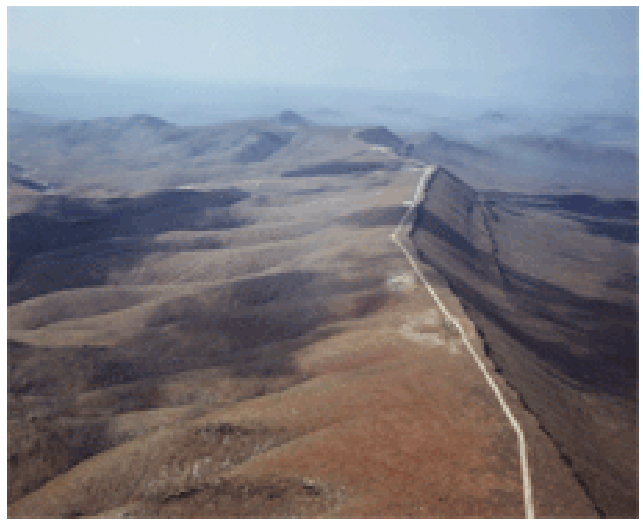
Status of the High Level Waste (HLW) Calcine Disposition Project

at the

Idaho National Laboratory (INL) Site

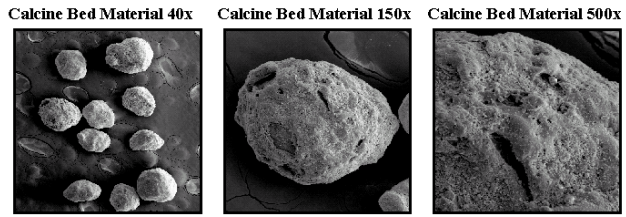
Description, Challenges, Technology, Issues, and Needs



August 19, 2008

Calcine Specifics

- ***Calcine is high level waste (HLW) by definition***
  - First cycle raffinate from reprocessing of spent nuclear fuel
- ***8-9M gallons liquid HLW converted to 4400 cubic meters of granular solid***
  - 7 to 1 volume reduction achieved
    - *Average particle size is 0.4 cm*
  - Contains roughly 44 metric tons heavy metal
    - *Acidic, abrasive, and hydroscopic*



- ***Currently stored in 43 bins in 6 bin-sets***
  - Designed for safe storage for several hundred years
  - Stored under 10-year RCRA Part B Permit issued 11/06

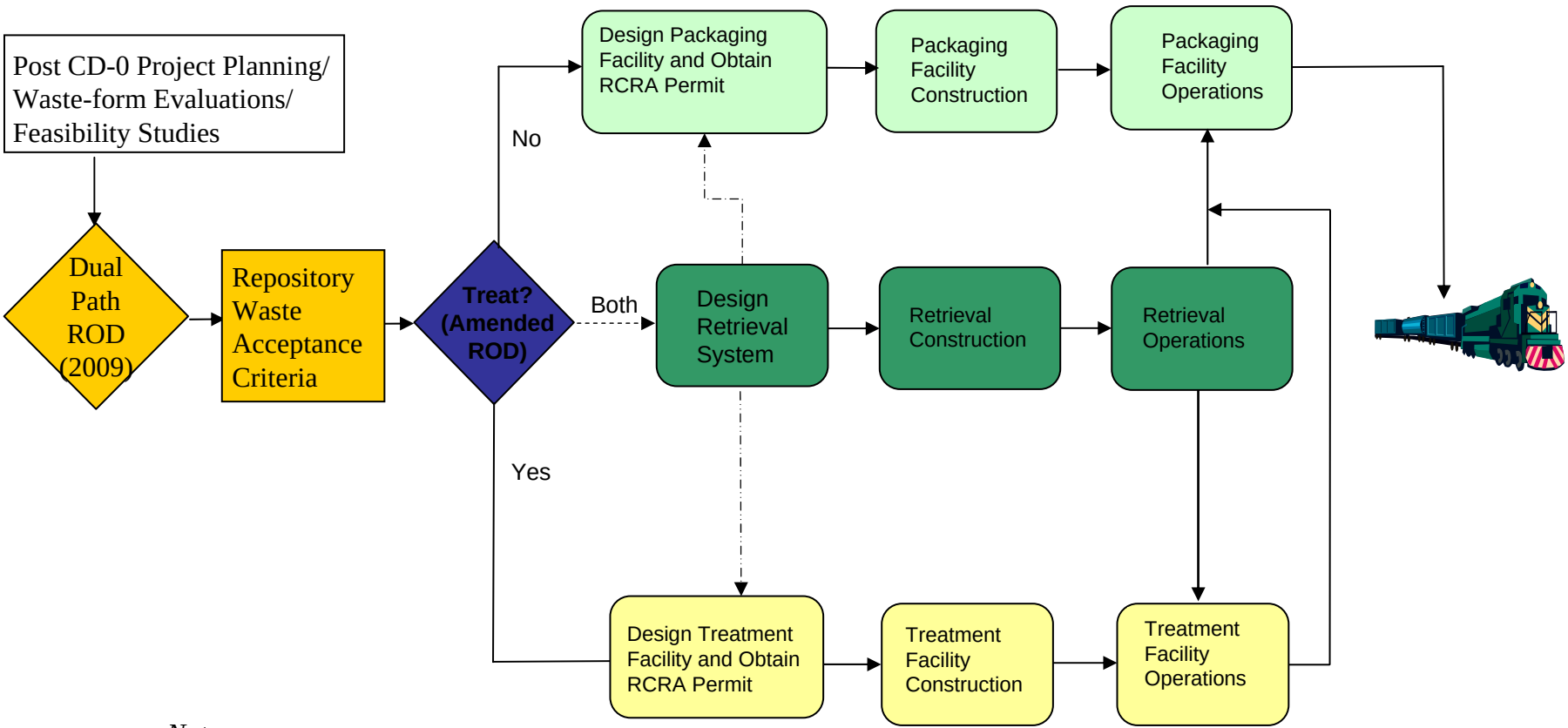
- ***Calcine is also classified as hazardous waste as it:***
  - Exhibits hazardous waste characteristics for toxicity for metals
    - *Waste numbers D004 through D011*
  - Contains listed wastes
    - *Spent solvents (hazardous waste numbers F001, F002, and F005)*
    - *Discarded hydrogen fluoride (hazardous waste number U134)*
- ***Chemical analysis has been performed on samples from:***
  - New Waste Calcining Facility (NWCF) Campaign H-4 (1998)
  - *NWCF Campaign H-3 (1993)*
  - *Alumina and zirconia calcine from CSSF 2 (1978)*

Regulatory Challenges: Calcine Disposition Project Drivers

- ***Meet Idaho Settlement Agreement (SA) milestones***
  - Issue a NEPA **Record of Decision (ROD) by December 31,2009** to identify method to treat calcine (if necessary)
    - *Dual path ROD may carry forward both a treatment and the direct disposal option*
  - Submit a **RCRA Part B Permit application by December 1, 2012** to the state of Idaho for retrieval and treatment (includes packaging)
  - Have all **calcine ready for transport out of the state of Idaho by a target date of December 31, 2035**

- ***Meet Idaho Site Treatment Plan (STP) milestones***
  - Approval of **CD-0 by June 30, 2007**
    - *Approved June 29, 2007 by Deputy Secretary Clay Sell*
  - Approval of **CD-1 by September 30, 2009**
    - *Was March 31, 2008 prior to receiving 18 month extension*
  - Submit an **enforceable schedule** for disposition of calcine (including design, construction, and start of operations) **by June 30, 2010**
- ***Fulfill calcine commitments in 2005 ROD from the Idaho HLW and Facilities Disposition EIS - DOE/EIS-0287***

Calcine Disposition Project Dual Path NEPA ROD Approach



Notes:

(1) Repository Waste Acceptance Criteria factors in RCRA compliance and waste-form performance

(2) Project will re-use the Integrated Waste Treatment Unit to the maximum extent practicable upon completion of the Sodium Bearing Waste Project mission

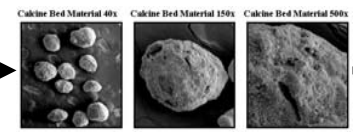
Project Status

- ***Canister modeling & selection for direct disposal option completed***
  - 10 foot tall by 24 inch diameter DOE standardized canister
- ***Detailed calcine characterization has been completed***
  - Process models, legacy sample analysis, thermodynamic computer modeling
- ***Groundwater modeling and Land Disposal Restriction evaluations***
  - Untreated Calcine disposal at the Repository will meet Total System Performance Assessment (TSPA) for both radioactive and chemical (RCRA) constituents
  - New EPA radiation standard for groundwater has no expected impact on modeling
- ***Critical Decision 0 (Approval of Mission Need) issued June 29, 2007***
- ***Conceptual design of retrieval system is complete***
  - Materials erosion, bin obstructions, transport options, etc.
  - Demonstrated 120 feet vertical and 650 feet horizontal pneumatic transport with cold calcine in North Carolina

- ***Closely following repository and regulatory developments***
- ***Down-selection to one treatment technology planned for December 2008***
  - Steam reforming, vitrification, and hot isostatic pressing remain under consideration
  - Will be followed by NEPA supplement analysis prior to development of ROD

Current Disposal Options for Calcine Remain as Follows:

- ***Retrieve, package and dispose of as is (direct disposal option)***
  - Idaho baseline approach – highest regulatory risk, lowest cost
  - Requires conditional exemption from RCRA
  - Granular waste form



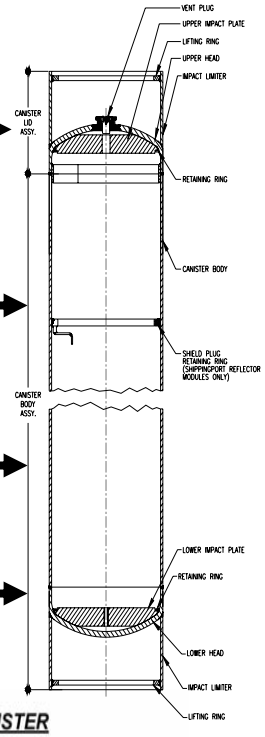
- ***Treatment by hot isostatic pressing***
  - Volume reduction – being evaluated by BEA and ANSTO, Inc.
  - Monolythic glass ceramic waste form
  - Could compact (~50% volume reduction) either of above

30% Volume Reduction

50% Volume reduction of granular form

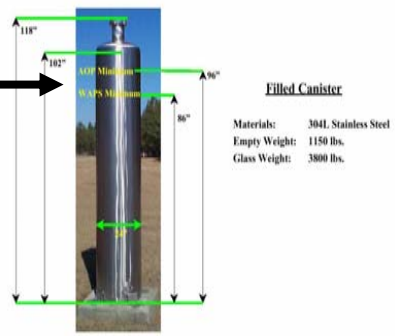
- ***Treatment by steam reforming***
  - Maximizes re-use of IWTU
  - Requires re-dissolution of calcine in nitric acid
  - Granular mineralized waste form – requires delisting

50-100% Volume Expansion



- ***Treatment by direct vitrification***
  - Lowest regulatory risk – highest cost and volume
  - Single phase borosilicate glass
  - Monolythic waste form – requires delisting

100% Volume Expansion



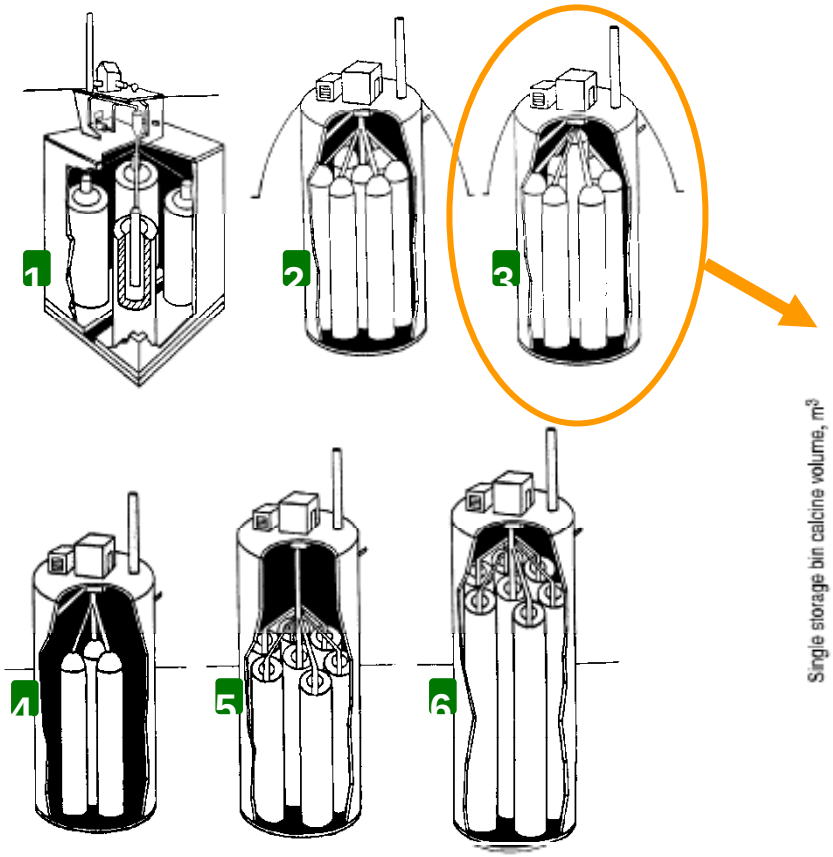
Basis for Pursuing the Direct Disposal Option

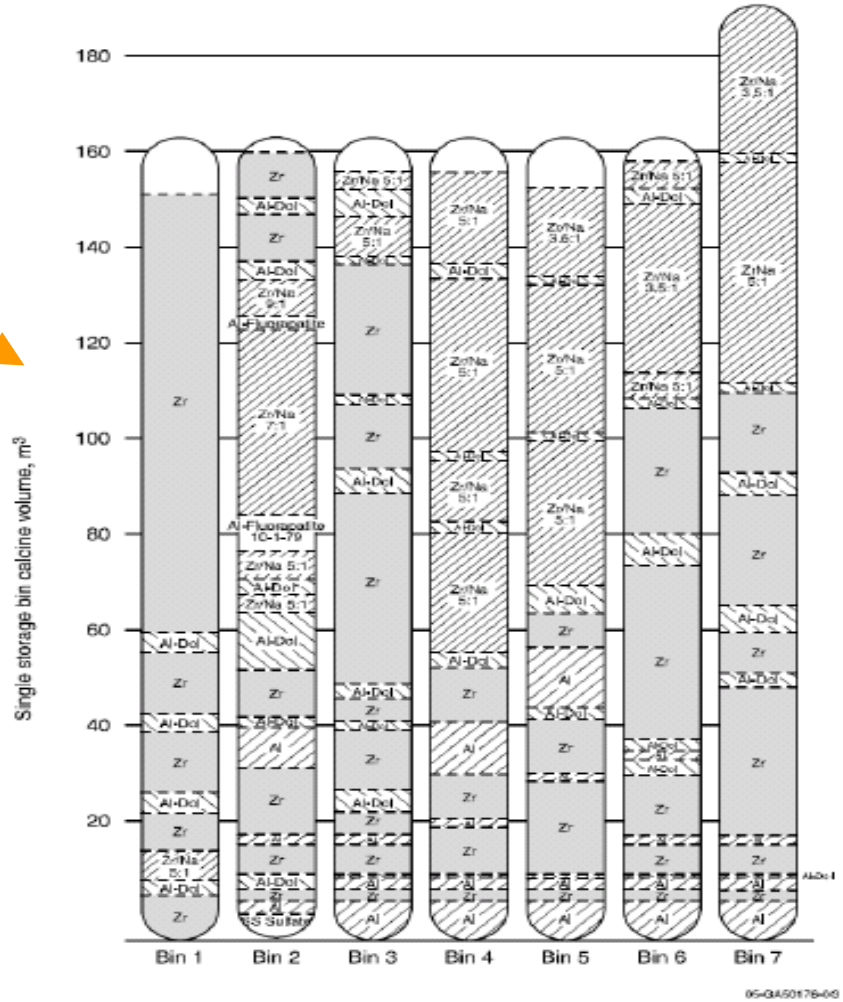
- ***Original path forward for calcine disposal:***
  - Retrieval and dissolution
  - Separation to concentrate radioactive constituents into high-activity fraction
  - Vitrification of high-activity fraction (approximately 1100 canisters)
  - Another option was direct vitrification of calcine without separations
- ***INL conducted preliminary long-term performance sensitivity analysis using Yucca Mountain Total System Performance Assessment (TSPA) model used in the Final EIS***
  - Used same radionuclide regulatory compliance point as EPA public health and environmental radiation protection standards for Yucca Mountain (40 CFR 197)
  - Hazardous constituents do not migrate beyond the repository boundary in concentrations above health-based levels at the radionuclide compliance point established in 40 CFR 197 during the proposed 1,000,000-year regulatory period
- ***INL also ran EPA's Industrial Waste Evaluation model using conservative site-specific data/assumptions for Yucca Mountain***
  - Results show that health-based limits are not exceeded at the hypothetical well (1 mile away) for any hazardous constituent
- ***Modeling therefore suggests no significant environmental benefit associated with further treatment***

Basis for Pursuing the Direct Disposal Option (cont.)

- ***DOE is thus considering petitioning EPA for a conditional exemption of calcined HLW from the regulatory definition of hazardous waste based on disposal at an NRC-licensed geologic repository and an exemption from land disposal prohibitions based demonstration of no-migration***
  - Regulatory precedent is "*Conditional Exemption for Low-Level Mixed Waste Storage and Disposal*" found at 40 CFR 266, Subpart N
  - Human health and environmental protection requirements for the geologic repository are more stringent than requirements for low-level waste disposal
- ***An INL petition would seek to demonstrate that an NRC-licensed repository will be as protective or more protective than a disposal unit permitted under RCRA***
  - DOE-ID needs access to the revision of the TSPA model supporting the NRC Yucca Mountain License Application to update the 2004 draft petition
  - NRC's confirmatory model would also be run
- ***DOE-ID opened discussions with EPA (Region 10) on February 5, 2008 regarding the regulatory feasibility of the direct disposal approach as well as the three treatment alternatives***
  - To discuss EPA's expectations regarding a potential petition for direct disposal without further treatment and the three treatment alternatives
  - The impact of the state of Nevada's RCRA authority was also discussed

Technical Challenge: Layering of Calcine (Bin Set #3 shown)





Further Evaluation of HIP Option Appears Warranted

Consolidation:	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: (relative to untreated calcine)	**15-45% reduction**	**~100% increase**
Temp:	2200°F	2100°F
Pressure:	4500 psi	atmospheric
Off-gas:	minimal	medium-high
Facility		
Future Mission Flexibility:	diverse/flexible	extremely limited/inflexible

Cold calcine in glass-ceramic matrix

Direct SBW compaction (no additives)

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

Technology Initiative: HIP Evaluation Funded by EM-20

- ***Contract between Battelle Energy Alliance and the Australian National Science and Technology Organization, Inc. was signed 2/28/2008***
  - Currently funded at $2.5M (FY-07 carry-over funds)
  - Will provide data necessary to proper downselection of treatment alternatives
- ***Calcine surrogate produced at STAR Center and shipped to ANSTO***
  - Three distinct alumina-calcine simulants containing low, medium, and high mercury concentrations
  - Three distinct zirconia-calcine simulants containing low, medium, and high cadmium concentrations
  - All other RCRA constituents at maximum

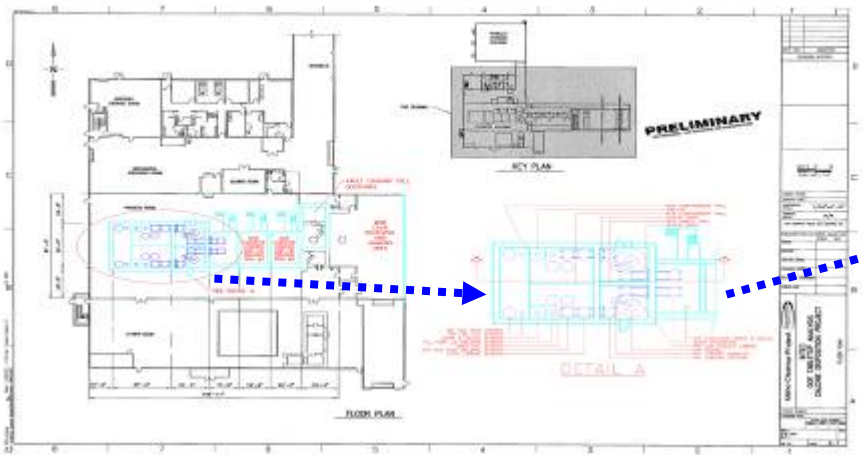
Sample of simulated alumina calcine showing fines (bottom ~10% of total), product (vast majority) and agglomerates (~1%).

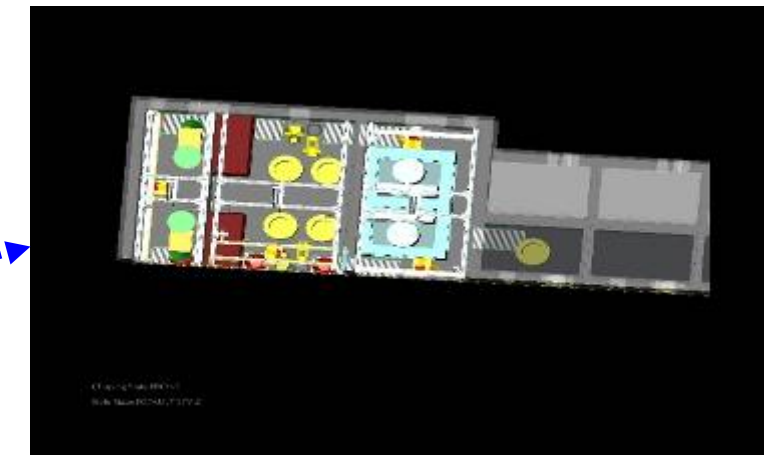
- ***ANSTO Inc. has performed industrial review of US HIP industry***
  - HIPs of up to 64 inch diameter operate above calcine pressure/temperature requirements
  - 24/7 production environment for over 30 years
    - *Work pieces up to 10,000 pounds are HIPed*
  - Main safety issue raised was asphyxiation
    Not a significant concern in controlled hot cell environment

Technology Initiative: HIP Evaluation Funded by EM-20 (cont)

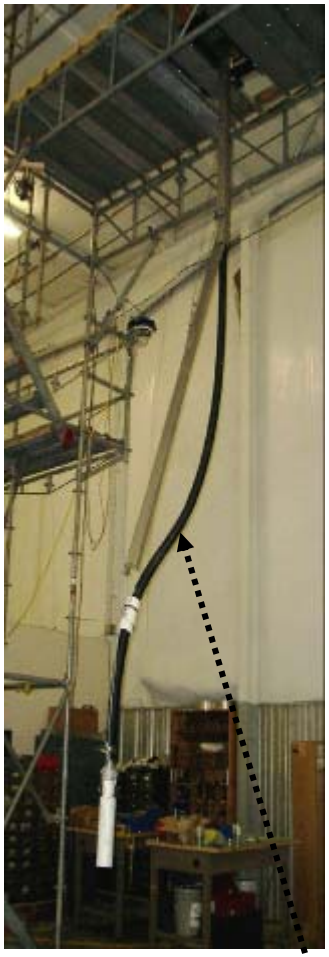
- ***HIP unit is installed in the HFEF hot-cell at INL***
  - Will first use to evaluate conduct of remote operations (filling, crimping, etc.) and potential HIPing of actual calcine
  - Also plan to evaluate treatment of a wide range of problem wastes difficult to incorporate into glass such as:
    - *CS/SR, Tc, sludges (such as Hanford K-basin)*
    - *Alpha ashes, impure actinides, corroded fuel pins, iodine*

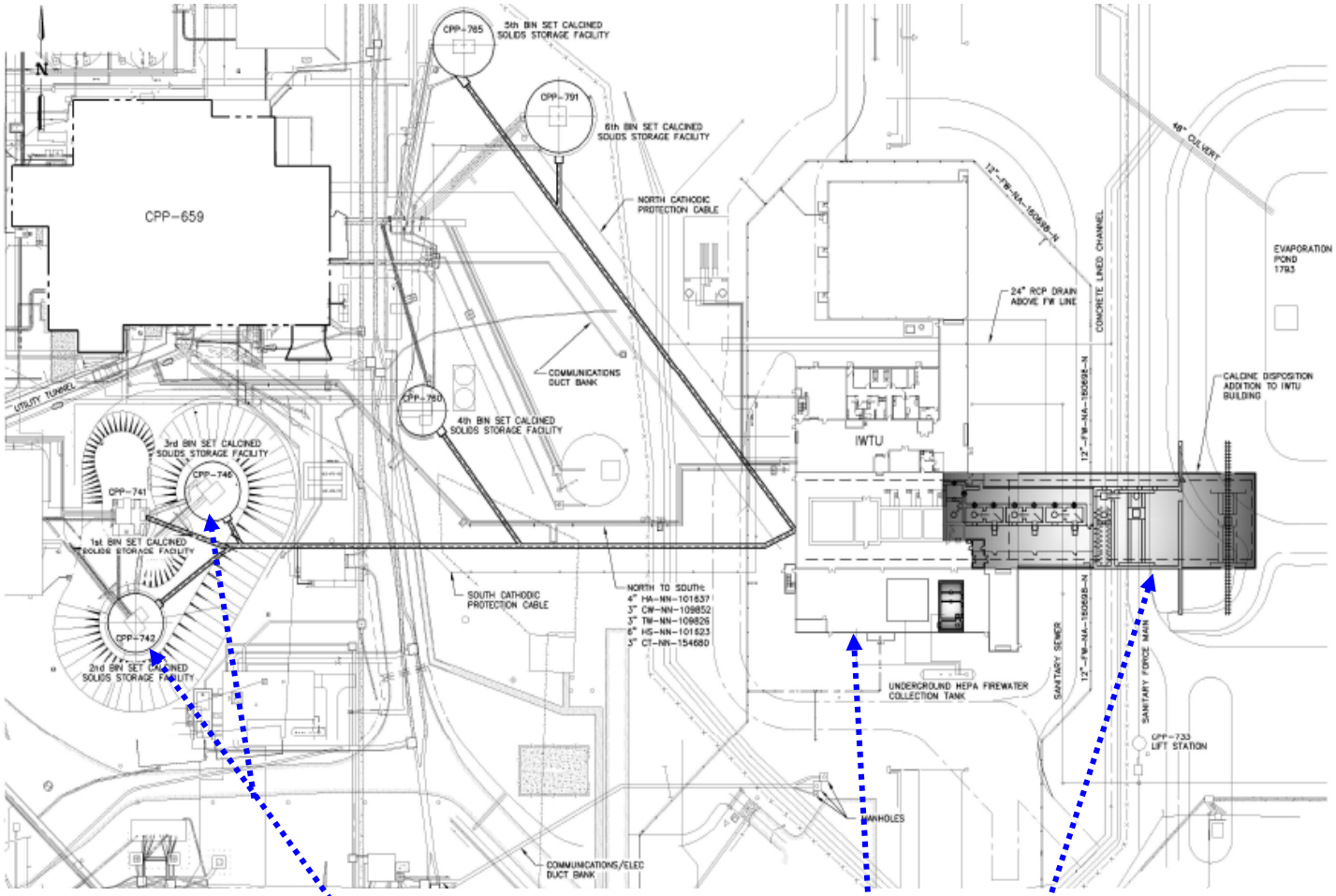
- ***Conceptual layouts of IWTU-based and "greenfield" facility evaluated***
  - It appears feasible to fit two HIP trains into existing IWTU cell footprint





CDP Pneumatic Transport Line Route and Retrieval Prototype





Prototype retrieval arm

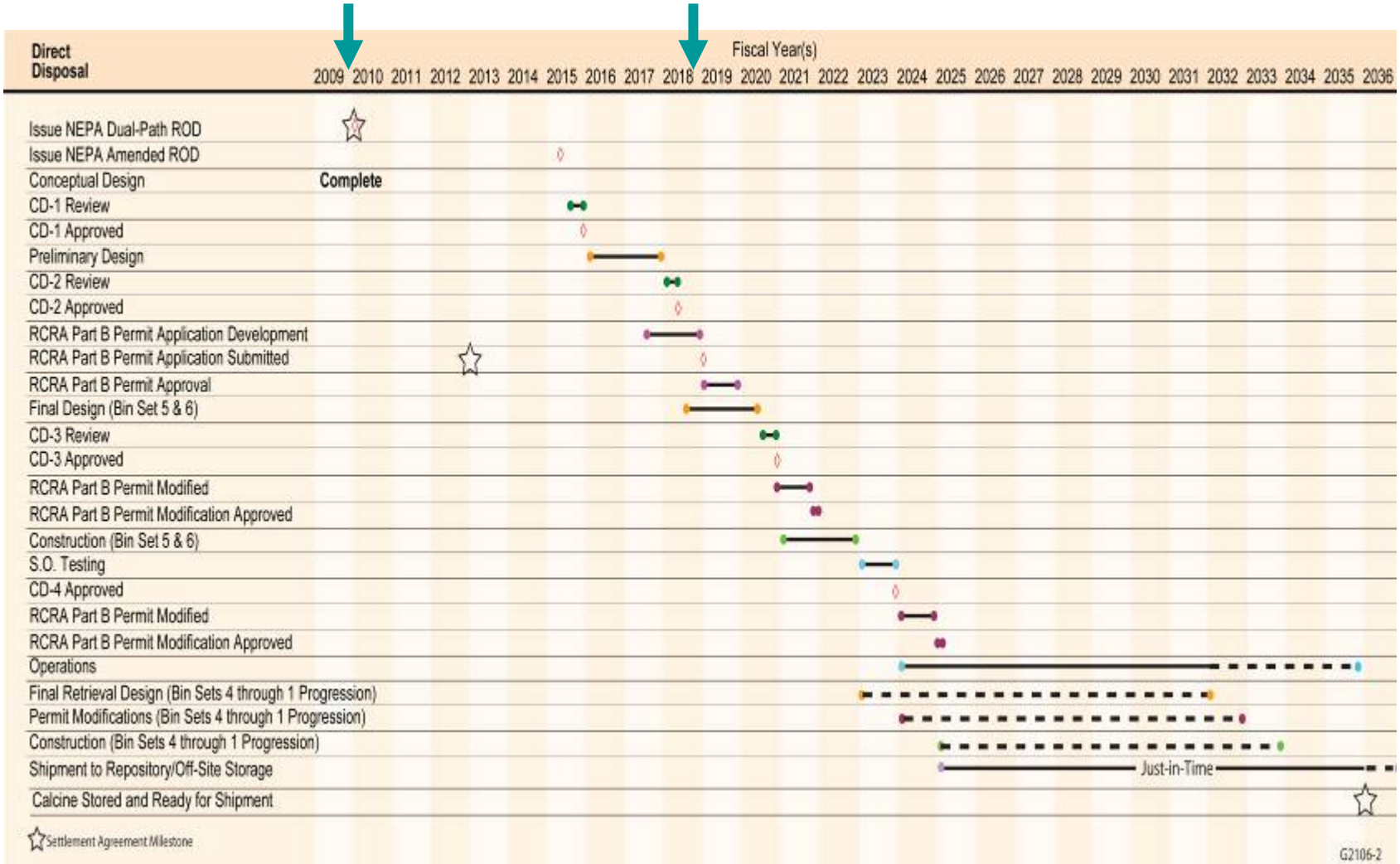
Bin sets (typical)

IWTU

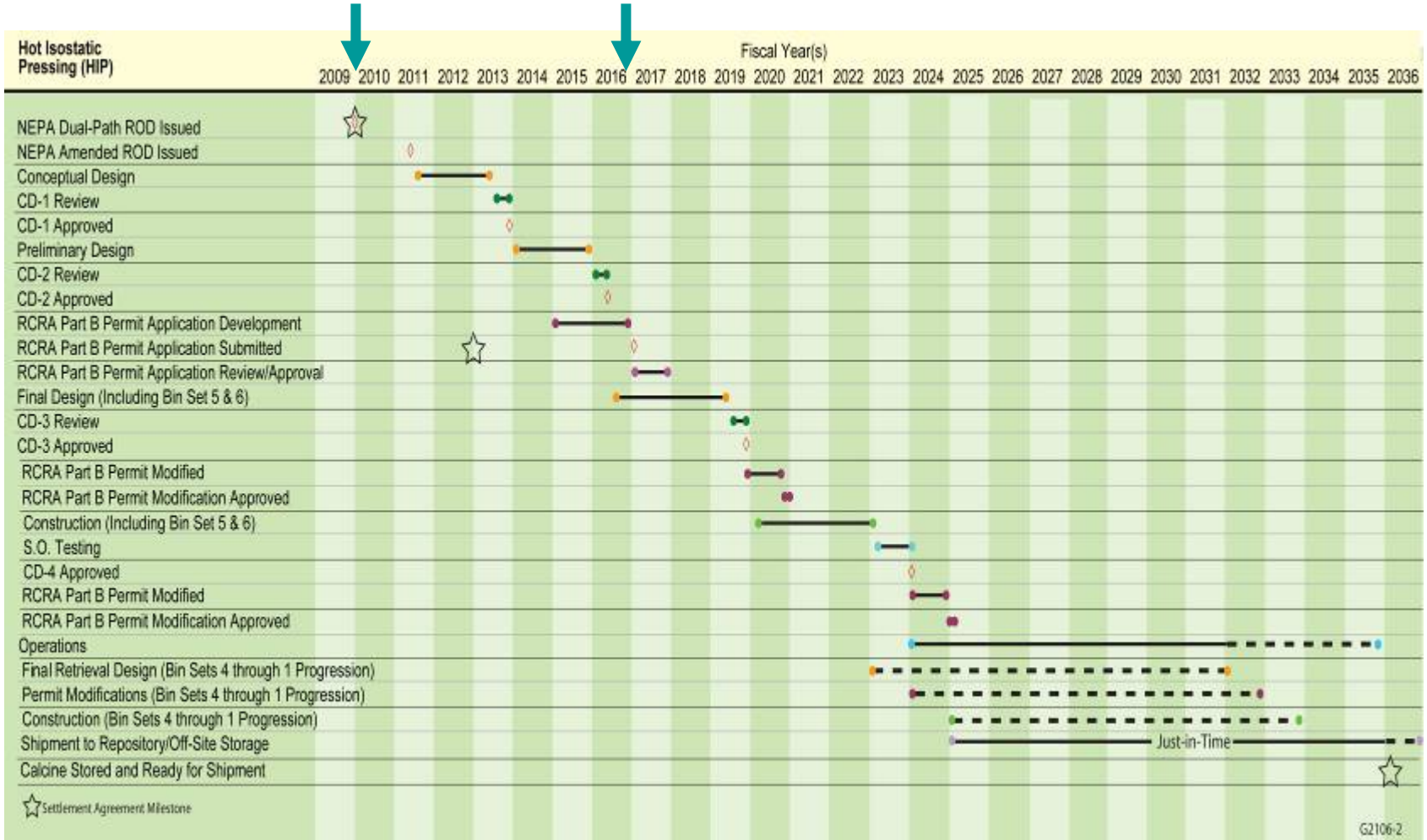
IWTU packaging annex

Backup Material

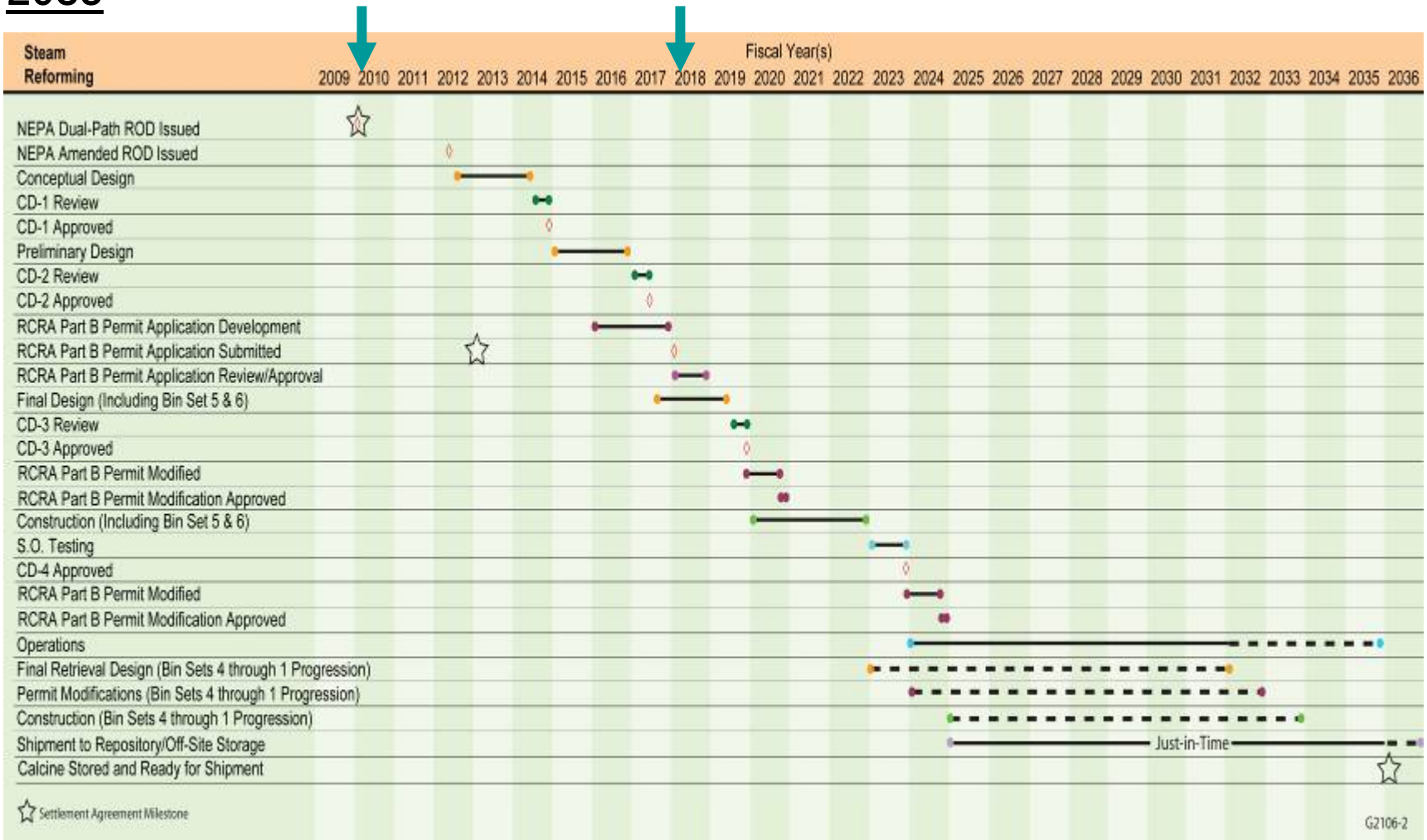
Conceptual Direct Disposal Schedule Working Forward from 2035



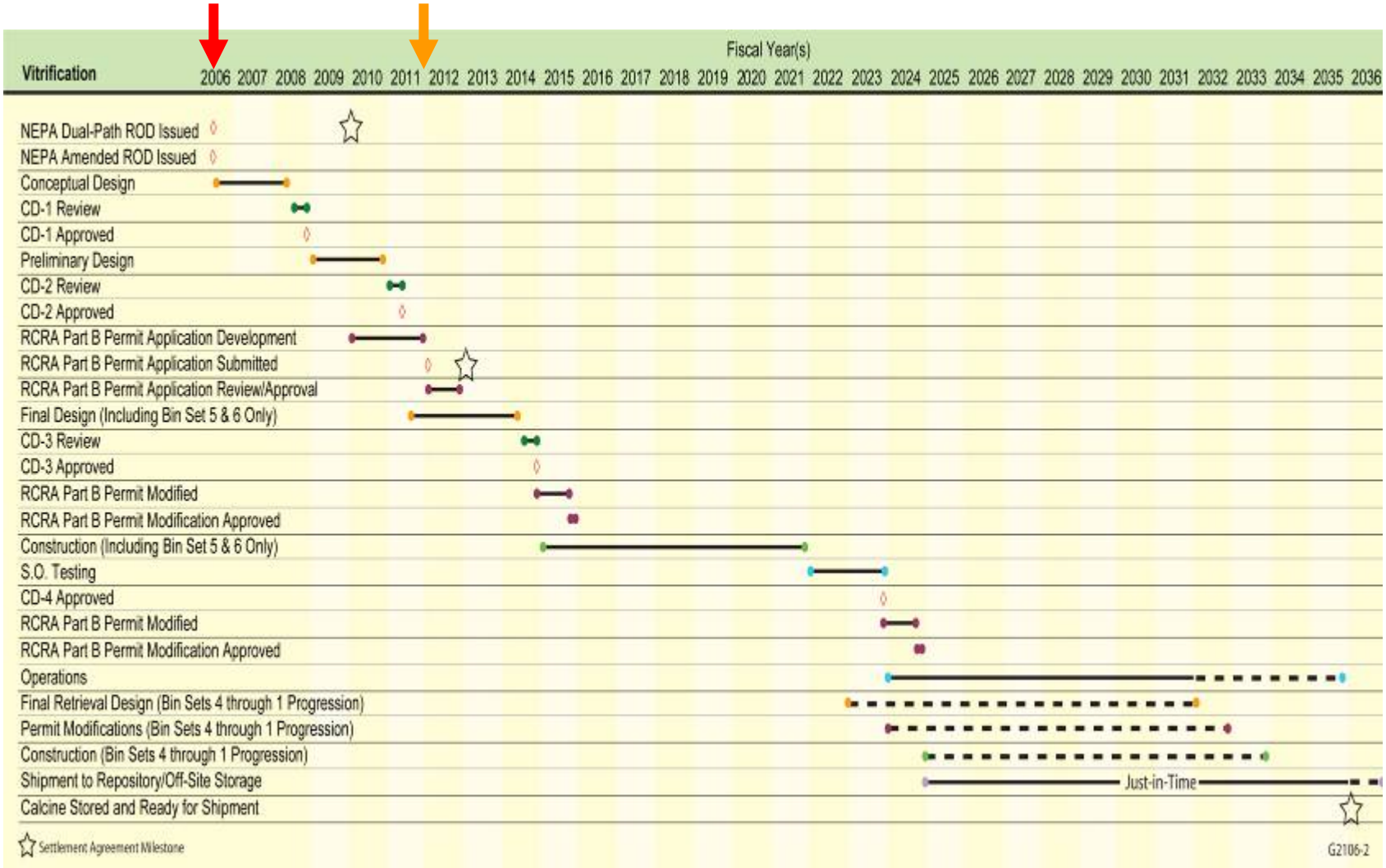
Conceptual HIP Schedule Working Forward from 2035



Conceptual Steam Reforming Schedule Working Forward from 2035



Conceptual Direct Vitrification Schedule Working Forward from 2035



Independent Life Cycle Cost Estimate Results *

Treatment Technology (project contingency)	Retrieve, Process, Store (1), D&D	Estimated Number of 10' Canisters	Repository Shipping & Disposal Charge (2)	Total Estimated Life-Cycle Cost (3)
Direct Disposal (40%)	$2.319B	6,660	$4.129B	$6.448B
Direct Vitrification (50%)	$16.307B	11,200	$6.944B	$23.251B
Steam Reforming (60%) See Note 4	$5.679B *(understated)*	6,660 *(understated)*	$4.129B *(understated)*	$9.808B *(understated)*
Hot Isostatic Pressing (50%) See Note 4	$13.324B *$4-5B*	3,300/4,400	$2.046B/$2.728B	$15.370B *$7-8B*

*** 85% confidence level and 2006$s**

Notes:
(1) Cost estimate does not include storage cost beyond reuse of limited IWTU storage
(2) Repository disposal charge based on current estimate of $620K per canister (includes shipping cost)
(3) Total estimated cost impact to DOE (2006 $'s)
(4) Differing professional opinions from conclusions in the ICE report