ORNL MVST Sludge (SL) Solidification Feasibility Study Overview

Presented at Slurry Retrieval, Pipeline Transport & Plugging and Mixing Workshop, January 14-18, 2008

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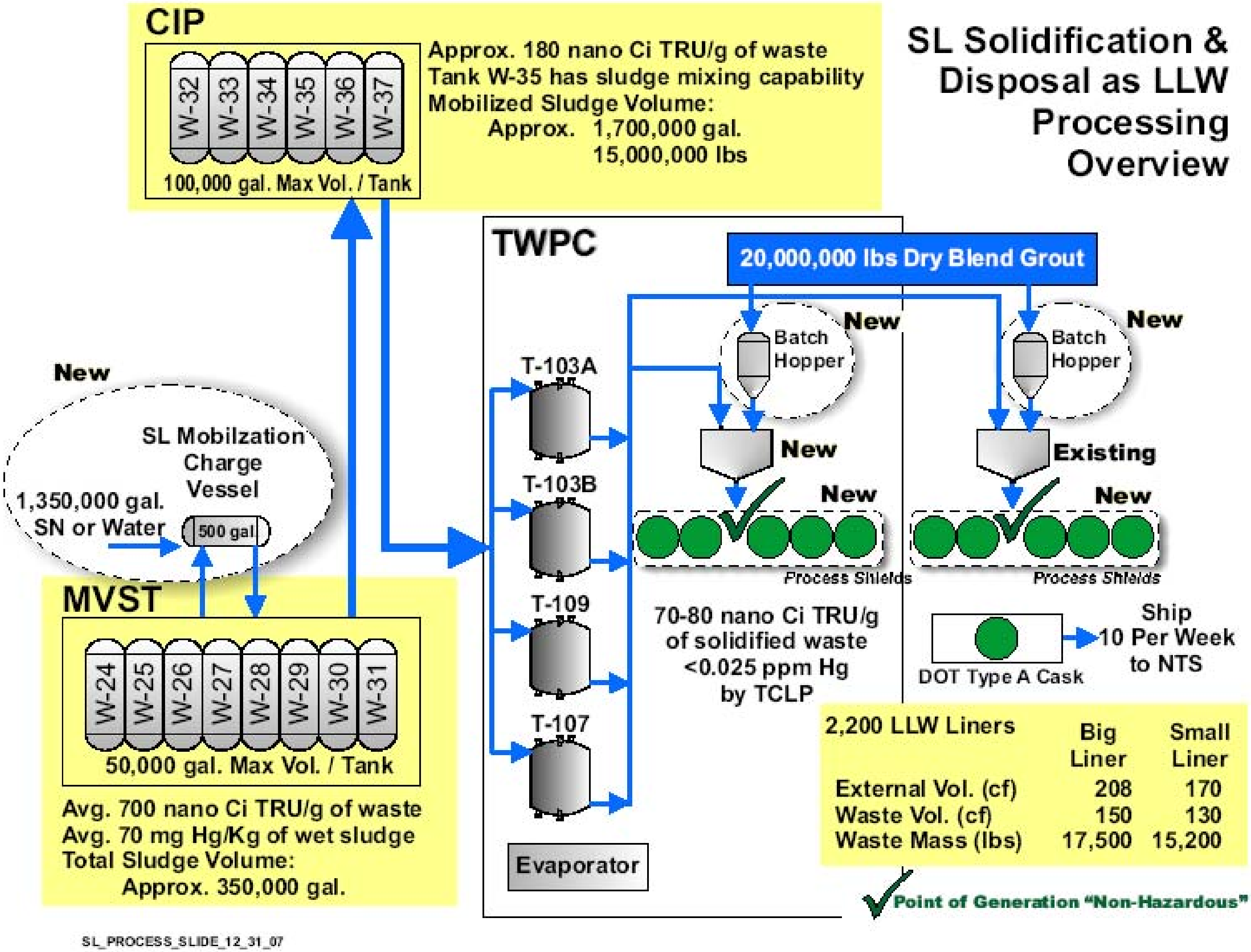

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Sampling/Analytical Cost

- Lowest sampling/analytical cost
- NTS has agreed to the "big batch" concept (i.e., 80,000 gallon batches in CIP tank W-35)
- Number of batches reduced from ~200 to ~20
- Minimizes the number of samples per batch
  - NTS minimum 4 per EPA SW-846
  - WIPP minimum 10 per waste stream/batch
- LLW Characterization/Analytical costs < ½ the cost of RH-TRU costs for WIPP even if WIPP can accept the "big batch" concept
- Potential for greater savings using modeling to confirm earlier sampling (i.e., gross alpha to TRU correlation)

Sampling/Analytical Cost

- MVST Sludge is well characterized
- Newer 2001 Keller Report on sample results correlates well with Bayne statistical analysis of historical data
- Poor correlation between total Cs-137 (primary gamma isotope) and total alpha, poor application for Dose to Curie (DTC)
- Excellent correlation between total TRU isotopes and Gross alpha ($R^2 = 0.9261$)
- Gross alpha analysis can be performed at ORNL (< $1,000/sample, <1 day TAT)

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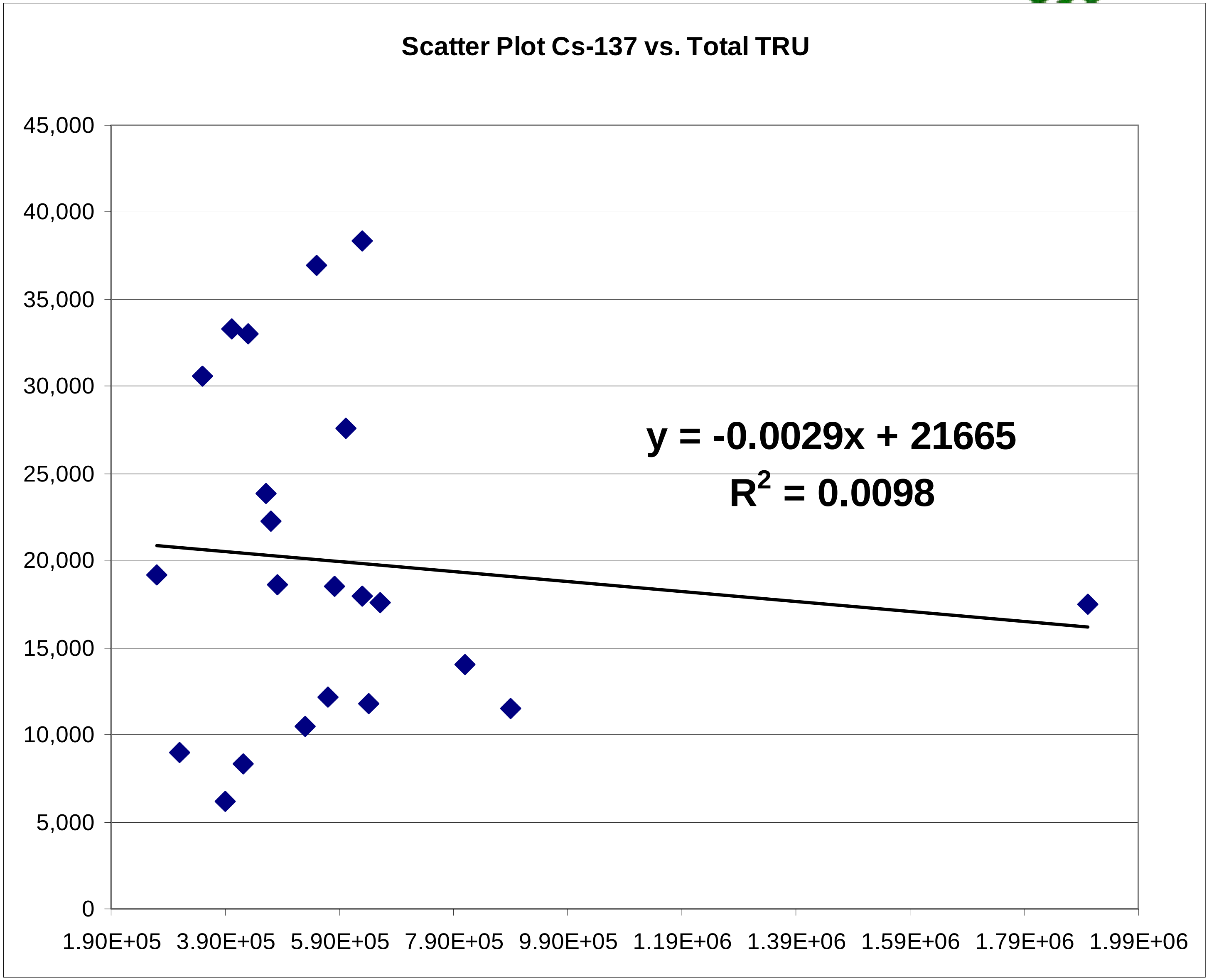

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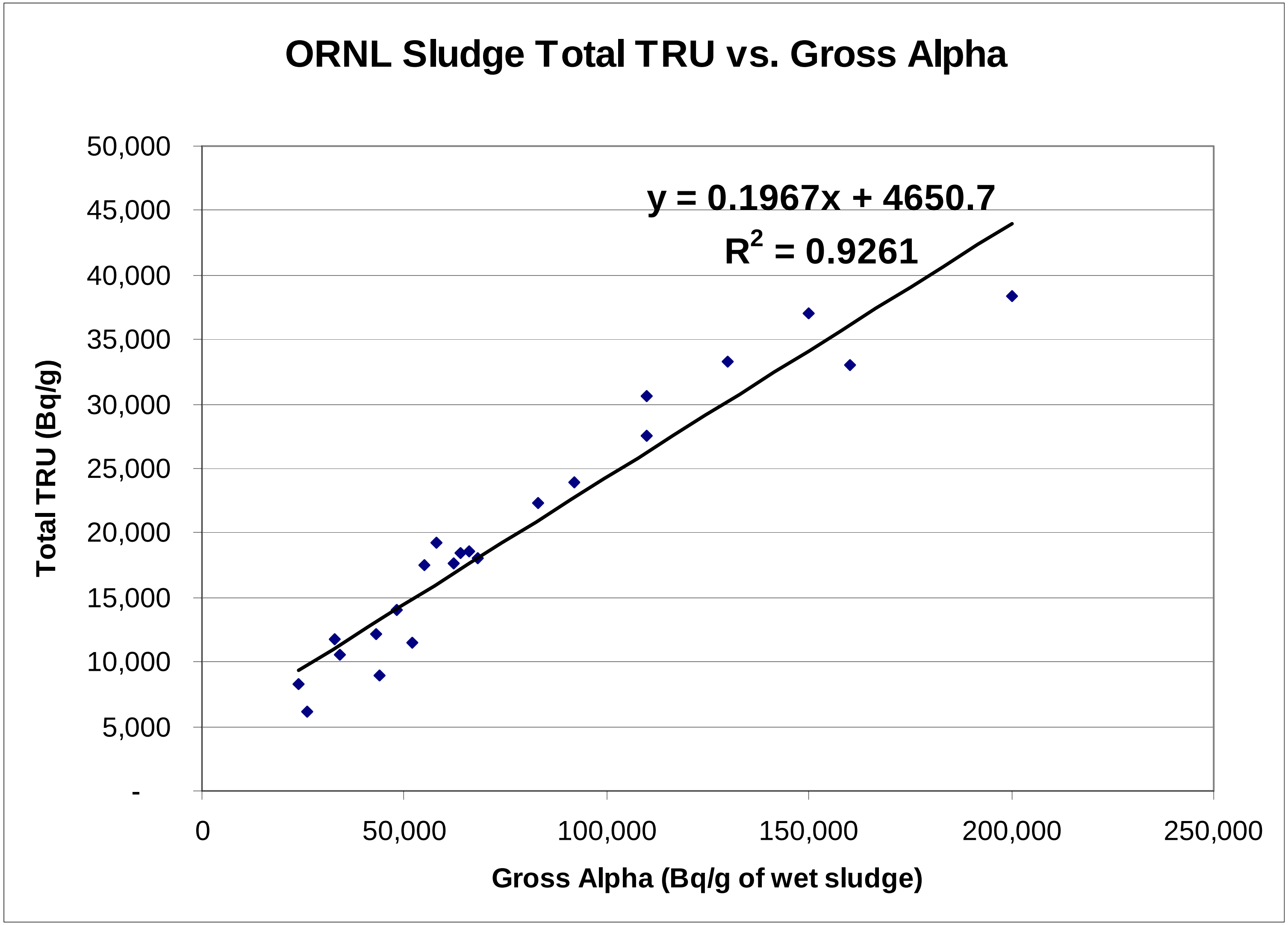

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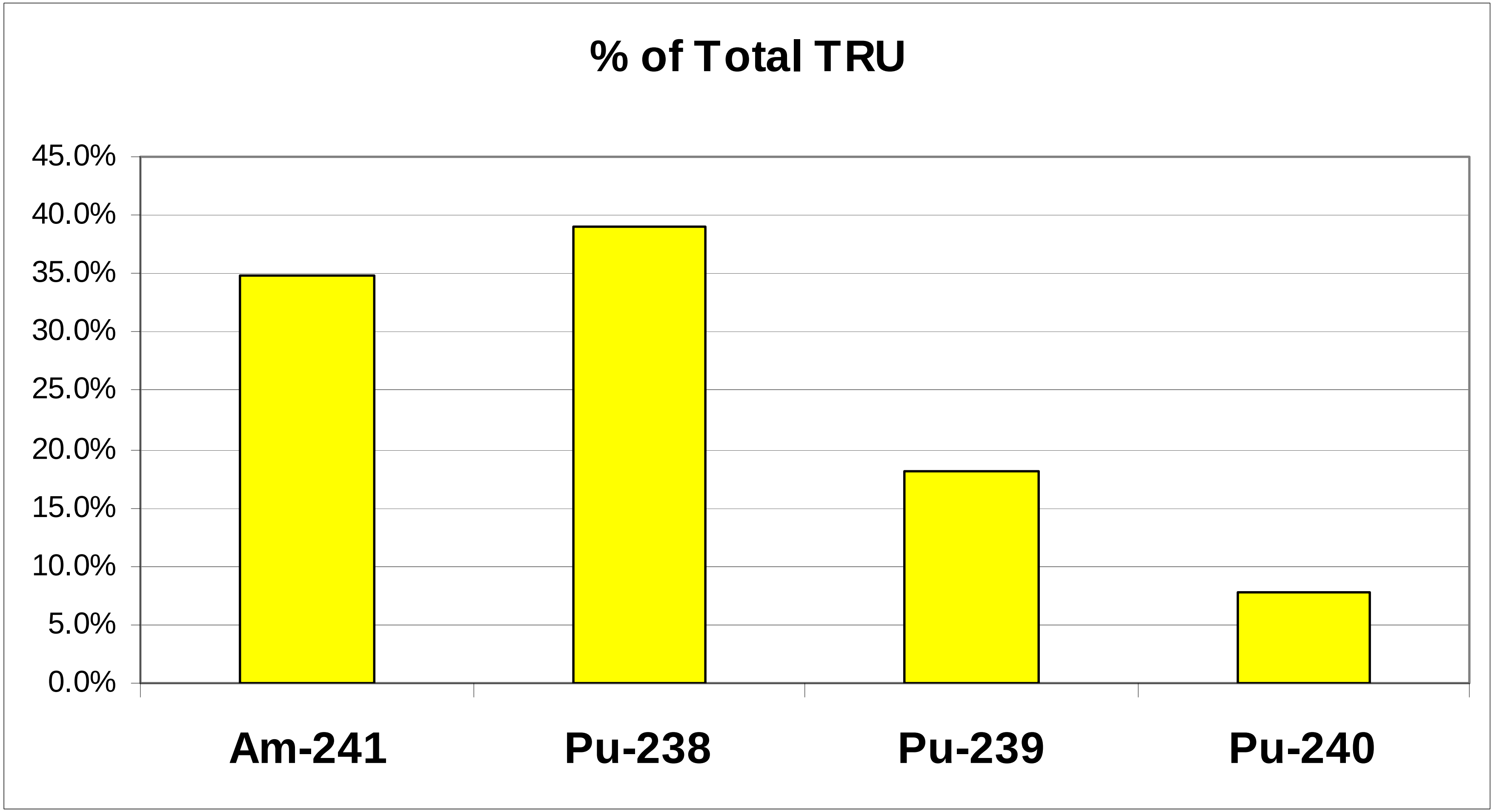

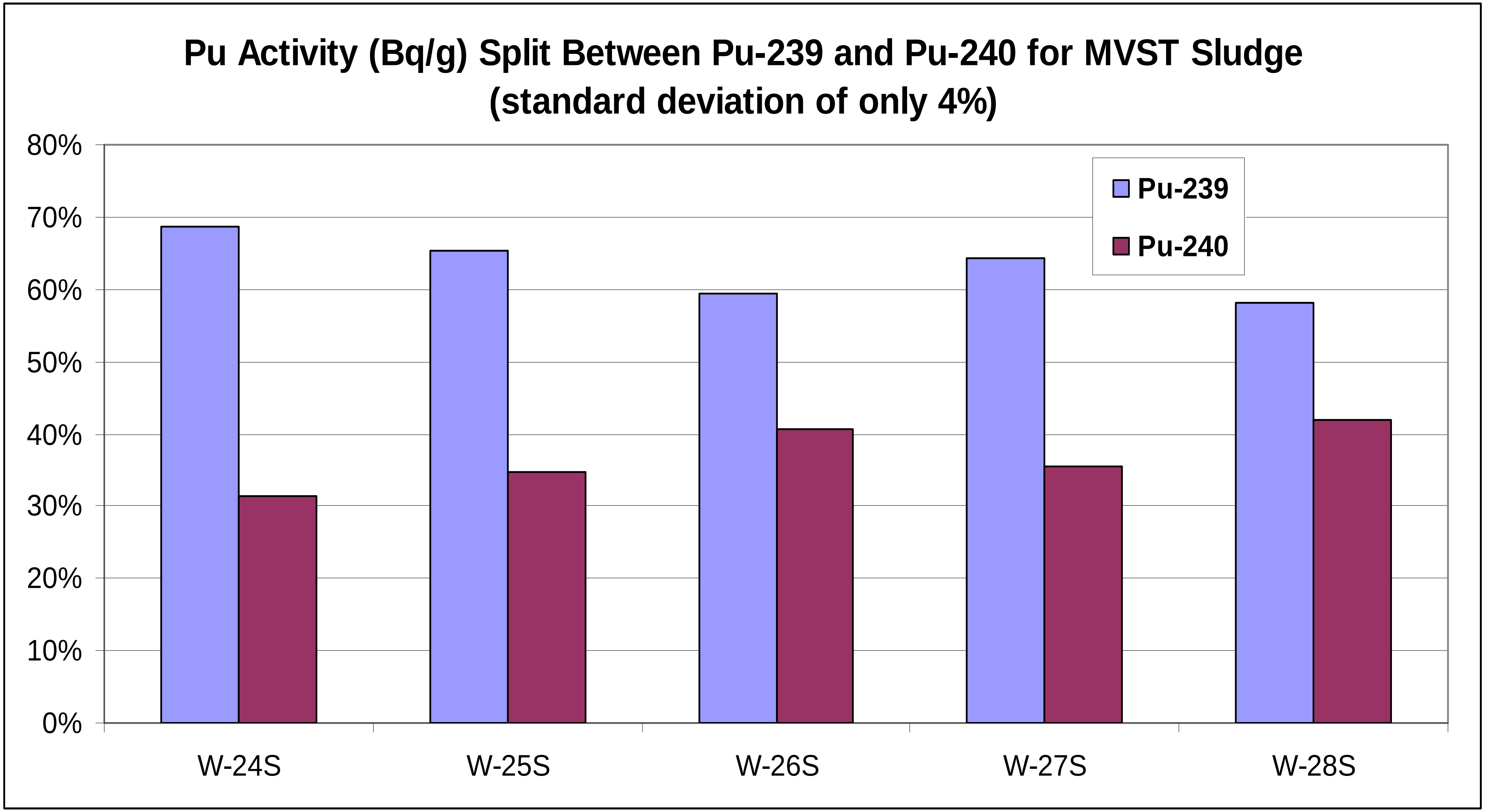
Pu Activity (Bq/g) Split Between Pu-239 and Pu-240 for MVST Sludge
(standard deviation of only 4%)
80%
70%
60%
50%
40%
30%
20%
10%
0%
W-24S
W-25S
W-26S
W-27S
W-28S
Pu-239
Pu-240

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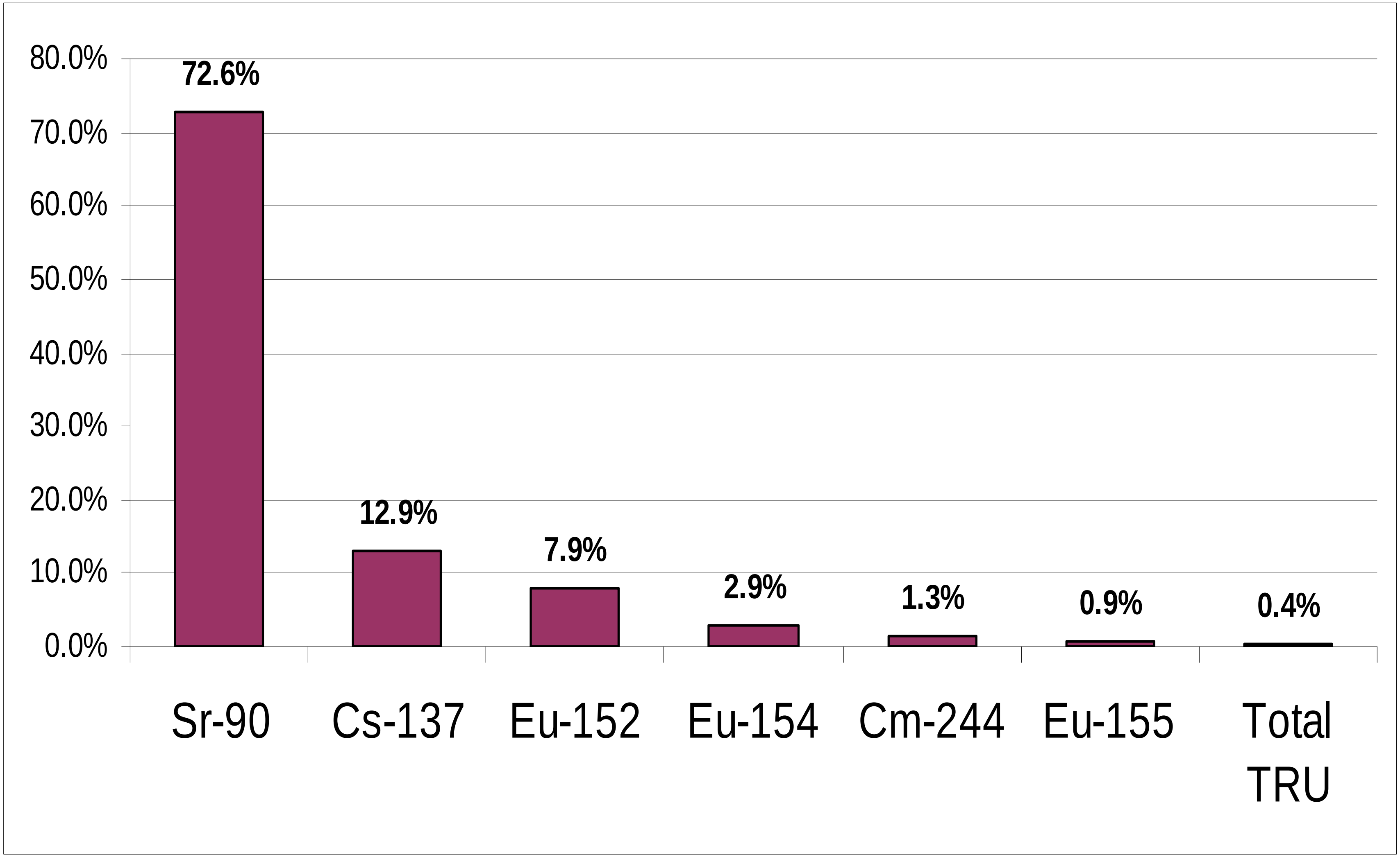

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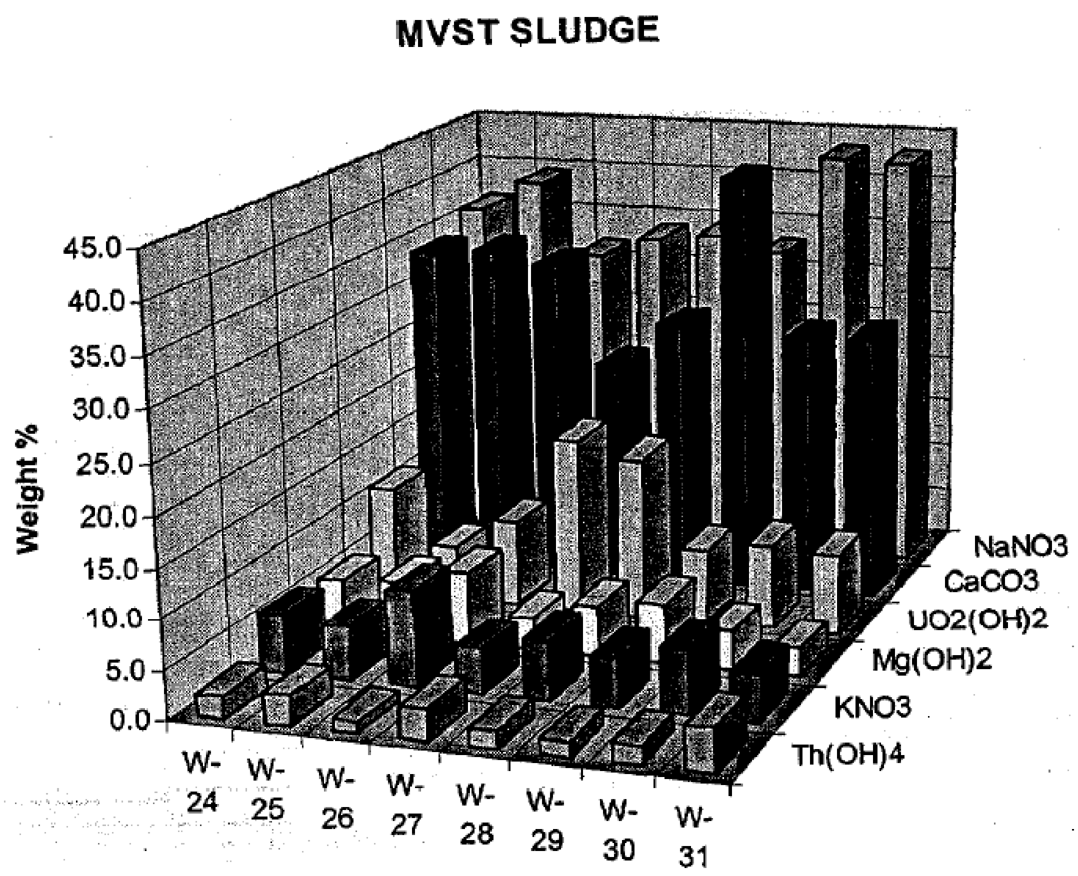
EnergX

MVST Sludge-Witches Brew

Figure 1 Distribution of Major Compounds in the MVST Sludge



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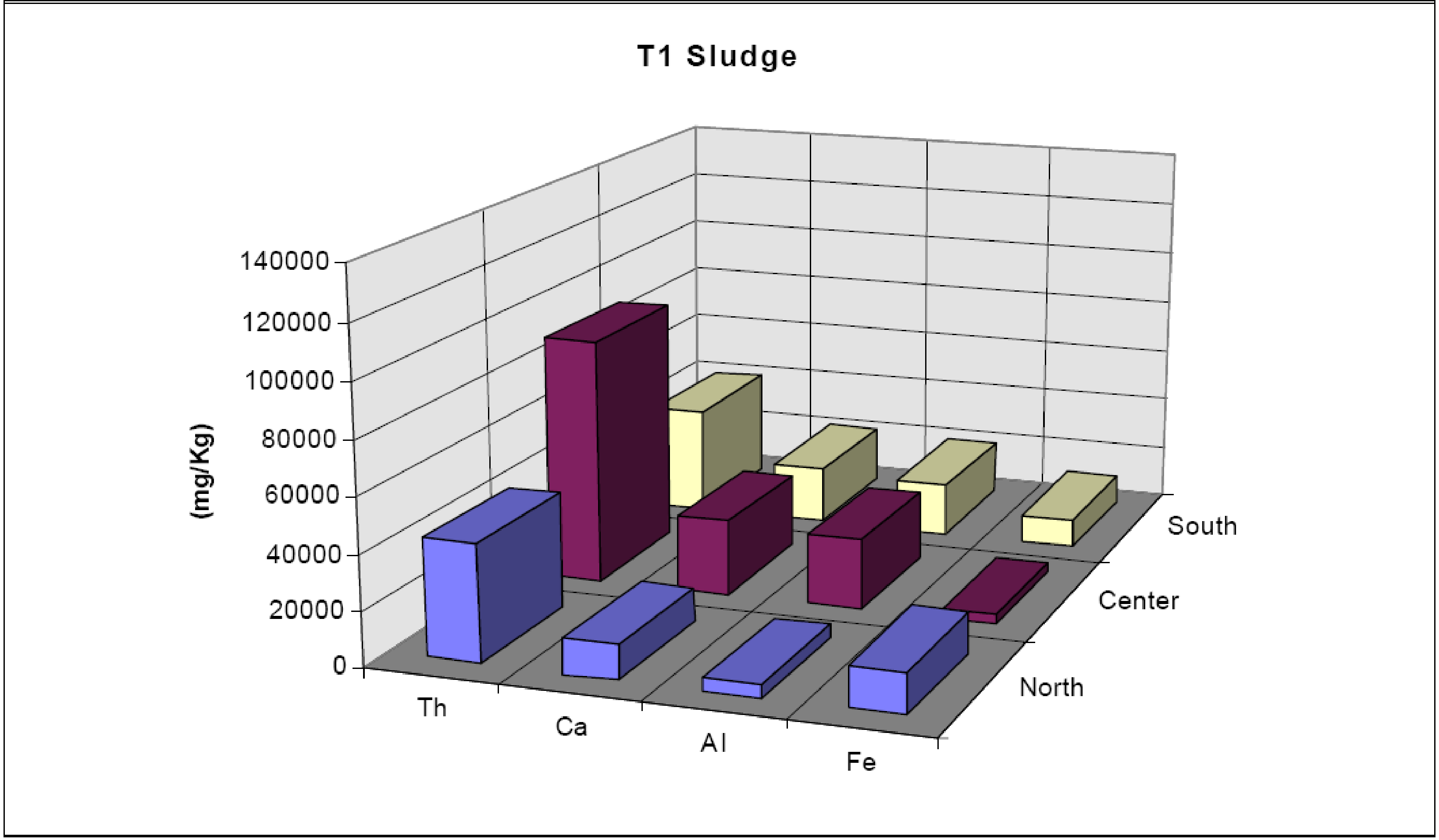
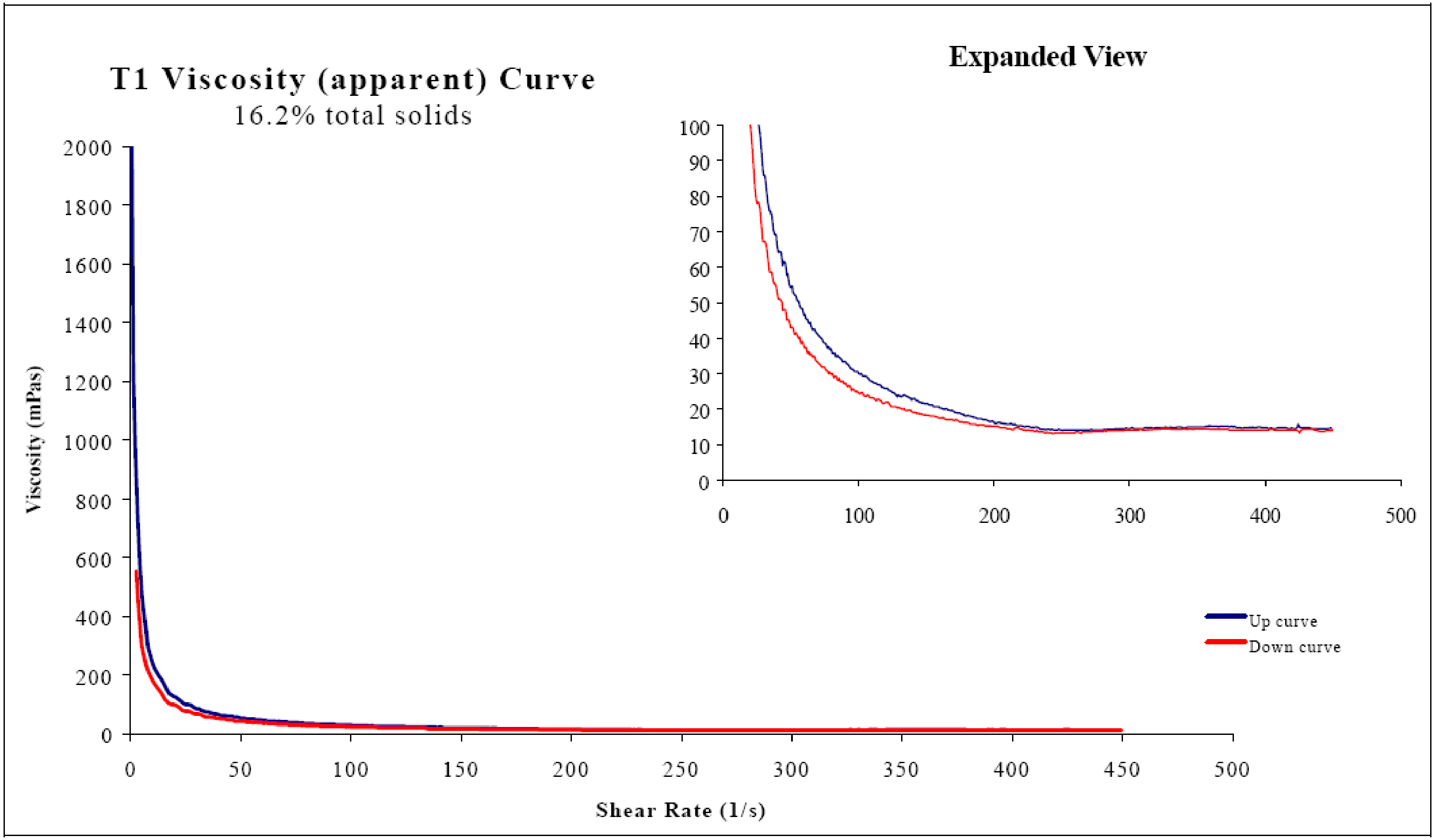
Sludge Major Metal Variation within a Tank

Figure 25 Lateral Distribution of Major Metals in T1 Sludge



OHF Sludge-1:1 Dilution w/ SN

Figure 15 Viscosity vs. Shear Rate for T1 Sludge Composite



Waste Package/Transportation $

- LLW Waste Package cost lower than 72-B
  - LLW liners (~$7k each)
  - 72-B canisters (~$15k each)
- Transportation costs to NTS are less than half the cost of 72-B cask shipping costs to WIPP
  - Type A cask to NTS (~$15k/trip)
  - 72-B shipping cask to WIPP (~$26k/trip)
- Total cost for LLW waste packages and transport is less than RH cost even if twice the LLW packages and shipments are required

D&D Costs

- Lowest D&D Cost option
- SN system (already contaminated) is modified for SL solidification
- SL systems and areas are not contaminated
- SL equipment can be used as spares for the SN systems

RH Debris Synergies-DOE

- Lowest risk of RH-Debris shipment disruption
- Enables 72-B cask fleet to meet DOE complex needs
- Eliminates handling/disposal of 1,600 RH Canisters at WIPP
- RH Debris operations throughput enhancements (e.g., additional shifts) could be achieved now that RH-Debris operations are not constrained by RH TRU SL
- TWPC better suited to handle additional RH Debris from other sites if DOE elects to centralize RH certification

Process Risk

- Lowest process risk
- Solidification is a mature and established technology
- Uses existing reliable SN equipment, with minor modifications, and additional simple poweder handling equipment & shielding
- Some risk that conversion of the Jaygo SN Dryer to a batch mixer may not provide adequate mixing
  - Bench scale testing on actual sludge and pilot scale mixing tests with surrogate needed to confirm that mixing is adequate
  - SN Dryer has a heavy duty shaft, ribbon style mixing blades, thick vessel wall, heavy duty pillar block bearings, custom live-loaded packing glands on shaft seals along with oversized gearbox/motor
  - SN Dryer is very similar to the Jaygo mixers used at Fernald for Silos 1 & 2 solidification campaign

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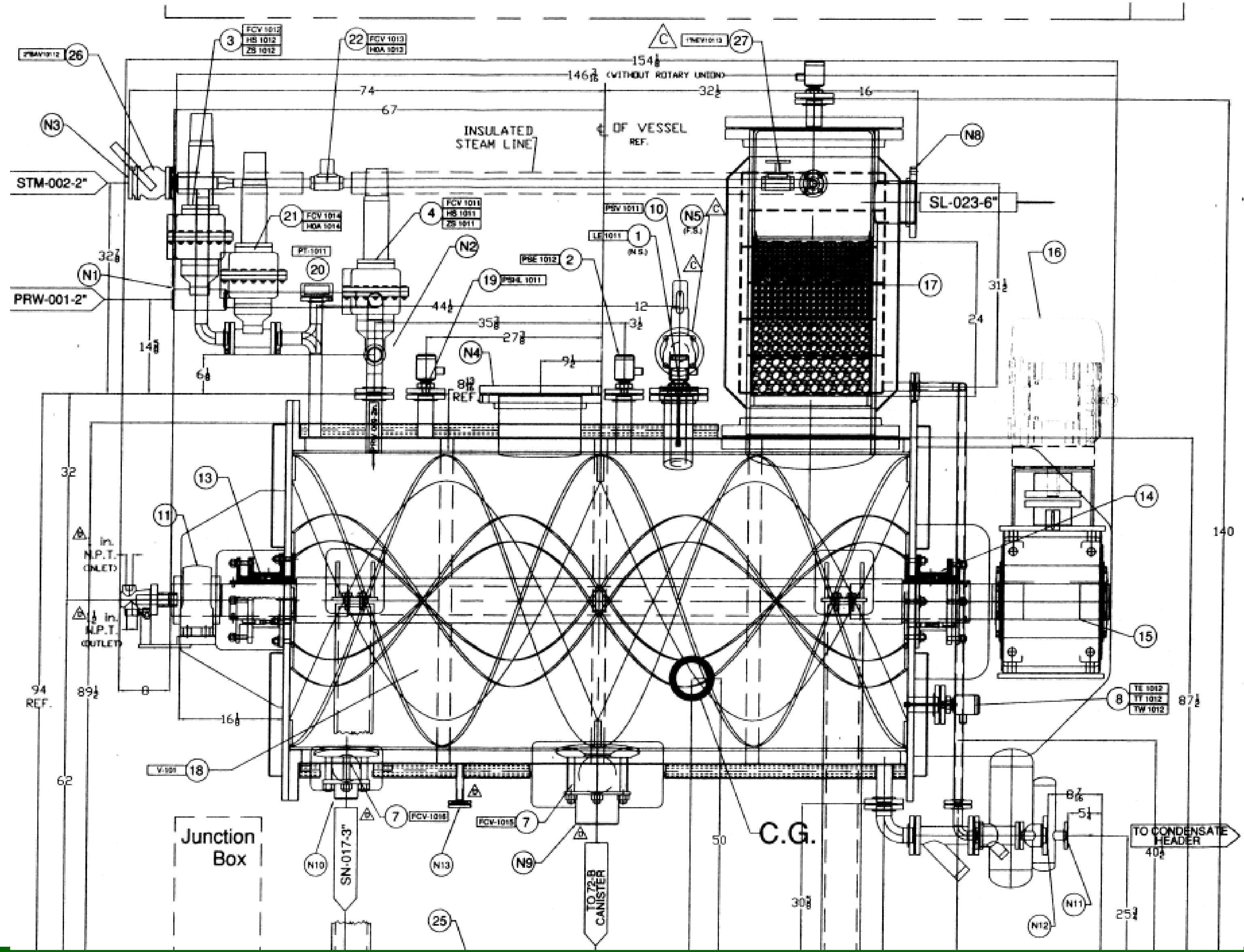


Process Risk: W-23

Recently provided isotopic estimates of W-23 SL

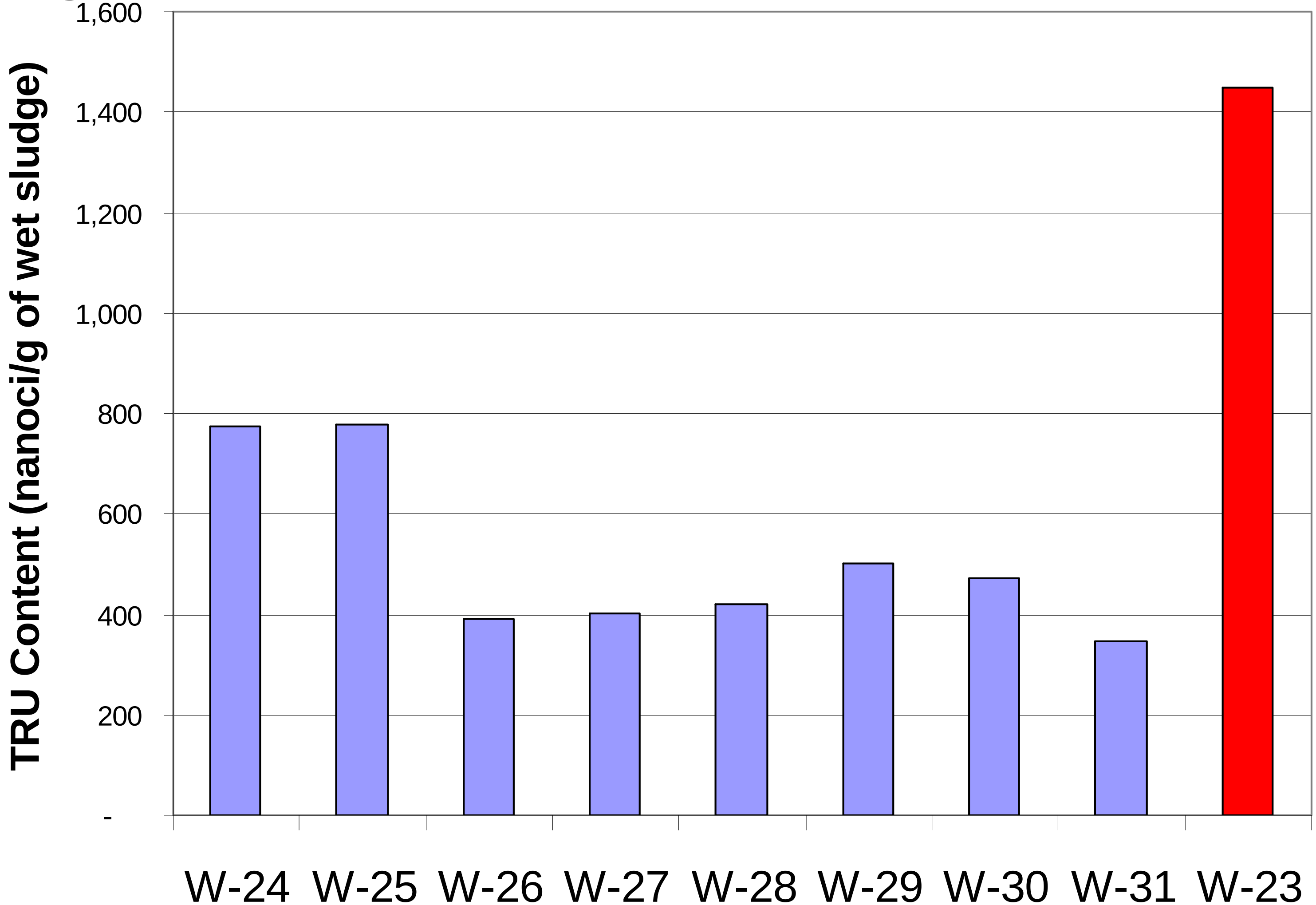
- Preliminary isotopic estimates of “New Generation” SL in W-23 containing dissolved sources are much higher than MVST mean values for Pu-241(non-TRU) and Am-241(TRU)
- Sludge mass in W-23 is lower than other tanks
- Total TRU curies in W-23 only 40% above average TRU curies per tank
- TRU level increasing each year of delay
  - ***Pu-241 decay to Am-241 (t1/2 = 14 years)***
- *May require processing, packaging, certification and disposal as RH-TRU at WIPP*
- *Mitigating risk by collecting and analyzing samples to ensure that the solidified waste will remain LLW*

Process Risk (W-23 as RH-TRU)

- Solidification is adaptable to fill small liners (i.e., to fit in a 72-B canister) to allow disposal at WIPP
- 200 RH Monolith canisters from W-23 if shorter liners are filled to minimize modifications
- Minimal benefit would be achieved by direct loading of 72-B canisters since WIPP WAC Rev. 6 gross canister weight limit has been reduced from 8,000 lbs to only 4,240 lbs. and FGE limitations
- Direct loading of canisters would be weight limited
  - ***Only reduces the number of W-23 canisters to 171***

EnergX

Avg. TRU Concentration in MVST/BVST Tanks



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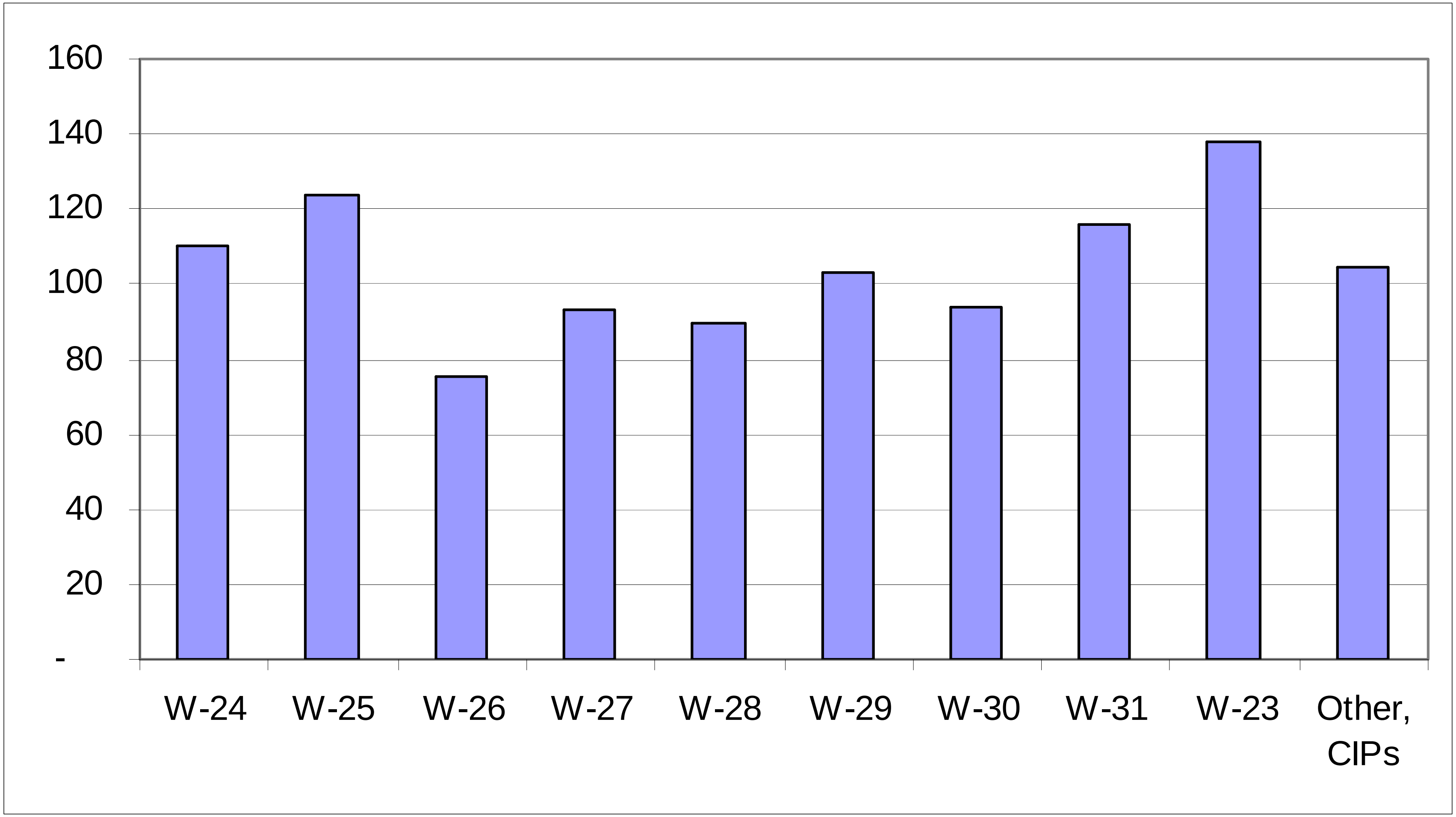
TRU Curies in MVST/BVST Tanks



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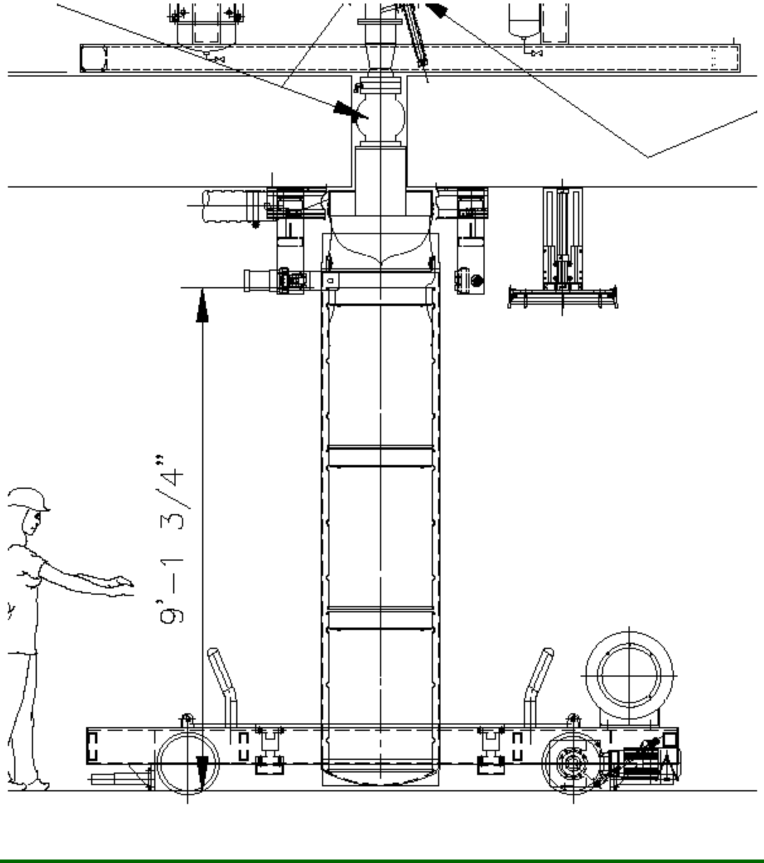
72-B Canister Liner Filling in LLW Liner Filling Station



Transportation Risk

- Modest increase in transport risk (e.g., potentially 50% increase in the number of cask shipments)
- However, robust, solidified, monolith provides added defense in depth against release from a transportation cask breach incident
- DOT Type A shipping casks
  - Readily available from commercial company
  - Large number of Type A casks eliminates the 72-B Cask bottleneck
  - May have to use a smaller liner at max shipping rate to allow usage of smaller Type A casks
  - Cost to build additional Type A casks (~$300k) is much lower than 72-B casks (~$1-2M), if additional casks required
- Initial transportation analysis indicates that the solidified SL meets the standard DOT Type A fissile exemption and no special permit is needed

ALARA/Criticality

- Lowest dose rates (3R/hr) on final form due to self shielding from added mass (grout/water)
- Negligible incremental airborne contamination risk vs. SN, lower airborne risk than dewatering
- Criticality remains incredible (lowest K_{eff} due to addition of boron and solidification additives)
- Simple, low risk process based on proven SN systems and extensive DOE solidification experience
- Lowest projected collective worker radiation exposure and lowest potential for internal exposure/uptake

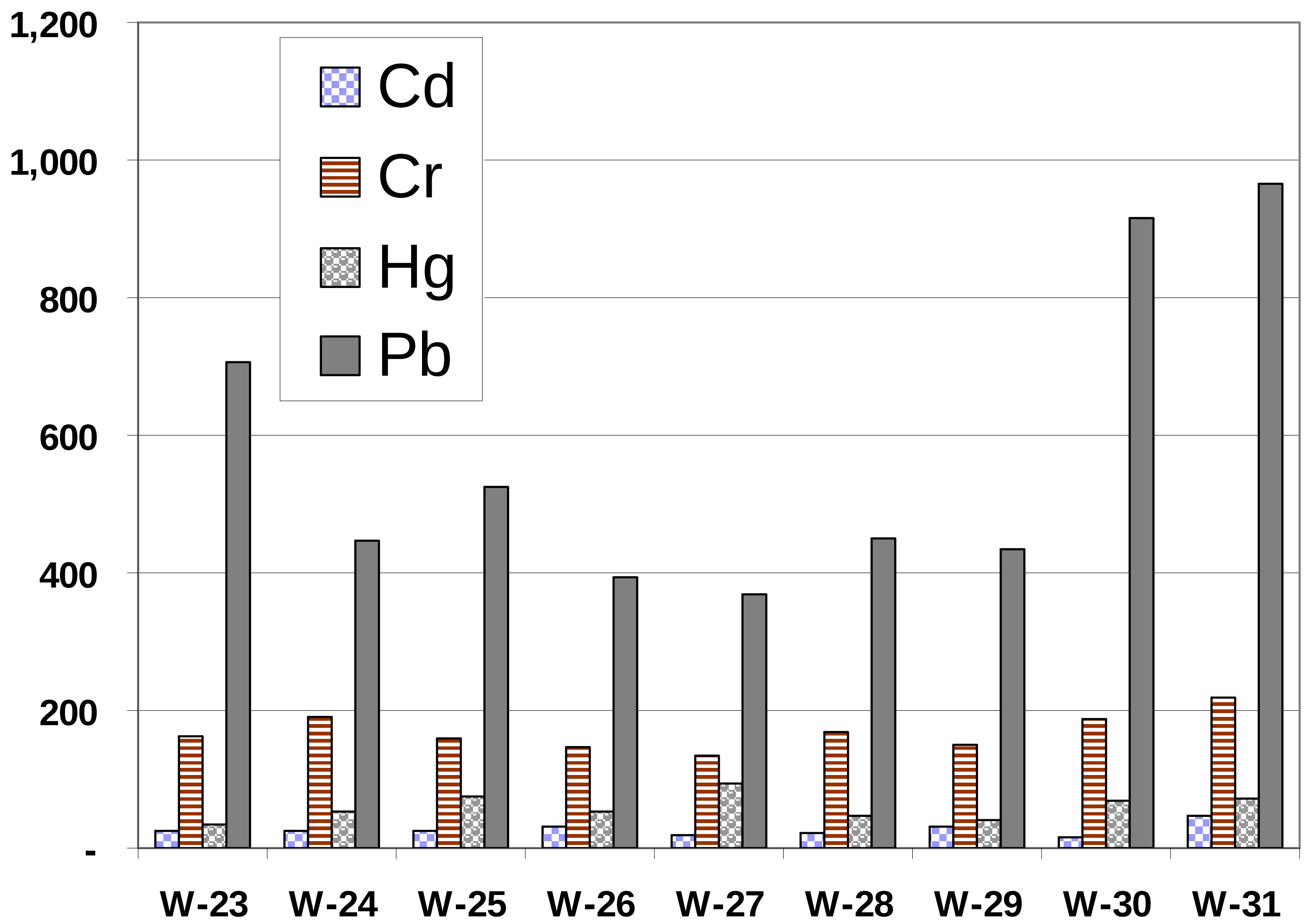
Training/Procedure Requirements

- Simple nature of the solidification process
- Use of existing SN equipment and most of the SN operations personnel are still at the TWPC
- Greatly reduced procedure and training needs
- Numerous TWPC Personnel have first hand experience solidifying this or very similar waste

Final Waste Form Attributes

- Superior final waste form
- Low dose rate (3 R/hr on contact)
- Robust, solid monolith that is no longer characteristic mixed waste
- Characteristic of toxicity eliminated by stabilizing RCRA metals (i.e., Cr, Hg, Pb,) to pass the TCLP
- Waste at “Point of Generation” is non-hazardous
- Simple verification of solid waste form (e.g., temperature profile exotherm, remote visual inspection via camera, or penetrometer)

Avg. Top 4 RCRA Metals per Tank (mg/Kg)



RCRA Perspective - Treatment vs. Dilution

- Not diluting the waste to avoid treatment
- RCRA metals stabilized via solidification/stabilization
- Water added to facilitate treatment (i.e., transfer, aggregation, homogenization, sampling, solidification)
- Self shielding from the water and cement reduces radiation levels and personnel exposure to radiation
- SL is fissile but over moderated, the addition of more water and the solidification agents reduces keff
- Hanford determined that adding water to mobilize and aggregate sludges was not impermissible dilution
- EPA acknowledges that dilution that is a necessary part of the treatment process, which otherwise destroys, removes, or immobilizes the hazardous constituents, is normally permissible

RCRA Perspective – TWPC part of WWTU

- Prior correspondence with TDEC confirms that the TWPC (Transuranic Waste Remediation Facility at that time) is part of the ORNL Liquid Low Level Waste System
  - RCRA Permit-by-Rule (PBR) Wastewater Treatment Unit Exclusion
  - DOE is exempt from RCRA Permitting
  - PBR notifications for changes or additions to the WWTU no longer required
  - The TWPC units are referenced in the ORNL NPDES permit application
  - As long as waste at the Point of Generation (POG) is non-hazardous, the UTS requirements are not applicable and the resulting LLW does not require disposal as mixed waste at NT
    - Note: NTS's permit for mixed waste disposal expires in 2010. Mixed LLW-GTCC generated after 2010 has no current disposition pathway (i.e. orphan waste)
    - Solidified sludge at POG must remain non-hazardous LLW

Grout Recipe

- Refine recipe from bench scale testing on actual MVST SL samples
- Dry blend similar to SRS Saltstone
  - 47% Fly Ash (Class F)
  - 47% Blast Furnace Slag (Grade 120)
  - 5% Portland Cement or MaG-Ox (MgO)
  - <1% fumed silica (powder flow agent)
- Stabilization additives (e.g., FeS for Hg)
- ORNL SN Monoliths used a blend of Portland cement, blast furnace slag, flyash, and fumed silica

Typical Grout Ingredients

Table 1: Slag Activity Index Requirements of ASTM C989

Chemical Constituents (as Oxides)	Type I Cement	Type C Fly Ash	Type F Fly Ash	GGBFS
SiO_2	21.1	33.5	43.4	40.0
Al_2O_3	4.6	22.9	18.5	13.5
CaO	65.1	27.4	4.3	39.2
MgO	4.5	4.6	0.9	3.6
Fe_2O_3	2.0	6.1	29.9	1.8
SO_3	2.8	2.8	1.2	0.2
L.O.I.	1.4	1.2	1.2	0.0

Benefits of Blast Furnace Slag

- Reduced setting rate/extended work time
- Lower heat of hydration
- Lower permeability and ionic diffusion rates
- Increased salt stability and metals stabilization
- Allows use of standard Type I or II Portland Cement, rather than Type IV
- Iron Sulfide (FeS) content stabilizes metals, especially mercury with low risk of overtreating (high excesses of soluble sulfides can form mercury polysulfides which are more soluble)

Benefits of Flyash

- Spherical particle shape and fine size
- Improves fluidity of grout
- Lower heat of hydration, reduces cure temperature
- Reacts with and consumes excess caustic
- Benefits to final monolith properties
  - Increased resistance to alkali-silica reactivity
  - Higher ultimate strength
  - Reduced permeability (lower leaching of metals)
  - Ion-selective material for Sr-90 Stabilization

CHARACTERISTICS

Size and Shape. Fly ash is typically finer than portland cement and lime. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100 micron (Figure 1-2). These small glass spheres improve the fluidity and workability of fresh concrete. Fineness is one of the important properties contributing to the pozzolanic reactivity of fly ash.

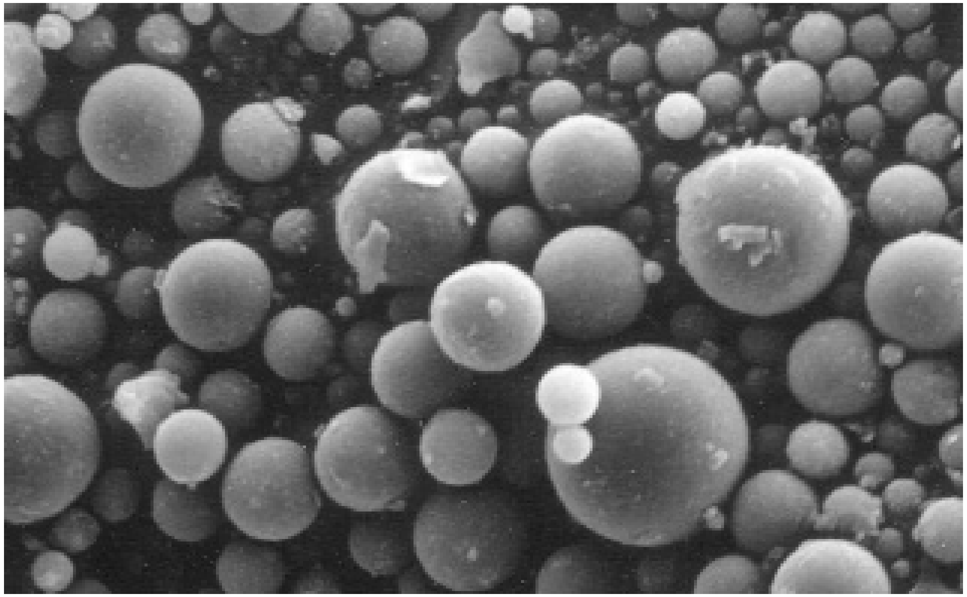


Figure 1-2. Fly ash particles at 2,000x magnification.

Bleed Water Control

- Bleed water (free water above grout) can occur during curing at high waste loadings
- Several options exist to control bleed water
  - Increasing dry blend to SL ratio (reduce waste loading)
  - Additives: bentonite clay, sodium silicates, polymers, methylcellulose, fumed silica
- Refine/adapt SRS “zero-bleed” grout recipes
- Multiple recipes with high dry blend to SL ratios will be developed to handle variations in SL composition and temperature to ensure no free liquid in the monolith
- Process can add anhydrous sodium metasilicate into the grout or as a monolith “cap” via Metso addition system
- Pre-load LLW liners with absorbent such as NoChar Acid Bond and Metso (Metso preload utilized during SN)

Process Control Approach

- Each "big batch/CIP tank" will be characterized for total alpha prior to solidification to ensure that the resulting monoliths will be LLW
- Confirmatory bench scale solidification testing for each big batch to confirm recipe will produce a monolith with no free liquid
- Mass ratio control via SL metering and dry blend charging weigh hopper
- Batch mixing provides high confidence level in batch composition control and LLW liner filling
- Visual observation (camera) of mixing and LLW filling to ensure grout consistency

SL Mobilization

Base Case is Pulse Fluidic Mobilization using AEAT, (now NuVision Engineering or NUVE)

SL Mobilization Alternatives

- Two Alternatives to NUVE Pulse Fluidic SL mobilization were evaluated
  - Mechanical mobilization using a remote manipulator sluicing wand
  - Chemical mobilization (in-tank dissolution of the SL using concentrated nitric acid)

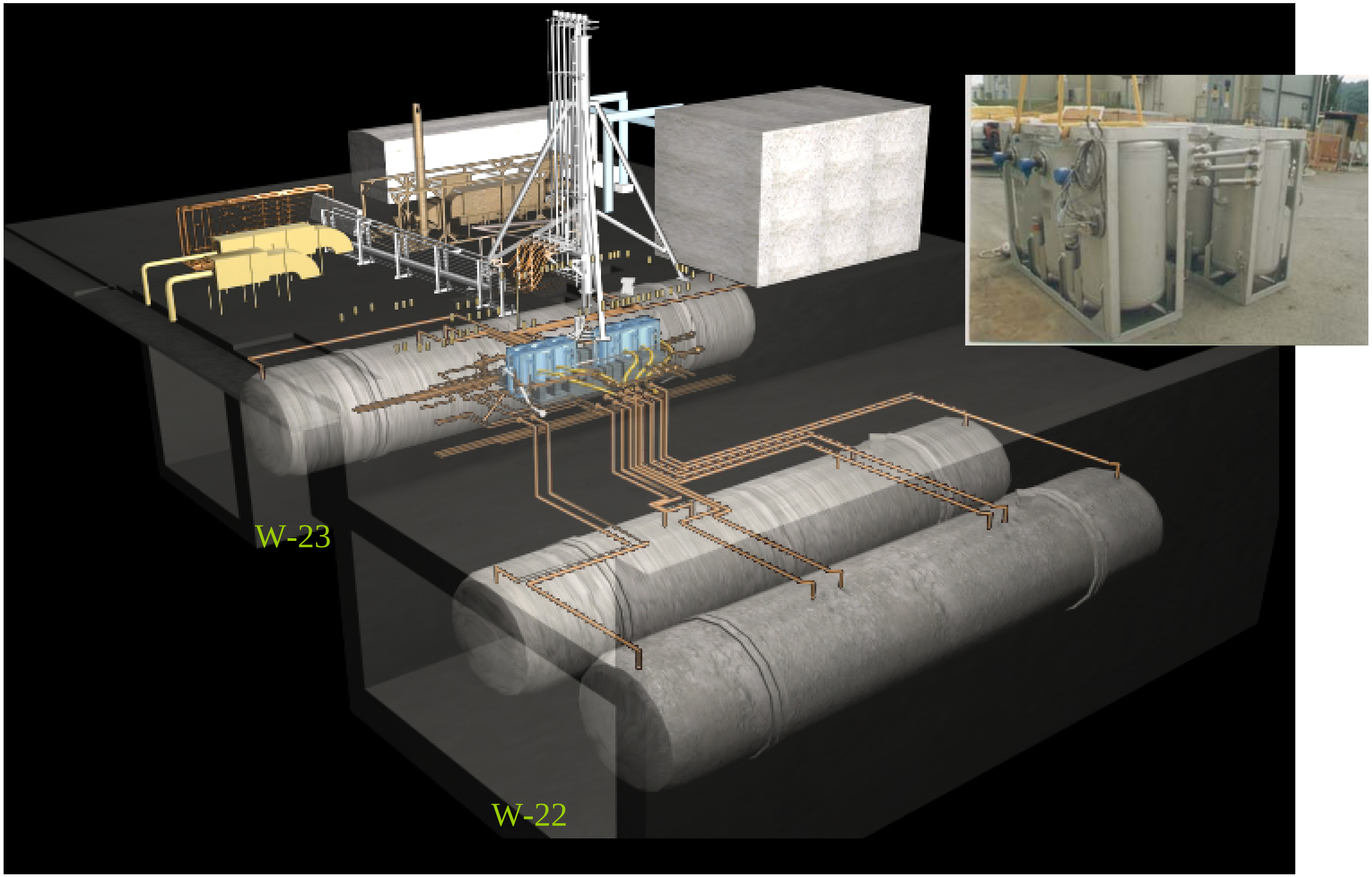
BVST Tanks Project ORNL

Tank W-23 Prior to Commencement of Pulse Jet Mixing Operations

Tank W-23 After Completion of Pulse Jet Mixing Operations & Waste Retrieval

NuVision Tank Mobilization Systems

BVEST
W-Tank
System



Mechanical Mobilization Alternative

- Mechanical mobilization using a remote manipulator sluicing wand
  - Lessons learned from ORNL Gunite Tanks cite maintainability/reliability issues (e.g., wrist)
  - Requires installation of manhole tank riser
  - Custom designed system, high upfront design $$
  - Would likely require two systems to allow feeding and blending of two MVSTs
  - Challenging tank geometry and tank centerline nozzle obstructions interfere with manipulator arm travel path
  - Unique/complex system requires specialized personnel to operate and maintain
- Evaluating more versatile/robust design from SA Robotics to mitigate traditional risks

Chemical Mobilization Alternative

- Alternative to mechanical mobilization
- Chemical mobilization (in-tank dissolution of the SL using concentrated nitric acid)
- Dissolved SL transferred to CIP tanks for blending, homogenization and sampling
- Solution neutralized prior to solidification with little or no increase in disposal volume vs. mechanical mobilization

Chemical Mobilization Advantages

- Eliminates the cost/time to design, build, operate and D&D the NUVE system, ~$5M savings
- Eliminates worker dose for installing and disconnecting ~56 hoses in high rad areas
- Accelerates earliest possible SL start date by 1 yr
- Produces a solution which is easier to blend and obtain representative samples. Minimizes analytical costs.
- Compatible with boric acid (possible criticality control)
- TWPC personnel already have experience using nitric acid for SN Decon

Chemical Mobilization Disadvantages

- Cost to design, build, operate and remove an acid system
- Chemical costs (nitric acid and caustic)
- Additional worker hazard related to handling strong acid
- Reduces MVST pump stator life, purchase of spare pump required, pump replacement may be required
- Will only remove soluble SL, insoluble content (silica, alumina, rust, grit…) will remain as a “heel” in the tanks
- Monitoring of offgas humidity, acid fume concentration needed to preserve function of ventilation system/HEPAs

Chemical Mobilization System

- Covered/bermed tanker unloading area
- Covered/bermed bulk acid storage tank
- Acid metering/injection system
- Sump pump/sump tank, acid resistant coating over the floor/berm walls
- Metal frame enclosure, unfiltered ventilation, unheated, non-sprinkled