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Radwaste and Primary Water Processing to Effectively Manage Tritium

Braidwood Tritium Recycle Team
December 2005

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Where Does Tritium Come From?

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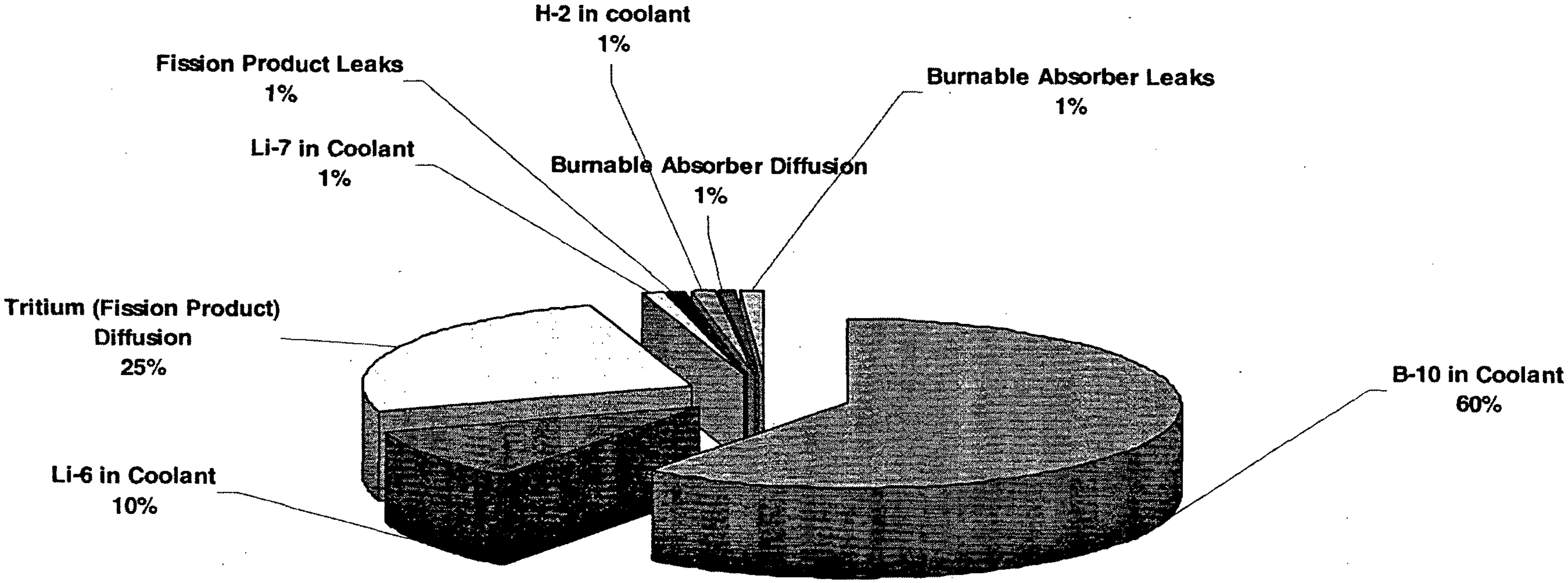
Estimated Sources of Tritium - PWR



Issues

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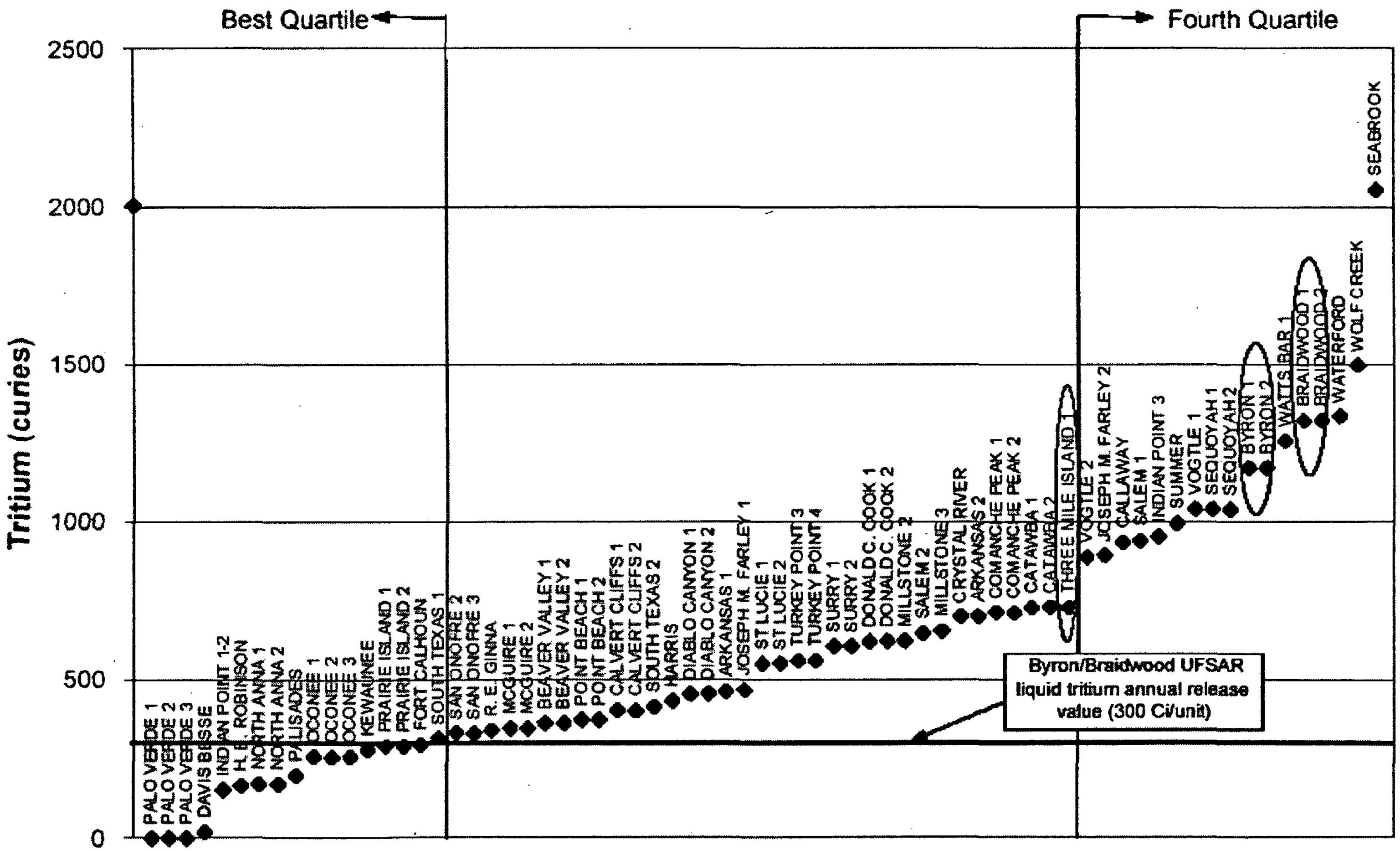
Braidwood is fourth quartile for liquid tritium released:

Liquid Effluent Tritium Released from US PWR Units - 2003



Note: 2003 is the last full year for which industry data is available.

Issues (cont)

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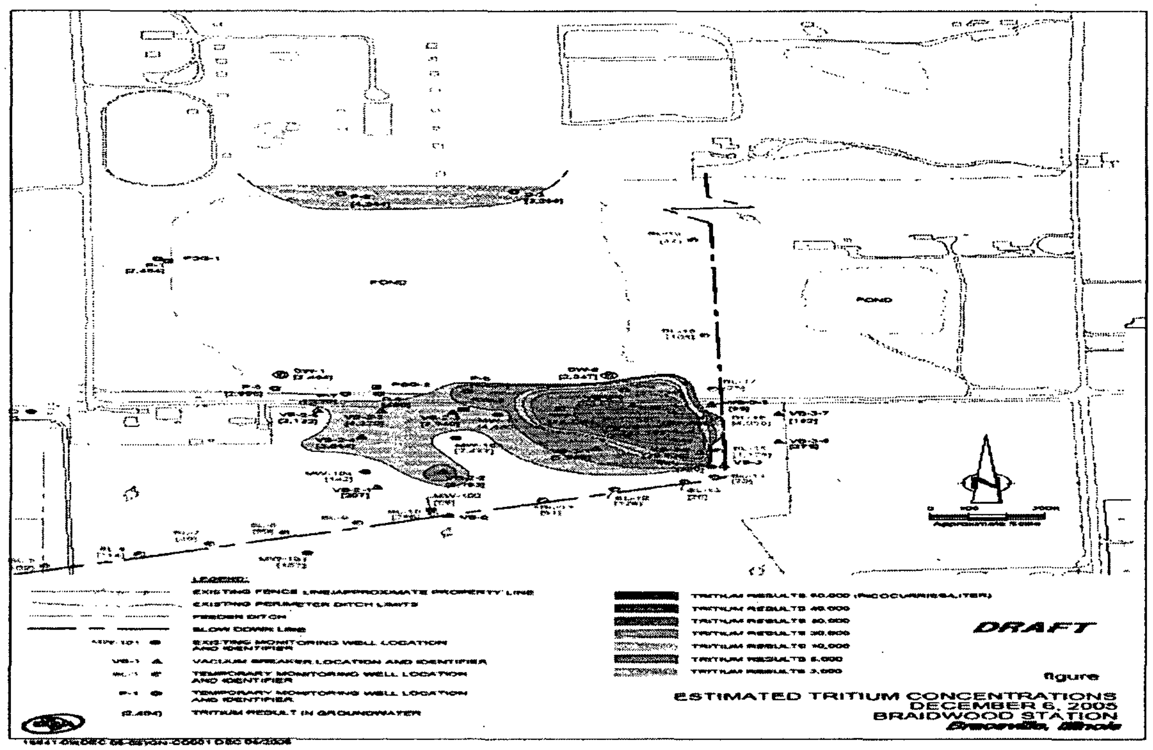
Braidwood Effluent is Affecting Groundwater and Residential Wells along the Blowdown Line:



Issues (cont)

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Elevated Tritium in the Groundwater

- Drilled over 100 sample wells and taken approximately 160 samples to characterize the extent of the elevated tritium levels.
- Contacted local residents potentially affected and sampled private ponds and drinking water wells. In addition to frequent individual contacts, the station has held one meeting with residents and is planning a second meeting.
- In the process of conducting a blowdown line integrity test and determining if additional testing is required.
- Notified regulatory agencies. The team is in the process of responding to a notice of violation received from the Illinois EPA. This response will contain an overall outline of the station's proposed corrective actions.
- In the process of completing a root cause investigation.

Short-Term Plan

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Criteria:

- Enable Braidwood to operate without liquid radwaste discharge.
- All equipment installed and operational before 4/1/06.
- Meet all requirements (e.g. chemistry limits, regulatory requirements) for safe, effective operation.
- Achieve goals for the lowest possible up-front and ongoing cost.

Actions – Braidwood Recycle Team

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Short Term (starting immediately through the next 1 – 3 years):

- Release tank liquid discharges were suspended at Braidwood Station
- Team develop methods to allow continued operation with zero liquid release from release tanks
- Water management
  - Reduce inputs to radwaste
  - Deborate using resin when RCS boron $\leq$ 200 ppm
  - Water management and effective use of installed demineralizers
  - Outage water management (e.g. loop fill source)

Long Term:

- Operate the plant as designed (recycle primary water)
  - Benchmarking revealed best-practice is to operate boric acid evaporators and reclaim primary water to the PWST
  - On-line and outage water management
  - Vigorously avoid introduction of non-contaminated water into plant drains

Braidwood Recycle Team

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- Jeff Odeen (Project Manager)
- Bob Claes (iSagacity, inc. - Braidwood Project Management)
- Dan Radice (Braidwood Engineering)
- Ray Rosczyk (Braidwood System Engineering)
- Molly Woodard (Braidwood System Engineering)
- Mike Gagnon (Braidwood RP)
- Larry Brooks (Braidwood Operations)
- Brian Bergmann (Braidwood Operations)
- Joe Williams (Sargent & Lundy)
- Dave Moschetti (Duratek Technician- Braidwood Radwaste)
- Tony Didgeon (Duratek)
- Darold Morris (Duratek)
- Miguel Azar (Cantera Radwaste)
- Dave Morey (Cantera Chemistry)
- Jeff Drowley (Cantera Engineering)

Temporary Storage – Frac Tank Locations

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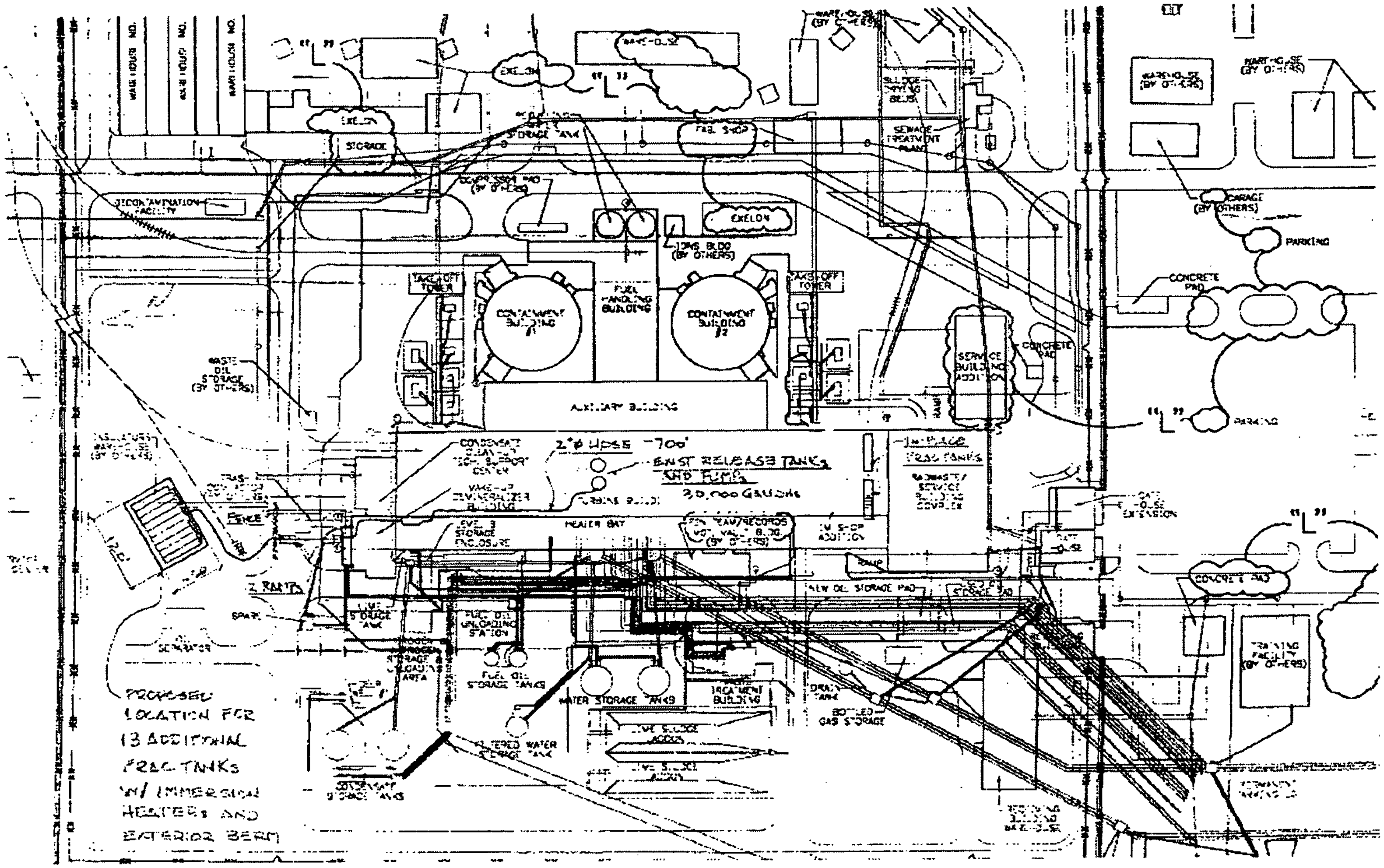

Significant Resin Management Implications

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- Pre-outage deboration with resin starting at ~ 250 ppm boron
- Spent resin tank manipulations and resin shipments
- Outage cleanup demineralizer strategy

Strategic Water Management – Issues and Objectives

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- Can we prepare HUT water pre-outage to use in combination with boration to make up for volume shrinkage?
- Adjust the timing of boration (where possible) and adjust boration rate to better coincide with cooldown so that boration is compensating for shrinkage as much as possible.
- Only borate RCS to approximately 1700 ppm (slightly above COLR limit) during shutdown. This will reduce the amount of dilutions required during startup.
- Raise the admin limit for BAST boron if possible. The limit is currently 7700 ppm boron.
- Manage pressurizer and/or VCT level to accommodate initial boration for the P11 limit.
- Re-use RCS drain water (loops, PZR, draining to flange) for RCS fill & vent. This water will require purification during the outage. The HUT recirculation rate through the AB condensate demineralizers is only 50 gpm. The RCS drain path is to the RCDT, then AB condensate demin, into the HUT. Don't use blended flow to fill the loops.
- Evaluation to add peroxide after RCPs are off and LSIVs are closed?
- Pre-outage activities related to resin management will increase significantly to accommodate deboration from 250 ppm using resin.
- Eliminate the practice of using 2 demineralizers in parallel during RCS cleanup to reduce resin transfer water and accommodate de-boration with resin.
- Fill the transfer canal with HUT water pre-outage and leave the transfer canal filled post-outage.

VA Chiller Drain Modification

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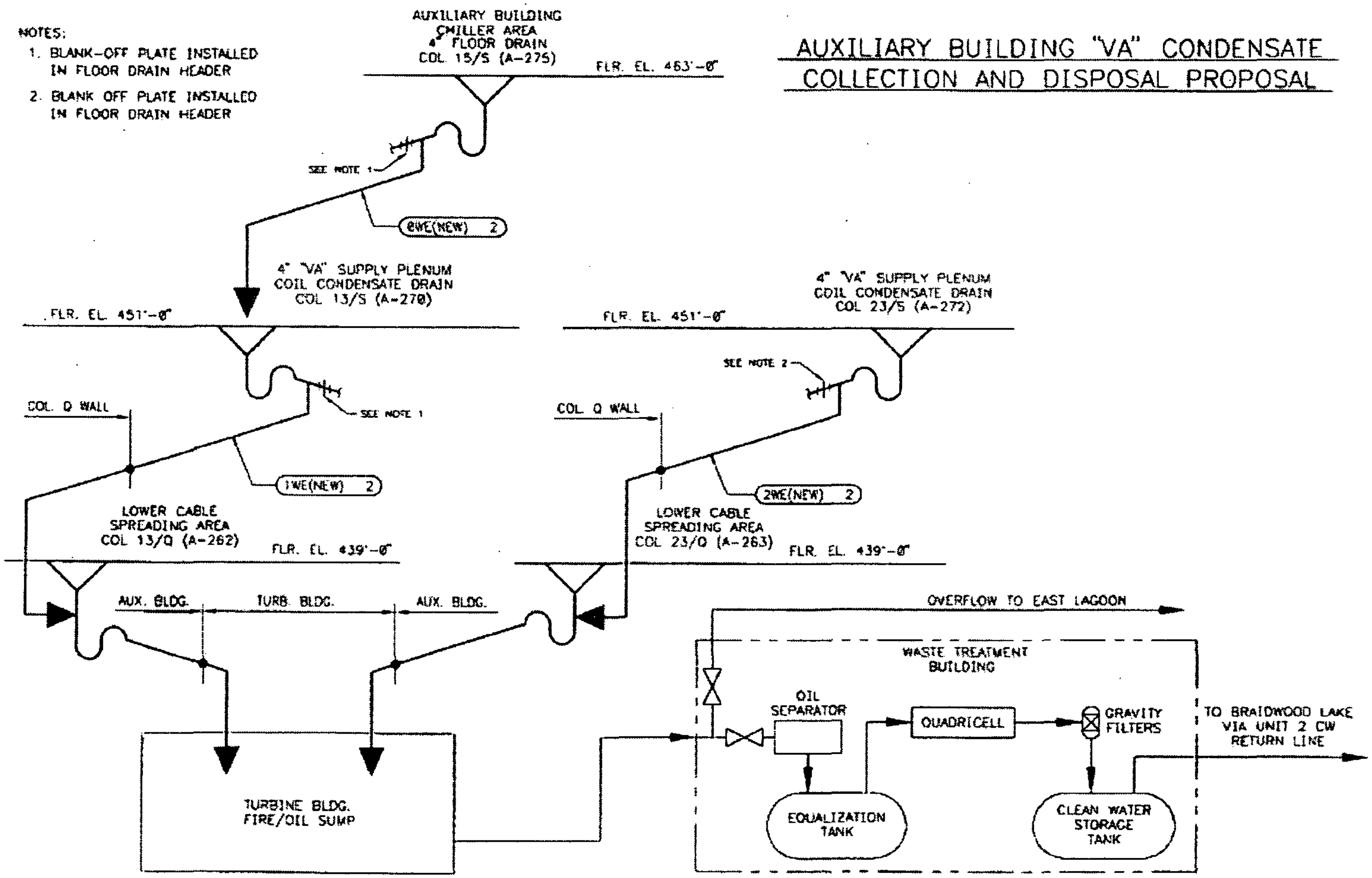

Non-Contaminated Drain Modification

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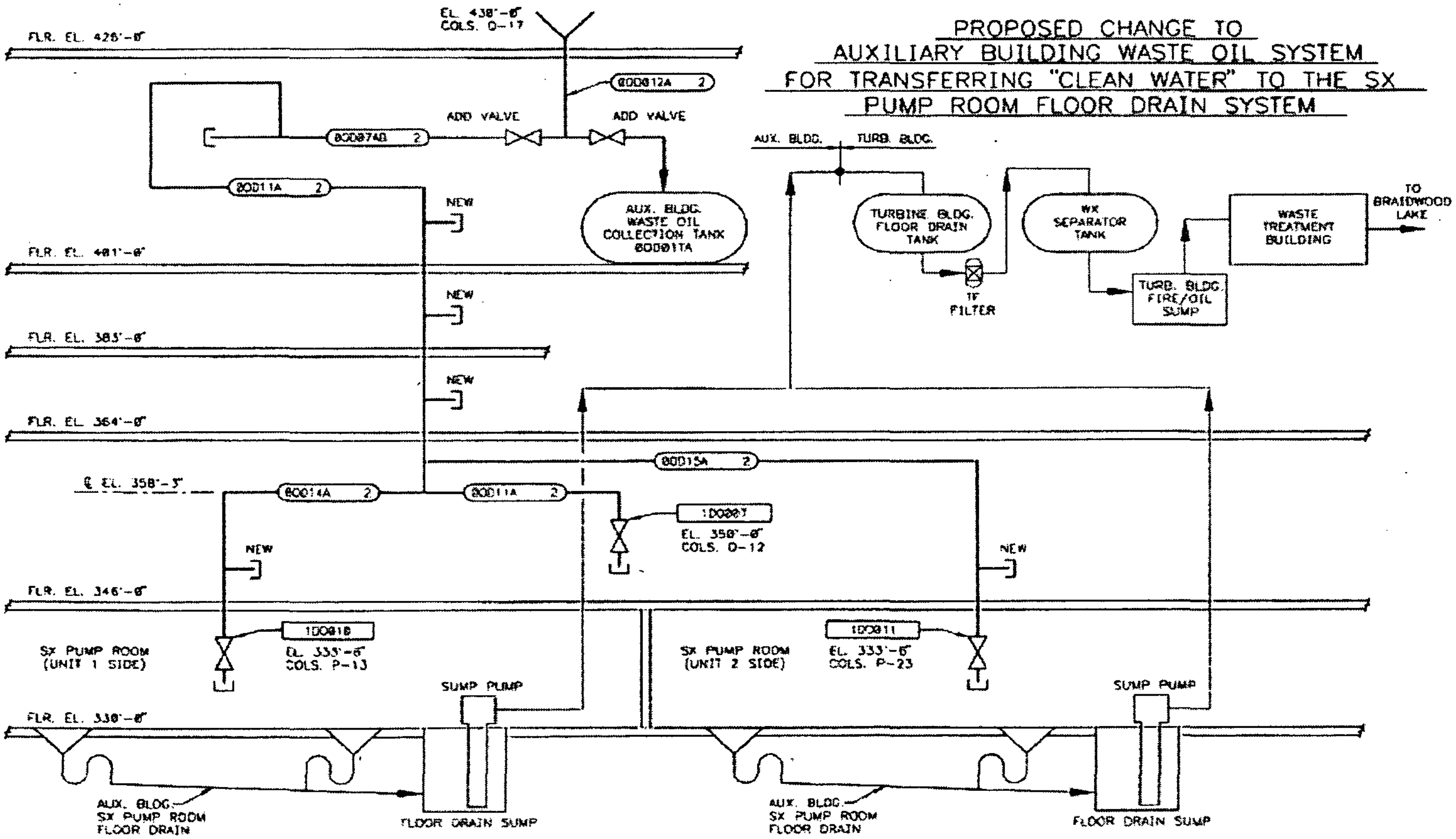

Recommended Radwaste Processing and Recycle Solution

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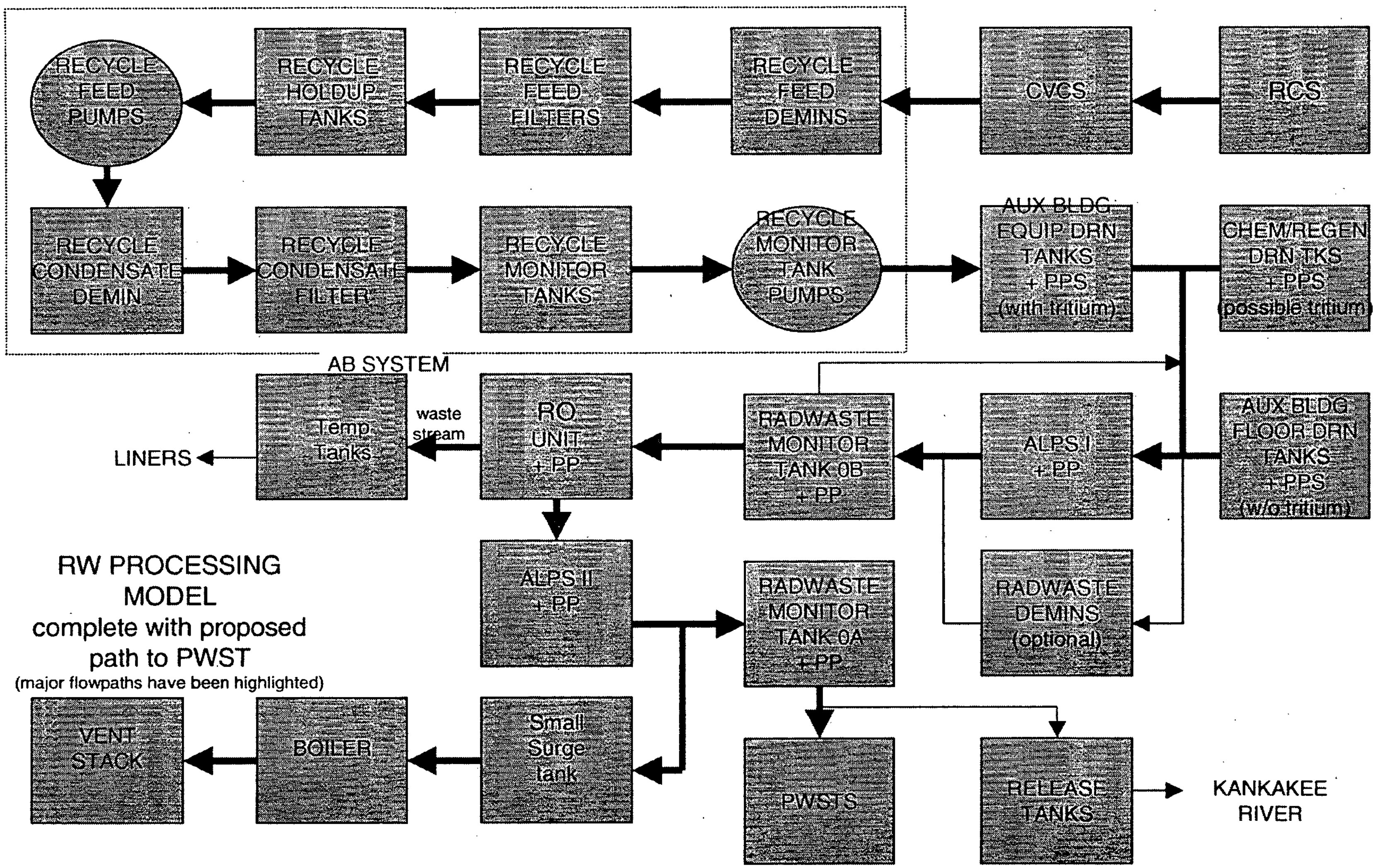
Process inputs to liquid radwaste from floor drains, equipment drains, reactor coolant letdown, and outage water movement using the existing treatment system and additional equipment as follows:

- ALPS I (existing system) – filters and demineralizers to remove $\geq$ ~ 99 % of all radionuclides from waste stream (except tritium)
- Reverse Osmosis – to separate contaminants such as silica, boron, hardness, alkalinity into a concentrated waste stream (much more efficiently than removal using ion-exchange). The waste stream would be stored for further processing, opportunistic disposal (with other waste), or shipped for vendor processing
- ALPS 2 – demineralizers to remove impurities remaining after reverse osmosis, and purify the water to reactor coolant makeup specifications. This water will then be recycled to the Primary Water Storage Tank, discharged via liquid effluent pathway, or further processed for release via gaseous pathway using a boiler (see below)
- Boiler (optional) – convert liquid stream to steam so that water (and tritium) can be released via a gaseous release pathway within UFSAR limitations

Radwaste Processing and Recycle Model



Radwaste Processing and Recycle System

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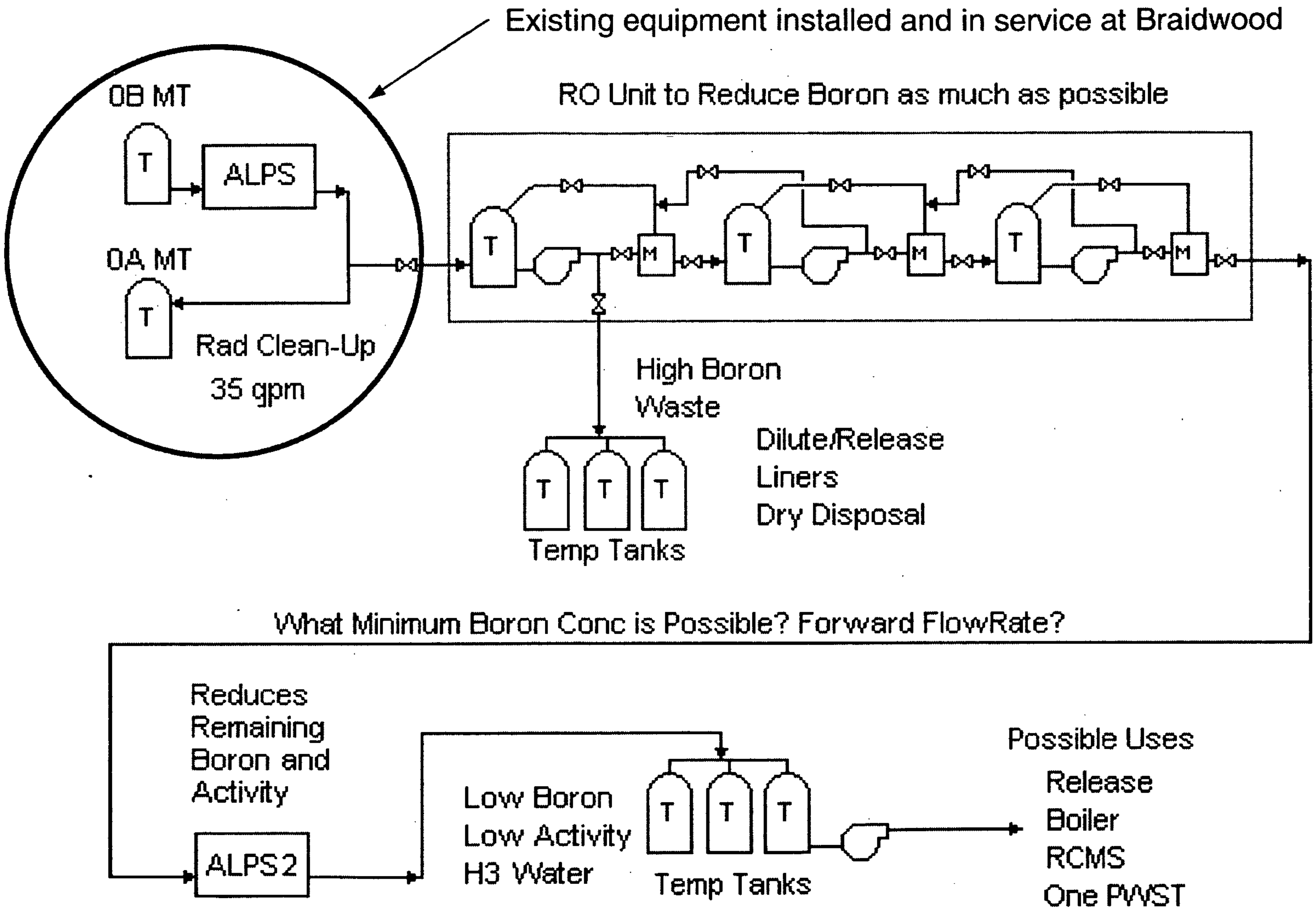
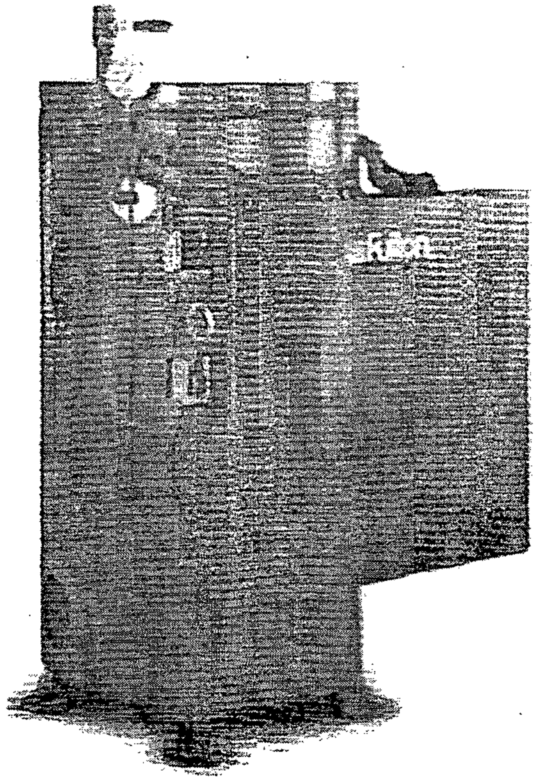


ALPS = Advanced Liquid Processing System

Radwaste Processing and Recycle System - Boiler



Cost Analysis for Recommended Radwaste Processing and Recycle Solution

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2005 Costs:

- Planning and logistics
- Design and drawings
- Engineering and Pre-Operational Testing
- Equipment configuration
- Equipment leases
    - Tanks
    - Reverse Osmosis
    - ALPS II
    - Boiler
- 3 Spare Pumps and 2 Sets of Sea Water RO Membranes
- Procedures
- Mobilization
- Transportation
- Setup, installation, shielding and hose package

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Total Capital Purchase (b)(4)

Total Capital Lease: (b)(4)

Total 2005 Cost (b)(4)

Cost Analysis for Recommended Radwaste Processing and Recycle Solution

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2006 Costs:

- Instruments, Data Acquisition and Controls [redacted] (b)(4)
- Project Manager (initial six months) [redacted] (b)(4)
- Media (purchase of resin and filter media) [redacted] (b)(4)
- Equipment Leases (RO/IX/fill head/Boiler Rental) [redacted] (b)(4)
- Install On-site SS Storage Tanks (One (1) [redacted] (b)(4)
- Total Disposal Cost (Liner, purchase, transport) [redacted] (b)(4)
- Vendor Technicians (3 Additional Techs, 24/7) [redacted] (b)(4)

Ex 4

Total O&M: [redacted] (b)(4)
Total Capital Lease: [redacted] (b)(4)
Total Capital Equipment: [redacted] (b)(4)

Total 2006 Cost: [redacted] (b)(4)

* Living expense included.
** Tank cost $2/gal does not include piping to/from tank, permitting, tank heater, pump and berm. 12-16 weeks installed after permitting and engineering approval by Exelon. **Storage tanks eventually fill up, requiring additional storage capacity or processing.** The waste stream would be stored for further processing, opportunistic disposal (with other waste such as Blowdown resin), or shipped for vendor processing **$3.1M or** installed boric acid dryers to process concentrates on-site for disposal **12- 16 months estimated cost $1.3 - $1.7 Million (does not include waste liners, transportation and disposal cost).**

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Cost Analysis for Recommended Radwaste Processing and Recycle Solution

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2007 Costs:

- Media (purchase of resin and filter media) [redacted] (b)(4)
- Equipment Leases (RO/IX/fill head/Boiler Renta[redacted]
- Total Disposal Cost (Liner, purchase, transport) [redacted]
- Vendor Technicians (3 Additional Techs, 24/7) [redacted]

Total O&M: [redacted] (b)(4)
Total Capital Lease: [redacted] (b)(4)
Total Capital Equipment: [redacted] (b)(4)

Total 2007 Cost: [redacted] (b)(4)

- * Living expense included.
- 250,000 gallons storage tanks is nearing capacity (205,000 gallons of boric acid concentrates), requiring additional storage capacity or processing. The waste stream can continued to be stored for further processing, opportunistic disposal (with other waste such as (Blowdown resin), or shipped for vendor processing $3.1M for2007 based on current Duratek contract 143 rates.

exemption 4