In-Riser Ion Exchange: RF or CST?

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SAVANNAH RIVER NATIONAL LABORATORY

We Put Science To Work

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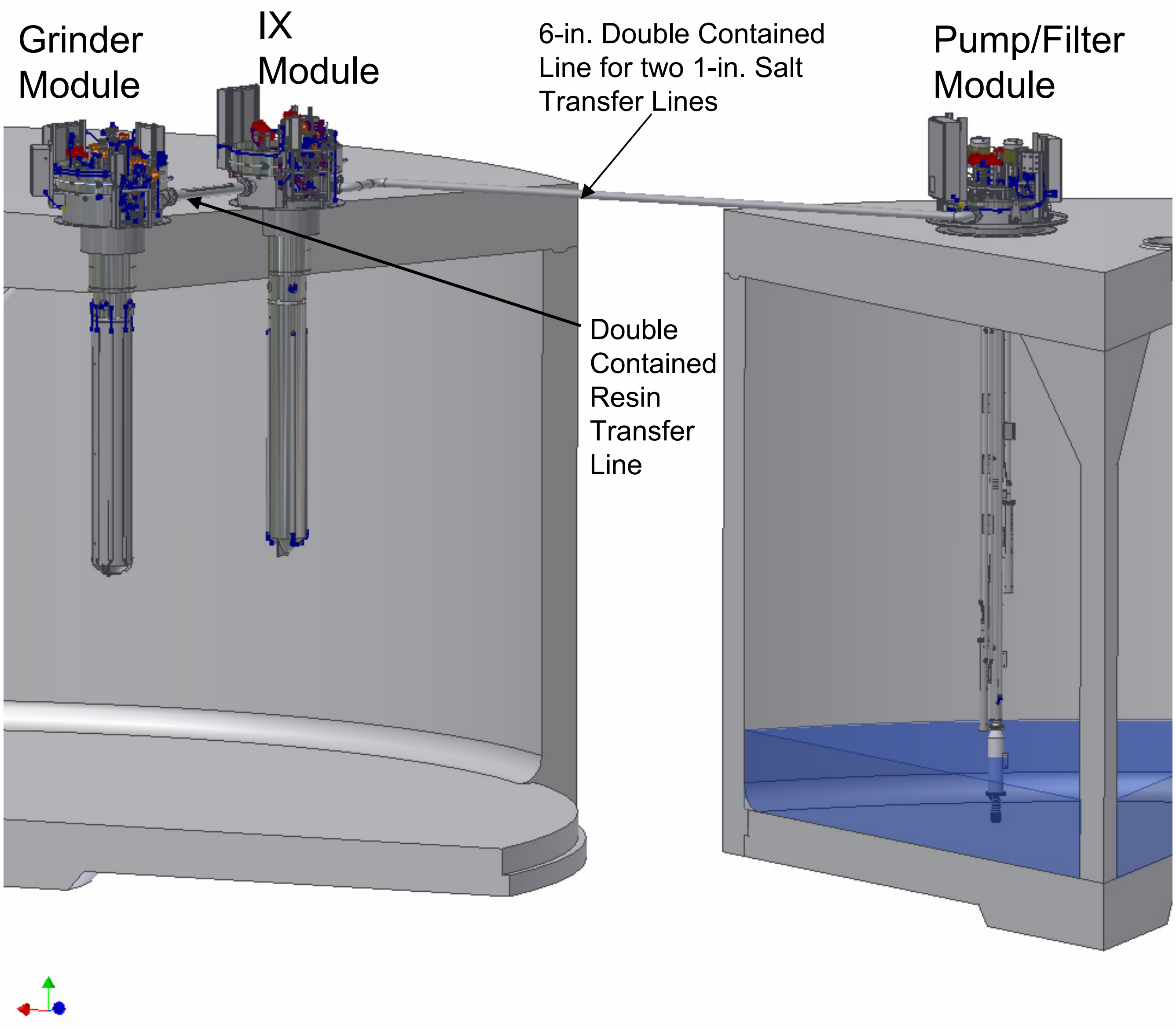
WSRC-STI-2007-00540

Original SCIX Objective

- Small Column Ion Exchange
  - Purpose
    - Develop an in-tank system to decontaminate HLW salt solution prior to disposal in Saltstone
      - Filter to remove entrained sludge
      - Ion Exchange to remove Cs-137
        - » CST (Crystalline Silicotitanate; Ionsiv® IE-911)
          - Grinder for size reduction
  - Dispose Cs-137 in DWPF glass
  - Concept similar to Cesium Removal Columns in use for years at SRS
  - Task led by ORNL, funded by DOE EM-21

Original Completed concept for SCIX installation in SRS HLW Tank Risers



SCIX Status

- **Completed for original single CST column concept:**
  - Performance modeling
  - Implementation evaluation
  - Consolidated Hazard Analysis
  - 100% Design for all modules
    - 28-inch diameter column, 13 ft bed depth
    - Water-cooled (6-inch diameter central; 4 exterior tubes)
    - Fit in 36-inch diameter riser (48-inch upper section)

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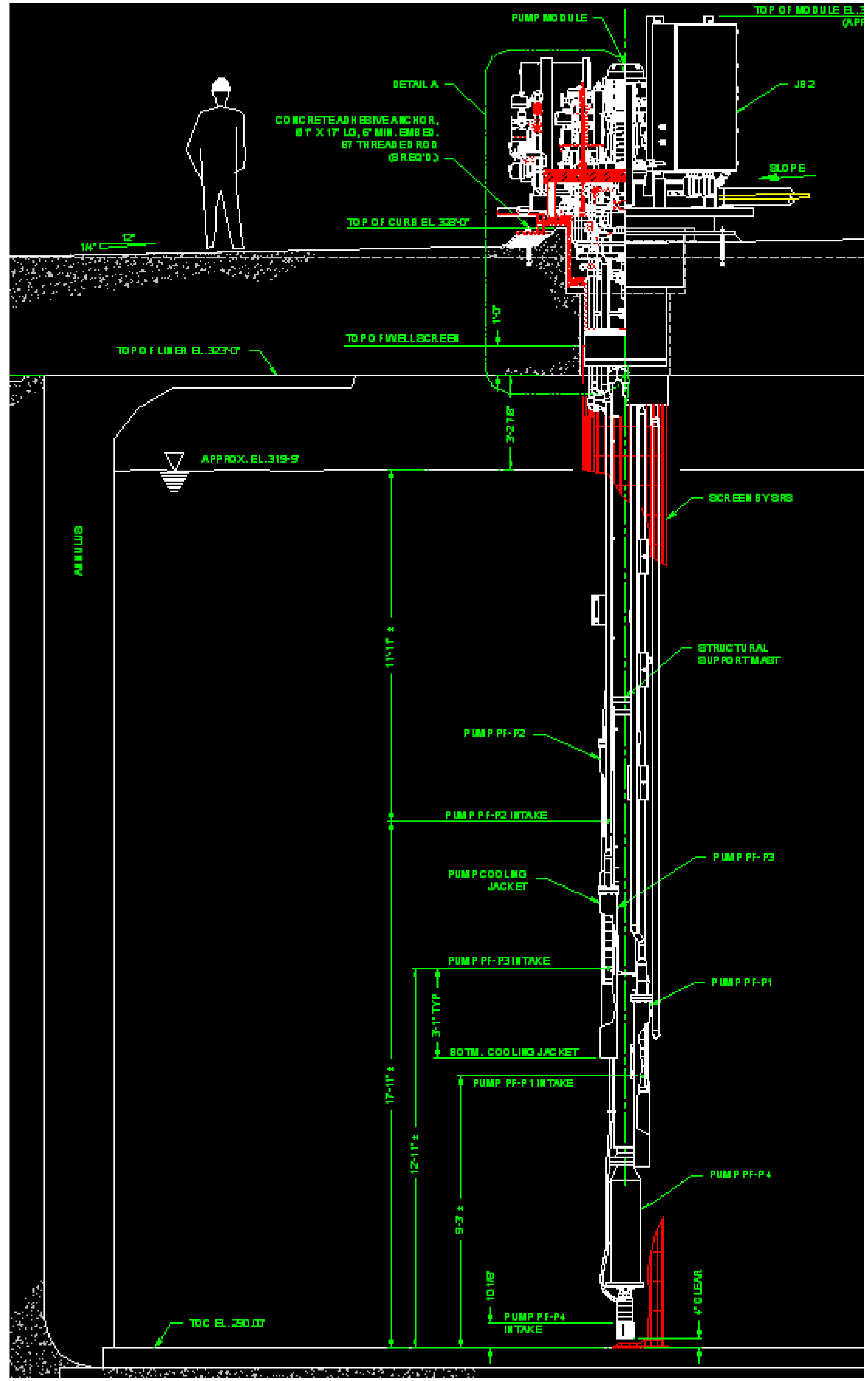
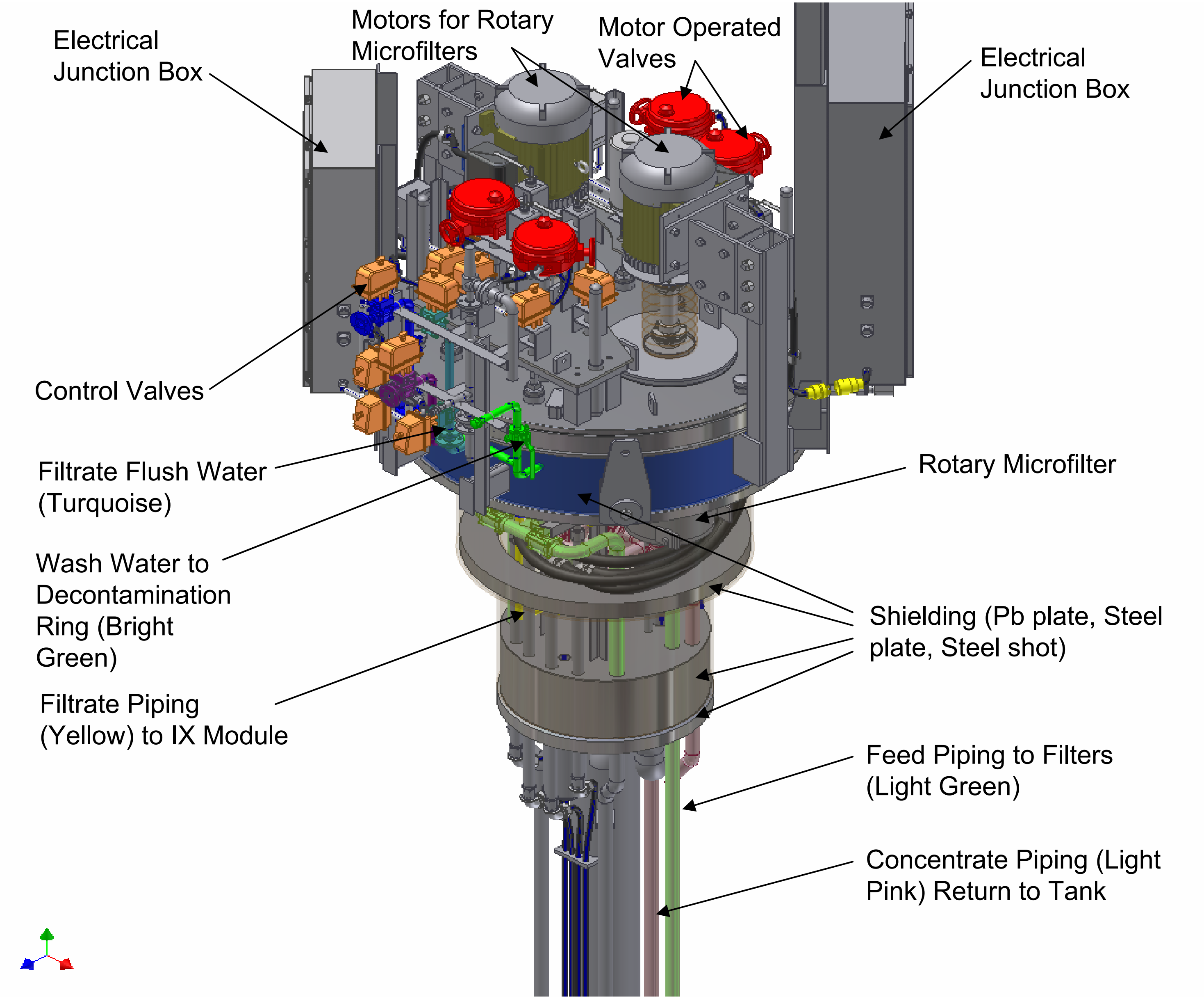
Original Design: Pump/Filter Module in HLW Tank Riser of Tank TK-41

- Sets inside 4-ft diam. riser with 3-ft diam. pass-through
- 4 pumps positioned at different elevations
- Extends ~32.7 ft below inside of tank top
  - Bottom pump intake through screen ~10- to 4-in. from tank floor

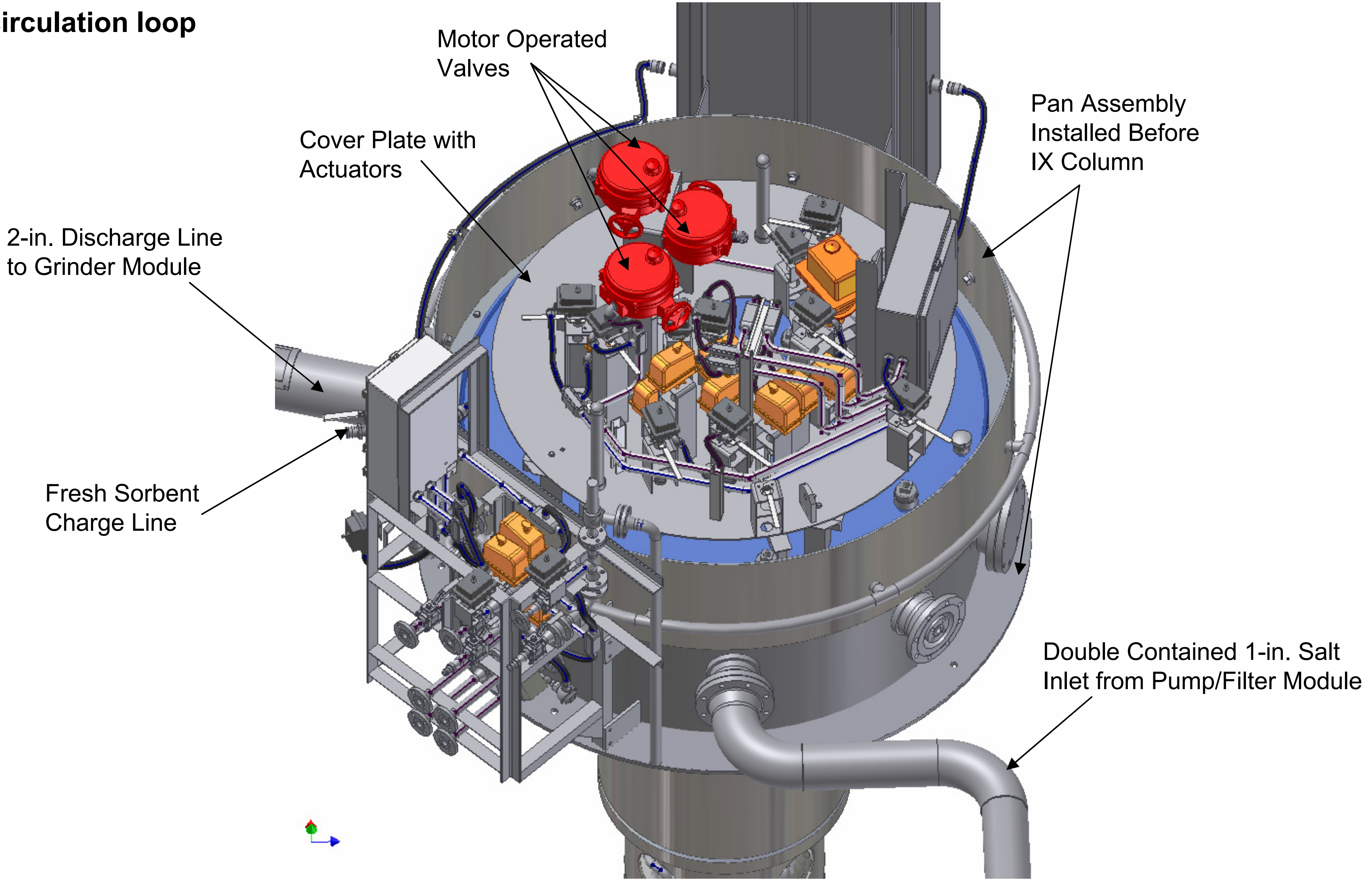


Pump/Filter Module



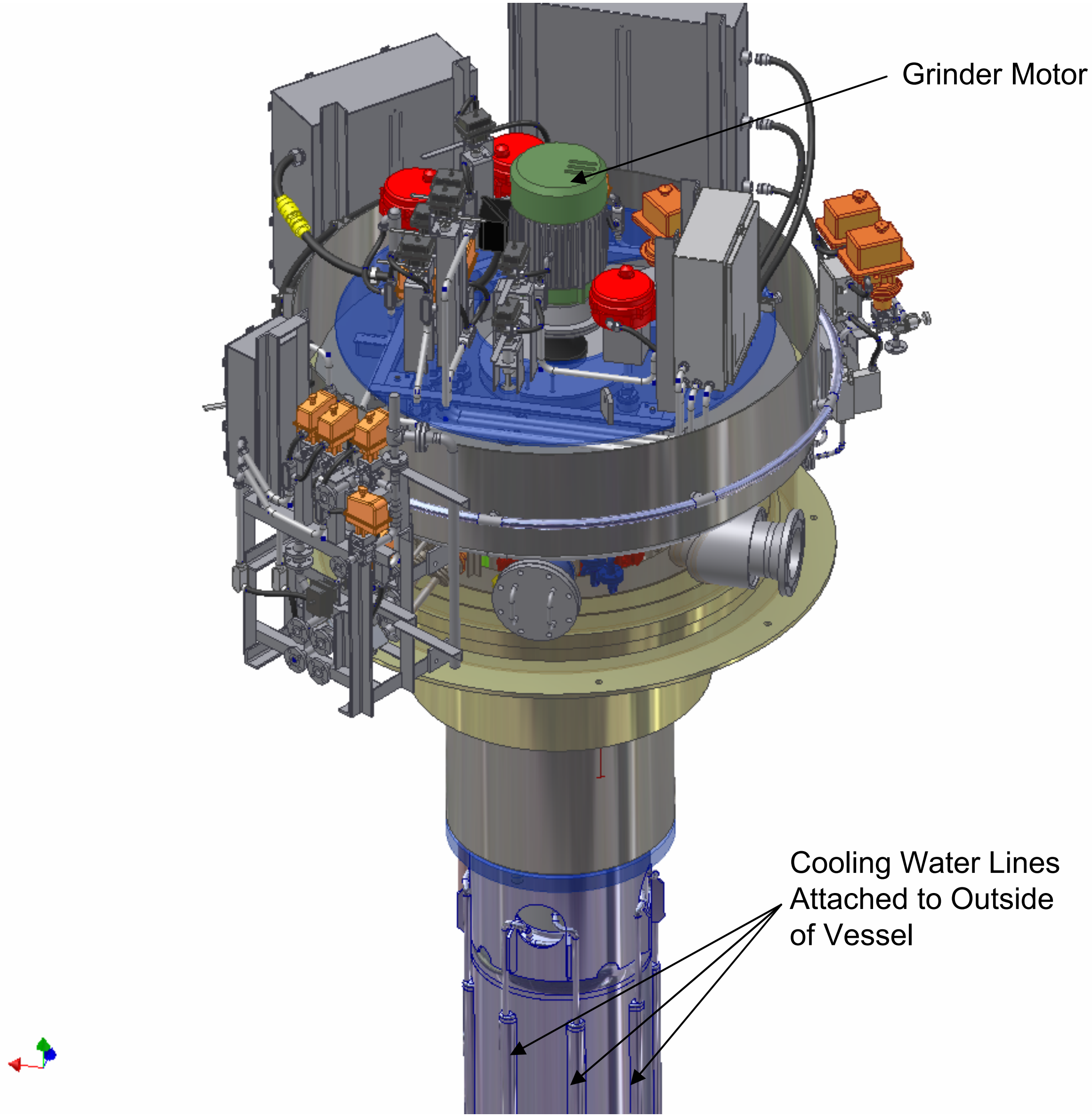
Ion Exchange Module

Column is cooled with interior and exterior water recirculation loop



Grinder Module

- **Tested with CST and Zeolite**
  - **Met DWPF sampler particle size/WAC requirements**
- **Sluice portion of IX Column per batch**
- **Ground sorbent is pressure transferred from Grinder to tank**
- **Sand pump circulates 30-50 wt% slurry to grinder inlet**
- **Extends ~17.5 ft below inside of tank top**



Modified SCIX Task

- Select media and configuration to meet new objectives
  - Modify design to accommodate higher Decontamination Factor requirement and alternate design parameters
  - Examine use of 3-4 Rotary Micro-Filters
- Determine design changes needed for spherical RF (sRF)
  - Elutable resin, no grinder

>> Differences in design are needed to select ion exchange media (i.e., sRF vs. CST)

Modified SCIX Objective

- Small Column Ion Exchange
  - Purpose
    - Develop an in-tank system to decontaminate HLW salt solution prior to disposal in Saltstone
      - Add and mix Mono Sodium Titanate to remove Sr/TRU
      - Rotary Microfilter to prefilter liquid
      - Ion Exchange to remove Cs-137
        - » CST (Crystalline Silicotitanate; Ionsiv® IE-911)
          - Grinder for size reduction
        - » Spherical Resorcinol-Formaldehyde (sRF) resin
  - Dispose Cs-137 in DWPF glass
  - Concept similar to Cesium Removal Columns in use for years at SRS
  - Task led by ORNL, funded by DOE EM-21

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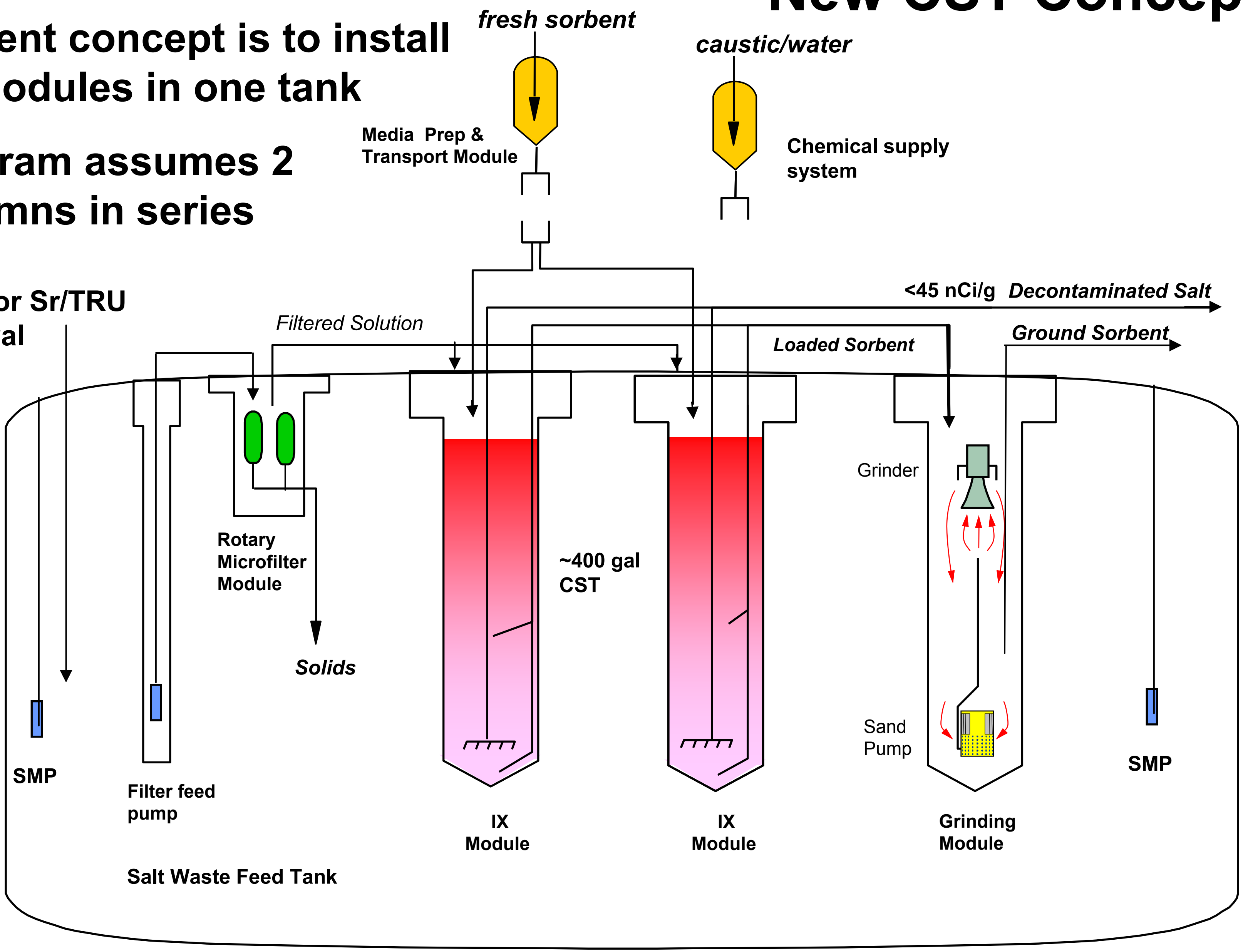
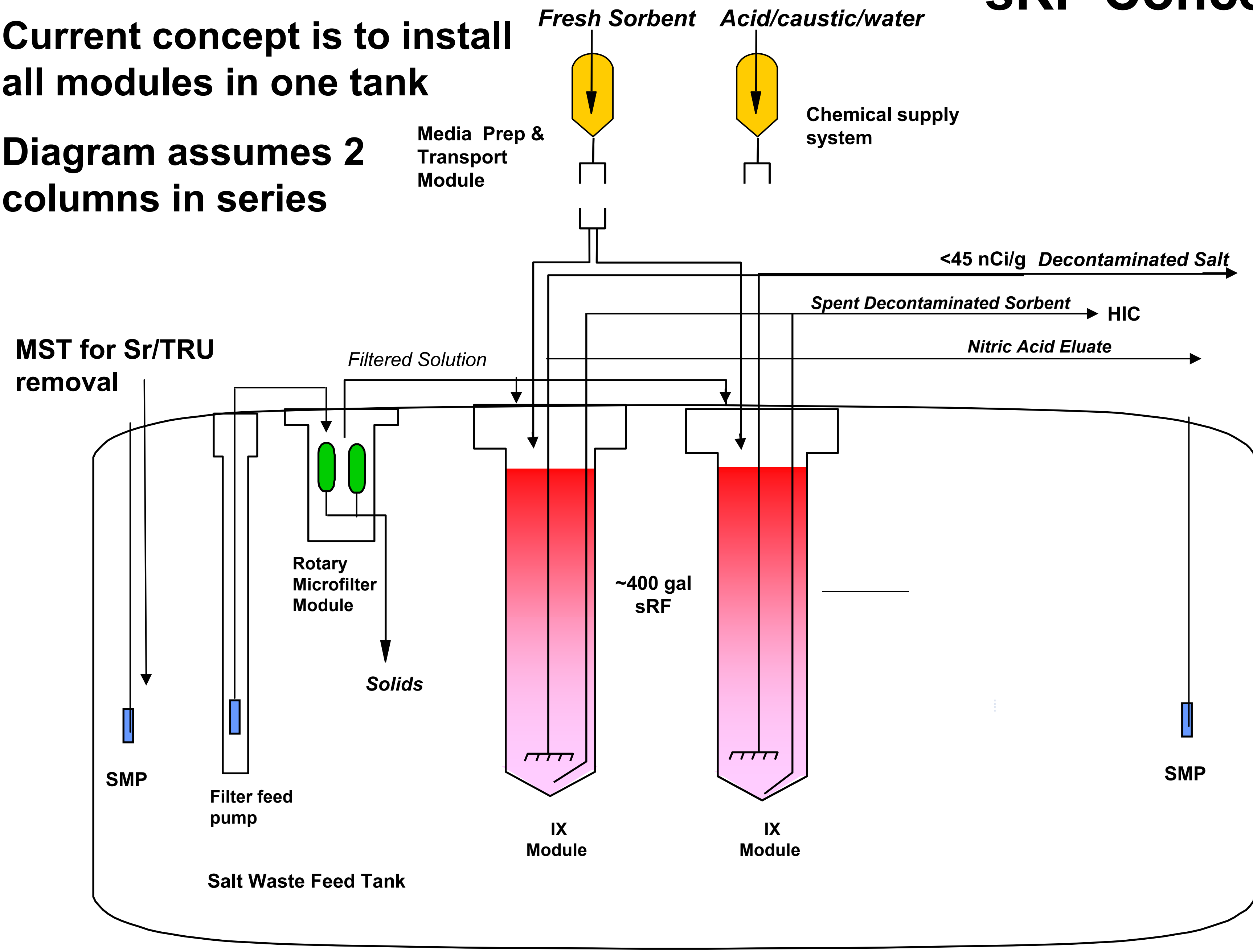
New CST Concept

- Current concept is to install all modules in one tank
- Diagram assumes 2 columns in series



sRF Concept

- **Current concept is to install all modules in one tank**
- **Diagram assumes 2 columns in series**



SCIX Media/Design Selection Steps

- **Objective:**
  - Determine optimum media and configuration for SRS application of in-tank ion exchange
- **System Engineering Evaluation process**
  - Develop selection criteria
  - Examine options for design and media
  - Determine impacts
  - Select preferred media and configuration

SCIX Media Comparison

	CST	sRF
Elutable?	no	yes
Grinder needed?	yes	no
Kinetics	moderate	fast
Radiation tolerance	high	moderate
Source term	high	moderate
Glass constituent of concern	Ti	Na
Evaporator burden	low	high
Tested w/ SRS waste?	yes	no
Secondary rad waste stream?	no	yes
Shrink/swell during cycles	no	yes

>>> numerous other parameters make selection very complex

SCIX Media/Design Selection Steps

- Performance modeling
  - Estimate composition of influent waste streams
  - Utilize equilibrium and dynamic models to predict performance for both media
  - Optimize column parameters
    - Length
    - Flow rate
    - Configuration (e.g. lead-lag)
    - Cs-137 loading (thermal load)
    - CST use
    - sRF eluate volume
    - sRF Rad dose

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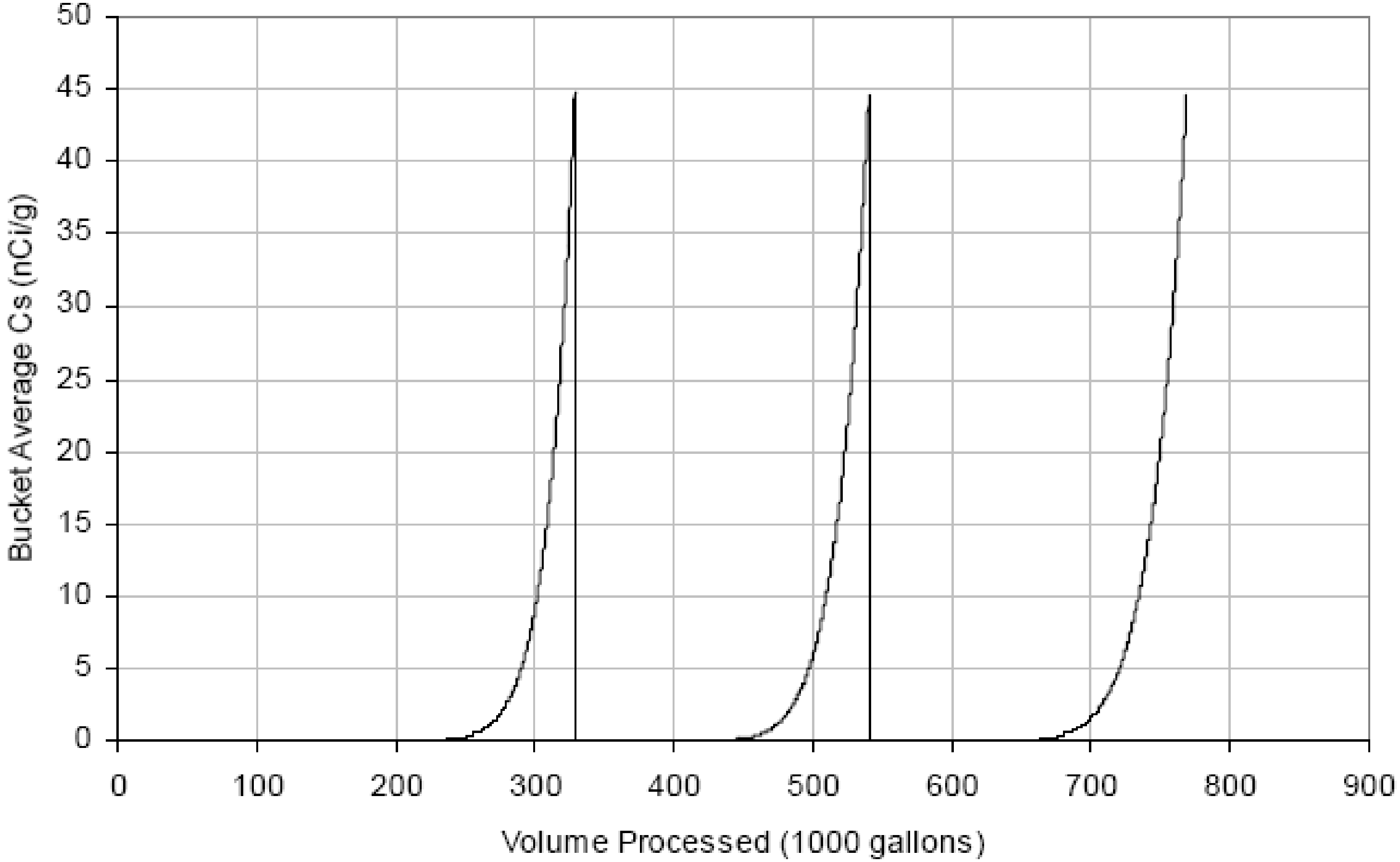
Example Performance Modeling Result



Cs-137 breakthrough profile for nominal case with CST (10 gpm, 15 ft bed depth, lead-lag configuration)

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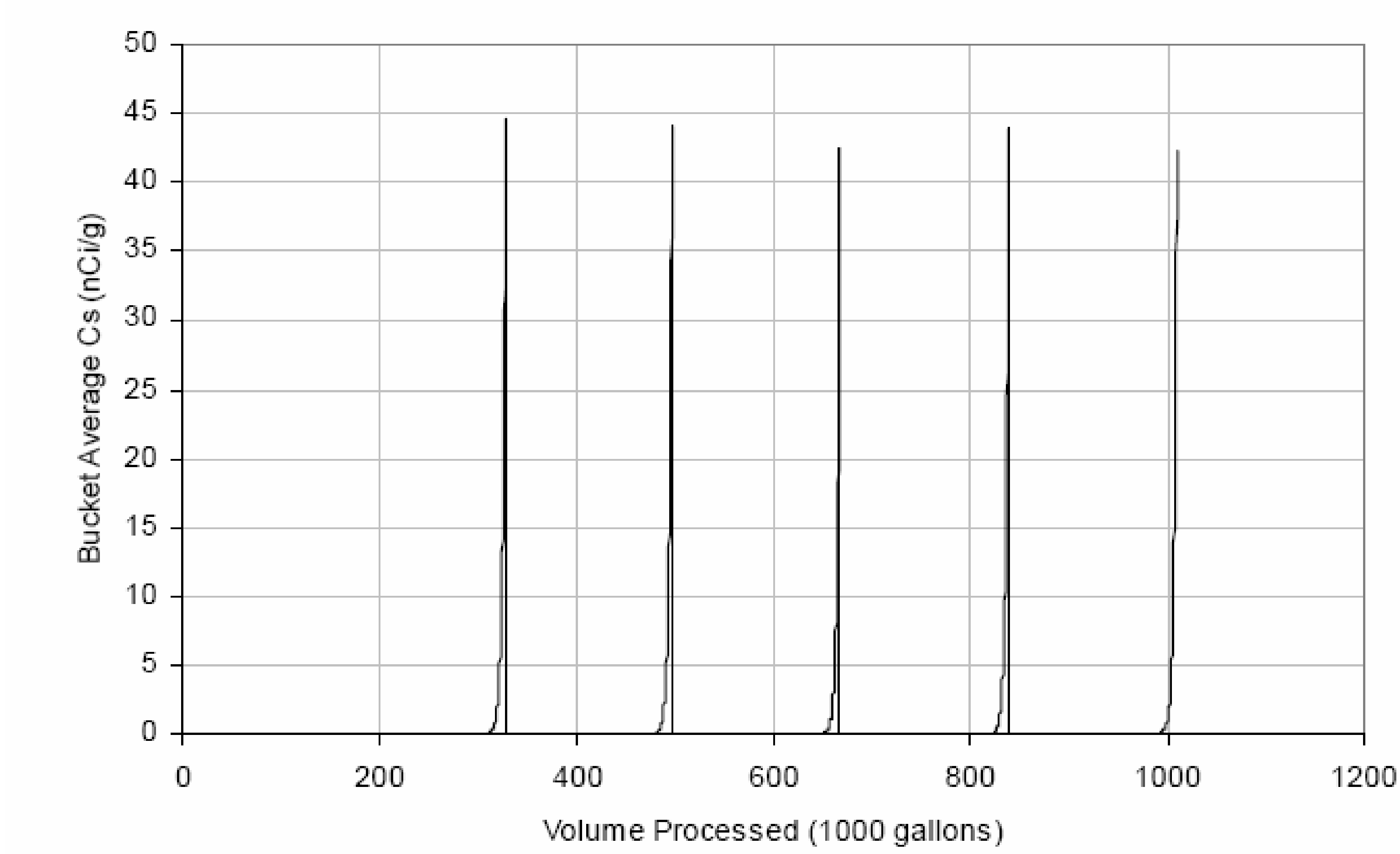
Example Performance Modeling Result



Cs-137 breakthrough profile for nominal case with sRF (10 gpm, 15 ft bed depth, lead-lag configuration, F-L isotherm)

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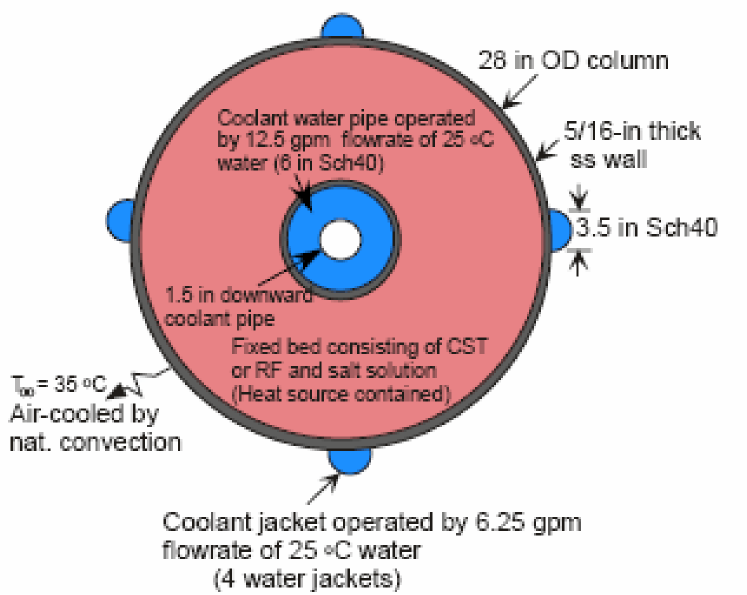
SCIX Media/Design Selection Steps

- Thermal modeling
  - Utilize heat transfer codes to determine need for cooling
    - Maintain <30 °C to optimize loading
    - Avoid exceeding temperature limits for media during loss of cooling event
    - Determine needed configuration and flowrate



SCIX Media/Design Selection Steps

- **Bed hydraulic testing for sRF**
  - Determine fluid flow characteristics
    - dP vs. Length/Diameter
    - Regeneration behavior (shrink/swell)

- **Develop flowsheets**
  - MonoSodium Titanate
  - Spherical Resorcinol-Formaldehyde
  - Crystalline SilicoTitanate

SCIX Media/Design Selection Steps

- Downstream impacts
  - Sludge washing
    - Ground CST impact
  - DWPF
    - Process throughput
      - sRF eluate impact on evaporator
      - Rheology & water retention
    - Process chemistry
      - sRF eluate nitrate redox
      - Hydrogen generation in SRAT/SME
    - Glass chemistry
      - Sodium from sRF eluate neutralization
      - CST components

SCIX Media Selection Steps

- Preliminary Consolidated Hazard Analysis
  - Determine Safety Significant and Safety Class controls
- Operational Complexity
  - Determine frequency and sequencing of equipment
- Technical Maturity
  - Gap analysis
- Costs
  - Design, construct, installation
  - Operational

SCIX Path Forward

- Completed
  - Performance Modeling
  - Thermal modeling
  - Hydraulic testing
  - Flowsheets

- Underway
  - Downstream impacts
  - Operational complexity
  - Hazard Assessment
  - Gap analysis

- Path Forward
  - Complete SEE
    - Provide recommended media and configuration