Three Mile Island Unit 2 Overview and Management Issues

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Subjects

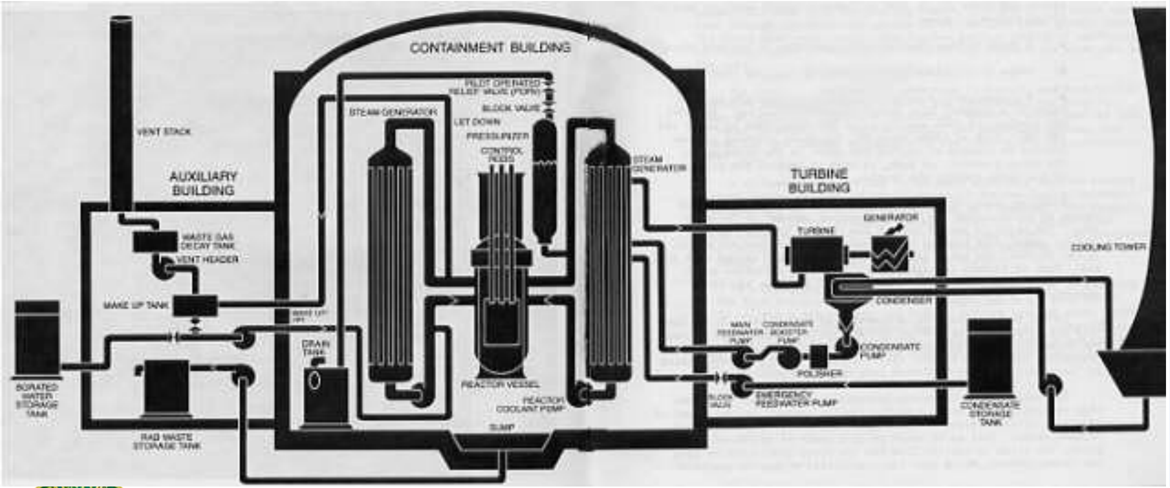
–TMI-2 Cleanup Description

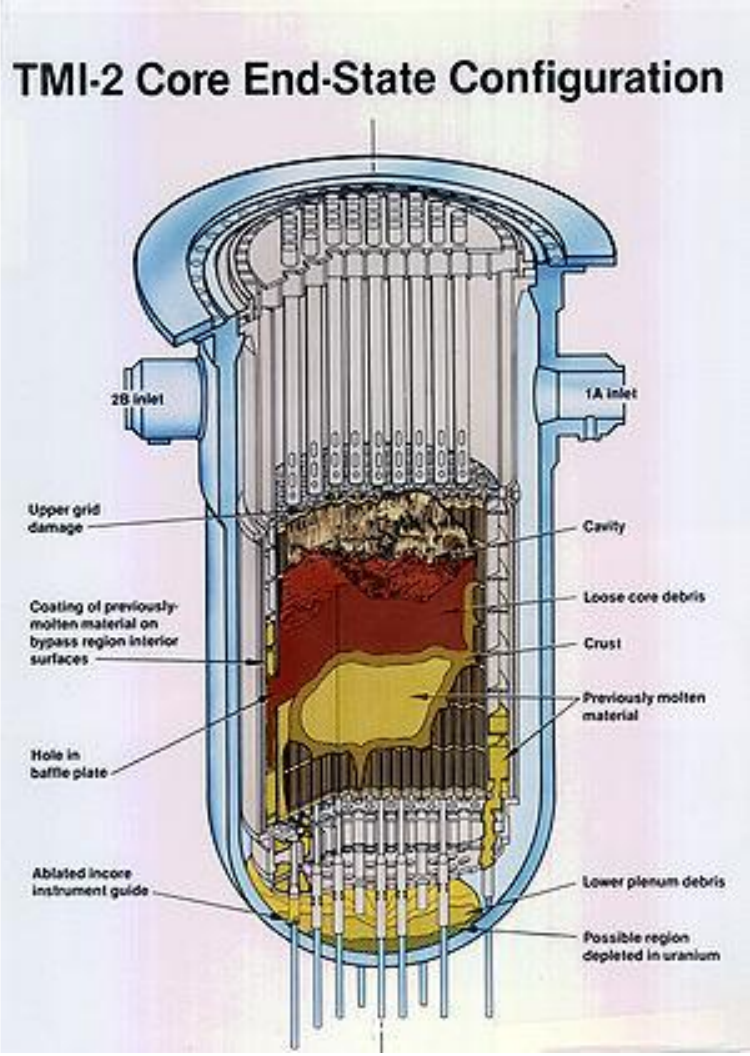
–Emphasis on fuel removal and water processing

–Comparison with Fukushima Daiichi

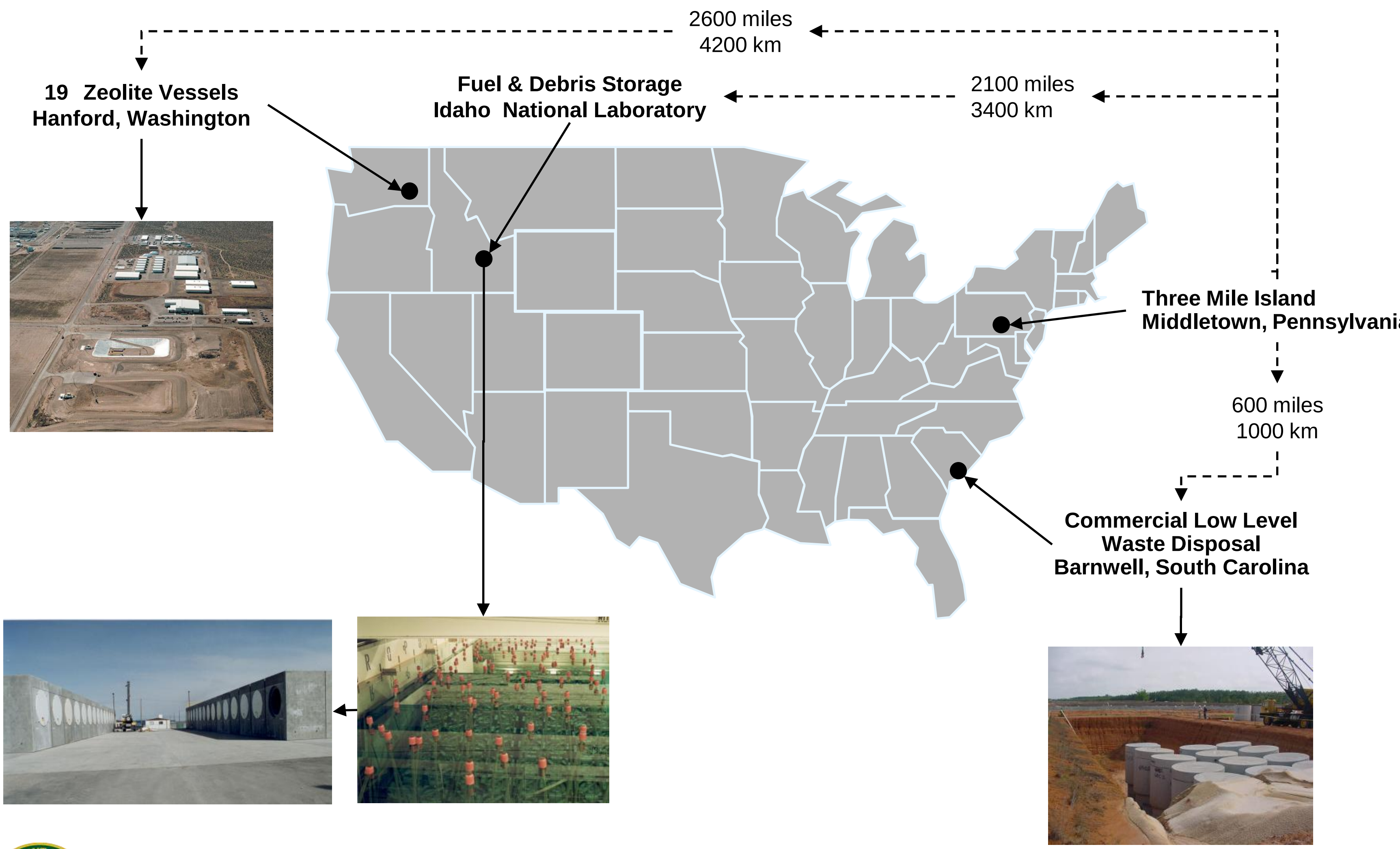
The TMI-2 Location & System

Unit 2 Containment





Important Locations for the TMI-2 Cleanup



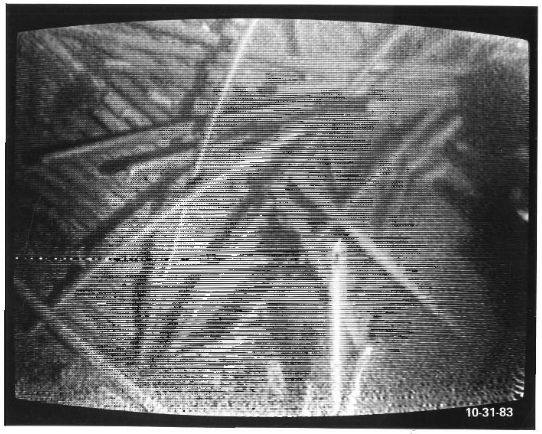
Some Important Defueling Related Events (1)

Events/Decisions	Significance
"Quick Look" video inside the vessel	First idea of what conditions really were; complete assessment took another year; could not proceed to plan, design and fabricate defueling without this knowledge
Decision to not to install in-core shredding equipment in the vessel	• New application for the proposed technology, concern that failure would cause problems • Relied mostly on manual manipulation with power assist • Allowed defueling to start earlier, knowing that overall schedule would not be minimized. This was preferred over a 3 year development before any fuel would be removed.
Decision to leave refueling canal dry	• Less depth for manually operated tools (picture later) • Shielded work platform 2m above the reactor pressure vessel flange avoided much longer reach for tools • Reduced need for water processing • Dose rates were low within the refueling canal
Use of Core Boring Machine	• Samples of the fuel and debris that was melted together • Breaking up the crust and molten mass when manual methods were unsuccessful

Some Important Defueling Related Events (2)

Events/Decisions	Significance
Biological growth in water	Caused a year delay; managing water clarity is extremely important
DOE to take Fuel & Debris New cask design and license Ship Fuel by Rail and not Truck	• Handling and shipping design and fabrication could not take place until destination was determined • New cask could be designed for the TMI canisters • Fewer shipments
Ship to Idaho	Allowed fuel & debris canisters to be removed from TMI
Final Accountability	Precision accountability not required; evaluated quantity of material remaining in the systems

Damage Examples



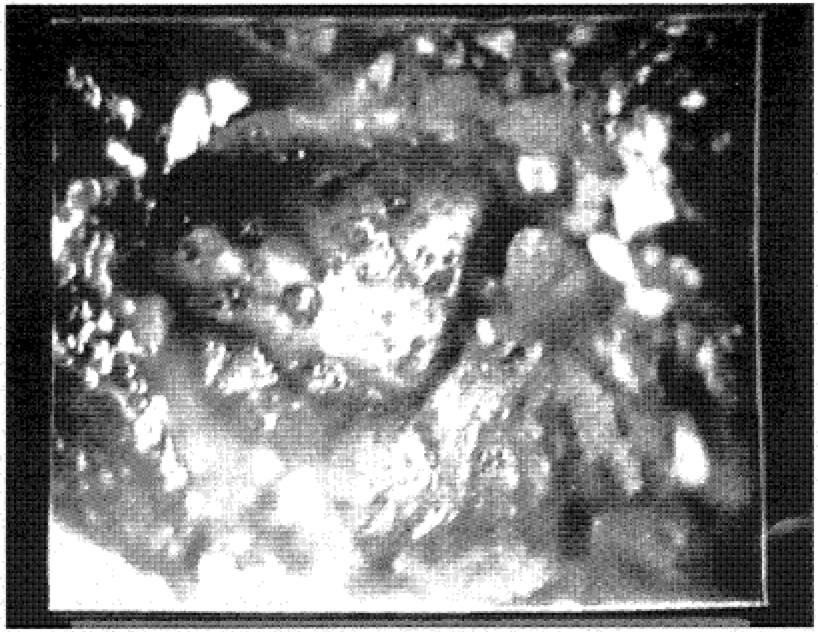
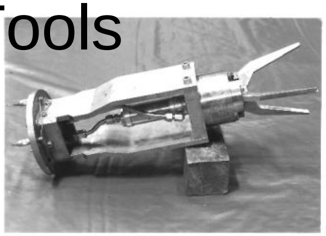
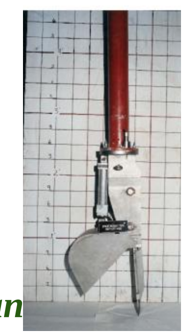


Photo 5-3. View of Debris Bed from Quick Look

Fuel Removal Tools and Equipment

Some Manual Tools





Powered Equipment

Core Boring Machine

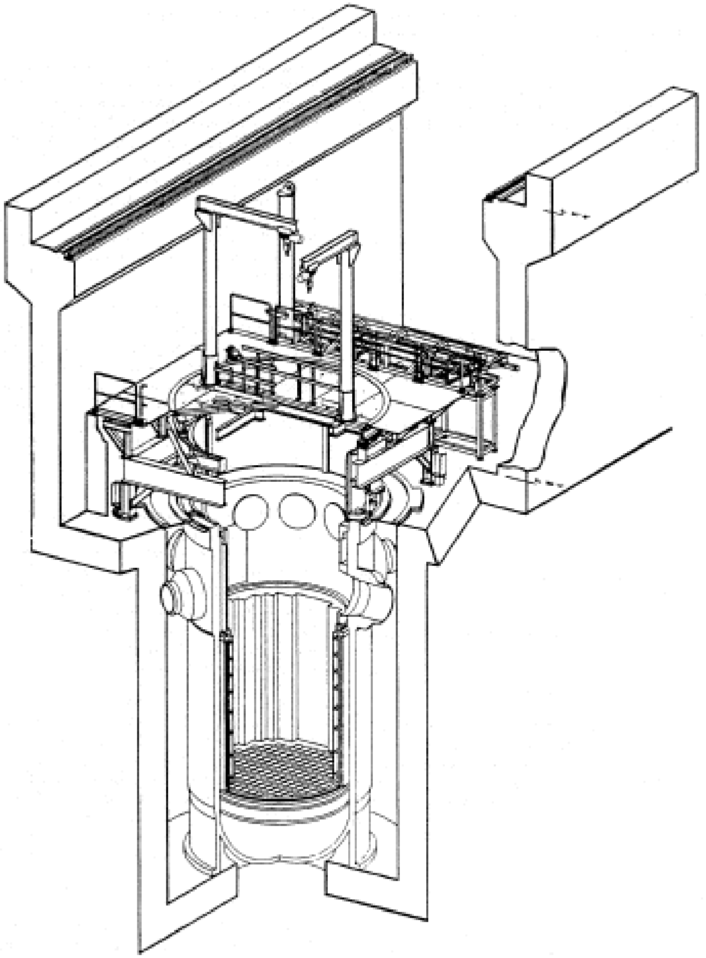
Plasma Arc

- Power Assisted shears

Bulk Removal

Water Vacuum and Air Lift

Work Platform



Remote Technology in the 1980s

Much of what was done was innovation based on the immediate need

The wagon is one example. A toy remote controlled vehicle was used to survey a very radioactive equipment cubicle.

Several robotic devices were created specifically for TMI-2; ROVER is one example. A miniature submarine is another.

Mini Submarine

Low Tech but Effective

ROVER

Core Boring Machine

One of the most important machines for the project

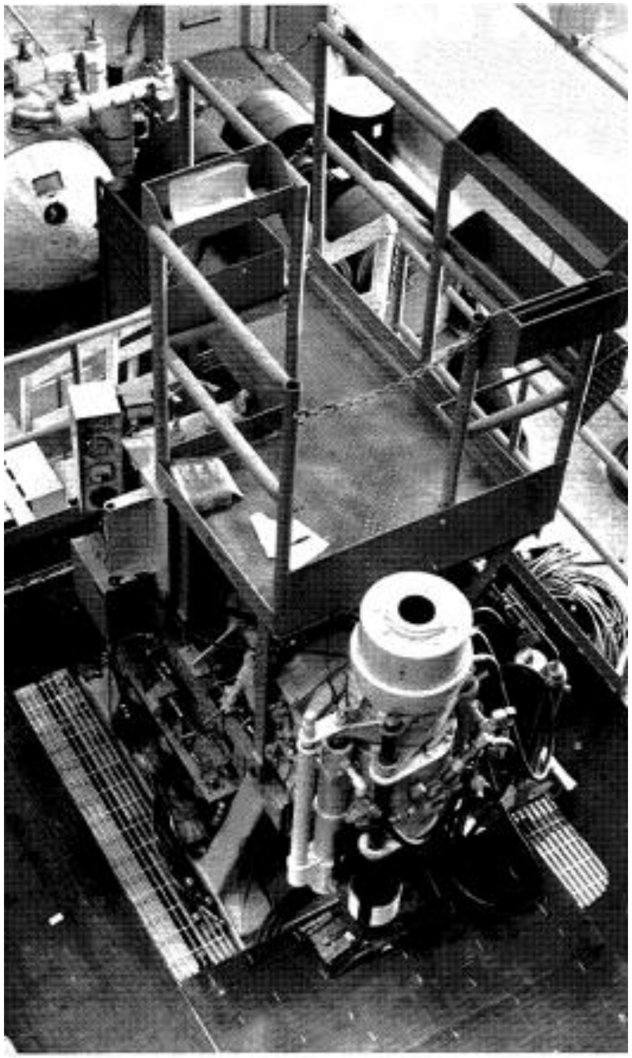
Adapted from commercial mining drilling equipment

First use with hollow core bits: 10 samples 1.8 m long x 6.4 cm diameter (figure below)

Second use with solid face bits to chew through the hard once-molten mass in the core region

Third use was to grind lower grid and instrument tubes

Tungsten Carbide Teeth with Synthetic Diamond



Packaging, Transport, & Storage of Fuel and Debris at Idaho

1986 to 1990
341 canisters of fuel & debris in 46 shipments by rail cask to the Idaho National Laboratory (140,000 Kg)

1990 to 2000
Wet Storage in Spent Fuel Storage Pool

2000 – 2001
Removed from pool, dewatered, dried, and placed in dry storage

Defueling Progress and Key Impacts

1982-1983
Defueling Options Evaluations

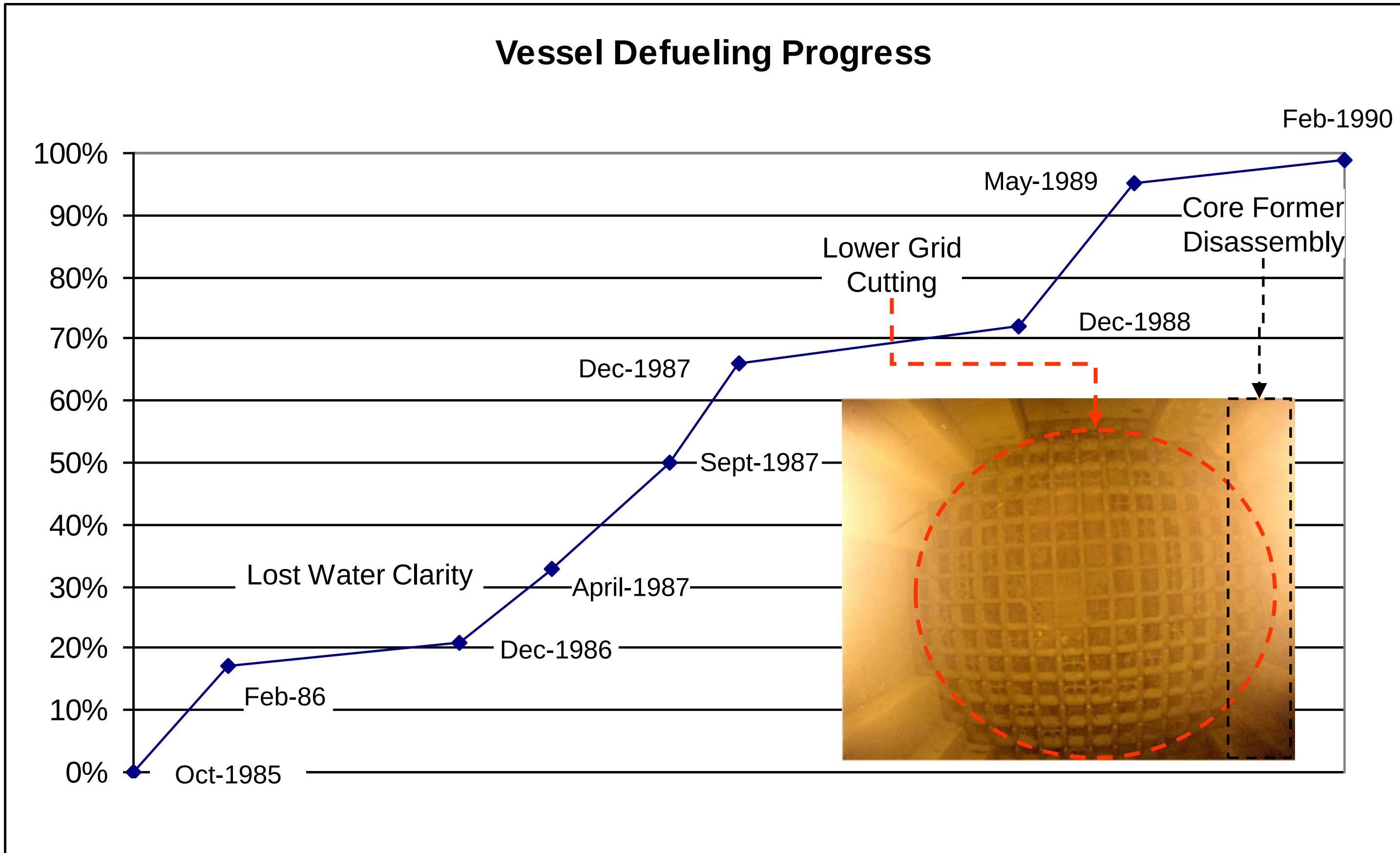
1982
First Video of Core

1983
First Sample

1983
Sonar Mapping & Improved Video

1984
Defueling Method Decision
Dry Canal & Mostly Manual

Mid-1984
Vessel Head Lift



Final Clean-Out Verification

Standard accountability was impossible

- NRC granted an exemption to the requirement
- Required a detailed survey conducted after defueling for what remained
- Computer code analyses conducted for fissionable nuclides: 1) existing prior to the accident, 2) remaining after the accident, and 3) radioactive decay
- Therefore the net balance is what was sent to Idaho

Assessment Required a Combination

- Video inspection for locations
- Gamma dose rate and spectroscopy
- Passive neutron solid state track recorders, activation, BF3 detectors, Alpha detection
- Active neutron interrogation
- Sample Analysis

Water Management

Contaminated Water (in Containment and Reactor Systems)

- Zeolite (Submerged Demineralizer System)
- Resin Demineralizers

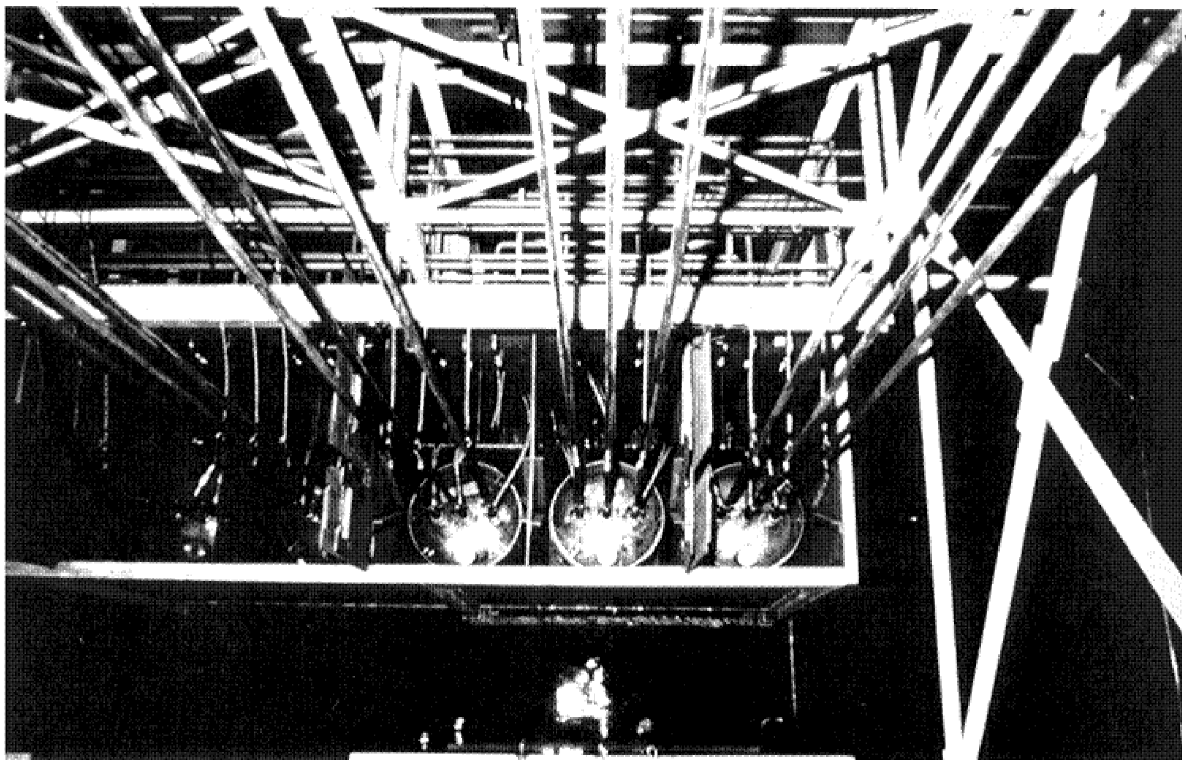
Defueling Water Cleanup System

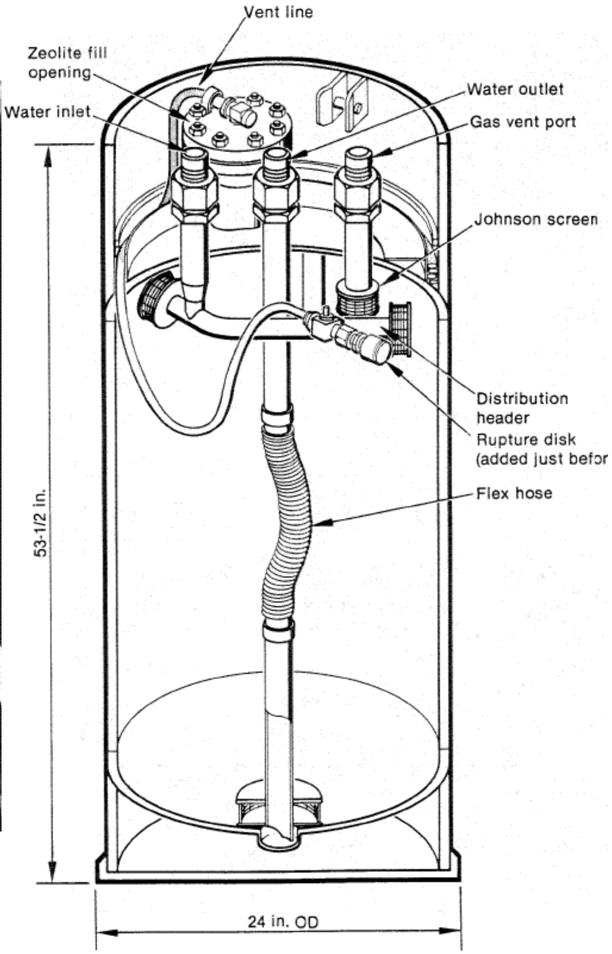
- Primarily filtration to control suspended solids
- Included zeolite and sand-charcoal media

Final Water Disposal

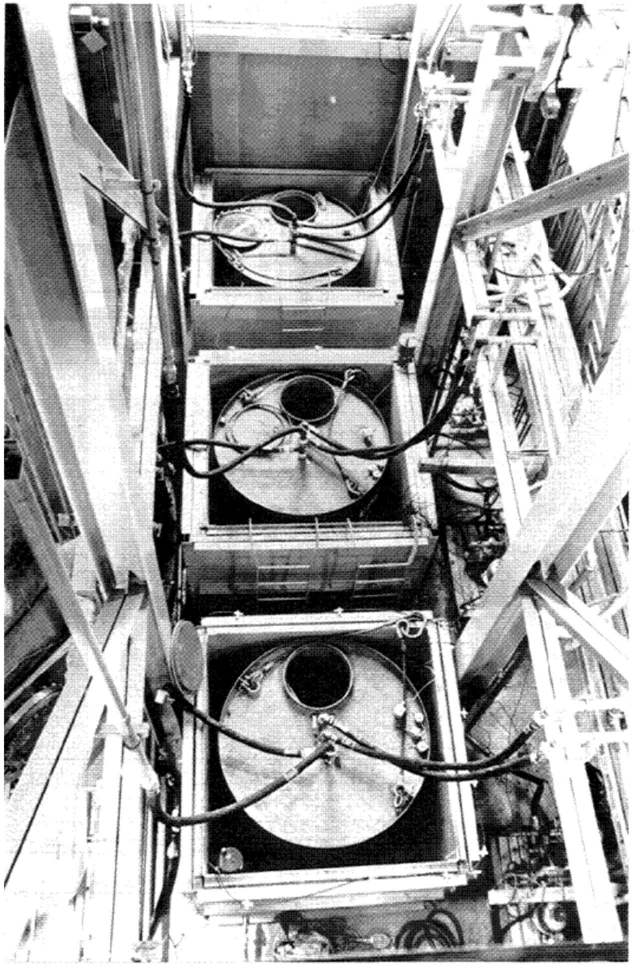
- Not allowed to discharge to the river because of tritium fears
- Used open cycle low temperature evaporator

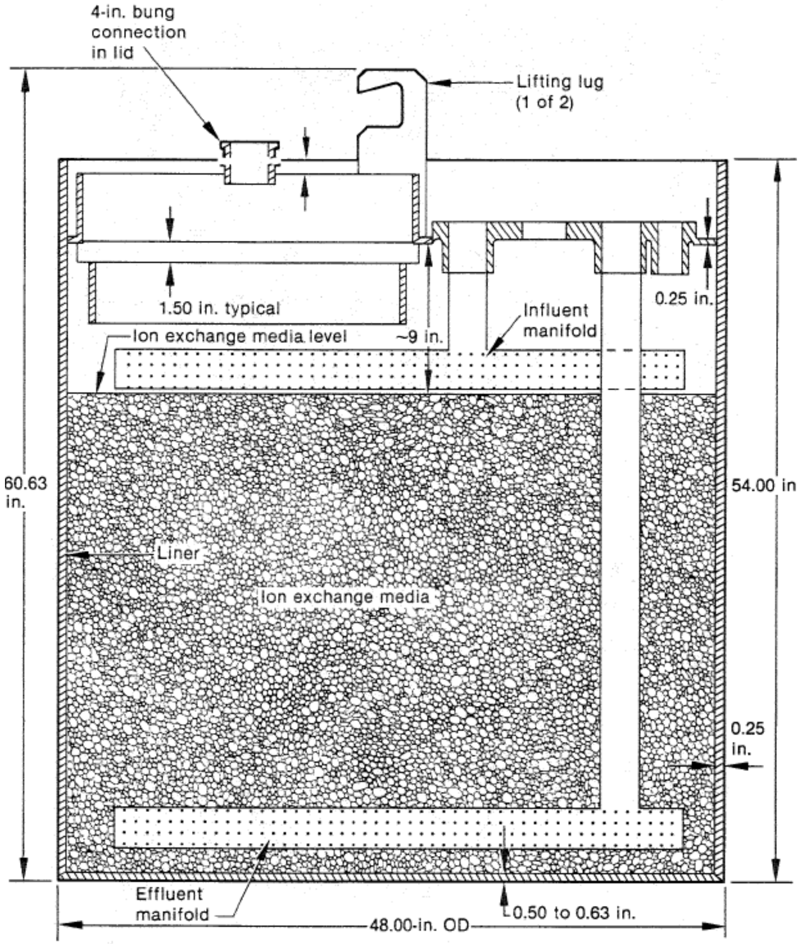
Submerged Demineralizer System (Zeolite)



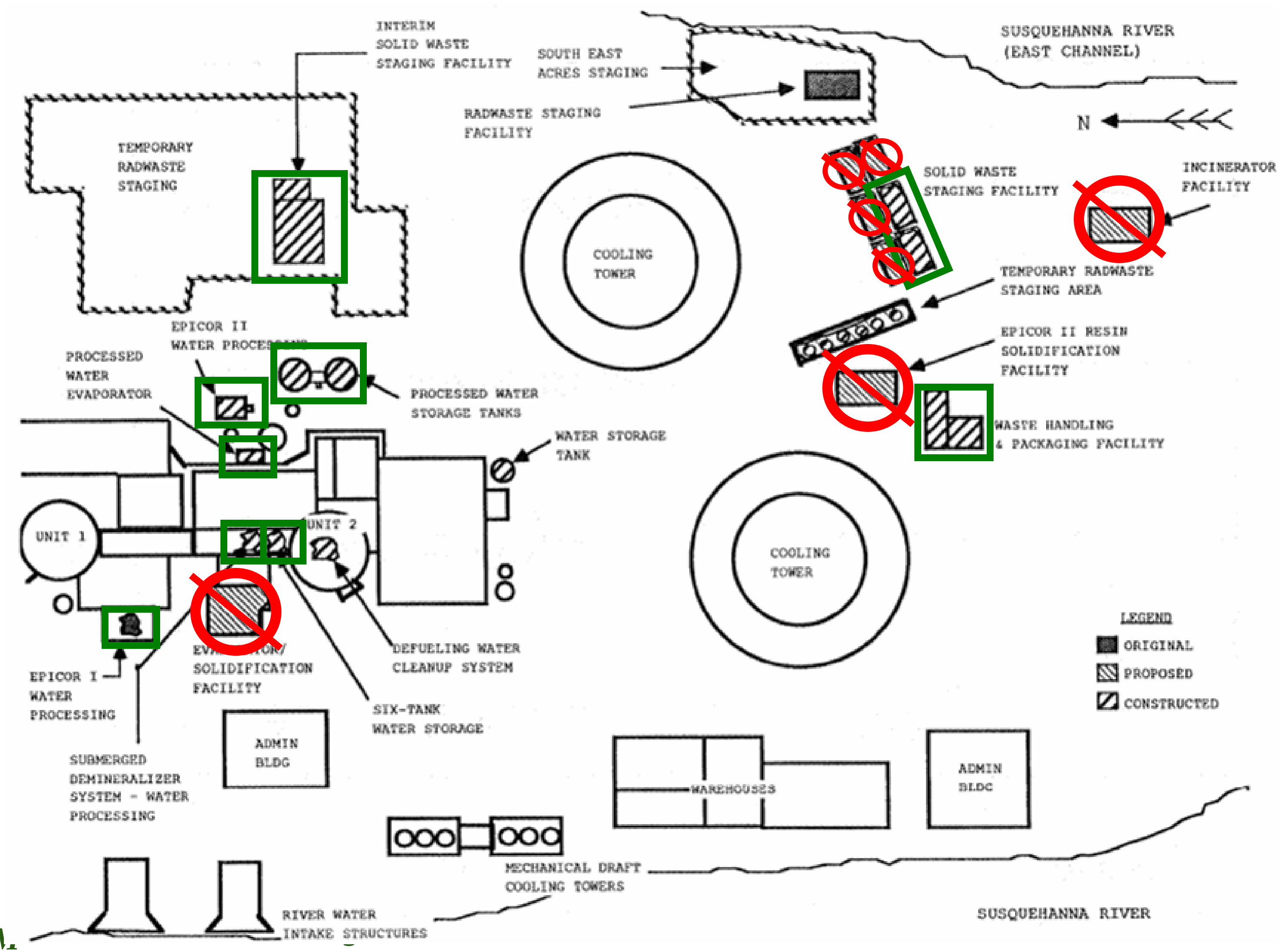


Key Resin Demineralizer System





Waste Management Facilities



Some TMI-2 Conclusions

- Much planning, methods, equipment development could only be done as real conditions became known
- Manual, less complex methods that meant a long schedule allowed quicker adjustment for unexpected surprises and to try new approaches
- On-site tool development resources and radio-chemistry labs helped considerably
- Often several options had to be carried forward until one evolved as preferable
- Existing Department of Energy personnel and facilities had experience with highly radioactive materials; this was essential to the success of the cleanup

Comparisons (1)

Beneficial to TMI-2

- Reactor had only operated 3 months
- Accident was terminated before there was serious damage to the reactor pressure vessel or primary coolant system
- Never lost electrical power
- Spent fuel pool was empty; used later for important cleanup operations

Detrimental to TMI-2

- There were no significant precedents prior
- Robotics and vision technology were not well advanced
- Did not anticipate biological growth in the defueling water
- Could not discharge processed “Accident Water”

Comparisons (2)

- **TMI = Pressurized Water Reactor**
- **Fukushima = Boiling Water Reactor**
- **Both events were compounded by design errors**
  - –TMI-2 relief valve position indicator did not show actual position which was a primary reason the accident was not terminated earlier
  - –Fukushima diesel generators vulnerable to the tsunami
- **TMI - all fuel contained within the reactor systems**
- **Fukushima**
  - –Access to within the containment and eventually to the reactor will be exceedingly more difficult
  - –Much greater amounts of water have been and will continue to be processed

Conclusions

- **Recognizing that:**
  - **Exact conditions following an "accident" cannot be known or accurately predicted**
  - **There are major differences between NPPs**
- **Considerations should be given to establishing:**
  - **Comprehensive emergency and response scenarios**
  - **Regional and/or local emergency response centers with capabilities and equipment**
  - **Specifically (given condition and task constraints) designed remote/robotic equipment**