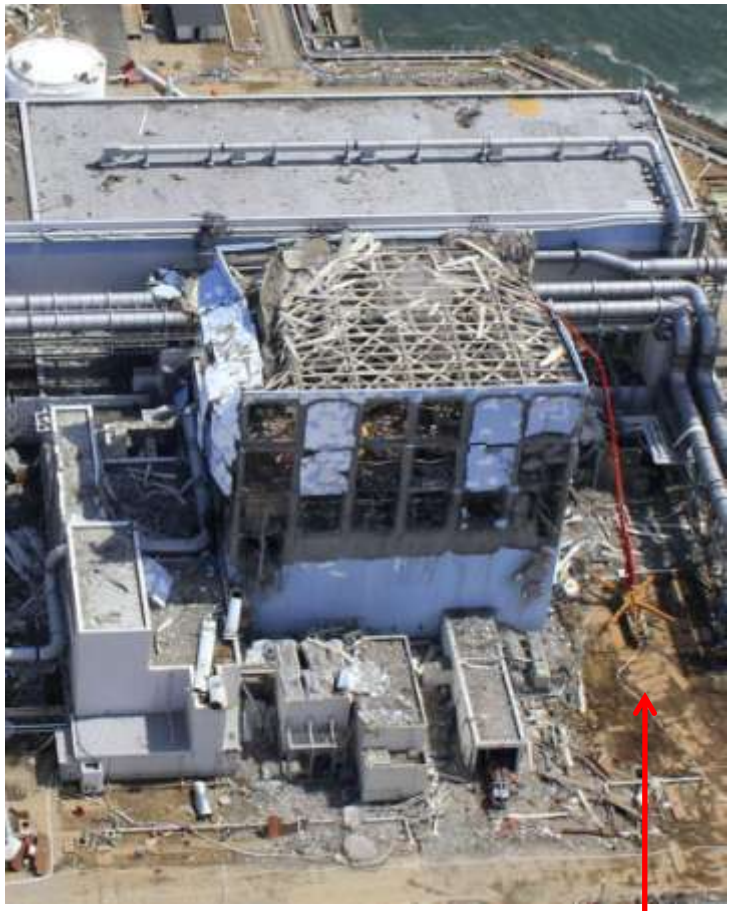
Clearing Wreckage To Inject U4 SFP Cooling Water

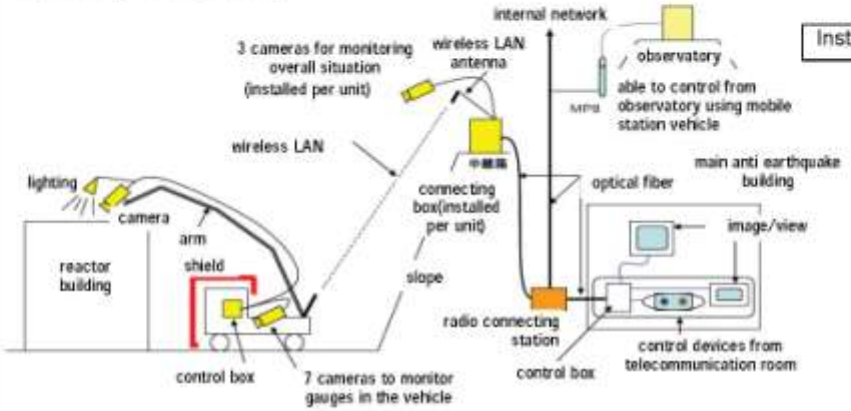
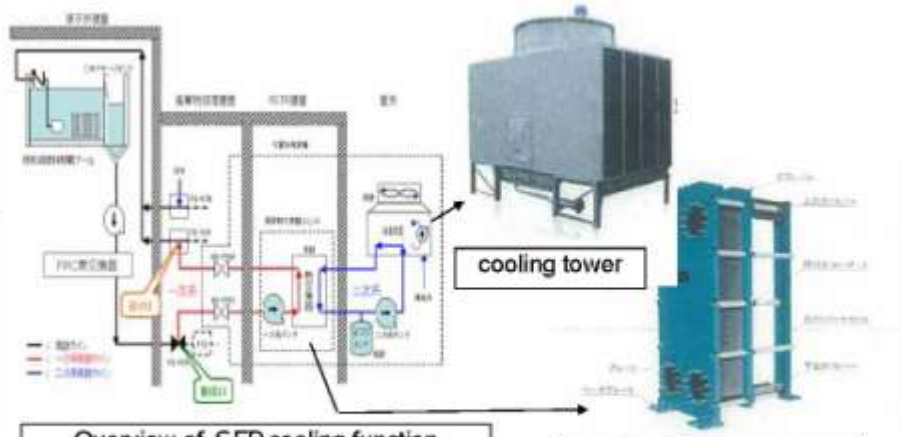
Debris Was Blocking Pumper Access to SFP



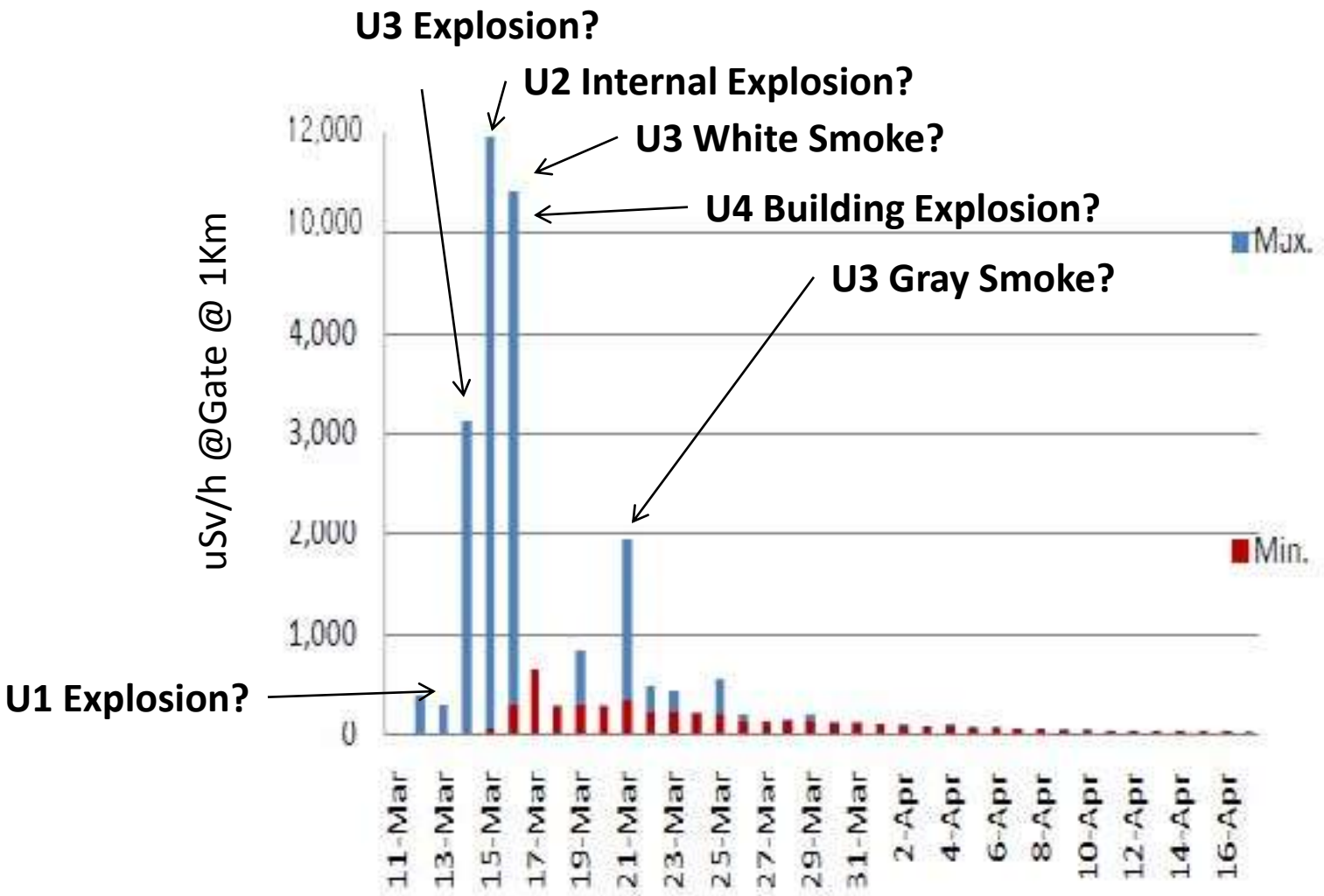
Debris Cleared For Pumper By Manual Tank-Bulldozer

Established Pool Recirculation Cooling

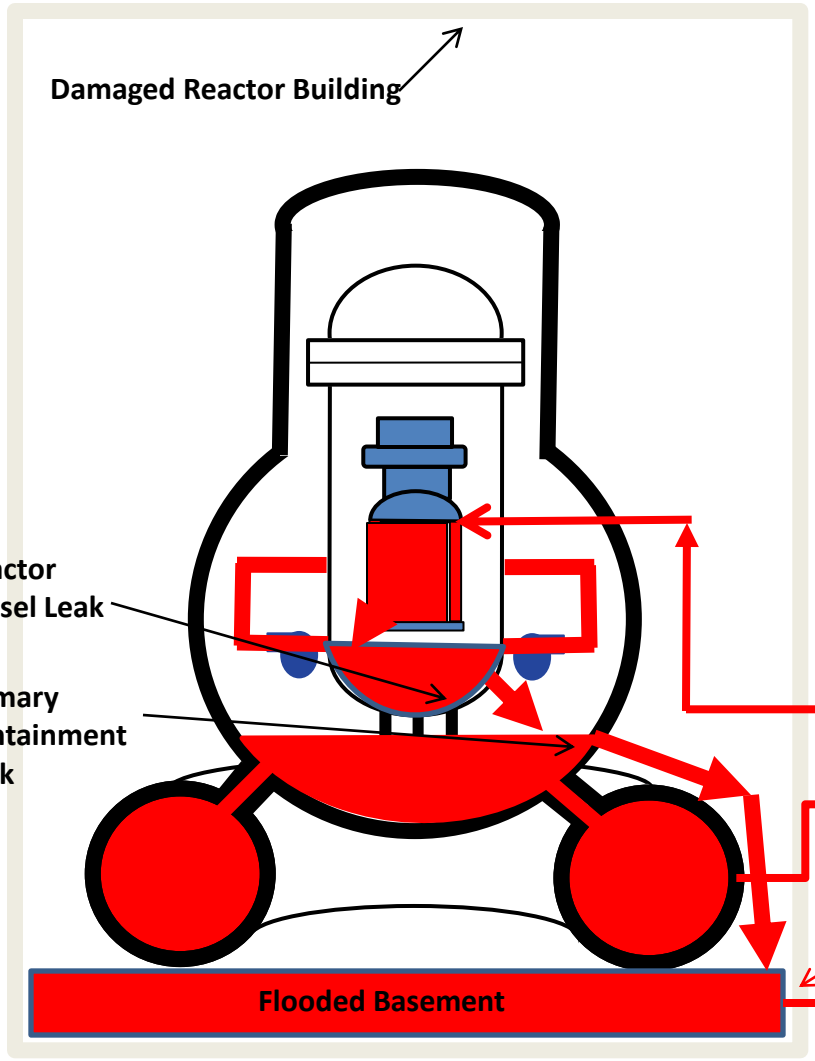
Progress status of cooling (Spent Fuel Pool) (Description)

Issues			Countermeasures	Implementation status	Photos and figures
I. Cooling	(2) Spent Fuel Pools	Unit 1	Countermeasure[22] Continuation of water injection by "Giraffe", etc	-Reliability improvement: enhanced durability of hoses -Measures to reduce radiation dose: switch to remote-controlled operation (arm, water injection operation)	Image of remote control operation of concrete pumping vehicle  Installation of camera at the top of the arm 
			Countermeasure[24] Restoration of normal cooling system	-Radiation measurement by γcamera and robot(from April 30 to May 6) -Radiation reduction by flushing and shielding facility(from May 11 to May 15)	
			Countermeasure[25,27] Install heat exchanger	-Manufacturing heat exchanger	

Release Periods Based On Site Gamma Levels



Establishing Core Recirculation Cooling In Early July



Need Water Recirculation System To Stop Feed & Bleed Venting & Radioactive Water Creation

~30M gallons High Rad Water

Heat

Water Purification

New Chemical/Radiological Purification System

Cable/Pipe Tunnels Leakage

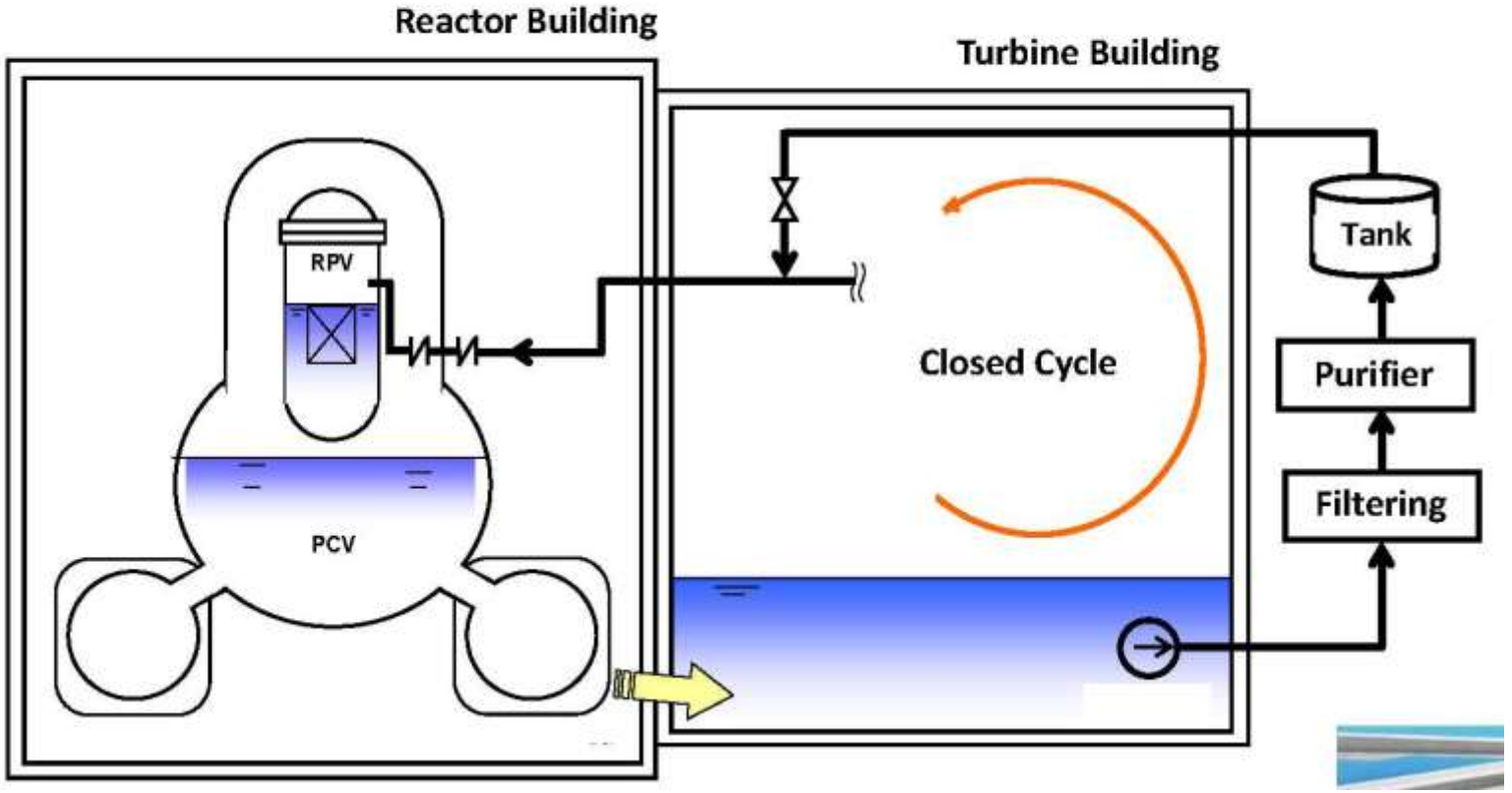
Turbine Building

Intake Strctrs

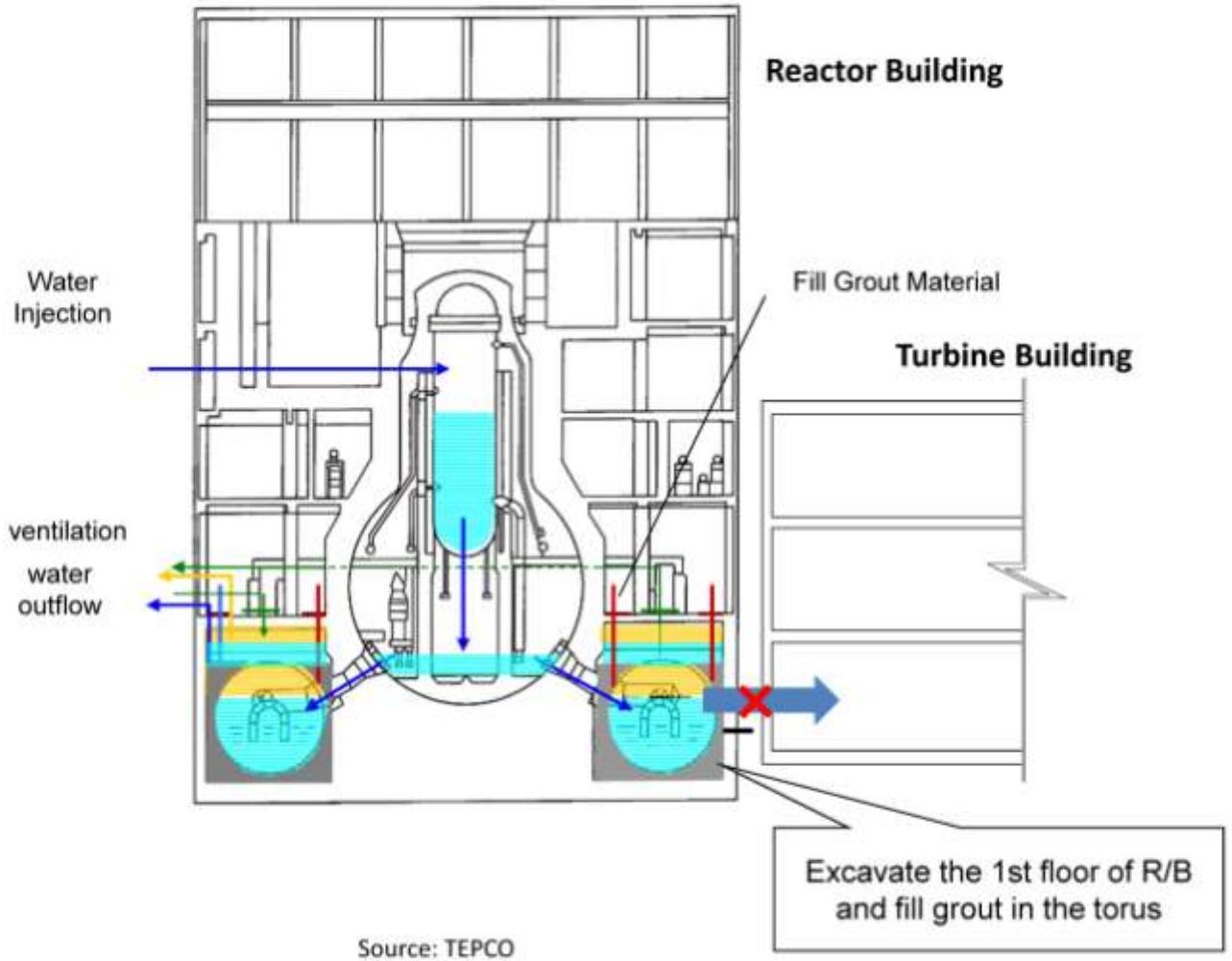
Sea

Recirc Core Cooling

System outline of water reuse as reactor coolant by processing accumulated water



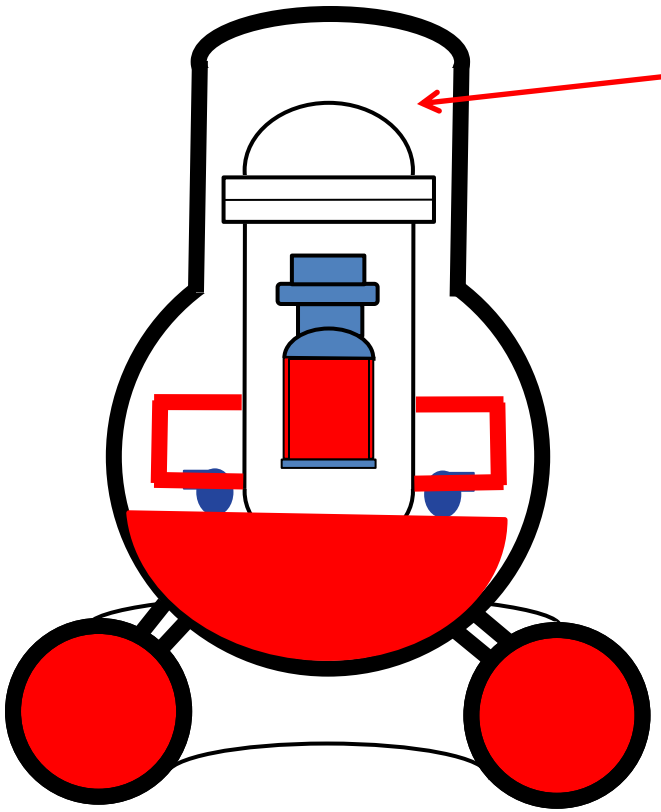
Countermeasure to Seal the Damaged Location in the PCV of the Unit 2



Source: TEPCO

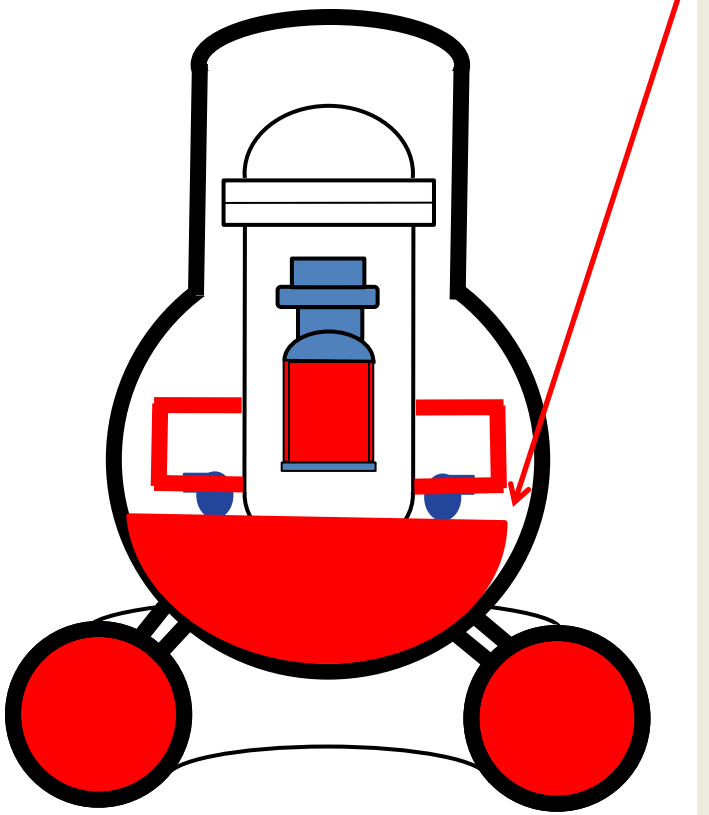
43

Current Primary Containment Integrity Oxygen-Hydrogen Risk



- Hydrogen & Steam Atmosphere Currently In Primary Containments
- As System Cools May Draw Air with Oxygen Back Into the Containment and Could Become Explosive
- Currently Injecting Inert nitrogen to Prevent Oxygen In-leakage, however Unit 3 has significant containment leakage

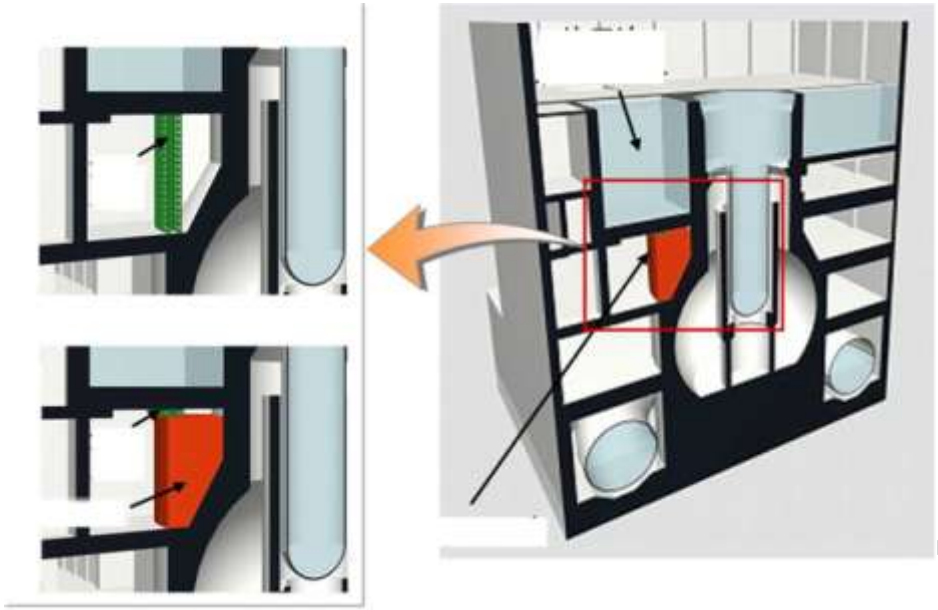
Current Primary Containment Integrity Seismic Risk



- Primary Containments are Partially Flooded with Core Feed Water Outflow Well Beyond Design Basis Levels
- Earthquake Aftershocks Add Increased Dynamic Stress to Higher than Design Static Stress
- Reactor Building Structure Has Likely Been Degraded by Explosions and initial Earthquake To an Unknown Degree
- Containment Integrity Margins being Evaluated

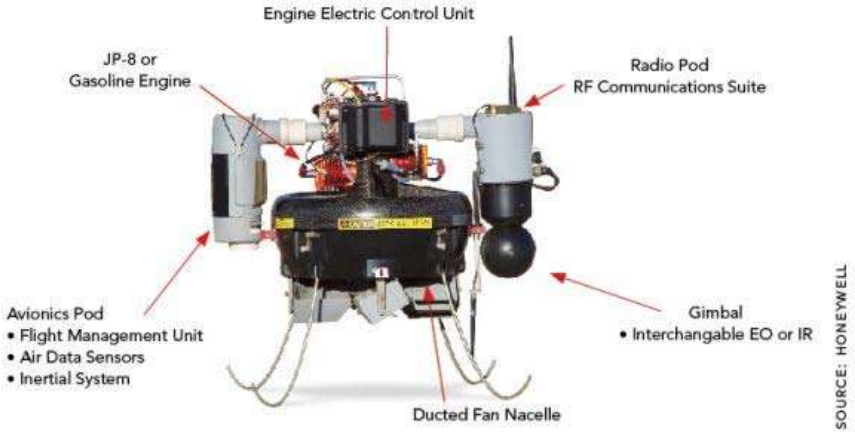
Current Unit 4 Reactor Building Structural Integrity Seismic Risk

- Explosions Have Weaken RB Structure
- A Large Earthquake Aftershock May Cause Building Failure
- Keeping Pool Water Level at a Minimum to reduce Loads



- Adding Steel & Concrete under Pool
  - High Gamma Field Causing Delays

Gather Data Inside Reactor Buildings



Adapted Military Drones With Thermal & Radiation Capabilities

Inside Reactor Buildings ~1-100R/Hr & U2 High Vapor

Working Conditions are Challenging

Restoring Power In High Radiation & Contaminated Areas

Control Room Power Restoration

Before Power Restored

After Power Restored

Working In Contaminated Buildings

Entering Waste Processing Building

Worker Showing TB Basement Floor Water Level

Reactor Building Air Filtration

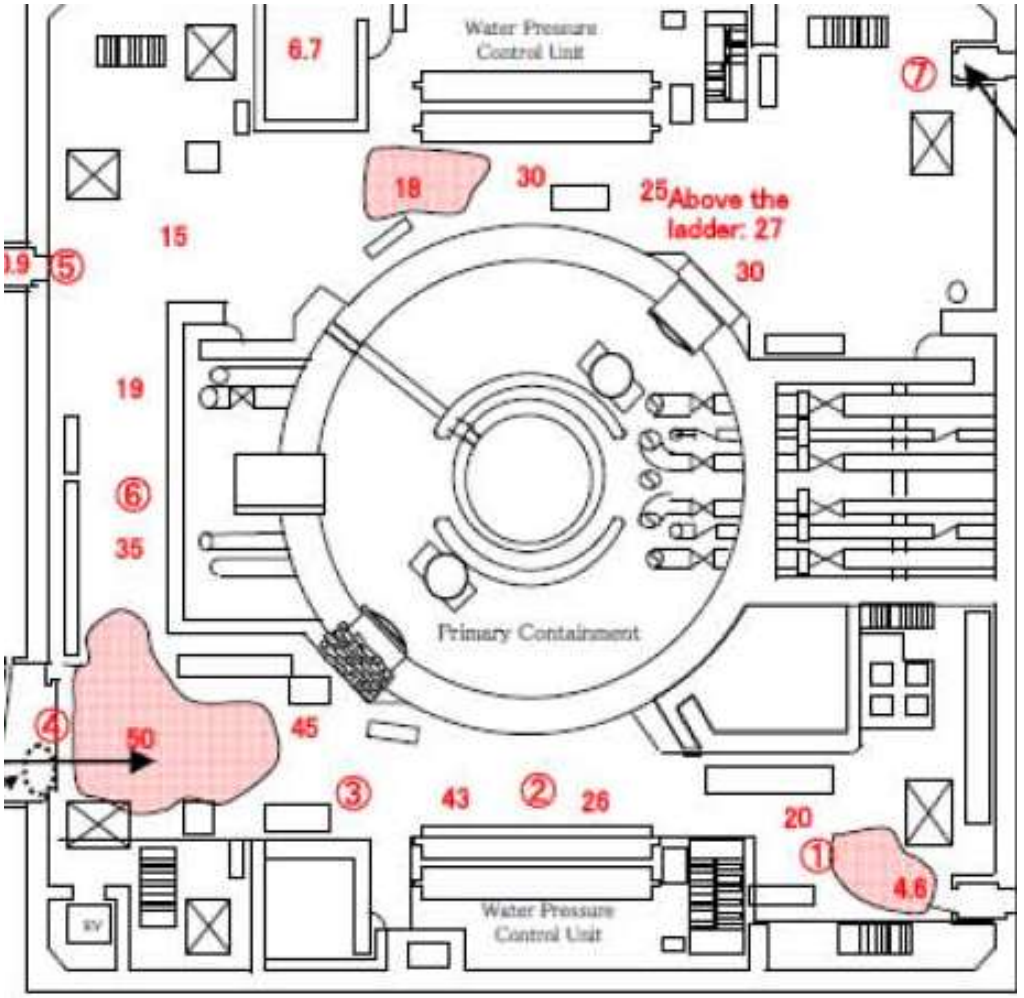
Access to Calibrate Reactor Water Level Instrumentation

U2 Reactor Building Conditions

Robots First

Personnel Second

Ground RB Floor

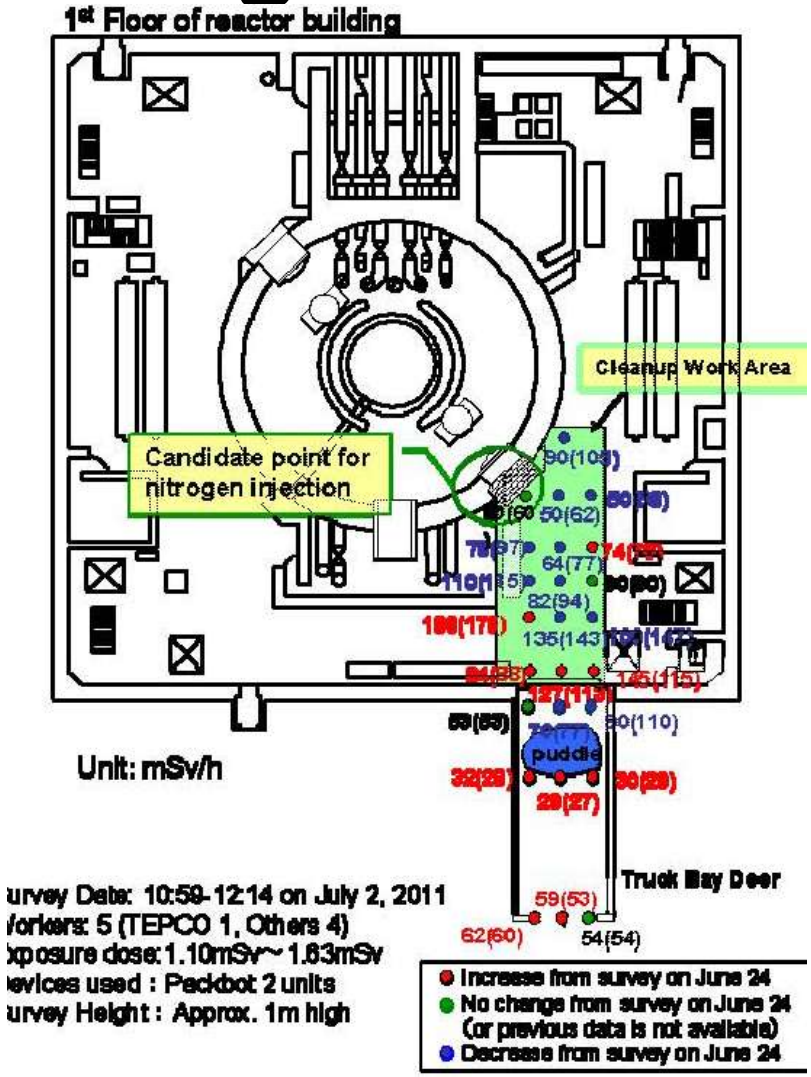


Water 4M deep in Basement

U3 Reactor Building Conditions

Robotic Vacuum Cleaner

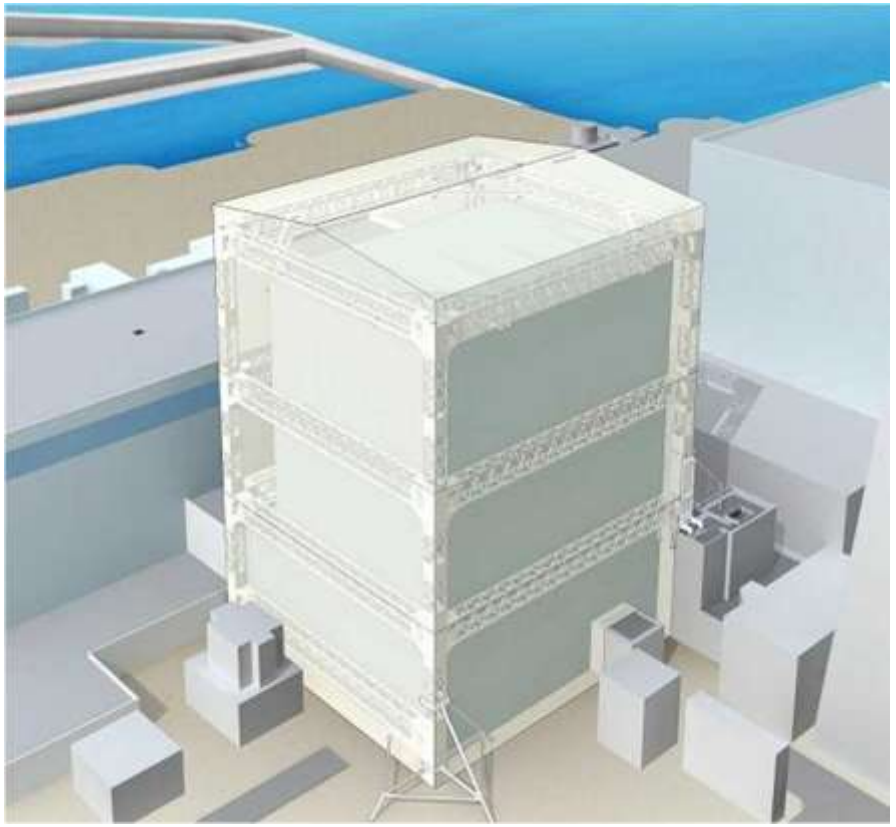
50-20mm Steel Plate Floor Shielding



Reducing 5-18R/hr Gamma Fields
For N2 Containment Injection

Airborne Mitigation

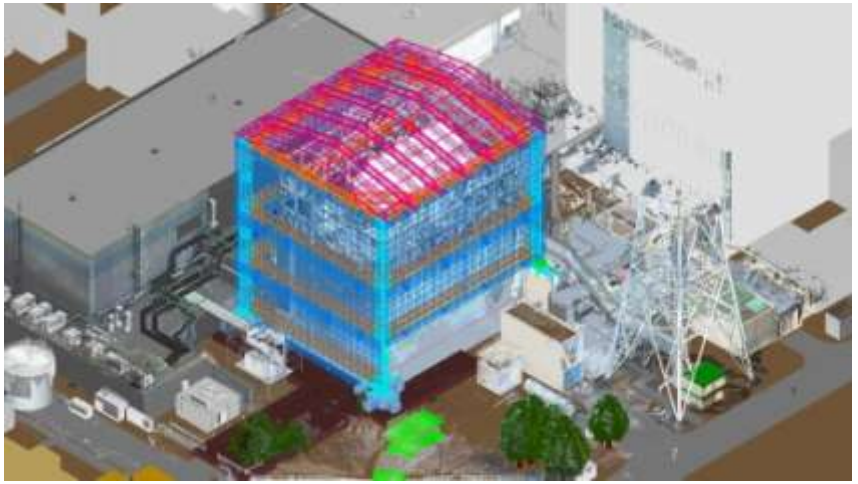
Dust Suppression Resin Application



Unit 1 Fabric Enclosure
55M High & 47M X 42M

Unit 1 Canopy Design/Construction Process

Laser Measure Existing Building



Laser Image New Enclosure

Construction Sequence Planing

New Fast Const Concepts

Mockup Const Training

Minimizing Building Rain In Leakage

Unit 1 Turbine Building Roof Patch

To Reduce Radioactive Water Overflow

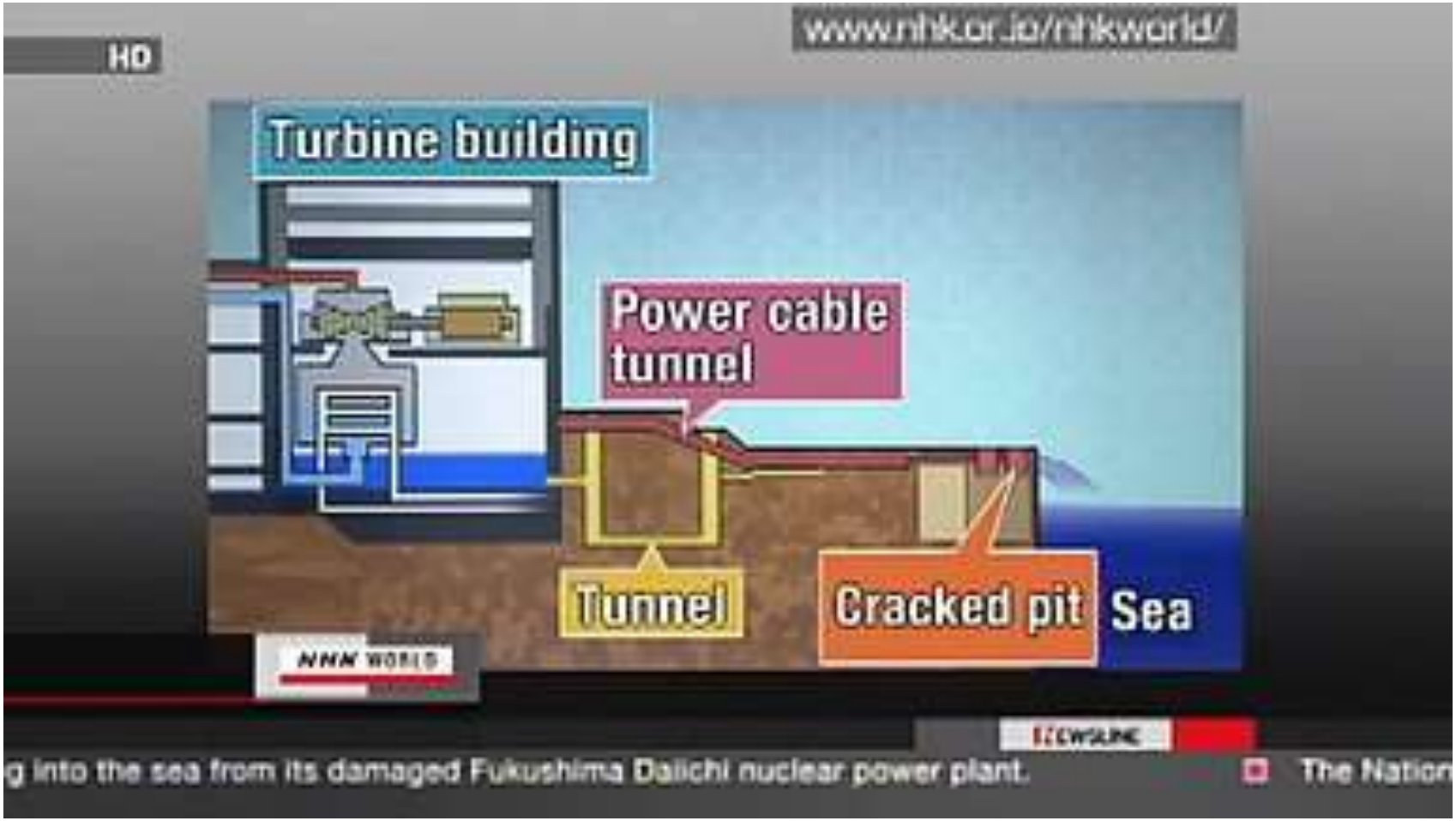
Current Rainy Season: Typhoon Ma On with 4” last week

Contaminated Water Accumulating

- **Feed & Bleed Core Cooling Flushed Large Amounts of Highly Radioactive Water into Building Basements**
- **Approximately 30 Million Gallons Now**
- **Approximately 25 Million Curies**
- **Increasing at ~100,000 gallons per day**
- **Rainy Season Adding More**

Effluent Release Flow Paths

Reactor Building-Turbine Building-Intake -Sea



Contaminated Water Containment

Overflow from U2 Reactor Bldg to Turbine Bldg to Intake Structure Wall Crack to Sea

27,000 Ci Cs-137 Released this Path 4/1-6

-Reference Chernobyl was 2MCi Cs-137 released

Non-Safety Grade intake Structure

Radioactive Water Leak 11-04-02

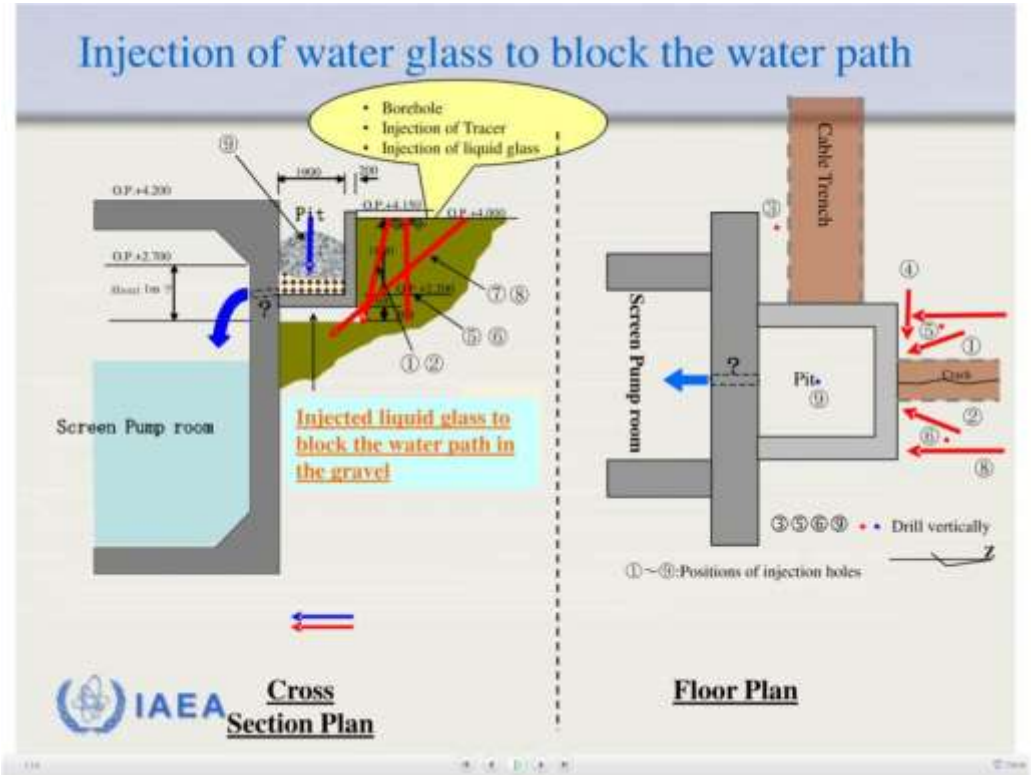
Leak Reduced 11-04-04

Leak Sealed 11-04-06
Sodium Silicate Injection

Contaminated Water Containment

How the Intake Wall Crack Leak was Stopped

Cable Chase Path



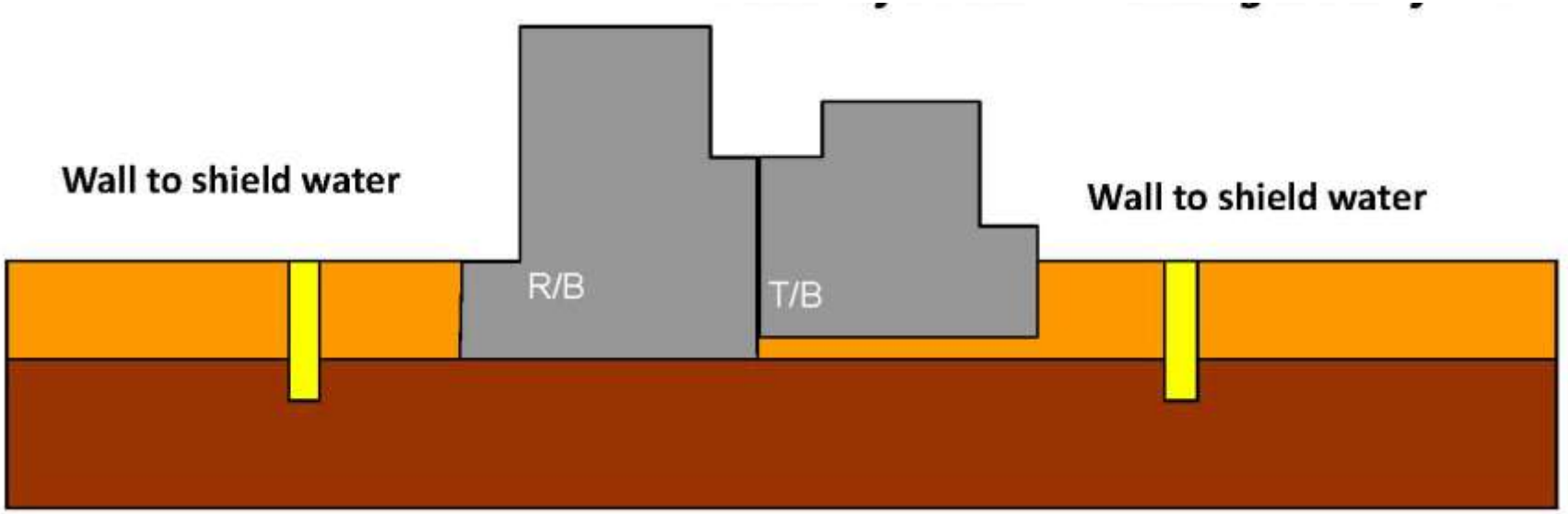
Leak Sealed 11-04-06
Sodium Silicate Injection

Other Similar Leakage Paths To Seal

Sealing Other Leakage Paths to Sea

Concreting One of ~37 Cable & Pipe Chase Paths

Mitigate Basement Leakage Into Groundwater Paths To Sea



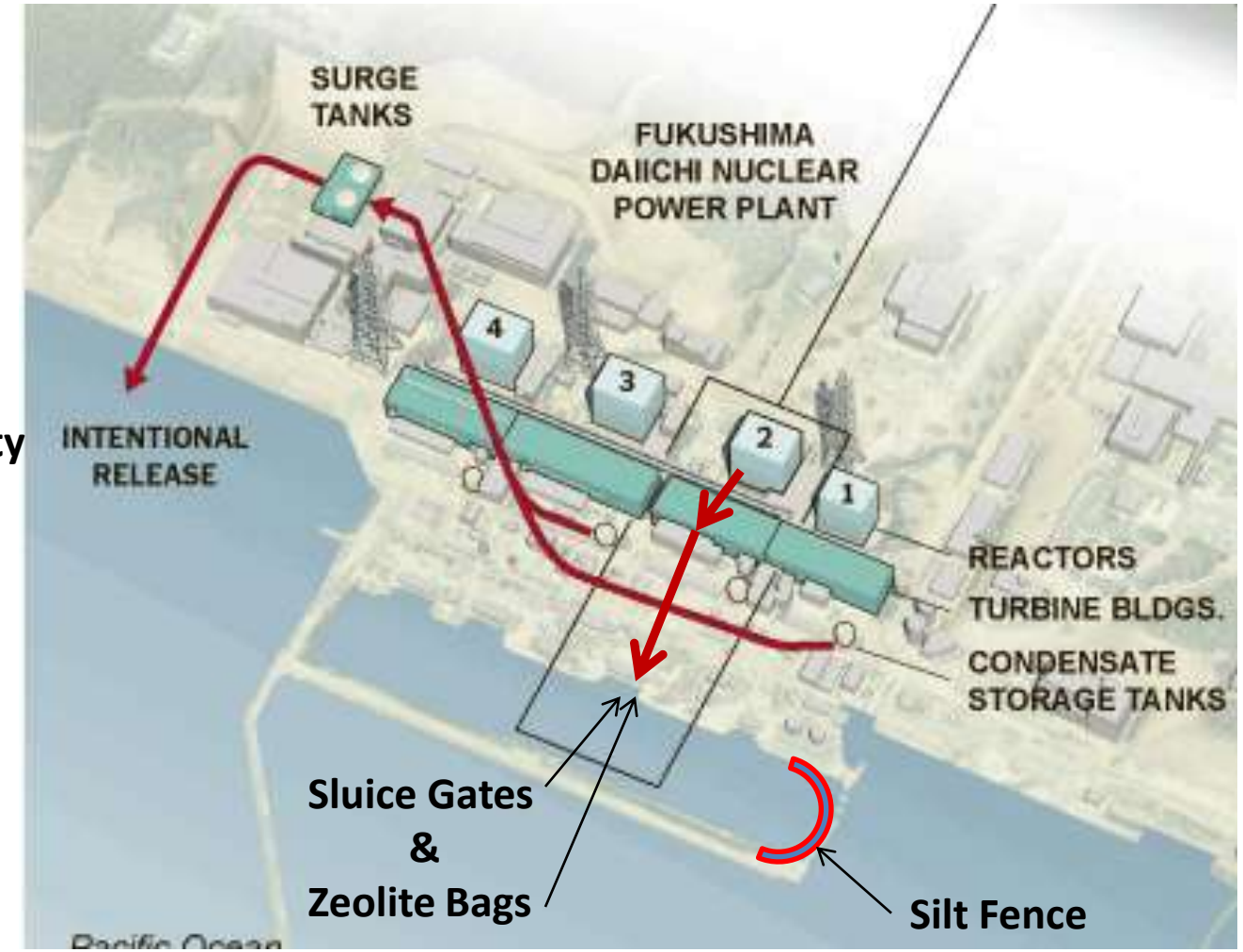
Planning Underground Barrier Walls to Bed Rock

Water Retention Tank Farms

Underground Tanks Under Construction

Accident Water Management

Relative Low Activity Released



20-50 Million Gallons Of Highly Radioactive Water To Be Transferred To Onsite Tankage

Water Release Mitigation

Contain/Retard Intake Structure Cs/Sr Contamination

Sluice Gate to Minimize Outflow To Ocean

Zeolite Bags To Adsorb Cs/Sr

Water Release Mitigation

Silt Fence to Retard Cs/Sr Release to Sea

Process Intake Canal Water Through Zeolite Beds to Remove Released Cesium

US Fresh Water Barge On Site-April

Japanese ship hauling US Navy water barge

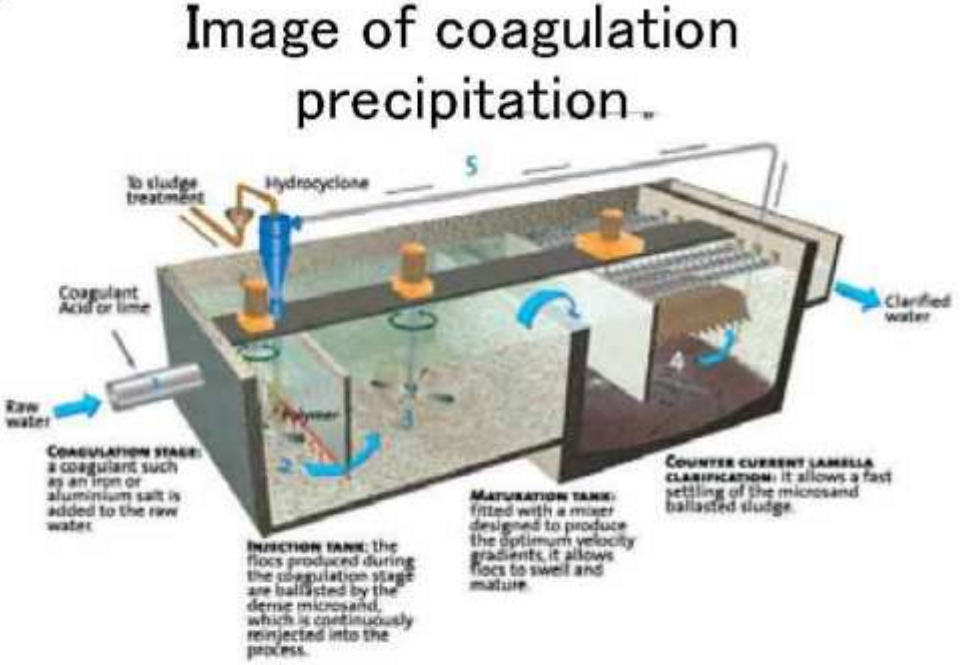
Japanese Tow Operators

New Water Barge On Site-June

2.5 Million Gallon Capacity Barge

Accident Water Treatment Plans

~30 Million Gallons in Basements



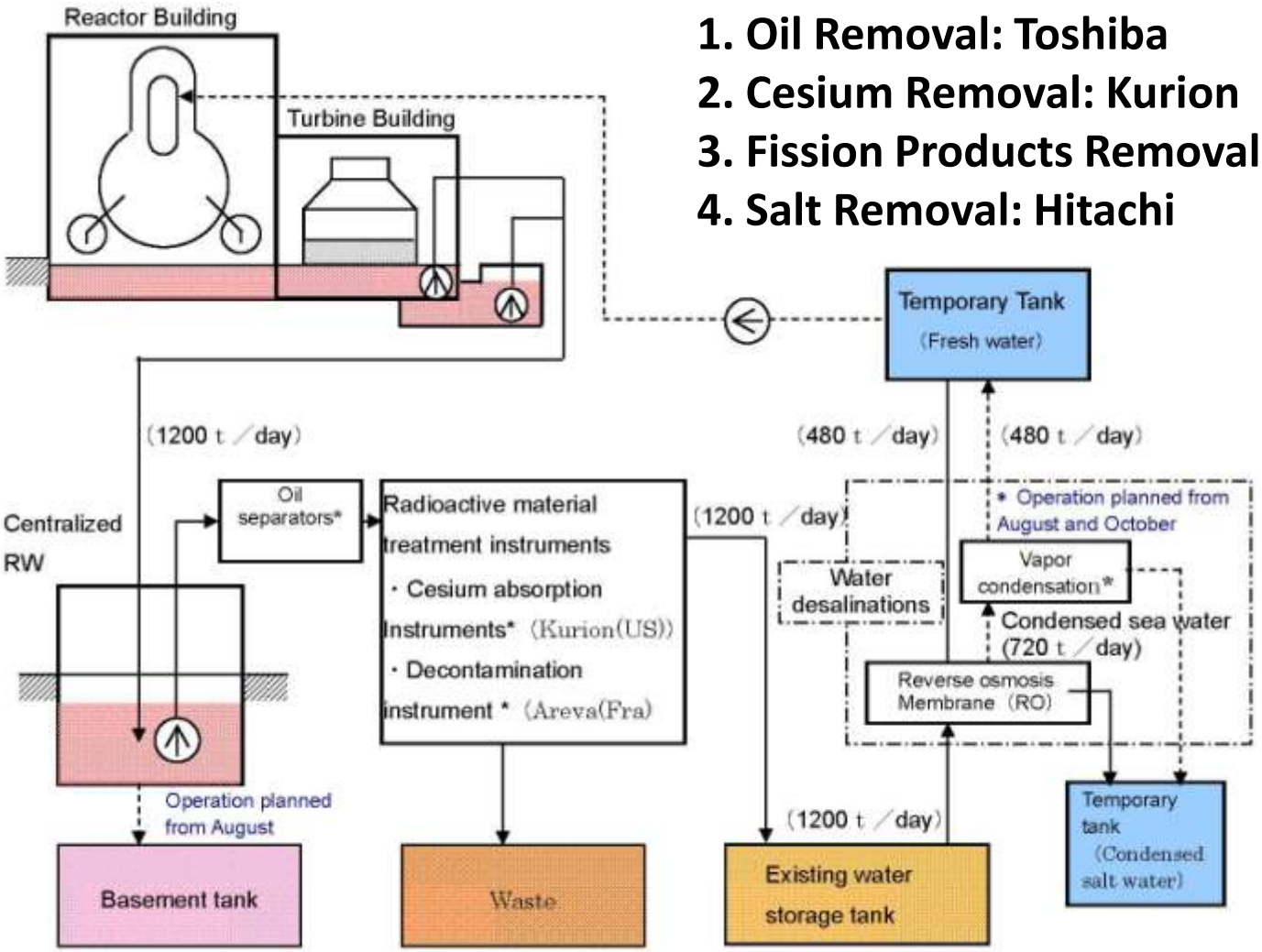
Treatment equipment

1200T/day (330Kgal/day or 200gpm) Rate Goal with 1E3 DF Startup Late June

Water Recirculation Processing Plan

Four Stage System

1. **Oil Removal: Toshiba**
2. **Cesium Removal: Kurion**
3. **Fission Products Removal: AREVA**
4. **Salt Removal: Hitachi**



Oil Removal

Separator Unit

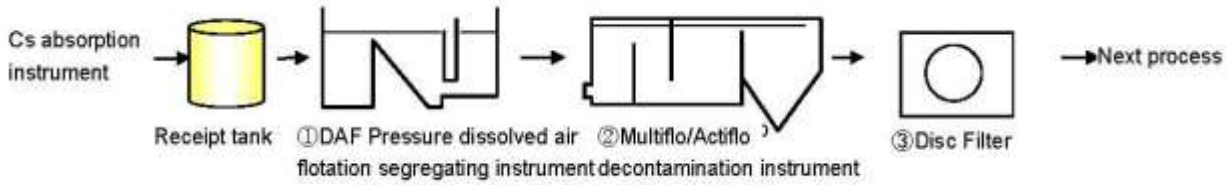
Separator Internals

Cesium Removal Stage

Individual Zeolite Beds

Shielded Skids

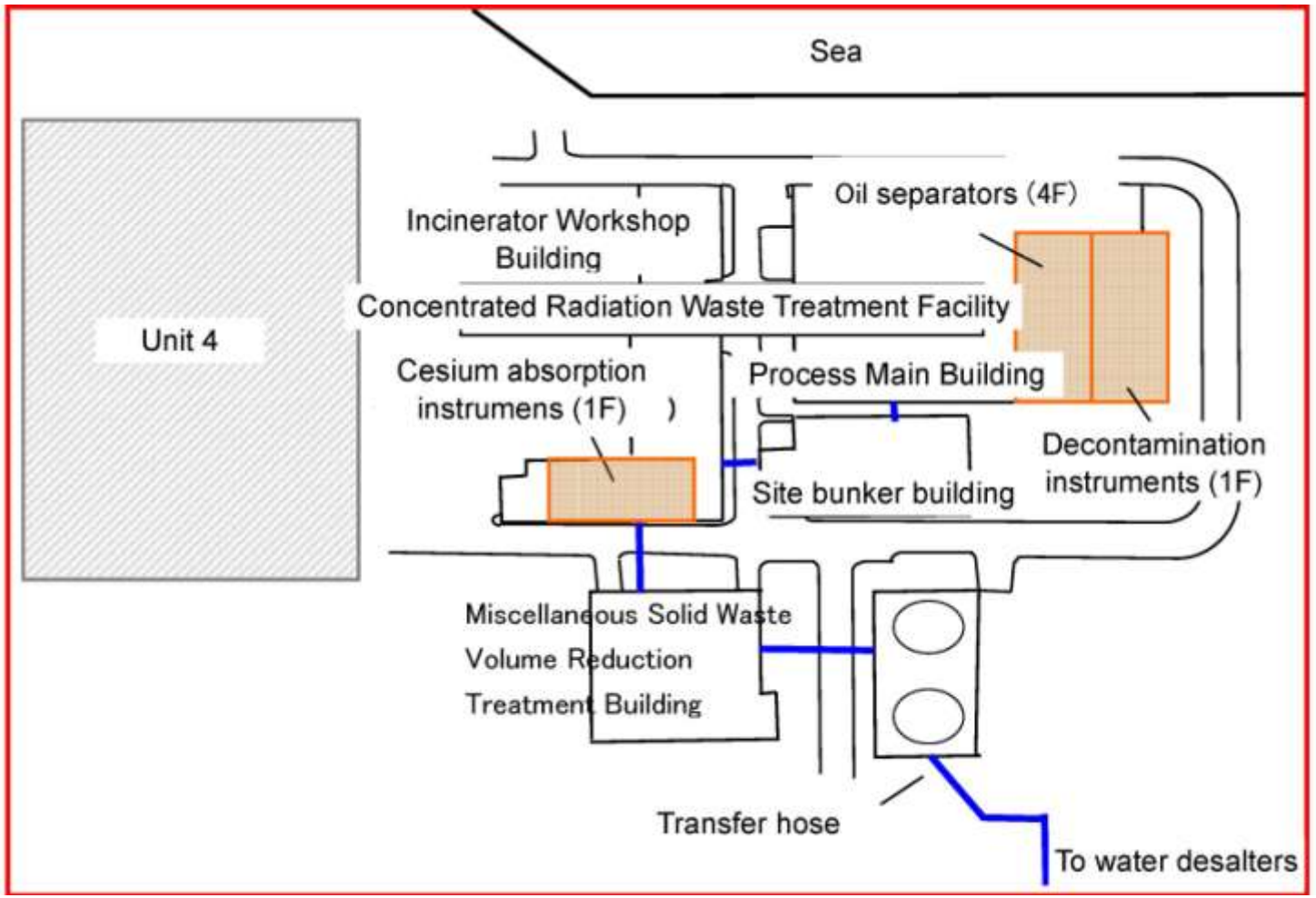
Fission Product Precipitation Stage



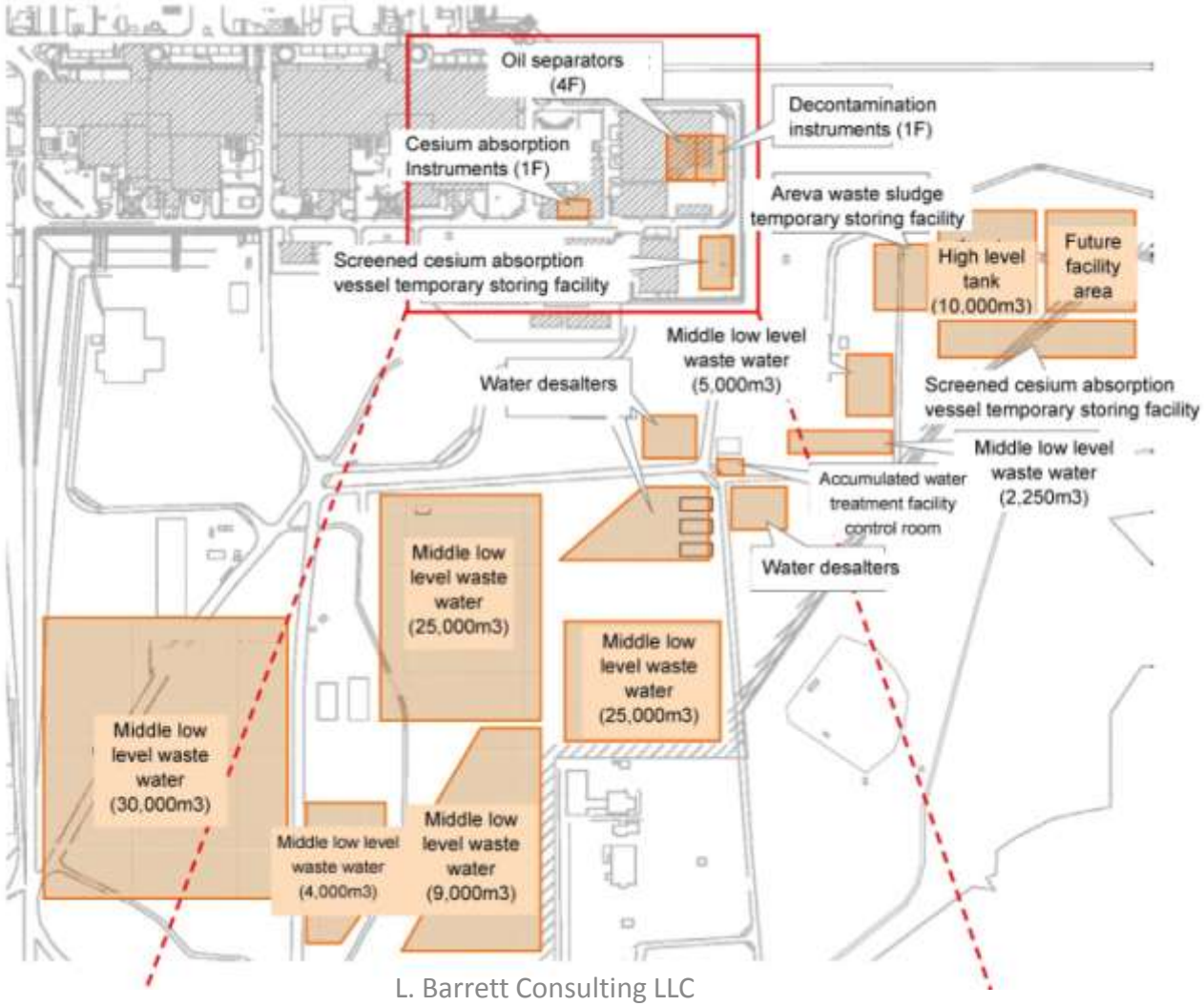
Chemical Injection Tanks

Installed Co-Precipitation Unit

Process System Locations



Water Tank & Systems Locations



Water Processing Difficulties With First Kurion/AREVA System

Many Systems Leaks & Issues

~60% Capacity

High Rad Sludge Management Challenges Will Emerge

New Water Processing System

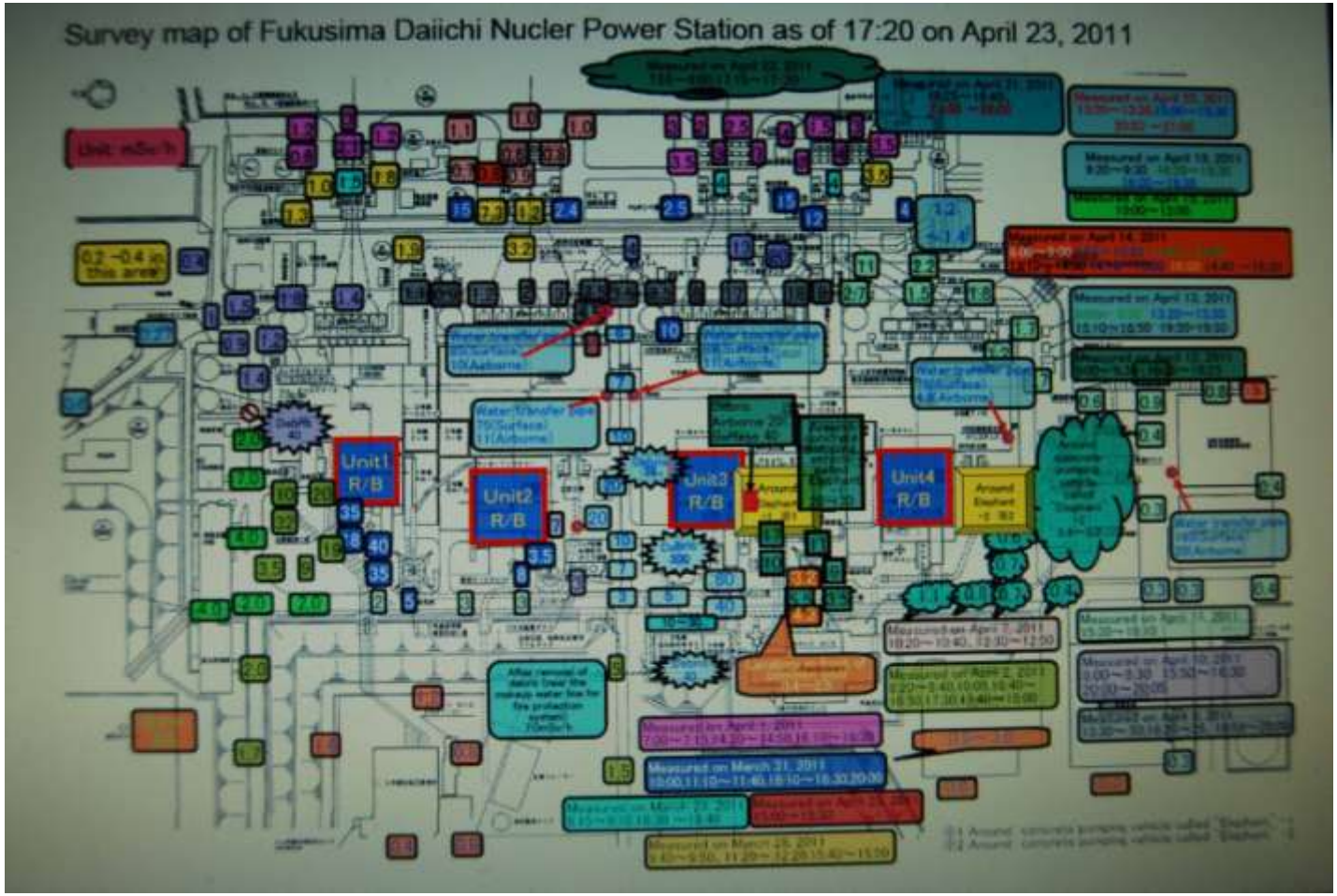
Simplified Active Water Retrieve and Recovery System (SARRY)

Toshiba Lead

2 Lines of 8 Larger (24Ton) Zeolite/Silicate Filter Beds to replace/augment Initial Kurion/AREVA System

Planned August Operation

Site Needs Extensive Decon



Debris Hotspots

100R/hr

Decontamination-Cleanup

High Radiation Field Work with Remotely Operated Equipment

Remote Equipment Operator

Remotely Operated Construction Equipment Reducing Gamma Field and Debris Removal

Decontamination Cleanup Solids

Remote Debris Removal
-90R/Hr Concrete Piece

Remote Debris Transporter
With Solid Waste Container

Onsite Solid Storage Area

~300+ 4M3 Containers to June

Solid Waste Handling Equipment

Shielded Fork Lift

Remote Controlled Equipment

On Site Personnel Facilities

Shielded Work Areas

Change House

Rest Areas

Off Site Personnel Facilities

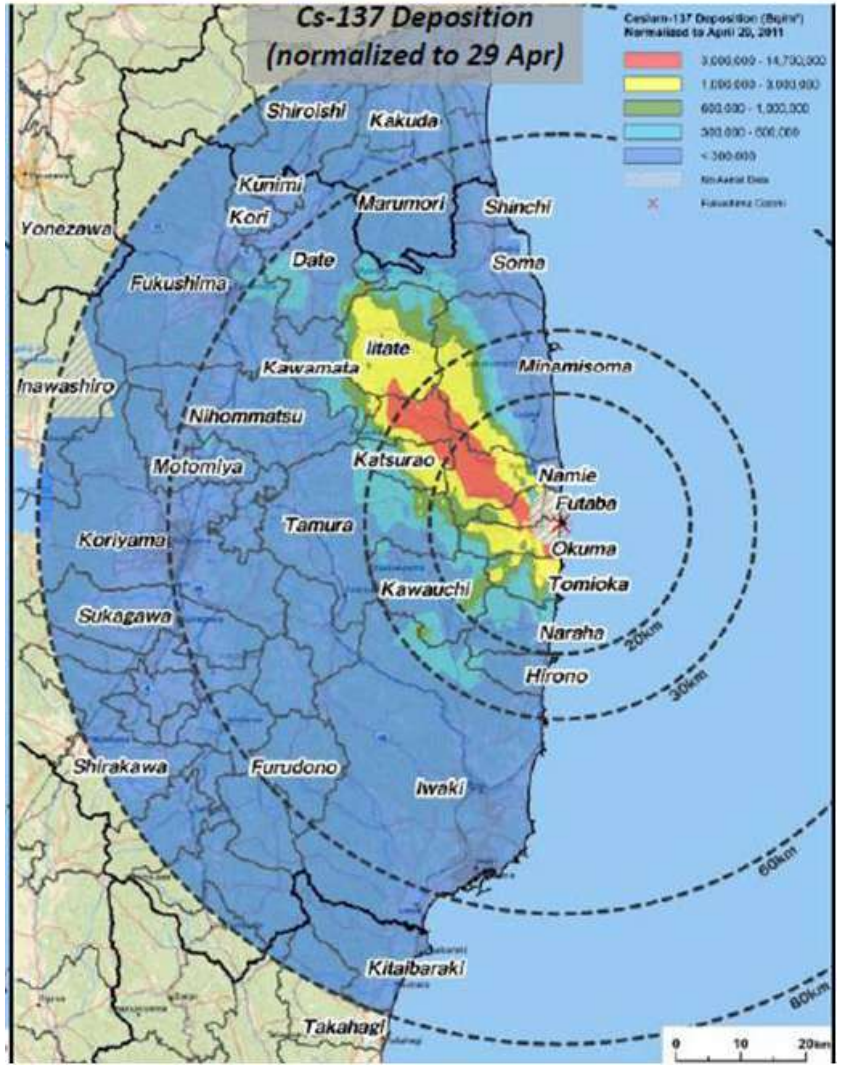
Temporary Dani Gym Dormitory

New Hirono Dormitory

Personnel Exposures

- ~4,000 Onsite Personnel
- Most are < 100 mSv (10R)
- ~100 are >100mSv (10R) < 250mSv (25R)
- ~6 are ~ 500-600mSv (50 to 60R)
  - Over Exposures
  - Internal Ingestions Issue
  - More Likely

Offsite impacts



Offsite Cs/Sr Contamination

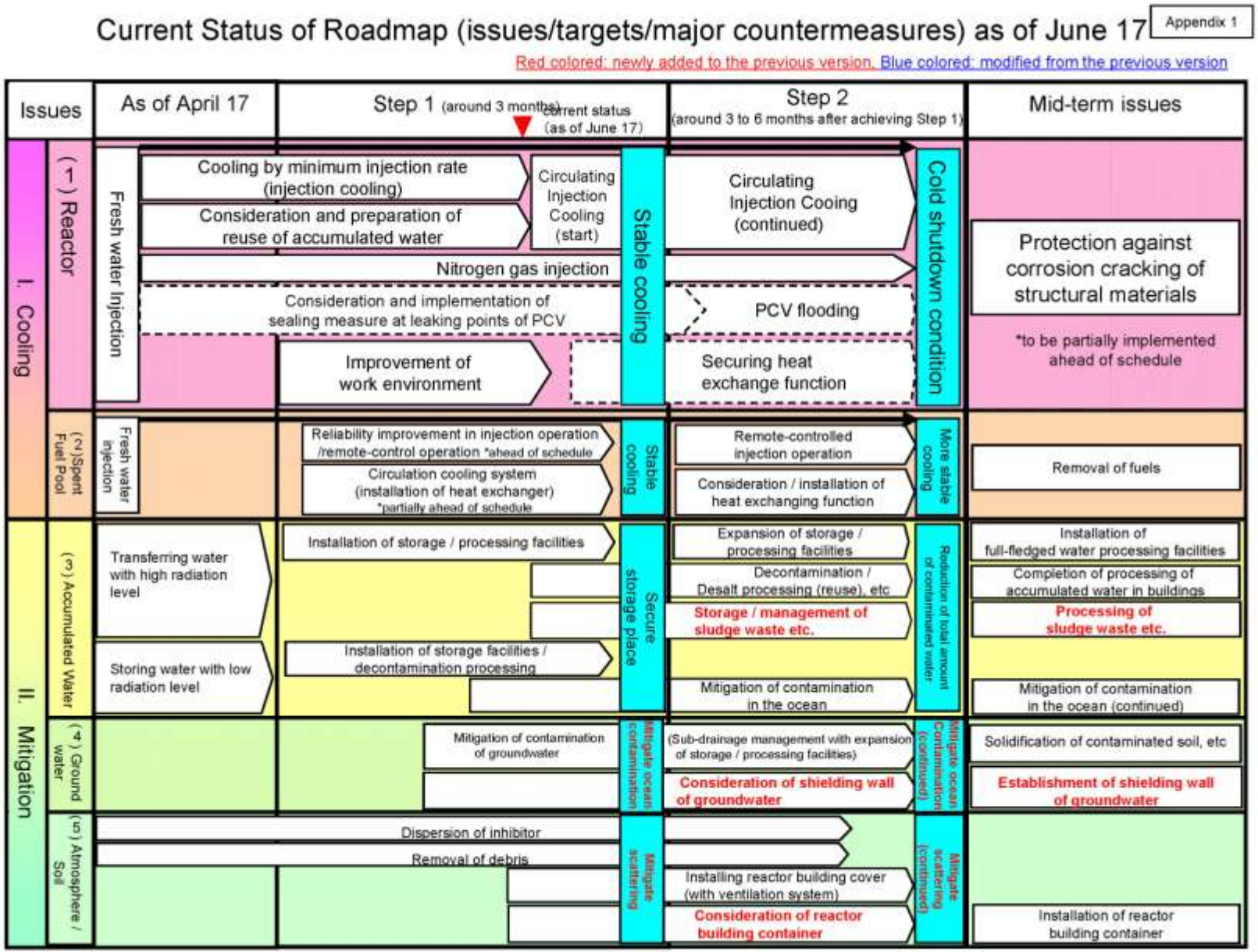
School Playground Dose Remediation

Offsite: Very Low Level Tsunami Debris

Millions of tons- Incinerate w Ash Disposal<8K Cs Bq/kg

Human Feelings & Reactions

TEPCO ROADMAP SEQUENCE 06-17



Current & Emerging Issues

- Maintain Sustainable Closed Cooling
- After Shock Structural Integrity
- Containment Degradation
- High Rad Water Containment
  ~30+ Million Gallons
- Highly Rad Water Processing Sludge
  - ~1,000R/hr range
  - 20-100 Mega Curie Amounts (TMI~1MCi)
  - Impact Site Recovery
- Building Containment/Filtration
- Offsite Remediation
- Management Restructure
- Regulatory Restructure
- Finance?

Internal Accident Recovery Phases

1. **Energy Heat Rejection Control**
   1. **Much Improved with Closed Residual Heat Removal**

- **Gas Release Control/Mitigation**
  1. **Containments**
  2. **Filtration**

1. **Liquid Release Control/Mitigation**
   1. **Control Highly Radioactive Water in Basements**
   2. **Initially Contain in Tanks**
   3. **Create Effective Purification Systems**
2. **Solids/Contamination Control Materials Management**
   1. **Contain/package**
   2. **Store/transport**
   3. **Dispose**

External Phases Of Accident

- **Plant Accident Recovery Period**
  - Impossible Information Demands
  - Stabilize/Remediate/Recover/Protect
  - Hours-Days-Weeks-Months-Years-Decades
- **Environmental Impact Period**
  - Public Perception/Impacts/Remediation (Offsite)
  - Weeks-Months-Years
- **Societal/Institutional Reactions Period**
  - Cultural
  - Political
  - Policy
  - Financial
  - Management

Personal Fukushima Observations

- **Not a Public Health Catastrophe**
  - Radiological Impacts Inconsequential Compared to Earthquake/Tsunami Impacts
- **Is An Industrial Plant Catastrophe Caused By A Natural Disaster**
  - The Tsunami was the Main Safety Issue
  - Three Melted Cores & Severely Damaged & Contaminated Buildings
  - Units 1-4 Complete Loss, Units 5 &6 Technically Recoverable
  - Cleanup Long & Expensive, but Technically Achievable (Much Larger than TMI)
- **Energy Dissipation is Getting Better, but Safety Challenges**
  - Aftershock Safety
  - System & Containment Degradation
  - Building Access Difficult
- **Environmental Release Mitigation is a Growing Challenge**
  - Water & Airborne Radioactive Effluents
  - Onsite & Offsite Environmental Impact Mitigation
- **Multiple Management, Social, Political & Economic Issues Ahead**
  - E.G. Waste & Spent Fuel Disposition Pathways
- **Lessons Learned Ahead**

Personal U.S. Nuclear Safety Observations

- **Current Reactors Have Adequate Safety Margins**
  - **U.S. Tsunami Risks are Limited To Only A Few U.S. Sites**
- **Past Risk Informed Severe Accident Improvements Have Already Addressed Many Fukushima Issues**
    - **Station Blackout & 911 Improvements**
- **Systematic, Methodical, & Risk Informed Fukushima Lessons Learned Evaluations Are Appropriate**
  - **Industry**
  - **NRC**
  - **Resist "Quick Fix" Emotional Reactions**
  - **Continuous Improvement Culture Will Further Strengthen U.S. Capabilities**
- **Lessons Learned From TMI Lessons Learned**
  - **TMI Lessons Learned Greatly Improved US Nuclear Safety and Productivity**
  - **Most Painful Lessons are the Most Teachable**
  - **Fukushima Lessons Should Improve Safety and Advance Global & U.S. Nuclear Energy As Three Mile Island Lessons Learned Did Thirty Years Ago.**

Lake H. Barrett

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Lake Barrett is a part time independent consultant in the energy field. He has worked in the nuclear energy and nuclear materials management areas for over 4 decades, most recently as the former head of the US Department of Energy's Office of Civilian Nuclear Waste Management which is responsible for implementing the United Sates' programs for spent nuclear fuel and high-level radioactive waste, as mandated by the Nuclear Waste Policy Act. In that capacity, he led the complex scientific Yucca Mountain Geologic Repository program through the statutory site selection process culminating with the Presidential site designation and following successful House and Senate votes.

He also served at U. S. Nuclear Regulatory Commission, where he was directly involved with the early response to the Three Mile Island reactor accident and became the Site Director, responsible for regulatory programs during the stabilization, recovery, and cleanup of the damaged reactor. He also has had extensive managerial and engineering experiences in DOE's Defence Programs and private industry at both Bechtel Power Corporation, with commercial nuclear power plants, and Electric Boat Division of General Dynamics with nuclear reactor and submarine systems design, operation, and decommissioning.