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Summary Technical Plan for TMI-2 Decontamination and Defueling

Metropolitan Edison Company
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SUMMARY
TECHNICAL PLAN FOR
TMI-2 DECONTAMINATION AND DEFUELING

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1.0 INTRODUCTION AND SUMMARY

Since the March 28, 1979 accident at TMI-2, the primary technical activity has been to achieve cold shutdown of the reactor, maintain reactor system stability, and protect the health and safety of the public. Other technical activities have focused on obvious near-term problems, which include cleaning up the radioactive water, auxiliary building decontamination, and gathering of sufficient data in order to complete a comprehensive plan for the decontamination and defueling.

To proceed with the decontamination and defueling in an orderly manner, formulation of an integrated technical plan has been in progress and is continuing. The plan will address the engineering, construction, and operational aspects of the decontamination and cleanup. It will specify technical activities to be performed.

The scope of this summary document is limited to containment entry and decontamination (Phase I) and fuel removal and reactor coolant system decontamination (Phase II).

The nature of the recovery necessitates a continually evolving technical plan as additional technical data and information are gathered, or as performance of implemented plans is assessed. New plan activities will be implemented as new information becomes available or as new options are developed or as other previously recognized options are foreclosed. It is intended that the technical plans be flexible and the planning effort be ongoing to recognize and accommodate this dynamic situation.

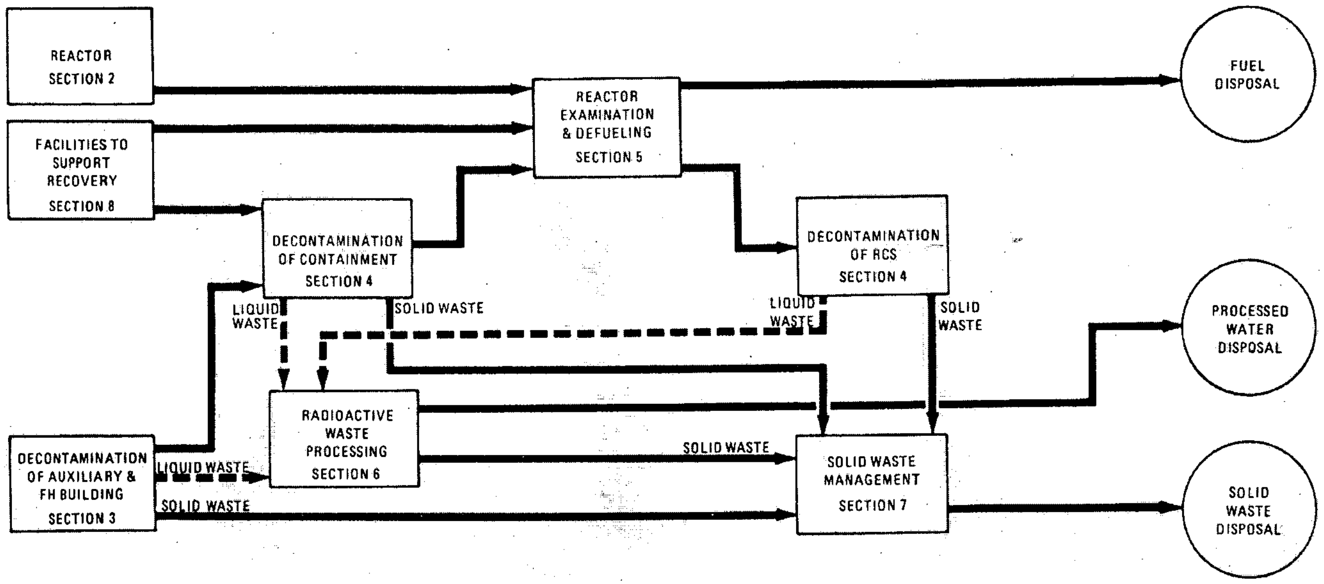
The major objectives of the TMI-2 decontamination and defueling plan are to:

- Maintain the reactor in a safe state,
- Decontaminate the plant,
- Process and immobilize dispersed fission products,
- Remove and dispose of the reactor core, and do so with maximum assurance of public health and safety.

Figure 1-1 presents an overview of the key activities which are individually summarized in other sections of this report.

The technical effort and planning to date concludes that TMI-2 can be decontaminated and defueled, and that resources and technology are available within the United States to perform this effort. The effort does represent, however, a major management and resource coordination challenge.

This decontamination and defueling can be accomplished within a time span of approximately 2 to 2-1/2 years from working entry to containment, given no unusual technical, regulatory, political, or financial constraints. Radiological control planning and preliminary environmental assessments concluded to date indicate no significant public health and safety impact arising from decontamination and defueling.



NOTE: THE RADIOLOGICAL CONTROL PROGRAM, SECTION 9, INTERACTS WITH ALL PHASES OF THIS PLAN

FIGURE 1-1

INTERRELATIONSHIP OF TECHNICAL PLAN TOPICS

2.0 REACTOR

The reactor is stable, under control, and imposes no immediate safety hazard. Decay heat is being generated by the core, the structural integrity of which is unknown. Cooling is by steaming through the "A" steam generator, with ultimate heat removal through the normal plant circulating water systems and cooling tower. Criticality control is by coolant boron concentration being maintained at greater than 3500 ppm. The scope of the reactor plan encompasses the long-term reactor cooling and criticality control, the primary system, the containment integrity, and auxiliary systems associated with maintaining and monitoring integrity.

Reactor plan objectives include:

- Remove decay heat in a manner compatible with decontamination and defueling plans, and with high reliability;
- Maintain reactor pressure and water inventory maintenance;
- Maintain reactor chemistry control;
- Eliminate or minimize structural disturbances to the core;
- Provide assurance of adequate reactor subcritical margin;
- Maintain emergency fallback operating modes for cooling and water inventory;
- Monitor for uncontrolled containment leakage.

The reactor decay heat generation rate is shown in Figure 2-1. Temperatures in the reactor coolant system are being kept as low as practical and still maintain adequate heat transfer characteristics under the current natural circulation cooling using "A" steam generator as a heat sink; the average reactor coolant temperature is between 160 and 170 F.

As decay power decreases, the natural circulation mode will become less stable and subject to increasing hydraulic fluctuations. At that point in the future when the reactor vessel head will be removed, natural circulation will not be a viable means of cooling. It is desirable, therefore, that the reactor be placed on a long-term cooling mode, in which temperatures and pressures can be individually adjusted and suitable for all operations through defueling. A special system (mini-decay heat removal, MDHS) has been designed and is being installed for this function. The MDHS transfers the reactor heat to the nuclear service water system and removes all thermal dependency from equipment in the turbine building or the secondary plant circulating water systems. Fallback or emergency cooling modes exist through the long-term "B" steam generator cooldown system, the normal in-plant decay heat system, and reversion to natural circulation.

Reactor pressure is maintained by balancing the supply and discharge from the reactor coolant system in a closed cycle operation. The standby pressure control (SPC) system, installed following the accident, is available as a backup. Water inventory can be maintained by makeup from either the normal supply system or from the SPC. Before the MDHS or other long-term cooling system is placed in operation, reactor pressure will be reduced from the current 275 to 290 psig range in steps to about 100 psig, as illustrated in Figure 2-1. Pressure reduction is desirable to reduce system leakage and necessary prior to going on a decay heat system. The precise pressure reduction schedule is yet to be specified.

Chemistry control has as primary objectives: 1) Maintaining boron concentrations greater than 3500 parts per million while monitoring of reactor coolant system and all water introduced to the reactor coolant system; 2) Maintaining oxygen concentrations as low as possible to minimize corrosion; 3) pH maintenance greater than 7.5; and 4) Controlling chlorides and other potentially harmful elements to the extent possible given other constraints on the reactor coolant system.

Prevention of significant flow forces from disturbing the core is accomplished by not operating main coolant pumps, and by using natural circulation cooling or decay heat removal systems with very low flow rates.

Containment pressure has been maintained slightly subatmospheric since March 28. The building has remained isolated, with only controlled openings for hydrogen recombiner operation, sampling of the atmosphere and the sump, and insertion of a television camera and radiation monitors. As presented in Section 6, it is intended to purge the Krypton-85 from the reactor building to permit personnel working access. Should containment cooling fans fail, the containment may revert to a positive pressure with resultant uncontrolled Krypton-85 leakage and higher site and offsite radiation exposures as compared to controlled purge.

The reactor and containment integrity is monitored by changes in:

- Reactor and containment temperature and pressure
- Containment sump water level
- Ground water radioactivity (wells surrounding containment to be installed)
- In-containment TV and radiation detectors
- Reactor coolant system water inventory balance
- Source neutron level
- Reactor coolant system chemistry

The general reactor plan is illustrated in Figure 2-2.

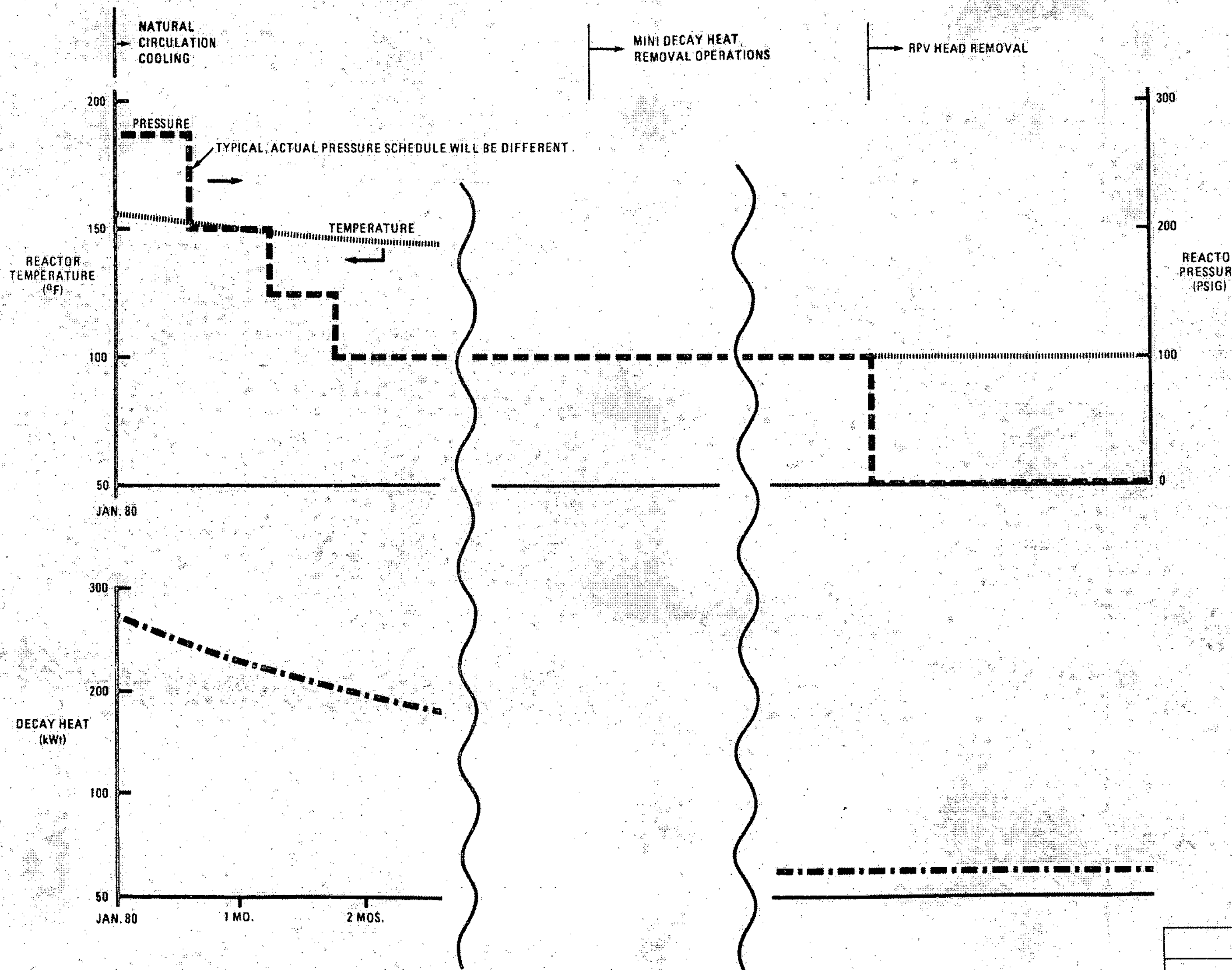


FIGURE 2-1

REACTOR PARAMETERS

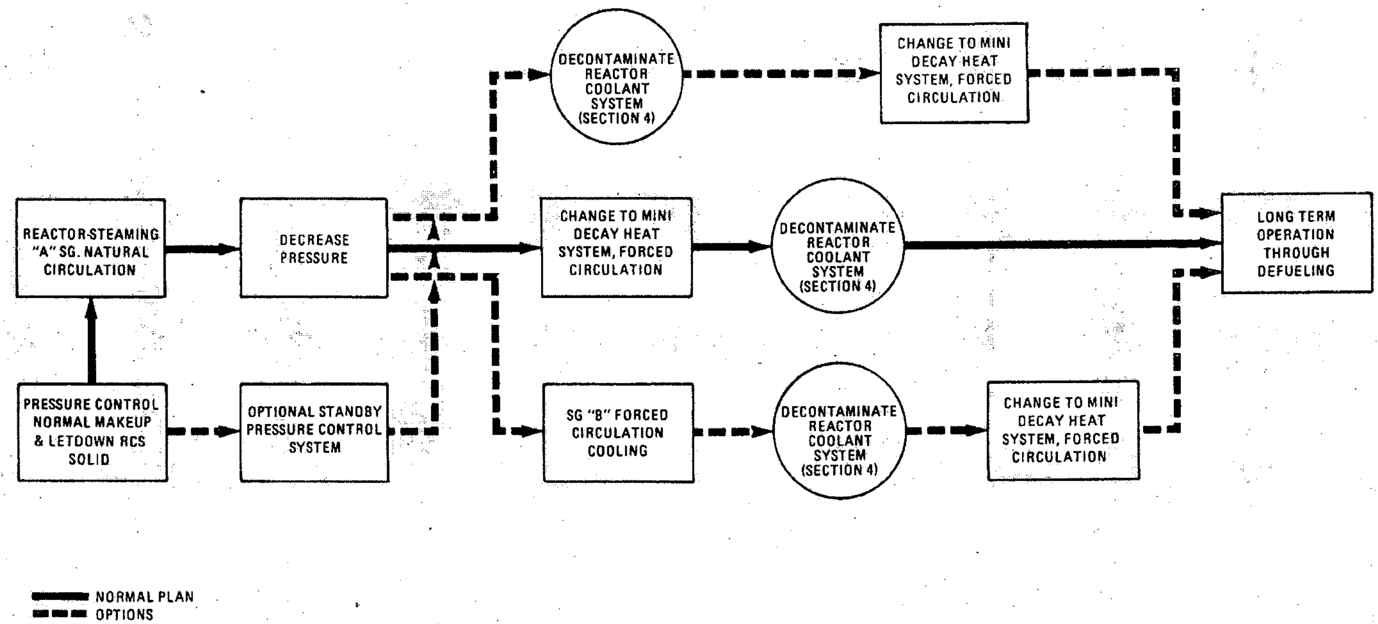


FIGURE 2-2

REACTOR PLAN

3.0 DECONTAMINATION OF AUXILIARY AND FUEL HANDLING BUILDINGS

Decontamination of the auxiliary and fuel handling buildings encompasses cleanup of the interior building surfaces, the exterior surfaces of the equipment, and the interior of ventilation and piping systems and their connected equipment, such as tanks.

The primary objective of the auxiliary and fuel handling building decontamination plan is to allow access without restriction because of surface or airborne contamination. Additional objectives are to minimize radiation exposure from gamma sources contained within piping and components and to eliminate beta activity from within piping and components to prevent recontamination in the event of leaks. These objectives will be considered achieved when the following criteria are satisfied:

- Smearable contamination is less than 1,000 DPM/100 cm^2
- Airborne contamination is within 10CFR20 limits
- General area radiation levels are at plant design values.

If the above criteria cannot be met, the levels will be reduced to as low as reasonably achievable and normal radiological control practices will be implemented.

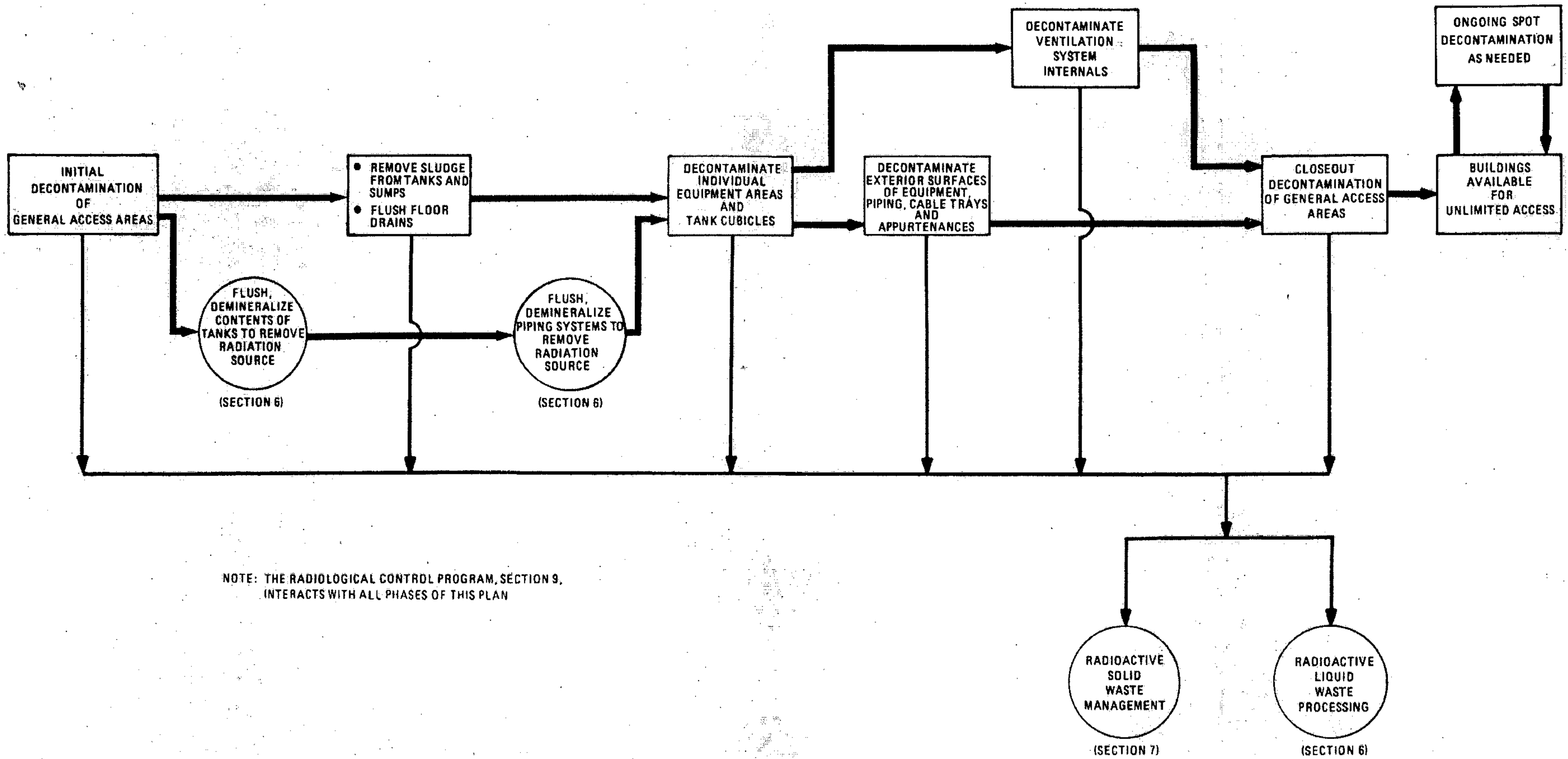
The open areas, passageways, stairwells, and other general access areas of the auxiliary and fuel handling buildings have been decontaminated to levels which allow unrestricted access. In order to decontaminate equipment areas, tank cubicles, and other individual areas, radiation sources internal to piping systems and tanks will first be removed in order to reduce the area dose rate from these sources. The sequence is shown in Figure 3-1. Removal of sludge from tanks and sumps, changeout of filters, and flushing of piping systems will be conducted. The schedule for these operations must be integrated with the processing of water as discussed in Section 6.

A number of decontamination techniques have been used in the auxiliary and fuel handling buildings. These include:

- Abrasive scrubbing combined with solvents and followed by wet-dry vacuuming for floors
- High pressure water jets on metal surfaces
- Manual wiping and dry vacuuming of electrical and other selected equipment
- Sandblasting or otherwise removing a layer of surfaces that have adsorbed contamination
- Coating of surfaces to fix and shield adsorbed beta sources.

The decontamination operation is being conducted in accordance with approved procedures that have been reviewed with respect to:

- Satisfying radiological control requirements
- Minimizing resultant radwaste volume
- Coordination with plant operations
- Compatibility with waste processing
- Effectiveness of techniques and solvents to be used.



NOTE: THE RADIOLOGICAL CONTROL PROGRAM, SECTION 9, INTERACTS WITH ALL PHASES OF THIS PLAN

FIGURE 3-1

DECONTAMINATION OF AUXILIARY AND FUEL HANDLING BUILDINGS

4.0 DECONTAMINATION OF CONTAINMENT AND REACTOR COOLANT SYSTEM

This portion of the technical plan addresses major in-containment cleanup work other than reactor defueling, which is covered in Section 5. The objectives of this work are twofold:

- To establish and maintain radiological conditions (i.e., general area radiation, airborne gaseous and particulate activities, and surface contamination levels) which will permit reactor defueling activities to proceed.

- To effect, upon completion of reactor defueling, decontamination of the reactor coolant system itself.

These two objectives are distinct and, in effect, will comprise two separate elements of containment recovery. The sequence and interrelationship of activities associated with each of these phases are shown graphically in Figures 4-1 and 4-2, respectively.

It is important to note that detailed planning and execution of work will be largely dependent on information developed in prior elements. This portion of the technical plan, at this point, can only be conceptual. However, it does represent a logical approach to the problem and provisions for methodical refinement and development as the recovery effort proceeds.

As shown on Figure 4-1, the initial steps in the containment decontamination are associated with the determination of radiological and physical conditions inside the building and improvement of those conditions to the extent necessary to permit access by the decontamination forces. The program for determination of conditions inside the building has included the following:

- Analytical reconstruction of the accident

- Obtaining and analyzing gas and liquid samples from inside the building, via remote sampling devices through existing penetrations in the building walls

- Obtaining and assessing direct radiation data from various sources and locations, both inside (via wall penetrations) and outside the building

- Visual examination of interior conditions via television camera inserted through an existing wall penetration

- Surface contamination samples.

These steps are essentially complete, and general area dose rates inside the containment are now estimated as shown on Table 4-1. With this information, the next step in the plan is to collect more comprehensive information via human entry into containment. Detailed plans for the initial entry are well under way and include selection and training of team personnel, preparation of procedures, determination of life-support equipment (clothing, breathing apparatus, communication equipment, etc.), and development of data gathering techniques. After this initial entry, it is expected that other exploratory entries will be planned and executed to collect data to aid in developing detailed recovery plans which minimize exposure to workers.

On Figure 4-1, containment purge (i.e., the controlled release of radioactive gases, primarily Krypton-85, currently in the building) is shown as a prerequisite to initial entry, with the option of entry without purge. While the latter option is physically possible, it is considered highly undesirable in that it would result in an additional radiation exposure to the entry team. Moreover, even if the purge is not accomplishd prior to the inital entry, the radioactive gas must be removed from the building before large-scale entry by decontamination forces. The current technical plan presumes that these gases will be removed via the controlled purge method, since that method is the simplest, safest, and only permanent solution available.

After access has been gained to the building, overall decontamination work will be done in two parts, first a gross decontamination and cleanup effort to decrease exposures from major sources as quickly and efficiently as possible, and then a local, more thorough "hands-on" decontamination to reduce radiation levels to a point which will allow defueling and subsequent recovery work.

There are several techniques for performing gross decontamination. The preferred techniques are those that involve the fewest personnel, the most directional coverage, and highest decontamination effectiveness. Steam jets, water cannons and sprinklers are among the techniques which are being evaluated. Final decisions as to the application of these techniques will be made in the detailed planning phase, based on information gathered by entry teams.

Some consideration has been given to accomplishing gross decontamination remotely (i.e., controlled from outside of containment) by spraying the containment with large volumes of water, and possibly detergents, chemicals, and steam, via the installed containment spray system. This method is shown as an option in Figure 4-1, but at this point such an approach is considered unlikely, in light of lower radiation levels as reflected in Table 4-1, uncertain effectiveness, and the large volumes of waste as well as possible equipment damage that could result.

Following gross decontamination, overall radiation levels will have been reduced, but more thorough manual decontamination techniques will be employed to further reduce radiation levels and to eliminate hot spots. The following manual techniques are being evaluated:

- semi-remote fire hose sprays
- hand-held steam nozzles
- hydrolasers

- grinding and/or needle guns
- manual or power scrubbing
- electropolishing of metal surfaces
- crushed ice impact sprays
- water cannons
- confined liquid freon spraying.

Because of the wide variety of techniques available, efforts are under way to determine which process will yield the highest decontamination factors with the least personnel exposure and with a minimum amount of waste. Final selection of techniques to be used will depend on the results of these evaluations, as well as on assessment of radiation and contamination survey data collected from various containment entries.

With respect to equipment and components inside the containment building, some may be completely decontaminated in place, using the techniques outlined above, while others will require decontamination in place followed by dismantling, further decontamination, and either disposal or refurbishment. Techniques chosen for each component must consider the potential for reusing the component. Again, final selection of techniques will be based on detailed survey information available after building entry.

The containment decontamination work will lead directly into the reactor examination and defueling effort described in Section 5.0. At the completion of that work, reactor coolant system (RCS) decontamination can proceed, as outlined graphically in Figure 4-2.

A major aspect of RCS decontamination, but one which cannot be defined or planned in detail until actual physical conditions inside the primary system are ascertained, is the cleanup of fuel debris. At this point it is assumed that some fuel material has been physically separated from the core and has been deposited in the reactor vessel or distributed elsewhere around the system. Furthermore it is presumed that some of this fuel debris will remain in the system after defueling, and must be removed. Techniques employed may be mechanical (such as vacuuming) or chemical, and they will probably require special development or adaptation to specific conditions encountered.

Following cleanup of fuel debris, it is expected that some removal of activity deposited on or absorbed into the system's corrosion film will also be required. Based on existing industry experience, it is anticipated that chemical techniques will prove to be the most effective for the work. A number of mechanical decontamination techniques, such as ultrasonics, hydrolasers, and ice-blasting, are also being considered and, if found useful, will be integrated into the overall RCS decontamination plan as applicable. Final selection of techniques will be based on analysis and testing with actual specimens of RCS materials, such as steam generator manway covers and control rod drive mechanisms.

In general, RCS decontamination will present a variety of technical problems, and it is anticipated that a number of organizations with specialized experience or capabilities will be called on to assist in their resolution.

Both containment and reactor coolant system decontamination efforts will require utilization of support facilities, such as the containment recovery service building and personnel access facility, as described in Section 8.0. Also, both of these activities will result in generation of liquid and solid radioactive waste material, to be processed and disposed of as described in Sections 6.0 and 7.0.

The completion of the RCS decontamination will permit subsequent containment recovery work, not covered by this technical plan, to proceed.

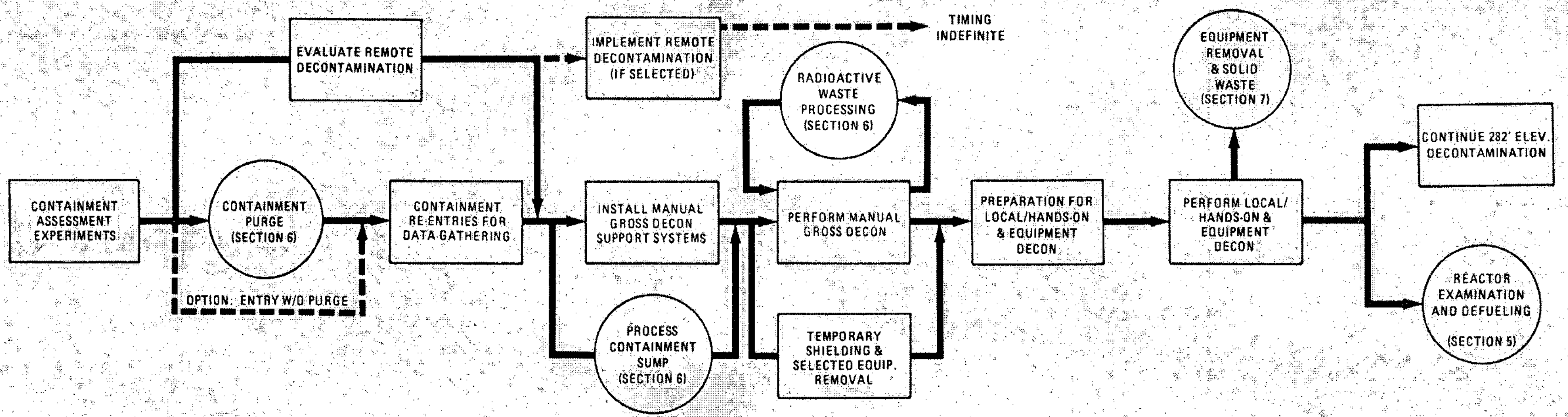
TABLE 4-1

TMI-2 Containment General Area Gamma Dose Rates (Rads/hr)*
(Normalized for decay to December 1, 1979, assuming sump has been drained and Krypton-85 purged)

Dose Points	Estimated in Initial Planning Study (July 1979)**	Estimate Based on Currently Available Information
Elevation 282'	2.2-19	1.2-9.9
Elevation 305'	6.6	0.26
Elevation 347'	320	0.51-0.7

*Does not include local hot spots.

**Initial planning study keyed on radiation levels measured by containment dome monitor. Later alternate measurements show that dome monitor was in a failed condition.



NOTE: THE RADIOLOGICAL CONTROL PROGRAM, SECTION 9, INTERACTS WITH ALL PHASES OF THIS PLAN

FIGURE 4-1

CONTAINMENT DECONTAMINATION

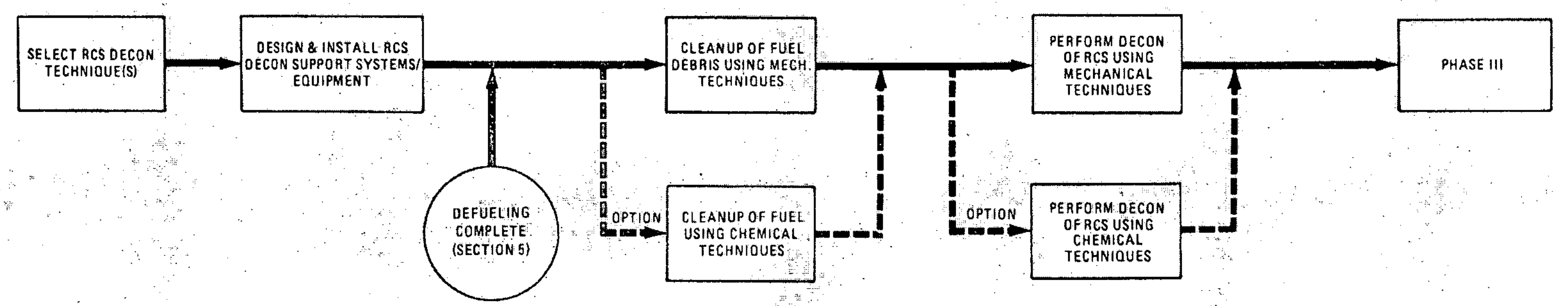


FIGURE 4-2

REACTOR COOLANT SYSTEM DECONTAMINATION & CLEANUP

5.0 REACTOR EXAMINATION AND DEFUELING

The examination of the reactor internals and removal of the fuel may represent the most complex operation of the recovery. The planning complexity is heightened by the uncertainty surrounding the actual physical configuration of the core and reactor vessel upper internals. The scope and primary objective of reactor examination and defueling are to:

- o Provide through analysis and inspection information assurance that the reactor vessel head and the upper internals can be removed without disturbing the existing core configuration
- o make the core accessible by removing the reactor vessel head and upper internals
- o remove the fuel and encapsulate it for transfer to the spent fuel pool.

Other activities that will be required in order to meet these objectives are the creation of special inspection and handling mechanisms, preparation of the area around the reactor vessel head, preparation of the reactor internals for decontamination, and modification of the spent fuel pool to hold encapsulated fuel prior to shipment. Figure 5-1 shows the overall sequence of these activities.

Because of the uncertainty regarding the actual core condition, planning activities must develop several alternatives for the foregoing activities. As the results of examinations become available and the preparatory activities are completed, the optimum approach will be selected and developed in detail sufficient to establish final designs and procedures.

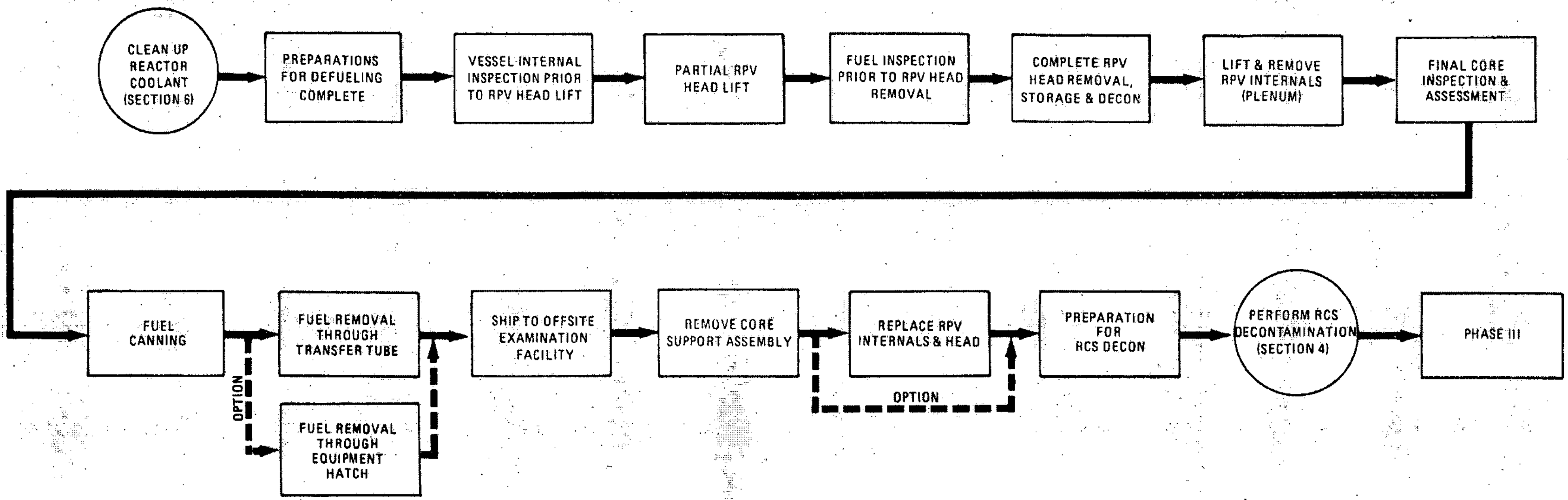
In general, after preparatory activities are complete, and prior to the reactor pressure vessel (RPV) head lift, a thorough evaluation to verify the methods for uncoupling of control components will be conducted. The RPV head lift will be made and continue to a height sufficient to permit additional inspection of the upper plenum area. When the head is removed, it will be lifted out of the refueling canal and placed on its storage stand on the operating deck. Additional temporary shielding will be installed to reduce the radiation levels associated with the head and service structure.

Prior to upper internals removal, inspection will be performed through the 69 control rod guide tubes and through the lattice area of the upper internals to assess the core conditions. In order to detect any mechanical binding of the upper internals a load cell will be used to determine the force being exerted by the crane during the lift. Visual inspections and hold points will occur throughout the lift to obtain the maximum information regarding the status of the core. When the upper internals lift has proceeded to about 2 feet, larger underwater cameras with better lighting will be inserted into the annulus between the internals and the core support assembly. Video inspection of the entire top of the core will be conducted. The lift will then continue until the upper internals clear the reactor vessel.

With removal of the internals, the top of the core will be exposed for a thorough inspection. This examination will provide a basis for the final selection of the optimum fuel removal technique and a sequence for removal of the fuel assemblies. It is anticipated that the first assembly removed will be on the core periphery, the most likely location of fuel assemblies which can be lifted intact. Complete video scans of the top of the fuel and the sides of each assembly when it is removed from the core will ascertain and record conditions of the fuel assemblies. Once the first peripheral fuel assembly is removed, a camera can be lowered into the vacated location to determine the condition of adjacent fuel assemblies. Removal of peripheral assemblies, which are anticipated to be intact, but structurally weakened, requires new fuel handling tools be designed which will provide means for lifting and transporting an assembly in a manner which generates no tensile forces in the assembly. Custom designed equipment will be utilized for removal of the more centrally located assemblies which are anticipated to have been geometrically reconfigured. This equipment may include vacuum or other debris extraction devices. Failed fuel cans to limit the leaching and spread of contamination will be used. The actual procedure for movement of the fuel into the cans will depend on many factors which will not be known until the condition of the fuel is assessed. The fuel will then be staged for shipment to a fuel examination facility for detailed inspection and experimental activities.

The primary method for reactivity control will be by maintaining boron concentration in the reactor coolant system greater than 3500 ppm. Special instrumentation will be installed for reactivity measurement.

A special materials accountability program will be implemented for fuel accountability.



RCS = REACTOR COOLANT SYSTEM
RPV = REACTOR PRESSURE VESSEL

NOTE: THE RADIOLOGICAL CONTROL PROGRAM, SECTION 9, INTERACTS WITH ALL PHASES OF THIS PLAN

FIGURE 5-1

REACTOR EXAMINATION AND DEFUELING

6.0 RADIOACTIVE WASTE PROCESSING

Radioactive waste processing activities addressed in this section include the collection, treatment, handling, and solidification of liquid radioactive waste. Subsequent on-site staging and off-site disposal of resultant solidified material are discussed in Section 7. Section 6 also addresses the program for removal of radioactive gas from containment.

The primary objective of liquid radioactive waste processing is to reconcentrate radioactive fission products which are dispersed in liquids and as surface contamination throughout the plant. This processing will result in waste forms suitable for safe handling, storage, and disposal consistent with applicable regulatory requirements.

With respect to radioactive gas processing, the primary objective is to remove radioactive gaseous material (primarily Krypton-85) from the containment in a manner which is safe, expeditious, and consistent with applicable regulatory requirements and technical specifications.

There are two general categories of radioactive water which will require processing:

- accident water, i.e., water which was contaminated with fission products during the accident and is now retained within the reactor coolant system, containment sump, or in auxiliary building tanks

- decontamination (decon) water, i.e., water which will be used in cleanup of systems, structures, and equipment contaminated during the accident, and which will become contaminated in the process.

Quantities and characteristics of accident water are presented in summary form in Table 6-1. Quantities, chemical, and radionuclear characteristics of decon water are not yet well defined.

Reconcentration of fission products contained in accident and decon water will be accomplished by a variety of systems specially designed and installed at TMI-2 for that purpose. These treatment systems can be described briefly, as follows:

<u>EPICOR-II</u> - This system employs a series of filters and ion-exchangers (or "demineralizers") to remove suspended and dissolved impurities (both radioactive and non-radioactive) from contaminated water. EPICOR-II has been specifically designed for treatment of "intermediate level" accident water, contaminated to a level between 1 μc/cc and 100 μc/cc. The major source of this class of water is that which was released from the primary plant and transported to the auxiliary building early in the accident. Fission products removed from water treated by this system are captured via ion exchange on organic resin materials in steel liners. When depleted these liners are removed from service, stored, and will ultimately be disposed of. The resultant water

effluent from the system is essentially non-radioactive except for tritium content which is unaffected by the ion exclusive process.

The EPICOR-II system has been in operation since early October and as of December 1 has successfully processed about 65,000 gallons (about 15% of the intermediate water in the auxiliary building).

Evaluations are under way which consider modifications of the EPICOR-II system to permit its use for other processing requirements, such as the water in the reactor coolant system (RCS).

Submerged Demineralizer System (SDS) - The SDS is an ion exchange system conceptually similar to the EPICOR II system, but designed to accommodate much higher levels of radioactive waste water, such as that presently retained in the RCS and containment sump. There are two major differences between the SDS and the EPICOR II system. The SDS will utilize inorganic ion exchange materials (Zeolites) which permit far higher radiation loadings than organic resins. The SDS system will be located underwater in the TMI-2 spent fuel pool, to provide shielding from high radiation levels to be encountered during operation.

Effluent materials from the SDS include contaminated ion exchange materials in liners, and processed water which contains tritium and only trace amounts of other radioactive isotopes.

The SDS system is being fabricated and should be operational in the latter half of 1980. Because of possible schedule problems, particularly the competing needs for the fuel pool by the SDS and preparations for fuel storage, some alternatives to the SDS are being evaluated. These include modifications to the system to simplify it, thus making it available sooner, and other major design changes which would permit processing in locations other than the spent fuel pool. Both of these alternative concepts would require some combined use of this system with EPICOR-II.

Evaporator/Solidification System

Since ion exchange systems may not be suitable for processing of decon solutions containing detergents or other chemical cleaning agents, it may be necessary to provide other means of reconcentrating fission products from decon water. An evaporator/solidification facility has been selected for this purpose. This facility is in the detailed design phase and will contain a large capacity radwaste evaporator, associated support systems including tankage, feed treatment, filtration, process control, polishing, solidification of concentrates, and storage and handling capabilities.

Since this system is inherently quite complex, the total installation will require at least two years. Once installed, however, the system will be useful not only for treatment of decon solutions, but also for treatment of any residual accident water.

Low Activity Waste Processing System

At the present time, TMI-2 low activity waste water (water not generated by the accident and having fission product concentrations less than 1 μCi/cc) is being processed by an ion-exchange system called EPICOR-I. In time, this system will be reserved exclusively for TMI-1 use, and a replacement system will be provided for TMI-2. Such a system is in the conceptual design stage now.

Plans are being made to provide solidification capability for the concentrated radioactive materials resulting from EPICOR II, the SDS, and the evaporator. Solidification of radioactive evaporator concentrates is normally required as a prerequisite to shipment and burial, and the required equipment will be provided as part of the evaporator solidification facility. Solidification of contaminated ion exchange materials has not normally been required in the nuclear industry, but such a requirement has been formally invoked by NRC for EPICOR II resins and is expected for SDS ion exchange material as well. As a result of this action by NRC, plans are under way to provide solidification capability for EPICOR II and SDS ion exchange material.

All processing systems are being designed to produce effluent water which meets all established discharge quality standards. At this time, however, TMI-2 is prohibited by court order from discharging any accident water, even if processed, into the Susquehanna River. Because of the long term uncertainty of this issue, large processed water storage tanks are being installed on-site and additional methods of disposing of processed water (such as evaporation, and solidification) are being examined. Also, it is intended that processed water be recycled for cleanup or other plant use to the maximum extent possible.

It is necessary to remove the radioactive Krypton-85 gas from the containment. It is intended to accomplish this via a controlled release of the gas to the atmosphere. This method is a safe, simple, and permanent solution to the problem, presents no safety hazard to the public, and is in compliance with all applicable regulations and technical specifications. Technical and safety evaluations have shown this method to be superior to any alternates which have been proposed. As discussed in Section 4.0, containment purge is a prerequisite to containment and RCS decontamination.

TABLE 6-1

Radioactive Water Status

LOCATION	APPROXIMATE QUANTITY (Gallons)	DEGREE OF CONTAMINATION (Activity, μCi/ml) Tritium	Gross Activity
1. Auxiliary and Fuel Handling Building Tanks and Sumps	350,000	<0.3	10-70
2. Reactor Coolant System	90,000	<0.3	200 (approximate)
3. Containment Sump	700,000	1.0	250 (approximate)
4. Future Decontamination Water	Unknown	Variable	Variable

Note: 65,000 gallons of water has currently been processed through EPICOR II and is stored in the EPICOR II facility.

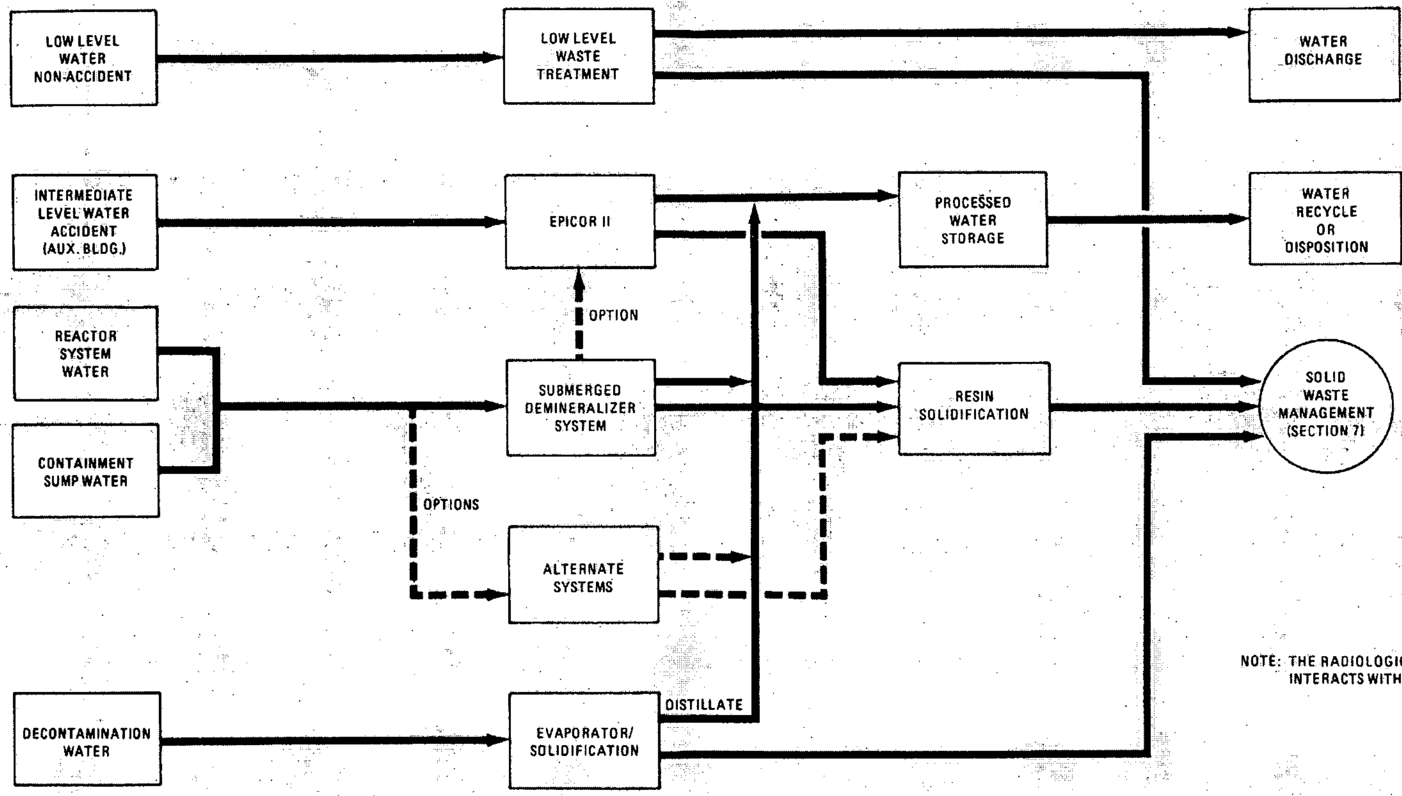


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FIGURE 6-1

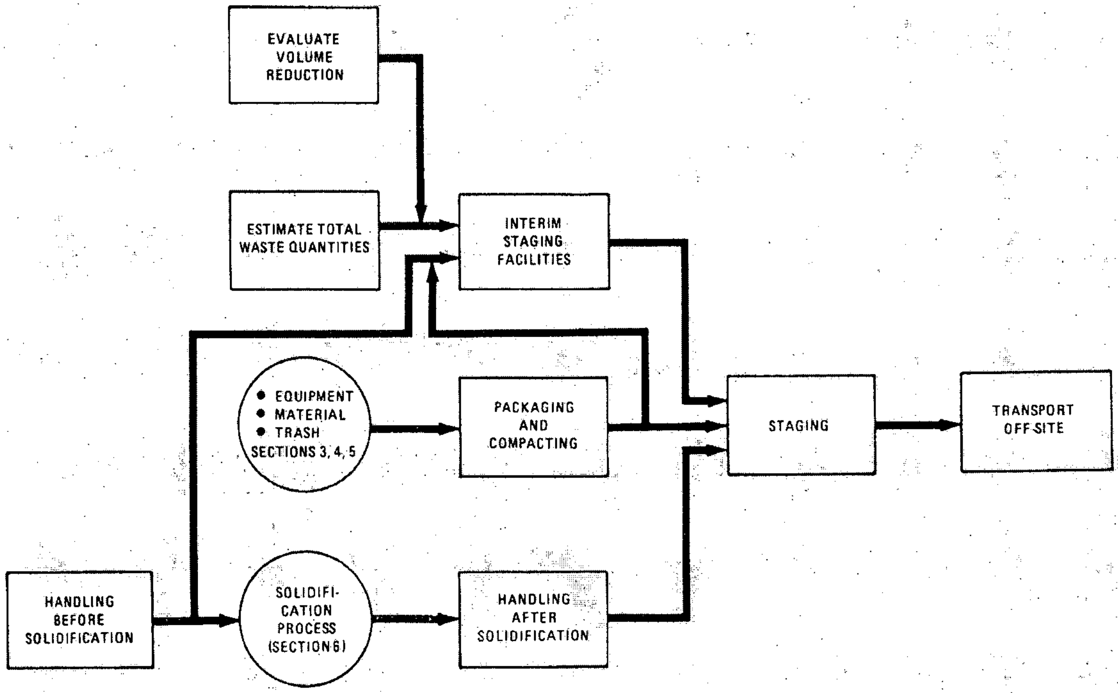
RADIOACTIVE WASTE PROCESSING

7.0 SOLID RADIOACTIVE WASTE MANAGEMENT

The objectives of solid waste management are to safely accumulate, package, stage, and make available for transport offsite all solid radioactive waste material. This is to be accomplished in a manner which does not create personnel hazard, spread of contamination, satisfies packaging, shipping, and disposal regulations. Disposal of the reactor fuel is specifically excluded from this section and is discussed in Section 5.0.

The largest source of solid radioactive waste results from cleanup materials expended in the decontamination efforts. Another major source of solids includes the products of processing water contaminated as a result of the accident and used in decontamination operations, including demineralization material, filter elements, and evaporator concentrates. Plant equipment and materials for which decontamination is not feasible or effective from the standpoint of cost or personnel dose also contribute to the solid radioactive waste inventory.

The management of solid radioactive wastes primarily consists of inventory control and radiological protection. The major engineering requirement is determining the criteria for size, type, and operational dates of required staging facilities. After waste quantities are projected, the staging facilities can be sized and constructed. This is shown in Figure 7-1. Special technical requirements will apply to handling highly radioactive solids such as demineralizer liners and evaporator bottoms. The movement, storage, and disposition of solid waste must be monitored by a suitable inventory tracking system. Facilities are outlined in Table 8-1.



NOTE: THE RADIOLOGICAL CONTROL PROGRAM, SECTION 9, INTERACTS WITH ALL PHASES OF THIS PLAN

FIGURE 7-1

SOLID WASTE MANAGEMENT

8.0 FACILITIES

TMI-2 recovery operations require support facilities in addition to those existing prior to the accident. These additional facilities include:

- those which directly support recovery technical activities
- those which result from indirect or peripheral requirements

Direct recovery facilities are needed to support the significant increase in the number and diversity of personnel working on the site, support decontamination and the increase in radioactive waste processing and staging, and to maintain conditions safe for workers and the general public. A mixture of temporary and long-term facilities will result.

All recovery support facilities, including those required for radioactive waste processing, are summarized in Table 8-1. Radioactive waste processing facilities are further discussed in Sections 6 and 7. Figure 8-1 is a facilities plan identifying specific locations on the TMI-2 site for each major facility.

TABLE 8-1

Facilities Required for TMI-2 Recovery

FACILITY	DESCRIPTION	PURPOSE	STATUS
Containment Recovery Service Building	Concrete and steel structure. Includes HVAC systems with particulate filters, decontamination capability, misc. service equip., heavy handling capability, and truck access	Provide control of contamination during recovery, contain equipment and systems used during cleanup, provide staging for removal, decontamination, packaging, and shipment of equipment and materials removed from the containment building.	Detailed criteria being defined; preliminary design initiated.
Personnel Access	Steel construction. Includes lockers, change areas and showers, and personnel monitoring equipment.	Provide personnel control with changing, cleaning, and monitoring facilities adequate to support the large numbers of personnel expected to participate in containment cleanup operations.	Detailed criteria being defined; preliminary design initiated.
Health Physics	Undefined at this time.	Provide capability for calibrating health-physics instruments, health-physics measurement technique development.	Detailed criteria being developed
Chemistry & Radiochemistry Laboratory	Steel building. Includes internal contamination controls and shielded counting areas.	Analytical and radiochemistry analysis to support processing and decontamination, fluid samples, surface samples from low to high activity levels. Minimize/eliminate dependency on outside laboratory efforts.	Detailed criteria being developed.

TABLE 8-1 (Continued)

FACILITY	DESCRIPTION	PURPOSE	STATUS
Laundry	Temporary or frame building. Includes HVAC system with exhaust filtration, small liquid radwaste collection.	Clean large quantities of anti-contamination clothing and respirators with fast turn-around time.	On-site dry cleaning and off-site commercial laundering are being evaluated.
Command Center	Steel Frame Construction. Including TV and communications systems and monitoring instrumentation.	Provide central and overall control for the containment decontamination, cleanup and recovery (as an adjunct to, but not a replacement for, the plant main control room).	Detailed criteria being defined.
Administration Building	Standard commercial office building.	Provide working space for technical, administrative, and clerical personnel, and to house central files, computer terminals, document control, and site library.	Specification approved; out for bid.
Site Upgrading and Modifications including Guard Facility, TLD Building Expansion, Security Processing Center, South Bridge, Drainage, Sewage Treatment, etc.	Misc. small bldgs., sewage treatment plant, and site upgrading. System modifications to separate Units 1 & 2 (sampling, fuel bldg. atmosphere, demineralized water, etc.)	To separate Units 1 and 2, and to provide adequate capacity and durability of support services and functions to accommodate Unit 2 operations	Various stages of completion.

TABLE 8-1 (Continued)

FACILITY	DESCRIPTION	PURPOSE	STATUS
EPICOR II	Ion Exchange System	Process contaminated water ≧1μCi/ml.	In operation
Unit 2 Low Activity System	Ion Exchange System	Process non-accident water ≦1μCi/ml. Processed water suitable for discharge.	Criteria being defined.
Submerged Demineralizer System (SDS)	Ion Exchange System	Process relatively high activity water (Other options being studied and system may be modified).	In design/fabrication
Evaporator/Solidification	Evaporator and solidification system, housed in new concrete/steel structure.	Process/decontamination water. Treat/solidify concentrates in a form suitable for shipment.	In design
EPICOR II Solidification	Undefined	Solidify resin liners from EPICOR II	Concept definition
Processed Water Storage Tanks	Large capacity water storage tanks	Temporary storage for processed water	Two 500,000 gal. tanks on order, additional tankage requirements being studied
Interim Liner Staging	In-ground, shielded concrete storage vaults	Store resin liners from EPICOR I, EPICOR II, and SDS	One module in place, 2nd module in const., total of six planned
Interim Waste Staging	Steel building, truck access, fire protection	Storage of miscellaneous compacted and uncompacted radioactive trash.	Criteria being developed, some existing site facilities in temporary use.

TABLE 8-1 (Continued)

FACILITY	DESCRIPTION	PURPOSE	STATUS
Equipment and Material Staging	Steel/concrete structure	Stage, prior to shipping, all packaged radwaste not accommodated in other facilities. Provide interim storage to decouple from tight dependency on off-site disposal	Criteria being defined
Maintenance	Undefined	Support normal plant maintenance and balance-of-plant layup	Criteria being defined

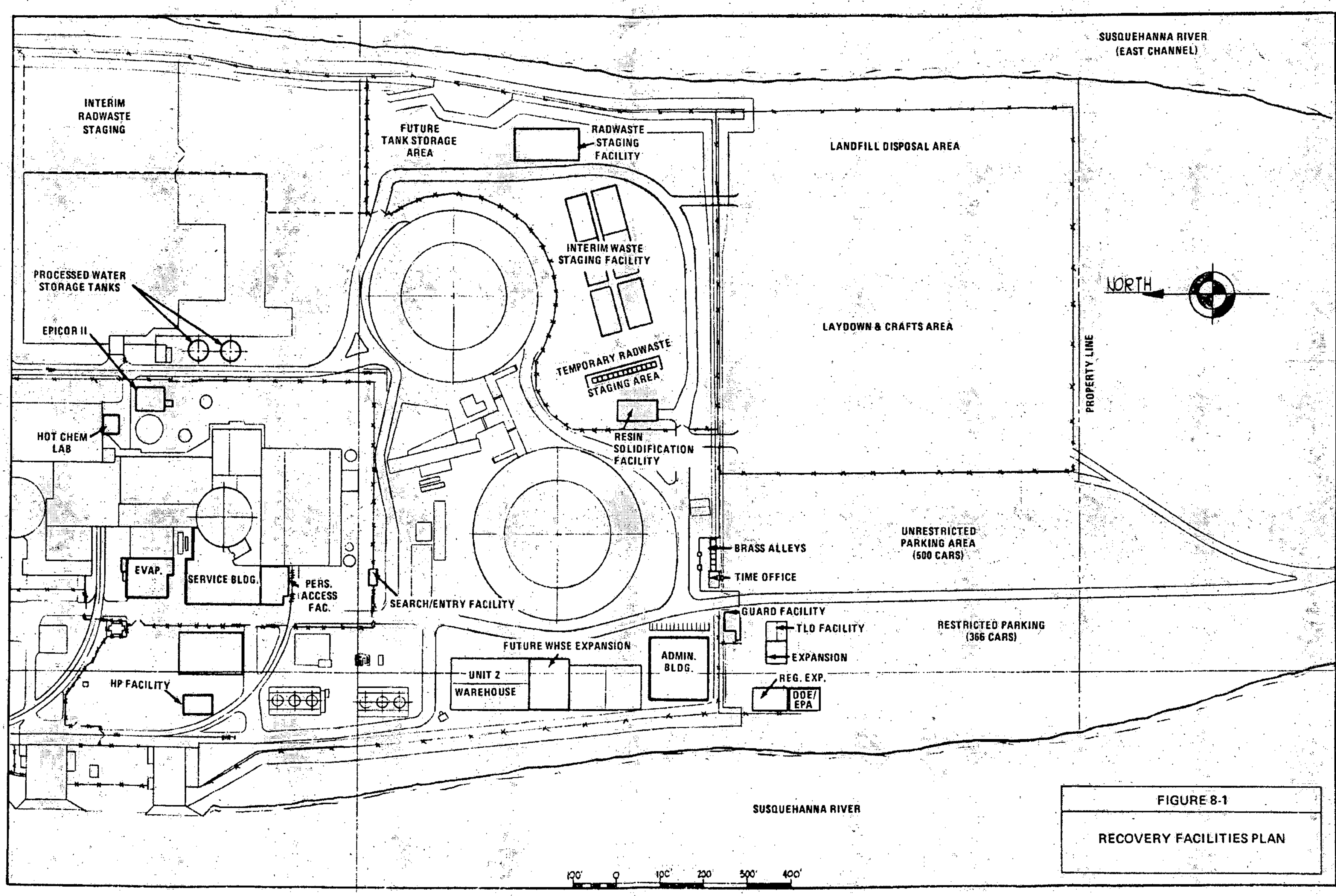


FIGURE 8-1

RECOVERY FACILITIES PLAN

9.0 RADIOLOGICAL CONTROL

The accident which occurred at TMI-2 has created an environment of radiological conditions which is unique to the commercial nuclear power industry. These conditions include high levels of contamination and work in high radiation fields. The accident has focused a tremendous amount of attention on the subject of radiological control as it relates to both worker exposures and releases to the environment.

The radiological control program, shown on Figure 9-1, must be fully integrated into the recovery effort. As such, elements of the program will have an impact on activities associated with the technical plan. Specific objectives of the radiological control program are the following:

- o maintain individual and cumulative external exposure to as low as reasonably achievable (ALARA)
- o prevent significant internal exposure to radioactivity
- o prevent uncontrolled release of radioactive material to unrestricted areas.

The bases for radiological control shall be the NRC Radiation Protection Plan and the plant technical specifications. Some specific regulations invoked by the above include:

- o 10CFR 19, which addresses worker protection
- o 10CFR 20, which provides radiation protection criteria
- o 10CFR 50, which outlines emergency planning requirements and requires adherance to the "As Low As Reasonably Achievable" (ALARA) principle with respect to occupational exposures and to releases to the environment
- o 10CFR 71, which provides packaging and shipping criteria.

The radiological control functions that are applicable to this technical plan are:

- o occupational exposure control
- o in-plant contamination control
- o prevention of uncontrolled releases to the environment
- o effluent control and monitoring
- o environmental monitoring.

Occupational Exposure Control

Limiting radionuclide ingestion by personnel is normally accomplished by engineering controls including process, containment, and ventilation. When such controls are not feasible, respiratory protection is required. Monitoring and air sample analysis provides warning of the presence of airborne radioactivity.

External radiation exposure is limited by measures such as decontamination, processing to remove sources, engineering design (including modifications such as temporary shielding), administrative controls such as work planning and rehearsal, access control, and administrative exposure authorization requirements. Considerations of external occupational exposure are vital in developing the overall recovery schedule, equipment, facilities, and sequence.

In-Plant Contamination Control

Contamination control is exercised by maintaining the integrity of systems and components that contain radioactive material, as well as by administrative measures. When operations require opening contaminated systems or moving contaminated items, contamination control methods shall be used to prevent the uncontrolled spread of radioactive material. Contamination control considerations shall be incorporated into the design of facilities and process systems and the criteria for operations and maintenance activities to prevent the inadvertent release of radioactive contamination.

Prevention of Uncontrolled Releases to the Environment

Systems, facilities, and procedures which are being developed in support of TMI-2 decontamination and defueling reflect the principle that releases to the environment must not occur in an uncontrolled fashion.

Effluent Control and Monitoring

Effluent control includes all components and procedures (such as filters, processing systems, etc.) which are designed to control releases to the environment "As Low As Reasonably Achievable" (ALARA) as prescribed in Appendix I to 10CFR 50 and implemented via the plant environmental technical specifications. Verification of compliance with these specifications is achieved by the effluent monitoring program which measures the release of radioactive material from the plant via air and water pathways. The environmental monitoring program provides additional verification by measuring the impact on the environment.

Environmental Monitoring

A comprehensive sampling bioassay and analysis program is in operation to assess the effect, if any, of the accident on the environment surrounding TMI-2.

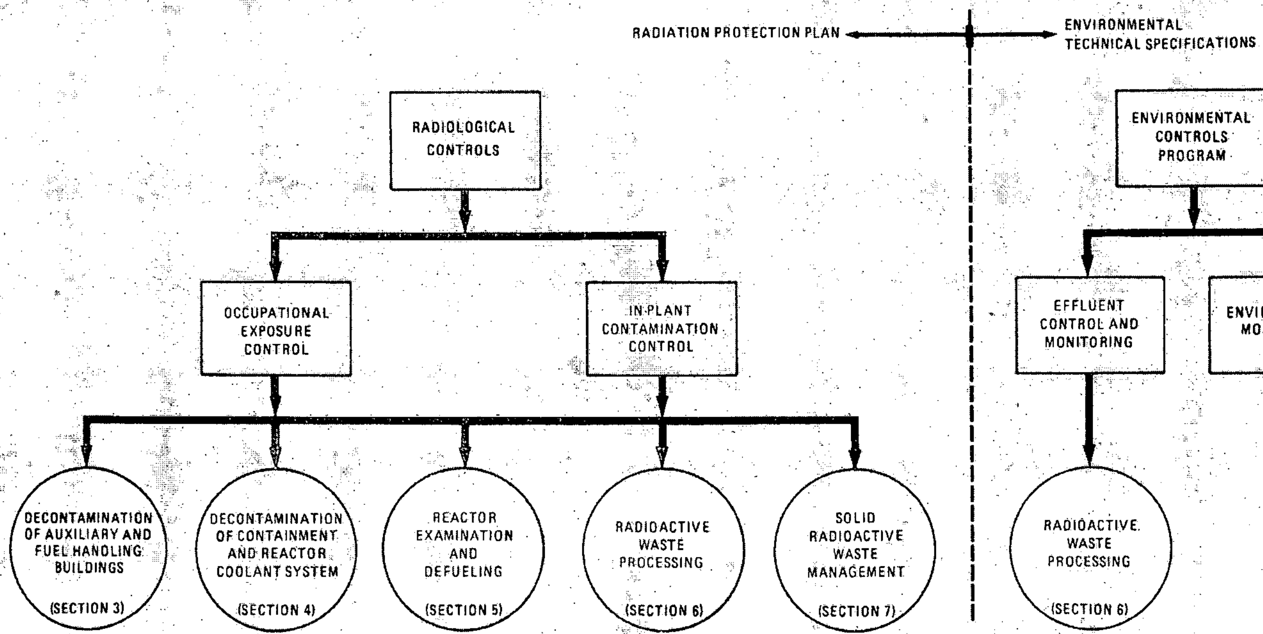


FIGURE 9-1

RADIOLOGICAL CONTROL PROGRAM

APPENDIX A

General Schedule and Assumptions

The schedule shown in Figure A-1 represents the first two major phases of the overall recovery effort at TMI-2. The schedule addresses significant activities of Phase I and Phase II and reflects the logic set forth in this report.

Phase I, Containment Entry and Decontamination, commences at the time of the accident, 3/28/79, with plant cooldown. This phase is complete after containment decontamination. The key events of Phase I include Krypton-85 purge, containment entry, accident water processing, site facilities completion, auxiliary building decontamination, and containment decontamination. The containment decontamination activity will extend in time past the start of Phase II.

Phase II, Fuel Removal and Reactor Coolant System Decontamination, commences with preparation for reactor pressure vessel head removal. This phase is complete after reactor coolant system decontamination. The primary milestones for Phase II are reactor pressure vessel head removal, fuel removal, and reactor coolant system decontamination complete.

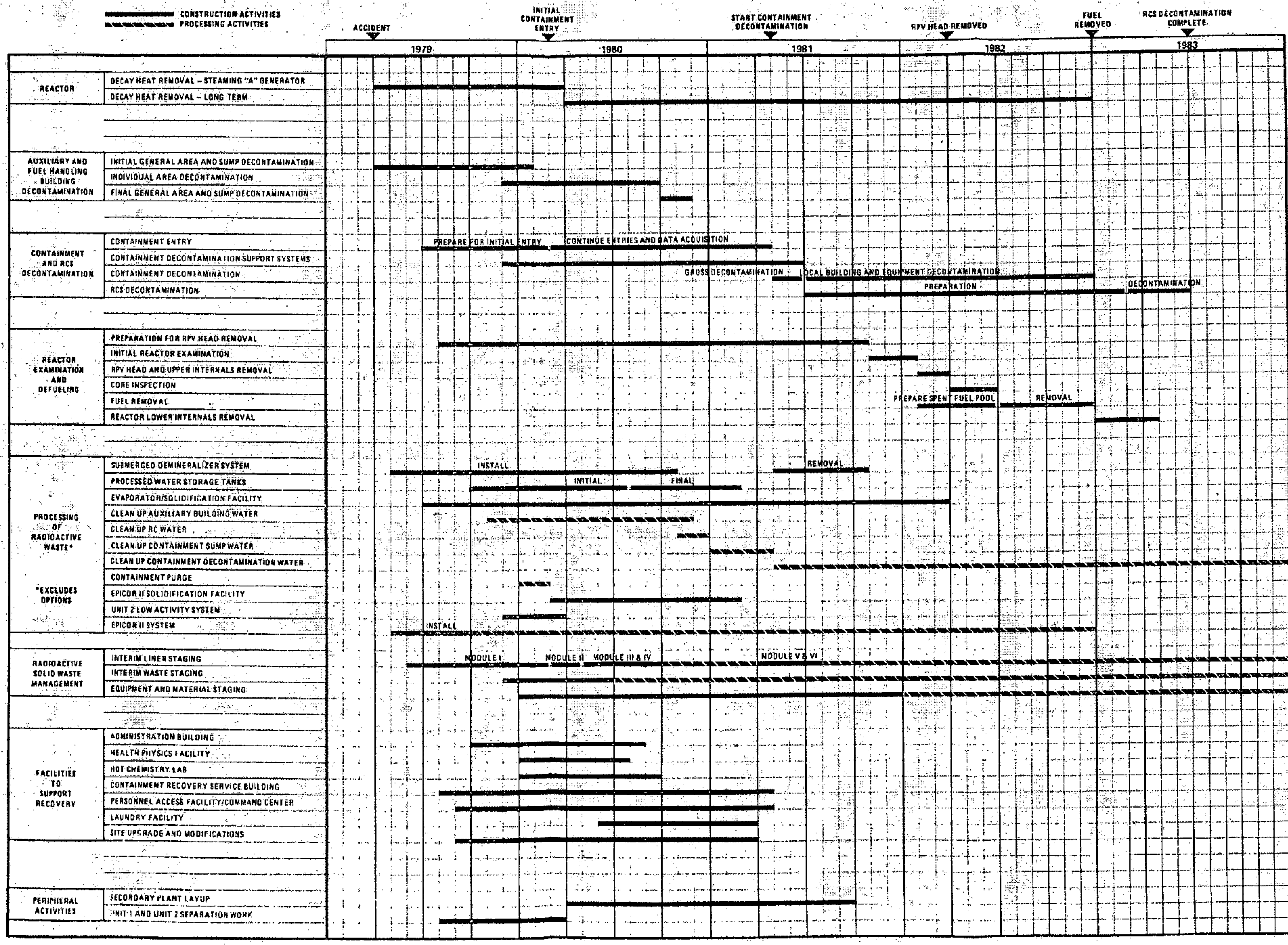
This schedule will be significantly influenced by many factors which cannot be defined precisely at this time. The following major assumptions and qualifications are reflected in the development of this schedule.

- There are several planning studies and option evaluations currently being conducted which will undoubtedly result in schedule changes.
- The radiochemical status has not been completely defined at this time.
- Financial limitations may further impact these scheduled dates.
- It has been assumed that required NRC approvals will be obtained as shown in Appendix C.
- It is assumed that a stable regulatory environment exists throughout the recovery schedule.
- Extraordinary political or legal actions are assumed not to impact TMI-2 recovery.
- It is assumed that the recovery schedule will not be impacted due to craft labor and material availability.
- Off-site radwaste disposal will be continuously available.

- Unique capabilities of industries or government agencies can be made available as needed for TMI-2 recovery.

- Research and development are assumed to not significantly impact the recovery schedule.

FIGURE A-1
TMI-2 RECOVERY SCHEDULE
PHASE I AND PHASE II



APPENDIX B

Key Recovery Decisions

There are several decisions which will have a significant impact on the planning of recovery technical activities; some of these decisions have supporting studies under way. These decisions are presented in Table B-1 for Phases I and II and are referenced to the appropriate sections of this report. Required NRC approvals are treated separately in Appendix C.

TABLE B-1

Key Recovery Decisions

REPORT SECTION	DECISION	SIGNIFICANT FACTORS
2	Timing of use of the mini-decay heat removal system (early 1980).	System availability, reactor coolant system processing, alternate cooling system capability, magnitude of natural circulation instabilities, etc.
2, 4, 6	Initiation of containment purge (early 1980).	Affects containment entry, containment decontamination and subsequent recovery activities; awaiting NRC approval.
4	Timing of containment entry (early 1980).	Data acquisition is essential to follow-on recovery planning.
4	Remote decontamination implementation (mid 1980).	Data acquisition from containment entry needed to evaluate if remote decontamination can be of significant benefit. System construction may be required. Implementation may dictate additional radioactive waste processing capability.
4	Selection of chemicals used in containment and reactor coolant system decontamination (early 1980).	Impacts potential for future requalification of equipment, compatibility of liquid waste processing systems.
4, 9	Selection of methods for reducing beta radiation exposure (early 1980).	Beta activity may be controlling; special radiological controls and engineering developments may be required.
4, 5	Method of requalification of polar crane (mid 1980).	Refurbishment in-place is preferred; other options may extend schedule.

TABLE B-1 (Continued)

Key Recovery Decisions

REPORT SECTION	DECISION	SIGNIFICANT FACTORS
4	Method for reactor coolant system decontamination after fuel removal (mid 1981).	Long lead times may be required. Chemical decontamination, if chosen, will require more extensive preparations.
4	Method for retrieval of fuel debris from reactor coolant and other systems (late 1980).	Confidence that the method selected will assure complete removal.
4	Procedures for reactivity control during in-vessel activity (early 1981).	Special monitoring instrumentation is required, control methodology.
5	Methods for removal of RPV head and upper internals (late 1980).	Uncertainty regarding condition of reactor internals and effect of these operations. Special unique tooling will be required.
5	Handling method for fuel removal (early 1981).	Uncertainty regarding condition of the core and retention of integrity when removed.
6	Disposition of tritiated water (early 1981).	Storage capability, water management flexibility, alternate disposal methodology.
6	Optimum system configuration for cleanup of reactor coolant system (early 1980).	Timing of cooling by mini decay heat removal system, maintainability of cooling systems, auxiliary building cleanup.

TABLE B-1 (Continued)

REPORT SECTION	DECISION	SIGNIFICANT FACTORS
6	Optimum system configuration for cleanup of containment sump water (early 1980).	Installation of the SDS in the spent fuel pool, alternate processing options, gross decontamination schedule dependency.
6	Definition of solidification facilities (early 1980).	Transportation restriction, acceptability of solidification techniques, facility availability.
7	Definition of radioactive waste staging facilities (early 1980).	Processing and decontamination methodology, ability to estimate waste quantities, ability to estimate site staging buffer time, etc.

APPENDIX C

Required NRC Approvals

Identified and itemized below are dates for significant regulatory approvals upon which this technical plan is based. It is assumed that the NRC site office remains fully cognizant of the status of work leading to the preparation of major NRC submittals.

1.	Purge of Krypton-85 from containment	January 1980
2.	Initial containment entry plans	February 1980
3.	TMI-2 radiological protection plan	February 1980
4.	Transfer of reactor to long term cooling mode	March 1980
5.	NRC TMI-2 environmental impact statement available	July 1980
6.	Discharge of processed and cleaned accident water (within technical specification limits)	January 1981
7.	Design basis for all processing systems and facilities installed on site	30 days following submission of criteria documents
8.	Operation of all processing systems and facilities installed on site	At the time of system availability
9.	Summary plan for containment decontamination	30 days after submittal
10.	Summary plan for reactor defueling	30 days after submittal
11.	Summary plan for reactor and reactor coolant system decontamination and cleanup	30 days after submittal
12.	Planning document for reactor fuel transportation offsite for examination	30 days after submittal
13.	Site procedures	3 days after submittal
14.	NRC approval for the interim storage onsite of projected quantities of radioactive waste	30 days after submittal

APPENDIX D

Applicability of NRC Regulatory Guidance

The recovery effort involves three major concerns that directly influence design and operations. These concerns are environmental impact, public health and safety, and occupational dose reduction. Many of the recovery activities contain first-of-a-kind operations that require innovative solutions and are, therefore, beyond the main stream of typical power reactor design. Each of these activities will be carefully evaluated by Metropolitan Edison against current regulations to ensure minimal environmental impact, lowest public risk, and occupational exposures meeting "As Low as Reasonably Achievable" guidelines. The current regulations are sufficient to cover the breadth of recovery activities at the TMI-2 site.

During the design of the facilities and services for the recovery effort, regulatory documents (e.g., Regulatory Guides, Standard Review Plans, and General Design Criteria) will be reviewed for applicability, taking into account the low stress condition of the plant and temporary nature of many of the facilities. When applicable, current sections of the appropriate documents will be considered part of the design criteria. It is the intent that facilities and systems constructed solely for the recovery period will not be designed to regulatory guidance based on hypothesis of accidents at power. Rather, the low pressure, low temperature condition of the recovery facilities will be used as the bases for design and safety evaluation. This will result in simplification of the design, improved schedule, lower occupational exposure, and cost savings, without additional public risk or environmental hazard. Structural design codes will be determined in part by the temporary or permanent nature of a particular building or system, and in part by the hazard imposed by the failure of the structure.

Guidance for design and operation of facilities to minimize occupational exposure will be developed primarily by adhering to the "As Low As Reasonably Achievable" principle outlined in Division 1 and 8 Regulatory Guides. Radiation protection procedures and practices are being implemented to maintain occupational exposures within the requirements of 10CFR20. Existing radiological effluent limits of the TMI Unit 2 Technical Specifications will be used as upper bound design limits for effluent products and the TMI Unit 2 Environmental Technical Specifications will be used as a design objective. These limits are consistent with the existing license and operational "Final Environmental Impact Statement."

In general, most facilities and services constructed for the recovery effort only will be separate from existing facilities and services. This approach minimizes the impact on existing facilities and services and thus minimizes the possibility of compromising their original design bases. Permanent additions to plant facilities will be designed to provide the maximum long-term compatibility with the existing plant facilities while fulfilling the objectives of the recovery program.

APPENDIX E

Peripheral Site Activities

During the recovery period various activities will be initiated or continued which are not directly related to recovery. These activities can be categorized as indirect support activities, generally administrative in nature, or routine plant maintenance or layup. Some of these activities were planned or evaluated prior to the TMI-2 accident, while others would not have been necessary or cost-effective had the accident not occurred. A summary description of these activities follows.

Separation of Unit 1 from Unit 2 - To enable Unit 1 restart operations to proceed unimpeded by Unit 2 recovery operations, Unit 1 will be separated from Unit 2 as completely as is practicable. The major shared structure is connection of adjoining fuel handling buildings. The major shared system is the low-level radwaste processing system; an evaluation is under way to determine the best means of achieving separation of this system. Several service functions such as the fire main, potable water, sewage treatment, industrial waste, and others do not require separation nor directly impact plant operation.

Turbine and Auxiliary System Layup - Several auxiliary and power producing systems will not be used during the recovery. In order to preserve them for future use, a program of protective layup will be conducted.

Administration Building - A permanent administration building is desired to accommodate approximately 300 persons. The building will house site administrative services and technical support personnel.

Guard Facility - As part of the program to separate Unit 1 from Unit 2, a separate access control facility will be constructed.

TLD (Dosimetry) Building Expansion/Security Processing Center - The existing TLD building will be expanded to house facilities for personnel clearance and indoctrination with respect to health-physics and security requirements.

Upgrading of the South Bridge - In order to implement recovery operations with minimum impact on Unit 1, it will be necessary to upgrade the south bridge to provide full capacity access to the Unit 2 end of the island.

Upgrading of Other Site Support Services - To accommodate the large numbers of personnel expected to be involved in recovery activities, such services as sewage treatment, parking lot accommodations, and site drainage will be expanded or upgraded as necessary.

APPENDIX F

Research and Development

The TMI-2 accident was the largest, single integral safety test of a complete PWR reactor and associated systems. As undesirable as the accident was, the existence of the plant in its current condition presents opportunities for significant extension of the industry's safety knowledge. In addition, the decontamination and cleanup activities themselves provide opportunities for the development or testing of new techniques and new systems which can have generic industry-wide benefit and importance to the nation.

It is recognized that the industry, governmental research and development organizations, and regulatory agencies will desire to extract all available information from TMI-2. To facilitate this research and development effort, the GPU System, the Department of Energy, the Nuclear Regulatory Commission, and the Electric Power Research Institute are developing a joint cooperative program. Through this program it is expected the reactor core, selected equipment from within containment, and the broad scope of cleanup and decontamination data will be made available to all interested groups. Off-site fuel and equipment examination will be facilitated and coordinated. Installation of demonstration facilities at the TMI-2 site, as they relate to decontamination and waste processing development, could be important for the country as a whole.

The detailed technical planning for research and development has just begun. The plans reflected in this report have not as yet integrated the results of proposed research and development tasks. The GPU System will attempt to accommodate this research and development within the TMI-2 recovery, recognizing that customers of the Metropolitan Edison system cannot be expected to bear the cost burden of development effort nor recovery schedule perturbations.