APPENDIX 20A

AP1000 OUTLINE DECOMMISSIONING PLAN

20A.1 Introduction

The “AP1000 Outline Decommissioning Plan” demonstrates the technical and practical feasibility of one method by which the AP1000 can be safely decommissioned. It provides assurance that decommissioning can be safely accomplished within the currently acceptable limits of personnel exposure to radiation.

A basic premise for this option is that the major components will be removed as complete units and processed in a waste facility in close proximity to, but away from the plant. The preferred process will be to remove complete components and process them in the purpose built facility. Waste processing and volume reduction activities will be conducted in the buildings only where necessary. This will provide the maximum opportunities for robot applications for cutting and handling in a facility specifically designed for it. This will also provide opportunities to implement measures to reduce personnel exposure.

It is also practicable to dismantle components in situ; however, this option is not considered in this document.

At a predetermined point during the operating life of the plant closer to the end of that period, a detailed decommissioning plan will be commissioned, which will expand or improve upon the provisions identified herein. It will also reflect the improved technology that will be available at that time.

The removal and disposal of the conventional buildings and equipment that are not active waste are not addressed herein, but will be a part of the detailed commissioning plan to be generated later. The sequence in which these activities will be implemented will also be a part of the detailed decommissioning plan.

This document does not address the disposal of non-nuclear waste, but does recognize that the detail decommissioning plan must address the total plant decommissioning scope. In essence, the same measures taken to reduce active waste must be implemented to reduce waste in total.

The process described herein incorporates the staged process set out in Section 20.3.

Before beginning any dismantling work, an identified area will be erected within the site boundaries suitable for use as an intermediate-level waste/low-level waste (ILW/LLW) solid waste process area. The facility will be large enough to facilitate storage of at least two steam generators, one reactor vessel, and sundry other equipment; and will include a remote handling and waste reduction process area. This is not shown in Stage 1 because it is assumed this will be designed and installed prior to decommissioning. The identified area has not been finalized; however, it is considered that it may be close enough to tie into the plant’s active drain system.
This will be one of the two the areas where the waste will be reduced to appropriate sizes and processed in accordance with the applicable radiological disposal requirements. ILW waste will also be stored and processed in the modified spent fuel building as shown in Stage 2.

The nature of the AP1000 design is amenable to all options described herein, but lends itself to the immediate dismantlement option. This approach does not require the significant civil engineering effort associated with the Safstor approach.

The significantly reduced building volumes are the result of a design that has less equipment, piping, and the like, than a conventional PWR; thus the potential for a much reduced radiological waste inventory exists. Table 20A-1 provides an estimate of the overall quantities of residual waste.

20A.2 AP1000 Design Features Facilitating Decommissioning

20A.2.1 AP1000 Design Features for Radiation Protection

The AP1000 design provides features for protection against radiation including the following:

- Plant and building layout, which incorporates substantial shielding
- Elimination or minimization of materials used in the construction, which may give rise to activity, activated components/commodities
- Primary circuit chemistry requirements, which minimize corrosion products

Equipment maintenance access requirements will be incorporated; for example, remote working, based on ALARP principles, which will similarly support decommissioning.

20A.2.2 AP1000 Design Features for Protection Against Limitation of Contamination

The AP1000 design provides features for protection against the occurrence and spread of contamination, including the following:

- Sealed surfaces, including steel wall and floor surfaces, which prevent penetration and facilitate decontamination
- Provision of HVAC within the secondary containment areas, which limits contamination spread
- Spent fuel pit design incorporates thicker and larger plates

Where possible, this plate becomes the formwork. This eliminates the potential for voids between the plates and the concrete, which eliminates the potential for unsupported areas of plate and thus potential for high stress areas.

The larger plates significantly reduce the amount of welds and particularly in situ welding. Welds performed before installation can be volumetrically inspected. In addition, reduction in the weld
surfaces reduces the damage to the plate surface finish. Leaks in the spent fuel pit are primarily associated with welds that have been significantly reduced in quantity in this design. In addition, leak chases are provided. These provide for evidence of leakage and direct any contaminated leakage flow to the waste handling systems. They also prevent the leaching of active fluid into the concrete should a leak occur.

The same advantages are applicable to the refueling water storage tank and the reactor cavity.

20A.2.3 AP1000 Design Features Supporting Decommissioning

The AP1000 design incorporates features which facilitate decommissioning as follows:

- Access routes for equipment have been considered in the design; optional routes are available through the equipment hatches. Temporary access through the steel containment is easily provided and controlled.

- Specific equipment at the lower levels has been provided with removable shielded hatch covers; for example, CVCS demineralizers.

- The polar crane structure has sufficient capacity to handle heavy equipment with the addition of a larger capacity hoist module. In addition the polar crane can accommodate the upper assembly of the steam generators between the girders.

- Laydown areas have been provided for protecting and wrapping potentially contaminated equipment prior to transportation to the site decontamination and sorting facility(s).

- Removable gratings have been used for floors to facilitate the transport and handling of equipment.

- Where practicable, floor slabs have been designed to support the weight of equipment during the decommissioning process.

Decommissioning commences after normal end-of-life cessation of electrical power generation and the safe shutdown of the plant to stable conditions.

Stage 1 may begin as soon as the plant ceases to generate power as defined above; however, there is a need to allow the core barrel radioactivity levels to decay to a level where it can be safely dismantled and packaged in accordance with the requirements in force at that time.

It is anticipated Stage 1 will take approximately 2 years, while Stages 3 and 4 will be approximately 6 years each. These durations may be reduced and activities implemented in parallel when the final decommissioning plan is generated.

20A.3.1 Stage 1—Description of Activities

The principal activities to be accomplished during Stage 1 are as follows:

- Removal of fuel from the reactor and disposal per the established practices
20. Decommissioning

- Cleaning, decontamination, and surveying of all areas to facilitate dismantling and removal from site of all readily removable radioactive items
- Preparation for, and implementation of, the chemical decontamination active circuits
- Decontamination of active circuits
- Establishment of new radiation control areas based on the above actions as work progresses
- Demonstration that radioactive waste systems are in working order for use during decommissioning

20A.3.1 Fuel Removal

Removal and transport from the reactor and the spent fuel storage pit to the designated facility per the processes established at that time.

20A.3.1.2 Cleaning and Decontamination

After the removal of the fuel, the reactor cavity and other areas will be decontaminated, cleaned, and surveyed. Equipment needed to support plant operations (which can be removed) will be dismantled and removed. Temporary lifting and handling equipment to support plant dismantling will be brought in and installed. The active drain system will remain in operation.

Non-nuclear facilities (for example, circulating water cooling system and turbine hall) will be dismantled and systematically removed per the schedule established at that time. As the plant cleanup continues and clean areas are established, other parts of the plant can be systematically dismantled.

20A.3.1.3 Preparation and Conduct of Active Circuits Decontamination

At this time, an oxidative decontamination process has been selected for the decontamination of active piping circuits.

The process solutions will be selected initially with a bias toward cleaning the stainless steel piping rather than Inconel. The use of Inconel is somewhat restricted in its application, which renders it easier to provide effective local shielding. Stainless steel since it is widely used forms a significant source of exposure to radiation.

The steam generator tubing may require a separate process with process solutions selected specifically for Inconel.

The process involves ion exchange. Anion and cation resins will be used, will become active, and must be treated as active waste. It is anticipated that the AP1000 circuits will be significantly less contaminated due to the chemistry and the addition of zinc acetate. The resins that will retain all of the activity cleaned from the circuit could exceed 10 m³ in volume.
Decontamination factors of up to 10 for stainless steel and 2 to 3 for Inconel are anticipated for the initial phases and up to 10 for the separate Inconel phase.

This method of decontamination will require the provision of dedicated reagent tanks, pump skid, and the like. It may be possible to utilize existing plant equipment, which eventually will be explored during the development of the detailed decommissioning plan.

All waste, active or not, will be treated in accordance with the requirements in force at the time of decommissioning.

The system will be designed to minimize exposure and limit the potential for active water to leak and contaminate surfaces. The connections to the systems to be cleaned and the piping and equipment layout will be defined later.

20A.3.1.4 Radiation Control Areas

At the time the plant enters the decommissioning phase, the existing radiological control area will remain in place. As work progresses and activity levels permit, the boundaries will be successively reduced.

20A.3.1.5 Plant Radwaste Systems

The existing plant radwaste systems will remain in use while Stage 1 and possibly Stage 2 are in progress. The point at which they will be decommissioned will be defined in the detail decommissioning plan. However, it is assumed it will be during Stage 3.

20A.3.2 Stage 2–Description of Activities

The principal activities to be accomplished during Stage 2 are as follows:

- Conversion of fuel handling building into an interim waste storage, decontamination, waste reduction, packaging, and processing area for intermediate-level waste (ILW)

- Component removal to the interim storage areas of all active equipment with the exception of the reactor pressure vessel and the internal (The concrete and steel shield will remain in place.)

- Radiation and security controls

20A.3.2.1 Conversion of Fuel Handling Building

Stage 1 requires the removal of all fuel from the reactor and the spent fuel area. Once this has been accomplished, the spent fuel racks will be dismantled and the pit will be cleaned and decontaminated. The HVAC systems will remain in operation. This area will then be used as a decontamination and waste reduction area.

This building, together with the temporary facility described earlier, will be sufficient to store all of the dismantled equipment removed from the plant during decommissioning. The basic premise
is that there is significantly less building volume and equipment and that less of this reduced volume will be active. As items are confirmed as clean, they will be removed from the site and disposed.

This facility will be used for processing ILW waste. Items will be reduced in size to accommodate their disposal in the standard waste casks in use at that time for that waste level.

Equipment to perform cutting and volume reduction activities will be installed in this building. The reduction process will be designed to minimize personnel exposure, and minimize and contain the generation of dust, and the like.

20A.3.2.2 Component Removal

The main subject of this section is to establish that the largest, heaviest, and most active components can be safely removed and transported to the waste processing facility. These are the steam generators and the reactor vessel.

The detailed decommissioning plan will select the steam generator removal option from those identified below subject to the availability of improved technology. The steam generator options are as follows:

- Provide crane access through the top of the containment, remotely cut the hot and cold legs lift, and remove the steam generators to their designated storage areas. This will not involve the use of the polar crane, but will require a heavy lift crane located outside the containment.

- Provide access through the containment at the 135’ (110.67 m) operating deck level. Remotely cut and remove the steam dome and internal moisture separators. They will not be contaminated and will significantly reduce the weight and height of the steam generator. Provide a temporary shielding cover to reduce exposure from the steam generator tubes and remotely fix in place. Lift the lower assembly with the polar crane, which will be equipped with a construction trolley sized to lift the steam generator lower assembly. The polar crane main structure is sized to hoist the complete steam generators. The lower assembly will be transferred to a horizontal position using an “upender” designed for this purpose. It may then be taken through the opening to a jacking tower, which will lower it to a transporter for transfer to the storage building.

- The steam generator may be hoisted and removed as a single item provided the steel platforms on top of the steam generator housing are removed and approximately 10 feet (3.04 m) of one side of the concrete removed. It can then be lifted and upended in the manner shown previously. It would then be transported through the temporary opening, lowered to the transport using the jacking tower, and taken to the temporary facility. The steam dome can then be removed and the contaminated lower assembly processed as described above.

The cutting of the hot and cold legs will be carried out remotely with the legs filled with water up and into the steam generator channel head to provide the maximum personnel protection. The processes that will be used are those developed for the steam generator replacement program.
is an area of continuous improvement, and it is anticipated improved methods will be available at the time of decommissioning.

The temporary opening will be equipped with an airlock, which will remain closed except for the period when the steam generators are passing through. During this period, the containment pressure level will be maintained lower than ambient to prevent the egress of any potentially contaminated air.

All major equipment may be removed through this temporary opening, or optionally, many may be removed through the equipment hatch. The need for the temporary opening is driven by the pressurizer, core makeup tanks, and accumulators. The bulk of the smaller equipment will be taken through the equipment hatches.

Detailed plans for the dismantling of all major equipment will be developed in the detailed decommissioning plan. Such plans will include detail provisions for limiting personnel exposure.

20A.3.2.3 Radiation and Security Controls

Before transportation to the LLW or ILW areas, equipment will be examined to determine its activity levels and securely protected for transportation. Stations will be set up in the auxiliary and containment buildings to provide this function. Items determined to be clean will be routed to an interim clean storage area where they will await disposal.

20A.3.3 Stage 3–Description of Activities

The principal activities to be accomplished during Stage 3 are as follows:

- Removal and dismantling of the reactor pressure vessel and internals
- Cutting, processing, and removal of active and clean concrete in the containment vessel and fuel handling building
- Dismantling of the containment vessel and shield building
- Dismantling of the auxiliary building
- Dismantling of the temporary waste facilities

20A.3.3.1 Removal of Reactor Pressure Vessel and Internals

The hot and cold legs will have been remotely cut and removed using techniques that minimize personnel exposure.

The removal of the reactor pressure vessel and internals can be undertaken only when the activity levels have reached the point where the dismembered pieces can be transported within the regulations applicable at that time. This may be a significant period of time and will result in the plant being maintained in Safstor for this period.
The reactor pressure vessel will be disconnected from its supports, and all piping will have been previously cut and removed. The details of this operation will be included in the detailed decommissioning plan.

A temporary shielding structure will be produced which will cover the reactor pressure vessel and internals during lifting, upending, and transport to the processing facility. The polar crane will be used for the lifting and upending to and on the 135’ (110.67 m) level. The reactor pressure vessel and its transport shield can then be passed through the temporary opening airlock to the jacking tower lowered to the transported and then taken to the processing facility. These activities can be largely completed remotely.

An option for the reactor pressure vessel will be to dismember it in situ, package it in the approved containers, and then remove the individual containers. This will require the provision of temporary shielding and cutting processes, which will allow for flooding the reactor vessel compartments to provide additional shielding. Alternatively, reactor vessels in the United States have been disposed intact.

The internals will have been removed, decontaminated, wrapped, and taken to the processing area. The transport route will be through the opening provided at the 135’ (110.67 m) elevation.

20A.3.3.2 Cutting and Removal of Concrete in Containment Vessel and Fuel Handling Building

Concrete is considered to be active no more than 3 feet (0.9 m) from the exposed outer edges. The cutting program will use a diamond wire technique, which will cut through the steel facing. The active concrete will be removed under controlled conditions and processed separately. The diamond wire process is relatively clean in that dust can be controlled and the limited quantities of water needed controlled and maintained within a closed circuit. Typically blocks of concrete are cut and the active piece removed using the same technique within the local area. The remove pieces are sized for packaging to suit the approved disposal containers. Once the wire is passed around the area to be cut, the machine can be located away from the active area and shielded to minimize personnel exposure.

It is anticipated that the only active concrete will be local to the reactor pressure vessel and possibly the spent fuel pit area. The same techniques will be used in both areas.

20A.3.3.3 Dismantling of Shield Building and Steel Containment

The removal of the steel containment and the shield building is a bulk material removal undertaking. This is simplified by the fact that both structures are freestanding and can be systematically removed from the top. The steel pressure vessel will be stable throughout the process and can support significant weight in terms of access attachments for personnel, and cutting equipment. During the removal process, individual sections of plate will need to be stabilized. None of this waste should be active and should be transported directly to the clean waste areas subsequent to monitoring.
20A.3.3.4 Dismantling of Auxiliary Building

The lower levels of the auxiliary building will remain in use as the active drains process tanks are located in this area. Once decommissioning has reached the stage where these drains are no longer needed, the auxiliary building will be systematically removed by cutting through the composite steel/concrete structure. Temporary HVAC together with temporary sealing for openings will ensure that airflow is controlled and inward only. None of this concrete will be active; however, some may be contaminated. Significant areas of the walls are steel faced and can be readily decontaminated. It is recognized that the tanks in the lower auxiliary building due to access considerations may need to be first removed to a local decontamination area and then taken to the processing facility. Such items due to access considerations may need to be disassembled prior to removal. This then allows work to decontaminate the walls in the lower auxiliary building to proceed.

Explosive removal of concrete has not been considered in the Nuclear Island.

Floor slabs will be supported, cut, and systematically removed to expose the equipment within the rooms. Much of this equipment will be active and will be removed, packaged for local transport, and taken to the waste processing area. Work to disconnect this equipment, most of which are modules from their systems, will have been previously completed.

20A.3.3.5 Dismantling of the Temporary Facilities

These facilities will be removed and disposed of as active waste.
### Table 20A-1 (Sheet 1 of 4)

#### ESTIMATED WASTE QUANTITIES NUCLEAR ISLAND

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Units</th>
<th>CV/AB/FHB&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>CV/AB/FHB</th>
<th>CV/AB/FHB</th>
<th>CV/AB/FHB</th>
<th>Clean Areas</th>
<th>Total</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Piping 3 in. (76.2 mm) and above</td>
<td>ft</td>
<td>Active Area</td>
<td>Non-Active Fluid</td>
<td>Active Fluid</td>
<td>Clean Areas</td>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
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<td>35,000</td>
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<td></td>
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<td>(7,315.2)</td>
<td>(10,668)</td>
<td>(11,227)</td>
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<td>16,000</td>
<td>25,000</td>
<td>70,000</td>
<td>111,000</td>
<td>(33,832)</td>
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<td></td>
<td></td>
<td></td>
<td>(4,876)</td>
<td>(7,620)</td>
<td>(21,336)</td>
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<td>8,500</td>
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<td>5,500</td>
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<tr>
<td>Piping supports 2 1/2 in. (65.5 mm) and below</td>
<td>Ea</td>
<td></td>
<td>70,000</td>
<td></td>
<td>40,000</td>
<td>40,000</td>
<td></td>
<td>Multi commodity modules, piping equipment, and the like. Piping is considered in 3 and 4.</td>
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<td>Equipment modules</td>
<td>Ea</td>
<td>37</td>
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<td>14</td>
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<td>Piping modules</td>
<td>Ea</td>
<td>9</td>
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<td>50</td>
<td>59</td>
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<td></td>
<td>Piping considered in 3 and 4.</td>
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<td>Concrete</td>
<td>yd³/ (m³)</td>
<td>33,000</td>
<td>1500</td>
<td>67,500</td>
<td>102,000</td>
<td>(51,607.46)</td>
<td>(77,984.60)</td>
<td>Rebar, embeds, Q decking, and CA composite concrete/steel modules (incl. reactor cavity and RWST, etc.) considered as concrete.</td>
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<td></td>
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<td>(25,230.31)</td>
<td>(1,146.83)</td>
<td>(51,607.46)</td>
<td>(77,984.60)</td>
<td>(51,607.46)</td>
<td>(77,984.60)</td>
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<td>Structural steel</td>
<td>t (tonne)</td>
<td>1,200</td>
<td></td>
<td>1,100</td>
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<td></td>
<td>200</td>
<td>Stairwells, miscellaneous items</td>
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<td></td>
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<td>(1,088.62)</td>
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<td>(997.903)</td>
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<td>Architectural items, doors, etc.</td>
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<td>200</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Commodity</td>
<td>Units</td>
<td>CV/AB/FHB&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>CV/AB/FHB</td>
<td>CV/AB/FHB</td>
<td>CV/AB/FHB</td>
<td>Clean Areas</td>
<td>Total</td>
<td>Remarks</td>
</tr>
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<tr>
<td>Durasteel, misc. fire insulation, etc.</td>
<td>yd&lt;sup&gt;3&lt;/sup&gt; (m&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>200 (152.911)</td>
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<tr>
<td>Cable</td>
<td>ft (km)</td>
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<td></td>
<td>2,200,000 (670.5)</td>
<td>2,600,000 (792.4)</td>
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<td>Cable tray</td>
<td>ft (km)</td>
<td>15,000 (4.6)</td>
<td>3,500</td>
<td>4,000</td>
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<td>4,000</td>
<td>40,000</td>
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<td>Cable tray supports</td>
<td>Ea</td>
<td>2,000</td>
<td>3,500</td>
<td>5,500</td>
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<tr>
<td>Insulation, pipe, and equipment</td>
<td>ft&lt;sup&gt;3&lt;/sup&gt; (m&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>600 (16.9)</td>
<td>700 (19.8)</td>
<td>1,400 (39.6)</td>
<td>2,700 (76.4)</td>
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<td>Duct and supports</td>
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<td>300 (272.155)</td>
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<td>Valves SB</td>
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<td>Conduit</td>
<td>ft (km)</td>
<td>230,000 (70.1)</td>
<td>200,000 (60.9)</td>
<td>430,000 (131)</td>
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<td>Conduit fittings, etc.</td>
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<tr>
<td>Polar crane T building crane</td>
<td>Ea</td>
<td>450</td>
<td>450</td>
<td>900</td>
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## ESTIMATED WASTE QUANTITIES NUCLEAR ISLAND

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<th>Commodity</th>
<th>Units</th>
<th>CV/AB/FHB&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>CV/AB/FHB Non-Active Fluid</th>
<th>CV/AB/FHB Active Fluid</th>
<th>CV/AB/FHB Clean Areas</th>
<th>Total</th>
<th>Remarks</th>
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<td>Steam generator x 2</td>
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<td></td>
<td></td>
<td></td>
<td>700</td>
<td>(635.029)</td>
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<td></td>
<td></td>
<td></td>
<td>1400</td>
<td>(1270.059)</td>
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<tr>
<td>Reactor vessel and cladding</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>330</td>
<td>(299.371)</td>
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<tr>
<td>Baffle, barrel, neutron pads, and formers</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66</td>
<td>(59.874)</td>
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<tr>
<td>Upper core plate, support plate, and columns</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>42</td>
<td>(38.102)</td>
</tr>
<tr>
<td>Lower core plate to lower tie plate</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41</td>
<td>(37.195)</td>
</tr>
<tr>
<td>Reactor pressure vessel supports</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>155</td>
<td>(140.614)</td>
</tr>
<tr>
<td>Reactor coolant loop pipes</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>(18.144)</td>
</tr>
<tr>
<td>Reactor vessel head</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>246</td>
<td>(223.167)</td>
</tr>
<tr>
<td>Pressurizer</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>(90.718)</td>
</tr>
<tr>
<td>Core makeup tank</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>115</td>
<td>(104.326)</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> CV/AB/FHB
Table 20A-1 (Sheet 4 of 4)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Units</th>
<th>CV/AB/FHB(^{(1)})</th>
<th>CV/AB/FHB</th>
<th>CV/AB/FHB</th>
<th>CV/AB/FHB</th>
<th>Clean Areas</th>
<th>Total</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Active Area</td>
<td>Non-Active Fluid</td>
<td>Active Fluid</td>
<td>Clean Areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effluent hold up tank</td>
<td>t (tonne)</td>
<td></td>
<td>130 (117.934)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accumulators</td>
<td>t (tonne)</td>
<td></td>
<td>50 (45.359)</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note:
1. CV = containment vessel
   AB = auxiliary building
   FHB = fuel handling building