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Report of Continuing Hydrogeologic Investigations in 2004

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Report of Continuing Hydrogeologic Investigations in 2004

Yankee Nuclear Power Station
Rowe, Massachusetts

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Executive Summary

This report discusses the results of continued ground water investigations conducted in 2004 at the Yankee Nuclear Power Station (YNPS) site in Rowe, Massachusetts. These activities included collection and analysis of four quarters of ground water samples, installation of an additional ten monitoring wells to further characterize the stratigraphy and hydrogeology at the site, and permanent abandonment of 22 older wells. Eight additional wells were temporarily abandoned as a protective measure due to their location in the vicinity of ongoing demolition activities. Twenty data-logging pressure transducers were installed in selected wells to continuously monitor ground water levels and a data-logging rain gauge was installed to record precipitation.

Tritium is the only plant-related radionuclide detected in ground water at the site. It occurs in a shallow stratified drift aquifer at concentrations ranging from non-detectable to about 5,000 pCi/L across the site. Tritium is also observed in thin discontinuous sand lenses 30 to 100 feet deep within a dense, otherwise dry lodgement till at concentrations ranging from non-detectable to about 42,000 pCi/L. It is noted that the Environmental Protection Agency's (EPA's) Maximum Contaminant Level (MCL) is 20,000 pCi/L for tritium. Flow of ground water within the till is limited to the sand lenses or fractures in the till, which are of relatively low yield. The highest tritium concentrations occur adjacent to the Spent Fuel Pool/Ion Exchange Pit (SFP/IX) complex. The lateral extent of tritium in the deeper sand lenses is limited by the discontinuous nature of these lenses within a dense lodgement till. Removal of spent fuel from the Spent Fuel Pool (SFP) in 2003 and subsequent draining of the SFP has eliminated the principal source of tritium to the groundwater.

Ground water investigations completed in 2004 have bounded the north, west, and southwest extent of tritium impact to both the shallow aquifer and the deeper sand lenses within the lodgement till. Monitoring of water levels in several wells equipped with data-logging pressure transducers while drilling new wells was used as a means of determining the presence/absence of a hydraulic connection between sand lenses within the lodgement till. Results indicated that while some of the sand lenses are hydraulically connected, most are not. Of particular importance is the lack of hydraulic connection at well MW-107C, the well with the highest concentration of tritium at the site. The lack of response in this well suggests that the sand lens in which the highest concentration of tritium was detected is relatively isolated, limiting the extent of tritium migration from this lens.

Because of the potential impacts of ongoing and planned decommissioning activities, initiation of any remedial measures at this time to address tritium in ground water at YNPS would be premature. The SFP/IXP structure will soon be excavated and removed. This structure, with its foundation within the top of the lodgment till, was the source of tritium in both the shallow aquifer and the thin sand lenses within the till. After the SFP/IXP is removed, the empty excavation will be surveyed, demonstrated to satisfy the radiological criteria for unrestricted use, then backfilled. Dewatering of the open excavation will be required during demolition and surveying. It is possible that this dewatering will remove tritium-impacted ground water in its vicinity. Continued sampling of ground water from monitoring wells in the vicinity of the

IXP/SFP complex will evaluate the effectiveness of the dewatering on tritium removal. YAEC anticipates that the processes of natural attenuation, including dilution, dispersion, and radioactive decay, will also continue to reduce the tritium concentrations, as observed during review of the ground water monitoring data, to levels below the EPA's MCL.

1.0 Introduction

During 2003, Yankee Atomic Electric Company (YAEC) began a comprehensive investigation of the hydrogeology at the Yankee Nuclear Power Station (YNPS) site. The investigation built upon the results of earlier work, and included drilling of an additional seventeen monitoring wells, as well as revising the ground water monitoring program to investigate thoroughly the ground water quality at the site. The results of the 2003 hydrogeologic investigation are detailed in Reference 1 and the results of the earlier work are summarized in Reference 2.

The 2003 study improved upon earlier work in several respects. The new monitoring wells completely penetrate the unconsolidated deposits that overlie bedrock and more fully characterize the local stratigraphy that controls the movement of ground water beneath the site. As a result, sand lenses impacted with tritium were found interlayered within a lodgement till that underlies the shallow stratified drift aquifer, where a plume of tritium had been identified earlier. Tritium concentrations within the deeper sand lenses are higher than those in the shallow aquifer as the sand lenses are discontinuous and are interlayered within a very dense, dry, lodgement till. Ground water flow within this deeper deposit is much more restricted and slower than in the shallow stratified drift deposits due to the higher hydraulic conductivity of the latter unit.

A schedule of quarterly ground water sampling has been implemented in all new and previously existing monitoring wells. This activity is completed using the low-flow sampling technique in accordance with YNPS Procedure AP-8601 (Reference 3) and includes a thorough process of data verification and validation. The radiochemical analysis of ground water samples includes tritium, gross alpha, gross beta, gamma-emitting radionuclides and eleven hard-to-detect species. A total of six rounds of quarterly samples, including one in each quarter of 2004, have now been collected and analyzed. The data indicate that tritium is the only plant-related radionuclide detected in ground water at the YNPS site.

The 2003 inquiry report (Reference 1) recommended installation of additional monitoring wells in areas of the site that had not been investigated, to further define the extent of tritium impact in ground water. Drilling in three additional locations was completed during the summer of 2004, and the details of that work are reported below. Geologic information gained from the 2004 drilling program resulted in a slightly revised interpretation of the sedimentary stratigraphy of the site and allowed improved characterization of the distribution of tritium in the ground water. The pertinent hydrogeologic data gathered during the investigation of 2004 are included in several summary tables. Significant findings and conclusions are supported by a comprehensive series of figures depicting features of interest at the site.

Other activities completed during 2004 include installation of 20 data-logging pressure transducers in selected monitoring wells (Reference 4). These instruments were used to record and store ground water levels. The ground water levels were evaluated for trends related to precipitation events or stresses imposed on the aquifer by drilling or demolition activities, in an effort to evaluate the connectivity of subsurface units at available monitoring wells. In addition, a total of twenty-two (22) monitoring wells constructed prior to 2003 were permanently abandoned in 2004 because they were located in areas of active demolition where the integrity of the well might have been compromised. Permanent abandonment was completed in accordance with Massachusetts Department of Environmental Protection guidance (Reference 5) and YNPS Procedure AP-8125 (Reference 6). Eight additional wells were temporarily abandoned by cutting and capping the well below ground surface, covering the wellhead with a steel plate and burying it to prevent damage during demolition. These wells will be restored following demolition and raised to new site grades to support future groundwater monitoring. Additional wells may be constructed at selected locations following site restoration to replace some of those abandoned.

Because of ongoing demolition activities at the site, monitoring wells have not yet been drilled at certain inaccessible locations. Two additional well clusters are anticipated in the vicinity of the SFP/IXP complex, which was the primary source of release of tritium to ground water. The purpose of these wells is to further characterize the stratigraphy and ground water flow domain and to verify that higher levels of tritium do not exist further down gradient. When access to many of the now inaccessible monitoring wells is possible later in 2005, the ground water sampling will continue, and will incorporate any new monitoring wells that may be drilled.

2.0 Monitoring Well Drilling

Ten wells were installed in three locations in 2004. The new wells are MW-106A, B, C, D; MW-108A, B, C; and MW-109B, C, and D. The well locations are shown in Figure 1. Monitoring wells MW-106B, MW-108B, and MW-109B were the first wells drilled at each respective location. Each "B" well penetrates the full thickness of sediments overlying bedrock, which ranged from 174 to 233 feet at these locations, and were completed thirty two, nineteen and sixteen feet into bedrock, respectively. Wells MW-106A and MW-108A were completed in the shallow aquifer comprised of stratified drift. The remaining five wells were completed in thin water-bearing sand lenses encountered interlayered within the lodgement till and glaciolacustrine sediments that underlie the stratified drift. Geologist's logs and construction details for each of the monitoring wells are in Appendix 1. Table 1 summarizes the completion details for the monitoring wells installed in 2003 and 2004.

As in 2003, the 2004 wells were drilled by the rotosonic method, in accordance with Reference 7 and Reference 8. The rotosonic drill uses a combination of high-frequency vibration, rotation, and down pressure on a string of drill rods to advance a core barrel attached to the bottom of the drill rod string. A continuous sample of soil from the formation is collected in the core barrel for examination, description, and analysis. The core barrel is advanced ahead of a steel drill casing of slightly larger diameter than the core barrel. The drill casing is advanced to stabilize and maintain an open borehole as drilling proceeds, and is withdrawn when the target depth has been reached and construction of a monitoring well is complete.

The drill casing also isolates any water-bearing zones encountered in the borehole from overlying and underlying strata, to minimize commingling of ground water from discrete zones or cross-contamination of aquifers as drilling proceeds. When a water-bearing zone was encountered, drilling continued to the bottom, until an aquitard was reached. A slurry consisting of bentonite clay and water was then placed in the casing. The casing was pressurized to force the slurry out from the bottom and up along the outside, to seal the sidewall of the borehole. This process was repeated several times in each borehole in which multiple water-bearing sand lenses were encountered, as noted in the logs in Appendix 1. Reference 1 provides a detailed description of the rotosonic drilling procedure used to advance the boreholes, collect soil samples, screen the samples in the field, and construct monitoring wells.

Ground water from each water-bearing zone encountered was sampled before drilling deeper. These screening samples were collected by bailing from the cased borehole with a disposable 3-foot long by 1½-inch diameter polyethylene bailer. A new bailer was used for each sample to ensure that contaminated sampling equipment did not affect the results of sample analysis.

Each screening ground water sample was analyzed for tritium in the on-site radiochemistry laboratory by liquid scintillation. No tritium was detected at a detection limit of 2,000 picocuries per liter (pCi/L) by the on-site lab in any of the ground water samples. The screening samples were also analyzed for gamma-emitting radionuclides by gamma spectroscopy in the on-site lab. No gamma-emitting radionuclides were detected.

These screening samples were also analyzed for tritium by an off-site contract radiochemistry laboratory, with a detection limit of 300 pCi/L. Table 2 summarizes the results of analysis for tritium of the screening samples collected during both the 2003 and 2004 drilling campaigns. Table 2 indicates that tritium was detected in only three of the screening ground water samples collected in 2004, at relatively low concentrations ranging from 460 to 880 pCi/L. As a point of reference, the United States Environmental Protection Agency has established a Maximum Contaminant Level of 20,000 pCi/L for tritium in drinking water.

The screening ground water samples were also analyzed for volatile organic compounds (VOCs) by EPA method 8260B by an off-site contract laboratory. A few VOCs were detected in the 2004 screening samples at concentrations below or near their detection limits of generally one to five micrograms per liter. These analyses were of screening samples collected from boreholes with drilling equipment installed in them, and not from developed wells. Because of the sampling method, their results are unreliable at the low concentrations measured and cannot be considered representative of the ambient ground water quality. The results of analysis of the screening ground water samples for VOCs, which are not validated, are summarized in Table 3.

After removal from the core barrel, each soil sample was screened for radioactivity at the field location with an Eberline RM14 Frisker. Only background radiation levels were detected. A composite sample consisting of approximately two kilograms of soil was prepared from each ~5-foot section of core. This composite sample was analyzed for gamma-emitting radionuclides by the on-site radiochemistry laboratory. Table 4 is a summary of the soil screening analytical data. Table 4 shows that no plant-related gamma-emitting radionuclides were found above the detection limits noted.

Each soil sample was also screened in the field for the presence of VOCs using a portable flame ionization detector (FID). VOCs were indicated in only one sample from a depth of 15 to 18 feet below grade in MW-108B at a concentration of 100 parts per million. An organic silt was encountered at this depth, in a location where fill was placed to construct the peninsula upon which the cooling water intake structure for the power plant was built. The fill buried the former lake-bottom sediment consisting of organic silt. Because no source of synthetic organic compounds existed in the vicinity of MW-108B and no plume of VOCs has been identified in the ground water, the FID measurement in this sample is inferred to be due to naturally-occurring methane in the silt. Soil gas surveys have identified the presence of naturally-occurring methane associated with organic deposits, such as peat, in other areas of the site, including the Southeast Construction Fill Area (SCFA) and the ISFSI.

A Massachusetts Licensed Land Surveyor determined the horizontal and vertical coordinates of each monitoring well. The horizontal location of each well is referenced to the State Plane Coordinate System and its vertical elevation is referenced to mean sea level. A summary of the coordinates for all monitoring wells is provided in Table 5.

2.1 Monitoring Well Development

Each well was developed shortly after construction using inertial displacement or electric submersible pumps to remove a minimum of three well volumes of ground water. This process removes fine-grained sediment that may have entered the well during construction, helps improve hydraulic connection between the screen zone of the well and the adjacent aquifer, and allows collection of ground water samples that are generally representative of the ambient water quality in the formation. Table 6 summarizes the results of development of the wells drilled in 2004.

2.2 Abandonment/Protection of Selected Monitoring Wells

Some monitoring wells installed prior to 2003 were in locations where ongoing demolition activities posed a risk of well damage. Twenty-two (22) of these older wells were permanently abandoned during the summer of 2004 to eliminate the potential for aquifer contamination resulting from damage. These wells were also of less precise construction compared to the current rotosonic method used for installation. For example, many of the wells were completed with screens spanning the contact between the shallow aquifer and the underlying lodgement till, or between bedrock and the overlying sediments. The rotosonic drilling method allows recovery of complete soil cores and accurate placement of well screens within the appropriate aquifer zones. The need for replacement wells in one or more of these areas will be evaluated as the ground water investigation proceeds. Table 7 summarizes the details of the abandoned monitoring wells and Figure 1 shows their locations. The wells were abandoned in accordance with Massachusetts Department of Environmental Protection guidance (Reference 5) and YNPS Procedure AP-8125 (Reference 6).

Three of the monitoring well clusters drilled in 2003 (MW-101, MW-102 and MW-107) are located directly beneath the reactor support structure and fully penetrate the sedimentary section overlying bedrock. Some of these specific wells contain significant concentrations of tritium and are essential to the ongoing ground water investigation at the site. Therefore, measures were taken to protect rather than permanently abandon them prior to active demolition of the structure.

In December 2004, the area around each well cluster was excavated to a depth of approximately five feet below grade. The casing of each well was cut at the bottom of the excavation, a water-tight plug was placed in each wellhead and a steel road box set in concrete was installed. A layer of soil was placed over each road box and a steel plate four by four feet square and one inch thick was then placed in the bottom of the excavation. The excavations were then backfilled to grade level.

These precautions will protect the wells during demolition of the reactor support structure and adjacent structures. When demolition is complete, the wellheads will be exposed and the well casings will be extended to the new grade elevation prescribed in the final site grading plan. New steel road boxes will again be set in concrete over each wellhead at the new grade level and sampling of ground water from the wells will resume.

3.0 Site Stratigraphy

Ground water investigations began at YNPS in 1977, with installation of the first monitoring well. Since then, a total of 65 additional monitoring wells have been installed. Sampling of the early wells identified tritium in shallow ground water within the stratified drift (water table aquifer) beneath the site. The concentration of tritium in the shallow ground water was generally low and ranged from non-detectable to about 5,000 pCi/L currently.

The most recent round of drilling occurred during the summer of 2004, when ten wells were installed to further characterize the hydrogeologic features at the site. This recently completed investigation followed a comprehensive episode of investigation during 2003 when the first deep exploration of the stratigraphy, hydrogeology, and ground water quality was conducted at the site.

Before 2003, virtually all of the wells installed (with the exception of the plant potable water wells) were shallow and did not penetrate the lodgement till, a dense, mostly dry unit directly underlying the stratified drift. Soil samples were not collected during drilling of the potable water wells, so little information regarding the stratigraphy at those locations was learned from these installations. The lodgement till is a dense and silty formation that does not store or transmit useable quantities of ground water. What little water may exist appears to be limited to fractures within the till.

During the 2003 Summer drilling program, for the first time, several monitoring wells were drilled and soil samples collected through the entire sequence of unconsolidated deposits overlying bedrock. Continental glaciers that occupied the region during the Pleistocene geologic epoch deposited these unconsolidated soils. The results of the 2003 investigation suggested that the lodgement till underlying the stratified drift was about thirty feet thick and was underlain by a thick sequence of glaciolacustrine sediments that had been deposited within a glacial lake. Several thin, discrete sand lenses containing tritium at concentrations greater than those measured in the stratified drift were encountered within what was then interpreted to be the glaciolacustrine sequence.

The 2004 drilling included installation of monitoring wells at two locations (MW-106 and 108) near the middle of the Deerfield River Valley. These were some of the deepest wells that have been drilled at YNPS and they penetrated the stratified drift, lodgement till, and glaciolacustrine deposits that had been encountered elsewhere on site. Correlation of the sediments exposed by the 2003 and 2004 drilling campaigns revealed that the contact between the lodgement till and glaciolacustrine deposits is gradational and that the lodgement till is thicker throughout the site than it was interpreted to be on the basis of the 2003 investigation. As a result, the top of the underlying glaciolacustrine sequence is deeper than originally thought. This interpretation implies that many of the thin, discrete sand lenses are interlayered within the lodgement till rather than the glaciolacustrine sequence as previously thought.

Figure 2 shows the trace at ground surface of five cross-sections. Figures 3 through 7 show the stratigraphy along these five cross-sections, A-A’, B-B’, C-C’, D-D’ and E-E’, oriented in various directions across the site. Except for section B-B’, each section passes through the central region of the radiologically controlled area (RCA) of the site. Cross-sections A-A' through D-D' are revised from those presented in Reference 1. Section E-E' is new to this report. The monitoring wells drilled in 2004: MW-106, MW-108, and MW-109, are shown in cross-sections A-A', C-C', and E-E', respectively.

The cross-sections show a sequence of three sedimentary units overlying bedrock. Immediately below ground surface is a layer of stratified drift ranging in thickness from zero to about 40 feet. A water table aquifer exists within this layer. Beneath the stratified drift is a very dense lodgement till that is not water bearing except for a few lenses of water-bearing silty sand, which are a few feet thick and are interlayered within the lodgement till. The till ranges in thickness from zero in the area of monitoring well CW-10 to at least 210 feet in the area of the plant potable water well.

The depositional process that produced the sand lenses within the till can be described as follows. Short-term fluctuations in climate caused warming that may have spanned a period of a few years to a few decades. This resulted in a temporary stagnation or retreat in movement of the ice sheet and a net increase in melt water. This melt water deposited the relatively clean, well-sorted sand lenses into crevasses and ice channels within or on the margins of the glacier. As the climate reverted to colder temperatures that were more normal throughout the Pleistocene, there occurred a net increase in snow accumulation and decrease in melt water. Under these conditions, the ice front advanced, once again depositing lodgement till beneath its base and overriding the crevasse and ice-channel filling.

This sequence of fluctuating climate, repeated during several episodes, resulted in a series of thin, discrete sand lenses that are found interlayered within the lodgement till at YNPS. The process by which the sand lenses apparently were deposited suggests that they are discontinuous and of limited extent. This stratigraphy has obvious implications for the transport of contaminants in ground water and suggests that the thin, discrete sand lenses do not provide a mechanism for flow over distances of more than a few hundred feet. This judgment is based upon the lack of correlation between water level measurements in sand lenses found in boreholes separated by more than a few hundred feet, as measured by installed pressure transducers. This judgment is also supported by the limited lateral distribution of tritium found within the sand lenses from screening data collected during the well installation process.

The observed stratigraphy also may explain why tritium is more concentrated in some of the sand lenses than in the shallow aquifer. As shown in Figures 3, 5, 6, and 7, the bottom slab of the SFP is below the top of the lodgement till. These figures show that the SFP/IXP complex is in direct contact with both the stratified drift and the underlying lodgement till. Therefore, a leak from the SFP/IXP complex likely would have released tritium to both the stratified drift and the lodgement till. Ground water flow within the deeper system is slower and more restricted than in the stratified drift, which has higher hydraulic conductivity and is more homogeneous and continuous. As a result, a greater number of aquifer volumes of fresh water have flushed through the shallow aquifer since tritium was released to the environment, compared to the deeper system. This issue is discussed further in Section 5.1.2.

A sequence of glacial lake deposits (glaciolacustrine sediments) underlies the lodgement till from the area north of the Radiologically Controlled Area (RCA) and extending north and west to the middle of the Deerfield River Valley. These lake deposits extend to the bedrock surface. This sequence is generally comprised of silt and clay, some of which is well laminated. Sandy zones that are water bearing are also found within the glaciolacustrine sediments. These sandy zones were likely formed during periods when stream flow into the lake was relatively high and coarser-grained sediment could be transported into the lake by the faster-flowing water.

The lake deposits are wedge-shaped in cross-section, being thickest toward the middle of the Deerfield River Valley, and thinning to the south where the lakeshore formerly existed. Sections D-D', E-E', and A-A' show the glaciolacustrine sediments pinching out at the southwest, west, and northwest perimeter, respectively, of the vapor container that enclosed the nuclear reactor. This configuration suggests that the lakeshore formerly curved around that portion of the site. The sediments laid down in the lake were later buried by more than 100 feet of lodgement till and stratified drift.

The local bedrock is a dark gray, medium to coarse-grained albite gneiss. In addition to abundant 2 to 5 millimeter megacrystals of albite, two other predominant minerals form this rock, quartz, and biotite. This is a metamorphic rock type that has been mapped by the United States Geological Survey as the Lower Cambrian Hoosac Formation (Reference 9). The monitoring wells recently installed in the bedrock indicate that the top few tens of feet of the rock are moderately fractured. The fractured rock comprises an aquifer that yields up to a few gallons per minute of water in some monitoring wells.

Figure 8 shows contours of equal elevation of the bedrock surface, which generally slopes down steeply toward the northwest and west, in the area west and north of the former turbine building. Beneath the vapor container and farther south, the slope of the bedrock surface is more gradual to the southwest and parallel to the axis of the Deerfield River Valley below Sherman Dam. This configuration of the bedrock mirrors the topography on the knoll to the east of the site, where the bedrock outcrops at ground surface and slopes steeply to the northwest and west, and more gently to the southwest. Figure 9 is a contour map showing the thickness of outwash (stratified drift) across the site. Figures 8 and 9 are revisions to Figures 2 and 3 from Reference 1.

4.0 Ground Water Level

Ground water levels were measured in accessible monitoring wells during one day each quarter in accordance with Reference 10. This synoptic round of water level measurements is collected during a one-day period to minimize the effects of diurnal ground water fluctuations. The synoptic water level measurements provide a gauge of the head distribution in the local ground water system. Table 8 is a summary of the quarterly synoptic ground water levels measured in 2004.

4.1 Ground Water Flow

The following discussion focuses on the potential for horizontal ground water flow. Vertical ground water flow potential will be discussed in Section 5.1, where vertical flow potentials are illustrated on several hydrogeologic cross-sections.

The depth to water in each monitoring well was measured from the top of casing of the well with an electronic water-level meter. By subtracting the measured depth to water from the surveyed elevation of the top of casing, the elevation of the water level in each well was calculated. These elevations were then plotted at the surveyed location of each well on a map of the site. All water-level elevations measured in wells completed in the same aquifer were then contoured to provide a map showing ground water equipotential lines within the aquifer. Flow within the aquifer is from areas of relatively high potential (elevation) to areas of lower potential, in a direction normal to the elevation contours.

Figure 10 is a compilation of contour maps of the water level elevations in the shallow aquifer for the four quarters of 2004. These maps demonstrate a generally northwest flow direction in the shallow aquifer through the Radiologically Controlled Area (RCA), with a more westerly flow downgradient of the RCA, toward the Deerfield River. A second flow path to the northeast and turning to the northwest is shown in the small sub-basin through which the tributary to Wheeler Brook flows, in the area of the Southeast Construction Fill Area (SCFA). The set of four figures shows generally the same flow pattern throughout the year, with a few feet of vertical fluctuation seasonally. The highest water levels generally occur in the second quarter and the lowest in the fourth quarter.

Figure 11 is a compilation of quarterly contour maps of the water level elevations in sand lenses 30 to 100 feet deep within the lodgement till during 2004. This set of maps shows a more westerly flow direction in the vicinity of the vapor container during each quarter, relative to the shallow aquifer. However, the flow subsequently turns toward the northwest and follows a path similar to that in the shallow aquifer, toward the Deerfield River. Comparison of Figure 10 with Figure 11 shows that the water level elevations in the deeper sand lenses are generally 10 to 15 feet, and as much as 30 feet lower than in the shallow aquifer.

Figure 12 is a compilation of quarterly contour maps of the water level elevations in the bedrock aquifer during 2004. The flow directions shown in these maps during each quarter are very similar to those shown in the sand lenses 30 to 100 feet deep.

4.2 Response of Ground Water Level to Precipitation

In September of 2004 a data-logging rain gauge was installed at the site. The gauge records accumulated precipitation in 0.01-inch increments that can be summed to provide a daily total. Figures 13 through 16 show the ground water levels logged in eight monitoring wells in which data-logging pressure transducers were installed, together with daily precipitation totals for the period of September 24 through October 22, 2004. With the exception of MW-106A (Figure 16), water levels in the wells show little correlation with precipitation.

This phenomenon is likely due to a soil moisture deficit at the end of the growing season, which prevents most rainwater from infiltrating deeper than the root zone to recharge the ground water. The exception is in MW-106A, a shallow well located adjacent to a small wetland and at the lowest surface elevation of the wells depicted in Figures 13 through 16. The delayed response of ground water levels to precipitation events provides insight to why no correlation between water level and tritium concentration is apparent as discussed in Section 5.1.4. Continued logging of water levels and precipitation accumulation throughout the year will likely show greater correlation between the two parameters in more wells, particularly during the spring.

4.3 Ground Water Level Change Related to Drilling or Demolition Activities

Figure 17 shows the locations of eighteen monitoring wells in which data-logging pressure transducers were installed during the summer of 2004. The instruments recorded water levels in these wells at 30-second intervals. New monitoring wells were drilled and developed at the MW-109 location during the period July 20 through August 12, 2004. By comparing the hydrographs of selected wells to the log of daily field activities it is possible to correlate water-level response to nearby drilling activities. This exercise provides insight to the degree of hydraulic connection between different hydrogeologic formations. Figure 17 illustrates that hydraulic connection was observed in four monitoring wells within about 250 feet of the MW-109 location.

Figure 18 is a hydrograph illustrating the water levels recorded in monitoring well CB-1 during the period when drilling occurred at the MW-109 location. This figure shows a clear connection between monitoring well CB-1 (screened in the shallow aquifer from 15 to 25 feet below grade) and the shallow aquifer in the location of MW-109. As shown on Figure 1, the horizontal distance between these two wells is approximately 250 feet. It is significant that no response is evident in CB-1 when drilling proceeded deeper at MW-109 into the lodgement till and interbeded sand lenses. The lack of water-level response suggests that the shallow aquifer and deeper sand lenses are not hydraulically connected in the area of these wells.

Similarly, Figure 18 illustrates that water-level response was recorded in MW-102A (screened from 33 to 38 feet below grade in a thin sand lens within the lodgement till) while completing various drilling activities in the depth range of 45 to 65 feet in the MW-109 location, approximately 140 feet away. However, it is again significant that no water-level response is evident in MW-102A while drilling MW-109 through the shallow aquifer, before reaching the deeper sand lens.

Figure 19 shows a water-level response in MW-102C (screened in a thin sand lens within the lodgement till from 94 to 99 feet below grade) while drilling into a thin sand lens 156 to 159 feet deep in the MW-109 location. This response indicates hydraulic connection between these two sand lenses. It is significant that although shallower sand lenses were encountered in MW-109 at depths of about 90 to 99 feet and 120 to 135 feet (Figure 7), no response was recorded in the hydrograph of MW-102C when drilling through these sand lenses at the location of MW-109. This observation is further evidence that the sand lenses are discontinuous and isolated. While some sand lenses may be hydraulically connected, not all are.

MW-107C is screened in a thin sand lens about 30 feet below grade adjacent to the SFP/IXP complex and contains ground water with the highest concentration of tritium at YNPS. MW-107D is located next to MW-107C, and is screened in another thin sand lens about 80 feet deep. Drilling at the location of MW-109, approximately 200 feet west of MW-107C and D, induced no response in the water-level data for MW-107C or MW-107D. The lack of any response in these wells, when responses were seen in nearby wells MW-102 A and C, suggests that the thin sand lenses in which MW-107C and D are completed are relatively isolated and of limited extent.

Figure 19 also shows a water-level response 120 to 130 feet deep in the bedrock aquifer at MW-102B while coring and sampling ground water from the bedrock 174 to 190 feet deep in the MW-109 location. No water-level response is evident in MW-102B while drilling in the lodgement till above the bedrock in MW-109, indicating that the bedrock aquifer is hydraulically isolated from the till in the area of these wells. The hydrograph of MW-102B also shows the effects of earth tides, a natural cyclic feature caused by changing gravitational forces, which is unrelated to drilling activities.

Figure 20 indicates a draw down of the water level in MW-103B (screened from 285 to 295 feet below grade in the bedrock) in response to pumping while developing MW-106B (screened from 251 to 261 feet below grade in bedrock), approximately 250 feet away. The lower plot in Figure 20 illustrates the very slow recovery of water level in MW-103C over an approximate 20-day period, after pumping and sampling the well. MW-103C is screened in silty sand with obviously very low hydraulic conductivity.

Figure 21 illustrates a hydraulic connection between another set of bedrock wells approximately 175 feet apart. The water level in MW-104B (screened from 184 to 194 feet below grade in the bedrock) was perturbed while drilling in the bedrock from 196 to 215 feet below grade in MW-108B. A lack of water-level response in the earlier part of the hydrograph for MW-104B indicates that no effects were recorded as MW-108B was drilled through the glaciolacustrine deposits above bedrock. This lack of response indicates that the bedrock and glaciolacustrine deposits are hydraulically isolated in the area of these wells.

Finally, the lower plot in Figure 21 shows the effect of demolition activities at YNPS on water level in MW-105C. Instantaneous response in water level is visible in the hydrograph of this well, which is screened in a sand lens from 27 to 37 feet below grade, to dropping of large sections of steel that were cut away from the vapor container.

5.0 Ground Water Quality

Six consecutive rounds of quarterly ground water samples, including one in each quarter of 2004, have been collected and analyzed under the revised ground water monitoring program. Each round of data has been fully validated and verified, in accordance with Reference 3. Reference 11 reported results of the first two quarters of sampling and analysis in 2004. The quarterly samples were obtained from accessible monitoring wells using a low-flow sampling technique in accordance with Procedure AP-8601 (Reference 3). Radionuclide analysis include tritium, gross alpha, gross beta, gamma-emitting radionuclides, and eleven hard-to-detect species. The data indicate that tritium is the only plant-related radionuclide detected in ground water at the YNPS site. Table 9 is a summary of the six quarters of validated analytical results.

5.1 Tritium in Ground Water

A plume of tritium exists in the shallow stratified drift aquifer. The concentrations in this plume range from non-detectable to about 5,000 pCi/L, with the highest concentrations located in the vicinity of the SFP/IXP complex. Figure 22 shows the configuration of the shallow tritium plume in plan view, for the four quarters of 2004. This figure reveals that the size and shape of the plume vary somewhat throughout the year, but the net concentrations remain relatively the same. The orientation of the shallow plume is generally aligned with the direction of shallow ground water flow shown in Figure 10.

Figure 23 depicts tritium impact during the four quarters of 2004 in deeper water-bearing sand lenses at 30 to 100 feet interlayered within the lodgement till, and possibly extending into the glaciolacustrine deposits. This deeper zone of impact is smaller in lateral extent relative to the shallow plume, but is more concentrated because of the restricted ground water flow within the discontinuous, low-yielding sand lenses. Concentrations in the deeper zone of impact range from about 5,000 to 42,000 pCi/L (in those sand lenses where tritium is detected) with the highest values again located adjacent to the SFP/IXP complex.

The shape of the impacted zone in the sand lenses 30 to 100 feet deep appears to be elongated in a northerly direction. This orientation is not what might be expected when viewing the ground water flow potential within these sands, as inferred in Figure 11. This discrepancy is likely related to the heterogeneous nature of the multiple discrete sand lenses that are inter-layered, but not hydraulically connected, within a virtually impermeable lodgement till, resulting in anisotropic flow along unpredictable contaminant flow paths.

Figure 23 reveals that the deeper zone of tritium impact appears to be less concentrated in March relative to the remaining three quarters in 2004. This condition resulted from damage to monitoring wells MW-107B, MW-107C, and MW-107D. Demolition activities early in 2004 damaged the road boxes allowing surface water runoff to enter the wells and dilute the ground water within them. The wellheads were repaired and infiltration of surface water was terminated shortly after the damage occurred. Figure 23 shows that during the last three quarters of 2004, ground water in the vicinity of the screen zones in MW-107C and D returned to tritium concentrations similar to those observed before the damage occurred. Refer to Figures 18 and 19 in Reference 1 for an illustration of the deeper zone of impact prior to March 2004.

5.1.1 Sources of Tritium in Ground Water

The source of tritium in ground water is from leaks of contaminated cooling water from plant equipment located in the SFP/IXP complex that occurred during plant operation. Table 10 is a summary of unplanned releases of radioactive material during the operating history of YNPS. The information in Table 10 is reproduced from Appendix A2 of the Historical Site Assessment (Reference 12) prepared for the YNPS License Termination Plan (Reference 13). The location of each event is shown in Figure 24. The descriptions in Table 10 indicate that most unplanned releases involved a small volume of water that was promptly contained. The impacted area was decontaminated and no significant impact to the environment occurred.

Comparison of Figure 24 with the shallow ground water flow in Figure 10 shows that the releases that occurred south (upgradient) of the SFP/IXP complex were located upgradient of several monitoring wells. These releases occurred at or within a few feet of ground surface and any impact to the ground water would have been revealed by sampling the shallow monitoring well network. Figure 22, showing tritium in the shallow aquifer, indicates no such impacts south of the SFP/IXP complex.

5.1.2 Conceptual Model of Tritium Source and Transport

Figure 25 is a cross-section of the west wall of the SFP/IXP complex, looking east. The figure shows the relation between the foundation of the SFP/IXP and the shallow stratigraphy in its vicinity. The approximate locations of those unplanned releases of radioactive material listed in Table 10 that occurred adjacent to the SFP/IXP complex are also illustrated in Figure 25.

As described in Table 10, most of the releases shown consisted of small volumes that were promptly contained and removed. The exception is described in Abnormal Operating Report (AOR) 64-13 that documented a leak at the construction joint at the common wall between the SFP and the IX Pit. The information in Table 10 indicates that this leak may have existed for several months. Figure 25 shows that a release of water contaminated with tritium at the location described in AOR 64-13 would have entered the stratified drift, flowed through the foundation backfill and into the top of the lodgement till. Tritium contaminated water likely flowed through the permeable foundation backfill and was present in the fill surrounding the fuel transfer chute under the SFP, which is the lowest part of the structure. Microfractures within the dense till likely allowed slow movement of the water downward and to the northwest, under the prevailing ground water flow gradient (Figures 10 and 26), where it was then within a few feet of the first sand lens within the till that was identified in MW-107C where the highest tritium concentration to date is found at YNPS.

This release mechanism and flow path resulted in the distribution of tritium observed in the monitoring well network. Figure 25 illustrates the vertical proximity of the impacted sand lens in which MW-107C is completed at the northwest corner of the SFP (approximately 27 feet deep) and at the bottom of the fuel transfer chute under the northeast corner of the SFP (approximately 24.5 feet deep). The vertical separation between these two features is about 2.5 feet, and as shown in Figures 26, 28, and 30 (Hydrogeologic Cross-Sections A-A', C-C', and E-E'), the vertical flow potential in this area of the site is downward from the shallow aquifer and backfill to the deeper sand lenses.

The release documented in AOR 64-13 was reported in 1964. The tritium concentration in the ion exchange pit water at that time was a few million picocuries per liter. Table 10 notes in AOR 66-7 that in 1966 the SFP water contained 5.4E-03 microcuries per milliliter (5.4E+06 pCi/L) of tritium. The tritium concentration in the SFP and IXP water was similar. Therefore, it is likely that shortly after the release, the tritium levels in both the shallow aquifer and deeper sand lenses were substantially higher than they are today. Reference 2 notes that the concentration of tritium measured in Sherman Spring in 1965 was about 2E+06 pCi/L.

The processes of natural attenuation, including dilution, dispersion, and radioactive decay, have significantly reduced the tritium levels over the intervening years. The levels are lower in the shallow aquifer because the higher hydraulic conductivity and more homogeneous flow domain in that unit have allowed more flushing and dilution compared to the deeper discontinuous sand lenses where flow is more restricted because the sands are interlayered within a virtually impermeable lodgement till.

5.1.3 Hydrogeologic Cross-Sections With Tritium

Figures 26 through 30 are compilations of Hydrogeologic Cross-Sections A-A' through E-E' showing tritium concentrations and ground water levels during each of the four quarters of 2004. Figure 2 shows the trace of each cross-section at ground surface on the YNPS site.

The cross-sections show tritium concentrations measured in screening samples collected in each sand lens encountered during drilling, as well as the results of tritium analyses of quarterly ground water samples. Comparison of the two results indicates that where both screening samples and quarterly samples have been collected from the same sand lens, the quarterly sample results are generally comparable to or substantially less than the screening sample results. This relationship has been confirmed through analysis of several quarters of ground water samples, and is illustrated on the cross-sections. This relationship shows that the screening sample analyses are representative of the maximum concentration of tritium that is measured within a sand lens. This allows for reliable characterization of the tritium distribution in a series of sand lenses in which screening data are available without completing monitoring wells in each sand lens.

Figure 26 illustrates tritium impacts in sand lenses 30 to 100 feet deep on cross-section A-A' during each quarter of 2004. Tritium results are less concentrated in the area of MW-107C and D in March relative to the remaining quarters in 2004 because of the damage to these wells in early 2004 discussed above. This figure shows that impacts within the deeper sand lenses appear to originate adjacent to the SFP/IXP complex and extend downgradient in the direction of ground water flow inferred in Figure 11, to a point somewhere beyond the MW-104 well cluster.

cross-sections also illustrates the water level in each monitoring well and the inferred vertical flow potential that these water levels imply. Whether or not vertical flow occurs in the directions shown is dependent upon hydraulic connection between units. Figure 26 shows a consistent downward flow potential from the shallow aquifer to the water-bearing sands 30 to 100 feet deep during each quarter of 2004. This figure also shows a consistent upward flow from the bedrock to the deeper sand lenses in the central part of the site, near the vapor container. Conversely, the vertical flow potential is from the deeper sand lenses to the bedrock farther downgradient, in the vicinity of the MW-104 well cluster.

Figure 27 shows the tritium distribution and water levels on cross-section B-B’ during the four quarters of 2004. Similar to the A-A’ cross-sections, the B-B’ sections also show a consistent downward flow potential from the shallow aquifer to the deeper sand lenses. One exception to this trend occurred in MW-105C in November. The B-B’ sections illustrate that the downward flow potential from the deep sands to the bedrock that was identified in the MW-104 well cluster on the A-A’ cross-sections (Figure 26) persist throughout all the wells on the B-B’ cross-section. This condition is reversed from what is observed farther upgradient, in the vicinity of the vapor container. Figure 2 shows that the B-B’ section is located downgradient from the RCA and is approximately normal to the predominant horizontal ground water flow direction.

Figures 28, 29, and 30 all show a consistent downward flow potential from the shallow aquifer to the deeper sand lenses during the four quarters of 2004 on cross-sections C-C’, D-D’ and E-E’. With one exception (MW-100 on cross-section D-D’) these figures also indicate an upward flow potential from the bedrock to the deeper sands in the central region of the site, but a reversal of this vertical flow potential in downgradient areas such as the vicinity of monitoring well clusters MW-105, MW-108, and MW-103.

5.1.4 Change in Tritium Concentration with Ground Water Level

Figures 31 through 39 illustrate the trend in tritium concentrations and ground water levels measured immediately before sampling in eighteen monitoring wells in which tritium has been consistently detected. These data are provided for six rounds of quarterly sampling. With a maximum of six data points, it is difficult to definitively identify correlations between tritium concentrations and well water levels.

On the basis of the limited data available, both direct and inverse relationships between the two parameters can be postulated in wells for which data are plotted in Figures 31 through 39. These include wells completed in the shallow aquifer, in sand lenses 30 to 100 feet deep and in the bedrock. These figures show that no consistent relation between tritium and ground water level is apparent in any of the three units. No conclusions regarding the relation between the two parameters can yet be drawn due to the sparsity of data. Continued monitoring of tritium concentrations and water levels may reveal a relationship as more data are developed.

5.1.5 Tritium Source Abatement

The SFP/IXP complex, including its foundation, is currently being demolished. Radiologically impacted soil excavated adjacent to the foundation will be removed from the site. After the SFP/IXP complex and impacted soil is removed, the empty excavation will be surveyed, demonstrated to satisfy the radiological criteria for unrestricted use, then backfilled. Dewatering of the open excavation during demolition may facilitate removal of tritium-impacted ground water. When the area is restored, monitoring wells beneath the reactor support structure that were temporarily abandoned during demolition will be extended to the new site grade level. Sampling of ground water from these and other monitoring wells in the vicinity of the IXP/SFP complex will resume after site restoration is complete, to demonstrate the effect of site remediation. YAEC anticipates that processes of natural attenuation, including dilution, dispersion, and radioactive decay, will continue to reduce tritium concentrations observed in the ground water.

5.2 Other Radionuclides in Ground Water

A review of Table 9 indicates that no plant-related radionuclides other than tritium have been detected in ground water at YNPS. Low levels of virtually every radionuclide analyzed have been reported infrequently at concentrations near the critical level (1.645 times the standard deviation of the total counts). However, these results are within the 5% of results expected to be statistically above the critical level but within the background distribution. A review of Table 9 reveals that the results are randomly distributed, both spatially and temporally.

Gross alpha radioactivity is detected occasionally in most wells, and gross beta activity is detected consistently in all wells. However, this radioactivity is naturally occurring in minerals found within the local soil and bedrock and is not related to operations at YNPS. Reference 14 provides a thorough discussion of the natural occurrence of radioactive materials and the relation between the concentrations of several naturally-occurring radionuclides in the U-238 and Th-232 decay chains that were measured in ground water samples from YNPS and the measured gross alpha and gross beta activity in those samples.

5.3 Non-Radioactive Constituents in Ground Water

Results of non-radiological analyses for ground water are summarized in the January 2005 Phase II-Comprehensive Site Assessment Report prepared by Environmental Resources Management for YAEC (Reference 15). This report summarizes the results of ground water quality testing for oil and/or hazardous materials (OHM) that was conducted in 2003 and 2004. The results indicate that impacts to site ground water are generally limited to: 1) polychlorinated biphenyls (PCBs) at MW-5 and MW-107D which are attributed to particulates in ground water samples due to infiltration of storm water containing PCB paint chips into damaged well road boxes; 2) 1,1-dichloroethene (DCE) in MW-105C at concentrations less than 2 micrograms per liter (µg/L); and 3) bis 2-ethylhexylphthalate (DEHP) in MW-108B at 36 µg/L. These impacts are limited to isolated wells, are not laterally extensive or indicative of a plume. Additional characterization of OHM in site ground water will be conducted as part of the continued assessment and monitoring associated with site closure.

6.0 Summary and Conclusions

Ground water investigations began at YNPS in 1977, with installation of the first monitoring well. Since then, a total of 65 additional monitoring wells have been installed. The most recent investigative phase occurred during the summer of 2004, when ten additional wells were installed to further characterize the hydrogeologic features at the site. This recently completed investigation followed a comprehensive episode of drilling that was completed in the previous year, which is reported in Reference 1.

Ground water has been sampled quarterly since July 2003 in all accessible monitoring wells. Tritium continues to be the only plant-related radionuclide detected in ground water at YNPS. It is found within two hydrogeologic units at the site: the shallow stratified drift aquifer and within deeper thin discrete sand lenses that are interlayered within a very dense, virtually dry lodgement till.

The maximum concentration of tritium found in the shallow aquifer is about 5,000 pCi/L where detected. The deeper impacted zone is smaller in extent, but ranges in concentration from about 5,000 up to about 42,000 pCi/L, where detected. The most concentrated portion of both the shallow and deeper impacted zones occurs adjacent to the SFP/IXP complex, which was the source of tritium as described earlier. The shallow aquifer is less concentrated, apparently because of its higher hydraulic conductivity and the greater number of aquifer volumes that have flushed through the shallow system compared to the lower hydraulic conductivity and more discontinuous, restricted flow domain within the deeper sand lenses.

Comparison of the results of screening ground water samples collected during drilling and quarterly ground water samples indicates that where both screening samples and quarterly samples have been collected from the same sand lens, the quarterly sample results are generally comparable to or substantially less than the screening sample results. This relationship shows that the screening sample analyses are a reliable estimate of the maximum concentration of tritium measured within a sand lens. This allows for reliable characterization of the tritium distribution in a series of sand lenses in which screening data are available without completing monitoring wells in each sand lens.

Since removal of all spent fuel from wet storage to dry storage in on-site vertical concrete casks during the summer of 2003, the SFP has been permanently drained and will shortly be demolished. Accordingly, the last source of tritium to the environment has been removed from YNPS.

The results of the 2004 drilling campaign, conducted on the margins of the presumed perimeter of the tritium contamination, confirm that monitoring well clusters MW-106, MW-108, and MW-109 bound the extent of tritium contamination to the north, west, and southwest of both the shallow and deeper zones of impact. Only minor concentrations of tritium (less than 1,000 pCi/L compared to the EPA MCL of 20,000 pCi/L) were detected in the shallow aquifer at MW-106 and in two of the deeper thin, discrete sand lenses at MW-109.

Correlation of the subsurface information developed during the 2003 and 2004 drilling programs has led to a slightly revised conceptual model of the sedimentary stratigraphy of the site. The lodgement till that lies under the shallow stratified drift aquifer is thicker and the top of the underlying glaciolacustrine sequence is deeper than originally thought. This interpretation implies that many of the thin, discrete sand lenses found at depths of about 30 to 100 feet are interlayered within the lodgement till rather than the glaciolacustrine sequence. The lodgement till is extremely dense, silty, and virtually dry. The interlayered sand lenses appear to be discontinuous and of limited extent. This stratigraphy has obvious implications for the transport of contaminants in ground water and suggests that the thin, discrete sand lenses do not provide a mechanism for flow of tritium over distances greater than a few hundred feet. It is also consistent with the occurrence of more concentrated tritium impacts within the deeper sand lenses where flow is more restricted, compared to the more homogeneous and higher hydraulic conductivity shallow aquifer.

Measurements of ground water levels in monitoring wells indicate a generally northwest flow direction in the shallow aquifer through the RCA, with a more westerly flow downgradient of the RCA, toward the Deerfield River. The highest water levels generally occur during the second quarter of the year and the lowest in the fourth quarter. A downward vertical flow potential exists across the site, from the shallow aquifer to the water-bearing sands 30 to 100 feet deep. The existence of a deeper zone of tritium impact within the 30 to 100-feet deep sand lenses is consistent with the downward flow potential. An upward flow potential exists from the bedrock to the deeper sands in the central part of the site, near the vapor container.

The relation between tritium concentrations and ground water levels has been evaluated. It appears that a complex set of conditions determines how tritium concentrations in ground water will vary as water levels change. The length of record for tritium concentrations and ground water level data is not sufficiently long to allow a meaningful predictive correlation between these two parameters to be developed at this time.

Monitoring of water levels in wells equipped with data-logging pressure transducers has identified apparent hydraulic connection between wells approximately 250 feet apart in the shallow aquifer. Hydraulic connection between some but not all discrete deeper sand lenses with a lateral separation of about 140 feet was also indicated. However, no connection was indicated between the shallow aquifer and the deeper sand lenses in the area studied. Similarly, no connection was indicted in MW-107C, the well with the highest concentration of tritium at the site, when drilling in a sand lens at a location about 200 feet away. The lack of response in MW-107C suggests that the sand lens in which it is completed is isolated and of limited extent. Response to drilling activities in the bedrock also indicates hydraulic connection between some wells in the bedrock with a lateral separation of about 250 feet, but no connection between the bedrock and the overlying deposits.

A data-logging rain gauge has been installed at YNPS. One month of data, from late September to late October 2004, was plotted on hydrographs of the water levels in several wells. These hydrographs show little correlation between precipitation events and change in ground water levels. The data available are limited and no conclusion regarding the relation between these parameters is reached at this time.

Twenty-two monitoring wells drilled prior to 2003 were permanently abandoned during the summer and fall 2004. These wells were in areas of active demolition and were of less specific construction than those installed by the current rotosonic installation process. Abandonment of the wells eliminated potential aquifer contamination resulting from demolition-induced damage. The need for replacement wells in one or more of these areas will be evaluated as the ground water investigation proceeds.

Gross beta activity is detected in all of the wells and gross alpha is detected in some of the wells. This activity is associated with naturally-occurring radioactivity from the uranium and thorium decay series.

7.0 Recommendations

1. Install multi-level clusters of monitoring wells at two locations shown as proposed wells MW-110 and MW-111 in Figure 40. Well screens should be completed at these two locations in the shallow aquifer, in any deeper saturated sand lenses with significant tritium concentration, and in the bedrock.

As evidenced in several figures throughout this report (Figures 22 through 26 and 28 through 30), the SFP/IXP complex is shown to be the primary source of plant-related impacts to ground water at YNPS. The saturated unconsolidated deposits beneath the location of the unplanned release documented in AOR 64-13, which occurred on the west side of the SFP/IXP complex in 1964, may contain the highest levels of tritium in the ground water. A second area that may contain elevated levels of tritium that may have contributed to the high levels measured in MW-107C, is at the northeast corner of the SFP/IXP. The proposed wells would target these areas.

The objectives of these additional wells would be to identify and characterize any discrete sand lenses 30 to 100 feet deep, to determine the interconnectivity between these discrete sand lenses and those already identified and the associated potential for contaminant transport, and to discover if tritium or other radionuclides exist at concentrations greater than those already identified. Wells completed in the shallow aquifer at these locations would replace recently abandoned wells CB-1 and MW-5, which consistently contained some of the highest tritium concentrations in the shallow aquifer. The proposed wells should be drilled as access to these areas becomes available and during the site restoration process.

2. Initiation of remedial measures to address tritium in ground water at YNPS is not recommended at this time.

The SFP/IXP structure will soon be excavated and removed. It is this structure, with its foundation within the top of the lodgment till, that was the primary source of tritium in both the shallow aquifer and the deeper sand lenses within the till. After the SFP/IXP complex and adjacent impacted soil is removed, the empty excavation will be surveyed, demonstrated to satisfy the radiological criteria for unrestricted use, then backfilled. Dewatering of the open excavation may remove impacted ground water in its vicinity. Continued sampling of ground water from monitoring wells in the vicinity of the IXP/SFP complex will demonstrate the effect of its removal. YAEC anticipates that the processes of natural attenuation, including dilution, dispersion, and radioactive decay, will continue to reduce tritium concentrations in the ground water. YAEC will determine future remedial actions based on continued data collection.

3. Ground water sampling should continue, with the addition of any new wells that may be drilled. Quarterly sampling should be postponed until the fourth quarter of 2005 (depending upon accessibility) to allow for completion of demolition activities and site restoration.

Six consecutive quarters of ground water sampling and analysis since July 2003 has led to a better understanding of the concentrations of tritium in the shallow aquifer, in sand lenses within the lodgement till and in the bedrock aquifer, and their variability over time. The quarterly sampling data have also confirmed the absence of other plant-related radionuclides in site ground water. The results of continued sampling may improve the ability to identify trends in tritium concentration related to change in ground water level, and will demonstrate a net reduction in tritium levels over time.

Most of the structures at YNPS have been removed and the remaining demolition is focused on the reactor support structure and the SFP/IXP complex within the RCA. Approximately thirty-five percent of the remaining monitoring well network is located within the immediate vicinity of these structures and will remain inaccessible until demolition and site restoration are complete sometime in the third quarter of 2005. These wells are essential to the continuing ground water investigations at the site. Sampling of the limited number of accessible wells was recently completed during the first quarter of 2005 to provide baseline data for future sampling events.

4. <u>Monitoring of ground water levels and precipitation with data-logging pressure transducers and a data-logging rain gauge should continue.</u>

Continued monitoring through the use of these electronic instruments will provide data useful for correlating changes in the two parameters. These correlations may prove useful in demonstrating the degree of hydraulic connection between aquifers at YNPS.

5. <u>Discontinuation of monitoring for gamma-emitting and hard-to-detect radionuclides in selected wells should be considered.</u>

No gamma-emitting or hard-to-detect radionuclides have been detected in ground water by analysis of several rounds of quarterly samples. Analysis for these types of radionuclides can be discontinued for samples obtained from monitoring wells where their absence has been confirmed over two consecutive quarters. The continuing ground water monitoring data should be evaluated to ensure resumption of these analyses is not warranted.

8.0 References

Reference 1: YA-REPT-00-004-04; Hydrogeologic Report of 2003 Supplemental Investigation, March 15, 2004

Reference 2: DESD-TD-YR-02-001, Rev 1; Site Ground Water Data Collection for YNPS Decommissioning, Framatome ANP DE&S, February 2003

Reference 3: AP-8601, Rev 4; Ground and Well Water Monitoring Program for the Yankee Nuclear Power Station Site, October 2003

Reference 4: DP-9746; Use of Data Logging Pressure Transducers to Continuously Monitor Water Levels in Ground Water Monitoring Wells and Rainwise Rain Monitoring System

Reference 5: Massachusetts Department of Environmental Protection Publication WSC-310-91; Standard Reference for Monitoring Wells, Section 4.6, Decommissioning of Monitoring Wells, November 1993

Reference 6: AP-8125; Procedure for Permanent Closure of Ground Water Monitoring Wells at YNPS

Reference 7: DP-8602; Ground Water Monitoring Well Drilling and Completion

Reference 8: AP-8122; Subsurface Soil Sampling and Monitoring Well Installation

Reference 9: Geologic Map of the Rowe Quadrangle, Franklin and Berkshire Counties, Massachusetts, and Bennington and Windham Counties, Vermont, 1967, by A.H. Chidester, N.L. Hatch, Jr., P.H. Osberg, S.A. Norton, and J.H. Hartshorn, Map GQ-642, Department of the Interior, United States Geological Survey

Reference 10: DP-9745; Ground Water Level Measurement and Sample Collection in Observation Wells

Reference 11: YA-REPT-00-013-04; Interim Ground Water Monitoring Report for Yankee Nuclear Power Station, September 2004

Reference 12: Yankee Nuclear Power Station Historical Site Assessment, Rev 1, September 30, 2004

Reference 13: Yankee Nuclear Power Station License Termination Plan, Rev 1, November 19, 2004

Reference 14: YA-REPT-00-014-00; Data Assessment Report on NORM in YNPS Ground Water

Reference 15: Phase II – Comprehensive Site Assessment Report, Yankee Nuclear Power Station, Environmental Resources Management, January 28, 2005