

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judges:

Ann Marshall Young, Chair
Dr. Peter S. Lam
Thomas D. Murphy

<p>In the Matter of</p> <p>CONNECTICUT YANKEE ATOMIC POWER COMPANY</p> <p>(Haddam Neck Plant)</p>	<p>Docket No. 50-213-OLA</p> <p>ASLBP No. 01-787-02-OLA</p> <p>October 15, 2003</p>
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INITIAL DECISION

This proceeding concerns the license amendment application of Connecticut Yankee Atomic Power Company (Connecticut Yankee, CY, Applicant or Licensee), seeking approval pursuant to 10 C.F.R. §§ 50.82(a)(9), (10), of a License Termination Plan (LTP) for its Haddam Neck Plant, located approximately 21 miles southeast of Hartford, Connecticut, on the east bank of the Connecticut River. Citizens Awareness Network (CAN) and the Connecticut Department of Public Utility Control (CDPUC or Connecticut) were admitted as intervenors in this proceeding in July 2001, at which time the Board also admitted 13 contentions filed by the parties. LBP-01-21, 54 NRC 33 (2001). CDPUC has since settled all its admitted contentions with CY, but has continued to participate in the proceeding as an interested governmental entity under 10 C.F.R. § 2.714(d).

On March 10-14, 2003, a hearing was held on the two CAN contentions remaining after settlement and/or withdrawal of its other contentions. The first of these two, Contention 1.5, relates to the adequacy of the site characterization and methodology for the detection and clean-up of transuranic, hard-to-detect nuclide (HTDN) and "hot particle" radioactive contamination. The second, Contention 6.1, relates to the adequacy of the dose modeling calculation methodology that CY employs in the LTP, and was admitted in limited form in LBP-01-21. 54

NRC at 93-94. For the reasons set forth herein, we find that CY has shown by a preponderance of the evidence that its LTP meets the requirements of 10 C.F.R. §§ 50.82(a)(9), (10), with regard to the issues raised in these contentions. Accordingly, we approve the license amendment application and terminate this proceeding.

BACKGROUND

In its July 7, 2000, license amendment request, Connecticut Yankee proposes to add a new license condition which would approve the LTP, also dated July 7, 2000, and allow the applicant to make changes to the approved LTP without prior NRC approval if certain criteria specified in the license condition are met. After a public meeting held October 17, 2000, the Staff proposed to determine that the amendment request involves no significant hazards consideration under 10 C.F.R. § 50.92(c), and provided notice of this finding and of the opportunity for a hearing with regard to the amendment request in the December 13, 2000, *Federal Register*. 65 Fed. Reg. 77,913, 77915-16 (Dec. 13, 2000). Thereafter, Petitioners CAN, appearing through non-attorney representatives,¹ and CDPUC filed their requests for hearing on January 10 and 12, 2001, respectively, and this matter was forwarded to the Atomic Safety and Licensing Board Panel on January 23, 2001.

¹At one point early in this proceeding there was some indication that CAN might be assisted by counsel, but the attorney in question withdrew from any representation of CAN, and

CAN currently appears through three non-attorney representatives, Ms. Rosemary Bassilakis, Director of Connecticut CAN; Ms. Deborah B. Katz, Executive Director of CAN; and CAN member Ms. Katie Flynn-Jambeck.

On January 31, 2001, this Licensing Board was established to preside over this proceeding. See 66 Fed. Reg. 9,111 (Feb. 6, 2001). Oral argument on the Petitioners' contentions was held in April and May 2001, Tr. 1-349, after which this Licensing Board issued LBP-01-21. Subsequently, in LBP-01-25, 54 NRC 177 (2001), the Licensing Board denied Connecticut Yankee's Motion for Reconsideration of the admission of Contention 6.1, the interlocutory appeal of which was denied by the Commission in CLI-01-25, 54 NRC 368 (2001). After settlement and/or withdrawal of 11 of the 13 contentions originally admitted in this proceeding, the Board conducted an evidentiary hearing on two CAN contentions, Contentions 1.5 and 6.1, in March 2003. Thereafter, on May 28, 2003, all parties filed their Proposed Findings of Fact and Conclusions of Law,² and on June 26 and 27, 2003, all parties filed response pleadings to each others' Proposed Findings.³ In addition, since the evidentiary hearing, various other pleadings have been filed both with this Board and with the Commission.

²Citizens Awareness Network Proposed Findings of Fact and Conclusions of Law Regarding Contentions 1.5 and 6.1 (May 28, 2003) [hereinafter CAN Proposed Findings]; NRC Staff's Proposed Findings of Fact and Conclusions of Law Concerning CAN Contentions 1.5 and 6.1 (May 28, 2003) [hereinafter Staff Proposed Findings]; Connecticut Yankee's Proposed Findings and Rulings in the Form of a Proposed Initial Decision (May 28, 2003) [hereinafter CY Proposed Findings].

³NRC Staff's Reply Findings of Fact and Conclusions of Law Concerning CAN Contentions 1.5 and 6.1 (June 26, 2003) [hereinafter Staff Reply Findings]; Citizens Awareness Network's Response to Connecticut Yankee's and NRC Staff's Proposed findings of Fact and

On March 21, 2003, CY filed a “Motion for Reconsideration: Motion to Compel (After-Acquired Information), Open Court, March 13, 2003,” relating to a discovery issue involving the duty to supplement discovery responses. After receiving responses from the other parties to this motion, a majority of the Board on May 20, 2003, issued a Memorandum and Order (Dismissing as Moot a Motion for Reconsideration of an Oral Discovery Ruling), with a Separate and Concurring Opinion filed by Administrative Judge Young.

Conclusions of Law Regarding Contentions 1.5 and 6.1 (June 27, 2003) [hereinafter CAN Reply Findings]; Connecticut Yankee’s Reply to Proposed Findings and Rulings Submitted by Citizens Awareness Network (June 27, 2003) [hereinafter CY Reply Findings].

Also, on April 1, 2003, CY requested that a supplemental exhibit – a March 21, 2003, document entitled “Effects of Recycling Sr-90 Contaminated Groundwater as Irrigation Water” – be received into evidence as Exhibit 60 (CY-17-Panel 1). In addition to other filings, CAN has submitted certain proposed additional evidence as well. On April 11, 2003, CAN filed a document entitled “Request for Admission of Late-Filed Amended Contention 6.1, Request that Consideration be Held in Abeyance, and Request to Hold the Record Open,” with Exhibits 1, 2 and 2A, and the same date mailed proposed Exhibits CAN-38-Resnikoff and CAN-39-Resnikoff, identified as CY’s Geoprobe Results and Surrogate Ratio, respectively, along with its request that these be received into evidence. Responses to CAN’s April 11 Requests were filed by CY and the Staff on April 28, 2003. Further, on June 27, 2003, CAN filed a Motion to Supplement Record, responses to which were filed by CY and the Staff on July 14, 2003.⁴

Finally, CAN filed with the Commission a document entitled “Citizens Awareness Network Petition for Consideration of Whether 25 mrem/Year Dose Standard Ensures Decommissioning Activities Are Not Inimical to the Health and Safety of Children in Satisfaction of 10 C.F.R. § 50.82(a)(10) And Request to Direct the Licensing Board to Accept Amended Contention 6.1” (April 14, 2003). After receiving responses from CY and the Staff opposing CAN’s Petition, the Commission on July 2, 2003, denied the Petition in its entirety and directed the Board to reject the proposed Amended Contention 6.1. CLI-03-07, 58 NRC __ (2003).

RULINGS ON PENDING MATTERS

No objections having been filed to CY’s proposed Exhibit 60 (CY-17-Panel1), or to CAN-38-Resnikoff and CAN-39-Resnikoff, and given the submission of these documents prior to the closing of the record in May 2003, see Memorandum and Order (Dismissing as Moot a

⁴Citizens Awareness Network’s Motion to Supplement Record (June 27, 2003) [hereinafter CAN Motion to Supplement]; Connecticut Yankee’s Response to “Motion to Supplement the Record” Filed by Citizens Awareness Network (July 14, 2003) [hereinafter CY Response to Motion to Supplement]; NRC Staff’s Opposition to CAN’s Motion to Supplement Record (July 14, 2003) [hereinafter Staff Opposition to Motion to Supplement].

Motion for Reconsideration of an Oral Discovery Ruling) (May 20, 2003), at 3, we admit them into evidence in this proceeding.

Based, however, on the Commission's ruling in CLI-03-07, the Board denies admission of proposed Amended Contention 6.1, and declines to admit related CAN Exhibits 1, 2 and 2A.

With regard to CAN's June 2003 Motion to Supplement Record, given that the record was closed in May 2003, we will treat this as a motion to reopen the record under 10 C.F.R. § 2.734. We find, as discussed below in our conclusions on Contention 1.5, that CAN's motion does not demonstrate that a materially different result would be likely based on the proffered new information, as required under 10 C.F.R. § 2.734(a)(3), and therefore deny the motion.

FINDINGS OF FACT - Contention 1.5

Contention 1.5 provides as follows:

Adequacy of Site Characterization, Methodology for Detection and Clean-up of Transuranic, Hard-to-Detect Nuclide (HTDN), and "Hot Particle" Contamination.

CY's LTP is insufficient in providing the methodology that will insure adequate detection and cleanup of transuranics (TRU), "hot particles," and hard-to-detect nuclide (HTDN) contamination. Contrary to the requirements of 10 C.F.R. § 50.82, the measurement methodology CY provides in its LTP Site Characterization and Final Site Survey Plan to determine alpha and beta emitting radioactivity, "hot particles," and HTDN, is not adequate to demonstrate that public and occupational health and safety will be protected.

LBP-01-21, 54 NRC at 80-81.

In admitting this contention, the Licensing Board noted that CAN "provided sufficient explanation, facts, expert opinion, sources, and documents to show that a genuine dispute [existed] on the material issue of the appropriate methodology to use to test for alpha contamination and 'hot particles' on the site, so as to warrant further inquiry." *Id.* The dispute on this contention centers on CAN's challenge to CY's program for the detection of "hot particles" and its plan to use a surrogate analysis technique for detecting hard to detect [HTD] radionuclides. We deal with each of these issues separately below.

The evidence on this contention includes the prefiled and hearing testimony of CY witnesses George E. Chabot, Ph.D., Russell A. Mellor, Kenneth J. Heider, Richard N. McGrath, Eric L. Darois, C.H.P., and James P. Tarzia, C.H.P.; CAN witness Dr. Resnikoff; and NRC Staff witness Jean-Claude Dehmel. Each of the witnesses has provided a curriculum vitae with his direct pre-filed testimony. The Board has reviewed this information for each witness and finds each qualified to testify as an expert to matters at issue with regard to Contention 1.5.

Hot Particles

Hot particles are small, discrete radioactive fragments consisting of metallic alloys or spent fuel, which are insoluble in water. They range from a few microns to a few millimeters in dimension, and are generally irregularly shaped; according to NRC Information Notice 90-48, a “hot particle” is less than 1 mm in any dimension. Pre-filed Direct Testimony of Russell A. Mellor, Kenneth J. Heider, Richard N. McGrath, Eric L. Darois, C.H.P., and James P. Tarzia, C.H.P. (“CY Panel”) Relating to CAN Contentions 1.5 and 6.1 (Feb. 7, 2003), fol. Tr. 1256, at 13 [hereinafter CY Panel Direct]; Prefiled Rebuttal Testimony of Russell A. Mellor, Kenneth J. Heider, Richard N. McGrath, Eric L. Darois, C.H.P., James P. Tarzia, C.H.P., and Stewart W. Taylor, Ph.D. (“CY Panel”) Relating to CAN Contentions 1.5 and 6.1 (Feb. 28, 2003), fol. Tr. 1256, at 1-2 [hereinafter CY Panel Rebuttal]; NRC Staff Testimony and Professional Qualification Statements of Jean-Claude Dehmel (Feb. 7, 2003), fol. Tr. 1756, at 4 [hereinafter Dehmel Direct].

Hot particles are characterized by elevated radioactivity levels and, as a result of radioactive decay, become electrically charged. Dehmel Direct at 4-5. The radiological properties of hot particles at a particular site are dependent on the nuclear plant’s operational history; “primary coolant chemistry which is responsible for metallic corrosion products[;] sudden changes in power levels which may result in thermal stress leading to premature fuel rod

failures[;] wear properties [of the] metallic alloys present in components”; the “level of neutron radiation and duration of irradiation; and how much of the fuel has been used.” *Id.*

Hot particles fall predominately into two categories: (1) “[M]inute specs of metallic alloys that have been activated by neutron irradiation, consisting primarily of Co-58 and Co-60, and, (2) Particles originating from failed fuel contain uranium and transuranics, comprising mainly of Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-243 and Cm-244. The predominant fission products present in spent fuel hot particles include Zr-95, Nb-95, Ru-103, Ba-140, Ce-141, and Ce-144 . . . and smaller amounts of other radionuclides such as, Sr-89, Sr-90, Cs-134, Cs-137, and Pm-147.” Dehmel Direct at 6.

According to the CY expert panel, hot particles are present within plant systems and “are typically found in radiologically controlled areas [(“RCA”)] of nuclear plants, where reactor coolant water may have cross-contaminated floors or components. Their characteristics are such that they rarely . . . become airborne. . . . Nuclear plants maintain . . . controls to monitor and prevent the spread of hot particles outside radiologically controlled areas.” CY Panel Rebuttal at 2. Routine surveys are performed during operation and decommissioning to ensure that contamination is detected. *Id.* If hot particles are found, additional surveys are performed in boundary areas to ensure that the probability of release outside the RCA is extremely remote. *Id.*

However, in the case of CY, there was an event in 1979-1980 during which hot particles were released outside the RCA from the vent stack. CY Panel Direct at 6; CY Panel Rebuttal at 2-3; Citizens Awareness Network’s Pre-Filed Testimony of Dr. Marvin Resnikoff Regarding Contentions 1.5 and 6.1 (Feb. 7, 2002), fol. Tr. 1482, at 4 [hereinafter Resnikoff Direct]. Because of their mass, the particles quickly fell to the ground. CY Panel Rebuttal at 2-3. Following this event, CY conducted radiological surveys in the outside areas of the site, and detected the presence of hot particles, which were located and remediated. CY Panel Direct at

6; CY Panel Rebuttal at 2-3; Resnikoff Direct at 4. The hot particles found following the vent stack release were primarily found northward of the plant approximately 200-300 meters and eastward of the plant approximately 200 meters. Tr. 1291-1297. The vast majority of the particles were found in a tight radius around the reactor containment building. Tr. 1295.

According to CY expert witnesses, subsequent routine operational surveys performed following the event have shown no additional particles meeting the definition of a hot particle used by CY in the affected areas outside of the RCA. CY Panel Rebuttal at 2-3. Although there is no absolute industry standard on how high the activity level of a particle must be to define it as a "hot particle," CY Panel Direct at 13, the definition used by CY is that it must exceed 20,000 counts per minute and be less than one millimeter in size. Tr. 1304-05. While areas of low-level contamination were found on the hillside outside the RCA, no discrete particles were found that met the CY definition of a hot particle. Tr. 1300-05, Ex. 9 (Hot Particle Log), Tr. 1391-93. And while hot particles were found within the RCA, as a result of breaching systems at the plant, processes and procedures were in place to prevent those particles from leaving the RCA. Ex. 8 (Silvia Memo); Tr. 1283-86. Follow-up surveys, asserted by CY witnesses to be rigorous, were performed in 1980. Tr. 1435. Thereafter, beginning in 1997, additional surveys were performed for the purpose of detecting hot particles, in which 100% of the areas most likely to be affected were surveyed but no hot particles, as CY defined them, were found. Tr. 1434-37.

There appears to be no conflict among the parties that hot particles have existed in the past or do exist now. See CAN Proposed Findings at 4-6.

CAN asserts that CY's Final Survey Status Plan [hereinafter FSSP], which is contained in the LTP at Chapter 5 (Exhibit 1 at 5-1 to -66), will not identify hot particles. CAN Proposed Findings at 6. CAN's expert, Dr. Resnikoff, claims that § 5.7.2.5.4 of the LTP, at 5-45, relates to surveying land areas, not to detecting hot particles that contain gamma radiation. Tr. 1706. In addition, CAN contends that the Multi-Agency Radiological Site Survey and Investigation Manual

(MARSSIM) does not provide guidance on the detection of hot particles. Tr. 1706, 1767. CAN asserts that the Staff testified that CY does not provide in the LTP a detailed final status survey plan for hot particles, contrary to the requirements of 10 CFR 50.82 (a)(9)(ii)(D), and also asserts that the LTP must be amended to include specific techniques for identifying hot particles. Tr. 1791-92; CAN Proposed Findings at 6; CAN Reply Findings at 4-5.

In addition, CAN challenges the sensitivity of CY's technique to detect hot particles, arguing that CY can not detect a fuel fragment with sufficient sensitivity to meet release criteria. CAN Proposed Findings at 7. CAN expert Resnikoff uses radiological information from a hot particle retrieved from the San Onofre reactor, called "Battelle Particle No. 7," as a surrogate for calculating the sensitivity of the technique for detecting hot particles. CAN Proposed Findings at 6-8; CAN Reply Findings at 5-7; Resnikoff Direct at 4-6. Dr. Resnikoff scaled the Battelle particle to 10 microns and calculated that such a particle inhaled would result in a dose that would be a significant fraction of the limits of 10 CFR 20.1402. *Id.* at 5-6; CAN Proposed Findings at 6-9; CAN Reply Findings at 9-15. During the hearing, however, Dr. Resnikoff stated that in performing his calculations he had incorrectly used the dose conversion factors for a 1-micron particle instead of a 10-micron particle. Tr. 1677-78. To correct for this error, he recalculated the adult dose using the 10-micron dose conversion factor and concluded that the dose should be 6.419 mrem rather than 15.71 mrem. Tr. 1677-80, Ex. 43 (1 micron vs. 10 micron DCF, ICRP-60).

Dr. Resnikoff also calculated the dose from inhalation of a particle 10 microns in diameter, testifying that his calculations were based on inhalation of the particle, which results in a higher dose than ingestion. Resnikoff Direct at 6. Further, he stated that he considered a particle 10-microns in diameter to be respirable. [CAN] Rebuttal Testimony of Dr. Marvin Resnikoff Regarding Contentions 1.5 and 6.1 (Feb. 28, 2003), fol. Tr. 1498, at 2 [hereinafter Resnikoff Rebuttal]. Dr. Resnikoff performed his calculation using the isotopic composition of

the Battelle No. 7 hot particle that had been measured in 1986. Resnikoff Direct at 5. He inferred the alpha emitting actinides using ratios from the ORIGEN2 code, considered the inventory had decayed for 12 and 22 years, and scaled the inventory from the 80 micron size of the San Onofre particle to a 10 micron diameter. *Id.* He then calculated the dose for an adult at 13-15 mrem; a 10-year old child at 15 to 18 mrem and a 5-year old child at 22-26 mrem. *Id.*

According to Connecticut Yankee, the Final Status Survey Plan was developed using the guidance of MARSSIM. Ex. 1 § 5.1, at 5-1. CY responds to CAN's challenge by asserting that the scan technique proposed in the LTP are consistent with the requirements of MARSSIM and has sufficient sensitivity to detect hot particles of a magnitude that are well within the dose release criteria of 10 CFR § 20.1402, Subpart E. CY Proposed Findings at 9; CY Reply Findings at 1; Ex. 1 § 5.5, at 5-24 to -26, § 5.7.1.1, at 5-38 to -39 (Table 5-9), § 5.7.3.1, § 5.7.3.2 .

CY proposes to use its surface soil survey methodology to detect any hot particles not previously detected and remediated. CY Proposed Findings at 9. This proposed methodology includes, first, dividing the land area of the site, per MARSSIM, into survey areas. See Ex. 45 (MARSSIM), § 4.4, at 4-11; Ex. 1, § 1.3.2. Survey areas are classified as Class 1, Class 2, Class 3 or Unaffected, based on their potential to bear residual radioactivity. Ex. 1 § 5.5, at 5-24 to -25, § 5.5.3.1, at 5-34 to -35; CY Panel Rebuttal at 10. For Class 1 areas, the surface soil survey methodology consists of fixed measurements of soil samples performed on a systematic grid, plus a 100% surface area scan. CY Panel Rebuttal at 10; Ex. 1 § 5.5, at 5-25. All other areas may be scanned with a lower fraction; however, judgment is used to determine the fractions and locations where 100% scan is performed within Class 2 and 3 survey units. The judgmental assessment includes a review of all historical information available for each survey unit and will include not only areas where particles are likely to be found, but also areas where it is possible they might be found. The process is a requirement of the "Data Quality Objective

(DQO) process committed to by the LTP for both characterization and final status surveys.” CY Panel Rebuttal at 10; Ex. 1 § 5.5, at 5-24 to -25, § 5.5.3.1, at 5-34 to -35.

CY claims the sensitivity of the scan methodology it proposes in the LTP is adequate to meet the requirements of Subpart E. As described by the CY Panel, “The scanning technique employed at the CY site for soils uses a gamma sensitive device (NaI detector) where the survey technique involves moving the detector from side-to-side at a rate of 0.5 m/sec as the surveyor slowly walks forward. This creates a serpentine detection pattern over the scanned soil. This scanning method is consistent with MARSSIM and sensitive to a level where the elevated measurement DCGL (or DCGL_{EMC}) is adequately detected as required by the LTP.” CY Panel Direct at 15-16; see MARSSIM at 6-13 to -15.

To determine whether this technique is sufficiently sensitive to detect a “hot particle” of significant dose potential, the CY Panel engaged in a two-step analysis. CY Panel Direct at 16. First, the Panel calculated the sensitivity of this scan technique. *Id.* This calculation is contained in Ex. 2, at 9, and was reviewed and concurred in by Dr. Chabot. Pre-Filed Direct Testimony of George E. Chabot, Ph.D, C.H.P. (Feb. 7, 2003) fol. Tr. 1443, at 10-12 [hereinafter Chabot Direct]; see Ex. 2 (Panel Attachment 2: “Health Physics Department, Technical Support Document, HP Number: BCY-HP-0081 Rev. 4: Scan MDC of Land Areas Using a 2-inch by 2-inch Sodium Iodide Detector” (2/03/03)). The result of the calculation is that the LTP surface soil scan technique has a sensitivity sufficient to detect a particle containing as little as 0.096 μCi of Co-60. CY Panel Direct at 16.

Next, the CY Panel calculated the dose that a particle containing this level of Co-60 activity would impart if ingested. The calculated dose from the inhalation/ingestion of a particle containing 0.096 μCi of Co-60 is 0.67 mrem. CY Panel Direct, at 16-17; Ex. 4 (Panel Attachment 4: “Health Physics Department, Technical Support Document, HP Number: BCY-HP-0125 Rev.

0: Dose Estimate for an Ingested Particle” (12/05/02)), at 7. Once again, this calculation was reviewed and concurred in by Dr. Chabot. Chabot Direct at 11-12.

To counter Dr. Resnikoff’s calculation of dose from the Battelle No. 7 particle scaled to 10 microns, the CY panel calculated the dose that might be imparted by the ingestion of an actual fuel fragment “hot particle” from the 1979-80 event on site, producing a calculated individual dose of “less than one mrem.” CY Panel Direct at 18; Ex. 5 (Panel Attachment 5: “Health Physics Department, Technical Support Document, HP Number: BCY-HP-0075 Rev. 0: Evaluation of the 1980 Particulate Activity for Impact on the PSR Survey (9/20/01) at 2, Attachment 1. CY also asserts errors in several key areas of Dr. Resnikoff’s calculations. For example, CY challenged Resnikoff’s use of a single 10 micron particle and showed that such a particle is very unlikely to be inhaled into the deeper regions of the lung. As CY expert Darois testified, the likelihood of deposition of a 10 micron particle in the deeper reaches of the lung is less than 1%. Tr. 1385-88; see also Ex. 14 at 139; Ex. 42 at 207-08. In addition, CY disputed Resnikoff’s use of a particle from another power reactor without relating it specifically to the conditions found at the Haddam Neck Plant. CY Proposed Findings at 12-13. CY also challenged Resnikoff’s use of ICRP 72 in his dose calculation without correcting for the parameters required by ICRP 72 in its modeling of lung dose. *Id.* at 11-19 & n.12; Ex. 14 (NCRP Report No. 130, Biological Effects and Exposure Limits for “Hot Particles”); Ex. 42 (Health Effects of Exposure to Radon, BEIR VI); Ex. 46 (ICRP-72). Finally, upon cross-examination by CY counsel, Dr. Resnikoff admitted he was in error in his use of a one meter survey meter height in his calculation of the sensitivity of the technique CY proposes to use to detect hot particles. Tr. 1652-53, 1703-04.

According to the Staff, prior to conducting the Final Status Survey (FSS), CY must demonstrate that it has identified and remediated hot particles. Dehmel Direct at 6-10. As decommissioning proceeds, the Staff will conduct in-process inspections to verify

implementation of the commitments made by CY in the LTP and to review all aspects of the procedures, methodology, equipment, training and qualifications, and Quality Assurance and Quality Control measures. *Id.* at 9. With respect to hot particles, the Staff will evaluate CY's characterization and post-remediation data for survey units where there has been a history of hot particle contamination or where there is a possibility that hot particles may be found based on past, current or future activities. *Id.* at 9-10. In addition, the Staff will conduct independent confirmatory surveys of such areas to confirm the results generated by CY, and conclusions on the post-remediation status presented by CY in final status survey reports. Staff Proposed Findings at 13; Dehmel Direct at 8-10. The Staff has reviewed the LTP and agrees that the LTP sufficiently describes CY's methodology to perform radiation and radioactivity surveys to detect hot particles. Staff Proposed Findings at 13-16; *see also* Dehmel Direct at 9-12.

For hot particles in particular, the survey method selected must take into account the specific radiological history of the survey unit, any remediation that may have been performed in the past and any specific technical challenges that may exist for the particular survey unit given the physical condition of the area. Dehmel Direct at 9-10.

With regard to what is meant by "detailed plans for the final radiation survey," the Staff argues as follows:

While detailed plans are necessary in the LTP, they need not address each and every aspect of how the radiological survey program will be implemented. This is because the appropriate means for conducting the final radiation survey will depend in large part on information which is obtained during the decommissioning process. Throughout this process, the licensee will gain information on the extent and the nature of contamination at the various survey units that will be surveyed.

Staff Reply Findings at 1-2.

Finally, the NRC staff has reviewed the information in the LTP for the Haddem Neck plant and believes that the "radiation survey plan in the LTP provides assurance that residual radioactive contamination levels will meet the criteria specified" in Subpart E for unrestricted use

and the licensee has conformed to 10 CFR 50.82(a)(9)(ii)(D). Ex.44 (Safety Evaluation Report) at 26-27.

Surrogate Analysis

The controversy concerning CY's plan to use a surrogate analysis technique stems from the undisputed fact that the radiological characterization of the site reveals numerous radionuclides, some of which are easy to detect (ETD) and some of which are hard to detect (HTD). CY Panel Direct at 6. According to Staff expert Dehmel, the term "hard-to-detect nuclides" refers to radioactive elements that are relatively difficult to measure using simple hand-held portable radiation survey instruments because they emit radiation that is easily attenuated or shielded by surrounding media, such as soil concrete, paint, metal, air, water or other commonly found materials in waste. Dehmel Direct at 6. Hard-to-detect nuclides can be activation or fission products of nuclear fuel and may emit only beta particles, only alpha particles or only low energy x-rays. CY Panel Direct at 6. During operation of the Haddam Neck Plant, CY experienced fuel failures during some of its operation cycles, causing some of the contamination at the site to contain a higher than typical amount of hard-to-detect radionuclides. *Id.*; Dehmel Direct at 5.

Because of the difficulty of detecting this type of radiation, a common practice is to obtain samples, which are analyzed "in a laboratory setting using specific equipment and procedural steps." Dehmel Direct at 6. For these samples, a relatively simple laboratory analysis is performed to detect gamma-emitting radionuclides, which are considered "easy to detect" in soil. CY Panel Direct at 7-8. The analysis for non-gamma emitting radionuclides is more complex. Thus the term "hard to detect." *Id.* at 8. Sample preparation to detect these radionuclides generally involves chemical separation methods conducted in a laboratory, which require several steps and take substantial time to complete. *Id.* This radiological analysis is performed using radiation detection devices that are sensitive to beta particles, alpha particles, or very low-energy

gamma rays which are incapable of being detected by gamma spectroscopy detection methods.

Id.

Because these methods are time consuming and costly, alternate methods are commonly used to account for the presence and dose contribution of hard-to-detect nuclides.

Id. An alternate method is the use of surrogate analysis when there is a reasonably consistent ratio between the laboratory-determined hard-to-detect nuclide and an easy-to-detect nuclide at a particular location. *Id.* The LTP identifies twenty specific nuclides that “may be considered at the time of the final status surveys . . . based on their potential for dose and a very conservative determination of their possible presence in contamination samples.” *Id.* at 8-9. These are identified according to the type of energy they emit: alpha, beta, gamma or low energy x-ray. Additionally, they are each identified as either hard- or easy-to-detect. *Id.* at 9.

These nuclides were created within the reactor core region as fission products or activation products and were transported to areas outside the reactor coolant system or to other support systems by the reactor coolant system. *Id.* at 10. Generally, these are transported together into the environment. *Id.* For this reason, they may be present in consistent ratios. *Id.* at 8, 10. When, and if, this is the case, the easy-to-detect nuclide may be used to infer the presence of the hard-to-detect nuclide. *Id.* at 8. This concept is used routinely by the nuclear industry in various applications. Dehmel Direct at 12.

There appears to be no conflict among the parties that hard-to-detect radionuclides have existed in the past and do exist now. CAN Proposed Findings at 9-10; Dehmel Direct at 11-13, CY Proposed Findings at 4-5. Nor does there appear to be a controversy about the use of a surrogate ratio technique to measure hard-to-detect radionuclides. Tr. 1654-56; Dehmel Direct at 12-13; CY Panel Direct at 10-11. CAN, however, contends that there is no evidence that consistent ratios between HTD and ETD radionuclides exist. CAN Proposed Findings at 10; Ex. 61 ([CY]'s Geoprobe Results); Ex. 62 (Surrogate Ratio Data Taken from Geoprobe Results).

CAN claims that the data in Exhibits 61 and 62 do not demonstrate that ratios fall within the 25% criteria of the LTP. CAN Proposed Findings at 10; Ex. 1 (LTP) § 5.4.7.3, at 5-18 to -19. Since such information does not exist, CAN contends that the FSS does not meet the “detailed” requirements of 10 C.F.R. 50.82(a)(9)(ii)(D). CAN Proposed Findings at 10-11 & n.6; CAN Reply Findings at 12-15. CAN complains that the LTP provides only a general road map for the use of surrogate analysis and fails to prescribe the methodology for direct measurements of HTD radionuclides if a surrogate cannot be employed in a given survey unit. CAN Proposed Findings at 10-11; CAN Reply Findings at 12-15. In support of its thesis, CAN suggests that elevated levels of Sr-90 have not been found in soil, even though it is present in ground water. Resnikoff Direct at 7; Resnikoff Rebuttal at 5-6.

CY responds that the use of surrogate analysis during the final status survey is governed by observations of the variability in the relative abundance of HTD's in the soil for the survey area in question. CY Panel Direct at 12. If the variability is high then CY will take appropriate action. *Id.* at 12-13. CY argues that LTP §5.4.7.3, Ex. 1 at 5-19, provides the necessary actions to be taken if surrogate ratios do not meet the required consistency. CY Reply Findings at 3.

Recognizing that at the time of the hearing no site-specific data had been obtained for determining surrogate ratios, Staff expert Dehmel accepted that it is not possible for CY to produce a set of consistent ratios while remediation and characterization is ongoing. Dehmel Direct at 12-13. Therefore, at the time of the final status survey, the Staff will require CY to provide supporting data for use of surrogate ratios. *Id.* The Staff also takes issue with CAN's analysis of radionuclide ratios, pointing out that Dr. Resnikoff did not account for the variability of sample locations, and other temporal and spatial variations. NRC Staff Rebuttal Testimony of Jean-Claude Dehmel (Feb. 28, 2003), fol. Tr. 1756, at 14-15 [hereinafter Dehmel Rebuttal]; see also Can Direct at 8, Chabot Rebuttal at 4. The Staff contends that CY recognizes that Sr-90

exists and will be accounted for. See Ex 1 § 2.3.3.4, at 2-122 (Table 2-12); Dehmel Rebuttal at 5-6, 14.

FINDINGS OF FACT - Contention 6.1

Contention 6.1 provides as follows:

Dose Modeling Calculation Methodology

Contrary to the requirements of 10 C.F.R. 50.82, the dose modeling calculation methodology CYAPCO employs in the LTP is not adequate to demonstrate that the LTP will assure the protection of the public health and safety.

See LBP-01-21, 54 NRC at 92. In LBP-01-25, this Board characterized the issue raised in Contention 6.1 as follows:

What are the appropriate factors and considerations relating to the “outdoors value,” yearly intake of water by residents, and the nature of and extent to which the characteristics of children must be taken into account in calculating the TEDE to the “average member of the critical group” in the “resident farmer scenario,” for purposes of the Haddam Neck site License Termination Plan, in order that the LTP can “demonstrate[] that the remainder of decommissioning activities . . . will not be inimical . . . to the health and safety of the public,” as required by 10 C.F.R. § 50.82(a)(10)?

LBP-01-25, 54 NRC at 197.

In addition to questioning whether CY used the correct RESRAD dose modeling code (a computer modeling code relating to RESidual RADioactivity) in its LTP, CAN challenges various parameters used by CY in its dose modeling as being insufficiently conservative, including those related to outdoor farm labor exposure, drinking water intake and other pathway parameters, and the inclusion of children in the dose modeling calculations. LBP-01-21, 54 NRC at 93. The Board admitted the contention in part, excluding from litigation the issue of the different RESRAD versions. *Id.* at 93-94. As indicated above, the Board denied a CY motion for reconsideration of our ruling on this contention in LBP-01-25.

The evidence on Contention 6.1 includes the prefiled and hearing testimony of CY witnesses Mellor, Heider, McGrath, Darois, Tarzia, Chabot, and Jeremy D. Foltz, Ph.D; CAN witness Resnikoff; and NRC Staff witnesses Christopher A. McKenney and Mark Thaggard. As

with those witnesses testifying on Contention 1.5 (some of whom are the same), we have reviewed the qualifications of each listed witness and find each to be qualified to testify as an expert on Contention 6.1.

Staff witness McKenney provided an appropriate definitional summary of the concept of “dose” in the Staff’s prefiled testimony. According to this testimony:

Dose is a measure of the amount of radiation a person is exposed to. Dose is generally divided into two types: external exposure (i.e., the source of radiation is outside the body) and internal exposure (i.e., the source of radiation is inside the body). To get an external dose, a person needs to be around a source strong enough to penetrate the skin, generally, with gamma rays. Cobalt-60 is an example of a source of external exposure. External dose is directly related to how long and how close a person is to the source of external exposure. To get an internal dose, the person needs to inhale or ingest the radioactive material. Part of what a person inhales or ingests will be incorporated, as any element would, into the body. How long the material stays in the body and where is described by biological kinetic models, also known as dosimetry models.

. . . .

. . . [Total Effective Dose Equivalent (TEDE)] is the total of the dose from external and internal sources of radiation. The internal doses are calculated using the organ weighting factors. . . .

NRC Staff Testimony and Professional Qualification Statements of Christopher A. McKenney and Mark Thaggard (Feb. 7. 2003), fol. Tr. 2074, at 4 [hereinafter McKenney/Thaggard Direct], at 4.

Mr. McKenney in his testimony cited various guidance documents that define intake-to-dose conversion factors. *Id.* The factors used to calculate internal exposures are found in Federal Guidance Report No. 11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” U.S. Environmental Protection Agency (EPA-520/1-88-20). McKenney/Thaggard Direct at 4. External dose factors are found in Federal Guidance Report No. 12 (EPA, 1993). McKenney/Thaggard Direct at 4. The internal dose conversion factors are based on adults, the external ones on a set of values

for physiological parameters developed by the International Committee on Radiological Protection (ICRP), which are collectively known as “Reference Man.” *Id.*

According to Mr. McKenney, although there are some relatively newer dosimetry models, contained in ICRP Publication 72, which are more sophisticated in that they can calculate dose based on age-specific physiology, called “effective doses,” relevant NRC regulations under 10 C.F.R. Part 20, “Standards for Protection Against Radiation,” are based on TEDE, which is derived from the dose modeling in an earlier ICRP document, Publication 30.

McKenney/Thaggard Direct at 5. A licensee may obtain an exemption from the NRC to use the newer dosimetry models, but CY did not seek such an exemption. *Id.*

With regard to doses related to license termination, a licensee is required to calculate TEDE for “the average member of the critical group.”⁵ *Id.* According to Mr. McKenney, each

⁵The “average member of the critical group” is the term used in 10 C.F.R. Subpart E, § 20.1402, regarding radiological criteria for unrestricted use after license termination, and the dose limit set therein is 25 mrem per year. This section provides as follows:

A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an *average member of the critical group* that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA

individual in the hypothetical “critical group” will have “slightly different habits and characteristics resulting in a range of doses,” which range should be no greater than a factor of 3 from the lowest to highest doses in most cases, according to ICRP 43, “Principles of Monitoring for the Protection of the Population,” 1984. *Id.* Further, states McKenney, in defining a “critical group” and applicable circumstances relating to such a group, the following questions should be considered:

[O]ne must ask either: “How could humans be exposed either directly or indirectly to residual radioactivity?” or “What is the appropriate exposure scenario?” First, the appropriate land use for the site needs to be chosen. After that, the analyst can investigate various exposure scenarios to find the critical group. Each exposure scenario must address the following questions: (1) how does the residual radioactivity move through the environment?; (2) where can humans be exposed to the environment concentrations; and (3) what are the exposure group’s habits that will determine exposure? (e.g., What is the land used for? What does the exposed population eat and where does the food come from? How much does the exposed population eat? Where do they get water and how much? How much time do they spend on various activities? etc.) By combining the answers to these scenario questions with the knowledge about the sources of

must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal.

10 C.F.R. § 20.1402 (2003) (emphasis added). The words, “critical group,” are defined at 10 C.F.R. § 20.1003 as “the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.”

residual radioactivity, the analyst can develop the critical group's scenario or "applicable set of circumstances."

Based on the scenario, a composite individual is created using the average habits and characteristics for the group. By knowing the habits, such as how much water the average individual drinks, the analyst can calculate the dose from that exposure pathway. The exposure from each pathway is summed over all pathways. According to 10 C.F.R. §20.1402 the total dose from all pathways cannot exceed 25 mrem/yr.

Id. at 6, *see supra* note 5.

Moreover, according to Mr. McKenney:

[T]he average member of a critical group is not necessarily the same as the maximally exposed individual. The average member of the critical group is an individual who is assumed to represent the most likely exposure scenario based on prudently conservative exposure assumptions and parameter values within model calculations. In some operational situations, it is possible to actually identify with confidence the most exposed member of the public (through monitoring, time-studies, distance from the facility, etc.). But identification of the specific individual who might receive the highest dose some time (up to 1000 years) in the future is impractical if not impossible. Speculation on his or her habits, characteristics, age, or metabolism could be endless. The use of the "average member of the critical group" acknowledges that any hypothetical "individual" used in the performance assessment is based, in some manner, on the statistical results from data sets (i.e., the breathing rate is based on the range of possible breathing rates) gathered from groups of individuals. While bounding assumptions could be used to select values for each of the parameters (e.g., the maximum amount of meat, milk, vegetables, possible exposure time), the result could be an extremely conservative calculation of an unrealistic scenario and may lead to excessively low allowable residual radioactivity levels.

McKenney/Thaggard Direct at 6-7.

Connecticut Yankee in its LTP uses two primary scenarios for identifying the critical group: a residential farmer scenario for considering contamination in soil, ground water, and concrete debris from demolished buildings; and a light-industrial building occupancy scenario for considering contamination in building structures. For both scenarios, CY used a hypothetical adult as the average member. *Id.* at 7. According to Mr. McKenney and Mr. Thaggard, the NRC Staff considers CY's use of an adult in the residential farmer and light-industrial scenarios as adequately representing the "average member of the critical group" at the site. A residential farmer was "considered to appropriately represent the average member of the critical group

based on demographic and economic data in the area,” where an agricultural lifestyle is considered feasible. *Id.* Further, because it allows consideration of a large number of exposure pathways, the Staff views the residential farmer scenario as providing “more restrictive [Derived Concentration Guideline Levels (DCGLs)]⁶ than other scenarios that are plausible,” and also considers the light industrial building occupancy scenario to be appropriate “based on the internal configuration of the buildings at the site, which was felt not to be suitable for residential use.” *Id.* at 7-8. According to Mr. McKenney and Mr. Thaggard, the two selected exposure scenarios are “the most conservative for the radionuclides at the site.” *Id.* at 8.

According to Mr. McKenney, “only in rare scenarios will a hypothetical infant or child receive a significantly higher calculated dose than an adult in a similar exposure scenario.” *Id.* at 8-9. Such rare scenarios “tend to be ones where someone could only get exposed to residual radioactivity through a much more limited set of pathways,” one example of which is “when the only pathway is through milk, since children generally drink more milk than adults.” *Id.* Thus, according to Mr. McKenney, “[i]f milk is the only pathway that could expose the individual to a dose, then the child would be a better representation of the average member of the critical group. But in most situations, especially ones involving multiple pathways and multiple radionuclides, the total dose of the adult is greater than or similar to that of a child.” *Id.* at 9.

⁶According to the LTP, “[s]urface or volumetric concentrations that correspond to the maximum annual dose criterion are referred to as [DCGLs]. A DCGL established for the average residual radioactivity in a survey unit is called a DCGL_w. Ex. 1 at 5-2.

A central challenge put forth by CAN in this proceeding questions the use of an adult or a “Reference Man” in calculating the doses in question, asserting that children take up radiation at different rates than adults, CAN Proposed Findings at 19-20, disagreeing with the position of the Applicant and Staff that ICRP-72 and ICRP-60 are not applicable in this proceeding, and asserting that both EPA and DOE have used dose conversion factors from ICRP 72. Resnikoff Rebuttal at 6-9.

In support of its contention challenging these and other factors relating to dose, CAN expert witness Dr. Resnikoff in his prefiled testimony, using the “family farm scenario” posited by CY in its application, see LBP-01-25, 54 NRC 177, provided two sets of calculations of dose contributions, those from water pathways and those from all other pathways. Resnikoff Direct at 9-10. For the water component, he used a spreadsheet and the radionuclide that is the “major contributor to radiation dose,” Sr-90, in a concentration of 143 pCi/L, the maximum Sr-90 concentration found in one well, according to a June 2001 Quarterly Groundwater Monitoring Report. *Id.* at 10 & n.17. Applying certain assumptions regarding intake of water, milk and meat, taken from EPA’s August 1997 Exposure Factors Handbook, as well as input assumptions from RESRAD and dose conversion factors from ICRP60 and ICRP72, *Id.* at 10 & n.18, Dr. Resnikoff calculated total radiation doses to an adult, a 5-year-old child, and a 10-year-old child, at 11.2, 14.4 and 18.5 mrem per year (mrem/y), respectively, *id.* at 11. He then added these to the doses from “water independent pathways calculated by RESRAD,” assuming – unlike CY or the Staff – a level of “feedback” based on Sr-90 contaminated water being used to irrigate the land, causing a buildup of radionuclides in the soil, which he contends would ultimately produce a result of 4.576 picocuries per gram (pCi/g). *Id.* at 11, 18-19. He also used a different input parameter for time spent outdoors, based on 1999 New England Agricultural Statistics. *Id.* at 19 & n.21. In addition, Dr. Resnikoff applied different mass loading parameters and added 100 mg

per day and 200 mg per day of incidental soil ingestion for an adult and child, respectively. *Id.* at 20.

Dr. Resnikoff's calculations produce total doses of from a minimum of 61.9 mrem/y to a maximum of 147.1 mrem/y for an adult, from 80.0 to 180.2 mrem/y for a 10-year-old child, and from 44.0 to 142.8 mrem/y for a 5-year-old child, all of which are "much greater" than the 25 mrem/y allowed by 10 CFR § 20.1402. *Id.* at 21 & Table 6. Pointing out that he did not include all radionuclides in his calculations, Dr. Resnikoff suggested that the Haddam Neck site must be remediated to a greater extent than provided in the LTP. *Id.* at 21.

CY expert witnesses disputed Dr. Resnikoff's calculations, noting among other things that he (and CAN) implicitly assume that the LTP proposes to release the site in its "as is" condition, when this is not what the LTP proposes. CY Panel Rebuttal at 17. Rather, the LTP proposes first to calculate the DCGLs that correspond to a yearly dose of 25 mrem for each radionuclide and each media separately. *Id.* Later, in performing the Final Status Survey for a land survey unit, as indicated above, sampling and the application of surrogate relationships will determine the concentrations of the various radionuclides present in soil and groundwater that will affect the survey unit. These concentrations will then be compared to the radionuclide and media specific DCGLs in the LTP to determine the fraction of the DCGL (fraction of 15 mrem/y) contributed by each radionuclide for each relevant medium. *Id.* at 17-18. Finally, the sum of the fractions must be less than 1, according to the "unity Rule described in MARSSIM and committed to in § 5.8.4 of the LTP." *Id.* at 18.

According to the CY panel, the correct method of showing the effect upon a family consisting of two adults, one 10-year-old child and one 5-year-old child, employing "Reference-Man based DCGLs," would be to calculate "children" DCGLs utilizing input parameters that apply to children, calculating the family average DCGL, and then comparing that value to the

Reference Man DCGLs contained in the LTP for the important radionuclides present at the site.

Id. Dr. Resnikoff did not, however, do this, according to the panel. *Id.*

CY expert witnesses Chabot, see Chabot Rebuttal at 4-5, and Taylor also disputed Dr. Resnikoff's "feedback" theory, with Dr. Taylor stating that it "violates fundamental physical laws and neglects key physical processes." In particular, according to Taylor, it "does not conserve radionuclide mass, does not consider radioactive decay, ignores the effects of precipitation, and neglects the discharge of groundwater to the Connecticut River." CY Panel Rebuttal at 13. Performing what he contends is the correct incremental Sr-90 burden to the soil under the "feedback" theory, Dr. Taylor produced a predicted value of less than 1% of Dr. Resnikoff's calculated value, a figure "so small as to be captured entirely by the uncertainties and conservatism in the calculations done without regard to this value," producing a "dose consequence of . . . zero." *Id.* at 14. Dr. Taylor in his own calculations used, among other things, a "mass balance model"; equilibrium partitioning of Sr-90 between the water and solid phases, and radioactive decay; the application of natural precipitation that would bring uncontaminated water into the subsurface system; leaching of Sr-90 from soil in the unsaturated zone and subsequent transport to the saturated zone; and the transport of Sr-90 in the saturated zone. *Id.* at 13-14.

The resulting mathematical model, according to Dr. Taylor, takes the form of a system of differential equations, which are then solved for the soil concentration and groundwater concentrations as a function of time using the physical and chemical characteristics of the system. Using this calculation, a predicted peak value of 0.0419 pCi/g of Sr-90 would occur after 34 years of irrigation. *Id.* at 14. According to Dr. Taylor, this value is conservative in that it assumes that the land being irrigated with contaminated groundwater overlies the plume of the Sr-90 contamination, whereas if other land were being irrigated with contaminated groundwater,

or if the well were installed outside the Sr-90 contaminant plume, then the “feedback” phenomenon would be diminished or eliminated. *Id.*

Dr. Resnikoff disagreed with Dr. Taylor’s inputs, and also proposed breaking the saturated zone into three layers, with the top one, where plant roots are located, being contaminated more at first. Tr. 1961-70, 2013-14, 2046-49. Dr. Resnikoff also stated that in selecting his soil concentration values he used areas that are not close to the plant, which he assumed might not be remediated as those close to the plant might be, Tr. 2022-23, and questioned whether there were actual plans to clean up the water. Tr. 2025, 2084-85. He admitted that 95% of what he obtained from his soil dose comes from the “feedback” theory for the adult, Tr. 2049-50, that he had not calculated as part of this theory the time it would take for various radioactive elements to decay, and that decay time would lower his results, *Id.* at 2053-54; see Tr. Tr. 2056-60. He maintained that the correct value would lie between his and that of Dr. Taylor, but he did not know where within that range. Tr. 2063.

After the hearing, in the late-filed exhibit submitted by CY, Dr. Taylor provided additional calculations on the “Effects of Recycling Sr-90 Contaminated Groundwater as Irrigation Water.” Ex. 60. These calculations support Dr. Taylor’s testimony at the hearing to the effect that using Dr. Resnikoff’s model and running the proper calculations according to Dr. Resnikoff’s recommendations, including the division of the unsaturated layer into thirds, the resulting peak Sr-90 concentration would be .26 picocuries per gram, which peak would occur approximately 30 years after the onset of irrigation. See Tr. 2109. This value is, according to Dr. Taylor’s calculations, approximately 5 % of the value that Dr. Resnikoff used in his analysis. *Id.*

In CAN’s Proposed Findings of Fact and Conclusions of Law, it states that it finds Dr. Taylor’s calculations reasonable, implicitly admitting that its original proposed value of 4.576 pCi/g was greatly overstated, but still asserts that the dose significance of the feedback buildup phenomenon was not evaluated by the Applicant, and that the effect would be significant. CAN

Proposed Findings at 15-16. As the Staff points out, however, the calculations provided to prove this do not take into account the decay of Sr-90 during the 30-year period used in the example.

Staff Reply Findings at 4.

More generally with regard to Contention 6.1, according to the prefiled direct testimony of CY's witness panel of Mellor, Heider, McGrath, Darois and Tarzia, prepared by all panel members collegially but with certain members taking the lead in certain areas, the LTP provides calculations for "Derived Concentration Guideline Levels (DCGLs) for soil, buildings and groundwater," corresponding to "a calculated amount of residual radioactivity at the time of unrestricted release of the site that could result in an average member of the critical group receiving the dose limit in Subpart E over some year within the next 1000 years, using a very conservative set of exposure assumptions and conditions." CY Panel Direct at 3, 19.⁷

⁷See *supra* note 5.

According to its expert panel, CY in its calculations used an adult as representative of the “average member of the critical group,” which is appropriate as well as “consistent with all applicable industry standards.” *Id.* Further, according to the panel’s testimony, if children were included in the critical group, the final DCGLs would be essentially identical to those presented in the LTP, because “the conversion factors used to equate dose into risk are based on data from various populations exposed to very high doses of radiation, such as the atomic bomb survivors,” which include individuals of all ages. *Id.* at 19-20. Therefore, the panel says, “variation of the sensitivity to radiation with age and gender is built into the standards, which are based on a lifetime exposure from birth to old age.” *Id.* at 20.⁸ Although CY calculated its doses applying the metabolic parameters of the “Reference Man” discussed in ICRP 23, which are more representative of an adult male, the panel asserts in its testimony that the “conservatism in

⁸The standards the panel refers to are those found in 10 C.F.R. Part 20. Under Subpart D of Part 20, regarding radiation dose limits for individual members of the public, all licensees are to conduct their operations so that, among other things:

[t]he total effective dose equivalent [TEDE] to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under § 35.75, from voluntary participation in medical research programs, and from the licensee’s disposal of radioactive material into sanitary sewerage in accordance with § 20.2003.

10 C.F.R. § 20.1301(a)(1).

As support for its statement that “variation of the sensitivity to radiation with age and gender is built into the standards, which are based on a lifetime exposure,” the panel cites the Commission’s statement in a different context (relating to spent fuel storage casks) at 64 Fed. Reg. 48,259, 48,263 (Sept. 3, 1999). There, the Commission went on to state:

Consequently, the unrestricted release limit of 0.25 mSv (25 mrem), a small fraction of the annual public dose limit, is protective of children as well as other age groups because the variation of sensitivity with age and gender was accounted for in the selection of the lifetime risk limit, from which the annual public dose limit was derived.”

Id. (cited at CY Panel Direct at 23. The panel also cites, among other things, the Commission’s statement to a similar effect at 65 Fed. Reg. 25,241, 25,245 (May 1, 2000), as well as an EPA statement that “the assumptions exemplified by Reference Man adequately characterize the general public, and a detailed consideration of age and sex is not generally necessary.” CY Panel Direct at 25, (citing a document described as “EPA’s Draft Guidance for Exposure of the General Public [EPA 1994]”).

the dose conversion factors ensures that the calculated doses are protective of all groups and genders.” *Id.*

The panel explains this conservatism by stating that the dose criterion for unrestricted use of 25 mrem/yr TEDE to the average member of the critical group⁹ is a “substantial margin of safety below the public dose limit of 100 mrem/yr. . . .”¹⁰ *Id.* The panel also cites NUREG 1757 for the statement that “only in rare cases will a non-adult individual receive a higher dose than an adult individual in a similar exposure scenario,” providing as an example the same one described by Staff witness McKenney – an operating plant where radioiodine is a necessary consideration due to the absorption of radioiodine in milk, since children generally drink more milk than adults – in contrast to most situations involving multiple pathways, including the resident farmer scenario used in the LTP, in which the total intake for an adult would be greater than that of a child. *Id.* at 25-26 (citing NUREG-1757, Volume 2, Consolidated NMSS Decommissioning Guidance).

According to the panel, even using other factors in the calculations, there would be no significant impact on calculated doses and DCGLs. *Id.* at 26. According to the panel’s calculations, some doses for children would be higher, but these would be for radionuclides that are present at the site in very low quantities and have low dose impacts; indeed, some doses to children, from common radionuclides, would be lower. *Id.* at 27-28. Also, their analysis shows that while the dose to children would be 3% to 4% higher than for adults from soil – causing the average family dose to increase by 1.5% to 2% – the DCGL from groundwater would increase by 7% and 69%, respectively, for 5 and 10-year-old children, meaning that the dose to children of these ages would decrease by the same amount. *Id.* at 29; Ex. 6 (Panel Attachment 6; “Summary and Analysis of Soil and Groundwater DCGLs for Different Age Groups”).

⁹See *supra* note 5

¹⁰See *supra* note 8.

In addition, Dr. Chabot stated, among other things, that the 25-mrem dose level is sufficiently low that the dose differential that might accrue to any individual member of the “critical group” other than the “Reference Man” will “not be a significant concern.” Chabot Direct at 8. As examples of this Dr. Chabot noted that allowances for releasing patients who have received therapeutic administration of radionuclides include the requirement that the projected dose to another individual with whom the patient might be in contact does not exceed 500 mrem, 20 times greater than the 25 mrem dose relevant in this proceeding, and that in many parts of the country, including New England, the annual variation in background dose can exceed 25 mrem. *Id.* at 9. Dr. Chabot stated that it is “not realistic to expect a child to receive *more* than 25 mrem/yr from a site that would give reference man exactly 25 mrem/yr.” *Id.*

The panel in its prefiled testimony also addressed the mass loading factors relating to inhalation and water consumption, in which CY used the parameter range provided in NUREG/CR-6697, and the methods provided in NUREG/CR 6676, suggesting that the upper-range values in NUREG/CR-5512 that were utilized by CAN are not appropriate for determining yearly dose. CY Panel Direct at 30-35 (citing NUREG/CR-6697, Development of Probabilistic RESRAD 6.0 And RESRAD-BUILD 3.0 Computer Codes, ANL (December 2000); NUREG/CR-6676, Probabilistic Dose Analysis Using Parameter Distributions Developed for RESRAD and RESRAD Build, ANL (July 2000); NUREG/CR-5512, Residual Radioactive Contamination from Decommissioning-Parameter Analysis, Sandia National Labs (Oct. 1999); U.S. Nuclear Regulatory Commission Preliminary Guidelines for Evaluating Dose Assessment in Support of Decommissioning (Sept. 23, 1999).

With regard to the water consumption parameter used in the LTP, i.e., 478.5 liters per year, the panel defended this and disputed CAN’s use of a 2-liter-per-day value, *id.* at 37-39 (citing NUREG/CR-5512, Vol. 3, at 6-126), noting that the EPA Exposure Factors Handbook from which CAN’s figure appears to have been taken itself describes this as an “upper-

percentile” rate corresponding to the 84th percentile of intake rate distribution among adults in a 1989 study, *id.* at 39-40. The panel notes that the handbook also describes a 1-liter-per-day intake for children as an upper percentile intake rate, and suggests a “Recommended Drinking Water Intake Rate for Adults - 50th percentile” of 1.3 liters per day, which is equivalent to 474.8 liters per year. *Id.* at 40 (citing EPA Exposure Factors Handbook at 3-1, 3-26). The panel also notes that the distinction in the EPA handbook between less active and more active adults is that the latter consume only about 14% more water. Also relevant, according to the panel, was another study cited in the EPA handbook that showed 14% lower water intake in the northeast than in the other three regions of the country. *Id.* (citing EPA Handbook at 3-3, 3-8).

Specifically with regard to children, the panel challenged the intake rates used by Dr. Resnikoff, namely, 1.5 L/day for 5 and 10-year-old children, which correspond to the 90th and 95th percentiles, respectively, in the EPA Exposure Factors Handbook. CY Panel Rebuttal at 20 (citing EPA Handbook at 3-26). CY also challenged values used by Dr. Resnikoff for water intake through cows’ milk and meat, as well as dose conversion factors he used for ingestion and inhalation, and soil ingestion rates. Additionally, the panel produced calculations showing that correcting Dr. Resnikoff’s errors would produce results such that a family average dose (including a 5-year-old child and a 10-year-old child) would be equal to slightly over 99% of the “Reference Man” dose used in the LTP. *Id.* at 21-25.

Dr. Chabot testified largely to the same effect, stating that taking the average of the doses calculated by Dr. Resnikoff for a family of two adults, one 10-year-old child and one 5-year-old child, and then expressing that as a function of the adult dose, the result is a ratio of 1.05 to the adult dose, not significantly different, thereby effectively tending to disprove the theory that Reference Man is not an appropriate standard to use. Chabot Rebuttal at 8. According to Dr. Chabot, Dr. Resnikoff’s dose values are “based on erroneous and/or arbitrary assumptions and, as such, cannot be used to draw informative conclusions.” *Id.* at 9.

The CY panel, as well as its witness Foltz, also challenged CAN's assumptions about time spent outdoors in the family farm scenario, i.e., 2190 hours per year, which is the default input parameter for the RESRAD computer program. CY Panel Direct at 46; see *also id.* at 34, 42-47; Pre-filed Direct Testimony of Jeremy D. Foltz, Ph.D., fol. Tr. 1845 [hereinafter Foltz Direct]; Pre-filed Rebuttal Testimony of Jeremy D. Foltz, Ph.D., fol. Tr. 1845 [hereinafter Foltz Rebuttal]. The panel challenged reliance on the default input without any justification, and argued that its own figures are more consistent with NRC and EPA guidance and research on farms in the lower Connecticut River area. CY Panel Direct at 46-47. Specifically, the panel cites NUREG/CR-5512 for the guidance that performance of dose calculations is to be done in "a prudently conservative (*not worst case*) manner" CY Panel Rebuttal at 20 (citing NUREG/CR-5512, Vol. 1, at xiii). Dr. Foltz went so far as to challenge the likelihood that the land would ever be used for farming, based on his own research on agriculture both in the Connecticut area and worldwide, as well as the sloping and swampy character of the land at the Haddam site, and plans to bury concrete debris on the site, which would render the soil unproductive for farming. Foltz Direct at 1-4.

The LTP uses a value of 11.81% of a year for time spent outdoors, which corresponds to 1035 hours per year, equivalent to 20 hours per week on a whole-year basis or 46 hours per week during the 156-day growing season in the Haddam, Connecticut area. CY Panel Direct at 43. This corresponds to the sum of time spent outdoors and time spent gardening provided in NUREG/CR-5512, which uses figures relating to men, who, according to various studies, spend more time outdoors than women. *Id.* (citing NUREG/CR-5512, Vol. 3, Table 6.11, § 6.2.3, and authorities cited therein). While agreeing that increasing the time-spent-outdoors parameter will increase the dose received by a modeled individual, the panel noted that this affects dose from each radionuclide differently, with the most significant impact occurring with radionuclides such as cobalt-60 and cesium-137, which cause whole body exposure to gamma radiation. *Id.* at 42.

With these, a 20% increase in time spent outdoors, while maintaining a constant time spent indoors (thereby increasing total time spent at the site), will result in decreased cobalt-60 and cesium-137 DCGLs of 7% and 3%, respectively, while reducing time spent indoors by the same amount as the increase in time spent outdoors will result in comparable DCGL decreases of 4% and 2%. *Id.*

CY witness Foltz did an analysis based on a posited 156-day growing season, and found that full-time vegetable farmers would spend a maximum of 1100 hours outdoors per year, while dairy farmers would spend 600 hours per year, and hay and/or horse farmers would spend 300 hours per year. *Id.* at 44 (citing Ex. 48 (Report: "Potential Farming Activities in the Lower Connecticut River Valley" (1/14/02))). Dr. Foltz stated that he believed the LTP 11.81% figure to be too high and "extremely unlikely of occurrence in the real world." Foltz Direct at 5. He also asserted that CAN's outdoors values are based upon an incorrect reading of New England Agricultural Statistical Service data, taking farm work as being all outdoors when in fact it is based on both outdoor and indoor work, such as milking cows. Foltz Rebuttal at 1.

CAN challenged Dr. Foltz's testimony about the length of the growing seasons, eliciting through cross-examination that he had used the same growing season as that for the town of Colchester, located in the hills 10.5 miles from Haddam and not on the same river as that on which Haddam is located. CAN also established that Chester, a town on the Connecticut River just south of Haddam, has a growing season that is 39 days longer – 195 days – than Colchester's 156-day season. Tr. 1853-58. Further, on cross-examination by CAN, Staff witness Thaggard agreed that if a person spent more time outdoors than that estimated by CY, the dose would increase, Tr. 2099, and that some of CY's data was based on time that people spend gardening, or "light farming and gardening," as opposed to farming. Tr. 2095-96.

As CY points out in its Reply Findings, however, CAN did not provide any calculations on the effect of the longer growing season as compared with the shorter one, whereas, as indicated

above, *supra* 33, CY did offer testimony that increasing time spent outdoors would have a “relatively low overall effect on dose.” CY Reply Findings at 8.

With regard to the “time spent outdoors” issue, the Staff’s determination was that CY’s use of NRC default behavioral and metabolic parameters was acceptable, based on its use of the generic residential farmer scenario as the basis for determining dose to the critical group. McKenney/Thaggard Direct at 12. The NMSS Decommissioning Standard Review Plan (NUREG-1727) permits a licensee who chooses to use a generic exposure scenario, such as the resident farmer or building occupancy scenario, also to use the default behavioral and metabolic parameter values of NUREG/CR-5512, Volume 3, which postdate the default values from RESRAD that Dr. Resnikoff used and are therefore considered to be more up-to-date. *Id.* at 12-13. Moreover, in its prefiled rebuttal testimony, the Staff also notes that NUREG-1727 states that default parameter values in RESRAD (used by CAN expert Resnikoff) “are not considered acceptable for performing dose assessments in support of decommissioning because some of these parameter values do not have a strong technical basis.” McKenney/Thaggard Rebuttal at 6-7 (citing NUREG-1727 at C79). The value used by Dr. Resnikoff is “considered to be extremely conservative as it would only be representative [of] the average attributes of someone using the site as a residential farmer in circumstances in which the time spent outdoors is within the top 10 percent of farms nationally.” *Id.* at 7. Instead, as in NUREG/CR-5512, the Staff recommends using a mean, which is considered to be “representative of the average attributes of the critical group.” *Id.*

The Staff took a similar approach to its evaluation of the “time spent outdoors” issue in considering CY’s drinking water consumption rate parameter. Because both are behavioral parameters, generic NRC-recommended default values are considered by the Staff to be permissible to use, in accordance with the guidance of NUREG 1727. McKenney/Thaggard Direct at 13-14. Moreover, the LTP value of 478.5 L/yr is consistent with the value

recommended in NUREG/CR-5512, the statistical distribution for which was developed after reviewing and considering several sources of information, including the EPA value and the RESRAD value of 510 used by CAN expert Resnikoff. *Id.* at 14. The Staff believes that additional water pathways suggested by CAN, including inhalation and absorption through bathing, showering and swimming, “would not provide any significant contribution to dose and therefore does not affect the conservatism of the modeling assumptions.” *Id.*

Also according to Mr. Thaggard, under Dr. Resnikoff’s “feedback” theory, “it would take over 700 years to accumulate enough activity of Sr-90 in the soil, based on the assumed irrigation rate used in Dr. Resnikoff’s analysis,” to obtain his results, when in actuality the Sr-90 will have essentially decayed away during such a 700-year period. McKenney/Thaggard Rebuttal at 3-4. Mr. Thaggard also questioned Dr. Resnikoff’s estimates of soil concentrations of Co-60 and Cs-137, because “[t]hey may not be representative of soil conditions at or after the time of site release,” and “are also not appropriate values to represent the average concentration over a 15,600 m² area,” which is “the maximum allowable size of a survey unit.” *Id.* at 4. According to Mr. Thaggard, Dr. Resnikoff’s assumption that an area would be allowed to remain with an average concentration of Co-60 that would exceed the permissible DCGL and release limits is unreasonable, as is his assumption that any individual would be exposed to Co-60 and Cs-137 at the same time as to Sr-90 concentrations, because of varying decay rates. *Id.* at 4-5.

Further, although Dr. Resnikoff relied on a water consumption rate that was previously used by the NRC in a 1994 guidance document in which “[d]ose calculations focused on the maximum exposed individual,” with the promulgation of the current license termination rule in 1997 the “focus [was changed] to the average member of the critical group.” *Id.* at 5. From that time to the present, relevant NRC guidance has been located in NUREG-1727, with “[s]upporting documentation on specific parameters . . . contained in NUREG/CR-5512, Vol. 3. *Id.* at 6.

According to Mr. Thaggard and Mr. McKenney:

The intent of the screening analyses was to ensure a high level of assurance that someone using a site released using the screening analysis would not receive a dose greater than the release limit. In the implementing guidance, Staff developed statistical distributions for parameters used in the screening analysis. These included parameters that were characterized as one of three types; physical, behavioral or metabolic. Physical parameters are those that describe the environment (e.g., rainfall, type of soil, size of the site, etc.). Behavioral and metabolic parameters describe the activities and characteristics of the critical group. These include matters such as how much drinking water is consumed, how much food is eaten, and the individual's breathing rate. Because the purpose of the calculation is to ascertain dose to the average member of the critical group, for behavioral and metabolic parameters the mean of the statistical distribution is selected for use in the screening analysis. Because the water consumption rate is classified as a behavioral type parameter in Staff guidance, the mean of the distribution is considered appropriate for evaluating impacts to the average member of the critical group. The statistical mean value for the drinking water ingestion rate for a resident farmer in the Staff's guidance, in NUREG-5512, Volume 3 at p. 6-30, Section 6.2.6, is approximately 1.3 Liters per day or a total of 478 liters per year.

Id.

In response to Dr. Resnikoff's prefiled testimony, the Staff in its rebuttal prefiled testimony also noted the inappropriateness of his calculations being based on doses that would result if the site were released in its present state of contamination, since further remediation would remedy this. *Id.* at 2. Staff expert Thaggard stated further as follows:

The purpose of the decommissioning process is to ascertain the extent of contamination and perform remediation to clean up the contamination to the point that the regulatory release criteria are met. The fact that the site may currently be contaminated beyond that criteria only means that further remediation is necessary. The only time when this type of calculation would be meaningful is after all remediation has been completed and the area for which the dose is calculated is being released.

Id.

When the Staff reviewed the LTP with regard to the dose modeling issue and children, it considered whether different doses to infants and children would be appropriate. McKenney/Thaggard Direct at 9. In its screening analysis it determined that "the primary residual radioactivity (e.g., Co-60 and Cs-137) at the Haddam Neck site results in external radiation being the most important route of exposure." *Id.* Primarily using "default probabilistic

parameter values in RESRAD version 6.2,” the Staff in its analysis modified the dose conversion factors to use the “appropriate age-specific dose conversion factors from International Commission on Radiological Protection (ICRP) ICRP-72 (ICRP, 1995) to calculate internal dose to an adult, infant or child in the comparison, as appropriate.” *Id.* The Staff also “modified the amount of soil ingestion, breathing rate, and food intake to correspond to an infant or child based on the age-specific information in NCRP Report No. 129 (NCRP, 1999) and Federal Guidance Report No. 13.” *Id.* In addition, the Staff “increased the external dose calculated by RESRAD by 30 percent for an infant and 20 percent for a child, as suggested by NCRP Report No. 129, as a conservative estimate of the effect of properly accounting for the effective height of the infant or child.” *Id.* In the opinion of Staff expert McKenney:

Because the external exposure is the most important pathway, a more detailed and realistic analysis that would likely reduce the assumed outdoor exposure time for an infant or child would result in lower total doses than the screening analysis. Also, a more detailed analysis would refine the external dose factors for children. To see if more detailed calculations would be necessary, the NRC staff maintained the same exposure time for an infant or child as that used for the adult. This assumption would skew the outcome since the exposure time for an adult would normally be significantly greater than that for a child. The results of the screening approach by the NRC staff found that the results for infant or child were similar to more detailed modeling done for the adult. Because the results of a more detailed calculation would be expected to be lower, since the exposure time for a child would be adjusted downward, the NRC staff did not calculate further the dose to an infant or a child. Therefore, the use of the adult as the average member of the critical group provides reasonable assurance that any actual doses will be less than the unrestricted release limit.

Id. at 10.

According to Staff expert Thaggard, the Staff also reviewed the approach and results of the sensitivity analysis used by CY to “identify key parameters and the selection of appropriate parameter values for those parameters,” conducted a sensitivity analysis “in order to determine the impact of a particular parameter on dose,” verified “that appropriate parameter values were used for those parameters that were not included within the sensitivity analysis,” and performed its own independent probabilistic calculations to verify that the DCGLs calculated by CY are

conservative. *Id.* at 11. The Staff determined that CY had carried out “an acceptable approach for identifying sensitive parameters, and assigning parameter values for these parameters.” *Id.* It found the approach used by CY for conducting its sensitivity analysis to be consistent with that used by Argonne National Laboratory in NUREG/CR-6676, a document produced under contract with the NRC to develop the probabilistic version of the RESRAD computer code. *Id.* The Staff also found that for those parameters that were not included in the sensitivity analysis, CY had used parameter values consistent with those recommended by NRC guidance. *Id.* at 11-12. Further, the staff’s own independent assessment showed that the DCGLs calculated by CY are conservative. *Id.*

Thus, although the relative differences shown by Dr. Resnikoff are in fact comparable to the results of the Staff’s screening analysis, more realistic calculations of exposure would reduce differences between exposure to children and adults, according to Staff experts McKenney and Thaggard, and the conservative nature of the overall family farm scenario, along with factors such as decay times, and the rule’s focus on the “average” member of the critical group, lead the Staff to view the LTP’s use of an adult to be appropriate. McKenney/Thaggard Rebuttal at 8-9. In this regard, the Staff noted that a five-year delay in a family moving onto the site to farm would reduce the dose from Co-60 by approximately 48% and the dose from Cs-137 and Sr-90 by approximately 10% each. *Id.* at 9.

The Staff adds that the 25 mrem/y dose limit itself, which refers to the “total dose from all pathways and all radionuclides,” supports the LTP dose calculations. According to Mr. McKenney, the Commission in establishing the rule recognized that “a dose of this limit would result in a lifetime fatal cancer risk of approximately .05%, assuming the linear no-threshold hypothesis and that the individual would be exposed for a period of 30 years at the dose limit,” but “[b]ecause of their half-lives, the use of a 0.25 mSv/y (25 mrem/y) limit overestimates the

lifetime risk for Co-60 by a factor of 4 and Cs-137 and Sr-90 by approximately a factor of 50%.”

Id. at 9-10. Continuing, Mr. McKenney states:

Overall, based on understanding that the screening analysis overstated the differences, the conservative nature of the scenario, previous staff experience with the inherent uncertainties involved in dose modeling, and the risks associated with the 0.25 mSv/y (25 mrem/y) unrestricted release limit for these radionuclides, the staff has reasonable assurance that the licensee’s use of an adult was an adequate representation of the dose that the average member of the critical group may receive. A difference of approximately 30% or less, as calculated in the screening analyses, in the selection of the critical group is not deemed to be significant in relation to the overall assessment.

Id. at 10.

CONCLUSIONS OF LAW

The governing standards in a license termination proceeding such as this one are found at 10 C.F.R. §§ 50.82(a)(9) and (10). 10 C.F.R. § 20.1402, regarding “Radiological criteria for unrestricted use” (a section found under 10 C.F.R. Part 20, Subpart E, which defines the “Radiological Criteria for License Termination”) is also relevant.

Section 50.82(a)(9) provides in pertinent part as follows:

All power reactor licensees must submit an application for termination of license. The application for termination of license must be accompanied or preceded by a license termination plan to be submitted for NRC approval.

* * * *

(ii) The license termination plan must include--

(A) A site characterization;

(B) Identification of remaining dismantlement activities;

(C) Plans for site remediation;

(D) Detailed plans for the final radiation survey;

(E) A description of the end use of the site, if restricted;

(F) An updated site-specific estimate of remaining decommissioning costs; and

(G) A supplement to the environmental report, pursuant to § 51.53, describing any new information or significant environmental change associated with the licensee's proposed termination activities.

10 C.F.R. § 50.82(a)(9)(ii).

Section 50.82(a)(10) establishes the following standard for approval of an LTP:

If the license termination plan demonstrates that the remainder of decommissioning activities [1] will be performed in accordance with the regulations in this chapter, [2] will not be inimical to the common defense and security or to the health and safety of the public, and [3] will not have a significant effect on the quality of the environment and after notice to interested persons, the Commission shall approve the plan, by license amendment, subject to such conditions and limitations as it deems appropriate and necessary and authorize implementation of the license termination plan.

10 C.F.R. § 50.82(a)(10).

10 C.F.R. § 20.1402, as noted above, provides in relevant part as follows:

A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an *average member of the critical group* that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

As indicated by the Commission in an earlier license amendment application proceeding involving proposed approval of an LTP, the license termination plan approval process has the “important *future* consequence” of being petitioners’ “one and only chance to litigate whether the survey methodology is adequate to demonstrate that the site [will ultimately be] brought to a condition suitable for license termination,” given that petitioners are precluded from participation in the final actual license termination stage.¹¹ *Yankee Atomic Electric Company* (Yankee Nuclear Power Station), CLI-98-21, 48 NRC 185, 206-07 (1998) (emphasis in original).

¹¹ As the Commission noted in *Yankee*, 10 C.F.R. § 50.82(a)(11) provides that: The Commission shall terminate the license if it determines that--

(i) The remaining dismantlement has been performed in accordance with the approved license termination plan, and

(ii) The terminal radiation survey and associated documentation demonstrates that the facility and site are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E.

Yankee, CLI-98-21, 48 NRC at 206 n.9.

According to the Commission, the purpose of the LTP process is “to ensure that the property will be left in such a condition that nearby residents . . . can frequent the area without endangering their health and safety.” *Id.* at 208.

We thus take very seriously our responsibility to consider all of the evidence presented fully and fairly. All parties proffered evidence that was relevant to the matters at issue, persuasive in parts, and straightforwardly presented. We note in particular the very effective presentation of CAN’s case through Ms. Bassilakis and its other non-attorney representatives, who provided a good-faith and strong presentation of their case, which involves serious matters of concern to those they represent, the residents who live near the Haddam Neck site. We also note the effective presentation of limited appearance statements by many of these residents, which we found to be representative of the best in citizen participation in the public arena.

With the above standards and guidance in mind, and based on the evidence presented in this proceeding, we reach the following conclusions in this proceeding:

Contention 1.5

With regard to Contention 1.5, the Board majority finds that Connecticut Yankee’s LTP satisfies the requirements of 10 C.F.R. §§ 50.82(a)(9) and (10), a conclusion not joined by Administrative Judge Young with regard to the specific issue of CY compliance with the requirement at § 50.82(a)(9)(ii)(D) for “[d]etailed plans for the final radiation survey.”

Hot Particles

Regarding Contention 1.5 and hot particles, the Board considers, first, CAN’s testimony challenging the ability of the plan proposed in the LTP to detect hot particles. In challenging the sensitivity of the LTP proposal for scanning, Dr. Resnikoff departed in his dose calculations from accepted scientific information concerning the low probability of a 10 micron particle depositing in the lung; used the radiological properties of a particle from another reactor without demonstrating its relevance to the Haddam Neck plant; and used, in error, a one-meter detector

scanning height. Moreover, Dr. Resnikoff conceded at the hearing that a 10 micron particle would only get deep in the lungs with less than a 5 % efficiency. Tr. 1746-51; Ex. 42. Given this concession, the Board believes that Dr. Resnikoff's dose calculations should be modified to a 5% probability of occurring, leaving his calculation at a small fraction of the dose limits.

Dr. Resnikoff 's calculations also improperly use the inhalation dose conversion factors in ICRP 72, which are not intended to be used to calculate dose from a single, relatively large particle, but instead assume inhalation of an aerosol consisting of small particles, having an activity median aerodynamic diameter (AMAD) of one micron. Tr. 1642-46. This error alone results in Dr. Resnikoff greatly overstating the potential effective dose. Pre-Filed Rebuttal Testimony of George E. Chabot, Ph.D., C.H.P. (Feb. 28, 2003), fol. Tr. 1443, at 2-3 [hereinafter Chabot Rebuttal]. As explained by Dr. Chabot, the mathematical model used in ICRP 72 assumes that a large number of particles are inhaled and distributed evenly throughout the whole respiratory tract. Tr. 1570-72, 1579. Further, because the particles are small, they are assumed to be subject to dissolution in the lung fluids and thereby transported to the blood system and from there to other internal organs. *Id.* at 1570-71. If a single particle is inhaled, none of those assumptions would apply. *Id.* at 1571, 1579. Instead, the dose delivered would be very localized, and the dose consequences would be entirely different. *Id.* The Board is not persuaded by Dr. Resnikoff's testimony in this regard.

Since it is CY's intent to completely dismantle the Haddam Neck Plant, with the exception of the separately-considered fuel storage facilities, what will remain at the site will essentially be a "green field" condition, assuming all relevant inspections are done and all requirements met during the final survey. Under these requirements, it will be incumbent on CY to demonstrate in the FSS – the final radiation survey performed after an area has been fully characterized and remediation has been completed – that this green field condition will meet the release criteria for unrestricted use of Subpart E. With respect to hot particles, CY's soil sampling techniques are

critical to making this showing and must be capable of detecting hot particles, and the NRC Staff will be responsible for assuring that they are so capable and do in fact detect any hot particles.

With regard to the requirement at 10 CFR 50.82(a)(9)(ii)(D) for “detailed plans for the final radiation survey,” the majority of the Board reasons that because the final radiation survey is not expected to be conducted until CY has completed remediation, it cannot, of necessity, be required to include details of its survey implementation unknown at the time the LTP is submitted to the Staff. As argued by CY and the Staff, what CY is required to provide in the LTP is as much detail of its proposed methodology for the final radiation survey as it can reasonably provide before it has the necessary data to conduct the survey. Indeed, the Staff recognizes this necessity in its guidance to Staff reviewers in NUREG-1727, NMSS Decommissioning Standard Review Plan.

Note to the NRC staff: NRC regulations require that decommissioning plans include a description of the planned final radiological survey. However, the Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM) approach requires that certain information needed to develop the final radiological survey be developed as part of the remedial activities at the site. As such, a complete description of the planned final radiological survey may not be available at the time the licensee or responsible party submits the decommissioning plan

Ex. 55 at 14.1-14.2.

Although not specifically identified as a process to identify hot particles, the use of the LTP scanning technique in LTP § 5.7.1.1, Ex. 1 at 5-38, as described by the CY Panel, is consistent with MARSSIM as a process to identify elevated areas of radioactivity. CY Panel Direct at 15-16; Ex. 45 § 6.4, at 6-13 to -15. The Board finds that the preponderance of the evidence supports CY’s calculations of the sensitivity of this process. CY Panel Direct at 11-18; Ex. 2; Ex. 4; Ex. 5. As described in MARSSIM, scanning is performed to identify areas of

elevated activity that may not be detected by other measurement methods. Ex. 45 § 6.4, at 6-10. Finally, the Board notes the Staff's recognition that all the information required to completely design the FSS was not available at the time the Staff did its review of the LTP, and that it will therefore conduct performance-based, in-process inspections of CY's program to verify implementation of the commitments made by the licensee in the LTP. Ex. 44 (Safety Evaluation Report) at 21.

Based on the above circumstances, the majority of the Board finds the LTP to be sufficiently detailed with regard to the detection of hot particles to assure that CY can demonstrate that it can meet the requirements of Subpart E and that the public health and safety can be protected, and sees no reason to condition the license on including in the LTP a procedure to detect hot particles, which by all indications would be identical to the scanning technique that CY now uses to meet the FSS requirements and the requirements of MARSSIM.

Surrogate Analysis

CAN's chief concern is that there is no data that has been presented that existing ratios between HTDs and ETDs are sufficiently consistent to permit use of the surrogate ratio technique. At this point, however, and until CY has completed remediation, it can not, of necessity, include unknown details of its survey implementation. Therefore, what CY is required to provide in the LTP is as much detail of its proposed methodology for the final radiation survey as it can reasonably provide before it has the necessary data to conduct the survey. We expect in addition that the LTP should contain sufficient detail to describe the methodology CY proposes for use of surrogate ratio analysis.

We find that the LTP need not depend on a consistency of ratios being found, a priori. Whether or not such ratios exist or have been demonstrated at the moment, or will exist in the future (when the final status surveys are performed), is not relevant to the sufficiency of the LTP on the issue of "hard to detect" nuclides. The LTP proposes using the surrogate ratio technique

only when survey data demonstrate that the necessary consistency of ratios between ETD and HTD radionuclides is present. Tr. 1808-11. We find that CAN's analysis of the sparse data from the site, see Exs. 61, 62, which shows no reasonable correlation in surrogate ratios, to be premature.

We also find that the LTP, Ex. 1 at § 5.4.7.3, p. 5-18, bolstered by the requirements of MARSSIM, Ex. 45, § 4.3.2 at 4-4, adequately describes the methodology CY proposes for its final radiation survey. Specifically, the LTP specifies the process that will be followed to identify the radionuclides for which surrogate analysis will be needed, the steps that will be followed in determining whether additional samples are needed to generate a robust ratio, the investigative steps that would force the re-examination of the characterization data providing the basis for the ratio, and general survey considerations regarding the design of the final status surveys.

Dehmel Direct at 13; Ex. 1 at 5-18. At the time of the final status survey, the Staff must be satisfied with the basis of the ratios used. Dehmel Direct at 13. This will require that the Staff examine, among other things, whether an appropriate number of samples have been taken, whether the samples are similar in physical and chemical properties as the surrounding media or materials, and the variability of the data. *Id.* Further, the Staff must assure that the technical basis for any surrogate ratios be fully documented. *Id.* at 13-14. These issues will be the subject of Staff scrutiny during the in-process inspections and the Staff review of the final status surveys. *Id.* at 14.

Finally, we observe that, in effect, CAN's objection to the LTP on "hard to detect" nuclides appears to be based on a misunderstanding as to what the LTP proposes to do. Where sufficient consistency of ratios does not exist, the LTP proposes to use the very methodology that CAN expert Resnikoff recommends. See Tr. 1730. In his testimony at the hearing, Dr. Resnikoff recommended the following:

DR. RESNIKOFF: Well, obviously if they don't find consistent ratios in a survey area they might try to break down the survey area into areas that where they do find consistent ratios.

But if that can't be done, then they will have to individually measure hard to detect nuclides. Each soil sample will have to be analyzed for some of these hard to detect nuclides. That would be increasingly expensive to the characterization in the final status survey. Tr. at 1730.

Tr. 1730. When the ratios are not sufficiently consistent; and where sufficient consistency of ratios has been demonstrated, the LTP proposes to use a methodology that Resnikoff finds not only "acceptable," but also "fairly standard." Tr. 1654; Ex. 1 at 5-18 to -19. There thus appears to be no controversy between the parties for this Board to resolve on this point, and we find that the LTP has adequately described the techniques CY will use for determining surrogate ratios and is adequate to demonstrate that the public health and safety will be protected.

With regard to CAN's request that the record be supplemented with a June 25, 2003, filing by CY to the NRC to the effect that recent Sr-90 and H-3 groundwater contamination data, of 138 and 27000 picocuries/L respectively, has been detected on site, this appears to be part of CY's ongoing remediation effort and not evidence of ground water contamination proposed to be in place at the time of site release. Staff Opposition to CAN's Motion to Supplement at 1,2. We find admitting this information does not add to our evaluation or understanding of the methodology CY plans to employ in releasing the site under the requirements of subpart E. As indicated above, the surrogate ratio technique can be used only when survey data demonstrate that the necessary consistency of the ETD and the HTD radionuclides is present. We see no advantage in our evaluation of the LTP to burden CY with having to upgrade the record with information that is only evidence of the Licensee's rate of progress toward final release.

Contention 6.1

With regard to Contention 6.1, notwithstanding a lack of complete clarity on the "average member of the critical group" and "Reference Man" concepts, see, e.g., McKenney/Thaggard Rebuttal at 5, CY Panel Direct at 20, cf. LBP-01-25, as well as on the appropriate ICRP and

NRC guidance documents to use in the context of license termination and decommissioning, see, e.g., McKenney/Thaggard Rebuttal at 5-10, we likewise find the LTP to meet applicable requirements at issue in this proceeding.

Balancing all the evidence presented in this proceeding on this contention, we find the testimony of the CY and Staff witnesses in this proceeding to be, overall, more thorough and persuasive than that of CAN witness Dr. Resnikoff. One exception that we note is that we find that Dr. Foltz understated the growing season in the Haddam area, and that the season is likely more similar to that in Chester, which is closer to Haddam and also near the river. We find, however, that the preponderance of the evidence is that this difference is not significant to a degree to place in question the adequacy of CY's dose modeling calculation methodology to protect the public health and safety, or such that it would cause there to be a "significant effect on the quality of the environment," 10 C.F.R. § 50.82(a)(10), as these requirements are, in practical effect, defined at 10 C.F.R. § 20.1402, regarding radiological criteria for unrestricted use after license termination – namely, that the TEDE to the *average member* of the critical group does not exceed 25 mrem (0.25 mSv) per year.

Nor do we find any other differences in Dr. Resnikoff's calculations to have been shown to have a level of significance that they would warrant a different ruling than we make herein. Section 20.1402 specifically uses the word "average" in defining what the NRC views as a dose that protects the public health and safety, and persuasive evidence was presented that the average for a family of two adults and two children aged 5 and 10 years would be very close to that for the "Reference Man" utilized by CY. Other evidence, summarized above, provides context illustrating the reasonableness of the 25 mrem per year dose standard set in § 20.1402.

See, e.g., discussion of testimony comparing pathways including through milk, *supra* 21-22, and testimony of Dr. Chabot, *supra* 28.

Applying the relevant regulatory standards, we conclude that Connecticut Yankee has shown by a preponderance of the evidence in this proceeding that its LTP should be approved under 10 C.F.R. §§ 50.82(a)(10).

ORDER

1. Based on the foregoing discussion, the entire evidentiary record, and the parties' arguments in this proceeding, it is, this 15th day of October, 2003, ORDERED that the LTP proposed by Connecticut Yankee be approved, and that this proceeding be terminated.

2. This Memorandum and Order is effective immediately and, in accordance with 10 C.F.R. § 2.760 of the Commission's Rules of Practice, shall become the final action of the Commission forty (40) days from the dates of its issuance, or on November 24, 2003, unless any party petitions the Commission for review in accordance with 10 C.F.R. § 2.786 or the Commission takes review on its own motion.

3. Within fifteen (15) days after service of this Memorandum and Order, any party may seek review by filing a petition for review with the Commission on the grounds specified in 10 C.F.R. 2.786(b)(4). The filing of a petition for review is mandatory for a party to exhaust its administrative remedies before seeking judicial review. 10 C.F.R. 2.786(b)(1).

4. Any petition for review shall be no longer than ten (10) pages and shall contain the information set forth at 10 C.F.R. § 2.786(b)(2). Any other party may, within ten (10) days after service of a petition for review, file an answer supporting or opposing Commission review. Any such answer shall be no longer than ten (10) pages and, to the extent appropriate, should concisely address the matters in 10 C.F.R. § 2.786(b)(2). 10 C.F.R. 2.786(b)(3). A petitioning party shall have no right to reply, except as permitted by the Commission. *Id.*

It is so ORDERED.

THE ATOMIC SAFETY
AND LICENSING BOARD¹²

Ann Marshall Young, Chair
ADMINISTRATIVE JUDGE

Dr. Peter S. Lam
ADMINISTRATIVE JUDGE

Thomas D. Murphy
ADMINISTRATIVE JUDGE

Rockville, Maryland
October 15, 2003

¹²Copies of this Memorandum and Order were sent this date by Internet e-mail or facsimile transmission, if available, to all participants or counsel for participants.

**Additional Statement of Administrative Judge Ann Marshall Young,
Dissenting from One Portion of Preceding Decision**

Although I join with my colleagues in the previous decision in the main, I differ on one point, regarding whether the licensee has fulfilled the requirement found at 10 C.F.R.

§ 50.82(a)(9)(ii)(D) that the LTP include “[d]etailed plans for the final radiation survey.”

Notwithstanding Connecticut Yankee’s “judgmental” sampling process, *see, e.g.*, Tr. 1409, 1413-14, 1432-45, 1448, 1454, 1475, 1479, and use of the data quality objective process described by Staff expert Dehmel, Dehmel Direct at 7, 12-13; *see also* Tr. 1438-39, 1510-12, Mr. Dehmel, testifying for the Staff, also stated as follows:

MS. BASSILAKIS: . . . Does the company provide detailed final status survey plan[s] for hot particles in the LTP? Yes or no?

MR. DEHMEL: No.

Tr. 1792. Although Staff counsel argued to the effect that this does not mandate a legal conclusion that the requirement of 10 C.F.R. § 50.82(a)(9)(D) for “[d]etailed plans for the final radiation survey” has not been met, *see* Tr. 1792-93, the plain meaning of “detailed plan” as a factual matter – the context in which expert Dehmel presumably responded to the above questions – suggests to the contrary.

To be sure, as also quite effectively articulated by Mr. Dehmel, the NRC Staff will be doing continuing technical evaluation and scrutiny as part of the in-process inspection program before the final survey. Mr. Dehmel in addition described very well the sorts of instrumentation and measurement issues that must be addressed. Dehmel Direct at 9-10. And, as my colleagues observe, certain provisions of MARSSIM bolster requirements of the LTP in this regard in some respects. *See supra* at 14, 18; *see also* Dehmel Rebuttal at 12-13, 16; Tr. 1782-91.

The LTP itself is, however, under 10 C.F.R. § 50.82(a)(9)(D), required to have “[d]etailed plans for the final radiation survey,” and according to the plain meaning of the words of this requirement, as apparently understood by Staff expert Dehmel in part of his candid and persuasive testimony, the LTP does not have such detailed plans with regard to the methods relating to detection and cleanup of hot particles, nor indeed, as argued by CAN, of hard-to-

detect nuclides. Much is left up to future judgment and discretion. This lack of detailed plans appears to me to be significant enough to require more than is currently included in the LTP, given the history of incidents at the Haddam Neck plant involving releases of radiological materials, the purpose of the LTP process “to ensure that the property will be left in such a condition that nearby residents . . . can frequent the area without endangering their health and safety,” the requirement that the Licensee demonstrate that the remainder of decommissioning activities “will not be inimical . . . to the health and safety of the public, and will not have a significant effect on the quality of the environment,” and finally, given that this proceeding is the petitioners’ “one and only chance to litigate whether the survey methodology is adequate to demonstrate that the site [will ultimately be] brought to a condition suitable for license termination.” See *Yankee Atomic Electric Co.* (Yankee Nuclear Power Station) CLI-98-21, 48 NRC 185, 206-08 (1998).