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December 15, 1992

Mr. Dominick Orlando
U. S. Nuclear Regulatory Commission
Division of Low Level Waste Management
and Decommissioning, NMSS
Decommissioning and Regulatory Issues Branch
Washington, D.C. 20555

Dear Mr. Orlando:

Reference: (a) USNRC Letter, D. Orlando (Docket 50-54, 70-687) dated December 4, 1992

The referenced letter requested additional information in support of the Cintichem, Inc. proposed residual soil contamination acceptance criteria that were included in our initial submission dated July 15, 1992 and recently modified in our submission dated October 22, 1992.

This information is enclosed and it is presented in the same order as the questions posed in the referenced letter.

Very truly yours,

J. J. McGovern
President/Plant Manager

JJMcG/bjc

Enclosures

cc: A. Dorozynski
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#1

Excavation soil on the Cintichem site is sampled and analyzed as follows. Sampling frequency is dependent on the anticipated probability of positive contamination in the soil for the HUT excavation and similar areas where clean. That is, soils that are being excavated to uncover expected contaminated soil has and will be sampled by collecting two aliquots of soil from each dump truck load (approximately 7 cu. yds) of soil dumped into a holding area. These aliquots may be composited with up to 9 other dump truck loads for that day or part of a day. This has been the procedure for the 5,400 cu yds excavated above the roof of the pump room and of the HUT. 90 separate assays for gamma emitting isotopes and 13 composites for the 26 feet of excavation below grade were accumulated for this material.

Surface or subsurface soil in proximity of known or expected contamination such as the hot cell exhaust duct area, gamma pit/canal area and subsurface HUT area have been or will be placed into 55 gallon drums or steel boxes. An aliquot from the container being filled from each 7 - 8 cf is composited with up to 11 other samples to get a composite sample representing approximately 90 - 100 cu yds (84 cu ft = 1 box) from one area. This sample is submitted for on site gamma analysis for minimum of 2 hour counts according to procedure HP-M-55 (attached). Composites for beta and alpha emitting isotopes will be taken from these samples. To date, 39 gamma assays have been run for the approximately 121.68 cu yds of soil excavated next to the HUT.

Each composite sample consists of about 6 - 8 pounds of soil. Samples are logged in in the environmental monitoring department through a chain of custody format. Approximately 4 - 5 pounds of soil is prepared for drying in our soil prep. lab. Large bits of rocks and vegetation are removed and the remainder is placed into a drying pan. After the soil has been stirred and air-dried or incubator-dried (60°C) until it appears dry, it is heated at 100°C for a minimum of 2 hours. While this procedure slightly differs from NUREG/CR 5849, the results are equivalent. The vast majority of the soil sampled requires only this amount of time to dry since it is sandy backfill or subsurface, non-loamy material. Soils are then sieved and prepped into a 250 ml geometry (approximately 400 g) for gamma analysis at Cintichem. Assay results are reviewed by senior staff and concentrations are compared to proposed criteria concentrations to determine the total sum of fractions of criteria.

An aliquot of the composite original sample representing a container (or composites representing more than one container of clean overburden material or any material from the same general source with similar gamma spectrographic characteristics [in this case similar is defined as all samples from a source having the same mix and that the amounts of radionuclides among samples are within a factor of two of each other]) will be used for alpha and

beta emitter isotope assay. These are sent to an outside vendor (e.g. Teledyne or Core Labs). Fe55, Ni63, Sr90 concentrations are determined by radiation chemistry assay, tritium by liquid scintillation assay and Pu238, Pu239, Pu240, Pu241, Cm242, Cm244 and uranium according to LA-1721 Radiochemical Procedures of Los Alamos Scientific Laboratory, September 1967. Other generic procedures that are currently being used by Teledyne are being requested and will be sent under separate cover.

Records of each analysis, both for gamma emitters and alpha and beta emitters are filed together with location and volume of sampled material. These will be summed to create a total site inventory for each category of soil for each location: surface and subsurface. Further details on soil disposition are in answer #5.

Quality assurance of on site HPGe samples are governed by procedures HP-M-37, Routine Source Check for HPGe Counting Systems, HP-M-43, Manual Control Charting for Standard and Blank Counts in Environmental Lab HPGe Detectors and HP-M-51 Routine QA Blanks for HPGe Counting Systems (all attached). These initiate the frequency and procedure for counting standards and blanks, the plotting of this data on control charts and procedures to follow when data is out of control.

#2

Soil remediation is planned to occur at nine discrete work areas on the Cintichem site. Three of these areas have very low levels of surface soil contamination. These areas are the waste storage building (WSB) yard, retention pond area, and the stack area. The other six areas are generally subsurface soil contamination areas which are associated with structures or systems that comprise the reactor and hot lab facilities. These subsurface soil areas are, the soil adjacent to the hold up tank (HUT) area, the soil under the reactor water storage tank, the soil in the area of the gamma pit/canal, the soil surrounding the hot cell underground air exhaust system, the soil surrounding the 5000 gallon mall tanks (5K tanks) and soil surrounding yard piping that provides connects between the 5K tanks, reactor building, hot lab building and building 4. The following describes the currently planned (or executed) remediation that will occur at each of these areas.

Waste Storage Building Yard

The area with known soil contamination is located behind the waste storage building (North side). The bulk of the affected area, which requires remediation, has a surface area of about 300 to 400 ft^2 and is about 0.5 feet deep. Soil contamination in this area is principally composed of Cs137, with traces of Cs134, Co60 and Sr90. Contamination levels that have been found range from 0.5 to 235 pCi/gm with an average level of 43 pCi/gm.

Soil remediation in this area will consist of excavating the affected soil manually and/or by machine. Generally the entire affected layer (about 200 ft^3) will be removed until the surface soil concentration criteria is met, the gamma dose rate resulting from any residual contamination is less than 5 uR/hr at one meter and any residual soil contamination (which meets the concentration criteria) be no more than six inches thick. After termination of the facility's NRC/NYDOL licenses, the area may or may not be re-graded.

Retention Pond Area

The areas with known soil contamination are spotty, but are generally located at the S-5 discharge pipe outfall and at a drainage trench about 100 ft South-east of the outfall. Depth of soil contamination generally ranges between 0 and 12 inches. The contaminated outfall area that requires remediation has an area of about 450 ft^2.

The drainage trench has an area of about 100 ft^2 that requires remediation. Contaminants are principally comprised of Cs137, Co60, Ce144, Sr90, Nb95, Cs134, Ru106 and Zr95. A hot spot contamination levels up to 60 pCi/gm have been found with average levels being less than 10 pCi/gm.

Soil remediation in the retention pond area will consist of removing about 300 ft^3 of soil. After completion of the soil removal, the areas will be allowed to revert back to nature, with the possible need for some slight regrading near the S-5 outfall to prevent pooling of surface run-off near an adjacent electrical service pit.

Exhaust Stack Area

The exhaust stack is located approximately 400 feet West of the hot lab building atop the 170 foot high cliff behind the building. Soil remediation is currently not planned for this area as it meets the proposed surface contamination criteria. Only Cs137 has been detected at levels generally less than 0.5 pCi/gm which is in the range that would be expected for global fallout. It is possible that some soil remediation could be required at the base of the exhaust stack after the stack has been removed.

Hold Up Tank

The hold up tank (HUT) is located outside at the South-east corner of the reactor building, under approximately 35 feet of soil overburden. The soil above this tank has been excavated. Approximately 150,000 ft^3 of soil overburden had to be removed to expose the top of the tank. No residual radioactive material has been found in this overburden. Recently, contaminated soil has been found and is being removed from along the sides of the tank. This contaminated layer started about 4 feet down from the top of the tank. This soil so far has been found to be contaminated with the following peak concentrations:

Co60	480 pCi/gm
Zr95	3 pCi/gm
Ag108m	28 pCi/gm
Ag110m	2 pCi/gm
Sb125	10 pCi/gm
Cs134	89 pCi/gm
Cs137	240 pCi/gm
Ce144	5 pCi/gm
Eu152	7 pCi/gm

The following radionuclides are estimated by scaling (pending laboratory results):

Ni63	12 pCi/gm
Fe55	480 pCi/gm
Sr90	961 pCi/gm

The HUT area soil is being characterized on an ongoing basis as the excavation process proceeds. During this process soil will be sorted as requiring disposal or meeting subsurface/surface soil criteria and retained for future backfill. Direct gamma exposure rates above this soil is approximately 2 mRem/hr.

It is currently estimated that 2000 - 3000 ft^3 of contaminated soil will require removal as radioactive waste. After remediation is complete, and concurrence is received from NRC/NYDOL to do so, the excavation will be filled with clean building rubble and/or soil meeting the subsurface acceptance criteria and covered with a meter of clean soil, and graded and seeded.

Storage Tank Soil

The reactor water storage tank is located about 100 feet South of the reactor building. The tank has a 600 ft^2 base. The presence of soil contamination under this tank is unknown at this time. After the tank has been removed soil under it will be characterized. If found, it would be removed by manual or mechanized excavation methods. Depending upon the depth of contamination (if found) the subsurface or the surface soil criteria could apply to this area. The area may or may not require backfilling or regrading after remediation.

Underground Exhaust System

The underground air exhaust system consists of an underground ceramic and concrete duct system and a semi-subsurface filter bank that is ventilated to the five hot cells. This system is located in the hot laboratory building. Remediation will consist of removal of the exhaust duct and filter bank, and any soil that may have become contaminated as a result of leaks from this system.

Soil contamination has been identified where soil samples could be obtained. However, the majority of potentially contaminated soil cannot be accessed for characterization until the concrete floor, duct or structures, have been removed. Soil characterization will be carried out on an "as you go" basis as excavation work progresses. During this process soil

excavated to facilitate removal of systems or structures will be sorted as requiring disposal as radioactive waste or as meeting subsurface or surface soil criteria. Excavated soil found to meet acceptance criteria will be retained for subsurface and/or surface backfilling. Additional soil will be removed, as necessary, to meet applicable soil criteria. Portions of the underground exhaust duct are not deep enough to allow application of subsurface excavation criteria, therefore, those areas will be subject to surface soil criteria.

Soil contaminants are expected to principally be Cs137, Sr90 and Ce144 in about equal proportions with peak contaminations possibly reaching the 10,000 pCi/gm level. It is currently estimated that about 17,000 ft^3 of soil from this area will require remediation. After soil remediation and building demolition, and concurrence from NRC/NYDOL to do so, the excavated areas will be backfilled with clean building rubble and/or soil that meets the subsurface or surface criteria as appropriate for the depth.

Gamma Pit/Canal Area

The gamma pit and canal structure is located between the reactor pool and the hot cells. This structure was constructed within a trench that was excavated into the bedrock and backfilled with sand/soil and/or concrete fill. Approximately 8000 ft^3 of soil was estimated as requiring remediation. This estimate was based upon the pre-decommissioning plan characterization performed in 1990. At that time, the canal and gamma pit had to be maintained in usable condition so the number of available soil samples were limited. However, as part of recent decommissioning activities in the canal/gamma pit, 12 additional core holes were drilled through the walls to characterize the radiological condition of the exterior concrete surfaces and surrounding soil.

The exterior concrete surfaces were found to be generally free of surface contamination except near a construction joint/crack. Three of the core holes were found with soil behind them and soil samples were retrieved. Traces of Cs137, Co60, Ag108m and Ag110m were detected in all three samples. However, the concentrations found meet both the proposed subsurface and surface soil criteria, with the highest concentration being; Cs137 - 0.2 pCi/gm, Co60 - 0.4 pCi/gm, Ag108m - 0.08 pCi/gm and Ag110m - 0.2 pCi/gm. This may indicate that soil contamination is less extensive than originally estimated.

As the canal/gamma pit structure is removed, surrounding soil must be removed and will be characterized and sorted, as requiring disposal or to be retained for future use as backfill material. After the canal/gamma pit structures are completely removed, additional soil will be removed as is required to meet release criteria. After completion of remedial activities, the subsurface portions of the excavation will be backfilled with concrete rubble and/or soil that meets the surface and/or subsurface soil criteria as appropriate and covered with at least a meter of clean soil, graded and seeded.

5K Tanks

The 5K tanks are located about 50 feet East of the reactor building tunnel, the administration and boilerhouse buildings. As part of the decommissioning process, the two 5K tanks will be removed. To accomplish this, the soil burden above and around the tanks will be removed. The presence of soil contamination around or under these tanks from leakage has not been confirmed. As such, soil will be characterized as the excavation progresses and dispositioned for disposal or retained as backfill material, as appropriate. Excavation will continue until soil is found to meet release criteria appropriate for the depth encountered. Upon conclusion of remedial activities and concurrence from NRC/NYDOL, the excavation will be backfilled with soil that meets surface soil contamination criteria, and graded and seeded as appropriate.

Yard Piping

Underground piping that could have potentially contained radioactive material between the reactor building, hot lab building, building 4 and the 5K tanks will be removed as part of the decommissioning process. It is not evident that any of this piping has leaked, however, excavated soil surrounding this piping will be characterized during the removal process. This soil will be sorted as requiring disposal or as backfill material based upon surface soil criteria. Should contaminated soil be encountered, the remaining soil would be characterized and remediated as necessary to appropriate release criteria for the depth encountered. Upon completion of remedial activities and concurrence by NRC/NYDOL these areas will be backfilled.

#3

Soil remediation activities will generate six categories of soils that can either be left in place, or used as backfill material or which must be disposed of as radioactive waste. The six categories of soil are as follows:

1. Surface soils which meet surface soil release criteria (which can be left in place).

2. Surface soils which exceed surface soil release criteria (which will be disposed of as radioactive waste).

3. Subsurface soils which exceed subsurface soil criteria (which will be disposed of as radioactive waste).

4. Overburden soils that are removed from subsurface remediation areas to gain access to subsurface contaminated soil/structures, which meets surface soil criteria. This soil will be retained for backfilling subsurface areas, capping backfilled areas or abandoned elsewhere on the Cintichem site.

5. Overburden soils that are removed from subsurface remediation areas to gain access to contaminated soil/structures, that exceeds surface soil criteria, but which meets subsurface soil criteria. This soil will be retained for backfilling in acceptable subsurface areas (see also response #9). Subsurface soils which could be left in place but are in excavations not deep enough to meet overburden requirements will be removed, retained and used as subsurface backfill elsewhere on site.

6. Subsurface soils which meets subsurface soil criteria and overburden requirements (see response to #9). This soil will be left in place.

Contaminated soils (category numbers 2 and 3) will be disposed of as radioactive waste at licensed disposal facilities, such as CNSI at Barnwell, SC or Envirocare, Inc. at Clive, Utah. This soil will be packaged and transported in accordance with DOT 49 CFR requirements and disposed of in accordance with 10 CFR 20 and 61 requirements.

Potential category 4 and 5 soils will be placed into strong-tight-leakproof containers (e.g. steel drums, bins or boxes) at the time of excavation. At that time, samples of the soil are taken (see number 1) for future laboratory analysis. Filled containers are next screened by direct gamma dose rate and/or direct gamma spectral analysis with a portable IG-MCA set up (when high NORM content is suspected). If this screening indicates that the potentially category 4 or 5 soils are really category 3 soils, they will be disposed of as radioactive waste. Otherwise, potential category 4 and 5 soils will be transferred to a locked holding area separate from the main RCA, which is controlled by Health Physics, pending laboratory results and

final categorization. Soil that is category 4 will be transferred and deposited on an open spoils pile(s) located within the main radiologically controlled area. Category 5 soil will be retained, in its containers, within the separate holding area until final disposition can be made.

Category 4 soil will be used for backfilling or capping any areas on the Cintichem site without restrictions. Category 5 soil will be used as backfill material in any subsurface area (under or adjacent to buildings 1 or 2) that meet depth and concrete rubble thickness requirements (see response to #9).

#4

Cintichem will use the guidance given in NUREG/CR 5849 to define allowable "hot spots". The following summarizes this approach:

The upper limit for soil activity hot spots at any location will be three times the applicable soil criteria using sum-of-fractions of the criteria for all radionuclides detected. Residual activity exceeding this level will be remediated and follow-up survey performed. Areas of elevated activity between one and three times the criteria (i.e., sum-of-fractions are >1 and $\leq$ 3) for the radionuclides present, will be tested to assure that the average concentration is less than $(100/A)^{\frac{1}{2}}$ times the criteria, where A is the area of the elevated activity in m^2. Levels exceeding this limit will be remediated. If this condition is satisfied, the average activity in the 100 m^2 contiguous area containing the elevated region will then be determined to demonstrate that the average level is less than or equal to one times the criteria using sum-of-fractions. The following equation from NUREG/CR 5849 with variables modified to use sum-of-fractions will be used to calculate average levels:

$$\bar{x}_w = \frac{1}{n_s} \sum_{i=1}^{n_s} x_i \left[1 - \sum_{k=1}^{n_k} A_k \right] + \sum_{k=1}^{n_k} y_k A_k$$

where

$\bar{x}_w$ = weighted mean including elevated area(s)
x_i = systematic and random measurements results (sum-of-fractions) at point i
n_s = number of systematic and random measurement locations
y_k = elevated area sum-of-fractions in area k
A_k = fraction of 100 m^2 occupied by elevated area k
n_k = number of elevated areas.

Scanning will be performed with collimated NaI detectors (gamma emitters) and large area beta/gamma detectors (beta emitters) to identify locations of elevated activity levels within grids known to have contained or potentially contained contaminated soil (i.e. biased area 100 m^2 survey grids). Areas of suspected elevated activity identified in this manner, will be evaluated by sampling and analyses to determine their activity level and arial extent. Additional cleanup will be performed, if required, and scanning repeated. After scanning has indicated the guidelines and conditions have been satisfied, systematic soil sampling of each affected area grid block is performed at locations equidistant between the center and each of the four grid block corners (see Figure 4.4 from NUREG 5849).

If scanning is not capable of detecting surface areas with activity levels $\leq$ 75% of the criteria for the radionuclides of interest, additional sampling will be required to provide an acceptable level of confidence that locations of elevated activity have been identified. An EPA procedure (EPA 1989) recommends a triangular grid with a sampling interval of 5 m on a side (enclosed area of approximately 10.8 m^2) for a 95% assurance that elevated areas in excess of 10 m^2 surface area are identified. By beginning with the standard systematic pattern and including additional sampling points, located along the 10 m grid lines, at block corners and centers, and midway between grid block corners (see Figure 4.5 from NUREG 5849), a triangular sampling pattern with spacing of 5 m or less (enclosed area of approximately 6.3 m^2) will be obtained. From this sampling pattern, a total of 13 measurement locations would be used to characterize hot spot area and levels.

#5

Cintichem intends to use the following background values and methodologies for differentiating Cintichem's radioactive material and its associated external exposure rate from that caused by Naturally Occurring Radioactive Material (NORM):

Background Radioactive Material Concentration (pCi/gm)

Radionuclide	Surface Soil	Sub-surface Soil	Bedrock
Cs-137 (a)	1.25	0	0
Sr-90 (a)	0	0	0
K-40 (a)	19.4	19.4	19.4
U-234/235/238 (b)	-- All at natural enrichment --		
Other NORM (i.e. Th-232 & D, Ra-226 & D)	-- Any amount found --		

(a) Determined by soil sampling off and on site. The background values are calculated at the 90th percentile using the methodology given in NUREG/CR 2082 "Monitoring for Compliance with Decommissioning Termination Survey Criteria", pp 64 - 66.

(b) Due to Cintichem's location within the Reading Prong, uranium concentrations can significantly vary by location and be quite high. Background uranium concentrations will therefore be considered to be present when the ratio between each of the uranium isotopes are found to be consistent with natural enrichment. Cintichem's uranium is high enriched at 93 wt. % U-235. Natural uranium has 0.72 wt. % U-235. As such, Cintichem's uranium can be readily differentiated from the varying background levels by comparison of the ratio of the individual uranium isotopes. Any uranium found not to have the correct ratios for natural uranium enrichment will be considered to be above background. The fractional make up of radioactivity by isotope for typical natural uranium and Cintichem's HEU are as follows:

Isotope	Natural (Background) U	93% HEU
U-234	0.489	0.9647
U-235	0.022	0.0350
U-238	0.489	0.0003
Total	1.000	1.000

The ratio between the individual isotopes for each mixture is as follows:

Mixture	U-234:U-238	U-234:U-235	U-235:U-238
HEU	3216	27.6	117
Nat-U	1	22	0.45

Background Radiation Exposure Rates

Background radiation levels within Cintichem's geographic region vary considerably from one location to the next due to natural deposits of uranium and thorium. Exposure rates on and surrounding the Cintichem facility have been found to vary from 6 uR/hr up to 160 uR/hr at one meter from the ground or bedrock surfaces. A contact exposure rate of 1000 uR/hr on bedrock has been found on the Cintichem site. Upon investigation, it was determined to be a natural deposit of Thorium-232 and daughters.

Therefore, it is not possible to directly measure for the 5 uR/hr criteria from Cintichem originated radioactive material in the presence of variable and high natural background radiation levels. Cintichem therefore proposes to indirectly determine radiation levels from Cintichem RAM in soil or bedrock and exclude the contribution from NORM. To accomplish this, Cintichem will determine the gamma ray-flux for at least one gamma ray from each non-NORM gamma emitting radionuclide present at each location of interest. Gamma rays from background radioactive material will be excluded.

The gamma ray fluxes will be determined by direct in-situ measurement with a portable intrinsic-germanium detector (EG&G ORTEC model Gamma-X HPGe 10200-P) and multi-channel analyzer (EG&G ORTEC model 7500B). At each location of interest, a gamma ray spectrum will be obtained and the resulting photopeaks identified. Photopeaks from naturally occurring radioactive material will be excluded, and the remaining ones attributed to Cintichem RAM. The count rate from each photopeak will then be converted to a gamma ray flux and attributed to a particular radionuclide. In some instances, some photopeaks from Cintichem RAM may be obscured by interferences from gamma rays from naturally occurring RAM or other Cintichem RAM. When this happens, corrections will be made to account for obscured gamma rays by inferring the gamma ray flux of those that cannot be seen to those that are present based upon the decay scheme of the gamma emitters found. As an example, Cobalt-60 has two gamma rays at 1.173 and 1.332 MEV at 100% abundance. If the 1.173 MEV gamma was detected, but the 1.332 MEV gamma was obscured, the 1.332 MEV gamma ray flux could be inferred to have an equal gamma ray flux as the 1.173 MEV gamma ray.

At each measurement location, the total gamma ray flux would be tabulated by energy grouping for the gamma rays produced by Cintichem RAM. The gamma ray flux profile would then be converted to a corresponding exposure rate. This exposure rate would then represent the exposure rate above a variable background.

The 5 uR/hr at one meter criteria will be applied to surface soil areas and bedrock surfaces to be left exposed. It is proposed that subsurface soil and bedrock surfaces not be held to the exposure rate criteria until backfilling and capping has taken place.

#6

Remediation of soil to the 10 mRem/yr level is estimated to require the removal and disposal of about 42,600 ft^3 of packaged soil. Using a 1993 rate of \$284/ft^3 for removal, handling and disposal (see response to question number 1 from the October 22, 1992 submittal), a cost of \$12,100,000 will be incurred. Remediation to the 20 mRem/yr level is estimated to require the removal and disposal of 7,350 ft^3 of packaged soil. Using the same rate as above, this would cost \$2,100,000. Soil remediation to a level of 5 mRem/yr is estimated to require the additional removal and disposal of 173,100 ft^3 of soil above the 42,600 ft^3 needed to meet the 10 mRem/yr criteria, producing a total soil volume of 215,700 ft^3. If the additional 173,100 ft^3 is assumed to meet disposal requirements of the Envirocare facility in Clive, Utah, which has a lower disposal rate, the total cost of remediating soil to the 5 mRem/yr level would be \$22,600,000. If the additional soil did not meet Envirocare facility criteria (which is currently the case) remediation to the 5 mRem/yr level would cost \$61,260,000.

The proposed criteria for residual soil contamination is deemed to be reasonable from the ALARA standpoint because of the following conservative assumptions that were made for calculating the dose pathway analysis and also because of the conservative approach taken for choosing distribution coefficients for use in the RESRAD model. These are summarized as follows:

Conservative Assumptions

- The time of maximum exposure from the radionuclides that will be left in soil after the decommissioning process is completed will not occur simultaneously. The proposed criteria assumes that it will. Therefore the actual maximum dose will only be a fraction of 10 mRem/year.

- No credit has been taken for shielding or distance from contaminated buried rubble in calculating the total dose.

- The estimate of the area of the affected zone (sub-surface) that was used in the model calculation is now known to be at least 61% of that postulated in the model and therefore the sub-surface criteria could be 39% higher than that proposed.

- The family-farmer scenario that was used as the basis for the dose calculation is not very likely to happen within the foreseeable future. This land is more likely to be used either as an industrial site or as a public park. Furthermore, the projected dose decreases significantly within 20 years following completion of decommissioning.

- Under any circumstance the most likely future water supply would be the reservoir as opposed to wells. It was assumed that future water supply would be from wells in the dose pathway analysis.

- Affected surface zones were assumed to be contiguous in the model calculation.

- Without any remediation accomplished to date on soils under the hot laboratory building, Sr90 is the only radioisotope of Cintichem origin currently detectable in monitoring well water and it is below the EPA drinking water limit in all but two wells that are adjacent to or under the affected zone. After contaminated soils are removed from underneath the hot lab building this condition will improve significantly.

- The current EPA drinking water standards limit the dose to any organ to less than 4 mRem as opposed to limiting the Committed Effective Dose Equivalent. The proposed acceptance criteria for soil and water will cause any ground water on site to be below EPA drinking water limits.

Conservative Choice of Distribution Coefficients

Cintichem's choice of distribution coefficients (K_d's) for use in the development of soil residual radioactivity guidelines has been directed by site-specific sampling, a review of available published data, the potential impact upon the project, and conservative engineering judgement. The following discusses items considered by Cintichem prior to the choice of the Sheppard and Thibault methodology, used to develop K_d's and subsequently employed in the RESRAD determination of soil guidelines.

Cintichem has previously stated that the determination of K_d for each potential radioisotope in each affected area of the site could potentially require several hundred measurements. Cintichem has chosen to eliminate the expense and time required by these determinations by the judicious choice of conservative, published values. The use of conservative K_d values will bound the RESRAD calculations, and will represent all contaminated areas and hydrogeolgic units along the transport pathway.

Appendix H in the documentation provided with the RESRAD manual describes three optional methods which may be used in lieu of site-specific values for K_d. These methods are referred to as the groundwater concentration method, the leach rate method, and the plant/soil concentration ratio (Sheppard and Thibault) method. Of these three optional methods, only the Sheppard and Thibault method may be used successfully. The groundwater concentration method requires input of the elapsed time since radioactive material placement, which Cintichem cannot reasonably determine in some areas. The leach rate method requires the determination of leach rates for each radioisotope in each location of interest (a task as difficult, if not more difficult than the determination of K_d's).

Cintichem has chosen to derive K_d's using the most conservative form of the Sheppard and Thibault methodology, i.e., for sandy soil. Previously, Cintichem submitted to the Staff results of K_d determinations for cesium, cerium and strontium to benchmark the calculated Kd values used. Additional K_d determinations for cobalt, europium and silver and other radionuclides have been performed with contaminated soil and water found in the HUT excavation (see response #8). These K_d determinations were made on soil samples considered most likely to provide conservative K_d values (sandy-type soils). A comparison of results is provided below.

Radionuclide	Measured K_d	K_d Used In RESRAD Calculation
Strontium-90	14.7	9.2
Cesium-134	106	92
Cesium-137	270	92
Cerium-144	171	184
Cobalt-60	> 99,379*	135
Europium-152	> 309*	82
Silver-110m	> 111*	11

(* See response #8)

The above results benchmark, and validate, Cintichem's use of the Sheppard and Thibault algorithm for sandy soil. The isotopes listed in the table above are anticipated to represent greater than 99% of the total activity to be found at the site.

The Sheppard and Thibault methodology allows Cintichem to determine K_d's for elements which do not have default values in the RESRAD code.

Cintichem has employed "bedrock" K_d's as suggested by Leggette, Brashears and Graham for the saturated zone beneath the subsurface contaminated zone in the RESRAD analyses. These K_d's are far more conservative than those contained in the RESRAD manual or developed using the Sheppard and Thibault algorithm, and will result in higher dose rates from the water-dependent pathways which dominate the dose rates due to the subsurface contaminated zone. However, considering the geology of the site, Cintichem deemed their use to be an appropriate conservatism.

Cintichem gave consideration to "bounding" the soil guidelines by considering artificially high and artificially low distribution coefficients. The uses of artificially high values retards radionuclide transport into the aquifer below. This would tend to increase the dose rates from the water-independent pathways. Cintichem discovered through RESRAD analyses that dose rates from water-independent pathways for the dominant isotopes (the strong gamma emitters, e.g. cobalt) were a maximum at t = 0 years. Thus, Kd has no effect upon the resultant dose rates for these isotopes.

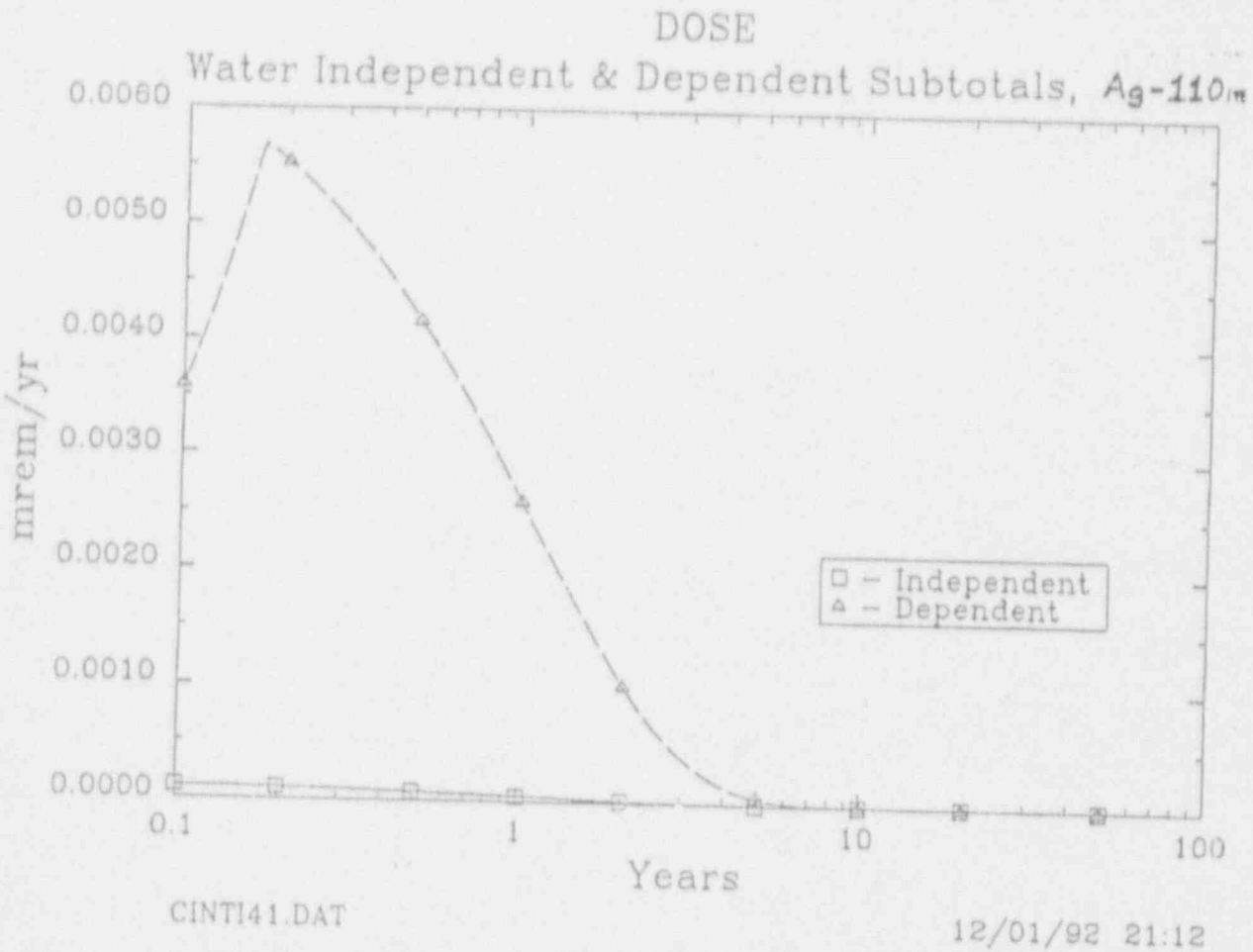
Cintichem was unable to justify the use of artificially low distribution coefficients. Setting K_d to 0 would appear at first to be a logical conservatism. However, if this were true, there would no longer be any radionuclides detectable in the soil.

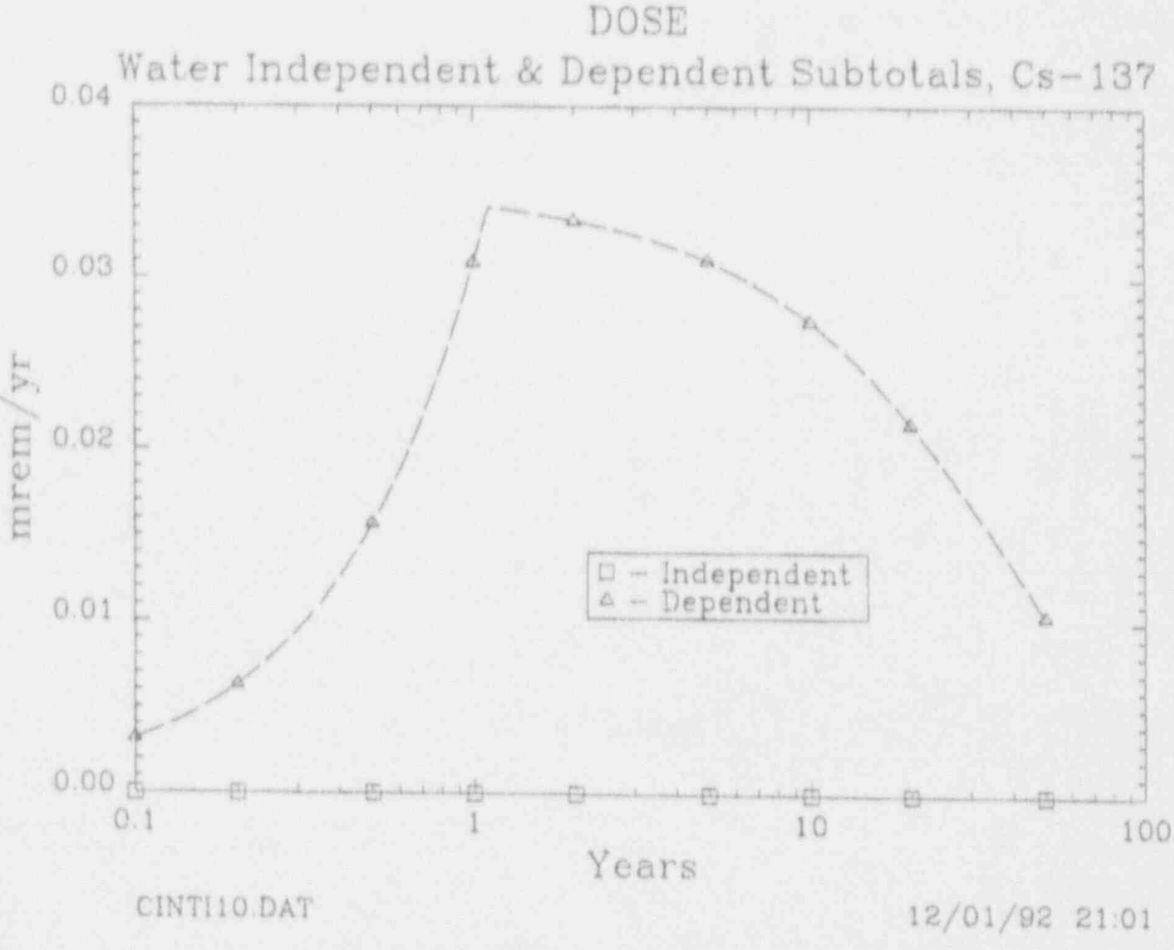
The conservatively low distribution coefficients published in the RESRAD manual (those listed for sandy soils in Table E.3) do not have strong analytical support. As noted in a footnote to the table, these values are simply taken to be 10% of the K_d values for soils and clays (except for cesium). Cintichem does not believe these values represent as valid set of K_d's as those derived using the Sheppard and Thibault methodology.

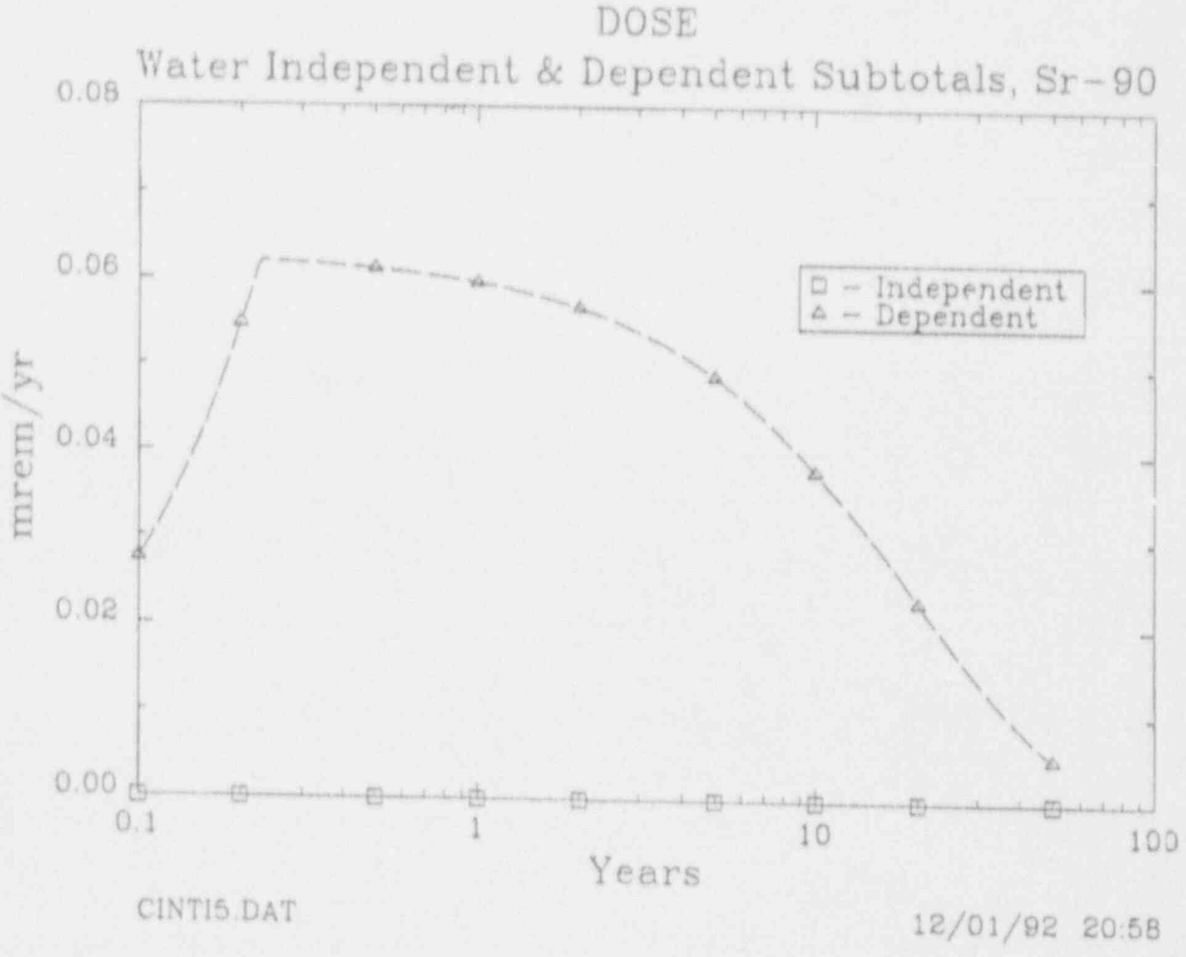
Additionally, as stated earlier, Cintichem has measured K_d values for those radionuclides expected to most significantly contribute to radiation doses. These measurements indicate K_d is not zero and that the use of the Sheppard and Thibault methodology most closely represents reality.

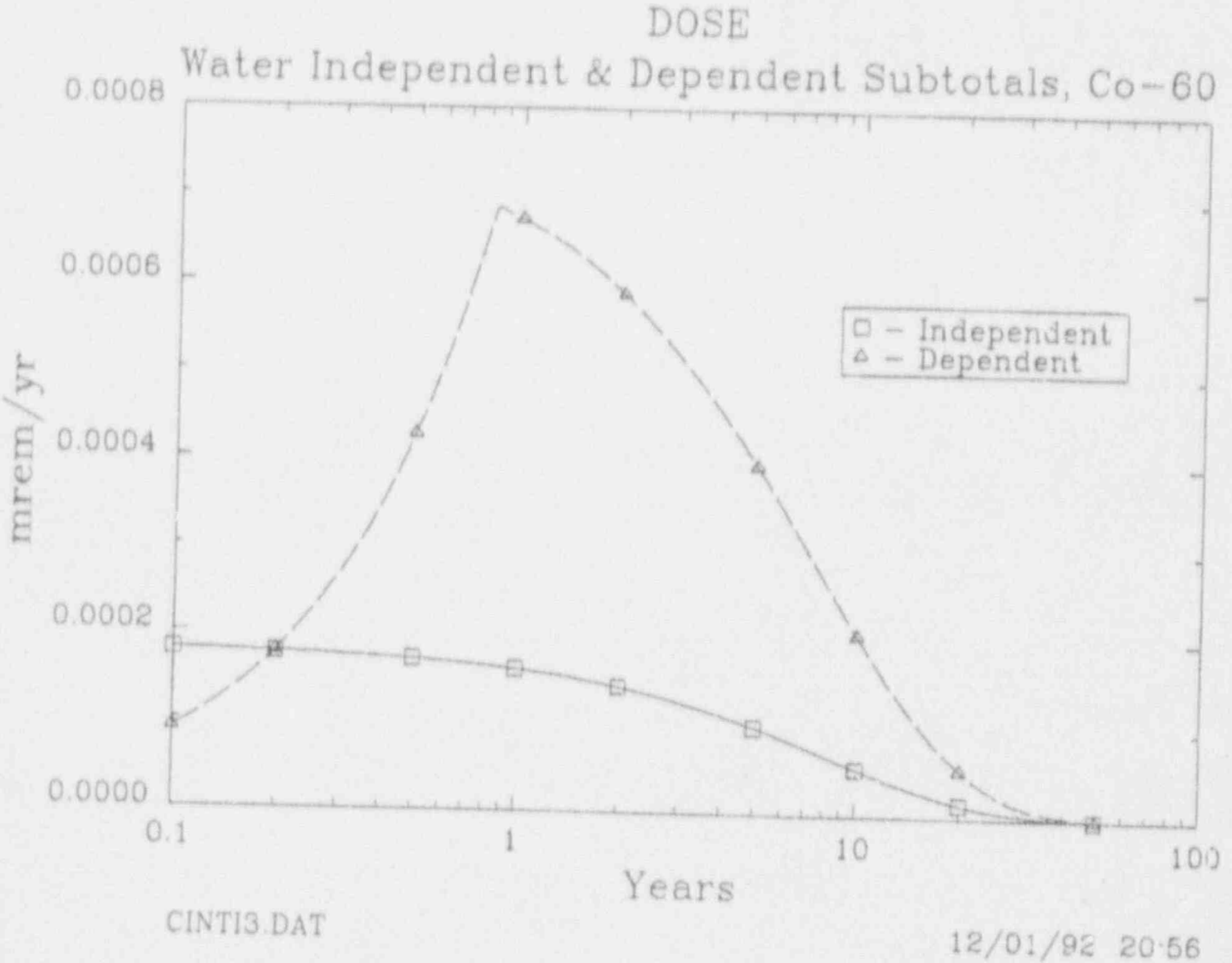
The following graphs present RESRAD calculations for the most significant radionuclides that have been found in the subsurface contaminated zone. As may be noted, all of these isotopes will reach their peak dose rate contributions at different times. The most significant contributors to dose are Sr90 and Cs137 and they peak at approximately 3 months and 1 year respectively after disposition in the soils. The other radionuclides of Ag110m, Co60, Ce144 and Eu152 also peak at different times but they are all at least an order of magnitude less than Sr90 and Cs137 at their respective peaks.

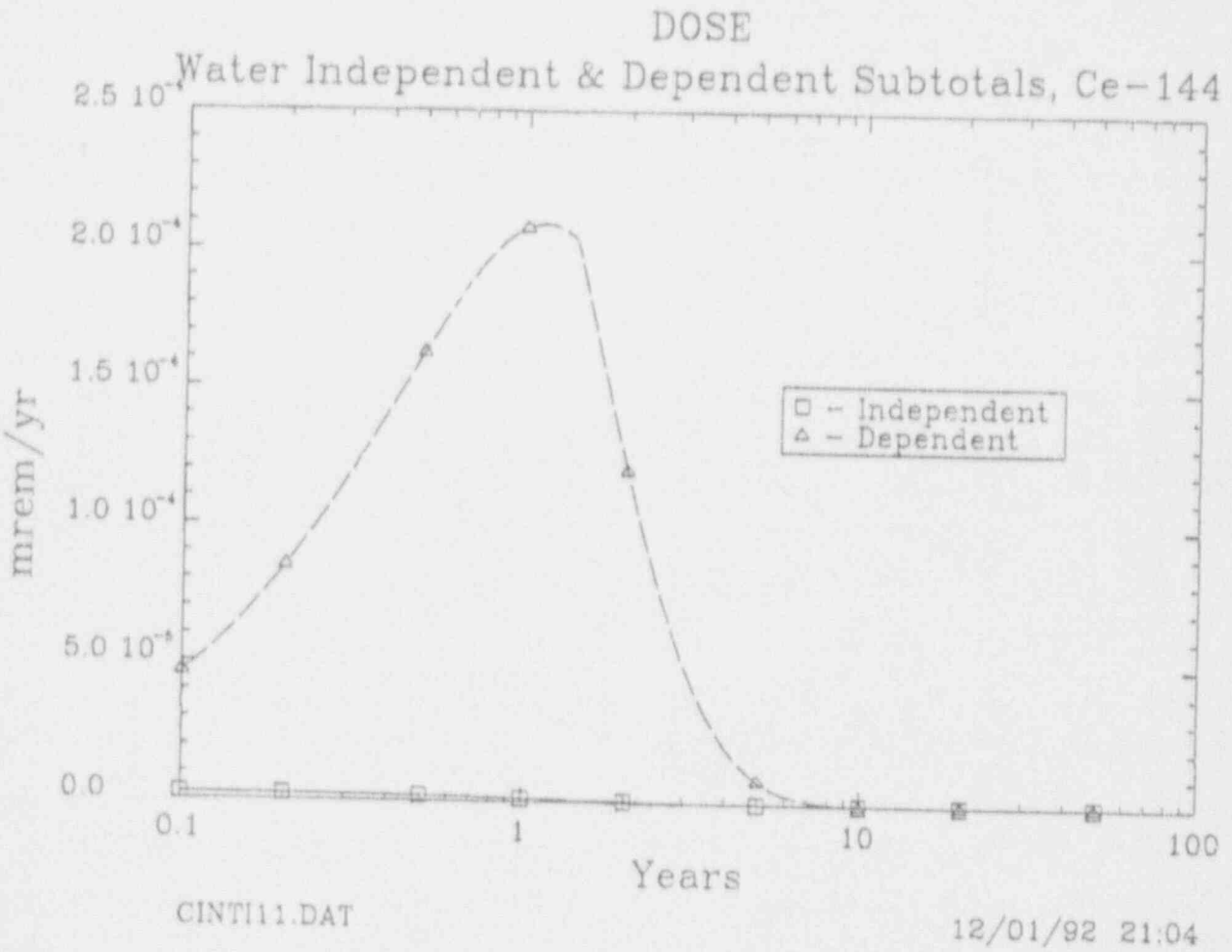
It may also be noted that all of these radionuclides will be a fraction of their peak ten or more years into the future.

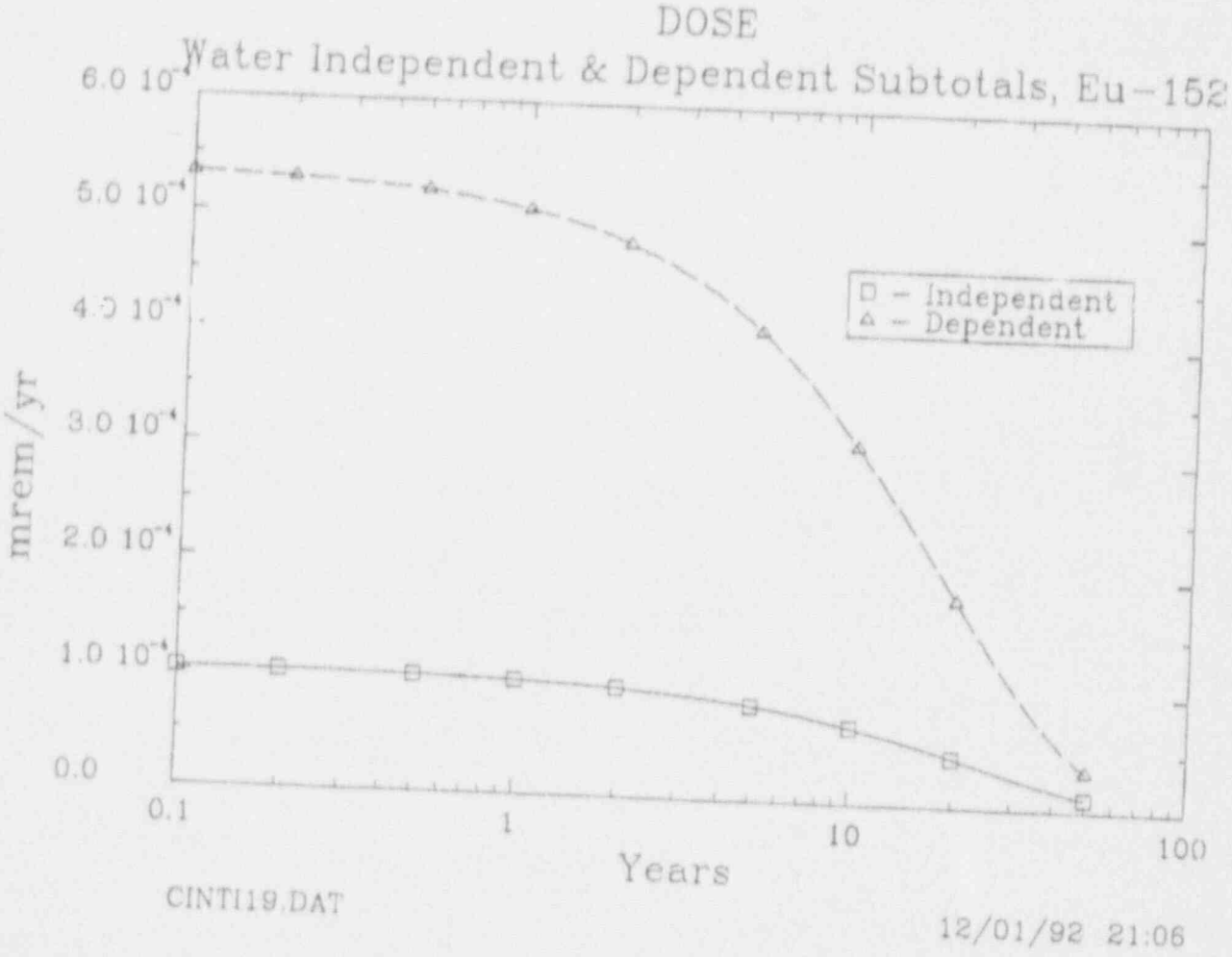

DOSE
Water Independent & Dependent Subtotals, Ag-110m
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
mrem/yr
0.1
1
10
100
Years
□ – Independent
△ – Dependent
CINTI41.DAT
12/01/92 21:12


DOSE
Water Independent & Dependent Subtotals, Cs-137
0.04
0.03
0.02
0.01
0.00
mrem/yr
□ - Independent
△ - Dependent
0.1
1
10
100
Years
CINTI10.DAT
12/01/92 21:01


DOSE
Water Independent & Dependent Subtotals, Sr-90
0.08
0.06
0.04
0.02
0.00
mrem/yr
□ - Independent
△ - Dependent
0.1
1
10
100
Years
CINTI5.DAT
12/01/92 20:58


DOSE
Water Independent & Dependent Subtotals, Co-60
0.0008
0.0006
0.0004
0.0002
0.0000
mrem/yr
□ – Independent
△ – Dependent
0.1
1
10
100
Years
CINTI3.DAT
12/01/92 20:56


DOSE
Water Independent & Dependent Subtotals, Ce-144
2.5 10⁻⁴
2.0 10⁻⁴
1.5 10⁻⁴
1.0 10⁻⁴
5.0 10⁻⁵
0.0
mrem/yr
□ - Independent
△ - Dependent
0.1
1
10
100
Years
CINTI11.DAT
12/01/92 21:04


DOSE
Water Independent & Dependent Subtotals, Eu-152
6.0 10⁻⁴
5.0 10⁻⁴
4.0 10⁻⁴
3.0 10⁻⁴
2.0 10⁻⁴
1.0 10⁻⁴
0.0
mrem/yr
□ - Independent
△ - Dependent
0.1
1
10
100
Years
CINTI19.DAT
12/01/92 21:06

#7

Cintichem does not believe that there are non-contiguous zones of subsurface soil contamination separated from the known or suspected contamination source areas.

All known and suspected soil contamination areas will be excavated or otherwise checked for contamination (as was described in the responses to NRC requests for additional information related to the Decommissioning Plan). Non-contiguous zones of soil contamination are not possible for the following reasons, (1) there are 29 monitoring wells that surround the facility at varying distances from the facility. None of these wells indicates the presence of soil contamination except where a known source location exists; (2) water monitoring well data indicates decreasing radionuclide concentrations with increasing distance from the soil contamination sources, (3) more significantly, the mechanism of contaminant migration in soil would not allow the front of a plume to become separated from the plume area near the source as long as the source is still present. That is, the concentration of a contaminant in a plume decreases expotentially with distance as long as the source is still contributing radioactivity to the plume. However, non-contiguous surface contamination is a possibility. These areas, if present, would be detected by the systematic and biased final survey direct measurements and soil sampling program (described in prior submittals).

#8

Cintichem has recently performed an additional benchmark of the calculated Kds that were used in the RESRAD calculations. Assays of excavated contaminated soil and the water were used to determine in-situ Kd's. At least two pounds of soil was taken from the excavation, prepared for assay, and assayed as described in answer #1. At least one liter of water at the approximate location of the soil was taken and analyzed as per HP-M-55 (attached). The following chart tabulates the soil concentrations, water concentrations and resultant Kd according to the formula:

$$Kd \text{ (in ml/g)} = \frac{(\text{g of sorbed nuclides})/(\text{g of solid})}{(\text{g of nuclide remaining in solution})(\text{ml of solution})}$$

(as seen on page 220 of the unpublished RESRAD manual.)

Isotope	Conc. in soil (uCi/gm)	Conc. in water (uCi/ml)	Kd
Mn54	2.79E-6	<1.18E-8	> 236.4
Co57	6.51E-7	<7.80E-9	> 83.5
Co60	4.80E-4	<4.83E-9	>99378.9
Zn65	6.17E-6	<4.48E-8	> 137.7
Zr95	2.80E-6	<1.15E-8	> 243.5
Ag-108m	2.73E-5	<5.84E-9	> 4760.3
Ag-110m	1.47E-6	<1.32E-8	> 111.4
Sb125	9.48E-6	<7.80E-9	> 1215.4
Cs134	8.93E-5	<2.88E-8	> 3100.7
C137	2.40E-4	<4.63E-9	>51835.9
Ce144	5.11E-6	<4.77E-8	> 107.1
Eu152	7.10E-6	<2.30E-8	> 308.7

These Kd results are greater than values since the water had only MDA values. While this determination was not performed in accordance with ASTM D4319, it does provide an indication that the Kds used are conservative.

#9

Airchem would prefer to cover soil meeting subsurface limits with a minimum of 20 feet of clean concrete rubble and fill with at least 3 feet of clean soil. Use of a 25 foot layer of concrete rubble may not provide a sufficient thickness unless the finished capped elevation was about five feet higher than the now existing grade.