Tetra Tech EM Inc.

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June 7, 1999

Mr. George Kikugawa
Remedial Project Manager
Naval Facilities Engineering Command
Engineering Field Activity West
900 Commodore Drive, Building 208
San Bruno, California 94066-2402

Subject: **Response to Comments on Interim Data Letter Report - Final**
C-Line and D-Line
Installation Restoration Sites 5 and 10
Alameda Point, Alameda, California
CLEAN II Contract No. N62474-94-D-7609, Contract Task Order No. 147 and 239

Dear Mr. Kikugawa:

Tetra Tech EM Inc. (TtEMI) is providing this response to comments on the interim data letter report for the C-Line and D-Line outside Building 5. The California Department of Toxic Substances Control (DTSC) and the California Department of Health Services (DHS) reviewed the report and submitted the comments. As requested by LCDR Vincent DeInnocentiis of the Radiological Affairs Support Office (RASO) by e-mail dated February 22 and at your technical direction, TtEMI is providing this response.

Four modified field sketch maps clarifying the C-Line and D-Line data set are provided as Attachment A. Our field survey personnel confirmed that the entire trench contained a 4- to 6-inch-deep layer of water during the D-Line survey. This layer of water resulted from higher-than-expected groundwater infiltration and the inability of available pumping capacity to keep up. In response to this problem, TtEMI modified the survey technique. The radiation detector was enclosed in a thin plastic waterproof case, weighted to keep the detector in intimate contact with the trench bottom, and dragged along the bottom of the trench. Any impact on our ability to identify elevated areas of soil was slight. The survey sketches where water was present have been so annotated and are also included with Attachment A.

Calculations demonstrating the impact of a layer of water on background detector response rates as requested by the DHS representative are enclosed as Appendix A to the response to comments. The difference between a detector in a dry trench and a detector whose background response is impacted by a layer of water is 1,040 counts per minute. This small difference did not impact the ability to detect sources of radium-226 at the project criteria.

The written response to DTSC and DHS comments on the interim data report is provided as Attachment B to this letter. It is anticipated that after all technical issues are resolved, the data will indicate that the site is

acceptable from both a risk-based evaluation and from a regulatory standard-based evaluation in accordance with the action memorandum.

If you have any questions, please call me at (415) 222-8280.

Sincerely,

Melissa Mannion for

Sven Edlund
Project Manager

Enclosures: Attachment A, C-Line and D-Line Information
Attachment B, Response to DTSC and DHS Comments

cc: LCDR Vincent DeInnocentiis, RASO
David Horton, IOC
Conrad Sherman, TtEMI
File

ATTACHMENT A

C-LINE AND D-LINE INFORMATION

Revised 3/9/99

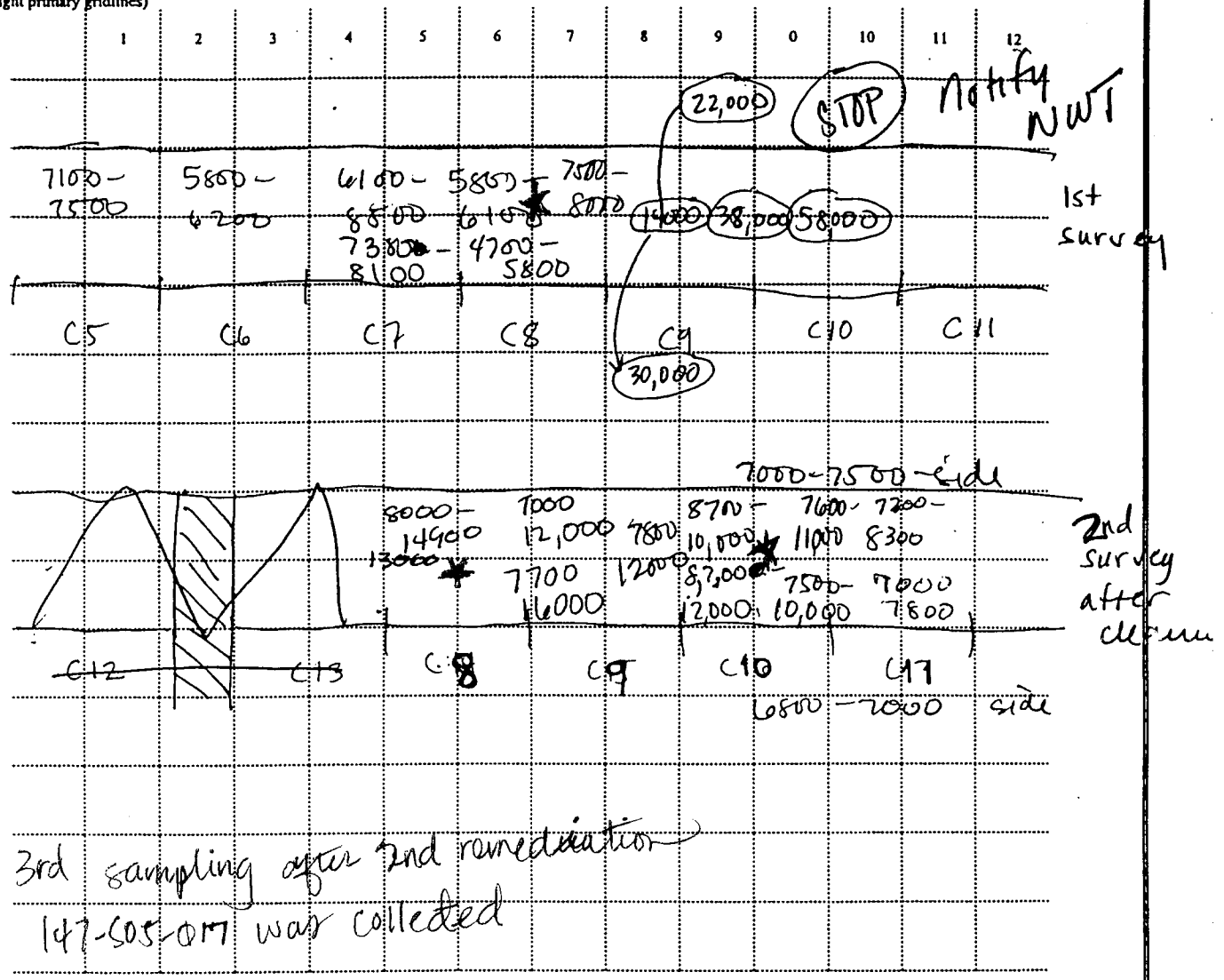
Radiation Survey Map

CTO 147 Site/Task Alameda Surveyor L. Neudert M. Mannion Employee No. — Employer TEMI Survey Date: 11/3/98

Instrument 247 Calibration No. — Check Source No. — Response — Background 3889 - inside ct. Background Time 1 min

Additional Set Up Notes: Outside trench - Bldg. 5 7598 - outside ct. 6743 - " "

Grid Sketch (highlight primary gridlines)



Notes:

~~147-S05-015~~ LAN

11/6/98 147-S05-017 collected from grids C8 + C11 after further remediation

11/4 147-S05-013 collected from grids C8 + C10 - Result > 5 picograms (LAN)

Leslie Neudert — Completed By: — Leslie Neudert — Sign — 11/3/98 — Date

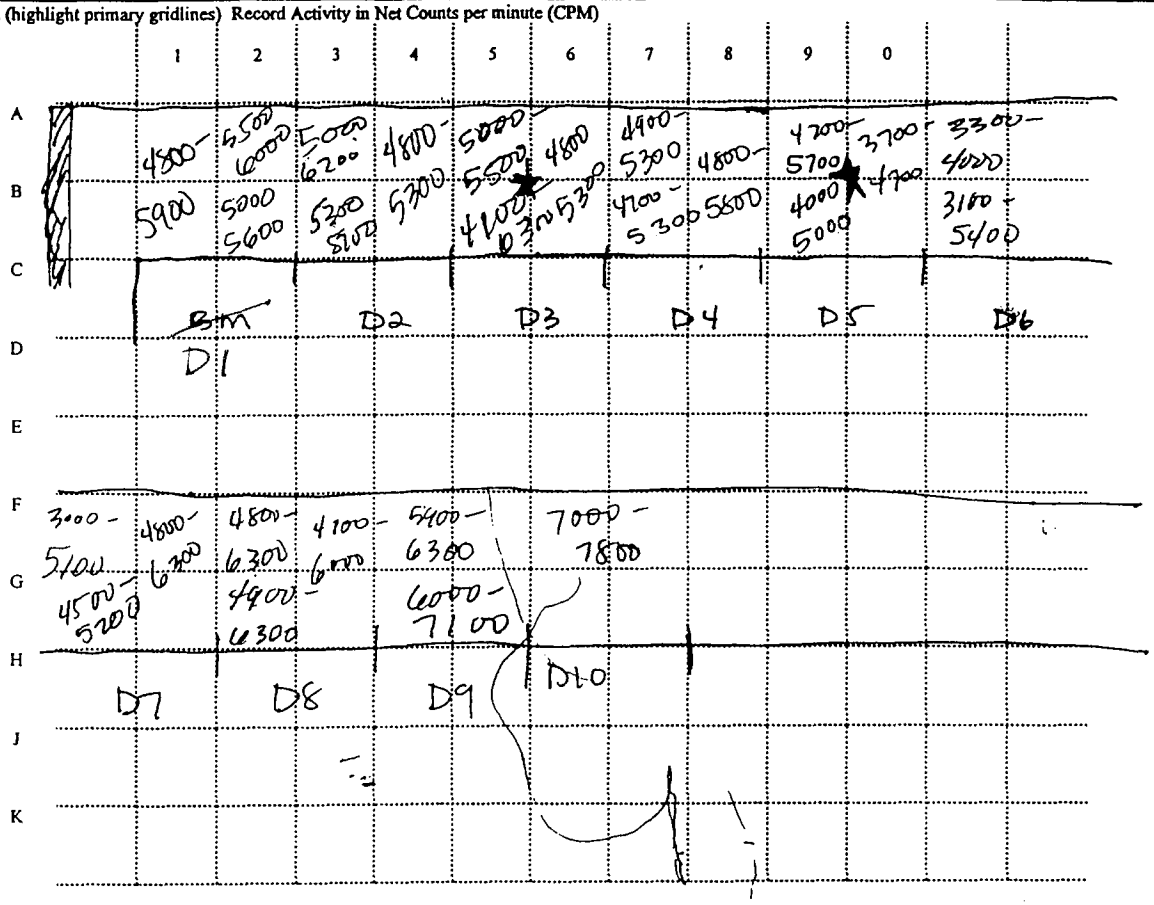
Carol Sloman — Reviewed By: — Carol Sloman — Sign — 1/12/99 — Date

AIR CCA 1/12/99

GAMMA GRID SURVEY DATA WORKSHEET CLEAN Program Form Serial No.

Project: Alameda	CTO: 147	Task: 100% scans	Date: 11/3/98
Building / No.: 5	Building Description: Building 5	Survey Section: BM/D2-D10	Additional Identifier: - NA
Originator: L. Neudert	Employer/Employee No.	Date: 11/3/98	
Measurement Purpose: Survey pipe trenches for clearance		Data Set Identifier: NA	Count Time (min): 1 min
Type of Survey	Instrument Model	Instrument No.: 221	Background Count Rate: 6285 / 6490 - in trench
Measurement Purpose	Detector Model: gamma scin.	Detector No.: 247	Net Count Action Level
Activity Conversion Factor	Set-Up Reference	Control Reference	

Grid Sketch (highlight primary gridlines) Record Activity in Net Counts per minute (CPM)



147-505-014

Area Above Action Level	Area Below Action Level
Average Activity Above Action Level (cpm)	Average Net Activity Below Action Level (cpm)
Average Activity (cpm): N/A	Blocks Represent Area (cm x cm)
Clean Up Goal	Action

Review		Action
Completed By: Leslie Neudert	Date: 12/2/98	
Review By: Carol Munn	Date: 1/12/99	
Validation: NR	Date: 1/12/99	

deep water in trench

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Note: all grids were under atleast 6" of water during survey 3/9/99

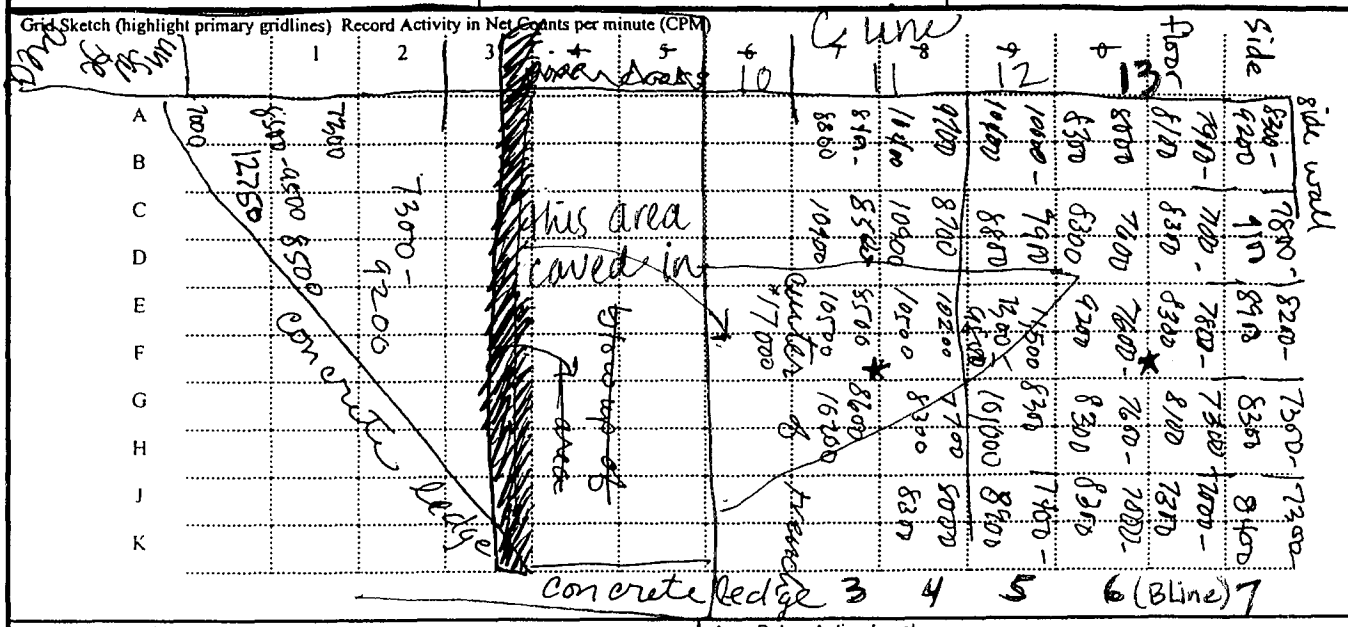
Revised 3/9/99

GRID SURVEY DATA WORKSHEET

CLEAN Program Form Serial No.

Project: Alameda	CTO: 147	Task: survey 2+2	Date: 10/21/98
Building / No.: 5 - outside	Building Description:	Survey Section: triangle area	Additional Identifier:
Originator: L. Neudert	Employer/Employee No.:	Date: 10/21/98	↳ C+B Line
Measurement Purpose: survey trench area - abandoned line outside		Data Set Identifier:	Count Time (min): 1
Type of Survey (α,β,χ,β-χ): 100% survey	Instrument Model: 2x2 gamma	Instrument No.:	Background Count Rate: 3784, 3978, 4013
Measurement Purpose:	Detector Model: ratemeter	Detector No.:	Net Count Action Level:
Activity Conversion Factor:	Set-Up Reference:	Control Reference:	

Grid Sketch (highlight primary gridlines) Record Activity in Net Counts per minute (CPM)



Area Above Action Level	Area Below Action Level
Average Activity Above Action Level (cpm)/(activity / 100 cm^2)	Average Net Activity Below Action Level (cpm)/(activity / 100 cm^2)
Average Activity (cpm)/(activity / 100 cm^2)	Blocks Represent Area (cm x cm)
Clean Up Goal	Action

Review

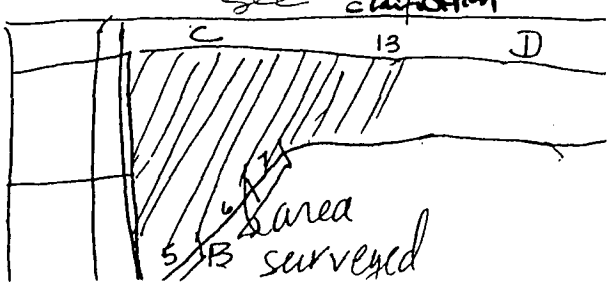
		Action
Completed By: Leslie Neudert	Date: 12/2/98	File
Review By: [signature]	Date: 12/6/99	File
Validation: WP CEA	Date: 1/6/99	Repair

Detector is inside ABS 3" pipe w/ rubber test plug bottom

source ✓ - ok

1 min background at side-trench 5252, 5405, 5439

standing water in center of trench



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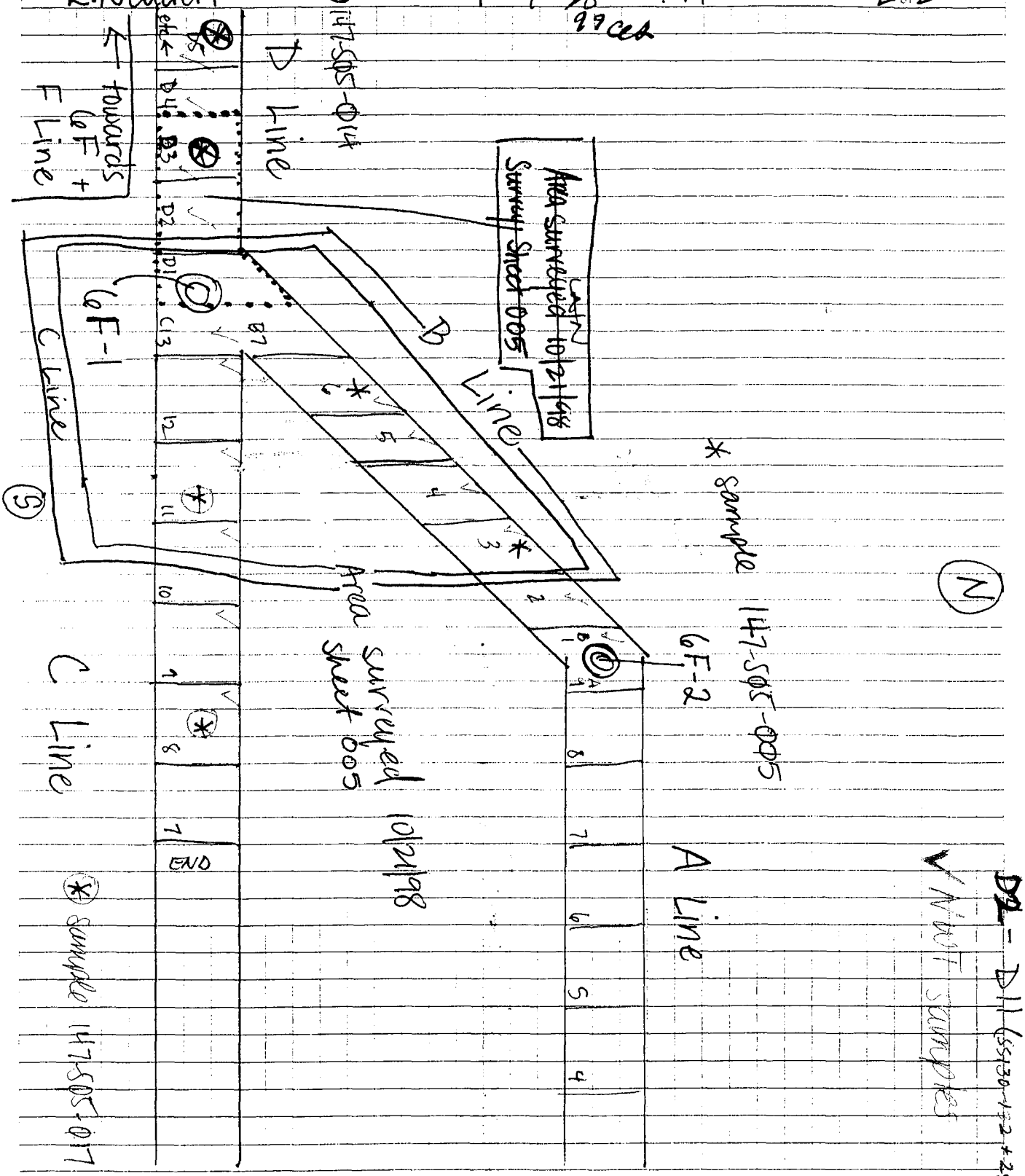
147305-005

Revised 3/9/99

Calculation Sheet

Attachment to Survey Sheet 005-A

Title	Location	Department
Outside Bldg 5 D, B, A + C Lines	Alameda	TEMI
Prepared by	**Date**	**Project Number**	**Page No.**
L. Neudert	1 7 98	147	2 of 2



Reviewed
Conrad Thornton 1/7/99

ATTACHMENT B

RESPONSE TO AGENCY COMMENTS ON THE REVIEW OF RADIATION SURVEYS AND SAMPLE DATA ASSOCIATED WITH THE STORM DRAIN AND INDUSTRIAL WASTE LINE REMOVALS AT SITES 5 AND 10 ALAMEDA POINT

RESPONSE TO AGENCY COMMENTS ON THE REVIEW OF RADIATION SURVEYS AND SAMPLE DATA ASSOCIATED WITH THE STORM DRAIN AND INDUSTRIAL WASTE LINE REMOVALS AT SITES 5 AND 10 ALAMEDA POINT

This document presents the U.S. Department of the Navy's (Navy) responses to comments from the regulatory agencies on radiation surveys and sample data associated with the storm drain and industrial waste line removals at sites 5 and 10, Alameda Point. Comments were received on the following information: (1) survey data of lateral pipes (performed by New World Technology [NWT]), received December 9, 1998; (2) field survey data forms and soil analysis reports, received December 15, 1998; (3) supplemental radiological survey data with cover letter, dated January 8, 1999; and (4) interim data letter report with survey data, dated January 25, 1999, from Edward Ho to George Kikugawa. The comments addressed below were received from the California Department of Toxic Substances Control (DTSC) and the California Department of Health Services (DHS).

Agency comments are presented in boldface type, and Navy responses are presented in normal type.

RESPONSE TO COMMENTS FROM THE DTSC

General Comments

1. **Comment:** **Our review indicates that the numerical goal of 5 pCi/g has been met for the following sample locations: Building 400 Industrial Waste Line (M-line); Building 5 and 5A, Storm Drain Line located in Grids A2 through 02; Building 5A, Storm Drain Line located in Grids B1 through B93; Outside Building 5A, Storm Drain Line identified as A-Line; Outside Building 5A, Storm Drain Line identified as B-Line. The numerical goal has not been met at the storm drain section outside Building 5A, Storm Drain Line identified as C-Line. It is undetermined if the storm drain section outside Building 5A, Storm Drain Line identified as D-Line meets the numerical goal. Our review also indicates that remediation is not necessary on lateral pipes located in Grid K and in the small parts paint shop and laterals connecting to the Building 5A Storm Drain Line located in Grids B1 through B93.**

We are concerned that information provided in the January 25, 1999 letter from Edward Ho contains references to documents which we consider to have been superseded by later comments and documents. We are also concerned about surveys conducted in standing water without adequate technical justification of the feasibility of such surveys. Until the technical justification is provided, DHS and DTSC will not accept survey data where standing water has interfered with the survey.

Response: The Navy believes that the removal action goals as set forth in the action memorandum have been achieved for all sections reported. The final report and risk assessment will demonstrate that the site meets the criteria established in the "Final Status Radiation Survey and Field Sampling Work Plan, Alameda Point, Alameda, California" (published in October 1998 by TtEMI and hereinafter referred to as the "workplan") for the survey unit as a whole, including the C-line and D-line data as part of a larger survey unit The criteria established are based on the statistical test prescribed by the workplan. The Navy also believes that the residual radioactivity in soil will be acceptable from a risk-based perspective. The responses to specific comments contain additional details on the sections identified as the C-line and the D-line.

All final analytical results have been less than 5 picoCurie per gram (pCi/g). Review of the field sample and scan data indicates that it is highly unlikely that significant areas exceeding 5 pCi/g have been missed. In all questionable cases where the detector response seemed higher than normal, NWT was routinely asked to excavate more soil. Soil confirmation samples were not collected by TtEMI until the soil met the definition of homogeneous described in the work plan.

A shallow layer of standing water does not interfere with the ability to detect elevated areas of radioactivity. The Navy's verification contractor, Tetra Tech EM Inc. (TtEMI), performed these surveys with a detector in a waterproof detector case. The case was weighted to assure direct contact and minimal source to detector distance for these surveys. The specific comments contain further details.

The Navy is committed to working with DHS and DTSC to assuage any remaining concerns regarding this site.

RESPONSE TO COMMENTS FROM THE DHS

General Comments

1. **Comment:** **<u>Building 400 Industrial Waste Line (M-line):</u>**

Laboratory results from the Navy and from DHS indicate that the numerical goal of 5 pCi/g for Radium-226 was met at those sample locations. The gamma scan data showed a range of 5500 cpm to 8900 cpm for the entire trench, which indicates that gamma radiation levels in the trench are relatively uniform and that the sampled locations would be representative of the entire branch.

Response: The comment is noted.

2. **Comment:** <u>Building 5 & 5A, Storm Drain Line located in Grids A2 through O2:</u>

Laboratory results from the Navy and from DHS indicate that the numerical goal of 5 pCi/g was met at those sample locations. The gamma scan data showed a range of 5200 cpm to 13,000 cpm for the entire trench, which does not indicate a relatively uniform radiation field. A sample was collected at the location of the highest scan value and a concentration below the numerical goal 5 pCi/g Radium-226 was measured, ensuring that the numerical goal was met. The surveys of lateral pipes located in Grid K and in the small parts paint shop indicate activities below the detection limit, and therefore the pipes do not require remediation.

Response: A higher count rate (13,000 cpm) does not always correlate (and the sample result maximum was 1.1 pCi/g.) with an exceeded numerical criteria. It is noted that a detector response of 13,000 counts per minute (cpm) and a count rate ratio of 2.5 to 1 does not exceed the numerical goal of 5 pCi/g nor the workplan criteria of a 3 to 1 count rate ratio for the definition of a hot spot requiring an additional sample. As explained in the following text, several factors account for the wide variation in detector response, and such a wide range of response is typical for this type of survey.

3. **Comment:** <u>Building 5A, Storm Drain Line located in Grids B1 through B93:</u>

Laboratory results from the Navy and from DHS indicate that the numerical goal of 5 pCi/g was met at those sample locations. The gamma scan data showed a range of 3700 cpm to 10,200 cpm for this entire trench section, which is an acceptable range and the sampled locations would be representative of the entire trench. The following surveys of lateral pipes indicate activities near or below the detection limit (Lateral pipes are identified by grid location, pipe size and direction from which it enters the main line): B-93, 6" pipe, North; B-16, 10" pipe, South; B-32, 8" pipe, South; B-36, 8" pipe, North; B-23, 4" pipe, North; B-62, 8" pipe, South; B-62, 8" pipe, South; B-65, 6" pipe, North; B-73, 6" pipe, North; B-73, 6" Pipe, South; and B-87, 6" pipe, South. Remediation is not necessary on these laterals.

Response: The comment is noted. The count rate ratio was 2.8 to 1 and the sample result maximum was 1.0 pCi/g.

4. **Comment:** <u>Outside Building 5A, Storm Drain Line identified as A-Line:</u>

Laboratory results from the Navy indicate that the numerical goal of 5 pCi/g was met at those sample locations. The TtEMI survey data could not be used since field staff was not required to report if the surveys were conducted with standing water in the trench. The technical feasibility of such a survey has not been demonstrated. However, NWT survey data was provided and a range of 5,000 cpm to 9,000 cpm was reported. (An elevated reading near a contaminated lateral pipe was not included due to the shine from the pipe.) The NWT survey data supports the conclusion that the

gamma radiation levels in the trench are relatively uniform and that the sampled locations would be representative of the entire trench.

Response: The comment is noted. During a meeting with the DHS representative, a study of the impact of standing water on background response was requested. TtEMI performed such a study for background soil concentrations using Microshield™ (MS) to calculate the detector response with and without standing water. It was determined that a layer of water would reduce the background detector response by about 1,040 cpm in an unimpacted trench, as shown by the MS calculations attached in Appendix A. In the worst-case situation, where the surveyor measures a background in a dry area then proceeds to survey in a wet area without understanding that the background has decreased, counts over a potential area of elevated activity would be reduced by 1,040 cpm. This is not enough of a difference to have affected any of the field sampling decisions that were made. Standing water does not interfere with the survey sensitivity. This is because the gap between the surface and the detector is composed of air or a thin layer of plastic (an insignificant attenuator of gamma radiation) so that the detector response was not reduced when scanning over an area of elevated activity. This was accomplished by enclosing the radiation detector in a dry case and weighting the detector to drag along the soil surface,.

5. **Comment:** **Outside Building 5A, Storm Drain Line identified as B-Line:**

Laboratory results from the Navy indicate that the numerical goal of 5 pCi/g was met at those sample locations. The TtEMI survey data could not be used since surveys were conducted with standing water in the trench. The technical feasibility of such a survey has not been demonstrated. However, NWT survey data was provided and a range of 3,530 cpm to 8,180 cpm was reported. The NWT survey data supports the conclusion that the gamma radiation levels in the trench are relatively uniform and that the sampled locations would be representative of the entire trench.

Response: The comment is noted. See the response to comment 4 for discussion of the technical feasibility of surveys with standing water.

6. **Comment:** **Outside Building 5A, Storm Drain Line identified as C-Line:**

The TtEMI survey data could not be used since it appears that the grid numbering is inaccurate. The field survey report indicates that Grid C5, C6 and C7 were surveyed, however, the storm drain was not excavated in these grids since this was outside the scope of work. In addition, Grid C12 and C13 should have been surveyed but weren't. This may also invalidate the samples collected since they may be identified as being from the wrong location. The NWT survey data was reviewed and the range was 6,380 cpm to 15,600 cpm, which does not indicate a uniform gamma radiation field. The information provided does not support the conclusion that the numerical goal was met.

Response: The sections C5, C6, and C7 were marked for identification on the ground by NWT and were surveyed by TtEMI for completeness. The Navy and TtEMI have reviewed the survey data and interviewed the survey personnel. We have concluded that the survey data and sampling locations are correct. The count rate ratio was only 2.4 to 1, and the highest sample result for this section was 1.9 pCi/g.

7. **Comment:** <u>Outside Building 5A, Storm Drain Line identified as D-Line:</u>

Laboratory results from the Navy and DHS indicate that the numerical goal of 5 pCi/g was met at those sample locations. The TtEMI survey data could not be used since surveys were concluded with standing water in the trench. However, NWT survey data was provided and a range of 6,240 cpm to 17,400 cpm was reported. This data does not indicate a uniform radiation field and unfortunately, the location with the highest scan value was not sampled. Therefore, it is undetermined if this storm drain section meets the numerical goal.

Response: The Navy considers this section complete. The maximum count rate ratio was 2.1 to 1 and the highest sample result was 0.7 pCi/g.

NWT survey data range is also less than a ratio of 3 to 1, which supports the TtEMI survey conclusions. The technical justification for the appropriateness of surveying in a shallow layer of standing water is set forth in above, in response to comment 4. No elevated locations above the criteria set forth in the work plan, even considering the impact of standing water reducing background, were identified in our review of the data. DHS also conducted sampling at this location and these results were in agreement with TtEMI results.

Comprehensive consideration of NWT, TtEMI, and DHS sample results supports the conclusion that the section satisfies the criteria of the action memorandum.

Specific Comments

1. **Comment:** **On Page 2 of this letter, the workplan is discussed, but current and very relevant information is not provided. For example, on December 10, 1998, DHS wrote that we could not concur with the work plan, and then provided detailed comments on January 14, 1999. (TtEMI only referenced the very outdated communications of September 23 and 24, 1998.) It is disconcerting to DHS that the project is in progress, and current information is not being provided to the Navy.**

Response: The December 10, 1999 DHS comment letter appeared to be based on concerns regarding the 6F to 5F segment, which had substantially different concerns than other line segments. By the time these comments were received, NWT had completed a substantial quantity of work in other sections. The responses were not intended to address all concerns regarding the 6F to 5F section. In fact, the revised work plan for the 6F to 5F section was only recently completed.

The interim data letter report was provided as a courtesy to DHS and DTSC at their request and was not a planned part of the project documentation. The purpose of the interim report was not to respond to comments but to summarize work already completed.

2. ***Comment:*** **On Page 4 of this letter, the second paragraph said that, "the CLEAN contractor collected a discrete sample at the hot spot". Using the CLEAN contractor's definition of hot spot, samples were not collected at hot spots in B-Line, C-Line, or D-Line. The data does not support the CLEAN contractor's conclusions. (For example, in Grid B-1 of the B-line, the ratio of high to low scan values is 3.3. Per the CLEAN contractor, this should have been sampled, but wasn't.) In addition, DHS also wrote comments on this on January 14, 1999, expressing concern that the methodology could not ensure that the numerical goal of 5 pCi/g would be met. And as discussed above, there is inadequate data on C-Line and D-Line.**

Response: The quotation has been taken out of context. The full quotation is as follows:

> "An area within a survey section was considered a hot spot if the highest count exceeded three times the lowest count. Hot spots were handled in one of two ways: (1) the CLEAN contractor requested the RAC to remove additional soil, or (2) the CLEAN contractor collected a discrete sample at the hot spot."

The basis for this approach was explained to DTSC and DHS representatives during a 2-day meeting attended by representatives from Naval Facilities Engineering Command, Engineering Field Activity West, Navy Radiological Affairs Support Office, and TtEMI on September 23 and 24, 1998. At that time, it was explained how the 3-to-1 ratio was selected. Based on the background data set, the detected response could vary as follows:

- A factor of 3 based on the range of activity in background soils
- A factor of at least 1.5 from surface to bottom of trench
- An additional factor based on proximity to detector to the wall and trench bottom would increase the count rate near the trench sidewalls.

Data discussed previously, for example in response to comment 2, show that specific count rates as high as 13,000 cpm do not result in an exceeded 5 pCi/g limit.

The Navy recognizes that the ratio was slightly exceeded for one very small area in the B-line. While this oversight should not impact the overall conclusion concerning the survey unit, the Navy will include an error adjustment factor for this location when demonstrating final compliance for the site using statistical

test methodology. The Navy would welcome any suggestions from DHS on this point.

3. **Comment:** **On Page 4 of this letter, scanning the trenches when standing water was present was discussed. Technical information is not provided to justify the feasibility of such surveys. In discussions with RASO staff, they agreed that surveys should be conducted without standing water. Therefore, DHS does not accept survey data where standing water has interfered with the survey.**

Response: Surveys were performed in standing water only if the water could not be eliminated from the trench with continuous pumping. The scanning technique was modified so that these surveys could be performed with the same or better sensitivity as surveys in dry trench sections. Standing water does not interfere with the survey because the gap between the surface and the detector is composed of air or a thin layer of plastic (an insignificant attenuator of gamma radiation). The basis for the adequacy of performing surveys in standing water are presented previously.

4. **Comment:** **Page 5: Neither the Navy nor the CLEAN contractor has provided data that the "laboratory demonstrated sufficient sensitivity and specificity for direct analysis." DHS found the data sufficient to determine if the numerical goal was met since the concentrations measured were far below the numerical goal and were within the range of DHS data. Comparisons to background are not substantiated by this method.**

Response: The Navy has provided additional performance evaluation sample results from the contract laboratory to DHS. The Navy has not taken credit for background in its preliminary data analysis. When background is used to determine net activity, it will be based on analysis of radium daughter activities of a sample that has been allowed to ingrow for an appropriate time period.

5. **Comment:** **Table 2: Data was reported for Grids B5, B6 and B7. The data sheet referenced did not contain scan data for these grids. (Data Sheet 19) Where did these numbers come from?**

Response: Refer to data sheets 005 and 005A. These have been edited for clarity and are enclosed with this report (revisions are shown in red). Refer to sheet 005A, which shows that grid B7 is also referred to as grid C-13 (Sheet 005) and D-1 (Sheet 013).

APPENDIX A

MICROSHIELD™ CALCULATIONS DESCRIPTION

APPENDIX A

MICROSHIELD™ CALCULATION DESCRIPTION

This appendix describes the way Microshield™ (MS) computer program may be used to study the effect of interposing of a layer of water between the soil and radiation detector on the radiation exposure rate (RER)

The MS program can be used to calculate the RER from a variety of specific radiation source geometries (Grove Engineering 1996). The use of MS is endorsed by the U.S. Environmental Protection Agency (EPA) "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) (EPA 1997) for calculating scan detection limits. MS allows for a calculation to consider variation in the following conditions:

- Source type (line, plan, volume)
- Source geometry (slab, cylinder, annulus)
- Source composition (soil, water, air, concrete)
- Radiation shield material (asphalt, air, water, soil, concrete)
- Immersion medium (air, water)

MS allows the user to choose radiation dose receptor position by specifying the x, y, and z coordinates of the receptor.

In MARSSIM (EPA 1997), EPA determines the minimum detectable concentration (MDC) of radioactivity in soil that can be identified by scanning measurement using a scintillation-type radiation detector. MS determines the RER from a specific source size, activity, concentration, and detector spacing. From the RER, the MDC can then be calculated in accordance with the specified methodology. In addition to the MDC, other radiation detection problems can be studied.

This approach described in MARSSIM (EPA 1997) can be modified to consider the effect of a shielding layer over the impacted soil. This layer may be asphalt paving material, sheet piling shoring (iron), water, or soil layers. The examples used by EPA can also be modified for additional factors

such as soil composition and soil moisture content. The set of standard factors used to model a specific condition are known as the "calculational basis."

The following calculational basis was used for this report:

Soil Composition	Sandy Loam Soil
Soil Moisture	29 percent
Soil Bulk Density	1.36, including moisture
Activity Concentration	1 picocurie per gram (pCi/g) of soil (dry) of natural radioactivity (uranium-238 and thorium-232)
Air Density	0.00122 gram per cubic meter

Additionally, an exposure rate to detector response factor is calculated for each energy group. The factors used are listed below in Table 1.

Each problem, defined as a shielding problem, may be investigated using MS by a single computation or by a series of computations. Each computation is referred to as a "case." To simulate a complex problem, the calculational results of several cases may be combined.

IMPACT OF WATER SHIELD ON SCAN MINIMUM DETECTABLE CONCENTRATION

A 29 percent moisture content was used in all calculations for soil, an approximation to the moist soil conditions experienced at Site 5. The soil composition used is presented as Attachment 1 to this appendix. Attachment 2 provides the attenuation properties tabulated by Microshield for this material composition. The calculated volume fractions of 0.395 for water and 0.605 for soil (of 1.6 grams per cubic centimeter [g/cm^3] density) used to calculate a bulk soil density of 1.36 g/cm^3. The soil concentration corresponding to 1 pCi/g of dry soil is 0.96 pCi/cm^3 of radium-226 and each series progeny, or 9.6×10^{-7} microcuries per cm^3 ($\mu Ci/cm^3$), which was then used for a source term as input to MS.

The response of the detector is calculated over the edge of a standard source soil 100 cm deep containing 1 pCi/g of uranium-238 (and a corresponding quantity of uranium-235 based on the natural ratio) in equilibrium with all progeny, and containing 1 pCi/g of thorium-232, also in equilibrium with

all progeny. Because contamination is assumed to occur on both sides of the detector symmetrically, the calculated detector response rates are doubled.

The calculation is repeated for a detector immersed in water, viewing the same source. The result of this calculation shows that the background count rate is approximately 1,040 cpm lower when a layer of water is interposed.

Each MS run's output consists of a case summary sheet describing the geometry of the source and receptor, the input source term, and the output. In the output data provided as Attachment 4, the last column (entitled "Exposure Rate mR/hr With Buildup") is the desired value for use in further calculations. Exposure rates in millirem per hour (mrem/hr) are multiplied by the conversion factors given in Table 1. These conversion factors provided are calculated explicitly for other radionuclides using the methodology described in "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (NUREG-1507) (Nuclear Regulatory Commission [NRC] 1998) from the energy group exposure rates provided in the MS output. MARSSIM (EPA 1997) and NUREG-1507 (NRC 1998) both explain the derivation of these response factors. The nominal detector response in cpm is the sum over all the energy groups of the product of energy group exposure rates and the energy group response conversion factors (see Table 6.3 of NUREG 1507).

The response of the detector is calculated over a soil volume representing the bottom of the trench as a source of naturally occurring radioactive material having the following dimensions; 100 cm deep, 300 cm wide, and 1000 cm long. The response is calculated for no shield (which corresponds to a scan for activity on the surface and for a 2-cm water layer, corresponding to a detector in contact with the source, covered with a layer of water). Table 2 summarizes the MS output.

All relevant MS data such as source activities and material composition files are provided in Attachment 3. MS run file names are listed and corresponding output files are attached as Attachment 4.

Water Shielded Source

The source size described above was used to calculate the detector response for the situation where a 2-cm water layer shields the source. A lower background, was calculated.

TABLE 1

ENERGY GROUP EXPOSURE TO COUNT RATE CONVERSION FACTORS FOR USE WITH MICROSHIELD™

Energy Group (MeV)	Counts per minute per microroentgen per hour (cpm/μR/hr)	Fraction of Total Response
0.015	2,200	3.36%
0.02	2,200	3.36%
0.03	5,160	7.87%
0.04	8,880	13.55%
0.05	11,800	18.01%
0.06	13,000	19.84%
0.08	12,000	18.31%
0.1	9840	15.02%
0.15	6040	9.22%
0.2	4230	6.46%
0.3	2520	3.85%
0.4	1700	2.59%
0.5	1270	1.94%
0.6	1010	1.54%
0.8	710	1.08%
1	540	0.82%
1.5	350	0.53%
2	259	0.40%
3	260	0.40%

TABLE 2

MICROSHIELD™ OUTPUT AND CALCULATED DETECTOR RESPONSE FOR SHIELDED (WATER) AND UNSHIELDED (DRY) CASE

Nuclide Series	Run File Name (*.MS5)	Exposure Rate mR/hr ($\times 10^{-3}$)	Response (cpm)[a,b]	Fraction of Total Response
Water - Shield Layer (2 cm)				
Uranium-235 + D	U5-W-SH	0.026	190	0.05
Uranium-238 + D	U8-W-SH	0.592	1,208	0.32
Radium-226 + D	RA-W-SH	0.454	688	0.18
Thorium-232 + D	TH-W-SH	1.6	1,694	0.45
Total	--		3,780	1
Detector Response (Water Shield) = 3,780 cpm				
Water - No Shield Layer				
Uranium-235 + D	U5-N-WA	0.034	256	0.05
Uranium-238 + D	URA-N-WA	0.732	1,536	0.032
Radium-226 + D	RAD-NO-W	0.685	968	0.20
Thorium-232 + D	TH-N-WA	1.89	2,060	0.43
Total	--		4,820	1
Detector Response (No Water Shield) = 4,820 cpm				

Notes:

cm	Centimeters
cpm	Counts per minute
a	Doubled to account for shielding calculation geometry
b	Values are rounded
MDC	Minimum detectable concentration
μR	Microroentgen

No Shield

The source size described above was used to calculate the detector response for the situation where no water layer shields the source. A higher background, was calculated.

Summary

The calculation result is presented for each run in Table 2. The result of this calculation shows that the effect of this shielding layer of water does not significantly impact background.

REFERENCES

Grove Engineering, 1996. Microshield, Version 5, Users Manual. Rockville, Md.

Nuclear Regulatory Commission. 1998. "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions." NUREG-1507. June.

U.S. Environmental Protection Agency. 1997. "Multi-Agency Radiation Survey and Site Investigation Manual." NUREG-1575/EPA-402-R-97-016. December.

ATTACHMENT 1

SOIL COMPOSITION

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
Custom Material : sandy loam moist-rev
sandy loam with moisture content-rev density
Density : 1.36 g/cm³
Average Atomic Number : 11.36 (based on average elements Z)
Effective Atomic Number : 10.15 (for Buildup Factor Interpolation)
Effective Atomic Weight : 12.9

	1 28.926%	2 63.854%	3 1.262%	4 4.561%	5 1.011%	6 0.385%
Hydrogen	2					
Oxygen	1	2	3	3	1	2
Aluminum				2		
Silicon		1				
Potassium					2	
Titanium						1
Iron			2			

ATTACHMENT 2

ATTENUATION PROPERTIES TABULATED BY MICROSHIELD™

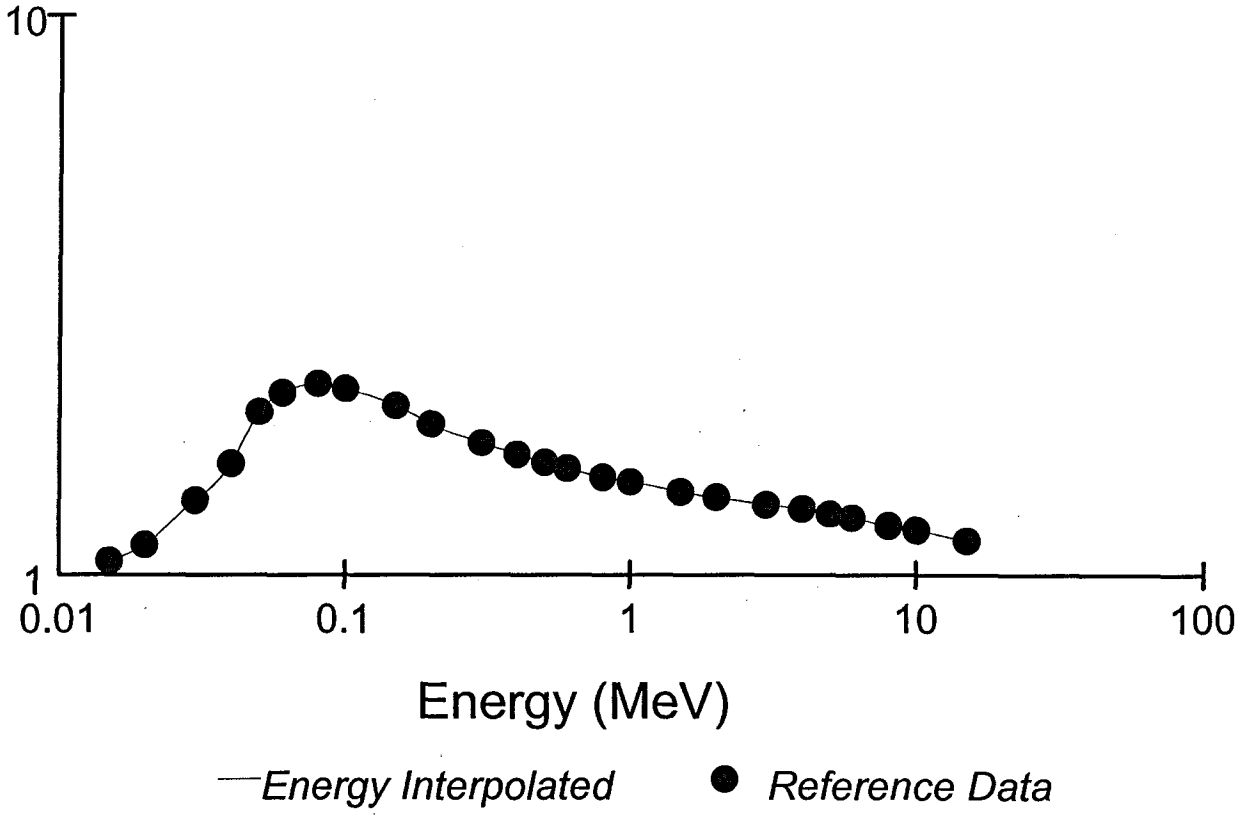
MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
Exposure Buildup Factors for sandy loam moist-rev

Energy	0.5 MFP	1.0 MFP	2.0 MFP	3.0 MFP	4.0 MFP	5.0 MFP	6.0 MFP	7.0 MFP
0.015	1.059e+00	1.077e+00	1.111e+00	1.138e+00	1.156e+00	1.171e+00	1.178e+00	1.191e+00
0.02	1.131e+00	1.183e+00	1.265e+00	1.328e+00	1.378e+00	1.416e+00	1.450e+00	1.483e+00
0.03	1.355e+00	1.541e+00	1.875e+00	2.117e+00	2.323e+00	2.500e+00	2.664e+00	2.813e+00
0.04	1.578e+00	2.091e+00	2.975e+00	3.678e+00	4.321e+00	4.930e+00	5.510e+00	6.072e+00
0.05	1.953e+00	2.796e+00	4.357e+00	5.895e+00	7.450e+00	8.992e+00	1.055e+01	1.214e+01
0.06	2.115e+00	3.248e+00	5.639e+00	8.222e+00	1.099e+01	1.392e+01	1.702e+01	2.033e+01
0.08	2.196e+00	3.638e+00	7.153e+00	1.143e+01	1.643e+01	2.213e+01	2.865e+01	3.589e+01
0.10	2.151e+00	3.632e+00	7.550e+00	1.269e+01	1.912e+01	2.673e+01	3.578e+01	4.630e+01
0.15	2.005e+00	3.337e+00	7.058e+00	1.236e+01	1.932e+01	2.809e+01	3.893e+01	5.199e+01
0.20	1.857e+00	3.027e+00	6.367e+00	1.111e+01	1.746e+01	2.550e+01	3.551e+01	4.760e+01
0.30	1.718e+00	2.690e+00	5.421e+00	9.260e+00	1.426e+01	2.061e+01	2.831e+01	3.752e+01
0.40	1.638e+00	2.496e+00	4.838e+00	8.050e+00	1.213e+01	1.717e+01	2.321e+01	3.024e+01
0.50	1.586e+00	2.358e+00	4.434e+00	7.178e+00	1.060e+01	1.474e+01	1.959e+01	2.512e+01
0.60	1.546e+00	2.262e+00	4.119e+00	6.543e+00	9.490e+00	1.299e+01	1.707e+01	2.171e+01
0.80	1.490e+00	2.114e+00	3.700e+00	5.664e+00	7.972e+00	1.063e+01	1.359e+01	1.697e+01
1.00	1.463e+00	2.027e+00	3.414e+00	5.069e+00	6.972e+00	9.108e+00	1.148e+01	1.409e+01
1.50	1.403e+00	1.881e+00	2.969e+00	4.192e+00	5.525e+00	6.978e+00	8.517e+00	1.015e+01
2.00	1.373e+00	1.801e+00	2.728e+00	3.717e+00	4.770e+00	5.879e+00	7.034e+00	8.236e+00
[illegible]	1.333e+00	1.696e+00	2.424e+00	3.162e+00	3.928e+00	4.714e+00	5.517e+00	6.339e+00
[illegible]	1.310e+00	1.616e+00	2.221e+00	2.814e+00	3.424e+00	4.037e+00	4.664e+00	5.294e+00
5.00	1.283e+00	1.546e+00	2.058e+00	2.561e+00	3.068e+00	3.571e+00	4.086e+00	4.603e+00
6.00	1.263e+00	1.506e+00	1.956e+00	2.398e+00	2.836e+00	3.276e+00	3.720e+00	4.167e+00
8.00	1.223e+00	1.423e+00	1.786e+00	2.128e+00	2.476e+00	2.826e+00	3.180e+00	3.531e+00
10.00	1.200e+00	1.363e+00	1.658e+00	1.948e+00	2.236e+00	2.526e+00	2.820e+00	3.107e+00
15.00	1.150e+00	1.266e+00	1.476e+00	1.676e+00	1.878e+00	2.086e+00	2.293e+00	2.500e+00

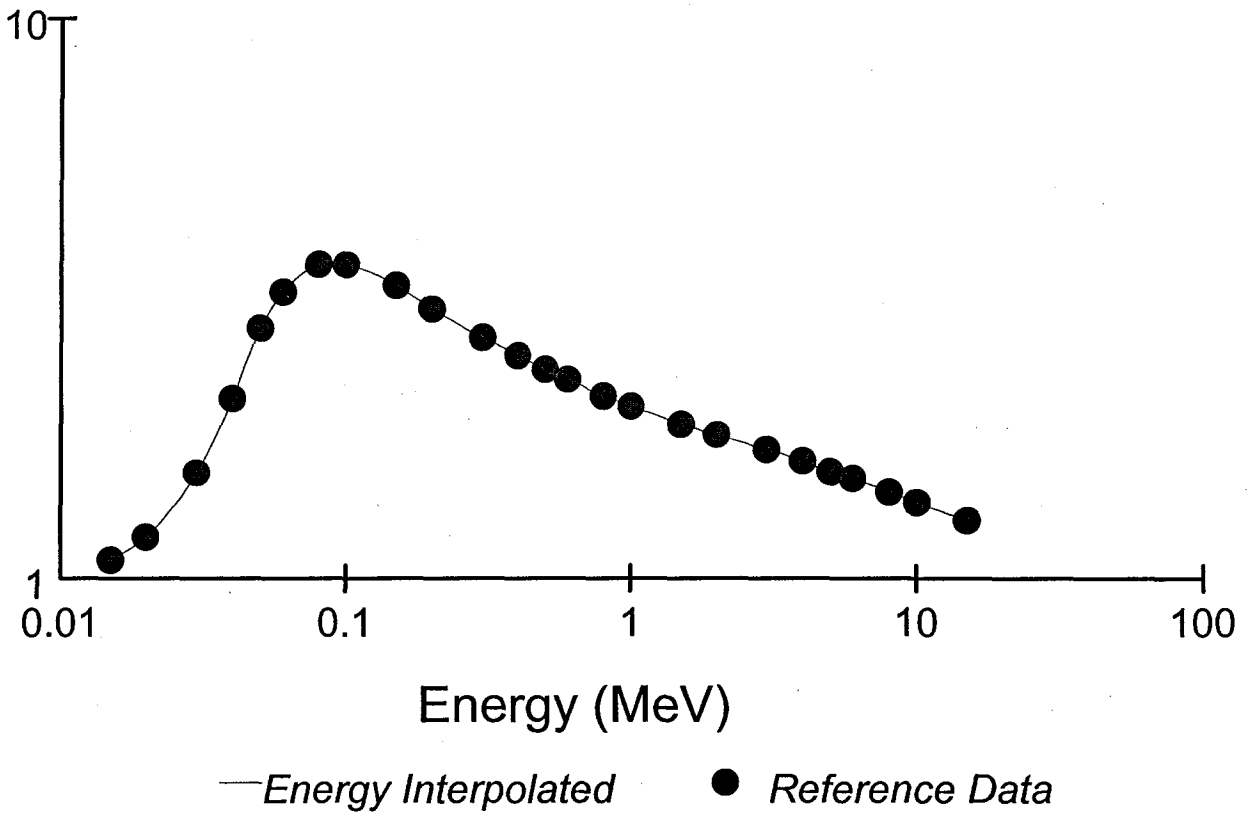
Energy	8.0 MFP	10.0 MFP	15.0 MFP	20.0 MFP	25.0 MFP	30.0 MFP	35.0 MFP	40.0 MFP
0.015	1.206e+00	1.220e+00	1.255e+00	1.274e+00	1.293e+00	1.310e+00	1.324e+00	1.337e+00
0.02	1.505e+00	1.556e+00	1.659e+00	1.725e+00	1.792e+00	1.839e+00	1.880e+00	1.914e+00
0.03	2.957e+00	3.210e+00	3.781e+00	4.263e+00	4.706e+00	5.107e+00	5.460e+00	5.732e+00
0.04	6.605e+00	7.661e+00	1.020e+01	1.265e+01	1.503e+01	1.735e+01	1.957e+01	2.168e+01
0.05	1.375e+01	1.714e+01	2.613e+01	3.600e+01	4.700e+01	5.891e+01	7.161e+01	8.487e+01
0.06	2.377e+01	3.141e+01	5.405e+01	8.233e+01	1.160e+02	1.554e+02	2.013e+02	2.566e+02
0.08	4.396e+01	6.267e+01	1.261e+02	2.169e+02	3.394e+02	4.993e+02	6.984e+02	9.427e+02
0.10	5.845e+01	8.789e+01	1.979e+02	3.721e+02	6.287e+02	9.864e+02	1.467e+03	2.091e+03
0.15	6.737e+01	1.068e+02	2.660e+02	5.427e+02	9.814e+02	1.628e+03	2.547e+03	3.807e+03
0.20	6.188e+01	9.850e+01	2.471e+02	5.054e+02	9.112e+02	1.506e+03	2.332e+03	3.432e+03
0.30	4.841e+01	7.548e+01	1.816e+02	3.557e+02	6.153e+02	9.721e+02	1.443e+03	2.018e+03
[illegible]	3.851e+01	5.845e+01	1.320e+02	2.456e+02	4.024e+02	6.092e+02	8.687e+02	1.184e+03
0.50	3.152e+01	4.671e+01	9.998e+01	1.762e+02	2.770e+02	4.031e+02	5.555e+02	7.328e+02

Energy	8.0 MFP	10.0 MFP	15.0 MFP	20.0 MFP	25.0 MFP	30.0 MFP	35.0 MFP	40.0 MFP
	2.689e+01	3.912e+01	8.051e+01	1.375e+02	2.111e+02	3.000e+02	4.046e+02	5.258e+02
0.80	2.066e+01	2.901e+01	5.541e+01	8.922e+01	1.301e+02	1.770e+02	2.304e+02	2.890e+02
1.00	1.690e+01	2.306e+01	4.182e+01	6.458e+01	9.091e+01	1.201e+02	1.532e+02	1.878e+02
1.50	1.187e+01	1.556e+01	2.580e+01	3.738e+01	5.008e+01	6.361e+01	7.799e+01	9.298e+01
2.00	9.474e+00	1.202e+01	1.899e+01	2.648e+01	3.430e+01	4.259e+01	5.106e+01	5.971e+01
3.00	7.179e+00	8.892e+00	1.333e+01	1.800e+01	2.284e+01	2.779e+01	3.280e+01	3.781e+01
4.00	5.938e+00	7.227e+00	1.054e+01	1.391e+01	1.733e+01	2.084e+01	2.435e+01	2.791e+01
5.00	5.120e+00	6.159e+00	8.796e+00	1.149e+01	1.413e+01	1.677e+01	1.923e+01	2.151e+01
6.00	4.619e+00	5.514e+00	7.797e+00	1.013e+01	1.244e+01	1.472e+01	1.722e+01	1.998e+01
8.00	3.879e+00	4.589e+00	6.364e+00	8.157e+00	9.952e+00	1.175e+01	1.366e+01	1.553e+01
10.00	3.399e+00	3.987e+00	5.482e+00	6.992e+00	8.536e+00	1.007e+01	1.165e+01	1.337e+01
15.00	2.714e+00	3.143e+00	4.248e+00	5.393e+00	6.570e+00	7.767e+00	8.932e+00	9.997e+00

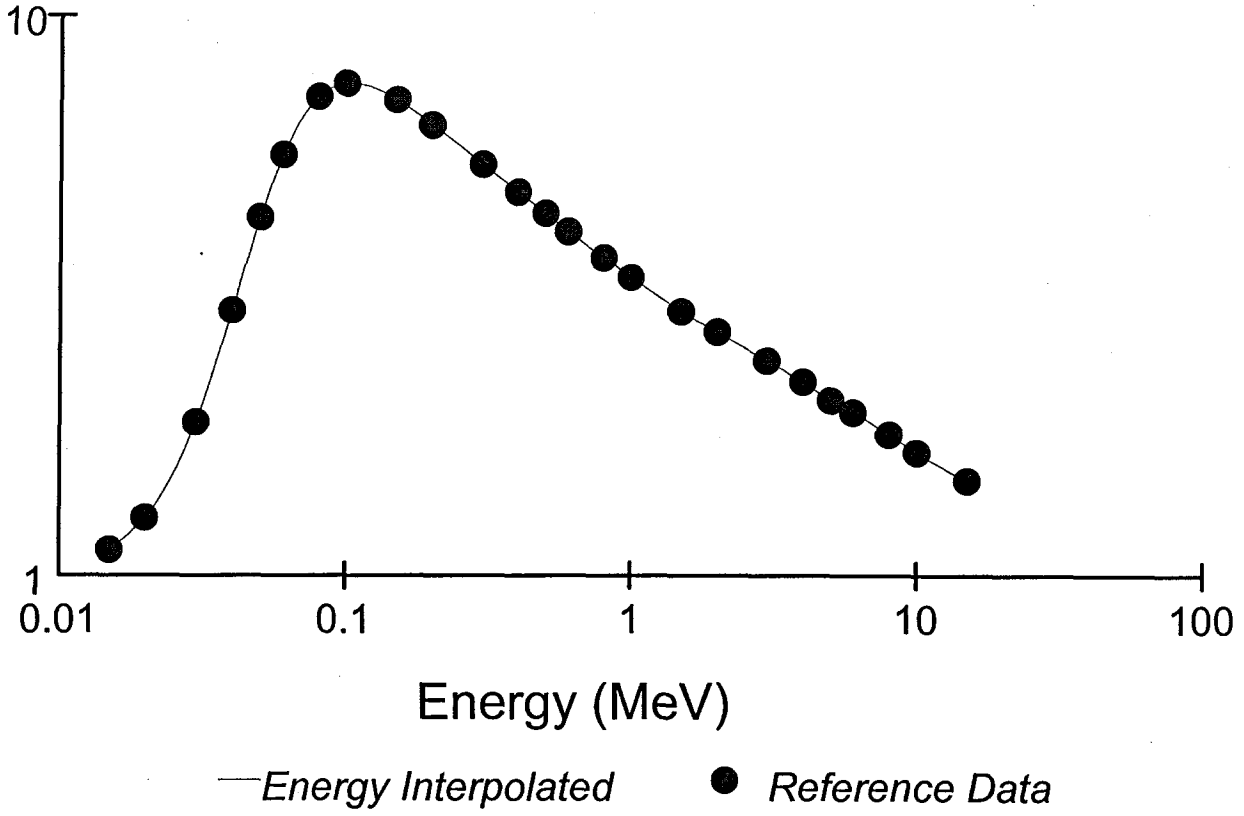
Buildup Factors at 0.5 MFP for sandy loam moist-rev



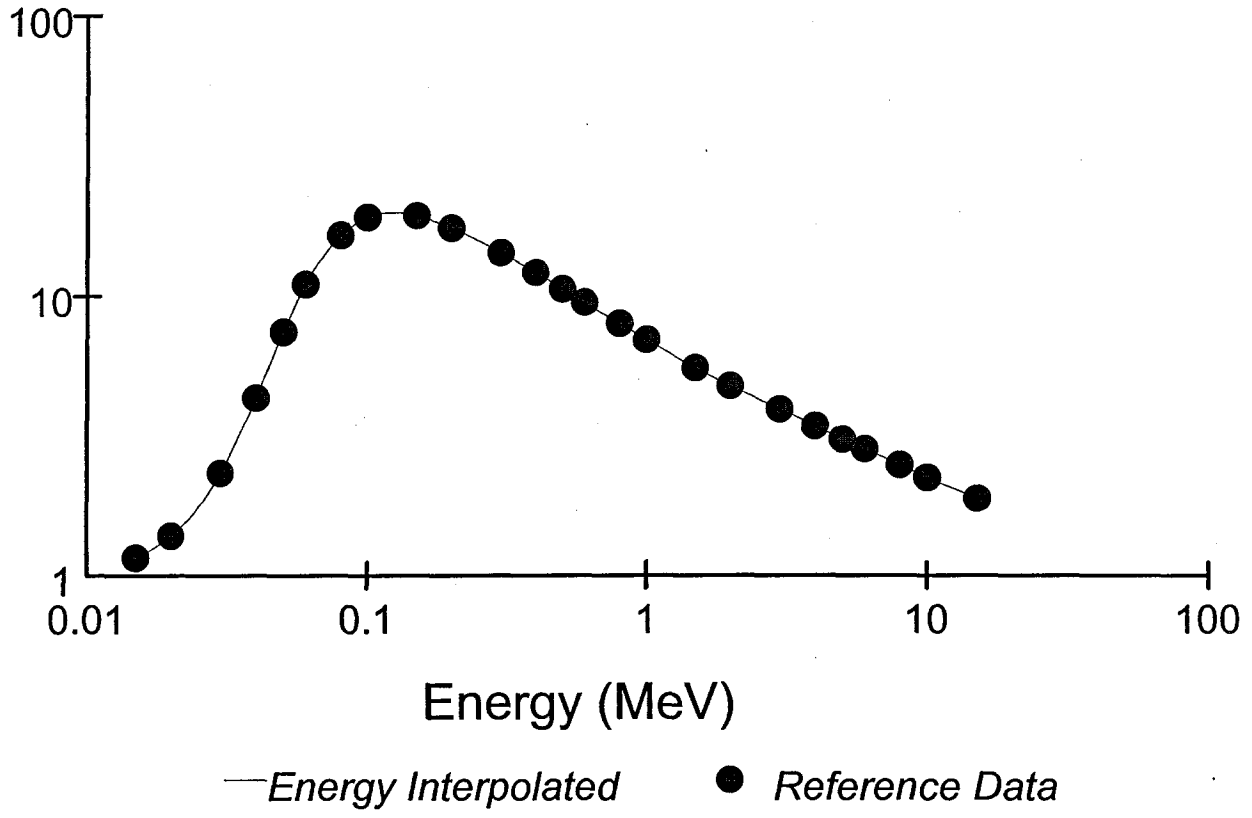
Buildup Factors at 1.0 MFP for sandy loam moist-rev



Buildup Factors at 2.0 MFP for sandy loam moist-rev



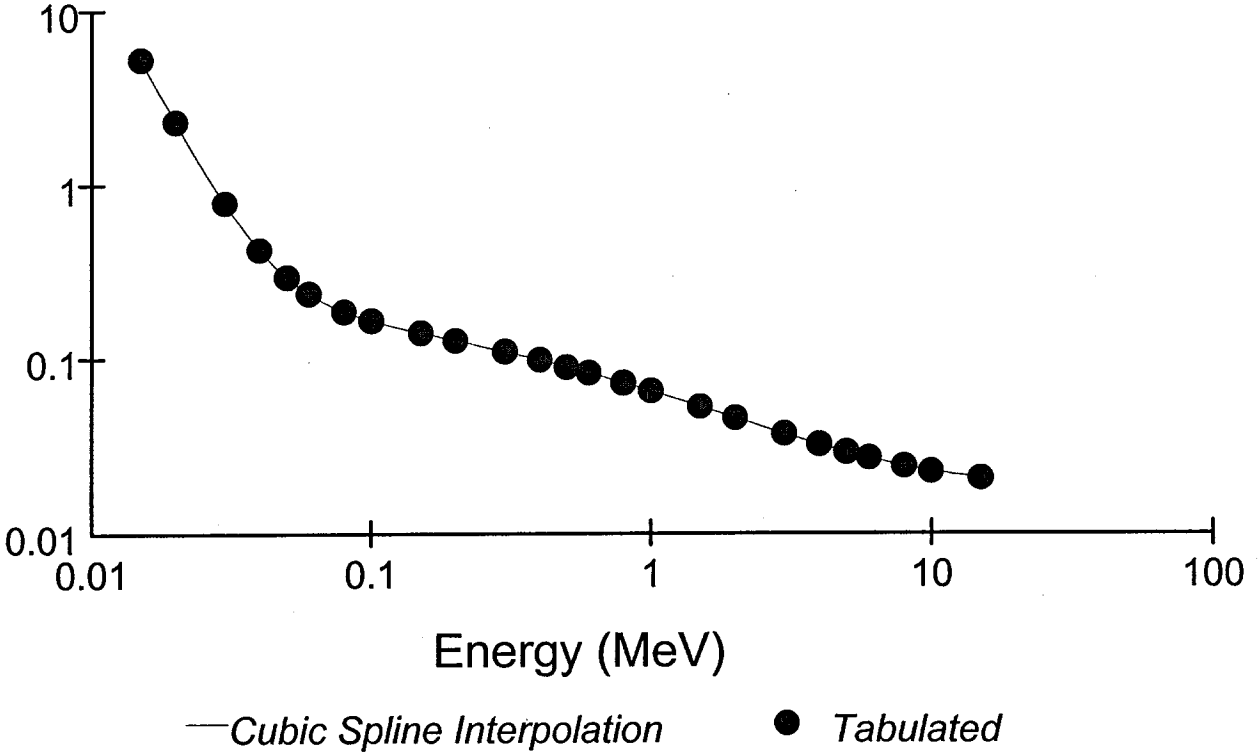
Buildup Factors at 4.0 MFP for sandy loam moist-rev



MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
Attenuation Coefficients for sandy loam moist-rev
(without coherent scattering)
Density: 1.36000 g/cm³

Energy (MeV)	Mass Atten Coeff (cm^2/gm)	Linear Atten Coeff (1/cm)	Half Thickness (cm)
0.015	5.27554	7.174741	.097
0.020	2.30259	3.131516	.221
0.030	.78502	1.067624	.649
0.040	.42165	.573447	1.209
0.050	.29300	.398483	1.739
0.060	.23531	.320024	2.166
0.080	.18615	.253161	2.738
0.100	.16489	.224252	3.091
0.150	.14027	.190761	3.634
0.200	.12668	.172283	4.023
0.300	.10939	.148773	4.659
0.400	.09777	.132962	5.213
0.500	.08920	.121311	5.714
0.600	.08249	.112190	6.178
800	.07244	.098522	7.035
.000	.06512	.088561	7.827
1.500	.05302	.072114	9.612
2.000	.04565	.062086	11.164
3.000	.03703	.050363	13.763
4.000	.03214	.043712	15.857
5.000	.02899	.039432	17.578
6.000	.02684	.036508	18.986
8.000	.02414	.032824	21.117
10.000	.02256	.030675	22.596
15.000	.02063	.028063	24.699

Mass Attenuation Coefficients (cm^2/g) for sandy loam moist-rev



ATTACHMENT 3

SOURCE ACTIVITY FILE

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
External Source File: URAN1PCI.MX5
Title: uranium 238 up to radium

Nuclide	µCi/cm³	Bq/cm³
Bi-210		
Bi-214		
Pa-234	9.6000e-007	3.5520e-002
Pa-234m	9.6000e-007	3.5520e-002
Pb-210		
Pb-214		
Po-210		
Po-214		
Po-218		
Ra-226		
Rn-222		
Th-230	9.6000e-007	3.5520e-002
Th-234	9.6000e-007	3.5520e-002
U-234	9.6000e-007	3.5520e-002
U-238	8.5000e-007	3.1450e-002

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
External Source File: U235-1.MX5
Title: u235 decayed based on u238/u235 ratio

Nuclide	µCi/cm³	Bq/cm³
Ac-227	1.7000e-007	6.2900e-003
Bi-211	1.7000e-007	6.2900e-003
Fr-223	2.0629e-009	7.6328e-005
Pa-231	1.7000e-007	6.2900e-003
Pb-211	1.7000e-007	6.2900e-003
Po-211	4.0810e-010	1.5100e-005
Po-215	1.7000e-007	6.2900e-003
Ra-223	1.7000e-007	6.2900e-003
Rn-219	1.7000e-007	6.2900e-003
Th-227	1.7000e-007	6.2900e-003
Th-231	1.7000e-007	6.2900e-003
Tl-207	1.7000e-007	6.2900e-003
U-235	1.6998e-007	6.2894e-003

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
External Source File: U235-1.MX5
Title: u235 decayed based on u238/u235 ratio

Nuclide	µCi/cm³	Bq/cm³
Ac-227	1.7000e-007	6.2900e-003
Bi-211	1.7000e-007	6.2900e-003
Fr-223	2.0629e-009	7.6328e-005
Pa-231	1.7000e-007	6.2900e-003
Pb-211	1.7000e-007	6.2900e-003
Po-211	4.0810e-010	1.5100e-005
Po-215	1.7000e-007	6.2900e-003
Ra-223	1.7000e-007	6.2900e-003
Rn-219	1.7000e-007	6.2900e-003
Th-227	1.7000e-007	6.2900e-003
Th-231	1.7000e-007	6.2900e-003
Tl-207	1.7000e-007	6.2900e-003
U-235	1.6998e-007	6.2894e-003

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
External Source File: THOR1.MX5
Title: th232 source

Nuclide	µCi/cm³	Bq/cm³
Ac-228	9.6000e-007	3.5520e-002
Bi-212	9.6000e-007	3.5520e-002
Pb-212	9.6000e-007	3.5520e-002
Po-212	9.6000e-007	3.5520e-002
Po-216	9.6000e-007	3.5520e-002
Ra-224	9.6000e-007	3.5520e-002
Ra-228	9.6000e-007	3.5520e-002
Rn-220	9.6000e-007	3.5520e-002
Th-228	9.6000e-007	3.5520e-002
Th-232	9.6000e-007	3.5520e-002
Tl-208	9.6000e-007	3.5520e-002

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.
External Source File: 1PC-SOIL.MX5
Title: soil volume 1 pci/gram from .85 pci/g radium 226

Nuclide	µCi/cm³	Bq/cm³
Bi-210	9.6000e-007	3.5520e-002
Bi-214	9.6000e-007	3.5520e-002
Pb-210	9.6000e-007	3.5520e-002
Pb-214	9.6000e-007	3.5520e-002
Po-210	9.6000e-007	3.5520e-002
Po-214	9.6000e-007	3.5520e-002
Po-218	9.6000e-007	3.5520e-002
Ra-226	9.6000e-007	3.5520e-002
Rn-222	8.5000e-007	3.1450e-002

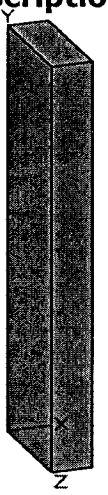
ATTACHMENT 4
MICROSHIELD™ OUTPUTS

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOC File : RA-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:35:34 PM
Duration : 00:00:11

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry 2CM shield RA+d contribution
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.6
Shield 1	2.0 cm	Water	1
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Bi-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Bi-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-218	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-226	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Rn-222	2.5500e-005	9.4350e+005	8.5000e-007	3.1450e-002

Buildup
The material reference is : Source

Integration Parameters

DOS File : RA-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:35:34 PM
Duration : 00:00:11

X Direction	10
Y Direction	20
Z Direction	20

Results

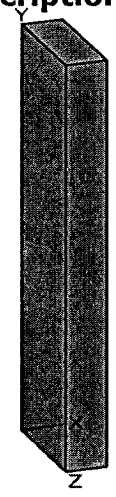
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.494e+04	1.661e-05	6.990e-05	4.424e-08	1.862e-07
0.08	2.457e+05	2.241e-04	1.451e-03	3.546e-07	2.296e-06
0.1	1.446e+03	1.954e-06	1.329e-05	2.989e-09	2.034e-08
0.2	1.148e+05	4.593e-04	2.547e-03	8.106e-07	4.495e-06
0.3	2.199e+05	1.647e-03	7.487e-03	3.124e-06	1.420e-05
0.4	4.078e+05	4.805e-03	1.894e-02	9.362e-06	3.691e-05
0.5	1.894e+04	3.184e-04	1.125e-03	6.250e-07	2.209e-06
0.6	5.138e+05	1.157e-02	3.755e-02	2.259e-05	7.329e-05
0.8	1.007e+05	3.619e-03	1.033e-02	6.884e-06	1.964e-05
1.0	3.336e+05	1.730e-02	4.513e-02	3.189e-05	8.318e-05
1.5	2.029e+05	2.064e-02	4.640e-02	3.473e-05	7.807e-05
2.0	2.852e+05	4.679e-02	9.644e-02	7.235e-05	1.491e-04
ALS:	2.500e+06	1.074e-01	2.675e-01	1.828e-04	4.636e-04

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : U5-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:33:07 PM
Duration : 00:00:15

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry 2CM shield u235+d contribution
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.36
Shield 1	2.0 cm	Water	1
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-227	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Bi-211	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Fr-223	6.1887e-008	2.2898e+003	2.0629e-009	7.6328e-005
Pa-231	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Pb-211	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Po-211	1.2243e-008	4.5299e+002	4.0810e-010	1.5100e-005
Po-215	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Ra-223	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Rn-219	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Th-227	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Th-231	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Tl-207	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
U-235	5.0995e-006	1.8868e+005	1.6998e-007	6.2894e-003

DOS File : U5-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:33:07 PM
Duration : 00:00:15

Buildup
The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

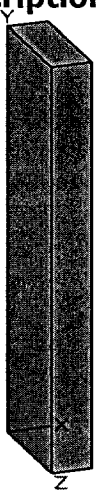
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	4.233e+02	6.049e-14	7.523e-14	5.188e-15	6.452e-15
0.02	1.055e+03	3.786e-10	5.522e-10	1.312e-11	1.913e-11
0.03	4.539e+04	1.659e-06	3.434e-06	1.645e-08	3.403e-08
0.04	7.152e+02	1.204e-07	3.584e-07	5.325e-10	1.585e-09
0.05	1.736e+04	6.342e-06	2.620e-05	1.689e-08	6.978e-08
0.06	1.358e+03	8.054e-07	4.167e-06	1.600e-09	8.276e-09
0.08	1.185e+05	1.284e-04	8.246e-04	2.032e-07	1.305e-06
0.1	5.331e+04	8.539e-05	5.773e-04	1.306e-07	8.832e-07
15	5.055e+04	1.538e-04	9.636e-04	2.532e-07	1.587e-06
.2	1.462e+05	6.919e-04	3.822e-03	1.221e-06	6.745e-06
0.3	1.138e+05	1.007e-03	4.562e-03	1.910e-06	8.654e-06
0.4	4.884e+04	6.793e-04	2.671e-03	1.324e-06	5.205e-06
0.5	9.245e+02	1.834e-05	6.465e-05	3.599e-08	1.269e-07
0.6	2.437e+00	6.476e-08	2.096e-07	1.264e-10	4.091e-10
0.8	7.578e+03	3.211e-04	9.143e-04	6.107e-07	1.739e-06
TOTALS:	6.060e+05	3.094e-03	1.443e-02	5.724e-06	2.636e-05

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : U8-W-SH.MS5
Run Date : May 13, 1999
Run Time: 3:34:27 PM
Duration : 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry 2CM shield u238+d contribution
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.36
Shield 1	2.0 cm	Water	1
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Bi-210				
Bi-214				
Pa-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pa-234m	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-210				
Pb-214				
Po-210				
Po-214				
Po-218				
Ra-226				
Rn-222				
Th-230	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002

DOS File : U8-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:34:27 PM
Duration : 00:00:14

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
U-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
U-238	2.5500e-005	9.4350e+005	8.5000e-007	3.1450e-002

Buildup
The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

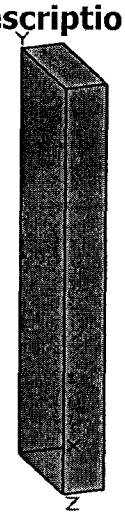
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.304e+03	2.196e-07	6.536e-07	9.712e-10	2.891e-09
0.05	1.257e+03	4.592e-07	1.897e-06	1.223e-09	5.053e-09
0.06	8.279e+04	4.909e-05	2.540e-04	9.751e-08	5.044e-07
0.08	2.817e+03	3.054e-06	1.961e-05	4.832e-09	3.103e-08
1	6.830e+05	1.094e-03	7.396e-03	1.674e-06	1.131e-05
15	3.367e+05	1.024e-03	6.419e-03	1.687e-06	1.057e-05
0.2	2.248e+05	1.063e-03	5.874e-03	1.877e-06	1.037e-05
0.3	7.739e+04	6.846e-04	3.102e-03	1.299e-06	5.884e-06
0.4	6.543e+04	9.101e-04	3.579e-03	1.773e-06	6.974e-06
0.5	9.717e+04	1.927e-03	6.795e-03	3.783e-06	1.334e-05
0.6	3.970e+05	1.055e-02	3.415e-02	2.059e-05	6.666e-05
0.8	8.368e+05	3.546e-02	1.010e-01	6.744e-05	1.920e-04
1.0	6.657e+05	4.069e-02	1.059e-01	7.500e-05	1.953e-04
1.5	1.491e+05	1.787e-02	4.010e-02	3.007e-05	6.747e-05
2.0	1.924e+04	3.715e-03	7.643e-03	5.745e-06	1.182e-05
TOTALS:	3.641e+06	1.150e-01	3.222e-01	2.110e-04	5.922e-04

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : TH-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:36:28 PM
Duration : 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry 2CM shield TH+d contribution
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.36
Shield 1	2.0 cm	Water	1
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Bi-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-216	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-224	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Rn-220	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-232	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Tl-208	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002

Buildup
The material reference is : Source

DOS File : TH-W-SH.MS5
Run Date: May 13, 1999
Run Time: 3:36:28 PM
Duration : 00:00:14

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.090e+04	1.834e-06	5.460e-06	8.113e-09	2.415e-08
0.06	7.367e+03	4.369e-06	2.260e-05	8.677e-09	4.489e-08
0.08	5.076e+05	5.502e-04	3.533e-03	8.707e-07	5.590e-06
0.1	7.561e+04	1.211e-04	8.188e-04	1.853e-07	1.253e-06
0.15	4.479e+04	1.362e-04	8.539e-04	2.243e-07	1.406e-06
0.2	5.821e+05	2.754e-03	1.521e-02	4.861e-06	2.685e-05
0.3	3.296e+05	2.916e-03	1.321e-02	5.531e-06	2.506e-05
0.4	2.521e+04	3.507e-04	1.379e-03	6.833e-07	2.687e-06
0.5	2.950e+05	5.851e-03	2.063e-02	1.148e-05	4.049e-05
0.6	9.139e+05	2.428e-02	7.860e-02	4.740e-05	1.534e-04
0.8	4.396e+05	1.862e-02	5.303e-02	3.543e-05	1.009e-04
1.0	6.252e+05	3.821e-02	9.949e-02	7.044e-05	1.834e-04
1.5	1.429e+05	1.713e-02	3.843e-02	2.882e-05	6.466e-05
2.0	3.234e+03	6.245e-04	1.285e-03	9.657e-07	1.987e-06
3.0	1.063e+06	3.984e-01	7.336e-01	5.405e-04	9.952e-04
TOTALS:	5.066e+06	5.099e-01	1.060e+00	7.474e-04	1.603e-03

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : U5-N-WA.MS5
Run Date : May 13, 1999
Run Time : 3:39:36 PM
Duration : 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry no shield u235+d contribution
Geometry: 13 - Rectangular Volume

Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.36
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-227	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Bi-211	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Fr-223	6.1887e-008	2.2898e+003	2.0629e-009	7.6328e-005
Pa-231	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Pb-211	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Po-211	1.2243e-008	4.5299e+002	4.0810e-010	1.5100e-005
Po-215	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Ra-223	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Rn-219	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Th-227	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Th-231	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
Tl-207	5.1000e-006	1.8870e+005	1.7000e-007	6.2900e-003
U-235	5.0995e-006	1.8868e+005	1.6998e-007	6.2894e-003

Buildup

DOS File : U5-N-WA.MS5
Run Date: May 13, 1999
Run Time: 3:39:36 PM
Duration : 00:00:14

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	4.233e+02	1.782e-12	2.177e-12	1.529e-13	1.867e-13
0.02	1.055e+03	2.114e-09	2.975e-09	7.322e-11	1.031e-10
0.03	4.539e+04	4.426e-06	8.343e-06	4.387e-08	8.269e-08
0.04	7.152e+02	2.773e-07	6.883e-07	1.226e-09	3.044e-09
0.05	1.736e+04	1.390e-05	4.506e-05	3.703e-08	1.200e-07
0.06	1.358e+03	1.720e-06	6.616e-06	3.415e-09	1.314e-08
0.08	1.185e+05	2.646e-04	1.203e-03	4.188e-07	1.903e-06
0.1	5.331e+04	1.712e-04	8.083e-04	2.620e-07	1.237e-06
0.15	5.055e+04	2.925e-04	1.295e-03	4.817e-07	2.132e-06
.2	1.462e+05	1.264e-03	5.035e-03	2.230e-06	8.887e-06
.3	1.138e+05	1.732e-03	5.896e-03	3.286e-06	1.118e-05
0.4	4.884e+04	1.119e-03	3.408e-03	2.180e-06	6.641e-06
0.5	9.245e+02	2.919e-05	8.171e-05	5.730e-08	1.604e-07
0.6	2.437e+00	1.003e-07	2.629e-07	1.958e-10	5.131e-10
0.8	7.578e+03	4.766e-04	1.132e-03	9.066e-07	2.153e-06
TOTALS:	6.060e+05	5.369e-03	1.892e-02	9.908e-06	3.452e-05

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : URA-N-WA.MS5
Run Date : May 13, 1999
Run Time : 3:47:02 PM
Duration : 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry no shield u-238+d contribution
Geometry: 13 - Rectangular Volume

Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	sandy loam moist-rev	1.36
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Bi-210				
Bi-214				
Pa-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pa-234m	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-210				
Pb-214				
Po-210				
Po-214				
Po-218				
Ra-226				
Rn-222				
Th-230	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
U-234	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002

DOS File : URA-N-WA.MS5
Run Date: May 13, 1999
Run Time: 3:47:02 PM
Duration : 00:00:14

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
U-238	2.5500e-005	9.4350e+005	8.5000e-007	3.1450e-002

Buildup
The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.304e+03	5.057e-07	1.255e-06	2.236e-09	5.552e-09
0.05	1.257e+03	1.007e-06	3.263e-06	2.682e-09	8.693e-09
0.06	8.279e+04	1.048e-04	4.032e-04	2.082e-07	8.009e-07
0.08	2.817e+03	6.292e-06	2.859e-05	9.957e-09	4.525e-08
0.1	6.830e+05	2.194e-03	1.036e-02	3.356e-06	1.584e-05
15	3.367e+05	1.948e-03	8.624e-03	3.208e-06	1.420e-05
.2	2.248e+05	1.942e-03	7.739e-03	3.428e-06	1.366e-05
0.3	7.739e+04	1.178e-03	4.009e-03	2.234e-06	7.604e-06
0.4	6.543e+04	1.499e-03	4.566e-03	2.920e-06	8.897e-06
0.5	9.717e+04	3.068e-03	8.589e-03	6.023e-06	1.686e-05
0.6	3.970e+05	1.634e-02	4.283e-02	3.190e-05	8.359e-05
0.8	8.368e+05	5.263e-02	1.250e-01	1.001e-04	2.377e-04
1.0	6.657e+05	5.847e-02	1.297e-01	1.078e-04	2.391e-04
1.5	1.491e+05	2.427e-02	4.806e-02	4.083e-05	8.087e-05
2.0	1.924e+04	4.862e-03	9.013e-03	7.518e-06	1.394e-05
TOTALS:	3.641e+06	1.685e-01	3.989e-01	3.095e-04	7.332e-04

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : RAD-NO-W.MS5
Run Date : May 13, 1999
Run Time : 3:50:23 PM
Duration : 00:00:11

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry no shield radium-226+d contribution
Geometry: 13 - Rectangular Volume

Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	103 cm	0 cm	150 cm
	3 ft 4.6 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	Sandy loam moist-rev	1.36
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Bi-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Bi-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-210	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-214	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-218	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-226	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Rn-222	2.5500e-005	9.4350e+005	8.5000e-007	3.1450e-002

Buildup
The material reference is : Source

Integration Parameters

X Direction	10

DOS File : RAD-NO-W.MS5
Run Date: May 13, 1999
Run Time: 3:50:23 PM
Duration : 00:00:11

Y Direction	20
Z Direction	20

Results

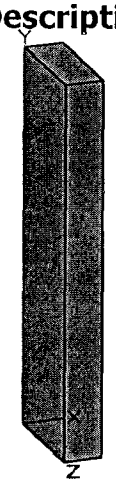
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.494e+04	4.804e-05	1.502e-04	1.280e-07	4.001e-07
0.08	2.457e+05	5.838e-04	2.557e-03	9.239e-07	4.047e-06
0.1	1.446e+03	4.915e-06	2.242e-05	7.519e-09	3.430e-08
0.2	1.148e+05	1.039e-03	4.057e-03	1.833e-06	7.161e-06
0.3	2.199e+05	3.490e-03	1.173e-02	6.620e-06	2.226e-05
0.4	4.078e+05	9.717e-03	2.936e-02	1.893e-05	5.720e-05
0.5	1.894e+04	6.213e-04	1.729e-03	1.220e-06	3.395e-06
0.6	5.138e+05	2.194e-02	5.730e-02	4.283e-05	1.118e-04
0.8	1.007e+05	6.565e-03	1.557e-02	1.249e-05	2.962e-05
1.0	3.336e+05	3.036e-02	6.738e-02	5.596e-05	1.242e-04
1.5	2.029e+05	3.420e-02	6.789e-02	5.755e-05	1.142e-04
2.0	2.852e+05	7.469e-02	1.389e-01	1.155e-04	2.147e-04
TOTALS:	2.500e+06	1.833e-01	3.966e-01	3.140e-04	6.891e-04

MicroShield v5.03 (5.03-00232)
Tetra Tech EM Inc.

Page : 1
DOS File : TH-N-WA.MS5
Run Date: May 13, 1999
Run Time: 3:51:43 PM
Duration : 00:00:14

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: water geometry
Description: water geometry no shield th+d contribution
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	100.0 cm	3 ft 3.4 in
Width	300.0 cm	9 ft 10.1 in
Height	1.0e+3 cm	32 ft 9.7 in

Dose Points

	X	Y	Z
# 1	110 cm	0 cm	150 cm
	3 ft 7.3 in	0.0 in	4 ft 11.1 in

Shields

Shield Name	Dimension	Material	Density
Source	3.00e+07 cm³	Sandy loam moist-rev	1.36
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ac-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Bi-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Pb-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-212	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Po-216	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-224	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Ra-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Rn-220	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-228	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Th-232	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002
Tl-208	2.8800e-005	1.0656e+006	9.6000e-007	3.5520e-002

Buildup
The material reference is : Source

DOS File : TH-N-WA.MS5
Run Date: May 13, 1999
Run Time: 3:51:43 PM
Duration : 00:00:14

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.090e+04	4.224e-06	1.049e-05	1.868e-08	4.638e-08
0.06	7.367e+03	9.326e-06	3.588e-05	1.852e-08	7.127e-08
0.08	5.076e+05	1.134e-03	5.152e-03	1.794e-06	8.152e-06
0.1	7.561e+04	2.429e-04	1.147e-03	3.716e-07	1.754e-06
0.15	4.479e+04	2.592e-04	1.147e-03	4.268e-07	1.889e-06
0.2	5.821e+05	5.030e-03	2.004e-02	8.877e-06	3.537e-05
0.3	3.296e+05	5.016e-03	1.707e-02	9.515e-06	3.239e-05
0.4	2.521e+04	5.775e-04	1.759e-03	1.125e-06	3.428e-06
0.5	2.950e+05	9.314e-03	2.607e-02	1.828e-05	5.118e-05
0.6	9.139e+05	3.762e-02	9.858e-02	7.342e-05	1.924e-04
0.8	4.396e+05	2.765e-02	6.564e-02	5.258e-05	1.249e-04
0	6.252e+05	5.491e-02	1.218e-01	1.012e-04	2.246e-04
.5	1.429e+05	2.326e-02	4.607e-02	3.914e-05	7.751e-05
2.0	3.234e+03	8.172e-04	1.515e-03	1.264e-06	2.343e-06
3.0	1.063e+06	4.976e-01	8.466e-01	6.751e-04	1.149e-03
TOTALS:	5.066e+06	6.635e-01	1.253e+00	9.832e-04	1.905e-03