Ashman Center

The Dow Chemical Company
Midland, Michigan 48674

January 31, 2002

Claudia Craig, Chief
Facilities Decommissioning Section
Decommissioning Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

SUBJECT: LICENSE AMENDMENT REQUEST TO SUPPLEMENT THE DECOMMISSIONING PLAN FOR REMOVAL OF MAGNESIUM-THORIUM SLAG
THE DOW CHEMICAL COMPANY'S BAY CITY, MI SITE
LICENSE NUMBER: STB 527

Dear Ms. Craig:

Per our October 4, 2001 conference call with Nuclear Regulatory Commission (NRC) Technical Staff, The Dow Chemical Company (TDCC) is re-submitting for NRC approval the attached revised supplement to the amend the decommissioning plan for License STB-527.

The attached response to NRC comments addresses each of the three specific comments received by TDCC on September 25, 2001. The supplement has been modified to address the NRC comments, as well as the comments received during the October 4, 2001 conference call with NRC technical staff. The responses include references to where in the supplement the specific comments have been addressed when appropriate. The proposed plan will allow the site to complete the decommissioning process by October 2003 and will allow for license termination shortly thereafter.

TDCC would appreciate your timely review of this supplemental plan, and TDCC looks forward to the opportunity to move forward and completion of the decommissioning process and license termination at the Bay City site.

We are willing to meet with agency staff at the appropriate time to discuss and resolve any questions that arise during the review. If you have any questions or comments concerning this supplemental plan, please contact me at (989) 636-0787.

Sincerely,

Ben Baker

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THE DOW CHEMICAL COMPANY, BAY CITY, MICHIGAN

RESPONSE TO NRC ADMINISTRATIVE REVIEW COMMENTS

OF SEPTEMBER, 25 2001

General Comment

The purpose of this response is to address the questions and deficiencies identified during the NRC administrative review of the Supplement to the Decommissioning Plan (SDP) submitted on August 17, 2001. Each of the NRC's three specific comments is addressed below, and they are referenced to the SDP where appropriate.

Specific Responses

1. The 12 issues raised in the May 29, 2001 letter to TDCC from the NRC were discussed during an October 4, 2001 conference call between Sam Nalluswami and Stewart Schneider of NRC, and Dave Fauver (RSI) and Corey McDaniel (EOP Group) for TDCC. Considering the NRC input during the call the following 12 responses were developed to correspond to the 12 NRC comments. In a number of cases, the response required that the SDP be revised and/or that additional information be included. In these cases, the affected section of the SDP is referenced.

    1. LEACH RATES - Existing leach rate data (Table 2), rather than K_D values, will be used to measure current and future radium concentrations in drinking water, as discussed in Sec. 3.3.1.

    2. FILL MATERIAL - The use of on-site fill material to regrade excavated areas within the site is addressed in Sec. 4.2, item 3. TDCC plans to use onsite material as fill in saturated area excavations.

    3. SOURCE TERM - A discussion of the approximation of the source term is addressed in Sec. 1.1.6.

    4. GROUNDWATER DOSE - The TDCC request is to apply the projected Ra-226 water concentration, after 1000 years in-growth, as the measure of compliance in accordance with the concentration based requirements of the SDMP Action Plan as discussed in detail in Section 3.1 of the SDP. The projected Ra-226 water concentration is believed to be the SDMP Action Plan

criteria that most directly applies to the material in the saturated zone and includes a high margin of conservatism. It is important to make two observations related to radionuclide concentrations in the saturated zone to help put the TDCC request in proper context, 1) that there is currently no Ra-226 in site groundwater – it is only after 1000 year in-growth that compliance is conservatively evaluated, and 2) that based on over 750 bore-hole sample results, the average concentrations of Th-232 and Th-230 in the saturated zone soil are approximately 3 pCi/g and 9 pCi/g, respectively, after background subtraction. These low existing average concentrations reflect the fact that there are very few, isolated areas of the site that exceed the proposed criteria and would require remediation. After remediation of these areas, the average concentration will be further reduced. Although not directly applicable to compliance based on the SDMP Action Plan concentration-based criteria, if a dose assessment where performed, it would be based on the above stated low average concentrations.

5. ISOTOPIC RATIOS - The ratio of Th-230/Ra-226 will behave identically to the ratio of Th-232/Ra-228 due to the fact that the elements, i.e., thorium and radium, are identical, and that they exist in identical chemical and physical matrices., as discussed in Sec. 3.3.1.

6. THORIUM RATIOS - The 3.0 ratio of Th-230 to Th-232 and Th-228 as approved in the current site license decommissioning criteria (License Amendment No.7) will remain unchanged, as discussed in Sec. 3.3.1. The request to modify the ratio to 1.26 has been withdrawn by TDCC, and further revisions are not anticipated.

7. CONCENTRATION VARIABILITY - The raw data from the 783 bore hole samples collected to date, has been submitted under separate cover directly to the NRC. The mean concentrations were about 3 pCi/g for Th-232 and Th-228 and 9 pCi/g for Th-230. The standard deviations of the mean were about 1.7 pCi/g for Th-232 and Th-228 and 4.8 pCi/g for Th-230. Regarding the question as to why the 7 samples greater than 25 pCi/g were removed to determine the 1.24 pCi/g average, this was done under the assumption that these 7 elevated

areas would be remediated and that 1.24 pCi/g was the best estimate of the post-remediation average.

8. RADIUM IN WATER - Additional groundwater samples were collected at the site locations previously sampled, as well as at 4 background locations, and analyzed for Ra-228. The results of these analyses are summarized in Table 2 of the SDP. The combined data confirm the assumptions presented in the initial version of the SDP, e.g., that most of the Ra-228 results previously reported were at or below background levels and that this was the major reason for the significant variability of the previously reported Ra-228/Th-32 ratios. The results reported in Table 2 include the average results from both rounds of samples and report Ra-228/Th-232 ratios that were calculated after subtracting Ra-228 water background. The ratio results for the three samples that contain Ra-228 in water in excess of background range from 5E-04 to 6E-02. The lowest ratio of 5E-04 is most likely to be the most correct of all three since it is the location with the highest Th-232 concentration, i.e., 1167 pCi/g. The two higher ratios are very likely to be attributable to background and analytical variability in Ra-228 concentrations, not an elevated Ra-228 leach rate. This position is further supported by the results from the five areas that had ratios of 0.0, which also had relatively high Th-232 concentrations. In all cases, regardless of the Th-232 concentration, the Ra-228 concentrations in water are very low and less than the Drinking Water criteria referenced in the SDMP Action Plan. In summary, the selected Ra-228/Th-232 ratio of 0.1 is believed to be a conservative and appropriate value to apply in the compliance calculations presented in the SDP.

9. MICROSHEILD MATERIAL COMPOSITIONS - Microshield does not contain a pure soil composition as a shielding material. In the absence of a soil material, concrete will be selected. This is considered sufficient for the application considering that the Microshield results are proposed only as a licensee tool to determine when backfill of an excavated saturated zone area should begin. As stated in Section 4.2 of the SDP, "The remediation action level will be calculated using Microshield to ensure that the 10 uR/hr exposure rate criterions will be satisfied after the area is backfilled and

graded to the original contour. *The remediation action level is a tool for TDCC's use to ensure that the criteria will be met after backfill and is not intended for regulatory compliance."*

10. MICROSHEILD GEOMETRY -. The Microshield runs will assume that the residual radioactivity is uniformly distributed. However, this assumption has no affect on final compliance, which will be demonstrated after the excavated area is backfilled and graded to original contour. If significant inhomogeneity exists that is not captured during excavation support surveys or predicted by the Microshield analysis, the final survey after backfill and grading to original contour will fail and additional remediation will be required.

11. INSTRUMENT CALIBRATION - Instrument calibrations are discussed in attached examples. Instruments will be calibrated using the methods and assumptions described in the NRC approved TDCC site Health and Safety Plan. This is considered adequate to perform excavation support surveys, including exposure rate measurements in dewatered areas. Final survey measurements will be performed after the excavated area is backfilled and graded to original contour. In this geometry, the instrument calibration assumptions have been found to be acceptable to NRC during numerous past NRC inspections of final survey activities.

12. BOUNDARY CONDITIONS - The boundary conditions, as discussed during the conference call, have been adequately identified in Sec. 3.3.1 and Sec. 4 thru 4.2.

2. The ground water monitoring program, as discussed during the October 4, 2001 conference call, is incorporated by reference in Section 3.3 from the program established as part of License Amendment No. 7 to establish the decommissioning criteria. This reference document was submitted to NRC following the conference call.

3. This establishment of the 3.0 ratio of Th-230 to Th-232 has been addressed in the sixth tab of response No. 1, which clarifies that the request to use the "1.26" value has been withdrawn by TDCC.

SUPPLEMENT TO THE DECOMMISSIONING PLAN

FOR REMOVAL OF MAGNESIUM-THORIUM SLAG FROM

THE DOW CHEMICAL COMPANY'S BAY CITY, MICHIGAN SITE

The Dow Chemical Company
Midland, MI 48674

January 28, 2001

CONTENTS OF SUPPLEMENTAL DECOMMISSIONING PLAN

1. GENERAL INFORMATION

The Decommissioning Plan ("DP") developed by the Dow Chemical Company ("TDCC") in October 1993 was based on removal of surface contaminated soils from the Midland and Bay City slag piles and disposal at Dow's Salzburg Landfill. The DP was supplemented in December 1995 to transport the material from the piles by rail to the Envirocare facility in Clive, Utah for disposal. The current supplement to the DP describes the decommissioning approach for achieving ALARA contamination levels in the subsurface of the Bay City site. Whenever possible, reference is made to the relevant information provided in the original DP, as supplemented.

The statements and commitments made in this supplement to the DP supercede any conflicting statements and comments made in the original DP or subsequent supplements.

The activities described in this submittal do not pose additional occupational radiation protection risks or generate additional pathways for release of radioactive material to the environmental beyond those previously described in License Amendments No. 6 and No.7. The DOW Thorad Project "Radiological Health and Safety Plan," approved March 6, 2001, provides the necessary organization, procedures, etc., to ensure that the activities described in this submittal are completed in accordance with applicable NRC regulations and guidance. In addition, the decommissioning cost estimate and Financial Assurance mechanism currently in place are sufficient for the activities proposed in this supplement.

1.1 Background

On July 19, 1996, the Nuclear Regulatory Commission (NRC) issued a license amendment to The Dow Chemical Company (TDCC) authorizing the remediation and offsite disposal of thorium contaminated material from storage piles at the Dow Midland and Bay City Sites (License No. STB-527, Amendment No. 6). On July 21, 1997, NRC in License Amendment No. 7 approved the unrestricted use criteria and final survey methods for the remediated areas.

After the remediation of the majority of the stockpiled surface material at the Bay City site was completed, Dow discovered that there was a significant volume of contaminated material at the Bay City site below the water table, i.e., in the saturated zone. The material in the saturated zone was not specifically addressed in License Amendments 6 and 7. TDCC is submitting this supplemental decommissioning plan to NRC to address this subsurface saturated zone material. This supplement proposes unrestricted use criteria, remediation methods, and final survey methods specifically applicable to the contamination within the saturated zone.

The development of effective final survey methods for material in the saturated zone required consideration of final survey methods for unsaturated subsurface soil/slag (hereafter referred to as "soil"), as well as surface soil. This supplement provides a comprehensive final survey approach for surface soil, unsaturated zone subsurface soil, and saturated zone subsurface soil that ensures compliance with all unrestricted use

criteria. The final survey methods provided in this supplement are intended to address areas of the site that have not been verified by NRC as of the date of this submittal and supercede any previous described final survey methods. The site areas that have been final surveyed and verified by NRC as of the date of this submittal (Verification Areas VA I-VI, see "Decommissioning Status" below) are considered suitable for unrestricted release and are not included in this supplement.

1.1.1 Site History

Beginning in the early 1940's and continuing into the early 1970's, TDCC produced a metallic magnesium alloy used in aircraft applications. The alloy was a lightweight material with improved high temperature strength. Production took place at two locations - in Bay City, Michigan, and in Midland, Michigan.

The production process yielded slag material as a by-product. The magnesium-thorium slag material, which is regulated as a radioactive material, has been stored on TDCC property at Bay City, Michigan under a license from the Nuclear Regulatory Commission (NRC).

1.1.2 Licensing History

A single license (STB-527) was granted by the Nuclear Regulatory Commission (NRC) in 1973 for the Bay City and Midland sites to store up to 200,000 pounds of Thorium as slag. This license expired in 1978, but has remained in effect under timely renewal. The Thorium-contaminated material was removed from the Midland site and this area was surveyed by the NRC in May 1997 and removed from the license.

The initial decommissioning plan for the Bay City site, approved on July 7, 1996, was for the removal of approximately 40,000 cubic yards of thorium-magnesium contaminated material located over an area of less than one acre. During the initial phase of material removal, new information regarding residual surface and subsurface contamination extending beyond the immediate slag pile area was discovered. Based on this information, it was determined that a new plan needed to be developed for the removal of the contaminated material. Subsequently, with communications with the NRC, the license was extended through June 2003.

1.1.3 Current Site Condition

The site is located adjacent to the Saginaw River near the mouth of the river where it discharges to the Saginaw Bay. The site is surrounded by a series of industrial service water ditches located to the north, west, and south. The only access to the site is through gated and fenced TDCC property via a gravel road and the only permanent structures near the site include the old Coast Guard Lighthouse to the north and a water pump house adjacent to the southern service water ditch near the Saginaw River. Other facilities on site include temporary offices, laboratory, and decontamination facilities. Most of the topography can be characterized as generally flat, low lying land with an average surface

elevation around 585 feet relative to the USGS datum. Most of the variation in the surface topography is a result of excavated areas or due to the temporary flood control earthen berm located along the eastern and northern sides of the site.

The geology at the site is simple, and consists of 6-12 feet of river sediment and fill overlying a hard, dense till clay. The river sediments consist predominantly of sand, silty sand, and clayey sand with occasional lenses of clay and silt. Organic material is common throughout the river sediment, and occasional lenses of peat are also present.

Some areas of the site contain up to 6 feet of fill. This fill consists primarily of rubble and soil, with pockets of magnesium/thorium slag. It appears that the fill was likely placed directly into low-lying areas and graded to match surrounding topography at the time they were placed or shortly thereafter. These low areas were once wetlands contiguous to the Saginaw River.

The glacial till consists of very hard, very dense gray silty clay with a trace of gravel. Information from other sites in the area also indicates that sand lenses are sometimes present within the glacial till, although these bodies tend to be widely dispersed and often discontinuous. Information from surrounding sites indicates that bedrock is encountered at between 80 and 90 feet below ground level in this area. Bedrock consists of sandstone and shale of the Saginaw Formation.

Groundwater is found within the river sediments, glacial till sands, if present, and Saginaw Formation. Groundwater in the river sediment is found between 3 and 5 feet below ground level at the site, and is essentially continuous with the surface water in the Saginaw River.

Groundwater levels indicate a very shallow east-northeast gradient (0.004 ft/ft) toward the Saginaw River. This gradient likely remains very low throughout the years and it is possible that there are occasional fluctuations in the flow direction based on the rise and fall of the Saginaw River.

The entire Bay City storage site is located within a wetland / floodplain adjacent to the Saginaw River. Decommissioning activities within the wetland area are being performed under Michigan Department of Environmental Quality, Natural Resources and Environmental Protection Act 451, PA 1994 Permit No. 00-09-0017-P and Department of the Army, Corps of Engineers Discharge and Dredge Materials Permit File No. 90-020-020-3. Under the conditions of the permits, excavated areas shall be graded and allowed to revert back into wetlands and will be left undisturbed.

Five water well records within a mile of the site were obtained from the Department of Health. Three of the wells within a mile of the site were water supply wells, four were monitoring wells (contained on one water well record), and one was a cathodic protection well. Water supply well #1 appears to be screened in a glacial till sand, and is located across the Saginaw River to the east of the site. Water supply wells 2 and 3 appear to be

screened in the Saginaw Formation, and are located to the northwest and southwest of the site, respectively.

Based on these logs and an evaluation of the local groundwater use for other sites in the area, it appears that the Saginaw Formation is the most significant source of groundwater in the area. Till sands may periodically be tapped for groundwater when present, but widespread use is unlikely given their sporadic and wide dispersal. It is unlikely that anything other than monitoring or cathodic protection wells are screened in the river sediment. Investigations at other sites in the area indicate that the river sediments thin significantly away from the Saginaw River, and may contain groundwater only on a sporadic or seasonal basis. Only those sediments adjacent to the Saginaw River provide a reliable groundwater source and the installation of wells within the shallow sediments in this area is unlikely, as it would be easier to pump directly from the river.

1.1.4 Decommissioning Status

Pre-decommissioning activities were initiated in November 1995 and included contractor procurement, health and safety planning, and transportation and disposal negotiations. During January – June 1996 the following major items were designed and installed in support of the decommissioning effort:

- On-site office and laboratory facilities (7,200 square feet)
- 4.2 miles of exclusion fencing and a perimeter air monitoring system
- 2.8 miles of road upgrade
- Personnel and equipment decontamination facilities
- Two on /off loading ramps and three acres of lined storage pads
- 1,200 gpm raw water system
- Environmental control systems (dust and water)
- Rail facility including spurs, weigh station, and covered loading station

Major excavations of waste materials were initiated in late June 1996 at both the Midland and Bay City sites. Waste shipping by rail to Envirocare of Utah was initiated in August 1996. The U. S. Nuclear Regulatory Commission (NRC) in May 1997 performed a final confirmatory survey of the Midland site and a determination was made in June 1997 that the site met unrestricted release guidelines.

With the exception of winter months, waste excavation activities at the Bay City site have continued to date. Five confirmatory surveys of six areas of the site have been completed by NRC Region III staff. Inspection reports received from the staff indicate that 31.33 acres (Table 1) meet unrestricted release guidelines.

Table 1
Decommissioning Status

U.S. NRC REGION III REPORT DATE	VERIFICATION AREA DESIGNATION	NO. OF SUBGRIDS (10m x 10m) MEETING UNRESTICTED CRITERIA	CORRESPONDING AREA IN ACRES
August 13, 1997	VA-I	430	10.75
January 7, 1998	VA-II	107	2.675
January 7, 1998	VA-III	335	8.375
October 20, 1998	VA-IV	163	4.075
December 17, 1998	VA-V	150	3.750
August 5, 1999	VA-VI	68	1.700
TOTALS		1253	31.33
REMAINING AREA		364	9.100
TOTAL SITE AREA		1617	40.425

1.1.5 Future Land Use

Future unrestricted land use at the Bay City site is such that the saturated zone contamination is not expected to contribute to a significant dose to a critical group. The average dose to the site critical group is expected to be significantly less than 25 mrem/year The low dose expectations at the site are based on the following future land use observations.

- The critical group will most likely consist of either recreational intruders or individuals that consume drinking water from a well that draws water from the site.
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- Recreational intruders have been observed near the site for a duration of no more than 4 hours during each visit. Intruders are primarily hunters, boaters, or bird watchers.

- There will be no direct radiation exposure pathways from Th-232 greater than the 10 uR/hr SDMP criteria.

- The primary exposure pathway will be from radium in drinking water, and the time of maximum exposure will begin after 1,000 years of ingrowth from Th-230.

- A resident farmer scenario is infeasible because of the wetland conditions at the site. A resident or industrial occupant at the site would likely have to add at least five feet of topsoil to construct a building. The only likely worst case dose to a resident of any type would be from the water that they might draw

from a well placed within the contamination. However, an onsite well in the contaminated zone is unlikely since the same water can be pumped directly from the river.

1.1.6 Source Term Estimation

The saturated zone source term is estimated as follows:

Assumptions:

- 364-100 m^2 subgrids
- Saturated zone fill material average 2 meters deep
- Fill material density approximated as 1.6 g/cm^3
- Average current radionuclide concentrations are 3.7 pCi/g Th-232, 3.5 pCi/g Th-228, and 10.8 pCi/g Th-230. These concentrations are the average results from over 750 soil sample collected from the site saturated zone
- Projected Ra-226 concentration after 1,000 years ingrowth = (10.8 pCi/g Th-230)(0.35 ingrowth factor) = 3.8 pCi/g Ra-226
- Background radionuclide concentrations are assumed to be a nominal 1 pCi/g for all radionuclides

Estimation:

- Total mass = (364 grids)(100m^2/grid)(2m depth)(1E+06cm^3/m^3)(1.6 g/cm^3) = 1.2E+11 g
- Th-232 source term = (1.2E+11g)(3.7-1.0 pCi/g) = 0.3 Ci
- Th-228 source term = (1.2E+11 g)(3.5-1.0 pCi/g) = 0.3 Ci
- Th-230 source term = (1.2E+11g)(10.8-1.0 pCi/g) = 1.2 Ci
- Ra-226 source term (after 1000 years) = (1.2E+11g)(3.8-1.0 pCi/g) = 0.3 Ci

If the thorium were present at concentrations equal to the Unimportant Quantity limit in 10 CFR 40.13 where persons are exempt from licensing, the thorium source term would be 13.0 Ci.

3. SATURATED ZONE SOIL UNRESTRICTED USE CRITERIA

This section describes the proposed unrestricted use criteria for the soil in the saturated zone and demonstrates that the proposed criteria are consistent with the SDMP Action Plan.

3.1 Unrestricted Use Criteria for Soil in the Saturated Zone

Amendment No. 7 to License No. STB-527 approved unrestricted use criteria for contaminated soil in storage piles above the ground surface and in surface soil. The approved SDMP criteria for soil contamination were designed to apply to surface soil

conditions, and are not appropriate for contamination in the saturated zone. The most likely exposure pathway for soil in the saturated zone is groundwater ingestion, which is not applicable to surface soil. Section 1.1.5 contains a discussion of the most likely future land use for the Bay City site. In addition, it is technically infeasible and prohibitively expensive to apply the surface soil criteria to material below the water table because it requires extensive excavation below the groundwater table.

The currently approved release criteria are consistent with the SDMP Action Plan and are comprised of concentration limits and exposure rate limits. Both the concentration limits and exposure rate limits are derived from the 1981 Branch Technical Position (1981 BTP) "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations" (46 FR 52601). The 1981 BTP soil concentration limits are based on the most limiting of three criteria: 1) 1 mrad/year to the lung through inhalation, 2) 3 mrad/yr to the bone through ingestion, or 3) 10 uR/hr through direct exposure. For natural thorium, the limiting criterion was the 10-uR/hr exposure rate and this was the basis of the 10 pCi/g total thorium concentration limit for surface soils.

The 1981 BTP assumes that contaminated soil is unsaturated and at a sufficient depth to allow root uptake by plants. Depending on the type of plant, this depth could range from 0.15m to 0.9m. Material in the saturated zone of a site was not considered in the 1981 BTP analyses. Saturated zone material would not contribute to dose through the inhalation and ingestion pathways and therefore the 3 mrad bone and 1 mrad lung criteria would not apply. As described previously in Section 1.1.5, there is very low probability that the material in the saturated zone would be excavated and is not considered a plausible scenario. The more likely scenario is that additional fill would be added since fill is required before a residential or commercial structure could be constructed, which would reduce the exposure rate measured during the final survey.

The material currently in the saturated zone could contribute dose through the direct radiation pathway and therefore the 10 uR/hr exposure rate criteria would still apply. In addition, the saturated zone material may also impact in groundwater. This potential pathway is addressed in the SDMP Action Plan, which provides specific unrestricted use criteria for groundwater (i.e., the EPA Safe Drinking Water Regulations).

In summary, consistent with the SDMP Action Plan, TDCC proposes that the unrestricted use criteria for the contaminated material in the saturated zone be based on compliance with the 10 uR/hr SDMP exposure rate criteria and the EPA Safe Drinking Water Regulations. Compliance with the drinking water regulations would be demonstrated at the time of license termination. In addition, as a conservative ALARA measure, the projected groundwater concentration of Ra-226 plus Ra-228 (Ra-226/228), after 1000 years of in-growth, will be estimated and limited to the 5 pCi/L limit in the EPA Drinking Water Standards (65 FR 76708).

The proposed unrestricted use criteria for the contamination in the saturated zone at the Bay City site are listed below:

- 10 uR/hr above background at 1 meter above the existing ground surface;
- EPA Drinking Water Standards demonstrated at time of license termination;
- 5 pCi/L Ra-226/228 after 1000 years in-growth.

3.2 Demonstrating Compliance with Exposure Rate Criterion

The 10-uR/hr SDMP criterion will be demonstrated with the unsaturated surface soil in place. This is appropriate since future excavation for the purpose of human habitation is very unlikely. The depth of the unsaturated zone ranges from 2-3 feet on the site. If remediation of the saturated zone is required in a given area, the noncontaminated (i.e., below the unrestricted use criteria) unsaturated soil in the area will be excavated and stockpiled. The contaminated material in the saturated zone will then be removed until the exposure rate is reduced to levels that would result in 10 uR/hr criteria after non-contaminated soil is replaced and regraded to the original contours. The Microshield Code will be used to calculate the saturated zone remediation action levels using this approach. The final compliance measure (i.e., the final survey measurement) for the 10 uR/hr criteria in the remediated area will be made after the original cover material, and any additional required fill, is replaced.

3.3 Demonstrating Compliance with Drinking Water Criterion

Compliance with the EPA Drinking Water Regulations will be demonstrated, at the time of license termination, through direct measurements of the groundwater at the Bay City site. Groundwater samples will be collected from at least 5 separate monitoring wells.

Compliance with the 1,000 year projected Ra-226/228 criteria of 5 pCi/L will be demonstrated using the following assumptions and methods:

1. Since Ra-226 is not currently present in the soil, direct measurements of Ra-226 groundwater concentration cannot be made.

2. The ratio of Ra-228 concentration in the saturated zone soil (pCi/g) to the Ra-228 concentration in surrounding groundwater (pCi/l) will be used as a surrogate for the future ratio of Ra-226 (pCi/g) to Ra-226 (pCi/l) after 1000 years in-growth.

   Note: Th-232 soil concentration was used as a surrogate for Ra-228 soil concentration in this analysis assuming Th-232 and Ra-228 are in equilibrium.

3. The assumption that future Ra-226 in soil will have the same characteristics as current Ra-228 is valid since identical elements are being evaluated in identical matrices.

4. The Th-230 and Th-232 in the saturated zone soil will be limited to the concentration that is projected to result in 5 pCi/l Ra-226/228 in water after 1000 years in-growth.

5. The Th-230 concentration will be determined by ratio to Th-232 using the onsite gamma spectroscopy system. A Th-230/Th232 concentration ratio of 3:1 will be applied.

3.3.1 Method for Determining Drinking Water Criterion

The following assumptions and calculations describe how compliance with the EPA drinking water standard, at 1,000 years in the future, will be demonstrated.

- Ra-226 concentration in 1000 years will equal 35% of the Th-230 concentration today.

- For the purpose of estimating Ra-226 and Ra-228 in drinking water 1,000 years in the future, a conservative value of 0.1 is assumed for the ratio of Ra-228 in groundwater (pCi/l) to Th-232 in saturated zone soil (pCi/g). In other words, the Ra-228 groundwater concentration equals 10% of the Ra-228 soil concentration (recall that Th-232 is used as a surrogate for Ra-228 in soil in this analysis).

- The ratio of Th-230/Th-232 is 3.0, as established in License Amendment No. 7.

- Th-232 concentration will be used as a surrogate for Th-230, assuming a 1/3 ratio.

- The SDMP adopts the EPA radium drinking water standard of 5 pCi/l Ra-226/228 as the decommissioning criteria.

- Thorium-232 and Ra-228 are assumed to be in equilibrium. Radium-228 concentrations in soil are determined by analysis of Th-232

- Table 2 provides the data used to select the 0.1 Ra-228/Th-232 ratio. The Ra-228 groundwater data listed in Table 2 was generated by analyses of two rounds of groundwater sample collected in the areas containing the highest concentrations of Th-232 in the saturated zone soil (also listed in Table 2). Background sample results are also provided. The Ra-228/Th-232 ratio was calculated after subtracting the average background value of 1.71 pCi/l Ra-228 . Note that 5 of the eight ratios are reported as 0.0. This indicates that the Ra-228 water concentration6s were less than the background concentration indicating no leaching from the material in the saturated zone. Three of the eight samples indicated Ra-228 concentrations above background. The highest Ra-228/Th-232 ratio was 0.06. The ratio of 0.1 exceeds the maximum measured ratio and was selected to ensure conservatism in the calculation of the saturated zone unrestricted use criteria.

Table 2
Concentration Ratios for Ra-228 to Th-232

		Background (1) Ra-228	Ra-228(2)	Th-232	Ratio(3)
SUBGRID	QUAD	pCi/l	PCi/l	pCi/g	Ra-228:Th-232
C5-2	D		0.98	42	0.0E-00
F5-4	A		3.73	32	6.3E-02
F5-5	D		2.29	1167	5.0E-04
F5-6	D		1.42	154	0.0E-00
F7-3	A		1.00	30	0.0E-00
F7-4	A		1.90	9.6	2.0E-02
I5-5	C		0.75	279	0.0E-00
I6-8	C		1.70	56	0.0E-00
BKG-N1		1.42			
BKG-SE1		1.63			
BKG-SR1		1.36			
BKG-SW4912		2.42			

(1) Background average: 1.71 pCi/L
BKG-N1 - At background soil area
BKG-SE1 - SE corner of parking lot
BKG-SR1 - Inlet canal to pump-house
BKG-SW4912 - SW field along road
(2) Average of saturated soil samples collected during 2001
(3) Ratio calculated after subtracting the average Ra-228 background level

Calculations/equations to determine the Th-232 and Th-230 soil concentrations for demonstrating compliance with the drinking water criteria

Criterion:

Ra-226 + Ra-228 < 5 pCi/l at t = 1,000 y (1)

Groundwater to Soil Ratio:

(Ra-228 pCi/l) / (Ra-228 pCi/g) = (Ra-226 pCi/l) / (Ra-226 pCi/g) = 0.1 (2)

Saturated Zone Soil Concentrations:

Ra-228 pCi/g = Th-232 pCi/g (3)

Th-230 pCi/g = (3.0)(Th-232 pCi/g) (4)

$$\text{Ra-226}_{t=1000y}\ \text{pCi/g} = (0.35)(\text{Th-230}_{t=0y}\ \text{pCi/g}) = (0.35)(3.0)(\text{Th-232 pCi/g}) \quad (5)$$

Groundwater Concentration:

$$\text{Ra-226}_{t=1000y}\ \text{pCi/l} = (0.1)(\text{Ra-226}_{t=1000y}\ \text{pCi/g}) = (0.1)(0.35)(3.0)(\text{Th-232}_{t=0y}\ \text{pCi/g}) \quad (6)$$

$$\text{Ra-228}_{t=1000y}\ \text{pCi/l} = (0.1)(\text{Th-232}_{t=0y}\ \text{pCi/g}) \quad (7)$$

<u>Thorium Saturated Soil Concentration to Demonstrate Compliance with Groundwater Criterion at t= 1000y</u>

$$5\ \text{pCi/l (Ra-226 + Ra-228)} = (0.1\ \text{pCi/l per pCi/g})(0.35)(3.0)(\text{pCi/g Th-232}) + (0.1\ \text{pCi/l per pCi/g})(\text{pCi/g Th-232}) \quad (8)$$

$$5\ \text{pCi/l} = (0.105\ \text{pCi/l per pCi/g})(\text{pCi/g Th-232}) + (0.1\ \text{pCi/l per pCi/g})(\text{pCi/g Th-232}) \quad (9)$$

$$5\ \text{pCi/l} = (0.205\ \text{pCi/l per pCi/g})(\text{pCi/g Th-232}) \quad (10)$$

Rearranging terms:

$$\text{pCi/g Th-232} = (5\ \text{pCi/l}) / (0.205\ \text{pCi/l per pCi/g}) = 24\ \text{pCi/g Th-232} \quad (11)$$

$$\text{Th-230} = (3.0)(\text{Th-232 pCi/g}) = 72\ \text{pCi/g} \quad (12)$$

The saturated zone unrestricted use criteria for Th-232 and Th-230 are 24 pCi/g and 72 pCi/g, respectively.

<u>Groundwater Concentration at Thorium Concentration Criteria (t = 1000y)</u>

$$\text{Ra-228 pCi/l} = (0.1\ \text{pCi/l per pCi/g})(24\ \text{pCi/g Th-232}) = 2.4\ \text{pCi/l Ra-228} \quad (13)$$

$$\text{Ra-226 pCi/l} = (0.1\ \text{pCi/l per pCi/g})(0.35)(72\ \text{pCi/g Th-230}) = 2.5\ \text{pCi/l Ra-226} \quad (14)$$

Total Groundwater Concentration (Ra-228 Ra-226) = 2.4 + 2.5 = 4.9 pCi/L

4. FINAL STATUS SURVEY

This section provides a description of the Final Status Survey (FSS) methods to be applied in site areas that have not completed FSS to date. This includes all site areas other than Verification Areas VA-I, II, III, IV, V, and VI (see Table 1). Attachment 1 provides a map indicating the areas remaining to be surveyed in accordance with the

methods described in this section. The FSS methods are consistent with NUREG/CR-5849 guidance and apply to surface soil, subsurface unsaturated soil, and subsurface saturated soil.

The original DP, as supplemented, and the Radiological Health and Safety Plan (approved June 2000) provide information regarding background radiation measurements, equipment, instrumentation, data management, etc. These methods are applicable to remaining FSS activities described below.

Future final surveys of surface soil will not include consideration of integrated gamma count rate since no soil compositing is proposed. In addition, background subtraction and the $(100/A)^{1/2}$ averaging criteria recommended in NUREG-5849 will be applied.

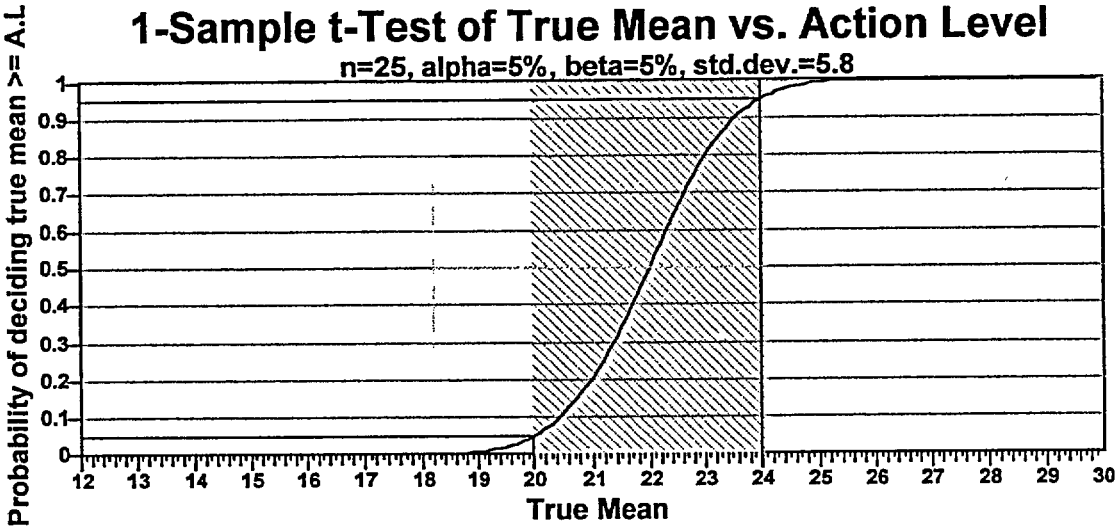
The proposed final survey method accounts for surface soil, unsaturated zone subsurface soil, subsurface saturated zone soil. The final survey plan is summarized as follows.

4.1 Final Survey of Saturated Zone Soil

As demonstrated above, the current concentration of Th-232 in the saturated zone soil can be used to predict the Ra-226/228 concentration in the groundwater 1000 years in the future. The Th-232 concentration in the soil will be sampled and measured directly using the onsite gamma spectroscopy laboratory. The final survey method for Th-232 in the saturated zone is described below:

- Compliance will be based on the mean concentration of Th-232 in saturated zone.
- The mean Th-232 concentration will be demonstrated at the 95% confidence level using Equation 8-13 in NUREG/CR-5849.
- A hot-spot criterion of three times the mean concentration limit will be applied, i.e., an individual sample may be between 1 and 3 times the criteria if the mean meets the criteria at the 95% confidence level.
- Sample frequency will be one borehole per 100 m^2 for a total of 330 samples. The acceptability of the proposed sample size was justified using the EPA and NRC Data Quality Objectives process. A power curve was developed to determine the number of samples required to ensure Type I and Type II errors for the mean are less than 5%.. The standard deviation (sigma) for the samples was assumed to be 5.8 pCi/g based on a review of saturated zone samples collected to date. As shown in Figure 1, a sample size of 25 would ensure a Type 1 error of 5% at the 24 pCi/g criteria with a Type 2 error of 5% at 20 pCi/g. This is well below the proposed sample size of 330.

Figure 1 – Power Curve for Determining Minimum Number of Saturated Zone Samples to for Final Survey.



- Each borehole sample will consist of a composite sample from the saturated zone, i.e., from water table to underlying clay layer.

- The composite sample will be analyzed for Th-232 using gamma spectroscopy.

- Any saturated zone areas found to contain Th-232 exceeding the unrestricted use criteria during the final survey will be remediated. After remediation, another borehole sample will be collected and including in the final survey data set. After all saturated zone remediation has been completed, the final survey of the surface soil and subsurface unsaturated zone soil will begin.

4.2 Final Survey of Surface Soil and Subsurface Unsaturated Zone Soil

- Scan ground surface using NaI detector;

- Within each 25 m^2 subgrid quadrant, at the location with the highest NaI surface scan result, perform exposure rate measurement at 1 meter above ground surface and collect surface soil sample (biased soil sample 0-6");

- If exposure rate measurement and surface soil sample meet unrestricted use criteria no further sampling required;

- If exposure rate measurement exceeds average regulatory criteria but is less than 2 times average, four additional exposure rate measurements will be performed within the 25 m^2 subgrid;

- If the average of the resulting 5 exposure rate measurements meet the criteria no further measurements required;

- If the surface soil sample is greater then the criteria but less than 3 times the criteria, collect three additional samples in the 25 m^2 subgrid;

- If the average of the resulting 4 soil samples meets the criteria no further soil sampling required;

- If the soil meets the criteria but the exposure rate exceeds criteria, collect a composite sample of the unsaturated zone soil (1-3 feet). Compositing over a 1 meter depth of subsurface soil is consistent with NRC guidance provided in "Method for Surveying and Averaging Concentrations of Thorium in Contaminated Subsurface Soil," February 13, 1997, letter from John T. Buckley, NRC, to Howard A. Pulsifer, AAR Corporation;

  - If the composite sample of the unsaturated zone soil column meets the soil criteria, then the elevated exposure rate is assumed to result from saturated zone soil and the following actions are taken:

    1. The non-contaminated unsaturated zone soil in the area exceeding the exposure rate criteria will be removed and stockpiled;

    2. The saturated soil will be excavated below the water table until the exposure rate is reduced to a pre-determined remediation action level. The remediation action level will be calculated using Microshield to ensure that the 10 uR/hr exposure rate criterions will be satisfied after the area is backfilled and graded to the original contour. *The remediation action level is a tool for TDCC's use to ensure that the criteria will be met after backfill and is not intended for regulatory compliance.*

    3. Compliance with the exposure rate criterion will be demonstrated after the excavated area is backfilled and graded to original contour. Since the fill material will consist of soil already on the site, no physical or chemical variations are anticipated to affect the movement of radium on the site.

5. SCHEDULE

A one and one-half year effort from initiation through final verification by TDCC and the NRC of acceptable residual concentrations and personnel demobilization is planned. An April 2002 project initiation and October 2003 completion is planned. This schedule supercedes all previously approved DP schedules.

Attachment 1 – Verification Areas Released and Remaining Subgrids to be Released