Approvals	
Work Assignment Manager	Date
Project Officer	Date

WORK PLAN, REVISION 1

Risk Assessment Revision for 40 CFR Part 61 Subpart W - Radon Emissions from Operating Mill Tailings

Prepared by:

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Under

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Prepared for:

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1.0 BACKGROUND AND OBJECTIVES

The Office of Radiation and Indoor Air (ORIA) promulgated a National Emission Standard for a Hazardous Air Pollutant (NESHAP) for radon emissions from operating uranium mill tailings impoundments (Subpart W) on 12/15/1989. Subpart W includes two separate standards. First, existing sources must ensure emissions from tailings impoundments not exceed 20 pCi/m2-sec of radon-222. Second, new sources must comply with the requirements for constructing one of two types of impoundment structures. Subpart W requires that existing sources file an annual report of the facility's emissions. Section 112(q) of the Clean Air Act, as amended (CAAA), requires EPA to review, and if appropriate, revise, this standard on a timely basis (10 year interval). The Agency has not reviewed this standard in the period allotted and now desires to do so.

The objective of this Work Assignment is to obtain the support of S. Cohen and Associates (SC&A) for the revision of the risk assessment for the National Emission Standards for Radionuclides from uranium mill tailing facilities. These facilities include mill tailing operations, in situ leach mining facilities, and potentially heap leach facilities. Specifically, SC&A will use its knowledge of these operational sites, and projections on potential future milling, in situ leach, and heap leach mining sites to revise the risks that were conducted in the final environmental impact statements conducted for this portion of the NESHAPs standard only. Risk assessments will be conducted for all existing facilities required to meet the Subpart W provisions, and SC&A will develop risk assessment scenarios for select representative future milling and mining operation sites. The information developed in this Work Assignment will be used by the Agency in the determination of whether the existing standards for Subpart W need revising, and, if so, what may represent reasonable revisions to the standard.

2.0 TASK DESCRIPTIONS AND APPROACH

SC&A will meet the objectives of this Work Plan by performing five distinct tasks, as described below. In meeting the requirements of this work assignment, SC&A will be in a support role, and will not be involved in the development of EPA policy, nor in any other activity that is an "inherently governmental function."

2.1 Task 1 – Prepare work plan and cost proposal

This Work Plan fulfills the deliverable requirements for Task 1. It presents SC&A's approach for accomplishing the Work Assignment, including a schedule of deliverables, staffing plan (with statements of experience), estimated labor hours, and a detailed cost proposal, with relevant ODCs, on a task-by-task basis. In developing the Work Plan, SC&A reviewed the original risk assessment material used to make the risk standard determination, included in the Final Environmental Impact Statement – NESHAPS for Radionuclides, Background Information Document - Volumes 1, 2, and 3 (EPA/520/1-89-005, EPA/520/1-89-006-1 & 2, and EPA/520/1-89-007, September 1989).

SC&A has reviewed the entire three-volume FEIS/BID. Volume 1 contains NESHAPS programmatic information that will not be revised or updated as part of this Work Assignment. SC&A has identified that Volume 2, Section 9 "Licensed Uranium Mill Tailings Facilities" and

Volume 3, Section 4 "Licensed Mill Tailings" are the main portions of the BID that are applicable to Subpart W. Most of the risk assessment information contained in Volume 2, Section 9 is also contained in Volume 3, Section 4. Volume 2, Appendix A contains the risk model data input sheets, which will be revised to reflect the risk model selected for use, as well as the sites to be analyzed. Volume 2, Appendix B contains the generic unit costs for earth cover-based radon control techniques, which will also be updated to reflect current cover designs (if different from the 1989 design) and current unit construction costs. All other sections of Volumes 2 and 3 address facilities other than operating uranium mills, and will not be revised or updated as part of the Work Assignment. Additional specifics on the FEIS revisions and updates are provided below under Task 4.

2.2 Task 2 – Prepare a Quality Assurance Project Plan and a Quality Assurance Report

SC&A's QA Manager will prepare a brief Quality Assurance Project Plan (QAPP) and a Quality Assurance Report. The QAPP will include:

1. Two reviews of the deliverables listed in Tasks 4 and 5 to determine the reliability of the information provided in the two reports.
2. A QA appendix will be attached to each report from Task 4 and Task 5 which documents the verification activities performed by SC&A's QA organization

The QAPP will be approved by SC&A's QA Manager before any work begins on Task 4. The QAPP will be approved by the EPA WAM and EPA QA Coordinator.

The QA Report will include all required reviews to make the product meet Agency QA standards.

2.3 Task 3 – Risk Assessment Model

The FEIS/BID used AIRDOS to calculate dose and risk to the public. SC&A will review the appropriateness of using AIRDOS to calculate individual and population dose and risk. SC&A will also use our knowledge of existing models to determine if other models exist for calculating dose and risk from the management of uranium byproduct materials from the processing of uranium ores. Candidate models that will be evaluated by SC&A include:

- **CAP88**: The CAP88 (which stands for Clean Air Act Assessment Package - 1988) computer model is a set of computer programs, databases, and associated utility programs for estimation of dose and risk from radionuclide emissions to air. CAP88 is composed of modified versions of AIRDOS-EPA and DARTAB. CAP88-PC Version 3 incorporates dose and risk factors from Federal Guidance Report 13. CAP88-PC is an EPA-approved system for demonstrating compliance with 40 CFR 61 Subpart H, the Clean Air Act standard which applies to U.S. Department of Energy (DOE) facilities that emit radionuclides to air. EPA will provide the latest version of CAP88 to SC&A for evaluation; otherwise, SC&A will evaluate Revision 3, currently available from the EPA website: http://www.epa.gov/radiation/assessment/CAP88/.

- **GENII**: The GENII system, developed by the Pacific Northwest National Laboratory, includes the capabilities for calculating radiation doses following chronic and acute releases. Radionuclide transport via air, water, or biological activity may be considered. Air transport options include both puff and plume models. Building wake effects can be included in acute atmospheric release scenarios. The code provides risk estimates for health effects to individuals or populations; these can be obtained using the code by applying appropriate risk factors to the effective dose equivalent or organ dose. In addition, GENII Version 2 uses cancer risk factors from Federal Guidance Report 13 to estimate risk to specific organs or tissues.
- **RESRAD**: RESRAD is a computer model developed by Argonne National Laboratory to estimate radiation doses and risks from RESidual RADioactive materials. Since 1989, RESRAD has been used widely by the U.S. Department of Energy (DOE), its operations and area offices, and its contractors for deriving limits for radionuclides in soil. RESRAD has also been used by the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers, U.S. Nuclear Regulatory Commission (NRC), industrial firms, universities, and foreign government agencies and institutions.
- **MILDOS-AREA**: The Argonne National Laboratory also developed MILDOS-AREA, a computer code that calculates the radiological dose commitments received by individuals and the general population within an 80-km radius of an operating uranium recovery facility. The transport of radiological emissions from point and different area sources is predicted with a sector-averaged Gaussian plume dispersion model. Mechanisms such as radioactive decay, plume depletion by deposition, in-growth of decay products, and resuspension of deposited radionuclides are included in the transport model. Alterations in operation throughout the facility's lifetime can be accounted for in the input stream. The exposure pathways considered are inhalation; external exposure from groundshine and cloud immersion; and ingestion of vegetables, meat, and milk. Dose commitments are calculated primarily on the basis of the recommendations of the International Commission on Radiological Protection (ICRP). Only airborne releases of radioactive materials are considered in MILDOS-AREA; releases to surface water and to groundwater are not addressed in MILDOS-AREA. MILDOS-AREA is a multi-purpose code that can be used to evaluate population doses for NEPA assessments, maximum individual doses for predictive 40 CFR 190 compliance evaluations, or maximum offsite air concentrations for predictive evaluations of 10 CFR 20 compliance.
- **MEPAS**: Multimedia Environmental Pollutant Assessment System (MEPAS), developed by the Pacific Northwest Laboratory (PNL), is a suite of integrated impact assessment software comprising physics-based fate and environmental transport models of air, soil, and water media. MEPAS simulates the release of contaminants from a source; transport through the air, groundwater, surface water, and/or overland pathways; and transfer through food chains and exposure pathways to the exposed individual or population. For human health impacts, risks are computed for carcinogens and hazard quotients for noncarcinogens.
- **AERMOD**: AERMOD was developed by the AERMIC (American Meteorological Society (AMS)/U.S. Environmental Protection Agency (EPA) Regulatory Model Improvement Committee), as a state-of-the-practice Gaussian plume dispersion model whose formulation is based on planetary boundary layer principles. The AERMOD

model utilizes a probability density function and the superposition of several Gaussian plumes to characterize the distinctly non-Gaussian nature of the vertical pollutant distribution for elevated plumes during convective conditions; otherwise, the distribution is Gaussian. Also, nighttime urban boundary layers (and plumes within them) have the turbulence enhanced by AERMOD to simulate the influence of the urban heat island. The AERMOD model is applicable to rural and urban areas, flat and complex terrains, surface and elevated releases, and multiple sources (including, point, area, and volume sources).

Additional programs that may be discussed, but are not expected to make the formal evaluation process, include: GASPAR – used by the NRC to demonstrate compliance with the airborne dose limits of 10 CFR Part 50, Appendix I and GENII-NESHAPS – designed to help site managers plan and improve compliance with 40 CFR 61, Subparts H and I.

Before proceeding with the detailed evaluation a preliminary screening of the codes will be performed. The preliminary screening will eliminate codes that lack a major feature required for the analysis (e.g., the code does not calculate dose), as well as codes which may have the same or similar development histories. Those codes that pass the preliminary screening would be evaluated against a series of criteria, and given a score from 1 to 5. An initial list of the evaluation criteria include:

- **Exposure Pathways Modeled (2)**: Are all of the exposure pathways that are essential to this analysis included in the code? Additionally, does the code allow for exposures to different age groups (i.e., adults, teens, children, infants) and/or sexes to be calculated?
- **Dose Factors Used (1.75)**: Does the code utilize dose conversion factors based on the most recent International Commission on Radiological Protection (ICRP) recommendations?
- **Risk Factors Used (1.75)**: Does the code utilize the most recent risk factors?
- **Processing of Meteorological Data (1.5)**: Can the code process "raw" meteorological data, or does the meteorological data need to be pre-processed prior to being entered into the code? For example, does the code accept "raw" meteorological tower data (e.g., from http://www.epa.gov/scram001/surfacemetdata.htm), or does it accept joint frequency data, or does it only accept dispersion and deposition factors? If a code does not include the capability to process "raw" meteorological data, then a separate code (e.g., STAR from http://www.epa.gov/scram001/metobsdata_procaccprogs.htm) would need to be run to generate the input necessary for the risk assessment model.
- **Source Term Calculation (1.5)**: Can the code calculate radon releases, or must the releases be pre-calculated and entered into the code? If a code does not include the capability to calculate the radon releases, than an additional calculation would be needed to estimate the source term so that it can be entered into the risk assessment model. Alternatively, a code that contains an internal source term calculation would be difficult to modify, should the source term model change.
- **Input Parameter Sensitivity Analysis (1.5)**: Does the code have the capability to perform sensitivity analyses on the input data, or must parameter sensitivity be

determined by multiple runs, each run varying a single parameter? EPA/520/1-89-005, Section 7 describes uncertainty analyses that were performed. Although this Work Assignment does not specify them, EPA may want to perform similar uncertainty analyses for this revision in the future.

- **Verification and Validation (1.25)**: Is there a readily available V&V package that supports the code? Is the V&V package complete? Has there been independent (i.e., by someone other than the code's developer) V&V performed?
- **Ease of Use/User Friendly (1.25)**: Is the code provided with a user interface that is intuitive and easy to understand and use? Alternatively, does the code require the user to manipulate structured input data files? Additionally, does the code have features not required for this analysis, but that might complicate its use?
- **Documentation (1)**: Is the code well documented? Are there User's Manuals readily available? In addition to providing instructions as to how to use the code, are the mathematical models used by the code well documented? It is expected that all of the codes selected for evaluation would have high scores for this criteria.
- **Probabilistic Analysis Capability (1)**: Is there a probabilistic analysis version of the code available? Although the calculations being performed for WA 1-04 are being done deterministically, at some point the EPA may desire to perform a probabilistic analysis, and it would be desirable to use the same code for both analyses.
- **SC&A Familiarity (tie breaker):** If two or more models have identical (or nearly identical [i.e., within 10%]) scores based on the above criteria, then the SC&A recommendation will be based on how familiar SC&A is with the operation of each code.

The above list of evaluation criteria is preliminary, and SC&A will work with the WAM to finalize the code evaluation criteria. As can be seen from the above list, some criteria are of greater importance than other criteria. To account for this, each criterion will be given a weighting factor ranging from 1 to 2; preliminary weighting factors are shown in parenthesis on the above list of evaluation criteria. SC&A will work with the WAM to develop the final weighting factors for each criterion. The final score of the evaluation will be the sum of each criterion's score times its weighting factor.

SC&A will provide a recommendation to the WAM on the best model for use in presenting findings on individual and population dose and risk. This task will be completed prior to proceeding with the detailed risk estimates in Task 4.

2.4 Task 4 – Detailed Risk Estimates

SC&A will develop detailed risk estimates for each currently operating source of emission regulated by Subpart W from the management of uranium byproduct materials from the processing of uranium ores. These estimates were presented on a facility-by-facility basis in the 1989 EIS, and SC&A will conduct them in the same format for this analysis for all currently operating uranium mills (i.e., permanently shut-down mills and mills in DOE's long-term care will not be analyzed). Tables 1 and 2 present a preliminary list of operating conventional and in situ uranium mills, respectively.

Table 1. Tailings Impoundments at Conventional Uranium Mills

Mill	Total Acres	Ponded	Wet	Dry	Radium Content (pCi/g)
Sweetwater	37	30	0	2	280
White Mesa	130	55	70	5	961
Canon City	130	128	2	0	400

Source: SC&A Report to EPA WA 4-11, Task 5, July 18, 2008, Table 1

Table 2. Operating ISL Facilities

Company	Site	State
Cameco	Smith Ranch – Highland	WY
Cameco	Crow Butte	NE
Hydro Resources	Crown Point	NM
Cogema*	Christenson/Irigaray	WY
Hydro Resources	Church Rock	NM
Mestena	Alta Mesa 1,2,3	TX
Uranium Resources	Kingsville Dome 1,3	TX
Uranium Resources	Vaquez 1,2	TX

Source: SC&A Report to EPA WA 4-11, Task 5, July 18, 2008, Table 4
* Provided by B. Littleton, EPA, April 28, 2010

The Tables 1 and 2 lists of sites to be evaluated are preliminary, but have been used to provide a cost estimate for this Work Assignment. SC&A will work with the WAM to finalize the list of currently operating uranium mills to be included in the analysis.

In addition to currently operating facilities, SC&A will identify two or three representative facilities that will be used to approximate conditions of new facilities. This will be done to accommodate the recognition that several new processing facilities are expected to apply for licenses in the near future.

SC&A will develop a report that may be used to revise the specific text, tables, and figures of the FEIS – NESHAPS for Radionuclides, Background Information Document. Specifically, as specified by the Work Assignment, SC&A will address the following four topics:

(1) The source category, the processes that result in the releases of radionuclides into the environment, and existing controls.

For each of the uranium mills identified in Tables 1 and 2, SC&A will perform a literature search to obtain information relevant to the characterization of the facility. As stated above, the characterization will begin with the source category (e.g., operating in situ, standby conventional, etc.), a description of the processes involved, a description of the site layout (including a plot plan, if possible), and a description of existing radon control devices.

Sources contacted by SC&A will include the Nuclear Regulatory Commission, Agreement State regulatory agencies, the Department of Energy, and the owner/operator of the mill. Types of documents consulted will include license applications, responses to requests for additional information (RAIs), safety evaluation reports, environmental assessments, radiological and environmental monitoring reports, inspection reports, etc. For example, the NRC's Agency Document Access and Management System (ADAMS) contains 577 documents the contain Crow Butte in their title.

Due to our previous work with ORIA, SC&A is already in possession of many of the documents that are needed to complete this portion of the Work Assignment.

If necessary, visits to one or more of the facilities by SC&A may be necessary to obtain additional necessary information.

SC&A will present the facility-specific information obtained in a summary table, similar to EPA/520/1-89-007, Table 4-25.

(2) The bases for the risk estimate, including reported emissions, source terms used, and other site parameters relevant to the dose assessment.

The second Task 4 subtask is also a data collection task. Specifically, the data collected in this subtask will be used as the input for the exposure and risk assessment models. First of all, radon release, or source term, data are necessary. It may be possible to reconstruct the source term from the semi-annual radiological effluent and environmental monitoring reports that are required from each facility (e.g., there are 23 such reports in the NRC's ADAMS for the Crow Butte facility). For example, Appendix E of the 2009 Third and Fourth Quarter Crow Butte effluent report indicated the following radon releases:

Second Half 2009 Startup:	7 Ci
3rd Quarter 2009 Leaching Operations (26,445 liters processed)	1,772 Ci
4th Quarter 2009 Leaching Operations (26,358 liters processed)	1,745 Ci
Restoration – Wellfield Loss	87 Ci
Restoration – Ion Exchange Loss	26 Ci
Restoration – Reverse Osmosis Loss	105 Ci
Startup of New Restoration	1 Ci
Total Estimated Radon Release, Second Half 2009	3,744 Ci

Similar reports exist for the other operating uranium facilities, and each facility's reports will be obtained, reviewed, and the data utilized, as appropriate.

As an alternative and/or supplement to the data from the semiannual effluent reports, SC&A will calculate the source term. For tailing areas that have been covered, SC&A will use the methodology documented in NRC's Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers", Appendix B "The RADON Program".

Alternatively, the World Information Service on Energy (WISE) Uranium Project websites contain: (1) a Uranium Mill Tailings Radon Flux Calculator (http://www.wise-uranium.org/ctb.html) to determine the radon flux from a bare and/or water-covered uranium mill tailings pile, and (2) a Uranium Mill Tailings Cover Calculator (http://www.wise-uranium.org/ctc.html) to determine the radon flux through a multi-layer soil cover of an uranium mill tailings pile and/or optimize the cover for a given flux. SC&A may use either or both of the WISE calculators to determine the radon flux. The radon emission from evaporation ponds scenario developed under Task 5 of this Work Assignment may be used by SC&A to model the source term from evaporation ponds.

For tailing areas that have not been covered, SC&A will estimate the source term from: the radon flux per unit area, the fluxing area of the tailings pile, and the duration, in years. To calculate the radon flux from bare tailings, SC&A may use either a radon flux per unit area of 1 pCi/m^2/s radon-222 is emitted per pCi/g radium-226 (consistent with EPA/520/1-89-007) and/or the WISE calculator, described in the preceding paragraph.

The semiannual effluent reports may also provide information on the ambient radon (and U-natural and Pb-210) concentration at off-site air monitoring locations. These radon air concentration data may be used to directly calculate the exposure/risk to an individual assumed to be living at the air monitoring location. This type of calculation will be used by SC&A to either check or supplement the individual exposure/risk results obtained from the risk assessment model.

SC&A will present the facility-specific source term in a summary table, similar to EPA/520/1-89-007, Table 4-26.

In addition to developing source term data (either from effluent reports or calculated), SC&A will need to collect demographic and meteorological data for the area surrounding each of the Tables 1 and 2 facilities. Information on the reasonable maximum exposed individual (RMEI) (i.e., the nearest resident) will be obtained from available facility documentation [see subtask (1), above]. In the unlikely event that no information can be located to define the nearest resident, SC&A would estimate the RMEI exposure/risk at the facility's site boundary in the most frequent downwind direction.

SC&A will obtain regional (i.e., within 80 kilometers) population data from the 2000 U.S. census. SC&A is aware that for the years between censuses, the U.S. Census Bureau provides estimates of the population. SC&A will work with the WAM to determine whether to use the data from the 2000 census directly or to use a Census Bureau estimate for a later year, i.e., 2009. The SECPOP code may be used to convert the census data into sector- and distant-dependent data for each site.

SC&A will present the facility-specific population data in a summary table, similar to EPA/520/1-89-007, Table 4-27.

For each facility SC&A will obtain meteorological data from the nearest National Weather Service (NWS) station. NWS data are available from the EPA website (http://www.epa.gov/ scram001/surfacemetdata.htm) in the form of "raw" meteorological data (e.g., ceiling height, wind direction, wind speed, dry bulb temperature, and cloud cover). Alternatively, NWS data may be taken from CAP88 (even if CAP88 is not selected as the risk assessment model). The CAP88 weather data library provides data in the form of joint frequency tables (i.e., wind speed, wind direction, and stability class). Depending on the risk assessment model used, either source of meteorological data may need pre-processing prior to its use.

The Work Assignment has requested that two or three representative facilities be used to approximate conditions of new facilities. Like the facilities in Tables 1 and 2, these representative facilities would be defined by their source term, demographics, meteorology, and nearest resident. For the representative facility source term, SC&A would select a specified percentile source term that was developed for the Tables 1 and 2 facilities. SC&A will work with the WAM to decide whether to select the 50^{th}, 90^{th}, or some other percentile, and whether one or more source terms are necessary.

There are a couple of possible ways to specify the demographics and meteorology for the reference facility. First, a specific location within the country could be selected (possibly a location that has shown an interest in developing a uranium mill). Once the location is selected, the demographics and meteorology data would be obtained from the U.S. Census Bureau and National Weather Service, just as it was for the Tables 1 and 2 facilities. Alternatively, all of the U.S. Census Bureau and National Weather Service national data could be used to calculate a national distribution of the relevant parameters (e.g., population density, atmospheric dispersion); then the representative facility's values could be selected at the 50^{th}, 90^{th}, or some other percentile level (the exact percentile would be decided in consultation with the WAM).

The reference facility's nearest resident, or RMEI, would be located at a specified distance in the most frequent downwind direction. The distance could be based on the distance to the nearest resident at the Tables 1 and 2 facilities, or it could be simply a nominal distance (e.g., a half-mile, a half-kilometer). SC&A will work with the WAM to select the nearest resident distance for the reference facility. (Note, although this discussion refers to a reference facility, SC&A would actually evaluate two or three reference facilities, as per the Work Assignment.)

(3) The results of the dose and risk calculation, along with an extrapolation to the entire category.

This section would present the results of the dose and risk facility-by-facility risk assessment model results. An extrapolation of the doses and risks to the entire source category will also be provided. SC&A will present the facility-specific estimated exposures and risk in a summary table, similar to EPA/520/1-89-007, Table 4-29. Estimated total cancers per year will be presented in a table similar to EPA/520/1-89-007, Table 4-30, while the estimated distribution of the fatal cancer risk will be presented in a table similar to EPA/520/1-89-007, Table 4-31.

Additionally, the risk assessment model data input sheets will be provided in a manner similar to the input sheets in EPA/520/1-89-006-2, Appendix A. SC&A will work with the WAM to determine the exact form of the input data sheets, i.e., whether they are to be data summaries (similar to what is currently in Appendix A), or whether they are the exact files used as input to the risk assessment model. The advantage of the latter is that it allows for the risk assessment model to be easily run; its disadvantage is that it may be difficult to understand by anyone not intimately familiar with the operation of the risk assessment model.

Note: EPA/520/1-89-006-1 and EPA/520/1-89-007 presented individual and population exposures in units of working-level (WL) and person-working level month (person-WLM), respectively. SC&A proposes to present individual and population exposures in the more conventional units of millirem and person-rem, respectively.

(4) A description of supplementary emissions controls and their cost and effectiveness in reducing dose and risk.

EPA/520/1-89-006-1, Section 8.4 evaluated the effectiveness of eight emission control technologies: Earth Cover, Water Covers, Synthetic Covers and Chemical Sprays, Thermal Stabilization, Chemical Processing, Soil Cement Covers, Deep-Mine Disposal, and Caliche Cover. For various reasons, Section 8.4 found that (with the exception of the earth cover) none of the technologies were effective at controlling radon emissions. SC&A will review the currently available literature to determine whether sufficient progress has been made in any of the technologies since 1989 to modify the EPA/520/1-89-006-1 conclusion. SC&A will also review the literature to determine whether there are any additional technologies that have been developed since 1989, which could be used to control radon emissions. The information gathered by SC&A during this effort will be presented in a manner similar to that used in EPA/520/1-89-006-1, Section 8.4.

EPA/520/1-89-006-2, Appendix B presents a generic cost estimate for the installation of an earth cover to control radon emissions. Because EPA/520/1-89-006-1, Section 8.4 identified the earth cover as the only effective emission control technology, the earth cover was the only technology that had an Appendix B generic cost estimate. The Appendix B costs were based on five basic steps or operations required to place earthen covers on inactive tailings piles: (1) regrading the slopes of the pile to achieve long-term stability; (2) procurement and placing of the dirt cover; (3) placing gravel on the pile tops; (4) placing of riprap on the pile sides; and (5) reclamation of the borrow pits.

To arrive at the earth cover generic cost, Appendix B is divided into three sections: Section B.2 – the formulas used to calculate the depth of cover required to meet specified emission rates; Section B.3 – a summary of the geometry required to estimate the pile volumes and surface area; and Section B.4 – the development and documentation of the generic units costs. SC&A will review the formulas and geometry used in Appendix B to insure that they remain valid. If it is discovered that the current earth cover design differs significantly from the 1989 design, SC&A will update and revise Sections B.2 and B.3 accordingly.

However, at this time SC&A believes that most of the effort of this subtask will be for updating the unit costs contained in Section B.4. As done in the 1989 Appendix B, construction cost data will be taken from the cost compendiums published by the RS Means Company (e.g., Heavy Construction Cost Data 2010 Book, Site Work & Landscape Cost Data 2010 Book, Environmental Remediation Estimating Methods).

Even though most of Sections B.1 through B.3 will not be changed by this update, in order to keep all of the unit cost information together, SC&A proposes to re-issue EPA/520/1-89-006-2, Appendix B in its entirety. As in the current Appendix B, the report will include the inputs, the calculation, the basis of all parameters, and the methodology used to calculate the costs and effectiveness of earthen covers to control radon emissions from area sources. The revised earth cover unit costs will be provided in two tables – the first in units of dollars per square yard or cubic yard, and the second in units of dollars per square meter or cubic meter, similar to current Tables B-9 and B-10.

Because EPA/520/1-89-006-1, Section 8.4 identified the earth cover as the only effective emission control technology, the earth cover was the only technology that had an Appendix B generic cost estimate. Should SC&A's literature review reveal that there are additional effective emission control technologies, SC&A will provide generic cost estimates for implementing those technologies using a similar approach as was used to develop the earth cover generic cost estimate.

2.5 Task 5 – Radon Emissions from Evaporation Ponds

SC&A will develop a scenario to bound radon emissions from evaporation/settling ponds in a worst-case scenario. This bounding emission calculation will be based on the highest concentrations of contaminants in the ponds and will model upset conditions which include reasonable time periods for turbulent flow conditions. The results will be included in a report, along with a detailed explanation of the scenario and the basis of all parameters included in the analysis.

Estimates of radon from water-covered tailings were presented in the ORNL-TM-4903[1] review of the uranium extraction industry. The ORNL report used a "stirred pond model" which assumed all radon from the decay of radium is dissolved in the pond water and all radon which diffuses to the solid liquid interface is released to the atmosphere. Subsequently, radon from the surface of tailings ponds was ignored, as diffusion calculations indicated radon would travel no more than a few centimeters due to its very low diffusion coefficient in water (of the order of 10^{-5} cm^2/sec or so. Nielson and Rogers[2] noted that the tailings ponds were not motionless, but had considerable water motion. They considered the advective transport of radon from the surface of tailings ponds. The World Information Service on Energy (WISE) Uranium Project website contains a Uranium Mill Tailings Radon Flux Calculator (http://www.wise-uranium.org/ ctb.html) that uses Nielson and Rogers' methodology to determine the radon flux from a bare and/or water-covered uranium mill tailings pile.

Mudd[3] has used the Nielson and Rogers studies to show estimates of radon from Australian uranium tailings ponds are problematic. Other authors used one-dimensional vertical advection-diffusion models to estimate radon exchange from sediments and fluxes to the atmosphere. These models are particularly important in oceanographic studies where radon is used as a natural tracer. For example, a 2000 study by Burnett, et al.[4] Also, in an anticipated paper[5], Simonds, Schierman, and Baker describe a method for predicting the radon flux from a water body, which incorporates Fick's laws of diffusion and the stagnant-layer theory of gas-water exchange. Good agreement was found between the model predictions and measurements obtained from floating adsorption canisters on an evaporation pond containing elevated Ra-226 concentrations.

Evaporation ponds are used to retain process-related liquid effluents that cannot be discharged directly to the environment. These effluents are considered byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act of 1954. The residual solid waste materials normally

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[1] ORNL (Oak Ridge National Laboratory) 1975. "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides-Milling of Uranium Ore," ORNL-TM-4903 Volume 1, Sears, M.B., R.E. Blanco, R.C. Dahiman, G.S. Hill, A.D. Ryan, and J.P. Witherspoon. May 1975.

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[3] Mudd G.M. (2002). Uranium Mining in Australia: Environmental impact, radiation releases and rehabilitation. *Protection of the Environment from Ionising Radiation-Proceedings of the Third International Symposium,* Darwin, Australia, 22-26 July 2002, Vienna, International Atomic Energy Agency.

[4] Burnett, W.C., J. Chanton, D.R. Corbett and K Dillon, "The Role of Groundwater in the Nutrient Budget of Florida Bay". Part I Final Report, NOAA Project # NA96OP0234, July 14, 2000.

[5] Simonds, M.H., M.J. Schierman, and K.R. Baker, "Radon Flux from Evaporation Ponds Containing Elevated Concentrations of Radium-226," Environmental Restoration Group, 55th Annual Meeting of the Health Physics Society, 27 June - 1 July 2010, Salt Lake City, Utah.

remain in ponds until the ponds are decommissioned, when sludges are disposed of as 11e.(2) material at a licensed disposal facility. A typical facility may have three evaporation ponds, with each pond having a surface area of up to 6.2 acres and a depth of about 17 feet[6].

Finally, SC&A understands that the EPA has requested that ISL facilities provide radon flux data from their evaporation ponds[7]. SC&A will utilize any data that are provided as a result of that request in the development of an evaporation pond radon emission model.

Based on the above discussion, SC&A will review the various models and parameters, select an appropriate model, and develop a set of parameters to use for predicting evaporation pond radon emissions, including an upper bound, worst-case scenario.

2.6 Communication

Principal communications will be between the WAM and the SC&A Task Manager. As warranted, some communications will also include the SC&A Project Manager and other SC&A technical staff assigned to work on specific aspects of the WA. SC&A will file a written monthly report with the WAM that summarizes the work accomplishments during the previous month, discusses any issues that have arisen and actions taken or underway to resolve those issues, and estimates the level of effort that will be accomplished in the upcoming month. At least monthly, SC&A will participate in a teleconference with the WAM.