State of Utah

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Department of
Environmental Quality

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DIVISION OF RADIATION CONTROL
Rusty Lundberg
*Director*

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DRC-2014-005881

October 3, 2014

Mr. Vern Rogers, Acting Director of Compliance and Permitting
EnergySolutions, LLC
423 West 300 South, Suite 200
Salt Lake City, UT 84101

SUBJECT: Clive Environmental Monitoring Plan: Radioactive Material Licenses UT 2300249 and UT 2300478

Dear Mr. Rogers:

Enclosed is a copy of the revised Environmental Monitoring Plan (Plan) dated July 22, 2104. As you are aware, the public comment period closed September 22, 2014, and the Division of Radiation Control (DRC) did not receive any public comments regarding changes to the Plan.

The Environmental Monitoring Plan (Appendix M) in the Low Level Radioactive Waste License Renewal Application was reviewed separately as per the licensee's request. Based on DRC's review of Plan and closure of the public comment period, the Director hereby approves the Environmental Monitoring Plan dated July 22, 2014. This revised Plan will be incorporated into License Condition 26 in Radioactive Material Licenses (RML) UT2300249 and License Condition 12.1 in RML UT2300478 during a future amendment or renewal license.

If you have any questions or concerns regarding the letter, please contact John Hultquist at (801) 536-4250.

Sincerely

Rusty Lundberg

Rusty Lundberg, Director

RL/RJ:rj

Enclosure

# ENVIRONMENTAL MONITORING PLAN

## 1.0 PURPOSE AND SCOPE

**Purpose:** The purpose of the Environmental Monitoring Plan is to provide a comprehensive plan for monitoring radiation and radioactive emissions from Energy*Solutions'* Clive radioactive waste-licensed facilities to the environment. This information will be used to demonstrate regulatory compliance and evaluate the effectiveness of measures to control the environmental impact of disposal operations and the effectiveness of Energy*Solutions'* ALARA philosophy.

**Scope:** The scope of this Plan includes the activities Energy*Solutions* performs to monitor the site and surrounding area during operations at the Clive radioactive waste disposal facilities, and to report the net radiological effects that result from managing licensed material. The details of this Plan include the applicable assumptions, tested parameters, and testing methods that collectively express regulatory compliance with regard to radioactive emissions and non-occupational radiation doses.

With the exception of the PCB soil sampling, this Plan does not include meteorological, occupational, chemical, or groundwater monitoring requirements.

## 2.0 REFERENCES

CDC, *Evaluation of Exposure to Radon Progeny During Closure of Inactive Uranium Mines – Colorado* (2011-0090-3161) National Institute for Occupational Safety and Health, U.S. Centers for Disease Control and Prevention. July, 2012.

Clive, *Radiation Protection Program*, Salt Lake City, Energy*Solutions,* Inc, Utah, As Revised.

Clive, *Clive Facility Security Operations Protocol* (CL-SE-PR-001), As Revised.

Energy*Solutions* (2014). *Environmental Monitoring Plan Interrogatory Responses (received April 9, 2014 and June 2, 2014).* Energy*Solutions*, July 18, 2014.

Energy*Solutions*, *Quality Assurance Program* (ES-QA-PG-001), As Revised.

Environmental Protection Agency, "Statistical Analysis of Groundwater Monitoring Data at RCRA Facility: Unified Guidance, (EPA 530/R-09-007)" Office of Resource Conservation and Recovery, Program Implementation and Information Division, U.S. Environmental Protection Agency, March 2009.

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ICRP Publication 60, *Recommendations of the International Commission on Radiation Protection*, Annals of the International Commission on Radiation Protection Vol. 21 No. 1-3, 1990.

ICRP Publication 65, *Protection against Radon-222 at Home and at Work*, Annals of the International Commission on Radiation Protection Vol. 23 No. 2, 1993.

ICRP Publication 66, *Human Respiratory Tract Model for Radiation Protection*, Annals of the International Commission on Radiation Protection Vol. 24, 1994.

ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, Annals of the International Commission on Radiation Protection Vol. 24 No. 4, 1995.

ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides*, Annals of the International Commission on Radiation Protection Vol. 26 No. 1, 1996.

*Regulating the Disposal of Low-Level Radioactive Waste – A Guide to The Nuclear Regulatory Commission's 10 CFR Part 61*, United States Nuclear Regulatory Commission, 1989

Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, United States Nuclear Regulatory Commission, 1974

NRC Staff Interim Guidance, *Evaluations of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of Compliance with 10 CFR 20.1301 – Revised Draft Report for Comment*, March 2014.

NUREG-1388, *Environmental Monitoring of Low-Level Radioactive Waste Disposal Facility*, United States Nuclear Regulatory Commission, 1989

NUREG-1573, *A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities*, United States Nuclear Regulatory Commission, 2000

NRC Regulatory Guide 3.64, *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, United States Nuclear Regulatory Commission, 1989

NRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, United States Nuclear Regulatory Commission, 1980

NRC Regulatory Guide 4.15, *Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment, United States Nuclear Regulatory Commission*, 2007.

NRC Regulatory Guide 4.18, *Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste,* United States Nuclear Regulatory Commission, 1983.

NRC Regulatory Guide 4.20, *Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors*, United States Nuclear Regulatory Commission, 1996.

NRC Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*, United States Nuclear Regulatory Commission, 1992.

NRC Regulatory Guide 8.37, *ALARA Levels for Effluents from Materials Facilities*, United States Nuclear Regulatory Commission,1993.

NRC *Radon Presentation* Oak Ridge Institute for Science and Education, 2011.

NRC, *NRC Staff Interim Guidance, Evaluation of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of compliance with 10 CFR 20.1301*, September 2011.

10 CFR Part 20, *Standards for Protection Against Radiation*, United States Nuclear Regulatory Commission, As Revised.

10 CFR Part 40, *Domestic Licensing of Source Material*, United States Nuclear Regulatory Commission, As Revised.

49 CFR.173.428, *Empty Class 7 (radioactive) materials packaging*, United States Department of Transportation, As Revised

49CFR 173.443, *Contamination control*, United States Department of Transportation, As Revised.

United Nations Scientific Committee on the Effects of Atomic Radiation (*UNSCEAR*), Volume I: Sources, 2006.

Utah Administrative Code, R313-15, *Standards for Protection against Radiation*, As Revised.

Utah Administrative Code, R313-25, *Requirements for the Land Disposal of Radioactive Waste*, As Revised.

## 3.0 DEFINITIONS

**Activity Mean Aerodynamic Diameter (AMAD):** Fifty percent of the activity in the aerosol is associated with particles of aerodynamic diameter greater than the Activity Mean Aerodynamic Diameter.

**As Low As Reasonably Achievable (ALARA):** Reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken. The determination of what is "reasonable" considers; the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations.

**Non-contaminated Restricted Area Exits:** A gate in the Restricted Area Security fence used to exit directly from a Non-contaminated Restricted Area.

**Committed Dose Equivalent (CDE):** The dose equivalent to organs or tissues from an intake of radioactive material by an individual during the 50-year period after intake.

**Committed Effective Dose Equivalent (CEDE):** is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. The organ-weighted factors, included as ECL values in Table 4, are multiplied by net isotopic airborne concentrations to determine isotopic CEDE values.

**Controlled Area:** an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

**Deep Dose Equivalent (DDE):** applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1,000 mg/cm$^2$).

**Dose Coefficient:** Factors determining the radiation exposure of individual organs and the whole body by incorporated radioactive substances. Dose factors depend on the radionuclide, the incorporation type (inhalation/ingestion), the chemical compound of the radionuclide and on the age of the person.

**Effluent Concentration Limit (ECL):** Radionuclide which, if inhaled or ingested continuously over the course of a year, would produce a stochastic total effective dose equivalent of 50 mrem. With the exception of radon-220 (radon) and radon-222 (thoron), the dose coefficients from International Commission on Radiation Protection Publication 68 and International Commission on Radiation Protection Publication 72 were used to calculate effluent concentration limit values. The Dose Coefficients used assume a 50 year CEDE and a 1 um AMAD particle size. Table 4 lists the "ECL" values for several licensed radionuclides, and provides additional details regarding the ECL derivation process.

**Equilibrium Equivalent Concentration (EEC):** The concentration of radon-222 (with decay products in secular equilibrium) that has the same potential alpha energy as the existing non-equilibrium mixture of decay products.

EEC = C x F = 0.105 [Po-218 concentration in pCi/L]
+ 0.516 [Pb-214 concentration in pCi/L]
+ 0.379[Bi-214 concentration in pCi/L]

Where:

| | | |
|---|---|---|
| C | = | Radon -222 concentration (pCi/L) |
| F | = | Equilibrium Factor, representing how close to secular equilibrium the radon-222 decay products are with radon-222. The equilibrium factor is low close to the source of radon, increasing with distance until equilibrium is reached. NRC reports F decreases as wind speed increases and is initially expected to be completely devoid of its decay products when released to the atmosphere (i.e., F=0). For a maximum transport distance from opposing corners of Section 32 (licensed area), average winds (MSI, 2013), and associated travel time of 938 seconds, an average F of 0.4 is calculated, which is equivalent to the mean F cited for outdoor air around abandoned mines, caves, mill tailings piles, and other significant sources (CDC 2012, pg.22). |

**Glass Fiber Filter:** Glass fiber filters used to collect airborne particulates. Filters must demonstrate a minimum of a 95% DOP collection efficiency for 0.3 um particles (according to ASMT method D-2986).

**Member of the Public:** A member of the public as defined by Utah Administrative Code (UAC), R313-15-301 is "*any individual except when that individual is receiving an*

*occupational dose*". A member of the public as applied to UAC R313-15-101(4), and UAC R313-25-19 is unassociated with Site operations and located outside controlled area boundaries.

**Minimum Detectable Concentration (MDC):** the smallest amount of radioactivity in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

**Occupancy Factor:** The fraction of time a person may have occupied a space or area having a known quantity of exposure. The exposure rate is assumed to be fairly constant for the entire exposure period.

**Particulate Air Sample (PAS) Action Levels:** Airborne particulate alpha or net beta concentration used to insure that the PAS results remain below the ECL. The alpha action level is 1.4E-13 uCi/ml, based on the thorium-230 Class S effluent concentration limit, and the beta action level is 2.1E-12 uCi/ml, based on the lead-210 Type F effluent concentration limit.

In the past the alpha PAS action level was based on the Th-232 ECL. While Table 4 of the Environmental Monitoring Plan indicates that Th-232 is more restrictive, Th-232 is always accompanied by several alpha emitting decay progeny at or near secular equilibrium with the Th-232 parent. The Th-232 ECL must be adjusted to account for the alpha emitting daughters when it used as the PAS Action Level. For this reason the Th-230 ECL is more restrictive.

Regulatory Guide 3.51 states that thorium in ore, yellowcake, and tailings dusts is 100% class Y, which is consistent with most of the waste containing Th-230. Class "Y" under the ICRP 30 system is analogous to type "S" under the newer ICRP recommendations.

**Radon Action Level (RAL):** Net airborne radon concentration limit of 50% of the upper exposure concentration limit defined in Section 5.1.3 (e.g., 2.43 pCi/L in compliance with UAC R313-15-301(a)) set to insure that the doses to the general public from the inhalation of radon remain below applicable regulatory limits. If, following resampling and/or reassessment, a net airborne radon concentration limit still exceeds the RAL, then corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

**Relative Measurement Difference (RMD):** Fractional measurement of the difference between two analytical results of the same environmental sample.

$$RMD = \frac{|A-B|}{A}$$

Where:

| | | |
|---|---|---|
| A | = | First analytical result. |
| B | = | Second analytical result |

RMD confirmatory analysis will be used, as follows:

Confirmation of laboratory Q/C through blind spikes: Stability of the laboratory measurement instruments and material handling/analysis procedures are monitored for accuracy, precision and freedom from interferences. When the analysis of a blindly-spiked sample measurement to its original-spiked activity exceeds an RMD of 0.1, it will be reanalyzed and used to complete a Condition Report. If, RMDs of blind spikes exceed 0.2 for three consecutive sample periods, then corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

**Replicate Error Ratio (RER):** The difference between two different analytical results divided by the statistical sum of their analytical uncertainty. The value is used to assess amount of agreement between two different analytical results with respect to their analytical uncertainty.

$$RER = \frac{|A-B|}{\sqrt{\sigma_A{}^2 + \sigma_B{}^2}}$$

Where:

| | | |
|---|---|---|
| A | = | First analytical result. |
| B | = | Second analytical result |
| $\sigma_A$ | = | Reported analytical uncertainty for the first sample. |
| $\sigma_B$ | = | Reported analytical uncertainty for the second sample. |

RER confirmatory analysis will be used, as follows:

Confirmation of field samples through duplicate/split analysis: Stability of the laboratory measurement instruments and material handling/analysis procedures are monitored for accuracy, precision and freedom from interferences. When a duplicate sample measurement has an activity that is less than 5 times the isotope's detection limit and exceeds an RER of 2, it will be reanalyzed. If, after the reanalysis the RER still exceeds 2, then a second set of samples of equivalent medium will be collected from the same location and reassessed. If, following resampling and reassessment, the RER still exceeds 2, then corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

**Restricted Area:** An area where access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. The fenced area that includes the disposal embankments and associated radioactive waste handling areas is generally referred to as the Restricted Area.

**Soil Action Levels:** Net 5 pCi/g by gamma spectroscopy for a naturally occurring radionuclide (other than potassium-40), 3 pCi/g cesium-137, or 2 pCi/g for any other radionuclide. Since potassium-40 (K-40) is typically found in soil at concentrations equivalent to 17 pCi/g, there are few, if any, industrial or scientific processes that generate K-40 above these concentrations. Therefore, K-40 is a poor indicator of radioactivity released into the environment. As such, it is excluded from the Soil Action Level definition.

**Soil Reporting Levels:** This level is defined as the level of concentration of radionuclides that exceeds the Soil Action Levels. When exceeded, sample shall also be analyzed for isotopic thorium. Energy*Solutions* shall initiate corrective actions (as documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program*). The exceeding radionuclide concentrations, results of the investigation and findings, and mitigating measures taken to correct the problem shall be reported to the Utah Division of Radiation Control (Division) in the subsequent semi-annual Report.

**Soil Triggering Levels:** Levels defined as isotopic concentrations above which an investigation is required. Soil Triggering Levels shall be deemed to be exceeded when 3 consecutive isotopic concentrations from any station increase by more than 1 standard deviation in each sample period or a single isotopic concentration is statistically categorized as an Outlier according to either the Dixon's (for less than 26 samples) or Rosner's Tests (for more than 25 samples) (as defined in Sections 12.3 and 12.4 of EPA, 2009). When triggered, further investigation and corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

**Total Effective Dose Equivalent (TEDE):** The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

**Vacuum Assisted Thermal Desorption (VTD)**: Treatment used to extract volatile contaminants from Mixed Waste. The VTD unit is located in the Mixed Waste Storage Building.

## 4.0 DESCRIPTION

The Site is located in the semi-arid west desert of Utah. The surrounding region is restricted by zoning statute for exclusive use by the hazardous waste industry. The closest residents are the live-in care takers at the I-80 rest stop, seven miles northeast of the Site.

The disposal site is a parcel of land, consisting of one square mile in Tooele County, Utah. Energy*Solutions* also owns the adjacent one square mile section of land to the north and an adjacent 0.5 square mile section of land to the south. The area used for waste disposal, unloading, hauling, and handling waste (Restricted Area) is completely surround by fence. There is a buffer area of 300 feet between the closest edge of any embankment and the property line. Most of the other land within a 10 mile radius of the site is public domain administered by the Bureau of Land Management. The dry arid desert limits use of the land to sheep grazing, jack rabbit hunting, and recreational driving.

As required by CL-SE-PR-001, "*Clive Facility Security Operations Protocol*," the site boundaries are under continuous electronic surveillance by a full-time security staff. Any unauthorized individuals found near the controlled area are advised by the security staff not to loiter near the Site.

## 4.1 EXPOSURE PATHWAY: INGESTION

Regulatory Guide 4.14 states that vegetation and surface water samples should be collected "*Where a significant pathway to man is identified in individual licensing cases.*" Because there is no significant ingestion pathway, vegetation and surface water samples are not taken.

The site has no nearby residents or crops. The groundwater is not suitable for irrigation, or consumption by either humans or animals. Surrounding vegetation is accessible to grazing animals but the sparse foliage and water sources are not adequate to keep livestock near the site for periods of time exceeding the general spring and summer vegetation growth period continuously (e.g., approximately 6 months).

There are no natural bodies of surface water near the site, and storm water quickly evaporates from the puddles which appear temporarily in shallow depressions following precipitation events. There is no natural drainage of this storm water away from the site area, and the facility design precludes runoff outside the approved waste management areas.

Administrative procedures require an immediate response to promptly characterize and remediate any suspected radioactive liquid found anywhere outside of the approved waste management areas. Any incidental deposition of effluent radionuclides outside of the restricted areas is easily detected by soil sampling.

## 4.2 EXPOSURE PATHWAY: EXTERNAL RADIATION

External radiation to members of the public is limited to gamma radiation. The potential sources of radiation during operations include the waste disposal cells, waste unloading areas, treatment areas, storage pads, the rotary dump, the shredder, the laboratory, and haul roads. Once operations have ceased, decontamination and decommissioning activities will be taken so that there will not be any remaining sources of external radiation and the embankments will be closed.

External radiation is monitored at designated air stations located along the Restricted Area boundaries. In addition, monitors are set up, as needed, inside buildings and on the Restricted Area fence to ensure compliance with the regulations.

## 4.3 EXPOSURE PATHWAY: INHALATION

Direct inhalation of radioactive airborne particulates and radon has the highest potential for off-site dose. Sources of inhalation exposure particulates during active operations include the rotary dump, the shredder, rail car unloading area, bulk waste storage areas, haul roads, the VTD, and waste disposal cells. Once operations have ceased and the embankments are closed, sources of inhalation exposure will consist of gaseous radon - 222 that has diffused into the atmosphere through the engineered cover systems.

Airborne radioactive particulates and gasses are continuously monitored at designated monitoring stations. With the exception of locations used to establish background and the VTD effluent monitoring station, the monitored locations are situated near the fenced boundaries that surround waste management areas. The overall sampling pattern is

designed to intercept airborne radioactive effluents leaving the site in any direction. The airborne exposure measured at these monitoring stations is used to calculate the dose received from Site airborne effluents.

## 4.4 DOSE LIMITS

Energy*Solutions'* RML requires compliance with applicable requirements of UAC R313. Dose limits during active operations to members of the General Public have been promulgated in UAC R313-15-301 and R313-15-101(4). Dose limits following facility closure are promulgated in R313-25-19. The methodology employed to demonstrate compliance with these limits is consistent with equivalent NRC-issued regulatory standards.

The application of each of these regulations requires; identifying the "*member of the public*", determining occupancy, identifying the applicable exposure types, converting measured results to potential exposure, and identifying the applicable limit. A general process is used to convert measured results to potential exposure for all three limits. The process assumes the monitoring results measured at the environmental monitoring station represent the potential exposure for the "*member of the public*" for a continuous occupancy. Compliance with "*member of public*" limits is determined by adjusting the measured monitoring station results by an occupancy factor related to the specific limit being evaluated.

### 4.4.1 UAC R313-15-101(4) ALARA Constraint During Operations

ALARA is evaluated in terms of population doses for the design options that are considered. This allows design options to be compared, and, ultimately, to be optimized. This regulation requires meeting a constraint of 10 mrem per year CEDE (excluding radon-222 and its decay products) to the individual member of the public who is likely to receive the highest dose from effluent air emissions during operations. NRC Regulatory Guide 4.20, "*Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors*", outlines the acceptable methods for demonstrating compliance with this regulatory requirement. Additional instructions in NRC Regulatory Guide 4.20 state, "*licensees need not consider nonresidents within the facility boundary*" Therefore, because of the remoteness of the Clive Facility and the associated types of activities in which humans might engage, members of the public for which ALARA constraint compliance is demonstrated include ranchers, hunters and off-highway vehicles enthusiasts that do not breach the controlled or restricted area boundary. As a result, an occupancy fraction of 1 week in a position "*likely to receive the highest dose from effluent air emissions during operations*" per year (i.e., 0.02) is used to demonstrate compliance.

### 4.4.2 UAC R313-15-301 Public Dose Limits During Operations

This regulation requires that the TEDE to individual members of the public from licensed or registered operations does not exceed 100 mrem in a year. Compliance is determined by UAC R313-15-302(2)(a). Since the most common activities involving the longest duration of possible exposure by the general public currently observed near the Clive facility are those of Energy*Solutions'* industrial neighbors, an occupancy factor of 2,000

hours per year (equivalent to a fulltime employee, or 0.25) is applied to demonstrate compliance with UAC R313-15-301.

### 4.4.3 UAC R313-25-19 Post Closure Public Dose limits

Following facility closure, the radioactive material which may be released to the general environment shall not result in an annual dose exceeding 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of a member of the public. In NUREG-1573, NRC recommends consideration of a 25 mrem/year TEDE as a more conservative approach to demonstrative compliance with UAC R313-25-19 (10 CFR 61.41). However, since this Public Dose Limit is restricted to concentrations of radioactive material which may be released to the general environment following facility closure, the calculated TEDE values used to demonstrate compliance should not include the DDE exposure measured during operations from active waste management and an unclosed disposal embankment. Placement of the engineered cover and radioactive decay during the Institutional Control Period is expected to eliminate any direct external exposure to the buried waste. Since this limit applies to Post Closure Members of the General Public, an occupancy of 1 week per year (0.02) is used to demonstrate compliance (as defined in Section 4.4.1).

## 5.0 OPERATIONAL REQUIREMENTS

## 5.1 AIR SAMPLING

### 5.1.1 AIRBORNE PARTICULATES - Alpha/Beta Screening

Air is continuously sampled at the sample locations, listed in Tables 1 through 3 and Drawing 10014-U03, as revised, with the exception of the VTD effluent which is only sampled during VTD operation. The stations located around the Restricted Area perimeter are used to determine the airborne concentration of radioactive particulates from disposal operations. Station A-16, located west of the Site, at the Clean Harbors Clive facility, is used to determine background.

Radioactive airborne particulate samples are collected using a constant-flow air sampler to draw air through a glass fiber filter, or a functionally similar particulate sampling media. The particulate air sampling apparatus maintains a flow rate of approximately 60 liters per minute through the filter media. With the exception of scheduled site shutdowns when no waste is managed – during which the airborne particulate sampling filters must be changed at least once in 9 days, the airborne particulate sampling filters are changed at least once a week (unless excessive particulate loading warrants more frequent replacement).

All particulate filters are analyzed for alpha and beta activity at least 7 days but not more than 14 days after collection. The delay of 7 days is needed to allow for the decay of short-lived radon progeny that could potentially interfere with detecting the long-lived contaminants of concern. The time limit of 14 days is to ensure that samples are analyzed in a timely manner. With the exception of the VTD sample, the alpha and beta concentration measured at Station A-16 is subtracted from the concentrations measured at the other stations. If for some reason the data from A-16 is not available or is

indeterminate, no background will be subtracted for the samples collected during the sampling period, so the gross concentrations will be used instead of the net concentrations.

Any individual sample filters with a net alpha or net beta concentration above the applicable PAS Action Level will be analyzed by gamma spectroscopy within 3 working days of the alpha/beta analysis. Gamma spectroscopy analysis results will be reviewed to determine if any additional actions need to be taken.

When an individual filter has a net alpha concentration above 3E-12 uCi/ml or net beta concentration above 5E-11 uCi/ml (originally computed as approximately 25 times the PAS Action Level and 25 filters per quarter per location), additional radiochemical analyses will be performed on that filter according to the requirements for semi-annual composite filters, unless gamma spectroscopy associates at least 50 percent of the net alpha or net beta activity present on the filter with gamma-emitting radionuclides. Other corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

### 5.1.2 AIRBORNE PARTICULATE – Composite Filters

All particulate air sample filters collected during the period are gathered into a composite sample and analyzed semi-annually for each air monitoring station. Each composite sample is analyzed by gamma spectroscopy using either the on-site instruments or a contractor laboratory. The composite samples (with the exception of VTD) will also be analyzed specifically for uranium-238 (U-238), uranium-234 (U-234), and uranium-235 (U-235), thorium-228 (Th-228), thorium-230 (Th-230), and thorium-232 (Th-232), radium-226 (Ra-226), lead-210 (Pb-210), and polonium-210 (Po-210). The specific analytical methods are determined by the accredited laboratories doing the analysis.

In order to maximize the detection sensitivity for the important radionuclides, any additional radiochemical analyses shall be limited to those radionuclides that could reasonably be expected to contribute more than five percent of the aggregate CEDE over the monitoring period. The potential relative dose fraction for each radionuclide will be determined each monitoring period by weighting its effective inhalation dose coefficient according to its relative abundance in the waste received during the monitoring period. Containerized Waste, large components, and encapsulated Mixed Waste are inherently not wind dispersible, so the nuclide activities of these waste types are therefore excluded from consideration for the semi-annual nuclide dose fraction determination.

### 5.1.3 RADON

Since NRC recognizes that because of its extremely short half-life (and comparatively short half-lives of radon-220 [thoron] daughters) when measuring outdoor gaseous radon-222 (radon) and thoron concentrations that, "*thoron concentrations are especially variable. The effective surface source of [thoron] is about 0.1 km$^2$ which means that thoron [observed] at a given location can be assumed to have originated within that immediate area.*" (NRC, 2011 pg. 21). As such, any thoron released will decay to undetectable levels in air sampled at locations not directly in contact with an open embankment. Therefore, air is continuously sampled for radon at the locations listed in Tables 1 through 3 and Drawing 10014-U03, as revised.

Unless statistically classified as outlying the distribution of associated historic background concentrations according to either the Dixon's (for less than 26 samples) or Rosner's Tests (for more than 25 samples) (as defined in Sections 12.3 and 12.4 of EPA, 2009) from the specific background location, the arithmetic mean of the radon concentrations measured at a minimum of three locations (Stations B-2, A-27 and A-16) will be used to characterize background and net radon concentrations. If statistically outlying, the arithmetic mean of the radon concentrations from the remaining stations will be used.

Compliance with the limits of UAC R313-15-301(a) is demonstrated by limiting exposure to a Rn-222 concentration below 4.9 pCi/L (Energy*Solutions*, 2014). Similarly, compliance with the limits of UAC R313-25-19 is demonstrated by limiting exposure to a Rn-222 concentration below 15 pCi/L (Energy*Solutions*, 2014) (assuming the absence of dose contributions from exposure to any other environmental constituents). When demonstrating compliance with the applicable dose limits of Section 4.0, exposure to the measured particulate and external exposure to gamma will be combined with the dose-impact from the inhalation to radon.

Any individual radon concentration measurement above the Radon Action Level will be reevaluated. Other corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

Radon concentrations are monitored using Landauer RadTrak® Dosimeters. The radon monitoring locations, listed in Tables 1 through 3 and Drawing 10014-U03, as revised, are selected to demonstrate compliance as the significant radon effluent sources are generally large uncovered areas of dispersed radium-bearing wastes placed in the embankments.

### 5.1.4 AIRBORNE TRITIUM (H-3)

When managing tritium-bearing wastes with the potential for occupational internally-absorbed tritium exposures, Energy*Solutions'* Radiation Safety Procedure CL-RS-PR-200 "*Air Sampling*", as revised - requires the continuous use of lapel pumps and tritium bubblers to measure atmospheric tritium concentrations during active waste management operations. When indicated by the air sample results, CL-RS-PR-200 further requires the collection of bioassay samples from all potentially-exposed radiation workers according to Energy*Solutions'* Radiation Safety Procedure CL-RS-PR-221 "*Bioassay Monitoring and Internal Dose*", as revised. For each semi-annual Monitoring Period, the total activity of tritium managed during that Period and the maximum tritium-related occupational exposure will be reported to the Division. If the maximum tritium-related occupational exposure exceeds the general public dose limits of UAC R313-15-101(4) or UAC R313-15-301, then corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions'* Quality Assurance Program..

## 5.2 VTD EFFLUENT

### General

The VTD discharge is sampled for airborne particulates. The VTD discharge stack is located downstream of the stack filters but up stream of the discharge blower. VTD

effluent concentration for each of these sample types is determined by dividing the measured VTD air sample concentrations by the sample flow rate (typically 200 mL/min). This is done to account for the effluent dilution resulting from the blower. Because the VTD particulate air sampler draws suction from a closed system the results do not include a background, consequently the A-16 concentration is not subtracted from the measured concentrations.

**Alpha/Beta Screening**

Air is continuously sampled at the VTD discharge while the VTD is used to treat radioactive wastes. Radioactive airborne particulate samples are collected using a constant-flow air sampler to draw air through a glass fiber filter, or a functionally similar particulate sampling media. The particulate air sampling apparatus maintains a flow rate of approximately 60 liters per minute through the filter media. A new filter is used prior to each VTD startup. Filters are then changed at least once per week during the specific VTD campaign. All particulate filters are analyzed for alpha and beta radioactivity at least 7 days but not more than 14 days after collection.

Any individual sample filters with a net alpha or net beta concentration above the applicable PAS Action Level will be analyzed by gamma spectroscopy within 3 working days of the alpha/beta analysis. Gamma spectroscopy analysis results will be reviewed to determine if any additional actions need to be taken.

When an individual filter has a net alpha concentration above 3E-12 uCi/ml or net beta concentration above 5E-11 uCi/ml (approximately 25 times the PAS Action Level), additional radiochemical analyses will be performed on that filter according to the requirements for semi-annual composite filters, unless gamma spectroscopy associates at least 50 percent of the net alpha or net beta activity present on the filter with gamma-emitting radionuclides. Other corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

**Airborne Particulate – Composite samples**

Semi-annual composite VTD samples will be analyzed by gamma spectroscopy using either the on-site instruments or a qualified laboratory and those isotopes expected to contribute more than five percent to the aggregate CEDE. The potential relative dose fraction for each radionuclide will be determined semi-annually by weighting its effective inhalation dose coefficient according to its relative abundance in the waste treated using VTD during the reporting period.

## 5.3 GAMMA RADIATION

Gamma radiation is continuously monitored at each designated airborne radioactivity monitoring location listed in Tables 1 through 3 and Drawing 10014-U-03, as revised, using an optically stimulated luminescent dosimeter (OSL) or a functionally equivalent device. Unless statistically classified as outlying the distribution of associated historic background concentrations from the specific background location according to either the Dixon's (for less than 26 samples) or Rosner's Tests (for more than 25 samples) (as defined in Sections 12.3 and 12.4 of EPA, 2009), the arithmetic mean of the gamma

radiation exposure measured at Stations B-2, A-27 and A-16 will be used to characterize background and net gamma radiation exposures. If statistically outlying, the arithmetic mean of the net gamma concentrations from the remaining stations will be used. Additional monitoring is performed, as directed by the Radiation Safety Officer (RSO).

## 5.4 SOIL

### 5.4.1 General

Environmental Soil samples are analyzed by Gamma spectroscopy. In order to facilitate the accurate measurement of radionuclides, the samples shall be collected from the top one inch of soil. To prepare the soil samples for gamma spectroscopy analysis the soil sample shall be dried, sifted, homogenized for matrix uniformity, and placed in sealed containers.

Soil samples shall be sealed, or canned, for at least 14 days prior to analysis in order to ensure the accurate measurement of Ra-226. Soil samples used to facilitate remediation activities are not required to be held for 14 days after canning for gamma spectroscopy analysis however, a 14 day hold time is required for the soil samples used to verify that an area is below the soil action levels.

Routine soil samples that exceed the Soil Reporting Levels shall also be analyzed for isotopic thorium. The locations of any soil sample above these Soil Reporting Levels will be further characterized by additional sampling to verify the initial finding, and to subsequently determine the nature, extent, and cause of any problem once the initial finding is verified. Areas with confirmed radioactivity above the Soil Reporting Level shall be remediated. Other corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

Except for sampling activities, the Director of the Division shall be notified prior to disturbing the soil inside soil monitoring stations.

### 5.4.2 Annual Soil Samples

Annual soil sample locations and analytical requirements are listed in Tables 1 through 3 and Drawing 10014-U03, as revised. Annual soil samples will also be collected radially to assess potential windblown contamination from the site. Radial surface soil samples will be collected from the soil stations in Tables 1 through 3. Radial surface soil samples will be collected at 300 meter intervals along the 8 compass directions centered near the center of Section 32. The first sample will be taken just outside the site boundary and additional samples will be taken at 300 meter intervals extending out to 1,500 meters. All 48 samples will be analyzed by gamma spectroscopy. Annual soil samples are also required at active Non-contaminated Restricted Area exits, in accordance with Section 5.4.4.

### 5.4.3 PCB Soil Samples

Samples are also collected to determine PCB concentrations in soil. Soil samples are collected twice each year from the Soil Monitoring stations identified in Tables 1 through 3 and Drawing 10014-U03, as revised. The samples are collected from the soil surface

and each sample will weigh approximately 30 g. Samples are refrigerated and stored in the dark when collected. Sample analytical preparation shall be started within 14 days after collection and the analysis shall be completed within 40 days after collection.

### 5.4.4 Restricted Area Exit Gate Soil Samples

Radioactivity concentrations in the soil near rail gates and gates that directly access Non-contaminated Restricted Areas shall be monitored. An annual soil sample shall be taken near rail gates used to exit the Restricted Area during the reporting period. An annual soil sample shall also be taken at gates that directly access Non-contaminated Restricted Areas; where vehicles, personnel, or material were permitted to exit during the reporting period without a radiological release. The sample shall be taken where the soil is most likely to be affected by contamination that may be present on vehicles exiting the Restricted Area. All soil samples will be analyzed by gamma spectroscopy.

Additional soil samples shall be collected when soil sample radioactivity exceeds the Soil Action Level to determine the cause and scope of the elevated radioactivity. Areas found to exceed the soil action levels shall be remediated as necessary until the radioactive contamination in the area is below the Soil Action Level. Other corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

## 6.0 QUALITY ASSURANCE/QUALITY CONTROL

In general, when conditions are identified that are adverse to quality, investigation and corrective actions are taken and documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program.*

## 6.1 ANALYTICAL LABORATORY QUALIFICATIONS

Analyses to be used for dose determination or for comparison to standards are performed by laboratories accredited or certified by the National Environmental Laboratory Accreditation Conference (NELAC) or the State of Utah to perform radiochemical and gamma spectroscopy analysis on environmental samples.

The Energy*Solutions* gamma spectroscopy system has been qualified by a company that performs such evaluations as a commercial service. The State of Utah has accepted that as evidence of Energy*Solutions*' qualifications for performing gamma spectroscopy analysis.

## 6.2 MDC REQUIRMENTS

### 6.2.1 General

The detection sensitivity can be influenced by several factors. These include branching ratios, the presence of interfering contaminants, and the probability of a given type of emission per disintegration. Most gamma emitting radionuclides of concern are easily detected by gamma spectroscopy at the specified sensitivity levels. In practice the typical

detection levels achieved in radiological analysis of environmental samples are very close to natural background radiation levels.

All analyses will achieve the specified MDC at the commonly accepted error of two standard deviations, or an approximate confidence interval of 95%.

Samples that indicate a positive result for the target analyte(s) need not be counted to achieve the specified MDC(s) if the counting uncertainty is less than 50% of the reported concentration.

### 6.2.2 Particulate Air Sample Alpha/Beta screening

The required MDC for the initial alpha and beta screening is based on 50% of the Th-230 concentration action level, or 7E-14 uCi/ml for gross alpha before the background contribution is subtracted. The gamma spectroscopy performed on samples above the alpha or beta action levels will be sensitive enough to detect 50% of the concentration listed in Table 4 of the Environmental Monitoring Plan for the gamma emitting nuclides of concern, or as needed to positively characterize the major contributors to the activity present.

### 6.2.3 Particulate Air Sample Semi-Annual Composite

The MDC for the semi-annual composite air samples will be sufficiently sensitive to detect or reject the presence of the target analyte(s) at a concentration equal to 10% of the applicable ECL. The use of certified or accredited laboratories is considered sufficient evidence of analysis quality, since an approved Quality Assurance plan is one prerequisite for attaining certification. Each contractor laboratory performs a method blank, split, duplicate, and/or spike tests as controls for each analysis according to the requirements of the approved Quality Assurance plan.

## 6.3 RADON DETECTOR QUALITY CONTROL REQUIREMENTS

As a test of repeatability, each semi-annual sample period one additional radon monitor will be placed at three air monitoring station as a field replicate. The stations to be used as field replicates will be selected at random each semi-annual sample period.

Each sample period, Energy*Solutions* will submit four detectors used to measure radon for exposure to a calibrated radon chamber standard. RERs and RMDs will be calculated to compare the results to the exposure to demonstrate the accuracy and precision of the routine measurement technique and the associated calculations. Corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program* when quality is not demonstrated.

## 6.4 GAMMA DETECTOR QUALITY CONTROL REQUIREMENTS

As a test of repeatability, each reporting period one additional gamma monitor will be placed at three air monitoring station as a field replicate. The stations to be used as field replicates will be selected at random. RERs and RMDs will be calculated to compare the additional gamma monitor results. Corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program* when quality is not demonstrated.

Each reporting period four detectors used to monitor gamma radiation will be concurrently exposed to a known dose from a calibrated gamma source. RERs and RMDs will be calculated to compare the result to the known exposure value. Corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program* when quality is not demonstrated.

## 6.5 SOIL SAMPLING QUALITY CONTROL REQUIREMENTS

Soil sample gamma spectroscopy:

- Shall be counted for at least 1,000 seconds
- The uranium-238 MDC value shall be less than or equal to 1.5 pCi/g except when the uncertainty is less than 50% of the measured activity.

Four of the routine soil samples from each sampling event will be split. The routine samples and the split samples will be analyzed at different laboratories. RERs and RMDs will be calculated to compare the results from the routine samples with the corresponding split samples to verify the precision of the results obtained between different laboratories. Corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program* when quality is not demonstrated.

Four of the routine soil samples are collected twice as simultaneous blind field replicates. All four routine samples and their blind duplicate will be analyzed by gamma spectroscopy at the same laboratory. One of the four routine samples and its blind duplicate will also be analyzed for Th-230 and Th-232. The RERs and RMDs of the analytical results will be used to indicate the laboratory's analytical repeatability and the error associated with the sampling technique. Corrective actions will be documented in the semi-annual report, via Condition Report in accordance with Energy*Solutions' Quality Assurance Program* when quality is not demonstrated.

## 6.6 AIR SAMPLER FLOW INDICATOR CALIBRATION FREQUENCY

Air sampler flow indicators will be calibrated at intervals not to exceed 12 months.

# 7.0 ENVIRONMENTAL MONITORING REPORT

A semi-annual report will be created for monitoring periods; January 1 to June 30 and July 1 through December 31. The reports will be submitted to the Division within three months after the last day of each monitoring period, unless otherwise approved by the Director of the Division.

Each Report shall include a brief introduction and narrative that summarizes and explains the data, results, MDA, errors, statistically-observable trends, and conclusions. The narrative shall also explain any unusual or anomalous results and list any exceedance of a limit listed in this Plan that occurred during the reporting period.

Each Report shall also include the following data from the reporting period:

- Contract laboratory data that pertains to any sample analysis that was performed under this program. The data package shall include the results of QC checks the contractor laboratory performs in the course of analyzing the samples (splits and duplicates, for example). The outside laboratory data may be submitted either electronically or by hard copy.
- The analytical results from gamma spectroscopy performed on soil samples and associated analytical results from soil samples used to verify soil radioactivity in areas where the environmental soil samples exceed the Soil Action Levels.
- The results of any quality control tests performed to meet a requirement of the Environmental Monitoring Plan, including but not limited to duplicates, split samples, and known exposures.
- A summary and tabulation of any data acquired as a result of sampling performed during the reporting period, to the extent that such data applies to a requirement of the Environmental Monitoring Plan.
- A table listing the activities and estimated relative dose weighting of each disposed radionuclide considered for additional radiochemical analysis according to the selection criteria of section 5.1.2 of the Environmental Monitoring Plan.
- The VTD Operating History and results for any VTD monitoring performed during the reporting period.
- Results of weekly alpha-beta counting of air filters at each monitored location.
- Semi-annual average alpha and beta air particulate concentrations at each monitored location.
- The cumulative TEDE, DDE, and CEDE at each POC for the current reporting period.
- The calculated annual dose from the monitoring results to demonstrate compliance with UAC R313-15-301, R313-15-101(4), and R313-25-19. The information shall include DDE, CDE, CEDE, and TEDE calculations.
- Soil Sample Results.
- A brief narrative summarizing the dosimetry data and explaining the CEDE estimates.

## TABLE 1: DIRECTIONAL RADIOLOGICAL SUMMARY

| COMPASS SECTOR | PAS - (5.1.1, 5.1.2, 5.2) | Radon - (5.1.3) | Gamma Spec - (5.4.2) | Th-232 & 230 (5.4.2) | PCB (5.4.3) | Gamma - (5.3) |
|---|---|---|---|---|---|---|
| N | A-35 | A-35 | S-72 | S-72 | | A-35 |
| | | | S-73 | | S-73 | |
| NNW | A-30 | A-30 | S-66* | S-66* | | A-30 |
| | | | S-71 | | S-71 | |
| WNW | A-29 | A-29 | S-65 | S-65 | | A-29 |
| | | | S-66* | | S-66* | |
| W | A-28 | A-28 | S-59 | S-59 | | A-28 |
| | | | S-64 | | S-64 | |
| WSW | A-22 | A-22 | S-56 | S-56 | | A-22 |
| | | | S-57 | | S-57 | |
| SSW | A-13 | A-13 | S-39 | S-39 | | A-13 |
| | | | S-40 | | S-40 | |
| S | A-11 | A-11 | S-36 | S-36 | | A-11 |
| | | | S-37 | | S-37 | |
| SSE | A-10 | A-10 | S-28 | S-28 | | A-10 |
| | | | S-29 | | S-29 | |
| ESE | A-17 | A-17 | S-26 | S-26 | | A-17 |
| | | | S-27 | | S-27 | |
| E | A-19 | A-19 | S-22 | S-22 | | A-19 |
| | | | S-24 | | S-24 | |
| ENE | A-18 | A-18 | SA-18 | SA-18 | | A-18 |
| | | | S-19 | | S-19 | |
| NNE | A-36 | A-36 | S-74 | S-74 | | A-36 |
| | | | S-77 | | S-77 | |
| VTD | VTD | | | | | |
| | | | | | | |
| BACKGROUND | | B-2 | B-2 | B-2 | | |
| | A-16 | A-16 | | | | A-16 |
| | | A-27 | | | | |

*Because S-66 is located at the boundary of the NNW and WNW sectors, it is a representative second station for each.

## TABLE 2: RADIOLOGICAL PROGRAM SUMMARY

| | PAS - (5.1.1, 5.1.2, 5.2) | Radon - (5.1.3) | Gamma Spec - (5.4.2) | Th-232 & 230 (5.4.2) | PCB (5.4.3) | Gamma - (5.3) |
|---|---|---|---|---|---|---|
| A-10 | X | X | | | | X |
| A-11 | X | X | | | | X |
| A-13 | X | X | | | | X |
| A-16 | X | X | | | | X |
| A-17 | X | X | | | | X |
| A-18 | X | X | | | | X |
| A-19 | X | X | | | | X |
| A-22 | X | X | | | | X |
| A-27 | | X | | | | |
| A-28 | X | X | | | | X |
| A-29 | X | X | | | | X |
| A-30 | X | X | | | | X |
| A-35 | X | X | | | | X |
| A-36 | X | X | | X | | X |
| B-2 | | X | X | X | X | |
| S-19 | | | X | | X | |
| S-22 | | | X | X | | |
| S-24 | | | X | | X | |
| S-26 | | | X | X | | |
| S-27 | | | X | | X | |
| S-28 | | | X | X | | |
| S-29 | | | X | | X | |
| S-36 | | | X | | | |
| S-37 | | | X | | X | |
| S-39 | | | X | X | | |
| S-40 | | | X | | X | |
| S-56 | | | X | X | | |
| S-57 | | | X | | X | |
| S-59 | | | X | X | | |
| S-64 | | | X | | X | |
| S-65 | | | X | X | | |
| S-66 | | | X | X | X | |
| S-71 | | | X | | X | |
| S-72 | | | X | X | | |
| S-73 | | | X | | X | |
| S-74 | | | X | X | | |
| S-77 | | | X | | X | |
| SA-18 | | | X | X | | |
| VTD | X | | | | | |

## TABLE 3: ACTIVE AND INACTIVE MONITORING LOCATIONS

NOTE: Point of Beginning is the Clive monument at the Southwest corner of Section 32

| Station | North | East | | Station | North | East | | Station | North | East |
|---|---|---|---|---|---|---|---|---|---|---|
| A-1* | 5163 | 2749 | | S-3* | 4891 | 3463 | | S-38* | 40 | 600 |
| A-4* | -88 | 5252 | | S-4* | 4883 | 3812 | | S-39 | 1050 | 200 |
| A-5* | -14 | 2647 | | S-5* | 4877 | 4204 | | S-40 | 1600 | 200 |
| A-10 | -10 | 4124 | | S-8* | 3599 | 4209 | | S-50* | 4440 | 4175 |
| A-11 | 28 | 1196 | | S-12* | 1992 | 4155 | | S-51* | 4023 | 4168 |
| A-13 | 499 | 198 | | S-13* | 2002 | 3679 | | S-52* | 3118 | 4149 |
| A-16 | 2412 | -6633 | | S-15* | 2011 | 3111 | | S-53* | 2659 | 4140 |
| A-17 | 2167 | 5323 | | S-17* | 5195 | 3399 | | S-54* | 2367 | 4137 |
| A-18 | 5417 | 4853 | | S-18* | 5035 | 4015 | | S-56 | 2551 | 85 |
| A-19 | 3965 | 5383 | | S-19 | 5213 | 5162 | | S-57 | 2963 | 91 |
| A-20* | 5084 | 5409 | | S-21* | 4537 | 5359 | | S-58* | 3339 | 99 |
| A-21* | 2162 | 71 | | S-22 | 3967 | 5356 | | S-59 | 3735 | 106 |
| A-22 | 2962 | 88 | | S-23* | 3347 | 5344 | | S-64 | 4038 | 272 |
| A-26* | -129 | 3282 | | S-24 | 2764 | 5335 | | S-65 | 4430 | 286 |
| A-27 | -2701 | 3406 | | S-25* | 2169 | 5322 | | S-66 | 4801 | 335 |
| A-28 | 4043 | 104 | | S-26 | 1596 | 5375 | | S-71 | 5291 | 796 |
| A-29 | 4636 | 115 | | S-27 | 379 | 5355 | | S-72 | 5282 | 1222 |
| A-30 | 5287 | 319 | | S-28 | -70 | 4754 | | S-73 | 5273 | 1658 |
| A-33* | 5501 | 2762 | | S-29 | -229 | 3389 | | S-74 | 5256 | 2429 |
| A-35 | 5280 | 1495 | | S-32* | 2047 | 2690 | | S-75* | 4471 | 2724 |
| A-36 | 5256 | 2402 | | S-33* | 3238 | 2694 | | S-76* | 2784 | 2703 |
| A-37* | 658 | 5377 | | S-34* | 3764 | 2717 | | S-77 | 5174 | 2678 |
| B-2 | 2650 | 13200 | | S-36 | -5 | 2200 | | S-78* | 2162 | 76 |
| S-1* | 4892 | 2745 | | S-37 | 10 | 1600 | | S-79 | -2709 | 3438 |
| S-2* | 4896 | 3126 | | | | | | | | |

*Housing structure and power are maintained at inactive particulate air stations. Visual barrier flags/posts and markers, signage and other delineation for inactive soil stations are removed, as necessary.

## TABLE 4: ECL FOR SELECTED RADIONUCLIDES

The listed concentration values are listed in units of uCi/ml and are based on continuous exposure for one year equals 50 mrem.

| Element | Isotope | Type | ECL** |
|---|---|---|---|
| Thorium | Th-228 | S | 4 8E-14 |
| | Th-230 | M | 4 7E-14 |
| | Th-232 | M | 4 5E-14 |
| | Th-234 | S | 2 6E-10 |
| Uranium | U-234 | S | 2 2E-13 |
| | U-238 | S | 2 6E-13 |
| Radium | Ra-224 | M | 6 5E-13 |
| | Ra-226 | M | 1 2E-13 |
| | Ra-228 | M | 7 2E-13 |
| Plutonium | Pu-238 | M | 4 4E-14 |
| | Pu-239 | S | 1 3E-13 |
| Strontium | Sr-90 | S | 1 3E-11 |

| Element | Isotope | Type | ECL** |
|---|---|---|---|
| Actinium | Ac-228 | F | 7 5E-11 |
| Bismuth | Bi-210 | M | 2 2E-11 |
| | Bi-212 | M | 6 3E-11 |
| | Bi-214 | M | 1 3E-10 |
| Lead | Pb-210 | F | 2 1E-12 |
| | Pb-212 | F | 9 9E-11 |
| | Pb-214 | F | 6 5E-10 |
| Polonium | Po-210 | M | 6 3E-13 |
| Protactinium | Pa-234 | S | 4 7E-09 |
| Cobalt | Co-60 | S | 6 5E-11 |
| Radon* | Rn-222 | | 4 9E+00 |

Notes:

* ECL for radon is provided in units of pCi/L and is value equivalent to the value compliant with UAC R313-15-301(a) (Energy*Solutions*, 2014).

** ECL is provided in Units of uCi/ml, unless otherwise noted

These updated "ECL" values were calculated following the general technique described in Appendix B to Part 20 which relates the Annual Limit on Intake to the Effluent Concentration Limit.

The 50-year committed effective equivalent inhalation dose conversion factors for an adult worker, for an AMAD of 1 um, from ICRP 68 were multiplied by the 3.7E9 conversion factor which relates the given units of Sv/Bq to mrem/uCi.

The resulting DCF in mrem/uCi was then divided into the effective dose limit of 5,000 mrem/year to obtain the value for the ALI in uCi/year.

The ALI is divided by breathing rate for an adult worker of 2 4E9 ml/yr, and also divided by the additional factor of 300 used in Appendix B to Part 20 to relate the stochastic DAC to the ECL

The ICRP 68 biological elimination type designations "F" (Fast), "M" (Medium), and "S" (Slow) are roughly analogous to the Part 20 "D" (Day), "W" (Week), and "Y" (Year) solubility classes