EPA-5206

Angelique Diaz

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Cameco

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April 27, 2009

United States Environmental Protection Agency
Attn: Charles Garlow, Attorney-Advisor
OECA, Air Enforcement Division
1200 Pennsylvania Avenue, NW-MC 2242A
Washington, D.C. 20460

Dear Mr. Garlow:

Power Resources, Inc. (Power Resources) and Crow Butte Resources, Inc. (Crow Butte Resources) doing business as (d/b/a) Cameco Resources (hereinafter "Cameco Resources) are in receipt of the Environmental Protection Agency's (EPA's) Request to Provide Information Pursuant to the Clean Air Act received November 26, 2008 (hereinafter "Information Request"). On March 13, 2009, Cameco Resources submitted a Partial Response to this Information Request, which reflected responses to the November 26, 2008 and the March 3, 2009 Information Requests (Received), in which a full response to Question 3b and partial responses to Questions 1 and 2 were provided. By this letter, Cameco Resources hereby submits its Response to the remainder of the Information Request. In addition, please see the attached Response for the certification requested by EPA on Page 2 of the Information Request.

As stated in Appendix A of your Information Request, Cameco Resources is entitled to request protection from public disclosure for certain corporate, transactional or other information submitted as part of its response as confidential business information (CBI) under Section 114(c) of the Clean Air Act (42 U.S.C. § 7414). After a thorough review of the Response attached to this letter, Cameco Resources has determined that no information constitutes CBI requiring protection from public disclosure.

If you have any questions regarding any aspects of the attached response, please do not hesitate to contact me at 720-879-5518. Thank you for your time and consideration in this matter.

As required by EPA, I certify under penalty of law that I have examined and am familiar with the information in the enclosed documents, including all attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are, to the best of my knowledge and belief, true and complete. I am aware that there are significant penalties for knowingly submitting false statements and information, including the possibility of fines or imprisonment pursuant to Section 113(c)(2) of the Act and 18 U.S.C. §§ 1001 and 1341.

Respectfully submitted,

Stephen P. Collings

Stephen P. Collings
President, Cameco Resources

Enclosures
c: Andrew M. Gaydosh, Assistant Regional Administrator, Region 8

CERTIFICATE OF MAILING

I, Margie Storms, certify that I sent a Response to the Request to Provide Information Pursuant to the Clean Air Act by Certified Mail, Return Receipt Requested, to:

United States Environmental Protection Agency
Attn: Charles Garlow, Attorney-Advisor
OECA, Air Enforcement Division
1200 Pennsylvania Avenue, NW-MC 2242A
Washington, D.C. 20460

on the 27th day of April, 2009.

Margie Storms

Margie Storms, Executive Assistant

Certified Mail Receipt Number 7005 0390 0003 9500 7756

CAMECO RESOURCES' RESPONSE TO UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S NOVEMBER 26, 2009 INFORMATION REQUEST

PREAMBLE

Prior to providing responses to the specific questions in the Information Request, Cameco Resources would like to provide EPA with additional context upon which such responses will be based. As a general proposition, based on a thorough review of the administrative rulemaking record and associated history, it is Cameco Resources' position that the provisions of 40 CFR Part 61, Subpart W referenced in the Information Request are not applicable to a uranium in-situ leaching facility, including specifically "impoundments" or "ponds" used at Cameco Resources' uranium in-situ leaching facilities such as evaporation or settling ponds as referenced in the Information Request.

Currently, with respect to Atomic Energy Act (AEA) uranium recovery facilities (i.e., facilities generating 11e.(2) byproduct material), Congress has vested EPA with certain regulatory authorities pursuant to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). In addition, Congress also has vested additional authority over certain aspects of such facilities through the Clean Air Act (CAA). In 1977, Congress enacted provisions of the CAA to address potentially hazardous radiological *air* emissions at a variety of facilities, including uranium recovery facilities. In response to this Congressional mandate, EPA promulgated 40 CFR Part 61 to address such radiological *air* emissions.

40 CFR Part 61, Subpart T *National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings* (hereinafter "Subpart T") were promulgated by EPA to address potential hazardous air pollutants (e.g., radon because particulate emissions were addressed effectively under 40 CFR Part 190 fuel cycle regulations) at uranium mill tailings facilities regulated under Title II of UMTRCA, which were *no longer operational*. Subpart T stated, in pertinent part:

> "Radon-222 emissions to the ambient air from uranium mill tailings piles that are no longer operational shall not exceed 20 pCi/(m^2 -sec) (1.9 pCi/(ft^2 -sec)) of radon-222."

Subsequently, after challenges to Subpart T were filed in the United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit), Subpart T was the subject of settlement discussions between the American Mining Congress (now NMA), EPA, and environmental groups, with NRC and Agreement States monitoring as interested, but not formally litigating, parties. These negotiations ultimately led to NRC revising its mill tailings regulations to require licensees to achieve enforceable "milestones" leading to accelerated placement of radon barriers at *non-operational* (i.e., no longer actively milling or on standby) Title II mill tailings disposal sites[1] to satisfy EPA's and the

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[1] 59 Fed. Reg. 28,220 (1994).

environmental groups' concerns that the potential threat from radon emissions be addressed by the prompt placement of radon barriers over disposal areas.[2] After NRC finalized its revisions to 10 CFR Part 40, Appendix A in accordance with this settlement, EPA rescinded Subpart T of its 40 CFR Part 61 regulations and, as such, its requirements no longer apply to conventional uranium mills.[3]

40 CFR Part 61, Subpart W *National Emission Standards for Radon Emissions from Operating Mill Tailings* (hereinafter "Subpart W") was promulgated to address radon emissions at *active* (including standby) uranium mill tailings facilities. Thus, Subpart W applies to operators of uranium mill tailings facilities while they are processing uranium/thorium ores and creating 11e.(2) byproduct material:

> "The provisions of this subpart apply to owners or operators of facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores, commonly referred to as uranium mills and their *associated tailings*. This subpart does not apply to the [final] disposal of *tailings*."

A 20 pCi/m2-s averaged over the entire area of a uranium mill tailings piles/impoundment standard was incorporated by EPA into 40 CFR § 61.252(a) as a standard for all uranium mill tailings impoundments existing on December 15, 1989, because EPA determined that it was technologically infeasible to force licensee to conform existing mill tailings impoundments/piles to the newly promulgated work practice standards.

On the other hand, new tailings impoundments constructed after December 15, 1989 must comply with one of two *work practice* standards:[4] (1) *phased disposal* in lined impoundments of forty (40) acres and meet the requirements of 40 CFR § 192.32(a) with no more than two impoundments in operation at one time; or (2) *continuous disposal* of tailings that are dewatered and immediately disposed of with no more than ten acres uncovered at one time. Compliance with these *work practice* standards in Subpart W makes the measurement for radon emanations during active operations unnecessary. The annual reporting requirements in 40 CFR § 61.254 apply only to *existing* mill tailings impoundments as of December 15, 1989, that have to comply with the *emissions standard* in Subpart W. Compliance with the emission standard in Subpart W for existing mill tailings impoundments is to be determined annually by the use of Method

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[2] EPA was clearly concerned with prompt placement of radon barriers over mill tailings piles/impoundments and EPA, thus, indicated that the primary purpose of the settlement was:

> "to ensure that owners of uranium mill tailings disposal sites ... bring those piles into compliance with the 20 pCi/m^2s[ec] flux standard as expeditiously as practicable considering technological feasibility . . . with the goal that all current disposal sites be closed and in compliance with the radon emission standard by the end of 1997, or within seven years of the date on which existing operations and standby sites enter disposal status."

59 Fed. Reg. 36,280, 36,282 (1994).

[3] *See* 61 Fed. Reg. 68972 (December 30, 1996) (emphasis added).

[4] 40 CFR § 61.252(a) (2007).

115 of Appendix B (40 CFR § 61.253). The owners of existing (pre-December 15, 1989) mill tailings piles/impoundments shall report the results of compliance calculations required by Section 61.253 and the input parameters in each year by March 31 of the following year (40 CFR § 61.254). EPA's radon measurement Method 115 requires measurement of the different "regions" of tailings disposal facilities except those covered by water.[5]

After a thorough review of the administrative rulemaking record associated with the promulgation of both Subparts T and W and the processes and facilities used at uranium in-situ leaching facilities, Cameco Resources has determined that Subpart W does not apply to any of its uranium in-situ leaching facilities. First, as stated above, the Proposed Rules for both Subparts T and W demonstrate that EPA was concerned about *uranium mill tailings piles/impoundments* and not impoundments or ponds used for evaporation or settling purposes. Nowhere in the titles of either of these two Subparts or in the language of the Proposed Rules did EPA indicate that they were intended to apply to anything other than *inactive* (Subpart T) or *active* (Subpart W) uranium mill tailings impoundments (i.e., uranium mill tailings impoundments receiving tailings from active uranium milling operations), as opposed to impoundments or ponds used solely for evaporation or settling purposes.

Second, the Final Rules promulgated in Subparts T and W provide additional evidence of the limited scope of their application to uranium mill tailings piles/impoundments. On December 15, 1989, EPA published a Federal Register Notice promulgating its final Section 112 NESHAP standards governing radon emission standards for *non*-operational, operational uranium mill tailings impoundments, and future impoundments, analyzing the risks associated with radon emissions from such impoundments, and discussing the potential effects of the proposed 20 pCi/m2-s standard on such impoundments. The final rule makes no reference whatsoever to evaporation ponds at uranium mill sites, but did explicitly reference the types of radon source terms to which Subparts T and W were intended to apply. For example, when describing the process of uranium milling, EPA states:

> "The process of separating uranium from its ore creates waste material called uranium mill tailings....These tailings are collected in impoundments that vary in size from 20 to 400 acres....For the current radionuclides NESHAP rulemaking, EPA is promulgating rules for three different subcategories that deal with mill tailings: operating mill tailings—existing *piles*, operating mill tailings—new

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[5] The Response to Comments to EPA's Final Rule on radon-222 emissions from licensed mill tailings demonstrates that EPA considered an emission standard and determined that "boundaries could be changed to comply with an emission standard which is not an acceptable practice under the CAA. Also, methods to determine emissions from tailings piles also have not been sufficiently developed to provide accurate and consistent measurements of radon emissions." United States Environmental Protection Agency, Office of Radiation Programs, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings*, Response to Comments (August, 1986).

> technology, and disposal of uranium mill tailings (as a separate source category....Existing mill tailings *piles are large piles of wastes that emit radon.*"

As discussed below, the use of the term mill tailings *piles* in this notice is consistent with the language used by Congress when defining "tailings" in UMTRCA:

> "the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted."[6]

This notice also reinforced a commonly accepted premise that would suggest that an evaporation pond would not be a significant radon source term because, as EPA states, "[r]adon emissions from these piles are retarded by the presence of water. However, if operations cease, and the pit is allowed to dry out, emissions can increase significantly."[7] Thus, EPA expressly recognized that the presence of water *in tailings* will significantly retard radon emissions. Accordingly, evaporation ponds which contain process or waste water do not represent a significant potential source of radon emissions.

Third, the rescission of Subpart T also provides additional evidence to support Cameco Resources' position described above. On December 31, 1991, EPA proposed to rescind 40 CFR Part 61, Subpart T "as it applies to owners and operators of uranium mill tailings disposal sites that are licensed by the Nuclear Regulatory Commission (NRC) or an affected NRC Agreement State...."[8] EPA's proposed rescission notice included a section specifically devoted to the question of "whether the requirement extends to the evaporation pond thereby jeopardizing the other remedial aspects of the UMTRCA program."[9] This discussion recognized that evaporation ponds can play an important role in the UMTRCA remedial action programs at uranium mill tailings sites:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the *disposal piles* as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the (once controlled) piles against erosion, and the reclamation and maintenance of groundwater....*These actions entail the use of evaporation ponds that in some instances....have been placed directly upon the disposal site.*"[10]

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[6] It is also common sense that a uranium mill tailings *pile* would not be an evaporation pond, because water generally does not collect and remain in a *pile*.

[7] 54 Fed. Reg. 51654 (December 15, 1989).

[8] 56 Fed. Reg. 67561. This language demonstrates that EPA acknowledges that evaporation ponds are not to be considered as part of the class of facilities known as "uranium mill tailings piles."

[9] *Id.*

[10] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was

After discussing whether evaporation ponds were to be subject to its 40 CFR Part 61, Subpart T standard, EPA concluded:

> "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved."[11]

Indeed, EPA's Proposed Rule prescribed an approach to evaporation pond remediation as follows: "the evaporation pond area may be covered to control radon *after it is no longer in use and ready for covering*."[12] EPA supported this conclusion by reasoning that:

> "the ponds themselves serve as an effective radon barrier, thus this decision is bolstered by the absence of any evidence that there is a significant public health risk presented by the radon emissions from these evaporation ponds during the period they are employed as part of the overall remediation of the site."[13]

Based on this determination, EPA concluded:

> "EPA believes the overall public health interest in comprehensively resolving the problems associated with each site is best served by requiring that the radon cover be expeditiously installed in a manner that does not require interruption of this other aspect of remediation....Rather, EPA believes that provided all other parts of the pile are covered with the earthen cover, compliance with the 20 pCi/m2 standard will result...."[14]

EPA's conclusions about the potential radon source term from evaporation ponds being actively used in uranium mill tailings site reclamation efforts are no less valid for such ponds being actively used during uranium recovery operations at an operational facility subject to Subpart W work practice standards. In addition, on December 30, 1996, EPA's Final Rule rescinding Subpart T contained no statements indicating any change in its interpretation of the scope of Subpart W's work practice standards.

Lastly, on November 15, 1993, EPA promulgated a Final Rule containing Amendments to its regulations applicable to operational NRC/Agreement State licensed uranium mill tailings facilities. In this Federal Register notice/Final Rule, EPA responded to a number of public comments, including comments related to the application of Subpart W requirements to evaporation ponds. As stated by EPA:

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made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

[11] *Id.*

[12] 56 Fed. Reg. 67561 (emphasis added).

[13] *Id.*

[14] *Id.*

> "*EPA reiterates that the Agency does not intend the expeditious radon cover requirement to extend to areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency...to be an appropriate aspect of the overall remedial program for the particular site."[15]

Essentially, in this Final Rule, EPA restated its conclusion from the Subpart T rescission administrative rulemaking record that active evaporation ponds do not represent a significant potential radon source term.[16]

Per the above discussion, the entirety of the administrative rulemaking record associated with the promulgation of Subparts T and W and the subsequent rescission of Subpart T demonstrate that their provisions were not intended to apply only to impoundments actually receiving tailings and not to impoundments used for evaporation or settling purposes. In addition to the administrative rulemaking record, aspects of current statutory and regulatory language pertaining to EPA's authority over uranium recovery facilities that support Cameco Resources' position. As will be demonstrated below, despite the fact that evaporation pond fluids contain some fines from mill processing (which can be considered "tailings-like" 11e.(2) byproduct material) that are either suspended in the fluids or that have settled on the liner of the pond as such fluids have evaporated, neither the fluids with entrained solid fines nor the fines themselves typically would be considered "tailings" in a pond used solely for evaporation purposes during *active* or closure operations. An *active* tailings pile/impoundment is one into which tailings (a mixture of sands, slimes, and fluids) are placed during ongoing uranium recovery operations. The sands and slimes constitute the bulk of the material (typically 70% plus).

First, UMTRCA's definition of "tailings," as incorporated by EPA in 40 CFR Part 61 from UMTRCA, indicates: "[t]he term 'tailings' means *the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted*."[17] Water stored in an evaporation pond from either active recovery operations or groundwater corrective action is not consistent with the UMTRCA definition of "tailings" as the water is added to the processing circuit for the ore (or removed from the groundwater), and is not part of "the remaining portion of the metal-bearing ore from which uranium was extracted." Given that EPA's regulations in 40 CFR Part 61, Subpart T incorporate the UMTRCA definition of "tailings,"[18] EPA arguably has accepted the distinction between tailings in a tailings pile or impoundment and water related to uranium milling in an evaporation pond that may have resulted either from processing or from a groundwater corrective action program.

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[15] 56 Fed. Reg. 67561 (emphasis added).

[16] *Id.*

[17] 42 U.S.C. § 7911(8)

[18] It should be noted that Subpart W's definition of "uranium byproduct material or tailings" adopts essentially the same definition of "11e.(2) byproduct material in Section 11(e) of the AEA, as amended by UMTRCA.

Second, as discussed above, EPA's 40 CFR Part 61, Subpart W work practice standards consistently utilize the terms "tailings *pile*" and "tailings impoundment" when discussing site facilities that are covered by Subpart W work practice standards, which, on their face, do not apply to a liquid storage facility. For example, 40 CFR § 61.221 states in pertinent part:

> "As used in this subpart, all terms not defined here have the meanings given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:
>
> (a) *Long term stabilization* means the addition of material on a uranium mill *tailings pile* for the purpose of ensuring compliance with the requirements of 40 CFR 192.02(a). These actions shall be considered complete when the Nuclear Regulatory Commission determines that the requirements of 40 CFR 192.02(a) have been met."[19]

In addition, when prescribing the 20 pCi/m2-s standard in former Subpart T, EPA states:

> "(a) Radon-222 emissions to the ambient air from uranium mill *tailings piles* that are no longer operational shall not exceed 20 pCi/(m^2 -sec) (1.9 pCi/(ft^2 -sec)) of radon-222.
>
> (b) Once a uranium mill *tailings pile or impoundment* ceases to be operational it must be disposed of and brought into compliance with this standard within two years of the effective date of the standard. If it is not physically possible for an owner or operator to complete disposal within that time, EPA shall, after consultation with the owner or operator, establish a compliance agreement which will assure that disposal will be completed as quickly as possible."[20]

EPA's Subpart W regulations use both the term "tailings impoundment" and the term "tailings pile" when discussing the facilities to which Subpart W's 20 pCi/m2-s radon emission standard applies and the work practice standards for operational and potential future tailings facilities.[21] The use of the term "pile" is consistent with prior practices at uranium mill tailings sites where mill tailings were routinely placed in a "pile" rather than the current practice of placing mill tailings in an "impoundment." However, the random use of the terms "pile" and "impoundment" suggests that as technology was transforming, the terms were being interchangeably applied to mill "tailings" disposal

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[19] 40 CFR § 61.221(a-b).

[20] 40 CFR § 61.222(a-b).

[21] *Compare* 40 CFR § 61.252(a); 40 CFR § 61.252(b-c). This is entirely consistent with the history of the development of uranium mill tailings disposal facilities in that the older uranium mills constructed "piles" for disposal of tailings; but by the time that EPA's CAA regulations were being developed and promulgated, the technology had advanced to use "impoundments" which were, and are, more stable and controllable in both the short and long-term context than the old "piles."

facilities. As a result, Subpart W appears to apply to "tailings" as described in EPA's rulemaking materials, whether the term "piles" or "impoundments" is used.

Additional evidence for the positions espoused above can be found in EPA's background and guidance documents on NESHAPs, its Final Rule on Subpart W work practice standards, and their application to uranium mill tailings piles/impoundments and the appendix setting out Method 115 entitled *Monitoring for Radon Emissions*. Initially, EPA's NESHAP documents expressly recognize that the scope of the Subpart W work practice standards was intended to reach *tailings* stored in on-site tailings piles/impoundments *and not* to other site facilities such as evaporation ponds:

> "As with any ore-processing operation, uranium milling produces large quantities of waste rock. Uranium mill wastes, *or tailings*, are usually stored in an impoundment located on the mill site."[22]

Further, EPA's guidance on work practices includes a discussion of potential work practice procedures for controlling radon emissions from milling operations that result in tailings. These practices include the use of "earthen covers" to be applied to tailings to reduce potential fugitive emissions such as radon:

> "Earth covers which consist of layered soil approximately 3 meters deep are frequently used on waste piles, reclaimed lands, or inactive surface mining areas to reduce both particulate and radon emissions."[23]

However, the use of an earthen cover to retard radon emissions from an evaporation pond rather than a mill tailings pile/impoundment is unnecessary because the water in the pond retards such emissions, and EPA's recognition that, when the pond is no longer actively used, it will be dried and covered or, if lined, its liner will be disposed in a mill tailings pile as 11e.(2) material.

EPA's background document for its Subpart W work practice standards contains additional evidence to support the conclusion that such standards do not apply to evaporation ponds. When describing what is encompassed by the term "tailings," EPA states:

> "Tailings include the barren crushed ore material plus process solutions. These tailings consist of mixtures of sands and slimes (coarse and fine tailings). *Evaporation ponds used to contain excess liquid from tailings impoundments also contain suspended...tailings....*"[24]

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[22] United States Environmental Protection Agency, *Radionuclides: Background Information Document for Final Rules*, Volume I at 4-29 (October, 1984).

[23] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings: Background Information Document* at 7-2 to 7-3 (August, 1986).

[24] *Id.* at 3-19. In addition, the statement following this quote further demonstrates that EPA considered fluids in evaporation ponds to not be a radon source term: "*If exposed,* these solids are

This statement appears to support the fact that the term "tailings" is intended to apply to the materials in a site's active mill tailings impoundments and not to fluids in impoundments used solely as evaporation ponds, as evaporation ponds are considered a separate point of analysis from mill tailings impoundments. EPA's Response to Comments also includes evidence that the work practice standards were not intended to apply to evaporation ponds due to their minimal radon emissions:

> "Recent technical assessments of radon emission rates from tailings indicate that radon emissions from tailings covered with less than one meter of water, or merely saturated with water, are about 2% of emissions from dry tailings. *Tailings covered with more than one meter of water are estimated to have a zero emissions rate. The Agency believes this calculated difference between 0% and 2% is negligible. The Agency used an emission rate of zero for all tailings covered with water or saturated with water in estimating radon emissions.*"[25]

Additionally, as Method 115, paragraph 2.1.3 states, "radon flux measurements shall be made within each region on the pile, *except for those areas covered with water.*" Paragraph 2.1.3(a) also states, "*Water covered area*--no measurements required as radon flux assumed to be *zero.*"[26]

Finally, significantly, EPA also discusses the relatively small amount of radon potentially emitted from on-site impoundments at uranium in-situ leaching facilities: "A small amount of radon is released from the waste impoundments used to store contaminated liquids from the operation." Further, EPA's Background Information Document on *Radionuclides* states regarding uranium in-situ leaching facilities: "The radioactive emissions from this source are small compared to the other sources."[27] These statements are bolstered by EPA's response to comments on its final NESHAP rule for underground uranium mines:

> "The Agency has not ignored the risks from surface and <u>in situ</u> uranium mining...Standards were not proposed for either of these technologies as the

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assumed to emit radon-222 at the same specific flux as tailings impoundments." The low nature of tailings covered by water is also noted by EPA in Volume I of its Background Information Document on *Radionuclides*: "When tailings impoundment areas are almost completely covered by water, radionuclide emissions will be low."

[25] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings: Response to Comments* at 11 (October, 1984).

[26] Emphasis added. *See also* Method 115, Paragraph 2.1.6 *Radon Flux Measurement*...The radon collector is placed *on the surface* of the pile area to be measured and allowed to collect radon for a time period of 24 hours. The detailed measurement procedure provided in Appendix A of EPA 520/5-85-0029(1) shall be used to measure the radon flux on the uranium mill tailings except the *surface of tailings* shall not be penetrated by the lip of the radon detector as directed in the procedure, rather the collector shall be carefully positioned *on a flat surface* with soil or tailings used to seal the edge.

[27] *See* United States Environmental Protection Agency, *Radionuclides, Background Information Document for Final Rules*, Volume II, p. 5-2 (October, 1984).

> maximum ground level air concentrations of radon emitted from these activities are significantly lower than those which result from underground mining."[28]

Thus, the administrative records in the Subpart T, all Subpart W, and even the Subpart B administrative record for underground uranium mine radon emissions, as well as EPA's Method 115 rationale and procedures suggest strongly that evaporation ponds at conventional uranium milling facilities, much less those at uranium in-situ leaching facilities do not have to comply with nor do they warrant the application of work practice standards or a 20 pCi/m2/sec standard to control radon emissions.

In addition, as stated above, the nature of the process and the types of facilities used at Cameco Resources' uranium in-situ leaching facilities demonstrates that Subpart W work practices standards do not apply to such Cameco Resources facilities. Uranium in-situ leaching facilities do not utilize traditional uranium mill tailings impoundments as envisioned by EPA in its Subpart W work practice standards, because they do not generate uranium mill tailings that are traditionally generated at conventional uranium mills as envisioned by Congress in UMTRCA and do not require any long-term on-site storage and containment of such tailings thereby resulting in what has been termed "irretrievable and irrevocable" impacts. For purposes of this Response, the following uranium in-situ leaching process discussion is specifically related to Cameco Resources' uranium in-situ leaching facilities.

Cameco Resources' uranium in-situ leaching facilities employ a process in which native ground water from the production zone in the aquifer is pumped to the surface for fortification with oxygen and carbon dioxide. This fortified water or "lixiviant" is then returned to the production zone through a series of injection wells in varying patterns in the wellfields. The extraction pumping causes the injected lixiviant to move through the uranium ore body oxidizing and solubilizing the uranium present in the host sandstone. The water from the production wells is processed through ion exchange (IX) resin in IX columns to remove the uranium from solution. After the resin in a column is loaded with uranium, the column is isolated from normal process flow and the loaded resin is removed for elution. During the elution process, the resin is chemically treated in a manner very similar to regenerating a conventional home water softener unit. Following elution, the product is dewatered and dried to produce yellowcake.

After uranium removal in the IX column, the water in the circuit is re-fortified and re-injected as part of a continuous process until the uranium in the ore zone is exhausted. To maintain hydraulic control of lixiviant in the production zone during wellfield operations, more water is extracted than re-injected, thereby creating a hydraulic cone of depression. The difference between the amount of water extracted and re-injected is the wellfield "bleed". This "bleed," which contains elevated levels of radium and other progeny, can be treated in settlement ponds or by filtration to remove the radium using a barium-radium sulphate precipitation method. Ultimately, the treated or untreated waste water is discharged to holding ponds or tanks and from there it must

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[28] United States Environmental Protection Agency, *Radionuclides: Response to Comments for Final Rules*, Volume I at 87 (October, 1984).

be disposed of using deep well injection, solar evaporation or some combination of these methods. Other waste water effluents produced from uranium in-situ leaching processes and/or ground water restoration are treated and disposed of in the same manner.

Thus, as can be seen from the discussion above, Cameco Resources reiterates its position that EPA Subpart W work practice standards do not apply to uranium in-situ leaching facilities and, more specifically, do not apply to evaporation or settling ponds used at such facilities. As a result of this position, the amount of data and documentation available with respect to uranium in-situ leaching facilities owned and operated by Cameco Resources will be limited. Further, Cameco Resources' response to the specific questions offered by EPA in its Information Request will incorporate, to the extent relevant, aspects of this position.

RESPONSE TO SPECIFIC QUESTIONS

Question #1: Please list each uranium mill located in the United States of America that has been, or is currently, owned or operated, by Cameco Resources or affiliated corporations located in the United States of America. Include the exact location of each uranium mill by map and legal property description.

Response to Question #1: Cameco Resources and its affiliated companies do not, and have not, owned or operated any uranium mills in the United States America.

Question #2: Please list each uranium in-situ leaching facility located in the United States of America that has been, or is currently, owned or operated, by Cameco Resources or affiliated corporations. Please include the exact location of each uranium mill by map and legal property description.

Response to Question #2: The operational and non-operational uranium in-situ leaching facilities owned and operated by Cameco Resources and its affiliated corporations in the United States of America are summarized in the table below. Maps showing the location of each project are included in Attachment A. Cameco Resources also notes that there are several descriptions of each project in publicly available documents such as Permit to Mine application documents through the Wyoming Department of Environmental Quality and Class III UIC Permit documents through the Nebraska Department of Environmental Quality. Copies of Permit to Mine documents for Cameco Resources in situ leaching facilities in the state of Wyoming can be obtained from the Wyoming Department of Environmental Quality, Land Quality Division office in Cheyenne, Wyoming. A copy of Class III UIC Permit No. NE0122611 for the Crow Butte facility is provided in Attachment D.

Corporate Entity	Uranium In-Situ Leaching Facility	Geographic Location	Description
PRI	Smith Ranch-Highland Uranium Project	Converse County, WY	Full Uranium In-Situ Leaching Operations*
PRI	Reynolds Ranch	Converse County, WY	Satellite**
PRI	Gas Hills Uranium In-Situ Leaching Project	Fremont and Natrona Counties, WY	Satellite**
PRI	Ruth Uranium In-Situ Leaching Project	Johnson County, WY	Satellite**
PRI	North Butte Uranium In-Situ Leaching Project	Campbell County, WY	Satellite**
CBRI	Crow Butte	Dawes County, NE	Full Uranium In-Situ Leaching Operations*

PRI – Power Resources, Inc. d/b/a Cameco Resources
CBRI – Crow Butte Resources, Inc. d/b/a Cameco Resources
* Full uranium in-situ leaching operations include wellfields, satellite IX and central processing (i.e., elution, precipitation, drying, and packaging of yellowcake
** Satellite operations consist only of wellfields and satellite IX with no central processing facility.

<u>Question #3:</u> Please provide the following information for each uranium mill and uranium in-situ leaching facility identified in questions 1 and 2:

As a general matter, EPA developed its Subpart W work practice standards to create an efficient alternative method of achieving compliance with the radon flux standard of 20 pCi/m2-s. Prior to the application of Subpart W work practice standards to post-December 15, 1989 uranium mill tailings piles/impoundments, the 20 pCi/m2-s for radon-222 emissions from mill tailings piles impoundments was the standard. This standard was also consistent with EPA's promulgation of *generally applicable standards* pursuant to Congressional mandate under UMTRCA. In 1983, three years after NRC issued its *Final Generic Environmental Impact Statement* ("GEIS") on uranium milling and accompanying Part 40 regulations for licensed (i.e., *active*) sites, EPA promulgated a set of *generally applicable standards* for inactive sites.[29] These standards applied to abandoned *inactive* sites regulated to be under Title I of UMTRCA that were no longer operated under an *active* license. Further, as with the *inactive* sites regulations, EPA's *active* site regulations require that radon emanations from tailings disposal sites be limited to 20 pCi/m^2-s.[30] In these regulations, EPA concluded that a radon emission standard of 20 pCi/m^2-s was adequately protective of human health and safety, as compared to the 2 pCi/m^2-s standard originally adopted by NRC for *active,* licensed sites. EPA's Subparts T and W regulations utilize an identical 20 pCi/m2-s radon emissions

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[29] DOE was given the responsibility under UMTRCA to reclaim the Title I sites subject to NRC-approved reclamation plans and, ultimately, after completion of reclamation, to be subject to NRC license requirements in perpetuity. 48 Fed. Reg. 590 (January 5, 1983).
[30] *Id.* at 45947.

limit for UMTRCA Title II sites that were no longer active (Subpart T) and for UMTRCA Title II sites that were active (Subpart W) that had active uranium mill tailings impoundments prior to 1989. After Subpart W was promulgated in final form, all new mill tailings impoundments were to satisfy one of the two work practice standards rather than the emissions limit.

As discussed above, Subpart W work practice standards were required to address radon emissions from UMTRCA Title II sites that currently had uranium mill tailings impoundments and/or were seeking to construct new impoundments. In its rulemaking, EPA evaluated the technologically feasibility of directing uranium mill tailings licensees to conform their existing impoundments to comply with Subpart W work practice standards. EPA determined that it was impractical to require such compliance and, as a result, included the 20 pCi/m2-s as the standard for existing mill tailings impoundments. For impoundments to be constructed after December 15, 1989, the Subpart W work practice standards were to provide a methodology by which uranium mill tailings licensees could protect public health and safety with an ample margin of safety and without the need for compliance monitoring.

However, it is important to note that NRC also requires uranium mill tailings licensees to maintain strict compliance with relevant public and occupational dose limits. NRC regulations currently require such facilities to comply with a dose limit to individual members of the public of 100 mrem/year and a dose limit of 5 rem/year to site workers. The NRC dose limits for members of the public and site workers are "all-pathways" dose limits that require submission of compliance reports to NRC in accordance with 10 CFR Parts 20 and 40 requirements and guidance.[31] Part 20.1101(b) requires that procedures and engineering controls be implemented to make occupational dosage and dosages to members of the public ALARA. Further, Part 20.1101(d) states that a *constraint* on air emission of radioactive material, excluding radon-222 and its daughter products, shall be implemented to limit doses to any single member of the public to 10 mrem/year. If this limit is not met, the licensee must report the occurrence and consider corrective action to attempt to satisfy the "*constraint*" limit. These requirements have been deemed to be adequately protective of public health and safety pursuant to NRC's statutory mission under the AEA.

(a) A complete description of each uranium mill and uranium in-situ leaching facility's operational status (e.g., permanently shut down, temporarily shut down, standby status, in full or partial operation), method of operation (continuous disposal, phased disposal or other method) and methods by which compliance with the NESHAP standards, specified at 40 C.F.R. § 61.252, is ensured (meeting emission limit in Section 61.252(a) and work practices in (b) and (c)). Include a description of the type of facility (conventional, in-situ leach, heap leach or combination);

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[31] *See* 10 CFR Part 20.1301(a)(1) which states that a 100 mrem/y dose rate is applicable to members of the public.

Response to Question #3(a): As stated in response to Question #1 (above), Cameco Resources and its affiliated companies do not, and have not, owned or operated any uranium mills in the United States of America. The operational status of Cameco Resources' uranium in-situ leaching facilities is provided in the table below. The terms "continuous disposal" and "phased disposal" as defined in 40 C.F.R. § 61.251(b) and (f), respectively, apply to conventional uranium mills only and are not applicable to uranium in-situ leaching facilities. The NESHAP standards specified at 40 C.F.R. § 61.252, including radon-222 emission limits in Section 61.252(a) and work practices in Sections 61.252(b) and (c), apply to uranium mill tailings only and are not applicable to uranium in-situ leaching facilities.

Facility	**Operational Status**	**Method of Operation**	**NESHAP Compliance Method**
Smith Ranch-Highland Uranium Project	Full Operation	Uranium In-Situ Leaching	Not Applicable
Reynolds Ranch	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Gas Hills Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Ruth Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
North Butte Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Crow Butte	Full Operation	Uranium In-Situ Leaching	Not Applicable

(b) A history of operation since 1975, including:

(i) the original date of construction of each uranium mill and uranium in-situ leaching facility located at each facility;
(ii) the plan of operation and plans to shut-in or close active operation;
(iii) ownership changes; and
(iv) whether the uranium mill and uranium in-situ leaching facility is existing, new, or has plans for reactivating any operations that have been curtailed.

Response to Question #3(b): On March 13, 2009, Cameco Resources submitted an Initial Response to EPA's Information Request that provided a detailed answer to this portion of Question #3. However, in addition to that response, Cameco Resources offers the following additional discussion. With respect to uranium in-situ leaching project plans of operation and plans to close active operations, uranium in-situ leaching projects traditionally do not have firm, fixed production start or termination dates. This is due to the need for extensive preliminary testing to ensure that site production wellfields are properly placed and are capable of maximizing uranium production while maintaining proper wellfield balance and addressing fluctuating economic markets, and NRC and State requirements for fully compliant groundwater restoration and site decommissioning.

Uranium in-situ leaching facility licensees typically can offer educated estimates on the timeframes for project startup, wellfield development, and groundwater restoration. However, these dates cannot be considered firm due to these factors noted above, as a result, uranium in-situ leaching licensees, including Cameco Resources, often cannot offer firm and fixed project timelines. As a supplement to the Initial Response to Question #3(b) provided under cover dated March 13, 2009, a brief historical summary of each project is also provided in the table below:

Uranium In-Situ Leaching Project	**Construction Date**	**Plan of Operation**	**Ownership Changes**	**Existing, New or Reactivation**
Smith Ranch	1991	Full Operation	Acquired in 2002	Existing
Highland Uranium Project	1987	Full Operation	Acquired in 1997	Existing
Reynolds Ranch	Not Constructed	Licensed But Not Constructed	None	New
Gas Hills Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	None	New
Ruth Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	Acquired in 2001	New
North Butte Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	Acquired in 2001	New
Crow Butte	1991	Full Operation	Acquisitions in 1994, 1998 and 2000	Existing

(c) The number and size (in acres), dimensions, locations within the facility or plant site, capacity in gallons and lining material of each existing mill impoundment, as that term is used in 40 C.F.R. [Part 61] Subpart W, and any other waste holding areas such as evaporation or settling ponds.

Response to Question #3(c): As discussed in the site-specific uranium in-situ leaching process description offered above, uranium in-situ leaching facilities do not generate uranium mill tailings like those generated at conventional uranium mill tailings facilities and, as such, do not require uranium mill tailings impoundments to provide adequate long-term, on-site storage and containment of such tailings pursuant to UMTRCA, EPA 40 CFR Part 192 regulations, and NRC 10 CFR Part 40, Appendix A

Criteria. In order to properly understand this portion of Cameco Resources' position, it is important to distinguish between the wastes generated during uranium in-situ leaching operations and groundwater restoration and uranium mill tailings as envisioned by Congress in UMTRCA.

In the mid-1970s, Congress identified uranium mill tailings generated at conventional uranium mills as a significant, potential threat to public health and safety and the environment. However, due to a perceived lack of authority on the part of NRC under the AEA, Congress enacted UMTRCA with the specific intent of creating a comprehensive statutory and regulatory scheme for the short and long-term oversight of uranium mill tailings. For example, Section 2 of UMTRCA states that one of its purposes is to establish:

> "a program to regulate *mill tailings* during uranium or thorium *ore* processing at active mill operations and after termination of such operations in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public."

The perceived threat was associated with the nature of typical uranium mill tailings generated at conventional uranium mill facilities. Uranium mill tailings are described by EPA as "the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted." Typically, uranium mill tailings generated at conventional uranium mills can be defined as earthen materials generally ranging in size from medium grained sand to clay sized particles and consist of ground ore from which uranium has been removed. Typical mill tailings exit a mill process in the form of solid/water slurry and are approximately fifty to fifty-five percent solids by weight. Particle size distributions for mill tailings samples can vary widely depending on the collection point in the impoundment from five percent fines and ninety-five percent sand to ninety-three percent fines and seven percent sands. Upon deposition in a tailings impoundment, tailings tend to classify by size with the coarser materials accumulating closer to the discharge with finer (clay-sized) materials accumulating furthest from the discharge. Uranium mill tailings generally are a buff to tan/brown color due to the oxidation process in the mill circuit and may be acid or alkaline-like in pH. As a result, waste management programs at conventional uranium mills focus primarily on the safe storage and containment of uranium mill tailings in licensed uranium mill tailings piles/impoundments and the transfer of such tailings to a mandatory federal custodian for long-term surveillance and monitoring pursuant to Section 83 of the AEA, as amended by UMTRCA.

However, conventional uranium mill waste management programs are not solely devoted to such tailings. As stated above, when UMTRCA was first enacted, Congress' intent was to address both the potential radioactive and *non*-radioactive hazards associated with uranium mill tailings. However, it was determined that additional waste streams generated at these facilities, while not being typical uranium mill tailings, should be contained on-site as part of the uranium milling waste management process. As a result, the waste classification of 11e.(2) byproduct material was determined to include all wastes, and not just uranium mill tailings, associated with the uranium milling process. Thus, to address the management, safe storage, and containment, (including the demolished mill buildings and other site equipment and material that cannot be decontaminated for unrestricted use), a program for eventual transfer of the site and all of its 11e.(2) byproduct material to a mandatory federal custodian for long-term surveillance and monitoring under a general license from NRC in perpetuity, was implemented pursuant to Section 83 of the AEA, as amended by UMTRCA.

As part of the overall waste management plan of a conventional uranium mill facility and to address waste streams other than uranium mill tailings such as process wastewater, such facilities utilize evaporation ponds and other types of impoundments or ponds (e.g., catchment basins, settling ponds, storage ponds) to temporarily contain waste streams such as process water management and for erosion control. It is also possible that some conventional mills may utilize storage ponds for water intended for reuse in the milling process. However, the *waste* streams[32] placed in these ponds or impoundments are not considered to be uranium mill tailings, but merely a type of 11e.(2) byproduct material that is not considered to be uranium mill tailings. Thus, conventional uranium milling facilities generate different types of 11e.(2) byproduct material such as process wastewater that are not considered to be uranium mill tailings and, as such, do not require the same radiation protection or handling procedures. Therefore, when evaluating which impoundments or ponds are subject to Subpart W work practice standards, it is important to differentiate between uranium mill tailings and other process waste streams that are not considered to be such tailings.

While conventional uranium mills generate uranium mill tailings and require extensive, ongoing regulatory oversight either by a private or federal/state licensee as described above, uranium in-situ leaching facilities do not generate such tailings and do not require such programs. Uranium in-situ leaching facilities are focused on the use of recovery solutions or lixiviant that are composed of native site groundwater and recovery agents such as oxygen and carbon dioxide to recover uranium from an identified underground ore body. These facilities do not engage in typical conventional uranium milling processes such as the crushing or grinding of ore that result in the generation of uranium mill tailings requiring long-term storage and containment in mill tailings impoundments. Since these facilities do not generate such uranium mill tailings, uranium in-situ leaching facilities do not have to be transferred to a mandatory federal custodian for long-term surveillance and monitoring and, traditionally, are

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[32] It is possible that impoundments could be used for storage of "clean," pre-process fluids which, of course, would not be classified as a waste and, thus, would not be 11e.(2) byproduct material.

released for unrestricted use after cessation of operations and completion of site decommissioning, including groundwater restoration.

Based on their process operation, however, uranium in-situ leaching facilities do generate process waste streams that qualify as 11e.(2) byproduct material but that do not constitute uranium mill tailings. The predominant process waste stream at such facilities is process wastewater in two forms: (1) process bleed and (2) restoration fluids. Each of these wastewater streams are handled using one of a number of options, including land application, solar evaporation or disposal via deep disposal wells. In each of these cases, uranium in-situ leaching facilities typically use evaporation or other types of settling/storage ponds to hold wastewater until it can be evaporated or removed for final disposition. Any other solid waste that is generated on-site is either transported off-site to a properly permitted facility for final disposition or is decontaminated for unrestricted release. Thus, based on this discussion, uranium in-situ leaching facilities do not engage in activities that result in the generation of uranium mill tailings, do not require waste management programs to address the storage of such tailings in on-site mill tailings impoundments, and do not require long-term surveillance and monitoring. Therefore, based on EPA's conclusion that evaporation ponds do not constitute a radon emissions source requiring Subpart W work practice standards and the discussion of the uranium in-situ process above, uranium in-situ leaching facilities do not utilize any on-site facilities that would require compliance with Subpart W work practice standards.

As stated in response to Questions #1 and #3(a) (above), Cameco Resources and its affiliated companies in the United States of America do not, and have not, owned or operated any uranium mills in the United States America and, therefore, do not own or operate any uranium mill tailings impoundments. Detailed information on other waste water holding areas, such as evaporation ponds and settling ponds, located at Cameco Resources uranium in-situ leaching facilities is summarized in the table below.

Uranium In-Situ Leaching Project	Waste Water Holding Area		Size (acres)	Dimensions (feet)	Location	Capacity (acre-feet (AF))	Lining Material
	#	Type					
Smith Ranch	2	Evaporation (Storage) Ponds (East and West)*	Approx. 0.23 Acres (each)	100 x 100 (each)	North of Central Processing Plant	0.78 AF (each)	Geosynthetic
Highland Uranium Project	2	Radium Settling Basins (East and West)**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Highland Uranium Project	1	Purge Storage Reservoir No. 1***	Approx. 10 Acres	Not Applicable	Near Satellite No. 1	54 AF	Clay
Highland Uranium Project	1	Purge Storage Reservoir No. 2***	Approx. 42 Acres	Not Applicable	Near Satellite No. 2	321 AF	Clay
Ruth Uranium In-Situ Leaching Project	2	Evaporation Ponds (East and West)****	Approx. 0.23 Acres (Each)	Approx. 100 x 100 (Each)	Pilot Plant Area	7.3 AF (Total)	Geosynthetic
Crow Butte	3	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	6.2 Acres (Each)	900 x 300 (Each)	West of Main Plant/Office Area	Approx. 75 AF (each)	Geosynthetic
Crow Butte	2	R&D Evaporation Ponds (East and West)	Approx. 0.23 Acres (Each)	Approx. 100 x 100 (Each)	Southeast of Main Plant/Office Area	4 AF (each)	Geosynthetic

[*] While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;

** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;

*** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8μCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;

**** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

(d) For each "existing mill impoundment, evaporation pond, and settling pond" identified in response this request, identify the date(s) each was:

- **(i) constructed;**
- **(ii) used for the continued placement of new tailings;**
- **(iii) placed on "standby status;" and**
- **(iv) closed, and during what periods they were operational.**

<u>Response to Question #3(d):</u> Dates associated with construction and operation of each waste water holding area identified in response to Question 3(c) (above) are provided in the table below.

Uranium In-Situ Leaching Project	**Waste Water Holding Area**	**Date Constructed**	**Date Used for Continued Placement of New Tailings***	**Date Placed on "Standby Status"**	**Date Closed / Operational Period****
Smith Ranch	Evaporation (Storage) Ponds (East and West)***	1981	Not Applicable	Not Applicable	Continuous operation since 2002
Highland Uranium Project	Radium Settling Basins (East and West)****	1987	Not Applicable	Not Applicable	Operational from approx. 1987-2002
Highland Uranium Project	Purge Storage Reservoir No. 1*****	1987	Not Applicable	Not Applicable	Operational from approx. 1987-2004
Highland Uranium Project	Purge Storage Reservoir No. 2*****	1994	Not Applicable	Not Applicable	Continuous operation since 1994
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)******	Approx. 1980	Not Applicable	Not Applicable	Operational from approx. 1980-1984
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	1991	Not Applicable	Not Applicable	Continuous operation since 1991
Crow Butte	R&D Evaporation Ponds (East and West)	1986	Not Applicable	Not Applicable	Periodic Operation Since 1986

* Each of the ponds/impoundments identified in this chart do not, at any time, receive and/or store uranium mill tailings. These ponds/impoundments merely receive process effluent in the form of process bleed, restoration fluid or other process-oriented water;
** See "*" description above
*** While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;
**** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;
***** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8μCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;
****** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

In addition to the chart provided in response to this portion of Question #3, Cameco Resources provides the following additional discussion. As discussed in the response to Question #3(c) above, uranium in-situ leaching facilities do not generate uranium mill tailings as envisioned by Congress in UMTRCA. Uranium in-situ leaching facilities utilize liquid recovery solutions to solubilize and recover uranium from an identified underground ore body and do not engage in conventional uranium milling processes that would result in the generation of uranium mill tailings such as crushing and grinding of ore. As a result, uranium in-situ leaching facilities do not utilize any facilities that would require compliance with Subpart W work practice standards. In addition, since there are no uranium mill tailings at uranium in-situ leaching facilities, no such tailings are placed in evaporation or other site ponds or impoundments as they are designed for handling process wastewater pending final disposition via land application, solar evaporation or deep well disposal. As stated above in the Preamble, while there may be fines from uranium recovery suspended in process wastewater stored in evaporation or other site ponds or impoundments, there are no uranium mill tailings placed in such ponds or impoundments at any time at Cameco Resources' uranium in-situ leaching facilities. Thus, Cameco Resources' response to Subsection (d)(ii) will be "not applicable" as there are not now, nor have there ever been, uranium mill tailings placed in Cameco Resources' uranium in-situ leaching facility ponds or impoundments.

In addition, with respect to the dates of construction for site ponds or impoundments, while Cameco Resources maintains that none of its site facilities are subject to Subpart W, if they were the date of construction would be important because any pond or impoundment subject to Subpart W that was constructed and/or in use prior to December 15, 1989 does not need to comply with either work practice standard, but rather with the aforementioned 20 pCi/m2-s standard.

<u>Question #4:</u> For each "existing mill impoundment, evaporation pond, and settling pond identified in response to request 3.(d) above:

Prior to providing specific responses to each subsection of Question #4, Cameco Resources believes that it is important to provide additional discussion regarding the Subpart W rulemaking and its conclusion that evaporation ponds are not within the scope of Subpart W. As stated above in the Preamble, EPA evaluated all potential sources of radon emissions at conventional uranium milling facilities. The scope of this evaluation included traditional uranium mill tailings piles/impoundments, as well as evaporation ponds or other similar ponds or impoundments. With respect to traditional uranium mill tailings piles/impoundments, the Final Rule for Subpart W identified three different subcategories of mill tailings facilities, "operating mill tailings—existing *piles*, operating mill tailings—new technology, and disposal of uranium mill tailings (*as a separate source category*." With respect to mill tailings piles [impoundments], EPA states, "[e]xisting mill tailings piles are large piles of wastes that emit radon." These tailings piles/impoundments were identified by EPA as a potential significant source of radon and post December 15, 1989 new facilities were deemed to require compliance with Subpart W work practice standards.

However, with respect to evaporation ponds or other similar ponds/impoundments, EPA separately evaluated such facilities because the characteristics of the stored wastewater are significantly different from uranium mill tailings. Indeed, this statement is supported by EPA's Subpart T rulemaking when it stated:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the disposal piles as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the piles (once controlled) against erosion, and the reclamation and maintenance of groundwater....*These actions entail the use of evaporation ponds that in some instances....have been placed directly upon the disposal site*."[33]

When evaluating evaporation ponds as a potentially significant radon emissions source, EPA stated, "*the ponds themselves serve as an effective radon barrier*." This was true, in part because, as stated by EPA, "[r]adon emissions from these piles are retarded by the presence of water...." Indeed, as stated in the Background Information Document to EPA's *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings*:

> "Water-covered tailings have a radon-222 flux of about 0.02 pCi/m2-s per pCi of radium-226 per gram of tailings compared with a dry tailings flux

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[33] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

> of about 1 pCi/m2-s per pCi of radium-226 per gram, *or a radon-222 reduction efficiency of about 98 percent….Emission estimates of zero are frequently used for ponded and saturated areas, and that assumption is used throughout this report*."[34]

This conclusion is supported by, as noted above, Method 115, paragraph 2.1.3 states, "radon flux measurements shall be made within each region on the pile, *except for those areas covered with water*." Paragraph 2.1.3(a) also states, "*Water covered area*--no measurements required as radon flux assumed to be *zero*."[35] As a result and due to the need for active evaporation ponds during site remedial action efforts, EPA concluded:

> "*EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved."[36]

To support this decision, EPA stated, with respect to evaporation ponds:

> "this decision is bolstered by the absence of any evidence that there is a significant public health risk presented by the radon emissions from these evaporation ponds during the period they are employed as part of the overall remediation of the site."[37]

In addition, in the Subpart W portion of the rulemaking, EPA reaffirmed this position by concluding:

> "*EPA reiterates that the Agency does not intend the expeditious radon cover requirement to extend to areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency…to be an appropriate aspect of the overall remedial program for the particular site."[38]

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[34] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings, Final Report, Background Information Document* at 7-9 (August 1986) (emphasis added).

[35] Emphasis added. *See also* Method 115, Paragraph 2.1.6 *Radon Flux Measurement*…The radon collector is placed *on the surface* of the pile area to be measured and allowed to collect radon for a time period of 24 hours. The detailed measurement procedure provided in Appendix A of EPA 520/5-85-0029(1) shall be used to measure the radon flux on the uranium mill tailings except the *surface of tailings* shall not be penetrated by the lip of the radon detector as directed in the procedure, rather the collector shall be carefully positioned *on a flat surface* with soil or tailings used to seal the edge.

[36] *Id.*

[37] *Id.*

[38] 56 Fed. Reg. 67561 (emphasis added).

The logic of this conclusion is equally applicable to such ponds or impoundments that are licensed by NRC or its Agreement States as "an appropriate aspect" of the operational uranium recovery program at the particular site. Therefore, based solely on the analysis provided by EPA in its Subparts T and W rulemakings, Cameco Resources reiterates its position that Subpart W work practice standards do not apply to uranium in-situ leaching facility or any other facility evaporation ponds or other similar ponds or impoundments.

(a) identify whether the "continuous disposal" method is used, 40 C.F.R. Section 61.252(b)(2);

Response to Question #4(a): As stated above in the response to Question #3, uranium in-situ leaching facilities do generate process waste streams that qualify as 11e.(2) byproduct material but do not constitute uranium mill tailings. The predominant process waste streams at such facilities are process wastewater in two forms: (1) process bleed and (2) restoration fluids. Each of these wastewater streams are handled using one of a number of options, including land application, solar evaporation or disposal via deep disposal wells. But, uranium in-situ leaching facilities do not, however, engage in conventional uranium milling activities that generate uranium mill tailings such as crushing or grinding ore. Thus, as will be discussed below, Subpart W does not apply to uranium in-situ leaching facilities as they do not handle uranium mill tailings.

With respect to the process wastewater in the form of process bleed and restoration fluids, site evaporation, settling or storage ponds merely receive such water pending final disposition via land application, solar evaporation or deep well disposal. Neither of these process water waste streams can be considered uranium mill tailings required long-term containment and control as envisioned by Congress in UMTRCA. First, the process bleed is a one to three percent process water stream taken from the native groundwater (fortified with lixiviant) used to extract uranium from the identified underground ore body. This process bleed is designed as a uranium in-situ leaching control measure to ensure that native groundwater within the ore/recovery zone remains within the boundaries of an EPA-approved aquifer exemption and does not migrate to adjacent, non-exempt aquifers. This process bleed is removed and either treated to meet applicable standards for land application, placed in evaporation ponds for final disposition or disposed of via deep disposal wells. While it is classified by NRC as 11e.(2) byproduct material, this process bleed does not in any way resemble uranium mill tailings as envisioned by Congress in UMTRCA.

Second, restoration fluids are process wastewater streams that result from mandatory groundwater restoration designed to return uranium in-situ leaching facility site groundwater consistent with pre-operational water quality standards. Active groundwater restoration requires that uranium in-situ leaching facility operators utilize wastewater control programs similar to those used to handle process bleed in that groundwater removed during restoration is classified as

11e.(2) byproduct material and is either treated for land application, placed in solar evaporation ponds for final disposition or disposed of via deep disposal wells. In addition, restoration fluids, while not considered to be process bleed by definition, are essentially the same physical media as process bleed in that it is in liquid form and does not resemble uranium mill tailings as envisioned by Congress in UMTRCA. Based on these descriptions, Subpart W does not apply to uranium in-situ leaching facilities used for wastewater management.

Further, it is apparent from the language of Subpart W's work practice standards that it could not have been intended to apply to uranium in-situ leaching facility evaporation ponds, settling ponds or other process wastewater handling facilities. Currently, Subpart W prescribes two methods of compliance, one of which is termed "continuous disposal." Under 40 CFR § 61.252(b)(2), EPA requires compliance by "continuous disposal of tailings such that tailings are dewatered and immediately disposed with no more than 10 acres uncovered at any time…."[39] Based on the language in this regulation, common sense dictates that such a requirement could no reasonably apply to an impoundment or ponds that receives and/or stores process wastewater for either treatment, evaporation or transport for deep well disposal. Further, it also makes common sense that you cannot "dewater water" as the standard appears to require. Given that uranium mill tailings often time have some water content, it appears that this standard was directed at such tailings and not uranium in-situ leaching or conventional mill process wastewater. Additionally, the cover requirement in this standard cannot apply to such impoundments or ponds as covering water sources is completely impractical and serves no purpose other than to add additional volume to the impoundment or pond and make the evaporation or transport process much more difficult. Thus, as a practical matter, the "continuous disposal" requirement cannot apply to uranium in-situ leaching facility ponds or impoundments.

Additionally, it is important to note that EPA's Subpart W analysis has determined that two forty (40) acre tailings impoundments operating at any one time are adequately protective of public health and safety. As a result, EPA should permit the use of whatever size and number of evaporation or other ponds or impoundments, because the Subpart W rulemaking concluded that even water covered tailings are a zero source term.

(b) describe the mechanical methods used to dewater tailings, the process used to dispose of tailings, the precise location of any and all disposal areas used for dewatered tailings, and the method used to cover such tailings;

Response to Question #4(b): This portion of Question #4 is inapplicable to uranium in-situ leaching facilities. In addition to the fact that uranium in-situ leaching facilities do not generate tailings, as stated in the answer to Question #3 above, it is impractical to assert that a uranium in-situ leaching facility operator can dewater process wastewater from active operations or groundwater

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[39] 40 CFR § 61.252.

restoration. As is the case with conventional uranium milling facilities that utilize evaporation ponds, settling ponds or catchment basins, uranium in-situ leaching facilities generate process wastewater that requires a waste management program that does not resemble that used for uranium mill tailings. While uranium mill tailings impoundments are designed specifically to meet UMTRCA's mandatory long-term closure requirements as delineated in 10 CFR Part 40, Appendix A and 40 CFR Part 192, evaporation or other ponds or impoundments do not have similar requirements as they are not designed to meet any such long-term closure requirements. Traditionally, conventional uranium mills and uranium in-situ leaching facilities utilize such ponds or impoundments on a temporary basis until their usefulness is exhausted; normally, this occurs at the conclusion of a groundwater corrective action program or just prior to license termination. At such time, these ponds or impoundments are reclaimed and tested to ensure that appropriate site soils standards are met. This distinguishing of uranium mill tailings impoundments from evaporation or other ponds or impoundments is envisioned by EPA in its Subpart W rulemaking:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the disposal piles as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the piles (once controlled) against erosion, and the reclamation and maintenance of groundwater....*These actions entail the use of evaporation ponds that in some instances....have been placed directly upon the disposal site.*"[40]

This language demonstrates that, while anticipating the need for a "cover" on tailings disposal areas, EPA also anticipated "ancillary" facilities such as evaporation ponds that did not involve the storage of tailings, but rather were used to be a part of the site's remedial program. This is reflected in EPA's subsequent statement in this rulemaking:

> "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located, even if on the pile itself, *to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved.*"[41]

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[40] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

[41] 56 Fed. Reg. 67561 (December 31, 1991). It is also important to note that uranium in-situ leaching facilities require evaporation or other similar ponds/impoundments as part of the overall operational and remedial action plans in a manner similar to that described by EPA for conventional uranium mill tailings facilities. Uranium in-situ facilities require these

By distinguishing between these two types of facilities, EPA demonstrates that the requirements imposed upon uranium mill tailings impoundments (Subpart W), do not apply to other "ancillary" site facilities such as evaporation or other ponds or impoundments.

(c) provide *all* disposal records maintained by you, including any records that reflect the manner of disposal and the method of covering such tailings;

Response to Question #4(c) (See Response to #4(b) above for additional discussion):

As stated above, the scope of the inquiry in Question #4(c) is strictly limited to the types of wastes generated by the uranium in-situ leaching process. These waste streams can be classified using the following 11e.(2) byproduct material sub-categories, none of which are disposed of on-site for permanent, long-term surveillance and monitoring under UMTRCA: (1) process wastewater streams such as process bleed or restoration fluids that have been classified as 11e.(2) byproduct material; and (2) solid wastes classified as 11e.(2) byproduct material such as spent IX resins and process materials that cannot be decontaminated for unrestricted use. As discussed above, process wastewater streams are generated during active operations and groundwater restoration and are either treated for land application, stored in evaporation ponds for final disposition or stored pending disposal via deep disposal wells. While some or all of the process wastewater streams are maintained in site evaporation or other ponds or impoundments for varying periods of time depending on the selected disposition method, no such waste streams are stored on-site permanently.

Solid wastes, if generated, are stored as appropriate and are not disposed of on-site in any tailings or other form of surface impoundment. While it is possible in the future for uranium in-situ leaching facilities to have permanent, on-site disposal of 11e.(2) byproduct material, NRC policy dictates that such facilities do not have permanent on-site disposal of such 11e.(2) byproduct material.[42]

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ponds/impoundments to maintain a "process bleed" by which excursions of recovery solutions to adjacent, non-exempt aquifers which would result in the need for groundwater corrective action can be avoided and to engage in active groundwater restoration at the conclusion of active uranium recovery operations. These actions are no different from a conventional uranium mill tailings facility engaging in groundwater corrective action to avoid migration of 11e.(2) byproduct material offsite and in final site reclamation to achieve site closure and license termination.

[42] Commission policy currently requires that all solid 11e.(2) wastes generated at uranium in-situ leaching facilities be disposed of at licensed 11e.(2) disposal facilities pursuant to 10 CFR Part 40, Appendix A, Criterion 2's requirement that the Commission avoid the proliferation of small 11e.(2) waste disposal sites. However, this policy is subject to change should a uranium in-situ leaching licensee request Commission authorization.

(d) provide all emissions data collected by you or anyone working on your behalf that show that emissions from disposed materials have "emissions consistent with applicable Federal standards" as defined in 40 C.F.R. § 61.252(a);

Response to Question #4(d): This portion of Question #4 requests emissions data for disposed materials to demonstrate compliance with applicable federal standards. As a preliminary matter, this portion of Question #4 is extremely vague as previous questions have specifically identified the "materials" to which they applied; in most cases uranium mill tailings. However, this portion merely references "disposed materials." But, as noted above, Cameco Resources' uranium in-situ leaching facilities do not engage in any on-site disposal of 11e.(2) solid waste materials at its project sites. Thus, Cameco Resources' response to this portion of Question #4 is "not applicable."

(e) describe the method of complying with requirement regarding the maximum of 10 acres uncovered at any one time, as specified in 40 C.F.R. Section 61.252(b)(2);

Response to Question #4(e): This portion of Question #4 requests processes and procedures for complying with Subpart W's requirement for the "continuous disposal" requirement under 40 CFR Part 61.252(b)(2). Cameco Resources' response to this request is "not applicable" for a number of reasons. First, as stated throughout this Response, Cameco Resources' position is that Subpart W work practice standards do not apply to its uranium in-situ leaching facilities, including site evaporation, settling or other ponds and impoundments. With that said, regardless of whether Cameco Resources' site evaporation ponds/impoundments are or exceed ten (10) acres in size, it is illogical to assert that the "continuous disposal" requirement under 40 CFR § 61.252(b) could possibly apply to such ponds/impoundments, because it is impractical, if not impossible, to have a "partially covered" evaporation pond at a uranium in-situ leaching facility. Evaporation ponds at uranium in-situ leaching facilities are designed to handle process wastewater or waste that is almost entirely, if not entirely, composed of water. In any event, evaporation ponds do not require covers when they are in use during active operations or for groundwater restoration. Further, as process wastewater is continuously flowing into these ponds and water does not remain in one portion of the pond over time, it is impractical to employ a "partial cover" requirement.

In addition, as stated above, EPA's Subpart W rulemaking expressly excludes evaporation ponds from the work practice standards due to their necessary role in site activities and the lack of any evidence of a potential radon emissions hazard. Evaporation ponds have been identified by EPA as an integral part of site operations and reclamation at both conventional mills and uranium in-situ leaching facilities, including their applications for active processing, groundwater restoration, and groundwater corrective action programs. As a result, EPA determined that, "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located…."[43] Thus, Cameco Resources asserts that its position that Subpart W does not apply to uranium in-situ leaching facilities is further confirmed by the fact that the 40 CFR § 61.252(b) "continuous disposal" work practice standard cannot be practically applied to such facilities.

(f) provide proof that your activities comport with the requirements of EPA regulations found at 40 C.F.R. § 192.32(a), including all pertinent documents and correspondence to and from the NRC;

Response to Question #4(f): This portion of Question #4 requests evidence or "proof" that Cameco Resources' uranium in-situ leaching facilities comport with EPA regulations at 40 CFR § 192.32(a). Cameco Resources' position on this portion of Question # 4 is that 40 CFR § 192.32(a) does not apply to its uranium in-situ leaching facilities, including specifically site evaporation, settling or other ponds/impoundments.

Initially, as a general matter, 40 CFR Part 192 entitled *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings* was promulgated by EPA pursuant to UMTRCA as part of its Congressional mandate to issue generally applicable standards for uranium mill tailings impoundments. Section 192.32(a) (part of Subpart D entitled *Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended*) specifically applies to uranium mill tailings impoundments that are engaging in active processing operations. These standards apply specifically to "surface impoundments subject to this subpart." Throughout Section 192.32, EPA refers to these surface impoundments as "uranium mill tailings and impoundments" and proceeds to discuss the requirements for such piles/impoundments, including emplacement of permanent radon barriers/covers. These requirements traditionally have been applied to "surface impoundments" that contain uranium mill tailings, as discussed throughout this Response, and not to facilities such as evaporation or settling ponds. These requirements are critical to uranium mill tailings impoundments because such impoundments are subject to Section 83 of the AEA's requirements for long-term surveillance and monitoring, while evaporation ponds that are part of the site to be transferred, do not have such stringent requirements for covers and stabilization.

Next, as stated several times in this Response, Cameco Resources asserts that the Subpart W work practice standards, which are implicated in this portion of Question #4, do not apply to uranium in-situ leaching facilities, including site evaporation, settling or other ponds/impoundments. Please see the Preamble and the Response to Question #3 above and under cover dated March 13, 2009 for more discussion.

Finally, given that 40 CFR Part 192 and other provisions of NRC and EPA regulations pertaining to uranium mill tailings recognize that site radon emissions are a potential threat to public health and safety, it is important to note that EPA's Subpart W rulemaking expressly states that, due to the water content in such ponds/impoundments,

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[43] *See* 56 Fed. Reg. 67561 (December 31, 1991).

potential radon emissions default to zero and have not exhibited any evidence that they pose a significant radon emissions risk. Please see the Response to Question #3 above for additional discussion.

(g) provide a copy of all construction and modification applications required by 40 C.F.R. § 61.07, a copy of all notifications of startup pursuant to § 61.09 and a copy of any approvals issued pursuant to and § 61.08 or any state authority, indicating by whom these approvals were issued (state or federal officials);

Response to Question #4(g): See response to Question #4(f) above.

(h) provide copies of any other permits that have been applied for and/or received under the Clean Air Act;

Response to Question #4(h): Copies of the following permits are included in Attachment B:

- Smith Ranch: Wyoming Department of Environmental Quality, Air Quality Division Permit No. CT-957 dated December 30, 1991
- Highland Uranium Project: Wyoming Department of Environmental Quality, Air Quality Division Permit No.MD-153 dated August 12, 1991

(i) provide copies of any licenses or license applications for construction or operation issued by or filed with the Nuclear Regulatory Commission;

Response to Question #4(i): Copies of License Nos. SUA-1548 and SUA-1534 from the U.S. Nuclear Regulatory Commission are provided in Attachment C. A summary of the corresponding license associated with each uranium in-situ leaching facility is also provided in the table below.

Corporate Entity	**Uranium In-Situ Leaching Project**	**Description**	**NRC License No.**
PRI*	Smith Ranch-Highland Uranium Project	Full Uranium In-Situ Leaching Operations***	SUA-1548
PRI	Reynolds Ranch	Satellite****	SUA-1548
PRI	Gas Hills Uranium In-Situ Leaching Project	Satellite****	SUA-1548
PRI	Ruth Uranium In-Situ Leaching Project	Satellite****	SUA-1548
PRI	North Butte Uranium In-Situ Leaching Project	Satellite****	SUA-1548
CBRI**	Crow Butte	Full Uranium In-Situ Leaching Operations***	SUA-1534

* PRI – Power Resources, Inc. doing business as Cameco Resources;

** CBRI – Crow Butte Resources, Inc. doing business as Cameco Resources;

*** Full uranium in-situ leaching operations include wellfields, satellite IX and central processing (i.e., elution, precipitation, drying and packaging of yellowcake);
**** Satellite operations consist of wellfields and satellite IX with no central processing facilities.

(j) provide copies of any other licenses issued by states under state authority;

Response to Question #4(j): Copies of licenses and/or permits issued by states with respect to the waste water holding ponds identified in response to Question 3(d) above are provided in Attachment D.[44] A summary of these various licenses and/or permits is also summarized in the table below.

Uranium In-Situ Leaching Project	Waste Water Holding Area	License and/or Permit	Authorizing Agency
Smith Ranch	Evaporation (Storage) Ponds (East and West)	Permit to Mine No. 633	WDEQ/LQD*
Highland Uranium Project	Radium Settling Basins (East and West) and Purge Storage Reservoirs Nos. 1 and 2	Permit to Mine No. 603	WDEQ/LQD
Highland Uranium Project	Purge Storage Reservoir No. 1	Permit No. 9289R	WSEO**
Highland Uranium Project	Purge Storage Reservoir No. 2	Permit No. P10045R	WSEO
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)	Permit to Mine No. 631	WDEQ/LQD
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)	Permit No. 8432 Res.	WSEO
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4) and R&D Evaporation Ponds (East and West)	Permit No. NE0122611	NDEQ***

* WDEQ – Wyoming Department of Environmental Quality/Land Quality Division
** WSEO – Wyoming State Engineer's Office
*** NDEQ—Nebraska Department of Environmental Quality

(k) provide current license status, indicating whether any license modifications are planned or have been agreed to;

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[44] Due to the large number of documents associated with Permits to Mine Nos. 603, 631, and 633, these permits are not included herein (Attachment D). Copies of these permits are available through the Wyoming Department of Environmental Quality (WDEQ), Land Quality Division office in Cheyenne, Wyoming.

Response to Question #4(k): With respect to the waste water holding ponds identified in response to Question 3(d) above, all licenses and/or permits identified in response to Questions 4(i) and (j) above are active and no modifications are planned.

(l) indicate whether all facilities and ponds/impoundments were constructed and are being operated in accordance with all permits and federal regulations;

Response to Question #4(l): All waste water holding ponds identified in response to Question 3(d) above have been constructed and, to the best of Cameco Resources' knowledge, are being operated in accordance with all permits and federal regulations.

(m) provide a description of any pollution control equipment; and

Response to Question #4(m): A description of pollution control equipment associated with each waste water holding area identified in response to Question 3(d) is summarized in the table below.

Uranium In-Situ Leaching Project	**Waste Water Holding Area**	**Lining Material**	**Pollution Control Equipment**
Smith Ranch	Evaporation (Storage) Ponds (East and West)*	Geosynthetic	Leak Detection
Highland Uranium Project	Radium Settling Basins (East and West)**	Not Applicable	Not Applicable
Highland Uranium Project	Purge Storage Reservoir No. 1***	Clay	Ground Water Monitoring
Highland Uranium Project	Purge Storage Reservoir No. 2***	Clay	Ground Water Monitoring
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)****	Geosynthetic	Leak Detection
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	Geosynthetic	Leak Detection; Ground Water Monitoring
Crow Butte	R&D Evaporation Ponds (East and West)	Geosynthetic	Leak Detection; Ground Water Monitoring

* While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;

** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;

*** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8µCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;

**** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

(n) state whether each of Cameco Resources' uranium mills and uranium in-situ leaching facilities is subject to the requirements of the National Emissions Standard for Hazardous Air Pollutants (NESHAP) for Radon Emissions from Operating Mill Tailings as defined under 40 C.F.R. §§ 61.250 et seq. If not, explain why not.

Response to Question #4(n): As stated in the Preamble above and in subsequent portions of this Response, Cameco Resources asserts that none of its uranium in-situ leaching facilities is subject to EPA's 40 CFR §§ 61.250 and associated requirements. Cameco Resources' position is that Subpart W does not apply to each of its uranium in-situ leaching facilities, because they do not generate and store uranium mill tailings as envisioned by Congress in UMTRCA. Further, Cameco Resources notes that EPA expressly excluded evaporation ponds and other associated ponds or impoundments from the scope of Subpart W during its administrative rulemaking. Please see the Preamble and the Responses to Question #3 above for additional discussion.

Question #5: Submit complete results of all air and radon emission tests, emissions characterizations, or emissions studies, conducted or attempted at each facility since January 1, 1980. Indicate whether these tests were conducted as specified in 40 C.F.R. §§ 61.253 and 61.255. Include with this information relevant operating parameters measured and all data recorded during these tests or studies, including the water level and moisture content as well as how it was determined that the "long term radon flux from the pile" was represented during the time of measurement, pursuant to 40 C.F.R. Part 61, Appendix B, Method 115, 2.1.1;

Response to Question #5: This Question requests submission of all air and radon emission tests, emissions characterizations, or emissions studies "conducted or attempted" at each Cameco Resources facility since January 1, 1980. Cameco Resources' uranium in-situ leaching facilities are not subject to EPA's Subpart W requirements for uranium mill tailings impoundments as each facility does not utilize such impoundments. However, Cameco Resources does submit semi-annual reports to NRC in compliance with its NRC license, each of which contains site dose monitoring data, including site worker exposure and off-site public exposure from all radiological pathways including any radon emissions from available pathways. These reports contain a significant amount of data and information regarding site emissions.[45] For example, Cameco Resources' NRC License No. SUA-1534 states:

> "Effluent and environment monitoring program results submitted in accordance with 10 CFR 40.65 shall be reported in the format shown in Table 3 of Regulatory Guide 4.14, (Rev. 1) entitled, "Sample Format for Reporting Monitoring Data." These reports also shall include injection rates, recovery rates, and injection manifold pressures."[46]

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[45] These reports are publicly available on NRC's ADAMS database. *See* NRC License No. SUA-1534 & SUA-1548 for reporting requirements.

[46] *See* SUA-1534, License Condition 12.1.

Question #6: **Provide copies of all monthly and annual compliance reports prepared and submitted to EPA, as specified in 40 C.F.R. § 61.254, or similar reports submitted to all other regulatory agencies. To the extent, that you have not submitted any such report(s) provide the reasons for not having done so, and reasons, if any, you claim as a basis for not submitting such reports.**

Response to Question #6: For the reasons discussed above, Cameco Resources' answer to this question is "not applicable," because, pursuant to 40 CFR § 61.254, a uranium recovery licensee is only required to comply with this reporting requirement to the extent that they are "[t]he owners or operators of operating existing mill impoundments…."[47] As stated throughout this Response, Cameco Resources does not own or operate any existing [uranium] mill tailings impoundments, as it only owns/operates uranium in-situ leaching facilities which, by definition, do not utilize uranium mill tailings impoundments. As a result, Cameco Resources is not required to comply with 40 CFR § 51.254 reporting requirements. However, as stated above, Cameco Resources does submit semi-annual reports to NRC in compliance with its NRC license, each of which contains site dose monitoring data, including site worker exposure and off-site public exposure from all radiological pathways including any radon emissions from available pathways.

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[47] *See* 40 CFR § 61.254.

EPA-5172

Angelique Diaz

To

cc

bcc

Subject UPLOAD C:\Users\adiaz01\Documents\TELECOMMUTE\Subpart W\W WORKGROUP\SubWFOIAResponsiveDocuments\2009-05-28 Cotter's Response to EPA's Request for Information_final_.pdf

- 2009-05-28 Cotter's Response to EPA's Request for Information_final_.pdf

Cameco

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April 27, 2009

United States Environmental Protection Agency
Attn: Charles Garlow, Attorney-Advisor
OECA, Air Enforcement Division
1200 Pennsylvania Avenue, NW-MC 2242A
Washington, D.C. 20460

Dear Mr. Garlow:

Power Resources, Inc. (Power Resources) and Crow Butte Resources, Inc. (Crow Butte Resources) doing business as (d/b/a) Cameco Resources (hereinafter "Cameco Resources) are in receipt of the Environmental Protection Agency's (EPA's) Request to Provide Information Pursuant to the Clean Air Act received November 26, 2008 (hereinafter "Information Request"). On March 13, 2009, Cameco Resources submitted a Partial Response to this Information Request, which reflected responses to the November 26, 2008 and the March 3, 2009 Information Requests (Received), in which a full response to Question 3b and partial responses to Questions 1 and 2 were provided. By this letter, Cameco Resources hereby submits its Response to the remainder of the Information Request. In addition, please see the attached Response for the certification requested by EPA on Page 2 of the Information Request.

As stated in Appendix A of your Information Request, Cameco Resources is entitled to request protection from public disclosure for certain corporate, transactional or other information submitted as part of its response as confidential business information (CBI) under Section 114(c) of the Clean Air Act (42 U.S.C. § 7414). After a thorough review of the Response attached to this letter, Cameco Resources has determined that no information constitutes CBI requiring protection from public disclosure.

If you have any questions regarding any aspects of the attached response, please do not hesitate to contact me at 720-879-5518. Thank you for your time and consideration in this matter.

As required by EPA, I certify under penalty of law that I have examined and am familiar with the information in the enclosed documents, including all attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are, to the best of my knowledge and belief, true and complete. I am aware that there are significant penalties for knowingly submitting false statements and information, including the possibility of fines or imprisonment pursuant to Section 113(c)(2) of the Act and 18 U.S.C. §§ 1001 and 1341.

Respectfully submitted,

Stephen P. Collings

Stephen P. Collings
President, Cameco Resources

Enclosures
c: Andrew M. Gaydosh, Assistant Regional Administrator, Region 8

CERTIFICATE OF MAILING

I, Margie Storms, certify that I sent a Response to the Request to Provide Information Pursuant to the Clean Air Act by Certified Mail, Return Receipt Requested, to:

United States Environmental Protection Agency
Attn: Charles Garlow, Attorney-Advisor
OECA, Air Enforcement Division
1200 Pennsylvania Avenue, NW-MC 2242A
Washington, D.C. 20460

on the 27th day of April, 2009.

Margie Storms

Margie Storms, Executive Assistant

Certified Mail Receipt Number 7005 0390 0003 9500 7756

CAMECO RESOURCES' RESPONSE TO UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S NOVEMBER 26, 2009 INFORMATION REQUEST

PREAMBLE

Prior to providing responses to the specific questions in the Information Request, Cameco Resources would like to provide EPA with additional context upon which such responses will be based. As a general proposition, based on a thorough review of the administrative rulemaking record and associated history, it is Cameco Resources' position that the provisions of 40 CFR Part 61, Subpart W referenced in the Information Request are not applicable to a uranium in-situ leaching facility, including specifically "impoundments" or "ponds" used at Cameco Resources' uranium in-situ leaching facilities such as evaporation or settling ponds as referenced in the Information Request.

Currently, with respect to Atomic Energy Act (AEA) uranium recovery facilities (i.e., facilities generating 11e.(2) byproduct material), Congress has vested EPA with certain regulatory authorities pursuant to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). In addition, Congress also has vested additional authority over certain aspects of such facilities through the Clean Air Act (CAA). In 1977, Congress enacted provisions of the CAA to address potentially hazardous radiological *air* emissions at a variety of facilities, including uranium recovery facilities. In response to this Congressional mandate, EPA promulgated 40 CFR Part 61 to address such radiological *air* emissions.

40 CFR Part 61, Subpart T *National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings* (hereinafter "Subpart T") were promulgated by EPA to address potential hazardous air pollutants (e.g., radon because particulate emissions were addressed effectively under 40 CFR Part 190 fuel cycle regulations) at uranium mill tailings facilities regulated under Title II of UMTRCA, which were *no longer operational*. Subpart T stated, in pertinent part:

> "Radon-222 emissions to the ambient air from uranium mill tailings piles that are no longer operational shall not exceed 20 pCi/(m^2 -sec) (1.9 pCi/(ft^2 -sec)) of radon-222."

Subsequently, after challenges to Subpart T were filed in the United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit), Subpart T was the subject of settlement discussions between the American Mining Congress (now NMA), EPA, and environmental groups, with NRC and Agreement States monitoring as interested, but not formally litigating, parties. These negotiations ultimately led to NRC revising its mill tailings regulations to require licensees to achieve enforceable "milestones" leading to accelerated placement of radon barriers at *non-operational* (i.e., no longer actively milling or on standby) Title II mill tailings disposal sites[1] to satisfy EPA's and the

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[1] 59 Fed. Reg. 28,220 (1994).

environmental groups' concerns that the potential threat from radon emissions be addressed by the prompt placement of radon barriers over disposal areas.[2] After NRC finalized its revisions to 10 CFR Part 40, Appendix A in accordance with this settlement, EPA rescinded Subpart T of its 40 CFR Part 61 regulations and, as such, its requirements no longer apply to conventional uranium mills.[3]

40 CFR Part 61, Subpart W *National Emission Standards for Radon Emissions from Operating Mill Tailings* (hereinafter "Subpart W") was promulgated to address radon emissions at *active* (including standby) uranium mill tailings facilities. Thus, Subpart W applies to operators of uranium mill tailings facilities while they are processing uranium/thorium ores and creating 11e.(2) byproduct material:

> "The provisions of this subpart apply to owners or operators of facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores, commonly referred to as uranium mills and their *associated tailings*. This subpart does not apply to the [final] disposal of *tailings*."

A 20 pCi/m2-s averaged over the entire area of a uranium mill tailings piles/impoundment standard was incorporated by EPA into 40 CFR § 61.252(a) as a standard for all uranium mill tailings impoundments existing on December 15, 1989, because EPA determined that it was technologically infeasible to force licensee to conform existing mill tailings impoundments/piles to the newly promulgated work practice standards.

On the other hand, new tailings impoundments constructed after December 15, 1989 must comply with one of two *work practice* standards:[4] (1) *phased disposal* in lined impoundments of forty (40) acres and meet the requirements of 40 CFR § 192.32(a) with no more than two impoundments in operation at one time; or (2) *continuous disposal* of tailings that are dewatered and immediately disposed of with no more than ten acres uncovered at one time. Compliance with these *work practice* standards in Subpart W makes the measurement for radon emanations during active operations unnecessary. The annual reporting requirements in 40 CFR § 61.254 apply only to *existing* mill tailings impoundments as of December 15, 1989, that have to comply with the *emissions standard* in Subpart W. Compliance with the emission standard in Subpart W for existing mill tailings impoundments is to be determined annually by the use of Method

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[2] EPA was clearly concerned with prompt placement of radon barriers over mill tailings piles/impoundments and EPA, thus, indicated that the primary purpose of the settlement was:

> "to ensure that owners of uranium mill tailings disposal sites ... bring those piles into compliance with the 20 pCi/m^2s[ec] flux standard as expeditiously as practicable considering technological feasibility . . . with the goal that all current disposal sites be closed and in compliance with the radon emission standard by the end of 1997, or within seven years of the date on which existing operations and standby sites enter disposal status."

59 Fed. Reg. 36,280, 36,282 (1994).

[3] *See* 61 Fed. Reg. 68972 (December 30, 1996) (emphasis added).

[4] 40 CFR § 61.252(a) (2007).

115 of Appendix B (40 CFR § 61.253). The owners of existing (pre-December 15, 1989) mill tailings piles/impoundments shall report the results of compliance calculations required by Section 61.253 and the input parameters in each year by March 31 of the following year (40 CFR § 61.254). EPA's radon measurement Method 115 requires measurement of the different "regions" of tailings disposal facilities except those covered by water.[5]

After a thorough review of the administrative rulemaking record associated with the promulgation of both Subparts T and W and the processes and facilities used at uranium in-situ leaching facilities, Cameco Resources has determined that Subpart W does not apply to any of its uranium in-situ leaching facilities. First, as stated above, the Proposed Rules for both Subparts T and W demonstrate that EPA was concerned about *uranium mill tailings piles/impoundments* and not impoundments or ponds used for evaporation or settling purposes. Nowhere in the titles of either of these two Subparts or in the language of the Proposed Rules did EPA indicate that they were intended to apply to anything other than *inactive* (Subpart T) or *active* (Subpart W) uranium mill tailings impoundments (i.e., uranium mill tailings impoundments receiving tailings from active uranium milling operations), as opposed to impoundments or ponds used solely for evaporation or settling purposes.

Second, the Final Rules promulgated in Subparts T and W provide additional evidence of the limited scope of their application to uranium mill tailings piles/impoundments. On December 15, 1989, EPA published a Federal Register Notice promulgating its final Section 112 NESHAP standards governing radon emission standards for *non*-operational, operational uranium mill tailings impoundments, and future impoundments, analyzing the risks associated with radon emissions from such impoundments, and discussing the potential effects of the proposed 20 pCi/m2-s standard on such impoundments. The final rule makes no reference whatsoever to evaporation ponds at uranium mill sites, but did explicitly reference the types of radon source terms to which Subparts T and W were intended to apply. For example, when describing the process of uranium milling, EPA states:

> "The process of separating uranium from its ore creates waste material called uranium mill tailings....These tailings are collected in impoundments that vary in size from 20 to 400 acres....For the current radionuclides NESHAP rulemaking, EPA is promulgating rules for three different subcategories that deal with mill tailings: operating mill tailings—existing *piles*, operating mill tailings—new

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[5] The Response to Comments to EPA's Final Rule on radon-222 emissions from licensed mill tailings demonstrates that EPA considered an emission standard and determined that "boundaries could be changed to comply with an emission standard which is not an acceptable practice under the CAA. Also, methods to determine emissions from tailings piles also have not been sufficiently developed to provide accurate and consistent measurements of radon emissions." United States Environmental Protection Agency, Office of Radiation Programs, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings*, Response to Comments (August, 1986).

> technology, and disposal of uranium mill tailings (as a separate source category….Existing mill tailings *piles are large piles of wastes that emit radon.*"

As discussed below, the use of the term mill tailings *piles* in this notice is consistent with the language used by Congress when defining "tailings" in UMTRCA:

> "the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted."[6]

This notice also reinforced a commonly accepted premise that would suggest that an evaporation pond would not be a significant radon source term because, as EPA states, "[r]adon emissions from these piles are retarded by the presence of water. However, if operations cease, and the pit is allowed to dry out, emissions can increase significantly."[7] Thus, EPA expressly recognized that the presence of water *in tailings* will significantly retard radon emissions. Accordingly, evaporation ponds which contain process or waste water do not represent a significant potential source of radon emissions.

Third, the rescission of Subpart T also provides additional evidence to support Cameco Resources' position described above. On December 31, 1991, EPA proposed to rescind 40 CFR Part 61, Subpart T "as it applies to owners and operators of uranium mill tailings disposal sites that are licensed by the Nuclear Regulatory Commission (NRC) or an affected NRC Agreement State…."[8] EPA's proposed rescission notice included a section specifically devoted to the question of "whether the requirement extends to the evaporation pond thereby jeopardizing the other remedial aspects of the UMTRCA program."[9] This discussion recognized that evaporation ponds can play an important role in the UMTRCA remedial action programs at uranium mill tailings sites:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the *disposal piles* as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the (once controlled) piles against erosion, and the reclamation and maintenance of groundwater….*These actions entail the use of evaporation ponds that in some instances….have been placed directly upon the disposal site.*"[10]

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[6] It is also common sense that a uranium mill tailings *pile* would not be an evaporation pond, because water generally does not collect and remain in a *pile*.

[7] 54 Fed. Reg. 51654 (December 15, 1989).

[8] 56 Fed. Reg. 67561. This language demonstrates that EPA acknowledges that evaporation ponds are not to be considered as part of the class of facilities known as "uranium mill tailings piles."

[9] *Id.*

[10] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was

After discussing whether evaporation ponds were to be subject to its 40 CFR Part 61, Subpart T standard, EPA concluded:

> "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved."[11]

Indeed, EPA's Proposed Rule prescribed an approach to evaporation pond remediation as follows: "the evaporation pond area may be covered to control radon *after it is no longer in use and ready for covering*."[12] EPA supported this conclusion by reasoning that:

> "the ponds themselves serve as an effective radon barrier, thus this decision is bolstered by the absence of any evidence that there is a significant public health risk presented by the radon emissions from these evaporation ponds during the period they are employed as part of the overall remediation of the site."[13]

Based on this determination, EPA concluded:

> "EPA believes the overall public health interest in comprehensively resolving the problems associated with each site is best served by requiring that the radon cover be expeditiously installed in a manner that does not require interruption of this other aspect of remediation....Rather, EPA believes that provided all other parts of the pile are covered with the earthen cover, compliance with the 20 pCi/m2 standard will result...."[14]

EPA's conclusions about the potential radon source term from evaporation ponds being actively used in uranium mill tailings site reclamation efforts are no less valid for such ponds being actively used during uranium recovery operations at an operational facility subject to Subpart W work practice standards. In addition, on December 30, 1996, EPA's Final Rule rescinding Subpart T contained no statements indicating any change in its interpretation of the scope of Subpart W's work practice standards.

Lastly, on November 15, 1993, EPA promulgated a Final Rule containing Amendments to its regulations applicable to operational NRC/Agreement State licensed uranium mill tailings facilities. In this Federal Register notice/Final Rule, EPA responded to a number of public comments, including comments related to the application of Subpart W requirements to evaporation ponds. As stated by EPA:

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made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

[11] *Id.*

[12] 56 Fed. Reg. 67561 (emphasis added).

[13] *Id.*

[14] *Id.*

> "*EPA reiterates that the Agency does not intend the expeditious radon cover requirement to extend to areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency...to be an appropriate aspect of the overall remedial program for the particular site."[15]

Essentially, in this Final Rule, EPA restated its conclusion from the Subpart T rescission administrative rulemaking record that active evaporation ponds do not represent a significant potential radon source term.[16]

Per the above discussion, the entirety of the administrative rulemaking record associated with the promulgation of Subparts T and W and the subsequent rescission of Subpart T demonstrate that their provisions were not intended to apply only to impoundments actually receiving tailings and not to impoundments used for evaporation or settling purposes. In addition to the administrative rulemaking record, aspects of current statutory and regulatory language pertaining to EPA's authority over uranium recovery facilities that support Cameco Resources' position. As will be demonstrated below, despite the fact that evaporation pond fluids contain some fines from mill processing (which can be considered "tailings-like" 11e.(2) byproduct material) that are either suspended in the fluids or that have settled on the liner of the pond as such fluids have evaporated, neither the fluids with entrained solid fines nor the fines themselves typically would be considered "tailings" in a pond used solely for evaporation purposes during *active* or closure operations. An *active* tailings pile/impoundment is one into which tailings (a mixture of sands, slimes, and fluids) are placed during ongoing uranium recovery operations. The sands and slimes constitute the bulk of the material (typically 70% plus).

First, UMTRCA's definition of "tailings," as incorporated by EPA in 40 CFR Part 61 from UMTRCA, indicates: "[t]he term 'tailings' means *the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted*."[17] Water stored in an evaporation pond from either active recovery operations or groundwater corrective action is not consistent with the UMTRCA definition of "tailings" as the water is added to the processing circuit for the ore (or removed from the groundwater), and is not part of "the remaining portion of the metal-bearing ore from which uranium was extracted." Given that EPA's regulations in 40 CFR Part 61, Subpart T incorporate the UMTRCA definition of "tailings,"[18] EPA arguably has accepted the distinction between tailings in a tailings pile or impoundment and water related to uranium milling in an evaporation pond that may have resulted either from processing or from a groundwater corrective action program.

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[15] 56 Fed. Reg. 67561 (emphasis added).

[16] *Id.*

[17] 42 U.S.C. § 7911(8)

[18] It should be noted that Subpart W's definition of "uranium byproduct material or tailings" adopts essentially the same definition of "11e.(2) byproduct material in Section 11(e) of the AEA, as amended by UMTRCA.

Second, as discussed above, EPA's 40 CFR Part 61, Subpart W work practice standards consistently utilize the terms "tailings *pile*" and "tailings impoundment" when discussing site facilities that are covered by Subpart W work practice standards, which, on their face, do not apply to a liquid storage facility. For example, 40 CFR § 61.221 states in pertinent part:

> "As used in this subpart, all terms not defined here have the meanings given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:
>
> (a) *Long term stabilization* means the addition of material on a uranium mill *tailings pile* for the purpose of ensuring compliance with the requirements of 40 CFR 192.02(a). These actions shall be considered complete when the Nuclear Regulatory Commission determines that the requirements of 40 CFR 192.02(a) have been met."[19]

In addition, when prescribing the 20 pCi/m2-s standard in former Subpart T, EPA states:

> "(a) Radon-222 emissions to the ambient air from uranium mill *tailings piles* that are no longer operational shall not exceed 20 pCi/(m^2 -sec) (1.9 pCi/(ft^2 -sec)) of radon-222.
>
> (b) Once a uranium mill *tailings pile or impoundment* ceases to be operational it must be disposed of and brought into compliance with this standard within two years of the effective date of the standard. If it is not physically possible for an owner or operator to complete disposal within that time, EPA shall, after consultation with the owner or operator, establish a compliance agreement which will assure that disposal will be completed as quickly as possible."[20]

EPA's Subpart W regulations use both the term "tailings impoundment" and the term "tailings pile" when discussing the facilities to which Subpart W's 20 pCi/m2-s radon emission standard applies and the work practice standards for operational and potential future tailings facilities.[21] The use of the term "pile" is consistent with prior practices at uranium mill tailings sites where mill tailings were routinely placed in a "pile" rather than the current practice of placing mill tailings in an "impoundment." However, the random use of the terms "pile" and "impoundment" suggests that as technology was transforming, the terms were being interchangeably applied to mill "tailings" disposal

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[19] 40 CFR § 61.221(a-b).

[20] 40 CFR § 61.222(a-b).

[21] *Compare* 40 CFR § 61.252(a); 40 CFR § 61.252(b-c). This is entirely consistent with the history of the development of uranium mill tailings disposal facilities in that the older uranium mills constructed "piles" for disposal of tailings; but by the time that EPA's CAA regulations were being developed and promulgated, the technology had advanced to use "impoundments" which were, and are, more stable and controllable in both the short and long-term context than the old "piles."

facilities. As a result, Subpart W appears to apply to "tailings" as described in EPA's rulemaking materials, whether the term "piles" or "impoundments" is used.

Additional evidence for the positions espoused above can be found in EPA's background and guidance documents on NESHAPs, its Final Rule on Subpart W work practice standards, and their application to uranium mill tailings piles/impoundments and the appendix setting out Method 115 entitled *Monitoring for Radon Emissions*. Initially, EPA's NESHAP documents expressly recognize that the scope of the Subpart W work practice standards was intended to reach *tailings* stored in on-site tailings piles/impoundments *and not* to other site facilities such as evaporation ponds:

> "As with any ore-processing operation, uranium milling produces large quantities of waste rock. Uranium mill wastes, *or tailings*, are usually stored in an impoundment located on the mill site."[22]

Further, EPA's guidance on work practices includes a discussion of potential work practice procedures for controlling radon emissions from milling operations that result in tailings. These practices include the use of "earthen covers" to be applied to tailings to reduce potential fugitive emissions such as radon:

> "Earth covers which consist of layered soil approximately 3 meters deep are frequently used on waste piles, reclaimed lands, or inactive surface mining areas to reduce both particulate and radon emissions."[23]

However, the use of an earthen cover to retard radon emissions from an evaporation pond rather than a mill tailings pile/impoundment is unnecessary because the water in the pond retards such emissions, and EPA's recognition that, when the pond is no longer actively used, it will be dried and covered or, if lined, its liner will be disposed in a mill tailings pile as 11e.(2) material.

EPA's background document for its Subpart W work practice standards contains additional evidence to support the conclusion that such standards do not apply to evaporation ponds. When describing what is encompassed by the term "tailings," EPA states:

> "Tailings include the barren crushed ore material plus process solutions. These tailings consist of mixtures of sands and slimes (coarse and fine tailings). *Evaporation ponds used to contain excess liquid from tailings impoundments also contain suspended...tailings....*"[24]

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[22] United States Environmental Protection Agency, *Radionuclides: Background Information Document for Final Rules*, Volume I at 4-29 (October, 1984).

[23] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings: Background Information Document* at 7-2 to 7-3 (August, 1986).

[24] *Id.* at 3-19. In addition, the statement following this quote further demonstrates that EPA considered fluids in evaporation ponds to not be a radon source term: "*If exposed,* these solids are

This statement appears to support the fact that the term "tailings" is intended to apply to the materials in a site's active mill tailings impoundments and not to fluids in impoundments used solely as evaporation ponds, as evaporation ponds are considered a separate point of analysis from mill tailings impoundments. EPA's Response to Comments also includes evidence that the work practice standards were not intended to apply to evaporation ponds due to their minimal radon emissions:

> "Recent technical assessments of radon emission rates from tailings indicate that radon emissions from tailings covered with less than one meter of water, or merely saturated with water, are about 2% of emissions from dry tailings. *Tailings covered with more than one meter of water are estimated to have a zero emissions rate. The Agency believes this calculated difference between 0% and 2% is negligible. The Agency used an emission rate of zero for all tailings covered with water or saturated with water in estimating radon emissions.*"[25]

Additionally, as Method 115, paragraph 2.1.3 states, "radon flux measurements shall be made within each region on the pile, *except for those areas covered with water.*" Paragraph 2.1.3(a) also states, "*Water covered area*--no measurements required as radon flux assumed to be *zero*."[26]

Finally, significantly, EPA also discusses the relatively small amount of radon potentially emitted from on-site impoundments at uranium in-situ leaching facilities: "A small amount of radon is released from the waste impoundments used to store contaminated liquids from the operation." Further, EPA's Background Information Document on *Radionuclides* states regarding uranium in-situ leaching facilities: "The radioactive emissions from this source are small compared to the other sources."[27] These statements are bolstered by EPA's response to comments on its final NESHAP rule for underground uranium mines:

> "The Agency has not ignored the risks from surface and <u>in situ</u> uranium mining...Standards were not proposed for either of these technologies as the

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assumed to emit radon-222 at the same specific flux as tailings impoundments." The low nature of tailings covered by water is also noted by EPA in Volume I of its Background Information Document on *Radionuclides*: "When tailings impoundment areas are almost completely covered by water, radionuclide emissions will be low."

[25] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings: Response to Comments* at 11 (October, 1984).

[26] Emphasis added. *See also* Method 115, Paragraph 2.1.6 *Radon Flux Measurement*...The radon collector is placed *on the surface* of the pile area to be measured and allowed to collect radon for a time period of 24 hours. The detailed measurement procedure provided in Appendix A of EPA 520/5-85-0029(1) shall be used to measure the radon flux on the uranium mill tailings except the *surface of tailings* shall not be penetrated by the lip of the radon detector as directed in the procedure, rather the collector shall be carefully positioned *on a flat surface* with soil or tailings used to seal the edge.

[27] *See* United States Environmental Protection Agency, *Radionuclides, Background Information Document for Final Rules*, Volume II, p. 5-2 (October, 1984).

> maximum ground level air concentrations of radon emitted from these activities are significantly lower than those which result from underground mining."[28]

Thus, the administrative records in the Subpart T, all Subpart W, and even the Subpart B administrative record for underground uranium mine radon emissions, as well as EPA's Method 115 rationale and procedures suggest strongly that evaporation ponds at conventional uranium milling facilities, much less those at uranium in-situ leaching facilities do not have to comply with nor do they warrant the application of work practice standards or a 20 pCi/m2/sec standard to control radon emissions.

In addition, as stated above, the nature of the process and the types of facilities used at Cameco Resources' uranium in-situ leaching facilities demonstrates that Subpart W work practices standards do not apply to such Cameco Resources facilities. Uranium in-situ leaching facilities do not utilize traditional uranium mill tailings impoundments as envisioned by EPA in its Subpart W work practice standards, because they do not generate uranium mill tailings that are traditionally generated at conventional uranium mills as envisioned by Congress in UMTRCA and do not require any long-term on-site storage and containment of such tailings thereby resulting in what has been termed "irretrievable and irrevocable" impacts. For purposes of this Response, the following uranium in-situ leaching process discussion is specifically related to Cameco Resources' uranium in-situ leaching facilities.

Cameco Resources' uranium in-situ leaching facilities employ a process in which native ground water from the production zone in the aquifer is pumped to the surface for fortification with oxygen and carbon dioxide. This fortified water or "lixiviant" is then returned to the production zone through a series of injection wells in varying patterns in the wellfields. The extraction pumping causes the injected lixiviant to move through the uranium ore body oxidizing and solubilizing the uranium present in the host sandstone. The water from the production wells is processed through ion exchange (IX) resin in IX columns to remove the uranium from solution. After the resin in a column is loaded with uranium, the column is isolated from normal process flow and the loaded resin is removed for elution. During the elution process, the resin is chemically treated in a manner very similar to regenerating a conventional home water softener unit. Following elution, the product is dewatered and dried to produce yellowcake.

After uranium removal in the IX column, the water in the circuit is re-fortified and re-injected as part of a continuous process until the uranium in the ore zone is exhausted. To maintain hydraulic control of lixiviant in the production zone during wellfield operations, more water is extracted than re-injected, thereby creating a hydraulic cone of depression. The difference between the amount of water extracted and re-injected is the wellfield "bleed". This "bleed," which contains elevated levels of radium and other progeny, can be treated in settlement ponds or by filtration to remove the radium using a barium-radium sulphate precipitation method. Ultimately, the treated or untreated waste water is discharged to holding ponds or tanks and from there it must

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[28] United States Environmental Protection Agency, *Radionuclides: Response to Comments for Final Rules*, Volume I at 87 (October, 1984).

be disposed of using deep well injection, solar evaporation or some combination of these methods. Other waste water effluents produced from uranium in-situ leaching processes and/or ground water restoration are treated and disposed of in the same manner.

Thus, as can be seen from the discussion above, Cameco Resources reiterates its position that EPA Subpart W work practice standards do not apply to uranium in-situ leaching facilities and, more specifically, do not apply to evaporation or settling ponds used at such facilities. As a result of this position, the amount of data and documentation available with respect to uranium in-situ leaching facilities owned and operated by Cameco Resources will be limited. Further, Cameco Resources' response to the specific questions offered by EPA in its Information Request will incorporate, to the extent relevant, aspects of this position.

RESPONSE TO SPECIFIC QUESTIONS

Question #1: Please list each uranium mill located in the United States of America that has been, or is currently, owned or operated, by Cameco Resources or affiliated corporations located in the United States of America. Include the exact location of each uranium mill by map and legal property description.

Response to Question #1: Cameco Resources and its affiliated companies do not, and have not, owned or operated any uranium mills in the United States America.

Question #2: Please list each uranium in-situ leaching facility located in the United States of America that has been, or is currently, owned or operated, by Cameco Resources or affiliated corporations. Please include the exact location of each uranium mill by map and legal property description.

Response to Question #2: The operational and non-operational uranium in-situ leaching facilities owned and operated by Cameco Resources and its affiliated corporations in the United States of America are summarized in the table below. Maps showing the location of each project are included in Attachment A. Cameco Resources also notes that there are several descriptions of each project in publicly available documents such as Permit to Mine application documents through the Wyoming Department of Environmental Quality and Class III UIC Permit documents through the Nebraska Department of Environmental Quality. Copies of Permit to Mine documents for Cameco Resources in situ leaching facilities in the state of Wyoming can be obtained from the Wyoming Department of Environmental Quality, Land Quality Division office in Cheyenne, Wyoming. A copy of Class III UIC Permit No. NE0122611 for the Crow Butte facility is provided in Attachment D.

Corporate Entity	**Uranium In-Situ Leaching Facility**	**Geographic Location**	**Description**
PRI	Smith Ranch-Highland Uranium Project	Converse County, WY	Full Uranium In-Situ Leaching Operations*
PRI	Reynolds Ranch	Converse County, WY	Satellite**
PRI	Gas Hills Uranium In-Situ Leaching Project	Fremont and Natrona Counties, WY	Satellite**
PRI	Ruth Uranium In-Situ Leaching Project	Johnson County, WY	Satellite**
PRI	North Butte Uranium In-Situ Leaching Project	Campbell County, WY	Satellite**
CBRI	Crow Butte	Dawes County, NE	Full Uranium In-Situ Leaching Operations*

PRI – Power Resources, Inc. d/b/a Cameco Resources
CBRI – Crow Butte Resources, Inc. d/b/a Cameco Resources
* Full uranium in-situ leaching operations include wellfields, satellite IX and central processing (i.e., elution, precipitation, drying, and packaging of yellowcake
** Satellite operations consist only of wellfields and satellite IX with no central processing facility.

<u>Question #3:</u> Please provide the following information for each uranium mill and uranium in-situ leaching facility identified in questions 1 and 2:

As a general matter, EPA developed its Subpart W work practice standards to create an efficient alternative method of achieving compliance with the radon flux standard of 20 pCi/m2-s. Prior to the application of Subpart W work practice standards to post-December 15, 1989 uranium mill tailings piles/impoundments, the 20 pCi/m2-s for radon-222 emissions from mill tailings piles impoundments was the standard. This standard was also consistent with EPA's promulgation of *generally applicable standards* pursuant to Congressional mandate under UMTRCA. In 1983, three years after NRC issued its *Final Generic Environmental Impact Statement* ("GEIS") on uranium milling and accompanying Part 40 regulations for licensed (i.e., *active*) sites, EPA promulgated a set of *generally applicable standards* for inactive sites.[29] These standards applied to abandoned *inactive* sites regulated to be under Title I of UMTRCA that were no longer operated under an *active* license. Further, as with the *inactive* sites regulations, EPA's *active* site regulations require that radon emanations from tailings disposal sites be limited to 20 pCi/m^2-s.[30] In these regulations, EPA concluded that a radon emission standard of 20 pCi/m^2-s was adequately protective of human health and safety, as compared to the 2 pCi/m^2-s standard originally adopted by NRC for *active,* licensed sites. EPA's Subparts T and W regulations utilize an identical 20 pCi/m2-s radon emissions

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[29] DOE was given the responsibility under UMTRCA to reclaim the Title I sites subject to NRC-approved reclamation plans and, ultimately, after completion of reclamation, to be subject to NRC license requirements in perpetuity. 48 Fed. Reg. 590 (January 5, 1983).

[30] *Id.* at 45947.

limit for UMTRCA Title II sites that were no longer active (Subpart T) and for UMTRCA Title II sites that were active (Subpart W) that had active uranium mill tailings impoundments prior to 1989. After Subpart W was promulgated in final form, all new mill tailings impoundments were to satisfy one of the two work practice standards rather than the emissions limit.

As discussed above, Subpart W work practice standards were required to address radon emissions from UMTRCA Title II sites that currently had uranium mill tailings impoundments and/or were seeking to construct new impoundments. In its rulemaking, EPA evaluated the technologically feasibility of directing uranium mill tailings licensees to conform their existing impoundments to comply with Subpart W work practice standards. EPA determined that it was impractical to require such compliance and, as a result, included the 20 pCi/m2-s as the standard for existing mill tailings impoundments. For impoundments to be constructed after December 15, 1989, the Subpart W work practice standards were to provide a methodology by which uranium mill tailings licensees could protect public health and safety with an ample margin of safety and without the need for compliance monitoring.

However, it is important to note that NRC also requires uranium mill tailings licensees to maintain strict compliance with relevant public and occupational dose limits. NRC regulations currently require such facilities to comply with a dose limit to individual members of the public of 100 mrem/year and a dose limit of 5 rem/year to site workers. The NRC dose limits for members of the public and site workers are "all-pathways" dose limits that require submission of compliance reports to NRC in accordance with 10 CFR Parts 20 and 40 requirements and guidance.[31] Part 20.1101(b) requires that procedures and engineering controls be implemented to make occupational dosage and dosages to members of the public ALARA. Further, Part 20.1101(d) states that a *constraint* on air emission of radioactive material, excluding radon-222 and its daughter products, shall be implemented to limit doses to any single member of the public to 10 mrem/year. If this limit is not met, the licensee must report the occurrence and consider corrective action to attempt to satisfy the "*constraint*" limit. These requirements have been deemed to be adequately protective of public health and safety pursuant to NRC's statutory mission under the AEA.

(a) A complete description of each uranium mill and uranium in-situ leaching facility's operational status (e.g., permanently shut down, temporarily shut down, standby status, in full or partial operation), method of operation (continuous disposal, phased disposal or other method) and methods by which compliance with the NESHAP standards, specified at 40 C.F.R. § 61.252, is ensured (meeting emission limit in Section 61.252(a) and work practices in (b) and (c)). Include a description of the type of facility (conventional, in-situ leach, heap leach or combination);

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[31] *See* 10 CFR Part 20.1301(a)(1) which states that a 100 mrem/y dose rate is applicable to members of the public.

Response to Question #3(a): As stated in response to Question #1 (above), Cameco Resources and its affiliated companies do not, and have not, owned or operated any uranium mills in the United States of America. The operational status of Cameco Resources' uranium in-situ leaching facilities is provided in the table below. The terms "continuous disposal" and "phased disposal" as defined in 40 C.F.R. § 61.251(b) and (f), respectively, apply to conventional uranium mills only and are not applicable to uranium in-situ leaching facilities. The NESHAP standards specified at 40 C.F.R. § 61.252, including radon-222 emission limits in Section 61.252(a) and work practices in Sections 61.252(b) and (c), apply to uranium mill tailings only and are not applicable to uranium in-situ leaching facilities.

Facility	**Operational Status**	**Method of Operation**	**NESHAP Compliance Method**
Smith Ranch-Highland Uranium Project	Full Operation	Uranium In-Situ Leaching	Not Applicable
Reynolds Ranch	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Gas Hills Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Ruth Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
North Butte Uranium In-Situ Leaching Project	Licensed But Not Constructed	Uranium In-Situ Leaching	Not Applicable
Crow Butte	Full Operation	Uranium In-Situ Leaching	Not Applicable

(b) A history of operation since 1975, including:

- **(i) the original date of construction of each uranium mill and uranium in-situ leaching facility located at each facility;**
- **(ii) the plan of operation and plans to shut-in or close active operation;**
- **(iii) ownership changes; and**
- **(iv) whether the uranium mill and uranium in-situ leaching facility is existing, new, or has plans for reactivating any operations that have been curtailed.**

Response to Question #3(b): On March 13, 2009, Cameco Resources submitted an Initial Response to EPA's Information Request that provided a detailed answer to this portion of Question #3. However, in addition to that response, Cameco Resources offers the following additional discussion. With respect to uranium in-situ leaching project plans of operation and plans to close active operations, uranium in-situ leaching projects traditionally do not have firm, fixed production start or termination dates. This is due to the need for extensive preliminary testing to ensure that site production wellfields are properly placed and are capable of maximizing uranium production while maintaining proper wellfield balance and addressing fluctuating economic markets, and NRC and State requirements for fully compliant groundwater restoration and site decommissioning.

Uranium in-situ leaching facility licensees typically can offer educated estimates on the timeframes for project startup, wellfield development, and groundwater restoration. However, these dates cannot be considered firm due to these factors noted above, as a result, uranium in-situ leaching licensees, including Cameco Resources, often cannot offer firm and fixed project timelines. As a supplement to the Initial Response to Question #3(b) provided under cover dated March 13, 2009, a brief historical summary of each project is also provided in the table below:

Uranium In-Situ Leaching Project	**Construction Date**	**Plan of Operation**	**Ownership Changes**	**Existing, New or Reactivation**
Smith Ranch	1991	Full Operation	Acquired in 2002	Existing
Highland Uranium Project	1987	Full Operation	Acquired in 1997	Existing
Reynolds Ranch	Not Constructed	Licensed But Not Constructed	None	New
Gas Hills Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	None	New
Ruth Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	Acquired in 2001	New
North Butte Uranium In-Situ Leaching Project	Not Constructed	Licensed But Not Constructed	Acquired in 2001	New
Crow Butte	1991	Full Operation	Acquisitions in 1994, 1998 and 2000	Existing

(c) The number and size (in acres), dimensions, locations within the facility or plant site, capacity in gallons and lining material of each existing mill impoundment, as that term is used in 40 C.F.R. [Part 61] Subpart W, and any other waste holding areas such as evaporation or settling ponds.

<u>Response to Question #3(c):</u> As discussed in the site-specific uranium in-situ leaching process description offered above, uranium in-situ leaching facilities do not generate uranium mill tailings like those generated at conventional uranium mill tailings facilities and, as such, do not require uranium mill tailings impoundments to provide adequate long-term, on-site storage and containment of such tailings pursuant to UMTRCA, EPA 40 CFR Part 192 regulations, and NRC 10 CFR Part 40, Appendix A

Criteria. In order to properly understand this portion of Cameco Resources' position, it is important to distinguish between the wastes generated during uranium in-situ leaching operations and groundwater restoration and uranium mill tailings as envisioned by Congress in UMTRCA.

In the mid-1970s, Congress identified uranium mill tailings generated at conventional uranium mills as a significant, potential threat to public health and safety and the environment. However, due to a perceived lack of authority on the part of NRC under the AEA, Congress enacted UMTRCA with the specific intent of creating a comprehensive statutory and regulatory scheme for the short and long-term oversight of uranium mill tailings. For example, Section 2 of UMTRCA states that one of its purposes is to establish:

> "a program to regulate *mill tailings* during uranium or thorium *ore* processing at active mill operations and after termination of such operations in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public."

The perceived threat was associated with the nature of typical uranium mill tailings generated at conventional uranium mill facilities. Uranium mill tailings are described by EPA as "the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted." Typically, uranium mill tailings generated at conventional uranium mills can be defined as earthen materials generally ranging in size from medium grained sand to clay sized particles and consist of ground ore from which uranium has been removed. Typical mill tailings exit a mill process in the form of solid/water slurry and are approximately fifty to fifty-five percent solids by weight. Particle size distributions for mill tailings samples can vary widely depending on the collection point in the impoundment from five percent fines and ninety-five percent sand to ninety-three percent fines and seven percent sands. Upon deposition in a tailings impoundment, tailings tend to classify by size with the coarser materials accumulating closer to the discharge with finer (clay-sized) materials accumulating furthest from the discharge. Uranium mill tailings generally are a buff to tan/brown color due to the oxidation process in the mill circuit and may be acid or alkaline-like in pH. As a result, waste management programs at conventional uranium mills focus primarily on the safe storage and containment of uranium mill tailings in licensed uranium mill tailings piles/impoundments and the transfer of such tailings to a mandatory federal custodian for long-term surveillance and monitoring pursuant to Section 83 of the AEA, as amended by UMTRCA.

However, conventional uranium mill waste management programs are not solely devoted to such tailings. As stated above, when UMTRCA was first enacted, Congress' intent was to address both the potential radioactive and *non*-radioactive hazards associated with uranium mill tailings. However, it was determined that additional waste streams generated at these facilities, while not being typical uranium mill tailings, should be contained on-site as part of the uranium milling waste management process. As a result, the waste classification of 11e.(2) byproduct material was determined to include all wastes, and not just uranium mill tailings, associated with the uranium milling process. Thus, to address the management, safe storage, and containment, (including the demolished mill buildings and other site equipment and material that cannot be decontaminated for unrestricted use), a program for eventual transfer of the site and all of its 11e.(2) byproduct material to a mandatory federal custodian for long-term surveillance and monitoring under a general license from NRC in perpetuity, was implemented pursuant to Section 83 of the AEA, as amended by UMTRCA.

As part of the overall waste management plan of a conventional uranium mill facility and to address waste streams other than uranium mill tailings such as process wastewater, such facilities utilize evaporation ponds and other types of impoundments or ponds (e.g., catchment basins, settling ponds, storage ponds) to temporarily contain waste streams such as process water management and for erosion control. It is also possible that some conventional mills may utilize storage ponds for water intended for reuse in the milling process. However, the *waste* streams[32] placed in these ponds or impoundments are not considered to be uranium mill tailings, but merely a type of 11e.(2) byproduct material that is not considered to be uranium mill tailings. Thus, conventional uranium milling facilities generate different types of 11e.(2) byproduct material such as process wastewater that are not considered to be uranium mill tailings and, as such, do not require the same radiation protection or handling procedures. Therefore, when evaluating which impoundments or ponds are subject to Subpart W work practice standards, it is important to differentiate between uranium mill tailings and other process waste streams that are not considered to be such tailings.

While conventional uranium mills generate uranium mill tailings and require extensive, ongoing regulatory oversight either by a private or federal/state licensee as described above, uranium in-situ leaching facilities do not generate such tailings and do not require such programs. Uranium in-situ leaching facilities are focused on the use of recovery solutions or lixiviant that are composed of native site groundwater and recovery agents such as oxygen and carbon dioxide to recover uranium from an identified underground ore body. These facilities do not engage in typical conventional uranium milling processes such as the crushing or grinding of ore that result in the generation of uranium mill tailings requiring long-term storage and containment in mill tailings impoundments. Since these facilities do not generate such uranium mill tailings, uranium in-situ leaching facilities do not have to be transferred to a mandatory federal custodian for long-term surveillance and monitoring and, traditionally, are

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[32] It is possible that impoundments could be used for storage of "clean," pre-process fluids which, of course, would not be classified as a waste and, thus, would not be 11e.(2) byproduct material.

released for unrestricted use after cessation of operations and completion of site decommissioning, including groundwater restoration.

Based on their process operation, however, uranium in-situ leaching facilities do generate process waste streams that qualify as 11e.(2) byproduct material but that do not constitute uranium mill tailings. The predominant process waste stream at such facilities is process wastewater in two forms: (1) process bleed and (2) restoration fluids. Each of these wastewater streams are handled using one of a number of options, including land application, solar evaporation or disposal via deep disposal wells. In each of these cases, uranium in-situ leaching facilities typically use evaporation or other types of settling/storage ponds to hold wastewater until it can be evaporated or removed for final disposition. Any other solid waste that is generated on-site is either transported off-site to a properly permitted facility for final disposition or is decontaminated for unrestricted release. Thus, based on this discussion, uranium in-situ leaching facilities do not engage in activities that result in the generation of uranium mill tailings, do not require waste management programs to address the storage of such tailings in on-site mill tailings impoundments, and do not require long-term surveillance and monitoring. Therefore, based on EPA's conclusion that evaporation ponds do not constitute a radon emissions source requiring Subpart W work practice standards and the discussion of the uranium in-situ process above, uranium in-situ leaching facilities do not utilize any on-site facilities that would require compliance with Subpart W work practice standards.

As stated in response to Questions #1 and #3(a) (above), Cameco Resources and its affiliated companies in the United States of America do not, and have not, owned or operated any uranium mills in the United States America and, therefore, do not own or operate any uranium mill tailings impoundments. Detailed information on other waste water holding areas, such as evaporation ponds and settling ponds, located at Cameco Resources uranium in-situ leaching facilities is summarized in the table below.

Uranium In-Situ Leaching Project	Waste Water Holding Area		Size (acres)	Dimensions (feet)	Location	Capacity (acre-feet (AF))	Lining Material
	#	Type					
Smith Ranch	2	Evaporation (Storage) Ponds (East and West)*	Approx. 0.23 Acres (each)	100 x 100 (each)	North of Central Processing Plant	0.78 AF (each)	Geosynthetic
Highland Uranium Project	2	Radium Settling Basins (East and West)**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Highland Uranium Project	1	Purge Storage Reservoir No. 1***	Approx. 10 Acres	Not Applicable	Near Satellite No. 1	54 AF	Clay
Highland Uranium Project	1	Purge Storage Reservoir No. 2***	Approx. 42 Acres	Not Applicable	Near Satellite No. 2	321 AF	Clay
Ruth Uranium In-Situ Leaching Project	2	Evaporation Ponds (East and West)****	Approx. 0.23 Acres (Each)	Approx. 100 x 100 (Each)	Pilot Plant Area	7.3 AF (Total)	Geosynthetic
Crow Butte	3	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	6.2 Acres (Each)	900 x 300 (Each)	West of Main Plant/Office Area	Approx. 75 AF (each)	Geosynthetic
Crow Butte	2	R&D Evaporation Ponds (East and West)	Approx. 0.23 Acres (Each)	Approx. 100 x 100 (Each)	Southeast of Main Plant/Office Area	4 AF (each)	Geosynthetic

* While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;

** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;

*** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8μCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;

**** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

(d) For each "existing mill impoundment, evaporation pond, and settling pond" identified in response this request, identify the date(s) each was:

- **(i) constructed;**
- **(ii) used for the continued placement of new tailings;**
- **(iii) placed on "standby status;" and**
- **(iv) closed, and during what periods they were operational.**

Response to Question #3(d): Dates associated with construction and operation of each waste water holding area identified in response to Question 3(c) (above) are provided in the table below.

Uranium In-Situ Leaching Project	Waste Water Holding Area	Date Constructed	Date Used for Continued Placement of New Tailings*	Date Placed on "Standby Status"	Date Closed / Operational Period**
Smith Ranch	Evaporation (Storage) Ponds (East and West)***	1981	Not Applicable	Not Applicable	Continuous operation since 2002
Highland Uranium Project	Radium Settling Basins (East and West)****	1987	Not Applicable	Not Applicable	Operational from approx. 1987-2002
Highland Uranium Project	Purge Storage Reservoir No. 1*****	1987	Not Applicable	Not Applicable	Operational from approx. 1987-2004
Highland Uranium Project	Purge Storage Reservoir No. 2*****	1994	Not Applicable	Not Applicable	Continuous operation since 1994
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)******	Approx. 1980	Not Applicable	Not Applicable	Operational from approx. 1980-1984
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	1991	Not Applicable	Not Applicable	Continuous operation since 1991
Crow Butte	R&D Evaporation Ponds (East and West)	1986	Not Applicable	Not Applicable	Periodic Operation Since 1986

[*] Each of the ponds/impoundments identified in this chart do not, at any time, receive and/or store uranium mill tailings. These ponds/impoundments merely receive process effluent in the form of process bleed, restoration fluid or other process-oriented water;
** See "*" description above
*** While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;
**** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;
***** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8μCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;
****** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

In addition to the chart provided in response to this portion of Question #3, Cameco Resources provides the following additional discussion. As discussed in the response to Question #3(c) above, uranium in-situ leaching facilities do not generate uranium mill tailings as envisioned by Congress in UMTRCA. Uranium in-situ leaching facilities utilize liquid recovery solutions to solubilize and recover uranium from an identified underground ore body and do not engage in conventional uranium milling processes that would result in the generation of uranium mill tailings such as crushing and grinding of ore. As a result, uranium in-situ leaching facilities do not utilize any facilities that would require compliance with Subpart W work practice standards. In addition, since there are no uranium mill tailings at uranium in-situ leaching facilities, no such tailings are placed in evaporation or other site ponds or impoundments as they are designed for handling process wastewater pending final disposition via land application, solar evaporation or deep well disposal. As stated above in the Preamble, while there may be fines from uranium recovery suspended in process wastewater stored in evaporation or other site ponds or impoundments, there are no uranium mill tailings placed in such ponds or impoundments at any time at Cameco Resources' uranium in-situ leaching facilities. Thus, Cameco Resources' response to Subsection (d)(ii) will be "not applicable" as there are not now, nor have there ever been, uranium mill tailings placed in Cameco Resources' uranium in-situ leaching facility ponds or impoundments.

In addition, with respect to the dates of construction for site ponds or impoundments, while Cameco Resources maintains that none of its site facilities are subject to Subpart W, if they were the date of construction would be important because any pond or impoundment subject to Subpart W that was constructed and/or in use prior to December 15, 1989 does not need to comply with either work practice standard, but rather with the aforementioned 20 pCi/m2-s standard.

<u>Question #4:</u> For each "existing mill impoundment, evaporation pond, and settling pond identified in response to request 3.(d) above:

Prior to providing specific responses to each subsection of Question #4, Cameco Resources believes that it is important to provide additional discussion regarding the Subpart W rulemaking and its conclusion that evaporation ponds are not within the scope of Subpart W. As stated above in the Preamble, EPA evaluated all potential sources of radon emissions at conventional uranium milling facilities. The scope of this evaluation included traditional uranium mill tailings piles/impoundments, as well as evaporation ponds or other similar ponds or impoundments. With respect to traditional uranium mill tailings piles/impoundments, the Final Rule for Subpart W identified three different subcategories of mill tailings facilities, "operating mill tailings—existing *piles*, operating mill tailings—new technology, and disposal of uranium mill tailings (*as a separate source category*." With respect to mill tailings piles [impoundments], EPA states, "[e]xisting mill tailings piles are large piles of wastes that emit radon." These tailings piles/impoundments were identified by EPA as a potential significant source of radon and post December 15, 1989 new facilities were deemed to require compliance with Subpart W work practice standards.

However, with respect to evaporation ponds or other similar ponds/impoundments, EPA separately evaluated such facilities because the characteristics of the stored wastewater are significantly different from uranium mill tailings. Indeed, this statement is supported by EPA's Subpart T rulemaking when it stated:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the disposal piles as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the piles (once controlled) against erosion, and the reclamation and maintenance of groundwater.... *These actions entail the use of evaporation ponds that in some instances.... have been placed directly upon the disposal site*."[33]

When evaluating evaporation ponds as a potentially significant radon emissions source, EPA stated, "*the ponds themselves serve as an effective radon barrier*." This was true, in part because, as stated by EPA, "[r]adon emissions from these piles are retarded by the presence of water...." Indeed, as stated in the Background Information Document to EPA's *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings*:

> "Water-covered tailings have a radon-222 flux of about 0.02 pCi/m2-s per pCi of radium-226 per gram of tailings compared with a dry tailings flux

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[33] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

> of about 1 pCi/m2-s per pCi of radium-226 per gram, *or a radon-222 reduction efficiency of about 98 percent....Emission estimates of zero are frequently used for ponded and saturated areas, and that assumption is used throughout this report.*"[34]

This conclusion is supported by, as noted above, Method 115, paragraph 2.1.3 states, "radon flux measurements shall be made within each region on the pile, *except for those areas covered with water.*" Paragraph 2.1.3(a) also states, "*Water covered area*--no measurements required as radon flux assumed to be *zero*."[35] As a result and due to the need for active evaporation ponds during site remedial action efforts, EPA concluded:

> "*EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved."[36]

To support this decision, EPA stated, with respect to evaporation ponds:

> "this decision is bolstered by the absence of any evidence that there is a significant public health risk presented by the radon emissions from these evaporation ponds during the period they are employed as part of the overall remediation of the site."[37]

In addition, in the Subpart W portion of the rulemaking, EPA reaffirmed this position by concluding:

> "*EPA reiterates that the Agency does not intend the expeditious radon cover requirement to extend to areas where evaporation ponds are located*, even if on the pile itself, to the extent that such evaporation pond is deemed by the implementing agency...to be an appropriate aspect of the overall remedial program for the particular site."[38]

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[34] United States Environmental Protection Agency, *Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings, Final Report, Background Information Document* at 7-9 (August 1986) (emphasis added).

[35] Emphasis added. *See also* Method 115, Paragraph 2.1.6 *Radon Flux Measurement*...The radon collector is placed *on the surface* of the pile area to be measured and allowed to collect radon for a time period of 24 hours. The detailed measurement procedure provided in Appendix A of EPA 520/5-85-0029(1) shall be used to measure the radon flux on the uranium mill tailings except the *surface of tailings* shall not be penetrated by the lip of the radon detector as directed in the procedure, rather the collector shall be carefully positioned *on a flat surface* with soil or tailings used to seal the edge.

[36] *Id.*

[37] *Id.*

[38] 56 Fed. Reg. 67561 (emphasis added).

The logic of this conclusion is equally applicable to such ponds or impoundments that are licensed by NRC or its Agreement States as "an appropriate aspect" of the operational uranium recovery program at the particular site. Therefore, based solely on the analysis provided by EPA in its Subparts T and W rulemakings, Cameco Resources reiterates its position that Subpart W work practice standards do not apply to uranium in-situ leaching facility or any other facility evaporation ponds or other similar ponds or impoundments.

(a) identify whether the "continuous disposal" method is used, 40 C.F.R. Section 61.252(b)(2);

Response to Question #4(a): As stated above in the response to Question #3, uranium in-situ leaching facilities do generate process waste streams that qualify as 11e.(2) byproduct material but do not constitute uranium mill tailings. The predominant process waste streams at such facilities are process wastewater in two forms: (1) process bleed and (2) restoration fluids. Each of these wastewater streams are handled using one of a number of options, including land application, solar evaporation or disposal via deep disposal wells. But, uranium in-situ leaching facilities do not, however, engage in conventional uranium milling activities that generate uranium mill tailings such as crushing or grinding ore. Thus, as will be discussed below, Subpart W does not apply to uranium in-situ leaching facilities as they do not handle uranium mill tailings.

With respect to the process wastewater in the form of process bleed and restoration fluids, site evaporation, settling or storage ponds merely receive such water pending final disposition via land application, solar evaporation or deep well disposal. Neither of these process water waste streams can be considered uranium mill tailings required long-term containment and control as envisioned by Congress in UMTRCA. First, the process bleed is a one to three percent process water stream taken from the native groundwater (fortified with lixiviant) used to extract uranium from the identified underground ore body. This process bleed is designed as a uranium in-situ leaching control measure to ensure that native groundwater within the ore/recovery zone remains within the boundaries of an EPA-approved aquifer exemption and does not migrate to adjacent, non-exempt aquifers. This process bleed is removed and either treated to meet applicable standards for land application, placed in evaporation ponds for final disposition or disposed of via deep disposal wells. While it is classified by NRC as 11e.(2) byproduct material, this process bleed does not in any way resemble uranium mill tailings as envisioned by Congress in UMTRCA.

Second, restoration fluids are process wastewater streams that result from mandatory groundwater restoration designed to return uranium in-situ leaching facility site groundwater consistent with pre-operational water quality standards. Active groundwater restoration requires that uranium in-situ leaching facility operators utilize wastewater control programs similar to those used to handle process bleed in that groundwater removed during restoration is classified as

11e.(2) byproduct material and is either treated for land application, placed in solar evaporation ponds for final disposition or disposed of via deep disposal wells. In addition, restoration fluids, while not considered to be process bleed by definition, are essentially the same physical media as process bleed in that it is in liquid form and does not resemble uranium mill tailings as envisioned by Congress in UMTRCA. Based on these descriptions, Subpart W does not apply to uranium in-situ leaching facilities used for wastewater management.

Further, it is apparent from the language of Subpart W's work practice standards that it could not have been intended to apply to uranium in-situ leaching facility evaporation ponds, settling ponds or other process wastewater handling facilities. Currently, Subpart W prescribes two methods of compliance, one of which is termed "continuous disposal." Under 40 CFR § 61.252(b)(2), EPA requires compliance by "continuous disposal of tailings such that tailings are dewatered and immediately disposed with no more than 10 acres uncovered at any time…."[39] Based on the language in this regulation, common sense dictates that such a requirement could no reasonably apply to an impoundment or ponds that receives and/or stores process wastewater for either treatment, evaporation or transport for deep well disposal. Further, it also makes common sense that you cannot "dewater water" as the standard appears to require. Given that uranium mill tailings often time have some water content, it appears that this standard was directed at such tailings and not uranium in-situ leaching or conventional mill process wastewater. Additionally, the cover requirement in this standard cannot apply to such impoundments or ponds as covering water sources is completely impractical and serves no purpose other than to add additional volume to the impoundment or pond and make the evaporation or transport process much more difficult. Thus, as a practical matter, the "continuous disposal" requirement cannot apply to uranium in-situ leaching facility ponds or impoundments.

Additionally, it is important to note that EPA's Subpart W analysis has determined that two forty (40) acre tailings impoundments operating at any one time are adequately protective of public health and safety. As a result, EPA should permit the use of whatever size and number of evaporation or other ponds or impoundments, because the Subpart W rulemaking concluded that even water covered tailings are a zero source term.

(b) describe the mechanical methods used to dewater tailings, the process used to dispose of tailings, the precise location of any and all disposal areas used for dewatered tailings, and the method used to cover such tailings;

Response to Question #4(b): This portion of Question #4 is inapplicable to uranium in-situ leaching facilities. In addition to the fact that uranium in-situ leaching facilities do not generate tailings, as stated in the answer to Question #3 above, it is impractical to assert that a uranium in-situ leaching facility operator can dewater process wastewater from active operations or groundwater

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[39] 40 CFR § 61.252.

restoration. As is the case with conventional uranium milling facilities that utilize evaporation ponds, settling ponds or catchment basins, uranium in-situ leaching facilities generate process wastewater that requires a waste management program that does not resemble that used for uranium mill tailings. While uranium mill tailings impoundments are designed specifically to meet UMTRCA's mandatory long-term closure requirements as delineated in 10 CFR Part 40, Appendix A and 40 CFR Part 192, evaporation or other ponds or impoundments do not have similar requirements as they are not designed to meet any such long-term closure requirements. Traditionally, conventional uranium mills and uranium in-situ leaching facilities utilize such ponds or impoundments on a temporary basis until their usefulness is exhausted; normally, this occurs at the conclusion of a groundwater corrective action program or just prior to license termination. At such time, these ponds or impoundments are reclaimed and tested to ensure that appropriate site soils standards are met. This distinguishing of uranium mill tailings impoundments from evaporation or other ponds or impoundments is envisioned by EPA in its Subpart W rulemaking:

> "The regulations contemplated by this notice seek to control the emission of radon-222 by requiring the installation of an earthen cover over the disposal piles as expeditiously as practicable considering technological feasibility. However, there are other aspects to the UMTRCA regulatory scheme, including the long-term maintenance of the piles (once controlled) against erosion, and the reclamation and maintenance of groundwater....*These actions entail the use of evaporation ponds that in some instances....have been placed directly upon the disposal site.*"[40]

This language demonstrates that, while anticipating the need for a "cover" on tailings disposal areas, EPA also anticipated "ancillary" facilities such as evaporation ponds that did not involve the storage of tailings, but rather were used to be a part of the site's remedial program. This is reflected in EPA's subsequent statement in this rulemaking:

> "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located, even if on the pile itself, *to the extent that such evaporation pond is deemed by the implementing agency (NRC or an affected Agreement State) to be an appropriate aspect to the overall remedial program for the particular site involved.*"[41]

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[40] *Id.* (emphasis added). The fact that evaporation ponds could be (and had been) located on top of an inoperative tailings piles to de-water piles and assist in groundwater corrective action was made known to EPA by American Mining Congress (AMC) negotiators during the settlement negotiations that ultimately led to the rescission of Subpart T.

[41] 56 Fed. Reg. 67561 (December 31, 1991). It is also important to note that uranium in-situ leaching facilities require evaporation or other similar ponds/impoundments as part of the overall operational and remedial action plans in a manner similar to that described by EPA for conventional uranium mill tailings facilities. Uranium in-situ facilities require these

By distinguishing between these two types of facilities, EPA demonstrates that the requirements imposed upon uranium mill tailings impoundments (Subpart W), do not apply to other "ancillary" site facilities such as evaporation or other ponds or impoundments.

(c) provide *all* disposal records maintained by you, including any records that reflect the manner of disposal and the method of covering such tailings;

Response to Question #4(c) (See Response to #4(b) above for additional discussion):

As stated above, the scope of the inquiry in Question #4(c) is strictly limited to the types of wastes generated by the uranium in-situ leaching process. These waste streams can be classified using the following 11e.(2) byproduct material sub-categories, none of which are disposed of on-site for permanent, long-term surveillance and monitoring under UMTRCA: (1) process wastewater streams such as process bleed or restoration fluids that have been classified as 11e.(2) byproduct material; and (2) solid wastes classified as 11e.(2) byproduct material such as spent IX resins and process materials that cannot be decontaminated for unrestricted use. As discussed above, process wastewater streams are generated during active operations and groundwater restoration and are either treated for land application, stored in evaporation ponds for final disposition or stored pending disposal via deep disposal wells. While some or all of the process wastewater streams are maintained in site evaporation or other ponds or impoundments for varying periods of time depending on the selected disposition method, no such waste streams are stored on-site permanently.

Solid wastes, if generated, are stored as appropriate and are not disposed of on-site in any tailings or other form of surface impoundment. While it is possible in the future for uranium in-situ leaching facilities to have permanent, on-site disposal of 11e.(2) byproduct material, NRC policy dictates that such facilities do not have permanent on-site disposal of such 11e.(2) byproduct material.[42]

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ponds/impoundments to maintain a "process bleed" by which excursions of recovery solutions to adjacent, non-exempt aquifers which would result in the need for groundwater corrective action can be avoided and to engage in active groundwater restoration at the conclusion of active uranium recovery operations. These actions are no different from a conventional uranium mill tailings facility engaging in groundwater corrective action to avoid migration of 11e.(2) byproduct material offsite and in final site reclamation to achieve site closure and license termination.

[42] Commission policy currently requires that all solid 11e.(2) wastes generated at uranium in-situ leaching facilities be disposed of at licensed 11e.(2) disposal facilities pursuant to 10 CFR Part 40, Appendix A, Criterion 2's requirement that the Commission avoid the proliferation of small 11e.(2) waste disposal sites. However, this policy is subject to change should a uranium in-situ leaching licensee request Commission authorization.

(d) provide all emissions data collected by you or anyone working on your behalf that show that emissions from disposed materials have "emissions consistent with applicable Federal standards" as defined in 40 C.F.R. § 61.252(a);

<u>Response to Question #4(d):</u> This portion of Question #4 requests emissions data for disposed materials to demonstrate compliance with applicable federal standards. As a preliminary matter, this portion of Question #4 is extremely vague as previous questions have specifically identified the "materials" to which they applied; in most cases uranium mill tailings. However, this portion merely references "disposed materials." But, as noted above, Cameco Resources' uranium in-situ leaching facilities do not engage in any on-site disposal of 11e.(2) solid waste materials at its project sites. Thus, Cameco Resources' response to this portion of Question #4 is "not applicable."

(e) describe the method of complying with requirement regarding the maximum of 10 acres uncovered at any one time, as specified in 40 C.F.R. Section 61.252(b)(2);

<u>Response to Question #4(e):</u> This portion of Question #4 requests processes and procedures for complying with Subpart W's requirement for the "continuous disposal" requirement under 40 CFR Part 61.252(b)(2). Cameco Resources' response to this request is "not applicable" for a number of reasons. First, as stated throughout this Response, Cameco Resources' position is that Subpart W work practice standards do not apply to its uranium in-situ leaching facilities, including site evaporation, settling or other ponds and impoundments. With that said, regardless of whether Cameco Resources' site evaporation ponds/impoundments are or exceed ten (10) acres in size, it is illogical to assert that the "continuous disposal" requirement under 40 CFR § 61.252(b) could possibly apply to such ponds/impoundments, because it is impractical, if not impossible, to have a "partially covered" evaporation pond at a uranium in-situ leaching facility. Evaporation ponds at uranium in-situ leaching facilities are designed to handle process wastewater or waste that is almost entirely, if not entirely, composed of water. In any event, evaporation ponds do not require covers when they are in use during active operations or for groundwater restoration. Further, as process wastewater is continuously flowing into these ponds and water does not remain in one portion of the pond over time, it is impractical to employ a "partial cover" requirement.

In addition, as stated above, EPA's Subpart W rulemaking expressly excludes evaporation ponds from the work practice standards due to their necessary role in site activities and the lack of any evidence of a potential radon emissions hazard. Evaporation ponds have been identified by EPA as an integral part of site operations and reclamation at both conventional mills and uranium in-situ leaching facilities, including their applications for active processing, groundwater restoration, and groundwater corrective action programs. As a result, EPA determined that, "EPA does not intend that the expeditious radon cover requirement extend to the areas where evaporation ponds are located…."[43] Thus, Cameco Resources asserts that its position that Subpart W does not apply to uranium in-situ leaching facilities is further confirmed by the fact that the 40 CFR § 61.252(b) "continuous disposal" work practice standard cannot be practically applied to such facilities.

(f) provide proof that your activities comport with the requirements of EPA regulations found at 40 C.F.R. § 192.32(a), including all pertinent documents and correspondence to and from the NRC;

Response to Question #4(f): This portion of Question #4 requests evidence or "proof" that Cameco Resources' uranium in-situ leaching facilities comport with EPA regulations at 40 CFR § 192.32(a). Cameco Resources' position on this portion of Question # 4 is that 40 CFR § 192.32(a) does not apply to its uranium in-situ leaching facilities, including specifically site evaporation, settling or other ponds/impoundments.

Initially, as a general matter, 40 CFR Part 192 entitled *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings* was promulgated by EPA pursuant to UMTRCA as part of its Congressional mandate to issue generally applicable standards for uranium mill tailings impoundments. Section 192.32(a) (part of Subpart D entitled *Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended*) specifically applies to uranium mill tailings impoundments that are engaging in active processing operations. These standards apply specifically to "surface impoundments subject to this subpart." Throughout Section 192.32, EPA refers to these surface impoundments as "uranium mill tailings and impoundments" and proceeds to discuss the requirements for such piles/impoundments, including emplacement of permanent radon barriers/covers. These requirements traditionally have been applied to "surface impoundments" that contain uranium mill tailings, as discussed throughout this Response, and not to facilities such as evaporation or settling ponds. These requirements are critical to uranium mill tailings impoundments because such impoundments are subject to Section 83 of the AEA's requirements for long-term surveillance and monitoring, while evaporation ponds that are part of the site to be transferred, do not have such stringent requirements for covers and stabilization.

Next, as stated several times in this Response, Cameco Resources asserts that the Subpart W work practice standards, which are implicated in this portion of Question #4, do not apply to uranium in-situ leaching facilities, including site evaporation, settling or other ponds/impoundments. Please see the Preamble and the Response to Question #3 above and under cover dated March 13, 2009 for more discussion.

Finally, given that 40 CFR Part 192 and other provisions of NRC and EPA regulations pertaining to uranium mill tailings recognize that site radon emissions are a potential threat to public health and safety, it is important to note that EPA's Subpart W rulemaking expressly states that, due to the water content in such ponds/impoundments,

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[43] *See* 56 Fed. Reg. 67561 (December 31, 1991).

potential radon emissions default to zero and have not exhibited any evidence that they pose a significant radon emissions risk. Please see the Response to Question #3 above for additional discussion.

(g) provide a copy of all construction and modification applications required by 40 C.F.R. § 61.07, a copy of all notifications of startup pursuant to § 61.09 and a copy of any approvals issued pursuant to and § 61.08 or any state authority, indicating by whom these approvals were issued (state or federal officials);

Response to Question #4(g): See response to Question #4(f) above.

(h) provide copies of any other permits that have been applied for and/or received under the Clean Air Act;

Response to Question #4(h): Copies of the following permits are included in Attachment B:

- Smith Ranch: Wyoming Department of Environmental Quality, Air Quality Division Permit No. CT-957 dated December 30, 1991
- Highland Uranium Project: Wyoming Department of Environmental Quality, Air Quality Division Permit No.MD-153 dated August 12, 1991

(i) provide copies of any licenses or license applications for construction or operation issued by or filed with the Nuclear Regulatory Commission;

Response to Question #4(i): Copies of License Nos. SUA-1548 and SUA-1534 from the U.S. Nuclear Regulatory Commission are provided in Attachment C. A summary of the corresponding license associated with each uranium in-situ leaching facility is also provided in the table below.

Corporate Entity	Uranium In-Situ Leaching Project	Description	NRC License No.
PRI*	Smith Ranch-Highland Uranium Project	Full Uranium In-Situ Leaching Operations***	SUA-1548
PRI	Reynolds Ranch	Satellite****	SUA-1548
PRI	Gas Hills Uranium In-Situ Leaching Project	Satellite****	SUA-1548
PRI	Ruth Uranium In-Situ Leaching Project	Satellite****	SUA-1548
PRI	North Butte Uranium In-Situ Leaching Project	Satellite****	SUA-1548
CBRI**	Crow Butte	Full Uranium In-Situ Leaching Operations***	SUA-1534

* PRI – Power Resources, Inc. doing business as Cameco Resources;

** CBRI – Crow Butte Resources, Inc. doing business as Cameco Resources;

*** Full uranium in-situ leaching operations include wellfields, satellite IX and central processing (i.e., elution, precipitation, drying and packaging of yellowcake);
**** Satellite operations consist of wellfields and satellite IX with no central processing facilities.

(j) provide copies of any other licenses issued by states under state authority;

Response to Question #4(j): Copies of licenses and/or permits issued by states with respect to the waste water holding ponds identified in response to Question 3(d) above are provided in Attachment D.[44] A summary of these various licenses and/or permits is also summarized in the table below.

Uranium In-Situ Leaching Project	**Waste Water Holding Area**	**License and/or Permit**	**Authorizing Agency**
Smith Ranch	Evaporation (Storage) Ponds (East and West)	Permit to Mine No. 633	WDEQ/LQD*
Highland Uranium Project	Radium Settling Basins (East and West) and Purge Storage Reservoirs Nos. 1 and 2	Permit to Mine No. 603	WDEQ/LQD
Highland Uranium Project	Purge Storage Reservoir No. 1	Permit No. 9289R	WSEO**
Highland Uranium Project	Purge Storage Reservoir No. 2	Permit No. P10045R	WSEO
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)	Permit to Mine No. 631	WDEQ/LQD
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)	Permit No. 8432 Res.	WSEO
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4) and R&D Evaporation Ponds (East and West)	Permit No. NE0122611	NDEQ***

* WDEQ – Wyoming Department of Environmental Quality/Land Quality Division
** WSEO – Wyoming State Engineer's Office
*** NDEQ—Nebraska Department of Environmental Quality

(k) provide current license status, indicating whether any license modifications are planned or have been agreed to;

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[44] Due to the large number of documents associated with Permits to Mine Nos. 603, 631, and 633, these permits are not included herein (Attachment D). Copies of these permits are available through the Wyoming Department of Environmental Quality (WDEQ), Land Quality Division office in Cheyenne, Wyoming.

Response to Question #4(k): With respect to the waste water holding ponds identified in response to Question 3(d) above, all licenses and/or permits identified in response to Questions 4(i) and (j) above are active and no modifications are planned.

(l) indicate whether all facilities and ponds/impoundments were constructed and are being operated in accordance with all permits and federal regulations;

Response to Question #4(l): All waste water holding ponds identified in response to Question 3(d) above have been constructed and, to the best of Cameco Resources' knowledge, are being operated in accordance with all permits and federal regulations.

(m) provide a description of any pollution control equipment; and

Response to Question #4(m): A description of pollution control equipment associated with each waste water holding area identified in response to Question 3(d) is summarized in the table below.

Uranium In-Situ Leaching Project	Waste Water Holding Area	Lining Material	Pollution Control Equipment
Smith Ranch	Evaporation (Storage) Ponds (East and West)*	Geosynthetic	Leak Detection
Highland Uranium Project	Radium Settling Basins (East and West)**	Not Applicable	Not Applicable
Highland Uranium Project	Purge Storage Reservoir No. 1***	Clay	Ground Water Monitoring
Highland Uranium Project	Purge Storage Reservoir No. 2***	Clay	Ground Water Monitoring
Ruth Uranium In-Situ Leaching Project	Evaporation Ponds (East and West)****	Geosynthetic	Leak Detection
Crow Butte	Commercial Evaporation Ponds (Nos. 1, 3 and 4)	Geosynthetic	Leak Detection; Ground Water Monitoring
Crow Butte	R&D Evaporation Ponds (East and West)	Geosynthetic	Leak Detection; Ground Water Monitoring

* While identified as evaporation ponds, the ponds at Smith Ranch are used for limited storage of process effluent prior to disposal via deep well injection;

** Radium settling basins at Highland are in the process of being decommissioned and reclaimed;

*** Process effluents are treated for removal of radium-226 to meet the 10 CFR Part 20, Appendix B, Effluent Concentration Limit of 6.0E-8μCi/ml (60 pCi/l) prior to discharge into Purge Storage Reservoirs Nos. 1 and 2;

**** Ruth evaporation ponds have been non-operational since the completion of pilot plant operations on or around 1984.

(n) state whether each of Cameco Resources' uranium mills and uranium in-situ leaching facilities is subject to the requirements of the National Emissions Standard for Hazardous Air Pollutants (NESHAP) for Radon Emissions from Operating Mill Tailings as defined under 40 C.F.R. §§ 61.250 et seq. If not, explain why not.

Response to Question #4(n): As stated in the Preamble above and in subsequent portions of this Response, Cameco Resources asserts that none of its uranium in-situ leaching facilities is subject to EPA's 40 CFR §§ 61.250 and associated requirements. Cameco Resources' position is that Subpart W does not apply to each of its uranium in-situ leaching facilities, because they do not generate and store uranium mill tailings as envisioned by Congress in UMTRCA. Further, Cameco Resources notes that EPA expressly excluded evaporation ponds and other associated ponds or impoundments from the scope of Subpart W during its administrative rulemaking. Please see the Preamble and the Responses to Question #3 above for additional discussion.

Question #5: Submit complete results of all air and radon emission tests, emissions characterizations, or emissions studies, conducted or attempted at each facility since January 1, 1980. Indicate whether these tests were conducted as specified in 40 C.F.R. §§ 61.253 and 61.255. Include with this information relevant operating parameters measured and all data recorded during these tests or studies, including the water level and moisture content as well as how it was determined that the "long term radon flux from the pile" was represented during the time of measurement, pursuant to 40 C.F.R. Part 61, Appendix B, Method 115, 2.1.1;

Response to Question #5: This Question requests submission of all air and radon emission tests, emissions characterizations, or emissions studies "conducted or attempted" at each Cameco Resources facility since January 1, 1980. Cameco Resources' uranium in-situ leaching facilities are not subject to EPA's Subpart W requirements for uranium mill tailings impoundments as each facility does not utilize such impoundments. However, Cameco Resources does submit semi-annual reports to NRC in compliance with its NRC license, each of which contains site dose monitoring data, including site worker exposure and off-site public exposure from all radiological pathways including any radon emissions from available pathways. These reports contain a significant amount of data and information regarding site emissions.[45] For example, Cameco Resources' NRC License No. SUA-1534 states:

> "Effluent and environment monitoring program results submitted in accordance with 10 CFR 40.65 shall be reported in the format shown in Table 3 of Regulatory Guide 4.14, (Rev. 1) entitled, "Sample Format for Reporting Monitoring Data." These reports also shall include injection rates, recovery rates, and injection manifold pressures."[46]

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[45] These reports are publicly available on NRC's ADAMS database. *See* NRC License No. SUA-1534 & SUA-1548 for reporting requirements.

[46] *See* SUA-1534, License Condition 12.1.

<u>Question #6:</u> Provide copies of all monthly and annual compliance reports prepared and submitted to EPA, as specified in 40 C.F.R. § 61.254, or similar reports submitted to all other regulatory agencies. To the extent, that you have not submitted any such report(s) provide the reasons for not having done so, and reasons, if any, you claim as a basis for not submitting such reports.

<u>Response to Question #6:</u> For the reasons discussed above, Cameco Resources' answer to this question is "not applicable," because, pursuant to 40 CFR § 61.254, a uranium recovery licensee is only required to comply with this reporting requirement to the extent that they are "[t]he owners or operators of operating existing mill impoundments…."[47] As stated throughout this Response, Cameco Resources does not own or operate any existing [uranium] mill tailings impoundments, as it only owns/operates uranium in-situ leaching facilities which, by definition, do not utilize uranium mill tailings impoundments. As a result, Cameco Resources is not required to comply with 40 CFR § 51.254 reporting requirements. However, as stated above, Cameco Resources does submit semi-annual reports to NRC in compliance with its NRC license, each of which contains site dose monitoring data, including site worker exposure and off-site public exposure from all radiological pathways including any radon emissions from available pathways.

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[47] *See* 40 CFR § 61.254.

EPA-5177

Angelique Diaz

To

cc

bcc

Subject UPLOAD C:\Users\adiaz01\Documents\TELECOMMUTE\Subpart W\W WORKGROUP\SubWFOIAResponsiveDocuments\Attachment 1.pdf

- Attachment 1.pdf

State of Colorado
Department of Public Health and Environment

RADIOACTIVE MATERIALS LICENSE

Annex A
Perimeter Fence Metes and Bounds Description (South Area)

Commencing at the South ¼ of Section 9, being a GLO Brass Cap, from whence the Southwest corner of said Section 9 bears S 89° 01'57"W a distance of 2652.89 feet, said line forming the Basis of Bearing for this description; thence S 89° 24'00"E a distance of 26.67 feet to an existing fence corner, said point being the Point of Beginning. Thence along an existing fence line the following (52) fifty-two courses:

1. thence N 82°00'02" E a distance of 1436.22 feet
2. thence S 30°57'42" E a distance of 954.97 feet;
3. thence S 35°13'18" E a distance of 930.91 feet;
4. thence S 37°59'30" W a distance of 476.71 feet;
5. thence S 07°26'55" W a distance of 698.33 feet;
6. thence S 51°26'07" W a distance of 38.63 feet;
7. thence S 61°22'14" W a distance of 41.69 feet;
8. thence S 60°29'31" W a distance of 99.83 feet;
9. thence S 57°12'05" W a distance of 87.66 feet;
10. thence S 05°22'39" W a distance of 130.45 feet;
11. thence S 06°31'49" E a distance of 513.41 feet;
12. thence S 78°45'46" E a distance of 469.98 feet;
13. thence S 03°10'19" E a distance of 306.96 feet;
14. thence S 58°56'38" W a distance of 681.37 feet;
15. thence S 50°39'07" W a distance of 319.68 feet;
16. thence S 44°13'22" W a distance of 363.64 feet;
17. thence S 00°18'37" E a distance of 152.17 feet;
18. thence S 19°38'35" W a distance of 29.50 feet;
19. thence S 34°17'20" W a distance of 50.31 feet;
20. thence S 47°31'08" W a distance of 96.60 feet;
21. thence S 44°45'27" W a distance of 39.94 feet;
22. thence S 41°50'56" W a distance of 49.86 feet;
23. thence S 33°58'14" W a distance of 39.42 feet;
24. thence S 25°08'49" W a distance of 8.31 feet;
25. thence S 16°00'35" W a distance of 13.00 feet;
26. thence S 07°14'46" W a distance of 8.27 feet;
27. thence S 04°23'27" E a distance of 18.72 feet;
28. thence S 13°02'56" E a distance of 10.15 feet;
29. thence S 20°57'35" E a distance of 59.71 feet;
30. thence S 26°07'04" E a distance of 79.67 feet;
31. thence S 16°15'33" E a distance of 155.69 feet;
32. thence S 83°08'41" W a distance of 1166.75 feet;
33. thence N 58°27'24" W a distance of 1396.03 feet;
34. thence N 49°23'41" W a distance of 1909.64 feet;
35. thence N 01°08'05" W a distance of 3194.96 feet;
36. thence N 00°59'52" W a distance of 34.73 feet;

37. thence N 04°40’44” E a distance of 28.91 feet;
38. thence S 80°19’21” E a distance of 64.02 feet;
39. thence S 77°28’54” E a distance of 315.51 feet;
40. thence S 73°22’46” E a distance of 212.51 feet;
41. thence S 68°45’24” E a distance of 365.64 feet;
42. thence S 65°30’57” E a distance of 99.79 feet;
43. thence S 41°32’39” E a distance of 50.25 feet;
44. thence S 23°25’49” E a distance of 49.44 feet;
45. thence S 00°52’47” E a distance of 99.43 feet;
46. thence S 13°38’36” W a distance of 99.73 feet;
47. thence S 78°57’29” E a distance of 200.78 feet;
48. thence N 11°14’56” E a distance of 314.03 feet;
49. thence N 68°45’12” W a distance of 439.42 feet;
50. thence N 30°34’03” W a distance of 30.52 feet;
51. thence N 08°54’36” E a distance of 177.56 feet;
52. thence N 89°01’09” E a distance of 1779.49 feet to the Point of Beginning, containing 487.75 acres, more or less.

Total fence length = 20,391 linear feet, more or less.

Perimeter Fence Metes and Bounds Description (North Area)

Commencing at the South ¼ corner of Section 9, being a GLO Brass Cap, from whence the Southwest corner of said Section 9 bears S 89° 01’57”W a distance of 2652.89 feet, said line forming the Basis of Bearing for this description; thence S 88° 59’43”W a distance of 1,752.83 feet to an existing fence corner, said point being the Point of Beginning. Thence S 89° 28’12”W a distance of 167.20 feet to a found property corner, said point being the southwest corner of Tract A, Shadow Hills Golf Club Inc.; thence along the northwesterly line of said Tract A the following four courses:

1. thence N 64°40’37” E a distance of 614.12 feet;
2. thence N 39°43’49” E a distance of 592.75 feet to a found property corner;
3. thence N 59°46’39” E a distance of 644.41 feet to a found property corner;
4. thence N 48°36’44” E a distance of 541.88 feet to a found property corner;

thence N 00°29’19 W a distance of 2844.32 feet to an existing fence corner; thence along an existing fenceline the following twenty-six (26) courses:

1. thence N 89°42’50” E a distance of 2633.15 feet;
2. thence S 40°25’54” E a distance of 63.38 feet;
3. thence S 00°26’48” E a distance of 159.54 feet;
4. thence S 00°12’41” E a distance of 276.29 feet;
5. thence S 00°16’35’ W a distance of 186.41 feet;
6. thence S 08°48’29” W a distance of 95.71 feet;
7. thence S 00°12’46” E a distance of 549.03 feet;

8. thence N 76°46’38’ W a distance of 390.37 feet;
9. thence S 70°17’43” W a distance of 77.54 feet;
10. thence S 80°13’06” W a distance of 118.49 feet;
11. thence S 87°39’54” W a distance of 79.47 feet;
12. thence S 48°44’57” W a distance of 231.49 feet;
13. thence S 05°38’07” E a distance of 470.54 feet;
14. thence S 22°45’53” W a distance of 290.65 feet;
15. thence S 66°11’46” W a distance of 273.65 feet;
16. thence S 27°55’45” W a distance of 173.01 feet;
17. thence S 22°58’04” W a distance of 238.79 feet;
18. thence S 19°19’18” W a distance of 189.80 feet;
19. thence S 10°45’58” W a distance of 13.81 feet;
20. thence S 13°20’20” E a distance of 23.71 feet;
21. thence S 17°04’33” E a distance of 237.77 feet;
22. thence S 07°28’41” E a distance of 226.85 feet;
23. thence S 26°51’28” E a distance of 83.34 feet;
24. thence S 48°00’33” E a distance of 4.71 feet;
25. thence S 23°02’03” W a distance of 16.47 feet;
26. thence S 06°40’33” E a distance of 623.90 feet to an existing fence corner, said point being the point of terminus for this legal description, said point also being N 82° 09’25” E a distance of 1462.60 feet from the S ¼ corner of said Section 9. Total area = 206.04 acres, more or less. Total fence length = 13,720.73 linear feet, more or less.

RADIOACTIVE MATERIALS LICENSE

TOPOGRAPHIC SURVEY

A PORTION OF SECTION 16, T19S, R70W of the 6th P.M.
COUNTY OF FREMONT, STATE OF COLORADO

NOTES

1. NOTICE:
According to Colorado law, you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event may any action based upon any defect in this survey be commenced more than ten years from the date of certification shown hereon.

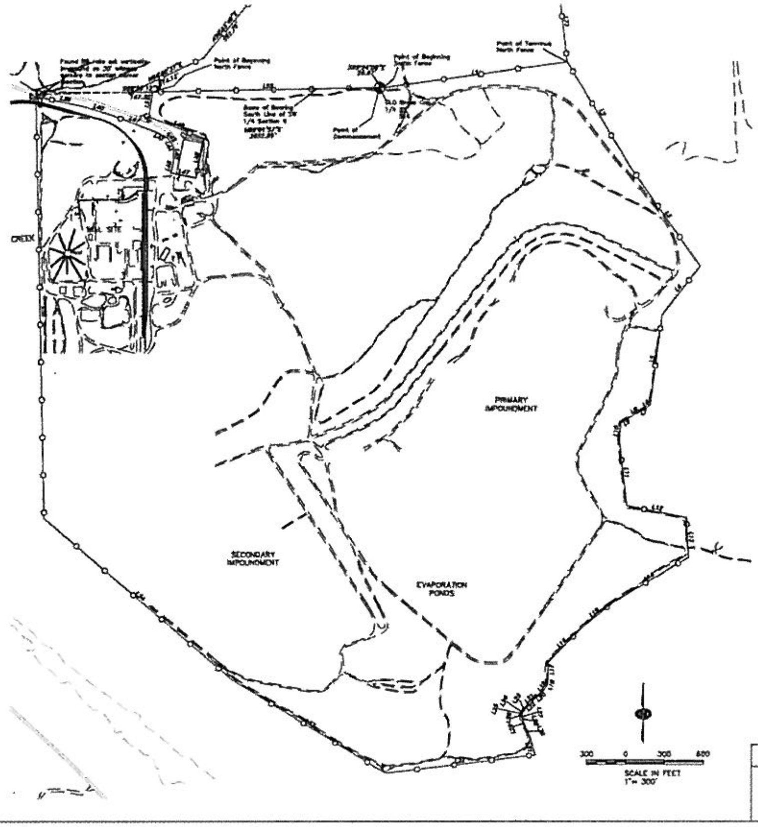
2. This topographic survey does not represent a boundary survey, land survey plat, or improvement survey plat.

LEGEND:

—o— perimeter fence

Surveyors Statement:

I, [illegible], a registered Land Surveyor in the State of Colorado, hereby state that a topographic survey of the site as shown hereon was made by me or under my direct supervision on September 19, 2007 and that the accompanying plat accurately and properly shows said site to the best of my knowledge and belief.

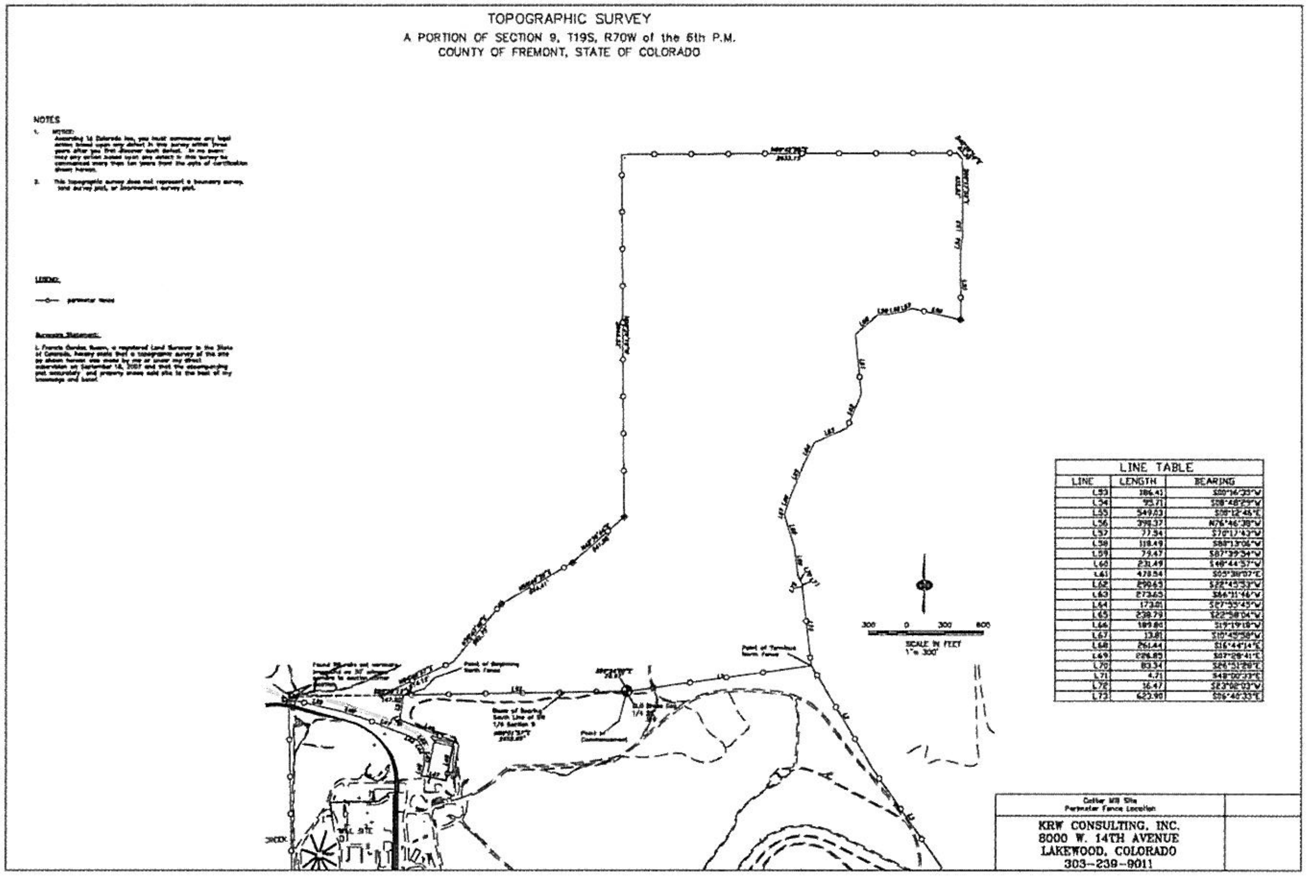


LINE TABLE		
LINE	LENGTH	BEARING
L1	1436.22	N92°00'02"E
L2	954.97	S30°57'42"E
L3	930.91	S35°13'18"E
L4	476.71	S37°39'30"W
L5	698.33	S07°26'55"W
L6	38.63	S51°26'07"W
L7	41.69	S61°22'14"W
L8	99.83	S60°29'31"W
L9	87.66	S57°12'05"W
L10	130.45	S05°22'39"W
L11	513.41	S06°31'49"E
L12	469.98	S78°45'46"E
L13	306.96	S03°10'19"E
L14	681.37	S58°56'38"W
L15	319.68	S50°39'07"W
L16	363.64	S44°13'22"W
L17	152.17	S00°18'37"E
L18	29.50	S19°38'35"W
L19	50.31	S34°17'20"W
L20	96.60	S47°31'08"W
L21	39.94	S44°45'27"W
L22	49.86	S41°50'56"W
L23	39.42	S33°58'14"W
L24	8.31	S25°08'49"W
L25	13.00	S16°00'35"W
L26	8.27	S07°14'46"W
L27	18.72	S04°23'27"E
L28	10.15	S13°02'56"E
L29	39.71	S20°37'35"E
L30	79.67	S26°07'04"E
L31	155.69	S16°15'33"E
L32	1166.75	S83°08'41"W
L33	1396.03	N58°27'24"W
L34	1909.64	N49°23'41"W
L35	3194.96	N01°08'05"W
L36	34.73	N00°59'52"W
L37	28.91	N04°40'44"E
L38	64.02	S80°19'21"E
L39	315.51	S77°28'54"E
L40	212.31	S73°22'46"E
L41	365.64	S68°45'24"E
L42	99.79	S65°30'57"E
L43	50.29	S41°32'39"E
L44	49.44	S23°25'49"E
L45	99.43	S00°52'47"E
L46	99.73	S13°38'36"W
L47	200.78	S78°57'29"E
L48	314.03	N11°14'56"E
L49	439.42	N68°45'12"W
L50	30.52	N30°34'02"W
L51	177.56	N08°54'36"E
L52	1779.49	N89°01'09"E

Cotter Mill Site
Perimeter Fence Location

KRW CONSULTING, INC.
6000 W. 14TH AVENUE
LAKEWOOD, COLORADO
303-239-9011

RADIOACTIVE MATERIALS LICENSE



LINE TABLE		
LINE	LENGTH	BEARING
L53	386.43	S00°16'33"W
L54	95.71	S38°48'29"W
L55	349.03	S08°12'45"E
L56	398.37	N76°46'38"W
L57	77.54	S70°17'43"W
L58	118.49	S88°13'06"W
L59	79.47	S87°39'34"W
L60	231.49	S48°44'57"W
L61	478.54	S05°38'07"E
L62	290.63	S22°45'53"W
L63	273.65	S66°11'46"W
L64	173.01	S27°55'45"W
L65	238.79	S22°58'04"W
L66	189.80	S19°19'19"W
L67	13.81	S10°45'58"W
L68	261.44	S16°44'14"E
L69	226.85	S07°29'41"E
L70	83.34	S26°51'29"E
L71	4.71	S48°00'33"E
L72	16.47	S23°02'03"W
L73	623.90	S06°40'33"E

Cotter Mill Site
Perimeter Fence Location

KRW CONSULTING, INC.
8000 W. 14TH AVENUE
LAKEWOOD, COLORADO
303-239-9011

EPA-5174

Angelique Diaz

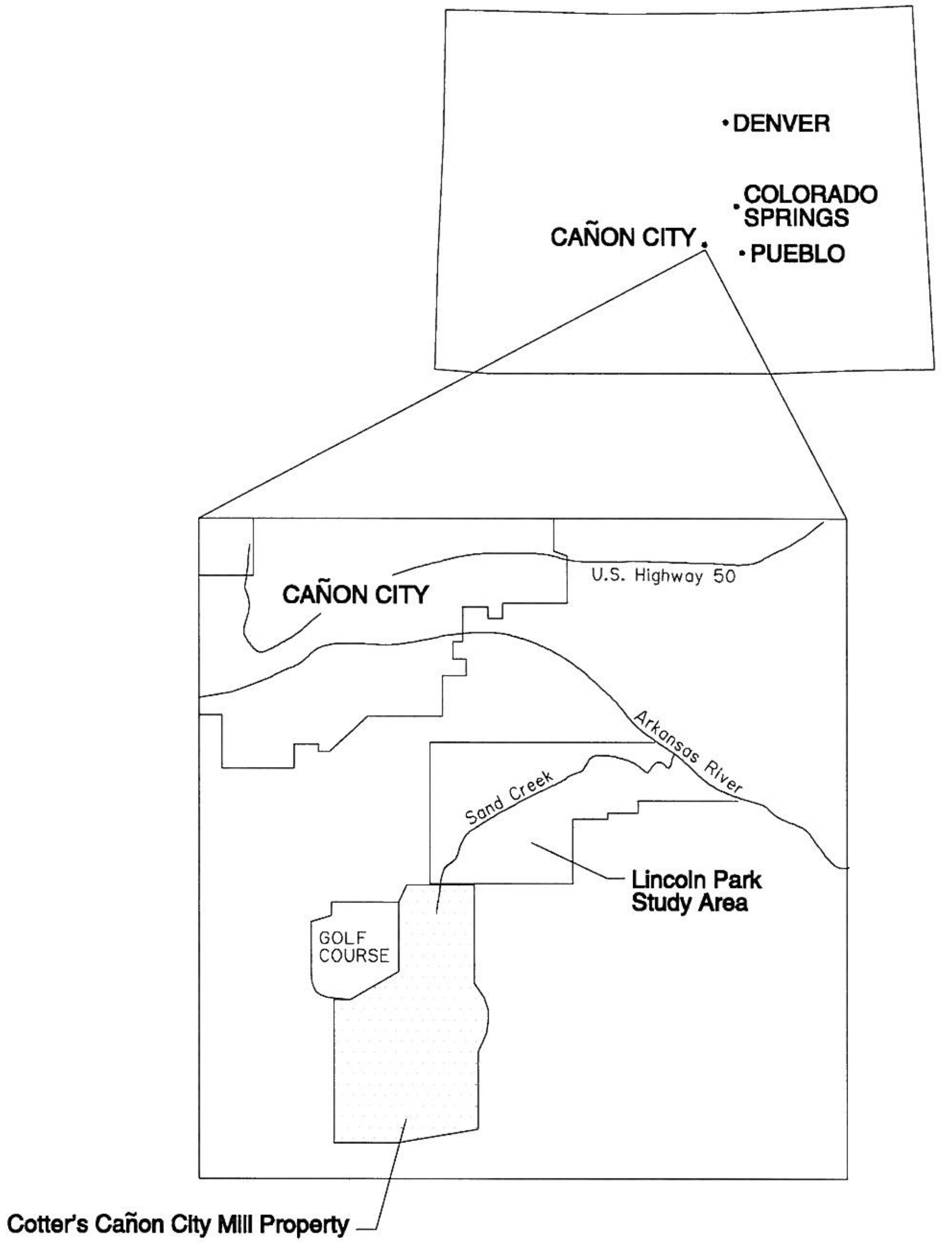
To

cc

bcc

Subject UPLOAD C:\Users\adiaz01\Documents\TELECOMMUTE\Subpart W\W WORKGROUP\SubWFOIAResponsiveDocuments\Attachment 1(a).pdf

- Attachment 1(a).pdf



NOT TO SCALE

Figure 1

Site Location Map

Lincoln Park Superfund Site
Cañon City, Colorado

T:\CADD\3280-RAC8\025-LincolnPark\ROD\CADD\FIG1.DWG

EPA-5175

Angelique Diaz

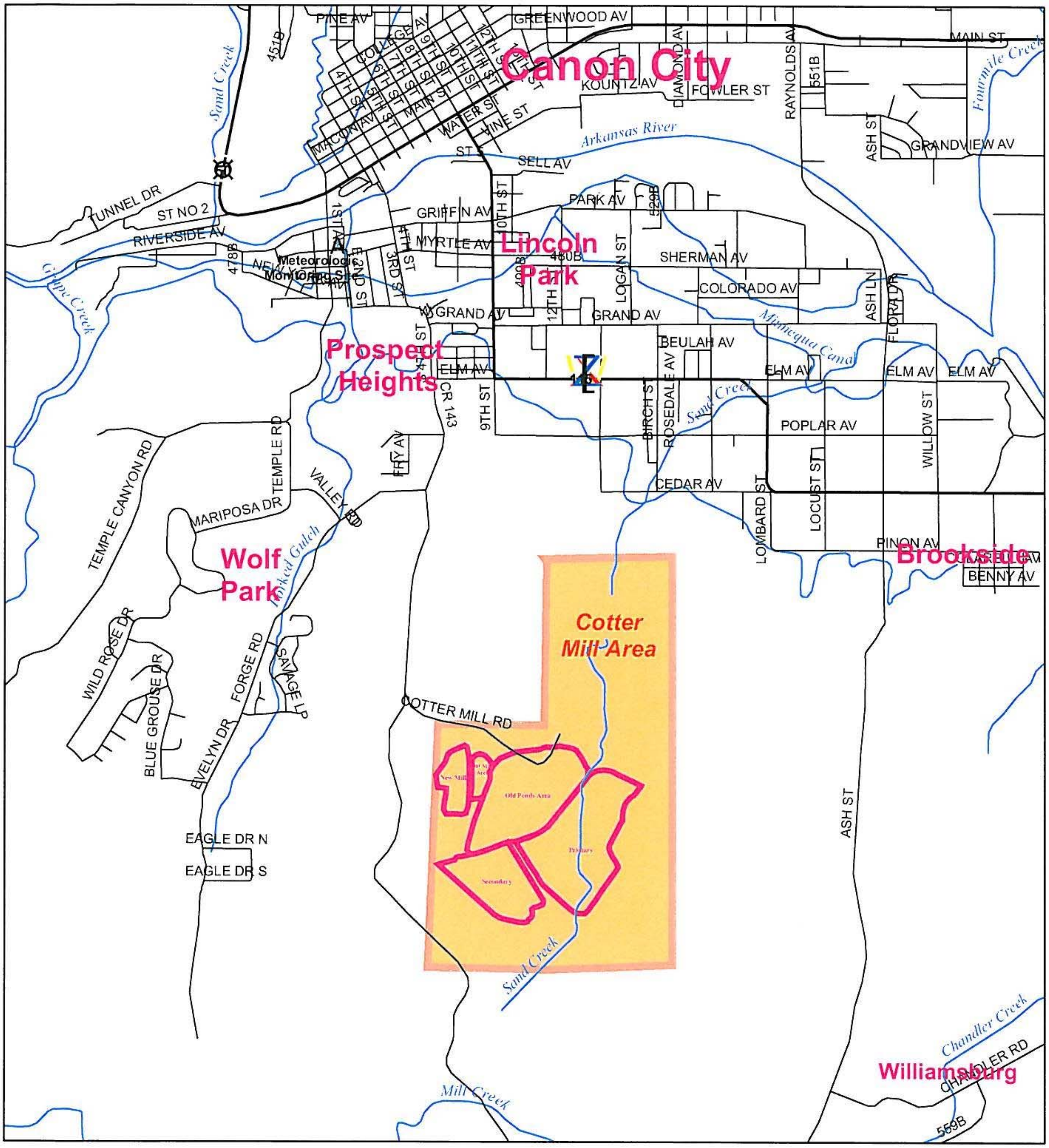
To

cc

bcc

Subject UPLOAD C:\Users\adiaz01\Documents\TELECOMMUTE\Subpart W\W WORKGROUP\SubWFOIAResponsiveDocuments\Attachment 1(b).pdf

- Attachment 1(b).pdf



Cotter Mill & Vicinity

Figure 2

Hazardous Materials & Waste Management Division

Colorado Department of Public Health and Environment

EPA-5176

Angelique Diaz	To	
	cc	
	bcc	
	Subject	UPLOAD C:\Users\adiaz01\Documents\TELECOMMUTE\Subpart W\WWORKGROUP\SubWFOIAResponsiveDocuments\attachment 1(c).pdf

- attachment 1(c).pdf


Figure 3
New Pond 3
Mill Site
Water Distribution Pond
Primary Impoundment
Secondary Impoundment
cotter
N
Feet
0
200
400
800

EPA-1471

Reid Rosnick/DC/USEPA/US
10/06/2010 10:53 AM

To Ron Wilhelm
cc
bcc
Subject ATSDR Document

Ron,

Here's the document I promised...

LincolnParkCotterUraniumMillPublicCommentPHA09092010.pdf

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Public Health Assessment for

LINCOLN PARK/COTTER URANIUM MILL
CAÑON CITY, FREMONT COUNTY, COLORADO
EPA FACILITY ID: COD042167585
SEPTEMBER 9, 2010

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

NOVEMBER 9, 2010

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at
1-800-CDC-INFO or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

LINCOLN PARK/COTTER URANIUM MILL

CAÑON CITY, FREMONT COUNTY, COLORADO

EPA FACILITY ID: COD042167585

Prepared by:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Site and Radiological Assessment Branch

This information is distributed by the Agency for Toxic Substances and Disease Registry for public comment under applicable information quality guidelines. It does not represent and should not be construed to represent final agency conclusions or recommendations.

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund law. This law set up a fund to identify and clean up hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate possible the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the public comments that related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Rolanda Morrison
ATSDR Records Center (MS F-09)
4770 Buford Hwy, NE
Building 106, Room 2108
Atlanta, GA 30341

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APPENDIX C - ATSDR'S EVALUATION PROCESS AND EXPOSURE DOSE CALCULATIONS

Acronyms and Abbeviations

CCAT	Colorado Citizens Against Toxic Waste
CDPHE	Colorado Department of Public Health and Environment
CREG	cancer risk evaluation guide
CV	comparison value
D	dissolved
EMEG	environmental media evaluation guide
EPA	US Environmental Protection Agency
LPWUS	Lincoln Park Water Use Survey
LTHA	lifetime health advisory for drinking water
MCL	maximum contaminant level
mg/L	milligrams per liter
µR/hr	microroentgen per hour
N	not defined in the CDPHE database
NA	not available
ND	not detected
NPL	National Priorities List
OU	operable units
pCi/g	picocuries per gram
pCi/L	picocuries per liter
ppm	parts per million
RAP	Remedial Action Plan
RBC	risk based concentration
RMEG	reference dose media evaluation guide
S	suspended
SCS	Soil Conservation Service
SSL	soil screening level
T	total
UMTRCA	1978 Uranium Mill Tailings Radiation Control Act
USGS	United States Geological Survey

I. SUMMARY

Introduction

ATSDR's top priority is to ensure that the community of Lincoln Park and surrounding communities have the best information possible to safeguard their health.

The purpose of this public health assessment (PHA) is to evaluate available data and information on the release of hazardous substances from the Cotter Uranium Mill to determine if people could be harmed by coming into contact with those substances. This PHA will also list actions, as needed, to be taken to protect the public's health.

Background

The Cotter Uranium Mill (Cotter) is located approximately two miles south of downtown Cañon City in Fremont County, Colorado. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill (Galant et al. 2007).

The 2,500-acre site includes two inactive mills, ore stockpile areas, a partially reclaimed tailings pond disposal area (i.e., the old ponds area), and a current tailings pond disposal area (i.e., the lined "main impoundment area"). A large portion of the site is used to store waste products in the impoundment area. The former mill area is fenced and is known as the "restricted area".

The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987, and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006. Cotter is currently evaluating whether to re-engineer the mill for future operation.

Wastes containing metals and radionuclides were released from Cotter and entered the nearby environment. People could potentially be exposed to these wastes if they come into contact with them in drinking water, soil, sediment, biota (fruits and vegetables) or ambient air.

Conclusions

After evaluating the available data, ATSDR reached four important conclusions in this public health assessment:

Conclusion 1

ATSDR concludes that drinking water from contaminated private wells could harm people’s health. This is a public health hazard.

Basis for Conclusion

Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people’s health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions. Individuals who do not take in enough dietary copper or who cannot process it correctly will be affected the most.

The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply makes these past exposures difficult to accurately assess.

Most town residents are now connected to the public water supply and have thus eliminated their exposure to contaminated water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

Conclusion 2

ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people’s health. However, ATSDR cannot make conclusions about whether lead in soils near Cotter Mill could harm people’s health in the future.

Basis for Conclusion

Currently, the property near the Cotter Mill property is restricted access, vacant or used for industrial purposes; therefore, contact with soils near the property should be minimal. The soil sampling conducted at the site does not allow ATSDR to accurately assess potential exposures if the area is ever developed for residential, commercial or recreational uses. Therefore, a conclusion regarding future exposures cannot be made because not enough information is available about future development of this area.

ATSDR recommends that lead contamination in soil be re-evaluated if

Next Steps

the area is considered for development for residential or non-industrial uses.

Conclusion 3

ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.

Basis for Conclusion

Sampled locally-grown fruits and vegetables did not indicate the presence of contaminants at levels that would cause non-cancer health effects. The increased cancer risk is based on a person consuming more fruits and vegetables (95th percentile range) than a typical consumer. The cancer estimate is conservative because it assumes that a person would grow and eat fruits and vegetables that contain arsenic every day for 30 years. The amount of fruits and vegetables eaten will likely be much less than estimated, mainly because the growing season is not year-round.

The amount of a contaminant ingested would depend upon the type of crop eaten, the likelihood of the crop bioaccumulating any of the contaminants, how often the crop is eaten, if contaminated well water is used to irrigate the crop, and if the crop is thoroughly cleaned prior to eating them.

Conclusion 4

ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.

Basis for Conclusion

With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.

ATSDR is taking the following follow-up actions at this site:

Next Steps

ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.

ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.

ATSDR will continue to work with appropriate state and federal agencies and review additional relevant environmental data (including the water use survey) as it becomes available.

ATSDR will update the action plan for this site as needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

For More Information

If you have concerns about your health, you should contact you health care provider. You can also call ATSDR at 1-800-CDC-INFO for more information on the Lincoln Park/Cotter Uranium Mill site.

II. BACKGROUND

A. Site description and operational history

The Cotter Mill is located approximately two miles south of downtown Cañon City in Fremont County, Colorado (see Figure 1) [Galant et al. 2007]. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill [Galant et al. 2007].

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The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987 [Weston 1998], and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001 [EPA 2002]. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006 [Cotter 2007]. Cotter is currently evaluating whether to re-engineer the mill for future operation [CDPHE 2008].

Additional information about the history and licensing of the Cotter Mill can be found on the Colorado Department of Public Health and Environment's (CDPHE) and the US Environmental Protection Agency's (EPA) Web sites at http://www.cdphe.state.co.us/hm/cotter/sitedescript.htm and http://www.epa.gov/region8/superfund/co/lincolnpark/.

B. Remedial and regulatory history

Originally, mill tailings (i.e., solid ore processing waste), raffinate (liquid waste that remains after extraction), and other liquids from the alkaline leach process were stored in ten on-site unlined ponds. In 1978, lined impoundments were built on site to store process waste products. The main impoundment contained two cells to segregate acid-leach tailings and liquids in the primary impoundment cell from alkaline-leach tailings in the secondary impoundment cell (EPA 2002). By 1983, more than 2.5 million cubic yards of waste products from historic operations were transferred from the original unlined ponds to the secondary impoundment. All new process wastes are stored in the lined primary impoundment [Galant et al. 2007].

Because Cotter Mill operations released radionuclides and metals into the environment, soil around the mill and groundwater in the nearby Lincoln Park community became contaminated, primarily with molybdenum and uranium [CDPHE 2008]. In 1984, the Lincoln Park/Cotter Mill Site was added to the Superfund National Priorities List (NPL) [EPA 2008]. EPA divided the site into two operable

According to a signed Memorandum of Understanding, CDPHE is the lead regulatory agency overseeing cleanup at the Cotter Mill.

units (OUs)—OU1 consists of the on-site contamination and OU2 is the neighborhood of Lincoln Park (i.e., the off-site impacted area) [CDPHE 2008; EPA 2007]. Together, the Lincoln Park/Cotter Mill Superfund Site encompasses about 7.8 square miles (5,000 acres) [EPA 2004].

In 1988, the Cotter Corporation and CDPHE signed a Consent Decree and Remedial Action Plan (RAP) [Galant et al. 2007]. The purpose of the court-ordered action was to assess and mitigate human and environmental impacts from the Cotter Mill. As part of the settlement, Cotter agreed to clean up the site at the corporation's expense [EPA 2008]. The cleanup was estimated to take 16 years and cost $11 million [Galant et al. 2007]. EPA and the US Department of Energy have also contributed to cleanup costs [DOE 2003]. Remedial activities have focused on eliminating the sources of contamination at the Cotter Mill and eliminating exposures to Lincoln Park residents [CDPHE 2008]. Many of the activities outlined in the 1988 RAP have been completed, including the following:

- Connecting Lincoln Park residents to city water;
- Constructing a groundwater barrier at the Soil Conservation Service (SCS) Flood Control Dam to minimize migration of contaminated groundwater into Lincoln Park;
- Moving tailings and contaminated soils into a lined impoundment to eliminate them as a source of contamination; and
- Excavating contaminated stream sediments in Sand Creek.

The old ponds area was undergoing reclamation in late 2008 [Pat Smith, EPA Region 8, personal communication, August 2008]. Remaining activities include groundwater remediation and final site cleanup [CDPHE 2008; Galant et al. 2007]. Groundwater remediation activities have shown some positive results. However, the balance of the remedial activities listed in the Consent Decree have not been successful enough in mitigating the plume, and most have been discontinued (e.g., barrier wall, dam to ditch flushing, calcium-polysulfide fix/flush, and permeable reactive treatment wall). Table 1 below lists a timeline of process events, remedial activities, and government actions for the Lincoln Park/Cotter Mill Superfund Site.

Table 1. Lincoln Park/Cotter Mill Superfund Site Activity Timeline

Date	Type of Event[1]	Event[2]
July 1958	Process	Cotter Corporation began alkali leach process operations (licensing by the Atomic Energy Commission)
June 1965	Event	Flood that caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park
1971	Remediation	SCS Dam completed; dam pumps impounded surface water back to the main impoundment (groundwater barrier completed at a later date after 1988 RAP)
July 1972	Remediation	Pond 2 lined
June 1976	Remediation	Pond 10 lined
1978–1979	Remediation	A new lined impoundment consisting of two cells (primary and secondary) constructed adjacent to the old ponds area for management of wastes from the new mill (alkali process)
1979	Remediation	The old mill was demolished and new mill construction began
1979–present	Remediation	Impounded water at the SCS Dam pumped back to the main impoundment
1979–1998	Process	Operations switched from an alkali leach process to an acid leach mill; continuing operations intermittently
1980	Remediation	Old upstream method tailings ponds replaced by a full-height compacted earth embankment
1980	Remediation	Construction of Well 333 just north of Cotter; well removes contaminated water flowing from the old ponds area
June 1981	Remediation	Pond 3 lined
1981–1983	Remediation	Tailings from the unlined old ponds area (~2.5 million cubic yards) removed and placed in the new impoundment
December 9, 1983	Government Action	State of Colorado files a complaint against Cotter under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
September 21, 1984	Government Action	Cotter (OU1) and Lincoln Park (OU2) added to the NPL
1985–1986	Investigation	Remedial Investigation and Feasibility Study (GeoTrans 1986)
April 1986	Government Action	Memorandum of Agreement between EPA and the state of Colorado
April 8, 1988	Government Action	Consent decree signed, including a RAP that required cleanup activities
1988	Remediation	An additional 2 feet of soil was removed from the old ponds area and placed in the lined primary impoundment
1988	Remediation	Lined water distribution/surge pond constructed over Pond 7
1988	Remediation	Installation of a hydrologic clay barrier upgradient from the SCS Dam
1989	Remediation	The secondary impoundment cell was covered with liquid for dust control and to create evaporative capacity; additional contaminated soils were removed from the old ponds area and placed in the primary impoundment cell

Date	Type of Event[1]	Event[2]
1989–2000	Remediation	Installation of two hydraulic barriers (injection/withdrawal systems) to control groundwater flow from the old ponds area; discontinued in 2000 because the system was unproductive
1990–1996	Remediation	SCS Dam to DeWeese ditch flushing project
1990–1998	Remediation	Four pilot tests to evaluate the effectiveness of active flushing of vadose zone and aquifer for contaminant removal in OU1
October 29, 1991	Report	Health Risk Assessment of the Cotter Uranium Mill Site: Phase I (HRAP 1991)
January 7, 1993	Report	RAP final report, Willow Lakes (Cotter)
1993–1999	Remediation	Sand Creek Soil Cleanup Action identified and removed approximately 9,000 cubic yards of tailings, soil, and sediment from Sand Creek (Cotter 2000)
1995	Licensing	Cotter filed a license amendment with the state for alkaline leach processing of uranium ore (approved 2/97)
November 19, 1996	Report	Supplemental Human Health Risk Assessment: Phase II Final Report (Weston 1996)
1996–1998	Remediation	Flush/fixation process using Calcium Polysulfide in surface infiltration cells
February 1997	Government Action	Radioactive materials license amendment became effective
1998	Process	Mill reconverted to an alkaline leach process
September 29, 1998	Report	Ecological Risk Assessment, Lincoln Park Superfund Site (Stoller Corporation and Schafer & Associates)
1998	Report	Supplemental Human Health Risk Assessment, Phase III Final Report (Weston 1998)
1999	Remediation	Old ponds area surface soils (~100,000 cubic yards) were removed and placed in the lined primary impoundment
May 1999	Process	Cotter resumed operations (which had been intermittent since 1979) with modified alkaline-leaching capability
September 30, 1999	Investigation	Final Focused Feasibility Study, Lincoln Park
June 2000	Remediation	Installation of a permeable reactive treatment wall across Sand Creek channel, north of SCS Dam in DeWeese Dye Ditch flush (to fulfill EPA requirement to address contaminated groundwater that was bypassing the SCS Dam barrier)
2000–2005	Process	Cotter proposes modifications to the circuit to process zircon ore. Process was not successful and discontinued by 2005.
January 2002	Government Action	EPA issued a Record of Decision for Lincoln Park requiring “No Further Action” for surface soils within Lincoln Park (EPA 2002)
April 2002	Government Action	The governor of Colorado passed an emergency bill requiring an Environmental Assessment be conducted before shipping out-of-state radioactive waste to Cotter
July 9, 2002	Government Action	CDPHE denied Cotter’s license amendment request, preventing receipt of shipments for direct disposal

Date	Type of Event[1]	Event[2]
September 13, 2002	Government Action	State of Colorado allowed Cotter to receive limited amounts of waste material as a test of its handling/storage capability
2002/2003	Investigation	Sampling for plutonium, uranium, lead and molybdenum in the Canon City vicinity (CDPHE 2003)
January 3, 2003	Government Action	EPA issued a notice of unacceptability under the Off-Site Rule regarding the five Proposed Units and impoundments previously found acceptable
2003	Remediation	Permeable reactive treatment wall not functioning as designed
September 9, 2004	Investigation	Cotter submits Feasibility Study for Old Ponds Area with six alternatives
December 15, 2004	Government Action	State health officials approved a 5-year extension of Cotter's uranium-processing license but denied requests to become a disposal facility for off-site radioactive materials
February 1, 2005	Government Action	Cotter filed a request for a hearing regarding the conditions of the license renewal
October 2005	Investigation	Survey of lead in indoor dust, soils, and blood in Lincoln Park to investigate potential impacts of historic smelters (ATSDR 2006a, 2006b, 2006c, 2006d)
April 2006	Government Action	A judge recommended in CDPHE's favor and Cotter filed an exception on the direct disposal issue only
2006	Remediation	To replace the permeable reactive treatment wall, water building up behind barrier is pumped back to the impoundments
January 2007	Government Action	CDPHE signed a Final Agency Decision, affirming the judge's Decision on the license. Cotter filed an appeal to be able to dispose of out-of-state soils in its primary impoundment.
2008	Process	Cotter decides not to take the case to the Court of Appeals, effectively ending the licensing issues from the 2004 renewal.

[1] Describes the general nature of events/actions relating to the Lincoln Park/Cotter Mill Superfund Site.

[2] Includes events/actions most pertinent to ATSDR's evaluation of exposures and potential health effects. Not all site-related events and reports are included.

C. Demographics

ATSDR examines demographic data to identify sensitive populations, such as young children, the elderly, and women of childbearing age, and to determine whether these sensitive populations are exposed to any potential health risks. Demographics also provide details on population mobility and residential history in a particular area. This information helps ATSDR evaluate how long residents might have been exposed to contaminants. According to the 2000 census, 1,170 people live within one mile of the Cotter Mill property—90 of whom are age 6 or younger, 190 are women of childbearing age (15–44 years), and 243 are age 65 or older. Figure 2 in Appendix B shows the demographics within one mile of the mill.

Cañon City is the largest population center in Fremont County with 15,760 residents (see Table 2 below). The Cañon City Metro area includes Cañon City, North Cañon, Lincoln Park, Brookside, Prospect Heights, Four Mile Ranch, Shadow Hills, Dawson Ranch, and the Colorado State Correctional Facilities. Florence is the second largest community in the area with a population of 3,816. The unincorporated portions of Fremont County represent 55% of the population and include Lincoln Park, Prospect Heights, and Shadow Hills [Cotter 2007].

Table 2. Population of communities near the Cotter Mill

Community	2000 Census Population	2006 Population Estimate
Brookside	219	218
Cañon City	15,431	15,760
Coal Creek	303	380
Florence	3,653	3,816
Lincoln Park	3,904	Not available
Rockvale	426	432
Williamsburg	714	700
Fremont County	46,145	47,727

Source: Cotter 2007; Galant et al. 2007

The unincorporated community of Lincoln Park is located in the greater Cañon City area, south of the Arkansas River and north of the Cotter Mill (see Figure 1). The community consists of single and multi-family homes, trailer parks, and rural single family homes. Many of the residents are retired and own their homes. The Lincoln Park area is currently experiencing growth [Galant et al. 2007].

The largest employers in Fremont County are the Colorado Department of Corrections and the Federal Bureau of Prisons. Tourism is the second largest employer in the Cañon City area [Cotter 2007; Galant et al. 2007]. Additional industry and manufacturing employers in Fremont County include Portec, Inc.; Holcim, Inc.; Thermal Ceramics; and Cañon Industrial Ceramics [Cotter 2007]. The health care and school systems also employ a substantial number of people in the county [CCAT, personal communication, August 2008].

D. Land use and natural resources

The Cotter Mill is located within an industrial zone. All abutting lands are zoned for agriculture-forestry. The semi-rural community of Lincoln Park is comprised predominantly of residential developments, agricultural plots and orchards, and small grazing parcels. The Shadow Hills Golf Course is located to the north of the Cotter Mill complex. The land to the south and east of the site is largely undeveloped. Recently, several high end homes have been built near the golf course and in the Wolf Park and Dawson Ranch areas. The distance from Cotter Mill's restricted area to the nearest home is about 0.25 mile [Galant et al. 2007].

Fremont County contains a large amount of public land managed by the US Department of the Interior Bureau of Land Management and the US Department of Agriculture Forest Service. Some of these areas are leased for livestock grazing, aggregate mining, and firewood removal. Visiting the many scenic attractions in Colorado's High Country (e.g., the Royal Gorge Bridge) and rafting in the Arkansas River are popular recreational activities [Cotter 2007].

1. Hydrogeology

In the vicinity of the Cotter Mill, contaminated groundwater primarily migrates along the near surface alluvium and fractured, weathered bedrock immediately underlying the alluvium (<100 feet deep) [USGS 1999a]. Groundwater migration is generally in northerly directions from the mill area, along the Sand Creek drainage area, through a gap in Raton Ridge, and into Lincoln Park. However, groundwater contamination has also been found in the vicinity of the Shadow Hills Golf Course, which is west of the Sand Creek drainage [EPA 2007]. The hydrogeology of the Lincoln Park/Cotter Mill Superfund Site can be conceptually divided into two areas: the upgradient area near the mill and the downgradient area to the north-northeast in Lincoln Park [USGS 1999a].

- In the upgradient area near the mill, the rate of groundwater flow is limited by small hydraulic conductivities [USGS 1999a]. However, cracks in the bedrock, fractures, and weathering enhance water transmission and allow groundwater to travel at considerable rates. Monitoring wells in the upgradient area, specifically in the Poison Canyon Formation, yield small amounts of water.

- The downgradient area in Lincoln Park is characterized by an "alluvial aquifer" comprised of alluvium and terrace alluvium, to a depth of 0–60 feet, and the underlying weathered and/or fractured bedrock below the alluvium. In this area, groundwater can be transmitted at substantial rates. The mix of gravel, sand, silt, and clay in this aquifer yields 10 to 400 gallons per minute to wells in Lincoln Park. The aquifer discharges to Sand Creek, as well as to multiple springs and seeps as far downgradient as the Arkansas River, approximately 2.5 miles downgradient from the Cotter site.

2. Geology

The Cotter Mill is located in a topographic depression resulting from an underlying structure called the Chandler syncline. The core of the syncline is the Poison Canyon formation, which is the uppermost bedrock unit beneath the site. Soils near the mill are shallow and well drained.

The top layer consists of brown loam. The subsoil is a pale brown loam, grading into a yellowish brown sandy loam. Areas north of the mill are covered with Quaternary alluvium consisting of gravel, cobble, boulders, and sand [EPA 2002].

3. Hydrology

The Cotter Mill lies within the Sand Creek watershed [HRAP 1991]. The main hydrologic feature of the Lincoln Park/Cotter Mill Superfund Site is Sand Creek, a primarily ephemeral creek [EPA 2007]. The creek originates at Dawson Mountain (south of the Cotter Mill), travels north through the Cotter Mill, intersects the DeWeese Dye Ditch, and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. The DeWeese Dye Ditch is one irrigation ditch that flows between the Cotter Mill and Lincoln Park.

> An ephemeral creek has flowing water only during, and for a short duration after, precipitation. A perennial creek has flowing water year-round.

Alluvial material (sediment deposited by flowing water) associated with Sand Creek is the predominant migration pathway for mill-derived contaminants in groundwater. Sand Creek carved a channel into the Vermejo formation at the Raton outcrop in the vicinity of the SCS Dam, which filled with permeable sediments, creating a preferential pathway for alluvial groundwater into Lincoln Park. The alluvial aquifer in Lincoln Park receives recharge from the DeWeese Dye Ditch, Crooked Ditch, Pump Ditch, ditch laterals, and ponds filled by the DeWeese Dye Ditch [EPA 2007].

4. Prevailing Wind Patterns

Cotter’s monitoring network includes an on-site meteorological station that continuously measures a standard set of meteorological parameters (e.g., wind speed, wind direction, temperature, and relative humidity). The wind rose in Figure 3 in Appendix B depicts the statistical distribution of measured wind speeds and wind directions. During 2008, wind patterns at the station were principally westerly (i.e., winds out of the southwest to northwest) and accounted for 55% of the total winds [Cotter 2008b]. Easterly winds (i.e., winds out of the southeast to northeast) accounted for a smaller, but still significant, portion (26%) of the observed wind directions. Southerly and northerly winds were much less common. A nearly identical profile was observed in 2007. Other average parameters measured in 2008 follow: air temperature of 53.4 °F; relative humidity of 41%; and rainfall of 5.18 inches.

The prevailing westerly and easterly wind patterns are reasonably consistent with trends in the observed concentrations. Ambient air concentrations of selected site-related pollutants were highest at the perimeter monitoring stations directly east and west of the primary operations. There is a hilly ridge that straddles the western border of the site, blocking much east/west wind flow. However, it should be noted that prevailing wind patterns measured at Cotter Mill may not be representative of surface winds throughout the area, especially considering the proximity of nearby terrain features.

E. Past ATSDR involvement

ATSDR has been involved with the Lincoln Park site in the past. In October 1983, ATSDR completed a Public Health Assessment for the site. After reviewing available groundwater data, ATSDR concluded that the potential long term health effects from consumption of the contaminated water were:

- cancer and kidney damage, from uranium;
- gout-like symptoms, from molybdenum; and
- possibly a group of physiological and psychological symptoms, from selenium.

None of the potential health effects were definitive.

Numerous questions and concerns have been voiced by residents of Lincoln Park regarding the historical sites of numerous milling and smelting facilities in the Cañon City area. Among the various concerns were specific concerns about residual lead contamination from these milling and smelting operations. In response to these concerns, and after a specific request by the EPA, ATSDR evaluated the health risks associated with lead contamination in the area. ATSDR focused on two primary issues: 1) the blood lead level of children living in the area and 2) lead contaminated dust in homes in the Lincoln Park area.

In September and October 2005, ATSDR conducted an Exposure Investigation (EI) to answer the questions presented by the community and EPA. Previously, ATSDR concluded that lead levels in house dust and lead exposures to children represented an indeterminate health hazard because of a lack of available data. ATSDR conducted the EI to gather data on blood lead levels in the children, and soil and indoor dust level from homes.

The activities of the EI included:

- Collecting 44 indoor dust samples from 21 homes in Lincoln Park
- Collecting 80 composite soil samples from 22 properties (sampling conducted by EPA)
- Obtaining 45 blood samples from 21 households (42 blood samples were analyzed)

After evaluating the data obtained during the EI, ATSDR concluded that blood lead levels in adults and children, lead levels in dust in homes, and lead levels in soil did not represent a public health harard. ATSDR recommended no further actions related to lead in dust in homes, but did recommend routine monitoring of children’s blood lead levels in the Lincoln Park area.

In September 2005, ATSDR conducted a blood lead testing program as a service to the community of Lincoln Park. A total of 115 children from a local school were tested for blood lead. None of the children tested had elevated blood lead levels. Therefore, ATSDR concluded that the children tested did not have unusual exposures to lead at the time of testing. ATSDR recommended that local and state agencies continue routine monitoring of lead levels in area children.

Full reports discussed above may be obtained by contacting any of the contacts listed at the end of this report, by visiting our website at www.atsdr.cdc.gov or by calling our toll-free hotline at 800-232-4636.

III. EVALUATION OF EXPOSURE PATHWAYS

A. What is meant by exposure?

An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The *source* is the place where the chemical or radioactive material was released. The *environmental media* (such as groundwater, soil, surface water, or air) transport the contaminants. The *point of exposure* is the place where people come into contact with the contaminated media. The *route of exposure* (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the *receptor population*.

ATSDR's public health assessments are driven by exposure to, or contact with, environmental contaminants. Contaminants released into the environment have the potential to cause harmful health effects. Nevertheless, *a release does not always result in exposure*. People can only be exposed to a contaminant if they come in contact with that contaminant—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant. If no one comes in contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come in contact with the contaminants.

The route of a contaminant's movement is the *pathway*. ATSDR identifies and evaluates exposure pathways by considering how people might come in contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant. ATSDR identifies an exposure pathway as completed or potential, or eliminates the pathway from further evaluation.

- *Completed exposure pathways* exist for a past, current, or future exposure if contaminant sources can be linked to a receptor population. All five elements of the exposure pathway must be present. In other words, people have or are likely to come in contact with site-related contamination at a particular exposure point via an identified exposure route. As stated above, a release of a chemical or radioactive material into the environment does not always result in human exposure. For an exposure to occur, a completed exposure pathway must exist.

- *Potential exposure pathways* indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. It exists when one or more of the elements are missing but available information indicates possible human exposure. A potential exposure pathway is one which ATSDR cannot rule out, even though not all of the five elements are identifiable.

- An *eliminated exposure pathway* exists when one or more of the elements are missing. Exposure pathways can be ruled out if the site characteristics make past, current, and future human exposures extremely unlikely. If people do not have access to contaminated areas, the pathway is eliminated from further evaluation. Also, an exposure pathway is eliminated if site monitoring reveals that media in accessible areas are not contaminated.

Contact with contamination at the Cotter Mill is an eliminated exposure pathway.

Because the mill site itself is fenced and access is restricted, exposure to on-site contamination by the public at the Cotter Mill is limited. Further, remediation efforts have removed some of the on-site soil contamination, including moving millions of cubic yards of tailings and contaminated soils from unlined ponds to lined impoundments (EPA 2002). In some areas, contaminated soil was removed down to bedrock. In addition, various process changes reduced the release of contaminated materials (EPA 2002). Any potential exposure by the occasional trespasser to remaining impacted soils at the Cotter Mill would be too infrequent to present a health hazard.

B. How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people could have been, are, or could be exposed (i.e., exposed in a past scenario, a current scenario, or a future scenario) to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, sediment, water, air, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation.

If exposure was, is, or could be possible, ATSDR scientists consider whether contamination is present at levels that might affect public health. ATSDR scientists select contaminants for further evaluation by comparing them to health-based comparison values. These are developed by ATSDR from available scientific literature related to exposure and health effects. Comparison values are derived for each of the different media and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

Comparison values are not thresholds for adverse health effects. ATSDR comparison values establish contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency of exposure), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects.

Some of the comparison values used by ATSDR scientists include ATSDR's environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs) and EPA's maximum contaminant levels (MCLs). EMEGs, RMEGs, and CREGs are non-enforceable, health-based comparison values developed by ATSDR for screening environmental contamination for further evaluation. MCLs are enforceable drinking water regulations developed to protect public health. Effective May 2008, Colorado established state groundwater standards for uranium and molybdenum.

You can find out more about the ATSDR evaluation process by calling ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636) or reading ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/.

C. If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects a person can experience because of contact with a contaminant depend on the exposure concentration (how much), the frequency (how often) and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur.

In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR scientists typically use worst-case exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs more detailed reviews of exposure and consults the toxicologic and epidemiologic literature for scientific information about the health effects from exposure to hazardous substances.

D. What exposure situations were evaluated for residents living near the Cotter Mill?

ATSDR obtained information to support the exposure pathway analysis for the Lincoln Park/Cotter Mill Superfund Site from multiple site investigation reports; state, local, and facility documentation; and communication with local and state officials. The analysis also draws from available environmental and exposure data for groundwater, soil, surface water and sediment, and biota. Throughout this process, ATSDR examined concerns expressed by the community to ensure exposures of special concern are adequately addressed. ATSDR identified the following exposure pathways for further evaluation:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.

2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.

3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.

4. Exposure from eating produce locally grown in Lincoln Park.

5. Exposure from site-related soil contaminants in windborne dust.

6. Exposure from air emission sources (stacks and uncontrolled fugitive dust)

This exposure pathway analysis focuses on past, current, and future exposures for residents living near the Cotter Mill, with a focus on the community of Lincoln Park. Some attention is also paid to exposures at the Shadow Hills Golf Course and along the county road. Table 3 below provides a summary of exposure pathways evaluated in this public health assessment.

1. *Exposure to groundwater in Lincoln Park*

In the past, a number of residences used wells[1] on their property (GeoTrans 1986; IMS 1989). Based on a 1989 water use survey in Lincoln Park, 60 out of 104 wells, springs, and cisterns were used to obtain water for domestic purposes, including consumption and irrigation (IMS 1989). See Table 14 in Appendix A for the reported groundwater uses in the Lincoln Park area. Seven survey respondents indicated that they used groundwater for domestic consumption, accounting for 5 to 100% of their total water consumption. Based on the survey, five residents had private wells that were affected by contaminated groundwater; these residents were connected to the municipal water supply between 1989 and 1993 [EPA 2002]. The 1988 RAP requires Cotter to connect eligible affected users with legal water rights for a well to the town water supply [CDPHE 2005]. Cotter checks the State of Colorado's Engineer's Office database for new water permits and reports their findings in their annual ALARA reports [Pat Smith, EPA Region 8, personal communication, August 2008].

The use of private groundwater wells in the past was a completed exposure pathway. Most residences are now connected to the public water supply. The current and future use of these wells is a potential exposure pathway because the extent to which these wells are used is not well documented.

While the majority of town residents are now connected to the public water supply [Galant et al. 2007], several residences also have operational private wells. A 2005 summary of the RAP status reports that some residents have refused public water supply connections [CDPHE 2005]. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park [EPA 2007]. The United States Geological Survey (USGS) reports that existing private wells are used primarily for stock watering and irrigation [USGS 1999a]. However, a newspaper article reports that at least one residence, located on Grand Avenue in Lincoln Park, used private well water for consumption as recently as 2002 [Plasket 2002]. Based on a 2007 review of Colorado State well permits for residences in the plume configuration, at least one well is permitted for irrigation and domestic use, but no details of actual use are documented [EA 2007]. On properties that continue to use private wells, new purchasers are offered connection to the town's municipal water system [Galant et al. 2007]. In late 2008, EPA conducted another water use survey to verify whether groundwater is being utilized by residences in Lincoln Park. Well water samples were also collected and analyzed. Once available, ATSDR will review the information and will revise the public health assessment, if needed.

2. *Contact with soil adjacent to the Cotter Mill and in Lincoln Park*

People (especially children) might accidentally ingest soil or exposed sediment, and dust generated from these materials, during normal activities. Everyone ingests some soil or dust every day. Small children (especially those of preschool age) tend to swallow more soil or dust than any other age group because children of this age tend to have more contact with soil through play activities and have a tendency for more hand-to-mouth activity. Children in elementary school, teenagers, and adults swallow much smaller amounts of soil or dust. The amount of grass

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[1] The term "well" is used to represent all groundwater sources, and includes both wells and springs.

cover in an area, the amount of time spent outdoors, and weather conditions also influence how much contact people have with soil.

a) Contact with soil near the Cotter Mill

Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates [CDPHE 2005]. Elevated levels are primarily detected in soils directly east and west of the facility [Weston 1998]. This distribution of contaminated soils is consistent with wind patterns in the area, which blow mainly from west to east with occasional flows from east to west. The primarily vacant areas directly east and west of the facility are referred to as a "buffer zone" between the Cotter Mill and residential developments [EPA 2002]. Therefore, limited opportunities for exposure to impacted site-adjacent soils exist—people are not expected to be in this area on a daily basis and for an extended period of time. One exception may be at the Shadow Hills Golf Course, located immediately north of the Cotter mill complex. Exposure to potentially impacted soil at this public golf course is unlikely due to grass cover.

Contact with contaminated soil near the Cotter Mill (i.e., in the buffer zone) is a past, current, and future potential exposure pathway.

For nearly 50 years, Cotter has intermittently hauled materials by truck, possibly losing some materials along the county road leading to the facility and along the access road entering the mill site [MFG 2005]. The public could be exposed to potentially impacted soils along the county road. However, there is limited potential for exposure to contaminants along the access road, since access to the Cotter Mill is restricted and Cotter remediated soil adjacent to the access road in 2007 and 2008.

b) Contact with soil and sediment in the community of Lincoln Park

The community of Lincoln Park is located approximately 1.5 miles north-northeast of the restricted area of the Cotter Mill. Contaminated materials from the Cotter Mill may have contributed to soil contamination in Lincoln Park in two ways:

1. Dust from soil or tailings associated with site operations could be transported by wind to Lincoln Park. However, wind patterns in the area suggest that wind-blown contamination is not likely a considerable source of soil contamination in Lincoln Park (Weston 1998). Additionally, on-site remediation at the Cotter Mill substantially reduced the sources of soil contamination.

2. Potentially impacted groundwater used for irrigation could lead to the accumulation of chemicals in town soils [Weston 1998].

Further, in the past, contaminated surface water runoff from the Cotter Mill entered Sand Creek, where it was transported downstream toward Lincoln Park [EPA 2002]. However, Sand Creek is not believed to be used for recreational activities—the creek is ephemeral and on private land until it goes under the river walk and enters the Arkansas River [Phil Stoffey, CDPHE, personal communication, June 2007].

Contact with contaminated sediment in Sand Creek was a past potential exposure pathway. Due to the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

Contact with contaminated soil in Lincoln Park was a past completed exposure pathway. Cotter has performed all required off-site soil cleanup activities, as outlined in the RAP [EPA 2002]. CDPHE reports that the Cotter Mill poses no risk to the residents of Lincoln Park by exposure to soil [Weston 1998], and EPA and CDPHE have advised "No Further Action" in regards to Lincoln Park soils [EPA 2002]. EPA's Record of Decision states that surface-soil cleanup activities have eliminated or reduced risks to "acceptable" levels [EPA 2002, 2007]. Therefore, current and future contact with soil and sediment is an eliminated exposure pathway.

3. Contact with surface water downstream from the Cotter Mill

In the past, people could have come in contact with contamination in surface water during recreational activities. The Arkansas River is used primarily for fishing and boating or rafting, as well as some swimming [Phil Stoffey, CDPHE, personal communication, June 2007]. Sand Creek is on private land until it goes under the river walk and enters the Arkansas River, and is generally not used for recreational activities [Phil Stoffey, CDPHE, personal communication, June 2007]. Many Lincoln Park residents use water from the DeWeese Dye Ditch to irrigate their orchards and gardens [Galant et al. 2007].

Contact with contaminated surface water near the Cotter Mill was a past potential exposure pathway. Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

4. Exposure from eating locally grown produce

Many Lincoln Park residents have orchards and gardens. Water from the DeWeese Dye Ditch is primarily used to irrigate the orchards and gardens, however, some residents use water from their groundwater wells [Galant 2007; IMS 1989]. If fruits and vegetables are grown in contaminated soil and/or irrigated with contaminated water, the people who eat this produce could be exposed to contamination.

5. Exposure from breathing windborne dust

Many Lincoln Park residents are concerned about the arid environment and the risks of breathing in contaminated dust from the site. The profile of air emission sources at Cotter Mill has changed considerably over the years. These sources include both releases through stacks and uncontrolled (or fugitive) dust emissions. Stack emissions occurred during times of active processing at Cotter Mill; however, the magnitude of these stack emissions has varied, depending on production rates and effectiveness of air pollution controls. The sources of fugitive dust emissions have also changed. In the past, the site had many uncontrolled sources of wind-blown dust, which would cause particulate matter (along with any chemical and radiological constituents) to be emitted into the air. Examples of these sources include ore handling operations, stockpiles, and the previous unlined holding ponds. Many of these sources of wind-blown dust have since been controlled or eliminated, causing facility-wide fugitive dust emissions to decrease considerably over the years, though some fugitive dust emissions (e.g., from unpaved roads) continue to occur.

Table 3. Exposure pathways for residents living near the Cotter Mill

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Groundwater							
Completed Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Past	Past consumption of groundwater from private wells has been documented and was, therefore, a completed exposure pathway.
Potential Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Current Future	The extent to which private wells are currently used in Lincoln Park is uncertain. Although most residents are supplied with town water, documents indicate that residents have been drinking private well water as recently as 2002, and are permitted to use wells for unspecified domestic purposes. However, it is believed that water from wells is used primarily for irrigation and other non-drinking purposes. Therefore, current and future use of water from private wells is a potential exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Soil and Sediment							
Completed Exposure Pathway							
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated by contaminated groundwater	Residences and public areas	Residents, including children	Dermal contact, Incidental ingestion, Inhalation	Past	Prior to remediation, contaminants were detected in soil from residential lawns and gardens. Therefore, contact with contaminated soil in Lincoln Park was a past completed exposure pathway.
Potential Exposure Pathways							
Surface soil near the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust	The Shadow Hills Golf Course west of the Cotter Mill; along the county road leading to the Cotter Mill	Golfers at the public golf course; people on the county road	Dermal contact, Incidental ingestion, Inhalation	Past Current Future	Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates. Therefore, contact with soil near the Cotter Mill, especially at the public golf course and along the county road, is a past, current, and future potential exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Along Sand Creek	Recreational users; children playing along Sand Creek	Dermal contact, Incidental ingestion	Past	There were limited opportunities for exposure since Sand Creek was not used for recreational purposes. Therefore, exposure to sediments prior to the Sand Creek Cleanup project was a past potential exposure pathway.
Eliminated Exposure Pathways							
Surface soil at the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; surface water runoff	Unauthorized access is not allowed	None	None	Past Current Future	Because the mill site itself is fenced and access is restricted, contact with on-site contamination is an eliminated exposure pathway. Further, remediation efforts have removed some impacted soils.

Exposure Pathway	**Exposure Pathway Elements**					**Time Frame**	**Comments**
	Sources of Contamination	**Fate and Transport**	**Point of Exposure**	**Exposed Population**	**Route of Exposure**		
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated with contaminated groundwater	Cleanup activities have eliminated or reduced risks to acceptable levels	None	None	Current Future	Due to the sampling and remediation in Lincoln Park, current and future contact with soil and dust is an eliminated exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Contaminated sediment was removed from Sand Creek	None	None	Current Future	Sediment in Sand Creek is no longer a hazard since the completion of the Sand Creek Cleanup project. Therefore, current and future contact with sediment in Sand Creek is an eliminated exposure pathway.
Surface Water							
Potential Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface water runoff; transport from Sand Creek to the Arkansas River	Along Sand Creek between the Cotter Mill and the Arkansas River; the DeWeese Dye Ditch; the Arkansas River	Recreational users (mostly in the Arkansas River, limited recreational use in Sand Creek); people irrigating with water from the DeWeese Dye Ditch	Incidental ingestion, Dermal contact	Past	In the past, surface water in Sand Creek was found to contain elevated levels of metals and radionuclides. Therefore, past contact with contaminated surface water near the Cotter Mill was a potential exposure pathway.
Eliminated Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface-water runoff; transport from Sand Creek to the Arkansas River	Contamination was removed from Sand Creek	None	None	Current Future	Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact with contaminated surface water is an eliminated exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Locally Grown Produce							
Potential Exposure Pathway							
Produce grown in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Produce grown in contaminated soil or irrigated with contaminated water	Orchards and gardens in Lincoln Park	People who eat locally grown produce	Ingestion	Past Current Future	Because many Lincoln Park residents have orchards and gardens, eating locally grown produce is a past, current, and future potential exposure pathway.
Air Emissions							
Completed Exposure Pathway							
Ambient air near the Cotter Mill facility	Ground-level fugitive emissions (e.g., wind-blown dust) and elevated point sources (e.g., stacks)	Windblown dust; stack emissions into the air and transport to off-site locations	Off-site or down-wind locations	People who live in the vicinity of Cotter Mill or downwind of the stacks	Inhalation	Past Future Present	Cotter's air monitoring network monitors air concentrations at off-site locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive; air quality impacts should be characterized by perimeter monitoring stations.

IV. EVALUATION OF ENVIRONMENTAL CONTAMINATION

A. Groundwater

Prior to 1980, Cotter disposed of waste in unlined ponds, which allowed contaminated liquids to leach into the groundwater [EPA 2002]. Groundwater was shown to be contaminated as far away as the Arkansas River, which is approximately 2.5 miles downgradient from the mill [EPA 2002]. Results from the 1984–1985 Remedial Investigation found that despite attempts at remediation, the new, lined impoundments were leaking and the old ponds area was a continuing source of groundwater contamination [GeoTrans 1986]. This study also found that a gap in the ridge at the SCS Dam, built in 1971 across Sand Creek on the Cotter property, was allowing shallow groundwater to move downgradient towards Lincoln Park, resulting in concentrations of molybdenum and uranium that were 2,000 times above background levels at that time.

Groundwater concentrations of molybdenum and uranium have decreased in recent years, but concentrations have not yet returned to background levels in some wells [Weston 1998]. Figures 4 and 5 show the extent of the molybdenum and uranium concentrations, respectively, above water quality standards (0.035 milligrams per liter [mg/L] for molybdenum and 0.03 mg/L for uranium). The highest levels in Lincoln Park were detected nearest to the Cotter property in the vicinity of the DeWeese Dye Ditch [Weston 1998]. Additionally, despite remediation efforts, the physical and chemical groundwater data suggest minor leakage from the primary impoundment at the Cotter site [CDPHE 2007a; EPA 2002; USGS 1999b].

1. Remedial actions for controlling groundwater contamination

Since the early- to mid-1980s, remedial actions aimed at controlling groundwater contamination and the spread of the resulting plume have taken place. Remediation has targeted the area along the primary surface groundwater migration pathway, which runs parallel to Sand Creek [USGS 1999a]. Remediation has included the following:

- In the early 1980s, contaminated materials were moved into lined impoundments [EPA 2002].
- In 1988, a hydrologic clay barrier was installed on the Cotter property to help contain the contaminated groundwater plume associated with the Cotter Mill.
- In 1989, a network of injection and withdrawal wells were constructed downgradient of the lined impoundment to reverse the hydraulic gradient and prevent the northward migration of contaminated groundwater. This system was discontinued in 2000, because the system had little or no discernable effect on groundwater conditions [CDPHE 2005].
- Dam to ditch flushing began in 1990. However, this effort was discontinued in 1996 due to citizens’ concerns about contaminant concentrations rising in groundwater wells as the plume was being flushed [CDPHE 2005].
- In 2000, a permeable reactive treatment wall was constructed across Sand Creek channel in the DeWeese Dye Ditch flush, downstream of the SCS Dam [EPA 2002]. Although the

permeable reactive treatment wall has not performed as anticipated, it is acting as a barrier to additional groundwater flowing into Lincoln Park [Phil Egidi, CDPHE, personal communication, July 2008].

These efforts have reduced groundwater contamination downgradient of the Cotter Mill [CDPHE 2008; EPA 2002; USGS 1999a], although the rate at which groundwater quality is being restored is slower than anticipated [EPA 2007]. Cotter and CDPHE continue to explore options for cleaning the groundwater. Until a solution is reached, contaminated groundwater is captured at the SCS Dam and pumped back to the on-site lined impoundments [CDPHE 2008].

2. Nature and extent of groundwater contamination in Lincoln Park

CDPHE maintains a database containing environmental sampling data from various sources dating back to 1961. The most recent data entered into the database are from September 2007. To evaluate exposures to residents of Lincoln Park, ATSDR identified data within the CDPHE database for the wells reported to be in use during the 1989 water use survey (see Table 14 in Appendix A). After discussions with a CDPHE representative, the following assumptions were made while summarizing the data within the database.

- For chemicals, samples that were designated “Y” in the detect flag column and contained a zero in the result value column, but no value in the reporting detection limit column were excluded from the summary statistics. For radionuclides, however, these samples were included in the summary statistics since zero is considered a valid result.
- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.
- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.
- Negative values[2] for radionuclides were included in the summary statistics.

a) Wells used for personal consumption

When this document was written, data from EPA’s 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified seven wells used for personal consumption (IMS 1989). Data for six of the wells are available in the CDPHE database (see Table 14). The seventh well had a broken pump at the time of the survey [IMS 1989]; no data for this well appear to be in the database. The data for wells reportedly used for personal consumption in 1989 are summarized in Table 15. Samples were collected intermittently from 1984 to 2007. The locations of these wells are shown in Figure 6. With the exception of molybdenum and uranium, the data are limited (e.g., only two wells were sampled for the majority of the chemicals and none were sampled for radionuclides).

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[2] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

However, all six wells were repeatedly tested for molybdenum and uranium, which were the only chemicals detected above comparison values (see Table 15). Of the personal consumption wells, Well 189 contains the highest molybdenum and uranium concentrations. Well 189 is the only well with levels of uranium consistently detected above the comparison value (see Figure 6).

It is difficult to evaluate the molybdenum and uranium data over time, because of the limited sampling data for these wells and the inconsistency of sampling the same wells over time. The molybdenum and uranium concentrations in the personal consumption wells over time are graphically shown in Figure 7 and Figure 8 in Appendix B, respectively. Well 168 (house well on Grand Avenue)[3] and Well 189 (house well on Hickory)[4] were sampled the most frequently. No clear pattern of decreasing concentrations from 1984 to 2007 exists.

The USGS identified Well 10 (So. 12th St.) and Well 114 (Pine) as representative of background for the Lincoln Park area [Weston 1998]. The data available in the CDPHE database for these two wells are summarized in Table 16.[5] The average concentration of molybdenum in the wells used for personal consumption (0.082 mg/L; see Table 15) is higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average uranium concentration in the wells used for personal consumption (0.028 mg/L; see Table 15) is only slightly higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Grand Avenue Well

In a 2002 newspaper article, a resident on Grand Avenue reported drinking water from their well [Plasket 2002]. Limited data (1 to 20 samples) are available in the CDPHE database for this location (see Figure 6). Samples were collected and analyzed for most chemicals in 1984, and then from either 2004 or 2005 to 2007. Samples from this well were also tested for molybdenum and uranium from 1988 to1991. The water from this well was tested for several chemicals, but not for radionuclides. None of the samples detected chemicals above comparison values (see Table 17).

b) Wells used to irrigate fruit and vegetable gardens

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to irrigate fruit and 21 wells used to irrigate vegetable gardens [IMS 1989].[6] Data for 28 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from

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[3] There are five non-detected molybdenum values for Well 168. Four of them are most likely due to the detection limit being too high for the level of molybdenum in that well. The detection limits were 0.01 mg/L for three of the samples and 0.05 mg/L for one of the samples. The concentrations in that well hover around 0.01 mg/L.

[4] One of the non-detected molybdenum concentrations in Well 189 is unexplainable. The detection limit (0.01 mg/L) is low enough to have detected the level of molybdenum typically found in the well. The detection limit (0.5 mg/L) for the other non-detected concentration is too high for the level of molybdenum typically found in the well.

[5] Groundwater samples from the background wells were not tested for radionuclides.

[6] Some wells were used for both purposes.

1995 to 2000. The data for wells reportedly used to irrigate fruit and vegetable gardens in 1989 are summarized in Table 18 (chemicals) and Table 19 (radionuclides). The locations of these wells are shown in Figure 9. The data for these wells are much more robust than the data available for the wells used for personal consumption, in part due to the increased number of wells. Molybdenum and uranium were sampled in all 28 wells used for irrigation. Five wells were tested for radionuclides.

The maximum concentrations in the wells used to irrigate fruit and vegetable gardens exceeded the comparison values for molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values only for molybdenum, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to irrigate fruit and vegetable gardens (0.99 mg/L; see Table 18) is higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). Similarly, the average uranium concentration in the wells used to irrigate fruit and vegetable gardens (0.13 mg/L; see Table 13) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16). The average concentration for total dissolved solids in the wells used to irrigate fruit and vegetable gardens (550 mg/L; see Table 18) is also higher than the average concentration found in the background wells (429 mg/L; see Table 16).

c) Wells used to water livestock

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to water livestock [IMS 1989]. Data for 19 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 and 1996. The data for wells reportedly used to water livestock in 1989 are summarized in Table 20 (chemicals) and Table 21 (radionuclides). The locations of these wells are shown in Figure 10. Only one to four wells were sampled for the majority of the chemicals, however, molybdenum and uranium were sampled in all 19 wells used to water livestock. Two wells were tested for radionuclides.

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available

The maximum concentrations exceeded the comparison values for molybdenum, sulfate, total dissolved solids, and uranium. The average concentrations only exceeded comparison values for molybdenum and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.08 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to water livestock (0.212 mg/L; see Table 20) is an order of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average uranium concentration in the wells used to water livestock (0.034 mg/L; see Table 20) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

d) *Wells used to water lawns*

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 42 wells used to water lawns [IMS 1989]. Data for all 42 wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for wells reportedly used to water lawns in 1989 are summarized in Table 22 (chemicals) and Table 23 (radionuclides). The locations of these wells are shown in Figure 11. Several wells were sampled for each chemical, and molybdenum and uranium were tested in all 42 wells used to water lawns. Seven wells were sampled for radionuclides.

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value from 2000 to 2007, while the average uranium concentration (0.03 mg/L) was at the comparison value.

The average concentration of molybdenum in wells used to water lawns (2.2 mg/L; see Table 22) is two orders of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average sulfate concentration in wells used to water lawns (351 mg/L; see Table 22) is almost six times higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in wells used to water lawns (746 mg/L; see Table 22) is higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in wells used to water lawns (0.233 mg/L; see Table 22) is an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Well 138

Well 138 (field well on Cedar Street; see Figure 11) was identified during the *1998 Supplemental Human Health Risk Assessment* as the maximally impacted off-site well [Weston 1998]. In 1989, Well 138 was used only to water the lawn [IMS 1989]. Adequate data for this well are available in the CDPHE database. Samples were collected from Well 138 and analyzed for various chemicals between 1968 and 2000. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for Well 138 are summarized in Table 24 (chemicals) and Table 25 (radionuclides).

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations also exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. A clear decrease in concentrations occurred over time for molybdenum (see Figure 12), selenium (see Figure 13), and uranium (see Figure 14).

Well 138 has higher levels of contamination than the wells that USGS identified as background for Lincoln Park. The average concentration of molybdenum in Well 138 (8.0 mg/L; see Table 244) is hundreds of times higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average sulfate concentration in Well 138 (1,059 mg/L; see Table 24) is considerably higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in Well 138 (1,530 mg/L; see Table 24) is three times higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in Well 138 (0.73 mg/L; see Table 24) is more than an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

e) Groundwater trends over time

To evaluate the levels of molybdenum, selenium, and uranium in groundwater over time, ATSDR combined and graphed all the groundwater data for the wells used for personal consumption, irrigating fruit and vegetables, watering livestock, and watering lawns (Figures 15 through 17 in Appendix B). Figure 15 shows a pattern of decreasing concentrations of molybdenum in groundwater over time. The concentrations of selenium seem to hold steady, but do decrease slightly over time (see Figure 16). The concentrations of uranium also clearly decrease over time (see Figure 17).

B. Soil and sediment

1. Background levels

Cotter was required by the 1988 RAP to establish background levels of certain elements in soils and sediments. Twenty soil samples were collected from five sub-basins considered free from mill-related contamination to represent natural background typical of the area near the mill [HRAP 1991]. Table 4 below presents the results of that study, which were further supported by additional sampling [CDPHE 2005].

Table 4. Background soil and sediment levels

	Soil		Sediment	
	Average	Upper Confidence Limit	Average	Upper Confidence Limit
Molybdenum	2.4 ppm	4.6 ppm	2.3 ppm	4.7 ppm
Uranium	2.1 ppm	2.9 ppm	2.0 ppm	3.4 ppm
Radium-226	1.3 pCi/g	1.9 pCi/g	1.1 pCi/g	1.7 pCi/g
Thorium-230	1.8 pCi/g	3.2 pCi/g	1.5 pCi/g	3.1 pCi/g
Gamma Exposure Rates	9.4 µR/hr	--	--	--

Source: CDPHE 2005; HRAP 1991
pCi/g – picocuries per gram
ppm – parts per million
µR/hr – microroentgen per hour

2. *Off-site soil contamination and remediation*

As part of the 1988 RAP, Cotter was required to survey soils outside the restricted area (the fenced active mill site) and to remediate contaminated soils with levels of radium and molybdenum that are above the established background [CDPHE 2005].

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], Weston (a contractor for Cotter) collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure 18 in Appendix B). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). The maximum concentrations exceeded the comparison values for arsenic[7] in all eight zones, for cadmium in all zones except one (D), for lead in three zones (F, G, and H), and for radium-226 in four zones (A, B, C, and E). The average concentrations also exceeded comparison values for arsenic[7] in all eight zones, for cadmium in one zone (F), for lead in one zone (H), and for radium-226 in two zones (A and B). The average radium-226 and thorium-230 concentrations were higher than the established average background levels in all eight zones (see 4 for background).

Cotter has occasionally hauled ore and other materials by truck to the site for processing at their facility. To assess the potential that material has been lost alongside the county road leading to the mill and the access road entering the mill site, MFG (a contractor to Cotter) scanned the county road (assuming CR 143) from the road leading to the Shadow Hills Golf Course to the Cotter Mill access road for gamma radiation (see Figure 19). They also collected soil samples to establish a correlation between the gamma exposure rate and the concentration of gamma emitters in the soil. A total of 16 locations were sampled—five along the county road, five along the mill's access road, and six from background locations. The locations were not chosen to estimate an average concentration, but rather to provide data for a range of gamma exposure rates. Each sample was a composite of 10 aliquots within a 100 x 100 meter area [MFG 2005]. The results of this sampling are shown in Table 28. The maximum and average radium-226 and natural uranium concentrations exceeded the comparison values for samples taken along the mill's access road. The maximum and average radium-226 concentrations also exceeded the comparison value for samples taken along the county road. Average concentrations of all radionuclides sampled were higher along the county road and the mill's access road than from those areas designated as background (see Table 28).

There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.

To address public concerns about the impact of the Cotter Mill on the health of Cañon City residents, CDPHE collected 21 soil samples in January 2003 [CDPHE 2003]. Each sample was a composite of 30–40 scrape samples[8] from each location. Seven samples from Lincoln Park were

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[7] The *1998 Supplemental Human Health Risk Assessment* found no discernible spatial pattern for arsenic around the Cotter Mill, indicating that arsenic levels have not been measurably altered by airborne releases from the mill (Weston 1998).

[8] Surface soil samples were collected using a method developed specifically to look for airborne contamination that settled to the ground (CDPHE 2003).

collected, including one sample of suspected flood sediment (Pine Street near Elm Avenue), two samples of dust (one from a barn loft and one from a residential attic), and four samples of surface soil (one from the McKinley Elementary School playground). Seven samples were collected from areas east of the mill, including the Brookside Head Start School. Six samples were collected from areas west of the mill, including a private residence. One sample was collected from the extreme northern part of Cañon City to represent the regional background (corner of Orchard Avenue and High Street). The sampling event was intentionally biased toward finding the highest amounts of contamination possible [CDPHE 2003]. Sample locations are shown in Figure 20. The data from this sampling event are summarized in Table 29 (chemicals) and Table 30 (radionuclides). The maximum concentrations for lead and radium-226 exceeded the comparison values. The average concentration for lead also exceeded the comparison value. The average concentration for radium-226 did not exceed the comparison value.

Since 1994, Cotter has been annually collecting surface soil samples (0–6 inches) at 10 environmental air monitoring stations that are located along the facility’s boundary and in residential areas (see Figure 21). From 1979 to 1993, soils were collected every 9 months. The data from this effort are summarized in Table 31. The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration of samples over the timeframe did not.

a) The nearest resident

The nearest resident is located 0.25 mile from the restricted area [Galant et al. 2007]. One of the air monitoring stations annually monitored by Cotter was established as “the nearest resident” (AS-212). This location is between the Cotter Mill and an actual residence [Cotter 2007]. The limited data for this location are shown in Table 32 (chemicals) and Table 33 (radionuclides). The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration did not.

b) Lincoln Park

EPA determined that sediment and soil in Lincoln Park are no longer an issue since the completion of the Sand Creek Cleanup project in 1998 [EPA 2002, 2007].

As part of the 1988 RAP, Cotter was required to conduct a gamma scintillometer survey in Lincoln Park to evaluate whether soils had been contaminated by windblown and waterborne contaminants from the facility. In December 1988, 127 scintillometer readings were taken near intersections in Lincoln Park. The average external gamma radiation for Lincoln Park was 9.8 microroentgen per hour (µR/hr), which is considered to show “no elevated gamma in Lincoln Park” [CDPHE 2005; HRAP 1991].

As part of the *1996 Supplemental Human Health Risk Assessment* [Weston 1996], Weston compiled data from several past soil studies, including the following:

- Samples collected at the air monitoring location in Lincoln Park in 1987 and 1988

- Samples collected from yards of 10 participants in the Lincoln Park water use survey in 1989
- Samples collected from residential gardens in Lincoln Park in 1990
- Samples collected from lawns and gardens in Lincoln Park in 1996

The data from these studies are collectively summarized in Table 34 (chemicals) and Table 35 (radionuclides). Only the maximum and average concentrations for arsenic exceeded the comparison value.

The soil samples collected from yards of the participants in the 1989 *Lincoln Park water use survey* were also analyzed for molybdenum and uranium. The average molybdenum concentration was 2.0 ppm and the average uranium concentration was 2.8 ppm [HRAP 1991]. The samples collected as part of the 1990 residential garden soil survey were also analyzed for molybdenum. The average concentration was 0.13 ppm [HRAP 1991]. These concentrations are well below the comparison values for molybdenum (300 ppm) and uranium (100 ppm).[9]

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], 73 surface soil samples were collected from lawns (0–2 inches) and gardens (0–6 inches) in Lincoln Park. For sampling purposes, Lincoln Park was divided into seven areas and 6–16 samples were taken from each area [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). Only the maximum and average arsenic concentrations exceeded the comparison value.

The effect of irrigation with contaminated well water on the levels in the soil was also examined during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. The soil samples from Lincoln Park were divided into two categories—those irrigated with well water that had been impacted by mill releases and those not believed to have been irrigated with contaminated well water. These data are shown in Table 36 (chemicals) and Table 37 (radionuclides). The concentrations of arsenic, molybdenum, and uranium were statistically higher in soil samples irrigated with impacted well water [Weston 1998].

(1) Lead in Lincoln Park

Residents of Lincoln Park expressed concerns about lead contamination in soil and dust due to historical and current mining and milling operations in the area. Six potential sources of lead are located near the community of Lincoln Park—the Cotter Mill, the Empire Zinc Smelter (also known as New Jersey Zinc and the College of the Cañons), the US Smelter Facility, the Cañon City Copper Smelter, the Ohio Zinc Company, and the Royal Gorge Smelter [EPA 2004]. The Lincoln Park neighborhood is located generally east-southeast of these facilities and the general wind direction is west to east.

To address the residents' concerns, EPA requested that ATSDR assess the health risk associated with lead contamination in Lincoln Park. After a site visit and discussions with the community,

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[9] The data for molybdenum and uranium are not summarized in Table because the raw data for these two chemicals are not presented in the *1996 Supplemental Human Health Risk Assessment* (Weston 1996).

ATSDR focused assessments on two primary issues—1) blood lead levels in children living in Lincoln Park and 2) lead contaminated dust in homes in Lincoln Park.

ATSDR reviewed the available data on blood lead levels in children and concluded that the rate of elevated blood lead levels for Fremont County is below the state average. However, it was not possible to evaluate whether area children, including "high risk" children, were being adequately screened for blood lead levels [ATSDR 2006a]. To further assess blood lead levels, ATSDR tested the blood level of 115 "at risk" school children in 2005. None of the children had elevated blood lead levels [ATSDR 2006b].

ATSDR reviewed the available data on lead levels in household dust and found the data to be sparse and/or lacking. ATSDR conducted a screening level evaluation of the available dust samples and concluded that the data were not sufficient to determine the magnitude or extent of the potential hazard associated with levels of lead in household dust [ATSDR 2006c]. To further assess the health impacts in Lincoln Park, ATSDR, in collaboration with the Colorado Citizens Against Toxic Waste (CCAT) and EPA, collected and analyzed 44 indoor dust samples, 80 surface soil samples (0–2 inches or 0–6 inches) from 22 properties, and 45 blood samples. The results of this exposure investigation did not indicate the presence of unusual levels of lead in residential indoor dust samples, the soil at those homes, or in the blood of occupants of those homes [ATSDR 2006d].

EPA's report documenting the residential soils sampling project can be accessed at the following site: http://www.epa.gov/region8/superfund/co/lincolnpark/.

c) Sand Creek

Sand Creek is primarily an ephemeral creek that passes through the Cotter Mill and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. Prior to the construction of the SCS Dam north of the Cotter Mill in 1971, surface water and sediment from the facility flowed down the Sand Creek drainage into Lincoln Park [CDPHE 2005; GeoTrans 1986]. Mill tailings in the Old Tailings Pond Area are the source of the mill-derived contaminants (primarily radium-226 and thorium-230) in Sand Creek [Cotter 2000].

During the *1986 Remedial Investigation* [GeoTrans 1986], sediment samples were collected from the following locations in Sand Creek to evaluate present (i.e., 1985) and historical loadings from the Cotter Mill.

- SD01 – mouth near the Arkansas River
- SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
- SD04 – below the SCS Dam in
  1. (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
  2. (2) in drainage (reflects historical picture of uncontrolled emissions)
  3. (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)

- SD05 – above the SCS Dam adjacent to the west property edge

The results of this sampling are presented in Table 38 and Table 39. Only the concentrations for arsenic and radium-226 exceeded ATSDR’s comparison values.

As part of the 1988 RAP, Cotter was required to evaluate the mill’s potential impacts to Sand Creek and remove sediments that exceeded the radium-226 cleanup goal of 4.0 picocuries per gram (pCi/g), which allows unrestricted use of the creek [Cotter 2000]. A total of 721 samples were systematically collected along the 1.25 mile stretch from just north of the Cotter Mill to where Sand Creek becomes perennial (see Figure 22). Surveying and cleanup began in the spring of 1993 and continued until remediation was completed in December 1998. Approximately 9,000 cubic yards of soil were removed from Sand Creek and disposed of on Cotter property [Cotter 2000]. The excavated areas were backfilled with clean soil [CDPHE 2005]. Thirty confirmatory samples established that the average site-wide radium-226 concentration was 1.5 pCi/g (below the cleanup goal of 4.0 pCi/g) and the average site-wide thorium-230 concentration was 3.9 pCi/g after remediation [Cotter 2000]. In addition to the sampling and remediation for radium-226, seven of the confirmation samples were analyzed for 10 chemicals in 1998 [Cotter 2000]. These results are presented in Table 40. Only the maximum and average concentrations for arsenic exceeded ATSDR’s comparison value.

At the time of mill closure, Cotter was required by the 1988 RAP to survey molybdenum and radium-226 in sediments in the perennial stream segments of Sand Creek and Willow (Plum) Creek to determine whether these areas have been impacted by the mill. If necessary, sediments above background will be removed and properly disposed of (CDPHE 2005).

d) The Fremont Ditch

The Fremont Ditch system is downstream of Sand Creek. It diverts water from near the confluence of Sand Creek and the Arkansas River downgradient toward Florence. The ditch receives substantial amounts of water from Sand Creek during low flows in the Arkansas River. During these periods, any contaminants moving down Sand Creek would likely be transported to Fremont Ditch [GeoTrans 1986].

As part of the 1988 RAP, Cotter was also required to conduct a gamma survey of the dry beds of the Fremont Ditch. Cotter sampled sediment in Fremont Ditch from its head gate near Sand Creek to about a quarter mile downstream. The average radium-226 level was 1.86 pCi/g, which was below the cleanup standard of 4 pCi/g. The state agreed with Cotter that the Fremont Ditch did not require remediation because the concentrations of gross alpha (3.8 pCi/g), uranium (6.6 ppm), and molybdenum (2.2 ppm) were also low [CDPHE 2005].

C. Surface water

1. Nature and extent of contamination

The Cotter Mill is a non-discharge facility, meaning that Cotter does not release wastewater to the surface water system. All remediation water is pumped to on-site impoundments for evaporation or recycling. However, prior to construction of the SCS Dam in 1971, storm events carried contaminated surface water and sediments from the facility down the Sand Creek drainage [CDPHE 2005]. One event in particular, a flood in June 1965, caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. Sediment in the Lincoln Park portion of Sand Creek was contaminated with tailings that were carried in surface water runoff from the mill [EPA 2007].

CDPHE maintains a database containing surface water monitoring data dating back to 1962. The most recent data entered into the database are from September 2007. To evaluate exposures to people living near the Cotter Mill, ATSDR extracted surface water data collected from Sand Creek, the DeWeese Dye Ditch, and the Arkansas River. After discussions with a CDPHE representative, the following assumptions were made while summarizing data within the database.

The SCS Dam was built to prevent surface water and sediment from flowing into Lincoln Park during storm-generated floods. Since the construction of the dam, Lincoln Park no longer receives runoff from the Cotter Mill. Additionally, since 1979, impounded water collected at the dam has been pumped back to the lined impoundment on site [EPA 2002; GeoTrans 1986; HRAP 1991].

- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.
- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.
- Negative values[10] for radionuclides were included in the summary statistics.

a) Sand Creek

From 1993 to 1998, Cotter conducted the Sand Creek Cleanup project to identify and remove mill tailings that had moved into the creek bed as the result of surface water runoff from the Cotter Mill prior to the construction of the SCS Dam. Sediments above the radium-226 cleanup goal of 4.0 pCi/g were removed, which allows unrestricted use of the creek [Cotter 2000; EPA 2002].

Two locations in Sand Creek—one at Ash Street (008) and one at the confluence with the Arkansas River (506)—are sampled as part of the surface water monitoring program (Cotter 2007). The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 41 (chemicals) and Table 42 (radionuclides). The maximum concentrations for manganese, molybdenum, sulfate, and total dissolved solids exceeded the comparison values. However, for all four of these chemicals, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. None of the average concentrations exceeded comparison values.

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[10] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

As part of the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991], the Health Risk Assessment Panel (HRAP) reviewed over 18,000 samples collected from 1976–1989, from 55 different surface water locations. More than 95% of the surface water data were collected from 10 main locations. The location in Sand Creek at Ash Street (008, formerly known as 555) was one of these locations. The average molybdenum (0.009 mg/L) and uranium (0.016 mg/L) concentrations from this location were well below the comparison values (molybdenum: 0.035 mg/L; uranium: 0.03 mg/L).[11]

b) DeWeese Dye Ditch

The DeWeese Dye Ditch is an irrigation ditch that flows between the Cotter Mill and Lincoln Park. The ditch diverts water from Grape Creek to irrigate about 1,200 acres during the summer growing period [GeoTrans 1986]. The ditch crosses Sand Creek downstream from the SCS Dam, but does not join it. Seepage from the ditch recharges groundwater within the Sand Creek drainage. This process dilutes and flushes the contaminated groundwater under Lincoln Park [EPA 2002].

The CDPHE database contains surface water monitoring data from two locations in the DeWeese Dye Ditch—one upstream of the confluence with Forked Gulch (520) and one at Cedar Avenue (526). The location at Cedar Avenue is sampled as part of the surface water monitoring program [Cotter 2007]. The data for both locations are summarized in Table 43 (chemicals) and Table 44 (radionuclides). The maximum concentrations exceeded the comparison values for iron, manganese, total dissolved solids, and dissolved uranium. However, for iron and manganese, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. Only three of the total dissolved solids samples and three of the dissolved uranium samples were detected above comparison values. None of the average concentrations exceeded comparison values.

Molybdenum and uranium data from 1984 to 1989, from the same two locations in the DeWeese Dye Ditch (520 and 526), are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* (HRAP 1991). The average molybdenum and uranium concentrations were well below the comparison values (see Table 5 below).

Table 5. Average molybdenum and uranium concentrations in the DeWeese Dye Ditch

Chemical	Average concentration at Location 520 (mg/L)	Average concentration at Location 526 (mg/L)	Comparison Value (mg/L)
Molybdenum	0.003	0.003	0.035
Uranium	0.002	0.0019	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

It was not possible to determine whether these data are included in the CDPHE database.

c) Arkansas River

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[11] It was not possible to determine whether these data are included in the CDPHE database.

The Arkansas River sampling plan was approved by the CDPHE Water Quality Control Division [CDPHE 2005].

From April 1989 to June 1990, Cotter and their consultant, Western Environmental Analysts, conducted bi-weekly sampling in the Arkansas River at the following five locations:

1. Parkdale (background)
2. Grape Creek
3. 1st Street (upstream of where Sand Creek enters the Arkansas River)
4. Mackenzie Avenue Bridge (downstream from where Sand Creek enters the Arkansas River)
5. Where Highway 67 to Florence crosses the river

Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) were collected and tested for molybdenum, uranium, radium-226, and thorium-230. Extremely low concentrations were detected, which indicated no statistical evidence of an increase in contamination downstream on the Arkansas River [CDPHE 2005].

In addition, four synoptic sampling events (i.e., sampling of water in-flows) were conducted between Canyon Mouth and Highway 67. The purpose of the synoptic sampling was to determine whether tributary flows reflect unusual sources of uranium or molybdenum. The sampling showed that other sources such as Fourmile Creek, as well as Sand Creek and Plum Creek, contribute to increases in the Arkansas River [CDPHE 2005].

Two locations in the Arkansas River—one upstream of Sand Creek at 1st Street (907) and one downstream of Sand Creek at Mackenzie Avenue (904)—are sampled as part of the surface water monitoring program [Cotter 2007]. The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 45 (chemicals) and Table 46 (radionuclides). At both locations, the maximum concentrations exceeded the comparison value for sulfate. The maximum concentration for total dissolved solids exceeded the comparison value for the upstream location, but not the downstream location. In all three instances, these maximum concentrations appear to be outliers and are the only concentrations that exceeded comparison values—the second highest detected concentrations were below comparison values. The maximum concentration for molybdenum also exceeded the Colorado state groundwater standard for the upstream location, but not the downstream location. None of the average concentrations exceeded comparison values.

Data from 1984 to 1989, from two locations in the Arkansas River—one upstream of Sand Creek near Grape Creek (502) and one downstream of Sand Creek near Fourmile Bridge (504)—are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991]. The average molybdenum and uranium concentrations were well below the comparison values (see Table 6 below).

Table 6. Average molybdenum and uranium concentrations in the Arkansas River

Chemical	Average concentration upstream of Sand Creek near Grape Creek (502) (mg/L)	Average concentration downstream of Sand Creek near Fourmile Bridge (504) (mg/L)	Comparison Value (mg/L)
Molybdenum	0.00391	0.0056	0.035
Uranium	0.00532	0.00574	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

d) Willow Lakes

The Willow Lakes are comprised of several small ponds near the Arkansas River in the Willow Creek watershed, which lies directly to the east of the Sand Creek watershed. The Willow Lakes receive water from shallow groundwater and surface runoff [HRAP 1991].

Cotter was required by the 1988 RAP to evaluate whether the Willow Lakes had been contaminated by the mill. Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) from the Willow Lakes and three comparison lakes were collected and tested for molybdenum, uranium, and radium. The information showed that the Willow Lakes had not been contaminated by the Cotter Mill [CDPHE 2005].

D. Locally grown produce

1. Nature and extent of contamination

As part of the *1996 Supplemental Human Health Risk Assessment* (Weston 1996), Weston compiled available food data from several past studies. Samples included chicken meat, fruit (apples, cherries, grapes), and vegetables (asparagus, carrots, lettuce, tomatoes, turnips). The local samples were compared to food collected from supermarkets. The data are presented in Table 47 and Table 48 in Appendix A. The limited sample data suggest that the chemicals and radionuclides found in the foods are probably natural in origin, however, it was not possible to exclude the possibility that some food types may be influenced by mill-related contaminants [Weston 1996].

To further evaluate exposures to residents who eat locally grown fruits and vegetables, a sampling program was initiated in Lincoln Park during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. People were asked to donate locally grown produce samples for analysis. The fruits and vegetables sampled are presented in the table below. The samples were tested for heavy metals and radionuclides. The analytical results of the sampling program are summarized in Table 49 and Table 50 in Appendix A.

Fruits Sampled

- Apples
- Cantaloupe
- Grapes
- Honey dew melon
- Plums
- Watermelon

Vegetables Sampled

- Acorn squash
- Beets
- Carrots
- Celery
- Corn
- Cucumbers
- Green Beans
- Green Onions
- Kohlrabi
- Patty pan squash
- Peppers
- Pumpkin
- Rhubarb
- Squash
- Tomatoes
- Turnip Greens
- Turnips
- Winter squash

The samples were divided into two categories—(1) produce that was grown in soil known to have been irrigated with contaminated well water (fruits n = 16; vegetables n = 43) and (2) produce that was grown in soil not believed to have been irrigated with contaminated well water (fruits n = 1; vegetables n = 6). A statistical comparison of the data for the two categories of vegetables indicated that irrigation with contaminated well water did not cause a significant increase in contaminant levels (Weston 1998). The following trends were also noted:

- The concentrations of most metals were higher in root vegetables than other types of vegetables and fruit.
- Concentrations were much lower in peeled turnips than in whole turnips, suggesting that most of the contamination was on or in the surface layer.
- There was high variability both within and between the different types of produce.
- Concentration values were below the limit of detection for many of the samples.

E. Ambient Air

ATSDR reviewed ambient air monitoring data and air sampling data collected from the following two sources:

- Cotter Mill has operated an ambient air monitoring program to characterize air quality impacts of radioactive particulates and radon for more than 20 years. ATSDR accessed summaries of the monitoring data from Cotter Mill's annual Environmental and Occupational Performance Reports, which are posted to the CDPHE's web site; and
- The state of Colorado operated three particulate monitoring stations in Fremont County, one each in Lincoln Park, Cañon City, and Florence. The station in Cañon City continues to operate today. ATSDR downloaded measured concentrations of particulate matter, and some chemical constituents of particulate matter, from EPA's Air Quality System (AQS) database—a publicly accessible online clearinghouse of ambient air monitoring data. Some of the measurements collected by these monitors date back 40 years.

Historically, Cotter Mill had two general types of air emission sources: ground-level fugitive emissions (e.g., wind-blown dust) that would be expected to have greatest air quality impacts nearest the source; and elevated point sources (e.g., stacks) that have the potential for having peak ground-level impacts at downwind locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive and their air quality impacts should be adequately characterized by the perimeter monitoring stations.

1. Nature and extent of air contamination

ATSDR compiled and evaluated ambient air monitoring data to assess potential air quality impacts from Cotter Mill's past and ongoing operations. As will be discussed later, ambient air concentrations of some substances changed considerably from one year to the next—in some cases, annual average concentrations vary by more than a factor of 250 over the period of record. These substantial changes in measured air contamination levels can sometimes be traced back to site-specific activities.

To provide background information and context for the air quality trends documented later in this report, the following list identifies key milestones over the history of Cotter Mill's operations. The timeline is not intended to be a comprehensive listing of site-specific events, but rather focuses on events and activities expected to be *associated with notable changes in the facility's air emissions*.

- 1958: Cotter Corporation begins its uranium milling operations at the Cotter Mill site
- 1979: Continuous operations cease, but intermittent operations continue
- 1981-1983: Cotter excavates 2,500,000 cubic yards of contaminated tailings from unlined holding ponds and places the material in a newly constructed, lined surface impoundment
- 1987: Cotter suspends its primary milling operations and only limited and intermittent ore processing occurs for the next 12 years
- 1993-1999: Cotter excavates 9,000 cubic yards of contaminated tailings, soil, and sediment from 1.25 miles of Sand Creek near the facility
- 1999: Cotter excavates 100,000 cubic yards of contaminated soil in "near surface soils" from the on-site Old Pond Area and places this material into the lined, surface impoundment
- 1999: Milling operations using a different production process begin
- 2005: Cotter ceases its routine operations and enters "stand down" status; site remediation activities continue; stack emissions from most sources continue into 2006, after which the main operational stack is for the laboratory baghouse
- 2009: Cotter submits letter to CDPHE announcing its intent to refurbish the mill, rather than decommission it

The following sections summarize the data and air quality trends for particulate matter, selected particle-bound radionuclides, radon gas and gamma radiation.

a) Ambient Air Monitoring for Radioactive Substances

The Cotter Mill monitoring network is operated by Cotter Mill in accordance with guidelines and requirements set forth by the U.S. Nuclear Regulatory Commission (USNRC 1980) and the Radioactive Materials License established between Cotter Mill and the state of Colorado [CDPHE 2009]. The purpose of the network is to characterize the extent to which Cotter Mill's operations affect off-site air quality.

Cotter Mill's ambient air monitoring network has been operating from 1979 to the present, but the number of monitoring stations included in the network has changed over time. In 1979, four stations were fully operational; this increased to seven by 1981 and to ten by 1999. These ten monitoring stations continue to operate today. Each station is equipped with the same monitoring equipment: an environmental air sampler used to collect particulates for analysis of particle-bound radionuclides; a radon track etch measurement device; and an environmental thermoluminescent dosimeter (TLD) for measuring gamma exposure. The height of the sampling inlet probes was not specified in the reports that ATSDR reviewed to prepare this health assessment. Table 51 in Appendix A identifies the monitoring stations and their periods of operation. Figure 23 in Appendix B shows the approximate locations of the monitoring stations. For purposes of this evaluation, ATSDR has classified the ten monitoring stations as being either "perimeter" or "off-site." The five "perimeter" monitoring stations are located along or just within Cotter Mill's property line; and the five "off-site" monitoring stations are located off-site, anywhere from 0.5 mile to 4 miles from the Cotter Mill property line.

(1) Particulate Matter

At each of the 10 monitoring stations described above, Cotter Mill operates a high-volume total suspended particulate (TSP) sampling device. For each sampling period, the devices are loaded with glass fiber filters that collect airborne particulates as ambient air passes through the sampling apparatus. The TSP sampling devices collect 1-week integrated samples; when the sampling period ends, field personnel remove filters, record observations on chain-of-custody forms, and store filters for subsequent laboratory analysis.

Cotter prepares annual summary reports for its environmental monitoring network, and those reports document monthly average TSP concentrations measured at each station. ATSDR had access to the summary reports for 2006, 2007, and 2008. TSP data from earlier years can be accessed through data reports that CDPHE has on compact disk. Over the last three years, annual average TSP concentrations were consistently higher in the more populated areas (Lincoln Park and Cañon City) than at the perimeter monitoring stations. In 2008, for instance, the annual average TSP levels at Lincoln Park and Cañon City were 29.9 $\mu g/m^3$ and 26.5 $\mu g/m^3$, respectively; in contrast, annual average concentrations at the five perimeter monitoring stations ranged from 15.5 $\mu g/m^3$ to 21.4 $\mu g/m^3$.

Although quantitative quality control information was not available when summarizing Cotter's TSP data, these measurements can be compared to CDPHE's PM_{10} monitoring results in Cañon City during the same time frame. From 2006 to 2008, the annual average TSP levels measured by Cotter Mill in Cañon City were 26.6 $\mu g/m^3$, 26.3 $\mu g/m^3$, and 26.5 $\mu g/m^3$, respectively; the annual average PM_{10} levels measured by CDPHE in Cañon City during these same years were

16.5 µg/m^3, 16.4 µg/m^3, and 15.0 µg/m^3. The difference between the TSP and PM$_{10}$ annual average concentrations in Cañon City are within the expected range and direction (i.e., TSP levels exceeding PM$_{10}$ levels), which gives some assurance in the quality of the underlying data sets.

(2) Particle-Bound Radionuclides

Weekly particulate filters collected at the 10 stations mentioned in the previous section are not only weighed for mass loading but are also analyzed at Cotter Mill's analytical laboratory for concentrations of five radionuclides, identified below. All laboratory analyses are conducted according to methodologies approved by CDPHE.

Field sampling and laboratory analyses for particle-bound radionuclides are conducted according to specifications outlined in Cotter Mill's Quality Assurance Program Plan (QAPP). This document is revised periodically and submitted to CDPHE for review. The QAPP outlines many quality control and quality assurance procedures implemented to ensure that the network's measurements are of a known and high quality. Examples of specific procedures followed include: routine collection and analysis of blank samples to ensure sampling media and laboratory equipment are not contaminated; quarterly calibration of flow rates for the "high volume" samplers; audit of sampler flow rates using special equipment; collection of duplicate samples that are analyzed in replicate to quantify measurement precision; and participation in a "laboratory exchange program" through which a subset of environmental samples (mostly water samples, by all appearances) are split and sent to Cotter Mill's laboratory and two commercial laboratories for analyses. While these and other quality control procedures give some assurance that samples are collected and analyzed with fine attention to data quality, the reports available to ATSDR during this review generally did not present the actual data quality metrics (e.g., the relative percent difference in duplicate samples or for inter-laboratory audits, contamination levels found in blanks) for the particle-bound radionuclides.

The key findings from the monitoring program for the five radionuclides measured are below. For each substance, a section compares the measured concentrations to regulatory limits or health-based comparison values, comments on temporal and spatial variations, and then presents a brief summary.

- **Natural uranium (^{nat}U).** Table 52 in Appendix A presents the history of annual average ^{nat}U concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.
  - *Screening.* Cotter Mill compares measured concentrations of ^{nat}U to an "effluent concentration" (9.0 x 10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 52 exceed this derived concentration guide. The highest annual average concentration over the period of record (2.5 x 10^{-14} µCi/ml at a perimeter monitoring station in 1982) is 3.6 times below this screening value. The highest annual average in 2008 (4.4 x 10^{-16} µCi/ml at a

  perimeter monitoring station) was approximately 200 times below the screening value, and larger margins are observed for the off-site monitoring stations.

  - *Spatial and temporal variations.* Generally, the highest annual average concentrations of ^{nat}U were observed at perimeter monitoring stations, with lower levels observed at the off-site stations. During most years, the annual average values did not vary considerably (by more than an order of magnitude) across all of the stations. As an exception, the 1982 annual average ^{nat}U concentration observed at the west boundary monitoring station was roughly 50 times greater than the annual averages observed at the other monitoring stations during the same year; this "spike" at one station during one year was most likely caused by air emissions associated with an on-site tailings excavation project. As another exception, in several years between 1998 and 2006, annual average ^{nat}U concentrations at the mill entrance road monitoring station were more than an order of magnitude higher than those recorded at all other stations, which most likely reflects contributions from clean-up of the site entry road and delivery of ores (which mostly ended in 2006). As noted above, the highest annual average concentration of ^{nat}U was observed in 1982, and more recent (2004-2008) annual average levels are considerably lower.

  - *Summary.* Every annual average concentration of ^{nat}U recorded to date has been lower than Cotter Mill's health-based regulatory limit. In the last five years, the annual average concentrations at every station have been at least 20 times below this limit. It seems unlikely that air emissions from the mill would lead to an off-site "hot spot" of ^{nat}U concentrations that could be considerably higher than the levels measured by the monitoring network.

- **Thorium-230 (^{230}Th).** Table 53 in Appendix A presents the history of annual average ^{230}Th concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{230}Th to an "effluent concentration" (2.0×10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. The annual average concentration at the west boundary monitoring station exceeded this value in 1981 and 1982, as did the annual average concentration in 1981 at the east boundary monitoring station. The highest annual average concentration recorded by this network (9.0×10^{-14} µCi/ml at the west boundary in 1982) was 4.5 times higher than the derived concentration guide. Concentrations decreased over the years, and the highest annual average in 2008 (7.2×10^{-16} µCi/ml at a perimeter monitoring station) was a factor of 28 times lower than the screening value, and larger margins are observed for the off-site monitoring stations.

  - *Spatial and temporal variations.* Without exception, the highest annual average concentrations of ^{230}Th were observed at perimeter monitoring stations, with considerably lower levels observed at the off-site stations—a spatial trend suggesting that Cotter Mill's emissions very likely account for a considerable portion of the measured levels. As with natural uranium, the ^{230}Th concentrations exhibited a notable "spike" in 1981-1982, when 2.5 million cubic yards of on-site tailings were excavated from the unlined ponds. As an illustration of this effect, the highest annual average concentration in 1981 (3.0×10^{-14} µCi/ml at a perimeter monitoring station) was nearly 370 times higher than the annual average concentration measured in Cañon City. Moreover, the highest concentrations were observed at the monitoring station closest to, and downwind from, the excavation activity. Average concentrations of ^{230}Th decreased markedly after the 1981-1982 peak: the most recent (2004-2008) annual average concentrations at perimeter stations are all at least 20 times lower than the highest levels from 1981-1982.

  - *Summary.* In 1981 and 1982, annual average concentrations of ^{230}Th at two perimeter monitoring stations exceeded Cotter Mill's health-based regulatory limit; however, for every other calendar year, every station's annual average concentration was lower than this limit. In the last five years, the annual average concentrations at every station were between six and 30 times below this limit. For the off-site monitoring stations, however, all annual average concentrations during this 5-year time frame were at least a factor of 40 below Cotter Mill's health-based regulatory limit.

- **Thorium-232 (^{232}Th).** Table 54 in Appendix A presents the history of annual average ^{232}Th concentrations measured in Cotter Mill's monitoring network. Laboratory analyses for this radionuclide first began in 2001. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{232}Th to an "effluent concentration" (4.0×10^{-15} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 54 exceed this derived concentration guide. In 2008, the highest annual average concentration (3.1×10^{-17} µCi/ml in Lincoln Park) was a factor of 128 lower than the screening value.

  - *Spatial and temporal variations.* Unlike ^{nat}U and ^{230}Th, for which measured concentrations were consistently (if not always) highest at perimeter monitoring stations, the highest annual average concentrations of ^{232}Th have always been observed at off-site monitoring stations, most commonly at the Lincoln Park monitoring station. Moreover, of all the radionuclides measured, annual average concentrations of ^{232}Th exhibited the least variability from station to station. For any given year between 2001 and 2008, annual average concentrations at the ten monitoring stations fell within a factor of three of each other. The annual average concentrations did not exhibit considerable variability from one year to the next.

  - *Summary.* Over the last five years, annual average concentrations of ^{232}Th at every monitoring station were more than 60 times lower than Cotter Mill's health-based regulatory limit. The spatial variations in ^{232}Th concentrations have been limited, suggesting that air emissions from Cotter Mill may be relatively insignificant for this radionuclide.

- **Radium-226 (^{226}Ra).** Table 55 in Appendix A presents the history of annual average ^{226}Ra concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{226}Ra to an "effluent concentration" (9.0 x 10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 55 exceed this derived concentration guide. In 2008, the highest annual average concentration (7.9 x 10^{-16} µCi/ml at a perimeter monitoring station) was three orders of magnitude lower than the screening value.

  - *Spatial and temporal variations.* In almost every year between 1979 and 2008, the highest annual average concentrations of ^{226}Ra were measured at perimeter monitoring stations, and primarily at the west boundary and mill entrance road locations. For most years, the highest annual average value at the facility's perimeter was usually between one and two orders of magnitude greater than the lowest annual average concentration at off-site locations—a pattern that points to facility emissions as a likely source for contributing to at least part of the measured concentrations. At the four perimeter stations with the longest period of record, the highest annual average concentrations occurred prior to 1985, and the current (2008) levels at these stations are between 10 and 100 times lower than those peaks.

  - *Summary.* The spatial variations in ^{226}Ra concentrations suggest that Cotter Mill's emissions contribute to the measured levels. However, over the last five years, annual average concentrations of ^{226}Ra at every monitoring station were more than 390 times lower than Cotter Mill's health-based regulatory limit.

- **Lead-210 (^{210}Pb).** Table 56 in Appendix A presents the history of annual average ^{210}Pb concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{210}Pb to an "effluent concentration" (6.0 x 10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 56 exceed this derived concentration guide. In 2008, the highest annual average concentration (1.9 x 10^{-14} µCi/ml at a perimeter monitoring station) was more than a factor of 30 lower than the screening value.

- *Spatial and temporal variations.* The main distinguishing feature of the ^{210}Pb monitoring data (when compared to data for the other radionuclides) is the low variability, both spatially and temporally. Since 1983, annual average concentrations across the ten monitoring stations tended to fall within a factor of two; and year-to-year variability was of a comparable magnitude. This lack of variability points to a "background effect" (i.e., the measured concentrations likely are not the result of Cotter Mill's emissions, but reflect typical atmospheric levels for this part of the country). In 1981-1982, annual average concentrations at a perimeter monitoring station were slightly higher than what was routinely measured at all other locations and years; and these slightly elevated levels likely reflected air quality impacts from the excavation of the unlined holding ponds.

- *Summary.* Of all the radionuclides considered, ^{210}Pb showed the least variability in annual average concentrations, suggesting that the monitoring data characterize background levels and not a site-specific contribution. From 1983 to the present, annual average concentrations during every year and at every station were generally at least 20 times below Cotter Mill's health-based regulatory limit.

With one exception, the five radioactive substances measured by Cotter Mill's network were below their corresponding health-based regulatory limits at all 10 monitoring stations and for the entire 30 years of record. As the exception, annual average ^{230}Th concentrations exceeded health-based regulatory limits during a tailing pond excavation project, but this was limited to a short time frame (1981-1982) and the immediate proximity of the facility (two fenceline monitoring locations). The spike in measured concentrations during this time frame was far less pronounced (if not completely imperceptible) at monitoring stations in Lincoln Park or Cañon City. Another spatial variation linked to site activities is the relatively elevated readings (e.g., for ^{nat}U) observed at the "mill entrance road" monitoring station between roughly 1997 and 2006.

Over the last five years, annual average concentrations of every radionuclide were at least 20 times lower than health-based screening limits at the five off-site monitoring stations. This large margin provides some assurance that the monitoring network has adequate coverage in terms of monitors—it is quite possible that annual average ambient air concentrations of radionuclides at some un-monitored off-site locations exceed what has been measured to date, but it is far less likely that the network is failing to capture a "hot spot" with concentrations more than 20 times higher than the levels that are currently measured.

b) *Radon Gas*

Cotter measures radon gas concentrations at the same ten monitoring stations where particle-bound radionuclides are sampled. The annual environmental monitoring reports provide very limited information on the sampling methodology, other than noting that the detectors are apparently exposed to ambient air for a calendar quarter and then retrieved for laboratory analysis. Recent data summary reports suggest that a new sampling and analytical method was implemented in the second quarter of 2002. This new method outputs combined ^{220}Rn (from natural thorium) and ^{222}Rn (from natural uranium). However, the report does not describe what the previous sampling and analytical method measured.

According to Cotter's radon sampling procedures (Cotter 2004b), the sampling devices are "Landauer Type DRNF Radon Detectors." The reports provided to ATSDR suggest that various quality control measures have been implemented for this sampling (e.g., collection and analysis of duplicate samples to characterize precision), but they do not document quantitative data quality metrics. The method detection limit for the combined ^{220}Rn/^{222}Rn measurement is 70 pCi/m^3 (Cotter 2004b). This appears to offer adequate measurement sensitivity, because most quarterly average concentrations measured since this method was implemented are at least an order of magnitude greater than the detection limit.

Table 57 presents the annual average ^{220}Rn/^{222}Rn concentrations that Cotter has measured from 2002 to the present. Data are not presented for earlier years (1979 to 2001), as they may not be directly comparable due to the use of different measurement technologies. Cotter has recently concluded that its radon monitoring data "demonstrate slightly elevated readings at boundary locations [when compared to] readings in residential areas at background levels" (Cotter 2008b). This statement seems to be supported, in a general sense, by the monitoring results, though the difference between the perimeter and the off-site concentrations is much lower in certain years, particularly in 2008.

The approach used for screening the ^{220}Rn/^{222}Rn concentrations differs from that used for other radionuclides. Cotter screens the ^{220}Rn/^{222}Rn using an approach approved by CDPHE. In this approach, Cotter derives an "effective effluent limit" based on a baseline regulatory limit, an equilibration factor for the measurements, and average background concentrations that are calculated semi-annually. The details of this derivation are documented in a letter that CDPHE sent to Cotter in June, 2004. The net effect of this calculation approach is that the "effective effluent limit" (i.e., the concentration used for screening purposes) can vary across the monitoring stations and years. To illustrate this point, between 2006 and 2008, the "effective effluent limit" of ^{220}Rn/^{222}Rn concentrations ranged from 1,290 to 1,981 pCi/m^3, depending on the magnitude of the background concentrations at the time. During this time frame, measured concentrations at perimeter monitoring stations reached as high as 85% of the "effective effluent limit."

c) *Gamma Radiation*

Cotter measures gamma radiation levels at the same ten monitoring stations where particle-bound radionuclides are sampled. Measurements are made using thermoluminescent dosimeters (TLDs) that are exposed for 3-month periods before being sent off-site for analysis. Every calendar quarter, an additional duplicate TLD is deployed to at least one monitoring station to assess measurement precision, and a control TLD is placed in a lead-shielded box at another location to serve as a "blank" sample. However, the site reports provided to ATSDR did not contain any quantitative metrics of data quality (e.g., relative percent difference in co-located samples).

Table 58 presents annual average gamma radiation exposure rates between 1979 and 2008, by monitoring station; these annual averages were calculated from the quarterly TLD measurements from each calendar year. For every year on record, the highest annual average exposure rate was observed at one of the perimeter monitoring stations. Since Cotter installed the monitoring station at the mill's entrance road in 1994, this station has recorded the highest annual average exposure rates every year through the present. The relatively high readings at this location are believed to result primarily from past spillage or incoming materials entering the facility (Cotter 2008b). Under oversight from CDPHE, Cotter removed contamination alongside the entrance road in 2006 and 2007, with exposure rates decreasing thereafter.

Cotter's monitoring reports do not include health-based screening evaluations for these measurements, but they do acknowledge that the exposure rates near the facility perimeter (and particularly along the entrance road) exceed background levels. Specifically, the reports assume that the Cañon City station's measurements reflect "background" contributions from all external sources. The report indicates that the reported background level at this station (10.2 µR/hr) is equivalent to a dose of 89 mrem/year.

d) *Ambient Air Monitoring for non-Radioactive Substances*

To prepare this summary, ATSDR accessed all ambient air monitoring data that the state of Colorado collected in Fremont County and reported to EPA's Air Quality System (AQS), an online clearinghouse of monitoring data that states collect to assess compliance with federal air quality standards. The AQS database included monitoring results for three locations in Fremont County: one in Cañon City, one in Lincoln Park, and one in Florence. This section summarizes only those data collected in Cañon City and in Lincoln Park given their closer proximity to Cotter Mill. However, the monitoring summarized in this section was not conducted to characterize air quality impacts associated with Cotter Mill's emissions; the measured concentrations at these locations likely reflect contributions from many different local emission sources (e.g., mobile sources, wind-blown dust, wood-burning stoves). The AQS database does not specify quality control parameters for the monitoring results; however, state agencies that submit data to AQS are supposed to thoroughly validate measured concentrations before entering them into the database.

(1) Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)

The state-operated Cañon City and Lincoln Park monitoring stations measured three different size fractions of particulate matter between 1969 and the present. Following standard practice, all three size fractions were measured in 24-hour average integrated samples that were typically collected once every 6 days, though more frequent monitoring occurred during some years. Measurements were collected using either standard technologies (e.g., high-volume samplers for TSP and PM_{10}) or EPA-approved Federal Reference Method devices. A brief summary of the measurements follows:

- **TSP measurements.** From 1969 through 1987, high-volume sampling devices were used to measure TSP. Table 59 in Appendix A presents the maximum and annual average TSP concentrations measured by the two monitoring stations over the period of record. Annual average TSP in Cañon City did not change considerably from 1969-1987. In Lincoln Park, only two calendar years have complete data sets; the annual average concentration in 1982 was below the range of annual averages observed at Cañon City.

The fact that TSP levels were lower in Lincoln Park than in Cañon City suggests that Cotter Mill's emissions are not the primary contribution to TSP levels in the area.

- **PM_{10} measurements.** The state of Colorado began monitoring PM_{10} in Cañon City in 1987 and continues this monitoring today. The monitoring station was originally located at the courthouse in Cañon City, but the state moved the monitoring equipment in 1987 to a less obstructed site at city hall. Annual average PM_{10} concentrations throughout the period of record range from 15 to 23 µg/m^3, well below EPA's former National Ambient Air Quality Standard for annual average levels (50 µg/m^3). Between 1987 and 2009, only one measured 24-hour average concentration exceeded EPA's current health-based standard; that occurred in 1988 and likely reflected contributions from many different local sources and should not be attributed solely to Cotter Mill's emissions.

- **$PM_{2.5}$ measurements.** In 1991 and 1992, the state conducted $PM_{2.5}$ monitoring at its Cañon City station. All measured 24-hour average concentrations and both annual average concentrations were lower than the health-based standards that EPA would develop later in the 1990s. This monitoring occurred before EPA designated Federal Reference Methods for $PM_{2.5}$ measurement devices.

(2) Constituents of Particulate Matter

Between 1978 and 1987, the state of Colorado analyzed some of the TSP filters collected in Cañon City and Lincoln Park for chemical constituents. This included analyses for metals (iron, lead, manganese, and zinc) and ions (nitrate and sulfate). Table 60 summarizes these measurements by presenting the highest 24-hour average concentration and the highest annual average concentration for the period of record.

V. PUBLIC HEALTH EVALUATION

A. Introduction

This section of the public health assessment evaluates the health effects that could possibly result from exposures to site-related contaminants at or near the Cotter Mill site. For a public health hazard to exist, people must contact contamination at levels high enough and for long enough time to affect their health. The environmental data and conditions at the site revealed five completed exposure pathways:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.
2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.
3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.
4. Exposure from eating produce locally grown in Lincoln Park
5. Exposure to ambient air near the Cotter Mill facility

B. How Health Effects are Evaluated

The potential health effects associated with completed exposure pathways (listed above) will be evaluated in this section. For chemicals found to exceed comparison values, ATSDR calculated exposure doses and estimated non-cancer and cancer risks, where applicable. The calculations estimate the amount of the chemical to which a person may have been exposed. Calculated exposure doses are then compared to the available health guidelines to determine whether the potential exists for adverse non-cancer health effects. In the event that calculated exposure doses exceed established health guidelines (e.g., ATSDR's Minimal Risk Levels or EPA's Reference Doses), an in-depth toxicological evaluation is necessary to determine the likelihood of harmful health effects. ATSDR also may compare the estimated amount of exposure directly to human and animal studies, which are reported in ATSDR's chemical-specific toxicological profiles. Not only do the toxicological profiles provide health information, they also provide information about environmental transport, human exposure, and regulatory status.

ATSDR's **Minimal Risk Level (MRL),** which is derived from human and animal studies, is an estimate of daily exposure to a contaminant below which non-cancer health effects are unlikely to occur.

EPA's **Reference Dose** An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments.

A detailed explanation of ATSDR's evaluation process for determining cancer and non-cancer health effects is contained in Appendix C of this document. The equations to calculate exposure doses, the exposure scenarios, and the exposure assumptions used to estimate exposures at this site are also in Appendix C.

C. Groundwater Pathway: Private wells used for personal consumption

As discussed above, the data from the 1989 *Lincoln Park Water Use Survey* survey indicated approximately 7 wells are used for personal consumption; sampling data for 6 of the 7 wells were available to ATSDR for evaluation. Samples were collected intermittently from 1984 to 2007.

Although most residents in Lincoln Park currently use municipal water for drinking purposes, the survey reveals that residents at 7 locations still use their private wells for drinking purposes. It is not verified whether residents who reported using their well water for personal consumption also use their well water for other household purposes, such as bathing and showering. Some residents report that they and others used their private wells for personal consumption and other household uses in the past (before the installation of the municipal water line). Therefore, it is reasonable to assume that many more people obtained their drinking water from private wells in the past, and that some people are continuing to use their private wells for drinking, and possibly, household purposes.

Very little quantitative information is known about what levels of contamination residents may have been exposed to in the past. However, ATSDR attempted to address this issue by assuming that the average resident would have been exposed to the average chemical concentration (i.e., temporal average per well) detected in the 6 private wells for which we have sampling data. There is some uncertainty in using this estimate because some people may have been exposed to more, and some to less, than the estimated amount. To capture the resident who may have been more highly exposed (or a worst case scenario), ATSDR used the average chemical concentration from the single private well that consistently contained the highest chemical concentrations (Well 189). ATSDR assumed that adults and children drank the water from this well for 350 days per year for 30 years (adults) and 6 years (children), respectively.

Molybdenum was the only chemical in private wells that had an average detected level (0.082 mg/L) that exceeded its comparison value (0.05 mg/L). The average level of molybdenum in Well 189 (0.16 mg/L) also exceeded the comparison value for molybdenum in drinking water. Therefore, molybdenum was retained as a chemical of concern and evaluated for possible adverse health effects. The maximum detected level of uranium (0.067 mg/L), but not the average detected level (0.028 mg/L), also exceeded the comparison value of 0.03 mg/L for uranium. Additionally, the average detected level of uranium in Well 189 (0.048 mg/L) exceeded the comparison value for uranium. Therefore, ATSDR evaluated uranium more closely for potential adverse health effects. Table 7 below summarizes the estimated child and adult doses for molybdenum and uranium that guide the health discussion below. (See Table C1 in Appendix C for a detailed discussion of how these values were derived.)

Table 7. Estimated Child and Adult Doses for Molybdenum and Uranium in Drinking Water

Chemical	Exposure Group	Adult Estimated Dose (mg/kg/day)	Child Estimated Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Molybdenum	Well 189 (high exposures)	0.004	**0.010**	0.005 Chronic Oral RfD
	All wells (average exposures)	0.002	0.005	
Uranium	Well 189 (high exposures)	0.001	**0.003**	0.002 Intermediate Oral MRL
	All Wells (average exposures)	0.0008	0.002	

1. *Molybdenum*

Molybdenum is a naturally occurring element found in various ores. Molybdenum is also considered an essential dietary nutrient in humans and animals. Foods such as legumes, leafy vegetables, nuts and cereals tend to be higher in molybdenum than meats, fruits, and root and stem vegetables [WHO 2003]. The Food and Nutrition Board (FNB) of the Institute of Medicine has determined the Tolerable Upper Intake Level[12] (UL) for molybdenum in children and adults [FNB 2001] as follows:

- children 1 to 3 years of age - 0.3 mg/kg/day;
- children 4 to 8 years of age - 0.6 mg/kg/day;
- children 9 to 13 years of age - 1.1 mg/kg/day;
- adolescents 14 to 18 years of age - 1.7 mg/kg/day; and
- adults - 2.0 mg/kg/day.

a) Health Evaluation of Molybdenum

Drinking water from a private well contaminated with molybdenum would result in an estimated dose of 0.002 mg/kg/day for an average adult and 0.005 mg/kg/day for an average child. The adult dose is lower than the oral RfD of 0.005 mg/kg/day for molybdenum. The estimated child dose is equal to the oral RfD (0.005 mg/kg/day) for molybdenum. Therefore, adverse health

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[12] UL = maximum level of daily nutrient intake that is likely to pose no risk of adverse health effects in all individuals. The UL represents the total intake from food, water, and supplements.

effects are not expected for the average adult or child who drank from a private well contaminated with molybdenum.

Adults who may have had high exposures, such as those similar to Well 189, have an estimated dose of 0.004 mg/kg/day, and children who may have had high exposures have an estimated dose of 0.010 mg/kg/day. The adult high dose is less than the oral RfD for molybdenum. However, the estimated child high exposure dose is 2 times greater than the oral RfD of 0.005 mg/kg/day for molybdenum. Because the estimated exposure dose for children exceeds the long-term health guidelines for molybdenum, the possibility of health consequences from this exposure was evaluated further.

To further evaluate the possibility of adverse health effects, ATSDR divides the lowest observed adverse effect level (LOAEL) and/or the no observed adverse effect level (NOAEL) by the site-specific exposure doses. Interpretation of the resulting value is subjective and depends on a host of toxicological factors. Further evaluation consists of a careful comparison of site-specific exposure doses and circumstances with the epidemiologic and experimental data on the chemical. The purpose of the comparison is to evaluate how close the estimated exposure doses are to doses that cause health effects in humans or animals.

The oral RfD for molybdenum is based on a human epidemiological study that found a LOAEL of 0.14 mg/kg/day for increased serum uric acid levels and prevalence of gout-like condition in Armenian villagers [Koval'skiy 1961]. A higher incidence (18-31%) of a gout-like disease was associated with high intake of molybdenum (10-15 mg/day) from soil and plants. The gout-like condition was characterized by pain, swelling, inflammation and deformities of the joints, and, in all cases, an increase in the uric acid content of the blood. In a number of cases, illnesses of the GI tract, liver, and kidneys accompanied the condition [EPA IRIS]. In deriving the oral RfD, an uncertainty factor of 3 was used for protection of sensitive human populations and a factor of 10 was used for the use of a LOAEL instead of a NOAEL for a long-term study in a human population. The estimated child high dose (0.010 mg/kg/day) for molybdenum at the Cotter Mill/Lincoln Park site is 14 times lower than the LOAEL from this study. There was no NOAEL determination for molybdenum from this study.

Molybdenum is known to interfere with copper metabolism in ruminant animals (grazing animals that "chew their cud," such as sheep or cows); the resulting copper deficiency is reported to cause the animal's hair/wool to turn white [FNB 2001]. This is a problem with ruminant animals in particular because high dietary molybdenum reacts with moderate to high dietary sulfur in the rumen (the first stomach) to form thiomolybdates. These compounds greatly reduce copper absorption, and certain thiomolybdate species can be absorbed and interfere systemically with copper metabolism [Spear 2003]. This interaction between thiomolybdates and copper is not expected to occur to a significant degree in humans [Turnlund 2002]. Although the exact effect of molybdenum intake on copper status in humans remains to be clearly established, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk of molybdenum toxicity [FNB 2001].

In conclusion, children who drink water containing high concentrations of molybdenum could be at increased risk of adverse health effects such as gout-like symptoms. However, molybdenum is not stored at high levels in the body, so it is unlikely that children will suffer long-term health effects once the exposure is stopped [FNB 2001]. In healthy people, excess molybdenum is not associated with adverse health outcomes. However, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk for adverse health effects. The actual risk of adverse health effects occurring depends on the concentration of molybdenum in the water and how much water is drunk. Therefore, private wells known to be contaminated with molybdenum should not be used for drinking purposes.

b) Additional Comments about Molybdenum in Drinking Water

- ATSDR did not evaluate potential exposures to molybdenum that could occur if well water is used for other household purposes such as showering or bathing. If it is confirmed that residents are using their wells for other potable purposes, then exposure levels would increase, as well as the likelihood of adverse health effects. However, exposure to airborne and/or dermal molybdenum is not likely to be a major exposure pathway because of the physicochemical properties of molybdenum.

- The estimated dose for children and adults at this site did not exceed the Tolerable Upper Intake Level (UL) for molybdenum established by the Institute of Medicine. However, ATSDR's evaluation did not consider molybdenum intake from other sources, including food and supplements, which would increase total intake.

- Molybdenum is often found naturally in the geology of this region. The wells identified and sampled as background for the Lincoln Park area contained an average molybdenum concentration of 0.023 mg/L. This concentration is lower than the average of 0.082 mg/L found in private wells used for personal consumption. The maximum concentration of molybdenum in a background well (0.3 mg/L) was about the same as that in a private well (0.28 mg/L) used for personal consumption.

- Overall molybdenum levels in groundwater decreased over time. Molybdenum levels measured from 1968 to 2000 show a clear pattern of decrease in molybdenum concentrations. Therefore, exposures to molybdenum in groundwater were likely higher in the past, and may continue to decrease in the future.

People who currently own private wells are not prevented from using their private wells for any purpose. New residents who move to the area may install new wells in the contaminated zone and use their well for any purpose. Therefore, this exposure pathway will continue to exist as a potential exposure pathway in the future.

2. Uranium

Throughout the world uranium is a natural and common radioactive element. Uranium is a silver-white, extremely dense, and weakly radioactive metal. It is typically extracted from ores containing less than 1% natural uranium. Natural uranium is a mixture of three isotopes: 238U (99.2739%), 235U (0.7204%), and 234U (0.0057%). It usually occurs as an inorganic compound with oxygen, chlorine, or other elements [NHANES 2005]. Rocks, soil, surface and ground water, air, plants, and animals all contain varying amounts of uranium. Colorado ranks third, behind Wyoming and New Mexico, tied with Arizona and Utah, as the state with the most uranium reserves in the United States [EIA 2001].

a) Health Evaluation of Uranium

Natural uranium is radioactive but poses little radioactive danger—it releases only small amounts of radiation that cannot travel far from its source. Moreover, unlike other types of radiation, alpha radiation released by natural uranium cannot pass through solid objects, such as paper or human skin. You have to eat, drink, or breathe natural uranium in order to be exposed to the alpha radiation; however, no adverse effects from natural uranium's radiation properties have been observed in humans. The National Academy of Sciences determined that bone sarcoma is the most likely cancer from oral exposure to uranium; its report noted, however, that this cancer has not been observed in exposed humans and concluded that exposure to natural uranium may have no measurable effect [BEIR IV].

Scientists have seen chemical effects in people who have ingested large amounts of uranium. Kidney disease has been reported in both humans and animals that were exposed to large amounts of uranium; however, the available data on soluble (more bioavailable) and insoluble uranium compounds are sufficient to conclude that uranium has a low order of metallotoxicity in humans [Eisenbud and Quigley 1955].

When uranium is ingested most of it leaves the body through the feces and a small portion (approximately 2% for an adult) will be absorbed into the blood stream through the gastrointestinal (GI) tract. Most of the uranium in the blood is excreted from the body through urine excretion within a few days; however, a small amount will be retained in the kidneys, bone, and soft tissue for as long as several years. The percentage of the uranium retained in the kidneys over time is different for acute and chronic ingestion of uranium (as long as the individual continues to drink the water). When an individual discontinues drinking the uranium contaminated water, the percentage of retention in the kidney decreases similar to an acute exposure. In the case of chronic ingestion of drinking water containing uranium, the kidney retention (or kidney burden) increases rapidly in the first two weeks. After approximately 100 days, the amount present in the kidney is approximately 5% of the daily intake for an infant and approximately 3% for all other ages. After 25 years of chronic ingestion, the uranium kidney burden reaches equilibrium for all age groups at approximately 6.6% of the daily intake [Chen et al 2004].

Nephrotoxicity (kidney toxicity) occurs when the body is exposed to a drug or toxin such as uranium that causes temporary or permanent damage to the kidneys. When kidney damage occurs, blood electrolytes (such as potassium and magnesium) and chemical wastes in the blood (such as creatinine) become elevated indicating either a temporary condition or the development of kidney failure. Creatinine is a chemical waste molecule that is generated from muscle metabolism. The kidneys maintain the blood creatinine in the normal range. Creatinine is a fairly reliable indicator of kidney function. As the kidneys are impaired, the creatinine level in the blood will rise because of the poor clearance by the kidney. If detected early, permanent kidney problems may be avoided.

Several mechanisms for uranium-induced kidney toxicity have been proposed. In one of these, uranium accumulates in specialized (epithelial) cells that enclose the renal tubule, where it reacts chemically with ion groups on the inner surface of the tubule. This interferes with ion and chemical transport across the tubular cells, causing cell damage or cell death. Cell division and regeneration occur in response to cell damage and death, resulting in enlargement and decreased kidney function. Heavy metal ions, such as uranyl ions, may also delay or block the cell division process, thereby magnifying the effects of cell damage [Leggett 1989, 1994; ATSDR 1999].

Animal and human studies conducted in 1940s and 1950s provide evidence that humans can tolerate certain levels of uranium, suffering only minor effects on the kidney [Leggett 1989]. Most of these studies involved inhalation exposures to uranium; however, the kidney is the target organ for inhaled as well as ingested uranium. On the basis of this tolerance, the International Council on Radiologic Protection (ICRP) adopted a maximal permissible concentration of 3 μg of uranium per gram of kidney tissue for occupational exposure in 1959 [Spoor and Hursh 1973]. This level has often been interpreted as a threshold for chemical toxicity.

More recent papers have been published on effects of uranium at levels below 3 μg/g, and those papers have discussed possible mechanisms of uranium toxicity [Diamond 1989; Leggett 1989, 1994; Zhao and Zhao 1990; Morris and Meinhold 1995]. It is thought that the kidney may develop an acquired tolerance to uranium after repeated doses; however, this tolerance involves detectable histological (structural) and biochemical changes in the kidney that may result in chronic damage. Cells of the inner surface of the tubule that are regenerated in response to uranium damage are flattened, with fewer energy-producing organelles (mitochondria). Transport of ions and chemicals across the tubule is also altered in the tubule cells [Leggett 1989, 1994; McDonald-Taylor et al. 1997]. These effects may account for the decreased rate of filtration through the kidney and loss of concentrating capacity by the kidney following uranium exposure. Biochemical changes include diminished activity of important enzymes (such as alkaline phosphatase), which can persist for several months after exposure has ended. Therefore, acquired tolerance to uranium may not prevent chronic damage, because the kidney that has developed tolerance is not normal [Leggett 1989]. Acting on the basis of this recent information for uranium, researchers have suggested that exposure limits be reduced to protect against these chronic effects on the kidney.

Renal damage appears to be definite at concentrations of uranium per gram of kidney tissue above 3 μg/g for a number of different animal species, but mild kidney injury can occur at uranium concentrations as low as 0.1 to 0.4 μg/g in dogs, rabbits, guinea pigs, and rats after they inhale uranium hexafluoride or uranium tetrachloride over several months [Maynard and Hodge 1949; Hodge 1953; Stokinger et al. 1953; Diamond 1989]. Zhao and Zhao proposed a limit of uranium to the kidney of 0.26 μg/g based on renal effects in a man who was exposed to high concentrations of uranyl tetrafluoride dust for 5 minutes in a closed room [Zhao and Zhao 1990]. The man showed signs of kidney toxicity, including increased protein content in the urine (proteinuria) and nonprotein nitrogen. These signs persisted for 4.6 years, gradually returning to normal values. The kidney content 1 day after the accident was estimated to be 2.6 μg/g.

A study conducted in Finland and published in 2002 observed 325 people that had used their drilled wells for drinking water over a period of 13 years on average (range 1 – 34 years) [Kurttio et. al 2002]. The median uranium concentration in the water was 28 ppb (range 0.001 –

1,920 ppb). The study showed an association between increased uranium exposure through drinking water and tubular function, but not between uranium exposure and indicators of glomerular injury. The primary target is the proximal convoluted tubule of the kidney which is where most of the sodium, water, glucose, and other filtered substances are reabsorbed and returned to the blood. The authors of the study indicated that tubular dysfunction may merely represent a manifestation of subclinical toxicity, and it is unclear if it carries a risk of development into kidney failure or overt illness. This study concluded that "The public health implications of these findings remain uncertain, but suggest that the safe concentration of uranium in drinking water may be close to the guideline values proposed by the WHO and the U.S.EPA." However, this study found that altered tubular function was statistically significant at water uranium concentrations exceeding 300 μg/L [Kurttio et. al 2002], or 0.3 mg/L, which is an order of magnitude higher than EPA's guideline (0.035 mg/l) and the highest average concentration at the Lincoln Park site (0.048 mg/L). At 300 μg/L and assuming ingestion of two liters of water per day, the kidney burden after 25 years of chronic ingestion would be 39.6 μg of uranium with a uranium concentration per gram of kidney tissue of 0.13 μg/g.

A review of studies of uranium effects on the kidney [Morris and Meinhold 1995] suggests a probability distribution of threshold values for kidney toxicity ranging from 0.1 to 1 μg/g, with a peak at about 0.7 μg/g. The researchers proposed that the severity of effects increases with increasing dose to the kidney with probably no effects below 0.1 to 0.2 μg/g, possible effects on the kidney at 0.5 μg/g, more probable effects at 1 μg/g, and more severe effects at 3 μg/g and above [Morris and Meinhold 1995; Killough et al. 1998b].

If an adult in Lincoln Park drank 2 liters (L) of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 µg/L) for 25 years or longer, then the maximum daily ingestion would be 96 µg of uranium, resulting in a uranium kidney burden of 6.3 µg (96 µg × 0.066). The weight of both kidneys in adults is about 300 g [Madsden et al 2007]. Thus, the uranium concentration per gram of kidney tissue for an adult would be 0.02 µg/g. If a child drank 1 L of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 µg/L) for 100 days to 25 years, then the maximum daily ingestion would be 48 µg of uranium, resulting in a uranium kidney burden of 1.4 µg (48 µg x 0.03). The weight of both kidneys in a child is about 100 g; therefore, the uranium concentration per gram of kidney tissue to be 0.01 μg/g. The calculated kidney uranium concentration for adults and children is below the level found to cause harm in published studies.

ATSDR's health-based guidelines for ingested (and inhaled) uranium are lower than the lower limit threshold for kidney toxicity proposed by Morris and Meinhold (1995). ATSDR's guidelines are derived by use of levels of toxicity observed in animal studies, and those guidelines incorporate safety factors to account for uncertainty in extrapolating from animals to humans and to protect the most sensitive human individuals [ATSDR 1999].

Note that urinalysis has limitations as a test for kidney toxicity. First, the presence of substances in urine may indicate that kidney damage has occurred, but it cannot be used to determine whether the damage was caused by uranium. Second, most uranium leaves the body within a few days of exposure, so that urine tests can be used only to determine whether exposure has occurred in the past week or two. Finally, the tests may be used to detect mild effects on the kidney, but such effects are generally transient in nature and may not result in permanent damage. More severe effects involve greater damage to the kidney that is likely to be clinically manifest and longer lasting. The kidney has incredible reserve capacity and can recover even after showing pronounced clinical symptoms of damage; however, biochemical and functional changes can persist in a kidney that appears to have recovered structurally [Leggett 1989, 1994; CDC 1998].

The maximum average uranium concentration detected in a private well was 0.048 mg/L, or 48 µg/L. The residence where this concentration was detected is not connected to the municipal water supply and is noted to use a private well for personal consumption. Drinking water from this private well containing uranium would result in an estimated dose of 0.001 mg/kg/day for an adult and 0.003 mg/kg/day for a child. The adult dose is lower than the intermediate oral MRL. The estimated child dose slightly exceeds the MRL of 0.002 mg/kg/day for an intermediate-duration oral exposure. The MRL level for intermediate-duration oral exposure is also protective for chronic-duration oral exposure because the renal toxicity of uranium exposure is more dependent on the dose than on the duration of the exposure. The MRL is based on a LOAEL of 0.05 mg U/kg/day for renal effects in rabbits. The estimated child dose is an order of magnitude lower than the LOAEL; therefore, adverse health effects are not likely.

Although older evaluations suggested carcinogenicity of uranium among smokers, the U.S. EPA has withdrawn its classification for carcinogenicity for uranium; the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP) have no ratings [NHANES 2005].

D. Soil Pathway: Surface Soil near Cotter Mill and Lincoln Park

As discussed above, surface soil samples were collected from areas around the Cotter Mill property, from property access roads and in the Lincoln Park area. Surface soil sampling data were available from eight designated zoned areas around Cotter Mill and in Lincoln Park. People who live or recreate in these areas could accidentally ingest some contaminated soil or get it on their skin. ATSDR evaluated these potential exposure scenarios to determine if concentrations of chemicals and radionuclides in soil are high enough to cause adverse health effects.

ATSDR assumed that the average adult would accidentally ingest 100 milligrams of soil per day and would also contact the contaminated soil with their skin (dermal). Small children were not assumed to access the soil around Cotter Mill because these areas are primarily industrial or vacant. The vacant area has been designated as a “buffer zone” between the Cotter Mill property and the residential areas. Therefore, it is unlikely that small children would access the area. A residential exposure scenario was used to evaluate potential exposures in Lincoln Park. For Lincoln Park, we assumed that a small child would ingest 200 mg of soil per day, and an adult would ingest 100 mg/day, for 350 days per year.

Concentrations of arsenic, cadmium and lead exceeded their comparison values in soil taken from the area surrounding Cotter Mill. The concentration of radium-226 was the only radionuclide to exceed its comparison value in soil near Cotter Mill. Arsenic was the only chemical to exceed its comparison value in soil in Lincoln Park. The highest zonal average concentration of arsenic, cadmium, lead and radium-226 was used to estimate exposure doses. If the highest zonal average concentration of a chemical would not result in adverse health effects, it follows that lower concentrations of the chemical would not as well.

1. *Soil Near Cotter Mill*

a) Arsenic

Arsenic is a naturally occurring element that is widely distributed throughout the earth's crust and may be found in air, water, and soil [ATSDR 2000]. Arsenic in soil exists as inorganic and organic arsenic. Generally, organic arsenic is less toxic than inorganic arsenic, with some forms of organic arsenic being virtually non-toxic. Inorganic arsenic occurs naturally in soil, and children may be exposed to arsenic by eating soil or by direct skin contact with soil containing arsenic [ATSDR 2007].

The estimated dose of arsenic for adolescents and adults at this site is 0.00002 mg/kg/day. This dose is lower than the Minimal Risk Level (MRL) of 0.0003 mg/kg/day for arsenic; therefore, non-cancer health effects are not likely from being exposed to arsenic in surface soil near Cotter Mill (Zones A through H). The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the identified chronic No Observable Adverse Effect Levels (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of three to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007].

The U.S. Environmental Protection Agency (EPA), the International Agency for Research on Cancer (IARC), and the National Toxicology Program (NTP) classify arsenic as a human carcinogen. The EPA has developed an oral cancer slope factor to estimate the excess lifetime risk for developing cancer. Using EPA's cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 1×10^{-5} for exposure to arsenic in soil near Cotter Mill. Qualitatively, we interpret this as a very low increased lifetime risk of developing cancer.

b) Cadmium

The estimated dose for adolescents and adults for cadmium is 0.00002 mg/kg/day, which is lower than the MRL of 0.0001 mg/kg/day for cadmium; therefore, non-cancer adverse health effects are not likely. The U.S. Department of Health and Human Services (DHHS), IARC, and EPA have determined that cadmium is carcinogenic to humans. Although cadmium can be carcinogenic when inhaled, human or animal studies have not provided sufficient evidence to show that cadmium is a carcinogen by oral routes of exposure (ATSDR 1999b). Therefore, a cancer evaluation for cadmium was not done as part of this assessment.

c) Lead

The highest average concentration of lead detected in any of the zones (Zone H) is 445 ppm, which is only slightly higher than the soil screening value of 400 ppm for lead. A value of 400 ppm is commonly used to evaluate lead in soil in residential properties. The property near the Cotter Mill site is currently restricted, vacant or used for industrial purposes; therefore contact with these soils should be minimal. Adverse health effects are not expected to occur from these limited exposures to soils near the site. Exposures to lead, however, should be re-evaluated should the area ever be considered for residential or other non-industrial use.

Maximum lead concentrations in zones F, G and H are 800 ppm, 450 ppm, and 1,400 ppm, respectively. To protect children from exposure to lead, it is important to know the average lead level in a yard or other frequent play area. The *1998 Supplemental Human Health Risk Assessment* provides the only characterization of surface soils adjacent to the Cotter Mill property (See Figure 17, Zones A through H). The soil sample results in this report were generated by collecting four samples from the center of a grid and compositing the samples to form a single representative sample. The size of each sampled grids, however, appears to be larger than 100 x 100 feet, which is the size that triggers additional sampling for lead (EPA 1995). Although the sampling in the *1998 Supplemental Human Health Risk Assessment* measured contamination in soils at several properties near Cotter Mill, it does not allow ATSDR to evaluate contamination in individual exposure units (yards, playgrounds, etc), as would be required to accurately assess exposures in a residential setting, commercial or recreational setting. The sample design is sufficient for making general public health decisions about exposure to lead in soil based on current use patterns. However, any future public health decision regarding the soil near the Cotter Mill property must be made with the limitations of the current sampling design in mind.

The Centers for Disease Control and Prevention (CDC) has established a level of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL). This means that when blood lead levels in children exceed 10 µg/dL, CDC recommends that steps be taken to lower their blood lead levels. However, some agencies and public health officials have mistakenly used this level in blood as a safe level of exposure or as a no effect level. Recent scientific research has shown that blood lead levels below 10 µg/dL cause serious harmful effects in young children, including neurological, behavioral, immunological, and development effects. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ), attention deficit hyperactivity disorder (ADHD), deficits in reaction time, visual-motor integration, fine motor skills, withdrawn behavior, lack of concentration, sociability, deceased height, and delays in puberty, such as breast and pubic hair development, and delays in menarche [CDC].

d) Radium-226

The average concentrations of radium-226 detected in Zones A and B are higher than allowed by the Uranium Mill Tailing Act (UMTRA). That standard does not apply in this case, since the Cotter Mill is still considered active.

The highest average soil concentration of 9.2 pCi/g in surface soil would result in a dose from radium's decay gammas of 58 mrem per year above background, assuming that residents spend 12 hours per day 365 days per year sitting or lying on the highest measured radium concentration of 9.2 pCi/g on the haul road. Since Zones A and B are buffer areas (actually haul roads), the time spent in these areas would be much lower (less than 2 hours per day) and the resulting dose would be roughly 10 mrem per year above background, to a maximally exposed individual.

2. *Soil in Lincoln Park*

a) Arsenic

The estimated arsenic dose for an adult in Lincoln Park is 0.00003 mg/kg/day, which is an order of magnitude lower than the MRL of 0.0003 mg/kg/day for arsenic. The estimated arsenic dose for a child in Lincoln Park is 0.0003 mg/kg/day, which is equal to the MRL of 0.0003 mg/kg/day for arsenic. Children are estimated to have higher arsenic doses than adults because they tend to engage in activities that increase their soil ingestion exposure, and because they weigh less than adults. Neither children nor adults should experience adverse health effects from exposure to arsenic in soil in Lincoln Park.

Arsenic is a naturally occurring element in soil. Arsenic has also historically been used in a variety of industrial applications, including bronze plating, electronics manufacturing, preserving animal hides, purifying industrial gases, and mining, milling and smelting activities. Studies of background levels of arsenic in soils have revealed that background concentrations range from 1 ppm to 40 ppm, with average values around 5 ppm [ATSDR 2007]. The average arsenic concentration detected in Lincoln Park was 31 ppm, a concentration within the observed background range but higher than the average background concentration. The maximum concentration of arsenic detected in Lincoln Park was 50 ppm.

Although the maximum arsenic concentration is higher than the observed background concentration, this fact alone does not definitely point to an anthropogenic source for the arsenic found in soil in Lincoln Park. Uncertainty exists regarding whether the arsenic levels detected are a natural occurrence or from past milling operations in the area.

Several factors contribute to whether people have contact with contaminated soil, including:

- grass cover, which is likely to reduce contact with contaminated soil when grass cover is thick but increase contact with soil when grass cover is sparse or bare ground is present,
- weather conditions, which is likely to reduce contact with outside soil during cold months because people tend to stay indoors more often,
- the amount of time someone spends outside playing or gardening, and
- people's personal habits when outside, for instance, children whose play activities involve playing in the dirt are likely to have greater exposure than other children

Using EPA’s cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 5×10^{-5} for exposure to arsenic in Lincoln Park. Qualitatively, we interpret this as no apparent increased lifetime risk of developing cancer.

E. Surface Water: Sand Creek, DeWeese Dye Ditch, and the Arkansas River

People who swim or wade in the surface waters of Sand Creek, the DeWeese Dye Ditch, or the Arkansas River will get surface water on their skin and they might also accidentally ingest some of the surface water. To estimate exposures to adults and children who may have come into contact with contaminated surface water, ATSDR assumed that adults and children will swallow 50 mL of water per hour while swimming or wading, for 104 days per year for 30 and 6 years, respectively. Molybdenum exceeded its comparison value in Sand Creek and the Arkansas River. Manganese exceeded its comparison value in Sand Creek and the DeWeese Dye Ditch. ATSDR conservatively selected the maximum concentration for each chemical to estimate exposures.

1. Manganese

The estimated exposure dose for manganese is 0.0007 mg/kg/day for adults and 0.0006 mg/kg/day for children. Both adult and child doses are considerably lower than the reference dose of 0.05 mg/kg/day for manganese. Therefore, no adverse health effects are expected to occur as a result of exposure to manganese in surface waters.

2. Molybdenum

The estimated exposure dose for molybdenum is 0.00002 mg/kg/day for adults and 0.00006 mg/kg/day for children. Both adult and child doses are below the chronic oral reference dose (RfD) of 0.005 mg/kg/day for molybdenum. Therefore, no adverse health effects are expected to occur as a result of exposure to molybdenum in surface waters.

F. Homegrown Fruits and Vegetables

Ingestion of contaminated foods is a potential exposure pathway for this site. Residents may have been exposed to contaminants when they ate homegrown fruits and vegetables after using contaminated groundwater (either surface water or private well water) to irrigate their crops, or after growing their crops in contaminated soil. The soil may become contaminated from contaminated water or from tailings, dusts and other wastes deposited in the soil in the past.

Eating fruits, vegetables, herbs, or other produce grown in gardens with contaminated soil can cause exposure. This type of exposure occurs because some plants slowly absorb small amounts of the chemicals found in soil into their plant tissue or because contaminated soil can adhere to the exterior surface of produce, particularly low-growing leafy produce or produce where the underground portion is eaten. Some of these absorbed chemicals are essential nutrients and are actually good for humans to eat, but other chemicals can present health hazards if they are found at high enough levels and are consumed on a regular basis.

Generally, there is not a strong relationship between levels of heavy metals in soils and plants [Vousta 1996]. The uptake of heavy metal concentration depends on speciation of metal, soil characteristics, the type of plant species and other characteristics [Laizu 2007]. Table 8 below developed by Sauerbeck (1988) provides a qualitative guide for assessing heavy metal uptake into a number of plants.

Table 8. Plant Uptake of Heavy Metals

High	Moderate	Low	Very Low
Lettuce	Onion	Corn	Beans
Spinach	Mustard	Cauliflower	Peas
Carrot	Potato	Asparagus	Melons
Endive	Radish	Celery	Tomatoes
Crest		Berries	Fruit
Beet			
Beet leaves			
Source: USEPA (1991), Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."			

To address the concern regarding contaminated crops, residents contributed locally grown produce for sampling analysis. ATSDR used the sampling results to estimate an exposure dose for each contaminant using typical consumption rates for the average and above-average (95th percentile) consumer in the Western United States. Child and infant consumption rates were also used to assess exposures to these vulnerable populations. Table 9 below provides the consumption rates used by ATSDR for homegrown fruits and vegetables.

Table 9. Homegrown Fruit and Vegetable Consumption Rates for the Western United States

Food	Consumer Type†	Intake Rate (g/kg/day)	Standard Error
Homegrown fruits	Average consumer	2.62	0.3
	Above-average consumer	10.9	
	Child	4.1	NA
	Infant (1 to 2 years)	8.7	
Homegrown vegetables	Average consumer	1.81	0.1
	Above-average consumer	6.21	
	Child	2.5	NA
	Infant (1 to 2 years)	5.2	

Sources: EPA Exposure Factors Handbook, Volume II, 1997; Child-Specific Exposure Factors Handbook, 2008
g/kg/day: grams per kilogram per day
NA = not applicable
†An average consumer is represented here as a person who eats fruits and vegetables in the typical range (mean intake). An above average consumer is a person who eats more fruits and vegetables than is typical, represented here by the 95th percentile intake.

All of the estimated fruit and vegetable doses were below health guideline values except for those for arsenic (See Table C4 in Appendix C). The estimated doses for fruits for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The above-average consumer and infant doses for fruit are 0.0006 mg/kg/day and 0.0004 mg/kg/day, respectively. Also, the estimated doses for vegetables for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The vegetable doses are 0.0005 mg/kg/day for an above-average consumer and 0.0004 mg/kg/day for an infant. These doses exceed the chronic oral MRL of 0.0003 mg/kg/day for arsenic.

Next, ATSDR assumed that a person will eat both fruits and vegetables daily. To do this, we added the calculated doses for fruits and vegetables to derive a single dose. The estimated fruit and vegetable doses for the above-average consumer, child and infant exceed the health guideline of 0.0003 mg/kg/day for arsenic. The above-average consumer dose is 0.001 mg/kg/day; the child dose is 0.0004 mg/kg/day; and the infant dose is 0.0008 mg/day/day.

The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the chronic No Observable Adverse Effect Level (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of 3 to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007]. The child and infant doses are below or equal to the NOAEL, and the above-average consumer dose is 14 times lower than the dose that caused adverse health effects in epidemiologic studies. Therefore, adverse health effects are not expected in infants, children or the above-average consumer.

Using EPA's cancer slope factor for arsenic and the above consumer exposure dose, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 6 x 10^{-4} for exposure to arsenic in fruits and vegetables. Qualitatively, we interpret this as a low to moderate increased risk of developing cancer over a lifetime.

ATSDR conservatively assumed that every consumer ate homegrown fruits and vegetables every day for 30 years. In reality, it is likely that most people only eat homegrown fruits and vegetables during a defined season, usually a 3 to 4 month period during the summer/fall growing season. Therefore, the true risk to consumers is likely overestimated.

ATSDR also noted that the highest arsenic level detected in lawns and gardens in Lincoln Park was 50 ppm. This level is near what is typically observed as background arsenic levels (1 ppm to 40 ppm) in soil. This suggests that the contaminated well water used to irrigate crops is not contributing significantly to arsenic soil levels, or other soil additives may have been added that dilute soil contamination [ODEQ 2003]. The highest arsenic level detected in soil at the site was 86 ppm. There were no sampling data for arsenic in drinking or irrigation water. ATSDR is unsure if the arsenic found in soil at this site is a natural occurrence or from an anthropogenic (man-made) source.

Plants vary in the amount of arsenic they absorb from the soil and where they store arsenic. Some plants move arsenic from the roots to the leaves, while others absorb and store it in the roots only [Peryea 1999]. The best method of reducing exposure to external arsenic from homegrown vegetables is to soak and wash residual soil from produce before bringing it into the home and washing the produce again thoroughly indoors before eating [ATSDR 2007]. It is always a good health practice to wash all fruits and vegetables thoroughly before eating, whether they are bought or homegrown.

Molybdenum was the only other contaminant to approach a health guideline when calculating a single dose for fruits and vegetables. The above-average consumer and infant doses are 0.005mg/kg/day, which is equal to the chronic health guideline of 0.005mg/kg/day for molybdenum.

G. Air Pathway

ATSDR looked at all the air data collected from 1979 to present. Concentrations of radionuclides in air from direct release or re-suspension of radioactive contaminants in soil were less than a tenth of ATSDR's health based comparison value (100 millirem per year) at all off-site sampling locations (CC-1/2, LP-2, AS-210, AS-212, OV-3). ATSDR evaluated doses to all age groups and found that adults would have received the highest doses, because of their higher breathing rate. Infants only received one quarter the dose of an adult.

Table 10 below breaks down the dose estimates by age group and by the highest annual concentration measured for each radionuclide and by the highest location. The two highest doses were both in 1982, during the excavation of the unlined settling ponds and were measured at the on-site sampling location AS-204, that was directly adjacent to the dewatered ponds. Neither of those doses would have been to the public. The combined dose to a worker near AS-204 would have been less than a third of the sum in the table since the worker was there less than 8 hours per day for 5 days a week, or 70 mrem of inhalation dose for the year 1982, while the numbers in Table 10 reflect 24/7 exposure through the year. Doses listed in Table 10 did not result in any elevated exposures to the public.

Table 10. Annual Effective Doses by Highest Concentration, Location and Age Group

Radionuclide	Highest Year	Highest Location	Concentration (µCi/ml)	Dose to Infant (mrem/yr)	Annual Dose to Adult	Notes
Natural Uranium (µCi/ml)	1979	AS-204	2.48E-14	2.72	5.97	
Thorium-230 (µCi/ml)	1982	AS-204	8.95E-14	71.57	272.68	
Thorium-232 (µCi/ml)	2001	CC#2	8.33E-17	0.07	0.27	
Radium-226 (µCi/ml)	1985	AS-202	9.63E-15	1.25	2.75	
Lead-210 (µCi/ml)	1982	AS-204	9.95E-14	7.01	16.77	Dose from Radon Progeny
Radon-220/222 (pCi/l)	2004	AS-202	1.50E+00	NA	NA	No dose from Radon

Most of the calculated inhalation dose was from the isotope Thorium-230 (Th-230). Table 11 below lists just the dose from Th-230 for the highest annual average concentration at each sampling station. Again it can be seen that the on-site concentrations are consistently orders of magnitude higher than at off-site locations in Cañon City, Lincoln Park and west of the site boundary.

Outdoor concentrations of radon contributed zero dose to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay. On the other hand, the dose from radon decay products (e.g., lead-210) attached to respirable dust held constant year over year and accounted for an annual inhalation dose of four to seven millirem annually. Radon decay product concentration off-site did not appear to be related to releases from the site. Radon and its decay products appear to be from natural background and do not represent any health threat at the reported concentrations.

Table 11. Annual Doses from Thorium-230 by Location and Year

Year	Highest Location	Concentration (µCi/ml)	Annual Dose to Infant (mrem/yr)	Annual Dose to Adult(mrem/yr)
1982	AS-204	8.95E-14	71.57	272.68
1982	AS-202	2.12E-14	16.95	64.59
1983	AS-203	9.79E-15	7.83	29.83
1982	AS-206	1.26E-14	10.08	38.39
2000	AS-209	4.16E-15	3.33	12.67
2005	AS-210	4.85E-16	0.39	1.48
2000	AS-212	6.69E-16	0.53	2.04
1982	LP-1/2	7.49E-16	0.60	2.28
1982	CC-1/2	9.18E-16	0.73	2.80
1982	OV-3	3.15E-15	2.52	9.60

VI. COMMUNITY HEALTH CONCERNS

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. The community associated with a site is both an important resource for and a key audience in the public health assessment process. Community members can often provide information that will contribute to the quality of the health assessment. Therefore, during site visits and telephone conversations with community members, ATSDR obtained information from the community regarding their specific health concerns related to the site.

In some cases, ATSDR was unable to address a community health concern because 1) adequate scientific information on the particular health effect is not available or is limited or 2) the available scientific data are insufficient to assess whether the specific health effect is related to exposure to a particular chemical. Where feasible, ATSDR addressed the health concerns identified by the community. Below is a summary of the community concerns and ATSDR's response to those concerns.

1. How did the 1965 flood event affect my health?

In June 1965, prior to the construction of the SCS Dam in 1971, a flood caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. According to the residents, the waters flowed north through the gap in the ridge, down Pine Street, and ultimately down 12th Street (Sharyn Cunningham, CCAT, personal communication, February 2008). There is concern that this flood event contaminated groundwater wells and that dust from soil or tailings may have been resuspended by wind and distributed in Lincoln Park. Community members are very concerned that current illnesses may be a result of this tailings pond flood event.

There is documentation that ponds at the Cotter Mill historically overflowed, which led to the construction of the SCS Dam. Aerial photography from October 1970 indicates that one of the evaporation ponds overflowed into an alluvial channel tributary to Sand Creek (Wilder et al. 1983). A chronology compiled by CDPHE states that in October 1970 and January 1971, an evaporation pond overflowed with high levels of total dissolved solids, sodium, molybdenum, sulfate, and high radiation (CDPHE 1975).However, since the construction of the SCS Dam, there are no recorded surface water discharges past the dam (GeoTrans 1986).

ATSDR tried to locate data to evaluate the potential health effects resulting from this flood event. No data from 1965 or 1966 exist in the CDPHE database. The *1986 Remedial Investigation* (GeoTrans 1986) states that off-site groundwater contamination in the Lincoln Park areas was first identified in 1968; therefore, any data prior to 1968 are unlikely to exist. The only data ATSDR found related to this flood event were from a sediment sample collected in January 2003 (CDPHE 2003). To address community concerns, CDPHE collected a sample of suspected flood sediment from Pine Street near Elm Avenue. This area was identified by a property owner who was present during the flood. The sample was collected from two locations. About 250 grams of soil were collected from each location to a depth of approximately 18 inches. No obvious soil horizons were identified, and no significant differences in gamma radiation were noted between shallow and deep soils. The results are presented in Table 12 below. All concentrations from this one sample are below comparison values.

The results of the sediment sample from the flood did not exceed any comparison values. If this sample was representative of the material moved by the floodwaters, it would not cause any adverse health effects.

Table 12. Concentrations found in a suspected flood sediment sample, January 2003

Chemical	**Concentration (ppm)**	**Comparison Value (ppm)**
Lead	87	400
Molybdenum	Not detected	300
Uranium	1.6	100
Radionuclide	**Concentration (pCi/g)**	**Comparison Value (pCi/g)**
Cesium-137	0.12	Not available
Lead-210	2.2	Not available
Plutonium-239, 240	Not detected	Not available
Potassium-40	22.5	Not available
Radium-226	2.2	15
Radium-228	1.3	15

Source: CDPHE 2003

2. Were an adequate number of soil samples collected during the *1998 Supplemental Human Health Risk Assessment*?

The community expressed concern that not enough samples were collected during the *1998 Supplemental Human Health Risk Assessment*. Weston, a contractor for Cotter, collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample (Weston 1998). The dates the samples were collected were not specified in the report; however, it is assumed to be in the 1994–1996 timeframe. In 1995, EPA released guidance for obtaining representative soil samples at Superfund sites (EPA 1995). The systematic grid sampling approach used by Weston conforms with EPA's guidance for delineating the extent of contamination. The number of samples taken from each grid for compositing, however, is not entirely consistent with EPA's guidance. For grids larger than 100 x 100 feet, which it appears that the grids established by Weston are, EPA recommends collecting nine aliquots from each grid. Compositing four aliquots from each grid is recommended for grids smaller than 100 x 100 feet (EPA 1995). Because the timeframe of the sampling is unclear, it is not known whether EPA's 1995 guidance was available during Weston's sampling effort.

3. Are there high levels of thorium near the Black Bridge?

The community expressed concern that high thorium levels were detected in surface water near the Black Bridge. This bridge is located where a railroad spur crosses the Arkansas River between the 4th Street and 9th Street bridges. The closest sampling location in the Arkansas River is upstream at 1st Street (907). Thorium-230 was sampled at this location as part of the surface water monitoring program between 1995 and 2007. These data are summarized below in Table 13. The highest thorium-230 concentration detected was 2.5 picocuries per liter (pCi/L) (suspended sample) in August 2007. This concentration is below levels known to cause adverse health effects. It should also be noted that the Black Bridge is located upstream of the confluence with Sand Creek.

Table 13. Thorium-230 data upstream of the Black Bridge

Chemical	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)
Thorium-230 (D)	121/127	-0.1	0.1	1
Thorium-230 (S)	115/120	0	0.2	2.5
Thorium-230 (T)	7/7	0.1	0.3	0.7

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Thorium-230 “D” and “S” samples were collected between 1995 and 2007. Thorium-230 “T” samples were only collected in 1995.

D – dissolved
pCi/L – picocuries per liter
S – suspended
T – total

4. I grew up near the Cotter plant. Does this increase my risk of getting cancer?

Soil sampling data from the nearest residence to the Cotter plant did not indicate the presence of chemicals at levels above established guidelines. Soil sampling data from the Lincoln Park community did not reveal the presence of contaminants at levels associated with adverse health effects, including cancer. Air data do not indicate the presence of chemicals at levels associated with adverse health effects, including cancer. If you drank water from a contaminated private well, you might be at increased risk for gout-like conditions, such as pain, swelling, inflammation and deformities of the joints. However, once exposure is stopped, the risk of adverse health effects goes down.

5. I used water from my private well or surface water to irrigate my crops and garden vegetables. Am I going to get sick?

According to our evaluation, people who ate fruits or vegetables irrigated with contaminated well water are not at increased risk for non-cancer health effects. However, people who eat more than the average amount of fruits and vegetables (95th percentile consumers) might be at increased risk for developing cancer over a lifetime. This conclusion is based on a person eating approximately 4 times more fruits and vegetables than the average person every day for 30 years.

People who grew fruits and vegetables at their home and used their well water to irrigate their crops submitted crop samples for analysis. The analysis revealed that vegetables irrigated with well water did not cause a significant increase in contaminant levels (Weston 1998). As a precaution, however, we recommend washing all homegrown fruits and vegetables before eating them.

6. **I have lived in Lincoln Park since the 1960s. I know of many neighbors and family members who are sick. Is uranium from the mill making us sick?**

Uranium primarily acts as a heavy metal toxin. Renal toxicity is the hallmark effect of uranium exposure, specifically to the proximal tubules of the kidney. We looked at CDC's Compressed Mortality Database "WONDER" looking specifically at specific modes of kidney failure that could be associated with uranium toxicity. Fremont County in Colorado had an age adjusted rate for renal failure as the cause of death of 7.1 per 100,000, for the years 1999-2006. The state average during that same period was 12.1 per 100,000[13]. From the available health outcome data, it does not appear that residents in the area have elevated rates of kidney disease, which could be associated with uranium exposure.

7. **My husband worked at the plant. Was I possibly exposed when he brought his dirty work clothes home?**

Workers in industrial settings have the potential to expose their household members to work-related chemicals if residues attach to the worker's clothing, skin, shoes, or in their vehicles and is inadvertently brought into the home. Whether and to what magnitude these take-home exposures actually occur depends on a number of factors, including the nature of the job held by the worker, the occupational practices of the industrial facility (e.g., providing workers with disposable gowns and gloves), and the precautions/practices of the worker and other family members. ATSDR did not evaluate potential exposures to workers' families because the data needed to quantitatively or qualitatively make a determination on potential health effects were not available.

8. **I used contaminated water from my private well water for many years as a potable source of water for my family. Are we now at risk for adverse health effects?**

The levels of molybdenum were high enough in some wells to cause adverse health effects in individuals who were exposed for many years. Once exposure is stopped, the risk of adverse health effects goes down. Residents, particularly individuals who do not take in enough dietary copper or cannot process copper correctly, might be at increased risk for gout-like conditions. The levels of other contaminants are too low to cause adverse health effects.

9. **CCAT conducted a health survey and submitted it to ATSDR. Why didn't ATSDR use the results of this survey to determine if people are experiencing adverse health effects in the community?**

The community organization CCAT conducted a health survey in 2004–2005. The survey included responses from 239 individuals in the Lincoln Park area. Volunteers went door-to-door in Lincoln Park and the surrounding areas to administer the health surveys. Each person filled out a survey and submitted it to a volunteer. A tabulation of self-reported illnesses reported by respondents included occurrences of cancer; lung, health, skin, central nervous system, kidney, and thyroid problems; reproductive issues, including chromosomal and congenital defects;

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[13] Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2006. CDC WONDER On-line Database, compiled from Compressed Mortality File 1999-2006 Series 20 No. 2L, 2009. Accessed at http://wonder.cdc.gov/cmf-icd10.html on Sep 30, 2009 10:42:05 AM

autoimmune disease, psychological disorders, and gout. Although ATSDR could not use the survey to make conclusions about disease associations, we did use the survey results to focus our attention and pursue a more in-depth scientific analysis of the health conditions identified by the community.

While the CCAT health survey was a good effort by the community to examine the frequency of their various health concerns, there are many issues that make it of limited use in determining the prevalence of adverse health effects present in the entire community and their potential associations with exposure to environmental contaminants. Some of these issues include the use of a relatively small convenience sample, the lack of medical verification of self-reported health outcomes, and the need for individual-level exposure data. Convenient samples are typically not representative of the entire population, so results cannot be extrapolated to the community. People who participate in nonrandomized surveys such as this may provide biased information because of perceived relationships between environmental contamination or other risk factors and their health. Many of the self-reported health outcomes measured in the survey are present in most populations and are related to several different potential causes beyond environmental exposures, such as lifestyle or genetics. Therefore, without any assessment of exposure, it is not possible to link the occurrence of disease to environmental concerns.

10. **CDPHE previously ordered Cotter to have all environmental samples analyzed by an external laboratory until Cotter could demonstrate that its laboratory had addressed various deficiencies. Why was this done and how did it affect the data used by ATSDR?**

Cotter’s license requires the company to collect and report a wide range of environmental measurements. Cotter’s own analytical laboratory conducted most of the measurements between the late 1970s and the present. The main exception is that an external analytical laboratory measured contamination levels in most of the samples collected in 2005 and 2006.

For many years, Cotter has participated in so-called “round robin” inter-laboratory performance evaluations. As part of these evaluations, selected environmental samples are split every calendar quarter and simultaneously sent to Cotter’s laboratory and to three external analytical laboratories for analysis. The measurement results are then compared to assess the performance of Cotter’s laboratory. CDPHE’s website presents data from these inter-laboratory comparisons from 2007 to the present. Earlier comparisons are not readily available, mostly because Cotter’s laboratory was not analyzing samples throughout much of 2005 and 2006 and data from earlier years have since been archived from CDPHE’s website.

In September 2008, Cotter submitted a letter to CDPHE documenting five quarters of inter-laboratory comparisons for groundwater samples [Cotter 2008]. These comparisons presented “round robin” data for more than two dozen substances or indicators, including uranium, molybdenum, selenium, nitrate, and selected radionuclides. In some cases, Cotter’s laboratory tended to measure higher concentrations than the other participating laboratories; but in other cases, the opposite was observed. With one exception, the differences between the measurements made by the various laboratories fell within the range typically observed or expected.

The exception is for molybdenum, for which Cotter's laboratory did not meet pre-established comparability limits for the "round robin" sampling. Specifically, in two out of the five quarters of samples that were collected, Cotter's laboratory did not meet the acceptable limits.[14] In contrast, the three external laboratories' molybdenum measurements met the pre-established comparability limits for all five quarters considered in this report. The table below presents the specific concentration measurements for the two quarters of interest, and these measurements show that (in these two instances) the molybdenum levels measured by Cotter were less than 50 percent of the average concentrations calculated from the three external laboratories' measurements.

After CDPHE requested that Cotter investigate the issue further, Cotter prepared a written response to the issue [Cotter 2009]. The response suggests that the poor performance on these samples resulted from the analytical method used. Cotter uses atomic adsorption to measure molybdenum levels in groundwater samples, and the external laboratories used a different method (inductively coupled plasma with mass spectrometry). When molybdenum concentrations are below roughly 0.5 mg/L, Cotter measures molybdenum by atomic adsorption *graphite furnace* analysis; but at higher concentrations, analysis is by atomic adsorption *flame* analysis. The two quarters with the poor comparisons both had concentration levels below 0.5 mg/L, leading Cotter to infer that the underreporting was associated with the graphite furnace analyses. In January 2009, Cotter proposed several measures that were believed to cause the graphite furnace analyses to perform better, and CDPHE approved of the proposed remedy.

Overall, the "round robin" studies have demonstrated that Cotter's analytical laboratory met pre-specified performance criteria for almost every one of the substances considered. Only for molybdenum was a performance issue noted, and it appears that Cotter's laboratory previously used a method that would understate molybdenum concentrations, but typically only when those concentrations were less than approximately 0.5 mg/L. This issue was observed for samples collected between January 2007 and March 2008, but it likely also affected earlier samples that Cotter's laboratory analyzed; and this negative bias should be considered in any uses of these data. Measurements collected since this timeframe likely do not exhibit the same negative bias, given the changes that Cotter proposed to its analytical methods.

Inter-Laboratory Comparison Results for Molybdenum: First Quarter 2007 & First Quarter 2008

Parameter	Analytical Laboratory			
	Cotter	Laboratory #1	Laboratory #2	Laboratory #3
Inter-Laboratory Comparison for First Quarter 2007				
Measurement 1 (mg/L)	0.012	0.0263	0.027	0.024
Measurement 2 (mg/L)	0.012	0.025	0.027	0.0232
Average (mg/L)	0.012	0.0257	0.027	0.0236
Avg across three comparison laboratories (mg/L)		0.025		
Inter-Laboratory Comparison for First Quarter 2008				
Measurement 1 (mg/L)	0.01	0.0281	0.029	0.0267
Measurement 2 (mg/L)	0.011	0.0274	0.029	0.0274
Average (mg/L)	0.011	0.0278	0.029	0.0271
Avg across three comparison laboratories (mg/L)		0.028		

Note: Every laboratory was supposed to analyze each sample twice, thus providing data allowing for intra-laboratory and inter-laboratory comparisons.

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[14] CDPHE actually voiced concern about three quarters of Cotter's molybdenum data, even though only two of these three quarters did not meet the pre-established comparability limits.

VII. CONCLUSIONS

ATSDR reached four important conclusions in this public health assessment:

1. ATSDR concludes that drinking water for many years from contaminated private wells could harm people's health. This is a public health hazard.

   Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people's health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions, particularly individuals who do not take in enough dietary copper or cannot process copper correctly.

   The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply make these past exposures difficult to accurately assess.

   Most town residents are now connected to the public water supply and have eliminated their exposure to the contaminated well water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

2. ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people's health. However, ATSDR cannot make conclusions about soils near Cotter Mill if the properties closest to the facility are developed for residential or other non-industrial uses in the future.

3. ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.

4. ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in completed exposures to the public at levels that could cause adverse health outcomes. With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.

VIII. RECOMMENDATIONS

Based upon ATSDR's review of the environmental data and the concerns expressed by community members, the following recommendations are appropriate and protective of the health of residents in and around the Lincoln Park area.

- Residents should be informed about the health risks associated with contaminated private wells and advised to connect to the public water supply if possible. Local officials should advise new residents who move to the area of the groundwater contamination and that they should have their water supply tested before using groundwater for household purposes.

- Residents should discontinue of use of any impacted private wells for household purposes, including watering livestock and crops.

- CDPHE should continue to monitor the groundwater contaminant plume to assess whether additional wells may be impacted in the future.

- CDPHE should conduct a water use survey in the affected area to determine how groundwater is being utilized by residents in Lincoln Park.

- CDPHE should evaluate the need for further analysis of lead in soil should the areas adjacent to the Cotter Mill property change current use patterns.

- ATSDR in the short-term, and CDPHE in the long-term, should advise residents who have fruit and vegetable gardens to wash the crops thoroughly before eating them. This measure is just a precaution to remove soil adhering to the surface of the crop.

IX. PUBLIC HEALTH ACTION PLAN

The public health action plan for the site contains a description of actions that have been taken or will be taken by ATSDR or other government agencies at the site. The purpose of the public health action plan is to ensure that this document both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from exposure to the hazardous substances at this site.

Public health actions COMPLETED:

- ATSDR conducted site visits to gather community health concerns, to communicate to identified stakeholders, and to gather relevant site-related data;
- ATSDR's Exposure Investigations and Site Assessment Branch (EISB) performed two Exposure Investigations to 1) evaluate blood lead levels in children living in the Lincoln Park area and 2) evaluate lead in dust in homes in the Lincoln Park area. (These documents are available on our website at www.atsdr.cdc.gov.)

Public health actions PLANNED:

- ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.
- ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.
- ATSDR will continue to work with appropriate state and federal agencies and review, if requested, additional relevant environmental data (including the water use survey) as it becomes available.
- ATSDR will re-evaluate and revise the public health action plan if needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

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Appendix A - Tables

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Table 14. Well Use in Lincoln Park, 1989

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
117	Logan (LPWUS)		✓			✓
119	Birch (LPWUS)			✓		✓
122	Elm (LPWUS)					✓
123	Cedar (LPWUS)					✓
124	Elm (LPWUS)			✓		✓
129	Elm (LPWUS)		✓	✓		✓
130	Poplar (LPWUS)		✓			✓
138	Field well, Cedar (LPWUS)					✓
139	House well, Cedar (LPWUS)					✓
140	C. R. Ransom house well, Cedar (LPWUS)		✓	✓		✓
144	Cedar (LPWUS)		✓	✓	✓	✓
165	Spring, Elm (LPWUS)	✓		✓		✓
166	Willow (LPWUS)				✓	✓
168	Grand (house well) (LPWUS)	✓			✓	✓
173	Beulah (LPWUS)		✓			✓
174	Chestnut (LPWUS)		✓		✓	✓
189	Hickory (LPWUS)	✓				
198	Grand (LPWUS)	✓	✓	✓	✓	✓
206	Grand (field well) (LPWUS)				✓	
212	Cedar (LPWUS)		✓	✓		✓
219	Locust (LPWUS)	✓				
221	Elm (LPWUS)					✓
222	Elm (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
223	Elm (LPWUS)				✓	
224	Elm (LPWUS)		✓			✓
226	Chestnut (LPWUS)					✓
229	Grand (LPWUS)				✓	✓
230	Birch (LPWUS)		✓			✓
231	Birch (LPWUS)		✓	✓		
235	Elm (LPWUS)				✓	
237	Elm (LPWUS)				✓	
239	Grand (LPWUS)		✓	✓	✓	✓
241	Grand (LPWUS)				✓	
243	Chestnut (LPWUS)					✓
245	Elm (LPWUS)				✓	
246	Elm (LPWUS)		✓			✓
252	Poplar (cistern* in barn) (LPWUS)					✓
255	Riley Dr. (LPWUS)	✓	✓			✓
261	Elm (LPWUS)		✓	✓		✓
262	Cedar (LPWUS)		✓	✓		✓
263	Willow (LPWUS)					✓
264	Chestnut (LPWUS)		✓	✓		✓
266	Willow (LPWUS)		✓	✓		✓
267	Willow (spring) (LPWUS)		✓	✓	✓	✓
269	Birch			✓		✓
273	Willow (cistern #1) (LPWUS)			✓		✓
274	Grand (LPWUS)		✓	✓		✓
278	Cedar (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
280	Grand (LPWUS)				✓	
284	Spring - Grand St. (LPWUS)				✓	
285	Grand (LPWUS)				✓	
286	Willow (cistern #2) (LPWUS)				✓	
287	Willow (LPWUS)			✓		✓
288	Poplar (cistern* on porch)					✓
293	Cedar (LPWUS)		✓	✓	✓	✓
	Totals	6	22	20	19	42

Source: IMS 1989

*Modified from the original spelling: “cystern”
Street numbers have been excluded for privacy reasons.

LPWUS – Lincoln Park Water Use Survey

Table 15. Groundwater sampling data (chemicals) from wells used for personal consumption

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Chloride	N/T*	11/11	4.5	8.8	14	Spring, Elm [165]	13-Mar-84	250 (Secondary MCL)	165, 168	1984, 2005–2007
Iron	D	2/12	0.04	0.06	0.1	Grand (house well) [168]	19-Aug-05	26 (RBC)	165, 168	1984, 2004–2007
Manganese	D	2/12	0.002	0.008	0.01	Grand (house well) [168]	13-Dec-04	0.5 (RMEG, child)	165, 168	1984, 2004–2007
Molybdenum	D	52/59	0.007	**0.082**	**0.28**	Hickory [189]	19-Jan-89	0.035 (SS); 0.05 (RMEG, child)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2000–2007
Nitrate	T	8/8	0.5	2.9	7.7	Grand (house well) [168]	19-Mar-07	10 (MCL)	168	2005–2007
Selenium	D	0/2	ND	ND	ND	--	--	0.05 (c-EMEG, child)	165, 168	1984
Sulfate	N/T*	11/11	15	62	214	Grand (house well) [168]	19-Aug-05	250 (Secondary MCL)	165, 168	1984, 2005–2007
Total Dissolved Solids	N/T*	11/11	240	330	410	Spring, Elm [165]	13-Mar-84	500 (Secondary MCL)	165, 168	1984, 2005–2007
Uranium	D	56/57	0.001	0.028	**0.067**	Hickory [189]	15-Dec-06	0.03 (MCL)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2001–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used for personal consumption at 1935 Elm [165] was a spring.

* For chloride, sulfate, and total dissolved solids, 1984 data were designated “N” and 2005–2007 data were designated “T”.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 16. Groundwater sampling data (chemicals) from background wells

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/25	ND	ND	ND	--	10 (c-EMEG, child)	1981, 1988–1994
Ammonia	N	3/45	0.02	0.4	4.2	26-Jan-90	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T*	168/168	3	12	110.3	07-Jan-80	250 (Secondary MCL)	1975, 1976, 1978–2007
Iron	D	24/79	0.02	0.03	0.3	16-May-89	26 (RBC)	1981–2007
Manganese	D	13/79	0.005	0.007	0.05	16-Mar-99	0.5 (RMEG, child)	1981–2007
Molybdenum	D	116/193	0.005	0.023	**0.3**	09-Nov-82, 09-Jun-76	0.035 (SS); 0.05 (RMEG, child)	1975, 1976, 1979–2007
Nitrate	N/T*	70/79	0.4	2.5	**50.4****	10-Feb-89	10 (MCL)	1988–2007
Selenium	D	10/103	0.001	0.003	0.015	15-Apr-80	0.05 (c-EMEG, child)	1975, 1977–1988, 1996–2000
Sulfate	N/T*	171/171	10	61	**434**[§]	18-Aug-80	250 (Secondary MCL)	1975–2007
Total Dissolved Solids	N/T*	171/171	286	429	**1,580**[†]	18-Aug-80	500 (Secondary MCL)	1980–2007
Uranium	D	155/193	0.004	0.021	**0.29**	07-Aug-79	0.03 (MCL)	1975–1977, 1979–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The USGS identified Well 10 (1220 So. 12th St.) and Well 114 (1408 Pine) as representative of background for the Lincoln Park area (Weston 1998).

* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
** Only two of 79 samples were above the CV.

[§] Only one of 171 samples was above the CV.
[†] The maximum concentration appears to be an outlier. The next highest concentration is 590 mg/L.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 17. Groundwater sampling data (chemicals) from the Grand Avenue Well

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Chloride	N/T*	10/10	4.5	8.250	11	20-Jun-84, 20-Jun-05	250 (Secondary MCL)	1984, 2005–2007
Iron	D	2/11	0.04	0.06	0.1	19-Aug-05	26 (RBC)	1984, 2004–2007
Manganese	D	2/11	0.002	0.009	0.01	13-Dec-04	0.5 (RMEG, child)	1984, 2004–2007
Molybdenum	D	15/20	0.008	0.01	0.015	21-Jun-04	0.035 (SS); 0.05 (RMEG, child)	1984, 1988–1991, 2004–2007
Nitrate	T	8/8	0.5	2.9	7.7	19-Mar-07	10 (MCL)	2005–2007
Selenium	D	0/1	ND	ND	ND	--	0.05 (c-EMEG, child)	1984
Sulfate	N/T*	10/10	15	58	214	19-Aug-05	250 (Secondary MCL)	1984, 2005–2007
Total Dissolved Solids	N/T*	10/10	240	322	402	19-Mar-07	500 (Secondary MCL)	1984, 2005–2007
Uranium	D	20/20	0.001	0.013	0.0218	28-Mar-05	0.03 (MCL)	1984, 1988–1991, 2004–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, sulfate, and total dissolved solids, 1984 data were designated "N" and 2005–2007 data were designated "T".

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 18. Groundwater sampling data (chemicals) from wells used to irrigate fruit and vegetable gardens

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	3/120	0.01	0.186*	0.02	Elm [124] & Elm [129]	15-Mar-95	10 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144	1981, 1988–1995
Ammonia	N	10/53	0.01	0.3	0.6	house well, Cedar [140]	23-Aug-88	30 (LTHA)	119, 124, 129, 130, 140, 144	1988–1995
Ammonium	T	0/3	ND	ND	ND	--	--	NA	119, 140, 144	1995
Cadmium	D	0/3	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 140, 144	1995
Chloride	N/T**	784/793	2.5	19.6	232	house well, Cedar [140]	05-Apr-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/3	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 140, 144	1995
Iron	D	114/398	0.011	0.029	0.31	Elm [129]	21-Apr-03	26 (RBC)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1981–2007
Manganese	D	69/397	0.0007	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1981–2007
Molybdenum	D	1,052/1,077	0.004	0.99	42	house well, Cedar [140]	12-May-73	0.035 (SS); 0.05 (RMEG, child)	All 28 wells (see Table 14)	1968–2007
Nickel	D	0/3	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 140, 144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T**	159/185	0.1	1.7	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 124, 129, 130, 140, 144, 174, 224	1970, 1988–2007
Selenium	D	115/626	0.001	0.003	**0.082**[†]	house well, Cedar [140]	21-Apr-78	0.05 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224, 264	1974–1988, 1995–2000
Sulfate	N/T**	798/800	8	214	**25,460**[‡]	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975–2007
Total Dissolved Solids	N/T**	767/767	31	**550**	**3,438**	house well, Cedar [140]	20-Apr-81	500 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1980–2007
Uranium	D	1,048/1,088	0.0003	**0.13**	**2.54**	house well, Cedar [140]	05-Jan-79	0.03 (MCL)	All 28 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	1/20	0.081	0.005[§]	**0.081**	house well, Cedar [140]	27-May-97		140, 174, 224	1995–2000
Vanadium	D	0/3	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 140, 144	1995
Zinc	D	2/3	0.005	0.01	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used to water fruits and vegetable gardens at 1935 Elm [165] was a spring.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
[†] Only two of 626 samples were above the CV.
[‡] The maximum concentration appears to be an outlier. The next highest concentration is 1,948 mg/L from the same well [140] in 1981.
[§] The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 19. Groundwater sampling data (radionuclides) from wells used to irrigate fruit and vegetable gardens

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	29/29	-0.2	0.22	1.5	Birch [119]	21-Jun-95	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	-0.1	0.15	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		140, 174, 224	1995–2000
Polonium-210	D	29/29	-0.1	0.13	0.6	Cedar [144]	08-Mar-95, 21-Jun-95,	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	0	0.12	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		140, 174, 224	1995–2000
Radium-226	D	29/29	0	0.12	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 140, 144, 174, 224	1995–2000
	S	19/19*	0	0	0	--	--		140, 174, 224	1995–2000
Thorium-230	D	28/28	-0.1	0.08	0.3	Birch [119] house well, Cedar [140]	25-Aug-95 21-Feb-95	NA	119, 140, 144, 174, 224	1995–2000
	S	17/17	0	0.08	0.3	house well, Cedar [140]	05-May-99		140, 174, 224	1995–2000

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is "Y" for all 19 samples, however, the result value is zero for all 19 samples.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 20. Groundwater sampling data (chemicals) from wells used to water livestock

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	0/19	ND	ND	ND	--	--	10 (c-EMEG, child)	144	1981, 1988–1995
Ammonia	N	0/10	ND	ND	ND	--	--	30 (LTHA)	144	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	--	NA	144	1995
Cadmium	D	0/1	ND	ND	ND	--	--	0.002 (c-EMEG, child)	144	1995
Chloride	N/T*	160/160	2.5	14	185	Cedar [144]	24-Aug-83	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975, 1976, 1979–1989, 1991–2007
Copper	D	0/1	ND	ND	ND	--	--	0.1 (i-EMEG, child)	144	1995
Iron	D	27/97	0.03	0.04	0.19	Cedar [144]	18-Oct-01	26 (RBC)	144, 166, 168, 174	1970, 1981–2007
Manganese	D	14/96	0.0007	0.007	0.02	Cedar [144]	13-Jul-81, 13-Sep-83, 17-May-01, 06-Jun-02, 23-Oct-03	0.5 (RMEG, child)	144, 166, 168, 174	1981–2007
Molybdenum	D	271/286	0.006	0.212	1	Cedar [144]	12-May-71	0.035 (SS); 0.05 (RMEG, child)	All 19 wells (see Table 14)	1968–1971, 1975–1977, 1979–2007
Nickel	D	0/1	ND	ND	ND	--	--	0.2 (RMEG, child)	144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T*	55/58	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	144, 168, 174	1970, 1988–2007
Selenium	D	10/119	0.001	0.003	0.011	Cedar [144]	19-Mar-80	0.05 (c-EMEG, child)	144, 166, 168, 174	1975–1977, 1979–1988, 1995–2000
Sulfate	N/T*	162/162	10	95	**1,650****	Cedar [144]	18-Aug-80	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975–1977, 1979–1989, 1991–2007
Total Dissolved Solids	N/T*	162/162	195	465	**860**	Cedar [144]	18-Aug-80	500 (Secondary MCL)	144, 166, 168, 174	1970, 1980–2007
Uranium	D	283/302	0.001	**0.034**	**0.46**	Cedar [144]	28-Jun-68	0.03 (MCL)	All 19 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1975–1977, 1979–2007
	S	0/1	ND	ND	ND	--	--		174	1996
Vanadium	D	0/1	ND	ND	ND	--	--	0.03 (i-EMEG, child)	144	1995
Zinc	D	0/1	ND	ND	ND	--	--	3 (c-EMEG, child)	144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
** The maximum concentration appears to be an outlier. The next highest concentration is 340 mg/L from the same well [144] in 1984.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 21. Groundwater sampling data (radionuclides) from wells used to water livestock

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	4/4	-0.1	0.1	0.3	Cedar [144]	08-Mar-95	NA	144, 174	1995, 1996
	S	1/1	0.2	0.2	0.2	Chestnut [174]	19-Sep-96		174	1996
Polonium-210	D	4/4	-0.1	0.3	0.6	Cedar [144]	08-Mar-95, 21-Jun-95	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Radium-226	D	4/4	0.1	0.1	0.1	--**	--**	5 (MCL radium-226/228)	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Thorium-230	D	4/4	0	0.05	0.1	Cedar [144] Chestnut [174]	20-Sep-95 19-Sep-96	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** All four result values were 0.1 pCi/L.

CV – comparison value
D – dissolved
MCL – maximum contaminant level

NA – not available
pCi/L – picocuries per liter
S – suspended

Table 22. Groundwater sampling data (chemicals) from wells used to water lawns

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	11/239	0.01	0.19*	0.13	Field well, Cedar [138]	18-Dec-90	10 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1981, 1988–1995
Ammonia	N	21/112	0.01	0.3	0.9	Field well, Cedar [138]	23-Aug-88	30 (LTHA)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1988–1995
Ammonium	T	0/5	ND	ND	ND	--	--	NA	119, 138, 139, 140, 144	1995
Cadmium	D	0/5	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 138, 139, 140, 144	1995
Chloride	N/T**	1,362/1,372	2.5	30	450	Field well, Cedar [138]	12-Aug-80	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/5	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Iron	D	205/683	0.005	0.031	0.31	Field well, Cedar [138] Elm [129]	09-Mar-95 21-Apr-03	26 (RBC)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1981–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Manganese	D	134/683	0.0005	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1979, 1981–2007
Molybdenum	D	1,755/1,790	0.004	2.2	56.7	Field well, Cedar [138]	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	All 42 wells (see Table 14)	1968–2007
Nickel	D	0/5	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 138, 139, 140, 144	1995
Nitrate	N/T**	277/314	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 168, 174, 224	1970, 1988–2007
Selenium	D	320/1,105	0.001	0.005	0.134	Field well, Cedar [138]	13-Jul-81	0.05 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224, 264	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	1,382/1,384	8	351	25,460[†]	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Total Dissolved Solids	N/T**	1,311/1,311	31	**746**	**4,373**	Field well, Cedar [138]	06-Mar-81	500 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1980–2007
Uranium	D	1,733/1,789	0.0003	**0.233**	**5.161**	Field well, Cedar [138]	01-Aug-68	0.03 (MCL)	All 42 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	4/38	0.0067	0.010	**0.26**	Field well, Cedar [138]	27-May-97		138, 140, 174, 224	1995–2000
Vanadium	D	0/5	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Zinc	D	3/5	0.005	0.007	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 138, 139, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
[†] The maximum concentration and the second highest concentration (23,200 mg/L from Well 138 in 1978) appear to be outliers. The third highest concentration is 3,360 mg/L from Well 138 in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 23. Groundwater sampling data (radionuclides) from wells used to water lawns

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	53/53	-0.2	0.2	1.5	Birch [119]	21-Jun-95	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	-0.1	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		138, 140, 174, 224	1995–2000
	T	1/1*	0	0	0	Field well, Cedar [138]	06-Sep-96		138	1996
Polonium-210	D	53/53	-0.1	0.2	0.9	Field well, Cedar [138]	04-May-99	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	0	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		138, 140, 174, 224	1995–2000
	T	1/1	0.5	0.5	0.5	Field well, Cedar [138]	06-Sep-96		138	1996
Radium-226	D	51/51	0	0.1	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	37/37**	0	0.003	0.1	Field well, Cedar [138]	30-Oct-95		138, 140, 174, 224	1995–2000
	T	2/2	0	0.05	0.1	Field well, Cedar [138]	06-Sep-96		138	1995–1996
Thorium-230	D	51/51	-0.1	0.08	0.4	Field well, Cedar [138]	06-Aug-98	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	34/34	0	0.06	0.3	house well, Cedar [140]	05-May-99		138, 140, 174, 224	1995–2000
	T	1/1	0.1	0.1	0.1	Field well, Cedar [138]	06-Sep-96		138	1996

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** For all but one sample, the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available

pCi/L – picocuries per liter
S – suspended
T – total

Table 24. Groundwater sampling data (chemicals) from Well 138

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	8/57	0.05	0.23*	0.13	18-Dec-90	10 (c-EMEG, child)	1981, 1988–1995
Ammonia	N	10/42	0.02	0.29	0.9	23-Aug-88	30 (LTHA)	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	NA	1995
Cadmium	D	0/1	ND	ND	ND	--	0.002 (c-EMEG, child)	1995
Chloride	N/T**	199/199	5.5	70	450	12-Aug-80	250 (Secondary MCL)	1975, 1976, 1978–2000
Copper	D	0/1	ND	ND	ND	--	0.1 (i-EMEG, child)	1995
Iron	D	21/106	0.01	0.025	0.31	09-Mar-95	26 (RBC)	1981–2000
Manganese	D	21/107	0.01	0.008§	0.06	11-Jun-91	0.5 (RMEG, child)	1979, 1981–2000
Molybdenum	D	253/253	1.1	8.0	56.7	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	1968–1973, 1975, 1976, 1978–2000
Nickel	D	0/1	ND	ND	ND	--	0.2 (RMEG, child)	1995
Nitrate	N/T**	59/62	0.7	2.3	4.1	11-Jun-91	10 (MCL)	1988–2000
Selenium	D	102/151	0.001	0.011	0.134†	13-Jul-81	0.05 (c-EMEG, child)	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	200/200	71	1,059	23,200‡	01-Nov-78	250 (Secondary MCL)	1975, 1976, 1978–2000
Total Dissolved Solids	N/T**	202/202	290	1,530	4,373	06-Mar-81	500 (Secondary MCL)	1980–2000

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Uranium	D	253/253	0.0005	**0.73**	**5.161**	01-Aug-68	0.03 (MCL)	1968, 1974–1976, 1978–2000
	S	3/18	0.007	0.016	**0.26**	27-May-97		1995–2000
Vanadium	D	0/1	ND	ND	ND	--	0.03 (i-EMEG, child)	1995
Zinc	D	0/1	ND	ND	ND	--	3 (c-EMEG, child)	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
§ The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
† Only three of 151 samples were above the CV.
‡ The maximum concentration appears to be an outlier. The next highest concentration is 3,360 mg/L in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 25. Groundwater sampling data (radionuclides) from Well 138

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	21/21	-0.2	0.22	1.1	03-Aug-95	NA	1995–2000
	S	18/18	0	0.08	0.2	27-May-97, 06-Feb-98, 29-Jul-99, 19-Oct-99		1995–2000
	T	1/1*	0	0	0	06-Sep-96		1996
Polonium-210	D	21/21	0	0.28	0.9	04-May-99	NA	1995–2000
	S	18/18	0	0.11	0.4	28-Aug-00		1995–2000
	T	1/1	0.5	0.5	0.5	06-Sep-96		1996
Radium-226	D	19/19	0	0.13	0.4	21-Mar-96	5 (MCL radium-226/228)	1995–2000
	S	18/18	0	0.006	0.1	30-Oct-95		1995–2000
	T	2/2	0	0.05	0.1	06-Sep-96		1995, 1996
Thorium-230	D	20/20	0	0.07	0.4	06-Aug-98	NA	1995–2000
	S	17/17	0	0.04	0.2	04-May-99, 29-Jul-99		1995–2000
	T	1/1	0.1	0.1	0.1	06-Sep-96		1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is “Y” even though the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended
T – total

Table 26. Surface soil sampling data (chemicals) from eight zones around the Cotter Mill and from Lincoln Park

Chemical		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (ppm)
Arsenic	Range (ppm)	**33–69**	**19–39**	**14–42**	**10–40**	**16–38**	**17–60**	**17–33**	**19–86**	**13–50**	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	**45**	**30**	**25**	**26**	**28**	**35**	**26**	**42**	**31**	
Beryllium	Range (ppm)	0.5–1.6	0.5–0.9	0.6–1	0.5–1.2	0.6–1.7	0.5–0.7	0.6–0.7	0.5–0.9	0.5–1.7	100 (c-EMEG, child)
	Frequency of Detection	9/10	11/12	9/12	10/10	6/8	8/8	4/4	7/8	72/73	
	Average (ppm)	0.8	0.7	0.7	0.6	0.7	0.6	0.7	0.6	0.7	
Cadmium	Range (ppm)	**1.2–15**	**2.1–13**	**2.2–16**	2.5–6.8	**5.3–18**	**8.9–110**	**1.6–20**	**4.4–51**	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	68/73	
	Average (ppm)	6.9	6.4	6.4	4.1	9.8	**36.5**	7.9	**21.1**	1.4	
Lead	Range (ppm)	43–270	45–240	46–260	47–130	100–280	**68–800**	**37–450**	**61–1,400**	17–270	400 (SSL)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	132	104	113	74	173	380	201	**445**	120	
Manganese	Range (ppm)	180–480	320–630	200–500	110–750	150–420	140–400	200–370	210–770	290–640	3,000 (RMEG , child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	336	422	356	391	298	268	290	439	424	
Selenium	Range (ppm)	5–7	39	7–16	5	ND	ND	ND	7	5–44	300 (c-EMEG, child)
	Frequency of Detection	5/10	1/12	2/12	1/10	0/8	0/8	0/4	1/8	7/73	
	Average (ppm)	4.2*	5.5*	4*	2.8*	ND	ND	ND	3.1*	3.5*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
See Figure for a map of the sampling zones.

* The calculated averages are lower than the minimum detected concentrations due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Table 27. Surface soil sampling data (radionuclides) from eight zones around the Cotter Mill and from Lincoln Park

Radionuclide		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (pCi/g)
Lead-210	Range (pCi/g)	1.6–9.7	3.0–14.4	2.5–6.0	2.3–4.5	2.6–6.1	2.7–4.9	1.2–4.4	1.5–4.7	0.7–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.3	8.2	4.1	3.4	4.4	3.9	2.9	2.6	2.1	
Radium-226	Range (pCi/g)	2.4–10.7	3.6–16.5	1.3–5.7	1.4–2.3	2.5–5.6	1.9–3.0	1.4–1.9	1.2–2.2	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.6	9.2	2.6	1.8	3.9	2.5	1.7	1.5	1.5	
Thorium-230	Range (pCi/g)	3.6–35.3	5.8–40.1	1.6–21.7	1.8–4.4	4.3–12.1	3.6–8.3	1.7–2.8	1.6–11.9	1.0–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	17.7	20.9	5.9	2.5	7.7	5.2	2.4	3.3	1.7	
Uranium, natural	Range (pCi/g)	0.871–4.288	1.541–5.427	0.737–5.628	0.737–1.64	1.005–2.412	0.6432–1.943	0.5561–1.005	0.536–1.206	0.6566–3.417	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	2.45	3.29	1.98	1.17	1.52	1.21	0.83	0.73	1.215	
Uranium-234	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Radionuclide		**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone F**	**Zone G**	**Zone H**	**Lincoln Park**	**CV (pCi/g)**
Uranium-238	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
See Figure for a map of the sampling zones.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 28. Surface soil sampling data (radionuclides) from the county road and the Cotter Uranium Mill access road

Radionuclide		Samples from background areas	Samples along the county road	Samples along the access road*	CV
Radium-226	Range (pCi/g)	0.8–2.1	3.8–14	2.7–**351**	5 pCi/g (UMTRCA, surface)
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	1.42	7.7	**65**	
Thorium-230	Range (pCi/g)	0.2–2.4	9.7–25	10–395	NA
	Frequency of Detection	3/5	5/5	6/6	
	Average (pCi/g)	1.53	20	87	
Uranium, natural	Range (ppm)	1.18–3.05	5.28–29.2	4.31–**922**	100 ppm (i-EMEG, child for highly soluble salts)
	Frequency of Detection	5/5	5/5	6/6	
	Average (ppm)	1.87	13.6	**161**	
Uranium-238**	Range (pCi/g)	0.39–1.01	1.74–9.64	1.42–304	NA
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	0.62	4.5	53	
Gamma Exposure Rates	Range (µR/hr)	NA	13.8–55.3	18.6–893	NA
	Frequency of Detection	NA	NA	NA	
	Average (µR/hr)	15.7	25.8	73.7	

Source: MFG 2005

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Each sample consists of 10 aliquots taken from 0–6 inches within a 100 m^2 area.
See Figure for a map of the sampling locations.

*There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.
**Uranium-238 concentrations were calculated by multiplying the natural uranium concentrations by 0.33.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
µR/hr – microroentgen per hour
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 29. Soil data (chemicals) from samples taken by CDPHE, January 2003

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	CV (ppm)
Lead	20/20	23	**410**	**3,651***	Private barn in Lincoln Park (dust sample)	400 (SSL)
Molybdenum	0/20	ND**	ND**	ND**	--	300 (RMEG , child)
Uranium	20/20	1.2	6.0	31	Mill Entrance Road	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

*The second highest lead concentration is 908 ppm from a location northwest of the Cotter Mill.
**The molybdenum detection limit was 25 ppm.
§ Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Concentrations from the Background Location§

Lead	36 ppm
Molybdenum	ND
Uranium	1.3 ppm

Table 30. Soil data (radionuclides) from samples taken by CDPHE, January 2003

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Location of Maximum	CV (pCi/g)
Cesium-137	20/20	0	0.64	1.33	Private residence in Lincoln Park (dust sample)	NA
Lead-210	20/20	1.9	9.7	22.8	East of the Cotter Mill	NA
Plutonium-239, 240	9/20	0.03	0.03*	0.06	East of the Cotter Mill & a private residence in Lincoln Park (dust sample)	NA
Potassium-40	20/20	17.6	22.6	31.9	East of the Cotter Mill	NA
Radium-226	20/20	1.4	7.8	21.2	East of the Cotter Mill	15 (UMTRCA, subsurface)
Radium-228	20/20	0.6	1.0	1.3	Private barn in Lincoln Park (dust sample), private residence in Lincoln Park (dust sample), Pine St near Elm Ave in Lincoln Park (sediment sample), Northwest of the Cotter Mill	15 (UMTRCA, subsurface)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

* The calculated average is the same as the minimum detected concentration due to including ½ the detection limit in the calculation.
** Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Concentrations from the Background Location**

Cesium-137	0.2 pCi/g
Lead-210	3.2 pCi/g
Plutonium-239, 240	ND
Potassium-40	19.5 pCi/g
Radium-226	1.9 pCi/g
Radium-228	1.0 pCi/g

Table 31. Surface soil sampling data from 10 air monitoring locations

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Date of Maximum	Years Sampled	CV (ppm)
Molybdenum	106/134	0.6	15.1	251.3	AS-204 (West Boundary)	2002	1992–2006*	300 (RMEG, child)
Radionuclide	**Frequency of Detection**	**Minimum (pCi/g)**	**Average (pCi/g)**	**Maximum (pCi/g)**	**Location of Maximum**	**Date of Maximum**	**Years Sampled**	**CV (pCi/g)**
Radium-224**	10/10	-5.7	-2.9	0.3	Lincoln Park	2006	2006	5 (UMTRCA, surface)
Radium-226	246/251	<0.5	3.9	**53.5**	AS-209 (Mill Entrance Road)	2002	1979–2006†	5 (UMTRCA, surface)
Thorium-230	107/107	0.4	22.2	354	AS-209 (Mill Entrance Road)	2002	1996–2006	NA
Thorium-232	60/60	0.5	1.4	7.9	AS-209 (Mill Entrance Road)	2002	2001–2006	NA
Uranium	258/262	<0.001	4.6	73.6	AS-209 (Mill Entrance Road)	2002	1979–2006	NA

Source: Cotter 2007; GeoTrans 1986

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Uranium and radium-226 were also tested in soil from two additional off-site locations (Oro Verde #1 and Oro Verde #2) in 1983 and 1984.
See Figure for a map of the air monitoring locations.

*Data from 2006 are unavailable.
**Data are blank corrected.
†Results from 2005 were not reported based on quality assurance analysis (Cotter 2007).

CV – comparison value
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
RMEG – reference dose media evaluation guide
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 32. Soil sampling data (chemicals) from location AS-212 (the Nearest Resident)

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Date of Maximum	Years Sampled	CV (ppm)
Lead	1/1	199	199	199	15-Jan-03	2003	400 (SSL)
Molybdenum	7/8	1.6	11.3	42.4	2005	1999–2005	300 (RMEG , child)
Uranium	1/1	4.9	4.9	4.9	15-Jan-03	2003	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2007b, Cotter 2007

Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for the location of AS-212, the nearest resident.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 33. Soil sampling data (radionuclides) from location AS-212 (the Nearest Resident)

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Date of Maximum	Years Sampled	CV (pCi/g)
Cesium-137	1/1	0.61	0.61	0.61	15-Jan-03	2003	NA
Lead-210	1/1	8	8	8	15-Jan-03	2003	NA
Plutonium-239, 240	1/1	0.03	0.03	0.03	15-Jan-03	2003	NA
Potassium-40	1/1	17.7	17.7	17.7	15-Jan-03	2003	NA
Radium-224*	1/1	-3.6	-3.6	-3.6	2006	2006	5 (UMTRCA, surface)
Radium-226	8/8	1.4	3.3	7.5	2004	1999–2004, 2006	5 (UMTRCA, surface)
Radium-228	1/1	0.9	0.9	0.9	15-Jan-03	2003	5 (UMTRCA, surface)
Thorium-230	8/8	3.3	10.1	20	2004	1999–2006	NA
Thorium-232	6/6	0.7	1.0	1.1	2001, 2002	2001–2006	NA
Uranium	8/8	2.0	5.2	13	2004	1999–2006	NA

Source: CDPHE 2007b, Cotter 2007

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
See Figure for the location of AS-212, the nearest resident.

*Data are blank corrected.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 34. Surface soil sampling data (chemicals) from lawns and gardens in Lincoln Park

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Years Sampled	CV (ppm)
Arsenic	15/15	31	**44**	**50**	garden soil	1996	0.5 (CREG), 20 (c-EMEG, child)
Beryllium	14/15	0.5	0.7	1.1	lawn soil	1996	100 (c-EMEG, child)
Cadmium	14/15	0.5	1.2	1.9	lawn soil	1996	10 (c-EMEG, child)
Manganese	15/15	290	428	640	lawn soil	1996	3,000 (RMEG , child)
Selenium	1/32	18	1.7*	18	garden soil	1990, 1996	300 (c-EMEG, child)

Source: Weston 1996 (some or all of these data may also be included in Table)

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
ppm – parts per million
RMEG – reference dose media evaluation guide

Table 35. Surface soil sampling data (radionuclides) from yards, gardens, and air monitoring locations in Lincoln Park

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Source of Maximum	Years Sampled	CV (pCi/g)
Lead-210	17/17	0.4	1.6	2.5	0–2” garden sample	1990	NA
Polonium-210	17/17	1.1	1.7	2.6	0–2” garden sample	1990	NA
Radium-226	19/19	0.8	1.5	2.0	0–2” garden sample	1987, 1988, 1990	5 (UMTRCA, surface)
Thorium-228	17/17	1.0	1.4	1.8	0–2” garden sample	1990	NA
Thorium-230	17/17	1.0	1.5	2.3	0–2” garden sample	1990	NA
Uranium-234	29/29	0.355	1.23	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA
Uranium-235	0/17	ND*	ND*	ND*	--	1990	NA
Uranium-238	29/29	0.355	1.21	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA

Source: Weston 1996

*The uranium-235 detection limit was 0.2 pCi/g.

CV – comparison value
LPWUS – Lincoln Park Water Use Survey
NA – not available
ND – not detected
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 36. Surface soil data (chemicals) from lawns and gardens in Lincoln Park

Chemical		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (ppm)
Arsenic	Range (ppm)	14–50	13–38	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	36*	28*	
Beryllium	Range (ppm)	0.5–1.1	0.6–1.7	100 (c-EMEG, child)
	Frequency of Detection	25/26	47/47	
	Average (ppm)	0.7	0.8	
Cadmium	Range (ppm)	0.6–1.9	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	23/26	45/47	
	Average (ppm)	1.2	1.5**	
Lead	Range (ppm)	17–270[†]		400 (SSL)
	Frequency of Detection	73/73[†]		
	Average (ppm)	122	121	
Manganese	Range (ppm)	290–640	320–580	3,000 (RMEG , child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	430	421**	
Molybdenum	Range (ppm)	*Data not available*[§]	*Data not available*[§]	300 (RMEG , child)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	1.7*	0.5*	
Selenium	Range (ppm)	18	5–44	300 (c-EMEG, child)
	Frequency of Detection	1/26	6/47	
	Average (ppm)	3.1	3.8	
Uranium	Range (ppm)	*Data not available*[§]	*Data not available*[§]	100 (i-EMEG, child for highly soluble salts)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	2.3*	1.6*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The concentrations were statistically higher in irrigated soil samples.
**The calculated averages for cadmium and manganese differ slightly from the reported mean concentrations in Table 3-3.
[†] The raw data for lead are not presented by whether the samples were taken from locations irrigated with contaminated well water. However, Table 3-3 presents the mean concentrations by manner of irrigation.
[§] The raw data for molybdenum and uranium are not presented in the report. Therefore, the range and frequency of detection could not be determined. Table 3-3 presents the mean concentrations.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Table 37. Surface soil data (radionuclides) from lawns and gardens in Lincoln Park

Radionuclide		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (pCi/g)
Lead-210	Range (pCi/g)	0.8–3.0	0.7–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	2.2	2.1*	
Radium-226	Range (pCi/g)	1.3–1.7	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.4	1.5	
Thorium-230	Range (pCi/g)	1.1–2.2	1.0–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.6*	1.7	
Uranium, natural	Range (pCi/g)	0.871–3.417	0.6566–2.077	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	1.514	1.05	
Uranium-234	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	
Uranium-238	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	

Source: Weston 1998

The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The calculated averages for lead-210 and thorium-230 differ slightly from the reported mean concentrations in Table 3-3.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 38. Sediment sampling data (chemicals) from Sand Creek

Chemical	Location Concentration (ppm)						CV (ppm)
	SD01	SD02*	SD04			SD05	
			1	2	3		
Arsenic	NA	13.7	13	NA	17	<5	20 (c-EMEG, child)
Cadmium	NA	3.9	7.2	NA	7.6	1.5	10 (c-EMEG, child)
Cobalt	NA	11.3	43	NA	21	10	500 (i-EMEG, child)
Copper	19	52.3	46	NA	38	19	500 (i-EMEG, child)
Lead	27	106	93	NA	130	22	400 (SSL)
Molybdenum	4.4	2.6	8	NA	7.9	9.4	300 (RMEG , child)
Nickel	NA	17	63	NA	28	18	1,000 (RMEG, child)
Zinc	NA	343	540	NA	580	106	20,000 (c-EMEG, child)

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
    (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
    (2) in drainage (reflects historical picture of uncontrolled emissions)
    (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that chemical.
Samples were collected July 10–20, 1985.

*Values are the mean of three field replicates.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Table 39. Sediment sampling data (radionuclides) from Sand Creek

Radionuclide	Location Average (pCi/g)						CV
	SD01	SD02	SD04			SD05	
			1	2	3		
Gross Alpha	22±3	47±9	240±40	74±9	39±7	22±5	NA
Gross Beta	29±6	43±8	90±20	34±7	32±7	32±6	NA
Radium-226	1.21±0.06	1.7±1	**12.8±0.6**	3.5±0.2	3.4±0.2	2.3±1	5 (UMTRCA, surface)
Throium-230	4.6±0.3	34±2	82±4	32±2	15.5±0.8	5.2±0.3	NA
Total Uranium	2.4	4.3	11.7	3.4	3.4	3.9	NA

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
  (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
  (2) in drainage (reflects historical picture of uncontrolled emissions)
  (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that radionuclide.
Samples were collected July 10–20, 1985.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 40. Chemical sampling for the Sand Creek Cleanup Project

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	CV (ppm)
Arsenic	7/7	2.7	3.9	6.9	20 (c-EMEG, child)
Barium	7/7	69	106	160	10,000 (c-EMEG, child)
Beryllium	7/7	0.2	0.3	0.6	100 (c-EMEG, child)
Chromium	7/7	7.4	9.5	12.8	200 (RMEG, child for hexavalent chromium)
Lead	7/7	17	35	75	400 (SSL)
Manganese	7/7	258	343	502	3,000 (RMEG , child)
Molybdenum	7/7	2.1	2.8	3.5	300 (RMEG , child)
Nickel	7/7	8	10.9	16	1,000 (RMEG , child)
Selenium	0/7	ND*	ND*	ND*	300 (c-EMEG, child)
Vanadium	7/7	16.1	20.3	26.1	200 (i-EMEG, child)

Source: Cotter 2000

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Samples were collected in April and May 1998.

*The selenium detection limit was 5 ppm.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 41. Surface water sampling data (chemicals) from Sand Creek

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/2	ND	ND	ND	--	10 (c-EMEG, child)	1988
Ammonia	N	2/35	0.5	0.43*	0.8	10-Nov-88	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T**	92/92	3	8	14	13-May-04	250 (Secondary MCL)	1986–2007
Iron	D	21/55	0.03	0.04	0.26	07-Nov-02	26 (RBC)	1986–1988, 1995–2007
Manganese	D	36/55	0.0084	0.04	**1.3**[†]	19-Nov-01	0.5 (RMEG, child)	1986–1988, 1995–2007
Molybdenum	D	98/104	0.005	0.02	**0.051**[†]	01-Dec-87	0.035 (SS); 0.05 (RMEG, child)	1986–2007
Nitrate	N/T**	75/87	0.5	1.1	4.7	03-May-06	10 (MCL)	1988–2007
Selenium	D	0/8	ND	ND	ND	--	0.05 (c-EMEG, child)	1986–1988
Sulfate	N/T**	94/94	12	65	**310**[†]	11-Oct-96	250 (Secondary MCL)	1986–2007
Total Dissolved Solids	N/T**	99/99	10.7	369	**1,372**[‡]	22-Aug-91	500 (Secondary MCL)	1986–2007
Uranium	D	101/101	0.006	0.012	0.0267	01-Aug-95	0.03 (MCL)	1986–2007
	S	8/48	0.000098	0.001	0.0031	10-Jan-00		1995–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
[†] Only the maximum concentration was above the CV.
[‡] This appears to be an outlier. The next highest concentration is 460 mg/L. Only the maximum concentration was above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 42. Surface water sampling data (radionuclides) from Sand Creek

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	40/49	-0.2	0.39	3.7	06-Aug-07	NA	1995–2007
	S	40/49	-0.1	0.40	4.6	06-Aug-07		1995–2007
Polonium-210	D	41/49	-0.1	0.15	0.6	28-Nov-06	NA	1995–2007
	S	40/49	0	0.13	1.6	09-Nov-99		1995–2007
Radium-226	D	45/49	0	0.12	0.6	03-May-06	5 (MCL radium-226/228)	1995–2007
	S	42/47	0	0.06	0.4	09-Nov-99, 28-Nov-06		1995–2007
Thorium-230	D	44/49	-0.1	0.13	0.8	28-Nov-06	NA	1995–2007
	S	41/46	0	0.16	0.9	06-Aug-07		1995–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 43. Surface water sampling data (chemicals) from the DeWeese Dye Ditch

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	1/4	0.02	0.06*	0.02	14-Jun-95	10 (c-EMEG, child)	1981, 1995
Ammonia	N	0/2	ND	ND	ND	--	30 (LTHA)	1989, 1995
Chloride	N/T**	95/102	2	7	18	08-May-01	250 (Secondary MCL)	1981–1989, 1995–2007
Iron	D	22/50	0.029	0.9	**43**[†]	09-Jun-99	26 (RBC)	1981–1987, 1995–2007
Manganese	D	28/50	0.004	0.05	**1.9**[‡]	09-Jun-99	0.5 (RMEG, child)	1981–1987, 1995–2007
Molybdenum	D	10/120	0.001	0.013[§]	0.013	06-Aug-03	0.035 (SS); 0.05 (RMEG, child)	1981–2007
Nitrate	N/T**	7/26	0.1	0.3	0.8	10-May-00, 02-Aug-06	10 (MCL)	1989, 1995–2007
Selenium	D	4/76	0.005	0.003[††]	0.011	22-Jun-87, 25-Apr-88	0.05 (c-EMEG, child)	1981–1988, 1995
Sulfate	N/T**	102/102	6	31	95	28-Apr-82	250 (Secondary MCL)	1981–1989, 1995–2007
Total Dissolved Solids	N/T**	119/119	12.9	231	**1,647**[‡‡]	10-Sep-90	500 (Secondary MCL)	1981–2007
Uranium	D	86/116	0.0004	0.01	**0.11**[§§]	05-May-83	0.03 (MCL)	1981–2007
	S	0/8	ND	ND	ND	--		1996–1999

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
[†] This appears to be an outlier. The next highest concentration is 0.24 mg/L from the same location in 2003. Only the maximum concentration was above the CV.
[‡] Only the maximum concentration was above the CV.
[§] The calculated average is the same as the maximum detected concentration due to including ½ the detection limit in the calculation.

[††] The calculated average is the lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
[‡‡] This appears to be an outlier. The next highest concentration is 870 mg/L. Only three of the 119 samples were above the CV.
[§§] Only three of the samples were above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 44. Surface water sampling data (radionuclides) from the DeWeese Dye Ditch

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	8/8	0	0.3	1.2	09-May-96	NA	1996–1999
	S	8/8	0	0.09	0.2	12-May-97		1996–1999
Polonium-210	D	8/8	0	0.1	0.2	09-Jun-99, 02-Sep-99	NA	1996–1999
	S	8/8	0	0.05	0.2	09-Jun-99		1996–1999
Radium-226	D	8/8	0	0.04	0.1	09-May-96, 16-Jul-96, 02-Sep-99	5 (MCL radium-226/228)	1996–1999
	S	7/7	0	0.01	0.1	02-Sep-99		1996–1999
Thorium-230	D	8/8	0	0.025	0.2	12-May-97	NA	1996–1999
	S	7/7	0	0.07	0.2	09-Sep-98		1996–1999

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 45. Surface water sampling data (chemicals) from the Arkansas River

Chemical	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (mg/L)
Chloride	T	Range (mg/L)	3–60	3–14	250 (Secondary MCL)
		Frequency of Detection	127/130	127/130	
		Average (mg/L)	8	8	
Molybdenum	D	Range (mg/L)	0.0029–**0.046**	0.003–0.029	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	32/142	46/142	
		Average (mg/L)	0.025	0.025	
Molybdenum	S	Range (mg/L)	0.0019–0.022	0.0017–0.016	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	8/135	6/135	
		Average (mg/L)	0.025	0.025	
Molybdenum	T	Range (mg/L)	0.006	0.005	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	1/7	1/7	
		Average (mg/L)	0.003*	0.003*	
Sulfate	T	Range (mg/L)	10–**1,300****	5–**4,200****	250 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	41	84	
Total Dissolved Solids	T	Range (mg/L)	45–**2,880**†	62–337	500 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	172	192	
Uranium	D	Range (mg/L)	0.0003– 0.0135	0.0002–0.0155	0.03 (MCL)
		Frequency of Detection	129/130	130/130	
		Average (mg/L)	0.004	0.005	
Uranium	S	Range (mg/L)	0.0002– 0.014	0.0002–0.0043	0.03 (MCL)
		Frequency of Detection	16/121	14/121	
		Average (mg/L)	0.001	0.001	
Uranium	T	Range (mg/L)	0.0033–0.0056	0.0029–0.0054	0.03 (MCL)
		Frequency of Detection	7/7	7/7	
		Average (mg/L)	0.004	0.004	

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
All samples were collected between 1995 and 2007. The "T" samples for uranium were only collected in 1995.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** This appears to be an outlier. The next highest concentration is 200 mg/L. Only the maximum concentration was above the CV.
† This appears to be an outlier. The next highest concentration is 405 mg/L. Only the maximum concentration was above the CV.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
mg/L – milligrams per liter
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 46. Surface water sampling data (radionuclides) from the Arkansas River

Radionuclide	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (pCi/L)
Lead-210	D	Range (pCi/L)	ND	3.7	NA
		Frequency of Detection	0/1	1/1	
		Average (pCi/L)	ND	3.7	
Lead-210	S	Range (pCi/L)	ND	0	NA
		Frequency of Detection	0/1	1/2	
		Average (pCi/L)	ND	0.25*	
Polonium-210	D	Range (pCi/L)	ND	ND	NA
		Frequency of Detection	0/1	0/1	
		Average (pCi/L)	ND	ND	
Polonium-210	S	Range (pCi/L)	ND	0.26–3.3	NA
		Frequency of Detection	0/1	2/2	
		Average (pCi/L)	ND	1.8	
Radium-226	D	Range (pCi/L)	0–0.6	0–0.4	5 (MCL radium-226/228)
		Frequency of Detection	119/128	116/127	
		Average (pCi/L)	0.13	0.07	
Radium-226	S	Range (pCi/L)	0–0.8	0–2.3	5 (MCL radium-226/228)
		Frequency of Detection	114/120	112/119	
		Average (pCi/L)	0.08	0.09	
Radium-226	T	Range (pCi/L)	0.1–0.7	0.1–0.7	5 (MCL radium-226/228)
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.3	
Thorium-230	D	Range (pCi/L)	-0.1–1	-0.1–1.2	NA
		Frequency of Detection	121/127	116/127	
		Average (pCi/L)	0.1	0.1	
Thorium-230	S	Range (pCi/L)	0–2.5	0–2.4	NA
		Frequency of Detection	115/120	113/119	
		Average (pCi/L)	0.2	0.2	
Thorium-230	T	Range (pCi/L)	0.1–0.7	0–0.6	NA
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.2	

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Radium-226 and thorium-230 “D” and “S” samples were collected between 1995 and 2007. The radium-226 and thorium-230 “T” samples were only collected in 1995. Lead-210 and polonium-210 were sampled upstream (907) in 2005 (“D” and “S”) and downstream (904) in 2005 (“D”) and 2006 (“D” and “S”).

* The calculated average is higher than the detected concentration due to including ½ the detection limit in the calculation.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
ND – not detected
pCi/L – picocuries per liter
S – suspended
T – total

Table 47. Sampling data (chemicals) for local and supermarket foods

Chemical	Food Type	Average (mg/kg)	
		Local	Supermarket
Barium*	Vegetables	4.75	NA
Cadmium*	Vegetables	0.215	NA
Chromium*	Vegetables	0.095	NA
Manganese*	Vegetables	11.25	NA
Molybdenum	Chicken	0.19	0.72
	Fruits	0.079	0.017
	Vegetables	0.667	0.023
Selenium	Chicken	0.31	0.18
	Fruits	0.024	0.017
	Vegetables	0.061	0.020
Strontium*	Vegetables	22	NA
Uranium	Chicken	0.061	0.001
	Fruits	0.0056	0.0013
	Vegetables	0.0043	0.0013
Vanadium*	Vegetables	0.105	NA
Zinc*	Vegetables	7.5	NA

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
Vegetables were also tested for arsenic, beryllium, cobalt, lead, mercury, nickel, and silver, but none of these chemicals were detected.

*Chicken and fruits were not analyzed for these chemicals.

NA – not available
mg/kg – milligrams per kilogram

Table 48. Sampling data (radionuclides) for local and supermarket foods

Radionuclide	Food Type	Average (pCi/kg)	
		Local	Supermarket
Lead-210	Chicken	1.26	1.70
	Fruits	1.48	1.18
	Vegetables	0.58	0.60
Polonium-210	Chicken	3.79	21.75
	Fruits	2.26	1.30
	Vegetables	1.13	1.56
Radium-226	Chicken	0.64	2.60
	Fruits	1.34	0.05
	Vegetables	1.37	0.07
Thorium-228	Chicken	0.39	ND
	Fruits	0.33	ND
	Vegetables	0.41	1.42
Thorium-230	Chicken	1.01	0.53
	Fruits	1.85	ND
	Vegetables	0.27	0.29
Uranium-234	Chicken	1.10	1.05
	Fruits	1.53	0.34
	Vegetables	0.55	0.76
Uranium-235	Chicken	ND	0.36
	Fruits	0.13	0.13
	Vegetables	0.13	0.14
Uranium-238	Chicken	1.59	0.53
	Fruits	1.41	0.23
	Vegetables	0.44	0.25

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.

ND – not detected
pCi/kg – picocuries per kilogram

Table 49. Sampling data (chemicals) for local produce irrigated with contaminated well water

Chemical		Fruits	Vegetables
Arsenic	Frequency of Detection	2/16	14/43
	Average (mg/kg)	0.051	0.077
	Maximum (mg/kg)	0.2	0.4
Barium	Frequency of Detection	7/16	33/43
	Average (mg/kg)	0.44	1.6
	Maximum (mg/kg)	0.9	15
Cadmium	Frequency of Detection	2/16	18/43
	Average (mg/kg)	0.041	0.034
	Maximum (mg/kg)	0.23	0.14
Chromium	Frequency of Detection	12/16	39/43
	Average (mg/kg)	0.052	0.056
	Maximum (mg/kg)	0.1	0.19
Cobalt	Frequency of Detection	0/16	6/43
	Average (mg/kg)	ND	0.02
	Maximum (mg/kg)	ND	0.07
Lead	Frequency of Detection	3/16	26/43
	Average (mg/kg)	0.13	0.2
	Maximum (mg/kg)	1.2	1.9
Manganese	Frequency of Detection	16/16	43/43
	Average (mg/kg)	0.87	2.4
	Maximum (mg/kg)	1.8	11
Molybdenum	Frequency of Detection	6/16	41/43
	Average (mg/kg)	0.11	0.68
	Maximum (mg/kg)	0.3	9.8
Nickel	Frequency of Detection	0/16	2/43
	Average (mg/kg)	ND	0.075
	Maximum (mg/kg)	ND	0.2
Strontium	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.6	4.9
	Maximum (mg/kg)	8.5	33
Uranium	Frequency of Detection	3/16	14/43
	Average (mg/kg)	0.0074	0.0071
	Maximum (mg/kg)	0.035	0.041
Vanadium	Frequency of Detection	0/16	16/43
	Average (mg/kg)	ND	0.046
	Maximum (mg/kg)	ND	0.21

Chemical		Fruits	Vegetables
Zinc	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.4	3.1
	Maximum (mg/kg)	4.0	10

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

ND – not detected
mg/kg – milligrams per kilogram

Table 50. Sampling data (radionuclides) for local produce irrigated with contaminated well water

Radionuclide		Fruits	Vegetables
Lead-210	Frequency of Detection	3/16	8/43
	Average (pCi/kg)	12	21
	Maximum (pCi/kg)	21	51
Radium-226	Frequency of Detection	1/16	15/43
	Average (pCi/kg)	5.7	6.2
	Maximum (pCi/kg)	18	41
Thorium-230	Frequency of Detection	1/16	8/43
	Average (pCi/kg)	3.9	5.1
	Maximum (pCi/kg)	10	20
Uranium (natural)	Frequency of Detection	3/16	14/43
	Average (pCi/kg)	5.0	4.8
	Maximum (pCi/kg)	23	27

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
pCi/kg – picocuries per kilogram

Table 51. Characteristics of Cotter Mill's Ambient Air Monitoring Stations

Monitor Code	*Monitor Location*	*Years of Operation*	*Monitor Type*	*Area Description*
AS-202	East Boundary	1979 – present	Perimeter	Eastern perimeter of Cotter Mill facility
AS-203	South Boundary	1979 – present	Perimeter	Southern perimeter of Cotter Mill facility
AS-204	West Boundary	1979 – present	Perimeter	Western perimeter of Cotter Mill facility
AS-206	North Boundary	1981 – present	Perimeter	Northern perimeter of Cotter Mill facility
AS-209	Mill entrance road	1994 – present	Perimeter	Entrance road to Cotter Mill
AS-210	Shadow Hills Estates	1997 – present	Off-site	Near Shadow Hills Golf Club
AS-212	Nearest resident	1999 – present	Off-site	Residential
LP-1/LP-2	Lincoln Park	1980 – present	Off-site	Residential
CC-1/CC-2	Cañon City	1979 – present	Off-site	Residential
OV-3	Oro Verde	1981 – present	Off-site	Remote (1 mile west of AS-204)

Notes: Both the Lincoln Park and Cañon City monitoring stations moved locations in the 1991-1992 time frame. The original station in Lincoln Park (LP-1) operated from 1980 to 1992, and the new station (LP-2) operated from 1991 to the present. The original station in Cañon City (CC-1) operated from 1979 to 1992, and the new station (CC-2) operated from 1991 to the present.

Table 52. Average Annual ^{nat}U Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	6.19E-15	1.50E-15	2.26E-15	--	--	--	--	--	1.00E-15	--
1980	3.71E-15	1.55E-15	2.82E-15	--	--	--	--	8.36E-16	1.40E-15	--
1981	4.07E-15	1.54E-15	5.28E-15	8.30E-15	--	--	--	1.03E-15	1.02E-15	1.37E-15
1982	2.31E-15	1.26E-15	2.48E-14	2.79E-15	--	--	--	5.28E-16	4.79E-16	5.96E-16
1983	1.26E-15	1.43E-15	1.32E-15	1.63E-15	--	--	--	4.77E-16	6.86E-16	5.03E-16
1984	5.50E-16	7.64E-16	8.36E-16	1.52E-15	--	--	--	2.78E-16	3.27E-16	4.01E-16
1985	1.42E-15	1.22E-15	8.96E-16	1.92E-15	--	--	--	4.56E-16	5.77E-16	6.66E-16
1986	6.71E-16	6.56E-16	4.05E-16	9.36E-16	--	--	--	2.95E-16	2.93E-16	4.84E-16
1987	8.08E-16	1.03E-15	1.09E-15	1.05E-15	--	--	--	4.66E-16	5.12E-16	4.60E-16
1988	6.73E-16	6.96E-16	9.03E-16	5.51E-16	--	--	--	1.85E-16	1.95E-16	1.89E-16
1989	9.58E-17	9.95E-17	2.86E-16	3.62E-17	--	--	--	8.37E-17	9.38E-17	6.38E-17
1990	5.59E-17	3.14E-17	1.06E-16	3.10E-17	--	--	--	6.18E-17	1.26E-16	9.09E-17
1991	1.12E-16	9.18E-17	2.65E-16	1.24E-16	--	--	--	1.70E-16	1.73E-16	2.60E-16
1992	6.55E-17	7.84E-17	1.12E-16	6.48E-17	--	--	--	9.71E-17	9.40E-17	8.23E-17
1993	7.13E-17	9.08E-17	1.61E-16	6.30E-17	--	--	--	8.26E-17	1.20E-16	2.55E-16
1994	1.25E-16	4.68E-17	1.00E-16	3.68E-17	1.55E-16	--	--	9.68E-17	8.12E-17	2.54E-16
1995	2.99E-16	5.86E-17	1.53E-16	5.23E-17	2.11E-16	--	--	9.34E-17	1.26E-16	4.83E-16
1996	2.25E-16	1.43E-16	2.26E-16	8.62E-17	2.44E-16	7.89E-17	--	9.73E-17	1.25E-16	5.93E-17
1997	1.23E-16	1.18E-16	2.20E-16	1.19E-16	1.51E-16	1.75E-16	--	1.27E-16	2.00E-16	9.48E-17
1998	1.32E-16	1.02E-16	3.29E-16	1.06E-16	2.27E-15	2.32E-16	--	8.13E-17	7.50E-17	2.43E-16
1999	4.06E-16	1.49E-16	2.91E-16	3.23E-16	1.46E-15	2.82E-16	4.59E-16	1.16E-16	9.41E-17	7.97E-17
2000	4.33E-16	2.04E-16	2.61E-16	1.63E-16	1.49E-15	1.89E-16	4.82E-16	5.39E-17	5.33E-17	5.39E-17
2001	4.96E-16	6.19E-16	4.96E-16	5.29E-16	1.32E-15	2.06E-16	2.88E-16	4.96E-17	3.80E-17	5.18E-17
2002	6.50E-16	4.93E-16	6.21E-16	3.24E-16	9.91E-16	3.69E-16	4.05E-16	2.46E-16	1.59E-16	2.05E-16
2003	3.55E-16	2.19E-16	2.55E-16	2.01E-16	4.91E-16	2.21E-16	2.20E-16	2.11E-16	2.07E-16	2.62E-16
2004	2.51E-16	1.95E-16	2.40E-16	1.99E-16	6.27E-16	1.40E-16	2.30E-16	9.69E-17	9.68E-17	8.61E-17
2005	4.54E-16	2.77E-16	2.87E-16	1.58E-16	3.97E-15	4.85E-16	5.25E-16	1.68E-16	1.29E-16	1.23E-16
2006	5.14E-16	2.68E-16	3.24E-16	2.12E-16	1.72E-15	6.62E-16	3.40E-16	2.20E-16	1.75E-16	1.87E-16
2007	3.56E-16	1.51E-16	2.03E-16	1.39E-16	3.13E-16	1.46E-16	1.33E-16	1.41E-16	1.43E-16	1.27E-16
2008	4.36E-16	8.61E-17	1.72E-16	8.44E-17	2.17E-16	9.77E-17	9.78E-17	9.02E-17	8.97E-17	6.43E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2.

For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; “--” indicates that no data are available because the station was not yet operating.

Table 53. Average Annual ^{230}Th Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.33E-15	1.05E-15	8.08E-15	--	--	--	--	--	3.07E-16	--
1980	2.50E-16	8.76E-16	2.81E-16	--	--	--	--	8.17E-17	1.30E-16	--
1981	2.60E-15	3.50E-15	3.00E-14	6.93E-15	--	--	--	1.42E-16	8.17E-17	3.92E-16
1982	2.12E-14	1.94E-14	8.95E-14	1.26E-14	--	--	--	7.49E-16	9.18E-16	3.15E-15
1983	5.86E-15	9.79E-15	5.64E-15	8.26E-15	--	--	--	3.74E-16	3.12E-16	1.07E-15
1984	1.64E-15	2.98E-15	3.82E-15	6.35E-15	--	--	--	2.69E-16	2.00E-16	2.89E-16
1985	1.84E-15	2.15E-15	4.86E-15	3.73E-15	--	--	--	2.60E-16	2.64E-16	2.84E-16
1986	3.70E-15	5.55E-15	3.13E-15	4.68E-15	--	--	--	3.70E-16	3.08E-16	2.41E-16
1987	1.21E-15	1.29E-15	2.28E-15	1.08E-15	--	--	--	2.06E-16	1.77E-16	9.90E-17
1988	2.58E-15	3.51E-15	5.85E-15	2.05E-15	--	--	--	1.41E-16	1.72E-16	1.70E-16
1989	6.33E-16	3.85E-16	9.17E-16	1.08E-16	--	--	--	8.93E-17	9.03E-17	9.24E-17
1990	7.63E-16	4.00E-16	5.86E-16	1.09E-16	--	--	--	7.40E-17	7.04E-17	7.20E-17
1991	7.25E-16	4.59E-16	8.75E-16	2.83E-16	--	--	--	1.91E-16	1.25E-16	1.33E-16
1992	4.57E-16	2.20E-16	4.71E-16	9.46E-17	--	--	--	6.58E-17	5.98E-17	9.56E-17
1993	4.45E-16	3.03E-16	6.42E-16	9.32E-17	--	--	--	1.06E-16	9.17E-17	2.33E-16
1994	1.18E-15	2.96E-16	1.08E-15	1.24E-16	9.20E-16	--	--	1.54E-16	1.16E-16	2.83E-16
1995	1.65E-15	5.33E-16	1.24E-15	1.18E-16	8.88E-16	--	--	9.80E-17	1.12E-16	3.30E-16
1996	2.21E-15	2.95E-16	8.13E-16	8.85E-17	7.67E-16	2.33E-16	--	7.11E-17	5.08E-17	6.39E-17
1997	7.64E-16	1.31E-16	6.17E-16	6.49E-17	1.99E-15	3.82E-16	--	8.37E-17	7.86E-17	3.24E-17
1998	2.88E-15	2.02E-16	9.34E-16	1.15E-16	2.17E-15	3.32E-16	--	7.70E-17	7.99E-17	7.82E-17
1999	3.76E-15	3.24E-16	1.09E-15	1.84E-16	2.19E-15	4.15E-16	3.02E-16	7.37E-17	9.51E-17	1.11E-16
2000	1.22E-15	2.48E-16	1.01E-15	2.02E-16	4.16E-15	4.71E-16	6.69E-16	1.47E-16	1.57E-16	1.27E-16
2001	8.20E-16	5.19E-16	9.67E-16	2.61E-16	4.15E-15	4.04E-16	4.61E-16	1.56E-16	9.95E-17	1.13E-16
2002	5.84E-16	2.76E-16	5.95E-16	2.57E-16	1.25E-15	2.38E-16	3.13E-16	8.15E-17	8.54E-17	8.55E-17
2003	5.19E-16	2.62E-16	4.90E-16	9.73E-17	1.40E-15	4.11E-16	1.77E-16	8.27E-17	8.91E-17	5.30E-17
2004	2.17E-16	8.26E-17	3.87E-16	8.33E-17	6.57E-16	2.26E-16	1.08E-16	5.36E-17	5.62E-17	6.07E-17
2005	3.17E-16	1.97E-16	3.51E-16	2.64E-16	3.41E-15	4.85E-16	4.81E-16	1.04E-16	1.05E-16	1.08E-16
2006	5.17E-16	2.91E-16	4.74E-16	1.77E-16	1.40E-15	4.73E-16	3.27E-16	2.73E-16	2.04E-16	2.85E-16
2007	6.62E-16	1.90E-16	4.32E-16	1.48E-16	1.05E-15	2.77E-16	2.23E-16	1.68E-16	1.57E-16	1.53E-16
2008	7.21E-16	1.87E-16	5.12E-16	1.32E-16	6.21E-16	2.88E-16	2.05E-16	1.11E-16	1.08E-16	1.16E-16

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating; bold cells are concentrations above Cotter Mill's regulatory limit

Table 54. Average Annual ^{232}Th Concentrations 2001-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP #2	CC #2	OV-3
2001	5.78E-17	7.62E-17	6.97E-17	6.37E-17	8.32E-17	4.58E-17	6.67E-17	6.85E-17	8.33E-17	5.68E-17
2002	4.67E-17	3.81E-17	3.09E-17	4.55E-17	4.34E-17	3.17E-17	3.35E-17	5.36E-17	3.51E-17	4.68E-17
2003	4.57E-17	4.14E-17	4.84E-17	2.06E-17	5.72E-17	4.61E-17	3.71E-17	6.21E-17	4.61E-17	3.96E-17
2004	1.39E-17	2.53E-17	2.53E-17	1.40E-17	1.57E-17	1.99E-17	1.65E-17	3.24E-17	2.28E-17	2.39E-17
2005	2.83E-17	2.40E-17	2.86E-17	3.09E-17	3.36E-17	2.53E-17	3.42E-17	3.99E-17	3.57E-17	3.45E-17
2006	4.11E-17	5.18E-17	4.82E-17	4.29E-17	5.54E-17	4.33E-17	4.79E-17	6.25E-17	4.98E-17	3.65E-17
2007	4.07E-17	3.47E-17	4.60E-17	4.14E-17	4.12E-17	3.99E-17	3.51E-17	5.43E-17	4.48E-17	3.92E-17
2008	1.08E-17	1.63E-17	1.15E-17	9.89E-18	1.57E-17	2.30E-17	1.26E-17	3.13E-17	2.25E-17	2.03E-17

Note: Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating

Table 55. Average Annual ^{226}Ra Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	1.55E-15	3.75E-16	7.89E-15	--	--	--	--	--	3.07E-16	--
1980	3.61E-15	7.81E-16	1.62E-15	--	--	--	--	2.78E-16	1.58E-15	--
1981	4.19E-15	2.35E-15	2.94E-15	2.96E-15	--	--	--	3.79E-16	4.59E-16	6.30E-16
1982	6.53E-15	6.92E-15	3.81E-15	3.82E-15	--	--	--	6.07E-16	4.02E-16	1.25E-15
1983	2.00E-15	5.08E-15	4.95E-15	2.85E-15	--	--	--	9.42E-17	1.76E-16	5.30E-16
1984	1.11E-15	1.84E-15	3.63E-15	2.20E-15	--	--	--	1.18E-16	1.67E-16	1.87E-16
1985	9.63E-15	1.11E-15	1.78E-15	1.97E-15	--	--	--	1.69E-16	1.88E-16	1.89E-16
1986	1.47E-15	1.98E-15	1.61E-15	2.60E-15	--	--	--	1.43E-16	3.45E-16	2.22E-16
1987	5.91E-16	7.52E-16	1.19E-15	4.74E-16	--	--	--	1.83E-16	1.15E-16	1.89E-16
1988	1.29E-15	2.05E-15	2.53E-15	3.60E-16	--	--	--	1.24E-16	5.09E-17	1.09E-16
1989	2.72E-16	1.81E-16	3.30E-16	4.79E-17	--	--	--	1.02E-16	8.89E-17	7.77E-17
1990	1.75E-16	1.68E-16	1.92E-16	4.36E-17	--	--	--	6.69E-17	8.36E-17	7.82E-17
1991	1.19E-16	1.25E-16	2.68E-16	6.17E-17	--	--	--	6.85E-17	7.16E-17	1.37E-16
1992	8.46E-17	7.30E-17	1.50E-15	3.71E-17	--	--	--	5.10E-17	5.80E-17	1.17E-16
1993	9.11E-17	1.14E-16	2.49E-16	5.99E-17	--	--	--	6.14E-17	6.72E-17	2.20E-16
1994	1.03E-16	7.57E-17	1.69E-16	4.96E-17	1.55E-16	--	--	7.80E-17	8.68E-17	2.64E-16
1995	1.21E-16	1.14E-16	2.07E-16	7.46E-17	2.06E-16	--	--	6.88E-17	1.05E-16	3.99E-16
1996	1.78E-16	1.02E-16	2.08E-16	5.33E-17	2.11E-16	5.82E-17	--	5.22E-17	6.67E-17	3.59E-17
1997	1.29E-16	7.55E-17	2.01E-16	5.66E-17	9.45E-16	1.06E-16	--	5.09E-17	5.40E-17	4.84E-17
1998	2.89E-16	8.22E-17	2.95E-16	9.43E-17	1.34E-15	1.21E-16	--	6.21E-17	6.71E-17	4.24E-17
1999	4.18E-16	1.29E-16	3.81E-16	1.02E-16	1.26E-15	1.46E-16	2.13E-16	8.27E-17	9.21E-17	5.90E-17
2000	3.37E-16	1.53E-16	4.64E-16	1.40E-16	2.38E-15	2.21E-16	4.60E-16	7.41E-17	4.64E-17	5.10E-17
2001	2.15E-16	2.09E-16	4.36E-16	1.38E-16	1.92E-15	1.51E-16	1.99E-16	7.01E-17	6.82E-17	5.16E-17
2002	1.55E-16	1.17E-16	2.34E-16	7.51E-17	3.83E-16	1.05E-16	1.14E-16	8.41E-17	6.07E-17	6.72E-17
2003	1.45E-16	1.10E-16	1.75E-16	8.02E-17	2.96E-16	1.23E-16	9.65E-17	9.70E-17	8.40E-17	8.93E-17
2004	7.81E-17	7.35E-17	1.41E-16	6.14E-17	3.30E-16	9.05E-17	8.14E-17	5.79E-17	6.26E-17	4.95E-17
2005	1.78E-16	1.56E-16	1.75E-16	1.97E-16	2.29E-15	2.49E-16	2.95E-16	1.08E-16	1.22E-16	9.58E-17
2006	4.10E-16	1.40E-16	2.17E-16	1.34E-16	7.52E-16	1.69E-16	1.42E-16	1.20E-16	1.03E-16	1.15E-16
2007	8.67E-16	1.11E-16	2.07E-16	1.00E-16	2.31E-16	1.16E-16	9.11E-17	1.09E-16	9.66E-17	1.11E-16
2008	7.92E-16	7.36E-17	2.00E-16	5.16E-17	1.78E-16	7.33E-17	5.71E-17	6.21E-17	5.91E-17	3.28E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2. Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 56. Average Annual ^{210}Pb Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.11E-14	1.65E-14	2.08E-14	--	--	--	--	--	2.30E-14	--
1980	1.81E-14	1.69E-14	1.25E-14	--	--	--	--	1.86E-14	1.98E-14	--
1981	2.01E-14	1.72E-14	4.71E-14	2.34E-14	--	--	--	1.57E-14	1.70E-14	2.11E-14
1982	3.87E-14	4.35E-14	9.95E-14	4.07E-14	--	--	--	2.50E-14	3.31E-14	4.05E-14
1983	1.70E-14	1.73E-14	1.82E-14	1.95E-14	--	--	--	1.29E-14	1.79E-14	1.44E-14
1984	1.44E-14	1.46E-14	1.60E-14	1.43E-14	--	--	--	1.26E-14	1.15E-14	1.48E-14
1985	9.12E-15	8.12E-15	8.80E-15	9.30E-15	--	--	--	9.97E-15	1.14E-14	9.90E-15
1986	1.26E-14	1.19E-14	1.12E-14	1.22E-14	--	--	--	1.07E-14	1.22E-14	8.81E-15
1987	1.95E-14	1.92E-14	2.22E-14	2.35E-14	--	--	--	2.17E-14	2.01E-14	1.43E-14
1988	2.15E-14	1.94E-14	2.10E-14	1.93E-14	--	--	--	2.04E-14	2.11E-14	1.76E-14
1989	2.28E-14	2.30E-14	1.98E-14	2.34E-14	--	--	--	2.43E-14	2.35E-14	2.40E-14
1990	2.05E-14	2.10E-14	2.07E-14	2.07E-14	--	--	--	2.24E-14	2.00E-14	1.95E-14
1991	2.40E-14	2.15E-14	2.15E-14	2.13E-14	--	--	--	2.23E-14	2.15E-14	1.07E-14
1992	2.16E-14	2.00E-14	2.20E-14	2.19E-14	--	--	--	1.99E-14	1.61E-14	2.20E-14
1993	2.38E-14	2.35E-14	2.35E-14	2.49E-14	--	--	--	2.22E-14	2.13E-14	2.10E-14
1994	2.21E-14	2.07E-14	2.10E-14	2.24E-14	2.18E-14	--	--	2.33E-14	2.38E-14	2.06E-14
1995	2.07E-14	2.07E-14	2.02E-14	2.01E-14	2.11E-14	--	--	1.97E-14	2.03E-14	1.74E-14
1996	2.02E-14	2.01E-14	2.16E-14	2.21E-14	2.11E-14	--	--	2.08E-14	1.96E-14	1.98E-14
1997	2.21E-14	2.07E-14	2.12E-14	2.20E-14	2.26E-14	2.05E-14	--	2.13E-14	2.00E-14	1.98E-14
1998	2.01E-14	2.07E-14	1.98E-14	2.11E-14	2.01E-14	1.93E-14	--	2.01E-14	2.01E-14	1.93E-14
1999	2.14E-14	1.94E-14	1.83E-14	1.84E-14	2.03E-14	1.94E-14	2.03E-14	2.03E-14	1.94E-14	1.78E-14
2000	2.07E-14	2.05E-14	2.01E-14	2.23E-14	2.37E-14	2.00E-14	2.07E-14	2.16E-14	2.08E-14	2.03E-14
2001	3.10E-14	3.04E-14	2.91E-14	3.11E-14	3.06E-14	2.94E-14	3.12E-14	3.06E-14	2.96E-14	2.79E-14
2002	2.36E-14	2.20E-14	2.28E-14	2.25E-14	2.30E-14	2.37E-14	2.40E-14	2.46E-14	2.33E-14	2.17E-14
2003	2.19E-14	2.11E-14	2.16E-14	2.06E-14	2.28E-14	2.12E-14	2.18E-14	2.11E-14	1.94E-14	2.27E-14
2004	1.72E-14	1.64E-14	1.58E-14	1.60E-14	1.66E-14	1.45E-14	1.79E-14	1.56E-14	1.54E-14	1.59E-14
2005	2.45E-14	2.74E-14	2.82E-14	2.54E-14	3.11E-14	2.91E-14	2.92E-14	3.11E-14	3.15E-14	2.94E-14
2006	2.11E-14	2.31E-14	2.47E-14	2.31E-14	2.09E-14	2.08E-14	1.89E-14	1.98E-14	1.89E-14	2.12E-14
2007	1.88E-14	1.64E-14	1.79E-14	1.82E-14	1.54E-14	1.58E-14	1.49E-14	1.66E-14	1.61E-14	1.72E-14
2008	1.65E-14	1.48E-14	1.64E-14	1.93E-14	1.66E-14	1.73E-14	1.57E-14	1.67E-14	1.61E-14	1.61E-14

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 57. ^{220}Rn/^{222}Rn Concentrations 2002-2008 (pCi/m^3)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
2002	543	975	1125	693	1475	700	698	875	673	625
2003	700	825	775	900	625	675	700	375	800	567
2004	1500	850	1025	950	1100	850	925	825	875	825
2005	925	1025	850	700	1025	675	775	700	900	800
2006	1250	1275	1275	1450	1400	1125	1275	1075	1375	1200
2007	1000	1100	1175	1100	1250	975	825	925	1175	975
2008	850	900	925	950	1075	950	850	800	925	825

Notes: Data are presented for only those years when measurements quantified combined levels of the two isotopes.
Shaded cells are the highest annual averages for the calendar year.

Table 58. Environmental TLD Measurements, 1979-2008 (μR/hr)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
1979	14.0	12.6	12.7	--	--	--	--	11.8	11.4	--
1980	13.4	11.7	12.9	--	--	--	--	10.4	11.4	--
1981	14.3	12.8	12.7	--	--	--	--	10.6	12.3	12.3
1982	13.7	12.6	14.7	20.4	--	--	--	9.9	11.2	12.7
1983	13.6	12.6	14.2	15.6	--	--	--	10.6	11.6	12.0
1984	14.5	14.3	14.6	14.8	--	--	--	12.3	11.2	13.2
1985	14.3	13.5	14.5	14.8	--	--	--	10.5	11.2	12.3
1986	13.9	13.7	14.5	14.2	--	--	--	11.0	10.7	11.8
1987	12.9	12.5	12.6	12.6	--	--	--	9.6	9.7	10.4
1988	15.0	13.6	12.8	13.4	--	--	--	9.3	11.6	10.2
1989	14.7	14.9	15.3	15.9	--	--	--	10.6	13.7	11.9
1990	13.2	13.1	14.8	15.2	--	--	--	9.6	11.5	11.7
1991	14.1	13.2	15.7	17.5	--	--	--	10.0	12.9	12.4
1992	13.7	13.2	16.0	18.3	--	--	--	9.6	12.1	11.3
1993	12.5	12.6	14.4	15.6	--	--	--	8.6	10.7	10.9
1994	14.3	13.8	15.9	16.2	27.8	--	--	10.8	12.1	12.3
1995	12.5	13.7	14.0	15.4	23.0	--	--	9.2	10.3	11.3
1996	13.1	13.2	14.5	16.2	27.2	13.0	--	9.7	10.9	11.4
1997	12.6	13.1	13.8	15.7	29.1	12.3	--	9.1	10.2	11.1
1998	12.3	12.0	13.4	15.9	28.0	12.0	--	9.0	10.3	11.5
1999	12.7	12.0	13.8	16.0	29.6	12.2	9.1	9.3	10.6	10.9
2000	12.7	12.6	14.7	16.6	27.7	12.5	9.3	9.5	10.7	11.4
2001	13.7	14.3	15.4	18.6	26.2	13.9	9.7	10.4	12.0	12.2
2002	14.0	14.4	15.9	17.7	30.3	14.3	10.5	10.5	12.3	12.6
2003	12.8	13.3	14.8	15.5	27.7	13.3	10.0	10.0	11.7	11.8
2004	13.6	14.1	15.5	14.7	25.5	14.2	10.9	10.5	12.2	12.5
2005	12.8	13.5	14.8	13.8	22.9	12.9	9.9	10.1	11.5	11.5
2006	12.7	13.4	14.6	14.2	21.5	12.6	9.5	10.1	11.5	11.7
2007	12.9	13.2	14.6	14.1	17.8	12.7	9.5	10.1	11.5	11.6
2008	13.9	13.5	15.5	14.9	18.7	13.3	10.2	10.8	12.2	12.6

Notes: Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 59. TSP Air Concentrations (μg/m^3) from 1969-1987

Year	Cañon City		Lincoln Park	
	Maximum	**Average**	**Maximum**	**Average**
1969	172	64.2	--	--
1970	200	55.9	--	--
1971	148	58.7	--	--
1972	240	69.9	--	--
1973	229	66.1	--	--
1974	187	58	--	--
1975	419	73.7	--	--
1976	174	56.8	--	--
1977	227	62.7	--	--
1978	313	84.7	--	--
1979	286	72.6	--	--
1980	304	70.4	--	--
1981	180	56.8	61*	8.2*
1982	525	84	228	51.7
1983	187	65.2	106	77.6
1984	571	70.9	--	--
1985	334	64.8	--	--
1986	402	66.3	--	--
1987	385	65.2	--	--

Notes: Data downloaded from EPA's Air Quality System database.
EPA's former annual average National Ambient Air Quality Standard for TSP was 75 μg/m^3.
* The TSP monitoring station in Lincoln Park started operating late in 1981; therefore, the statistics reported are not representative of the entire calendar year.

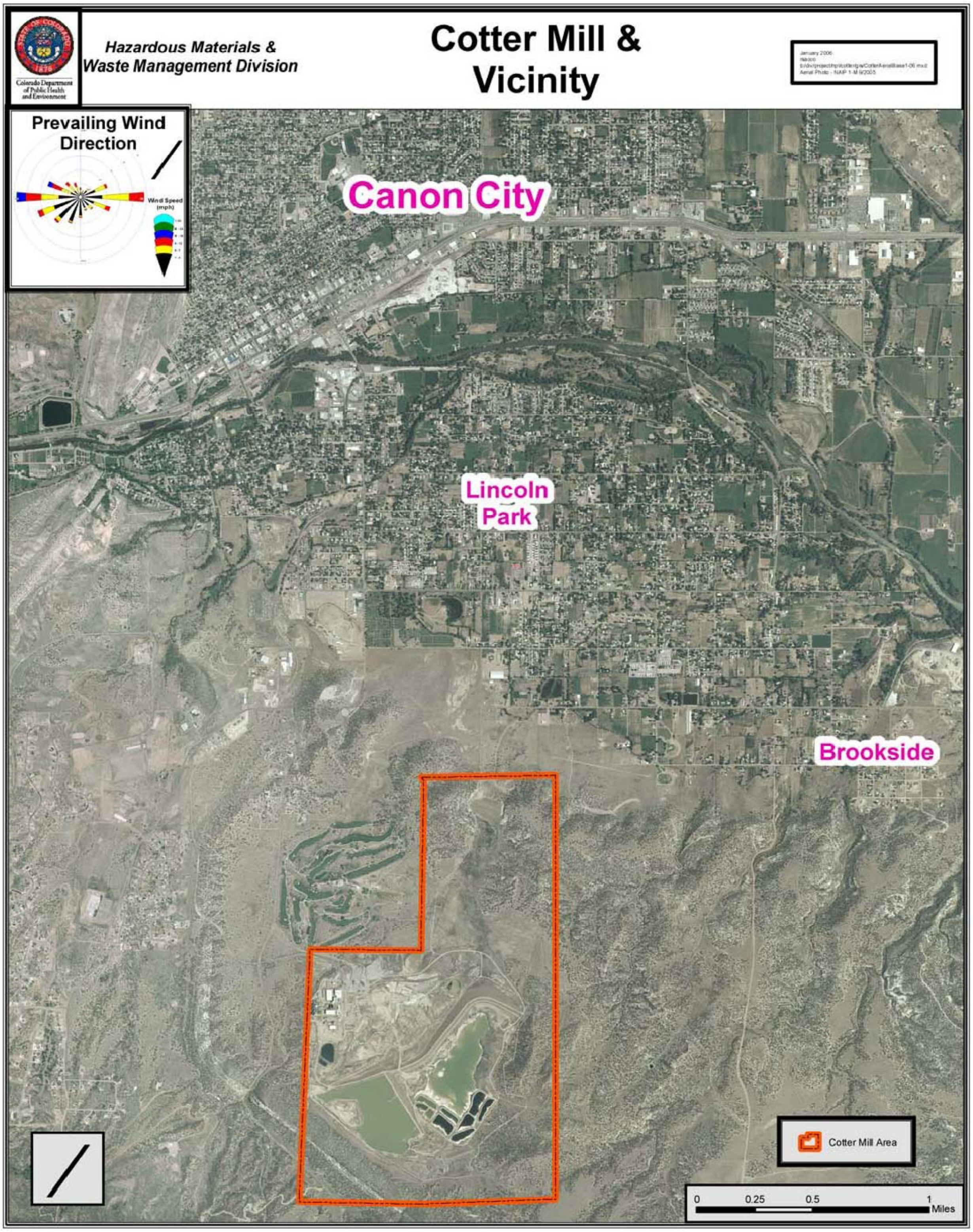
Table 60. Monitoring Data for Constituents in TSP (1978-1987)

Constituent	Location	Years of Data	Concentrations (μg/m^3)	
			Highest 24-Hour Average	**Highest Annual Average**
Iron	Lincoln Park	1981-1982	1.2	0.8
Lead	Lincoln Park	1981-1982	0.1	0.034
Manganese	Lincoln Park	1981-1982	0.03	0.0185
Nitrate	Cañon City	1978-1987	14.3	2.35
	Lincoln Park	1981-1982	4.7	1.81
Sulfate	Cañon City	1978-1987	18.4	5.99
	Lincoln Park	1981-1982	13	6.48
Zinc	Lincoln Park	1981-1982	0.04	0.0283

Notes Data downloaded from EPA's Air Quality System database.

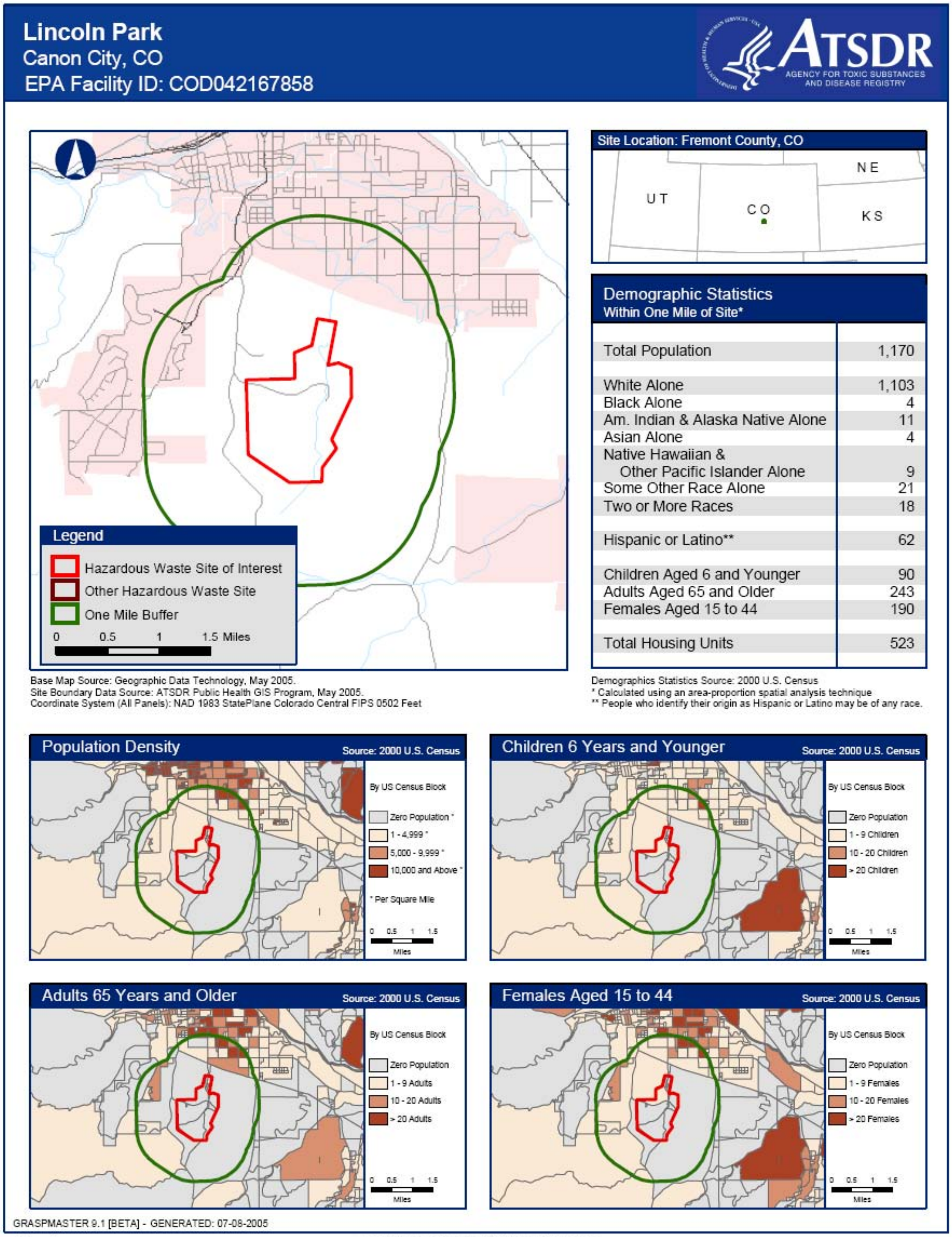
Appendix B - Site Figures

Figure 1. Location of the Cotter Mill, Lincoln Park, and Cañon City



Source: Galant et al. 2007

Figure 2. Demographics within 1 mile of the Cotter Mill property



Lincoln Park
Canon City, CO
EPA Facility ID: COD042167858

Site Location: Fremont County, CO

Demographic Statistics
Within One Mile of Site*

Total Population	1,170
White Alone	1,103
Black Alone	4
Am. Indian & Alaska Native Alone	11
Asian Alone	4
Native Hawaiian & Other Pacific Islander Alone	9
Some Other Race Alone	21
Two or More Races	18
Hispanic or Latino**	62
Children Aged 6 and Younger	90
Adults Aged 65 and Older	243
Females Aged 15 to 44	190
Total Housing Units	523

Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD 1983 StatePlane Colorado Central FIPS 0502 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

Population Density — Source: 2000 U.S. Census

Children 6 Years and Younger — Source: 2000 U.S. Census

Adults 65 Years and Older — Source: 2000 U.S. Census

Females Aged 15 to 44 — Source: 2000 U.S. Census

GRASPMASTER 9.1 [BETA] - GENERATED: 07-08-2005

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Figure 3. Wind Rose for Cotter Mill, 2008

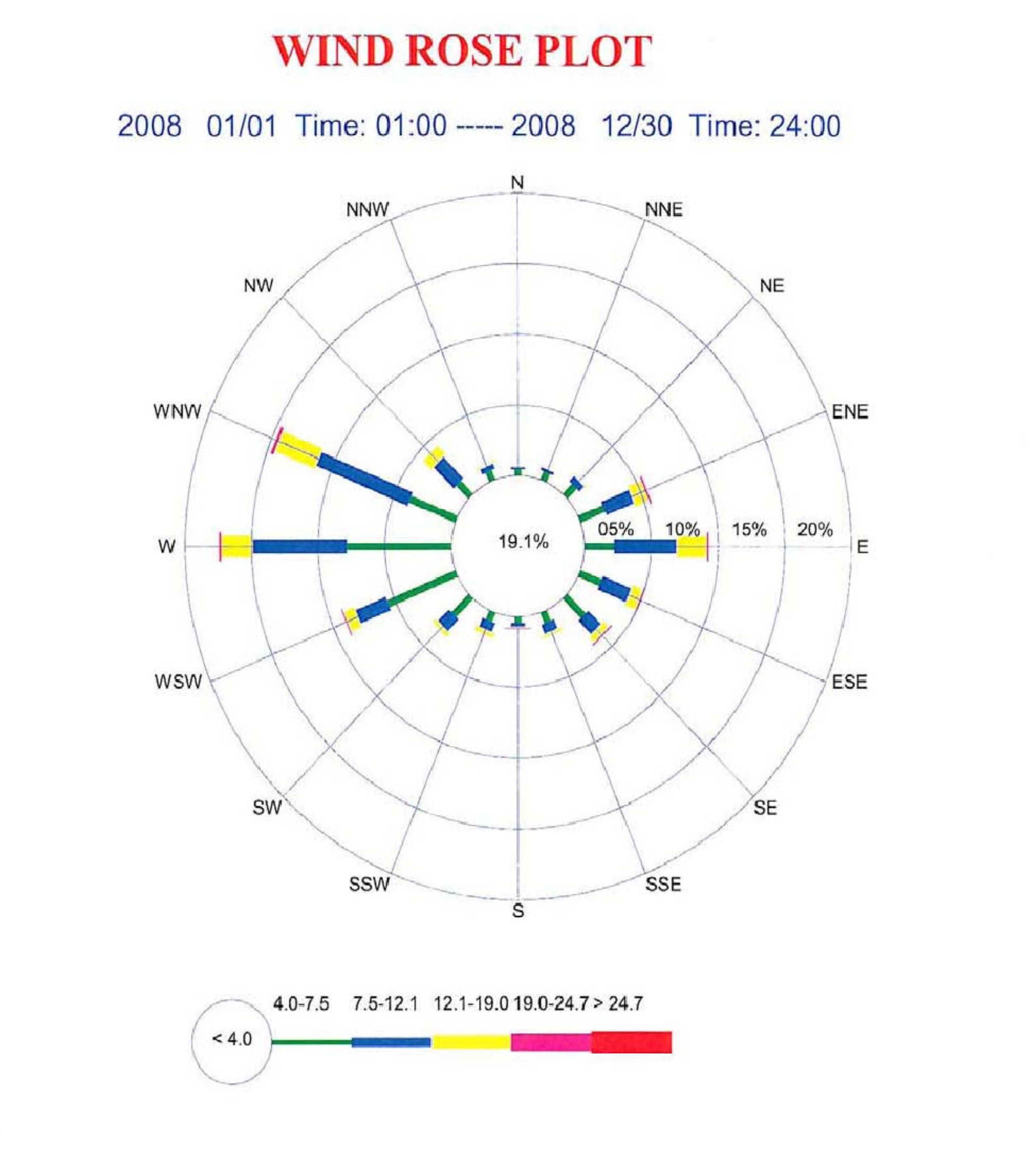
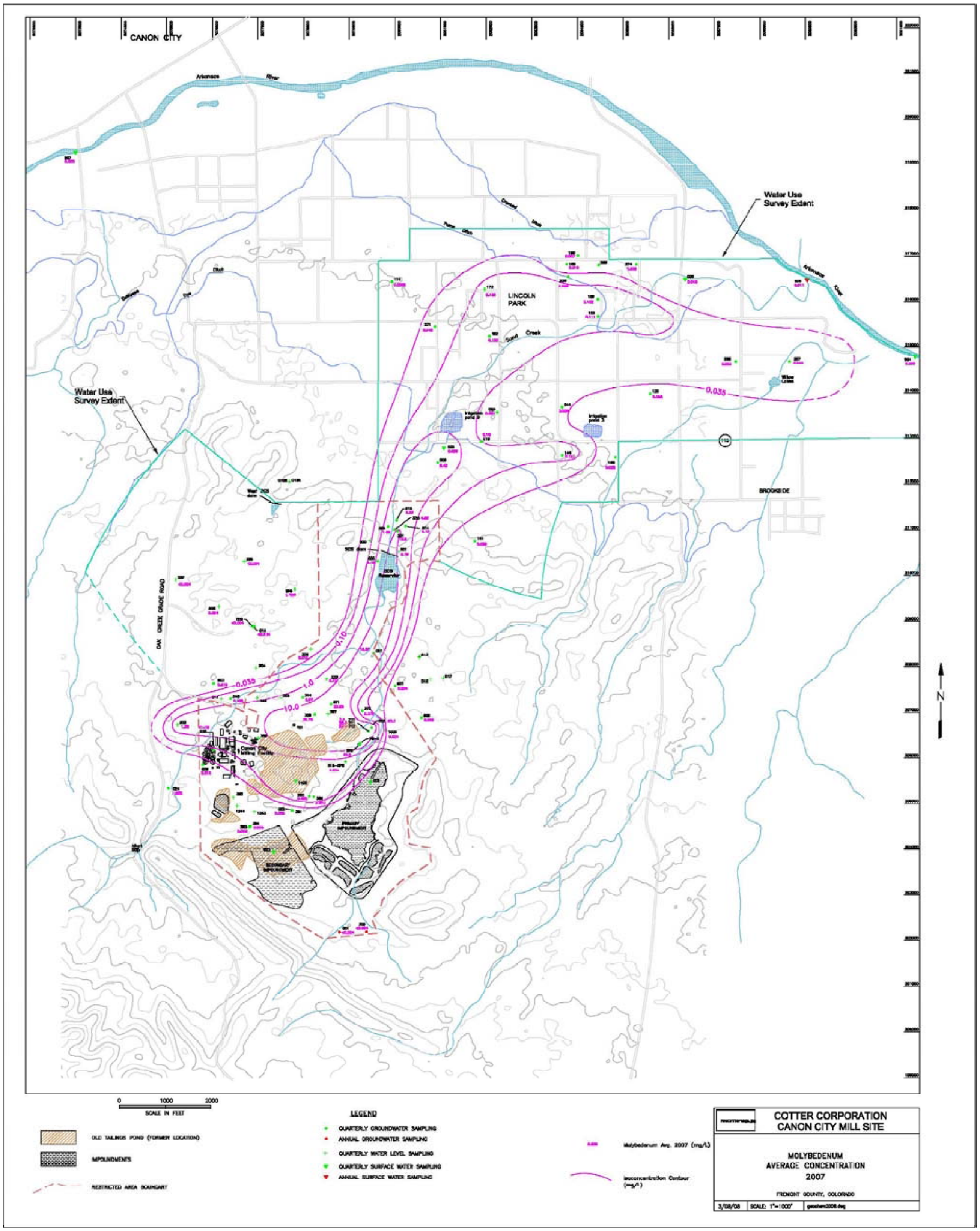
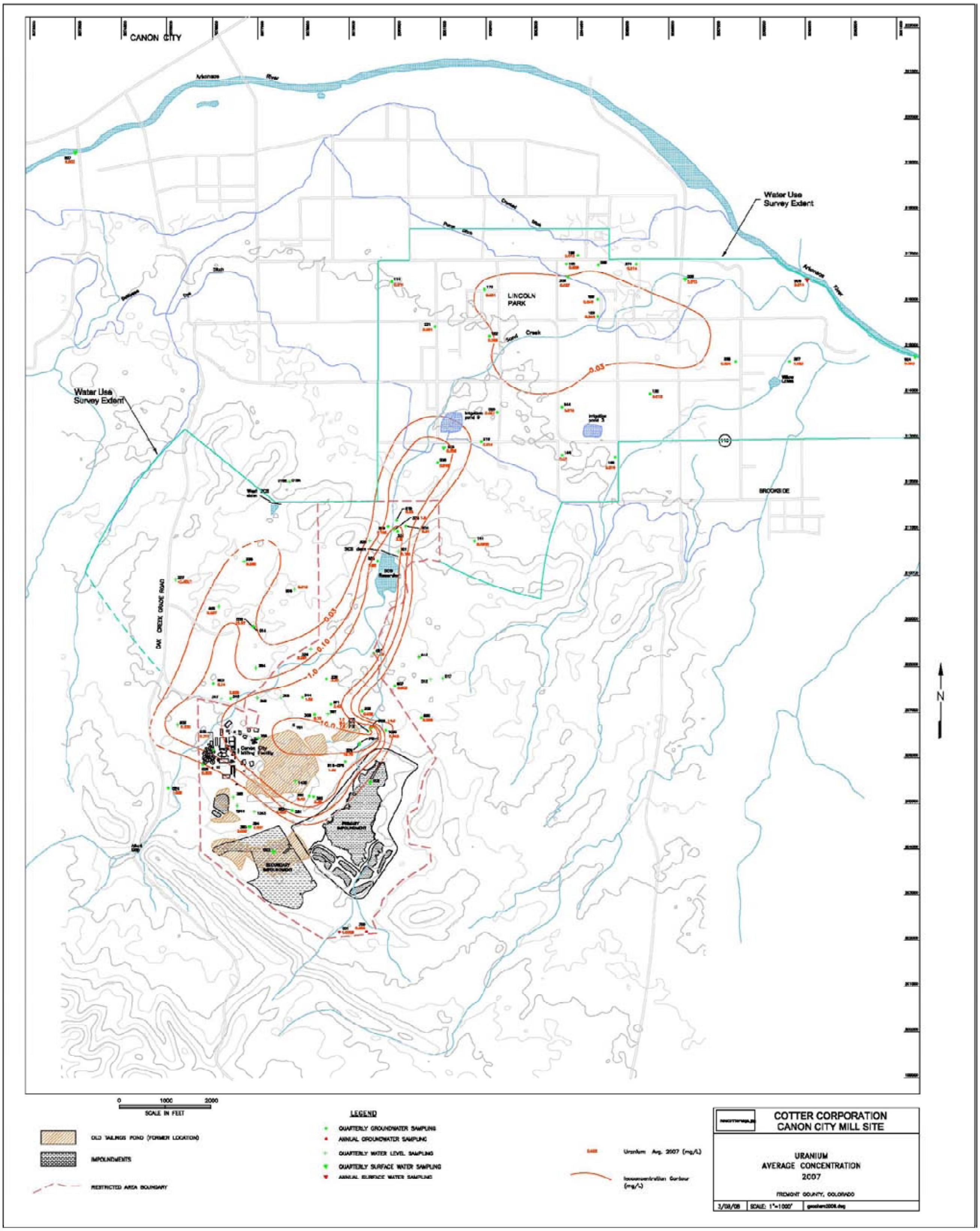


Figure 4. Molybdenum Plume Map



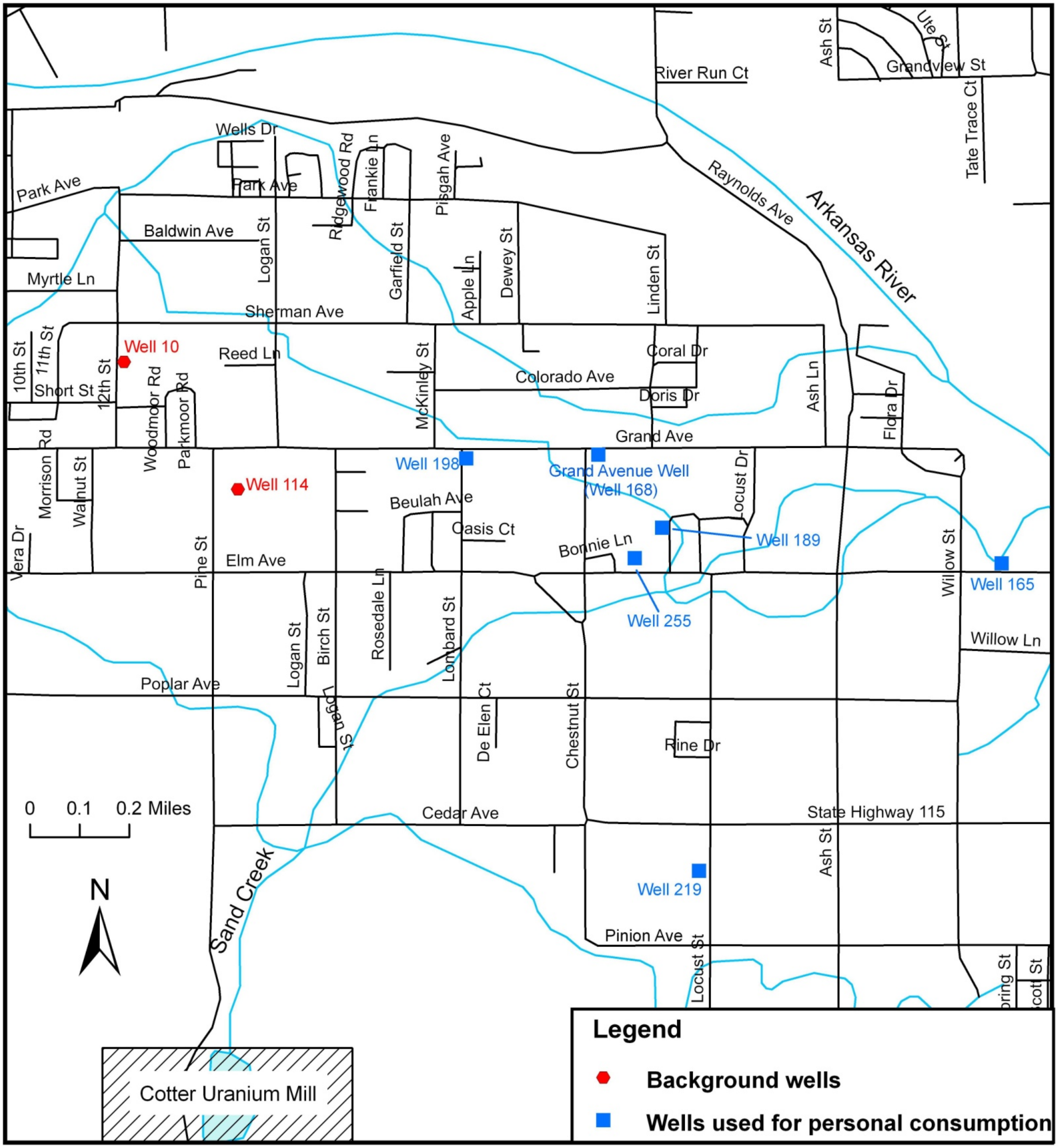
Source: Cotter 2008

Figure 5. Uranium Plume Map



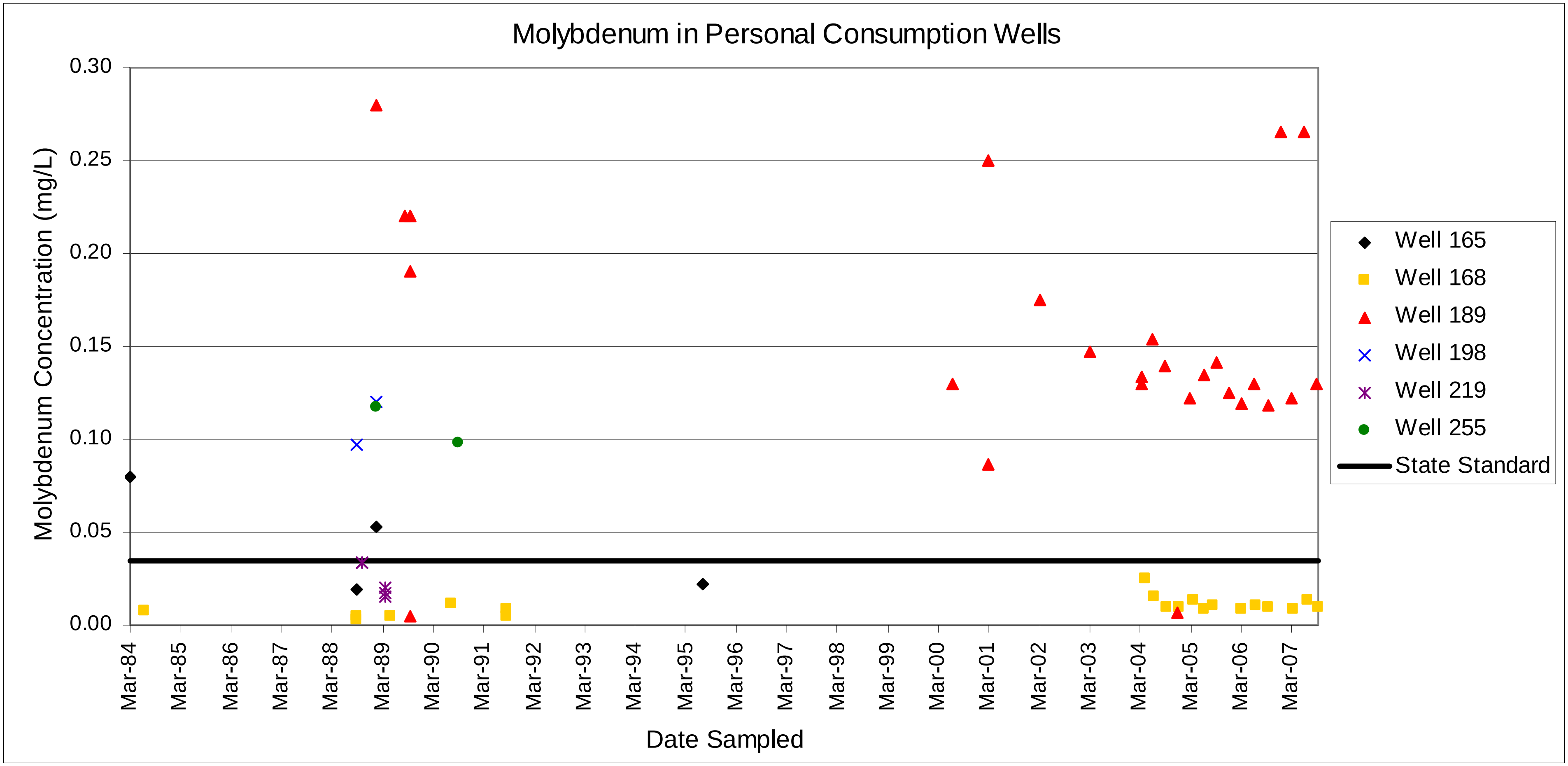
Source: Cotter 2008

Figure 6. Wells in Lincoln Park used for personal consumption



Source: CDPHE 2007b (coordinates)

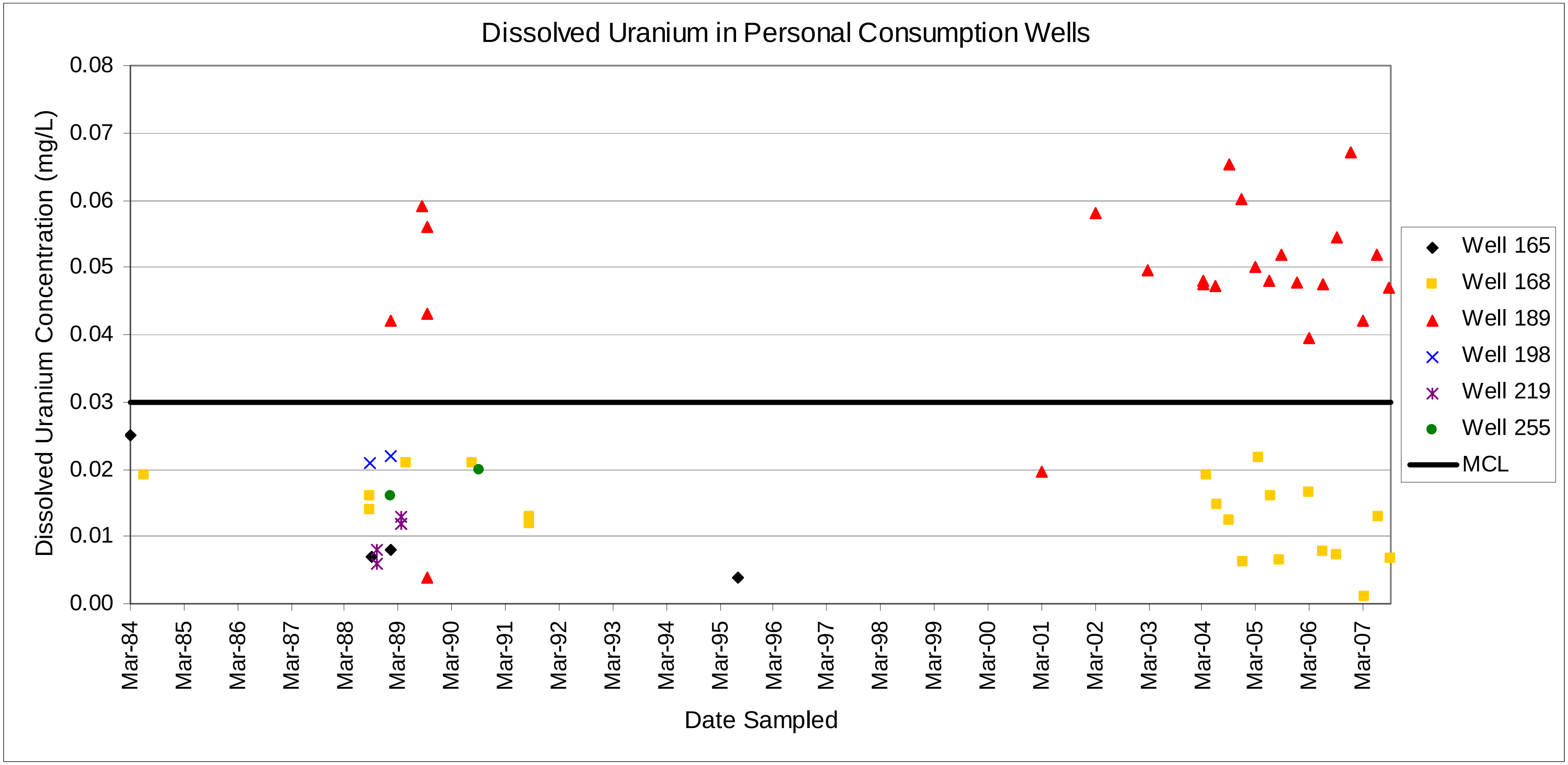
Figure 7. Molybdenum concentrations in wells used for personal consumption



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

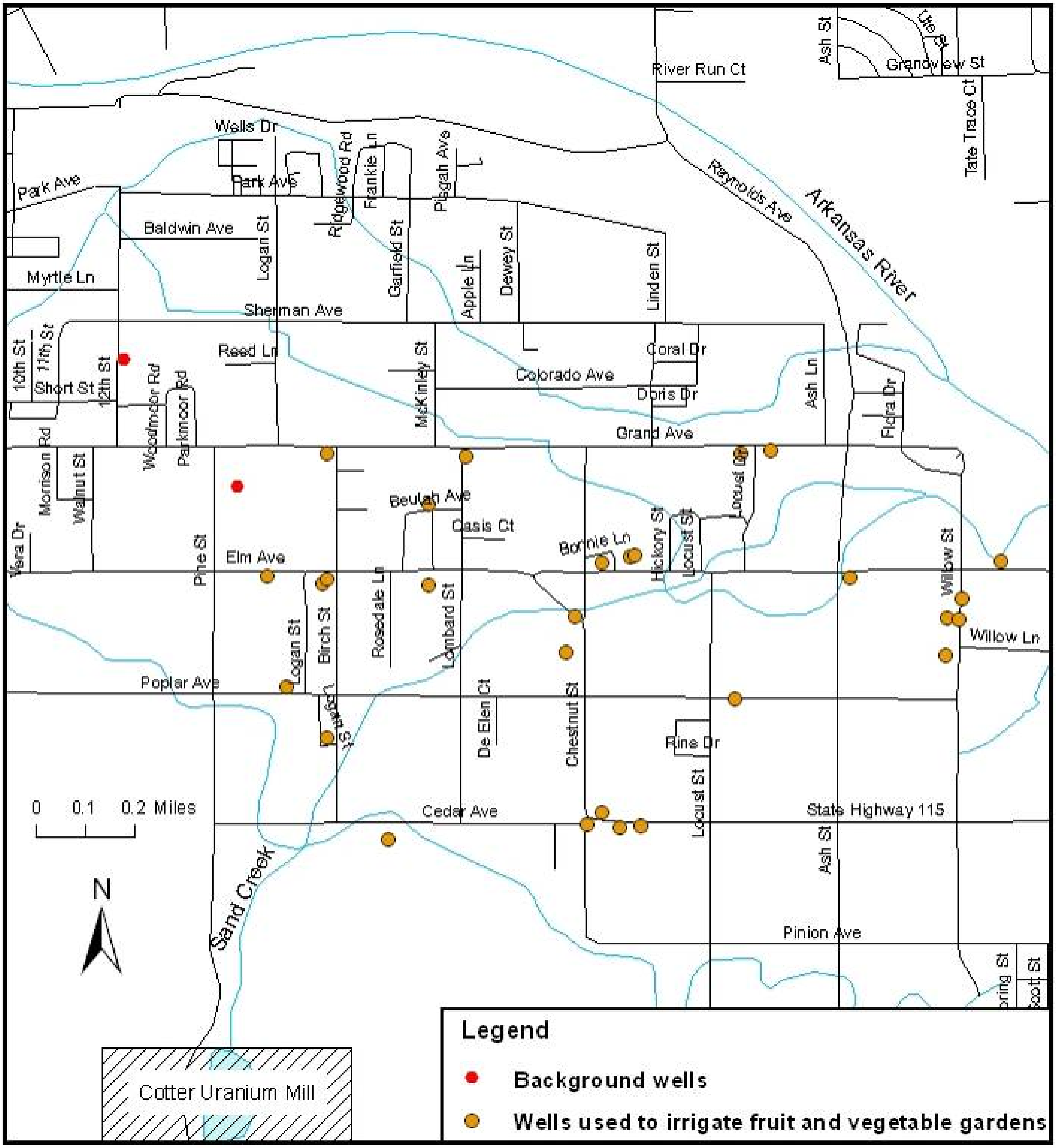
Figure 8. Dissolved uranium concentrations in wells used for personal consumption



Source: CDPHE 2007b

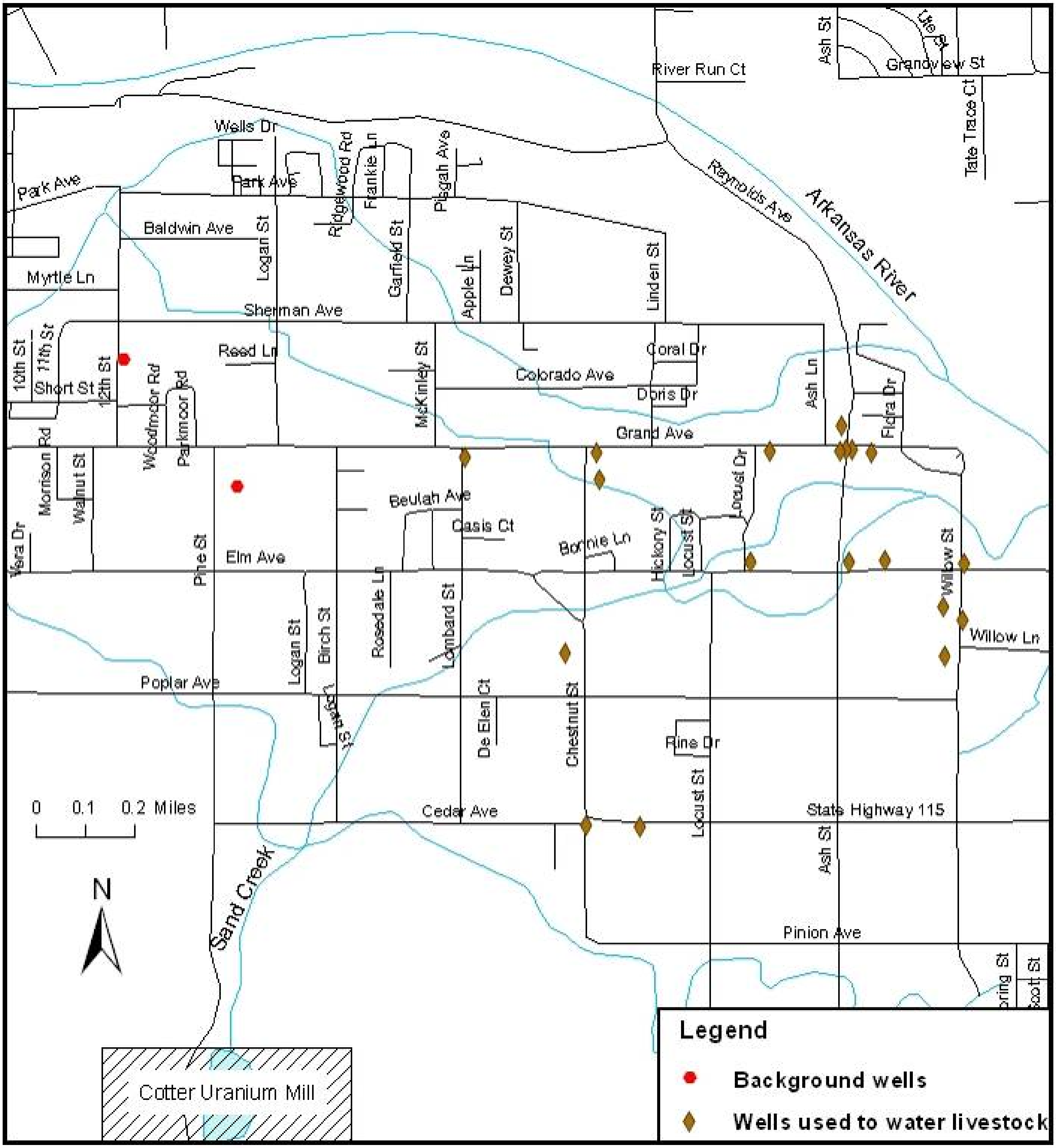
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 9. Wells in Lincoln Park used to irrigate fruit and vegetable gardens



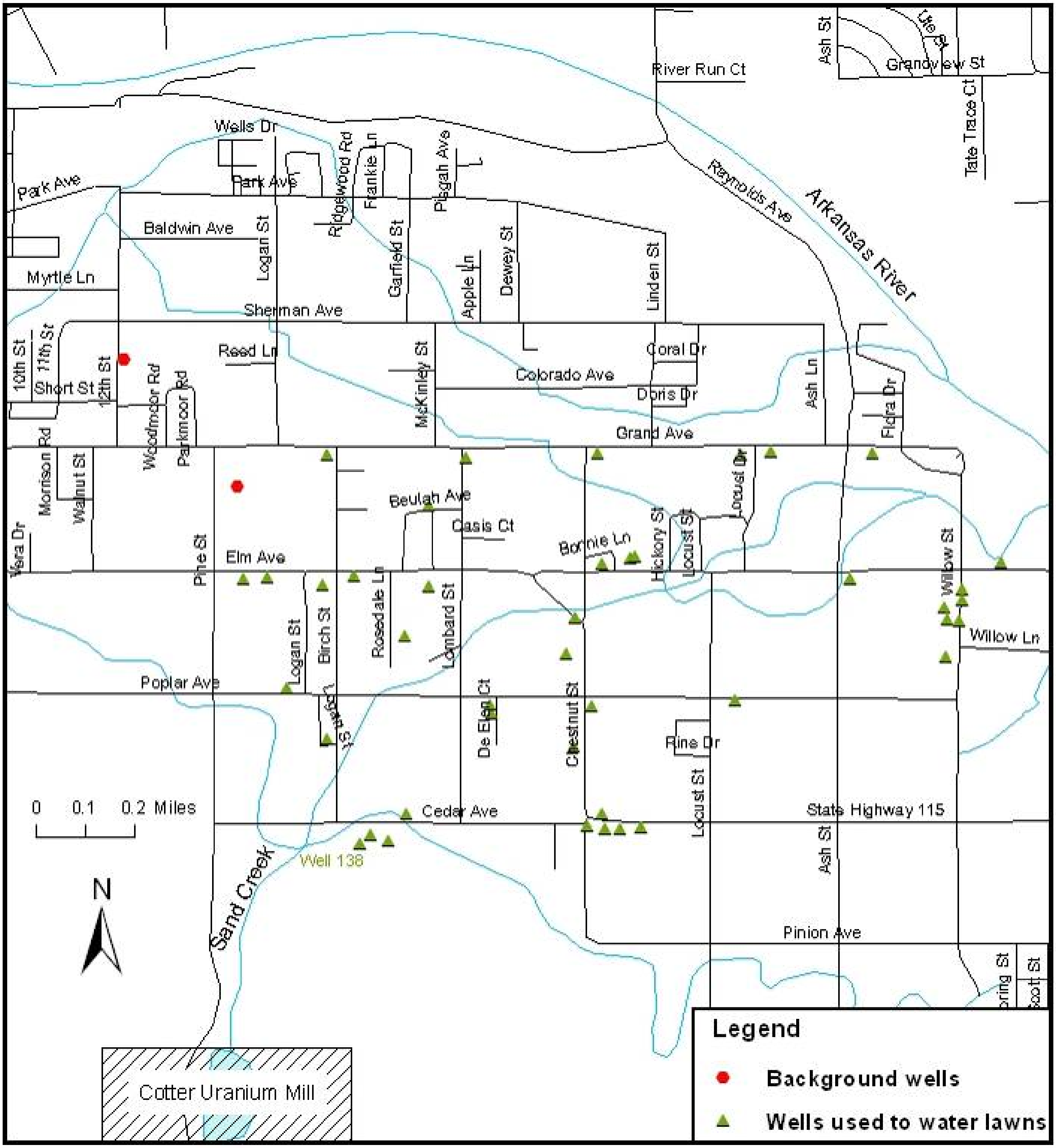
Source: CDPHE 2007b (coordinates)

Figure 10. Wells in Lincoln Park used to water livestock



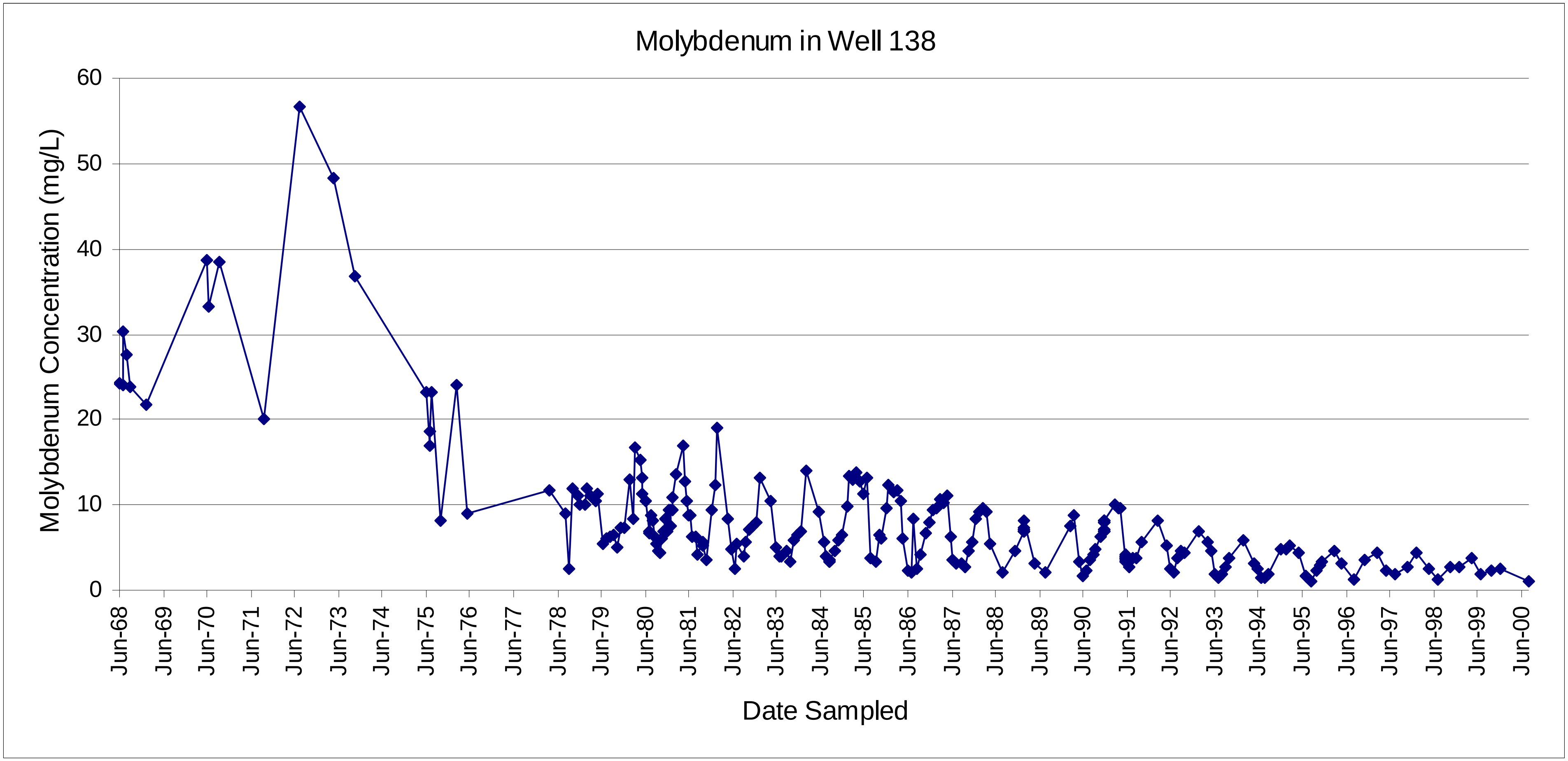
Source: CDPHE 2007b (coordinates)

Figure 11. Wells in Lincoln Park used to water lawns



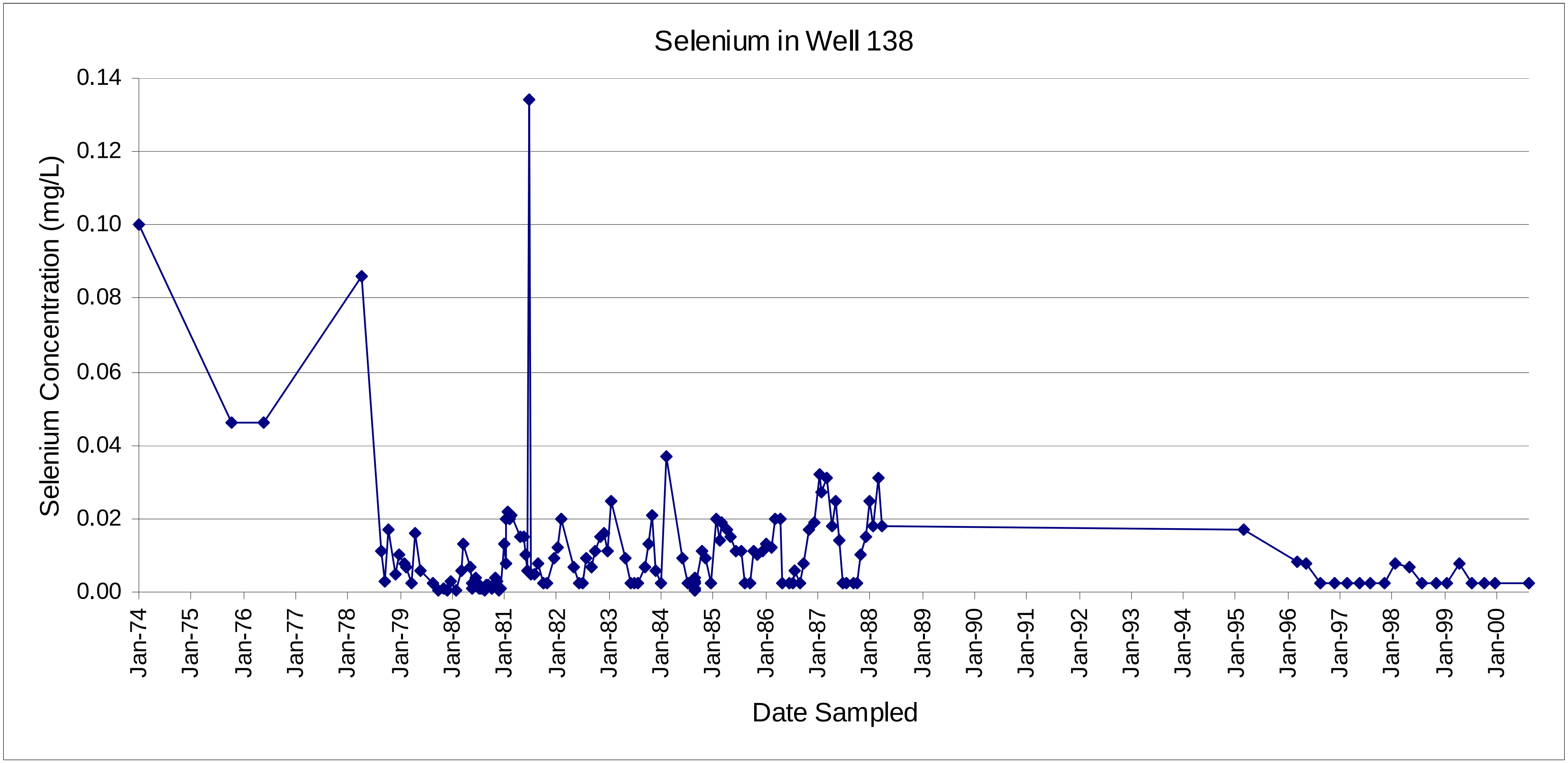
Source: CDPHE 2007b (coordinates)

Figure 12. Molybdenum concentrations in Well 138



Source: CDPHE 2007b

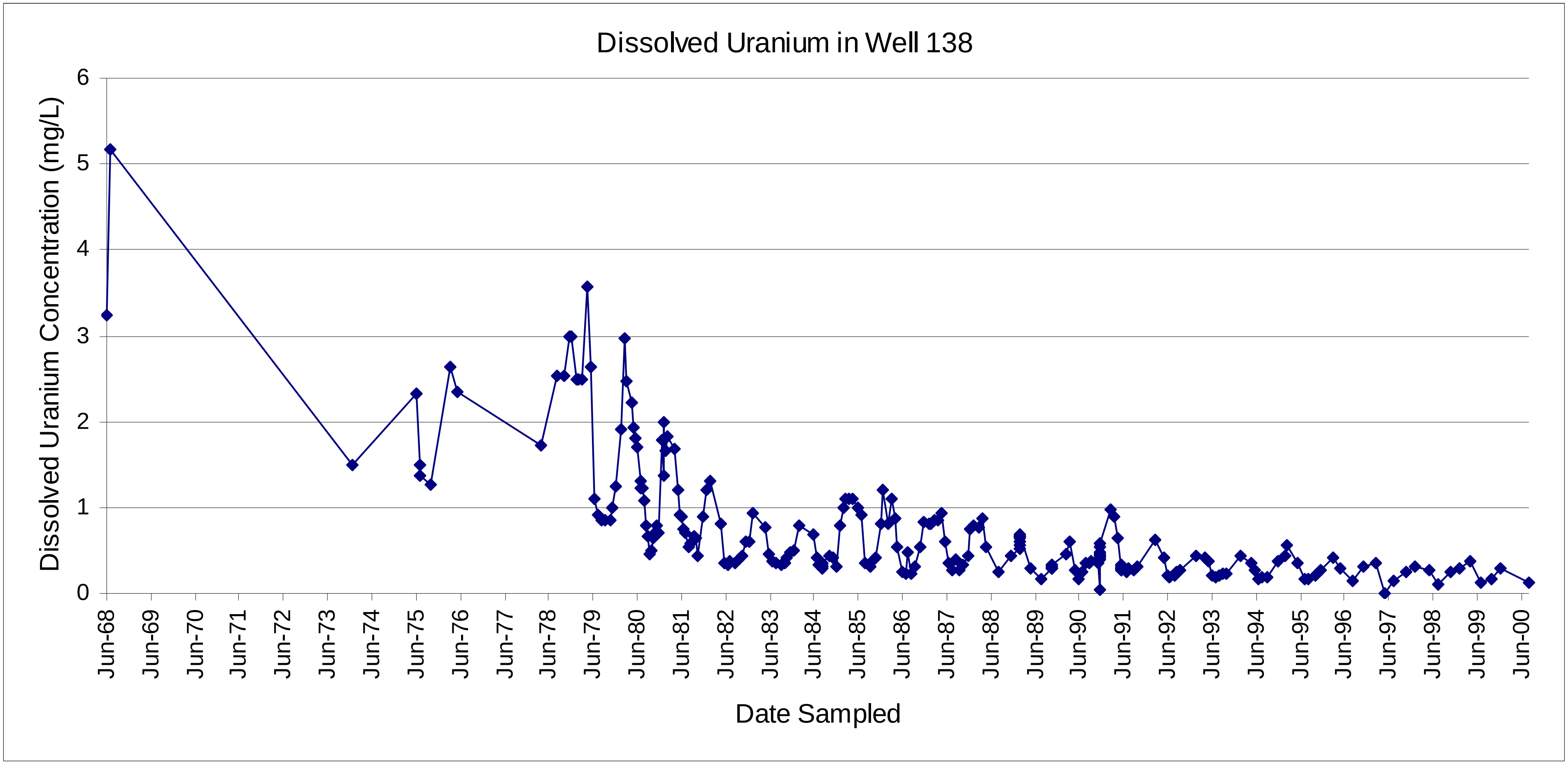
Figure 13. Selenium concentrations in Well 138



Source: CDPHE 2007b

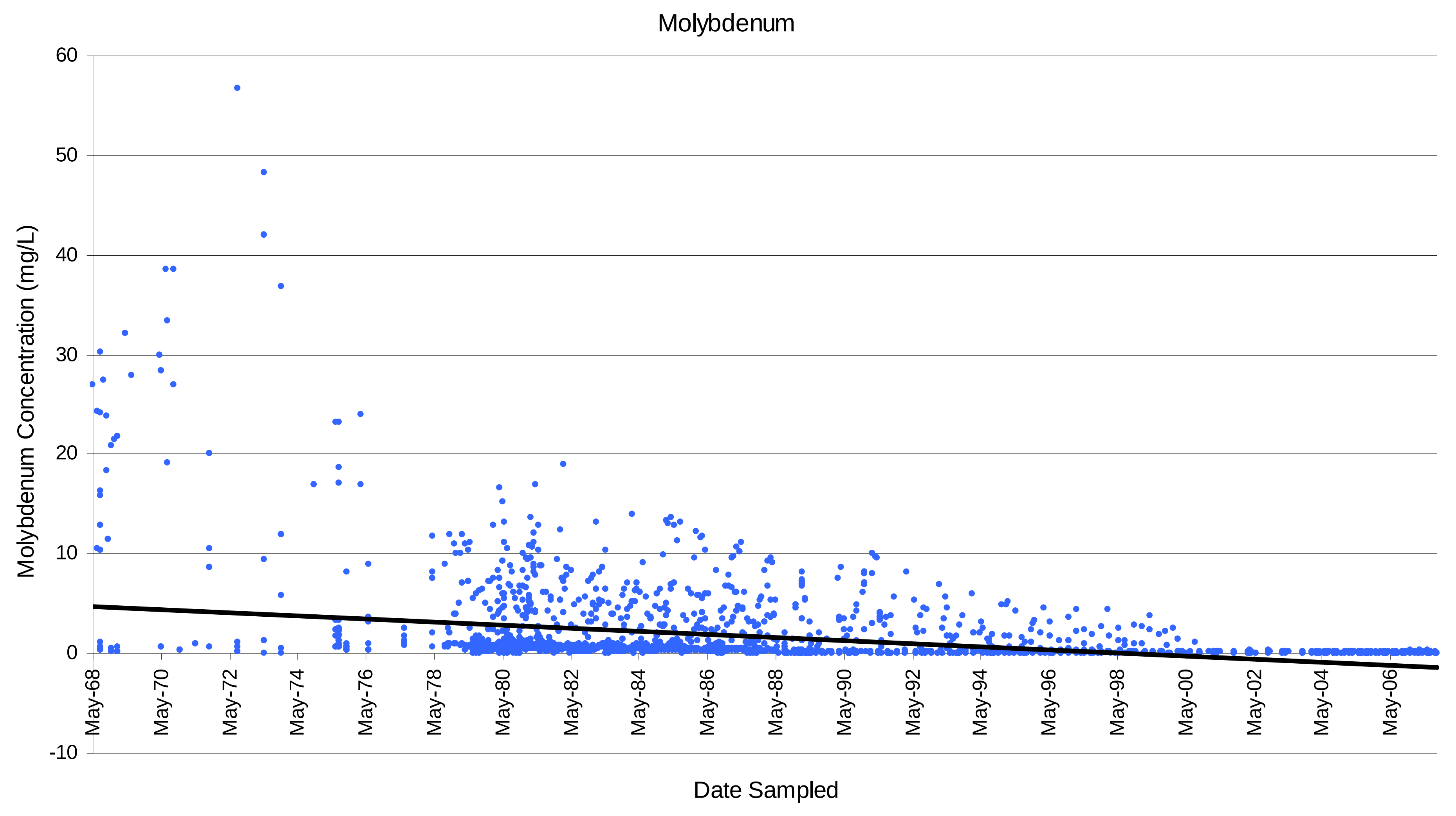
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 14. Dissolved uranium concentrations in Well 138



Source: CDPHE 2007b

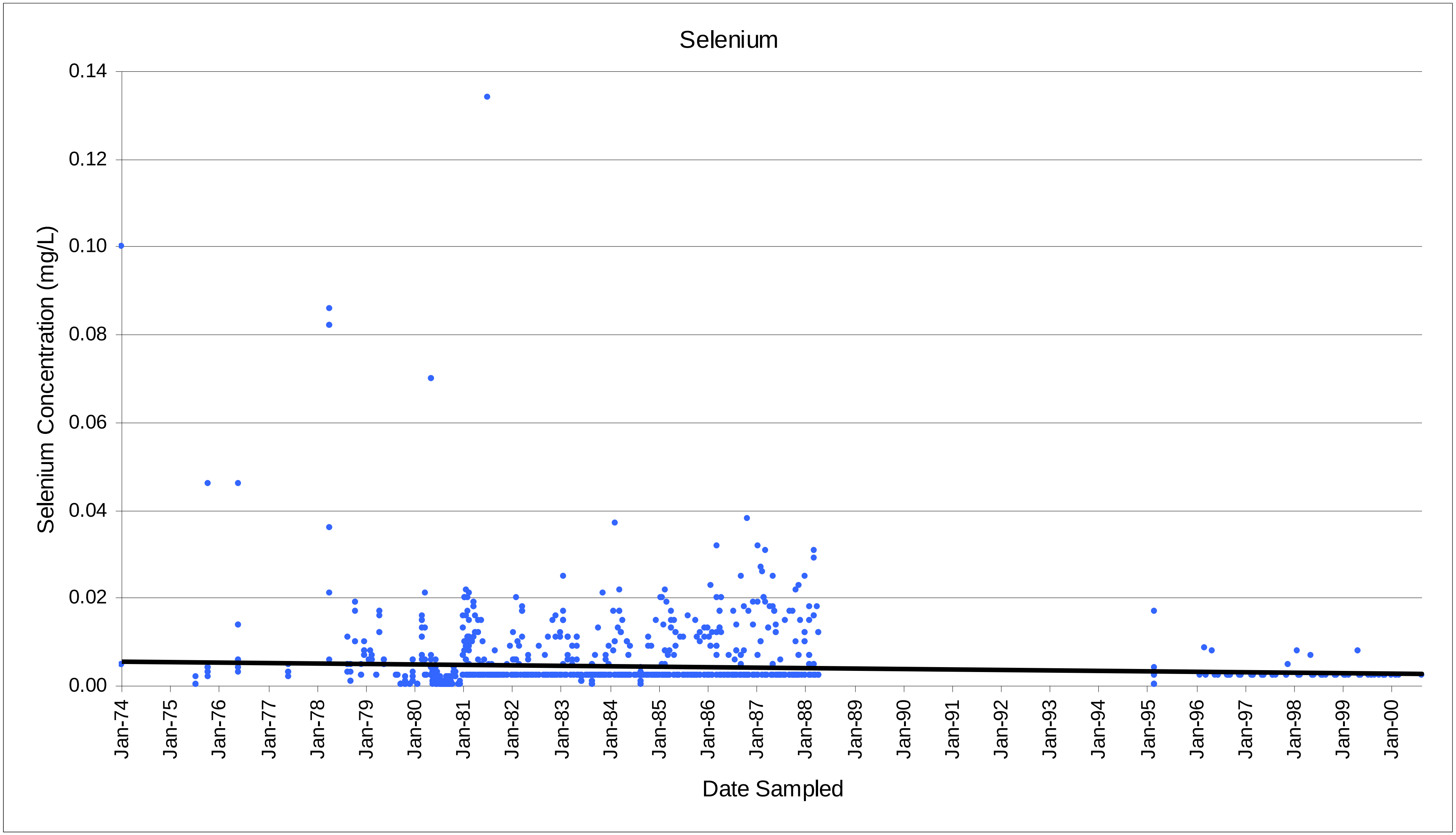
Figure 15. Molybdenum concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

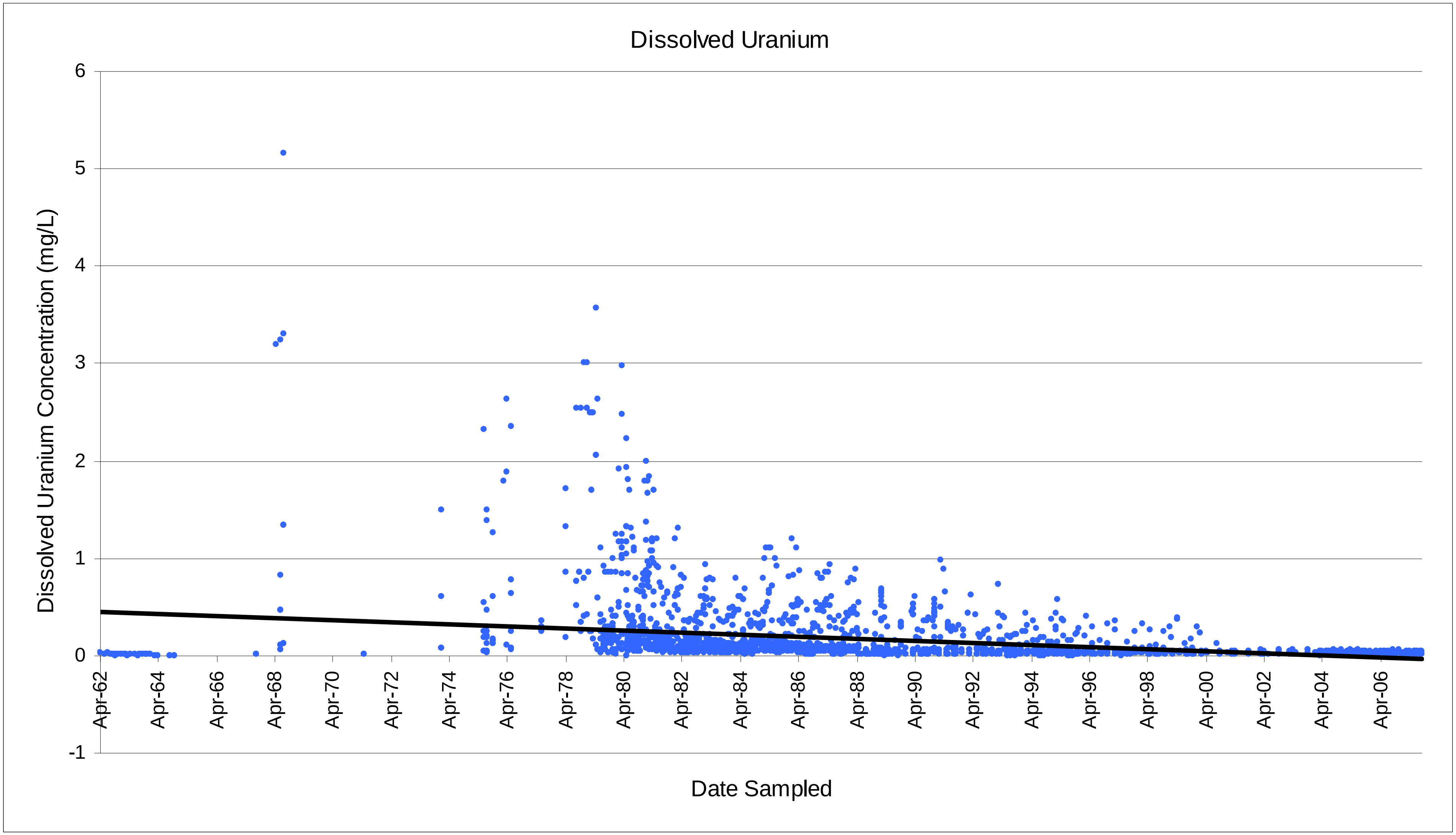
Figure 16. Selenium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

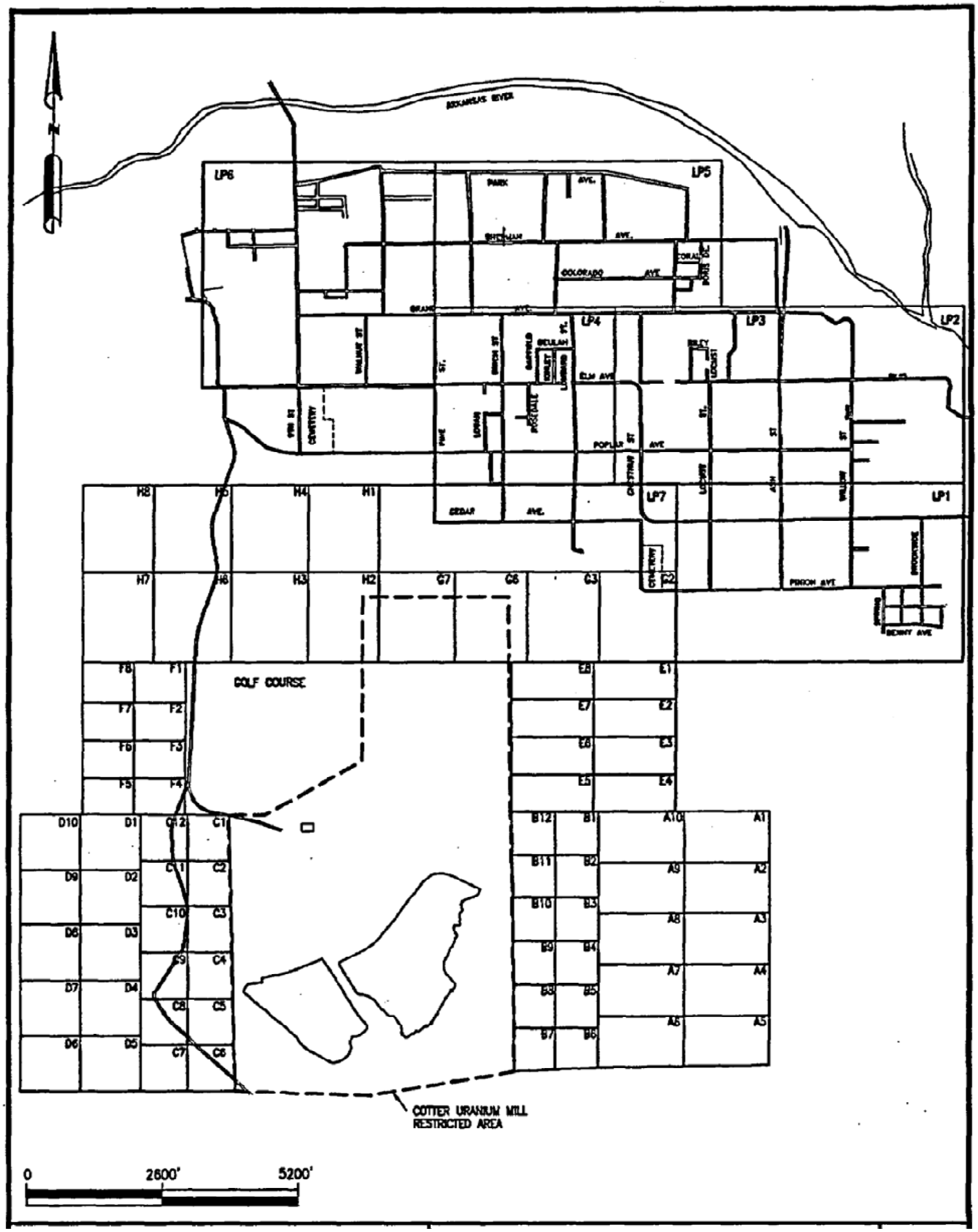
Figure 17. Dissolved uranium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

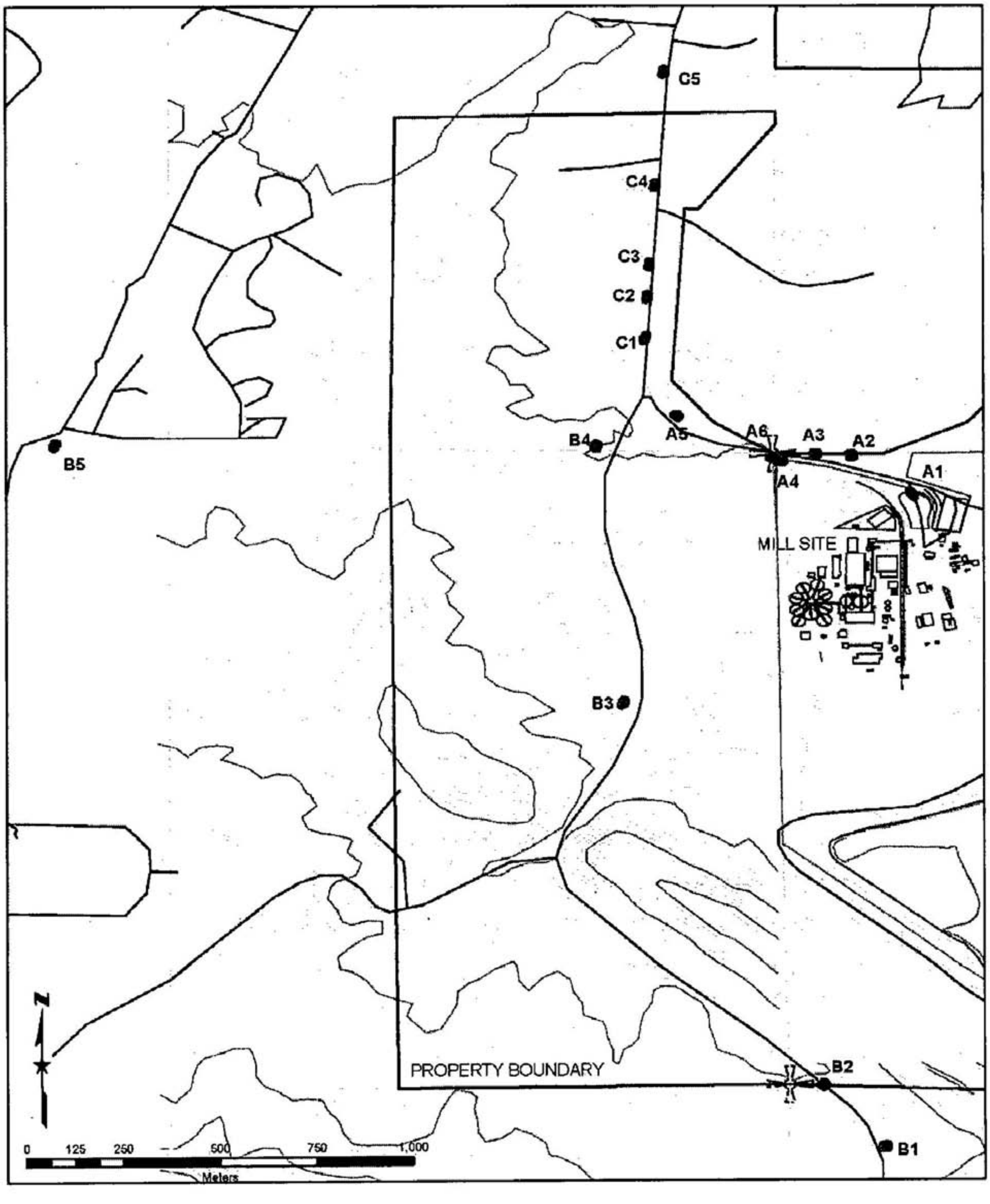
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 18. Sampling zones established during the 1998 Supplemental Human Health Risk Assessment



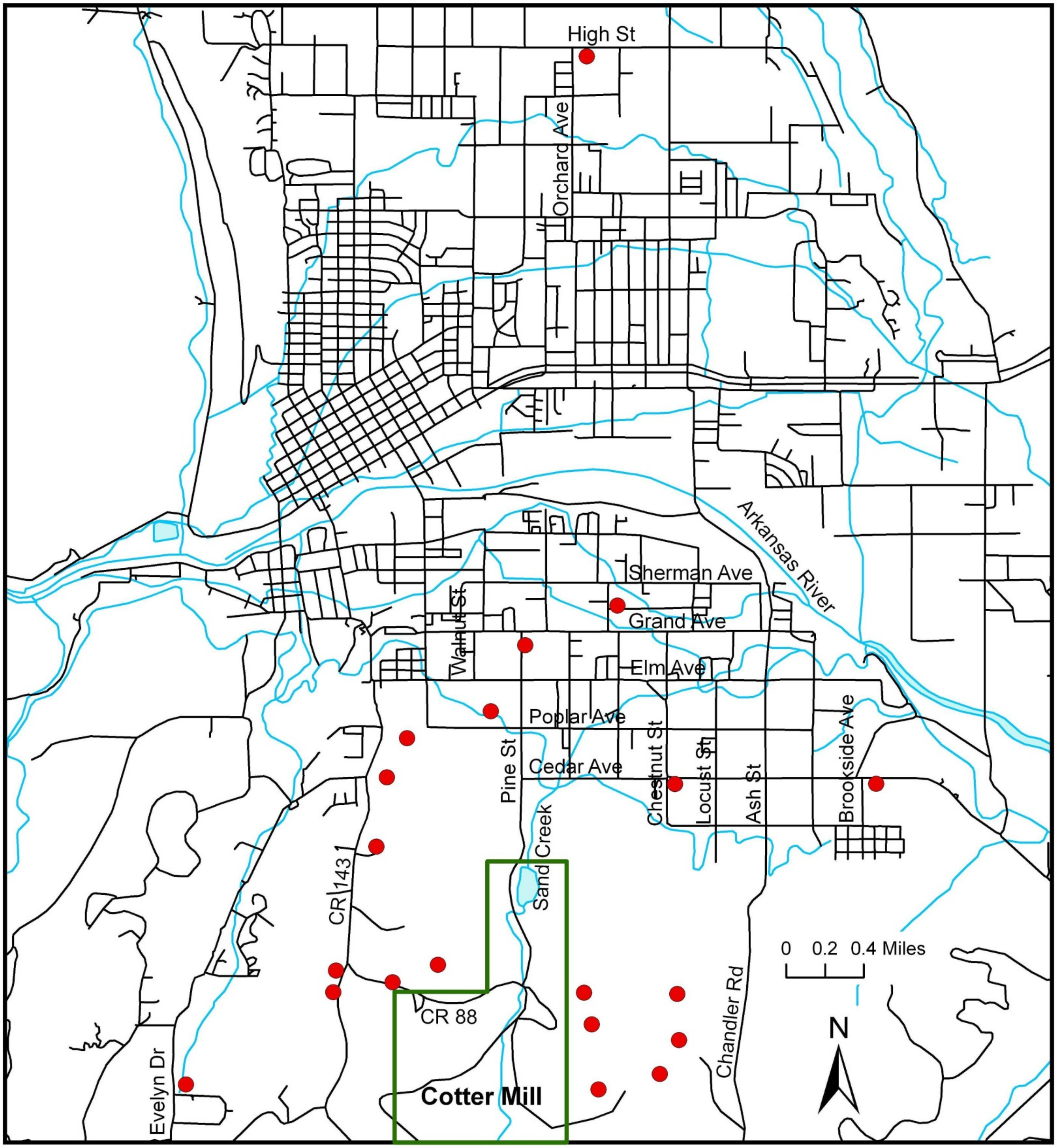
Source: Weston 1998

Figure 19. Locations of soil samples taken along the county road and Cotter Mill's access road



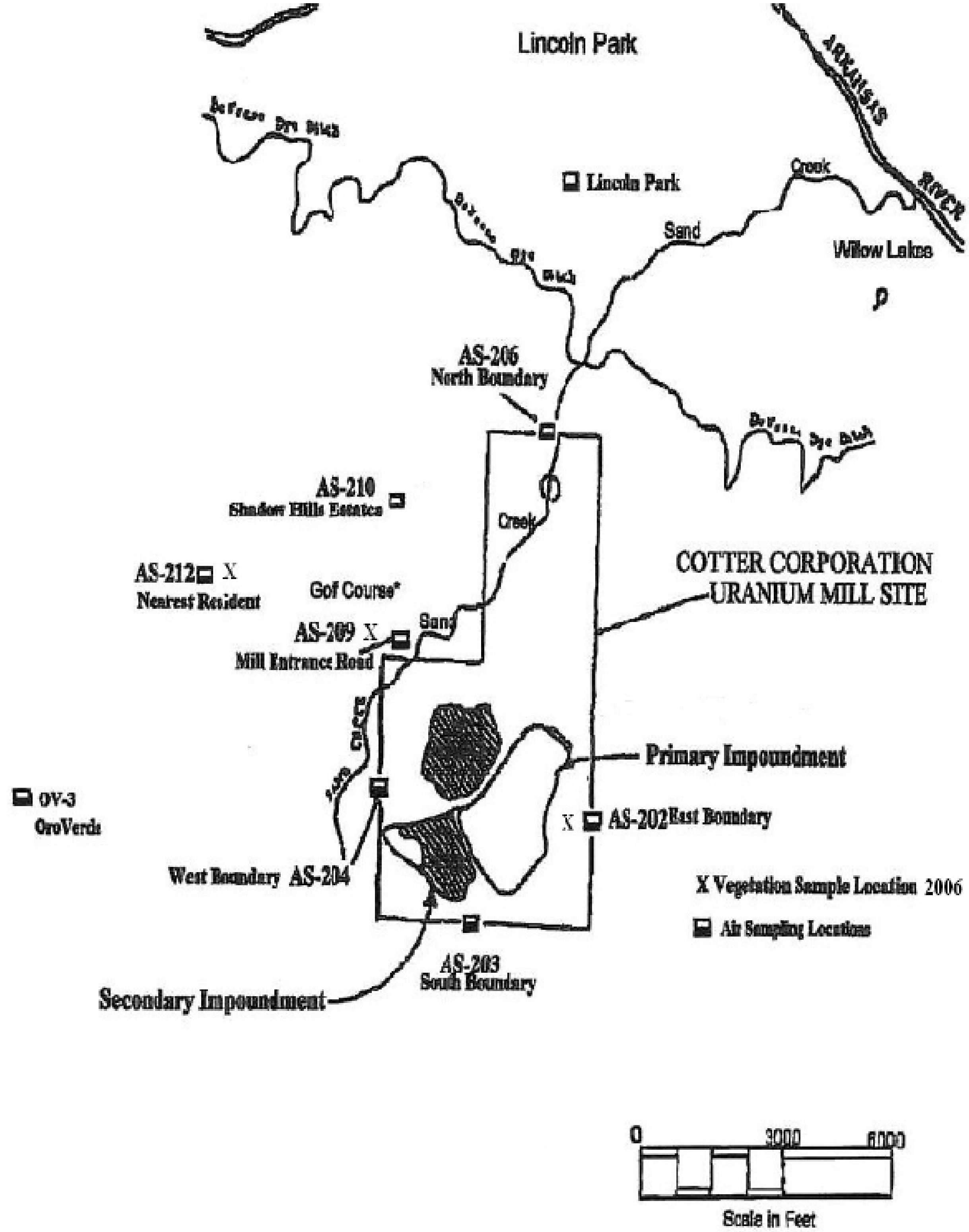
Source: MFG 2005

Figure 20. Locations of soil samples taken by CDPHE in January 2003



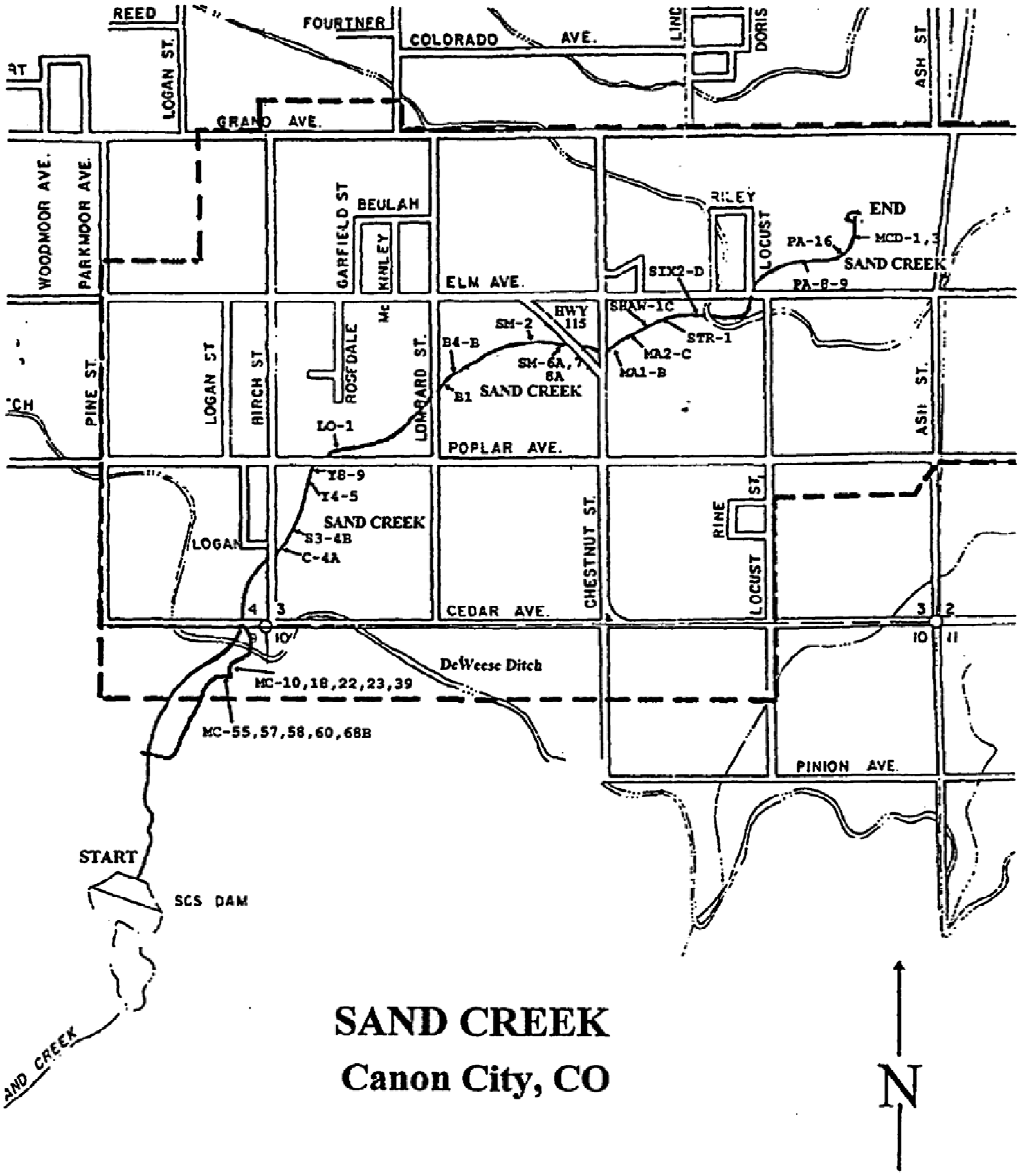
Source: CDPHE 2007b (coordinates)

Figure 21. Location of air sampling locations where soil samples are collected



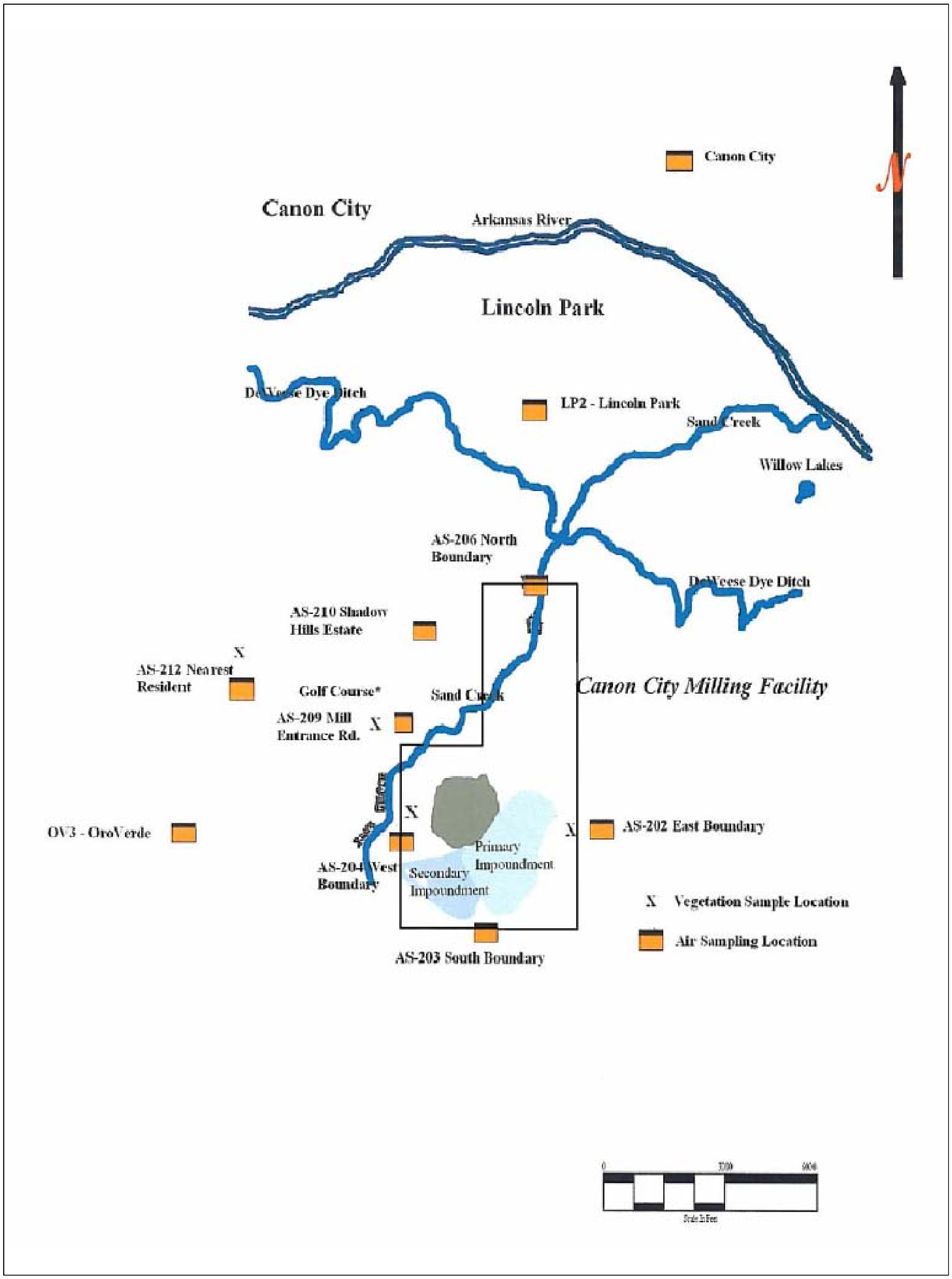
Source: Cotter 2007
Note: An additional air sampling station is located in Cañon City (not depicted on the figure).

Figure 22. Sand Creek Cleanup Project



Source: Cotter 2000

Figure 23. Approximate Locations of Cotter Mill Monitoring Stations



Notes: Figure reproduced from: Cotter 2008

APPENDIX C:
ATSDR’s Evaluation Process
And
Exposure Dose Calculations

ATSDR's Evaluation Process

Step 1 – Comparison Values and the Screening Process

To evaluate the available data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (for example: air, soil, or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, or soil that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. These values are used only to screen out chemicals that do not need further evaluation; CVs are not intended as environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based comparison values are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation risk unit. CVs based on cancerous effects account for a lifetime exposure (70 years) with an unacceptable theoretical excess lifetime cancer risk of 1 new case per 1 million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the comparison for conservatism.

Step 2 – Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific exposure scenarios, using assumptions regarding an individual's likelihood of accessing the site and contacting contamination. A brief explanation of the calculation of estimated exposure doses is presented below. Calculated doses are reported in units of milligrams per kilograms per day (mg/kg/day). Separate calculations have been performed to account for non-cancer and cancer health effects, if applicable, for each chemical based on the health impacts reported for each chemical. Some chemicals are associated with non-cancer effects while the scientific literature many indicate that cancer-related health impacts are not expected from exposure.

Exposure Dose Factors and Calculations

When chemical concentrations at the site exceed the established CVs, it is necessary for a more thorough evaluation of the chemical to be conducted. In order to evaluate the potential for human exposure to contaminants present at the site and potential health effects from site-specific activities, ATSDR estimates human exposure to the site contaminant from different environmental media by calculating exposure doses.

A discussion of the calculations and assumptions used in this assessment is presented below. The equations are based on the EPA Risk Assessment Guidance for Superfund, Part A (1989), or ATSDR's Public Health Guidance Manual (2005), unless otherwise specified. Assumptions used were based on default values, EPA's Exposure Assessment Handbook (1997) or Child-Specific Exposure Factors Handbook (2008), or professional (site-specific) judgment. When available, site-specific information is used to estimate exposures.

Ingestion of Chemicals in Well Water:

The exposure dose formula used for the ingestion of chemicals in well water is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in water in milligrams per liter (mg/L)*
IR *= ingestion rate in liters per day (L/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

Note: In the intake equation, averaging time (AT) for exposure to non-carcinogenic compounds is always equal to ED; whereas, for carcinogens a 70 year AT is still used in order to compare to EPA's cancer slope factors typically based on that value.

This pathway assumes that an adult resident drinks 2 liters (L) of water per day for 350 days per year. In terms of exposure duration (ED), the adult resident is assumed to live in the same home and drink the same well water for 30 years. The drinking water ingestion rate for children was assumed to be 1 L per day for 350 days per year for 6 years. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

ATSDR used the average chemical concentration in Well 186 to represent a high exposure scenario from a single well. Well 186 was selected because it consistently contained the highest chemical concentrations over time. The average concentration for all private wells was used to represent exposures to a typical well user.

Table C1. Summary of Exposure Factors and Exposure Doses for the Drinking Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Drinking Water Pathway: Ingestion – ADULT and CHILD								
Molybdenum ADULT	0.16 *WELL 189** HIGH EXPOSURE	2	350	30	70	10950	0.004	0.005 Chronic Oral RfD
Molybdenum CHILD		1	350	6	16	2190	**0.010**	
Molybdenum ADULT	0.082 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.002	
Molybdenum CHILD		1	350	6	16	2190	0.005	
Uranium ADULT	0.048 Well 189* HIGH EXPOSURE	2	350	30	70	10950	0.001	0.002 Intermediate Oral MRL
Uranium CHILD		1	350	6	16	2190	**0.003**	
Uranium ADULT	0.028 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.0008	
Uranium CHILD		1	350	6	16	2190	0.002	

Bolded type exceeds a comparison value.

* "Well 189" represents a high exposure scenario. This well contained the highest level of chemicals in the sampled group.

"All wells" is used to represent an average exposure scenario for the average private well drinker.

Accidental Ingestion of Chemicals in Soil

The exposure dose formula for incidental ingestion of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in soil in milligrams per kilogram (mg/kg or ppm)*
IR *= ingestion rate in milligrams per day (mg/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10^{-6} kg/mg)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that the average adolescent (11 to 16 years of age) or adult resident accidentally ingests 100 milligrams of soil per day. Because the area is in a primarily vacant “buffer zone” between the Cotter Mill and residential homes, ATSDR assumed that very young children would not access the area. Adolescent and adults would access the site infrequently. Therefore, exposure duration (ED) for an adolescent and adult resident was assumed to be 2 days per week (or 104 days/year) for 30 years. For average body weight, 57 kg was used for an adolescent and70 kg was used for an adult.

In this evaluation, the bioavailability from incidental ingestion of arsenic in soil was assumed to be 80% because it is protective of health. Cadmium was assumed to be 100% bioavailable, which is also conservative but protective of health.

Direct Skin (Dermal) Contact with Chemicals in Soil

Dermal absorption of chemicals from soil depends on the area of contact with exposed skin, the duration of contact, the chemical and physical attraction between the contaminant and soil, the ability of the chemical to penetrate the skin, and other factors.

The exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= chemical concentration (mg/kg)*
SA *= surface area exposed (square centimeters/day or cm^2/day)*

AF *= soil to skin adherence factor (milligrams per square centimeters or mg/cm*^{2}*)*
ABS *= Absorption factor (unitless)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10*$^{-6}$ *kg/mg)*
BW *= body weight (kg)*
AT *= averaging time (days)*

Note: Absorption factors (ABS) are used to reflect the desorption of the chemical from soil and the absorption of the chemical across the skin and into the bloodstream.

For the dermal contact pathway, ATSDR assumed that the surface area available in an adolescent for direct skin contact is 4,300 cubic centimeters per day (cm^2/day); the surface area available in an adult is 5,000 cm^2/day. An adherence factor of 0.07 milligrams per cubic centimeter (mg/cm^3) was used. An absorption factor of 0.03 was used for arsenic and 0.01 was used for cadmium. Individuals were assumed to weigh 57 kg as an adolescent and 70 kg as an adult, and to be exposed for 6 and 30 years, respectively.

The total soil oral and dermal non-carcinogenic dose was estimated as follows:

$$\textit{Total Dose (TD)} = \mathbf{ID + DD}$$

Where:

TD *= total soil ingestion and dermal non-carcinogenic dose*
ID *= Soil ingestion non-carcinogenic dose (mg/kg/day)*
DD*= Soil dermal non-carcinogenic dose (mg/kg/day)*

Cancer Risk Estimates

EPA classifies arsenic as a Class A known human carcinogen by the oral and inhalation routes. Cadmium is classified by EPA as a probable human carcinogen, but only via the inhalation route of exposure. Therefore, only arsenic is evaluated for its carcinogenic risk.

The Lifetime Estimated Cancer Risk for arsenic is estimated as follows:

$$\textit{LECR} = \mathbf{TDs \times CSF \times EF}$$

Where:

LECR *= lifetime estimated cancer risk*
TDs *= total soil oral and dermal non-carcinogenic dose (mg/kg/day)*
CSF *= cancer slope factor ((mg/kg-day)*$^{-1}$*)*
EF *= Exposure factor (unitless) = exposure duration / lifetime = (30 years) / (70 years) = 0.4*

The cancer slope factor for arsenic is 1.5 mg/kg-day. Therefore, the LECR is 1.2 x 10^{-5}.

Table C2. Summary of Exposure Factors and Exposure Doses for the Soil Exposure Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/kg)	Daily Intake Rate (mg/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Soil Exposure Pathway: Accidental Ingestion and Direct Skin Contact - ADULT and ADOLESCENT								
Arsenic (ingestion)	45	100	104	30	70	10950	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	30	70	10950	0.000002	
TOTAL DOSE ARSENIC - Adult							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	30	70	10950	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	30	70	10950	0.0000005	
TOTAL DOSE CADMIUM -Adult							0.00002	*Below Guideline*
Arsenic (ingestion)	45	100	104	6	54	2190	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	6	54	2190	0.000002	
TOTAL DOSE ARSENIC - Adolescent							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	6	54	2190	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	6	54	2190	0.0000006	
TOTAL DOSE CADMIUM - Adolescent							0.00002	*Below Guideline*

Incidental Ingestion of Chemicals in Surface Water

The ATSDR exposure dose formula used for the ingestion of chemicals in surface water while wading or swimming is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in water in milligrams per liter (mg/L)*
IR *= ingestion rate in liters per day (L/day); based on contact rate of 50 ml/hr*
ET *= exposure time (hours/event)*
EF *= exposure frequency (events/year)*
ED *= exposure duration (years)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that adult and children residents would accidentally swallow 50 milliliters of water per hour while swimming, wading or recreating in Sand Creek or the DeWeese Dye Ditch. In terms of exposure time and frequency, ATSDR conservatively assumed an adult and child resident would recreate in these waters for 2 hours per day, 2 days per week (or 104 days/year) for 30 years and 6 years, respectively. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

Direct Skin (Dermal) Contact with Chemicals in Surface Water

ATSDR's exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= chemical concentration (mg/L)*
SA *= surface area exposed (cm^2)*
PC *= chemical-specific dermal permeability constant (cm/hr)*
ET *= exposure time (hours/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= volumetric conversion factor for water (1L/1000 cm^3)*
BW *= body weight (kg)*
AT *= averaging time (days)*

The dermal contact pathway assumes that the total body surface area available for contact with water is 20,000 cm^2 for adults and 9,300 cm^2 for children. Adults were assumed to weigh 70 kg and to be exposed for 30 years. Children were assumed to weigh 16 kg and to be exposed for 6 years. Adults and children were conservatively assumed to swim in the contaminated water 2 days per week (104 days per year) for 2 hours per recreating event. A dermal permeability constant of 0.001 cm/hr was used for both manganese and molybdenum.

Table C3. Summary of Exposure Factors and Exposure Doses for the Surface Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Surface Water Exposure Pathway: Accidental Ingestion and Direct Skin Contact while Wading or Swimming – ADULT and CHILD								
Manganese* Adult Ingestion	1.9	0.1	104	30	70	10950	3.9 x 10^{-4}	0.05 Chronic Oral RfD
Manganese Adult Dermal		NA	104	30	70	10950	3.1 x 10^{-4}	
		TOTAL DOSE MANGANESE – Adult					7 x 10^{-4}	*Below Guideline*
Manganese Child Ingestion		0.1	104	6	16	2190	1.7 x 10^{-3}	0.05 Chronic Oral RfD
Manganese Child Dermal		NA	104	6	16	2190	6.3 x 10^{-4}	
		TOTAL DOSE MANGANESE - Child					2.3 x 10^{-3}	*Below Guideline*
Molybdenum† Adult Ingestion	0.051	0.1	104	30	70	10950	1.0 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Adult Dermal		NA	104	30	70	10950	8.3 x 10^{-6}	
		TOTAL DOSE MOLYBDENUM - Adult					1.8 x 10^{-5}	*Below Guideline*
Molybdenum Child Ingestion		0.1	104	6	16	2190	4.5 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Child Dermal		NA	104	6	16	2190	1.7 x 10^{-5}	
		TOTAL DOSE MOLYBDENUM - Child					6.2 x 10^{-5}	*Below Guideline*

*Maximum concentration of manganese in surface water detected in DeWeese Dye Ditch

†Maximum concentration of molybdenum in surface water detected in Sand Creek

Consumption of Homegrown Fruits and Vegetables

The following formula presents the method for calculating an exposure dose for a typical consumer of homegrown fruits and vegetables:

$$\text{Exposure Dose (mg/kg/day)} = \mathbf{C \times IR \times CF}$$

Where:

C *= contaminant concentration (mg/kg)*
IR *= intake rate of fruit or vegetable (g/kg/day)*
CF *= conversion factor (1 x* 10^{-3} *kg/mg)*

Exposure doses for ingestion of garden vegetables were calculated using the average detected concentration of each contaminant measured in fruit and vegetable samples, in mg/kg, multiplied by average consumption rates of homegrown fruits or vegetables in grams per kilogram of body weight per day (g/kg/day). Intake rates were taken from EPA's Exposure Factors Handbook for adults, and EPA's Child-Specific Exposure Factors Handbook for children, for the Western United States. The average consumption rate was used to represent a "typical" fruit and vegetable consumer. The 95 percentile consumption rate was used to represent an "above average" consumer of fruits and vegetables. The calculated value was multiplied by a conversion factor of 0.001 kilograms per gram.

Table C4. Summary of Exposure Doses for Local Fruits and Vegetables Irrigated with Contaminated Well Water

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
Arsenic	Average consumer	0.0001	0.0001	0.0003, Chronic Oral MRL
	Above Average Consumer	0.0006	0.0005	
	Child	0.0002	0.0002	
	Infant	0.0004	0.0004	
Barium	Average consumer	0.001	0.003	0.2 Chronic Oral MRL
	Above Average Consumer	0.005	0.010	
	Child	0.002	0.004	
	Infant	0.004	0.008	
Cadmium	Average consumer	0.0001	0.0001	0.001, RfD
	Above Average Consumer	0.0005	0.0002	
	Child	0.0002	0.0001	
	Infant	0.0004	0.0002	
Chromium	Average consumer	0.0001	0.0001	1.5 RfD
	Above Average Consumer	0.0006	0.0003	
	Child	0.0002	0.0001	
	Infant	0.0005	0.0003	
Cobalt	Average consumer	ND	0.00004	0.01 Intermediate MRL
	Above Average Consumer	ND	0.00012	
	Child	ND	0.00005	
	Infant	ND	0.0001	
Lead	Average consumer	0.0003	0.0004	NA
	Above Average Consumer	0.001	0.001	
	Child	0.0005	0.0005	
	Infant	0.001	0.001	
Manganese	Average consumer	0.002	0.004	0.14 RfD
	Above Average Consumer	0.01	0.02	
	Child	0.004	0.006	
	Infant	0.008	0.01	
Molybdenum	Average consumer	0.0003	0.001	0.005 RfD
	Above Average Consumer	0.001	0.004	

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
	Child	0.0005	0.002	
	Infant	0.001	0.004	
Nickel	Average consumer	ND	0.0001	0.02 RfD
	Above Average Consumer	ND	0.0005	
	Child	ND	0.0002	
	Infant	ND	0.0004	
Strontium	Average consumer	0.004	0.009	0.6 RfD
	Above Average Consumer	0.02	0.03	
	Child	0.007	0.01	
	Infant	0.01	0.03	
Uranium	Average consumer	0.00002	0.00001	0.002 Intermediate MRL
	Above Average Consumer	0.00008	0.00004	
	Child	0.00003	0.00002	
	Infant	0.00006	0.00004	
Vanadium	Average consumer	ND	0.00008	0.003 Intermediate MRL
	Above Average Consumer	ND	0.0003	
	Child	ND	0.0001	
	Infant	ND	0.0002	
Zinc	Average consumer	0.004	0.006	0.3 Chronic Oral MRL
	Above Average Consumer	0.02	0.02	
	Child	0.006	0.008	
	Infant	0.01	0.02	

Bolded text exceeds a health guideline.
ND = not detected
NA = not available

ATSDR's Evaluation of Cancer and Non-Cancer Health Effects

Non-Cancer Health Effects

The doses calculated for exposure to each individual chemical are compared to an established health guideline, such as a MRL or RfD, in order to assess whether adverse health impacts from exposure are expected. These health guidelines, developed by ATSDR and EPA, are chemical-specific values that are based on the available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus, exposure doses at or below the established health guideline are not expected to result in adverse health effects because these values are much lower (and more human health protective) than doses, which do not cause adverse health effects in laboratory animal studies. For non-cancer health effects, the following health guidelines are described below in more detail. It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for potentially cancer-causing chemicals detected in samples at this site. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Minimal Risk Levels (MRLs) – developed by ATSDR

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (RfDs) – developed by EPA

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. Non-cancer health effects from dermal exposure were evaluated slightly differently that ingestion and inhalation exposure. Since health guidelines are not available for dermal exposure, the calculated dermal dose was compared with the oral health guideline value (RfD or MRL).

If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the PHA. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's Integrated Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

Cancer Risks

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated excess risk of developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific adult exposure doses, with a slight modification, by EPA's chemical-specific Cancer Slope Factors (CSFs or cancer potency estimates), which are available at http://www.epa.gov/iris. Calculated dermal doses were compared with the oral CSFs.

An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular contaminant. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer. The recommendations of many scientists and EPA have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-5}) are not typically considered a health concern. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate EPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

Because of the uncertainties involved with estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data. Therefore, the carcinogenic risk is also described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and the site-specific doses for the site is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

Appendix D. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause

harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often

and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR’s public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period

(acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)