CSMRI SITE ENVIRONMENTAL CONDITIONS:

HISTORY, INVESTIGATION, AND CLEANUP IMPLEMENTATION REPORT AS OF 2011

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Table of Contents

1 Executive Summary

The Colorado School of Mines Research Institute ("CSMRI") Site ("Site") was a major mining and mineral research center located on a portion of the campus of the Colorado School of Mines ("School") in Golden, Colorado. The operations date back to the original Experimental Plant constructed in 1912 for metallurgical research. After the creation of CSMRI in 1949, the operations expanded from the original 1912 building to 17 buildings by the time research operations ceased in 1987.

The research center's purpose was to develop mining and extraction methods for metals. Hundreds of research sponsors (business and governmental entities) performed thousands of research projects on many tons of ore and mineral samples provided by them. A large, indeterminate amount of waste project materials and wastes from the projects were disposed of at various locations on the Site.

CSMRI, EPA, and the School have investigated the Site for contamination. These investigations, in areas that define the Site, have resulted in either cleanup actions being done, or a determination that no cleanup was necessary. The Site includes the area covered by CSMRI's radioactive materials license.

In areas where cleanup was required, with two exceptions, cleanup has addressed metals and radionuclides to applicable goals to the satisfaction of the Colorado Department of Public Health and Environment (CDPHE). The two exceptions are (1) an approximate 1,400 cubic yard stockpile of material from work on the Lower Terrace in 2010, and (2) the groundwater in the shallow aquifer on the Lower Terrace around monitoring well 8B exceeding groundwater protection standards for uranium. The 1,400 yards of soils are estimated to be disposed of later this year. The groundwater on the Lower Terrace will be monitored quarterly for uranium over the next six quarters to determine if any further action is required.

2 General Site History and Background

The Site is located at the eastern base of the Rocky Mountains in Golden, Colorado on the south bank of Clear Creek. The Site is partially located on the campus of the Colorado School of Mines and partially on the Parfet/City of Golden property.

In the 1800's a coal mine, clay mines, and a clay brick factory operated on or adjacent to the Site. A smelter may have been located on or near the Site during the 1800s. The second half of the 1800's saw intensive mining for gold and silver in the mountains west of Golden using placer and hard-rock underground mining techniques. Seven or eight

ore smelters served the mining industry at this time and operated in the valley where the city of Golden is located. Later mining operations were conducted in the Clear Creek watershed for other minerals including lead, zinc, uranium, and molybdenum. The clay pits, located south of the CSMRI operations area described in the next paragraph, were extensively mined beginning in the early 1900's. According to EPA, spoils from this original mining activity were possibly used to build up the embankment areas and playing fields adjacent to the Site.[1]

In 1910, the State of Colorado appropriated funds for the construction of a metallurgical Experimental Plant at the Colorado School of Mines. The Plant's purpose was to develop mining and extraction processes for metals. The Experimental Plant rented equipment and facilities to the mining industry for the pilot-scale crushing, grinding, beneficiation and treatment, as well as bench-scale and laboratory research, of ores and minerals provided by the research sponsors. The Experimental Plant also conducted such work under contract as specified by the research sponsors on the materials provided by the research sponsors. In 1949, the Colorado School of Mines Research Foundation. (CSMRF) was founded to continue the operations as an entity independent of the Colorado School of Mines. CSMRF leased the area where the research buildings were located from the School. In 1969, CSMRF changed its name to the Colorado School of Mines Research Institute ("CSMRI"). When CSMRF was founded, the operations consisted of one building with 5 or 6 laboratories and 4 School part-time employees. Between 1949 and 1987, the operations grew to 17 buildings with approximately 300 persons employed by CSMRI.

Between 1912 and 1987, research sponsors performed, or conducted under contract, thousands of projects on a wide variety of ore and minerals. Many projects focused on copper, lead, nickel, iron, zinc, coal, oil shale, and gold. Some focused on radiological materials like uranium. The research issues varied widely across a broad range of technical mining-related areas, including: development of mining exploration techniques, mineralogical laboratory analyses, refraction techniques, crushing, grinding, sizing, beneficiation, leaching, hydraulic transportation methods, rock mechanics, metallurgical processing methods, flotation systems, cyanide treatment, ball mills, classifiers, screening tables, consulting services to mining sites and mining operations, sulfur studies, pyrometallurgical reactions, liquid ion exchange processing, copper electrolysis, smelting process technologies, halogenation of ores and metallurgical products, fused salt electrolysis, economic feasibility studies, phosphate studies and analysis, handling of limestone, geophysical, petrographic, and stratographic studies, spectrographic studies, x-ray diffraction studies, instrument calibration and construction, fatty acid studies, well log studies, sand heat treatment methods, and evaluation of different clays, among other studies.

[1] Summary Report on Site Investigation and Removal Activities, CSMRI Creekside Site, Golden, Jefferson County, Colorado, Ecology and Environment, Inc., March 17, 1993.

The research sponsors provided the process materials for the projects. The quantity sent to CSMRI was dependent upon the type of project (e.g., laboratory test/ bench scale projects required much less material than a full pilot plant project). The research sponsor's waste (unused/unwanted) process materials, process tailings, other materials used in the project, and wastes generated during the project were disposed of on the leased property, or other nearby areas on the School campus. These process wastes contained metals and radionuclides, which are the contaminants of concern at the Site. Some of the tailings/unused materials piles were paved over or buildings were constructed over the piles. In approximately 1950, a surface impoundment was constructed on property not leased by CSMRI between the northern end of the Upper Terrace and Clear Creek.[2] This area where the pond was located is referred to as the "Lower Terrace" or "Flood Plain." The impoundment is designated as the "Settling Pond" or "Tailings Pond" (hereinafter "Pond"). CSMRI's non-sanitary drainage system collected liquid-borne wastes from the operations by a system of sumps and drains in the buildings, and discharged to the Pond where it was treated.[3] In May 1973, sediment dredged from the Pond was placed in the area now referenced as the "Clay Pits."[4]

Economic conditions in the 1980's caused a dramatic downturn in the mining industry, which in turn lead to the cessation of CSMRI's research operations. Investigation of contamination at the Site began shortly before the cessation of research activities in 1987. In 1990, CSMRI fenced the leasehold property on the Upper Terrace, as well as, the State-owned and Parfet/City of Golden property on the Lower Terrace, inclusive of the Pond, to exclude unauthorized persons (collectively the "Fenced Area").

[2] The Pond was on both State of Colorado-owned land and on property owned by the Parfet family; primarily on the Parfet property. The City of Golden acquired the Parfet Parcel in the 2000's and still owns it.
[3] The sanitary drainage system discharged to Golden's public treatment works.
[4] The "Clay Pits" refers not to the overall complex of mined and filled areas extending for miles throughout Golden, but only to that specific area on the south part of the Colorado School of Mines campus where the sediment from the Pond was deposited in 1973. Subject: Golden Tailing Pond, memorandum, Coulson to Krause, June 11, 1976.

2.0 Site Geology

The geologic setting of the site is complex.[5] The Site is not atop a consistent geology with a single set of background values for the contaminants brought to the Site. Multiple strata, alluvial deposits, man-made fill, historic mining activities, and effluent from earlier smelting operations all contributed to varying levels of metals and radionuclides that were present in the area before research operations began.

Situated at the eastern edge of the Rocky Mountains, the Site is located on a geologic feature known as the Dakota Hogback. As the Rocky Mountains were formed, the uplifting tilted older, originally horizontal sedimentary strata, along the edges of the mountains to the vertical. The resulting Dakota Hogback formation has vertical layers of sandstone, clay, coal, and shale at the Site. See Figure 1. Each of the geologic features present at the Site contains naturally occurring concentrations of minerals specific to each feature. The clay and coal deposits were mined during the 1800's, leaving vertical fins of sandstone sticking out of the ground adjacent to the Site extending several miles south. The trenches between the sandstone fins were eventually backfilled with soil, construction debris, trash, and other materials from across the area during the 1900's. At the Site the bedrock is covered with alluvium from the Clear Creek watershed.

2.1 Site Definition

In this report, "Site" consists of the areas of the Colorado School of Mines campus and the Parfet/City of Golden Parcel investigated to determine if there were metals and/or radionuclides from the Experimental Plant or CSMRI's operations that required cleanup. These investigations were conducted by CSMRI, EPA, and the School. The Site consists of the following areas: CSMRI's investigations of the Upper Terrace and Lower Terrace; EPA's investigation of the Upper Terrace (including the buildings and associated drainage system) and Lower Terrace; the School's investigation of the Upper Terrace Fenced Area, the Softball Field, the Area North of and under the Softball Field, and the Lower Terrace Fenced Area; the School's investigation of the Parfet/City of Golden Parcel, and the School's investigation of the Clay Pits. See Figures 2, 3, and 4 and Appendix A

[5] This section of the document is largely based upon Section 2, Site History/Chronology, CSMRI Site Remedial Action Implementation Report, S.M. Stoller, September 2009, which is incorporated by reference.

The Site is broader than, but inclusive of, the area covered by CSMRI's radioactive materials license. The CDPHE Radioactive Materials License number 617-01 is not totally specific as to the applicable area, but authorizes storage "at and contiguous to West 12th Street, Golden, Colorado, including the clay pits, [legal description of the Clay Pits[6]], ..." This legal description is the 0.34 acre where the Pond sediments were placed in 1973 and referenced as the Clay Pits (see sections 2, f.n. 4, and 4.5). Investigation has been done at all areas where metals and radionuclides from the Experimental Plant or CSMRI's operations might have required cleanup. As described in the following sections, the Site investigations have resulted in either remedial actions being done, or a determination that no investigation or cleanup was necessary.

2.2 Ground Water Description and Chronology

Ground water at the Site occurs under unconfined conditions in the alluvium/colluvium and generally follows the bedrock surface. Depth to the water table ranges from about 3 to 30 feet below ground surface, depending on the distance from Clear Creek and the depth to bedrock. Based on surface and bedrock topography, groundwater generally flows to the north-northeast toward Clear Creek. The alluvial/colluvial deposits are mainly recharged by infiltration of precipitation and to a limited extent by Clear Creek within the Flood Plain Area during periods of high flow. The alluvial/colluvial system naturally discharges to Clear Creek.[7] The locations of the Site monitor wells are shown on Figure 5.

Ground water in the shallow alluvium/colluvium has been shown to contain elevated concentrations of uranium (see sec. 3.0.3), a Site contaminant of concern that also occurs naturally in the bedrock formations and in the surficial deposits that comprise the Site.

Although ground water wells had been sampled periodically before 2005, the School began in 2005 regular quarterly sampling and reporting up to the current time and added new wells. Ground Water Monitoring Reports summarize sampling procedures, present and evaluate analytical data, and discuss observed trends. At the request of the CDPHE radiation unit, seven additional ground water wells were installed at the Site

[6] "a parcel of land in former Block 20, Mineral Land Company's Addition to the City of Golden, Colorado, Jefferson County, more particularly described as beginning at the intersection of 12th and Maples Streets of said City of Golden, then S54°33'55"W along the centerline of said 12th Street 696.06 feet to a point, thence S44°29'54"E 233.47 feet to the true point of beginning, then N60008'35''E 10.0 feet to a point, thence S29°51'25"E 73.65 feet to a point, thence S60008'35''W 20.0 feet to a point, thence N29°51'25"W 73.65 feet to a point, thence N60008'35''E 10.0 feet to the true point of beginning, containing 0.034 acres more or less), pending decommissioning and disposal activities approved by the Department"

[7] CSMRI Site Remedial Action Implementation Report, S.M. Stoller, September 2009

in February 2007 to track the effectiveness of excavation of contaminated soils in the Upper Terrace to cleanup goals. Ground water monitoring wells CSMRI-1B, CSMRI-6B, CSMRI-7B, CSMRI-8, CSMRI-9, CSMRI-10, and CSMRI-11 were installed at the CSMRI Site in February 2007. The "B" designation in the monitor well label denotes a replacement monitor well.[8] The results of Site ground water monitoring are set forth in the appropriate sections below.

3 Environmental Investigation and Cleanup Activities

In the 1980s, most operations were moved to the Table Mountain Research Center (TMRC) east of Golden, Colorado. Most laboratory equipment and chemicals were removed for use at TMRC. This report does not address the environmental history, investigation, or cleanup of the TMRC facility.

CSMRI continued maintenance and some use of the facility adjacent to Clear Creek. Drums of process materials, ores, tailings, some containers of laboratory chemicals, and old compressed gas cylinders were left on site. CSMRI and the School performed initial investigations of contamination and environmental issues between 1985 and 1992.[9],[10]:

- CSMRI removed several thousand drums of research materials during this time.
- In 1985 the Colorado School of Mines (School) performed an evaluation of the 17 buildings at the Site.[11]
- In 1987, Jacobs Engineering assessed and inventoried hazardous materials including chemicals, radiation and radon hazards (including the Pond), and asbestos threat.
- Industrial Compliance inventoried and removed all chemicals from building 106.
- In May 1988, CDH conducted a radiological inspection and concluded that while there are "numerous places at the facility that need to be cleaned and decontaminated," there was no "emergency at CSMRI regarding potential personnel exposure or of offsite releases."
- In October 1988, the School investigated the Clay Pits where approximately 500 cubic yards of CSMRI pond sediment were disposed of by CSMRI in 1973.
- In April 1989, CSMRI conducted a radiological survey of the Pond in preparation for the installation of a fence.
- In September 1989, Radiant Energy Management preliminarily assessed radiological risks.

[8] Groundwater Monitoring Well Installation Work Plan CSMRI Site, S.M. Stoller Corporation, December 6, 2006.
[9] Colorado School of Mines Research Institute, Tailings Pond Sampling Report, Industrial Compliance, Inc., 1989.
[10] Task 1: Site Characterization and Pathways Analysis, Claypits Site and CSMRI Facility, Golden, Colorado, James L. Grant & Associates, April 30, 1990.
[11] CSMRI Facilities Condition Report, Colorado School of Mines Facilities Department, August 1, 1985.

- In 1989 and 1990, Industrial Compliance sampled the Pond, conducted a radiological survey of the Site, excavated discrete areas of contaminated soils, removed laboratory chemicals and other materials from the Site, and sampled and secured the remaining 700 drums. The October 1989 report on the sampling of the Pond was inconclusive. It identified radiological levels above background levels and recommended that the regulatory agencies and an environmental attorney be consulted to classify the Pond materials and the applicable cleanup standards before any further action.
- In October 1989, Advanced Sciences attempted to assess the potential for water-borne migration of contaminants in the Clay Pits.
- In 1990, James Grant & Associates designed and implemented an environmental monitoring program in the area to determine potential pathways of migration for radioactive materials, organic and inorganic chemicals, and heavy metals.
- In March 1991, CSMRI submitted a $14.8 million reclamation plan to CDH for closure of the CSMRI facility and the remaining CSMRI property at the Table Mountain facility. CSMRI did not have sufficient funds to implement the plan.
- Also in March 1991, EPA's contractor conducted a radiological gamma survey of the Pond, identifying the presence of radionuclides in the Pond. As a follow-up, James L. Grant & Associates conducted a comprehensive soil gamma survey of the CSMRI area and the suspected Clay Pits area in December 1991.

Site investigation and cleanup work accelerated significantly in 1992 following a water main break that flooded the Pond. EPA initiated a CERCLA Response Action. The Response Action focused primarily on the Pond, but EPA also investigated and performed significant cleanup on the Upper Terrace between 1992 and 1997. Subsequently, the School performed additional investigation and cleanup of the Upper Terrace and the Lower Terrace. This report is organized by Site area. Activities within each Site area are organized chronologically.

3.0 Lower Terrace Investigation and Cleanup

3.0.1 EPA Response Action

EPA's CERCLA Response Action following the water main rupture on January 25, 1992 included investigation and evaluation of materials, chemicals, and hazards on the Upper Terrace and Lower Terrace of the Site. During the Response Action EPA evaluated a broad range of potential hazards. This evaluation reduced the primary concerns at the Site to metals and radionuclides. EPA's actions with respect to the Upper Terrace are addressed in section 4.

Both EPA and a contractor hired by CSMRI took extensive emergency water and sediment samples of Clear Creek, the Coors pond, the Farmer's Highline Canal, the Croke

Canal, Standley Lake, and the Maple Grove Reservoir during and after the release event. The Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the sampling results for radionuclides and metals. ATSDR concluded that the overflow posed no adverse health threat to any public drinking sources.

EPA gathered all existing sampling data. EPA's on scene coordinator determined that sufficient data had been developed by previous Site investigations and activities, including the Grant, Jacobs and Industrial Compliance data. EPA conducted selective soil sampling to augment the existing data. EPA's risk assessment concluded that radiological risks were dominated by radium-226 and its daughters in the decay chain. These risks were of concern to hypothetical on-site workers and residents due to radon inhalation and direct gamma exposure. Radon exposure was of more concern than direct gamma exposure. For metals, the primary risk was from arsenic.

EPA delineated the area to be excavated from the Pond and surrounding area on the Lower Terrace. See Figures 2 and 3. EPA cleaned the buildings and drains leading to the Pond before excavation of the Pond area to prevent recontamination of the area. EPA then excavated soils from the Pond and areas to the west of the Pond. A soil stockpile was constructed on an area now referred to as the "Softball Field." EPA also excavated and placed soils in this stockpile from an area north of building 101, an isolated area to the west of building 101, and from the north face of the Softball Field and the north perimeter of the School's baseball field.[12] See Figures 3 and 4. EPA excavated a total of 22,000 cubic yards of soils from the Site and placed those materials in the stockpile. Investigation, construction, and disposal of this soil stockpile are addressed in section 3.1.

EPA performed confirmation sampling in the Pond and embankment after excavation operations were complete. "Results indicated that all samples had concentrations of less than 15 pCi/gm [radium 226+228], the limit prescribed by the Nuclear Regulatory Commission (NRC) for soils below six inches of cover."[13] Following confirmation that the soil met the EPA limit for radium, clean fill was added. Following placement of the fill, additional confirmation sampling was conducted to demonstrate that the area met the NRC standard of 5 picocuries per gram radium for the top six inches of soil. Eventually approximately 6,000 cubic yards of clean fill were placed in the area of the former Pond and adjacent bank.

EPA then issued a CERCLA administrative order to other entities to perform a study on how to dispose of the stockpiled soil and then implement the disposal. The School proposed to dispose of the stockpiled soils at the Conservation Services Inc. landfill in

[12] Summary Report on Site Investigation and Removal Activities, CSMRI Creekside Site, Golden, Jefferson County, Colorado, Ecology and Environment, Inc., March 17, 1993
[13] Ibid.

Bennett, Colorado, and then did so, after an extensive public comment period, in 1995 and 1996.[14]

In November 1996, CDPHE informed EPA that,

> "The removal action involved the stabilization, storage, and ultimately the disposal of approximately 22,000 cubic yards of contaminated soil. The enivronmental [sic] and human health risks associated with this removal action have been adequately addressed."[15]

In 1997, EPA terminated its CERCLA removal action after confirming that the stockpile was properly disposed.

3.0.2 East Lower Terrace Fenced Area

Following EPA's Response action, the School continued investigation and cleanup of the Site. The contaminants of potential concern were metals (arsenic, lead, mercury, molybdenum, and vanadium) and radionuclides (radium-226, thorium, and uranium). Data collected during the Site Remedial Investigation/Feasibility Study (RI/FS) in 2004 indicated elevated concentrations of Ra-226 were present on the Flood Plain east of the Pond. This area contained mature trees and had not been investigated by EPA. This eastern portion of the Lower Terrace was within the Fenced Area and included the Parfet/City of Golden parcel.

Investigative work was performed by Stoller in 2006 in accordance with the Site Characterization Work Plan. The characterization effort determined the extent of Ra-226 impacts to the eastern Lower Terrace.

In August and September of 2007, approximately 210 cubic yards of contaminated soil from the flood plain was relocated to Stockpile B (see section 4.4 of this document). Samples were collected to provide data about the final stage of the flood plain work. The samples indicated that the eastern Lower Terrace met the Site cleanup criteria. (Section 4.4.)

[14] Removal Action Options Analysis, Colorado School of Mines Research Institute, Golden, Colorado, June 12, 1995;
[15] Subject: Coordination of Future Regulatory Efforts at the Colorado School of Mines Research Institute Site, Golden, Colorado, Quillin and Roitman, CDPHE to Dodson & Rushin, U.S. EPA, November 8, 1996.

3.0.3 West Lower Terrace Fenced Area and Lower Terrace Groundwater

Prior to 2007, all ground water monitor wells at the Site consistently had no or only isolated exceedances of Colorado ground water protection standards for any measured contaminant, with the sole exception of monitor well CSMRI-4.

Monitor well CSMRI-4, located near Clear Creek at the northeast corner of the Flood Plain Area, is on the Parfet/City of Golden parcel. This well historically had elevated concentrations of uranium. Values had been declining since 1991 with a few exceptions as depicted on Figure 7. Historically, the concentration of uranium in this monitor well spiked once in 1999 and again in 2003. The spike in the uranium concentration in 2003 was attributed to precipitation effects and removal of asphalt and concrete.[16]

In 2009 a rise in the uranium concentration in monitor well CSMRI-4 appeared to be attributed to a new stormwater discharge. Precipitation from the athletic fields collected in the new storm sewer system, discharged near the northern edge of the bench of the Upper Terrace, and flowed down a riprap-embedded concrete rundown onto the Lower Terrace, just upgradient of CSMRI-4. During the process, the discharge water became oxygenated and was introduced into the poorly oxygenized environment in the Lower Terrace. This oxygenated discharge water mobilized uranium present in the saturated sediments of Lower Terrace and flowed toward monitor well CSMRI-4. Uranium concentrations climbed steadily from 43 micrograms per liter (µg/L) in September of 2008[17] to 160 µg/L in September of 2009[18]. In early 2010, the soccer field discharge pipe was relocated to the east to avoid any outlet onto the Lower Terrace. The uranium concentrations in Well CSMRI-4 then dropped steadily. By June of 2011, the uranium concentration had dropped to 44 µg/L[19]. The data suggest the storm water sewer discharge was, but is no longer, affecting this monitor well.

The overall concentrations of uranium in ground water show a strong downward trend from levels seen before investigation, excavation, and re-routing of the storm sewer outfall.

In February 2007, a new monitor well (CSMRI-8) was installed at the west end of the Lower Terrace near the foot of the bank below the location of the original Experimental Plant building. The shallow ground water at the new well had an initial concentration of uranium 810 µg/L[20]. This concentration was significantly above the Colorado ground water uranium limit of 30 µg/l. Between February of 2007 and September of 2010

[16] Remedial Investigation/Feasibility Study and Proposed Plan, Colorado School of Mines Research Institute Site, Golden, CO, New Horizons Environmental Consultants, Inc., January 21, 2004, Section 4.2.2.
[17] Monitoring Report for CSMRI Site Third Quarter 2008, S.M. Stoller Corporation, November 2008.
[18] Monitoring Report for CSMRI Site Third Quarter 2009, S.M. Stoller Corporation, November 2009.
[19] Monitoring Report for CSMRI Site Second Quarter 2011, S.M. Stoller Corporation, August 2011.
[20] Monitoring Report for CSMRI Site Second Quarter 2007, S.M. Stoller Corporation, August 2007.

uranium concentrations in CSMRI-8 varied between a high of 1800 µg/L in November 2007[21] to a low of 520 µg/L in September 2010. CDPHE requested additional investigation and remediation to address the exceedance of the uranium ground water standard in Well #8.[22] In October of 2010 the well was abandoned in preparation for soil excavation in the immediate vicinity of the well as described below in this section.

In February of 2010 CDPHE approved a Work Plan to investigate the elevated uranium concentrations in Well #8.[23] Before executing the Work Plan, additional work was conducted during the spring and summer of 2010, including several test pits to determine bedrock depth, preliminary chemical and metals data, and uranium solubility properties for the Site soils.

In August of 2010 CDPHE approved the revised Work Plan[24]. [25] The contaminants of potential concern were metals (arsenic, lead, mercury, molybdenum, and vanadium) and radionuclides (radium-226, thorium, and uranium). The investigation used methods developed by Stoller during work in the Upper Terrace Area (See Section 4.4 below). This work identified contaminated soils and excavated to clean soil or bedrock. Upon reaching clean soil or bedrock, confirmatory samples were collected from the remaining clean material, and the excavation backfilled with clean fill similar to the native material excavated.

1,400 cubic yards of soil were excavated and temporarily stored in a lined and secured stockpile on the Upper Terrace Area. Confirmation sampling demonstrated that the soil remaining on the west Flood Plain Area met and were below the Site cleanup criteria for each of the constituents of concern. The confirmatory data are presented below in Tables One and Two. Final data will be published in the forthcoming Remedial Investigation/Feasibility Study report. Sample locations are shown in Figure 23.

[21] Monitoring Report for CSMRI Site Fourth Quarter 2007, S.M. Stoller Corporation, February 2008.
[22] RE: Colorado School of Mines Research Institute -Creekside Facility Radioactive Materials License Number 617-01 Creekside Remedial Implementation Action Report, Tarlton to Havelick, October 14, 2009.
[23] Draft Work Plan Environmental Assessment and Characterization Colorado School of Mines Research Institute Site Flood Plain Area Golden, Colorado, January 8, 2010, S.M. Stoller Corporation.
[24] Final Revised Draft Work Plan Environmental Assessment and Characterization Colorado School of Mines Research Institute Site Flood Plain Area Golden, Colorado, August 2010, S.M. Stoller Corporation.
[25] RE: Colorado School of Mines Research Institute - Creekside Facility, Radioactive Materials License Number 617-01, CSMRI Environmental Assessment and Characterization, Opila to Havelick, August 20, 2010.

Table 1: Laboratory Confirmation Samples and Summary Statistics for Metals (mg/kg)[26]

Location	U	Pb	As	Mo	Hg	V
00163	9.4	86	23	8.2	2.7	20
00257	5.2	19	3.3	1.2	0.29	14
00259	11	51	11	3.2	0.89	29
00267	8.4	160	14	5.2	12	31
00279	3.1	87	17	2.2	1.2	25
00305	13	68	11	4.1	0.84	25
00353	3.3	26	15	1.6	0.03	36
00354	4.5	29	10	0.53	0.094	34
00355	2.6	66	8	4.1	1.5	36
00357	2.6	28	3.1	0.83	0.024	19
00374	3.3	61	4.8	5.1	0.44	32
00375	4.9	170	24	1.7	14	27
00381	11	41	1.8	5	0.26	19
00384	6.7	95	3.8	9.3	1.2	25
00388	3.1	40	2.6	6.1	0.35	29
00422	2.9	60	8.4	8.3	0.48	54
Mean	5.94	67.94	10.05	4.17	2.27	28.44
Std dev	3.51	44.34	7.04	2.79	4.26	9.36
geo mean	5.08	56.46	7.66	3.13	0.60	27.10
Tentative goal	14	400	39	390	23	78

According to the laboratory confirmation sampling, the confirmation results indicate that the cleanup goals for the Flood Plain Area soil were met. Figure 8 shows the sampling locations for the confirmation results. Figures 9 through 14 show the sample frequency distributions for laboratory results.

[26] Draft Final Remedial Investigation/Feasibility Study and Proposed Plan Colorado School of Mines Research Institute Site Flood Plain Area, Golden, Colorado, S.M. Stoller Corporation, November 2011.

Table 2: Laboratory Confirmation Samples and Summary Statistics for Radionuclides (pCi/g)[27]

Location	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-234	U-235	U-238
00163	11	2.9	2.0	10	1.8	4.3	0.20	4.2
00257	3.9	2.0	2.1	2.5	1.7	2.3	0.12	2.1
00259	5.2	2.7	2.4	6.7	2.0	4.2	0.25	4.1
00267	4.3	2.3	2.5	6.2	1.9	4.5	0.24	4.5
00279	1.9	2.0	2.3	1.7	2.0	1.8	0.11	1.8
00305	4.7	2.3	2.1	4.6	1.8	4.3	0.24	4.3
00353	1.9	1.7	2.3	1.2	1.9	1.5	0.09	15
00354	1.9	1.9	2.3	1.1	1.7	2.3	0.11	2.3
00355	2.5	2.3	3.0	2.8	2.9	1.7	0.07	1.9
00357	1.4	1.7	2.0	0.73	1.6	1.3	0.06	1.1
00374	4.2	3.5	2.9	2.8	2.7	1.4	0.07	1.3
00375	2.6	3.3	3.0	1.8	2.6	2.1	0.09	2.0
00381	2.4	2.2	2.4	1.5	2.0	3.7	0.15	3.9
00384	6.4	2.6	2.1	4.7	1.8	2.8	0.12	2.6
00388	2.4	3.1	2.0	1.3	1.7	1.8	0.086	1.7
00422	4.2	1.8	1.8	3.5	1.5	1.5	0.074	1.6
mean	3.82	2.40	2.33	3.35	1.98	2.59	0.13	2.56
Std dev	2.41	0.56	0.36	2.62	0.41	1.20	0.07	1.20
geo mean	3.29	2.34	2.30	2.58	1.95	2.35	0.12	2.32
Tentative goal	4.14	4.6	6.47	11.53	3.88	254.9	4.97	21.8

Figure 8 shows the sampling locations for the confirmation results. Figures 15 through 22 show the frequency distributions for the radionuclide results.

As of November 2011, the following tasks remain for the Lower Terrace. A Remedial Investigation/Feasibility Study Report for soil is nearing completion that will outline alternatives for final disposition of the 1,400 cubic yard stockpile of contaminated soil excavated from the Lower Terrace. Remediation of the soil stockpile according to the recommendations of the RI/FS and a Proposed Plan is expected to be completed later in 2011. Part of the Revised Work Plan required installation of monitor well CSMRI-8B at the same location as the previous well CSMRI-8 and a deep monitor well CSMRI-14 to determine the condition of ground water in the deeper aquifer. Monitor well CSMRI-14, was installed into the shale bedrock beneath the Site at a depth of 55 feet below ground surface. Uranium results in CSMRI-14 have consistently been at 1.5 to 2.1 µg/kg uranium. Thus, there is no contamination of the deep aquifers detected.[28]

[27] Draft Final Remedial Investigation/Feasibility Study and Proposed Plan Colorado School of Mines Research Institute Site Flood Plain Area, Golden, Colorado, S.M. Stoller Corporation, November 2011.
[28] Monitoring Report for CSMRI Site Second Quarter 2011, S.M. Stoller Corporation, August 2011.

A two-year monitoring period is currently being conducted to confirm the effectiveness of the previous investigation and remedial work performed at the Upper Terrace and the investigation of the Flood Plain Area of the Site. The current ground water monitoring program consisting of quarterly sampling and analysis will be continued until such a time as levels drop to either below the Colorado groundwater Standard or conditions demonstrate that it is appropriate to do so. At the end of the two-year period, the ground water monitoring program and results will be assessed as to next steps.

3.1 EPA Soil Stockpile Formerly Located at Softball Field

EPA placed the approximate 22,000 cubic yards of excavated material it removed from the Lower Terrace in 1992 and areas on the Upper Terrace (see sec. 3.0.1) in an area west of the School's baseball field now known as the Softball Field.[29] This area had historically been used by the School for disposal of soil, demolition debris, and landscaping refuse. EPA's contractor performed a gamma survey of the stockpile area prior to construction. The survey indicated no elevated levels of gamma radiation. EPA's contractor also collected composite soil samples from the surface of the stockpile area. The samples indicated no elevated levels of metals. The northern most face of the construction fill area, however, did contain tailings material, according to EPA's contractor. CSMRI had placed tailings in this area. North face material did have elevated levels of metals and radiation.[30] Prior to placing any of the contaminated soils, EPA completed construction in July 1992 of a "clay pad" on top of the designated area to keep the contaminants in the stockpile from contaminating the clean area below the stockpile.

The Removal Action Options Analysis (RAOA) listed eleven inorganic and seven radionuclides as Contaminants of Concern (COC's).[31] Toxicity Characteristic Leaching Procedure (TCLP) tests found the soil stockpile did not exceed RCRA regulatory limits for toxicity characteristics; therefore, the soil was not classified as a RCRA Hazardous Waste. The stockpiled soil was found to contain the following concentrations for COC's:

[29] The School built the Softball Field after disposal of the soil stockpile and clearance of the area by EPA and CDPHE.

[30] Letter Report Surface Gamma Radiation Survey Former Soil Stockpile Location Colorado School of Mines Golden, Colorado, Earth Sciences Consultants, Inc., July 20, 1996

[31] Removal Action Options Analysis, Colorado School of Mines Research Institute, Golden, Colorado, Submitted to: U.S. Environmental Protection Agency, June 12, 1995.

Table 3: Selected Contaminants of Concern

Constituent	Result
Radium-226 (pCi/g)	47
Uranium (nat) (µg/kg)	46
Arsenic (mg/kg)	92
Barium (mg/kg)	705
Chromium (mg/kg)	25
Lead (mg/kg)	328

The soil stockpile COC's were found to meet the acceptance criteria for the Conservation Services, Inc. (CSI) industrial waste landfill at Bennett, Colorado. The soil was transported and disposed at the CSI landfill in 1996 and 1997. Following the shipment and off-Site disposal of the soil stockpile, the location of the former stockpile and surrounding surface areas were surveyed to ensure that no residual radioactive materials remained. Surface gamma readings were at background levels with the exception of an area north of the former stockpile.[32] That area is discussed below in Section 4.4.

Following completion of that portion of the project, the CDPHE "determined that the Colorado School of Mines (CSM) Softball Field is not a part of the licensed CSMRI Creekside Site, RML 617-01. We [CDPHE] have also determined that the CSM Softball Field is suitable for release for unrestricted use."[33]

4 Upper Terrace Investigation and Remediation

4.0 Building and Drum Assessment and Demolition

In addition to the activities completed on the Lower Terrace (section 3.0.1), EPA also completed the following actions on the Upper Terrace as part of the Response Action it initiated in 1992: (1) collection and disposal of all chemicals in the buildings (including PCBs, cyanides, acids, bases, and other various reagents); (2) decontamination of the buildings for explosive and radiation hazards; and (3) excavation of contaminated soils

[32] Surface Gamma Radiation Survey Former Soil Stockpile Location, Earth Sciences Consultants, Inc., July 10, 1996. That area was investigated and remediated separately from the EPA soil stockpile project as the Niobium Ore Area (see section 3.2 of this report).

[33] Colorado Radioactive Materials License #617-01, Colorado School of Mines Research Institute (CSMRI), Golden, Colorado, Simpson to Iatridis, February 18, 1998.

at identified locations on the Upper Terrace (both within and outside the Fenced Upper Terrace Area).[34]

In 1996 the materials and containers were reviewed by the School and analyzed to determine content and, where possible, ownership. Drums and/or materials that were identified as belonging to specific entities were returned to owners. Materials not matched to specific owners were evaluated and disposed off-Site.[35]

The presence of buildings prevented investigation access to subsurface soils. They needed to be demolished to allow access for investigation. Buildings were first evaluated by the School for contaminants. Building contaminants identified included radionuclides, trichloroethylene, asbestos, polychlorinated biphenyls (PCB's), and heavy metals. A 1994 Radiological Survey Plan identified procedures for the survey and identification of contaminated materials and their extent, and distribution.[36] Each building was decontaminated and demolished according to work plans.[37] Additional studies and surveys conducted in 1995 further defined the nature and extent of contaminated materials. That survey determined that the great majority of above-grade building materials could be managed as conventional building demolition debris suitable for disposal as solid waste. Buildings were demolished and small portions of the building structures were handled separately as "special solid waste".[38]

4.1 Concrete and Asphalt Evaluation and Demolition

Following demolition of the above-ground building structures, several acres of the Site had concrete or asphalt cover from building floors, driveways, roadways, parking lots. Concrete and asphalt needed to be demolished to allow access to subsurface soils for investigation. In 2001, the School prepared a Characterization Survey Work Plan to guide subsequent investigation at the Site.[39] Testing and sampling of the concrete and asphalt determined that, "The majority of the site concrete and asphalt areas appear to be at background levels of the key radionuclides that were measured. The isolated

[34] Summary Report on Site Investigation and Removal Activities, CSMRI Creekside Site, Golden, Jefferson County, Colorado, Ecology and Environment, Inc., March 17, 1993.
[35] Final Report – Drummed Research Materials Disposal, Environmental Resources Management (ERM), July 25, 1997.
[36] Colorado School of Mines Research Institute Radiological Survey Plan, September 12, 1994, Wastren Remediation.
[37] e.g. Track 1 Comprehensive Work Plan, Dismantling, Demolition and Removal of Building 101 at the CSMRI Site, Golden, Colorado, AWS Remediation, Inc., March 1996.
[38] Draft Materials Characterization, Colorado School of Mines Research Institute Experimental Plant, January 18, 1996, AWS Remediation, Inc.
[39] Characterization Survey Work Plan, Colorado School of Mines Research Institute Site, Golden, Colorado, July 23, 2001, URS Corporation.

areas of elevated radioactivity are generally discrete and identified in extent by the radiation survey measurements.[40]

The concrete and asphalt materials were demolished and sent off site for recycle or disposal depending on the level of contaminants detected. 2,550 cubic yards of concrete and asphalt were landfilled at the BFI Foothills Landfill in Golden, Colorado, and 2,970 cubic yards of the materials were recycled at the Recycled Materials, Inc. plant in Arvada, Colorado. 1.6 cubic yards of materials that exceeded standards for recycle or municipal landfill disposal were held for later disposal.[41] This small quantity of materials was disposed of at the RCRA Subtitle C, American Ecology disposal site in Grand View, Idaho in 2004.

4.2 2003 – 2004 Upper Terrace Fenced Area Soil Investigation

A Remedial Investigation/Feasibility Study report published in January 2004 estimated the volumes of contaminated soils necessary to remediate the Upper Terrace. The contaminants of potential concern were metals (arsenic, lead, mercury, molybdenum, and vanadium) and radionuclides (radium-226, thorium, and uranium). The volume estimates were based on surface and subsurface data and estimation techniques. An estimated volume of 9500 cubic yards of soil would be excavated and transported to a local solid-waste landfill and 500 cubic yards would have been shipped to a specialized waste facility in Idaho.[42]

The 2004 RI/FS calculated Site-specific tentative cleanup goals are shown in Table 4.[43]

[40] Colorado School of Mines Research Institute, Concrete and Asphalt Characterization, Golden, Colorado, Final Report, July 15, 2002, URS Corporation.
[41] Concrete/Asphalt Removal and Disposal, Colorado School of Mines Research Institute Site Environmental Assessment and Response (Phase 1), Draft, April 11, 2003, New Horizons Environmental Consultants, Inc.
[42] Remedial Investigation/Feasibility Study and Proposed Plan, Colorado School of Mines Research Institute Site, January 21, 2004, New Horizons Environmental Consultants.
[43] Ibid.

Table 4: 2004 Site Cleanup Goals (exclusive of background)

Radionuclide	Site Goal (pCi/g)		Metal	Site Goal (mg/kg)
Lead-210	4.44		Arsenic	0.39
Polonium-210	192		Barium	5,277
Radium-226	1.44		Cadmium	76.1
Radium-228	2.20		Chromium (total – includes Cr VI)	223
Thorium-228	3.77		Lead	400
Thorium-230	9.83		Mercury (elemental)	1.1
Thorium-232	1.48		Mercury (compounds)	23
Uranium-234	253		Molybdenum	390
Uranium-235	4.88		Selenium	380
Uranium-238	20.2		Silver	380
			Vanadium	550
			Zinc	22,825

Excavation of contaminated soil started in 2004. Two classes of excavated soil were created based on landfill waste acceptance criteria. Soil under the 3 pCi/g Ra-226 limit could be disposed at the Foothills Landfill as approved by CDPHE prior to the start of the project. Soils with higher radium concentrations would be shipped to a disposal site in Idaho.[44]

Before initial excavation had proceeded across approximately one-third of the Site, the excavated volume of soil above the 3 pCi/g radium-226 limit exceeded the estimated quantities by several times. The project was halted at that point because it was clear that the previous investigation was inadequate to estimate nature and extent of contamination, additional investigation was necessary, and budget authority did not exist for the work that would have been required.[45]

At the point that the study was halted, the School's contractor had performed excavation work that included containerizing approximately 1,870 cubic yards of soil. Some of the containerized soil had been shipped to the RCRA Subtitle C, American Ecology disposal site in Grand View, Idaho, but the majority remained containerized until additional characterization work could be completed.

[44] Subject: CSMRI soil cutoff values for planning and budgeting purposes, Schieffelin to Havelick, February 26, 2004.
[45] Colorado School of Mines Research Institute Site, Revised Remedial Investigation/Feasibility Study and Proposed Plan, May 2007, S.M. Stoller Corporation.

In 2005, a risk assessment was performed of the containerized soil if it were to be disposed of at the Foothills Landfill in Jefferson County, Colorado. The risk assessment assumed that 30,000 cubic yards of soils were disposed at the landfill with similar characteristics to the containerized soil. The associated risks were determined to be well below the 25 millirem per year unrestricted use criteria.[46] CDPHE authorized the disposal of up to 30,000 cubic yards of contaminated soil from the CSMRI Site at the Foothills Landfill, if the soil was similar in nature to the containerized soil.[47]

The containerized soil that had been excavated in 2004 was transported to the Foothills Landfill for disposal in 2005.

4.3 Area North of and Under Softball Field: Niobium Ore Excavation and Disposal

An investigation determined that niobium ore had been mostly buried at the bottom of a slope north of the softball field. This deposit produced gamma radiation at levels two to six times background. During the spring of 1996, approximately 120 cubic yards of niobium ore was excavated and stockpiled in an area apart from EPA's clay lined stockpile area on the Softball Field. Excavations were backfilled with clean fill. Additional survey of the area was conducted in 1997 and an additional 100 – 120 cubic yards of soil and ore was excavated. Following the 1997 excavation and backfill, the areas excavated measured a gamma exposure rate of 16 µR/hr one meter above the surface.[48] The material was disposed of at the Denver Arapahoe Disposal Landfill in Arapahoe County, Colorado.

The niobium ore was evaluated for hazardous waste characteristics and for radioactive materials classification. The Colorado Department of Public Health and Environment "determined the material is not source material, meets the guidelines for release for unrestricted use of the U.S. Nuclear Regulatory Commission, Regulatory Guide 1.86, and is suitable for disposal as a solid waste."[49] The material was determined to not be a RCRA Hazardous Waste as determined by the TCLP test.

Following completion of that portion of the project, the CDPHE "determined that the Colorado School of Mines (CSM) Softball Field is not a part of the licensed CSMRI

[46] Dose Assessment for the Emplacement of the CSMRI Site Containerized and Remaining Subsurface Soil into a RCRA Subtitle D Solid Waste Landfill, S.M. Stoller Corporation, April 1, 2005.
[47] Subject: Colorado School of Mines Research Institute (CSMRI) Creekside Facility Site Remediation, Vranka to Havelick, August 26, 2005.
[48] Summary Report Regarding Removal of Niobium Ore, Gravel Application, and Surface Gamma Radiation Survey Activities at the Former Colorado School of Mines Research Institute, August 25, 1997.
[49] Simpson & Mallory to Arnott & Krumberger, Re: Colorado Radioactive Materials License #617-01, April 25, 1997.

Creekside Site, RML 617-01. We [CDPHE] have also determined that the CSM Softball Field is suitable for release for unrestricted use."[50]

4.4 2005 – 2007 Upper Terrace Fenced Area Soil Investigation

The School's contractor, Stoller, performed additional investigation in 2005-2007 at the Upper Terrace within the Fenced Area. Stoller revised the 2004 RI/FS in May 2007.[51] The Revised RI/FS provided the nature and extent of contamination, re-evaluated alternative remedies, and proposed an off-site disposal remedy that differed from the remedy selected in 2004. The Revised RI/FS incorporated portions of the 2004 RI/FS, replaced some portions, and supplemented other portions.

As noted above in section 4.2, a risk assessment was performed specific to the Foothills Landfill in Golden, Colorado for disposal of up to 30,000 cubic yards of Site soil that had similar contamination to that found in the containerized soil. Subsurface soil contamination still existed at the Site then.

Upper Terrace characterization activities were completed following the procedures set forth in a 2006 Work Plan.[52] The investigation entailed excavating the impacted soil and stockpiling it on-site to determine the nature and extent of contamination. This excavation method was analogous to the method used by the EPA to address the former settling pond in 1992-1993.

Two soil stockpiles were generated during the Upper Terrace characterization activities. The majority of the excavated material contained less than 100 pCi/g total activity with approximately 12,500 cubic yards in Stockpile A.[53] Stockpile B contained approximately 200 cubic yards of soil from Upper Terrace areas previously identified as containing greater than 100 pCi/g total radioactivity.

After soil was excavated and the two stockpiles were created, the in situ soil remaining in the Upper Terrace excavation areas was sampled and analyzed to confirm that Site soil cleanup levels had been achieved. The following tables provide the summary

[50] Colorado Radioactive Materials License #617-01, Colorado School of Mines Research Institute (CSMRI), Golden, Colorado, Simpson to Iatridis, February 18, 1998.
[51] Colorado School of Mines Research Institute Site, Revised Remedial Investigation/Feasibility Study and Proposed Plan, May 2007, S.M. Stoller Corporation, May, 2007.
[52] CSMRI Creekside Site Final Site Characterization Work Plan, May 12, 2006, S.M. Stoller Corporation
[53] Revised Remedial Investigation/Feasibility Study and Proposed Plan, S.M. Stoller Corporation, May, 2007.

results for the Upper Terrace soil data for radionuclides and metals.[54] All Site soil cleanup criteria were met and the nature and extent of the soil contamination in the Upper Terrace could be reliably estimated.

CSMRI Radionuclide Statistics Summary
(2007 Revised RI/FS)

Radioisotope Tentative Site	Mean ($\bar{x}$) (pCi/g)	Standard Deviation (s)	Upper One-Sided Confidence Limit	Action Level (pCi/g)
Ra-226	3.52	2.28	4.09	4.14
Ra-228	1.95	0.66	2.10	4.6
Th-228	1.88	0.60	2.02	6.47
Th-230	2.27	1.75	2.66	11.53
Th-232	1.76	0.58	1.89	3.88
U-234	2.08	1.84	2.50	254.9
U-235	0.24	0.33	0.32	4.97
U-238	2.14	1.91	2.58	21.8

The confirmation sampling for soils and metals was performed by in four separate Survey Units across the Upper Terrace. Soil cleanup criteria were met in each of the Survey Units as well as on the overall Upper Terrace for all radionuclides and metals. According to the RI/FS,

> "The survey identified two locations in Zone 2 with elevated activity that were adjacent to sanitary sewer lines and could not be excavated and one location with elevated activity at the edge of a steep slope. **However, these three elevated data points were included in the calculations of mean, standard deviation, and upper one-sided confidence limits, demonstrating that the Site cleanup criteria have been achieved**."[55] [Emphasis added.]

The 2007 RI/FS indicated that Site soil cleanup metals criteria had been met:

[54] Ibid, pages 4-6, 4-7.
[55] Ibid, page 4-6.

CSMRI Metals Confirmatory Samples Statistics Summary

(2007 Revised RI/FS)

Metal	Mean (x) (ppm)	Standard Deviation (s)	Upper One-Sided Confidence Limit	Tentative Site Action Level (ppm)
Arsenic	14.8	20.2	19.4	39
Lead	99.5	121.1	127.4	400
Mercury	0.6	0.9	0.8	23
Molybdenum	6.6	6.0	8.0	390
Vanadium	32.0	9.2	34.2	550

The results for lead and arsenic confirm that the cleanup criteria were met. Arsenic levels were reduced to 61% below the Site background level.

Following the excavation of contaminated soils and the performance of confirmation testing, large areas of the Upper Terrace were covered with up to several meters of clean fill soil. The construction of a new soccer pitch, parking lot pad, and entry road covered up to 80% to 90% of the footprint of the Upper Terrace with clean fill. In 2011, additional clean fill is being placed east of the existing parking lot pad to expand the future parking areas. The planned construction of a City of Golden bicycle path through the Site will effectively cover additional portions of the Site.

4.5 Ground Water at the Upper Terrace

During the course of work on the Upper Terrace a number of wells were installed on and around the Upper Terrace. The amount of uranium detected in ground water indicated that the portion of the Site where uranium exceeded the standard of 30 micrograms per liter appeared to be primarily limited to the Lower Terrace.

Well #4 at the east end of the Flood Plain Area had uranium dropping from about 90 µg/l to near the 30 µg/l limit over a period of 15 years. Wells #7 and #9 located at the interface between the Flood Plain Area and the Upper Terrace Area also exceeded the ground water standard for uranium, although at concentrations similar to those found historically in Well #4, not Well #8. Other wells on the Upper Terrace and Lower Terrace consistently had levels of uranium below the limit.

5 Clay Pits

Following the placement of Pond sediment in one of the trenches in 1973, the location (approximately 0.34 acres) was surveyed and a legal description of the location was determined.[56] The vast area of the clay pits in general, and the relatively small size of the Clay Pits area containing the Pond sediments, made finding the Clay Pits difficult. Two initial unsuccessful efforts[57,58], were followed by a third investigation in 2007 by the S.M. Stoller Corporation. To locate this area, Flatirons Surveying, Inc. of Boulder, Colorado created a plan view model based on the 1977 Bolis survey of the 1973 Pond sediment disposal. The model was then projected on City of Golden plats to re-establish the point of origin, as defined by Bolis, and the corners of the rectangle that defines the 1977 surveyed locations of where the dredged material was reportedly placed. Field implementation began at the point of origin and the corners of the rectangle were staked. A plat of this was filed with the County Surveyor making it an official part of the area's survey record.

Stoller made six borings through the staked area, encountering fill and debris. Each of the boreholes extended to native material underlying the debris – 40 to 56 feet below ground surface (bgs). Each boring was continuously cored with each core subjected to a continuous scan for radioactivity using a handheld sodium iodide gamma scintillator. Field observations (scanning results and sample collection locations) were recorded onto borehole log field forms. The activity scanning indicated background conditions for all soil in each core.

The Clay Pits area had the same cleanup goals as the Upper Terrace and followed the same procedures except as detailed in the letter work plan.[59,60] On September 14, 2007, the Colorado Department of Public Health and Environment's (CDPHE) radiation unit agreed no further action is required in the Clay Pits area.[61]

[56] Colo. School of Mines Research Institute Waste Disposal Pit, Louis E. Bolis, undated, and Location of Waste Dump, CSM Research Institute, drawing by Louis E. Bolis, January 3, 1977.
[57] Remedial Investigation/Feasibility Study and Proposed Plan, Colorado School of Mines Research Institute Site, Golden, CO, New Horizons Environmental Consultants, Inc., January 21, 2004.
[58] Colorado School of Mines Research Institute Site, Clay Pits Soil Boring Locations, URS Greiner Woodward-Clyde, April 1999.
[59] RE: Clay Pits Investigation Colorado School of Mines Research Institute Site, Brinkman to Stoffey, November 10, 2006.
[60] Clay Pits Area Remedial Site Investigation Report, April 2007, S.M. Stoller Corporation.
[61] RE: Clay Pits Area Remedial Site Investigation Report, Colorado School of Mines Research Institute – Creekside Facility, Radioactive Materials License Number 617-01, Tarlton to Havelick, September 14, 2007.

6 Summary and Conclusion

Between 1912 and 1987, research sponsors performed, or conducted under contract, thousands of metallurgical research projects on a wide variety of ore and minerals at the Experimental Plant and CSMRI. Research process wastes contained metals and radionuclides, which were the contaminants of concern at the Site as set forth in detail above. These research process wastes were disposed of on the Upper Terrace, Lower Terrace, and the Clay Pits. CSMRI, EPA, and the School have investigated the areas of the Site to determine if there were metals and/or radionuclides that required cleanup. Areas found to require cleanup have been cleaned up, except for the soil stockpiled on the Upper Terrace from execution of the Revised Work Plan on the Lower Terrace in 2010, and the Lower Terrace groundwater in monitoring well CSMRI-8a (section 3.0.3). Except for these two items, radionuclides are within acceptable standards.

In summary, the investigation and cleanup work implemented at the Site includes:

CSMRI and the School Early Investigations (section 3): CSMRI and the School performed initial investigations of contamination and environmental issues between 1985 and 1992.

EPA Response on the Upper Terrace and Lower Terrace (section 3.0.1, 3.1 and 4.0): After the water main break in 1992, EPA performed a CERCLA Response action on the Upper Terrace and the Lower Terrace. EPA decontaminated buildings and the drainage system discharging to the Pond. EPA excavated approximately 22,000 cubic yards of contaminated soils from the Pond and adjacent areas, and also from areas on the Upper Terrace. Before stockpiling the soil in an area to the west of the School's baseball field, EPA sampled the surface soils and determined there was no contamination to be cleaned up. A clay pad was constructed prior to placement of the stockpiled soils. The School subsequently disposed of the soils at the Conservation Services, Inc.(CSI) landfill near Bennett, Colorado in 1996.

Area North of and Under Softball Field (section 4.3): In 1996 and 1997, the School excavated several hundred cubic yards of niobium ore and other materials previously disposed of along the slope north of the softball field, west of the baseball field on the Upper Terrace. The niobium ore was evaluated for hazardous waste characteristics and for radioactive materials classification. The material was determined to not be a RCRA hazardous waste as determined by the TCLP test. Following completion of that portion of the project, the CDPHE "determined that the Colorado School of Mines (CSM) Softball Field is not a part of the licensed CSMRI Creekside Site, RML 617-01. We

[CDPHE] have also determined that the CSM Softball Field is suitable for release for unrestricted use."[62]

Above-Ground Facilities in Upper Terrace Fenced Area (section 4.0): Above-surface evaluation of drummed materials, ore stockpiles, building contents, building structures, and stored chemical materials was conducted between 1994 and 1997. These facilities were cleaned, abated, demolished, or disposed of generally by 1997. Solid wastes were disposed off-Site at the Foothills Landfill in Jefferson County and the CSI Landfill. Many research materials were also returned to research project sponsors.

Below-Ground Facilities in Upper Terrace Fenced Area (section 4.1): Concrete and asphalt at grade and below grade were evaluated and demolished between 1998 and 2003. These solid waste materials were recycled or landfilled at the Foothills Landfill . Less than two cubic yards of concrete and asphalt were held for later disposal at a landfill in Idaho that accepted solid wastes with radium-226 concentrations in excess of the waste acceptance criteria of the Foothills Landfill.

Surface and Sub-Surface Soil in Upper Terrace Fenced Area (section 4.2 and 4.4): Surface and subsurface soils in the Upper Terrace Area were investigated between 2003 and 2007. The investigation resulted in the creation of two stockpiles of contaminated soil. Most of the soil was disposed of as solid waste at the Foothills Landfill as authorized by CDPHE after preparation of a risk assessment specifically for disposal at the Foothills Landfill. In addition, approximately 200 cubic yards of soil were disposed of as solid waste at the Clean Harbors Environmental Services landfill in Adams County, Colorado in 2007. In a 2006 letter, CDPHE stated that these areas have been cleaned to unrestricted use.

Lower Terrace Fenced Area and Site Groundwater (sections 3.0.2 and 3.0.3): In August and September of 2007, approximately 210 cubic yards of the flood plains' contaminated soil was relocated to Stockpile B (see section 4.4). Samples indicated that the eastern Lower Terrace met the Site cleanup criteria (section 4.4.).

In August of 2010, pursuant to a Work Plan approved by CDPHE, approximately 1,400 cubic yards of soil were excavated and temporarily stored in a lined and secured stockpile on the Upper Terrace Area. Confirmation sampling demonstrated that the soil remaining on the west Flood Plain Area met and were below the Site cleanup criteria for each of the constituents of concern. CDPHE has stated that the stockpiled soil may be disposed of at the Foothills Landfill as solid waste. Remediation of that soil stockpile is expected by the end of 2011.

[62] Colorado Radioactive Materials License #617-01, Colorado School of Mines Research Institute (CSMRI), Golden, Colorado, Simpson to Iatridis, February 18, 1998.

The uranium concentrations in Well CSMRI-4 have steadily dropped following relocation of the soccer field storm discharge pipe in early 2010 to avoid any outlet onto the Lower Terrace. By June of 2011, the uranium concentration had dropped to 44 µg/L[63]. The data suggest the storm water sewer discharge was, but is no longer, affecting this monitor well.

The high uranium concentration in CSMRI-8 resulted in the Work Plan for the investigation of the Lower Terrace soils in 2010. As a result of this work the old CSMRI-8 was abandoned and several new wells were installed. CSMRI-13 was installed in the deeper aquifer in the Lower terrace and has shown no contamination. A shallow ground water well (CSMRI-14) was installed adjacent to CSMRI-13. The presence of uranium in shallow ground water but not in deep ground water demonstrates that the deep aquifer has not been impacted. Two years of groundwater monitoring will be completed to determine the condition of the shallow aquifer. CSMRI-8B replaced CSMRI-8, and a couple of additional monitoring wells were added on the Lower Terrace in the shallow aquifer. This monitoring well and another well CSMRI-12 have had uranium concentrations above the Colorado groundwater standard for uranium for two quarters.

Clay Pits Area (section 5): The Pond sediments disposed of in the Clay Pits were investigated in 2007. Borings were taken in the area suspected to contain the deposited materials. The activity scanning indicated background conditions for all soil in each core. The Clay Pits area had the same cleanup goals as the Upper Terrace and followed the same procedures except as detailed in the letter work plan. The investigation concluded no further action was necessary at the Clay Pits area. CDPHE radiation unit agreed no further action is required in the Clay Pits.

[63] Monitoring Report for CSMRI Site Second Quarter 2011, S.M. Stoller Corporation, August 2011.

7 Figures

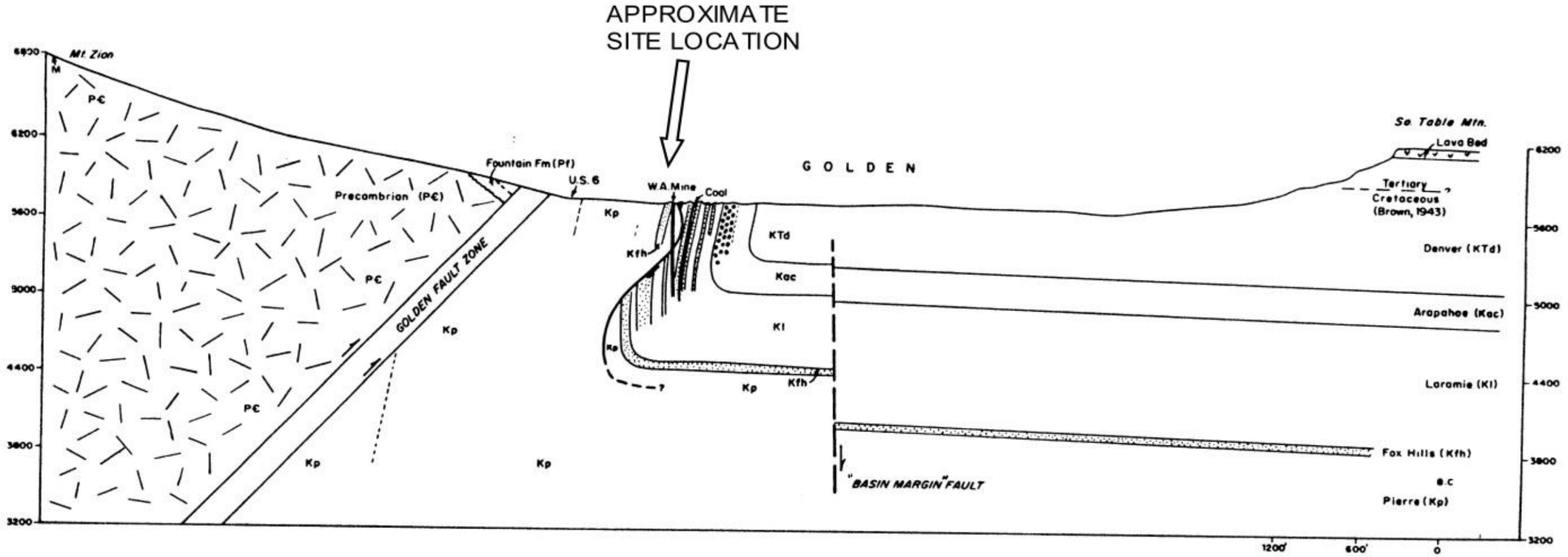


Figure 1: East-West Section of CSMRI Site Geology[64]

[64] Source: Weimer, 1976, Cretaceous Stratigraphy, Tectonics and Energy Resources, Western Denver Basin (Figure 16)

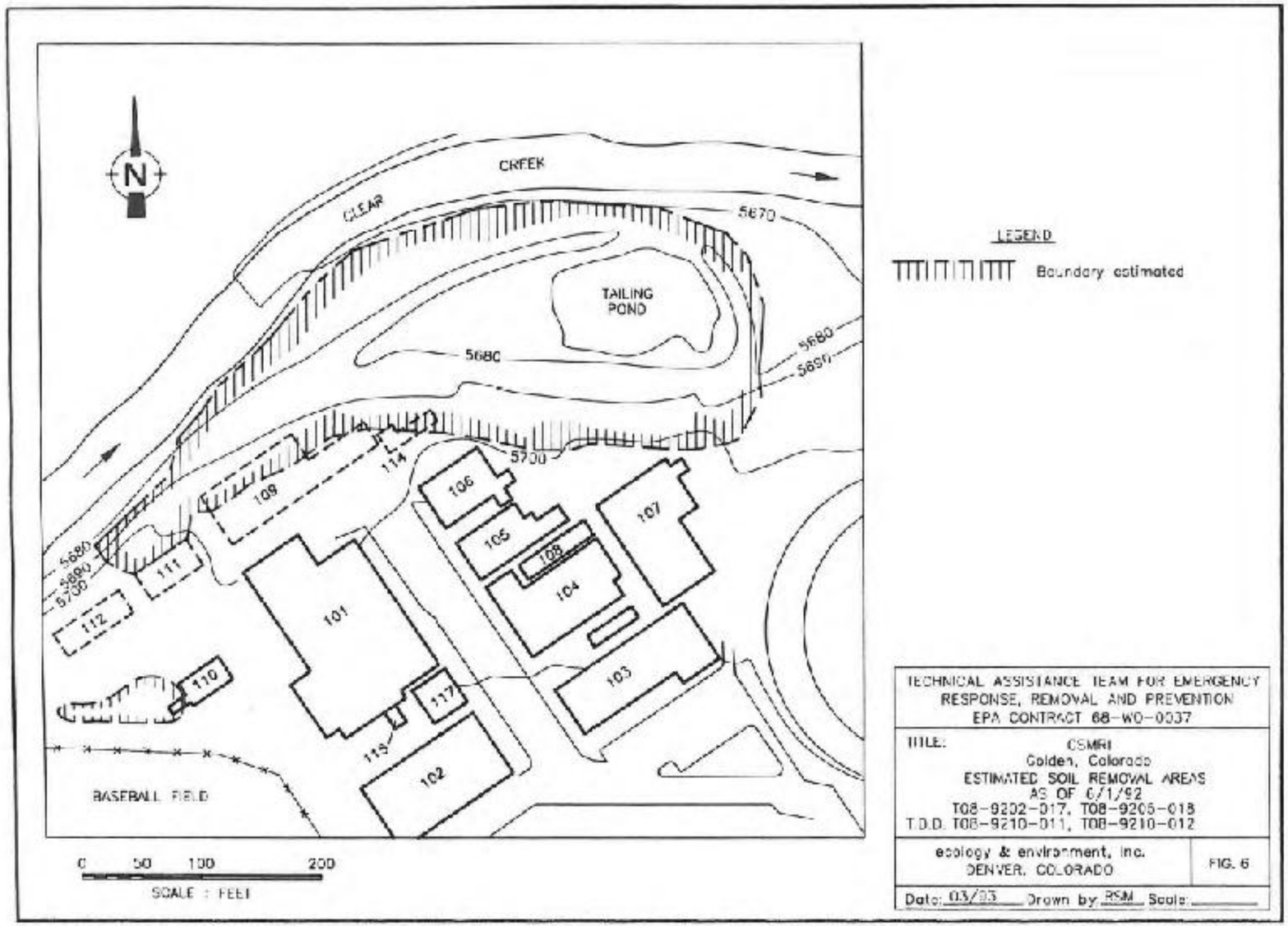


Figure 2: EPA Estimated Soil Removal Areas 1992[65]

[65] from Summary Report on Site Investigation and Removal Activities CSMRI Creekside Site, 3-17-1993 Volume One, Figure 6

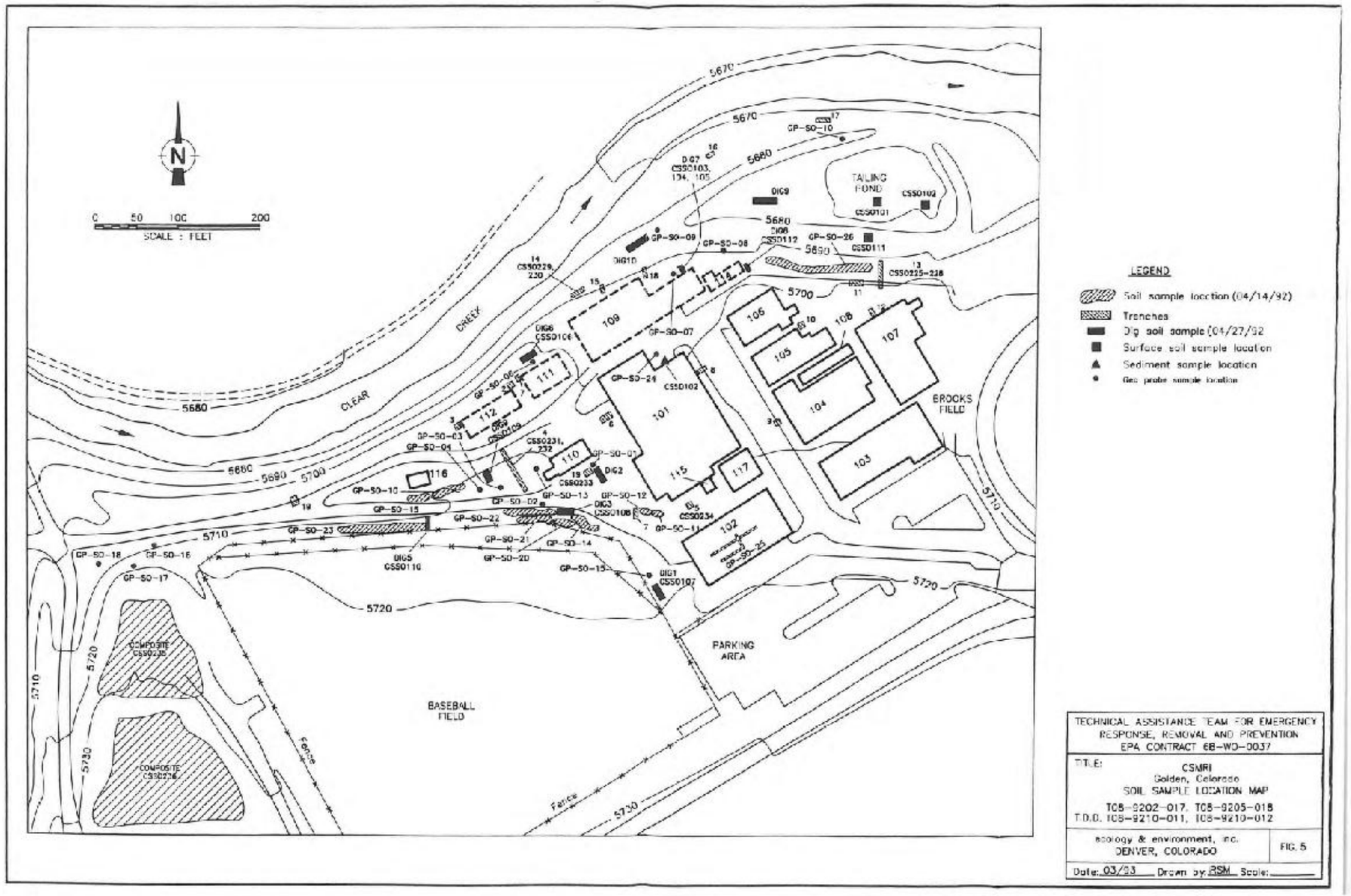


Figure 3: EPA Investigation Areas 1993[66]

[66] from Summary Report on Site Investigation and Removal Activities CSMRI Creekside Site 3-17-1993 Volume One, Ecology & Environment, 1993, Figure 5

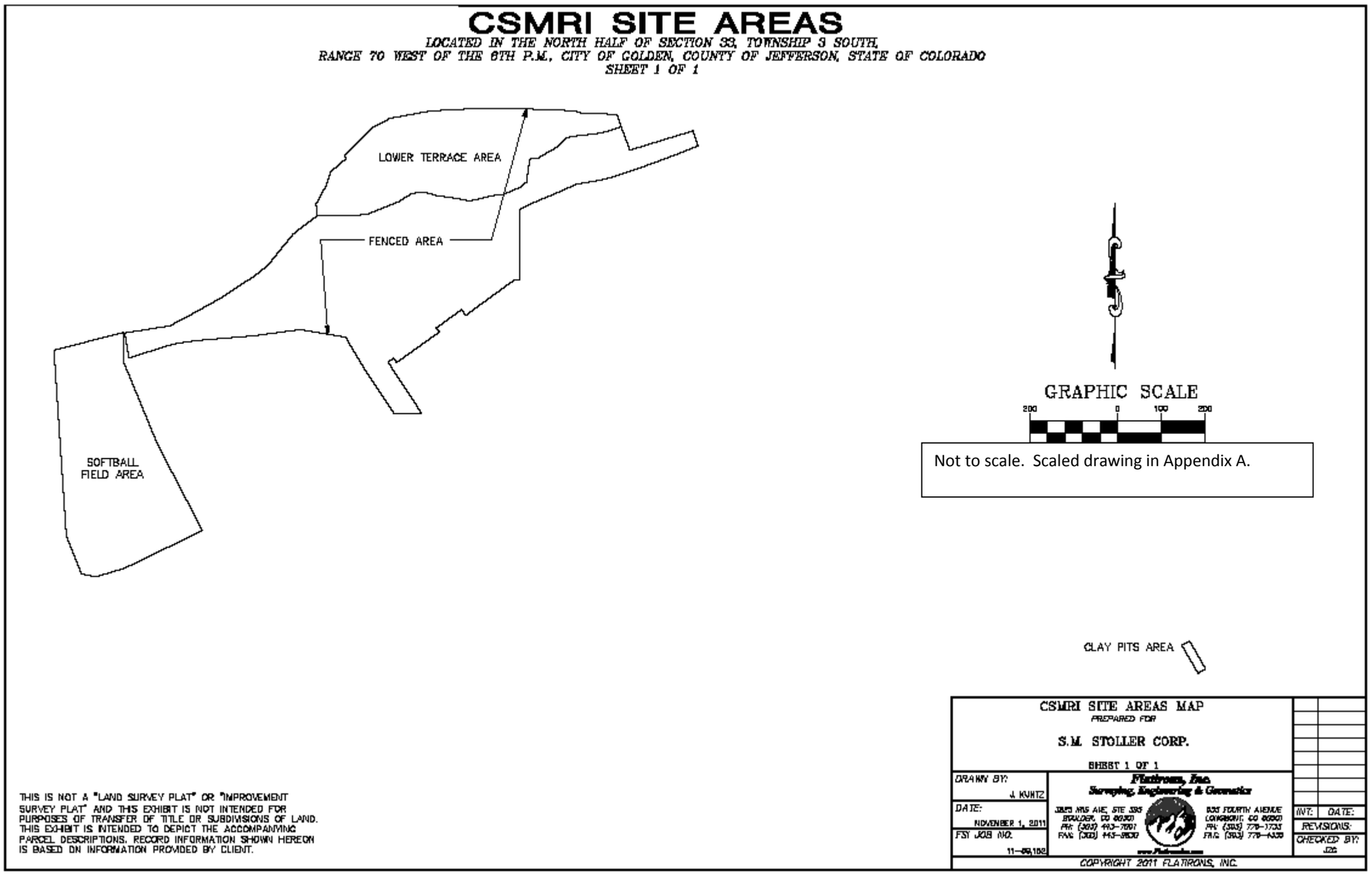


Figure 4: CSMRI Site Areas

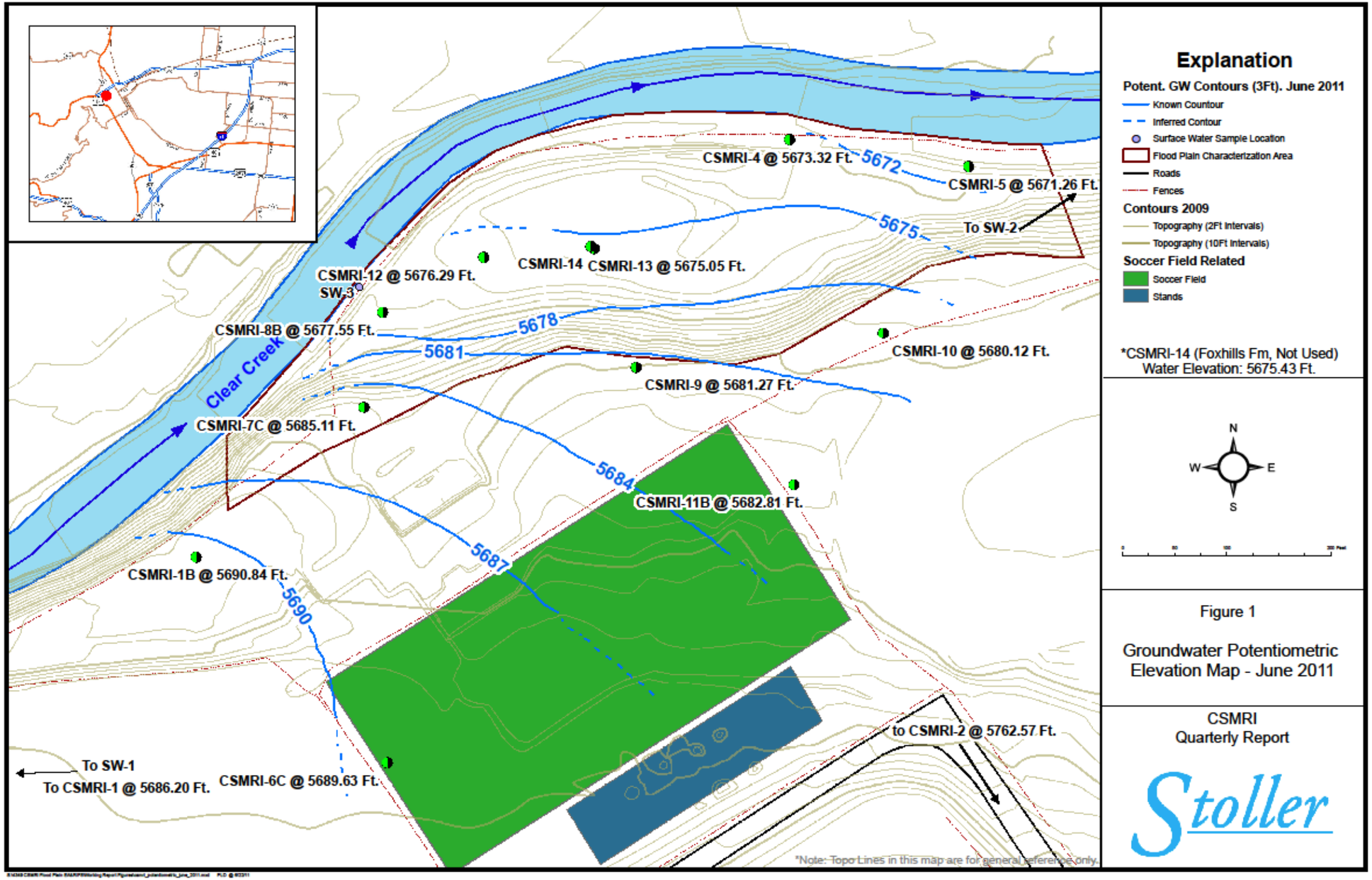


Figure 5: Well Location Map[67]

[67] from Monitoring Report for CSMRI Site, 2nd Quarter 2011, S.M. Stoller, August 2011, Figure 1

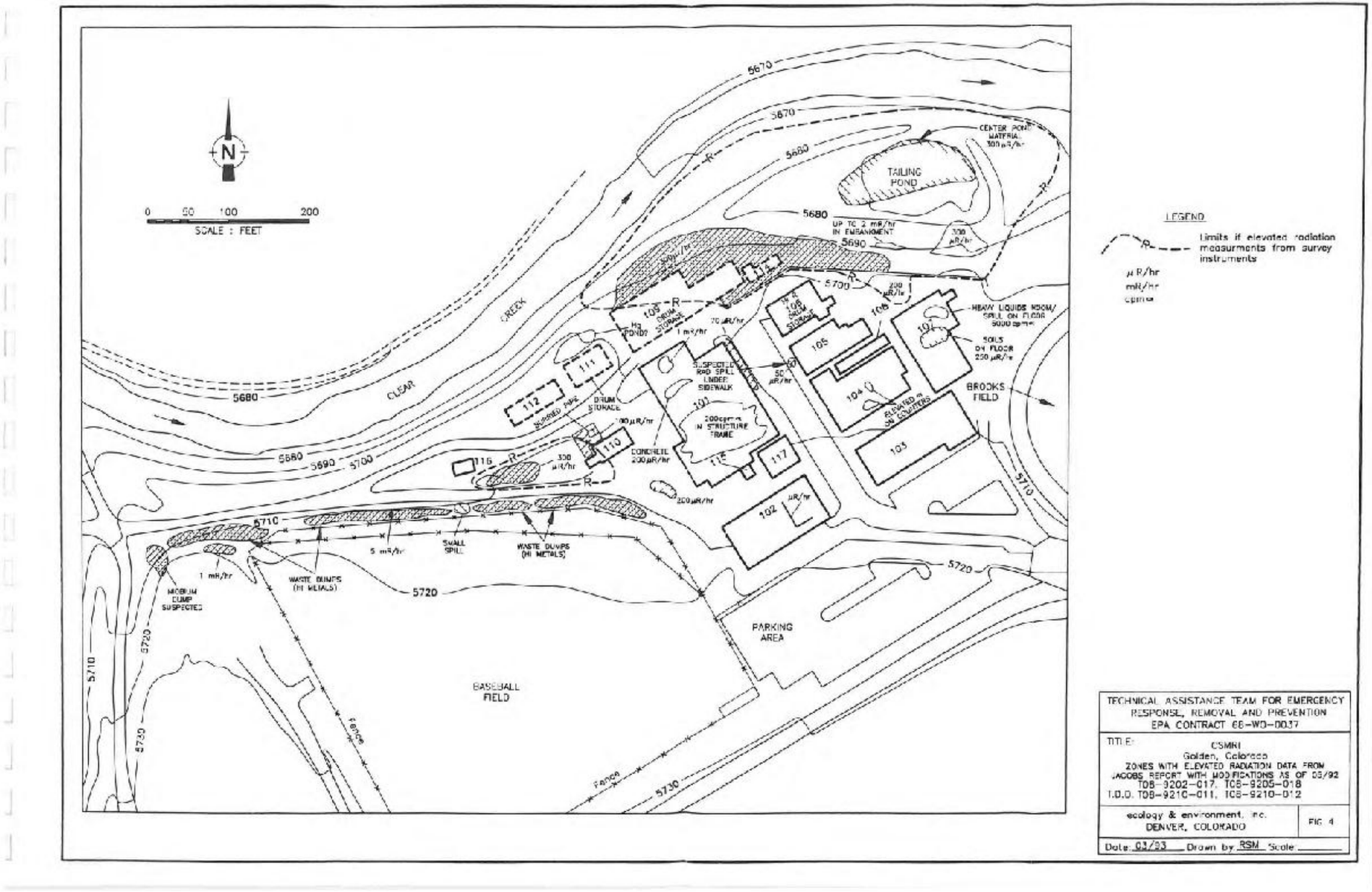


Figure 6: EPA Work Areas 1993[68]

[68] from Summary Report on Site Investigation and Removal Activities, CSMRI Creekside Site, Golden, Jefferson County, Colorado, Ecology and Environment, Inc., March 17, 1993, Figure 4

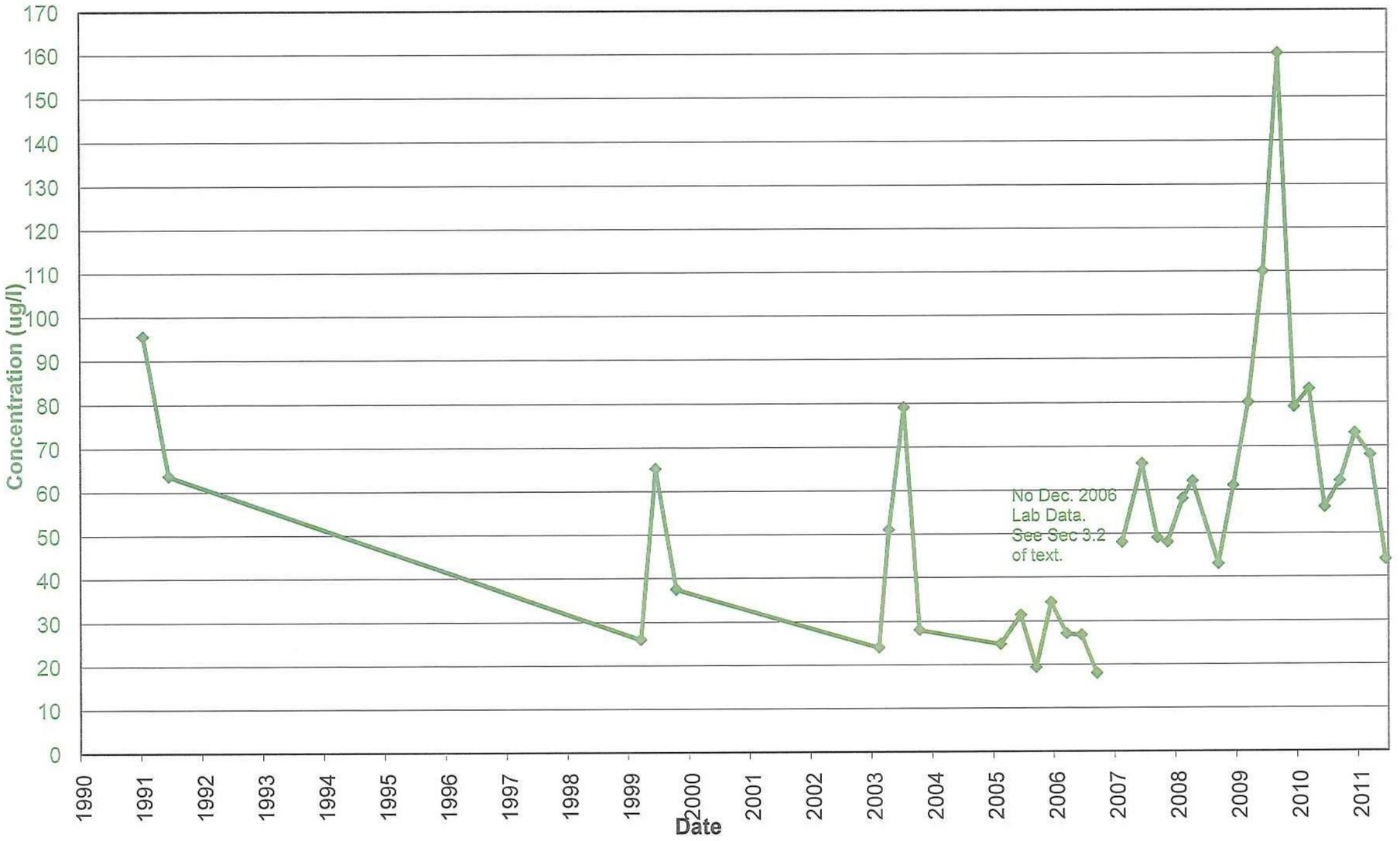


Figure 7: CSMRI Well #4 Historical Total Uranium Concentrations, micrograms U per liter[69]

[69] Monitoring Report for CSMRI Site, Second Quarter 2011, S.M. Stoller Corporation, August 2011, Figure 5

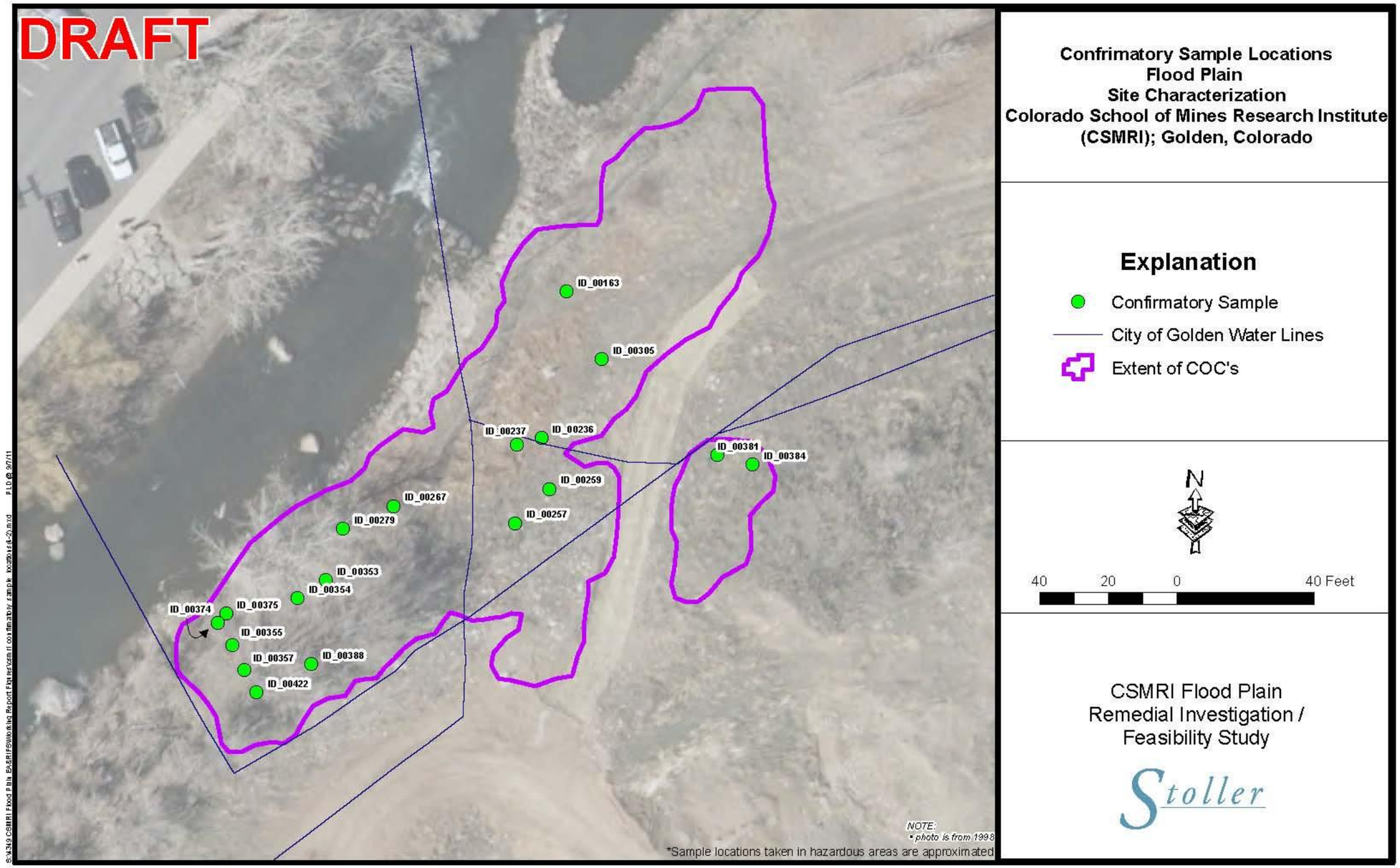
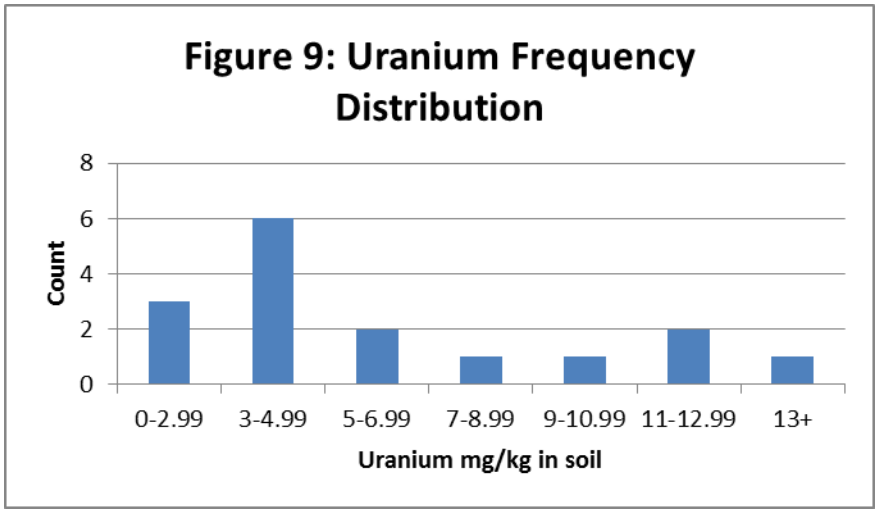
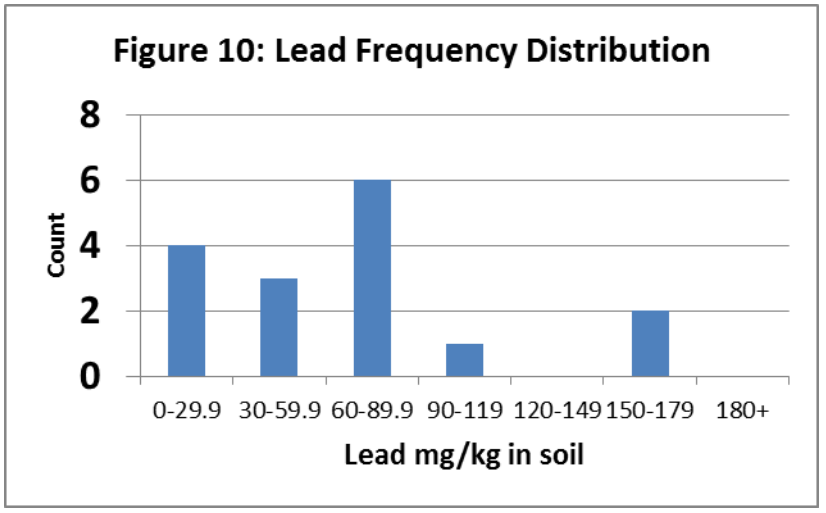
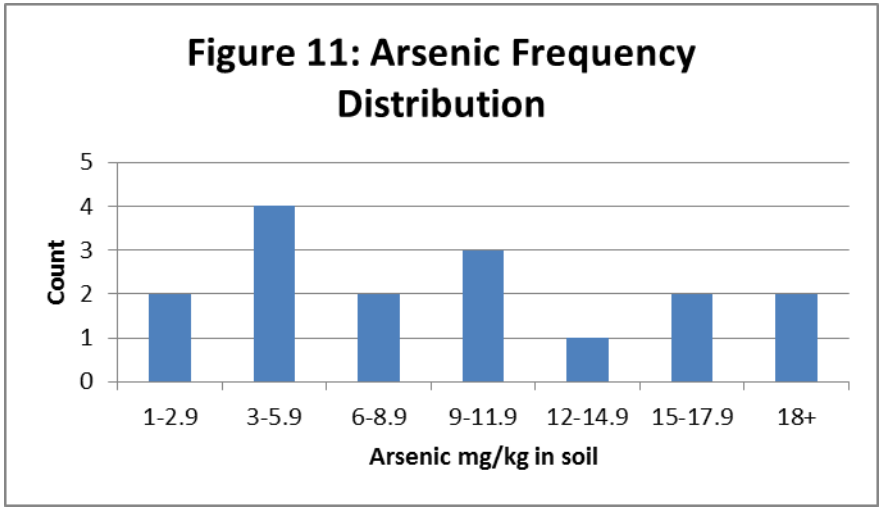


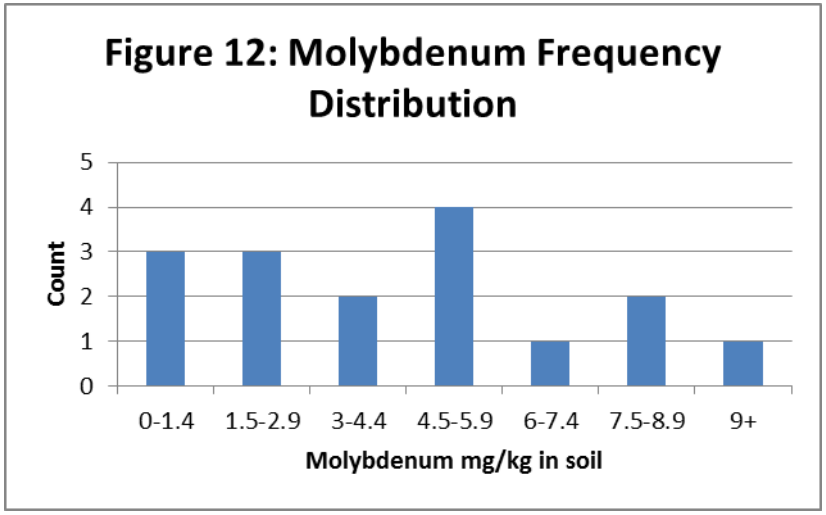
Figure 8: West End of Lower Terrace Soil Confirmation Sample Locations

WEST FLOOD PLAIN AREA CONFIRMATION SAMPLES
FREQUENCY DISTRIBUTIONS









FREQUENCY DISTRIBUTIONS (Cont.)

Figure 13: Mercury Frequency Distribution

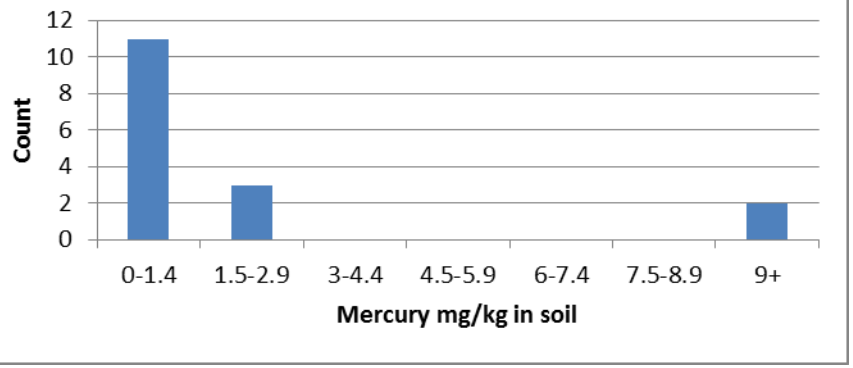


Figure 14: Vanadium Frequency Distribution

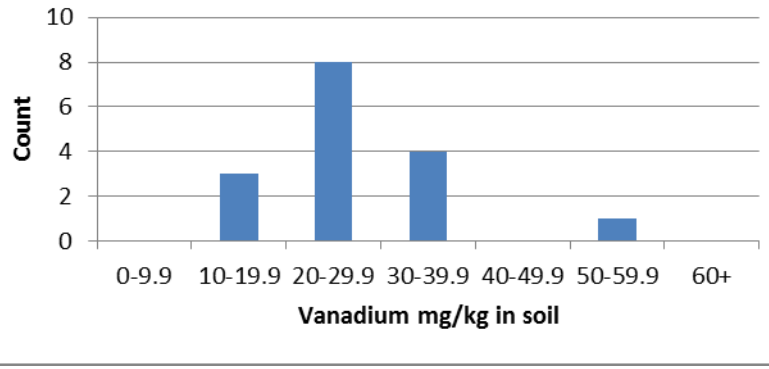


Figure 15: Radium-226 Frequency Distribution

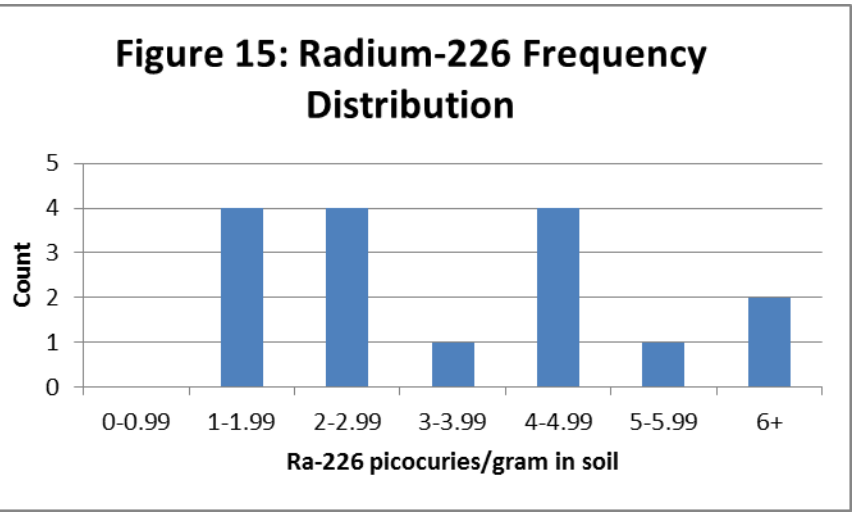
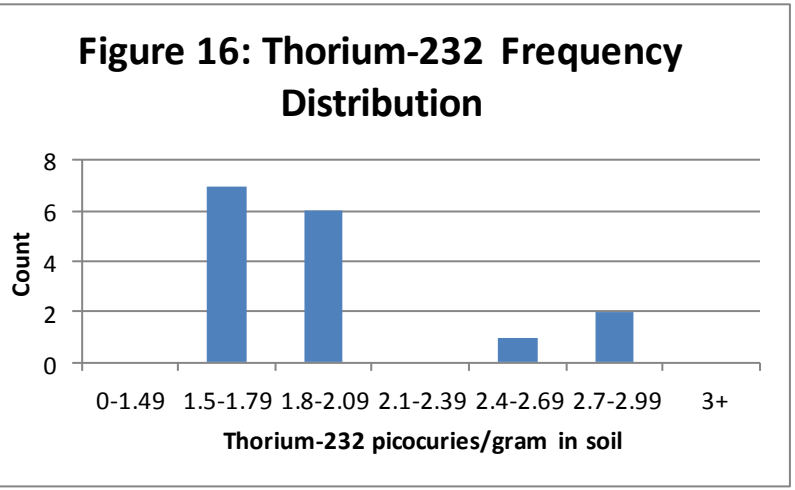


Figure 16: Thorium-232 Frequency Distribution



WEST FLOOD PLAIN AREA CONFIRMATION SAMPLES

FREQUENCY DISTRIBUTIONS (Cont.)

Figure 17: Thorium-228 Frequency Distribution

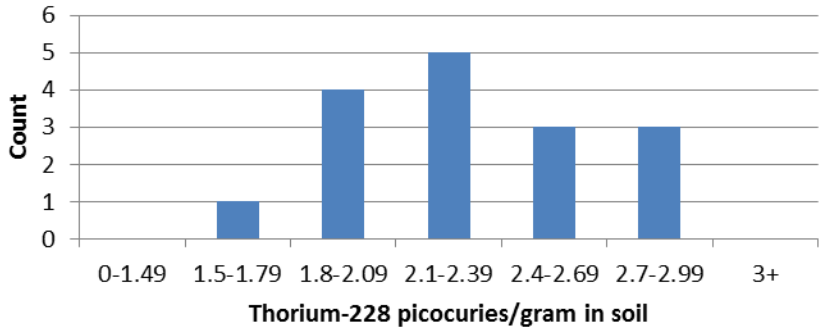


Figure 18: Thorium-230 Frequency Distribution

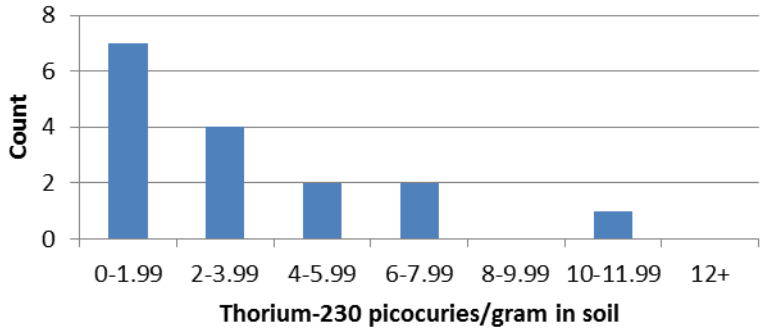


Figure 19: Uranium-234 Frequency Distribution

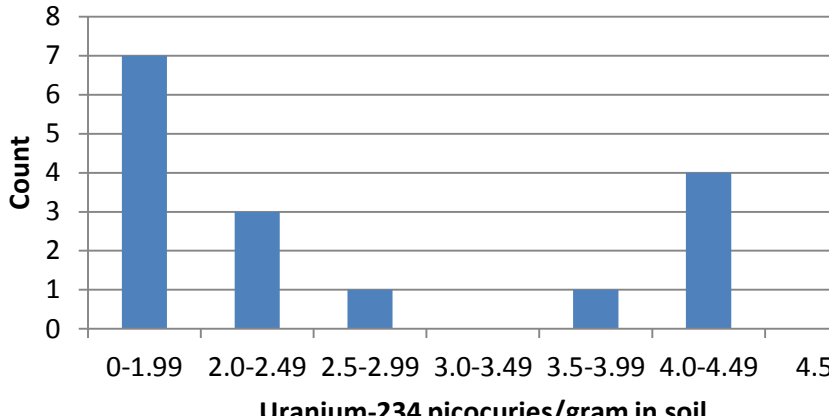
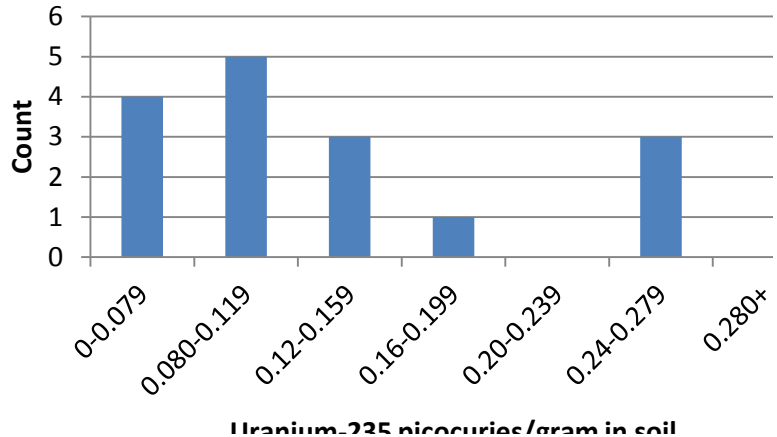
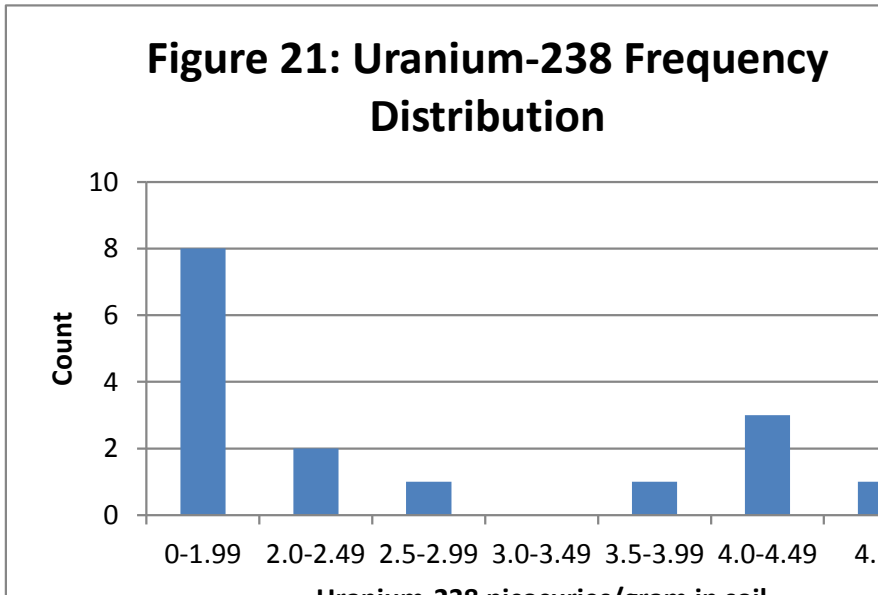


Figure 20: Uranium-235 Frequency Distribution



WEST FLOOD PLAIN CONFIRMATION SAMPLES
FREQUENCY DISTRIBUTION (Cont.)



8 APPENDIX A: CSMRI SITE AREAS