SA/TIB-25

IMPACT OF THE SCHWARTZWALDER MINE
ON THE WATER QUALITY OF
RALSTON CREEK, RALSTON RESERVOIR, AND UPPER LONG LAKE

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U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

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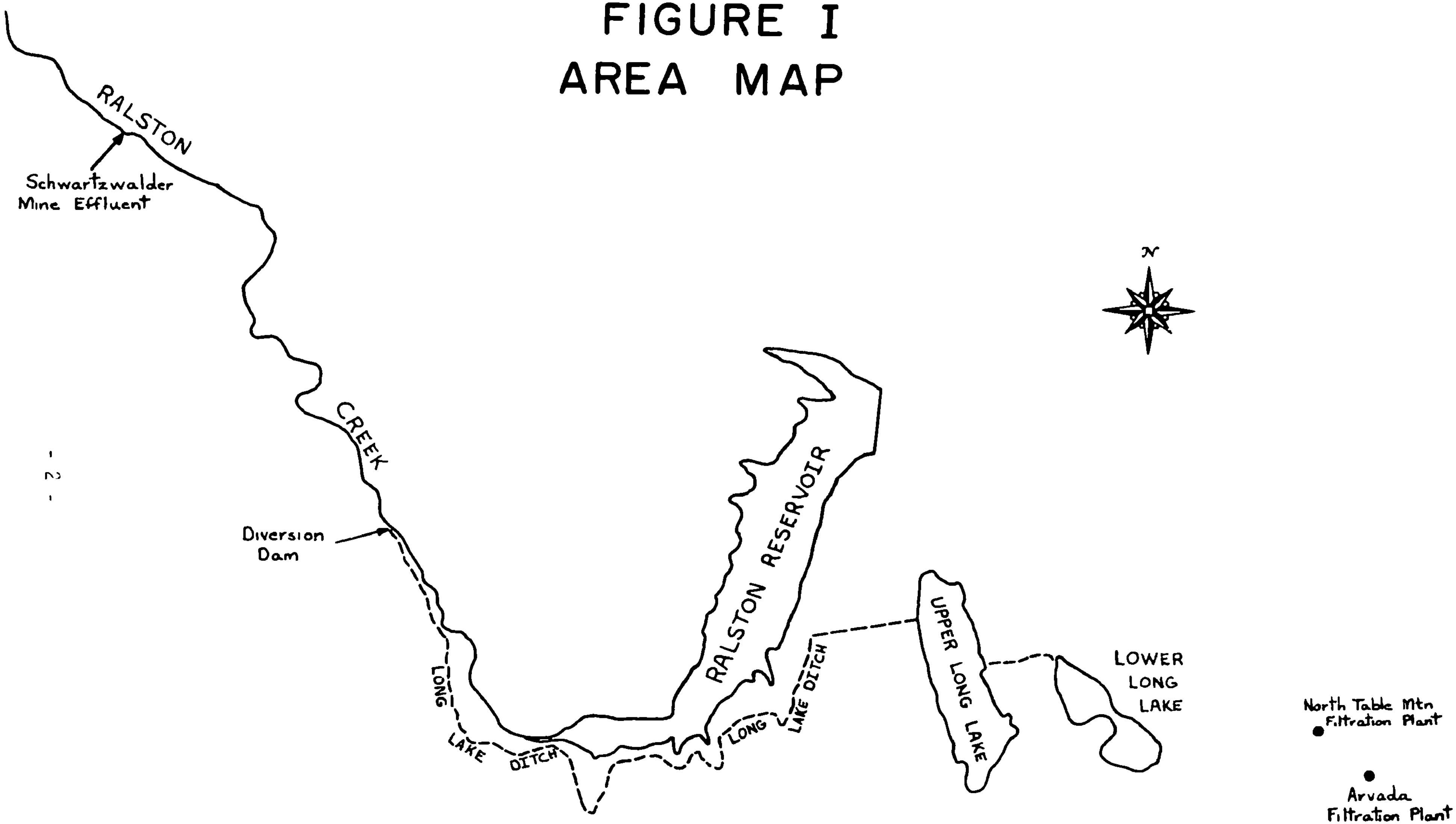
BACKGROUND

In March of 1972, results of the Colorado Department of Health/ Denver Water Board monitoring program for Ralston Creek in the vicinity of the Schwartzwalder uranium mine were brought to the attention of EPA Region VIII. These data (Appendix A) showed a significant degradation of radiological water quality attributable to the mine effluent. At a location immediately downstream of the mine discharge, radium-226 and uranium concentrations in the creek reached levels that approached two orders of magnitude greater than natural background concentrations.

Considering the magnitude of radioactivity concentrations in Ralston Creek and use of the stream as a primary water source for two water supply reservoirs - Ralston Reservoir and Upper Long Lake, Region VIII initiated a limiting monitoring effort to supplement the State/Water Board program. This monitoring activity extended over the period of May through September, 1972. Emphasis was placed on eliminating critical data voids; i.e., radioactivity concentrations in the waters of Ralston Reservoir and Upper Long Lake. In addition to the grab water samples collected from these impoundments, sample collection included the mine effluent, water and bottom sediment samples from Ralston Creek and Long Lake ditch, and bottom sediment samples from the two impoundments.

A map of the area of concern is shown in FIGURE I. As illustrated, the diversion of Ralston Creek flow to Upper and Lower Long Lakes is accomplished by means of a small diversion dam. According to Denver Water Board personnel, this diversion is the only source of water for Upper Long Lake and, therefore, the North Table Mountain Water District. Although located south of the North Table Mountain plant, the Arvada water treatment plant uses Ralston Reservoir as the source of raw water.

FIGURE I
AREA MAP



SCHWARTZWALDER URANIUM MINE

Owned and operated by the Cotter Corporation, the Schwartzwalder uranium mine is located on Ralston Creek between Ralston Buttes and Belcher Hill; north of Golden, Colorado. During the first half of 1972, ore production was about 300 tons per day, but the plan for the immediate future called for increasing production to 500 tons per day. Ore is trucked in "small" trucks from the mine site to a "dump" point adjacent to the Coors Company landfill. From this point, it is reloaded and transported to the Cotter Corporation uranium mill at Canon City, Colorado.

The main effluent from the mine originates from dewatering operations. Throughout 1972, the only treatment provided was some degree of solids removal in a shallow sedimentation pond. After discharge from a pipe, the liquid waste flowed a short distance across the ground and entered the shallow pond. Pond effluent was conveyed to Ralston Creek by a ditch. Grab samples of the mine effluent showed high concentrations of dissolved uranium and radium-226 on the order of 15 mg/L and 80 pCi/L, respectively (TABLE I). Selected metals analysis of the sample collected on 7/20 showed 5 μg/L arsenic, 1.0 mg/L fluoride, 15 μg/L lead, <2 μg/L selenium, and 18 μg/L zinc (Appendix B).

In addition to the main effluent, two small pipes located on the west side of the road discharge relatively minor flows into a small pond (less than 20 feet in length). There is no direct connection between this pond and the creek and liquid loss appears to be by seepage. Although the exact source(s) of the effluents was not determined, mine personnel were of the opinion that the source was overflow from the process and potable water system (ground water source). The radium and uranium results for grab samples of these effluents confirmed this point of view since the respective concentrations were comparable to those which can be expected in ground water taken from uranium-bearing strata. The dissolved radium-226 concentration was about 0.5 pCi/L and dissolved uranium in the range of 400-500 μg/L (TABLE I).

Chemical treatment of the mine effluent has been the subject of a lengthy research project (2½ years) conducted by the Colorado School of Mines Research Institute. The treatment scheme developed to reduce dissolved uranium and radium concentrations involves a two-step, sequential, precipitation process: addition of ferric sulfate and lime to produce a ferric hydroxide precipitation followed by barium chloride addition to effect a barium sulfate precipitation. Uranium-bearing sludge is to be collected in two settling ponds with periodic removal for reclaiming uranium values at the Canon City mill. The schedule for treatment installation and operation was set forth in a letter of October 4, 1972 (Appendix C) from Mr. D. P. Marcott, Executive Vice President, Cotter Corporation, to Mr. E. D. Dildine, Permits Branch.

TABLE I

RADIOACTIVITY IN SCHWARTZWALDER MINE EFFLUENTS

Effluent	Date of Collection	Radium-226 Content of Suspended Solids (pCi/gram)	Dissolved Radioactivity: Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium (μg/L)	Thorium (μg/L)	Alpha Thorium (pCi/L)
Main mine effluent at pipe outfall, upstream of sedimentation ponds.	5/12/72	-	2080	3800	86	14,200	49	18
	7/20/72	709	-	-	72	15,600	-	-
Effluents from adjacent small pipes, each draining into a small pond on the west side of the road (no overflow from pond).								
(a) Pipe closest to road.	7/21/72	-	-	-	0.4	470	-	-
(b) Pipe farthest from road.	7/21/72	-	-	-	0.5	400	-	-

A. Mine water treatment precipitation system in operation	October 31, 1972
B. Commence monitoring of raw and treated mine water	November 1, 1972
C. Submit first monthly report (for November) covering water treatment operation	December 15, 1972
D. Compliance with effluent limitations considered to be reasonably attainable	November 1, 1973

The effluent limitations referred to in D (above) are 3 pCi/L and 5 mg/L for dissolved radium-226 and uranium, respectively.

ENVIRONMENTAL MONITORING

Water

Radioactivity results for grab water samples collected from Ralston Creek, Ralston Reservoir, and Upper Long Lake are presented in TABLES II, III, and IV. These tables also contain the descriptions of the sampling stations. For Ralston Reservoir and Upper Long Lake, the sampling station locations are shown in FIGURES II and III.

Consistent with the findings of the State/Denver Water Board monitoring program, the two sets of grab samples from Ralston Creek showed significant degradation in radiological water quality attributable to the untreated mine discharge (TABLE II). Typically for an intermittent, mountain stream, the degree of deterioration intensified from spring to summer as flow decreased. At the time of the May 12 collection with significant creek flow upstream of the mine, the dissolved concentrations immediately downstream of the mine discharge were 3 pCi/L and 82 μg/L of dissolved radium-226 and uranium, respectively. This approximated a dilution factor of 20 times. However, in July there was no surface flow upstream and the flow immediately downstream was totally mine drainage. This was verified by dissolved concentrations of radium-226 and uranium in the creek comparable to those in the mine effluent - 81 pCi/L and 20,3000 μg/L, respectively.

The results for the May 12 samples did not indicate any significant difference between the radioactivity concentrations in Ralston Creek immediately downstream of the mine and at the diversion dam. However, in the case of the July 21 samples, there was a 40 fold reduction in the corresponding concentrations at these same locations. Although the data were too limited for a positive explanation, the possible reasons include (a) mass transfer of radioactive constituents from the water phase to bottom sediment, (b) dilution from tributaries and/or ground water inflow to the creek, and (c) the grab samples at each location being representative of different flow regimes.

Although biological investigations were not conducted, the magnitude of dissolved uranium concentrations observed in Ralston Creek during July, 1972, were sufficiently high to constitute a toxic environment. Existing knowledge of uranium toxicity to aquatic biota is limited and lacking in many areas. However, bioassays which have been conducted indicate an environment with the potential for acute toxicity for fish when the dissolved uranium concentration exceeds 1.0 mg/L in "soft" water (Appendix D).

Grab water samples were collected over the entire length of Ralston Reservoir on six (6) transects (FIGURE II). At each sampling location, samples were collected from the water column at the surface and within a few feet of the bottom. The dissolved uranium results for the selected samples analyzed showed no detectable effect from the Schwartzwalder effluent (TABLE III). These data showed a range of <0.1 - 2.5 μg/L which is typical for dissolved uranium in surface waters (normally less than 10 μg/L). The dissolved radium-226 data supported this finding with the

TABLE II

RADIOACTIVITY IN WATER SAMPLES FROM RALSTON CREEK AND LONG LAKE DITCH

Station Description	Date of Collection	Radium-226 Content of Suspended Solids (pCi/gram)	Dissolved Radioactivity					
			Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium (μg/L)	Thorium (μg/L)	Alpha Thorium (pCi/L)
Ralston Creek								
(a) At footbridge crossing, upstream of mine effluent.	5/12/72	-	5	30	0.1	0.9	3	0.2
	7/20/72	-	-	-	0.6	8	-	-
(b) Several hundred yards downstream of mine effluent.	5/12/72	-	7	22	3.1	82	37	0.9
	7/20/72	-	-	-	81	20,300	-	-
(c) Approximately 0.5 mile downstream of mine at road culvert.	7/21/72	-	-	-	22	4,670	-	-
(d) Approximately one mile downstream of mine at road culvert.	7/21/72	-	-	-	15	3,400	-	-
(e) Pool behind diversion dam for Long Lake ditch.	5/12/72	-	53	260	5.6	106	3	1
	7/20/72	-	-	-	1.7	2,560	-	-
	9/27/72*	-	740	750	9.2	1,170	-	3
(f) Below diversion dam; approximately 100 yards upstream of Ralston Reservoir.	9/27/72**	-	290	270	2.2	425	-	3
Long Lake Ditch								
At mouth, just upstream of discharge into Upper Long Lake.	7/20/72	-	-	-	3.3	1,470	-	-

* Other results Suspended solids - 0.3 pCi/L gross alpha and 14 pCi/L gross beta, dissolved lead-210 - 32 pCi/L
** Other results: Suspended solids - 0.3 pCi/L gross alpha and 5 pCi/L gross beta, dissolved lead-210 - 9 pCi/L

TABLE III

RADIOACTIVITY IN RALSTON RESERVOIR WATER SAMPLES

Station[a]	Suspended Radioactivity Gross α (pCi/L)	Suspended Radioactivity Gross β (pCi/L)	Suspended Radioactivity Radium-226 (pCi/gram)	Dissolved Radioactivity Gross α (pCi/L)	Dissolved Radioactivity Gross β (pCi/L)	Dissolved Radioactivity Lead-210 (pCi/L)	Dissolved Radioactivity Radium-226 (pCi/L)	Dissolved Radioactivity Uranium (μg/L)	Dissolved Radioactivity Alpha Thorium (pCi/L)
T-1.									
A - Surface	<0.3	<1	-	1	3	<1	5.9	1.5	0.2
Bottom	<0.3	<1	-	1	3	<0.4	0.4	1.9	<0.1
B - Surface	<0.3	<1	-	1	4	<1	0 1	1.0	<0.1
Bottom	←				Sample Lost				→
T-2.									
B - Surface	<0.3	<1	-	1	5	<0.4	0 1	1.0	<0.1
Bottom	<0.3	<1	12	<1	3	1	0 2	0.8	<0.1
T-3									
A - Surface	<0.3	<1	-	1	3	<0.6	0.2	1.8	0.2
Bottom	<0.3	<1	-	1	3	<0.9	0.2	1.3	1
C - Surface	<0.3	<1	-	<1	4	<1	0.2	1.3	<0.1
Bottom	<0.3	<1	-	<1	3	<0.5	0.1	0.9	<0.1
T-4									
B - Surface	<0.3	<1	-	<1	4	<0.6	0 1	1 5	0.1
Bottom	<0.3	<1	2.1	<0.3	2	<0.6	0 2	0.5	0.1
T-5									
A - Surface	<0.3	<1	-	<1	2	<0.9	<0.1	2.1	0.2
Bottom	<0.3	<1	3.0	<1	2	1	<0.1	<0 1	0.3
B - Surface	<0.3	<1	-	<1	4	<0.7	<0.1	1.0	<0.1
Bottom	<0.3	<1	5.0	<0.3	3	<1	<0.1	0.6	0.1
T-6									
- Surface	<0.3	<1	-	<1	2	<1	0.6	2.5	<0.1
Bottom	<0.3	<1	-	<0.3	3	<0.5	0.2	1.2	1
Finished water - Arvada water treatment plant (7/21/72)	-	-	-	-	-	-	0 2	3.0	-

(a) Except as noted for the sample collected at the Arvada water treatment plant, the date of sample collection was 9/27/72.

TABLE IV

RADIOACTIVITY IN WATER SAMPLES FROM UPPER LONG LAKE

Station[a]	Radium-226 Content of Sus. Solids (pCi/gram)	Dissolved Radioactivity	
		Radium-226 (pCi/L)	Uranium (μg/L)
1 - Surface	-	0.9	260
2 - Surface	-	0.9	250
3 - Surface	-	0.7	260
Bottom	-	0.6	210
4 - Surface	-	0.9	250
Bottom	-	1.0	220
5 - Surface	-	0.8	270
Bottom	12	0.5	200
6 - Surface	-	0.8	270
Bottom	-	0.3	210
7 - Bottom	-	0.8	250
8 - Surface	-	0.9	280
Bottom	-	0.8	250
Finished water - North Table Mountain water treatment plant (7/21/72)	-	0.7	170

(a) Except as noted for the grab sample collected at the North Table Mountain water treatment plant, the date of collection was 7/20/72.

FIGURE II
RALSTON RESERVOIR SAMPLING STATIONS

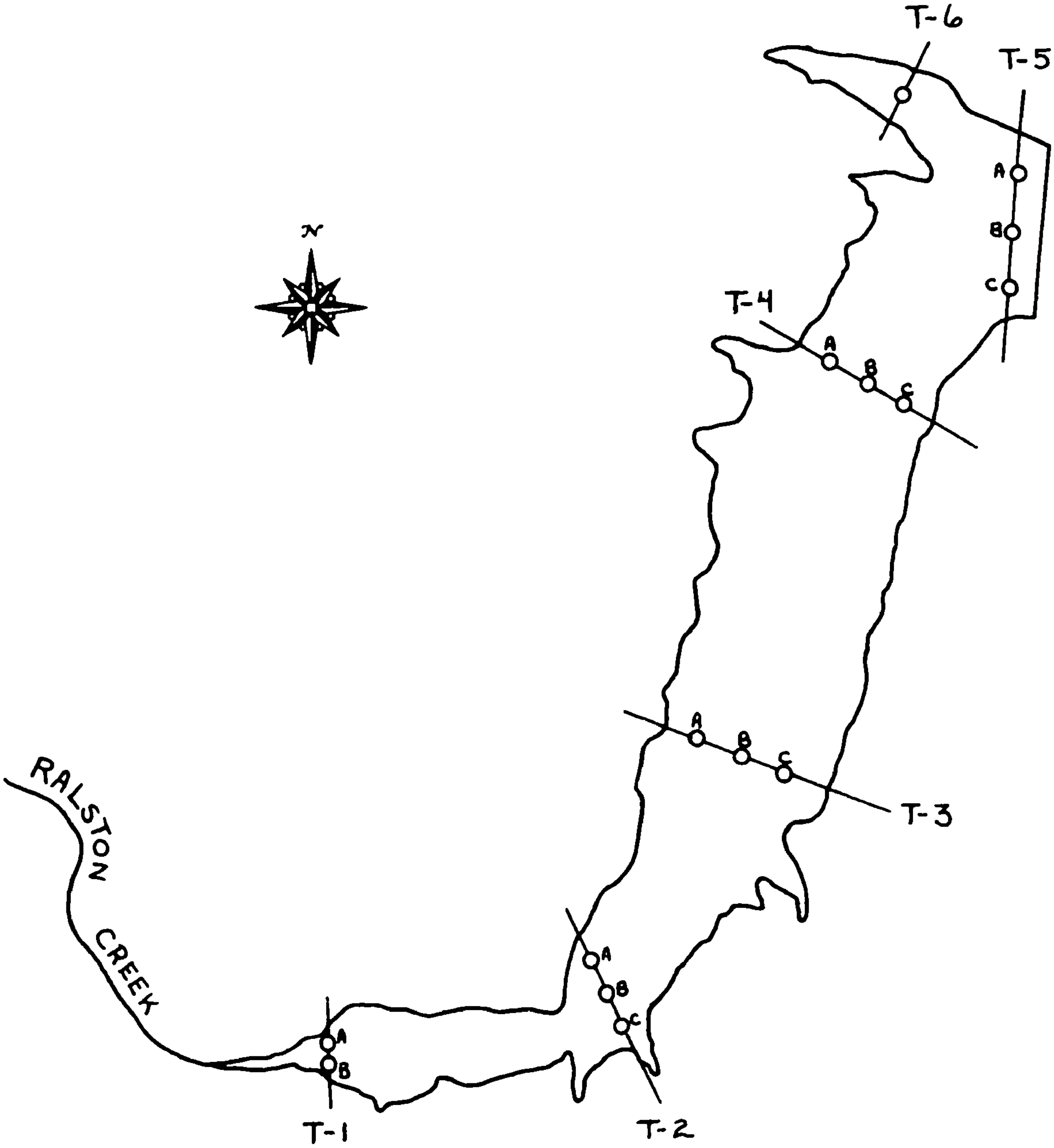
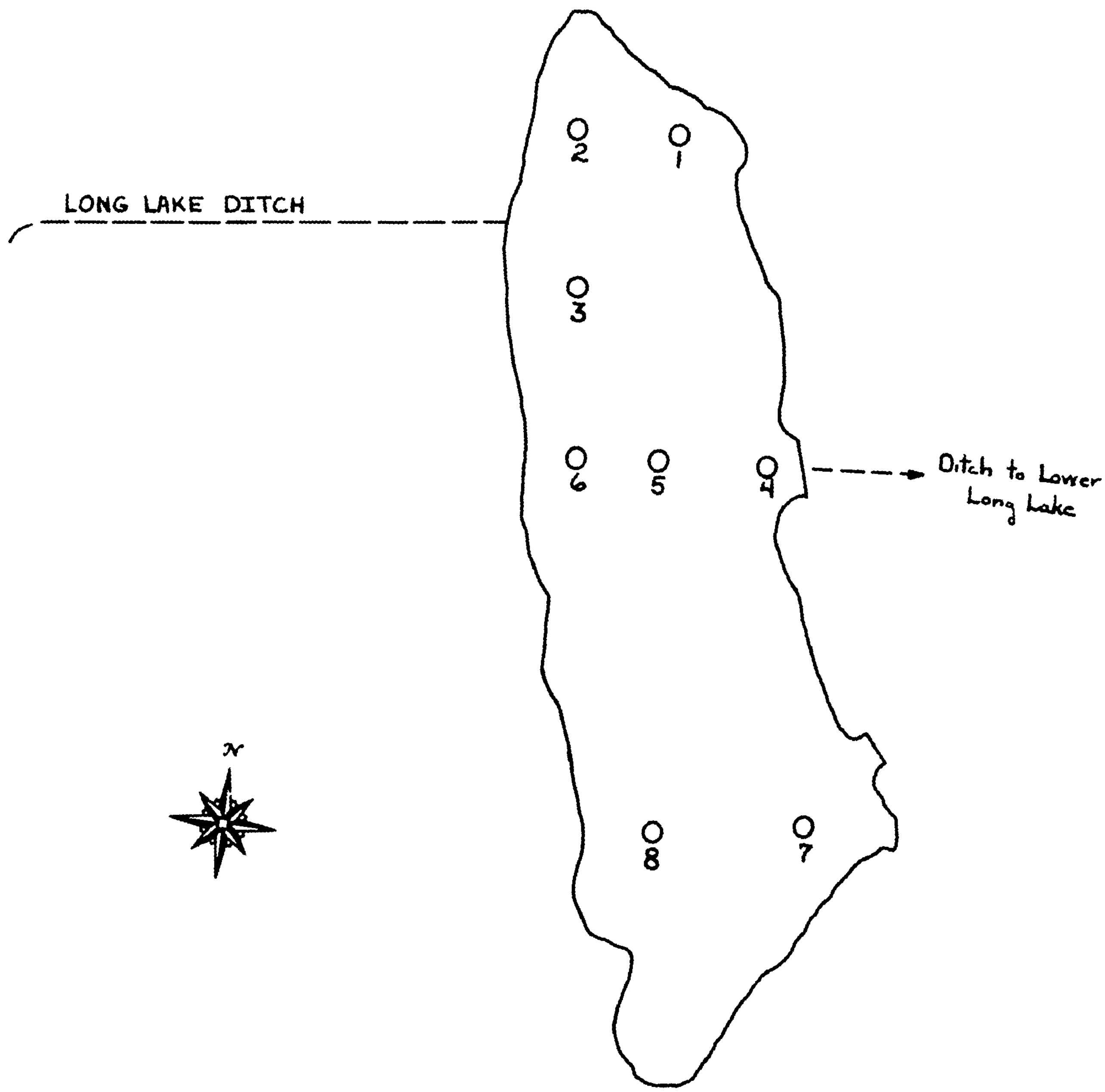


FIGURE III
UPPER LONG LAKE SAMPLING STATIONS



specific exception of the surface sample collected at location A on transect, T-1. The dissolved radium-226 concentration in this sample was found to be 5.9 pCi/L; indicative of contamination from the mine effluent. Although such a finding was not unrealistic for the upper end of the reservoir near the creek mouth, the specific result must be considered anomolous since it was not consistent with the corresponding uranium result as well as the dissolved radium-226 concentration in the surface water sample collected at the adjacent location B. The dissolved radium-226 concentration in the latter sample was a typical background value of 0.1 pCi/L.

In contrast to no detectable impact on the water quality of Ralston Reservoir, water samples from Upper Long Lake showed elevated concentrations of dissolved radium-226 and uranium. As shown in TABLE IV, overall average concentrations in the lake were 0.8 pCi/L and 230 μg/L for dissolved radium-226 and uranium, respectively. Compared to natural background concentrations, the dissolved radium-226 was about 4 times higher and uranium about 20 times higher. The distribution of radium-226 and uranium seemed to uniform throughout the lake without significant concentration differences among sectors or with depth.

Water treatment processes consisting of rapid sand filtration or chemical coagulation and rapid sand filtration are relatively ineffective for the removal of dissolved radium-226 and uranium. This was illustrated by the results for the grab samples of finished water collected from the Arvada and North Table Mountain treatment plants (TABLES III and IV). In each case, the dissolved radium-226 and uranium concentrations were comparable to those in the reservoir used as the raw water source. For example, the sample of North Table Mountain finished water contained 0.7 pCi/L of dissolved radium-226 and 170 μg/L of dissolved uranium in comparison to the above cited averages of 0.8 pCi/L and 230 μg/L for Upper Long Lake.

There is no question that the discharge of untreated mine water to Ralston Creek increased the dose to ionizing radiation received by the consumers served by the North Table Mountain District water system. Based on the limiting rates of daily intake recommended by the Federal Radiation Council and the National Committee on Radiation Protection (TABLE V), the dose corresponding to daily consumption of 1.0 liters of North Table Mountain is approximately 5% of the limit for a population group. Despite the fact that this level of exposure does not constitute a significant public health threat, the lack of waste treatment and the resultant exposure was not consistent with the Federal doctrine to minimize radiation exposure insofar as is practicable. It is to be noted that if the limit for uranium, as recommended by the International Committee on Radiological Protection, was applicable, the estimated dose for the consumption of North Table Mountain water increases to nearly 40% of the dose limit.

Trace metals analysis of samples collected from Ralston Creek and the two water plants on July 21 showed metals concentrations that were comparable to or greater than the metals concentrations in the effluent sample collected on July 20. These data are summarized in Appendix B.

TABLE V

RADIUM-226 & URANIUM STANDARDS

Radionuclide	Limiting Rate of Daily Intake from All Sources (Annual Average)	Drinking Water Standard	Recommending Authority
Radium-226	20[a]	20 pCi/L[b]	Federal Radiation Council
Uranium	- -	4.5 mg/L-Permissible Absent-Desirable[c]	U.S. Dept. of the Interior, Federal Water Pollution Control Administration ("Report of the Committee on Water Quality Criteria")
	22 mg/day[d]	22 mg/L[b]	National Committee on Radiation Protection (NCRP)
	0.7 mg/day[d]	700 μg/L[b]	International Commission on Radiological Protection (ICRP)

(a) Upper limit of Range II; corresponds to Radiation Protection Guide for average of suitable sample of exposed population group.

(b) Calculated from the limiting rate of daily intake by assuming a daily intake from drinking water of 1.0 liter/day and no intake from other sources.

(c) Adopted by the U.S. Public Health Service; basis is one-half the limit for taste and color.

(d) Based on 1/30 of the maximum permissible concentration for natural uranium for continuous occupational exposure, the specific activity for uranium-238, and activity ratio (uranium-234/uranium-238) equal to unity, and a daily water intake of 2.2 liters/day from all sources.

Bottom Sediment

Radioactivity in bottom sediment does not normally contribute to the exposure to individuals. The value of analyzing bottom deposits for radioactivity content is that the concentrations at a given location provide insight to the relative magnitude of concentrations carried in the overlying water phase between periods of sediment flushing. Additionally, the accumulation of radioactive materials in bottom deposits produces reservoirs of these materials from which release can occur at some time in the future. Under certain conditions, this release mechanism could have a significant impact on water quality.

The results for all sediment samples are presented in TABLE VI. A high level of contamination was observed in Ralston Creek and Long Lake ditch. The maximum radium-226 concentrations in the creek and ditch sediments approached or fell within the range characteristic of spent tailings generated in the refining of uranium ore (150 to 500 pCi/gram). Despite the fact that sediment samples were collected from the creek and ditch during two distinctly different flow conditions, the radium-226 data when viewed in a composite manner exhibited the classical pattern of decreasing concentration with increasing distance downstream from the pollution source. The uranium data showed the same general pattern. However, the maximum uranium concentration - 6 times higher than any other result - was obtained for the sample collected at the mouth of Long Lake ditch. This anomoly cannot be explained since the sample represented more than an isolated "hot-spot" (the sample comprised a composite of grab samples collected over several yards of the ditch bed).

A definitive assessment of the level of contamination in the bottom deposits of Ralston Reservoir and Upper Long Lake is not possible since data are not available on the radium and uranium content in sediment prior to the operation of the Schwartzwalder mine. Moreover, the sediment sample collected on May 12, 1972, at the footbridge crossing is apparently the only "background" sediment sample collected after mine start-up. For this sample, the uranium content was typical for a background location whereas the radium-226 was substantially higher than would be expected. Based on field studies conducted throughout the United States, the background concentrations of radium-226 and uranium in bottom sediment have been found to be less than 2 pCi/gram and less than 2 μg/gram, respectively. Using these concentrations as the baseline for comparison, sediment at all locations in Ralston Reservoir and Upper Long Lake showed radium-226 and/or uranium contamination. The data for Ralston Reservoir did not show significant concentration gradients from the mouth of Ralston Creek to the dam. Such a finding had been expected since it was assumed that the bulk of the contaminated sediment carried into the reservoir from Ralston Creek would settle out in the head-end of the reservoir.

TABLE VI

RADIOACTIVITY IN SEDIMENT SAMPLES

Station Description	Radioactivity Content (dry weight basis) Gross α (pCi/g)	Gross β (pCi/g)	Radium-226 (pCi/g)	Uranium (μg/g)	Thorium (μg/g)	Alpha Thorium (pCi/g)
Schwartzwalder mine - soil sample from the ditch conveying the mine effluent to the first sedimentation pond (5/12/72)	3270	7900	1230	2810	19	520
Ralston Creek						
(a) At footbridge crossing, upstream of mine effluent (5/12/72)	15	22	6	1	9	5
(b) Several hundred yards downstream of mine effluent (5/12/72)	350	860	188	270	31	65
(c) *Approximately 0 5 miles downstream* of mine at road culvert (7/21/72)	-	-	139	520	-	-
(d) Approximately one mile downstream of mine at road culvert (7/21/72)	-	-	77	214	-	-
(e) Upstream of diversion dam for Long Lake ditch (9/27/72)	-	-	29	123	25	8
(f) Below diversion dam, approximately 100 yards upstream of Ralston Reservoir (9/27/72)	-	-	17	49	19	10
Long Lake Ditch						
(a) Immediately downstream of diversion dam (5/12/72)	220	570	117	132	40	37
(b) At mouth (7/20/72)	-	-	24	3450	-	-
Ralston Reservoir (9/27/72)						
T-1						
A	-	-	4 3	32	27	17
B	-	-	9 8	34	23	13
T-2						
A	-	-	2 5	6	19	7
B	-	-	8 3	21	26	15
C	-	-	5 8	7	23	15
T-3						
A	-	-	4 9	17	23	9
B	-	-	12	67	27	19
C	-	-	2 3	10	24	5
T-4						
A	-	-	2 4	9	20	4
B	-	-	9 9	38	24	11
C	-	-	6 4	20	18	12
T-5						
A	-	-	2 2	37	20	9
B	-	-	4 3	17	20	9
C	-	-	2 0	15	18	7
T-6	-	-	2 0	27	25	7
Upper Long Lake (7/20/72)						
2	-	-	3 8	12	-	-
3	-	-	4 6	15	-	-
5	-	-	3 2	9	-	-
6	-	-	3 6	56	-	-
8	-	-	4 4	6	-	-

RECOMMENDATIONS

Since the Cotter Corporation has installed and is operating a treatment system designed to control the releases of radium-226 and uranium to Ralston Creek and downstream water supply reservoirs, follow-up action on behalf of the Environmental Protection Agency, in cooperation with the responsible State agency, should take the form of effective and thorough monitoring.

(1) The treated mine effluent should be monitored on a routine basis to verify the effectiveness and operational reliability of the treatment process.

(2) As a minimum, dissolved radium-226 and uranium concentrations in Ralston Creek should be determined monthly at three locations: (a) upstream of the location at which of the treated effluent enters the creek (b) downstream of the discharge point; after complete mixing is achieved, and (c) at the diversion dam. Sediment samples should be collected and analyzed bi-annually - immediately in the spring after high flow and in the fall. After the stability of the mine treatment system has been demonstrated, the sampling frequencies for water and sediment samples can be readjusted to less frequent collection.

(3) Radioactivity levels in the water and sediment of Ralston Reservoir and Upper Long Lake should be determined annually. This activity should be initiated during the fall of 1973.

(4) Chemical and radiological quality of North Table Mountain finished water should be determined monthly. The monthly analysis should be on composite samples prepared from daily (preferably) or weekly grab samples.

The basic objective should be to essentially eliminate the release of radioactivity-bearing solids (ore fines) to Ralston Creek and maintain dissolved concentrations of radium-226 and uranium in the creek as far below 1.0 pCi/L and 1.0 mg/L, respectively, as practicable. To maintain an environment suitable for the development of a diverse aquatic population, it may be necessary to maintain the dissolved uranium concentration below 500 μg/L.

APPENDIX A

COLORADO DEPARTMENT OF HEALTH/DENVER WATER BOARD MONITORING DATA

RALSTON CREEK ABOVE SCHWARTZWALDER MINE

Date	Sample Designation	Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium-natural (pCi/L)
1/7/72	X-112	MDA	50.7±13.5	0.21±0.11	MDA
2/1	X-124	9.4±7.1	MDA	0.12±0.11	MDA
2/16	X-125	MDA	MDA	MDA	4.25±2.12
3/3	X-132	MDA	MDA	MDA	1.40±1.40
3/17	X-146	MDA	MDA	0.30±0.11	MDA
3/31	X-153	MDA	MDA	0.09±0.09	MDA
4/14	X-177	MDA	MDA	MDA	0.41±0.41
4/28	X-183	9.0±5.3	MDA	1.24±0.18	0.95±0.63
5/12	X-191	MDA	MDA	MDA	
5/26	X-198	MDA	15.2±14.7	0.10±0.10	
6/16	X-242	MDA	MDA	0.10±0.01	

MDA - Minimum Detectable Activity

SCHWARTZWALDER MINE EFFLUENT

Date	Sample Designation	Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium-natural (pCi/L)
1/17/72	X-110 (Untreated)	3697±118	242±228	151.2±1.8	768±53
1/17	X-113 (Treated)	3446±115	196±26	78.7±1.3	687±53
2/1	X-123	8196±179	746±48	180.4±2.0	616±109
2/16	X-126	4229±128	397±35	106.5±1.6	813±54
3/3	X-133	4437±134	378±34	113.8±1.6	1466±65
3/17	X-147	3477±120	290±30	97.4±1.5	510.8±49.8
3/31	X-156	5766±149	491±39	100.5±1.5	1731±50
4/14	X-180	9277±192	829±68	145.2±1.8	3804±50
	X-186	9976±204	1023±75	129.9±1.7	1012±22
5/12	X-194	5778±147	918±69	117.8±1.6	
5/26	X-201	3249±103	464±50	145.0±1.8	
6/16	X-245	13881±242	1576±91	158.7±1.9	

RALSTON CREEK BELOW MINE PONDS

Date	Sample Designation	Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium-natural (pCi/L)
1/17/72	X-109	425±28	69.5±15.7	9.01±0.46	159±3
2/1	X-122	1170±51	152±	25.10±0.74	359±5
2/16	X-127	751±39	55.1±14.7	4.42±0.33	20.8±2.2
3/3	X-134	409±28	23.2±11.5	6.79±0.40	35.3±19.6
3/17	X-148	178±17	21.3±10.8	2.98±0.28	47.3±3.5
3/31	X-154	299±22	24.3±11.2	3.49±0.28	9.12±1.4
4/14	X-178	563±30	76.1±23.6	6.38±0.39	50.00±12.19
	X-184	157±16	20.4±17.6	4.75±0.34	86.21±6.29
5/12	X-192	111.0±13.3	24.6±16.6	2.88±0.26	
5/26	X-199	171.8±16.6	30.5±17.6	6.11±0.37	
6/16	X-243	482.5±29.4	51.2±21.0	5.37±0.36	

RALSTON CREEK AT DIVERSION DAM

Date	Sample Designation	Gross α (pCi/L)	Gross β (pCi/L)	Radium-226 (pCi/L)	Uranium-natural (pCi/L)
1/17/72	X-111	457±29	60.1±15.0	6.16±0.38	217±3
2/1	X-121	2085±71	162±23	10.01±0.47	660±54
2/16	X-128	662±35	70.2±15.9	6.41±0.39	34.9±2.2
3/3	X-135	310±27	26.4±11.8	6.00±0.37	171.3±20.0
3/17	X-149	255±20	18.5±10.6	5.22±0.35	61.18±3.66
3/31	X-155	432±28	28.6±11.7	3.94±0.30	105.9±14.0
4/14	X-179	426±28.2	55.7±21.3	5.40±0.35	73.17±12.19
	X-185	184±17	26.3±18.4	3.03±0.27	88.10±6.29
5/12	X-193	117.2±13.6	38.1±18.3	4.31±0.32	
5/26	X-200	771.1±58.3	48.5±21.6	4.35±0.33	
6/16	X-244	423.4±27.6	51.5±20.9	2.78±0.26	

APPENDIX B

METALS CONCENTRATIONS IN SELECTED WATER SAMPLES

METALS IN SELECTED WATER SAMPLES

Station Description	Dissolved Concentration (μg/L)[a] Arsenic	Fluoride	Lead	Selenium	Zinc
Schwartzwalder mine; main effluent (7/20/72)	5	1.0	15	<2	18
Ralston Creek (7/21/72)					
(a) Approximately 0.5 miles downstream of mine at road culvert.	5	2.1	55	<2	21
(b) Approximately one mile downstream of mine at road culvert.	5	1.0	20	<2	88
(c) Pool behind diversion dam for Long Lake ditch.	<5	0.8	20	<2	58
Finished water - Arvada water treatment plant (7/21/72)	<5	0.6	100	2	22
Finished water - North Table Mountain water treatment plant (7/21/72)	5	0.5	95	2	270

(a) Fluoride reported as mg/L.

APPENDIX C

LIQUID WASTE TREATMENT AND EFFLUENT MONITORING COMMITMENTS

FOR THE SCHWARTZWALDER URANIUM MINE

October 4, 1972

Mr. Evan D. Dildine
Chief, Permits Branch
Enforcement Division
Environmental Protection Agency
Region VIII
Suite 900, 1860 Lincoln Street
Denver, Colorado 80203

Re: Refuse Act Permit Application
CO-2SB-OXT-2-000256
(Cotter Corp., Schwartzwalder
Mine, Golden, Colorado)

Dear Mr. Dildine:

We are submitting this voluntary commitment letter as a result of our meeting on September 13, 1972.

During the past 2½ years we have been investigating means of controlling the radioactive constituents in the mine water discharging into Ralston Creek. As a result of our research effort, conducted primarily by the Colorado School of Mines Research Institute, we are currently installing a mine water treatment plant utilizing a precipitation technique to reduce the uranium and radium 226 concentrations to acceptable levels. This method involves the addition of soluble iron (ferric) sulfate to the water and subsequent coprecipitation of the radioactive constitutents with the flocculant ferric hydroxide precipitate by increasing the water pH to approximately 10 by the addition of a milk of lime slurry. A solution of barium chloride is added after the lime treatment to form a dense precipitate of barium sulfate which coprecipitates the remaining radioactive constituents. If necessary, sulphuric acid will be introduced into the system to reduce the pH to an acceptable level.

The precipitation method has been demonstrated by laboratory and pilot plant testing to be an effective method for controlling the concentrations of soluble radium

226 and uranium in the mine water; however, the most practical methods of effecting a liquid solids separation and compaction of the precipitated solids will need to be investigated and resolved after the precipitation equipment is put into operation. Currently, two settling ponds (40' x 120' and 60' x 120') have been provided to collect the precipitated solids so that their further treatment can be investigated. A third pond for stand-by purposes is now being constructed. As often as is necessary to maintain effective operation of the system, the precipitated solids in the form of a wet sludge will be removed from the ponds and transported with the uranium ore to our chemical processing plant at Canon City, Colorado.

Since radioactivity in the mine water was our primary concern our research program and plant design were not specifically related to the non-radioactive items set forth in the List of Minimum Effluent Limitations attached hereto as Exhibit 1. Consequently, concentrations of the constituents other than the radioactive ones will have to be monitored for the next several months to determine their concentration levels in the treated mine water effluent. Further treatment methods will have to be considered as required.

We expect to meet minimum effluent limitations that are reasonably attainable no later than November 1, 1973, and we expect to meet those required for "best practicable treatment" within one year or earlier but not later than 1976. A one year period was selected because mine water flows and resulting metal concentrations vary on a seasonal basis.

Specific dates for significant steps to be accomplished are as follows:

A.	Mine water treatment precipitation system in operation	October 31, 1972
B.	Commence monitoring of raw and treated mine water	November 1, 1972
C.	Submit first monthly report (for November) covering water treatment operation	December 15, 1972

D. Compliance with effluent limitations considered to be reasonably attainable — November 1, 1973

We agree to maintain the level of removal of pollutants at minimum concentrations attained, consistent with raw mine water concentrations and flows experienced during the first year's operation of the mine water treatment system.

We will monitor the treated mine water effluent discharging into Ralston Creek in accordance with the Monitoring Schedule attached hereto as Exhibit 2, in order to measure those parameters for which minimum effluent limitations have been established in Exhibit 1.

As a contingency plan for operation of the plant facility, we will maintain a third pond for stand-by purposes. We will maintain a diversion dike to protect the ponds from excessive surface run-off. If the ponds or any other part of the treatment system become ineffective or inoperative so that the effluent limitations cannot be maintained, we will suspend pumping operations in the mine and permit water to accumulate in the mine until the integrity of the system can be re-established. We will notify the Environmental Protection Agency and the Colorado Water Pollution Control Division as to our routine monitoring and will give prompt notification as to any emergency situations.

All hazardous materials stored or used at the mine or in connection with the water treatment system will be stored in containers designed to prevent leakage and spillage. They will be stored in locations selected to prevent accidental spills that might pollute the environment. If, despite these safeguards, an accidental spill occurs, we will report such spill at once to the following:

Environmental Protection Agency	
Denver, Colorado	232-3611, Ext. 2336
Non-duty hours:	
Les Springer	985-7043
Alvin York	278-1319
B. David Clark	986-3533

Colorado Water Pollution Control Division
Denver, Colorado 388-6111, Ext. 231

Non-duty hours:
Frank Rozich 377-4689
Fred Matter 771-0254
E. B. Pugsley 771-2088

If it appears that domestic water users downstream may be affected by any accidental spill we will immediately notify the following users:

Denver Board of Water Commissioners
City of Arvada
Dow Chemical Company
(Rocky Flats)
North Table Mountain
Water & Sanitation District

We have set forth our voluntary commitment to commence and maintain a satisfactory abatement program. We wish to assure you our continued cooperation in this regard.

Very truly yours,

COTTER CORPORATION

By David P. Marcott
David P. Marcott
Executive Vice President

cc: E. B. Pugsley
Colorado Water Pollution
Control Commission

October 17, 1972

Mr. Richard Andrews
Environmental Protection Agency
Region VIII
Suite 900 - 1860 Lincoln Street
Denver, Colorado 80203

Dear Mr. Andrews:

As you requested in your telephone call of October 16, I am enclosing copies of Exhibit 1 and Exhibit 2, which were to have been included with our recent letter to Mr. Dildine.

Please accept our appologies for the oversight. If we can be of further assistance, please do not hesitate to call.

Very truly yours,

COTTER CORPORATION

Theda L. Hoyt

Theda L. Hoyt (Mrs.)
Secretary to Mr. Marcott

Exhibit 1

List of Minimum Effluent Limitations

Parameter	Value Concentration
pH	6.5 - 9.0
Tot. Susp. Solids (TSS)	30 mg/l
Mn	1.0 mg/l
U	5 mg/l
Pb	0.1 mg/l
Zn	1.0 mg/l
Cd	0.01 mg/l
Cu	1 mg/l
Fe	2 mg/l
$SO_4^{=}$	500 mg/l
Ba	1 mg/l
Ra^{226}	3 pCi/l
BOD_5	10 mg/l
Fecal Coliform	200/ml
Se	not established
V	not established
Cr	not established
Mo	not established

Exhibit 2

Schwartzwalder Mine Water Effluent

Monitoring Schedule

Parameter	Units	Frequency	Type Sample
Flow	MGD	weekly	
pH	std.	daily	grab
TSS	mg/l	weekly	8-hour composite
iron	mg/l	monthly	8-hour composite
Mn	mg/l	monthly	8-hour composite
U	mg/l	monthly	8-hour composite
Pb	mg/l	monthly	8-hour composite
Zn	mg/l	quarterly	8-hour composite
Cd	mg/l	quarterly	8-hour composite
Cu	mg/l	quarterly	8-hour composite
$SO_4^=$ (s)	mg/l	monthly	8-hour composite
Ba	mg/l	monthly	8-hour composite
BOD_5	mg/l	monthly	4-hour composite
Ra-226, dissolved	pCi/l	monthly	8-hour composite
total fecal coliform	#/100 ml	monthly	grab
selenium	mg/l	once*	8-hour composite
vanadium	mg/l	once*	8-hour composite
molybdenum	mg/l	once*	8-hour composite
chromium	mg/l	once*	8-hour composite

*frequency to be determined based on initial results

APPENDIX D

WATER QUALITY CRITERIA FOR URANIUM

URANIUM

1. General. Uranium and many of its salts are reported to be highly toxic (364, 2129, 2972), but the literature does not always confirm this observation. In addition to its significance in atomic energy, uranium has been used in photography, in glazing and painting porcelain, and in chemical processes. Many of the salts of uranium are freely soluble in water and, hence, they may constitute a health hazard if present in a water supply. Roubault et al. (3711), however, imply from a limited study of certain areas that natural uranium in the soil, which is absorbed by persons through the water and foodstuffs grown on the land, may be a limiting factor in the incidence of leukemia.

Most of the literature concerning uranium in water relates to the radiological hazards. Results are expressed in terms of radiation parameters rather than in concentrations of uranium in mg/l. Such references are covered in Chapter VIII, Radioactivity. The criteria in the following paragraphs deal with chemical effects without reference to radiological hazards.

2. Cross References. See Radioactivity, Chapter VIII.

3. Effects Upon Beneficial Uses.

a. Domestic Water Supply. The Division of Industrial Hygiene, Ontario Department of Health, has suggested a maximum allowable concentration for neutral uranium in drinking water of 500 to 1000 micrograms per liter (3747).

b. Stock and Wildlife Watering. In tests using two uranium-fluorine compounds, the insoluble uranium tetrafluoride, UF_4, and and soluble uranyl fluoride, UO_2F_2, Maynard et al. (3748) found that 2 percent of UF_4 and 0.05 percent of UO_2F_2 had no toxic effect in the diet of rats. Interference with growth and a depressed body weight were observable during the second year in animals on dietary concentrations of 20 percent UF_4 and 0.15 percent of UO_2F_2. Some tendency toward anemia was discovered in male rats fed diets containing 0.25 and 0.5 percent UO_2F_2. While only mild injury was found in the kidneys of rats whose diets contained 20 percent of UF_4, definite renal tubular damage was found in rats fed diets of 0.15 percent or more of UO_2F_2. In a one-year feeding experiment on dogs the same authors observed doses of 0.01 g/kg UO_2F_2 and 1.0 g/kg UF_4 were without effect on body weight, but animals fed 5 g/kg of UF_4 did not gain weight as almost all other animals did. The minimum dose given for one year that provided unmistakable renal damage in dogs was 0.025 g/kg/day for UO_2F_2 and 0.2 g/kg/day for UF_4. Moxan and Rhian (1481) reported that a concentration of 5 mg/l of uranium in the drinking water increased mortality among rats being fed a ration containing 11 mg/l of selenium.

c. Fish and Other Aquatic Life. Hoffman (769) examined the water of the River March between Czechoslovakia and Germany and found that it contained 0.001 mg/l of uranium. Much of this uranium was absorbed by algae but it was not toxic to them. The alga *Ochromonas* was reported to concentrate natural uranium (U-238) by a factor of 330 from water in 48 hours (3386). In a study of the Black Sea, Pshenin (2919) found yeasts to be more active than bacteria in taking up uranium.

Tarzwell and Henderson (2154) found the 96-hour TL_m of fathead minnow in soft water (pH = 7.4, alkalinity = 18 mg/l, hardness = 20 mg/l) was 2.8 mg/l for uranyl sulfate, $UO_2SO_4 \cdot 3H_2O$, 3.1 mg/l for uranyl nitrate, $UO_2(NO_3)_2 \cdot 6H_2O$, and 3.7 mg/l for uranyl acetate, $UO_2(C_2H_3O_2)_2 \cdot 2H_2O$. In hard water (pH 8.2, total alkalinity = 360 mg/l, hardness = 400 mg/l), the 96-hour TL_m of uranyl sulfate was increased to 135 mg/l. Thus it appears that uranium compounds are considerably more toxic in soft water than in hard water (2107, 2110, 2973).

In Japan, it was observed that 250 mg/l of uranyl nitrate in sea water inhibited the formation of the fertilization membrane in *Urechis* eggs and led to polyspermy (3749). Bringmann and Kuhn (2158, 3343) using River Havel water, reported the threshold effect of uranyl nitrate on *Daphnia* to be 13 mg/l, on *Scenedesmus*, 22 mg/l, on *E. coli* 1.7 to 2.2 mg/l, and on a protozoan (*Microregma*) 28 mg/l, all expressed as uranium.

From: "Water Quality Criteria," Second Edition by J.E. McKee and H.W. Wolf, California State Water Resources Control Board, Publication 3-A (Repring December, 1971)