TABLE 7.4
CALCULATION OF ANNUAL DOSE FROM DRINKING SURFACE WATER AND/OR
WELL WATER AT CIMARRON
CALENDAR YEAR 1997 AND 1st QUARTER 1998

Assumptions/Notes:
person drinks 2 liters per day
Federal Radiation Guidance Report No. 11 DCF's for Tc-99
ICRP Publication 69 DCFs for Uranium-234, 235, and 238
Annual dose in mrem/y is effective dose (i.e. whole body equivalent)
No background subtraction performed
Tc-99 data available at selected locations only
EPA MCL for Tc-99 (equivalent to 4 mrem/y effective dose) = 3750 pCi/l
WP = Waste Pond, BA = Burial Area
ND = Not Detected (i.e., <MDA)
NM = Measurement not required (gross beta less than 30 pCi/L and/or beta/alpha ratio < 3 to 1)

Location	Sample Date (U)	U-234 (pCi/l)	U-235 (pCi/l)	U-238 (pCi/l)	Isotopic U, total (pCi/l)	mrem/y from uranium	Tc-99 (pCi/l)	mrem/y from Tc-99	Comments
SURFACE WATER									
1201	6/97	5.5	0.1	2.5	8.1	1.09	NM	NM	Cimarron River, upstream
1202	6/97	4.1	0.1	3.1	7.3	0.99	NM	NM	Cimarron River, downstream
1204	6/97	1.6	ND	0.5	2.1	0.28	NM	NM	Reservoir #1 (West Lake)
1205	6/97	0.5	ND	0.2	0.7	0.09	NM	NM	Reservoir #2 (East Lake)
1206	3/97	125.0	5.3	33.2	163.5	22.08	12.2	0.01	East of Sanitary Lagoons
1206	6/97	117.0	3.7	42.4	163.1	22.03	25.4	0.03	East of Sanitary Lagoons
1206	9/97	97.2	5.2	25.6	128.0	17.29	54.4	0.06	East of Sanitary Lagoons
1206	12/97	No Sample-Dry							East of Sanitary Lagoons
1206	3/98	115.0	9.6	64.5	189.1	25.54	NM	NM	East of Sanitary Lagoons
1206 Average		113.6	6.0	41.4	161.0	21.74	30.7	0.03	East of Sanitary Lagoons
1208	3/97	37.0	1.8	11.7	50.5	6.82	3960.0	4.22	Seep on bluff NE of WP#2
1208	6/97	8.3	0.6	3.5	12.4	1.67	2800.0	2.98	Seep on bluff NE of WP#2
1208	9/97	24.7	1.3	8.0	34.0	4.59	3040.0	3.24	Seep on bluff NE of WP#2
1208	12/97	40.1	1.8	13.6	55.5	7.50	2080.0	2.22	Seep on bluff NE of WP#2
1208	3/98	29.0	1.8	17.6	48.4	6.54	2300.0	2.45	Seep on bluff NE of WP#2
1208 Average		27.8	1.5	10.9	40.2	5.42	2836.0	3.02	Seep on bluff NE of WP#2
1209	6/97	1.7	0.1	1.1	2.9	0.39	NM	NM	Reservoir #3
WELLS									
1307	6/97	3.4	0.1	1.5	5.0	0.68	NM	NM	Junction Hwys 33/74
1311	3/97	1.3	0.1	0.9	2.3	0.31	18.1	0.02	Waste Pond #1, upgradient
1311	6/97	3.0	0.4	2.1	5.5	0.74	NM	NM	Waste Pond #1, upgradient
1311 Average		2.2	0.3	1.5	3.9	0.53	18.1	0.02	Waste Pond #1, West side
1312	3/97	18.5	0.7	5.8	25.0	3.38	3680.0	3.92	Waste Pond #1, West side
1312	6/97	18.7	0.9	6.0	25.6	3.46	1470.0	1.57	Waste Pond #1, West side
1312	9/97	17.2	0.8	5.7	23.7	3.20	2190.0	2.33	Waste Pond #1, West side
1312	12/97	14.8	2.2	6.0	23.0	3.11	1570.0	1.67	Waste Pond #1, West side
1312	3/98	21.0	1.1	10.0	32.1	4.34	1850.0	1.97	Waste Pond #1, West side
1312 Average		18.0	1.1	6.7	25.9	3.50	2152.0	2.29	Waste Pond #1, West side
1313	6/97	31.0	1.0	10.0	42.0	5.67	1190.0	1.27	Waste Pond #1, downgradient
1313	9/97	28.2	1.0	8.4	37.6	5.08	1560.0	1.66	Waste Pond #1, downgradient
1313	12/97	22.5	1.2	7.2	30.9	4.17	874.0	0.93	Waste Pond #1, downgradient
1313	3/98	27.7	1.3	10.3	39.3	5.31	562.0	0.60	Waste Pond #1, downgradient
1313 Average		27.4	1.1	9.0	37.5	5.06	1046.5	1.12	Waste Pond #1, downgradient
1314	6/97	1.3	0.1	0.6	2.0	0.27	NM	NM	Burial Area #1, upgradient
1315	3/97	1410.0	76.0	819.0	2305.0	311.29	NM	NM	Burial Area #1, downgradient
1315	6/97	1770.0	74.2	1200.0	3044.2	411.12	NM	NM	Burial Area #1, downgradient
1315	9/97	546.0	24.9	374.0	944.9	127.61	NM	NM	Burial Area #1, downgradient
1315	12/97	822.0	68.3	579.0	1469.3	198.43	NM	NM	Burial Area #1, downgradient
1315	3/98	1320.0	25.0	855.0	2200.0	297.11	NM	NM	Burial Area #1, downgradient
1315 Average		1173.6	53.7	765.4	1992.7	269.11	NM	NM	Burial Area #1, downgradient
1316	3/97	73.9	3.7	33.4	111.0	14.99	NM	NM	Burial Area #1, downgradient
1316	6/97	136.0	5.0	59.5	200.5	27.08	NM	NM	Burial Area #1, downgradient
1316	9/97	53.5	2.4	24.2	80.1	10.82	NM	NM	Burial Area #1, downgradient
1316	12/97	53.2	4.0	22.8	80.0	10.80	NM	NM	Burial Area #1, downgradient
1316	3/98	65.6	3.1	40.7	109.4	14.77	NM	NM	Burial Area #1, downgradient
1316 Average		76.4	3.6	36.1	116.2	15.69	NM	NM	Burial Area #1, downgradient
1317	6/97	247.0	11.7	150.0	408.7	55.19	NM	NM	Burial Area #1, NNW
1317	3/98	39.5	2.8	20.4	62.7	8.47	NM	NM	Burial Area #1, NNW
1317 Average		143.3	7.3	85.2	235.7	31.83	NM	NM	Burial Area #1, NNW
1319	6/97	27.9	1.7	4.8	34.4	4.65	NM	NM	East U Plant Yard

Location	Sample Date (U)	U-234 (pCi/l)	U-235 (pCi/l)	U-238 (pCi/l)	Isotopic U, total (pCi/l)	mrem/y from uranium	Tc-99 (pCi/l)	mrem/y from Tc-99	Comments
1320	6/97	1.2	ND	1.0	2.2	0.30	34.0	0.04	Waste Pond #2
1321	6/97	11.1	0.2	5.3	16.6	2.24	NM	NM	Waste Pond #2 (deep)
1322	6/97	7.5	0.1	3.8	11.4	1.54	NM	NM	N of Bldg. #4 @ flamm. stor. pad
1323	6/97	20.0	0.6	9.7	30.3	4.09	NM	NM	N of Bldg. #4 @ flamm. stor. pad (deep)
1324	6/97	0.9	ND	0.4	1.3	0.18	NM	NM	BTP Opt. #2 disp. area, East
1325	6/97	0.9	0.1	0.3	1.3	0.18	NM	NM	BTP Opt. #2 disp. area, upgradient
1326	3/97	5.0	0.7	1.6	7.3	0.99	21.9	0.02	East of U Plant Yard
1326	6/97	4.8	0.1	2.2	7.1	0.96	13.1	0.01	East of U Plant Yard
1326	9/97	4.0	0.1	1.1	5.2	0.70	41.3	0.04	East of U Plant Yard
1326	12/97	2.9	0.1	1.7	4.7	0.63	NM	NM	East of U Plant Yard
1326 Average		4.2	0.2	1.7	6.1	0.82	25.4	0.03	East of U Plant Yard
1327B	6/97	3.1	ND	1.2	4.3	0.58	NM	NM	West of Bldg. #1
1328	6/97	20.7	0.5	10.5	31.7	4.28	NM	NM	South of Bldg. #1 (deep)
1329	6/97	4.5	0.2	2.0	6.7	0.90	NM	NM	South of Bldg. #1
1330	6/97	7.4	0.2	2.8	10.4	1.40	NM	NM	South of Bldg. #1
1331	6/97	127.0	4.7	25.0	156.7	21.16	NM	NM	West of Burial Area #2
1331	9/97	137.0	6.7	31.0	174.7	23.59	NM	NM	West of Burial Area #2
1331	12/97	126.0	11.4	27.4	164.8	22.26	NM	NM	West of Burial Area #2
1331	3/98	110.0	3.2	31.5	144.7	19.54	NM	NM	West of Burial Area #2
1331 Average		125.0	6.5	28.7	160.2	21.64	NM	NM	West of Burial Area #2
1332	6/97	18.9	0.3	9.3	28.5	3.85	NM	NM	NW of West Sanitary Lagoon (deep)
1333	6/97	9.1	0.3	3.8	13.2	1.78	NM	NM	NW of West Sanitary Lagoon
1334	6/97	7.4	0.3	3.2	10.9	1.47	NM	NM	Sanitary Laggons, downgradient
1335A	6/97	1.6	ND	0.7	2.3	0.31	NM	NM	West of BTP Option #2 Disposal Area
1336A	3/97	37.5	8.1	15.0	60.6	8.18	2590.0	2.76	Waste Pond #2, downgradient
1336A	6/97	23.2	1.1	9.1	33.4	4.51	1930.0	2.06	Waste Pond #2, downgradient
1336A	9/97	23.6	1.8	7.2	32.6	4.40	1880.0	2.00	Waste Pond #2, downgradient
1336A	12/97	22.9	0.8	8.1	31.8	4.29	1200.0	1.28	Waste Pond #2, downgradient
1336A	3/98	28.7	3.1	12.3	44.1	5.96	1600.0	1.71	Waste Pond #2, downgradient
Well 1336A Average		27.2	3.0	10.3	40.5	5.47	1840.0	1.96	Waste Pond #2, downgradient
1337	6/97	8.0	0.6	3.1	11.7	1.58	NM	NM	Waste Pond #2, NE
1338	6/97	0.7	0.1	0.4	1.2	0.16	NM	NM	Waste Pond #2, NE
1340	6/97	2.7	0.2	1.0	3.9	0.53	NM	NM	Waste Pond #1, East
1341	6/97	1.5	0.1	0.6	2.2	0.30	NM	NM	Waste Pond #1, East
1342	10/97	3.7	0.3	1.7	5.7	0.77	11.4	0.01	NW of facility near site boundary
1342	12/97	4.9	0.3	3.1	8.3	1.12	NM	NM	NW of facility near site boundary
1342	3/98	3.7	0.3	2.5	6.5	0.88	NM	NM	NW of facility near site boundary
1342 Average		4.1	0.30	2.43	6.83	0.92	11.4	0.01	NW of facility near site boundary
1343	10/97	20.9	0.9	13.8	35.6	4.81	12.5	0.01	N of Waste Pond #2 near site boundary
1343	12/97	14.0	1.0	9.5	24.5	3.31	NM	NM	N of Waste Pond #2 near site boundary
1343	3/98	10.5	0.6	7.6	18.7	2.53	NM	NM	N of Waste Pond #2 near site boundary
1343 Average		15.1	0.8	10.3	26.3	3.55	12.5	0.01	N of Waste Pond #2 near site boundary
1344	10/97	5.0	0.1	3.5	8.6	1.16	9.0	0.01	N of Burial Area #2 near site boundary
1344	12/97	1.7	0.2	1.0	2.9	0.39	NM	NM	N of Burial Area #2 near site boundary
1344	3/98	2.5	0.1	1.9	4.5	0.61	NM	NM	N of Burial Area #2 near site boundary
1344 Average		3.1	0.1	2.1	5.3	0.72	9.0	0.01	N of Burial Area #2 near site boundary

TABLE 7.5
SUMMARY OFAVERAGE ANNUAL DOSE AT FOUR AREAS
CALENDAR YEAR 1997 AND 1st QUARTER 1998

Area	Well #	Average Annual Dose Total Uranium (mrem)	Average Annual Dose Technetium-99 (mrem)	Comment
Burial Area #1	1314	0.27	Not Measured*	Upgradient
	1315	269	Not Measured*	Downgradient
	1316	15.7	Not Measured*	Downgradient
	1317	31.8	Not Measured*	Downgradient
Uranium Waste Pond #1	1311	0.53	0.02	Upgradient
	1312	3.5	2.3	West Side
	1313	5.1	1.1	Downgradient
Uranium Waste Pond #2	1325	0.18	Not Measured*	Upgradient
	1320	0.3	0.04	Near Southwest Corner
	1321	2.2	Not Measured*	Near Southwest Corner (deep)
	1336A	5.5	2.0	Downgradient
	1337	1.6	Not Measured*	Northeast of Pond
	1338	0.16	Not Measured*	Northeast of Pond
Burial Area #2	1331	21.6	Not Measured*	West of Burial Area in Draw
	1332	3.9	Not Measured*	NW of West Sanitary Lagoon (deep)
	1333	1.8	Not Measured*	NW of West Sanitary Lagoon

Not Measured* = Measurement of Tc-99 is performed only when gross beta concentration exceeds 30 pCi/L and beta/alpha ratio is equal to or exceeds 3 to 1.

8.0 DISCUSSION OF CHEMICAL TOXICITY EVALUATION

In addition to radiogenic properties, uranium is considered to have chemical toxicity. The ICRP and others have indicated that risk evaluation of uranium in drinking water is more properly based on chemical toxicity rather than on hypothetical radiological toxicity, which has not been observed in either humans or animals (Wrenn, 1985; ATSDR, 1997). Therefore, the potential chemical toxicity associated with the highest concentration of uranium in groundwater at the Cimarron site, i.e., Burial Area #1, is discussed in this section. It should be noted that chemical toxicity risk is not additive with hypothetical radiological toxicity. Further, uranium is not considered to have chemical carcinogenic effects.

Technetium-99 was not evaluated for chemical toxicity, since its chemical toxicity, if any, is not well documented and the dose was within the EPA dose standard of 4 mrem for man-made radionuclides. The highest annual radiological dose from drinking water with Tc-99 present at the site is approximately 3 mrem/year (TEDE), as described in Section 7.0.

8.1 Uranium Chemical Toxicity

8.1.1 Comparative Chemical and Radiogenic Toxicities

Uranium is a chemical substance which has biological effects related to its radioactivity and its chemical interaction with body tissues, namely the kidney. Although uranium may present a radiological health hazard, uranium-associated cancers have not been seen in humans. At this time, the US Environmental Protection Agency (EPA) has not classified uranium for carcinogenicity (EPA, 1998). The results of studies in both humans and animals are consistent with this conclusion that uranium does not present a

chemical carcinogenic risk (ATSDR, 1997). Therefore, carcinogenic risk is not considered in the chemical toxicity assessment.

Non-cancerous adverse effects to the lung and cardiovascular systems have been noted in animal species. The potential for these adverse non-cancerous radiological health effects is dependent on several factors, including the distribution in the various body organs, the biological retention time in the tissues, the energy and intensity of the radiation, and the half-life; the potential for such effects is independent of the chemical toxicity. However, because the specific activities of natural and depleted uranium are low, no radiological health hazard is expected from exposure to natural and depleted uranium (ATSDR, 1997).

Uranium forms compounds and complexes of different solubilities. The chemical toxicity of the compound or complex is related only to chemical properties and is unrelated to the specific activity or isotopic number. The chemical toxicity of natural, depleted, and enriched uranium is identical because chemical action depends only on chemical properties which are identical (ATSDR, 1997).

Current toxicological evidence is suggestive that the toxicity of uranium is largely due to its chemical properties rather than its radiogenic properties. In terms of chemical toxicity, renal toxicity is the major adverse effect of uranium. Exposure of the general public to natural uranium is unlikely to pose an immediate lethal threat to humans. No human deaths have been reported that are definitely attributable to uranium ingestion; therefore, no lethal dose has been reported for humans. One study reported renal effects in humans following exposure to uranium, while several other studies have found no increased deaths in uranium workers due to kidney disease (ATSDR, 1997).

Animal studies have reported renal effects associated with chronic inhalation and oral exposure to uranium. Lethal doses of uranium in animals (dog) have been reported to be as low as 14 mg/kg-day following 23-day oral exposures. Uranium chemical toxicity depends on the solubility of the uranium compound tested (higher solubility compounds having greater toxicity, especially in the kidney), route of exposure, and animal species (Elless et al, 1997). However, the available data in both humans and animals is sufficient to conclude that even for soluble compounds, uranium has a low order of metallotoxicity in humans (ATSDR, 1997).

8.1.2 Gastrointestinal and Dermal Absorption Rates

Uranium is absorbed from the intestine or the lungs, enters the bloodstream, and is rapidly deposited in the tissues, predominantly kidney and bone, or excreted in the urine. In the bloodstream, uranium is associated with red cells, and its clearance is relatively rapid (Taylor, 1997). The fractional absorption of uranium compounds following oral exposure is generally considered to be quite low and mostly dependent upon chemical form and length of time since the last intake of food. Human drinking water studies indicate that absorption of ingested uranium is 0.006 to 0.015 (mean fraction absorption). Wrenn et al (1985) reviewed the literature regarding gastrointestinal absorption and concluded that fractional absorption is most likely 0.01 to 0.02 and is reasonably independent of age or the mass of uranium ingested. Leggett and Harrison (1995) reported that average gastrointestinal uptake of uranium in adult humans appears to be about 0.01 to 0.015. Differences with age in uranium uptake were not noted; therefore, it would appear that fractional absorption is in the same range for children. EPA has also indicated no differences in fractional absorption of children aged one and older (Eckerman, et al, 1998). Based on this information, ATSDR (1997), USEPA (1998) and Karpas et al (1998) have reported that the reference fraction for gastrointestinal absorption of

relatively soluble ingestion uranium should be less than 0.02. This absorption factor has been utilized in the intake calculations for the Cimarron site.

There is suggestive evidence in animals that certain uranium compounds in pure form may be absorbed through intact skin; however, there is a paucity of data with regard to potential absorption of uranium in water through skin (ATSDR, 1997). Therefore, the default dermal absorption rate for inorganics of 1 x 10^{-3} cm/hr has been utilized in Cimarron's risk evaluation (EPA, 1992).

8.1.3 Chemical Toxicity Values

No chronic effects have been reported in humans following oral exposure to uranium (ATSDR, 1997). Data available from populations occupationally exposed to high concentrations of uranium compounds through inhalation and information studies in experimental animals indicate that the critical organ for chronic uranium toxicity is the proximal tubule of the kidney (EPA, 1997d). In humans, chemical injury reveals itself by increased catalase excretion in urine and proteinuria. The lowest dose of uranyl nitrate that caused body weight loss and moderate nephrotoxicity in rabbits was 2.8 mg/kg-day (EPA, 1997d). This value was modified by an uncertainty factor of 1000 to provide the current Reference Dose (RfD) of 3E-03 mg/kg-day. The RfD is an estimate of a chemical dose at which consumption over a lifetime would not be likely to result in the occurrence of chronic, noncancer effects (EPA, 1997d).

8.2 Chemical Exposure Evaluation

Groundwater represents the primary media of concern for the Cimarrron site. Soils and deposited Option #2 materials at the site have previously been determined not to present any potential threats to human health or

the environment (NRC, 1994). Due to the nature of the site, exposures associated with re-entrained particulate materials in air are unlikely to occur. Reservoirs and the Cimarron River have been monitored for over a decade and no exceedences of MCLs have been noted and therefore, these surface waters do not constitute a potential exposure media.

8.2.1 Potential Exposure Scenarios for Groundwater

8.2.1.1 Vicinity Groundwater Use

The Garber-Wellington Aquifer is a primary water supply for Logan County. In the County, municipal (to a limited extent) and irrigation waters are drawn from groundwater; however, domestic water usage from wells in the vicinity of the site is minor due to the high naturally occurring hardness. The area is served by a rural water district (Grant, 1989). In general, groundwater in the alluvium is not used because of its salinity. Area investigations have shown there are four (4) domestic water supply wells screened in the Garber-Wellington Aquifer and located within a three-mile radius of the Site, on the south side of the Cimarron River (Grant, 1990). All of these wells are in an upgradient direction of the Facility. The average depth of these wells is 116.5 feet. Evaluation of these wells has demonstrated no impacts to off-site groundwater quality from the Cimarron site. The downgradient receptor for groundwater from the site is the Cimarron River. These data may also reflect these off-site wells have been completed in a more permeable part of the Garber-Wellington Aquifer which is located east of the site and runs north-south across the State (Chase, 1997).

8.2.1.2 Current Use Exposure Scenario (Trespasser)

The site is under the control of Cimarron such that potential receptors are limited to a trespasser or agricultural worker who may be exposed to

"seeps" resulting from the discharge of shallow groundwater in the areas of the bluffs at the site. The assumptions used in evaluating each of the scenarios are conservative to ensure that the estimated risks are greater than any actual exposure will likely be.

Other activities presently occurring within the Cimarron site are work involved with the overall decommissioning of the site, periodic ground maintenance (i.e., cutting the native grass), periodic environmental assessment activities, and non-radiation related research involving titanium dioxide pigment. Groundwater is not utilized by Cimarron personnel for any purpose; therefore, it does not constitute an exposure pathway for on-site workers.

There are significant portions of the site surroundings under agricultural use, therefore, cultivation activities as required are performed by an agricultural lease holder. Groundwater is not utilized at the site for irrigation purposes in these unrestricted use areas; therefore, it does not constitute an exposure pathway for agricultural workers.

The former processing area site is controlled with regards to the potential for unauthorized persons being on site by the presence of a security fence, and currently also by security guards. Potential receptors, such as trespassers, are not likely to be drawn to this area for any type of recreational activity due to the fencing and overall nature of the site. The Cimarron River is not used for recreation activities in this vicinity. The only potential exposure to impacted groundwater, therefore, is limited to a few localized "seeps" along the bluffs. The limited volume of groundwater discharging at these seeps and their location make it highly unlikely that water could be consumed as a drinking water supply by agricultural

workers or trespassers. If a trespasser should happen upon the site, the exposure to groundwater would be highly unlikely.

It is possible, although not highly probable, that a trespasser could have limited dermal contact with water from the "seeps", using it to wash dirt from hands and forearms. Therefore, as a worst case scenario, a situation which assumes contact with the water from the "seeps" on the hands and forearms of an adult trespasser was determined to be the most likely completed exposure scenario for evaluation. This scenario was also used in the non-radiological constituent risk assessment performed for the Oklahoma DEQ. The potentially complete pathway for current exposure considered for evaluation is:

- dermal contact with shallow groundwater.

8.2.1.3 Future Use Exposure Scenario (Groundwater Consumer)

Due to the nature of the groundwater underlying the Cimarron Site and the availability of surface and supplied water systems, the development of the groundwater resources for drinking, irrigation and livestock watering purposes is unlikely to occur. Studies (Grant, 1996; Chase, 1997) have revealed that, in general, the shallow aquifer would not yield the long-term sustainable pumping rate for groundwater at the site greater than approximately one to two gallons per minute. Further, groundwater near the site is hard to very hard, and naturally high in dissolved solids, chloride, and nitrates which further limit its usage. Most importantly and as described above, the ready access to other higher quality water supplies and the generally less-than-acceptable quality and quantity of the groundwater underlying the site, make the use of groundwater unlikely to occur, even if there are no controls on use of the Site. Moreover, governmental institutions and their associated support infrastructure will

remain in place, further limiting the possibility of any use of such a limited water source by a future resident.

Although the groundwater at the site would not typically be utilized for a drinking water supply because of its poor quality and marginal yield, the risk evaluation conservatively assumes that the waters could be utilized on an individual basis for domestic consumption. Therefore, a future exposure scenario which assumes consumption of groundwater and dermal exposure associated with domestic use was evaluated. Direct ingestion of groundwater is anticipated to represent the majority of the exposure potential due to the poor dermal absorption of uranium (see Section 8.1.2). The potentially completed pathways considered for evaluation for this scenario are:

- ingestion of water;
- dermal contact with water.

8.2.1.4 Exposure Point Concentrations for Groundwater

Table 8.1 summarizes the shallow groundwater data for the site for 1997 and first quarter 1998. The 95 upper confidence limit (95th UCL) of the arithmetic mean was calculated for the shallow groundwater system and the water surfacing at the "seeps" as shown in Table 8.1. Collectively, these concentrations are considered the exposure point concentrations used to evaluate the potential risk associated with the site. The use of 95UCL values to evaluate chemical toxicity is standard practice for chemical risk assessment in order to estimate reasonable maximum exposure levels. This is in contrast to the standard use of average concentrations when evaluating radiogenic risk as in Section 7.0. Both the shallow groundwater system data and the "seeps" data were utilized to evaluate the current trespasser scenario. The maximum concentration

in the shallow groundwater was utilized for the future-use groundwater consumer scenario.

8.2.2 Calculated Potential Daily Intake Values for Uranium

Chemical intake estimates are based on EPA methodology (EPA, 1989). All exposure equations used to calculate dose and intake from the ingestion of chemicals in soil and from dermal contact are presented in Table 8.2.

8.2.2.1 Current Use Exposure Scenario

The trespasser scenario assumed that a trespasser will have contact with the water from the "seep" for 1.5 hours per trespass event; this value is the EPA default value for adult time spent out of doors. It was assumed that 12 trespass events occurred per year. This value is consistent with the EPA default value for frequency of recreational water contact of 1 event per month (i.e., 12 per year). Since such contact is unlikely to occur over the colder months, this estimate is extremely conservative. The surface area of the hands and forearms of the adult trespasser was assumed to be 1,980 cm^2 which is the mean surface area as reported by EPA (EPA, 1997).

8.2.2.2 Future Use Exposure Scenario

The analysis of the future groundwater consumer scenario for domestic consumption of groundwater assumes that these waters serve as the sole source of drinking water for a user. It will be assumed that the water user will potentially consume water (2 L/day) and have dermal contact (full-body) with water from the shallow groundwater system 365 days/year for a 30 year period. Chemical intake estimates utilized were drawn from NRC and USEPA default exposure parameters (Kennedy, 1992; EPA, 1989; EPA, 1991; EPA, 1992a; EPA 1997a). The exposure factors

utilized in the risk evaluation and their source are summarized in Table 8.3.

8.2.3 Human Health Risk Characterization

8.2.3.1 Chemical Noncarcinogenic Dose-Response

Compounds with known or potential noncarcinogenic effects are assumed to have a dose below which no adverse effect occurs or, conversely, above which an adverse effect may be seen. This dose is the threshold dose. The threshold dose is called a No Observed Adverse Effect Level (NOAEL). The lowest dose at which an adverse effect occurs is called a Lowest Observed Adverse Effect Level (LOAEL). By applying uncertainty factors to the NOAEL or the LOAEL, RfDs for chronic exposures to chemicals with noncarcinogenic effects have been developed by EPA. The uncertainty factors account for uncertainties associated with the dose-response relationship such as the effects of using an animal study to derive a human dose-response value, extrapolating from high to low doses, and evaluating sensitive subpopulations. The source of the published dose-response value used in this evaluation was EPA's Integrated Risk Information System (IRIS) (EPA, 1997a).

For chemicals with noncarcinogenic effects, an RfD provides reasonable certainty that no noncarcinogenic health effects are expected to occur even if daily exposures were to occur at the RfD level for a lifetime. The RfD and exposure doses are expressed in units of milligrams of chemical per kilogram body weight per day (mg/kg-day). The oral RfD for uranium is 3.0E-03 mg/kg-day, as discussed in Section 8.1.3.

8.2.3.2 Human Health Risk Characterization

Risk characterization combines toxicity and exposure information to arrive at qualitative and quantitative evaluation of any potential human health hazards. The potential noncarcinogenic risk to each potential human receptor from ingestion of contaminants in groundwater was quantitatively evaluated.

For the chemical assessment, risk is defined as the estimate of exceeding toxic effect thresholds for noncarcinogens. A probabilistic approach is not used to estimate the potential for noncarcinogenic health effects. Instead, the potential for noncarcinogenic effects is evaluated by comparing the average daily exposure (intake) over a specified time period (exposure duration) with a RfD derived for similar exposure periods for each chemical. This ratio of exposure is called a hazard quotient (HQ) calculated as:

$$HQ = \frac{intake\ (mg\ /\ kg - day)}{RfD\ (mg\ /\ kg - day)}$$

HQ's may be summed to obtain a hazard index (HI) for each chemical and specific pathway. An HQ or HI greater than one has been defined as the level of concern for potential adverse noncarcinogenic health effects (EPA, 1989).

8.2.3.3 Risk Estimates for the Cimarron Facility

The noncarcinogenic risk estimates calculated are presented in Tables 8.4 through 8.9. The results are discussed in the following subsections.

On-Site Current Use Trespasser

The noncarcinogenic HQ/HI for dermal contact with shallow groundwater at the 95th UCL concentration of 1.07E-04 for the trespasser scenario is considerably less than the target level of 1.0 (Table 8.4). The dermal contact HQ/HI of 3.53E-05 for waters at the seeps where exposure is more likely to occur is also well below the target level of 1.0 (Table 8.5). If average concentrations had been utilized, the calculated HQ/HI would have been considerably lower. Therefore, the uranium compounds in groundwater at the site do not pose a hazard to a trespasser.

On-site Future Use Groundwater Consumer

The total noncarcinogenic HQ/HI associated with uranium for an on-site groundwater consumer was evaluated at both the 95th UCL concentration for the site and the maximum concentration at Well 1315 (3.1 mg/L) [3,044 pCi/L] which is located at Burial Area #1. The total noncarcinogenic HQ associated with dermal contact with uranium at the maximum concentration was an order of magnitude below the target level of 1.0 (Table 8.6). For ingestion, when fractional absorption of 2 percent is utilized, the HQ for ingestion of groundwater at the maximum concentration by a resident farmer is 5.90E-01 which is less than the target level of 1.0 (Table 8-7). The total HI (7.34E-01) for uranium considering both the dermal and ingestion pathways for the groundwater consumer exposed at the site maximum concentration is below the target level of 1.0. If the average concentration had been utilized as the basis of the risk calculation, the calculated HQ/HI would have been even lower. As can be noted from these data, direct ingestion of groundwater constitutes the major component of exposures and the HQ.

The 95th UCL concentrations were also evaluated (Tables 8.8 and 8.9). As with the maximum concentrations, the dermal contact and ingestion

when gastrointestinal absorption of 2 percent is utilized, the total HI of 5.44E-02 is well below the target level of 1.0. The evaluation demonstrates that it is unlikely that adverse health effects would occur if a groundwater consumer utilized groundwater at the Cimarron site at the highest impacted well for domestic purposes. Again, it can be noted that direct ingestion of groundwater contributes the majority of the HQ. Further, if the average concentration had been utilized as the basis of the risk calculation, the calculated HQ/HI would have been even lower. Use of groundwater at any other location on-site would result in exposure levels which would be significantly less than that evaluated at the highest concentration well.

8.2.4 Uncertainties In The Chemical Toxicity Evaluation

The risks calculated in this assessment are single point estimates of risk rather than probabilistic estimates. Therefore, it is important to discuss uncertainties inherent in the risk assessment in order to place the risk estimates in proper perspective. Uncertainties can be associated with sampling data adequacy, exposure assessment variables, and toxicity values.

Uncertainty is inherent in selection of data to represent the exposure point concentrations for the Site. Considerable data on uranium concentrations in groundwater, which had been collected since 1985, was available for use in the evaluation. The data collection program at the Cimarron Site has been comprehensive and hence, the uncertainty associated with the identification of exposure point concentrations for analysis is low.

Selection of the future use exposure scenario at the Facility may result in an overestimation of potential risk. Due to the water quality and the availability of rural water, it is unlikely that site groundwater would be utilized for

domestic consumption. The conservative nature of the scenario selected for analysis ensures that the potential risks are not underestimated, and are, in fact, likely to be greatly overstated.

The variables used for the exposure assessment were extremely conservative and would lead to an overestimation of risk. The exposure intake assumptions were those determined by the NRC and/or the EPA. The conservative nature of the assessment results in an overestimation of potential risk.

There is a great deal of inherent uncertainty in the toxicity values used for assessing potential risk to humans. Sources of uncertainty for calculating toxicity factors include extrapolation from short-term to long-term exposures, the amount of data supporting the toxicity factors and extrapolation from animal experiments. To the extent that humans differ from animals, the Facility-specific risk estimates based on these animal toxicity data may not reflect actual risk to humans.

In general, the assumptions built into this assessment are based on best practice and tend to overestimate rather than underestimate potential risks, including conservative assumptions for exposure point concentrations and exposure scenarios.

8.3 References

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TABLE 8.1

1997 AND FIRST QUARTER 1998 CHEMICAL CONSTITUENT DATA SUMMARY AND BENCHMARK COMPARISON FOR CIMARRON RIVER, SEEPS, AND SHALLOW GROUNDWATER SYSTEMS

CIMARRON CORPORATION

Contaminant	Range	Frequency of Detection	Mean	95th UCL	Benchmark Values			
					Background	Above/Below Background Values	Maximum Contaminant Level	Above/Below MCL
Shallow Groundwater Upgradient								
Total Uranium (mg/L)	0.0007 - 0.003	3/3	0.002	0.003	NA	NA	0.02	Below
Total Uranium (pCi/L) [1]	1.3 - 5.0	3/3	2.77	5.0	NA	NA	30	Below
Shallow Groundwater Downgradient								
Total Uranium (mg/L)	0.0005 - 3.1	67/67	0.12	0.23	0.0007 - 0.003 [2]	Above	0.02	Above
Total Uranium (pCi/L) [1]	1.2 - 3,044	67/67	161.4	278.7	1.3 - 5.0 [2]	Above	30	Above
Water at Seeps								
Total Uranium (mg/L)	0.007 - 0.114	9/9	0.05	0.076	0.0007 - 0.003 [2]	Above	0.02	Above
Total Uranium (pCi/L) [1]	12.4 - 189.1	9/9	93.0	136.9	1.3 - 5.0 [2]	Above	30	Above

[1] As determined by modified HASL300 analytical method

[2] Background values based on 1997 Shallow Groundwater Upgradient Well Data.

TABLE 8.2
PATHWAY-SPECIFIC FORMULAS USED FOR CHEMICAL EXPOSURE CALCULATIONS

Dermal Contact with Contaminants in Water

$$Intake\ (mg\ /\ kg\ /\ day) = \frac{C_W\ x\ SA\ x\ PC\ x\ EF\ x\ ED\ x\ ET\ x\ CF}{BW\ x\ AT}$$

where:

C_w	=Chemical concentration in water (mg/Lg)
CF	=Conversion factor for chemical fraction of water (1 L/1000cm^3)
EF	=Exposure frequency (days/year)
ED	=Exposure duration (years)
BW	=Body weight (kg)
AT	=Averaging time for pathway-specific exposure period
ET	=Exposure time (hours/day)
SA	=Skin surface area available for contact (cm^2)
PC	=Chemical-specific dermal permeability constant (cm/hr)

Drinking Water Ingestion

$$Intake\ (mg\ /\ kg\ /\ day) = \frac{C_W\ x\ CF\ x\ IR\ x\ ABS\ x\ EF\ x\ ED\ x\ FI}{BW\ x\ AT}$$

where:

C_w	=Chemical concentration in drinking water (☞g/L)
CF	=Conversion factor (10^{-3} mg/☞g)
FI	=Fraction Ingested from contaminated source
IR	=Ingestion rate (1/day)
ABS	=Fractional Absorption (unitless)
EF	=Exposure frequency (days/year)
ED	=Exposure duration (years)
BW	=Body weight (kg)
AT	=Averaging time for pathway-specific exposure period (days)

TABLE 8.3
SUMMARY OF EXPOSURE FACTORS

Exposure Factor	Value		Source
Body Weight (BW) (kg)	adult :	70	NRC
Averaging time (AT) (days)	noncarcinogens:	exposure duration x 365	EPA
Drinking water ingestion (IR_{water}) adult (L/day)	adult:	2	NUREG-5512
Exposure frequency (EF) (days/year)	residential: trespasser:	365 12	NRC EPA
Exposure time (ET) (hours/event)	residential trespasser	0.5 1.5	EPA
Exposure duration (ED) residential (years)	residential - adult: trespasser:	30 8	NRC EPA
Gastrointestinal Absorption (ABS) (unitless)	adult	0.02	ATSDR
Skin surface area - adult (SA) (cm^2)	hands/forearms: full body:	1,980 19,400	EPA
Dermal absorption rate - inorganics (cm/hr)	1×10^{-3}		EPA

TABLE 8.4. SUMMMARY OF INTAKE AND RISK ASSOCIATED WITH DERMAL CONTACT WITH SHALLOW GROUNDWATER TRESPASSER SCENARIO, CIMARRON CORPORATION

Chemical	95th UCL Concentration (mg/L)	Surface Area (sq cm)	Permeability Constant (cm/hr)	Exposure Time (hrs)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	0.23 [a]	1980	1.00E-03	1.5	12	8	70	2920	3.21E-07	3.00E-03	1.07E-04

[a] 278.7 pCi/L

TABLE 8.5. SUMMARY OF INTAKE AND RISK ASSOCIATED WITH DERMAL CONTACT WITH WATER AT THE SEEPS TRESPASSER SCENARIO, CIMARRON CORPORATION

Chemical	95th UCL Concentration (mg/L)	Surface Area (sq cm)	Permeability Constant (cm/hr)	Exposure Time (hours)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	0.076 [a]	1980	1.00E-03	1.5	12	8	70	2920	1.06E-07	3.00E-03	3.53E-05

[a] 136.9 pCi/L

TABLE 8.6. SUMMARY OF INTAKE AND RISK ASSOCIATED WITH DERMAL CONTACT WITH SHALLOW GROUNDWATER
GROUNDWATER CONSUMER SCENARIO AT 1997/FIRST QUARTER 1998 MAXIMUM CONCENTRATION, CIMARRON CORPORATION

Chemical	Maximum Concentration (mg/L)	Surface Area (sq cm)	Permeability Constant (cm/hr)	Exposure Time (hr)	Exposure Frequency (days)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	3.1	19400	1.00E-03	0.5	365	30	70	10950	4.30E-04	3.00E-03	1.43E-01

Maximum Concentration: Well 1315, 3/97, 3,044 pCi/L

TABLE 8.7. SUMMARY OF INTAKE AND RISK ASSOCIATED WITH INGESTION OF SHALLOW GROUNDWATER
GROUNDWATER CONSUMER SCENARIO AT 1997/FIRST QUARTER 1998 MAXIMUM CONCENTRATION, CIMARRON CORPORATION

Chemical	Maximum Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days)	Fractional Absorption (unitless)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	3.1	2	365	0.02	30	70	10950	1.77E-03	3.00E-03	5.90E-01

Maximum Concentration: Well 1315, 3/97, 3,044 pCi/L

TOTAL HAZARD INDEX FOR GROUNDWATER CONSUMER SCENARIO:	7.34E-01

TABLE 8.8. SUMMARY OF INTAKE AND RISK ASSOCIATED WITH DERMAL CONTACT WITH SHALLOW GROUNDWATER
GROUNDWATER CONSUMER SCENARIO AT 95th UCL CONCENTRATION, CIMARRON CORPORATION

Chemical	95th UCL Concentration (mg/L)	Surface Area (sq cm)	Permeability Constant (cm/hr)	Exposure Time (hr)	Exposure Frequency (days)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	0.23 [a]	19,400	1.00E-03	0.5	365	30	70	10950	3.187E-05	3.00E-03	1.06E-02

[a] 278.7 pCi/L

TABLE 8.9. SUMMARY OF INTAKE AND RISK ASSOCAITED WITH INGESTION OF SHALLOW GROUNDWATER
GROUNDWATER CONSUMER SCENARIO AT 95th UCL CONCENTRATION, CIMARRON CORPORATION

Chemical	95th UCL Concentration (mg/L)	Ingestion Rate (L/day)	Fractional Absorption (unitless)	Exposure Frequency (days)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Average Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Uranium	0.23 [a]	2	0.02	365	30	70	10950	1.31E-04	3.00E-03	4.38E-02

[a] 278.7 pCi/L

TOTAL HAZARD INDEX FOR GROUNDWATER CONSUMER SCENARIO:	5.44E-02

9.0 JUSTIFICATION FOR SITE UNRESTRICTED RELEASE LICENSE TERMINATION

9.1 Discussion Of The NRC December, 1997 Proposed Values

Cimarron requested NRC review the Commission Action Plan for Decommissioning and other potentially applicable drinking water standards and interpret their potential application at the Cimarron site as unrestricted use release criteria. The NRC conducted the review and proposed reference standards which Cimarron should consider for the protection of groundwater resources at the site in December, 1997 (NRC, 1997). In their letter, the NRC referenced the "Interim Primary Drinking Regulations" in 40 CFR Part 141 as possibly applicable standards and also stated that other groundwater criteria could be proposed by Cimarron.

For Tc-99 and other beta emitters, the cited reference standard (NRC, 1997) was based on the total average annual concentration of beta particle and photon radioactivity from man-made radionuclides which would result in an annual whole body dose of less than or equal to 4 mrem/year (based on consumption of 2 L/day of water) (EPA, 1976).

The NRC's referenced limit (NRC, 1997) for uranium was 30 pCi/L or 0.02 mg/L (20 μg/L) as provided in the proposed 1991 EPA Maximum Contaminant Level (EPA, 1991). This proposed level was based on chemical toxicity, not radiation effects. In developing this limit, EPA assumed a fractional absorption equal to 1.0 and therefore, multiplied the RfD of 3E-03 mg/kg-day (See Section 8.1.3) by 70 kg and divided by 2 liter per day water intake to derive a drinking water exposure limit and then applied a 20 percent relative source contribution factor to arrive at

0.02 mg/L MCL value. In proposing the standard, EPA indicated that the MCL was based on kidney toxicity rather than the carcinogenic potential associated with the radiogenicity of uranium. In general, EPA and ATSDR have characterized the carcinogenic potential of uranium as low (EPA, 1991; ATSDR, 1997).

The NRC also indicated that the reference standard for Radium-226 was 20 pCi/L and for adjusted gross alpha of other alpha emitting radionuclides (excluding uranium and Radium-226), the standard was 15 pCi/L.

9.2 Discussion Of Overlapping Requirements With Oklahoma Department Of Environmental Quality (DEQ) For Chemical Constituents

The DEQ, the successor agency to the Oklahoma Department of Health, has asserted jurisdiction over the chemical constituents: nitrate, fluoride and uranium (chemical toxicity only) in groundwater at the Cimarron site. As a part of the review of the site, the DEQ requested that Cimarron prepare a risk assessment for groundwater which addressed the three chemical contaminants since some site data exceeded the Oklahoma Drinking Water Standards (which are equivalent to the EPA Maximum Contaminant Levels) for fluoride, nitrate, and uranium of 4 mg/L, 10 mg/L, and 0.02 mg/L (30 pCi/L), respectively.

A work plan (RSA, 1997) was prepared and approved by DEQ (DEQ, 1997) which outlined the exposure scenarios to be addressed in the assessment. As a part of the review of the work plan, the DEQ concurred with Cimarron's assertion that because of the naturally occurring dissolved solids, chloride and nitrate content, the low long-term sustainable pumping rates, and the availability of high quality alternative

water sources, groundwater consumption by a domestic user was unlikely to occur in the future. Therefore, a resident farmer scenario was excluded from the assessment sent to DEP for assessment of current and/or future groundwater use at the site.

A trespasser scenario equivalent to the trespasser scenario evaluated in Section 8.2 was utilized for the assessment prepared for DEQ. The Hazard Index for noncancer risks calculated for fluoride, nitrate, and uranium were several orders of magnitude below the acceptable value of one. It was concluded that the groundwater at the site did not pose a risk to human health or the environment for these constituents.

Cimarron anticipates that DEQ will not require any corrective actions at the site in light of the absence of any meaningful likelihood of the use of the affected water. Rather, DEQ will require continued monitoring of the groundwater in localized areas for some period of time, as well as on-going oversight of the property by Cimarron. As a part of the risk assessment Cimarron has proposed "re-opening criteria" to the DEQ. The "re-opening" criteria represent risk-based concentrations which will be utilized to assess any need for continued monitoring of groundwater and oversight by Cimarron.

Cimarron proposed use of a background concentration of nitrate for the "re-opening criterion". The State concurred. The background concentration approach was proposed because upgradient groundwater and unaffected wells on site contain nitrate levels which exceed the drinking water standard, primarily related to the use of nitrogen-based fertilizers in the agricultural activities on-going on and surrounding the site. Based on data from the last time a monitoring well was sampled, eighteen (18) of the 27 downgradient shallow groundwater wells and "seeps" were

found to have nitrate concentrations below 40 mg/L, the current background concentration arising from agricultural activities on and around the site. Areas which have nitrate levels above background and are affected by past facility operations are the two "seeps", Uranium Waste Pond #1 and Uranium Waste Pond #2.

For fluoride, the Maximum Contaminant Level of 4 mg/L was proposed for use as the "re-opening criteria". Evaluation of the groundwater data from the last time a monitoring well was sampled, revealed that 21 of the 27 downgradient shallow wells and seeps have fluoride concentrations below the Maximum Contaminant Level of 4 mg/L. Elevated fluoride concentrations occur in the area of Waste Pond No. #1 and Waste Pond No. #2. In those areas, the highest fluoride concentration occurring during 1997 and first quarter 1998 was 88 mg/L. When only dermal exposure is considered (the most likely exposure scenario), the fluoride concentrations in the shallow groundwater are not a concern.

A risk-based "re-opening criterion" was proposed for uranium (chemical toxicity). The risk-based criterion was based on the unlikely scenario that a resident farmer would consume site groundwater as the sole source of water for domestic uses. Consumption by ingestion was the only exposure route considered, since it had been demonstrated that dermal exposure contributed only minimal exposure. Because of the nature of uranium and it's poor to non-existent percutaneous absorption, DEQ did not require potential dermal absorption be included in the calculation of the risk-based "re-opening" criterion. The proposed risk-based "re-opening criteria" for uranium is 0.11 mg/L based solely on ingestion of groundwater and on an assumed fractional absorption of 1.0. Table 9.1 presents the calculation of the chemical risk-based criterion. For uranium, all but two of the 27 downgradient shallow wells and "seeps" have

uranium concentrations below the 0.11 mg/L "re-opening criterion"; in fact 20 of the 27 downgradient wells and "seeps" have uranium concentrations on the last sampling below the Maximum Contaminant Level of 0.02 mg/L (30 pCi/L). When the actual fractional absorption for uranium of 0.02 is utilized, the risk-based criteria is 5.5 mg/L; all of the wells and seeps meet this criteria.

These chemical data and the risk assessment is provided in the document entitled *Risk Assessment for Groundwater, Cimarron Corporation, Crescent, Oklahoma* submitted to the DEQ on June 2, 1998.

9.3 Proposed Unrestricted Use Radionuclide Release Criteria

Cimarron is proposing the following criteria for radiological constituents in groundwater to be utilized by the NRC in evaluating the site groundwater regime for unrestricted release. In some cases, the concentrations are different from those proposed as standards by the NRC in December, 1997 (NRC, 1997). The different standard for uranium is justified based on the scientific underpinnings of the limit, site hydrogeology, current and future land uses, the existence of a strong governmental infrastructure, and Cimarron's continued control and use of the facilities for non-radiological research and development activities associated by Kerr-McGee's Chemical Division.

9.3.1 Criteria for Technetium

Cimarron agrees with the use of a dose-based criteria for Technetium based on an annual dose equivalent to the total body of 4 mrem/year. As discussed in Section 7.0, the dose equivalent calculated for groundwater at the Cimarron site, based on 1997 sampling results, are all below the 4 mrem/year criteria. Therefore, the site has met the criteria for unrestricted release for this species.

9.3.2 Criteria for Uranium

Cimarron proposes use of a risk-based criterion for uranium of 0.11 mg/L (180 pCI/L) total uranium, which corresponds to a theoretical annual dose of approximately 25 mrem/year calculated utilizing the method discussed in Section 7.1. The calculation of the risk-based criterion is presented in Table 9.1 and assumes only the direct ingestion of groundwater. It assumes that an adult resident would consume 2 L of water per day, every day for a period of 30 years, and absorbs 100 percent (fractional absorption of 1) of the uranium in the water. A fractional absorption of 1.0, which is considerably above the measured fractional absorption of uranium of 0.2, was utilized in order to allow for significant conservatism in the calculation of the criterion. Because uranium is poorly absorbed through skin, potential dermal absorption does not represent a major contributor to the risk and thus, was not included in the calculation of the risk-based criterion.

As discussed in Section 9.1, the reference standard for uranium suggested by the NRC, the current EPA-proposed MCL for uranium, allows for water consumption to contribute only 20 percent of the total exposure. Consistent with previous determinations at the site as discussed in Section 6, Cimarron has attributed 100 percent of potential exposure to ingestion of groundwater, since other potential exposure routes are insignificant. The attribution of 100 percent of the potential exposure to direct ingestion of water accounts for the differences in the risk-based criterion proposed by Cimarron and the reference standard proposed by the NRC.

As was noted in the discussion in Section 8.1.2, the gastrointestinal fractional absorption of soluble uranium salts is generally less than 0.02 which is considerably below the assumed fractional absorption rate of 1

for the criterion concentration. If the actual fractional absorption rate of 0.02 is utilized, the risk-based criterion would be 5 mg/L (calculated by dividing the criteria calculated in Table 9.1 by the fractional absorption of 0.02). Therefore, the risk-based 0.11 mg/L criterion selected for use is still extremely conservative.

It should be noted that it in light of the conservative nature of the assumptions that were applied in the development of the criterion, the true potential likelihood of developing an adverse effect associated with the consumption of groundwater which is at or below the criterion level is extremely low and may be zero. Further, because of the difference in chemical risk and radiogenic dose, the two doses or risks are not additive.

The concentration of 0.11 mg/L for uranium is consistent with the "re-opening criterion" or no further action proposed to the DEQ and with preliminary media goals set forth by EPA Regions 3, 6 and 9 (EPA, 1997, 1996b, 1996a) for use in evaluating contaminated sites. Further, this concentration is generally consistent with a revised MCL (0.05 to 0.07 mg/L) under consideration by EPA for promulgation in 2000 (Kirk, 1998) in which EPA has determined that the fractional absorption and source contribution factor need to be adjusted from the originally proposed MCL. Of course, the MCL proposed by the EPA in 1991 has never been promulgated as a final regulation and thus has no binding legal effect.

Further, as shown by Section 7.1 and Table 7.2, the risk-based criteria for uranium of 0.11 mg/L (180 pCi/L) corresponds to a theoretical annual dose of approximately 25 mrem/year. The limit thus is also consistent with generally accepted radiation dose-based criteria, that is, annual radiation doses at or below 25 mrem/year are generally considered acceptable. As discussed in Section 8.1.1, due to the low specific activity of uranium in

groundwater it is unlikely that radiation doses of this magnitude would even occur.

Reviewing the data from the last sampling event of each of the 27 shallow downgradient monitoring wells and "seeps" at the Cimarron site, all but two locations (MW-1315 and SW-1206) are below the proposed risk-based criteria. All of the monitoring wells and "seeps" would be far below the less conservative 5 mg/L risk-based concentration for uranium.

9.4 References

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EPA, 1976. 40 Code of Federal Regulations 141.16, Interim Primary Drinking Water Standards.

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EPA, 1997. Risk-Based Concentration Table, memorandum from Eric W. Johnson, Technical Support Section, Region 3, Environmental Protection Agency, Philadelphia, PA, dated October 22, 1997.

Kirk, S., 1998. EPA Holds Stakeholder Meeting on the Safe Drinking Water Act Amendments, HPS Newsletter, March 1998.

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NRC, 1997. Letter to Jess Larsen, Cimarron Corporation from Kenneth L. Kalman, Facilities Decommissioning Section, Nuclear Regulatory Commission, Washington, D.C., dated December 18, 1997.

RSA, 1997. Cimarron Corporation, Crescent, Oklahoma, Work Plan for A Risk Assessment for Groundwater, Roberts/Schornick and Associates, August 22, 1997.

RSA, 1998. Risk Assessment for Groundwater, Cimarron Corporation, Crescent, Oklahoma, Roberts/Schornick and Associates, April, 1998.

TABLE 9.1 CHEMICAL RISK-BASED UNRESTRICTED USE RELEASE CRITERIA
CIMARRON CORPORATION

Chemical	Target Hazard Index	Ingestion Rate (IR) (L/day)	Fractional Absorption (unitless)	Exposure Frequency (EF) (days)	Exposure Duration (ED) (years)	Body Weight (BW) (kg)	Averaging Time (AT) (days)	RfD (mg/kg-day)	Chemical Risk-based Criteria (mg/L)
Uranium	1	2	1	365	30	70	10950	3.00E-03	1.1E-01 [(a)]

Chemical Risk-based Criteria (mg/L) = (THI x BW x AT) / EF x ED x (1/RfD) x (IR x FA)

where:

THI = Target Hazard Index
BW = Body Weight
AT = Averaging Time = ED x 365 days/year
EF = Exposure Frequency
ED = Exposure Duration
RfD = Oral Reference Dose
IR = Ingestion Rate
FA = Fractional Absorption

See Table 8.3 for source of default values.

[(a)] 1.1E-01 mg/L is equivalent to 182.5 pCi/L.

10.0 CONCLUSION

As demonstrated in this report, Cimarron believes that all of the conditions and criteria for approval of the Cimarron Decommissioning Plan, including a derivation of appropriate groundwater criteria and a program to address any remaining groundwater impacts above the criteria, have been met. Also within this report, Cimarron has addressed each of the NRC staff comments regarding groundwater as described in NRC letters dated November 18, 1997 and December 18, 1997, as well as NRC staff comments provided in the NRC letter dated February 26, 1998 regarding the February 17, 1998 meeting with NRC staff in Washington, D.C.

As discussed in this report, there are effective confining mudstone strata between each of the groundwater zones of Sandstones A, B, and C found on-site. These mudstones influence the lateral flow of groundwater and act to limit the potential downward migration of shallow groundwater between the three sandstone units. Shallow groundwater in the A and B sandstone units generally discharges to the incised drainage pathways and seeps found in the low-lying bluffs and cliffs that border the floodplain of the Cimarron River. Deeper groundwater in both Sandstones B and C discharges to the alluvial deposits that underlie and comprise the Cimarron River bottom and the adjoining floodplain. Also, as discussed in this report, deeper groundwater is of poor quality and has not been impacted by prior site operations.

As documented in this report and in previous submittals to the NRC, the background quality and quantity of groundwater at the Cimarron site varies significantly, but is generally poor to marginal. The bluffs overlooking the Cimarron River represent a very large discharge zone that continually drains the upper sandstones and, in fact, the upper sandstones are not saturated in those site areas near the bluffs. Any recovery wells located in these areas, which include the areas impacted by prior site operations (e.g. Waste Ponds #1 and

#2), would experience a further decline in water level because they would be pumping from an already partially de-watered zone. Under these conditions, Cimarron believes it is highly unlikely that an individual would incur the cost to drill wells and install treatment systems (to reduce hardness) for that groundwater when alternate sources of better quality water with higher volumes are readily available. Alternate sources of water include the rural water system that presently supplies water to the site and the surrounding vicinity, and the large on-site reservoirs. The on-site reservoirs were constructed and used as sources of process and drinking water during early facility operations in lieu of groundwater that did not provide an adequate supply or quality. The rural water district was not available until after operations at the facility ceased.

The historical and more recent groundwater and surface water investigations clearly show that groundwater radionuclide impacts have abated and continue their decreasing trends from those levels presented in the 1989 Grant report. With additional sources removed in these areas and the site in the final phase of decommissioning, these recorded decreasing trends will continue.

As discussed in Sections 7.0, 8.0 and 9.0, Cimarron proposes the use of a uranium criterion for groundwater, based upon consideration of chemical toxicity and radiological impacts, to account for the limited possibility that the groundwater may be used in the future. The proposed uranium criterion corresponds to 0.11 mg/L for total uranium, or approximately 25 mrem/year TEDE to the hypothetical individual drinking the water. This report demonstrates that all areas of the Cimarron site meet the criterion for Tc-99 as proposed by NRC (i.e., 4 mrem/y TEDE). These proposed criteria serve to ensure that any risk of chemical toxicity or radiological impact to members of the public will be avoided.

The results of analyses undertaken in this report clearly show that, using conservative methods, only the shallow groundwater (Cimarron River alluvium) in

close proximity to former Burial Area #1 at the Cimarron site exceeds the proposed uranium criterion. Former Burial Area #1 is within the Cimarron River flood plain and is prone to inundation on a regular basis, thereby minimizing the likelihood of a downgradient residence or well.

In order to address the fact that groundwater in the vicinity of former Burial Area #1 does not meet the proposed criterion, Cimarron is moving forward with a further evaluation of former Burial Area #1 utilizing the protocols described below:

A. Cimarron will continue to monitor Former Burial Area #1 groundwater on a quarterly basis. Even though Cimarron believes that groundwater concentrations will continue to decrease, it will conduct additional studies for the purpose of understanding the attenuation mechanisms. These studies will include additional hydrogeologic evaluations of the general area.

B. Former Burial Area #1 is being surveyed and mapped using both conductivity and magnetometer non-intrusive subsurface investigation techniques. In an effort to assure that no other solid wastes remain:

    1. Any areas that are suspect due to the above studies will be investigated.

    2. Any discovered waste (e.g., drums, scrap, etc.) will be removed, properly packaged and shipped to an appropriate disposal site.

    3. Any suspect localized area soils that are revealed as a result of waste removal activities will be evaluated utilizing the NRC's Branch Technical Position and volumetric averaging guidance.

These activities will serve to assure that any identifiable source of lingering groundwater contamination is identified and removed.

C. Cimarron, through its parent Kerr-McGee Corporation, will retain and control the property areas formerly licensed under SNM-928 until the proposed groundwater criteria are met. In the unlikely event that the uranium concentrations do not decline sufficiently during the monitoring period, Cimarron will prepare a corrective action program.

The main plant site area will continue to be used by the Chemical Division, KMCLLC., for pilot plant studies related to titanium dioxide pigment activities. These research activities do not require the use or application of radioactive materials. With the submission of this report, Cimarron believes that it is now appropriate to approve the Cimarron Decommissioning Plan.

TABLE A-1

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1201 - CIMARRON RIVER UP-STREAM SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
6/85	<10	<20	<0.2	<5	0.005			
6/86	<10	21	0.3	4	0.004			
6/87	<10	<20	0.4	<1	0.01			
6/88	11	<20	<1	<1	0.018			
6/89	<10	<20	0.12	0.67	0.006			
6/90	10	<20	<0.5	1.4	0.005	3.61	4.21	0.033
6/91	<10	<20	0.4	0.65				
6/92	<10	<20	<0.4	0.8	0.006			
6/93	<10	<20	<0.2	0.5	0.008			
6/94	<10	<20	3.8	0.1	<0.005			
6/95	3.2	12.1	0.1	0.11	0.001			
4/96	4	9	0.37	<0.05	0.0085	2.66	3.63	0.37
6/97	14.5	ND	0.4	5.3		2.5	5.5	0.1

TABLE A-2

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1202 - CIMARRON RIVER DOWN-STREAM SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
6/85	23	22	<0.2	<5	<0.002			
6/86	<10	<20	0.3	4	0.004			
6/87	14	<20	0.4	1.1	0.021			
6/88	14	<20	<1	<1	0.018			
6/89	<10	<20	<0.20	0.6	<0.005			
6/90	<10	<20	<0.5	<0.5	<0.005	2.2	4.47	0.094
6/91	<10	<20	<0.4	<0.5				
6/92	<10	<20	<0.4	0.8	0.007			
6/93	<10	<20	<0.2	0.5	0.008			
6/94	<10	<20	3.9	0.1	<0.005			
6/95	3.9	16.2	0.2	<0.05	0.005			
4/96	10	15	0.39	<0.05	0.0085	2.50	3.29	0.25
6/97	15.4	15.7	0.4	<0.05		3.1	4.1	0.1

TABLE A-3

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1204 - POND WEST RESERVOIR #1 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
6/85	22	<20	0.4	2	<0.002			
6/86	<10	<20	0.4	1	0.006			
6/87	<10	<20	0.3	2.4	<0.005			
6/88	23	<20	<1	1.7	0.029			
6/89	10	<20	0.33	1	<0.005			
6/90	10	<20	<0.5	0.55	<0.005	2.4	9.4	0.21
6/91	12	<20	<0.4	<0.5				
6/92	<10	<20	<0.4	1	<0.005			
6/93	<10	<20	<0.2	3.6	<0.005			
6/94	<10	<20	0.3	0.1	<0.005			
6/95	1.1	11.9	0.1	<0.05	0.002			
5/96	10.5	11	0.38	0.25	0.0097	2.53	9.26	0.45
6/97	11.8	12.7	0.5	0.2		0.5	1.6	ND

TABLE A-4

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1205 - RESERVOIR #2 EAST SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
6/85	16	<20	0.3	<0.2	<0.002			
6/86	<10	<20	0.3	<1	0.002			
6/87	<10	<20	0.3	2	<0.005			
6/88	<10	<20	<1	<1	<0.005			
6/89	<10	<20	0.34	0.94	<0.005			
6/90	<10	<20	<0.5	<0.5	<0.005	0.37	0.61	0.02
6/91	<10	<20	<0.4	<0.5				
6/92	<10	<20	<0.4	0.9	<0.005			
6/93	<10	<20	<0.2	<0.7	<0.005			
6/94	<10	<20	0.3	0.1	<0.005			
6/95	1.3	3.3	<0.1	<0.05	0.001			
4/96	1	3.6	0.29	<0.05	0.0011	0.54	0.79	0.099
6/97	8.9	8.9	0.3	3.4		0.2	0.5	ND

TABLE A-5

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1206 - SEEP/ SURFACE DRAINAGE SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
6/85	195	216	4	130	0.15				
6/86	130	199	3.4	21	0.11				
6/87	27	<20	1.4	5.7	0.039				
6/88	330	150	2.7	36	0.39				
6/89	190	52	2	80	0.13				
6/90	260	62	3.4	53	0.14	69.0	230.0	9.1	
6/91	195	76	4.1	87	0.17	61.77	162.6	7.13	
6/92	126	<20	2.7	3.7	0.093	30.16	126.65	5.03	
6/93	11	<20	1.9	0.5	<0.005	<5.9	<4.95	<2.6	
6/94	261	37	3.6	61	0.14	182	252	83.4	
6/95	59.6	28.1	2.5	35.9	0.063				
4/96	258	77.6	3.5	39	0.2	63.5	164.3	8.68	
12/96	96.2	55.2			0.053	27.6	76.6	2.2	
3/97	162.0	40.5		16.6	0.01	33.2	125	5.3	12.2
6/97	273.0	116.0	3.7	48.9	0.096	42.4	117	3.7	25.4
9/97	155	64.1	4.2	58.4		25.6	97.2	5.2	54.4
12/97	DRY	DRY	DRY	DRY		DRY	DRY	DRY	
3/98	89.3	30.5	3.6	16.7		64.5	115	9.6	

TABLE A-6

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1208 - SEEP NORTH U Pond #2 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
6/85	<10	<20	0.6	0.6	<0.002				
6/86	46	600	18	15	0.008				
6/87	<10	<20	0.8	2.6	0.005				
6/88	<10	<20	<1	<1	0.007				
6/89	<10	<20	<0.2	1.3	<0.005				
6/90	<10	<20	<0.5	6.8	<0.005	0.55	1.3	0.041	
6/91	41	106	9.5	64	0.007	2.97	14.52	0.67	
6/92	10	21	<0.4	6.7	<0.005	1.61	8.047	0.36	
6/93	296	30	3.4	49	0.2	77.1	217	9.2	
6/94	1016	2360	35	1650	<0.005	26.3	52.5	9.3	
6/95	ND	72.8	0.3	953	0.005				
4/96	50	2990	34	1000	0.033	13.3	33.8	1.85	
10/96	24.7	2590	32.5	1750	<.6				
12/96	288	3190			0.026	14	38.3	2.8	
3/97	88.5	2210		1244	0.035	11.7	37	1.8	3,960
6/97	103	3060	62.5	1440		3.5	8.3	0.6	2,800
9/97	169	2590	31.8	1040	0.025	8	24.7	1.3	3,040
12/97	88.1	2730	30.7	1250		12.6	35	0.4	2,080
3/98	19.6	1330	27.6	915		17.6	29	1.8	2,300

TABLE A-7

CIMARRON FACILITY - ENVIRONMENTAL SURFACE WATER

#1209 - RESERVOIR # WEST SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
6/85	<10	<20	8.1	43	<0.002			
6/86	<10	<20	0.4	2	0.002			
6/87	<10	<20	0.2	1	<0.005			
6/88	<10	<20	<1	<1	<0.005			
6/89	<10	<20	0.45	0.66	<0.005			
6/90	<10	<20	<0.5	<0.5	<0.005	0.11	0.45	0.038
6/91	<10	<20	<0.4	<0.5				
6/92	<10	<20	<0.4	0.7	<0.005			
6/93	<10	<20	<0.2	0.5	<0.005			
6/94	<10	<20	2.3	0.2				
6/95	ND	6.7	0.1	0.05	0.002			
4/96	1.6	2.5	0.31	<0.05	<.001	0.31	0.41	0.108
6/97	2.3	7.7	0.3	3.03		1.1	1.7	0.1

TABLE A-8
CIMARRON FACILITY - ENVIRONMENTAL GRONDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1311 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
6/85	10	31	<0.2	57	<0.002				
4/86	<10	<20	1.0	80	0.003				
6/86	<10	<20	0.4	87	0.003				
6/87	<10	<20	0.4	34	0.005				
6/88	<10	<20	<1	38	<0.005				
3/89	<10	23	<0.2	66		0.77	0.99	0.018	
6/89	10	<20	0.32	0.34	<0.005				
10/89	<10	<20	0.21	45	<0.005	1.01	1.37	0.029	
6/90	32	45	<0.5	69	<0.005	1.87	4.11	0.084	
6/91	<10	<20	<0.5	36					
6/92	32	49	<0.2	160	<0.005	1.65	4.02	0.1	
6/93	13	<20	0.3	69	<0.005	1.7	1.6	0.4	
6/94	<10	<20	0.6	20.5	<0.005	0.3	24.1	1.1	
6/95	5.3	7.8	0.3	17.9	<0.001	0.4	1.2	0.1	
4/96	5.8	5.1	0.48	15	0.0029	0.89	1.52	0.14	
12/96	ND	3.6			<.001	1.2	1	0.1	
3/97	4.4	16.4		78.4	<.001	0.9	1.3	0.1	18.1
6/97	13.3	18.3	0.5	55.3		2.1	3	0.4	

TABLE A-9
CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1312 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/l
6/85	2220	8272	83	<20	0.26				
4/86	340	11800	96	1560	0.25				
6/86	94	7300	59	1310	0.017				
6/87	41	65	18	620	0.045				
6/88	90	231	22	480	0.144				
3/89	59	2370	50	1020		15.3	41.6	1.23	
6/89	250	8000	54	1100	0.15				
10/89	64	6200	<0.2	980	0.076	22.7	75	1.7	
6/90	200	1320	<0.5	490	0.017	7.3	20.1	1.02	
6/91	953	2620	31	837	0.033	10.8	32.7	1.9	
6/92	840	1200	28	530	0.029	9.44	30.52	1.33	
6/93	116	176	<.2	320	0.012	10.7	30.2	3.3	
6/94	348	521	22	406	0.016	0.6	1.6	0	
6/95	82.6	1670	22.2	12	0.025	7.9	23.3	1.4	
4/96	37	2600	36	736*	0.028	9.26	27.8	1.33	
10/96						8.9	29.6	1.6	856
12/96	34.6	1940			0.01	5.8	20.8	1.20	
3/97	33.5	1550		723	0.02	5.8	18.5	0.7	3680
6/97	92.5	1230	20.6	527		6.0	18.7	0.9	1470
9/97	31.3	1610	21.4	435		5.7	17.2	0.8	2190
12/97	27.3	1800	24.4	604		5.5	13.0	0.2	1570
3/98	15.8	1400	20.5	521		10.0	21.0	1.1	1850

*Data from resample event.

TABLE A-10

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1313 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
6/85	453	1512	120	<5	0.070				
4/86	140	208	140	630	0.078				
6/86	230	3000	157	690	0.077				
6/87	84	25	120	450	0.078				
6/88	61	24	3.1	570	0.128				
3/89	260	2200	140	720		30	84	2.7	
6/89	345	6400	221	1100	0.510				
10/89	100	3100	<0.2	540	0.120	36.7	130	2.65	
6/90	840	5760	200	1100	0.190	64.3	287	6.3	
6/91	880	2004	135	734	0.110	35.8	115.8	5	
6/92	1510	1580	97	640	0.062	20.19	69.08	2.83	
6/93	647	791	89	410	0.032	17.7	45.7	2.9	
6/94	936	1240	100	497	0.046	2.7	21.5	0.8	
6/95	115	2960	108	509	0.048	15.2	46.8	2.8	
4/96	28.5	1202	87	280	0.023	8.88	24	1.71	
10/96						8.3	25.9	1.9	1410
6/97	65.8	768	78.5	366		10.0	31.0	1.0	1190
9/97	65.4	1280	86	1600		8.4	28.2	1.0	1560
12/97	26.7	955	88	341		7.1	21.1	0.1	874
3/98	30.6	614	82	194		10.3	27.7	1.3	562

TABLE A-11

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1314 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
7/85	<10	<20	0.4	2	<0.002			
6/86	<10	<20	1.5	9	0.002			
6/87	<10	<20	1.3	4.8	0.005			
6/88	<10	<20	1.8	12	0.007			
3/89	<10	<20	<0.2	0.36		0.31	0.77	0.039
6/89	21	<20	<1	1	0.016			
10/89	<10	<20	<0.2	2.1	<0.005	0.48	1.47	0.027
6/90	<10	<20	<0.5	1.8	<0.005	0.69	1.61	0.022
6/91	<10	<20	<0.5	2				
6/92	<10	<20	<0.4	2	<0.005			
6/93	<10	<20	<.2	2.4	<.005			
6/94	<10	<20	1.2	0.5	<0.005			
6/95	ND	5.6	0.20	1.86	0.002	0.6	1.6	0.1
4/96	0.7	1.6	0.31	1.8	<.001	0.56	1.24	0.012
6/97	2.9	1.8	0.4	9.48		0.6	1.3	0.1

TABLE A-12
CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1315 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
7/85	3125	189	<0.2	11	5.56			
6/86	5400	740	0.5	5	7			
6/87	3850	2450	0.6	6.7	4.9			
6/88	3800	989	<1	<2	4.83			
9/88	3560	240	<1	<10	4.07			
12/88	6760	390	0.52	6.7		2038	3517	87
3/89	6440	660	0.22	13		1550	3570	110
6/89	5680	1120	<1	30	0.66			
10/89	2600	2200	0.38	6.5	4.21	2180	3270	130
1/90	5420	195	1.8	0.36		2000	3720	165
3/90	7000	770	1.6	9.8	8.8	2860	4990	230
6/90	6000	1300	1.2	6.1	5.81	2680	4090	162
9/90	1710	560	<0.5	4.5	2.05	970	1370	46
12/90	2500	300			2.56	1100	1870	51
6/91	2460	229	0.57	4	2.87	944.6	1243.6	69.6
6/92	2590	273	0.4	6.3	2.8	921.18	1386.56	69.91
6/93	2970	250	0.6	7.3	2.86	1240	2000	71.3
12/93	1440	115	0.5	3.8	1.27	550	790	38.7
3/94	2190	427			2.87	969	1490	65.38
4/94	1340	167			1.96	788	1190	70.7
5/94	2470	337			2.96	903	1250	170
6/94	1710	148	1	<0.1	1.3	609	853	77.8
7/94					1.75	476	750	74.9
8/94					1.54	614	898	55.7
9/94					1.43	526	842	43.1
10/94					1.4			
11/94						399	457	118
12/94					1.41			
1/95					1.49	676	950	51.7
2/95	2530	232			2.66	1050	1490	85.1
3/95	1540	126			1.99	545	811	52.9
4/95	1650	673			2.77	987	1620	75.5
5/95	1400	611			2.66	981	1640	143
6/95	1340	438	0.50	4.84	2.46	857	1340	56.4
7/95	2510	226			2.78	813	1260	70.7
8/95	806	274			1.36	505	753	40.4
9/95	484	105			1.04	292	420	22.2
10/95	1680	105			2	534	763	45.4
11/95	939	266			2.26	640	941	51.1
12/95	2450	258			2.79	792	1230	61.1
1/96	2320	407			3.2	741	1180	46.6
2/96	1970	362			2.85	1020	1460	173
3/96	2950	286			2.53	838	1540	86.5
4/96	2600	474	0.6	7.8	1.9	999	1710	87
5/96	3520	319			3.1	593	996	52.9
6/96	1940	184			1.76	578	807	45.4
7/96	1660	119			1.6	482	712	42.7
8/96	846	72.4			1.42	392	595	54
9/96	1180	96.8			1.06	434	682	23.5
10/96	685	112			0.9	254	375	30.4
11/96	1760	159			1.9	868	1280	57.5
12/96	1880	229			1.87	655	1070	43.8
3/97	3700	477			3.1	819	1410	76
6/97	3440	639	0.6	10.3		1200	1770	74.2
9/97	1080	145	0.7	8.32		374	546	24.9
12/97	1040	321	0.6	7.75		563	694	19.4
3/98	2100	755	0.5	19.7		855	1320	25

TABLE A-13

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1316 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
7/85	200	<20	<0.2	11	0.19			
6/86	608	140	0.8	4	1.6			
6/87	420	300	0.6	4.6	0.54			
6/88	378	116	<1	12	0.3			
3/89	331	100	<0.20	16		67	210	10
6/89	820	160	<1	57	0.73			
10/89	320	200	0.14	12	0.539	236	590	11.6
6/90	680	77	<0.5	9.2	0.57	215	547	22
6/91	2030	138	0.52	17	1.7	556.1	1262	62.4
6/92	776	85	0.4	5.9	0.68	222.62	505.1	23.79
6/93	473	37	0.5	7.7	0.35	164	388	23.4
12/93	474	43.3	0.6	1.1	0.37	50.7	111	5.6
3/94	163	28.6			0.23	96.5	174	4
4/94	89.7	23.1			0.21	63.1	143	6.1
5/94	232	57.8			0.27	71.8	155	13.4
6/94	233	<20	1.1	<0.1	0.18	84	166	14.6
7/94					0.18	40.5	93.7	5
8/94					0.14	37	89.2	3.2
9/94					0.07	20.1	48.2	2.1
10/94					0.07			
11/94						64.8	79.3	25.8
12/94					0.10			
1/95					0.17	64.8	152	6.8
2/95	132	22.5			0.16	70.2	154.0	8.6
3/95	290	16.4			0.45	133	293.0	17.2
4/95	92	63.7			0.2	71.6	168.0	10.5
5/95	120	51.2			0.187	58.7	137	13.5
6/95	290	46.4			0.267	67.2	153	5.9
7/95	204	25.4			0.28	89	186	12.3
8/95	146	62.1			0.146	48.2	107	4.5
9/95	135	39.4			0.288	73.5	157	6.1
10/95	154	18.2			0.16	47.4	108	3.5
11/95	73.6	25			0.151	43.4	100	4.6
12/95	116	60.8			0.164	40.3	94.1	4.7
1/96	165	20.5			0.137	48	106	12.7
2/96	131	40.2			0.158	67.6	166	29.1
3/96	61.8	15.6			0.109	24.5	73.9	7.9
4/96	85	15.5	0.52	6.2	0.082	29.8	70.8	4.1
5/96	102	21.8			0.087	36.7	73.1	9.4
6/96	86	17.6			0.063	28.8	65	2.7
7/96	74.2	28.9			0.052	19.4	40.9	2.3
8/96	47.4	18			0.042	19	37.3	1.5
9/96	49.4	11.3			0.087	18.8	51.7	4.8
10/96	72.7	19.9			0.051	24.5	47.8	7.4
11/96	103.0	17.1			0.101	33.5	73.8	3.5
12/96	169.0	29.2			0.105	33.7	85.1	3.1
3/97	172.0	22.0			0.110	33.4	73.9	3.7
6/97	190.0	18.3	0.6	9.9		59.5	136.0	5.0
9/97	90.5	3.3	0.5	12.2		24.2	53.5	2.4
12/97	50.4	4.7	0.6	8.0		21.6	48.2	1.5
3/98	55.0	11.2	0.4	6.9		40.7	65.6	3.1

TABLE A-14

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1317 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
7/85	20	27	<0.2	25	<0.002			
6/86	<10	21	0.4	8	0.02			
6/87	13	<20	0.3	2.2	0.01			
6/88	105	<20	<1	<1	0.128			
12/88	165	29	0.1	0.4		22.8	38.6	1.7
3/89	66	26	<0.20	0.38		8.1	15	0.58
6/89	49	<20	<1	2	0.070			
10/89	68	<20	<0.2	0.27	0.083	32.2	49.7	1.88
1/90	84	<20	1.1	7.2		34.9	57.4	1.94
3/90	92	<20	2.5	7.9	0.088	34.6	52.7	1.87
6/90	440	91	<0.5	0.71	0.31	160	326	12.9
9/90	260	39	<0.5	1.1	0.24	118	193	11
12/90	160	29			0.21	82.9	127	4.85
6/91	171	<20	<.5	<.5	0.2	65.8	99	5.1
6/92	311	41	0.4	1.1	0.33	108.5	163.4	8.57
6/93	286	37	0.2	0.5	0.26	100	170	3.8
6/94	56	20	1	<0.1	0.046	11.3	18.2	1.2
6/95	141	62	0.10	0.10	0.228	76.4	131.0	8.0
5/96	156	87	0.24	0.11	0.12	67.0	109.8	7.3
6/97	328	98.7	0.3	2		150	247	11.7
3/98	27.8	14.5	0.2	1.68		20.4	39.5	2.8

TABLE A-15

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1320 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
3/89	<10	<20	0.42	20		3.1	5.58	0.17	
6/89	12	<20	0.55	18	<0.005				
10/89	10	<20	0.49	15	0.005	1.3	2.99	0.045	
6/90	<10	<20	<0.5	16	<0.005	0.85	1.48	0.27	
6/91	10	<20	0.5	17					
6/92	14	<20	0.7	21	<0.005				
6/93	14	24	<.2	25	<.005	0.80	1.4	0.1	
6/94	19	<20	0.9	27	<0.005	10.7	20.8	0.6	
6/95	12.7	59.6	0.70	32.8	0.002	0.4	1.1	0.1	
4/96	3.9*	20.9*	0.66	21	0.002	0.81	1.48	0.146	
6/97	11.6	30.3	0.8	26.1		1	1.2	ND	34.0

* Data from Resample Event

TABLE A-16

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1321 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	18	26	<0.2	9.1		2.75	8.1	0.12
6/89	14	<20	<0.2	3.0	0.015			
10/89	18	<20	<0.2	1.6	<0.005	6.8	15	0.2
6/90	16	<20	<0.5	1.6	0.015	7.4	16	0.29
6/91	22	<20	<0.5	<0.5	0.021	6.9	14.3	0.3
6/92	20	<20	<0.2	1.0	0.016	5.28	12.88	0.31
6/93	21	<20	0.4	1.3	0.012	6.4	14.5	0.3
6/94	16	<20	2	0.9	0.007	3.7	6.6	0.22
6/95	38.9	17.8	0.20	0.89	0.015	5.2	11.6	0.4
4/96	14.2	7.8	0.30	0.59	0.015	4.87	11.76	0.59
6/97	30.7	ND	0.40	1.81		5.3	11.1	0.2

TABLE A-17

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1322 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	15	<20	<0.2	9.2		3.9	8.2	0.13
6/89	17	<20	0.29	7.5	0.009			
10/89	16	<20	<0.2	6.0	0.010	5.19	11.5	0.31
6/90	11	<20	<0.5	5.9	0.010	3.5	8.7	0.26
6/91	26	<20	<1	8.4	0.018	6.98	22.11	0.47
6/92	16	<20	0.4	4.7	0.010	3.29	7.43	0.26
6/93	22	<20	0.2	3.9	0.006	1.9	12.9	5.6
6/94	16	<20	0.9	4.8	0.006	3.4	6.3	0.4
6/95	40.4	37.6	0.40	21	0.009	3.1	6.2	0.4
5/96	5.7	10.7	0.42	5.2	0.011	3.5	6.14	0.53
6/97	34.4	16.5	0.3	6.3		3.8	7.5	0.1

TABLE A-18

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1323 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	51	<20	<0.20	1.7		9.8	17	0.42
6/89	37	<20	<0.2	1.6	0.028			
10/89	31	<20	<0.2	1.1	<0.005	13.1	27.1	0.45
6/90	38	<20	<0.5	1.9	0.034	10.8	26.7	0.22
6/91	172	44	<0.4	1.2	0.035	11.6	23.8	0.53
6/92	32	<20	<0.2	2.1	0.033	10.91	22.47	0.51
6/93	32	<20	<.2	1.7	0.021	12.6	22.1	1.3
6/94	42	<20	2.2	1	0.014	0.7	0.8	0
6/95	80.9	34.1	0.20	1.72	0.033	8.7	18.4	0.7
5/96	34	0	0.27	1.2	0.038	11.8	22.6	0.96
6/97	25.9	16	0.2	1.72		9.7	20	0.6

TABLE A-19

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1324 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	<10	<20	0.26	18		0.2	0.44	0.022
6/89	<10	<20	1.3	18	<0.005			
10/89	<10	<20	0.29	17	<0.005	0.54	1.07	0.022
6/90	<10	<20	<0.5	22	<0.005	0.62	1.15	0.048
6/91	<10	<20	<1	18				
6/92	10	<20	0.4	14	<.005			
6/93	<10	<20	0.3	14	<.005			
6/94	<10	<20	0.9	9.9	<0.005			
6/95	6.0	9.3	0.50	11.9	0.002	0.5	1.3	0.1
4/96	1.3	2.8	0.63	6.1	0.0013	0.43	0.81	0.157
6/97	3.7	12.4	0.7	11.2		0.4	0.9	ND

TABLE A-20

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1325 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	<10	<20	0.35	13		1	1.49	0.046
6/89	<10	<20	<1	51	0.006			
10/89	<10	<20	0.46	13	<0.005	0.82	1.63	0.028
6/90	<10	24	<0.5	13	<0.005	0.64	1.75	0.094
6/91	<10	<20	0.5	14				
6/92	<10	<20	0.4	14.4	<0.005			
6/93	<10	<20	0.3	14	<0.005			
6/94	<10	<20	0.8	14.7	<0.005			
6/95	5.3	6.3	0.50	14.7	0.001	3.4	10.3	0.6
4/96	1.7	5.1	0.64	9.3	0.0012	0.49	1.08	0.096
6/97	3.1	ND	0.7	17.8		0.3	0.9	0.01

TABLE B-21

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1326 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
3/89	14	25	<0.20	14		1.48	4.43	0.058	
6/89	175	9640	1.2	21	0.014				
10/89	16	<20	<0.2	16	<0.005	2.25	5.2	0.11	
6/90	16	21	<0.5	17	0.007	2.3	5.8	0.79	
6/91	14	<20	<1	10					
6/92	17	20	0.3	15	0.006	1.98	0.74	0.09	
6/93	16	<20	<.2	14	<.005	2.6	5.1	0	
6/94	19	<20	0.5	14.5	<0.005	6.3	14.3	0.6	
6/95	62.9	56.9	0.30	300	0.006	1.4	3.6	0.2	
4/96	96	457	0.39	5.5	0.0053	2.41	5.15	0.45	
10/96						1.5	2.8	0.2	8.6
12/96	3.8	26.7			0.003	2.4	3.7	0.2	
3/97	19.5	30		25.2	0.004	1.6	5.0	0.7	21.9
6/97	24.8	28.1	0.2	16.6		2.2	4.8	0.1	13.1
9/97	12.5	17.8	0.4	17.8	0.006	1.1	4	0.1	41.3
12/97	5.9	10.8	0.4	19.4		1.7	2.9	0.1	

TABLE A-22

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1327 B SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	<10	<20	0.2	8.2		1.52	2.8	0.14
6/89	<10	<20	0.36	6.6	<0.005			
10/89	<10	<20	<0.2	8.3	0.007	4.18	6.8	0.069
6/90	<10	<20	<0.5	7.2	<0.005	1.43	2	0.29
6/91	<10	<20	<0.5	7.5				
6/92	<10	<20	0.5	10	<0.005			
6/93	11	<20	10	10	0.006			
6/94	<10	<20	0.8	7.9	<0.005			
6/95	5.2	1.4	0.40	8.20	0.004	1.8	2.3	ND
5/96	1.6	2.9	0.48	5.8	0.0046	1.53	3.24	0.165
6/97	4.7	5.3	0.3	8.19		1.2	3.1	ND

TABLE A-23

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1328 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	29	<20	<0.2	2.2		9	18	0.66
6/89	23	20	<0.2	2	0.03			
10/89	30	<20	<0.2	1.8	0.04	15.1	28.2	0.37
6/90	35	<20	<0.5	2.1	0.033	14	25	0.41
6/91	38	<20	<0.4	1.7	0.034	11.2	21	0.51
6/92	31	<20	0.4	1.9	0.032	10.58	21.79	0.49
6/93	31	<20	<.2	2	<.005	11.3	18.9	1.8
6/94	28	<20	3	0.4	0.02	11.1	21.5	0.8
6/95	31.1	17.9	0.20	1.86	0.034	10.2	19.6	1.3
4/96	17	16	0.23	1.3	0.037	11.59	23.1	0.77
6/97	76.9	6.5	0.1	1.8		10.5	20.7	0.5

TABLE A-24

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1329 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	12	<20	<0.20	0.4		2.04	5.3	0.093
6/89	<10	<20	0.32	3.8	0.006			
10/89	<10	<20	0.29	3.5	<0.005	2.54	6.11	0.099
6/90	70	<20	<0.5	3.5	0.08	33.9	47.3	3.1
1/91	<10	<20	<0.4	4.5				
6/92	<10	<20	<0.4	3.9	0.006			
6/93	<10	<20	0.2	4.1	<.005			
6/94	<10	<20	4.3	0.7	<0.005			
6/95	5.2	16.8	0.30	6.22	0.005	1.6	2.9	0.1
4/96	26*	9.5*	0.43	5.7	0.0065	2.22	4.25	0.223
6/97	16.7	5.4	0.2	12.6		2	4.5	0.2

*Data from Resample Event

TABLE A-25

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1330 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	16	62	<0.2	172		2.4	5.17	0.1
6/89	19	25	<0.20	130	0.007			
10/89	<10	55	<0.2	110	0.007	3.6	8.5	0.26
6/90	18	<20	<0.5	77	0.009	2.99	9.2	0.38
6/91	<10	<20	0.91	77				
6/92	22	21	<.4	68	0.01	3.28	7.43	.33
6/93	27	<20	0.5	<.5	<.005	2.4	7.3	0.3
6/94	18	<20	1	55	0.006	3.8	9	0.9
6/95	8.8	23.4	0.40	44	0.007	2.9	9.5	0.6
5/96	4	15.8	0.59	35	0.0093	3.29	8.19	0.61
6/97	19.1	25.2	0.5	42.3		2.8	7.4	0.2

TABLE A-26

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1331 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	190	23	<0.2	5.7		35	126	3.7
6/89	280	39	0.29	14	0.114			
10/89	167	62	<0.2	11	0.12	63	309	0.85
6/90	330	25	<0.5	8.6	0.17	54	324	10.5
6/91	347	20	<0.5	14	0.17	72.1	120.98	4.56
6/92	289	<20	<0.4	10.3	0.13	41.85	193.13	9
6/93	135	<20	0.2	9.3	0.036	38.5	118	9.3
6/94	198	<20	1.1	22.6	0.09	40.5	139	25.1
6/95	250	40.8	0.30	17.00	0.103	38.7	168	10.8
5/96	111	23	0.47	17	0.071	23.9	100.2	5.23
6/97	202	29.9	0.5	18.0		25.0	127.0	4.7
9/97	200	13.4	0.6	26.0		31.0	137.0	6.7
12/97	134	19.5	0.6	32.3		25.5	116.0	4.5
3/98	131	25.1	0.6	22.2		31.5	110.0	3.2

TABLE A-27

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1332 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	23	<20	1.3	3.4		6.4	13.9	0.12
6/89	15	<20	<0.2	2	0.023			
10/89	17	<20	<0.2	0.39	0.031	13.1	25.3	0.042
6/90	32	<20	<0.5	1.5	0.03	13	23	0.33
6/91	31	<20	<0.4	2.5	0.032	10.6	19.8	0.48
6/92	30	<20	<0.4	1.2	0.03	9.92	20.43	0.46
6/93	35	<20	<.2	1.6	0.026	12.9	19.7	0.7
6/94	39	<20	4.5	0.3	0.008	12.7	21.4	1.5
6/95	77	55.7	0.30	1.50	0.035	10.1	19.2	0.8
4/96	18.9	9.1	0.87	5	0.012	4.42	12.27	0.88
6/97	107	53.7	0.2	<.05		9.3	18.9	0.3

TABLE A-28

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1333 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	47	<20	<0.20	6.3		6.2	18	0.71
6/89	26	<20	0.39	3.4	0.018			
10/89	12	<20	<0.2	2.8	0.002	9.54	26.6	0.91
6/90	32	<20	<0.5	3.5	0.025	9.2	26	0.61
6/91	20	<20	<0.5	2.1	0.033	5.91	14.55	0.02
6/92	25	<20	<0.4	1.5	0.016	5.25	10.89	0.49
6/93	28	<20	0.5	1.6	0.016	8.2	21.6	1.6
6/94	20	<20	1.3	1.5	0.01	2.8	9.7	0.2
6/95	53.4	47.9	0.60	4.00	0.013	0.5	1.7	0.2
4/96	17	17		1.2	0.037	11.77	20.6	1.06
6/97	37.4	28.9	0.5	5.5		3.8	9.1	0.3

TABLE A-29

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1334 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	30	<20	0.26	6.1		5	13.2	0.23
6/89	25	<20	0.44	3.9	0.016			
10/89	<10	<20	<0.2	1.4	0.005	23.2	35.4	1
6/90	43	<20	<0.5	1.9	0.044	23.6	37	1.46
6/91	22	<20	<0.5	1.5	0.025	7.0	14.3	0.2
6/92	12	<20	0.42	1.5	0.01	3.28	7.43	0.3
6/93	11	<20	0.5	1.1	<0.005			
6/94	15	<20	0.3	2	<0.005	1.4	3.7	0.2
6/95	46.5	15.3	0.40	2.99	0.027	6.6	10.7	0.4
5/96	13.2	7.4	0.56	2	0.021	6.82	11.1	0.81
6/97	14.8	4.9	0.6	2.8		3.2	7.4	0.3

TABLE A-30

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1335 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
3/89	<10	<20	0.24	22		1.25	1.64	0.1
6/89	<10	<20	0.41	22	<0.005			
10/89	<10	<20	0.26	22	<0.005	1.52	2.14	0.023
6/90	<10	<20	<0.5	23	<0.005	0.74	1.22	0.022
6/91	<10	<20	<0.5	23				
6/92	<10	<20	<0.4	20	<0.005			
6/93	<10	<20	0.3	0.3	<0.005			
6/94	<10	<20	0.9	20	<0.005			
6/95	ND	2.5	0.30	17.91	0.001	0.3	0.6	ND
4/96	1.6	0.2	0.58	14	0.0017	0.62	1.03	0.069
10/96 (1335A)	5	7		8.7	<.001	0.5	0.7	0.1
6/97	17.9	11.7	0.6	8.8		0.7	1.6	ND

TABLE A-31

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1336 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
3/89	140	4970	17	1260		23	76	2.4	
6/89	170	11000	<1	860	0.015				
10/89	28	8300	<0.2	1600	0.02	5.83	19.6	0.3	
6/90	980	5300	55	1600	0.077	32.2	99	3.4	
6/91	1010	2082	28	980	0.062	17.8	73.57	2.61	
WELL NO. 1336 OUT OF SERVICE AFTER 1991 - REPLACED WITH 1336A 6/94									
WELL NO. 1336A									
6/94	682	1100	36	673	0.014	5.7	17.3	1.1	
1/95	38.1	1140			0.016	5.8	19.3	1.0	
2/95	31	948			0.011	6.9	19.1	1.4	
3/95	37	1060			0.026	5.9	18.1	0.7	
4/95	53.4	1740			0.017	7.8	22.2	0.8	
5/95	18.5	1980			0.024	6.7	19	2.1	
6/95	67.6	2150	33.70	ND	0.023	7.3	24.3	1.1	
7/95	80.3	1500			0.028	7.1	20.8	0.8	
8/95	93	2090			0.022	6.1	23.6	1.3	
9/95	40.1	937			0.019	4.5	14.9	0.8	
10/95	50.8	1490			0.025	8.2	23.7	0.8	
11/95	26.7	1340			0.029	7.6	21.7	1.0	
12/95	32.3	1630			0.026	7.3	20.0	1.2	
1/96	43.1	1700			0.020	12.6	24.2	6.6	
2/96	21.0	1290			0.022	21.8	74.1	15.8	
3/96	41.6	1170			0.032	23.4	47.3	ND	
4/96	39	1398	32	400	0.024	8.6	25.3	1.09	
5/96	93.1	1210			0.022	13.1	22.8	3.3	
6/96	54.1	1330			0.023	9.4	26.8	1	
7/96	91.5	1060			0.034	11.7	31.8	3.6	
8/96	88.7	1520			0.034	32.7	47.3	17.1	
9/96	158	1470			0.027	12.1	36.2	2	
10/96	117	1730			0.029	13.1	30.7	5.2	
11/96	39.8	1400			0.026	8.3	27.9	1.3	
12/96	69.9	1340			0.021	7.1	24.6	1.2	
3/97	46.6	1520		786	0.028	15	37.5	8.1	2590
6/97	61.4	1430	35.2	766		9.1	23.2	1.1	1930
9/97	54.9	1390	31.5	589	0.027	7.2	23.6	1.8	1880
12/97	109	2200	37.5	725		8.1	22.9	0.8	1200
3/98	27.2	1400	34.3	667		12.3	28.7	3.1	1600

TABLE A-32

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1337 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
2/97	39.3	343.0	10.8	86.7	<.05	5.0	13.3	0.5
6/97	17.0	143.0	7.6	51.9		3.1	8.0	0.6

TABLE A-33

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1338 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
2/97	44.6	130.0	1.3	24.4	0.09	1.0	2.8	0.1
6/97	10.1	102	0.8	33.1		0.4	0.7	0.1

TABLE A-34

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1339 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
2/97	40.3	9.8	0.5	<.05	0.1	3.7	11.0	0.2

TABLE A-35

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1340 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
2/97	53.1	430.0	14.1	213	0.12	0.9	3.4	0.1
6/97	7.8	144.0	23.7	127		1.0	2.7	0.2
9/97	10.0	98.6	35.7	109				

TABLE A-36

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1341 SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L
2/97	10.9	117.0	5.0	28.6	0.16	1.3	1.8	ND
6/97	30.0	620.0	0.3	230		0.6	1.5	0.1
9/97	1.1	194.0	0.7	73.2				

TABLE A-37

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO.1342 (West) SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
10/97	20.2	21.0	0.6	0.15		1.7	3.7	0.3	11.4
12/97	14.3	1.2	0.3	1.12		3.1	4.9	0.3	
3/98	1.1	9.5	0.3	0.95		2.5	3.7	0.3	

TABLE A-38

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1343 (Middle) SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	Tc-99 pCi/L
10/97	82.6	46.5	0.5	19.2		13.8	20.9	0.9	12.5
12/97	25.2	7.9	0.5	32.2		9.5	14.0	1.0	
3/98	9.8	10.4	0.4	7.99		7.6	10.5	0.6	

TABLE A-39

CIMARRON FACILITY - ENVIRONMENTAL GROUNDWATER SAMPLE RESULTS

ENVIRONMENTAL WELL NO. 1344 (East) SAMPLE DATE	GROSS ALPHA pCi/L	GROSS BETA pCi/L	F mg/L	NO3 (N) mg/L	U mg/L	238 U pCi/L	234 U pCi/L	235 U pCi/L	235 U pCi/L
10/97	24.4	17.5	0.3	0.58		3.5	5.0	0.1	9.0
12/97	4.1	10.0	0.5	0.36		1.0	1.7	0.2	
3/98	0.3	6.9	0.4	1.1		1.9	2.5	0.1	