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ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT

Remedial Investigation Report for High Priority Sites

(881 Hillside Area)

Volume IV

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

1 MARCH 1988

Section 6.0

6.0 SURFACE WATER

6.1 SURFACE WATER

Woman Creek is an eastward flowing ephemeral stream located to the south of the 881 Hillside (Plate 6-1). The stream drains the southern portion of the Rocky Flats Plant site. The South Interceptor Ditch, located between the 881 Hillside and Woman Creek, extends from the old landfill to Pond C-2 in the Woman Creek drainage. The ditch isolates runoff from the south side of the plant (including the 881 Hillside) from Woman Creek. Surface water flowing in an easterly direction along the south Interceptor Ditch is collected in Pond C-2, from which it is discharged to Woman Creek in accordance with the Plant NPDES permit. The permitted discharge point is designated 007. Pond C-1 receives flow from Woman Creek. A diversion structure located upstream of Pond C-2, diverts flow in Woman Creek around Pond C-2 and into the Woman Creek channel downstream. Along Woman Creek and the south Interceptor Ditch, retention ponds C-1 and C-2, and the associated diversion structures, control surface water discharge from the Plant site.

Analytical results of surface water samples collected at stations along the South Interceptor Ditch, Woman Creek, and seeps, drainages and ponds along the 881 Hillside are discussed in this section of the report. In addition, the effect of the discharge from the Building 881 foundation drain on the water quality in the South Interceptor Ditch is discussed. A summary of surface water flow rates measured in Woman Creek and the South Interceptor Ditch follows.

6.1.1 Surface Water Flow

During August 1986, as part of the initial site characterization, flow rates were measured in all of the site natural drainages and ditches using a portable cut-throat flume and the Parshall flumes used for NPDES monitoring. The results of flow rate measurements for the South Interceptor Ditch and Woman Creek are discussed below. Flow rates were not measured during May 1987 surface water sampling.

Flow in the South Interceptor Ditch and Woman Creek is intermittent in nature, appearing and disappearing along various reaches of the drainages. During the 1986 initial site characterization, measurable flow occurred at less than one-third of the fifteen stations along Woman Creek and the south Interceptor Ditch (Rockwell International, 1986a). All recorded flows were less than 10 gpm (Table 6-1). During the investigations, there was no surface water flow in Woman Creek downstream of Pond C-2. The intermittent surface water flow observed in Woman Creek and the South Interceptor Ditch is indicative of frequent interaction of surface water with the shallow ground-water system. Insufficient data have been collected to calculate a water balance or to quantify the effect of the interaction between surface and shallow ground-water systems.

Of the six surface water stations established along the South Interceptor Ditch, only SW-31, near the 881 Hillside, had measurable flow rates (5.5 gpm) in August 1986. Stagnant water was encountered at SW-36, but flow was not measurable. The ditch was dry both upstream and downstream of these stations.

Along Woman Creek in August 1986, flow was measured at 2.2 gpm at the most upstream station, SW-42. There was no flow at Station SW-40, downstream of SW-42.

TABLE 6-1

SURFACE WATER FLOW RATES
AUGUST 1986

Station Number	Measurement Date	Flow Rate (cfs)	Flow Rate (gpm)
Woman Creek			
SW-42	8-07-86	0.0049	2.2
SW-41	8-20-86	0.0000	0.0
SW-40	8-20-86	0.0000	0.0
SW-39	8-20-86	0.0000	0.0
SW-34	8-20-86	0.0147	6.6
SW-33	8-21-86	0.0000	0.0
SW-32	8-20-86	0.0172	7.7
SW-29	8-20-86	0.0000	0.0
SW-28	8-21-86	0.0044	2.2
SW-26	8-19-86	0.0000	0.0
SW-02	8-20-86	0.0000	0.0
South Interceptor Ditch			
SW-38	8-20-86	0.0000	0.0
SW-36	8-20-86	0.0000	0.0
SW-35	8-20-86	0.0000	0.0
SW-31	8-20-86	0.0123	5.5
SW-30	8-20-86	0.0000	0.0

Note: Data are presented in downstream order.

At surface water Station SW-32 located downstream of the confluence of a small tributary of Woman Creek and Woman Creek itself, a flow rate of 7.7 gpm was measured. Upstream of SW-32 in Woman Creek, no flow was measurable. Upstream of SW-32 in the small tributary, a flow rate of 6.6 gpm was measured at SW-34. Therefore, the flow rate at SW-32 can be attributed to the flow from the small tributary to Woman Creek. Woman Creek was dry immediately below Pond C-1, was flowing at 2.2 gpm just upstream of the Woman Creek diversion around Pond C-2, and was dry just downstream of the diversion return to the stream channel.

6.2 SURFACE WATER CHEMISTRY

The surface water quality data collected to date include samples collected in August 1986, and May, July/August, and November 1987 (Table 6-2). The analytical data for the surface water samples are presented in Tables 6-3 through 6-6. All surface water sampling stations are depicted on Plate 6-1.

6.2.1 Background Surface Water Chemistry

Surface water chemistry within a single drainage is naturally variable. One of the factors affecting variability is the interaction of surface water and ground water. Therefore, to facilitate discussion of surface water chemistry, particularly inorganic chemistry and radionuclide concentrations, reference will be made to Table 6-7 which shows ranges of analyte concentrations in ground water in upgradient alluvial wells at the Plant. In addition, Table 6-8 lists the estimated background surface water chemistry at the Plant.

Surface water analyte concentration ranges are based on data collected during the 1986 initial site characterization for stations SW-42 and SW-05 on Woman Creek

TABLE 6-3

VOLATILE ORGANIC CONCENTRATIONS IN SURFACE WATER (ug/l)

Station	Date	1,1-DCE	t,1,2-DCE	$CHCL_3$	1,2-DCA	1,1,1-TCA	CCl_4	TCE	1,1,2-TCA	Toluene	PCE
Interceptor Ditch											
SW-37	8/86	NA*	<5	NA	NA	NA	NA	NA	NA	<5	<5
SW-38	8/86	dry									
SW-36	8/86	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-35	5/87	<4	<4	<4	<4	6	<4	<4	<4	NA	<4
SW-35	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-35	11/87	<5	<5	<5	<5	<5	6	<5	<5	12	<5
SW-31	8/86	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-31	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-31	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-30	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-30	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-30	11/87	<5	<5	<5	<5	7	<5	<5	<5	12	<5
SW-27	8/86	<5	<5	<5	<5	<5	<5	<5	<5	<5	10
SW-C2	8/86	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Woman Creek											
SW-41	7-8/87	<5	<4	<5	<5	<5	<5	<5	<5	NA	10
SW-41	11/87	<5	<5	<5	<5	<5	6	8	<5	12	<5
SW-40	7-8/87	<5	<4	<5	<5	<5	<5	<5	<5	NA	<5
SW-34	8/86	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-32	8/86	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-32	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-32	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-32	11/87	<5	<5	<5	<5	<5	6	26	<5	12	<5
SW-C1	8/86	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
SW-29	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-29	11/87	<5	<5	<5	<5	<5	7	42	<5	11	<5
SW-28	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
SW-62	7-8/87	<5	<5	<5	<5	<5	<5	<5	<5	NA	<5
881 Hillside											
SW-45	5/87	<4	<4	<4	<4	<4	<4	14	<4	NA	128
SW-45	11/87	<5	<5	<5	<5	<5	6	8	<5	12	16
SW-46	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-44	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4
SW-881HS	5/87	<4	<4	<4	<4	<4	<4	<4	<4	NA	<4

*NA = Not Analyzed

TABLE 6-4

RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER (pCi/l)

Station	Date	Gross Alpha	Gross Beta	Pu	Am	$U^{233+234}$	U^{238}	H^3	Sr^{90}	Cs^{137}
SW Background****		NA	NA	-0.02(0.04)-0.01(0.06)	0.02(0.03)-0.06(0.04)	0.13(0.09)-0.38(0.14)*	0.06(0.06)-0.12(0.08)	20(220)-80(220)	NA**	NA
Interceptor Ditch										
SW-36	8/86	24(8)*	17(4)	-0.04(0.07)	0.04(0.04)	3.9 (0.5)	17 (1)	90(240)	NA	NA
SW-35	5/87	20(10)	11(11)	0.16(0.69)	0.0 (1.2)	3.5 (1.1)	0.49(0.48)	<110	2.95	0.8
SW-31	8/86	17(7)	15(4)	-0.01(0.28)	-0.02(0.06)	3.1 (0.4)	10 (1)	80(240)	NA	NA
SW-31	5/87	77(24)	59(2)	0.39(0.84)	0.0 (1.3)	5.5 (1.3)	14 (2)	<110	3.43	<0.3
SW-30	5/87	18(14)	13(14)	0.04(0.68)	0.0 (1.9)	2.5 (1.2)	13 (2)	<110	2.03	<0.3
SW-27	8/86	33(12)	37(0.7)	0.10(0.20)	0.10(12)	4.1 (0.7)	6.1 (0.9)	-30(210)	NA	NA
SW-27	7/87	10(0)	61(3)	0.0 (1.0)	0.0 (1.6)	0.79(0.92)	5.8 (1.7)	<110	<1.0	<1.0
SW-64	7/87	34(7)	93(16)	0.1 (1.2)	0.01(1.3)	6.39(1.6)	4.9 (1.3)	<110	1.5	<1.0
Woman Creek										
SW-34	8/86	2(2)	1(2)	0.02(0.06)	-0.01(0.05)	-0.06(0.16)	-0.05(0.32)	100(210)	NA	NA
SW-33	8/86	0(1)	0(2)	-0.04(0.09)	-0.01(0.03)	-0.03(0.17)	-0.20(0.28)	70(210)	NA	NA
SW-32	8/86	4(3)	18(3)	0.23(0.87)	0.01(0.03)	0.03(0.13)	0.04(0.11)	50(220)	NA	NA
SW-32	5/87	8(4)	10(5)	0.26(0.82)	0.0 (1.2)	2.9 (1.9)	1.2 (1.3)	<110	3.15	<0.3
SW-29	5/87	0(0)	33(11)	0.0 (0.74)	0.0 (1.3)	0.62(0.94)	1.1 (1.0)	<110	1.80	0.3
SW-28	8/86	6(4)	4(3)	-0.04(0.08)	0.0 (0.04)	1.2 (0.3)	0.87(0.27)	90(210)	NA	NA
SW-28	7/87	2(17)	80(19)	0.1 (1.2)	0.0 (4.1)	0.13(0.79)	1.6 (1.3)	<110	1.4	<1.0
SW-62	7/87	100(20)	100(13)	1.3 (0.9)	0.0 (1.3)	3.2 (2.9)	5.1 (3.0)	<110	<1.0	1.9
881 Hillside										
SW-45	5/87	13(18)	14(31)	0.0 (0.55)	0.0 (1.2)	5.5 (1.9)	4.7 (1.7)	<110	1.78	<0.3
SW-46	5/87	9(6)	-5(7)	0.29(0.73)	0.0 (1.3)	7.5 (3.5)	0.9 (2.3)	NA	0.65	NA
SW-44	5/87	21(7)	59(5)	0.0 (0.71)	0.0 (1.2)	7.1 (1.8)	8.5 (1.9)	<110	<0.6	<0.3
SW-881HS	5/87	32(9)	61(12)	0.0 (0.67)	0.0 (1.2)	2.2 (1.9)	2.7 (1.9)	320	0.88	<0.3

* Parentheses indicate the 2 standard deviation counting uncertainty.
** NA = Not analyzed
*** Rocky Flats Plant raw water supply in 1986 had minimum, maximum, and average total uranium concentrations of 0.03(0.1), 2.4(0.3) and 1(0.05) pCi/l, respectively.
**** Background range based on estimated background surface water and alluvial groundwater chemistry, Table 6-6, 6-7.

TABLE 6-5

METAL CONCENTRATIONS ABOVE BACKGROUND IN SURFACE WATER (mg/l)

Station	Date	Al	As	Be	Ba	Ca	Cr	Cd	Fe	Cu	Mg	Mn	K	Na	Sr	Zn	Hg
Background	Range*	0.150-0.540	ND	ND**	ND	6.6-22	ND	ND	0.130-0.135	ND	1.1-5.2	ND-0.013	0.39-0.56	4-13	ND-0.110	0.005-0.016	ND-0.0005
Interceptor Ditch																	
SW-37	8/86	*** -	0.006	-	-	42.5	-	-	0.180	-	-	0.021	8.900	-	-	-	-
SW-36	8/86	-	-	0.090	-	123	-	-	-	-	10.0	0.120	-	14.9	0.420	1.00	0.00465
SW-35	5/87	NA	-	NA	NA	NA	NA	-	NA	-	NA	NA	NA	-	NA	NA	-
SW-35	7-8/87	-	NA	NA	-	65	-	NA	2.0	-	15.9	0.196	NA	26.9	0.4	-	NA
SW-31	8/86	3.470	-	0.090	-	103	-	-	0.200	-	10.00	0.070	-	18.70	0.380	0.589	-
SW-31	5/87	-	NA	NA	-	NA	NA	0.006	NA	NA	NA	NA	-	NA	NA	-	NA
SW-31	7-8/87	-	-	-	-	56.5	-	-	-	-	12.3	0.037	-	24.0	0.40	-	-
SW-30	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	NA	-	NA	NA	-	-
SW-30	7-8/87	-	NA	NA	-	36.1	-	NA	-	-	14.4	-	NA	36.9	0.3	-	NA
SW-27	8/86	-	-	-	-	42.50	-	-	0.180	-	2.400	0.021	8.90	-	-	-	-
SW-27	7/87	-	NA	NA	-	78.6	-	NA	-	-	16.1	0.153	NA	49.8	0.52	0.04	NA
SW-C2	8/86	-	-	0.100	0.240	20.6	0.021	-	-	-	10.3	-	-	33.9	0.230	-	-
Woman Creek																	
SW-40	7-8/87	2.5	NA	NA	-	68.1	-	NA	2.0	-	13.4	0.096	NA	25.0	0.4	0.06	NA
SW-41	7-8/87	-	NA	NA	-	98.3	-	NA	-	-	20.8	-	NA	45.8	0.6	-	NA
SW-34	8/86	-	-	-	-	65.0	-	-	-	-	7.2	-	0.750	0.170	-	-	-
SW-33	8/86	-	-	-	-	-	-	-	-	-	-	-	-	0.110	-	-	-
SW-32	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	NA	-	NA	NA	-	-
SW-32	7-8/87	-	NA	NA	-	49.2	-	NA	-	-	6.1	-	NA	14.5	-	-	NA
SW-C1	8/86	-	-	0.110	0.250	49.3	0.017	-	0.140	-	5.6	-	-	20.9	0.170	-	-
SW-29	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	NA	-	NA	NA	-	-
SW-28	8/86	-	-	-	-	90.00	-	-	-	-	17.00	0.054	8.25	42.00	0.460	0.022	-
SW-28	7-8/87	-	NA	NA	-	66.3	0.03	NA	0.23	0.027	15.7	0.144	0.144	55.0	0.43	-	NA
SW-62	7-8/87	-	NA	NA	-	67.9	-	NA	-	-	29.6	0.016	-	99.4	0.97	-	NA
881 Hillside																	
SW-45	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	-	-	NA	NA	-	-
SW-45	11/87	-	-	-	0.1547	85.34	-	-	-	0.0111	19.02	0.0060	-	41.76	0.6411	0.0426	-
SW-46	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	-	-	NA	NA	-	-
SW-44	8/86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW-44	5/87	NA		NA	NA	NA	NA		NA	NA	NA	-	-	NA	NA		
SW-881HS	5/87	NA	-	NA	NA	NA	NA	-	NA	NA	NA	-	-	NA	NA	-	-

* Background range based on estimated background surface water and alluvial groundwater chemistry, Table 6-6, 6-7.
** ND = Not detected; NA = Not analyzed
*** - Indicates that analyzed value is below background.

TABLE 6-6

CONCENTRATION OF MAJOR IONS ABOVE BACKGROUND IN SURFACE WATER (mg/l)

Station	Date	Chloride	Nitrate	Sulfate	TDS	Bicarbonate	Carbonate	Phosphate
Background Range*		0.7-20	ND-1.5**	ND-31	113-309	ND-130	ND-120	0.92-1.4(SW)
Interceptor Trench								
SW-36	8/86	29	- ***	64	320	-	160	-
SW-35	5/87	23.4	1.90	49.0	-	-	-	NA**
SW-35	7-8/87	33.6	1.80	74.0	-	-	-	NA
SW-31	8/86	40		-	320	-	160	-
SW-31	5/87	37.5	2.10	53.0	-	-	-	NA
SW-31	7-8/87	32.9	-	83.5	-	-	-	NA
SW-30	5/87	33.8	-	68.0	310	165	-	NA
SW-30	7/87	49.9	-	60.0	-	-	-	NA
SW-27	8/86	47	-	83	700	-	230	NA
SW-27	7/87	34	-	69.3	426	237	-	NA
SW-C2	8/86	31	NA	67	240	-	-	1.8
Woman Creek								
SW-41	7/87	82.5	7.3	54.5	498	236	-	NA
SW-40	7/87	23.9	3.6	65.0	-	131	-	NA
SW-33	8/86	-	-	-	-	-	-	-
SW-34	8/86	-	-	-	-	-	-	1.9
SW-32	8/86	-	-	-	-	-	-	2.1
SW-32	5/87	-	-	-	-	160	-	NA
SW-32	7-8/87	-	-	-	-	-	160	NA
SW-C1	8/86	22	NA	190	-	-	-	1.5
SW-29	5/87	-	-	-	-	160	-	NA
SW-28	8/86	39	-	89	370	-	-	1.7
SW-28	7/87	35	-	60	402	237	-	NA
SW-62	7/87	44.0	-	132	625	346	-	NA
881 Hillside								
SW-45	5/87	74.1	8.5	44.0	456	216	-	NA
SW-46	5/87	-	-	-	-	-	-	NA
SW-44	5/87	47.8	3.80	64.0	-	-	-	NA
SW-881HS	5/87	-	-	95.0	629	318	-	NA

* Background range based on estimated background surface water and alluvial groundwater chemistry, Table 6-6, 6-7.
**ND = Not detected; NA = Not analyzed
*** Indicates that analyzed value is below background.

TABLE 6-7
BACKGROUND ALLUVIAL GROUND-WATER QUALITY

METALS

Element	Concentration Range (mg/l)
Antimony	.060U*
Arsenic	.001U
Barium	.047-.190
Beryllium	.005U
Cadmium	.007U
Cesium	.1U
Chromium	.002U-.027
Cobalt	.05U
Copper	.02U-.046
Lead	.005U-.05
Manganese	.01U-.547
Mercury	.0002U
Molybdenum	.1U
Nickel	.04U-.07
Selenium	.005U
Silver	.01U
Strontium	0.02U-.20
Thallium	.01U
Vanadium	.005U-.047
Zinc	.005U-0.09

RADIONUCLIDES

Plutonium, Americium, Uranium-235	Below MDA
Uranium-234	Below MDA-3.5(.9)
Uranium-238	Below MDA-5.5(2.1)

MAJOR IONS

Ion	Concentration Range (mg/l)
Calcium	12-36
Magnesium	2-8
Potassium	.01U-5
Sodium	8-21
Bicarbonate	ND-130
Carbonate	ND-120
Chloride	.7-20
Nitrate	ND-1.5
Sulfate	1U-31
Total Dissolved Solids	113-309

* U indicates not detected and the values preceding the U are the detection limit.
ND = not detected.
MDA = Minimum detectable activity.

TABLE 6-8
ESTIMATED BACKGROUND SURFACE WATER CHEMISTRY

PARAMETER	CONCENTRATION RANGE
RADIONUCLIDES (pCi/l)	
Plutonium	-.02(.04) - .01(.06)
Americium	.02(.03) - .06(.04)
Uranium 233+234	.13(.09) - .38(.14)
Uranium 238	.06(.06) - .12(.08)
Uranium 235	NA
Tritium	20(220) - 80(220)
Strontium 90	NA
Cesium 137	NA
METALS (ug/l)	
Aluminum	150 - 540
Antimony	ND - 37
Arsenic	ND
Barium	ND
Beryllium	ND - 59
Cadmium	ND
Cesium	170 - 340
Chromium	ND
Cobalt	ND
Copper	ND
Iron	130 - 135
Lead	ND
Manganese	ND - 13
Mercury	ND - 0.5
Molybdenum	450 - 680
Nickel	43 - 82
Selenium	ND - 8.8
Silver	ND - 22
Strontium	ND - 110
Thallium	ND - 6
Vanadium	450 - 1200
Zinc	5 - 16
OTHER INORGANICS (mg/l)	
Calcium	6.6 - 22
Magnesium	1.1 - 5.2
Potassium	0.39 - 0.56
Sodium	4 - 13
Bicarbonate	11 - 23
Carbonate	23 - 64
Chloride	2 - 3.4
Cyanide	ND - 0.0016
Phosphate	0.92 - 1.4
Sulfate	ND
Nitrate	<5

and Rock Creek, respectively. The basis for the background alluvial ground-water ranges is discussed in Section 5. Because the surface water stations are at ground-water seeps or are otherwise flowing drainage where interaction with alluvial ground water is not quantified, an analyte concentration will be identified as possibly indicating contamination if it is greater than the maximum value specified for either background surface water or alluvial ground water. As defined in Section 4, there were no above background occurrences of plutonium and americium in surface waters of the South Interceptor Ditch and Woman Creek. Background data for strontium 90 and cesium 137 are not available. However, inspection of data at other stations indicates the concentrations observed do not constitute a contaminant release.

6.2.2 South Interceptor Ditch

The farthest upstream surface water station that had flow during the August 1986 sampling activities was SW-36. SW-37 and SW-38 were dry. At station SW-36, downstream of the old landfill, but upstream of the 881 Hillside, radionuclides and metals were elevated with respect to background. Of the radionuclides, $U\text{-}^{233+234}$ and $U\text{-}^{238}$ were elevated, at 3.9(0.5) and 17(1) pCi/l. The following metal concentrations were elevated relative to background: beryllium (0.090 mg/l), manganese (0.120 mg/l), mercury (0.00465 mg/l), strontium (0.420 mg/l), and zinc (1.00 mg/l). The dominant major ions were calcium (123 mg/l), carbonate (160 mg/l), chlorides (29 mg/l), and sulfate (64 mg/l). HSL volatile organics were not present above detection limits.

SW-35 is located downstream of SW-36, but upstream of the 881 Hillside area. Data for SW-35 (May 1987) show a general decrease in uranium concentrations over that observed at SW-36. Uranium-$^{233+234}$, and uranium-^{238} were 3.5(1.1), and

0.49(0.48) pCi/l, respectively. The reported uranium $-^{238}$ concentration is significantly lower than that observed at SW-36. The $U-^{238}$ concentration of 0.49 (0.48) pCi/l is likely in error because the ratio of $U-^{233+234}$ and $U-^{238}$ is inconsistent with the samples taken both up- and downstream of SW-35. In addition, the gross alpha values for SW-35 are consistent with the up- and downstream surface water samples. Tritium was non-detectable.

Trace metal concentrations in SW-35 were either not detectable or at values below background in May 1987. However, metals concentrations exceeded background concentrations in the July/August 1987 sampling for iron (2.0 mg/l), manganese (0.196 mg/l), and and strontium (0.40 mg/l). Except for calcium (65 mg/l), magnesium (15.9 mg/l) and sodium (26.9 mg/l), major ion concentrations at SW-35 were similar to that observed at SW-36.

Contamination of surface water at SW-35 is unlikely. In the May 1987 sampling, 1,1,1-trichloroethane was measured at 6 ug/l; however, the detection limits for 1,1,1-trichloroethane are 4 to 5 ug/l, and the analytical results from the other sampling periods at SW-35 indicated that 1,1,1-trichloroethane was not detected. This suggests that the 6 ug/l measurements is probably of little or no significance. The November 1987 sampling of SW-35 showed a CCl_4 and toluene concentration of 6 and 12 ug/l, respectively. However, with the exception of one surface water sample which had a toluene concentration of 11 ug/l, all other surface water samples collected in November 1987 had 12 ug/l of toluene. Also, four of the six samples collected in November 1987 had a CCl_4 concentration of 6 ug/l. Thus, the occurrence of CCl_4 and toluene in surface water samples is probably due to laboratory contamination or analytical error.

Three surface water stations are located on the 881 Hillside due south of Building 881. SW-45 is the 881 Building foundation drain discharge. This water flows into a skimming pond. Station SW-44 is the discharge from a pipe draining the skimming pond to the South Interceptor Ditch. The foundation drain is a slotted vitrified clay pipe which is buried 14 to 20 feet deep along the western and eastern sides of the 881 Building. The pipe from each side of the building drains water southward to a common pipe and then into the skimming pond (Figure 6-1). SW-46 is located at the pond formed by ground-water seepage from the 881 Hillside. The pond sampled by SW-46 is west and hydraulically upgradient of the skimming pond, and presumably is directly connected to the skimming pond by direct alluvial ground-water connection and by overflow between the two ponds. The distinguishable characteristics of the SW-45 discharge in May 1987 are the presence of tetrachloroethene (128 ug/l) and trichlorethene (14 ug/l). $U^{-233+234}$ (5.5 (1.9) pCi/l), U^{-238} (4.7 (1.7) pCi/l) were within or near background levels for alluvial ground water. The July 1987 analytical results indicate the presence of carbon tetrachloride (6 ug/l), trichloroethene (8 ug/l), toluene (12 ug/l) and tetrachloroethene (16 ug/l). The pond (SW-46) sample from May 1987 contained no volatile organics, and had similar concentrations of uranium to that observed for SW-45, although U^{-238} (0.9 pCi/l) was somewhat lower. The discharge to the interceptor ditch (SW-44) from the skimming pond also contained no volatile organics, and had similar concentrations of uranium to that observed at SW-45 and SW-46. Again, the uranium concentrations at SW-44, 45 and SW-46 are somewhat elevated relative to background alluvial ground water but generally indicate these waters are largely derived form alluvial ground water. The elevated levels may reflect some local release of uranium to alluvial ground water. It appears that the volatile organics entering the pond from the foundation drain are being volatilized during their detention in the skimming pond.

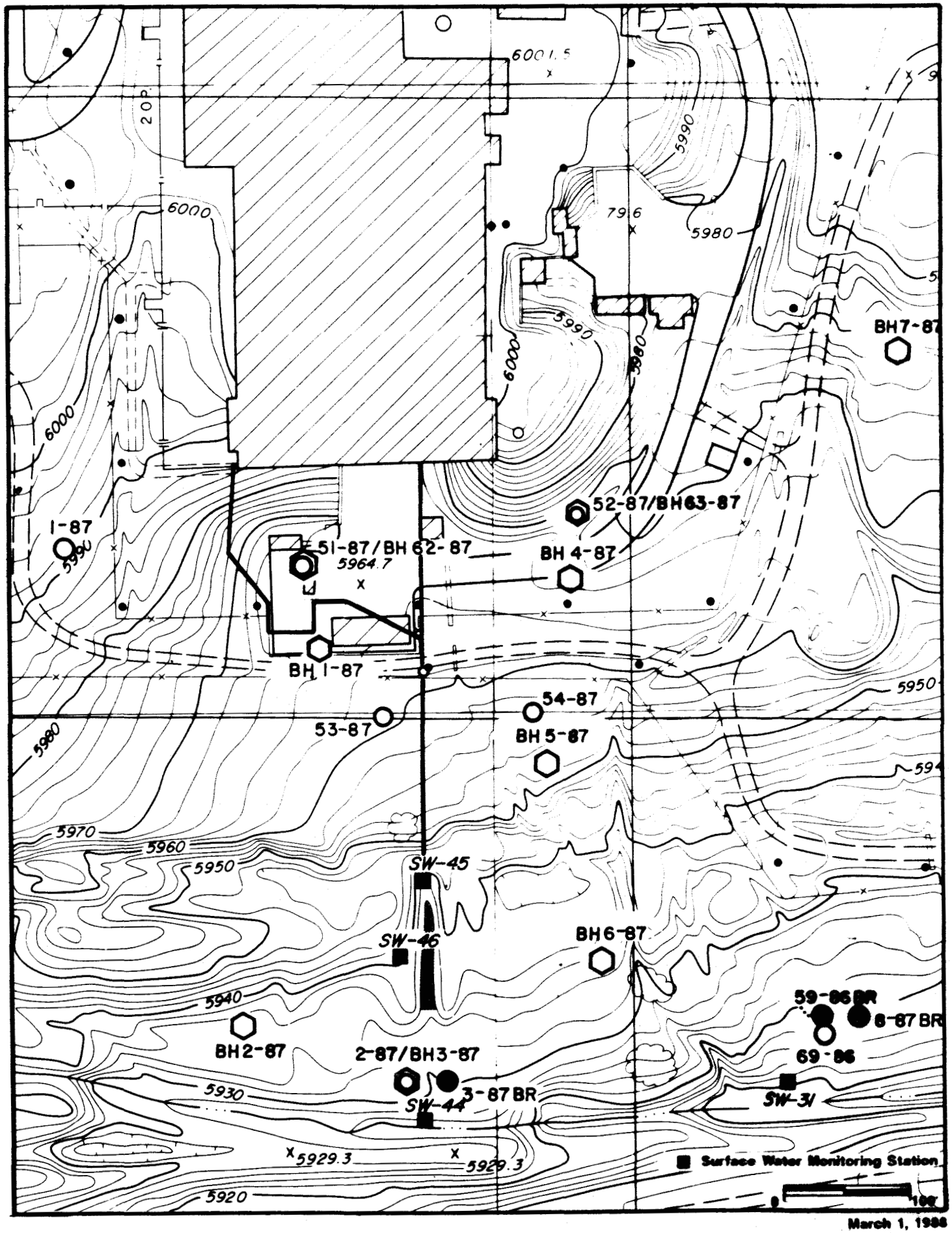


Figure 6-1: Foundation Drain Location Map

The detention time has been estimated at 18 hours, by calculations based on the volume capacity of the pond compared to the 5 gpm inflow rate from SW-45 (foundation drain).

It should be noted that the analyzed contaminants from the foundation drain discharge (SW-45) are the same organic contaminants and radionuclide species which have been analyzed as present in the process waste stream tanks located in Building 887 immediately adjacent to the foundation drain. Also, drums of oils and solvents may have been stored in the Building 885 drum storage area at a previous time. The drum storage area is also located at the surface, adjacent to the foundation drain. These may be potential sources for the organic and radioactive contamination of the foundation drain discharge.

Surface water stations SW-31 and SW-30 are located within the South Interceptor Ditch, south of 881 Hillside Area. The data indicate elevated concentrations of $U-^{238}$ (10(1)-14(2) pCi/l) compared to background.

The alluvial ground-water potentiometric surface map suggests that ground water should recharge the South Interceptor Ditch at the 881 Hillside and thus may be the source of the $U-^{238}$. However, sodium which can be considered a conservative tracer and is elevated in ground water in the vicinity of SW-31 (range 134-341mg/l; see Table 6-9), does not increase dramatically in surface water at stations SW-31 and SW-30. There is some increase which suggests there may be some recharge of surface water in the South Interceptor Ditch by ground water; however, this increase could also be due to the discharge from SW-45. Furthermore, alluvial ground water is characteristically elevated in $U-^{233+234}$ (range 8.4(0.9) - 26.8(3.2); see table 6-9), and increases in $U-^{233+234}$ in the South Interceptor Ditch downgradient of the 881

TABLE 6-9

881 HILLSIDE ALLUVIAL WELLS
RANGE OF RADIONUCLIDE CONCENTRATIONS

Well No.	No. of Samples	Isotopes (pCi/l) $U^{233+234}$	U^{235}	U^{238}	Pu^{239}	Am^{241}
2-87	2	8.9(2.4) - 11(1.0)	0.3(0.4) - 0.35(0.11)	3.7(1.4) - 4.5(0.5)	0.04(0.09) - 0.42(0.81)	-0.04(0.75) - 0.0 (0.20)
69-86	5	8.4(0.9) - 14(10)	0.3(0.51) - 0.8(0.5)	6.5(0.7) - 33(5)	0.02(0.69) - 0.0(0.22)	0.0(1.8) - 0.5(2.5)
4-87	2	16(3) - 26.8(3.2)	0.5(0.4) - 0.56(0.30)	12(2) - 17.4(2.3)	0.06(0.14) - 0.14(0.73)	0.02(0.07) - 0.70(0.86)

		Range of Major Ion Concentrations (mg/l) Chlorides	Nitrate	Sulfate	TDS	Bicarbonate	Sodium
2-87	2	66.0	<2.0-0.54*	81.0-99.0	547-549	275-283	144-147
69-86	4	85-114	1.10-2.30	43.0-270	237-929	362-385	134-142
4-87	3	200-458	3.76-9.50	310-700	1318-2374	309-421	341**

* Concentration is less than background range based on estimated background surface water and alluvial groundwater chemistry, Table 6-6, 6-7.

** One sample: 7-9-87.

Hillside are not readily apparent from the data. It is therefore concluded that the elevated $U-^{238}$ at stations SW-31 and SW-30 likely arises upstream at station SW-36.

Organics were detected during November 1987 at station SW-30. The November 1987 analytical results indicate 7 ug/l of 1,1,1-trichlorethane and 12 ug/l of toluene were present. As previously mentioned, the toluene value is considered suspect, and little significance can be placed on a concentration of 1,1,1-trichloroethane near the detection limit without further data.

Lastly there were few changes in major ion or metal concentrations at SW-31 and SW-30 relative to SW-35. In August 1986, the concentration of aluminum in the surface water at SW-31 was measured at 3.470 mg/l. Aluminum concentrations in the unfiltered samples represent total aluminum in the sample. Therefore, the increase in aluminum may represent suspended clays in the surface water runoff into the interceptor ditch.

Downstream of the 881 Hillside Area and the 903 Pad and East Trenches Area, at the entrance to Pond C-2 is surface water station SW-27. No HSL volatile organic contaminants were detected in the August 1986 sampling of SW-27. $U-^{238}$ showed a decrease between SW-30 and SW-27 stations. The interpretation that $U-^{238}$ decreases downstream is based on analyses performed one year apart. and during different seasons of the year. The May 1987 sample from SW-30 indicates a concentration of 13 (2) pCi/l, and the August 1986 and July 1987 samples from SW-27 indicate concentration of 6.1 (0.09) pCi/l 0.79 (0.92) pCi/l respectively. The results may be due to seasonal variations in ground-water inflow, downstream attenuation, or dilution of $U-^{238}$ in the South Interceptor Ditch. The concentrations of $U-^{233+234}$ and $U-^{238}$ at SW-27 are similar to background concentrations in alluvial ground

water. The concentrations for calcium, iron, magnesium, manganese, potassium, sodium, strontium, zinc, sulfate, bicarbonate and carbonate exceed the background limits for surface water and for alluvial ground water.. However, these concentrations observed at SW-27 are within the ranges of the upstream surface water samples in the interceptor ditch. This station was the only surface water station where HSL base neutral/acid compounds were detected above detection limits (1986 initial site characterization data). Phenol and 2-methylphenol occurred at 0.013 and 0.024 mg/l, respectively. These values may be statistical outliers. Therefore, until additional sampling verifies the presence of these constituents they will not be considered significant.

Pond C-2 is downstream of the 881 Hillside and the 903 Pad and East Trenches Areas, and receives flow from the South Interceptor Ditch. Radionuclide, metal and major ion concentrations are at levels similar to the farthest upstream station, SW-37. Barium was an exception to the comparison, occurring at 0.240 mg/l in the pond and otherwise non-detected in the interceptor ditch. The maximum concentrations of radionuclides reported for the NPDES discharge 007 from Pond C-2 are consistent with the interpretation that $U\text{-}^{238}$ is being diluted or attenuated downstream in the interceptor ditch and in Pond C-2 (Table 6-10). Historical radiochemistry data for Pond C-2 show all radionuclide concentrations to be at or near background levels for alluvial ground water.

No HSL volatile organics were detected in Pond C-2. However, 200 ug/l of N-Nitrosodiphenylamine(1), a HSL base/neutral acid compound, was detected in the August 1986 Pond C-2 sample. This compound was not detected in any of the upstream surface water samples, and is a common laboratory contaminant.

TABLE 6-10

PLUTONIUM, URANIUM, AMERICIUM, AND TRITIUM CONCENTRATIONS AT POND C-1[+]

(NUMBER OF SAMPLES)

RADIONUCLIDES	YEAR (Number of Samples)											
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Plutonium	(51)	(51)	(52)		(53)	(37)	(50)	(51)	(52)	(51)	(44)	(48)
C_{MIN}	0.013	<.01	<0.1		0.004±0.005	-0.002±0.007	-0.005±0.006	-0.01±0.01	0.000±0.005	0.00±0.02	-0.01±0.02	0.01±0.01
C_{MAX}	3.379	42.4*	0.5		<0.07	0.22±0.04	0.10±0.03	0.06±0.04	0.06±0.02	0.010±0.02	0.04±0.01	0.04±0.02
C_{AVG}	<0.275	<0.9	<0.1		<0.01	-0.29±0.002	0.016±0.002	0.012±0.001	0.017±0.003	0.027±0.002	0.015±0.002	0.022±0.004
Uranium**[•]	(38)	(54)	(52)		(53)	(37)	(50)	(51)	(52)	(51)	(44)	(48)
C_{MIN}	0.473	<0.1	<0.2		<0.1	-0.7±0.06	0.1±0.05	0.05±0.07	0.2±0.1	0.14±0.09	0.0±0.1	0.6±0.4
C_{MAX}	2.801	4.0	7.9		<11	6.5±0.2	8.4±0.8	5.3±0.4	7.4±0.3	6.5±0.8	4.6±0.4	3.6±0.2
C_{AVG}	1.191	<0.7	2.5		<30	2.23±0.03	2.0±0.2	1.66±0.03	2.00±0.04	2.84±0.05	1.30±0.03	1.74±0.06
Americium	(51)	(54)	(52)		(53)	(37)	(50)	(51)	(51)	(51)	(44)	(47)
C_{MIN}	0.003	<0.1	<0.1		<0.001	-0.01±0.02	-0.02±0.03	-0.05±0.02	-0.01±0.04	-0.04±0.06	-0.02±0.03	0.000±0.005
C_{MAX}	1.012	0.5	0.2		0.16±0.08	0.05±0.02	0.09±0.09	0.05±0.03	0.08±0.04	0.08±0.02	0.10±0.06	0.03±0.01
C_{AVG}	<0.103	<0.1	<0.1		<0.07	0.004±0.002	0.02±0.002	0.004±0.003	0.008±0.003	0.011±0.002	0.004±0.003	0.001±0.003
Tritium	(58)	(52)	(52)		(53)	(37)	(50)	(51)	(47)	(49)	(41)	(41)
C_{MIN}	<500	505	<500		<400	-500±500	-400±500	-300±600	-500±600	-1000±1000	-700±600	-100±500
C_{MAX}	1893	1017	1000		120±600	900±500	1200±500	600±800	900±800	300±700	600±500	400±200
C_{AVG}	<660	717	<700		<600	<400	400±100	100±100	100±100	100±100	100±100	125±82.5

* This value is suspect.

** Total uranium.

+ Concentrations pCi/l.

Ref. Rockwell International, 1977, 1978, 1979, 1980, 1981a, 1982a, 1983a, 1984a, 1985, 1986g, 1987a

In general, it appears that the South Interceptor Ditch is largely impacted by sites upstream of the 881 Hillside Area. The radionuclide concentrations in the South Interceptor Ditch generally decrease in magnitude between the upstream stations near the old landfill and the downstream stations. Alluvial ground water and the effluent from the 881 Building foundation drain (SW-44) may also impact the quality of the surface water in the South Interceptor Ditch to a small degree. Water quality in Pond C-2 is not adversely impacted by the presence of HSL organics or radionuclides observed at surface water stations upstream.

6.2.3 Woman Creek

Station SW-42, one of the background surface water sampling stations, is located west and hydraulically upgradient of the entire Plant. Results of SW-42 analyses are included within Table 6-8. In August 1986, HSL organics were not present above detection limits. The following metal concentrations were unusual but noted in the background SW-42 sampling: cesium (0.170 mg/l), molybdenum (0.680 mg/l), nickel (0.082 mg/l), and vanadium (0.450 mg/l). Neither strontium or nitrate were detected. Radionuclide levels were non-detectable. Major ions were at low concentrations, the dominant ions being calcium and carbonate occuring at 7 mg/l and 20 mg/l, respectively.

Surface water stations SW-40 and SW-41 are located on Woman Creek to the southwest of the 881 Hillside, and east of the old landfill. The two stations were sampled, and the samples analyzed in July/August and November of 1987. The SW-41 sample contained 10 ug/l of tetrachloroethene in the July/August sampling, and 6 ug/l of carbon tetrachloride, 8 ug/l trichloroethene, and 12 ug/l toluene in the November 1987 sampling. Again, as discussed previously, the toluene and CCl_4

concentrations appear to be laboratory contamination or analytical error; this further renders suspect the trichloroethene concentration detected. Both SW-41 and SW-40 samples contained metal concentrations above background, specifically aluminum (2.5 mg/l), iron (2.0 mg/l), magnesium (13.4-20.8 mg/l), sodium (25-45.8 mg/l), and strontium (0.3-0.97 mg/l) (Table 6-5). In addition, the concentrations of calcium, chloride, nitrate, sulfate, TDS, and bicarbonate exceeded the background ranges for ground water or surface water.

Stations SW-33, 32, and 34 are located on Woman Creek south of the 881 Hillside. Except at SW-32 in November 1987, at these sampling locations, no HSL organics were detected, and no major ions except calcium at 65 mg/l in SW-34 were above background. The November 1987 sample from SW-32 contained 6 ug/l carbon tetrachloride, 26 ug/l trichloroethene, and 12 ug/l toluene. As discussed for the SW-41 sample collected in November 1987, the organic concentrations may be due to laboratory contamination or analytical error. The radionuclide concentrations were at or below the background concentration ranges presented in Table 6-8. Metals concentrations exceeded background values at SW-34 for only magnesium (7.2 mg/l) and potassium (0.750 mg/l).

Downstream of surface station SW-32 on Woman Creek is Pond C-1. Samples of surface water in Pond C-1, collected in August 1986, contained no detectable concentrations of HSL volatile organics or HSL base/neutral acid compounds. Major ion concentrations were at or near background values. Concentrations of $U^{-233+234}$ and U^{-238} were 1.8 (0.3)and 1.5 (0.3) pCi/l, respectively. These concentrations are within background limits of alluvial ground water. The $U^{-233+234}$ and U^{-238} concentrations are similar to the concentrations present downstream in SW-29 and SW-28, and to the historical averages for Pond C-1 (Table 6-11).

TABLE 6-11

PLUTONIUM, URANIUM, AMERICIUM, AND TRITIUM CONCENTRATIONS AT POND C-2*

(NUMBER OF SAMPLES)

RADIONUCLIDES	YEAR											
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
	(Number of Samples)											
Plutonium						(3)	(3)	(9)	(7)	(1)	(1)	(5)
C_{MIN}						0.03±0.03	0.00±0.02	0.00±0.02	-0.05±0.04	0.05±0.03	0.0±0.0	0.019±0.027
C_{MAX}						0.05±0.02	0.09±0.05	0.06±0.03	0.11±0.07	0.05±0.03	0.0±0.0	0.05±0.03
C_{AVG}						0.04±0.02	0.05±0.02	0.03±0.01	0.04±0.02	0.05±0.03	0.0±0.0	0.034±0.012
Uranium**						(3)	(3)	(9)	(7)	(1)	(1)	(5)
C_{MIN}						1.8±0.2	1.4±0.02	2.8±0.2	3.7±0.4	3.7±0.5	8±2	3.6±0.05
C_{MAX}						4.3±0.1	3.2±0.4	5.0±0.3	6.3±0.6	3.7±0.5	8±2	6.9±0.9
C_{AVG}						3.0±0.1	2.0±0.2	4.0±0.1	5.3±0.2	3.7±0.5	8±2	4.9±0.24
Americium						(3)	(3)	(9)	(7)	(1)	(1)	(5)
C_{MIN}						0.00±0.04	-0.04±0.07	-0.03±0.04	-0.03±0.04	0.04±0.02	-0.03±0.08	-0.006±0.021
C_{MAX}						0.05±0.03	0.08±0.07	0.08±0.02	0.11±0.06	0.04±0.02	-0.03±0.08	0.03±0.02
C_{AVG}						0.02±0.02	0.02±0.04	0.01±0.02	0.03±0.02	0.04±0.02	-0.03±0.08	0.006±0.013
Tritium						(5)	(4)	(9)		(2)	(2)	(9)
C_{MIN}						-500±500	100±600	-200±500	-100±400	0±600	-100±400	-100±400
C_{MAX}						400±600	500±600	500±500	300±400	300±700	300±400	500±200
C_{AVG}						200±200	300±300	200±200	0±200	200±500	100±300	140±140

* Concentrations in pCi/l

** Total uranium

Ref. Rockwell International, 1977, 1978, 1979, 1980, 1981a, 1982a, 1983a, 1984a, 1985, 1986g, 1987a

Except in November 1987 at SW-29, at stations SW-29 and SW-28 the data indicate that HSL organics were not detected, and that metal and major ion concentrations were present above background levels. In the November 1987 sampling of SW-29, the following volatile organic compounds were measured above detection limits: carbon tetrachloride (7 ug/l); trichloroethene (42 ug/l) and toluene (12 ug/l). As previously discussed, the organic concentrations appear to be due to laboratory contamination or analytical error. The concentrations of the following metals and major ions exceeded background levels at SW-28: calcium, chromium, copper, magnesium, manganese, potassium, sodium, strontium, zinc, chlorides, sulfates, TDS, and bicarbonate (Tables 6-5 and 6-6). Alluvial ground water in the vicinity of station SW-28 is elevated in major ions, thereby indicating a possible interconnection between ground water and surface water at station SW-28.

In summary, surface water samples collected from the South Interceptor Ditch contained concentrations of U^{-238} above background and concentrations of $U^{-233+234}$ at or near background. The samples collected upstream of the 881 Hillside area have higher radionuclide concentrations than those downstream of the 881 Hillside area. Surface water samples from Woman Creek contained concentrations of radionuclides at or near background levels. Thus, the 881 Hillside Area is not impacting the surface water of the South Interceptor Ditch or Woman Creek with respect to radionuclides.

Except for the November 1987 sampling, HSL organics were not detected in the South Interceptor Ditch or Woman Creek. Carbon tetrachloride, trichloroethene toluene, and 1,1,1-trichloroethane were measured in samples collected both in Woman Creek and in the South Interceptor Ditch in November 1987. The concentrations of these contaminants were similar in all samples whether collected from upstream or

downstream stations, suggesting that these numbers are likely laboratory artifact. Therefore, it is concluded that the quality of the surface water in the South Interceptor Ditch or in Woman Creek is not being impacted in terms of volatile organics by the 881 Hillside Area.

The surface water of the South Interceptor Ditch and Woman Creek, in general, contained concentrations of metals and major ions within background surface water and alluvial ground water ranges. Except for sodium concentrations, no trends of increasing or decreasing metals and/or major ions are observable downstream of the 881 Hillside Area (Tables 6-5 and 6-6). The general increase in sodium concentrations downstream in both the South Interceptor Ditch and in Woman Creek may result from an increased influence of ground water recharge to surface water downstream of the 881 Hillside Area.

6.3 SEDIMENTS

Sediment samples were collected during the 1986 Phase 2 initial site characterization from creeks and ditches that traverse the Rocky Flats Plant. Impacts of the 881 Hillside Area and the 903 Pad and East Trenches Areas on stream sediments would be reflected in the data collected for sediment stations SED-1 and SED-2 in the Woman Creek drainage. Except for the presence of what appears to be laboratory introduced contamination (acetone and methylene chloride), HSL organics were not detected in these sediment samples. As radionuclides are the contaminants of greatest concern in terms of sediment transport, potential radionuclide contamination of downgradient sediments is the focus of this discussion.

6.3.1 Background Sediment Chemistry

SED-15 was collected in Woman Creek near the west boundary of the facility and is thus representative of background conditions. HSL organic compounds (other than suspected lab contaminants) were not present above detection limits. Major ion concentrations of this sediment sample consisted of calcium (360 ppm), magnesium (300 ppm), phosphate (310 ppm) and potassium (330 ppm). Other cations and anions, including nitrates, were approximately an order of magnitude lower in concentration.

Concentrations of metals and radionuclides (Table 6-12) were within apparent background values for soils and typical of values observed at another upstream station on Church Ditch.

6.3.2 Downgradient Sediment Chemistry

Downstream samples from the 881 Hillside were collected at stations SED-1 and SED-2, located adjacent to Indiana Street. Metals in SED-1 and SED-2 were in similar concentrations to background values. Major ions were elevated in SED-1 with calcium (1,740 ppm), magnesium (1,080 ppm), potassium (18,600 ppm), phosphate (4,990 ppm), and sulfate (244 ppm) concentrations being above background.

Plutonium was the only radionuclide above background in the sediments at SED-1 and SED-2. The respective concentrations were 0.06 (0.02) and 0.03 (0.02) pCi/g (Table 6-12). SED-2 is located on an ephemeral stream due north of Woman Creek, which drains the East Trenches Area. The elevated concentrations at SED-1 and SED-2 are similar to those reported for soils in this vicinity (Rockwell International, 1987a), implying that these elevated plutonium concentrations are simply due to resuspension and settling of contaminated dust from the 903 Pad Area. In 1986,

TABLE 6-12
WOMAN CREEK DRAINAGE-SEDIMENT SAMPLES (pCi/g)*
AUGUST 1986

Radiochemistry	SED-15	SED-1	SED-2
Uranium 238	0.36(0.22)	0.26(0.17)	0.49(0.24)
Uranium 233, 234	0.38(0.23)	0.47(0.23)	0.51(0.25)
Plutonium 239, 240	- 0.05(0.08)	0.06(0.02)	0.03(0.02)
Americium 241	0.02(0.07)	0.01(0.01)	0.01(0.01)
Tritium	0.21(0.26)	0.30(0.26)	0.32(0.26)

* Parentheses indicate the 2 standard deviation counting error.

surface water stations at SED-1 (SW-1) and SED-2 (SW-2) were both dry at the time sediment samples were collected.

6.4 FLOOD POTENTIAL

Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps were obtained for the areas surrounding the Rocky Flats Plant. These maps exclude the area within the Plant; however, they indicate a narrow 100-year flood plain for Woman Creek up to the eastern Rocky Flats property boundary. The FEMA map flood plain was extrapolated upstream into the facility along Woman Creek (Figure 6-1).

A review of topographic maps indicates that the 881 Hillside at Rocky Flats Plant is well above any potential 100-year flood plain. Elevations of SWMUs at the 881 Hillside area range from 5,944 to 5,995 feet above mean sea level. Average stream channel elevations for Woman Creek, below the 881 Hillside, ranges from 5,880 due south of SWMU 106 to 5,820 at Pond C-1.

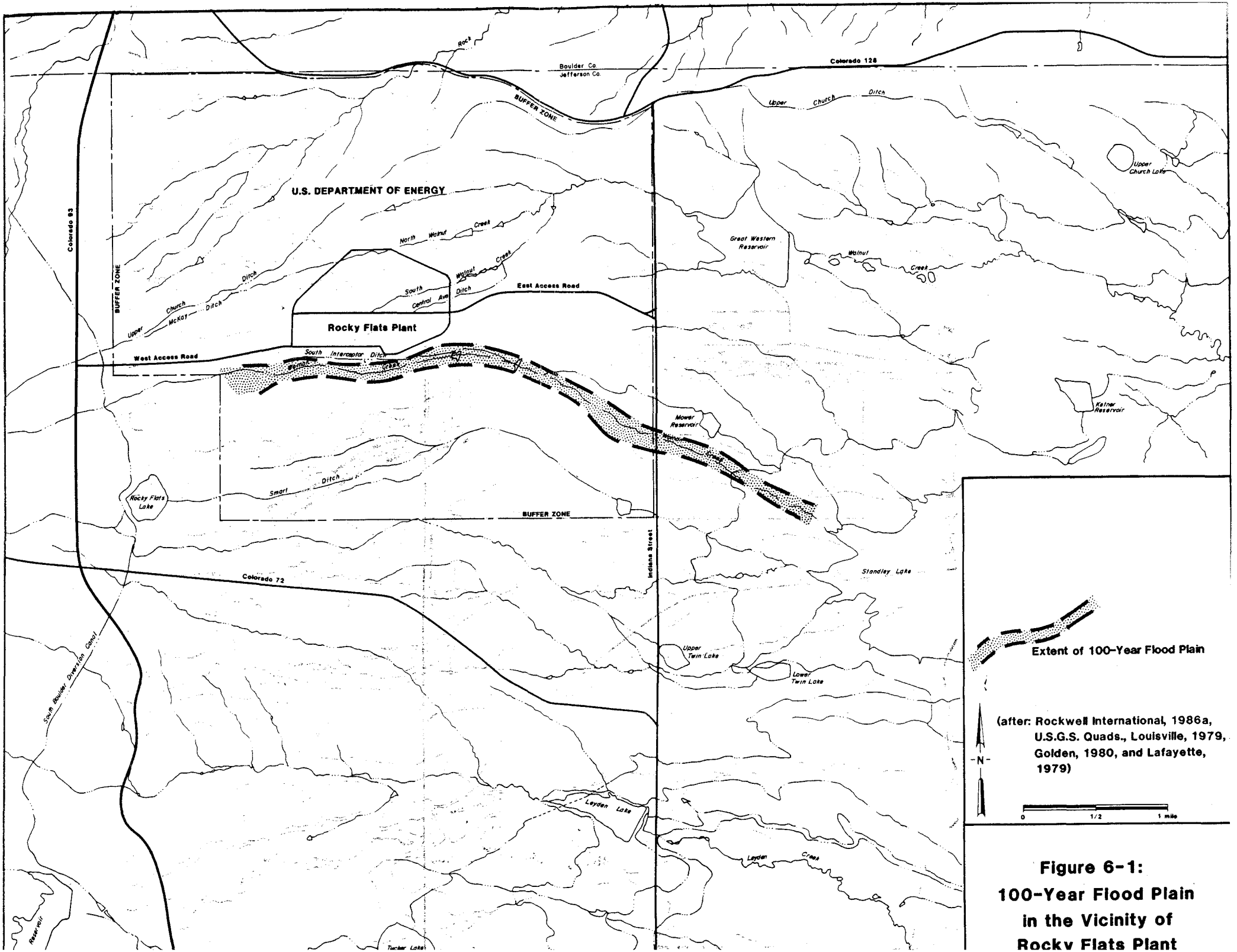


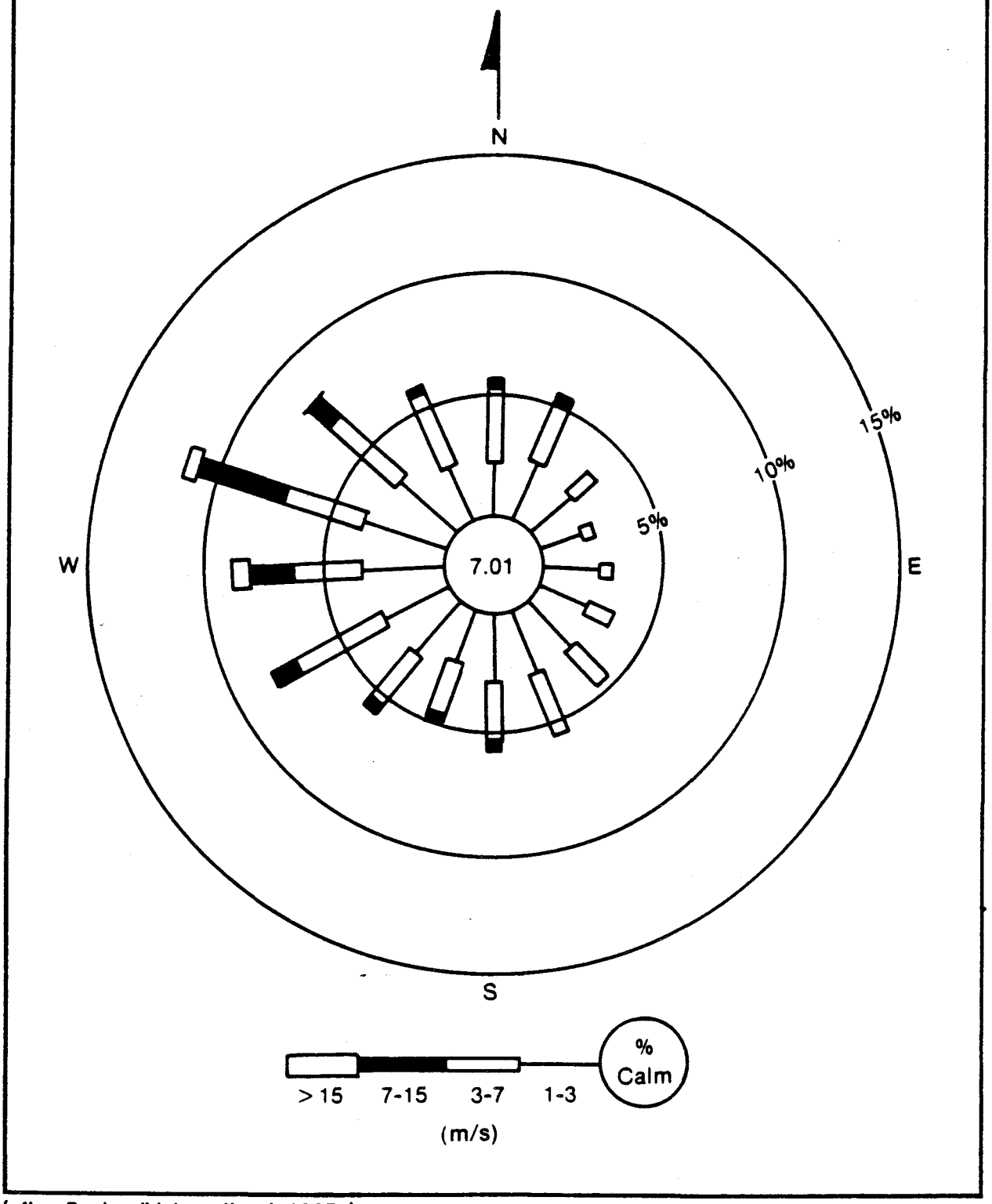
Figure 6-1:
100-Year Flood Plain in the Vicinity of Rocky Flats Plant

Section 7.0

7.0 AIR

The prevailing wind direction at the Rocky Flats Plant, as indicated by the 1986 Plant wind rose (Figure 7-1) is westerly ranging from northwesterly to southwesterly. Several Plant particulate air samplers which measure airborne plutonium contamination are located both upwind and downwind of the 881 Hillside Area. Results of the particulate air sampling indicate little difference between the airborne plutonium contaminants at the upwind and downwind sampling locations surrounding the 881 Hillside Area. Historically, the highest concentrations of airborne plutonium at the Plant have been measured by three air samplers downwind (east, southeast, and northeast) of the 903 Pad Area. These samplers are also downwind of the 881 Hillside Area. Long term air sampling has shown that there is a recognizable difference in plutonium concentrations between these downwind air samplers and the air samplers located between the 881 Hillside Area and the 903 Pad Area. Plutonium concentrations between the 881 Hillside and the 903 Pad are significantly lower than those collected east of the 903 Pad Area.

An analysis of ambient air data for 1987 indicates volatile organics were released to air during remedial investigation field activities, and plutonium concentrations in air were below the DOE Derived Concentration Guide of 0.02 pico Curies per cubic meter (pCi/m^3) of plutonium activity. These conclusions are based on 1) real time volatile organic monitoring conducted during 1987 field activities (Section 7.2); and 2) particulate sampler data from stations near the 881 Hillside Area (Section 7.1). The absence of radioactive contamination of either personnel or equipment associated with 881 Hillside field activities also supports these conclusions.



(after: Rockwell International, 1987a)

Figure 7-1:
1986 Annual Wind Rose for the Rocky Flats Plant

7.1 PLANT AMBIENT AIR MONITORING

Ambient air monitoring for radionuclides is conducted as a part of the routine environmental monitoring program at the Plant. The air samplers for these monitoring activities are sited at various locations within the Plant, around the Plant perimeter, at nearby locations readily accessible to the Plant, and at nearby community locations. In addition, sampling is conducted for the basic criteria pollutants established under the Clean Air Act (CAA) at a single location near the east gate.

7.1.1 Ambient Air Sampling for Radionuclides

The Plant Radioactive Ambient Air Monitoring Program (RAAMP) was developed by expanding upon the recommendations of the 1972 Colorado State University study. Most of these samplers have been in operation since their installation (May 1974 through January 1976). The program is currently comprised of fifty-one particulate air samplers (RAAMP samplers) which operate to determine total long lived alpha (TLL alpha) activity and plutonium concentrations for purposes of protecting human health and the environment. The RAAMP samplers operate at a volumetric flow rate of approximately twelve liters per second (25 cfm). Particulates are collected on a twenty by twenty-five centimeter (8x10 inch) fiberglass filter media. These filters are 99.42% efficient in collecting particulates in the 0.01 to 1.0 micron range, as characterized by the median aerodynamic diameter (Wedding and Carney, 1978; Wedding and others, 1984; and Schleicher and Schuell, Inc., 1982). As the particle size increases, the filter collection efficiency increases for these particles. These samplers have an approximate size cutoff in still air of 30 microns. This gives

excellent coverage of the total size range of respirable particles as discussed in applicable EPA publications (EPA 1982 and 1985a).

Figure 7-2 presents the location of the RAAMP samplers on and adjacent to the Rocky Flats Plant. Figure 7-3 shows the locations of off-site community RAAMP samplers. Twenty-three of these monitoring stations are located directly within or adjacent to the Plant security area (on-site samplers). Exposed filters from these twenty-three on-site samplers are collected biweekly and analyzed individually for TLL alpha activity. The exposed filters from the remaining twenty-eight sampler locations are collected bi-weekly and are composited by location into monthly samples and the composites are sampled individually for plutonium.

Filters from five of the twenty-three on-site samplers have historically shown a higher level of plutonium than other on-site RAAMP samplers. These sampler locations are S-5, S-6, S-7, S-8, and S-9. As indicated by Figures 7-1 and 7-2, each of these samplers can be directly impacted by potential emissions from the 903 Pad, Mound, and East Trenches Areas. In particular, samplers S-7, S-8, and S-9 are most likely to be impacted by soils disturbance activity in this area. Exposed filters from each of these five sampler locations are analyzed separately for plutonium on a biweekly basis. Increases in the plutonium concentrations measured at these sampler sites were noted in 1987. However, these concentrations were well below the DOE-DCG of 0.02 pCi/m^3 for plutonium in ambient air.

The samplers surrounding the 881 Hillside Area, S-10, S-11, S-12, S-17, S-18, S-19, S-23, are among the remaining eighteen on-site samplers. The exposed filters from these eighteen samplers are collected biweekly and analyzed individually for TLL alpha activity. Plutonium and uranium are both alpha particle emitters; therefore,

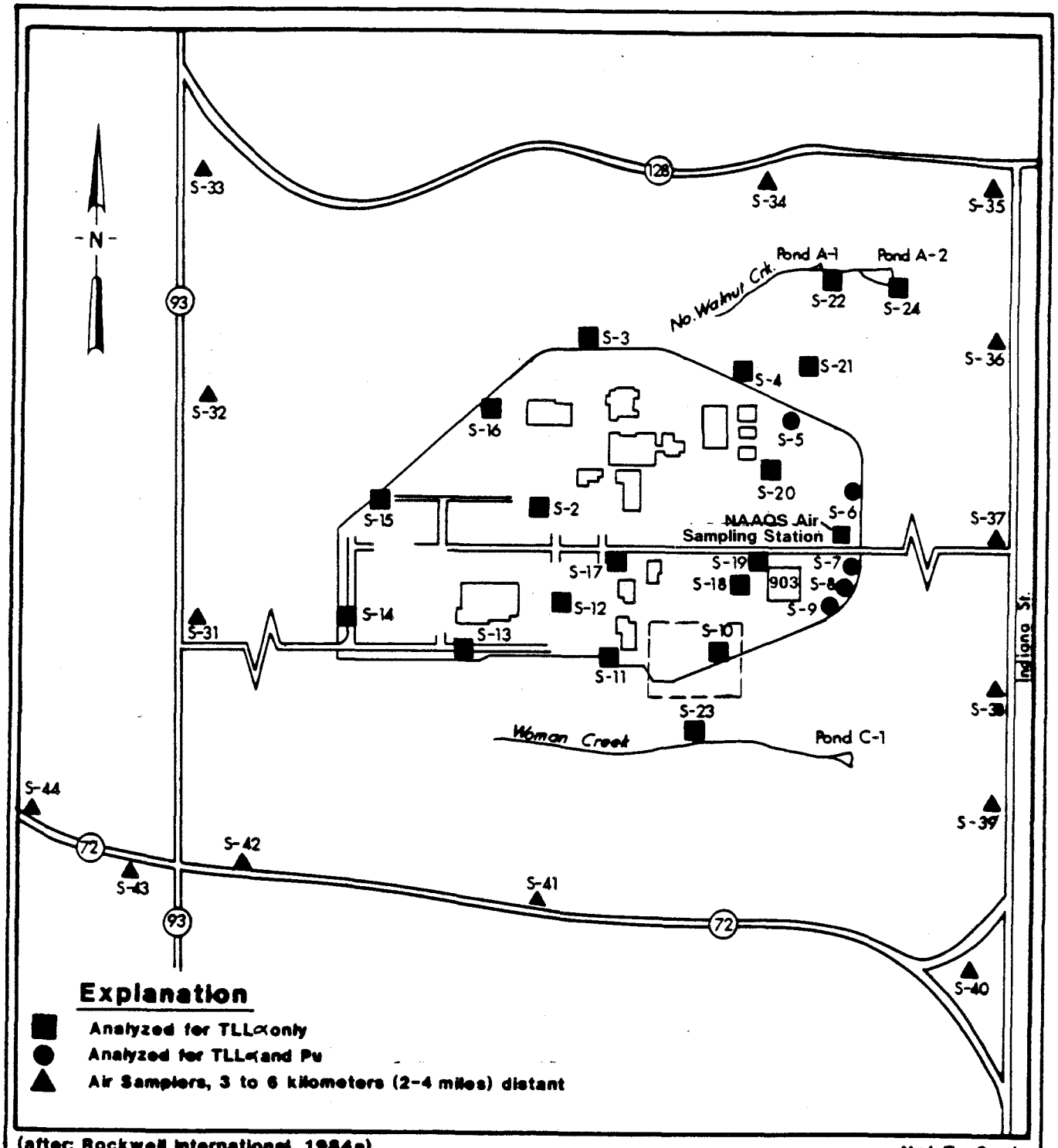
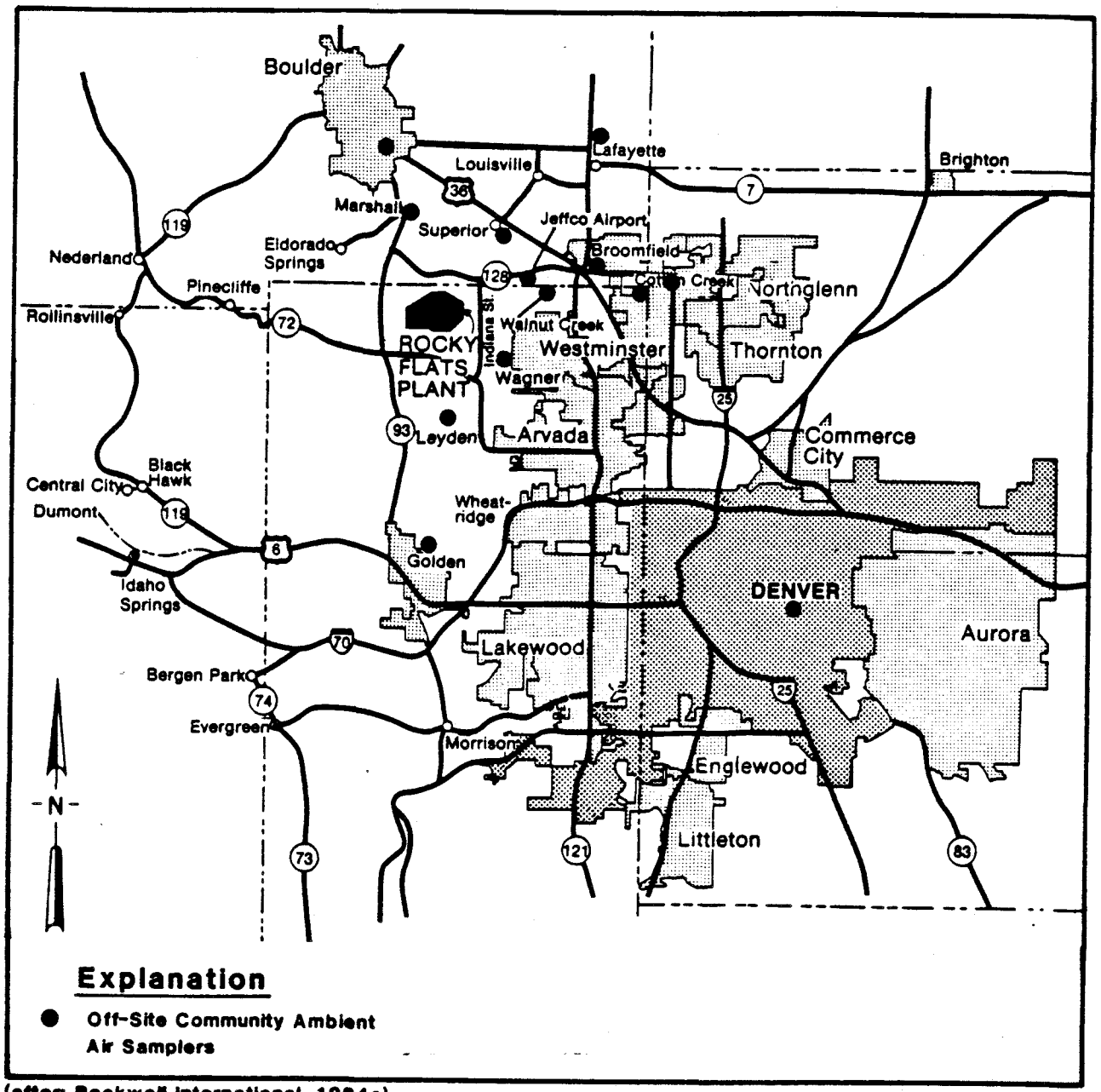


Figure 7-2

Location of On-Site and Plant Perimeter Ambient Air Samplers



(after: Rockwell International, 1984a)

Not To Scale

Figure 7-3:
Location of Off-Site Community Ambient Air Samplers

these filters are first analyzed for TLL alpha activity. A Plant Screening Guide (PSG) of 0.01 pCi/m^3 of TLL alpha activity has been established at the Rocky Flats Plant. The PSG is more conservative than the DOE DCG for plutonium inhalation by members of the public of 0.02 pCi/m^3. The PSG is used instead of the DCG because it is lower than the DCG and includes both plutonium and uranium.

Any of the exposed filters from these eighteen on-site samplers which exceed the PSG value are specifically analyzed for plutonium. Filters are only analyzed for plutonium, as it has historically been the radionuclide of concern at the Plant. In the last ten years, only three exposed filters have exceeded the PSG value and therefore been analyzed for plutonium. Two of these incidents occurred prior to the recent field activities at the 881 Hillside Area, and the third remaining exceedence occurred in December 1987 on the north side of the Plant (away from the 881 Hillside Area). Plutonium analyses of these filters indicated near fallout levels of plutonium (Section 7.1.3)

Results of the Plant RAAMP samples are published in the "Monthly Environmental Monitoring Report" and summarized on a yearly basis in the "Annual Environmental Monitoring Report". Appendix I provides summary data for at least ten years for the RAAMP program. These data are arranged by sampler location as determined by on-site (Appendix I-1), perimeter (Appendix I-2), or community samplers (Appendix I-3). As the tables indicate, since 1977, mean annual plutonium levels at all on-site samplers have been less than 7% of the DOE DCG of 0.02 pCi/m^3 plutonium activity. Perimeter and community ambient air samplers have recorded mean annual plutonium concentrations below 0.4% of the DOE DCG value since their installation.

7.1.2 Routine Nonradioactive Ambient Air Monitoring

The routine nonradioactive ambient air monitoring program was instituted at the Rocky Flats Plant to address regulations concerning criteria air pollutants (NAAQS). This program consists of one sampling station and includes some limited PM-10 sampler data. The NAAQS sampling program was not instituted to yield data specific to any area undergoing remedial investigations; however, the following information is presented for completeness.

Ambient air monitoring at the Plant includes the monitoring of the following pollutants: total suspended particulates (TSP), ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, and lead. These six parameters are criteria pollutants regulated by the EPA and the State of Colorado through the Clean Air Act (CAA), and they are monitored, at a single location near the east entrance to the Plant, throughout the year (Figure 7-2). This sampling is conducted in an open area near a traffic zone, generally downwind from Plant buildings. This sampling location is not intended to provide pollutant concentration data for site specific remedial investigation activities such as that conducted in the 881 Hillside Area during the summer and fall of 1987. As discussed in Section 7.2, short-term site specific sampling was conducted to monitor such activities.

In general, the values for all of the analyzed criteria pollutants (TSP, lead, sulfur dioxide, carbon monoxide, nitrogen dioxide, and ozone) were measured at 30 percent or less of any applicable limits or guidelines, with the exception of TSP and ozone. The highest TSP value for 1986 (a 24-hour sample) was 156 micrograms per cubic meter (ug/m^3), which is 60 percent of the primary 24-hour National Ambient

Air Quality Standard (NAAQS) standard of 260 ug/m^3. The annual TSP geometric mean value for 1986 was 48 ug/m^3, which is 64 percent of the NAAQS primary annual geometric mean standard of 75 ug/m^3.

The maximum 1-hour 1986 ozone value was 0.18 parts per million (ppm), which is 151 percent of the NAAQS primary one-hour standard of 0.12 ppm. The second highest 1-hour ozone value was 0.17 ppm. These ozone values are consistent with levels measured in the general Denver metropolitan area during high pollution episodes. Volatile organics emissions resulting from RI activities would not be sufficient to impact ambient ozone levels as measured at this location.

7.1.3 Special Dust Resuspension Studies

A number of studies have been conducted at Rocky Flats to investigate background levels of plutonium. No true background for plutonium exists since plutonium is a man-made element. Nevertheless, plutonium is found worldwide in extremely low concentrations due to atmospheric testing of nuclear weapons and the consequent fallout of plutonium from the atmosphere. Background levels of plutonium near the Plant were estimated in a Colorado State University study at less than 0.045 picocuries per gram (less than 0.1 dpm/gm) in 1979 (Whicker, 1979).

Research has been conducted at the Plant on the classical theory of soil resuspension by saltating soil particles (Sehmel, 1980; Environmental Studies Group 1981a; Environmental Sciences Branch 1981b; Environmental Sciences Branch 1982; Environmental Sciences Branch 1983; Environmental Sciences Group 1984; Application Technology Branch 1984; Application Technology 1986). The classic wind erosion theory for soil predicts resuspension to increase based on a third power relationship

with wind speed. On this basis, the airborne plutonium concentration should reflect the soil concentration as the dust in the air would originate uniformly from the soil. In a special study at the 903 Pad Area, airborne concentrations did not correlate with average wind speed and wind direction data, nor were any correlations observed between samplers (Environmental Sciences Branch, 1981a and 1983). In fact, during seven years of study at the Rocky Flats Plant, only two instances were identified in which resuspension was clearly affected by wind. These instances were major wind storms of 100 and 130 mph winds. The anticipated correlation between other high wind events, common in the area, and elevated plutonium concentrations is not borne out by the data.

While no working model for dust resuspension has been developed for the Plant, the research conducted at Rocky Flats indicates that 70 percent of all airborne plutonium activity was on particles greater than 15 microns in median aerodynamic diameter. Such large dust particles are in the non-respirable size range. Finally, the RAAMP samplers, operational at the RFP for over ten years, document that TLL alpha and plutonium concentrations have been far less than the applicable DCG.

7.2 REMEDIAL INVESTIGATION AIR SAMPLING RESULTS

7.2.1 Radiometric Survey

A radiometric survey of the entire Plant security area was completed in 1984 using a Field Instrument for Detecting Low Energy Radiation (FIDLER). Operations of the FIDLER probe gamma survey instrument are reviewed in Case and others (1971). This survey also included limited areas outside the Plant security area. The 881 Hillside Area was surveyed as a part of this study. The survey results indicated

background levels of gamma radiation (250 counts per minute) for most of the Plant site. Four small areas, eleven square feet each, were above background for gamma activity on the 881 Hillside Area (Figure 7-4).

FIDLER surveys were also performed at each specific drilling location prior to beginning drilling activities and after completion of the drilling activities. The results of these surveys indicated background levels of ionizing radiation.

Core samples were smeared and the smears counted using an air proportional detector. Smears of all cores indicated background levels. During Phase II of the drilling program, personnel were required to wear DOE white cotton coveralls and boot covers when drilling in the 881 Hillside Area. The personnel conducting the on-site drilling were required to wear Saranex coveralls, gloves, shoe covers, and supplied air respirators.

During Phase II, equipment and personnel were monitored for radioactive contamination when exiting the area. Personnel were monitored using an air proportional alpha survey meter. No contamination was noted on personnel during the field activities. Equipment was monitored with an air proportional alpha survey meter or by taking smears of the surface and counting the smear for alpha activity. No equipment was contaminated with radioactive material.

The extensive monitoring that was conducted and the fact that no contamination was ever found on equipment or personnel indicates that resuspension of radioactive material was not a problem at the 881 Hillside Area.

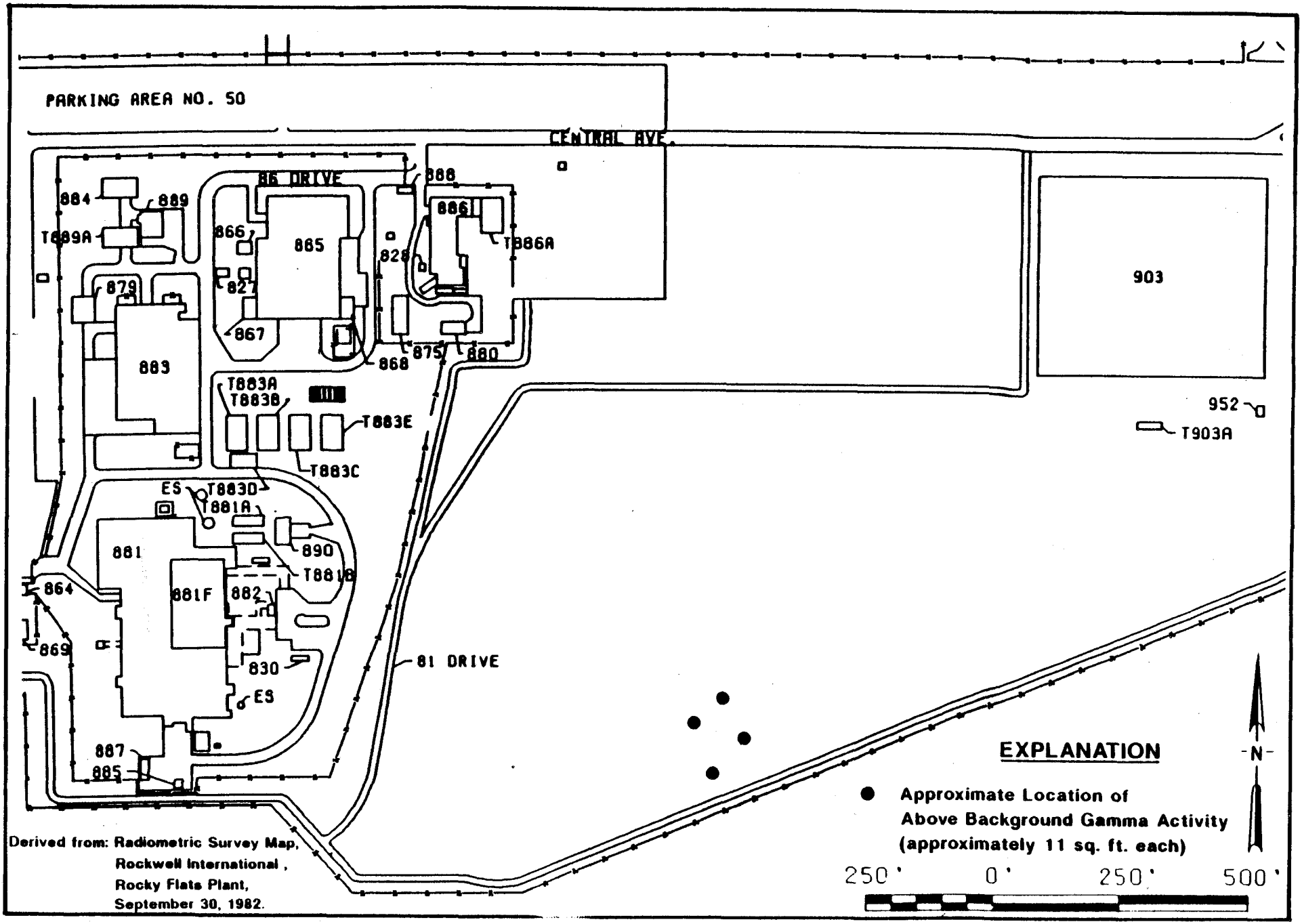


Figure 7-4: Results of Radiometric Survey

High volume samplers were installed and operated for the duration of the borehole and well drilling activity at the 881 Hillside Area. The samplers were located downwind of each drilling site. At the conclusion of the daily activity, the filters from the air samplers were removed and analyzed for TLL alpha activity. None of the samples collected during the borehole and well drilling activities showed excessive levels of TLL alpha activity.

The RAAMP data for the Plant site air samplers S-6, S-7, S-8, S-9, and perimeter sites S-38, S-39, and S-40 are presented in Table 7-1 for the months of May, June, October, November, and December 1987. These data were collected during the Phase I and Phase II borehole and well drilling activities at the 881 Hillside Area. Based on wind rose data for the Plant (Figure 7-1), these air sampler results have a high probability of indicating releases resulting from drilling and vehicular activity during the 881 Hillside activity. Sampler locations S-10, S-18, S-19, and S-23, located between the 903 Pad Area and the 881 Hillside Area, were not analyzed for plutonium during these months because the TLL alpha activity did not exceed PSG criteria.

The monthly averages for plutonium at the perimeter sampling sites (S-38, S-39, S-40) during the site investigation are the same or lower than the historical averages for the same sampling sites. The on-site samplers (S-6, S-7, S-8, S-9) recorded values during the 881 Hillside Site Investigation which are well below the DCG.

7.2.2 Volatile Organic Compound Survey

Personnel trained in industrial hygiene surveyed the 881 Hillside Area on March 21, 1987, for the presence of volatile organics in ambient air. The surveys

TABLE 7-1

RAAMP AIR SAMPLING SITES
PLUTONIUM-239 AND -240 CONCENTRATIONS (pCi/m^3)

	---S-6--	---S-7--	---S-8--	---S-9--	---S-38--	---S-39--	---S-40--
MAY 1987							
LCL	0.000029	0.000814	0.000802	0.001153	-0.000002	-0.000002	-0.000001
POINT ESTIMATE	0.000035	0.000575	0.000895	0.001290	0.000000	0.000004	0.000002
UCL	0.000041	0.000636	0.000928	0.001427	0.000002	0.000006	0.000005
JUNE 1987							
LCL	0.000038	0.000820	0.001343	0.001339	-0.000002	-0.000001	0.000003
POINT ESTIMATE	0.000046	0.000923	0.001550	0.001510	0.000002	0.000001	0.000006
UCL	0.000054	0.001026	0.001757	0.001681	0.000006	0.000003	0.000009
OCTOBER 1987							
LCL	0.001588	0.001000	0.001067	0.003459	0.000007	-0.000003	0.000001
POINT ESTIMATE	0.001815	0.001123	0.001198	0.003878	0.000010	0.000000	0.000004
UCL	0.002042	0.001245	0.001329	0.004297	0.000013	0.000003	0.000007
NOVEMBER 1987							
LCL	0.000041	0.000365	0.000494	0.001499	-0.000001	-0.000002	0.000000
POINT ESTIMATE	0.000050	0.000417	0.000561	0.001684	0.000002	0.000000	0.000002
UCL	0.000059	0.000469	0.000628	0.001869	0.000005	0.000002	0.000004
DECEMBER 1987							
LCL	0.000091	0.000165	0.000224	0.000393	0.000003	0.000003	0.000001
POINT ESTIMATE	0.000107	0.000188	0.000254	0.000443	0.000006	0.000006	0.000006
UCL	0.000123	0.000211	0.000284	0.000501	0.000009	0.000009	0.000007

were done with Dreager tubes sensitive to PCE and TCE. These two compounds were chosen since investigations prior to March 1987 had indicated PCE and TCE were the most commonly found contaminants at the 881 Hillside Area and were also found in higher concentrations than other contaminants. The detection limit for PCE and TCE by the Dreager tube method is one part per million.

Air sampling was conducted six inches above the ground, at numerous point locations throughout the 881 Hillside Area. All values were below detection limits except for two tetrachloroethane readings (Table 7-2). These readings were located near a currently operating hazardous waste satellite collection area for solvents. It is conjectured that the hazardous waste satellite collection station was the source of the 2 and 3 ppm values of PCE rather than sources of volatile organics in the soil.

TABLE 7-2

AMBIENT AIR SAMPLING FOR
VOLATILE ORGANIC COMPOUNDS
AT THE 881 HILLSIDE AREA

LOCATION	SAMPLE NUMBER	PCE (ppm)	TCE (ppm)	COMMENTS
Hillside	B881-032187-01	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-02	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-03	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-04	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-05	3	0	3/21/87 *DREAGER TUBE*
	B881-032187-07	2	0	3/21/87 *DREAGER TUBE*
	B881-032187-08	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-09	0	0	3/21/87 *DREAGER TUBE*
	N13488E21280	0	0	3/21/87 *DREAGER TUBE*
	N35000E21220	0	0	3/21/87 *DREAGER TUBE*
	N35000E21280	0	0	3/21/87 *DREAGER TUBE*
	N35060E21220	0	0	3/21/87 *DREAGER TUBE*
	N35060E21340	0	0	3/21/87 *DREAGER TUBE*
	N35060E21460	0	0	3/21/87 *DREAGER TUBE*
	N35120E21200	0	0	3/21/87 *DREAGER TUBE*
	N35120E21340	0	0	3/21/87 *DREAGER TUBE*
	N35120E21520	0	0	3/21/87 *DREAGER TUBE*
	N35120E21820	0	0	3/21/87 *DREAGER TUBE*
	N35180E21400	0	0	3/21/87 *DREAGER TUBE*
	N35180E21640	0	0	3/21/87 *DREAGER TUBE*
	N35180E21760	0	0	3/21/87 *DREAGER TUBE*
	N35240E21160	0	0	3/21/87 *DREAGER TUBE*
	N35240E21220	0	0	3/21/87 *DREAGER TUBE*
	N35300E21280	0	0	3/21/87 *DREAGER TUBE*
	N35300E21400	0	0	3/21/87 *DREAGER TUBE*
	N35300E22360	0	0	3/21/87 *DREAGER TUBE*
	N35420E21340	0	0	3/21/87 *DREAGER TUBE*
	N35420E21580	0	0	3/21/87 *DREAGER TUBE*
	N35420E21700	0	0	3/21/87 *DREAGER TUBE*
	N35420E21820	0	0	3/21/87 *DREAGER TUBE*
	N35420E22000	0	0	3/21/87 *DREAGER TUBE*
	N35900E23260	0	0	3/21/87 *DREAGER TUBE*

Section 8.0

8.0 BIOTA

This section will describe the flora, biota, and aquatic life found at Rocky Flats Plant (which includes the 881 Hillside Area) as described in previous investigations.

8.1 FLORA

The Rocky Flats Plant is located at an approximate elevation of 6,000 feet above mean sea level where plains grassland vegetation meets lower montane forest.

Within the Plant boundaries a variety of vegetation thrives. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions. Some areas are dominated by introduced Eurasian weeds. It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Land within the original 2,520-acre site boundary, however, has not been grazed since 1951 and generally has been undisturbed since that time. Some disturbed areas have been reseeded with native and introduced grass mixtures (DOE, 1980).

Weber and others (1974) conducted an inventory of the botany at the Plant from June through September of 1973. They reported that 327 species of vascular plants, 25 lichens, 15 bryophytes, and one macroscopic green algae species had been observed in the area. An annotated list of species occurring at Rocky Flats is given in Appendix G, none being on the endangered species list (DOE, 1980).

Within the property boundary, but west of the security area, the soils are primarily composed of gravelly, fine-textured soils. The vegetation is dominated by a mixture of warm season and cool season grasses. The vegetation on the eastern part of the property contains more cool season grasses and is more diverse due to the less uniform topography. Narrow bands of riparian vegetation line the drainage throughout the Plant site.

In 1975, about 4,000 acres surrounding the Plant were purchased to enlarge the buffer zone. Much of the area lying between the old and new boundaries had been overgrazed, but it appears that vegetation is recovering from grazing that occurred prior to Government acquisition of the land. This is evidenced by the presence of grasses like big bluestem and side-oats grama that are sensitive to disturbances.

The flora of the 881 Hillside are as described previously. Vegetation is currently growing heavily throughout the area, with efforts being taken to minimize the field work's impact on vegetation in order to prevent erosion and areas of bare soil.

8.2 WILDLIFE

A list of mammals, birds, amphibians, and reptiles observed at the Plant is given in Appendix G.

There are no effective barriers to animal migration or movement on or off the undeveloped areas of the Plant. This area supports a variety of animals classically associated with the western prairie regions. No rare or endangered species have been reported or have been found among the wildlife inhabiting or migrating through the area (Appendix G). The most common large mammal at the Rocky Flats site is the

mule deer. Most of the estimated 100-125 deer appear to be permanent residents of the site. White-tailed jack rabbits and the desert cottontail also inhabit the area. Carnivores in the area include coyote, red fox, striped skunk, and long-tailed weasel. Badger and raccoon are occasionally observed. Muskrat occur in the vicinity of the streams and ponds (DOE, 1980).

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow. A variety of ducks, killdeer, and red-winged black birds are seen in areas adjacent to ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks, red-tailed hawks, Ferruginous and American rough-legged hawks, and great horned owls (DOE, 1980).

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers have also been seen. The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE, 1980).

8.3 AQUATIC LIFE

Woman Creek is an intermittent stream that runs through the area south of the 881 Hillside. This stream receives snowmelt, storm runoff, and irrigation water, it does not currently receive discharges from Plant operations. Holding pond C-1 collects stream water and is used as a monitoring point for Woman Creek. Holding pond C-2 collects stormwater runoff from the South Interceptor Ditch. This diversion

system, including pond C-2, is isolated from Woman Creek, and is sampled before discharge.

Woman Creek supports an aquatic biota typical of small high-prairie streams receiving a minimum of agricultural land runoff and domestic or industrial wastes. Due to the low nutrient content in Woman Creek, the stream supports only a small algal population. The rocky bottom of Woman Creek supports a relatively diverse biota composed of mayflies, caddisflies, and other forms typical of clean water streams. Redside dace minnows are abundant in the stream and in the ponds; a few bluegill are also present. A list of the aquatic organisms known to occur in the streams and ponds of the Plant area is given in Appendix G.

Woman Creek water and sediments have been sampled for both radionuclides and hazardous constituents. The results of these sampling activities are discussed in Section 5.0 of this report. A biological sampling of the stream system is not justified at this time. Impacts of potential remedial alternatives on the stream will be evaluated, and additional sampling will be conducted if necessary.

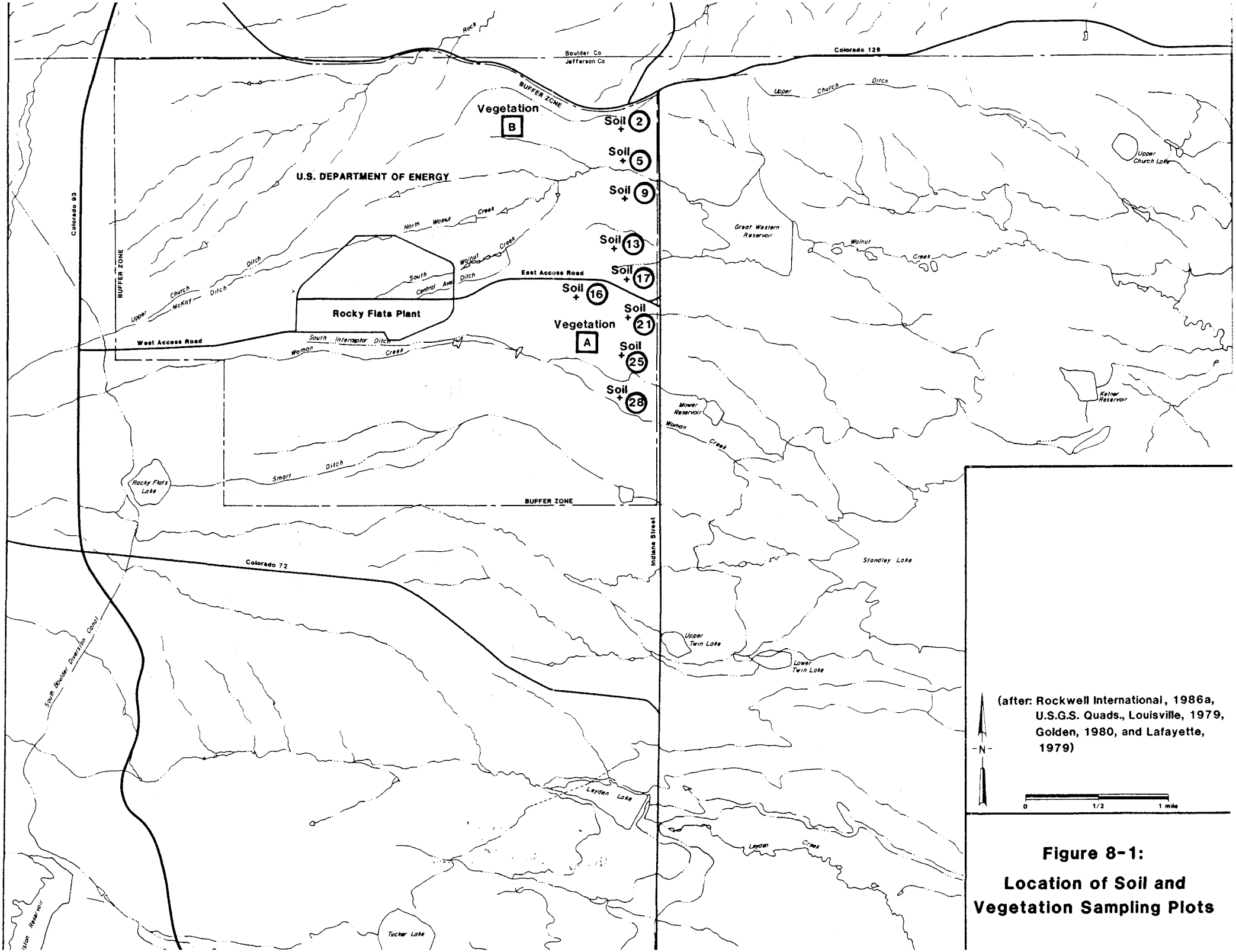


Figure 8-1:
Location of Soil and Vegetation Sampling Plots

Section 9.0

9.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

This section identifies potential receptors, public health impacts, and the environmental impacts of contaminants found at the 881 Hillside Area. Previous sections of this report have described remedial investigation sampling results. Samples were collected from air, soils, sediment, surface water, ground water, flora, and fauna. Soil gas techniques and geophysical techniques were also used to investigate the 881 Hillside Area. These data were used to evaluate contaminant presence, distribution, migration, and fate.

As discussed in Sections 4.0, 5.0, and 6.0, contaminated soil, ground water, and surface water occur at the 881 Hillside Area. The contaminants of greatest concern from a public health perspective are volatile organic compounds (VOCs) and uranium. VOCs occurred in both soil and water while uranium contamination appears to be confined to alluvial ground water and possibly surface water. Plutonium, americium, and tritium contamination is not apparent in any media. Metals were not found to be a contaminant of the soils; however, strontium and selenium were elevated above estimated background levels in both alluvial and bedrock ground water. Nickel also appears to be elevated above background levels in alluvial ground water.

9.1 POTENTIAL RECEPTORS

Based on 1980 Census data, approximately 1,585 individuals live within four miles of the Rocky Flats Plant. Approximately 2 million people live within a 50 mile radius of the Plant. Population density is greatest to the south and east of the Plant (Figure 3-1). A 6,150-acre buffer zone around the manufacturing facilities is

maintained as a restricted access area by the Plant and is actively patrolled by armed security guards. The buffer zone extends approximately 1.6 miles from the 881 Hillside Area to the nearest plant boundary. Therefore, a residence closer than 1.6 miles from the 881 Hillside Area is not possible. Currently the closest residence is 2.1 miles from the center of this area. The only possible routes of exposure to the 881 Hillside contamination are through direct exposure to waste sources and contaminated soil, inhalation of contaminated air, ingestion of contaminated ground water, and ingestion of contaminated surface water. Without primary exposure to contaminants through one of the above media, no secondary exposure to contamination can occur. Secondary exposure to contamination is defined as exposure to contamination caused by a change in the mode of transport of that contaminant. For instance, primary migration of volatile organics may occur in surface water. Secondary exposure could occur through consumption of food crops that have taken up the volatile organic compounds from irrigation water whose source was that surface water.

9.1.1 Direct Source Contact Potential Receptors

Since the 881 Hillside Area is within the Plant buffer zone and access to the buffer zone is restricted, direct exposure of the public to contaminated soil is not possible. Any potential for contact with contaminated soil will be limited to workers involved in investigative and remedial activities. All remedial action workers will be protected by protective clothing, the use of respirators when necessary, and by air monitoring during field activities. Industrial hygienists and health physicists will prepare a personnel protection plan prior to the initiation of remedial activities.

9.1.2 Potential Receptors of Contaminated Air

Long-term exposure of individuals to directly resuspended dust and to contaminated air can only occur to those individuals who are residents near the Plant because greater distances from the Plant will cause dilution of any plume by advection, dispersion, and diffusion. To be exposed to contaminated air, individuals would also need to be within a plume of contamination from the Plant. Winds at the Plant are predominantly from the northwest. A wind rose for the Plant is provided in Figure 7-1. The low population density within four miles of the Plant indicates that relatively few individuals are potential receptors of contaminated air.

9.1.3 Potential Receptors of Contaminated Ground Water

Table 9-1 presents all registered water supply well locations within three miles of the Plant. The closest downgradient water supply wells are numbers 11, 12, 13, 16, 17, and 20. Wells 11 and 12, approximately 2.2 miles east and north of the 881 Hillside Area could not be physically located in the summer of 1986. These two wells would be located on City of Broomfield land, and City employees had no knowledge of these wells (Rockwell International, 1986c). The majority of the wells presented in Table 9-1 are used to obtain drinking water for either humans or livestock. The nearest registered downgradient wells (wells 20, 13, 16, and 17) are located approximately 2.6 miles east and slightly south of the 881 Hillside Area.

TABLE 9-1

WELLS REGISTERED WITH THE COLORADO STATE ENGINEER WITHIN THREE MILES OF THE ROCKY FLATS PLANT

Ref. No.	Permit Number	Location Quarter	Sec.	Tsp.	Rng.	Use	Est. Zone of Completion	Owner
1	24243	SW/SW	31	T.1S.	R.69 W.	1	KA/KFL	Hardaway, R.
2	29289	SW/SW	31	T.1S.	R.69 W.	3	KA/KFL	Hardaway, R.
3	34582	SW/SE	31	T.1S.	R.69 W.	1	KA	Heath, G.D.
4	113864	NW/SW	31	T.1S.	R.69 W.	0	Unk	Waitman, D.B.
5	119287	SW/NW	31	T.1S.	R.69 W.	1	Unk	Roberts, B.A.
6	105613A	NE/NW	31	T.1S.	R.60 W.	1	Unk	Hart, G.D
7	108871	NW/NW	31	T.1S.	R.69 W.	1	Unk	Smith, M.R
8	28678F	SE/NW	6	T.2S.	R.69 W.	8	Unk	Carlson, C.F.
9	23591F	SW/NE	6	T.2S.	R.69 W.	8	Unk	Jeffco Air Pk
10	23590F	NE/NE	6	T.2S.	R.69 W.	8	Unk	Jeffco Air Pk
11	28779	SW/SW	6	T.2S.	R.69 W.	1	Qa	McCadden, R.D.
12	9126	NE/NW	7	T.2S.	R.69 W.	1	Qa	McCadden, R.D.
13	15044R	SW/NW	17	T.2S.	R.69 W.	5	KA	Lyons, M.D.
14	132576A	SE/SE	18	T.2S.	R.69 W.	3	Unk	Woodis, B.J
15	103583A	SE/SE	18	T.2S.	R.69 W.	3	Unk	Brauch, K.
16	962872	NE/SE	18	T.2S.	R.69 W.	0	Unk	Brauch, T.
17	29620	NE/SE	18	T.2S.	R.69 W.	1	KA	Brauch, D
18	52028	SE/SE	18	T.2S.	R.69 W.	2	KA	Brauch, K
19	132562	SE/SE	18	T.2S.	R.69 W.	3	Qa	Woodis, B.J
20	132563	NE/NE	18	T.2S.	R.69 W.	1	Qa	Woodis, B.J
21	138834	NE/NE	19	T.2S.	R.69 W.	1	Unk	Wacker, H.H.
22	26A	NE/NE	19	T.2S.	R.69 W.	1	Unk	Ladwig, A.E.
23	104756	NE/NE	19	T.2S.	R.69 W.	1	Unk	Welt, D.L.
24	89558	NE/NE	19	T.2S.	R.69 W.	1	Unk	Ladwig, W.E.
25	131220	NE/NE	19	T.2S.	R.69 W.	0	Unk	Wertz, R.H
26	122624	NE/NE	19	T.2S.	R.69 W.	1	Unk	Wertz, R.H
27	26730F	NW/NW	19	T.2S.	R.69 W.	6	Unk	Cook, M.E.
28	104756	NE/NE	19	T.2S.	R.69 W.	0	Unk	Welt, D.L.
29	26942F	NE/NW	19	T.2S.	R.69 W.	8	Unk	Cook, M.E.
30	131841	NE/NW	19	T.2S.	R.69 W.	6	Unk	Cook, M.E.

TABLE 9-1

WELLS REGISTERED WITH THE COLORADO STATE
ENGINEER WITHIN THREE MILES OF THE ROCKY FLATS PLANT
(Continued)

Ref. No.	Permit Number	Location Quarter	Sec.	Tsp.	Rng.	Use	Est. Zone of Completion	Owner
31	26937F	NW/NW	19	T.2S.	R.69 W.	8	Unk	Cook, M.E.
32	26	NE/NE	19	T.2S.	R.69 W.	1	KA	Ladwig, A.E.
33	1246	NE/NE	19	T.2S.	R.69 W.	1	KA	Church, M.F.
34	8117	NE/NE	19	T.2S.	R.69 W.	1	KA	Peterson, N.L.
35	14820	NE/SE	19	T.2S.	R.69 W.	1	KA	Welt, D
36	15251	SW/SW	19	T.2S.	R.69 W.	1	KA	Bray, M.V.
37	15252	SW/SW	19	T.2S.	R.69 W.	1	KA	Bray, M.V.
38	18383	NE/NE	19	T.2S.	R.69 W.	1	KA	Peterson, N.L.
39	19069	NE/NE	19	T.2S.	R.69 W.	1	KA	Welt, D.
40	32849	NE/NE	19	T.2S.	R.69 W.	1	KA	Peterson, N.L.
41	45855	NE/NE	19	T.2S.	R.69 W.	1	KA	Chisolm, B.D.
42	2862	SW/NW	33	T.1S.	R.70 W.	1	Unk	Weaver, J.E.
43	88218	NW/NE	34	T.1S.	R.70 W.	0	Unk	Hill, T.C
44	15060	NW/NE	36	T.1S.	T.70 W.	1	KA	Swanson, H.L
45	130482	NE/SE	36	T.1S.	R.70 W.	1	Unk	Verhey, R.J.
46	2651F	SW/NE	5	T.2S.	R.70 W.	5	Qa	Idealite Co.
47	3338	SE/NE	5	T.2S.	R.70 W.	1	Qa	Hogan, E.J.
48	42120	NE/NE	8	T.2S.	R.70 W.	1	Unk	Daniels, W.H.
49	28915	NW/SW	9	T.2S.	R.70 W.	2	Qa	Church, M.F.
50	17190F	NE/SE	16	T.2S.	R.70 W.	4	KFL	Co. Land Comm.
51	3257	NW/NE	21	T.2S.	R.70 W.	1	KFL	Church, M.F.
52	10003F	NE/SE	22	T.2S.	R.70 W.	5	KFL	Oil Shale Corp
53	23787F	NE/NE	22	T.2S.	R.70 W.	4	Unk	Cillissen, A.M
54	131860	NE/SE	23	T.2S.	R.70 W.	4	Unk	Storm, B.P
55	131861	NE/SE	23	T.2S.	R.70 W.	4	Unk	Bartel, L.G
56	2679F	SW/NE	24	T.2S.	R.70 W.	5	KA	Boise Cascade
57	20196	NW/SE	24	T.2S.	R.70 W.	3	KA	Westminster C
58	34955	SE/SE	24	T.2S.	R.70 W.	1	KA	Stevens, D.N.
59	97839A	NE/NE	25	T.2S.	R.70 W.	1	Unk	Taylor, L.O.
60	34149	NW/NW	25	T.2S.	R.70 W.	1	KA	Mentgen, G.

TABLE 9-1

WELLS REGISTERED WITH THE COLORADO STATE
ENGINEER WITHIN THREE MILES OF THE ROCKY FLATS PLANT
(Continued)

Ref. No.	Permit Number	Location Quarter	Sec.	Tsp.	Rng.	Use	Est. Zone of Completion	Owner
61	34541	NW/NE	25	T.2S.	R.70 W.	1	KA	Collicott, D.W
62	35405	NW/NE	25	T.2S.	R.70 W.	1	KA	Collicott, D.W
63	61190	NE/NE	25	T.2S.	R.70 W.	1	KA	Animal Relief
64	78493	SE/NW	26	T.2S.	R.70 W.	2	Unk	Harkness, W.W.
65	24583F	SE/NW	27	T.2S.	R.70 W.	5	Unk	Public Service
66	12307	NE/NE	26	T.1S.	R.70 W.	1	Unk	Wilson, T.L.
67	16207F	NW/SW	28	T.1S.	R.70 W.	4	Unk	Cinaquanta, F.
68	91184	SW/SW	7	T.2	R.70 W.	1	Unk	Ranson, A.L.

Uses:
0 Household (indoor) use only
1 Domestic (indoor and outdoor) use
2 Stock
3 Domestic and stock
4 Commercial
5 Industrial
6 Irrigation
7 Domestic and irrigation
8 Municipal

Estimated zone of completion:
Qa Quaternary alluvium
KA Arapahoe Formation
KFL Fox Hills - Laramie Aquifer
Unk Unknown

9.1.4 Potential Receptors of Contaminated Surface Water

The intermittent Woman Creek (isolated from surface water runoff from the Plant by the South Interceptor Ditch located due north of the creek) flows to the south of the 881 Hillside Area, and enters Standley Lake approximately four miles east of the Plant boundary. Standley Lake supplies drinking water to approximately 150,000 inhabitants of the cities of Westminster, Northglenn, and Thornton. Standley Lake is also used for irrigation water, boating, and fishing. The South Interceptor Ditch flows to Pond C-2 and discharges from the pond are monitored in accordance with the Plant's NPDES permit.

9.2 PUBLIC HEALTH IMPACTS

9.2.1 Direct Source Contact Exposure

Volatile and semivolatile organic contamination of soils exist at the 881 Hillside Area. The highest concentration detected for a chlorinated solvent was PCE at 190 ug/kg. Phthalates were the principal semivolatile contaminant of the soil, particularly bis(2-ethylhexyl)phthalate (DEHP). The maximum concentration of DEHP in the soil was 7,216 ug/kg.

Organic contamination of the soils is generally at depth effectively eliminating direct exposure to these contaminants. Furthermore, as discussed in Section 9.1.1, there is no potential for direct exposure of the public (access is controlled), or any livestock, to the 881 Hillside Area soil contamination. Therefore, there is no public health impact for this route of exposure. The reader is referred to the risk assessment performed as part of the feasibility study for the 881 Hillside Area (Rockwell

International, 1988) for discussion of this route of exposure and the associated risk pertaining to a future scenario where public access is uncontrolled. The risk assessment concludes that unacceptable risks are not posed by these contaminants through this route of exposure.

9.2.2 Exposure to Contaminated Air

An extensive air monitoring network known as the Radioactive Ambient Air Monitoring Program (RAAMP) is maintained at the Plant. Data from this network indicate that ambient air samples are well within applicable regulations and guidelines for the protection of human health and the environment for all radioactive contaminants that could possibly have originated from the Plant. No anomalous values were noted that correlated with any of the 881 Hillside Area field activities.

Available data for specific chemicals present in the ambient air at the 881 Hillside location is limited to Draeger tube readings for TCE and PCE taken during a one-day survey in March 1987, at 32 on-site locations. PCE was detected at 2 stations adjacent to an active solvent collection area (Building 952) at 2 and 3 ppm and is probably not related to past disposal activities. TCE was not detected at any of the locations surveyed. Based on this information, there is no public health impact from the air pathway at the 881 Hillside Area.

9.2.3 Exposure to Contaminated Ground Water

An extensive ground-water monitoring system (approximately 150 wells) has been installed at the Plant. Twenty-eight ground-water monitoring wells have been drilled within, and downgradient of, the 881 Hillside Area.

The highest concentrations of volatile organics in alluvial ground water were found at wells 9-74 and 43-87, which are adjacent to each other and located at the southern extent of SWMU 119.1. Data for the VOCs occurring at concentrations greater than 1,000 ug/l are summarized below:

VOC	Concentration (ug/l) 9-74	43-87*
1,1-DCE	703-48,000	32,687
1,1,1-TCA	4U-30,250	12,734
t-1,2-DCE	5U	5,070
CCl_4	4U-28,000	2,170
TCE	11,000-72,000	6,999
PCE	2,400-13,200	4,259

* Sample collected 12/17/87.

It appears these wells are within or near the major source of VOC contamination at the 881 Hillside Area. Alluvial ground-water flow is to the south, toward the South Interceptor Ditch and Woman Creek. The hydrogeologic data suggest that ground water discharges either to the surface water of the South Interceptor Ditch and Woman Creek drainage or continues movement as ground water within the valley fill alluvium of Woman Creek.

It appears volatilization, adsorption, and dilution have reduced VOC concentrations to non-detectable levels as alluvial ground water migrates to the south into the valley fill alluvium of Woman Creek. VOCs have not been detected at well 64-86 (located downgradient of the 881 Hillside Area and approximately 1.5 miles within the plant boundary) and have been reduced to low concentrations at well 4-87 located further upgradient at the 881 Hillside Area. Because VOCs are not migrating in alluvial ground water beyond the facility boundary, there is no impact to the public health from those contaminants via this pathway.

Uranium, selenium, nickel, and strontium contamination of alluvial ground water may exist at the 881 Hillside Area. It cannot be definitely stated whether the elevated uranium, metals, and major ion concentrations represent contamination or only reflect natural geochemical variations in ground water. The maximum concentration of uranium 233+234 [29.3(3.9) pCi/l], uranium 235 [1.3(0.6) pCi/l], and uranium 238 [25.3(3.4) pCi/l] occurred at well 6-87. However, downgradient at well 64-86 in the Woman Creek valley fill alluvium, concentrations were within background levels [at well 64-86, uranium 233+234 was 1.7(1.0) pCi/l, uranium 235 was not detected, and uranium 238 was 2.1(1.0) pCi/l]. The maximum selenium concentration (2.1 mg/l) occurred at well 10-74, but selenium was below detection limits at well 64-86. The maximum nickel concentration at the site occurred at well 4-87 (0.33 mg/l). At well 64-86, nickel was detected at 0.43 mg/l for a sample collected on 4/26/87 but was undetected (0.0037U mg/l) for a sample collected on 7/17/87. Further downgradient at well 65-86, nickel was detected once at 0.053 mg/l and was otherwise not detected during three other samplings. The maximum strontium concentration occurred at well 4-87 (2.43 mg/l). Downgradient within the Woman Creek valley fill alluvium, strontium was observed at the concentrations shown below:

Well	Concentration Range (mg/l)
64-86	0.42-0.70
65-86	0.53-0.79
66-86	0.21-0.27
1-86	0.19-0.42

These wells are listed upgradient to downgradient with well 1-86 located at the property boundary. As can be seen, strontium concentrations are reduced as alluvial ground-water flow approaches the boundary and is at or near background levels (0.20

mg/l) at the boundary. Thus, metals and uranium do not pose a present public health impact.

Because both deep and shallow bedrock ground water have similar inorganic characteristics, and the deep bedrock water bearing units are not being impacted by the 881 Hillside Area, metals and other inorganic species above background cannot be definitively attributed to contamination. There are two possible exceptions. As mentioned, alluvial ground water at the 881 Hillside Area contains elevated concentrations of both selenium and nitrate. At well 5-87, which is completed in a sandstone that subcrops beneath the 881 Hillside Area, nitrate and selenium concentrations are unusually high relative to deep bedrock ground water. However, the nitrate concentrations (8.6-9.6 mg/l) are below the primary drinking water standard (10 mg/l) and the selenium concentration (0.13 mg/l) is questionable because the most recent data (10/13/87) show selenium non-detected (0.005U). At well 59-86, selenium (0.04-0.15 mg/l) and nitrate (1.1-2.56 mg/l) are also present. It may be that the sandstone in which well 59-86BR is completed subcrops at the 881 Hillside Area and is thus recharged by alluvial ground water. It is likely that selenium is attenuated as ground water moves through bedrock sandstones as is apparent in the alluvial system. Thus, it is unlikely a public health impact would result from selenium or nitrate. Organics detected in bedrock ground water were either attributable to laboratory contamination, or were present at near detection limits and in subsequent samplings were not detected.

9.2.4 Exposure to Contaminated Surface Water

Surface waters of Woman Creek and the South Interceptor Ditch flow to Ponds C-1 and C-2, respectively, and discharges from these ponds to Woman Creek are

monitored in accordance with the Plant's NPDES permit. Sampling of the ponds indicate no VOCs are present, and radionuclides, metals, and major ions are within background levels. VOCs present in the 881 Building footing drain are diluted and/or volatilized quickly before the water enters Pond C-2. Elevated uranium 238 occurs in the South Interceptor Ditch upgradient of the 881 Hillside Area, but concentrations decrease to background levels at Pond C-2.

It is concluded that any contamination present in surface water near the 881 Hillside Area is removed by natural processes before the water migrates far from these areas. No contaminated surface water is leaving the Plant. Therefore, there is no off-site contaminant transport via this pathway, and consequently no public health impact from contaminated surface water.

9.3 ENVIRONMENTAL IMPACTS

As discussed in the previous section, environmental contamination originating from the 881 Hillside Area appears to be entirely confined to the general area. This contamination of soils, ground water, and surface water can be considered environmental impacts. Air contamination is unlikely to be occurring, even directly over this Area.

The Area is not used, nor intended for use as a public or recreational area, nor for the development of any unique natural resource. No unique ecosystems or endangered species have been observed at the Plant during extensive biological studies. The biota or flora present at the area does not exhibit obvious stress. For all of these reasons, there are no ecological impacts due to contamination at the 881 Hillside Area.

9.4 CONCLUSIONS

It is concluded that there is no imminent threat to the public health and environment by contaminants at the 881 Hillside Area. However, the travel time for a non-attenuated contaminant to reach the property boundary in the Valley Fill Alluvium is on the order of 80 years, and furthermore, the Risk Assessment (Rockwell International, 1988) documents that under these conditions an unacceptable risk could be posed to the public by consumption of contaminated alluvial ground water. Therefore, a feasibility study has been undertaken to select an appropriate remedial action.

Section 10.0

10.0 REFERENCES

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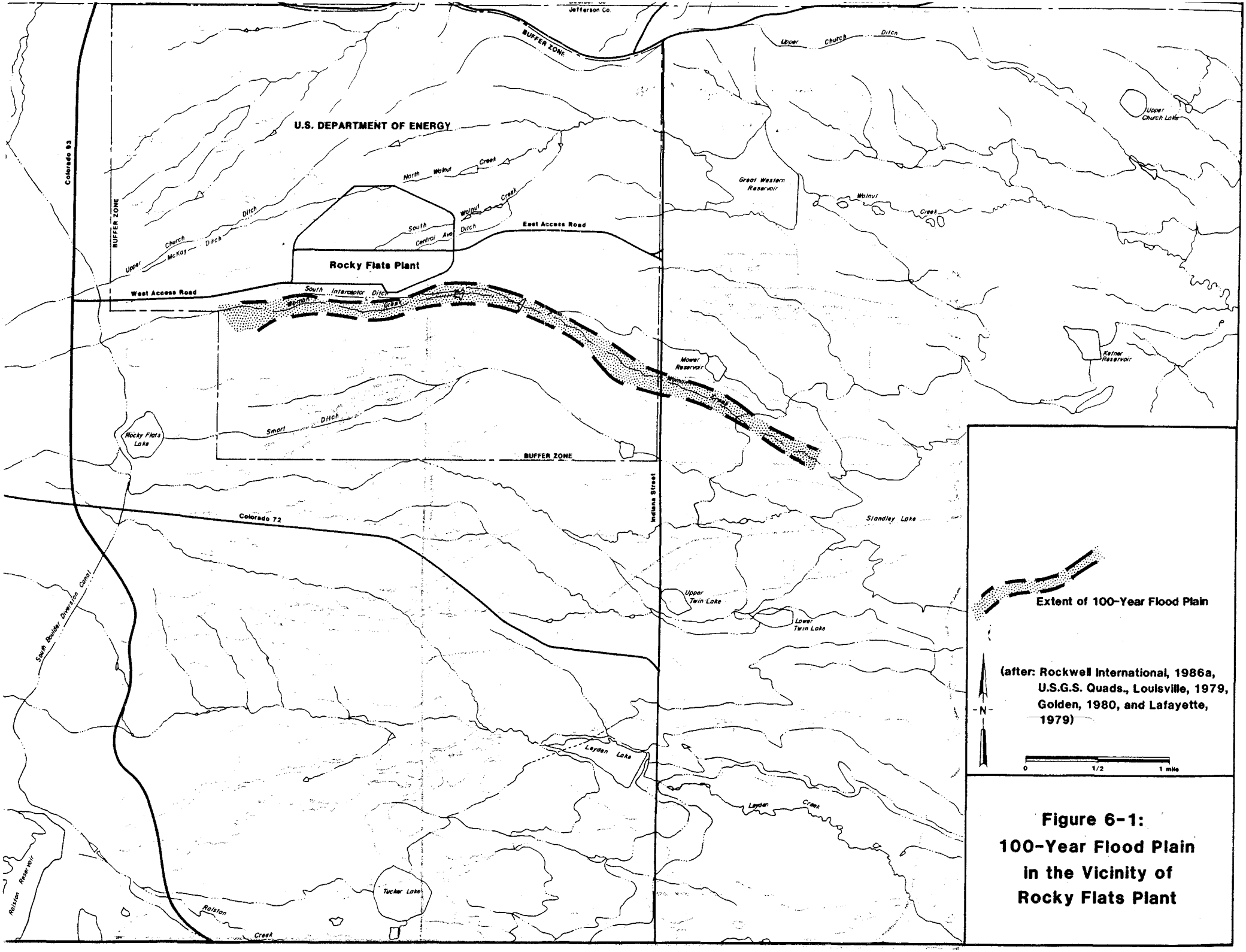


Figure 6-1: 100-Year Flood Plain in the Vicinity of Rocky Flats Plant

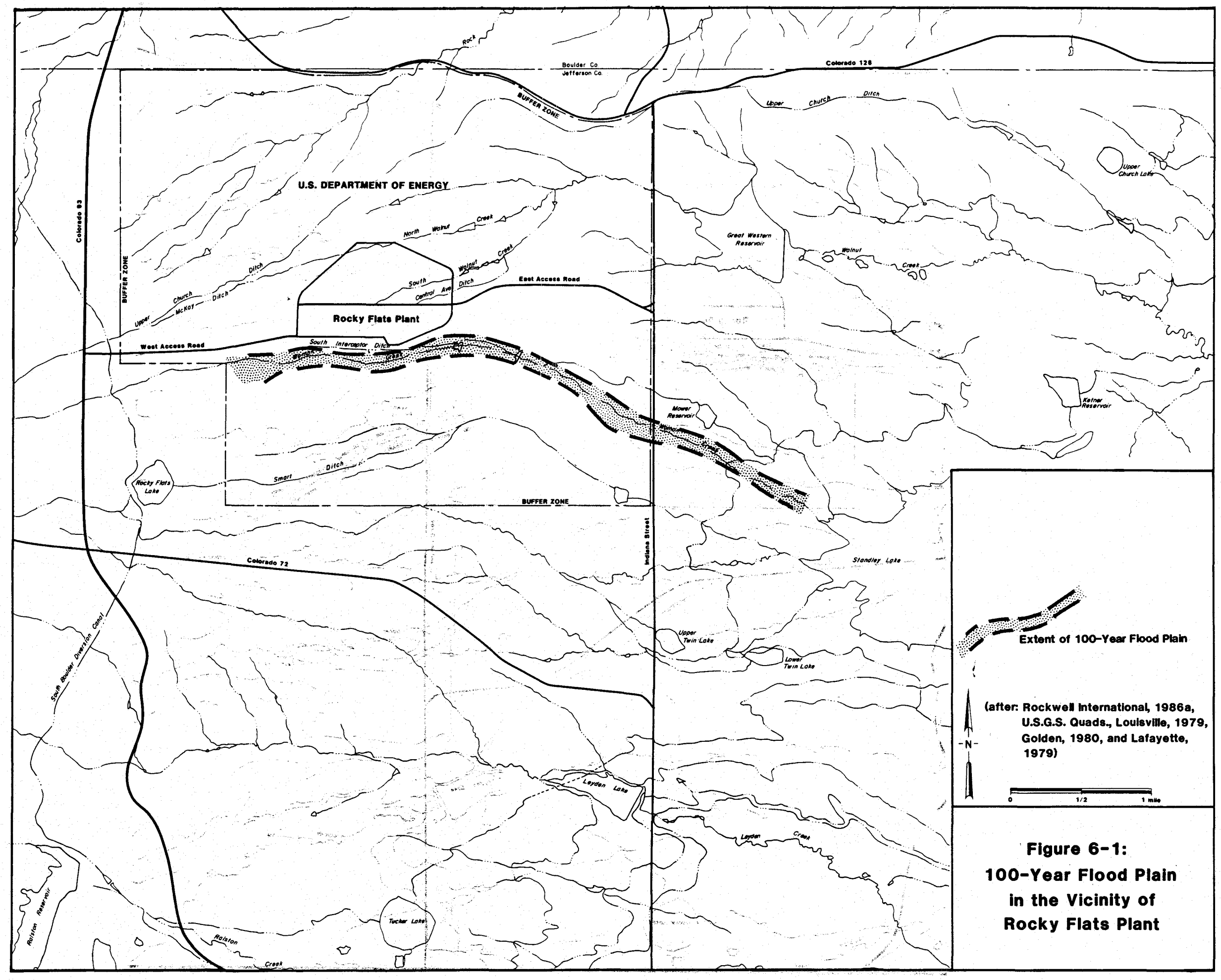
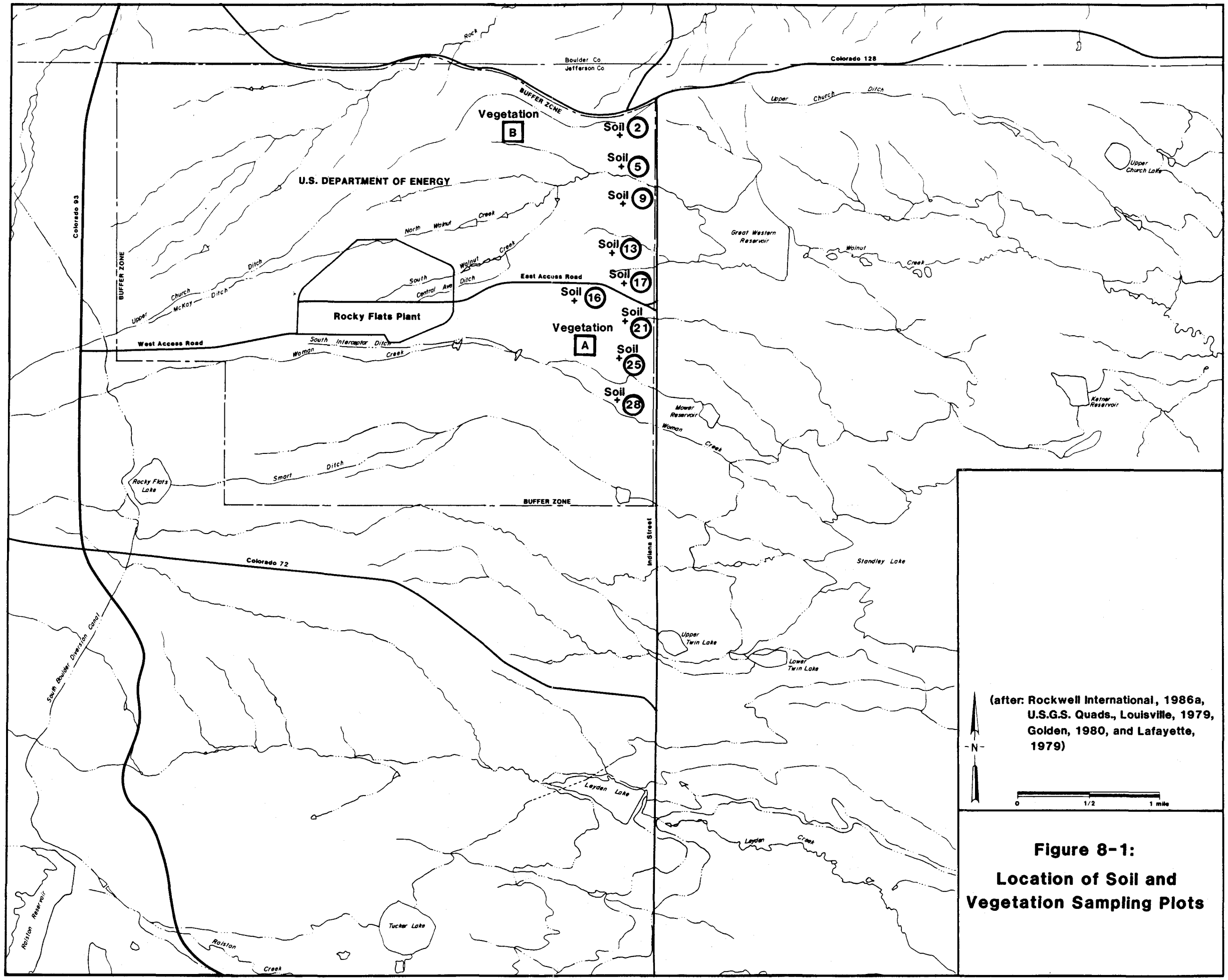
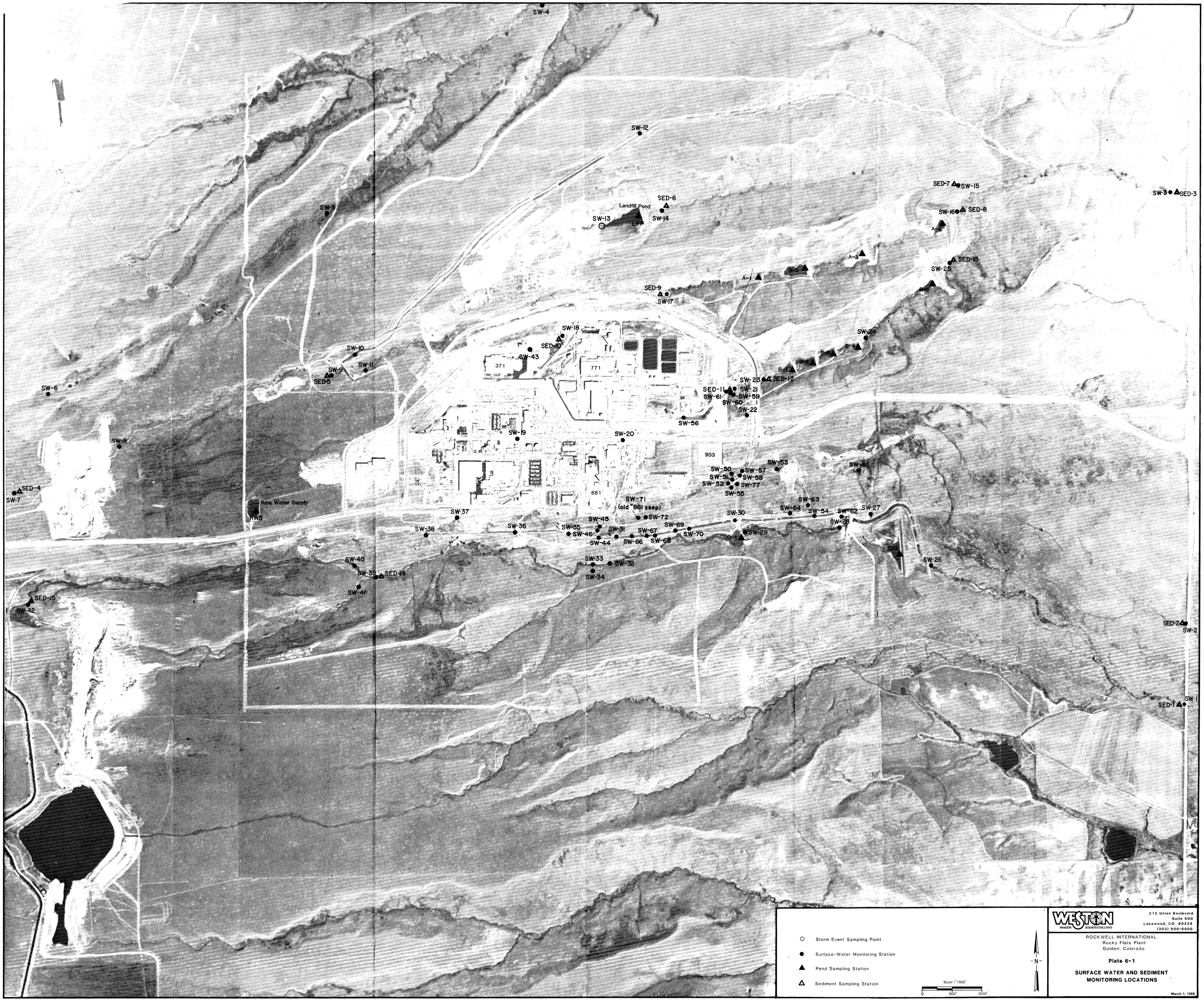


Figure 6-1:
100-Year Flood Plain in the Vicinity of Rocky Flats Plant



(after: Rockwell International, 1986a, U.S.G.S. Quads., Louisville, 1979, Golden, 1980, and Lafayette, 1979)

Figure 8-1:
Location of Soil and Vegetation Sampling Plots



- Storm Event Sampling Point
- Surface-Water Monitoring Station
- Pond Sampling Station
- Sediment Sampling Station

Scale 1"=500'
0 500' 1000'

-N-

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Plate 6-1

SURFACE WATER AND SEDIMENT MONITORING LOCATIONS

March 1, 1988