Table 2.9-26 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Crow Butte

Radionuclide	Sampling Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
January 2011				
Lead 210	<0.8 U	0.8	<0.8 U	0.8
Lead 210 MDC	0.8	--	0.8	--
Lead 210 precision (±)	0.5	--	0.5	--
Polonium 210	<0.7 U	0.7	<0.7 U	0.7
Polonium 210 MDC	0.7	--	0.7	--
Polonium 210 precision (±)	0.5	--	0.4	--
Radium 226	1.3	0.16	1.3	0.14
Radium 226 MDC	0.16	--	0.14	--
Radium 226 precision (±)	0.25	--	0.24	--
Thorium 230	<0.2 U	0.2	<0.1 U	0.1
Thorium 230 MDC	0.2	--	0.1	--
Thorium 230 precision (±)	0.1	--	0.05	--
Uranium Activity (uCi/ml)	5.9E-09	2.0E-10	5.1E-09	2.0E-10
Uranium (metal) (mg/l)	8.7E-03	3.0E-04	7.6E-03	3.0E-04
February 2011				
Lead 210	<1 U	1.2	<1 U	1.2
Lead 210 MDC	1.2	--	1.2	--
Lead 210 precision (±)	0.7	--	0.7	--
Polonium 210	0.8	0.5	<1 U	0.9
Polonium 210 MDC	0.5	--	0.9	--
Polonium 210 precision (±)	0.6	--	0.3	--
Radium 226	1.3	0.09	0.46	0.11
Radium 226 MDC	0.09	--	0.11	--
Radium 226 precision (±)	0.2	--	0.14	--
Thorium 230	<0.2 U	0.2	<0.2 U	0.2
Thorium 230 MDC	0.2	--	0.2	--
Thorium 230 precision (±)	0.08	--	0.07	--
Uranium Activity (uCi/ml)	5.4E-09	2.0E-10	4.9E-09	2.0E-10
Uranium (metal) (mg/l)	7.9E-03	3.0E-04	7.3E-03	3.0E-04
March 2011				
Lead 210	<0.9 U	0.9	<0.9 U	0.9
Lead 210 MDC	0.9	--	0.9	--
Lead 210 precision (±)	0.5	--	0.5	--
Polonium 210	<0.6 U	0.6	<0.6 U	0.6
Polonium 210 MDC	0.6	--	0.6	--
Polonium 210 precision (±)	0.3	--	0.4	--
Radium 226	0.56	0.12	1	0.12

Table 2.9-26 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Crow Butte

Radionuclide	Sampling Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
Radium 226 MDC	0.12	--	0.12	--
Radium 226 precision (±)	0.15	--	0.19	--
Thorium 230	<0.3 U	0.3	<0.1 U	0.1
Thorium 230 MDC	0.3	--	0.1	--
Thorium 230 precision (±)	0.1	--	0.07	--
Uranium Activity (uCi/ml)	5.0E-09	2.0E-10	5.4E-09	2.0E-10
Uranium (metal) (mg/l)	7.4E-03	3.0E-04	8.0E-03	3.0E-04
April 2011				
Lead 210	<1.6	1.6	<0.8	0.8
Lead 210 MDC	1.6	--	0.8	--
Lead 210 precision (±)	1	--	0.5	--
Polonium 210	<0.6 U	0.6	<0.6 U	0.6
Polonium 210 MDC	0.5	--	0.6	--
Polonium 210 precision (±)	0.4	--	0.3	--
Radium 226	0.2	0.1	<0.1	0.1
Radium 226 MDC	0.1	--	0.1	--
Radium 226 precision (±)	0.09	--	0.04	--
Thorium 230	<0.2	0.2	<0.8	0.8
Thorium 230 MDC	0.2	--	0.8	--
Thorium 230 precision (±)	0.1	--	0.4	--
Uranium Activity (uCi/ml)	7.0E-09	2.0E-10	5.9E-09	2.0E-10
Uranium (metal) (mg/l)	1.04E-02	3.0E-04	8.8E-03	3.0E-04
May 2011				
Lead 210	<1.2 U	1.2	<1.2 U	1.2
Lead 210 MDC	1.2	--	1.2	--
Lead 210 precision (±)	0.7	--	0.7	--
Polonium 210	<0.6 U	0.6	<0.6 U	0.6
Polonium 210 MDC	0.6	--	0.6	--
Polonium 210 precision (±)	0.4	--	0.3	--
Radium 226	0.3	0.1	<0.2 U	0.2
Radium 226 MDC	0.1	--	0.2	--
Radium 226 precision (±)	0.1	--	0.08	--
Thorium 230	<0.2 U	0.2	<0.2 U	0.2
Thorium 230 MDC	0.2	--	0.2	--
Thorium 230 precision (±)	0.1	--	0.1	--
Uranium Activity (uCi/ml)	5.8E-09	2.0E-10	5.0E-09	2.0E-10
Uranium (metal) (mg/l)	8.5E-03	3.0E-04	7.3E-03	3.0E-04

Table 2.9-26 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Crow Butte

Radionuclide	Sampling Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
June 2011				
Lead 210	<1.1 U	1.1	<1.1 U	1.1
Lead 210 MDC	1.1	--	1.1	--
Lead 210 precision (±)	0.6	--	0.7	--
Polonium 210	<0.4 U	0.4	<0.4 U	0.4
Polonium 210 MDC	0.4	--	0.4	--
Polonium 210 precision (±)	0.2	--	0.2	--
Radium 226	0.27	0.15	0.17	0.16
Radium 226 MDC	0.15	--	0.16	--
Radium 226 precision (±)	0.13	--	0.12	--
Thorium 230	<0.1 U	0.1	<0.3 U	0.3
Thorium 230 MDC	0.1	--	0.3	--
Thorium 230 precision (±)	0.04	--	0.2	--
Uranium Activity (uCi/ml)	1.2E-09	2.0E-10	3.3E-09	2.0E-10
Uranium (metal) (mg/l)	6.3E-03	3.0E-04	4.8E-03	3.0E-04
July 2011				
Lead 210	<0.8 U	0.8	<0.8 U	0.8
Lead 210 MDC	0.8		0.8	
Lead 210 precision (±)	0.5		0.5	
Polonium 210	<0.7U	0.7	<0.8 U	0.8
Polonium 210 MDC	0.7		0.8	
Polonium 210 precision (±)	0.4		0.6	
Radium 226	<0.1 U	0.1	<0.1 U	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.05		0.07	
Thorium 230	<0.1 U	0.1	<0.4 U	0.4
Thorium 230 MDC	0.1		0.4	
Thorium 230 precision (±)	0.08		0.2	
Uranium Activity (uCi/ml)	4.8E-09	2.0E-10	3.6E-09	2.0E-10
Uranium (metal) (mg/l)	7.1E-03	3.0E-04	5.3E-03	3.0E-04
August 2011				
Lead 210	<0.6 U	0.6	<0.6 U	0.6
Lead 210 MDC	0.6		0.6	
Lead 210 precision (±)	0.4		0.4	
Polonium 210	<0.4 U	0.4	<0.6 U	0.6
Polonium 210 MDC	0.4		0.6	
Polonium 210 precision (±)	0.2		0.2	
Radium 226	0.52	0.15	<0.14 U	0.14
Radium 226 MDC	0.15		0.14	

Table 2.9-26 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Crow Butte

Radionuclide	Sampling Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
Radium 226 precision (±)	0.15		0.1	
Thorium 230	<0.2 U	0.2	<0.2 U	0.2
Thorium 230 MDC	0.2		0.2	
Thorium 230 precision (±)	0.07		0.08	
Uranium Activity (uCi/ml)	2.4E-10	2.0E-10	5.2E-09	2.0E-10
Uranium (metal) (mg/l)	4.0E-04	3.0E-04	7.7E-03	3.0E-04
September 2011				
Lead 210	<0.7 U	0.7	<0.7 U	0.7
Lead 210 MDC	0.7		0.7	
Lead 210 precision (±)	0.4		0.4	
Polonium 210	<0.4 U	0.4	<0.6 U	0.6
Polonium 210 MDC	0.4		0.6	
Polonium 210 precision (±)	0.2		0.5	
Radium 226	0.52	0.15	<0.14 U	0.14
Radium 226 MDC	0.2		0.2	
Radium 226 precision (±)	0.2		0.1	
Thorium 230	<0.2 U	0.2	<0.2 U	0.2
Thorium 230 MDC	0.2		0.2	
Thorium 230 precision (±)	0.07		0.06	
Uranium Activity (uCi/ml)	5.0E-09	2.0E-10	4.5E-09	2.0E-10
Uranium (metal) (mg/l)	7.3E-03	3.0E-04	6.6E-03	3.0E-04
October 2011				
Lead 210	<0.8 U	0.8	<0.8 U	0.8
Lead 210 MDC	0.8		0.8	
Lead 210 precision (±)	0.5		0.5	
Polonium 210	<0.9 U	0.9	3.2	0.6
Polonium 210 MDC	0.9		0.6	
Polonium 210 precision (±)	0.5		1.3	
Radium 226	1	0.1	0.1	0.09
Radium 226 MDC	0.1		0.09	
Radium 226 precision (±)	0.2		0.07	
Thorium 230	<0.3 U	0.3	<0.1 U	0.1
Thorium 230 MDC	0.3		0.1	
Thorium 230 precision (±)	0.1		0.07	
Uranium Activity (uCi/ml)	6.8E-09	2.0E-10	6.1E-09	2.0E-10
Uranium (metal) (mg/l)	1.0E-02	3.0E-04	9.0E-03	3.0E-04

Table 2.9-26 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Crow Butte

Radionuclide	Sampling Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
November 2011				
Lead 210	<1.0 U	1	<1.0 U	1
Lead 210 MDC	1		1	
Lead 210 precision (±)	0.7		0.7	
Polonium 210	<0.5 U	0.5	4.6	0.5
Polonium 210 MDC	0.5		0.5	
Polonium 210 precision (±)	0.3		1.6	
Radium 226	1.2	0.1	0.2	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.2		0.1	
Thorium 230	<0.2 U	0.2	<0.2 U	0.2
Thorium 230 MDC	0.2		0.2	
Thorium 230 precision (±)	0.08		0.09	
Uranium Activity (uCi/ml)	6.1E-09	2.0E-10	5.0E-09	2.0E-10
Uranium (metal) (mg/l)	9.0E-03	3.0E-04	7.5E-03	3.0E-04
January 2012				
Lead 210	<0.9 U	0.9	<0.9 U	0.9
Lead 210 MDC	0.9		0.9	
Lead 210 precision (±)	0.5		0.5	
Polonium 210	0.8	0.6	<0.6 U	0.6
Polonium 210 MDC	0.6		0.6	
Polonium 210 precision (±)	0.7		0.4	
Radium 226	1.7	0.1	0.2	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.3		0.1	
Thorium 230	<0.1 U	0.1	<0.2 U	0.2
Thorium 230 MDC	0.1		0.2	
Thorium 230 precision (±)	0.06		0.06	
Uranium Activity (uCi/ml)	1.2E-09	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	1.8E-03	3.0E-04	<3.0E-04	3.0E-04

Notes:

MDC = minimum detectable concentration

mg/l = milligrams per liter

pCi/l = picoCuries per liter

RL = reporting limit

U = Not detected at minimum detectable concentration

uCi/l = microCuries per liter

Table 2.9-27 Niobrara River Suspended Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte	Sample Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
January 2011				
Lead 210	<1.0 U	1	<1.1U	1.1
Lead 210 MDC	1	--	1.1	--
Lead 210 precision (±)	0.6	--	0.6	--
Polonium 210	<0.3 U	0.3	<0.3 U	0.3
Polonium 210 MDC	0.3	--	0.3	--
Polonium 210 precision (±)	0.1	--	0.1	--
Radium 226	<0.18 U	0.18	<0.13 U	0.13
Radium 226 MDC	0.18	--	0.13	--
Radium 226 precision (±)	0.08	--	0.07	--
Thorium 230	<0.2 U	0.2	<0.06 U	0.06
Thorium 230 MDC	0.2	--	0.06	--
Thorium 230 precision (±)	0.2	--	0.04	--
Uranium Activity (uCi/ml)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-07
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04
February 2011				
Lead 210	1.4	1	<1 U	0.9
Lead 210 MDC	1	--	0.9	--
Lead 210 precision (±)	0.6	--	0.5	--
Polonium 210	<0.5 U	0.5	<0.2 U	0.2
Polonium 210 MDC	0.5	--	0.2	--
Polonium 210 precision (±)	0.2	--	0.2	--
Radium 226	<0.2 U	0.19	<0.2 U	0.19
Radium 226 MDC	0.19	--	0.19	--
Radium 226 precision (±)	0.13	--	0.08	--
Thorium 230	<0.1 U	0.1	<0.1 U	0.1
Thorium 230 MDC	0.1	--	0.1	--
Thorium 230 precision (±)	0.09	--	0.07	--
Uranium Activity (uCi/ml)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04
March 2011				
Lead 210	<0.9 U	0.9	<0.9 U	0.9
Lead 210 MDC	0.9	--	0.9	--
Lead 210 precision (±)	0.5	--	0.5	--
Polonium 210	<0.2 U	0.2	0.3	0.2
Polonium 210 MDC	0.2	--	0.2	--
Polonium 210 precision (±)	0.1	--	0.3	--
Radium 226	<0.13 U	0.13	<0.13 U	0.13
Radium 226 MDC	0.13	--	0.13	--
Radium 226 precision (±)	0.06	--	0.06	--
Thorium 230	<0.1 U	0.1	<0.1 U	0.1
Thorium 230 MDC	0.1	--	0.1	--
Thorium 230 precision (±)	0.1	--	0.1	--
Uranium Activity (uCi/ml)	<2.0E-10	2.0E-10	3.4E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	5.0E-04	3.0E-04

Table 2.9-27 Niobrara River Suspended Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte	Sample Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
April 2011 No suspended analyses performed				
May 2011				
Lead 210	<1.1 U	1.1	<0.9 U	0.9
Lead 210 MDC	1.1	--	0.9	--
Lead 210 precision (±)	0.6	--	0.5	--
Polonium 210	<0.2 U	0.2	<0.2 U	0.2
Polonium 210 MDC	0.2	--	0.2	--
Polonium 210 precision (±)	0.2	--	0.1	--
Radium 226	<0.1 U	0.1	<0.1 U	0.1
Radium 226 MDC	0.1	--	0.1	--
Radium 226 precision (±)	0.06	--	0.04	--
Thorium 230	<0.1 U	0.1	<0.1 U	0.1
Thorium 230 MDC	0.1	--	0.1	--
Thorium 230 precision (±)	0.06	--	0.06	--
Uranium Activity (uCi/ml)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04
June 2011				
Lead 210	<9.0 U	9	<0.8 U	0.8
Lead 210 MDC	9	--	0.8	--
Lead 210 precision (±)	5.3	--	0.5	--
Polonium 210	<0.2 U	0.2	<0.2 U	0.2
Polonium 210 MDC	0.2	--	0.2	--
Polonium 210 precision (±)	0.2	--	0.1	--
Radium 226	<0.13 U	0.13	<0.12 U	0.12
Radium 226 MDC	0.13	--	0.12	--
Radium 226 precision (±)	0.07	--	0.06	--
Thorium 230	0.07	0.05	<0.04 U	0.04
Thorium 230 MDC	0.05	--	0.04	--
Thorium 230 precision (±)	0.04	--	0.03	--
Uranium Activity (uCi/mL)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04
July 2011				
Lead 210	0.7	0.5	<0.5 U	0.5
Lead 210 MDC	0.5		0.5	
Lead 210 precision (±)	0.3		0.3	
Polonium 210	<0.2 U	0.7	<0.2 U	0.2
Polonium 210 MDC	0.2		0.2	
Polonium 210 precision (±)	0.2		0.1	
Radium 226	<0.1 U	0.2	<0.1 U	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.06		0.09	
Thorium 230	<0.1 U	0.1	<0.1 U	0.1
Thorium 230 MDC	0.1		0.1	
Thorium 230 precision (±)	0.08		0.08	

Table 2.9-27 Niobrara River Suspended Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte	Sample Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
Uranium Activity (uCi/mL)	3.6E-09	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	5.0E-04	3.0E-04	<3.0E-04	3.0E-04
August 2011				
Lead 210	<0.8 U	<0.8	<0.7 U	0.7
Lead 210 MDC	0.8	0.8	0.7	
Lead 210 precision (±)	0.5	0.5	0.4	
Polonium 210	0.4	0.4	<0.3 U	0.3
Polonium 210 MDC	0.2	0.2	0.3	
Polonium 210 precision (±)	0.3	0.3	0.2	
Radium 226	0.14	0.14	<0.08 U	0.08
Radium 226 MDC	0.08	0.08	0.08	
Radium 226 precision (±)	0.07	0.07	0.05	
Thorium 230	0.1	0.1	0.1	0.07
Thorium 230 MDC	0.05	0.05	0.07	
Thorium 230 precision (±)	0.05	0.05	0.05	
Uranium Activity (uCi/mL)	2.4E-10	2.0E-10	2.2E-10	2.0E-10
Uranium (metal) (mg/l)	4.0E-04	3.0E-04	3.0E-04	3.0E-04
September 2011				
Lead 210	<0.6 U	0.6	<0.6 U	0.6
Lead 210 MDC	0.6		0.6	
Lead 210 precision (±)	0.3		0.3	
Polonium 210	<0.2 U	0.2	0.3	0.2
Polonium 210 MDC	0.2		0.2	
Polonium 210 precision (±)	0.1		0.2	
Radium 226	0.1	0.1	0.1	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.06		0.06	
Thorium 230	0.2	0.1	0.2	0.1
Thorium 230 MDC	0.1		0.1	
Thorium 230 precision (±)	0.1		0.1	
Uranium Activity (uCi/mL)	2.2E-10	2.0E-10	4.5E-09	2.0E-10
Uranium (metal) (mg/l)	3.0E-04	3.0E-04	6.6E-03	3.0E-04
October 2011				
Lead 210	<0.5 U	0.5	<0.9 U	0.9
Lead 210 MDC	0.5		0.9	
Lead 210 precision (±)	0.3		0.6	
Polonium 210	0.3	0.3	0.3	0.3
Polonium 210 MDC	0.3		0.3	
Polonium 210 precision (±)	0.2		0.3	
Radium 226	<0.06 U	0.06	0.08	0.06
Radium 226 MDC	0.06		0.06	
Radium 226 precision (±)	0.03		0.05	

Table 2.9-27 Niobrara River Suspended Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte	Sample Locations			
	N1 (Niobrara River West Side)		N2 (Niobrara River East Side)	
	RESULTS	RL	RESULTS	RL
	pCi/l			
Thorium 230	0.2	0.1	0.2	0.1
Thorium 230 MDC	0.1		0.1	
Thorium 230 precision (±)	0.1		0.1	
Uranium Activity (uCi/mL)	2.3E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	3.0E-04 B	3.0E-04	<3.0E-04	3.0E-04
November 2011				
Lead 210	<0.6 U	0.6	<0.7 U	0.7
Lead 210 MDC	0.6		0.7	
Lead 210 precision (±)	0.4		0.4	
Polonium 210	<0.4 U	0.4	<0.4 U	0.4
Polonium 210 MDC	0.4		0.4	
Polonium 210 precision (±)	0.2		0.3	
Radium 226	0.1	0.1	0.1	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.05		0.05	
Thorium 230	0.1	0.1	<0.1 U	0.1
Thorium 230 MDC	0.1		0.1	
Thorium 230 precision (±)	0.07		0.07	
Uranium Activity (uCi/mL)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04
January 2012				
Lead 210	<0.7 U	0.7	<0.8 U	0.8
Lead 210 MDC	0.7		0.8	
Lead 210 precision (±)	0.4		0.5	
Polonium 210	<0.8 U	0.8	<0.8 U	0.8
Polonium 210 MDC	0.8		0.8	
Polonium 210 precision (±)	0.3		0.3	
Radium 226	<0.1 U	0.1	<0.1 U	0.1
Radium 226 MDC	0.1		0.1	
Radium 226 precision (±)	0.05		0.07	
Thorium 230	<0.1 U	0.1	0.2	0.1
Thorium 230 MDC	0.1		0.1	
Thorium 230 precision (±)	0.08		0.1	
Uranium Activity (uCi/mL)	<2.0E-10	2.0E-10	<2.0E-10	2.0E-10
Uranium (metal) (mg/l)	<3.0E-04	3.0E-04	<3.0E-04	3.0E-04

Notes:

B = Analyte was detected in the method blank

U = Not detected at minimum detectable concentration

MDC = minimum detectable concentration

pCi/l = picoCuries per liter

RL = reporting limit

uCi/ml = microCuries per milliliter

Table 2.9-28 Niobrara River Non-Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte Group	Units	N1 (Niobrara River West Site) 2/11/2011		N1 (Niobrara River West Site) 5/16/2011		N1 (Niobrara River West Site) 6/24/2011		N1 (Niobrara River West Site) 8/12/2011		N1 (Niobrara River West Site) 11/28/2011		N1 (Niobrara River West Site) 1/13/2012	
		RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
Major Ions													
Alkalinity Total as CaCO3	mg/L	230	1	261	1	235	1	185	1	208	1	187	1
Bicarbonate as HCO3	mg/L	271	1	297	1	286	1	226	1	254	1	229	1
Carbonate as CO3	mg/L	5	1	10	1	<1	1	<1	1	<1	1	<1	1
Calcium	mg/L	60	1	58	1	53	1	46	1	53	1	52	1
Chloride	mg/L	6	1	6	1	4	1	5	1	5	1	5	1
Fluoride	mg/L	0.7	0.1	0.8	0.1	0.7	0.1	0.7	0.1	0.7	0.1	0.7	0.1
Magnesium	mg/L	11	1	12	1	11	1	9	1	11	1	9	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.4	0.1	0.2	0.1	0.4	0.1	1	0.1	1.1	0.1	1.5	0.1
Potassium	mg/L	8	1	10	1	8	1	6	1	8	1	8	1
Silica	mg/L	62.4	0.2	41.3	0.2	45.2	0.2	58.1	0.2	53.1	0.2	58.1	0.2
Sodium	mg/L	22	1	38	1	25	1	24	1	23	1	22	1
Sulfate	mg/L	13	1	12	1	10	1	13	1	15	1	13	1
Physical Properties													
Conductivity @ 25 C	umhos/cm	460	1	498	1	443	1	388	1	440	1	422	1
pH	s.u.	8.11	0.01	8.38	0.01	8.16	0.01	8.2	0.01	8.05	0.01	8.13	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	315	10	335	10	313	10	262	10	276	10	252	10
Metals Dissolved													
Aluminum	mg/L	<0.1	0.1	0.2	0.1	<0.1	0.1	0.2	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.006	0.001	0.008	0.001	0.006	0.001	0.007	0.001	0.006	0.001	<0.001	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.03	0.03	0.2	0.03	0.07	0.03	0.27	0.03	0.04	0.03	<0.03	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	<0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	<0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.01	<0.01	0.01
Data Quality													
A/C Balance (± 5)	%	-0.594	--	1.1	--	-2.06		-0.351	--	-0.0267	--	1.95	--
Anions	meq/L	5.16	--	5.69	--	5.07		4.21	--	4.73	--	4.31	--
Cations	meq/L	5.1	--	5.82	--	4.87		4.18	--	4.72	--	4.48	--
Solids Total Dissolved Calculated	mg/L	344	--	342	--	312		292	--	312	--	302	--

Notes:

meq/L = milliequivalents per liter

mg/L = milligrams per liter

ND = not detected

RL = reporting limit

s.u. = standard units

umhos/cm = micromhos per centimeter

Table 2.9-28 Niobrara River Non-Radiological Water Quality Baseline Data Collected by Crow Butte

Analyte Group	Units	N2 (Niobrara River East Site)		N2 (Niobrara River East Site)		N2 (Niobrara River East Site)		N2 (Niobrara River East Site)		N2 (Niobrara River East Site)		N2 (Niobrara River East Site)	
		2/11/2011		5/16/2011		6/24/2011		8/12/2011		11/28/2011		1/13/2011	
		RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
Major Ions													
Alkalinity Total as CaCO3	mg/L	223	1	253	1	253	1	180	1	184	1	211	1
Bicarbonate as HCO3	mg/L	262	1	290	1	308	1	219	1	224	1	257	1
Carbonate as CO3	mg/L	5	1	9	1	<1	1	<1	1	<1	1	<1	1
Calcium	mg/L	57	1	56	1	54	1	48	1	49	1	57	1
Chloride	mg/L	5	1	5	1	5	1	5	1	5	1	6	1
Fluoride	mg/L	0.7	0.1	0.8	0.1	0.8	0.1	0.7	0.1	0.7	0.1	0.7	0.1
Magnesium	mg/L	10	1	12	1	12	1	9	1	9	1	10	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<1	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.2	0.1	<0.1	0.1	<0.1	0.1	0.9	0.1	1.3	0.1	1.6	0.1
Potassium	mg/L	7	1	9	1	11	1	7	1	7	1	9	1
Silica	mg/L	59.1	0.2	41.6	0.2	48.4	0.2	64.8	0.2	58.6	0.2	63	0.2
Sodium	mg/L	20	1	36	1	29	1	24	1	23	1	23	1
Sulfate	mg/L	12	1	12	1	9	1	13	1	14	1	17	1
Physical Properties													
Conductivity @ 25 C	umhos/cm	437	1	478	1	481	1	387	1	406	1	475	1
pH	s.u.	7.91	0.01	8.3	0.01	7.84	0.01	8.21	0.01	8.16	0.01	7.92	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	302	10	326	10	334	10	258	10	275	10	300	10
Metals Dissolved													
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.3	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.005	0.001	0.006	0.001	0.006	0.001	0.007	0.001	0.006	0.001	0.006	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.105	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	0.04	0.03	0.08	0.03	0.04	0.03	0.3	0.03	0.03	0.03	0.04	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	0.02	0.01	<0.01	0.01	0.04	0.01	0.06	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	<0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01
Data Quality													
A/C Balance (± 5)	%	-2.5	--	0.802	--	-1.79	--	2.51	--	2.19	--	0.624	--
Anions	meq/L	4.95	--	5.5	--	5.42	--	4.11	--	4.22	--	4.9	--
Cations	meq/L	4.71	--	5.58	--	5.23	--	4.32	--	4.41	--	4.96	--
Solids Total Dissolved Calculated	mg/L	325	--	330	--	334	--	300	--	298	--	333	--

Notes:

MDC = Minimum detectable concentration

pCi/L - picocuries per liter

RL = reporting limit

mg/L = milligrams per liter

meq/L = milliequivalents per liter

s.u. = standard units

umhos/cm = micromhos per centimeter

Table 2.9-29 Summary of Non-Radiological Baseline Data for Niobrara River Near Marsland Expansion Area Collected by Crow Butte

Analytes	Units	Crow Butte Niobrara River Sampling Locations			
		N-1		N-2	
		Minimum	Maximum	Minimum	Maximum
Alkalinity	mg/l	185	235	180	253
Bicarbonate	mg/l	226	297	219	308
Carbonate	mg/l	<1	5	<1	9
Conductivity @ 25° C	umhos/cm	388	498	387	481
Calcium	mg/l	46	60	48	57
Chloride	mg/l	4	6	5	6
Fluoride	mg/l	0.7	0.8	0.7	0.7
Magnesium	mg/l	9	12	9	12
Nitrogen Ammonia as N	mg/l	<0.05	<0.05	<0.05	<1.0
Nitrogen Nitrate-Nitrite as N	mg/l	0.4	1.5	0.9	1.6
Potassium	mg/l	6	10	7	11
Silicia	mg/l	41.3	62.4	41.6	64.8
Sodium	mg/l	22	38	20	36
Sulfate	mg/l	10	15	9	17
pH	s.u.	8.05	8.38	7.91	8.3
Total Dissolved Solids @ 180° C	mg/l	252	335	258	334
Dissolved Metals	The majority of parameters were measured at or below the RL (see Table 2.9-28.				

Individual analytical results with RLs are presented in Table 2.9-28.
s.u. = standard unit
mg/l = milligrams per liter
RL = Reporting Limit

Table 2.9-30 Daily Contents in Acre-Feet of Water for Box Butte Reservoir (USGS 06455000) – 2003 to 2010

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	Acre-feet											
2003												
Mean	8,489	9,899	11,053	12,365	13,503	13,380	11,134	5,236	4,151	4,841	5,587	6,376
Minimum	7,740	9,449	10,394	11,743	12,775	11,865	7,922	3,517	3,848	4,455	5,209	5,992
Maximum	9,390	10,359	11,818	13,167	14,000	14,588	14,051	7,805	4,434	5,176	5,974	6,950
2004												
Mean	7,182	8,138	9,232	9,969	11,743	11,610	9,468	4,779	4,018	5,142	6,205	7,266
Minimum	6,856	7,755	8,586	8,965	10,822	11,537	6,890	2,803	3,460	4,604	5,730	6,745
Maximum	7,683	8,775	9,976	11,158	11,865	11,715	11,658	7,137	4,566	5,695	6,712	7,769
2005												
Mean	8,285	9,482	10,710	12,018	13,504	14,668	12,782	7,578	5,691	6,752	7,668	8,662
Minimum	7,805	8,878	10,140	11,361	12,912	13,970	9,660	5,678	5,270	6,053	7,143	8,188
Maximum	8,839	10,089	11,324	12,872	13,949	15,158	15,137	9,593	6,035	7,110	8,151	9,169
2006												
Mean	9,811	10,956	12,473	14,207	14,968	14,703	9,481	4,465	3,891	4,084	4,497	4,815
Minimum	9,202	10,429	11,537	13,555	14,715	13,687	5,962	3,522	3,599	3,834	4,096	4,588
Maximum	10,385	11,500	13,475	14,683	15,094	14,936	13,535	5,968	4,366	4,229	4,802	5,081
2007												
Mean	5,381	6,102	6,791	--	--	11,312	7,073	3,603	3,830	4,311	4,912	5,559
Minimum	5,065	5,760	6,583	--	--	11,090	3,809	2,352	3,628	4,054	4,631	5,215
Maximum	5,730	6,524	7,063	--	--	11,445	11,213	4,721	4,019	4,609	5,192	5,895
2008												
Mean	5,019	5,570	6,636	7,923	9,034	9,502	7,200	4,212	4,308	4,699	5,474	6,130
Minimum	4,759	5,293	5,970	7,306	8,415	9,278	4,677	3,608	4,039	4,546	5,125	5,821
Maximum	5,275	5,914	7,272	8,361	9,220	9,572	9,563	4,999	4,536	4,875	5,797	6,375

Table 2.9-30 Daily Contents in Acre-Feet of Water for Box Butte Reservoir (USGS 06455000) – 2003 to 2010

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	Acre-feet											
2009												
Mean	6,682	7,375	8,360	10,159	11,859	12,619	11,155	7,021	6,273	7,029	8,508	9,733
Minimum	6,394	7.020	7,816	8,992	11,398	12,174	7,852	5,177	6,158	6,466	7,794	9,204
Maximum	7,000	7,765	8,943	11,313	12,095	12,950	13,512	8,562	6,446	7,743	9,171	10,213
2010												
Mean	10,650	11,550	13,893	16,421	18,491	20,587	20,265	13,904	11,666	12,048	12,884	13,938
Minimum	10,240	11,096	12,363	15,293	17,669	19,479	16,939	11,303	11,560	11,782	12,403	13,396
Maximum	11,068	12,293	15,180	17,644	19,440	21,432	21,500	18,366	11,782	12,373	13,344	14,523
2003–2010 Summary												
Mean [a]	7,687	8,634	9,894	11,866	13,300	13,548	11,070	6,350	5,479	6,113	6,967	7,810
Minimum	5,019	5,570	6,583	7,923	9,034	9,502	3,809	2,352	3,460	3,834	4,096	4,588
Maximum	11,068	12,293	15,180	17,644	19,440	21,432	21,500	18,366	11,782	12,373	13,344	14,523

Source: NDNR 2011a; USBR 2011b

[a] Average of average values presented in table.

Table 2.9-31 Range Values for Box Butte Reservoir Water Contents

Date	Average	Minimum	Maximum
	Acre-feet		
2003 – 2010	5,479 – 13,548	2,352 – 9,502	11,068 – 21,500

USGS Station 06455000

Table 2.9-32 Total Radionuclides and Metals in Tissue of Northern Pike Collected from Inlet of Box Butte Reservoir

Radionuclide - Total	Result [a]	Units	Qualifiers	RL
Lead 210	<1E-06	uCi/kg	U	1.E-06
Lead 210 Precision (±)	7.0E-07	uCi/kg	--	--
Lead 210 MDC	1.0E-06	uCi/kg	--	
Polonium 210	5.0E-07	uCi/kg	--	5.0E-07
Polonium 210 Precision (±)	4.E-07	uCi/kg	--	--
Polonium 210 MDC	5.0E-07	uCi/kg		
Radium 226	<2E-07	uCi/kg	U	2.0E-07
Radium 226 Precision (±)	1.0E-07	uCi/kg	--	--
Radium 226 MDC	2.0E-07	uCi/kg	--	--
Thorium 230	1.0E-05	uCi/kg	--	8.0E-06
Thorium 230 Precision (±)	6.0E-06	uCi/kg		
Thorium 230 MDC	8.0E-06	uCi/kg	--	--
Metals - Total				
Uranium, Total	<0.0003	mg/kg	--	0.0003
Uranium, Activity	<2E-07	uCi/kg	--	2.0E-07

[a] Results reported on a wet weight basis (as received) for composite of two or more samples (digestion, radiochemistry)..

uCi/kg = microcuries per kilogram.

U = Not detected at the reporting limit.

RL = Analyte reporting limit.

MDC = Minimum detectable concentration.

mg/kg – milligram per kilogram

Table 2.9-33 Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) Sample Locations

Radionuclide	Result	Units	Qualifier	Reporting Limit (RL)
	12/02/2011 (Collection Date)			
MED - 1				
Lead-210	0.2	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	--
Lead 210 MDC	0.2	pCi/g-dry	--	--
Radium 226	0.3	pCi/g-dry	--	0.02
Radium 226 precision (+)	0.04	pCi/g-dry	--	--
Radium 226 MDC	0.02	pCi/g-dry	--	--
Thorium 230	0.4	pCi/g-dry	--	0.1
Thorium 230 precision (+)	0.2	pCi/g-dry	--	--
Thorium 230 MDC	0.1	pCi/g-dry	--	--
METALS				
Uranium	0.5	mg/kg-dry	--	0.3
Uranium Activity	0.3	pCi/g-dry	--	0.2
MED - 2				
Lead-210	0.7	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	
Lead 210 MDC	0.2	pCi/g-dry	--	
Radium 226	0.4	pCi/g-dry	--	0.02
Radium 226 precision (+)	0.04	pCi/g-dry	--	
Radium 226 MDC	0.02	pCi/g-dry	--	
Thorium 230	<0.2	pCi/g-dry	U	0.2
Thorium 230 precision (+)	0.1	pCi/g-dry	--	
Thorium 230 MDC	0.2	pCi/g-dry	--	
METALS				
Uranium	0.5	mg/kg-dry	--	0.3
Uranium Activity	0.3	pCi/g-dry	--	0.2
MED - 3				
Lead-210	0.6	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	
Lead 210 MDC	0.2	pCi/g-dry	--	
Radium 226	0.4	pCi/g-dry	--	0.02

Table 2.9-33 Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) Sample Locations

Radionuclide	Result	Units	Qualifier	Reporting Limit (RL)
	12/02/2011 (Collection Date)			
Radium 226 precision (+)	0.04	pCi/g-dry	--	
Radium 226 MDC	0.02	pCi/g-dry	--	
Thorium 230	0.2	pCi/g-dry	--	0.2
Thorium 230 precision (+)	0.1	pCi/g-dry	--	
Thorium 230 MDC	0.2	pCi/g-dry	--	
METALS				
Uranium	0.5	mg/kg-dry	--	0.3
Uranium Activity	0.3	pCi/g-dry	--	0.2
MED - 4				
Lead-210	1.3	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	
Lead 210 MDC	0.2	pCi/g-dry	--	
Radium 226	0.8	pCi/g-dry	--	0.02
Radium 226 precision (+)	0.06	pCi/g-dry	--	
Radium 226 MDC	0.02	pCi/g-dry	--	
Thorium 230	0.5	pCi/g-dry	--	0.2
Thorium 230 precision (+)	0.2	pCi/g-dry	--	
Thorium 230 MDC	0.2	pCi/g-dry	--	
METALS				
Uranium	1.0	mg/kg-dry	--	0.3
Uranium Activity	0.7	pCi/g-dry	--	0.2
MED - 5				
Lead-210	1.5	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	
Lead 210 MDC	0.2	pCi/g-dry	--	
Radium 226	0.8	pCi/g-dry	--	0.02
Radium 226 precision (+)	0.06	pCi/g-dry	--	
Radium 226 MDC	0.02	pCi/g-dry	--	
Thorium 230	0.3	pCi/g-dry	--	0.2
Thorium 230 precision (+)	0.2	pCi/g-dry	--	
Thorium 230 MDC	0.2	pCi/g-dry	--	

Table 2.9-33 Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) Sample Locations

Radionuclide	Result	Units	Qualifier	Reporting Limit (RL)
	12/02/2011 (Collection Date)			
METALS				
Uranium	0.9	mg/kg-dry	--	0.3
Uranium Activity	0.6	pCi/g-dry	--	0.2
MED - 6				
Lead-210	1.3	pCi/g-dry	--	0.2
Lead 210 precision (+)	0.1	pCi/g-dry	--	
Lead 210 MDC	0.2	pCi/g-dry	--	
Radium 226	0.6	pCi/g-dry	--	0.02
Radium 226 precision (+)	0.05	pCi/g-dry	--	
Radium 226 MDC	0.02	pCi/g-dry	--	
Thorium 230	0.2	pCi/g-dry	--	0.2
Thorium 230 precision (+)	0.1	pCi/g-dry	--	
Thorium 230 MDC	0.2	pCi/g-dry	--	
METALS				
Uranium	0.6	mg/kg-dry	--	0.3
Uranium Activity	0.4	pCi/g-dry	--	0.2

MED – Marsland Ephermeral Drainage
RL - Analyte reporting limit
MDC – Minimum detectable concentration
mg/kg-dry – milligram/kilogram-dry weight
pCi/g-dry – picocuries per gram -dry weight

Table 2.9-34 Marsland Expansion Area Gamma Exposure Results

Location	Exposure of Dosimeter (mrems ambient dose equivalent)		Net Cumulative Totals			Number of Dosimeters Reported
	Gross	Net	Calendar Quarter	Year to Date	Permanent	
	10/01/2011 – 12/31/2011					
Transient Control	13.9	-1.0	--	--	--	--
Deploy Control	15.0	0.0	--	--	--	--
MA-1	21.7	6.7	6.7	6.7	6.7	1
MA-2	21.6	6.7	6.7	6.7	6.7	1
MA-3	21.4	6.5	6.5	6.5	6.5	1
MA-4	19.9	5.0	5.0	5.0	5.0	1
MA-5	20.9	5.9	5.9	5.9	5.9	1

mrem – millirems
MA-1 air sampling locations
Minimum Detectable Dose = 0.1 mrems ambient dose equivalent

Table 2.9-35 Marsland Expansion Area Preoperational/Preconstruction Monitoring Program

	Sample Collection				Sample Analysis	
Type of Sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
Air Particulates	3	On MEA northern boundary	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
	1	Nearest Resident	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
	1	Control background location east of MEA License Boundary	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
Radon Gas	3	On MEA northern boundary	Continuous	Quarterly	Quarterly	Rn-222
	1	Nearest Resident	Continuous	Quarterly	Quarterly	Rn-222
	1	Control background location east of MEA License Boundary	Continuous	Quarterly	Quarterly	Rn-222
Groundwater	1	Wells within MEA license boundary and 2 km radius: • Private Wells • MEA Brule Wells • MEA Ore Zone Wells (See Figures 2.7-6 and 2.9-3)	Grab	Quarterly	Quarterly	Suspended & Dissolved Natural Uranium, Ra-226, Th-230, Th-230 Pb-210 & Po-210
Surface Water	2 [a]	Niobrara River (N-1 and N-2) Ephemeral Drainages	Grab	Quarterly	Quarterly	Suspended & Dissolved Natural Uranium, Ra-226, & Th-230
			Grab	--	Semiannually	Suspended & Dissolved Pb-210 & Po-210
Vegetation	3	Grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during milling operations	Grab	3 times during grazing season	3 Times	Natural Uranium, Ra-226, Th-2320, Pb-210, & Pb-210
Food	3	Crops	Grab	Time of Harvest or Slaughter	1	Natural Uranium, Ra-226, Th-230, Pb-210, & Po-210
	3	Livestock			1	
	3	Private Garden Vegetables			1	
Fish	Each Body of Water	Collection of fish from Niobrara River (N-1 & N-2)	Grab	Semiannually	2	Natural Uranium, Ra-226, Th-230, Pb-210, & Po-210

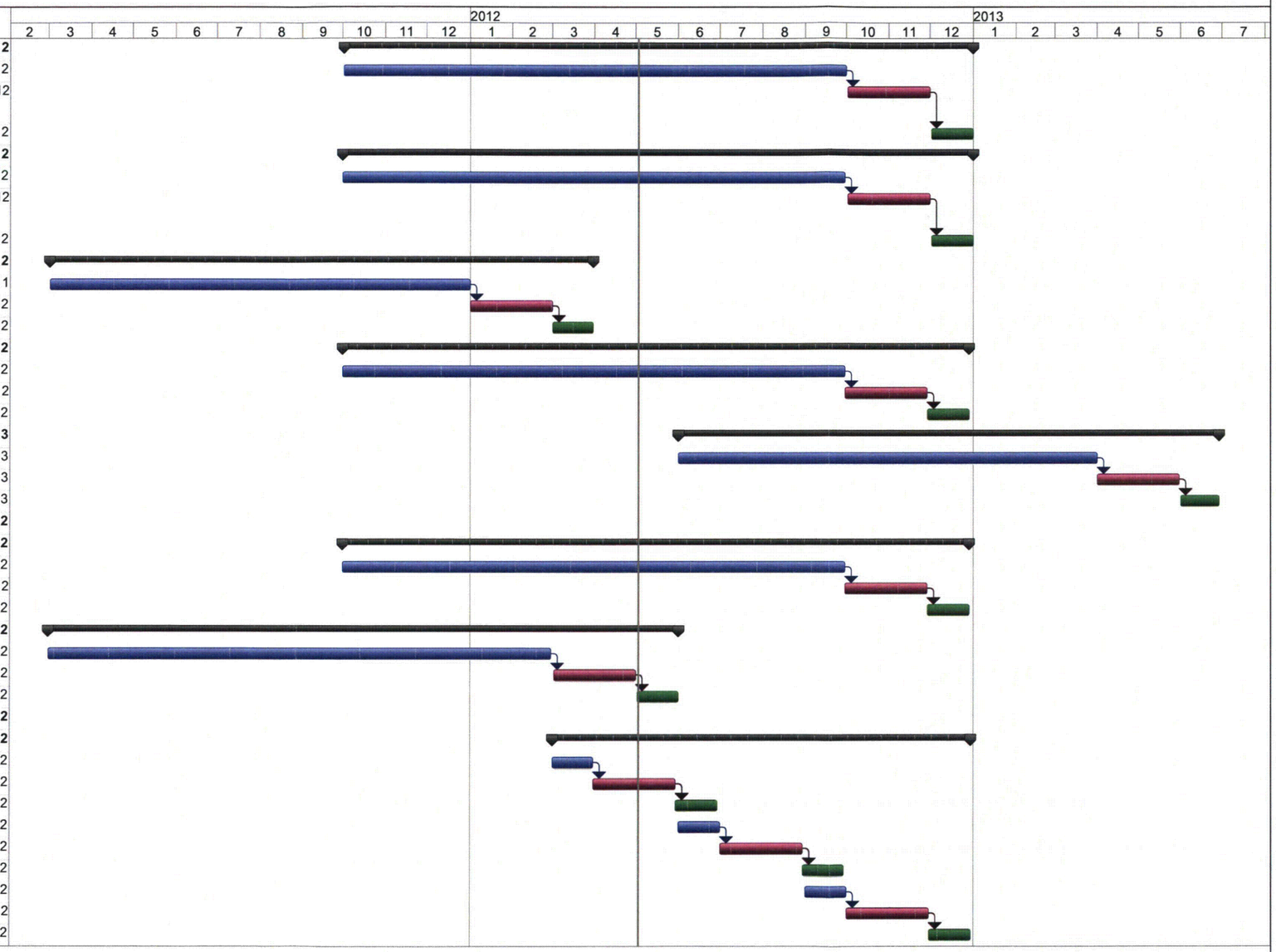
Table 2.9-35 Marsland Expansion Area Preoperational/Preconstruction Monitoring Program

	Sample Collection				Sample Analysis	
Type of Sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
Surface Soil [b]	Up to 40	300 meter intervals to a distance of 1500 meters in each of 8 directions from center-point of satellite facility; additional transects through wellfields	Grab	Once prior to construction. Repeat for location disturbed by excavation, leveling or contouring	1	All samples for Ra-226, 10% of samples natural uranium, Th-230 & Pb-210
	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	Natural Uranium, Ra-226, Th-230 & Pb-210
Subsurface Soil [c]	5	At center-point of satellite facility & at distances of 750 meters in each of 4 directions	Grab	Once prior to construction. Repeat for location disturbed by construction	1	Ra-226 (all samples) Natural Uranium, Th-203 & Pb210 (one set of samples)
Sediment [d]	2 from each stream	Up and down gradient samples from ephemeral drainages & Niobrara River (N-1 & N-2)	Grab (Composite samples)	Once following spring runoff & late summer following period of extended low flow	2	Natural Uranium, Ra-226, Th-230 & Pb-210
Direct Radiation (Survey)	Up to 80	150 meter intervals to a distance of 1500 meters in each of 8 directions from center-point of satellite facility	Grab	Once prior to construction. Repeat for areas disturbed by site preparation or construction	1	Gamma exposure using sodium iodide scintillometer
Direct Radiation (Continuous)	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	Gamma exposure using a continuous integrating device

[a] Two samples from the Niobrara River per sampling event and one (1) from each sampling point located on ephemeral streams (**Figure 2.7-4**).
[b] Surface soil samples collected to a depth of 5 cm using a consistent technique.
[c] Subsurface soil samples collected to a depth of 1 meter; samples divided into 3 equal sections for analysis.
[d] Sediment sample locations shown in Figure 2.7-4

Figure 2.9-1 Marsland Preoperational/Preconstruction Monitoring Schedule

ID	Task Name	Duration	Start	Finish
1	**Air Particulate Monitoring**	**326 days**	**Sat 10/1/11**	**Mon 12/31/12**
2	Sample Collection	365 edays	Sat 10/1/11	Sun 9/30/12
3	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 10/1/12	Fri 11/30/12
4	NRC 30-Day Review	30 edays	Sat 12/1/12	Mon 12/31/12
5	**Radon Gas**	**326 days**	**Sat 10/1/11**	**Mon 12/31/12**
6	Sample Collection	365 edays	Sat 10/1/11	Sun 9/30/12
7	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 10/1/12	Fri 11/30/12
8	NRC 30-Day Review	30 edays	Sat 12/1/12	Mon 12/31/12
9	**Groundwater (Non-Ore Zone)**	**283 days**	**Tue 3/1/11**	**Fri 3/30/12**
10	Sample Collection	305 edays	Tue 3/1/11	Sat 12/31/11
11	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sat 12/31/11	Wed 2/29/12
12	NRC 30-Day Review	30 edays	Wed 2/29/12	Fri 3/30/12
13	**Groundwater (Ore Zone)**	**325 days**	**Sat 10/1/11**	**Sat 12/29/12**
14	Sample Collection	365 edays	Sat 10/1/11	Sun 9/30/12
15	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sun 9/30/12	Thu 11/29/12
16	NRC 30-Day Review	30 edays	Thu 11/29/12	Sat 12/29/12
17	**Groundwater (Private Wells in 2 km radius)**	**281 days**	**Fri 6/1/12**	**Sat 6/29/13**
18	Sample Collection	304 edays	Fri 6/1/12	Mon 4/1/13
19	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 4/1/13	Fri 5/31/13
20	NC 30-Day Review	28 edays	Sat 6/1/13	Sat 6/29/13
21	**Surface Water**	**479 days**	**Tue 3/1/11**	**Sat 12/29/12**
22	**Ephemeral Drainages (a)**	**325 days**	**Sat 10/1/11**	**Sat 12/29/12**
23	Sample Collection	365 edays	Sat 10/1/11	Sun 9/30/12
24	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sun 9/30/12	Thu 11/29/12
25	NRC 30-Day Review	30 edays	Thu 11/29/12	Sat 12/29/12
26	**Niobrara River**	**328 days**	**Tue 3/1/11**	**Thu 5/31/12**
27	Sample Collection	365 edays	Tue 3/1/11	Wed 2/29/12
28	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Thu 3/1/12	Mon 4/30/12
29	NRC 30-Day Review	30 edays	Tue 5/1/12	Thu 5/31/12
30	**Vegetation**	**217 days**	**Thu 3/1/12**	**Sun 12/30/12**
31	**Forage Vegetation**	**217 days**	**Thu 3/1/12**	**Sun 12/30/12**
32	Sample Collection - Event 1	30 edays	Thu 3/1/12	Sat 3/31/12
33	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sat 3/31/12	Wed 5/30/12
34	NRC 30-Day Review	30 edays	Wed 5/30/12	Fri 6/29/12
35	Sample Collection - Event 2	30 edays	Fri 6/1/12	Sun 7/1/12
36	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sun 7/1/12	Thu 8/30/12
37	NRC 30-Day Review	30 edays	Thu 8/30/12	Sat 9/29/12
38	Sample Collection - Event 3	30 edays	Sat 9/1/12	Mon 10/1/12
39	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 10/1/12	Fri 11/30/12
40	NRC 30-Day Review	30 edays	Fri 11/30/12	Sun 12/30/12



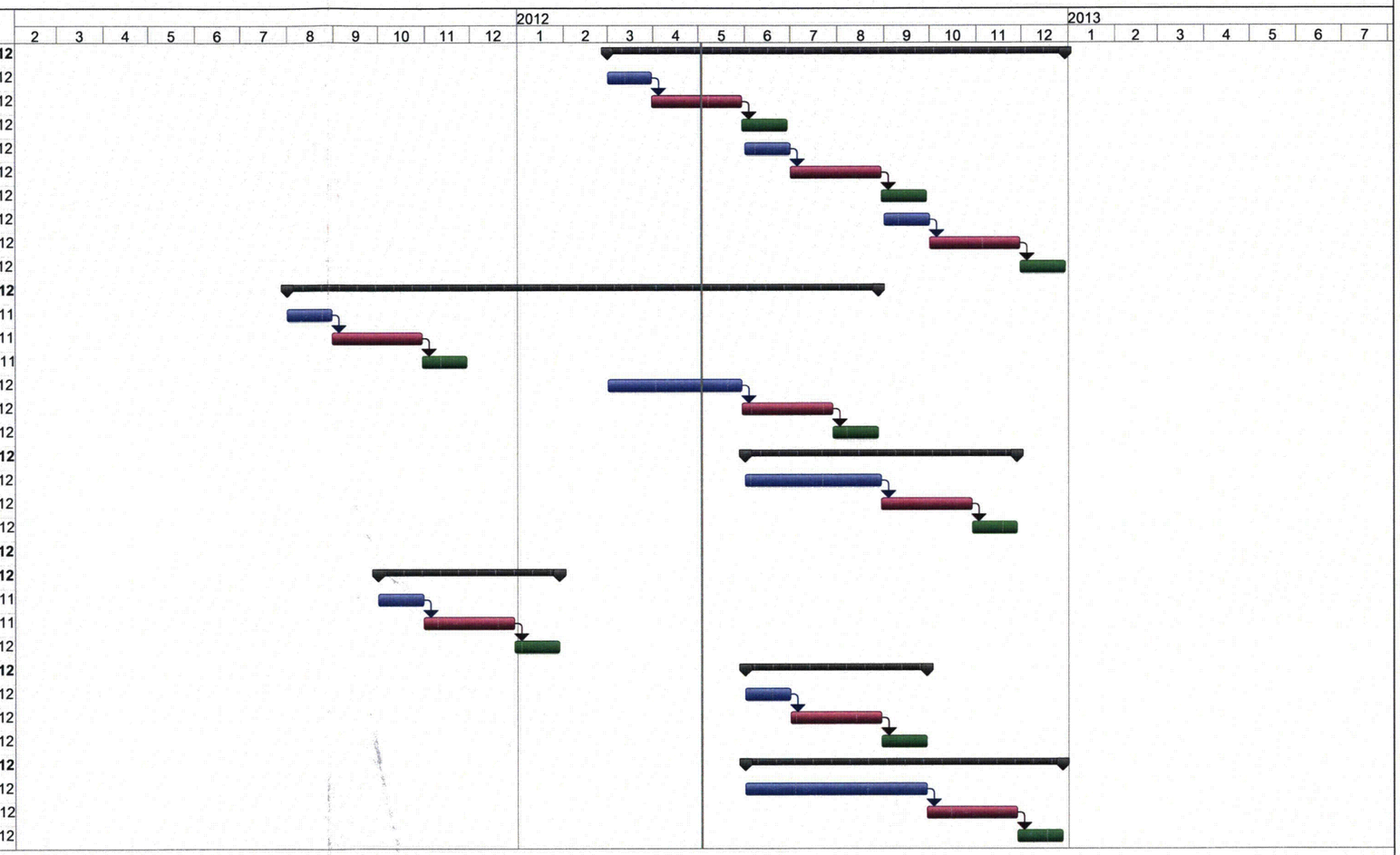
Project: Marsland Expansion Area
Date: Thu 5/3/12

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Progress
Split	External Tasks	Inactive Summary	Manual Summary	Deadline
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

Notes: (a) = Sampling will be conducted as water flow is available.
day = Business days (Monday - Friday), eday = Actual calendar days

Figure 2.9-1 Marsland Preoperational/Preconstruction Monitoring Schedule

ID	Task Name	Duration	Start	Finish
41	**Food**	**217 days**	**Thu 3/1/12**	**Sun 12/30/12**
42	Sample Collection - Event 1	30 edays	Thu 3/1/12	Sat 3/31/12
43	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sat 3/31/12	Wed 5/30/12
44	NRC 30-Day Review	30 edays	Wed 5/30/12	Fri 6/29/12
45	Sample Collection - Event 2	30 edays	Fri 6/1/12	Sun 7/1/12
46	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sun 7/1/12	Thu 8/30/12
47	NRC 30-Day Review	30 edays	Thu 8/30/12	Sat 9/29/12
48	Sample Collection - Event 3	30 edays	Sat 9/1/12	Mon 10/1/12
49	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 10/1/12	Fri 11/30/12
50	NRC 30-Day Review	30 edays	Fri 11/30/12	Sun 12/30/12
51	**Fish**	**281 days**	**Mon 8/1/11**	**Tue 8/28/12**
52	Sample Collection - Event 1	30 edays	Mon 8/1/11	Wed 8/31/11
53	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Wed 8/31/11	Sun 10/30/11
54	NRC 30-Day Review	30 edays	Sun 10/30/11	Tue 11/29/11
55	Sample Collection - Event 2	90 edays	Thu 3/1/12	Wed 5/30/12
56	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Wed 5/30/12	Sun 7/29/12
57	NRC 30-Day Review	30 edays	Sun 7/29/12	Tue 8/28/12
58	**Soil**	**128 days**	**Fri 6/1/12**	**Wed 11/28/12**
59	Sample Collection	90 edays	Fri 6/1/12	Thu 8/30/12
60	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Thu 8/30/12	Mon 10/29/12
61	NRC 30-Day Review	30 edays	Mon 10/29/12	Wed 11/28/12
62	**Sediment**	**260 days**	**Sat 10/1/11**	**Sat 9/29/12**
63	**Dry Season**	**85 days**	**Sat 10/1/11**	**Sun 1/29/12**
64	Sample Collection	30 edays	Sat 10/1/11	Mon 10/31/11
65	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Mon 10/31/11	Fri 12/30/11
66	NRC 30-Day Review	30 edays	Fri 12/30/11	Sun 1/29/12
67	**Wet Season**	**86 days**	**Fri 6/1/12**	**Sat 9/29/12**
68	Sample Collection	30 edays	Fri 6/1/12	Sun 7/1/12
69	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sun 7/1/12	Thu 8/30/12
70	NRC 30-Day Review	30 edays	Thu 8/30/12	Sat 9/29/12
71	**Direct Radiation**	**150 days**	**Fri 6/1/12**	**Fri 12/28/12**
72	Sample Collection	120 edays	Fri 6/1/12	Sat 9/29/12
73	Sample Mgmt/Analysis/Admin Record Entry	60 edays	Sat 9/29/12	Wed 11/28/12
74	NRC 30-Day Review	30 edays	Wed 11/28/12	Fri 12/28/12

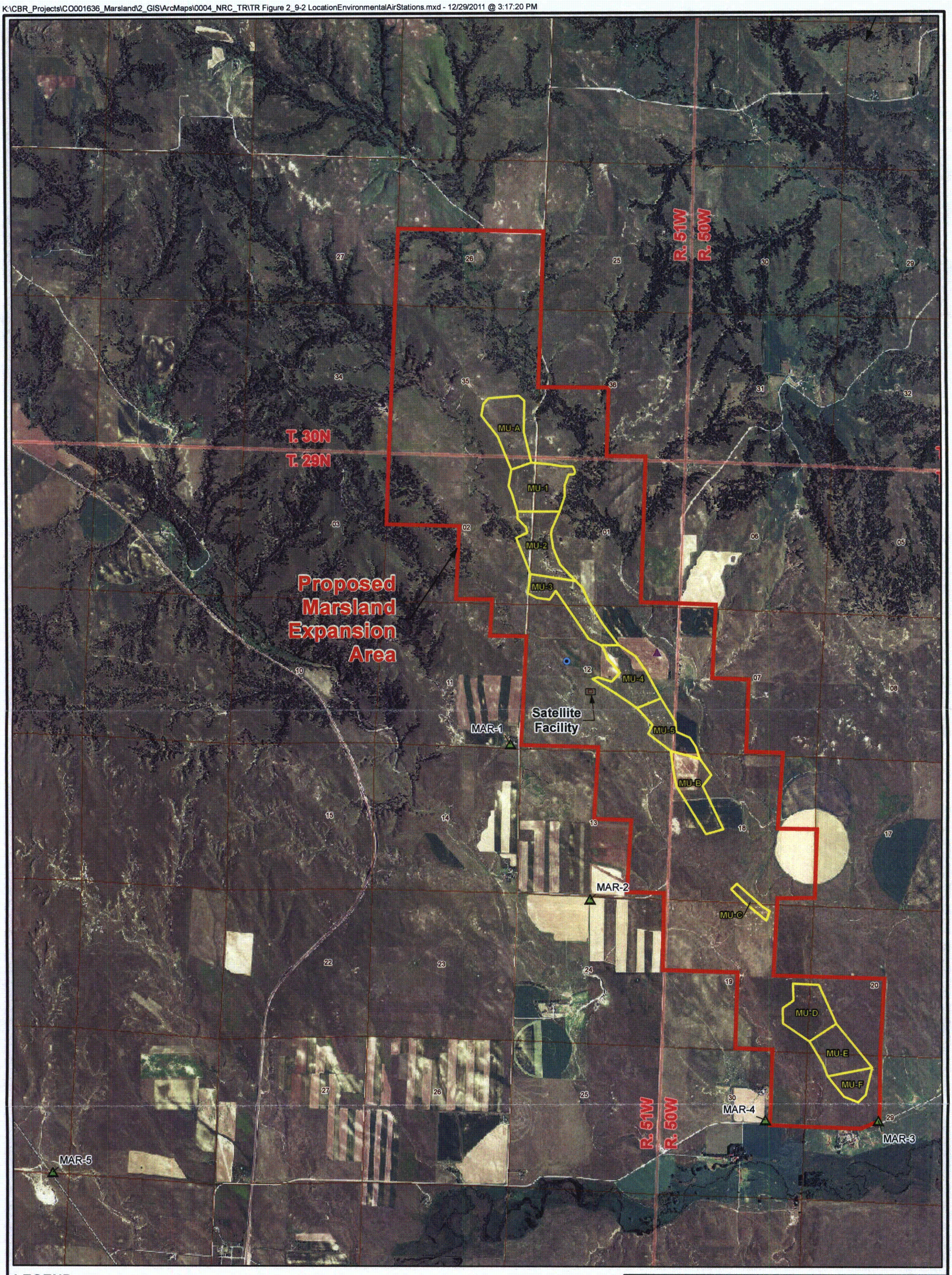


Project: Marsland Expansion Area
Date: Thu 5/3/12

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Progress	
Split		External Tasks		Inactive Summary		Manual Summary		Deadline	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

Notes: (a) = Sampling will be conducted as water flow is available.
day = Business days (Monday - Friday), eday = Actual calendar days

K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0004_NRC_TR\TR Figure 2_9-2 LocationEnvironmentalAirStations.mxd - 12/29/2011 @ 3:17:20 PM



LEGEND

- Proposed Deep Disposal Well
- Air Sample Station
- Met Station
- Mine Unit
- Proposed Marsland Expansion Area

N

0 3,000 6,000

Feet

PROJECTION: NAD1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USDA NAIP IMAGERY 2010

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FIGURE 2.9-2
LOCATION OF ENVIRONMENTAL AIR SAMPLING STATIONS AT MARSLAND EXPANSION AREA

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS

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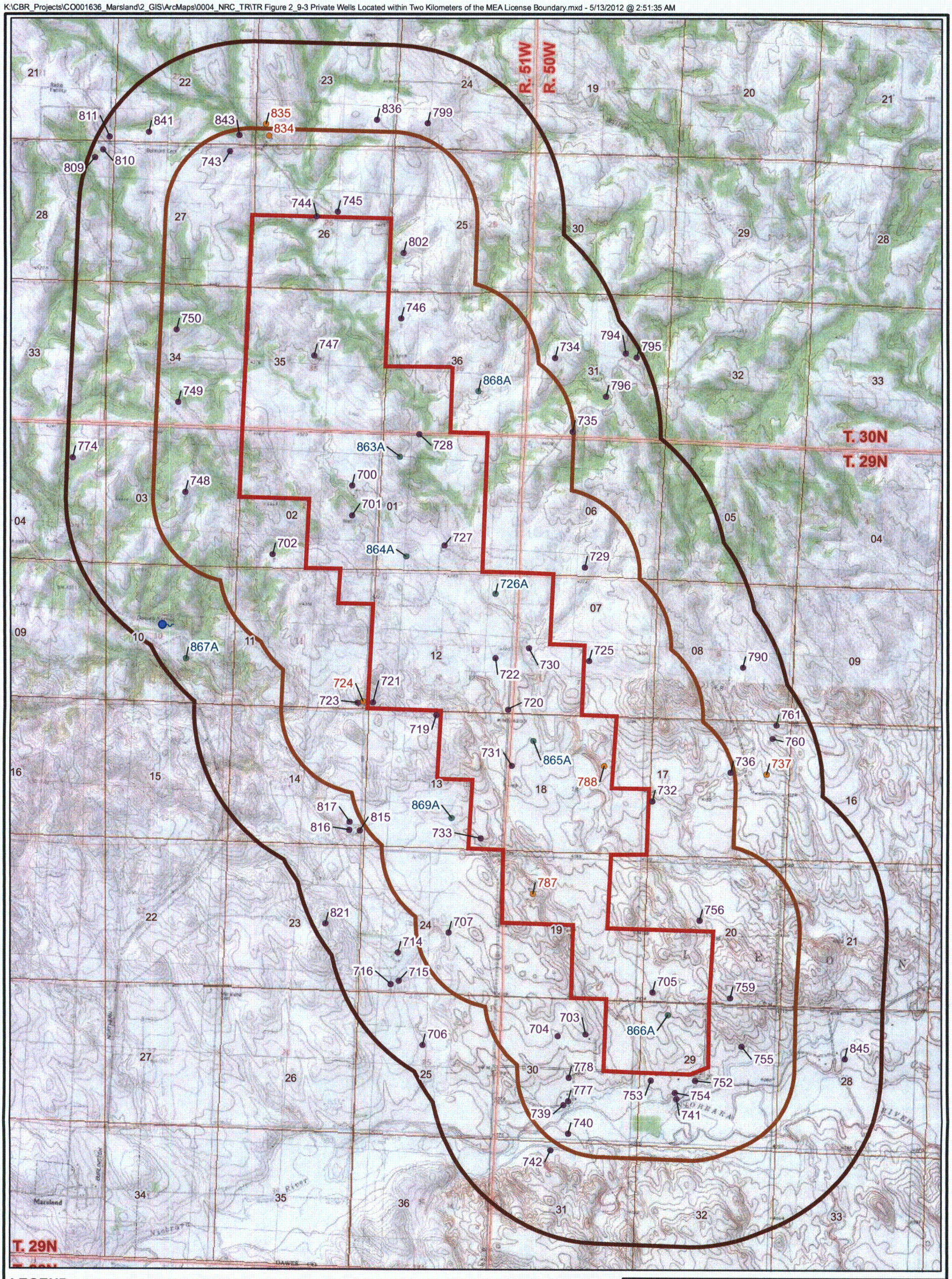
K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0004_NRC_TR\TR Figure 2_9-3 Private Wells Located within Two Kilometers of the MEA License Boundary.mxd - 5/13/2012 @ 2:51:35 AM



LEGEND

- Proposed Marsland Expansion Area (MEA)
- 2-Kilometer Radius of MEA
- 1-Kilometer Radius of MEA

Private Water Supply Wells

- 733 Active Well
- 787 Inactive Well
- 866A Abandoned Well

Natural Spring

N

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

0 1,750 3,500 Feet

0 500 1,000 Meters

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-3
PRIVATE WELLS LOCATED WITHIN ONE AND TWO KILOMETERS OF THE MEA LICENSE BOUNDARY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: J.CEARLEY

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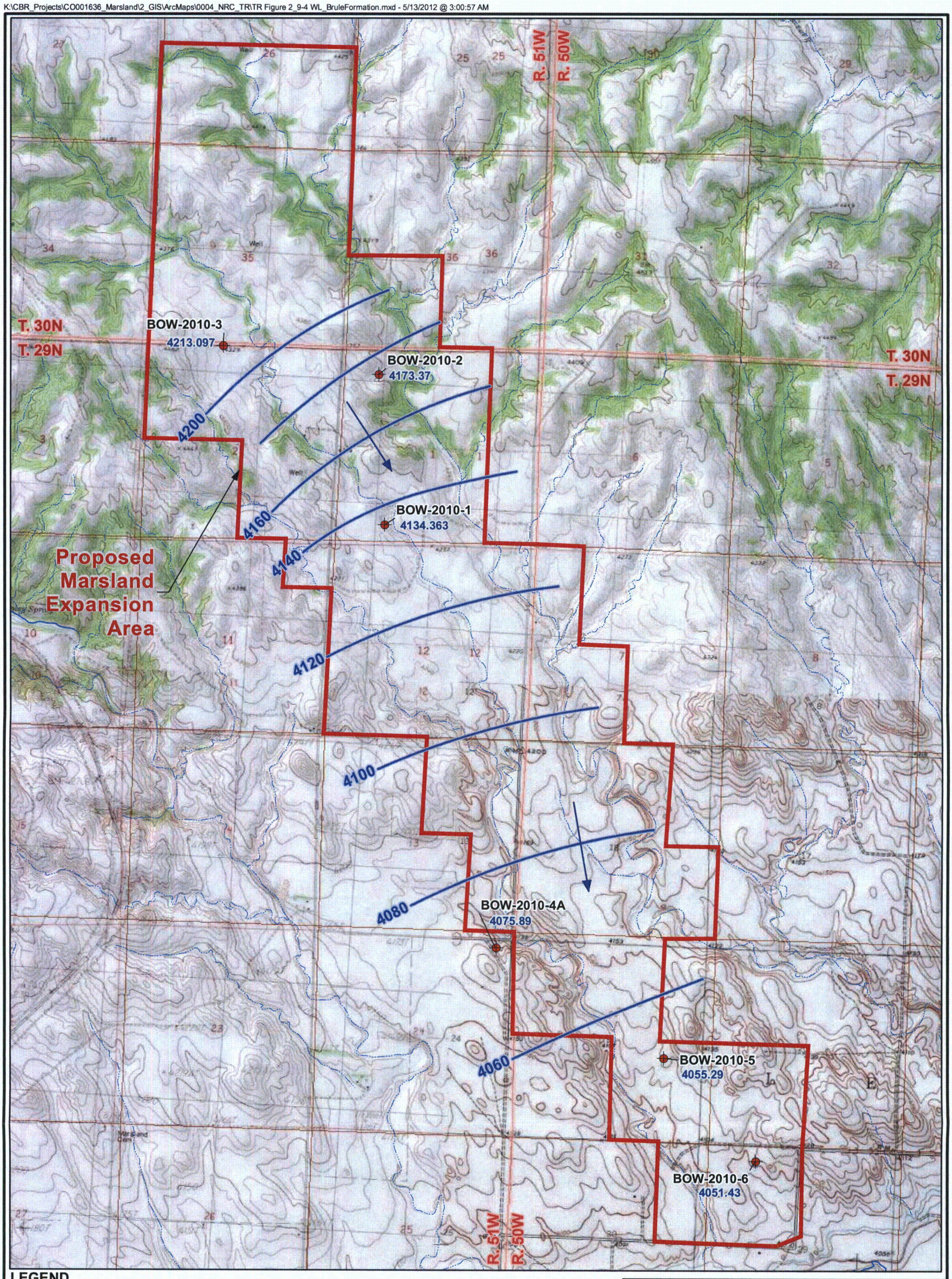

LEGEND

- Brule Formation Well
- Groundwater Elevation Contour
- Proposed Marsland Expansion Area
- Intermittent Stream/River
- 4051.43 Water Level (feet-above mean sea level)
- Groundwater Flow Direction

N

0 1,250 2,500
Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

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FIGURE 2.9-4
MARSLAND EXPANSION AREA
POTENTIOMETRIC SURFACE
BRULE FORMATION (2/22/11)

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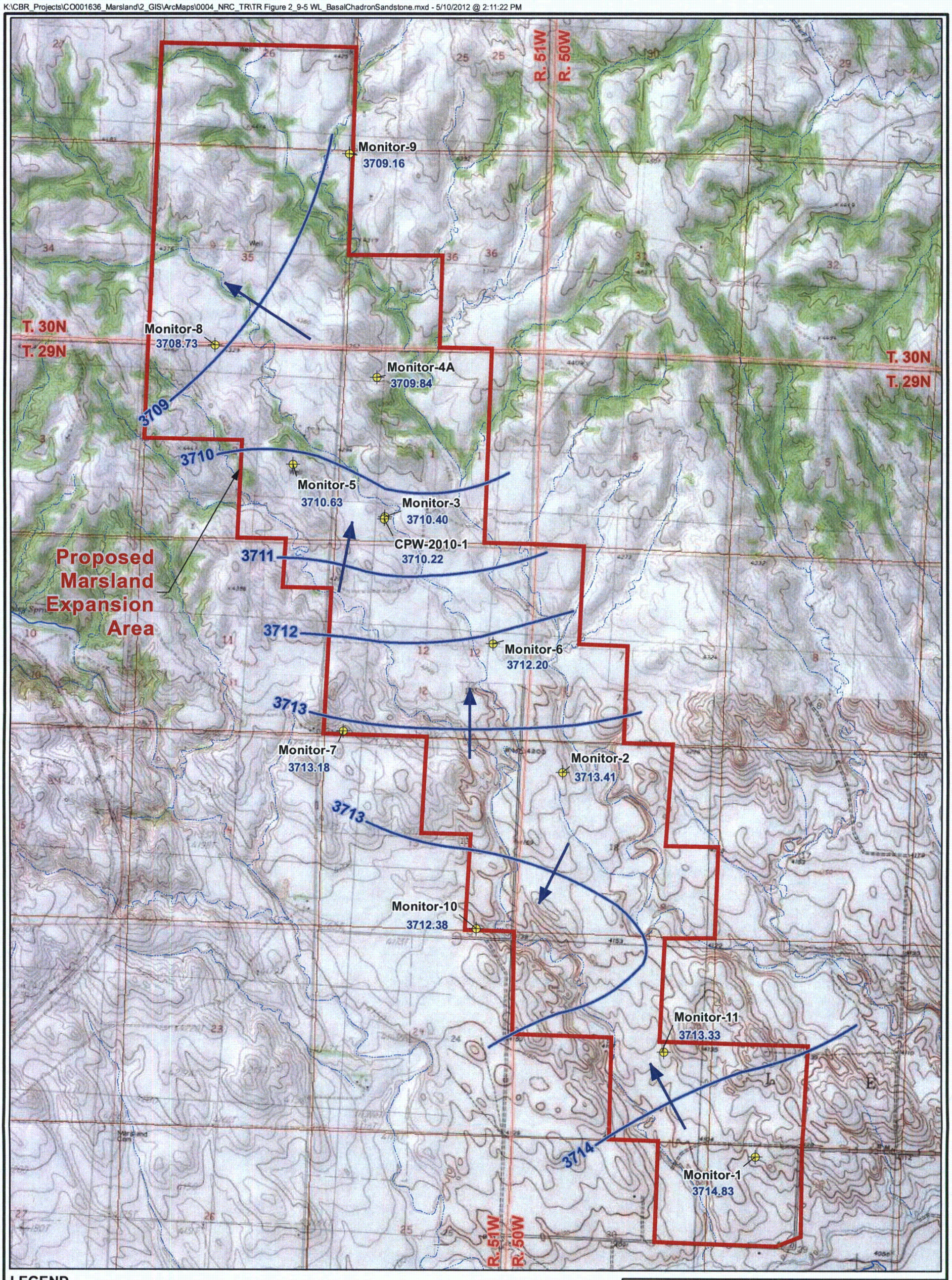

LEGEND

- Basal Chadron Sandstone Well
- Groundwater Elevation Contour
- Proposed Marsland Expansion Area
- Intermittent Stream/River
- 3714.83 Water Level (feet-above mean sea level)
- Groundwater Flow Direction

N

0 1,250 2,500
Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-5
MARSLAND EXPANSION AREA
POTENTIOMETRIC SURFACE
BASAL CHADRON SANDSTONE (2/22/11)

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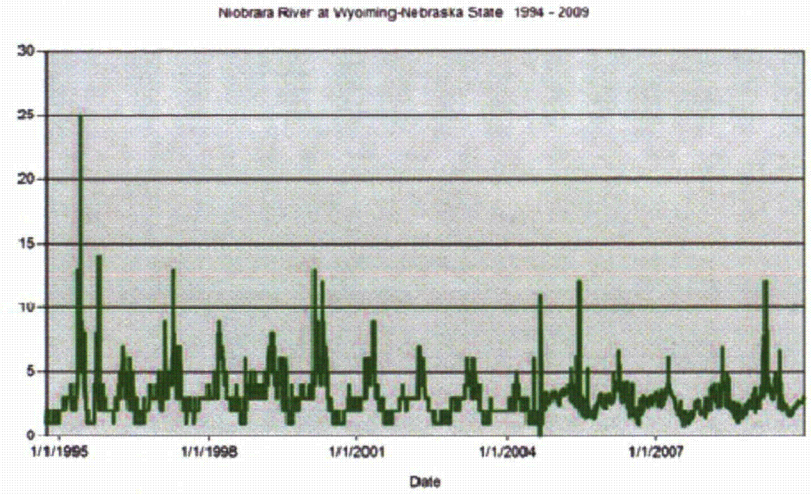

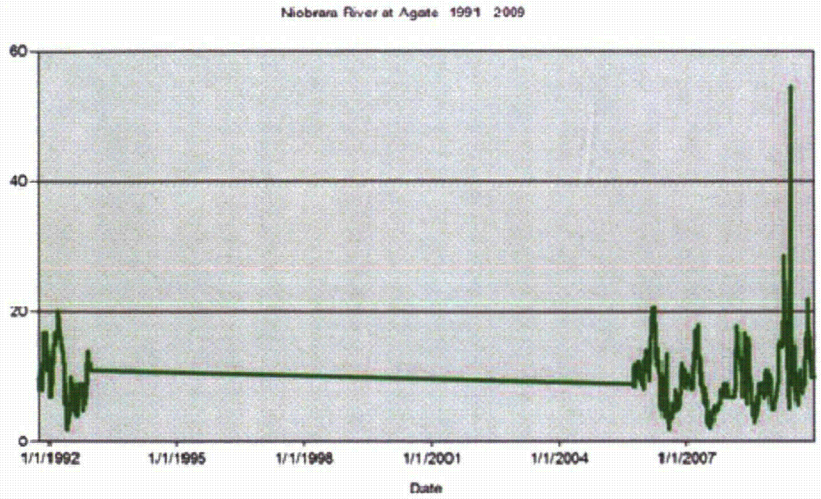

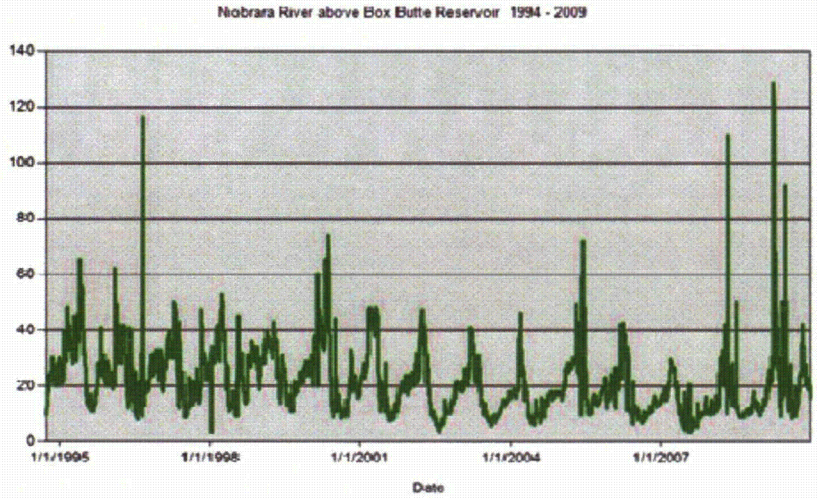

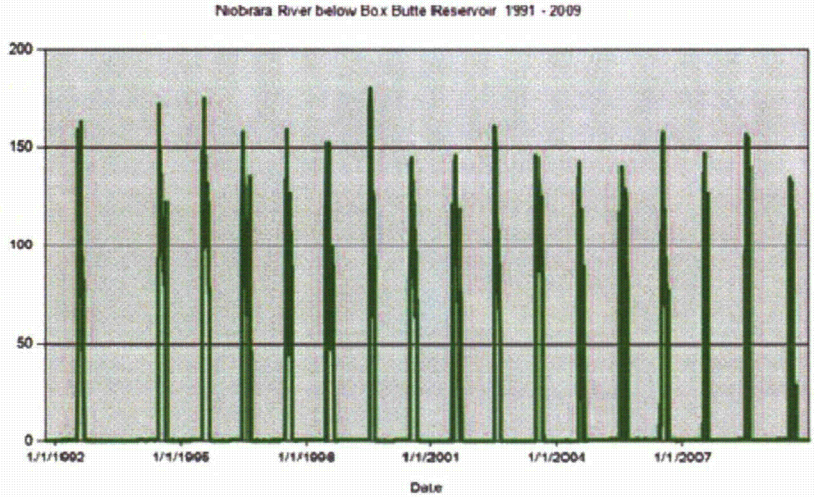

Source: NDNR 2011a

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FIGURE 2.9-6
MEAN STREAM FLOW (cfs) FOR NIOBRARA RIVER STREAM GAGING STATIONS IN UPPER AREA OF NIOBRARA RIVER

PROJECT: CO001636.00001 MAPPED BY: JC CHECKED BY: JEC

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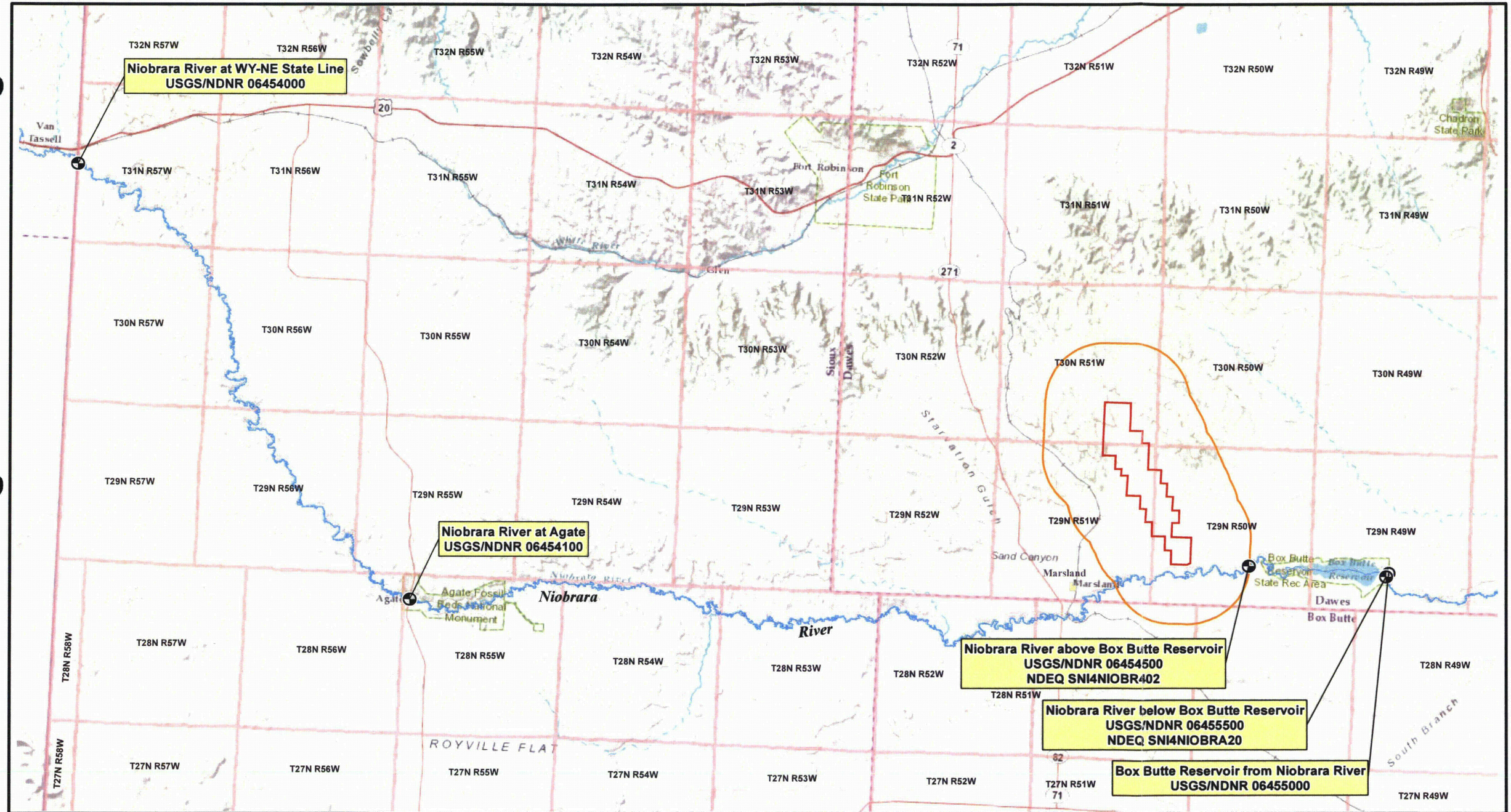
K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 2_9-6 Flow Charts for Upper Niobrara River1991 - 2009.ai @ 04/12/2012 BY: J.CHEN @ Boulder, CO



LEGEND

- USGS/NDNR Stream Gaging Station and NDEQ Sampling Location
- Niobrara River
- Proposed Marsland Expansion Area
- Area of Review (AOR)

PROJECTION: NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601
SOURCE: TOPOGRAPHIC MAP, SERVICED BY
ESRI ARCGIS ONLINE

N

0 2 4
Miles

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FIGURE 2.9-7
USGS/NDNR STREAM GAGING STATIONS AND NDEQ SAMPLING LOCATIONS FOR NIOBRARA RIVER

PROJECT: CO001636 MAPPED BY: JC

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Z:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0003_UIC\UIC_Fig_F_1-7_USGS_GagingStations_and_NDEQ_Sampling_Locations_for_Niobrara_River.mxd - 11/3/2011 @ 2:28:25 PM

3. DESCRIPTION OF PROPOSED FACILITY

Production of uranium by ISR mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by IX, and then from the IX resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluent) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium called yellowcake.

The MEA is being developed by CBR in conjunction with the CPF licensed under NRC Source Material License SUA-1534. The MEA will be developed by constructing independent mine units and mining support facilities while employing existing processing equipment for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance over which a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the MEA to provide chemical makeup of leach solutions, recovery of uranium by IX, and restoration capabilities. The IX processes at the satellite facility recover the uranium from the leach solution in a form (loaded IX resin) that is relatively safe and simple to transport by tanker truck to the CPF, which will serve as feed to the CPF for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the IX circuit.

3.1 Solution Mining Process and Equipment

3.1.1 Orebody

In the CPF license area, uranium is recovered by ISR from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The orebody ranges in grade from less than 0.05 to more than 0.5 percent U_3O, with an average grade estimated at 0.27 percent U_3O_8.

In the MEA license area, uranium will also be recovered ISR from the basal sandstone of the Chadron Formation. The depth to the ore body within the basal sandstone of the Chadron Formation in the MEA ranges from approximately 800 to 1,250 feet bgs (**Figures 2.63-a** through **2.63-n**). The width of the ore body varies from approximately 1,000 to 4,000 feet. The ore grade as U_3O_8 ranges from 0.11 to .33 percent with an average ore grade of 0.17 percent.

Typical stratigraphic intervals to be mined by the *in-situ* mining method are shown in the geologic cross-sections contained in Section 2.6. For ISR wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

3.1.2 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

3.1.2.1 Well Materials of Construction

The well casing material will be PVC. PVC well casing is 4.5- or 5-inch Standard Dimension Ratio-17 (SDR-17) or equivalent. However, should a larger pump size be required, larger-diameter casing may be used. The PVC casing joints are 20 feet long. The bottom joint can be made either 10 or 20 feet long depending on the casing depth. With SDR-17 PVC casing, each joint has a watertight O-ring seal and is held together with a high-strength nylon spline.

There are two types of well screen that will be used for development of the MEA – PVC and stainless steel (SS). Both types of screens have been used historically for the existing Crow Butte production, injection, and monitor wells. SS screens are more durable than PVC screens, are rated for greater depths than PVC screens, easier to install, and can achieve better flow. The SS screens are significantly more expensive than the PVC screens. Currently, CBR primarily uses SS screens, but would maintain the option to use PVC screens as necessary at the satellite facility based on site conditions and purpose of the borehole. For example, PVC well screens are currently used in both shallow observation monitor wells and commercial production monitor wells. This practice will be continued as an option for Marsland. The primary reason for use of the PVC screens for these types of wells is because these types of monitor wells typically have much longer screen intervals than other types of wells. This results in employee safety issues due to the handling of the heavy SS screens. In addition, flow rate using PVC screens is less of a concern for these types of wells.

The PVC well screen consists of a perforated 3-inch PVC pipe. PVC rods run longitudinally along the sides of the pipe. Keystone-shaped PVC wire is helically wrapped around the outsides of the pipe and ribs and solvent-welded to the pipe. Spacing between consecutive wraps of the wire varies depending upon the screen ordered. Slot sizes from 0.010 to 0.020 inches have been used successfully at Crow Butte. In most cases, a slot size of 0.020 inches is sufficient to prevent sand from entering the screens.

The SS well screen consists of longitudinal ribs of SS with a SS "V" shaped wire wrapped helically around the interior ribbing. The wire is welded to the circular rib array for support. As with PVC screens, slot sizes of 0.010 to 0.020 inches have been used historically at Crow Butte.

3.1.2.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells will be drilled through the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole will be logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described. Any of these methods is appropriate for monitor wells and have been approved by the NDEQ under the current Crow Butte Class III UIC Permit and recently issued Class III UIC Permit for the NTEA satellite facility. All wells will be constructed in accordance with the provisions of this section. Of the three methods, CBR primarily uses Method 1, shown on **Figure 3.1-1,** on a routine basis. Method 2 shown on **Figure 3.1-2** may be used by the CBR geologic staff when there is a need to study the geology of an area and to determine the best placement of the screens without having to attach screens to the casing string. Method 3, shown on **Figure 3.1-3,** is not routinely used, but this method is maintained as an option so that the method (including minor modifications) can be used if warranted for specific

geological formations. All of these methods are appropriate for monitor wells and have been approved by the NDEQ under the UIC Permit.

Method 1

For this method, the well is drilled to depth in the Pierre Shale and then logged. Based upon the e-log, geologic staff will pick a casing depth, and will then begin to review the local area wells for the best location (depth) to pick the screened interval. The well is cased through the mining zone and cemented in place. Cement flows down the inside of the casing, exits out the bottom, and flows back up the annulus to the surface. Cement may be pushed out of the bottom of the casing by use of a rubber cement plug that is pushed to the bottom and stays in the bottom of the well, or cement may be displaced using fresh water. If the cement is displaced with water, a rig will need to drill the excess cement out of the casing prior to under-reaming and setting screens. If the cement is displaced using a cement plug, then nothing further is required prior to under-reaming. The under-reaming process begins with a rig tripping (inserting in borehole) a specialized drill bit into the depths to be screened. Blades on the bit open outward to cut away and remove the casing and cement grout from the area to be screened. When the interval to be screened has been cut away, the drill rig removes the drill pipe, and the hole is logged to make certain that the cut is accurate. If the cut-check depths are determined to be satisfactory, the rig is used to place the screen assembly at the selected depth and then develop the well.

Method 1 is the primary method used for all injection and production wells. A slight variation of this method is used for monitor wells. Monitor wells are cased to the top of the mining zone, and cemented using water displacement. Allowing for time for the cement to set up (harden), the excess cement is drilled out of the casing and the well is logged to determine where to place the well screens.

Method 1 is similar to Method 2, except that a plug and weep holes are not used.

Method 2

Method 2 uses a screen telescoped down inside the cemented casing. A hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next, a string of casing with a plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and plug are drilled out, with the drilling continuing through the desired zone. The screen with a K-packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

Method 2 is an improvement over Method 3 due to drilling only to the top of the mining zone. At that point, the well is cased and cemented. Because the drill hole does not penetrate through the mining zone, no cement basket must be used. A cement plug and weep holes are used to place the cement.

Method 3

This method involves the setting of an integral casing/screen string. The method consists of drilling a hole to the Pierre Shale; geophysically logging the hole to define the desired screen interval; and reaming the hole, if necessary, to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent plugging of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weepholes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping.

For all three well completion methods, casing centralizers, located at a maximum of 100-foot spacing, are run on the casing to ensure that it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure that cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare cases, however, the drilling may result in a larger annulus volume than anticipated, and cement may not return all the way to the surface. In these cases, the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placing a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

Screening

The exact size of the screen slot is determined by analyzing the formation samples brought to the surface during the drilling process, and is selected at the discretion of the Crow Butte geologic staff. The location and amount of drill screen to be set in a well are based upon the geologic and economic factors. Well screens are placed at a selected depth using the drilling rig. The screens are secured in place using a rubber K-packer and blank assembly that is attached to the top of the screens. The K-packer suspends the screens in the open portion of the well until well development creates a natural gravel pack surrounding the screen.

For injection and production wells, the screen interval is determined by the geologic staff based on the location of sands and ore grade material. The zones to be mined are correlated and selected by reviewing geophysical logs, which also confirms that the screened intervals between wells are hydrologically connected . Typically, an interval of approximately 18 feet is screened; however, individual intervals may range from 6 feet to 35 feet in length.

For monitor wells, a slightly different process is followed for placement of the screens. When the monitor well is drilled, the total thickness of the production zone is calculated. The number of screens to be placed in the well must cover the production zone, and the screen-to-blank ratio must exceed 50 percent. Care should be taken to ensure that those zones impacted by nearby wells are covered by screens, not blank. A well completion report is documented for each well and maintained at the site for review. All wells are constructed by a licensed/certified water well

contractor, as defined by the Nebraska Health and Human Services System, Water Well Standards and Licensing Act, Article 46.

3.1.2.3 Cement/Grout Specifications

All cement will be ASTM International (ASTM) Type I, II or American Petroleum Institute (API) Class B or G and will meet the following criteria:

- The cement will have a density of no less than 11.5 lbs/gal.
- A bentonite grout shall be mixed as close as possible to a concentration of 1.5 lb. bentonite per gallon of water (1 quart polymer per 100 gallons of water may be premixed to prevent the clays from hydrating prematurely) and shall have a density of 9.2 lbs./gal or higher.

3.1.2.4 Logging Procedures and Other Tests

Appropriate geophysical logs and other tests are conducted during the drilling and construction of new Class III wells. These are determined based on the intended function, depth, construction, and other characteristics of the well; availability of similar data in the area of the drilling site; and the need for additional information that may arise from time to time as the construction of the well progresses.

Logging Equipment

CBR currently owns three operational logging units. All were built by Century Geophysical Corporation in Tulsa, Oklahoma. These units are capable of logging drill holes to a depth of approximately 2,000 feet.

These trucks are capable of using a wide variety of tools. All of these tools (or probes, as used by CBR) measure Single Point Resistance (RES), SP, Natural Gamma (GAM[NAT]), and Deviation. Some of the probes used by CBR are also capable of measuring temperature, 16-inch normal resistance, and 64-inch normal resistance (**Table 3.1-1**). Deviation with these units is measured using a slant angle and azimuth technique. Standardized procedures are used by trained personnel to carry out the logging tasks.

Borehole Geophysical Logs

As of November 1, 2011, there have been 1,653 exploration/development holes and 22 monitor and observation wells drilled within the MEA boundary. A sample portion of a borehole geophysical log (M-1251) is shown on **Figure 2.6-4.** Detailed analysis of a carefully chosen suite of borehole geophysics provides a method for interpreting lithology, stratigraphy, depositional environment; and for deriving porosity values, permeability index, and water salinity. The log curves used for interpretation and parameter derivation measure resistivity, spontaneous potential, natural radioactivity, and deviation.

Log interpretation and parameter evaluation involves analysis of the measured log curve values and responses. The measured curve and resultant analysis are affected by drilling processes, properties of the formation, and limitations of the logging tools themselves. Common hydrogeologic objectives of borehole geophysical logging include: (1) definition and correlation of aquifer or other lithologic units; (2) estimation of aquifer properties such as porosity and

permeability; and (3) assessment of physical properties of formation water including conductivity, TDS, and total hardness. These objectives must be considered in the design, selection, and implementation of an effective logging program.

There are three basic parameters derived or interpreted from borehole geophysical logs: lithology, resistivity, and porosity. From these basic parameters, there are numerous variations that can provide information regarding lithologic identification, correlation, facies evaluation, delineation of permeable and porous zones, and identification of pore fluids. The type of measurements used to determine this information are:

- spontaneous potential
- natural gamma radiation
- resistivity/induction

The following represent the general log suite at each borehole location:

Gamma ray (GR) tools measure naturally occurring GR radiation emitted spontaneously from the formation by uranium, thorium, and the potassium 40 isotope. Natural gamma logs are powerful tools in lithologic identification and correlation, identification of potential migration pathways, and evaluation of water quality with respect to radionuclides, such as uranium salts. GR logs usually show the clay content in sedimentary rocks because heavy radioactive elements (potassium, thorium, and uranium-radium) tend to concentrate in clays. While clays and clayey sands are higher in radioactivity, clean sands (no clay content) and carbonates usually exhibit low levels of radioactivity. The GR curve can differentiate among sands, clays, and the gradation between the two. As radioactive elements tend to concentrate in shales and clays, high GR readings reflect high shale or clay content in sedimentary units. Very low levels of radioactive elements or isotopes are present in clean formations (sands, gypsum, and anhydrite) unless contaminants are present such as dissolved potassium or uranium salts, volcanic ash, or granite wash. The tool records counts per second (CPS), which should be converted to API units. Natural gamma logs should always be calibrated in API units. The API unit is a unit of counting rate used for scaling GR logs and neutron logs (Schlumberger 2010). The API unit of radioactivity is used for natural GR logs and is based on an artificially radioactive concrete block located at the University of Houston, Texas. This unit was chosen because it was considered to be twice the radioactivity of typical shale. The United States Department of Energy (DOE) maintains facilities for the calibration of geophysical probes used in creating gamma logs with one being located in Casper, Wyoming. CBR employs the test pits monthly at the DOE Casper facility to calibrate the geophysical probes.

The Spontaneous Potential (SP) log is a measurement of the electrical potential (voltage) that occurs in a boring when fluids of different salinities are in contact. The electrical potential is produced by the interaction of formation water, conductive drilling fluids, and certain ion-selective sediments (clay). Because clays have a very low permeability, and sands have a high permeability, the SP can be a valuable lithology indicator. In general, clay-free permeable beds of moderate to low resistivity are sharply defined by the SP curve. High resistivity beds distort the SP currents, flattening the slope of the SP curve at bed boundaries. This causes poor bed boundary definition. In addition, the SP curve is also distorted (depressed or elevated) by permeable zones that contain clay, hydrocarbons, gas, or contaminants.

Single point resistance (RES) tools measure the resistance to current flow between a tool electrode and a ground electrode (conventional single point resistance), or between an electrode in the tool and the shell of the tool (differential single point resistance). Response of the log curve is attributed to lithologic units of varying resistance. Resistance increases in freshwater-filled sands or gravels and decreases in shales, clays, silts, and brine-filled sands. Curve values are recorded in ohms. Point resistance tools have a relatively small radius of investigation and poor thin bed resolution compared to resistivity tools. These logs are mainly used for correlation of beds.

The Neutron-Neutron (N-N) tool is a direct measurement of variations in the hydrogen content of the formation. An N-N probe takes a direct measurement of the variations in the hydrogen content profile. The neutron probe contains a source of high-energy neutrons (commonly americium-beryllium) with thermal neutron detectors at a fixed distance away from the source. The tool records CPS, which should be converted to API units. A high count indicates a low porosity, while a low count indicates a high porosity. Neutron logs are influenced by changes in the hole diameter.

Borehole Deviation Logging

Deviation of boreholes is measured using a slant angle and azimuth technique. CBR uses a Century Geophysical Corporation Tool Borehole deviation log tool 9057 or equivalent to record the attitude (dip angle and dip direction) of rock layers in the borehole. Borehole deviation and pad 1 azimuth are recorded in real time, via a deviation package contained within the tool, which contains the X-Y inclinometers and the X-Y-Z magnetometers. From these sensors, the Compu-Log computes and records slant angle (angle of the tool) and slant angle bearing (tool direction) as the tool proceeds along the borehole path. This device is aligned to correct for spatial indications with pad 1 azimuth. The deviation calibration is performed by recording two CPS rotating logs, and then using the dipmeter calibration to produce a special deviation calibration file (Century Geophysical Corporation 2009).

3.1.2.5 Field Observations and Core Samples Analysis

At CBR, subsurface formation lithology mapping and interpretation for boreholes during the drilling and construction of Class III wells are primarily based on field observations and geophysical logging. Field observations during drilling include depth, drilling rate, size of cuttings, and changes in lithology. Drill cuttings or core samples may be analyzed for physical and chemical parameters as needed in support of geophysical measurements. For example, core samples were recently collected in the MEA for four lithostratigraphic units. Sample analyses included XRD and sieve analysis (i.e., grain size distribution). Of particular importance for this sampling program was a better understanding of the hydraulic characterization of the upper and lower confining units for the basal sandstone of the Chadron Formation. This information was required for the Aquifer Exemption Petition.

Core samples may be collected as needed, but coring is typically not needed during the drilling and construction of Class III wells. The types of tests conducted on core samples are based on the intended need (e.g., porosity, relative permeability, and lithology).

Groundwater Measurements

Groundwater sampling and water level measurements are two tests typically conducted for new wells. Results of the groundwater sampling and analysis are used to evaluate water quality baseline values for future restoration to groundwater standards, and water level measurements provide for a more detailed understanding of the hydraulic gradient within the MEA. Groundwater monitoring for new wells is discussed below.

3.1.2.6 Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing, formation, and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

Initially, well development is generally performed by airlifting and cleanup with a drill rig. The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced.

When the water begins to become clear, the development flow will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will continue. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. pH and conductivity are monitored during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

Following well installation, all well development water will be captured in water trucks specifically labeled and dedicated for such purpose and equipped with signage indicating that these trucks may only discharge their contents for injection into the DDW. Section 3.1.5 (Wellfield and Process Waste) discusses process wastewaters generated by the wellfield and satellite facility in further detail.

3.1.2.7 Well Integrity Testing

All wells (i.e., injection, production, and monitor) are field tested using pressure-packer tests to demonstrate the mechanical integrity of the well casing. Every well will be tested after well construction is completed before it can be placed in service; after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing; at least once every 5 years; and whenever there is any question of casing integrity. To assure the accuracy of the

integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The mechanical integrity test procedure has been approved by the NDEQ and is currently contained in the SHEQMS Volume III, Operating Manual. These same procedures will be used at the MEA.

The following general mechanical integrity test procedure is used:

- The well is tested after well development and prior to the well being placed into service. The test consists of placement of two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen, and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).
- The well is then "closed in" and the pressure is monitored for a minimum of 20 minutes.
- If more than 10 percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Section 6.

CBR submits all mechanical integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

3.1.3 Wellfield Design and Operation

The proposed MEA mine schedule and MU map are shown on **Figure 1.7-4** and **Figure 1.7-5**, respectively. The preliminary map and mine schedule are based on current knowledge of the area. As the MEA is developed, the mine schedule and a mine unit map will be further developed. The MEA will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of wellhouses where injection and recovery solutions from the satellite facility building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellhouses will be either PVC or HDPE with butt welded joints or an equivalent. In the wellhouse, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite control room. The MEA mine units will be designed in a manner consistent with the existing CBR mine units.

The wellfield injection/production pattern employed is based on a hexagonal seven-spot pattern, which is modified as needed to fit the characteristics of the ore body. The standard production cell for the seven-spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown on **Figure 3.1-4**. The wellfield is a repeated seven-spot design, with the spacing between production wells ranging from 65 to 150 feet. Other wellfield designs include alternating single line drives.

All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within the monitor well ring, prior to stability monitoring, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed." The minimum overproduction or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 2.0 percent. Bleed is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression until stability monitoring described in Section 6.1.5 begins.

Monitor wells will be placed in the basal sandstone of the Chadron Formation and in the first significant water-bearing Brule sand above the basal sandstone of the Chadron Formation. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations.

Injection of solutions for mining will be at a rate of 6,000 gpm with a 0.5 to 2.0 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be pressure checked for leaks and buried prior to production operations.

A water balance for the proposed satellite facility is shown on **Figure 3.1-5**. The liquid waste generated at the satellite facility will be primarily the production bleed which, at a maximum scenario, is estimated at 1.5 percent of the production flow. At 6,000 gpm (4,500 gpm process flow and 1,500 gpm restoration flow), the maximum volume of liquid waste would be approximately 35,500,000 gallons per year. CBR proposes to handle the liquid waste using DDW injection.

Regional information, previous CBR license and permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 psi per foot of well depth. This value has historically and successfully been applied to CBR operations. Calculations for MEA result in a value of 0.53 psi. As such, the injection pressure is limited to less than 0.63 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

As discussed in Section 2.7, a regional pumping test has been conducted to assess the hydraulic characteristics of the basal sandstone of the Chadron Formation and overlying confining units. Pumping tests will also be performed for each MU not covered by the regional pump test to demonstrate hydraulic containment above the production zone, demonstrate communication between the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the basal sandstone of the Chadron Formation.

A full and detailed analysis of the potential impacts of the mining operations at Marsland on surrounding water users will be provided in an Industrial Groundwater Use Permit application. A

similar permit application was submitted by Ferret Exploration of Nebraska (predecessor to Crow Butte Resources) in 1991, and that application provides a reasonable analogy between the current licensed area and satellite facility. The application states that water levels in the City of Crawford (approximately 3 miles (4.8 km) northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the basal sandstone of the Chadron Formation during mining and restoration operations (based on a 20-year operational period).

A similar order of magnitude impact (drawdown) exists for the MEA operations. No impact to other users of groundwater is expected because there is no documented existing use of the basal sandstone of the Chadron Formation in the proposed MEA.

Because the basal sandstone of the Chadron Formation (production zone) is a deep confined aquifer, no surface water impacts are expected. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree and/or Brule Formation, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation.

Further, the geologic and hydrologic data presented in Sections 2.6 and 2.7, respectively, demonstrate that (1) uranium mineralization is limited to the basal sandstone of the Chadron Formation, and (2) this formation is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the basal sandstone of the Chadron Formation, and restoration operations will be conducted in the basal sandstone of the Chadron Formation following completion of mining.

Based on a bleed of 0.5 to 2.0 percent (0.5 to 1.5 percent have been successfully applied in the current licensed area), the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 98 percent) of groundwater used in the mining process will be treated and re-injected (**Figure 3.1-5**). Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

The data were evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent.
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping.
- The piezometric surface is horizontal prior to pumping.
- The well is pumped at a constant rate.
- No recharge to the aquifer occurs.
- The pumping well is fully penetrating.
- Well diameter is small, so well storage is negligible.

Based on a drawdown response observed during the MEA pumping test at the most distant observation well locations, the ROI during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all

observation wells completed in the basal sandstone of the Chadron Formation, with a maximum drawndown of 23.40 feet observed in the test pumping well during the test. During the test (pumping and recovery periods), no discernable drawdown or recovery responses attributed to the test were observed in overlying Brue Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation. Detailed discussions of the MEA pumping test are provided in Section 2.7.2.2 and in **Appendix F**.

As discussed in Section 5.7 of this application, an extensive water sampling program will be conducted prior to, during, and following mining operations at the satellite facility to identify any potential impacts to water resources in the area.

The groundwater monitoring program is designed to establish baseline water quality prior to mining, detect excursions of lixiviant either horizontally or vertically outside of the production zone, and determine when the production zone aquifer has been adequately restored following mining. The program will include sampling of monitoring wells and private wells within and surrounding the license area to establish pre-mining baseline water quality. Water quality sampling will continue throughout the operational phase of mining for detection of excursions. Water quality sampling will also be conducted during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved.

During operation, the primary purpose of the wellfield monitoring program will be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels, and water quality.

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfield. A bleed system will be employed that will result in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 to 2.0 percent will be maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, seven days per week in the control room. The alarms are set to prevent pressure in excess of 100 psi at the wellhouse manifold, below the 125psi integrity test pressure. Due to line losses, pressures at the wellheads remain below that which is monitored at wellhouse manifold.

Each new production well (extraction and injection) will be pressure-tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired or abandoned and replaced as necessary.

Water levels will be routinely measured in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may indicate fluid migration from the production zone. Adjustments to well

flow rates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also indicate casing failure in a production, injection, or monitor well. Isolation and shutdown of individual wells can identify the well causing the water level increases.

To ensure the leach solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will be sampled once every 2 weeks as discussed in Section 5.7.

Assessment of Flooding and Erosion Potential

The potential for flooding or erosion that could impact the proposed *in-situ* Marsland mining processing facilities and mine units has been assessed. The complete report of the hydrologic and erosion study, including tables and figures, is provided in **Appendix K** (ARCADIS 2011). The study addressed guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium *in-situ* facility. The ultimate objective of the MEA study was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

The study focused on catchment and watershed delineation, hydrologic characteristics, and determination of areas most prone to flooding and erosion due to rainfall runoff. The analysis identifies proposed wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. Four primary tasks comprise the comprehensive hydrologic and erosion analysis:

- Data collection and analysis: rainfall, digital elevation data, soil and land use data
- Watershed delineation: divide the project area basin into watersheds for detailed hydrologic analysis
- Hydrologic and erosion analysis: determine the flood routing characteristics of watersheds and generating the erosion risk map using hydrologic, land use, and soil data
- Erosion risk assessment: identify MEA wells and other site facilities in locations of high erosion potential that may require erosion mitigation

3.1.3.1 Data Collection

The data necessary to complete the study included terrain data or a digital elevation model (DEM), existing floodplain maps, land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

The terrain data were downloaded from the USGS National Elevation Dataset (NED) at a resolution of 30 m. DEM data were used throughout the model domain to describe watershed topography and streams within the hydrologic model. The project area is in the watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River Basin).

Floodplain maps in the form of Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) were downloaded from the FEMA Map Service Center (FEMA 2011). Land use data for the study area were the National Land Cover Data (NLCD) 2006, which were downloaded from the USGS seamless online Data Warehouse.

Supplementary data used to prepare and recondition the DEM include the USGS National Hydrography Dataset (NHD) published stream network, NHD Flowline (Simley and Carswell 2009) and the NRCS published 12-digit hydrologic unit (HUC12) watershed delineation (NRCS 2009).

Soil data were downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the Soil Conservation Service (SCS) Curve Number Method. Soil data were downloaded from the NRCS geospatial data gateway.

Meteorological data, including precipitation, evaporation, and runoff values, were collected from the National Ocean and Atmospheric Administration (NOAA) NWS and NCDC.

3.1.3.2 Analysis Procedures

A detailed description of procedures used for watershed delineation and basin characteristics, hydrologic and soil erosion analysis, and modeling is presented in **Appendix K.**

A GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]).was used to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results. The RUSLE model is relatively simple and is one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected due to its wide acceptance, including for construction site management at the federal level in National Pollutant Discharge Elimination System Phase II permitting (Wachal and Banks 2007, EPA 2000).

The RUSLE is the modified version of U.S. Department of Agriculture's Universal Soil Loss Equation (USLE), which has been in used to measure soil loss from agriculture lands with relatively uniform slopes. The RUSLE modified certain factors in USLE to more accurately account for more complex terrain. The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in **Appendix K.**

3.1.3.3 Erosion Risk Analysis

Mine units and other MEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. Proposed mine units, the satellite building, and the areas adjacent to the satellite building for potential placement of the access road and DDW were all evaluated. **Table 3.1-2** lists the risk of erosion for each mine unit. Maps displaying the average annual erosion potential as estimated by the RUSLE model in relation to the MUs and satellite facility locations are provided in **Appendix K**.

MU-A and MU-1 have low or very low erosion risk throughout the unit, while MU-C, MU-D, MU-E, and MU-F have very low erosion risk throughout the unit. MU-5 has multiple locations of moderate erosion risk. MU-2, MU-3, MU-4, and MU-B have locations of moderate and high erosion risk. Although MU-2, MU-3, MU-4, and MU-B have areas of high erosion risk, only 2 to 7 percent of the area within the units is at a moderate to high risk. Placement of well locations around areas of moderate and high potential erosion should be feasible in these units, particularly in MU-3, were only 2 percent of the land is at an increased risk of erosion. In comparison, 11

percent of MU-5 has a moderate risk of erosion. Though the overall risk of MU-5 is lower than other units, it may be more difficult to place wells without additional mitigation measures due to the widespread risk of erosion in the unit. If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction. Model results indicate that the risk of erosion is low or very low at the satellite facility, satellite facility access road, and DDW. Therefore, the probable need for erosion mitigation in this area is low.

As part of the concentrated flow analysis, drainage lines (i.e., channels, gullys, or areas of concentrated flow) and DFIRM floodplain extents were compared to MU locations. Although drainage lines are the primary contributor to increased erosion risk as part of the RUSLE analysis, the model was unable to accurately define erosion rates in these areas of concentrated flow during flood events. Thus, published FEMA DFIRM 100-year floodplain extents were compared to MUs in the area. MU locations within the 100-year floodplain should be considered at risk to flooding, as well as erosion caused by flood events. Further analysis, mitigation measures, or modification of well locations should be considered for those wells near concentrated flow routes or in the 100-year floodplain during the final engineering phase and prior to well installation and construction activities.

Figures 22 through **27** of **Appendix K** display the drainage lines and floodplain extents relative to the MU and satellite facility locations. Drainage line 21 (NRCS HUC number 149152245) runs generally north to south and crosses mining units MU-2, MU-3, MU-4, and MU-5. Well locations in these mining units should be positioned outside of the floodplain or should include flood protection measures in the final engineering plans. Drainage line 24 (NRCS HUC number 149157281) crosses the proposed access road to the satellite facility. However, the proposed access road and satellite facility are not within the 100-year floodplain. The access road should be constructed with consideration given to the location of the drainage and potential for concentrated runoff and erosion to occur. Drainage line 21 is predicted to accumulate notably more surface runoff than other drainages and therefore has a higher potential for flooding and erosion. Further analysis, mitigation measures, or modification of well locations will be considered for those wells near concentrated flow routes during the final engineering phase and prior to well installation and construction activities.

3.1.4 Process Description

Uranium solution mining is a process that takes place underground, or *in-situ*, by injecting lixiviant (leach) solutions into the ore body and then recovering these solutions when they are rich in uranium. The chemistry of solution mining involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the leach solution. H_2O_2 or gaseous O_2 is typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex.

The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation: $UO_{2\,(solid)} + H_2O_{2\,(in\ solution)} \longrightarrow UO_{3\,(at\ solid\ surface)} + H_2O$

$UO_{2\,(solid)} + \frac{1}{2} O_{2\,(in\ solution)} \longrightarrow UO_{3\,(at\ solid\ surface)}$

Dissolution: $UO_3 + 2\,HCO_3^{-1} \longrightarrow UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \longrightarrow UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{-2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Solutions resulting from the leaching of uranium underground will be recovered through the production wells and piped to the satellite facility for extraction. The uranium recovery process employs the following steps:

1. Loading of uranium complexes onto an IX resin;
2. Reconstitution of the leach solution by addition of CO_2 and/or $NaHCO_3$ and an oxidizer;
3. Elution of uranium complexes from the resin; and,
4. Precipitation of uranium.

The first two steps will be performed at the satellite facility. Steps 3 and 4 will be performed at the CPF. The process flow sheet for the above steps is shown on **Figure 3.1-6**. The left side of this figure depicts the uranium extraction process that is completed at the satellite facility. The right side of the figure shows the uranium recovery steps that will be performed at the CPF. Once the IX resin at the satellite facility is loaded to capacity with uranium complexes, the resin will be transferred to the CPF for the completion of uranium recovery.

3.1.4.1 Uranium Extraction

The recovery of uranium from the leach solution in the satellite facility will take place in the IX columns. The uranium-bearing leach solution enters the pressurized downflow IX column and passes through the resin bed. The uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$2\,R\,HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$

$2\,RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^-$

$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate, or sulfate ions.

The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals, as required, and pumped to the

wellfield for reinjection into the formation. The expected lixiviant concentration and composition are shown in **Table 3.1-3.**

3.1.4.2 Resin Transport and Elution

Once the majority of the IX sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The resin loaded with uranium will be transferred to a tanker truck for transport to the CPF for elution and final processing. Once the resin has been stripped of the uranium by elution, it will be returned to the satellite facility for reuse in the IX circuit.

At the CPF, the loaded resin will be stripped of uranium by an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{-2} \longrightarrow 2\,RCl + UO_2(CO_3)_2^{-2}$$

After the uranium has been stripped, the resin is rinsed with a solution containing $NaHCO_3$. This rinse removes the high-chloride eluent physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

3.1.4.3 Precipitation

When a sufficient volume of pregnant eluent is held in storage, it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2 The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\,CO_2\uparrow + 3H_2O$$

Sodium hydroxide (NaOH) is then added to raise the pH to a level conducive for precipitating pure crystals.

H_2O_2 is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

3.1.5 Wellfield and Process Wastes

All well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater surge/equalization tanks followed by disposal in the DDW.

The operation of the satellite facility will result in a production bleed stream that is continuously withdrawn from the recovered lixiviant stream at a rate that is expected to be 0.5 to 2.0 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of uranium by IX and has the same chemical characteristics as the lixiviant. The

production bleed waste stream will be managed by use of a DDW, which will be constructed and operational at the satellite facility prior to commencement of production.

The other source of wastewater resulting from uranium mining activities in the MEA is the eluent bleed stream at the CPF. This is an existing source of wastewater at the CPF that is currently produced at a rate of approximately 5 to 10 gpm. It is likely that the eluent bleed stream will increase by a maximum of 10 percent due to processing of IX resin from the satellite facility. The eluent bleed waste stream will be managed by reuse in the processing facility DDW injection at the CPF.

All byproduct material produced as a result of the operation of the satellite facility will be disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material, similar to provisions made for the byproduct material currently produced. All solid waste will be disposed of in an approved landfill in accordance with current practice. There will be no onsite disposal of these materials.

3.2 Central Processing Facility, Satellite Facility, Wellfield, and Chemical Storage Facilities – Equipment Used and Material Processed

The uranium recovery process described in the preceding section will be accomplished in two steps. The uranium recovery from the leach solution by IX will be performed at the satellite facility. The subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the existing CPF. Depending upon the mining schedules for the existing CPF wellfields and the MEA, it is possible that the belt filter and dryer capacity at the CPF may need to be increased.

3.2.1 Marsland Satellite Facility Equipment

Only the equipment proposed for the satellite facility is described in this section. The equipment and processes in the CPF are covered under the existing NRC Source Materials License Number SUA-1534. A general arrangement of equipment for the satellite facility is shown on **Figure 3.2-1**. The satellite facility equipment will be housed in a building approximately 130 feet long by 100 feet wide. The satellite facility equipment includes the following systems:

- Ion exchange
- Filtration
- Resin transfer
- Chemical addition.

The satellite facility will be located within a 1.8-acre fenced area in section 12, T29N, R51W. The DDW will be located nearby (**Figure 1.7-5**). **Figure 3.2-1** shows the plan view of the satellite facility.

The satellite facility will house the IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, a small laboratory, and an employee break room. Bulk soda ash, CO_2 and O_2 in compressed form, and/or H_2O_2 will be stored adjacent to the satellite facility or in the wellfield. $NaHCO_3$ and/or gaseous CO_2 are added to the lixiviant as the fluid

leaves the satellite facility for the wellfield. Gaseous O_2 is added to the injection line for each injection well at the wellhouses.

The IX system consists of eight fixed-bed IX columns. The IX columns will be operated as three sets of two columns in series with two columns available for restoration. The IX system is designed to process recovered leach solution at a maximum rate of 6,000 gpm. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport to the CPF. The downflow columns are pressurized, sealed systems, so there is no overflow of water; O_2 stays in solution; and radon emissions are contained. Radon releases from the pressurized downflow columns occur only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. One disadvantage of the downflow column is that there must be good pressure control. Exposure pathways associated with downflow columns to be used at MEA are discussed in Section 7.3.1.

After the IX process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals (i.e., $NaHCO_3$ and/or CO_2). The injection filtration system consists of optional backwashable filters, with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

The areas in the proposed satellite facility where fumes or gases could be generated are discussed in Section 7.3. The potential sources are minimal in the satellite facility because the mining solutions contained in the process equipment are maintained under a positive pressure. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the satellite facility air to the atmosphere.

3.2.2 Chemical Storage Facilities

Chemical storage facilities at the satellite facility will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Other non-hazardous bulk process chemicals (e.g., sodium carbonate [$NaCO_3$]) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

3.2.2.1 Process-Related Chemicals

Process-related chemicals stored in bulk at the satellite facility will include CO_2, O_2, and H_2O_2. Sodium sulfide (Na_2S) may also be stored for use as a reductant during groundwater restoration.

CO_2

CO_2 is stored adjacent to the satellite facility where it will be added to the lixiviant prior to leaving the satellite facility.

O_2

O_2 is also typically stored at the satellite facility, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Because O_2 readily supports combustion, fire and explosion are the principal hazards that must be controlled. The O_2 storage facility will be located a safe distance from the satellite facility and other chemical storage areas

for isolation. The storage facility will be designed to meet industry standards in NFPA-50 (NFPA 1996).

O_2 service pipelines and components must be clean of oil and grease because gaseous O_2 will cause these substances to burn with explosive violence if ignited. All components intended for use with the O_2 distribution system will be properly cleaned using recommended methods in CGA G-4.1 (CGA 2000). The design and installation of O_2 distribution systems is based on CGA-4.4 (CGA 1993).

Na_2S

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., Na_2S or hydrogen sulfide (H_2S) gas). To minimize potential impacts to radiological safety. These materials are stored outside of process areas. Na_2S is currently used as the chemical reductant during groundwater restoration at the current license area. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. H_2S gas has never been used at the CPF. In the event that CBR determines that use of H_2S as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the SHEQMS, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system is located only at the CPF and will not be used at the satellite facility.

None of the hazardous chemicals used at the CPF are covered under the EPA Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

3.2.2.2 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the satellite facility include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the satellite facility. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet regulatory requirements

3.3 Instrumentation and Control

The wellhouse will be located remotely from the satellite facility building. A distribution system will be used to control the flow to and from each well in the wellfield. Wellfield instrumentation will measure total production and injection flow and indicate the pressure being applied to the

injection trunklines. A wellhouse will be equipped with wet alarms to monitor the presence of liquids in the wellhouse sumps. The system is monitored 24 hours per day, 7 days per week by control room operators. The operators rely on visual and audible alarms from a variety of systems to control mine operations. Power failures, pressure exceedences and flow disruption are some of the conditions for which alarm systems will be monitored.

Instrumentation will monitor the total flow into the satellite facility, the total injection flow leaving the facility, and the total waste flow leaving the facility. Instrumentation on the facility injection manifold will record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The instruments used for flow measurement will include, but are not limited to, turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, and piezoelectric and vortex flow meters. The injection pumps are equipped with pressure reducing valves so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure to be applied to the injection wells. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control the trunkline pressures. During power failures, overpressuring of wells is not possible as all pump systems are shut down.

The basic control system at the satellite facility and associated wellfield will be built around a Sequential Control and Data Acquisition (SCDA) network. At the heart of this network is a series of programmable logic controllers. This system allows for extensive monitoring and control of all waste flows, wellfield flows, and facility recovery operations.

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to computer display screens. The software used to display facility processes and collect data incorporates a series of menus which allows the facility operators to monitor and control a variety of systems and parameters. Critical processes, pressures, and wellfield flows will have alarmed set-points that alert operators when any are out of tolerance. In addition, each wellhouse will contain its own processor, which will allow it to operate independent of the main computer. Pressure switches will be fitted to each injection manifold in the wellhouse to alert the facility and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible power supply systems with 30-minute supply in the event of a power failure.

Through this system, not only will the facility operators be able to monitor and control every aspect of the operation on a real-time basis, but management will be able to review historical data to develop trend analysis for production operations. This will not only ensure an efficient operation, but will allow Crow Butte personnel to anticipate problem areas and to remain in compliance with appropriate regulatory requirements.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

Detailed information on the instrumentation and controls will be developed as part of the final design activities prior to construction. This information will be made available to the NRC for review prior to any construction activities.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the satellite facility. Specifications for this equipment are included in the SHEQMS Volume IV, Health Physics Manual, and are discussed in further detail in Section 5. The locations of monitoring points, monitoring procedures, and monitoring frequencies for in-plant radiation safety are also discussed in Section 5.

The types of health physics instrumentation that would be used at the proposed MEA include the following:

Air Sampling Equipment

- Eberline RAS-1 or Aircon 2 samplers (0-100 lpm) or equivalent

  Calibrated semiannually or after repair on site with a primary standard instrument or a properly calibrated secondary standard instrument

- BDX II or SKC lapel samplers (0-5 lpm) or equivalent

  Calibrated daily before each use on site with a primary standard instrument or a properly calibrated secondary standard instrument.

External Radiation Equipment

- Ludlum Model 19 Gamma Meter (μR/hr) or equivalent
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector (mR/hr) or equivalent
- Ludlum Model 2221 Ratemeter/Scaler with a Ludlum Model 44-10 NaI detector (cpm) or equivalent

  Calibrated annually or after repair manufacturer or qualified accredited vendor.

Surface Contamination Equipment

- Ludlum Model 2241 scaler or a Ludlum Model 12 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent (Total Alpha)
- Ludlum Model 177 Ratemeter with a Ludlum Model 43-5 alpha scintillation probe or equivalent (Personnel Contamination)
- Ludlum Model 2000 Scaler or Model 2200 Scaler with an Eberline SAC-R5 or Ludlum Model 43-10 alpha scintillation sample counter or equivalent (Removable Alpha, Radon Daughters, Airborne Radioactivity)

Instruments will be calibrated annually or at a frequency recommended by the manufacturer, whichever is more frequent. Repairs will be by the manufacturer by or by a qualified accredited vendor, and the instrument will be calibrated following such repair. The calibration vendor shall provide the as-found calibration condition of each instrument. If more than 10 percent of the instruments are out of calibration when received by the calibration vendor, consideration would be given to increasing the calibration frequency.

New radiation survey instruments will be acquired for use at the MEA. The number of instruments purchased will be sufficient so that backup instruments are available in the event of failure of one, or if one instrument has been sent to the vendor for calibration or repair.

The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration will be performed as recommended in ANSI N323 and ANSI N323A. The ANSI standard requires that radiation detection instruments are performance tested annually to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instruments are discussed in the SHEQMS Volume IV Health Physics Manual.

RG 8.30 specifies requirements for routine maintenance and calibration of radiological survey instruments. RG 8.30 references the standards contained in ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration. ANSI is in the process of a major revision of this Standard that will result in three separate Standards that apply to radiological instrumentation. The first revision, ANSI-N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, was incorporated in this Chapter. When conflicts arise between NRC RG 8.30 and the ANSI Standard, the RG recommendations will be followed.

Calibration vendors will provide a certificate of calibration for all instruments. These calibration certificates will be maintained by the Radiation Safety Officer (RSO) on file for that instrument. Records of repair completed by the calibration vendor will also be maintained in the instrument file.

Documentation of calibration of air samplers performed on site will be maintained by the RSO in the sampler file.

Records of instrument checks, including the daily checks and initial checks, will be maintained in a format determined by the RSO. These records will be readily available and in a format that will allow the RSO to review the records for the types of potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 cpm).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details about calibration, functional tests, procedures, and recordkeeping/retention are discussed in the SHEQMS Volume IV Health Physics Manual.

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Wachal, D. and K.E. Banks. 2007. Integrating GIS and Erosion Modeling: A Tool for Watershed Management, ESRI 2007 International User Conference, Paper No. UC1038.

Table 3.1-1 Background Information for Logging Probes Used at the Marsland Expansion Area

Logging Tool	Tool Specifications
9060	Natural Gamma, Spontaneous Potential, Single Point Resistance
9055	Vertical Deviation, Natural Gamma, Neutron Detector, Neutron Porosity, Spontaneous Potential, Single Point Resistance
9144	Natural Gamma, 64-inch Normal Resistivity, 16-inch Resistivity, Fluid Resistivity, 48-inch Lateral Resistivity, Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Aximuth
9057	Natural Gamma, 64-inch Normal Resistivity, 16-inch Normal Resistivity, Neutron-Neutron, 48-inch Lateral Resistivity, Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Azimuth

Table 3.1-2 Summary of Risk of Erosion for Proposed Marsland Expansion Area Mine Units

Mining Unit	MU Maximum Soil Loss (ton/acre/year)	MU Maximum Erosion Risk	Percent MU Area of Moderate to High Erosion Risk	Drainage Lines Crossing MU
MU-A	3.3	Low	N/A	N/A
MU-1	3.4	Low	N/A	N/A
MU-2	18.7	High	5	21
MU-3	22.2	High	2	21
MU-4	24.5	High	7	21
MU-5	13.5	Moderate	11	21
MU-B	20.0	High	6	N/A
MU-C	2.7	Very Low	N/A	N/A
MU-D	0.9	Very Low	N/A	30
MU-E	1.1	Very Low	N/A	N/A
MU-F	0.7	Very Low	N/A	N/A

Table 3.1-3 Typical Lixiviant Concentrations

Species	Range (in mg/l)	
	Low	High
Na	≤ 400	6,000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2,500
HCO_3	≤ 400	5,000
Cl	≤ 200	5,000
SO_4	≤ 400	5,000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12,000
pH	≤ 6.5	10.5

Note:
The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid."

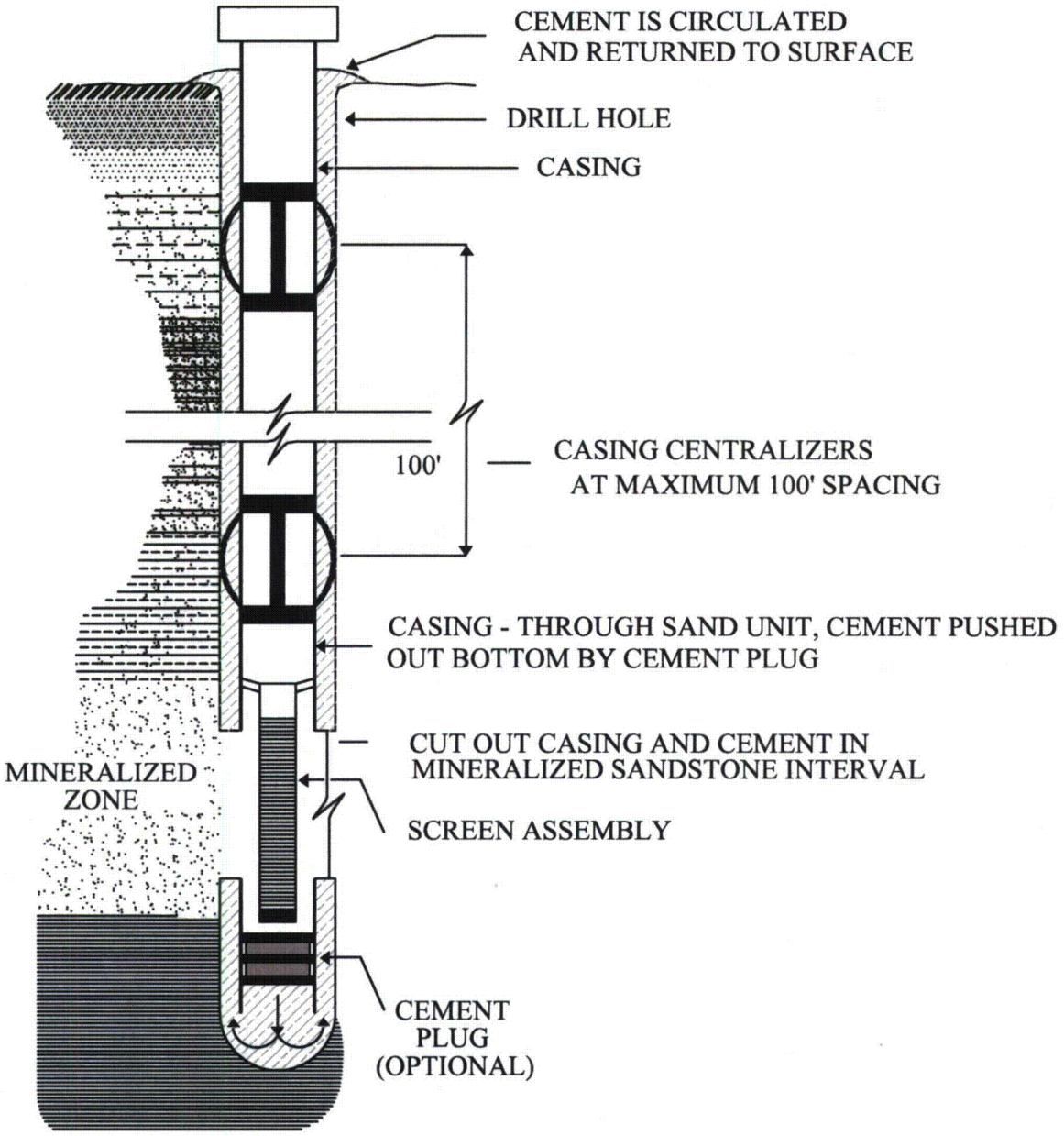

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FIGURE 3.1-1

TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS

METHOD NO.1

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PATH: K:\CBR_[...]CO001396_ThreeCrow\1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: TechRpt_No1 TIME: 2/2/2010 2:24 PM

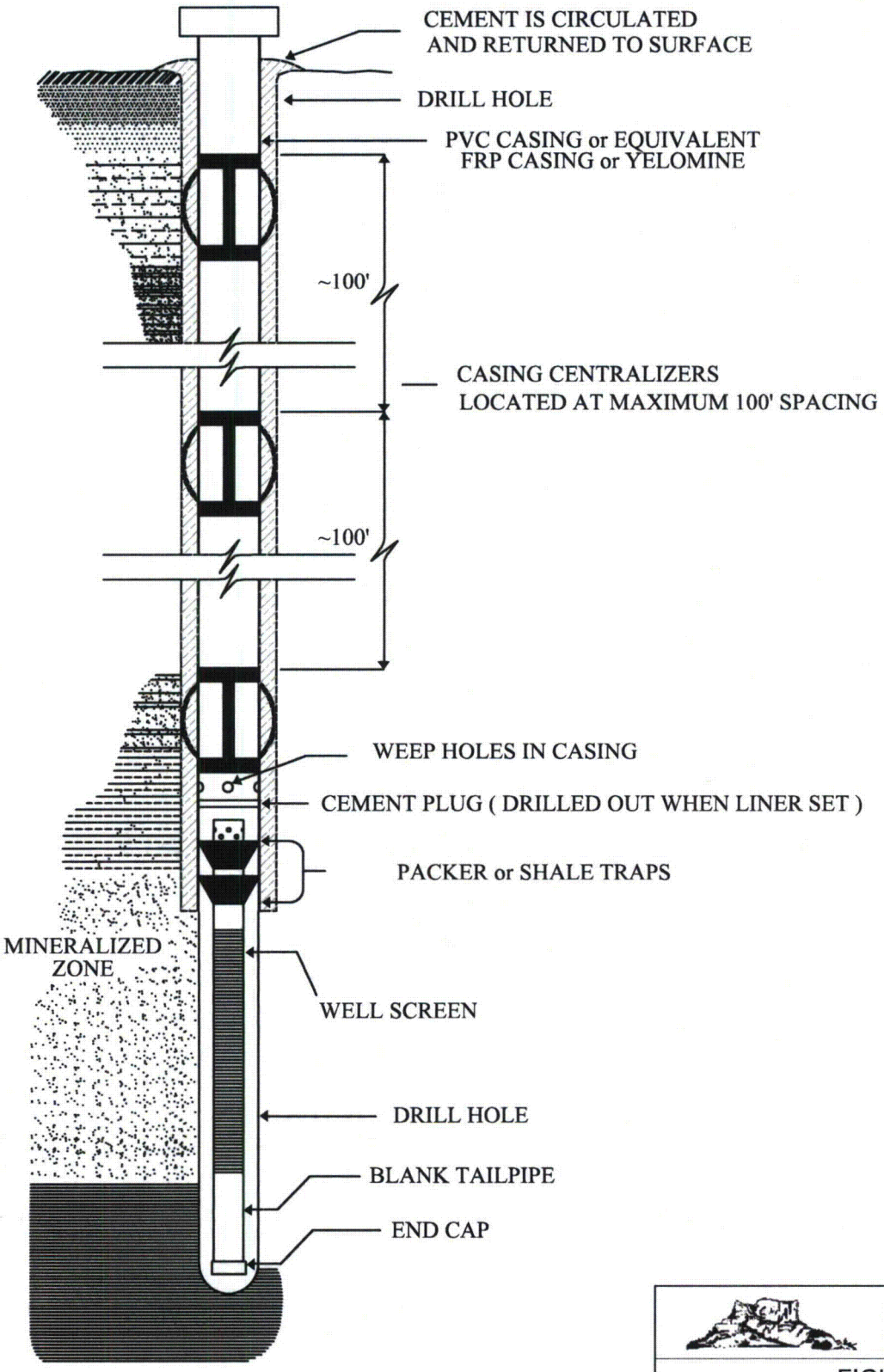

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FIGURE 3.1-2

TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.2

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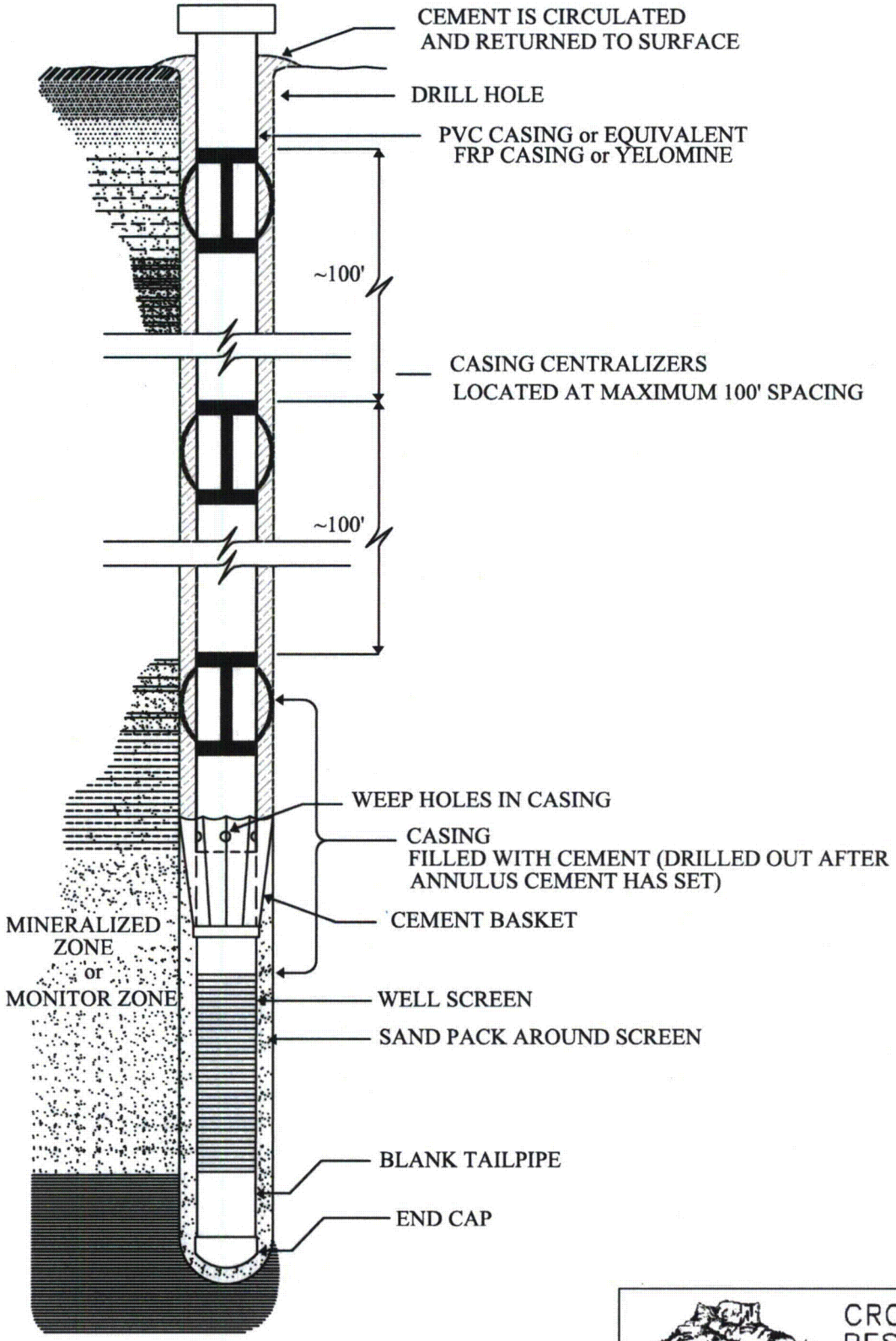

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FIGURE 3.1-3

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.3

PROJECT: CO001396.02 MAPPED BY: JC CHECKED BY: JEC

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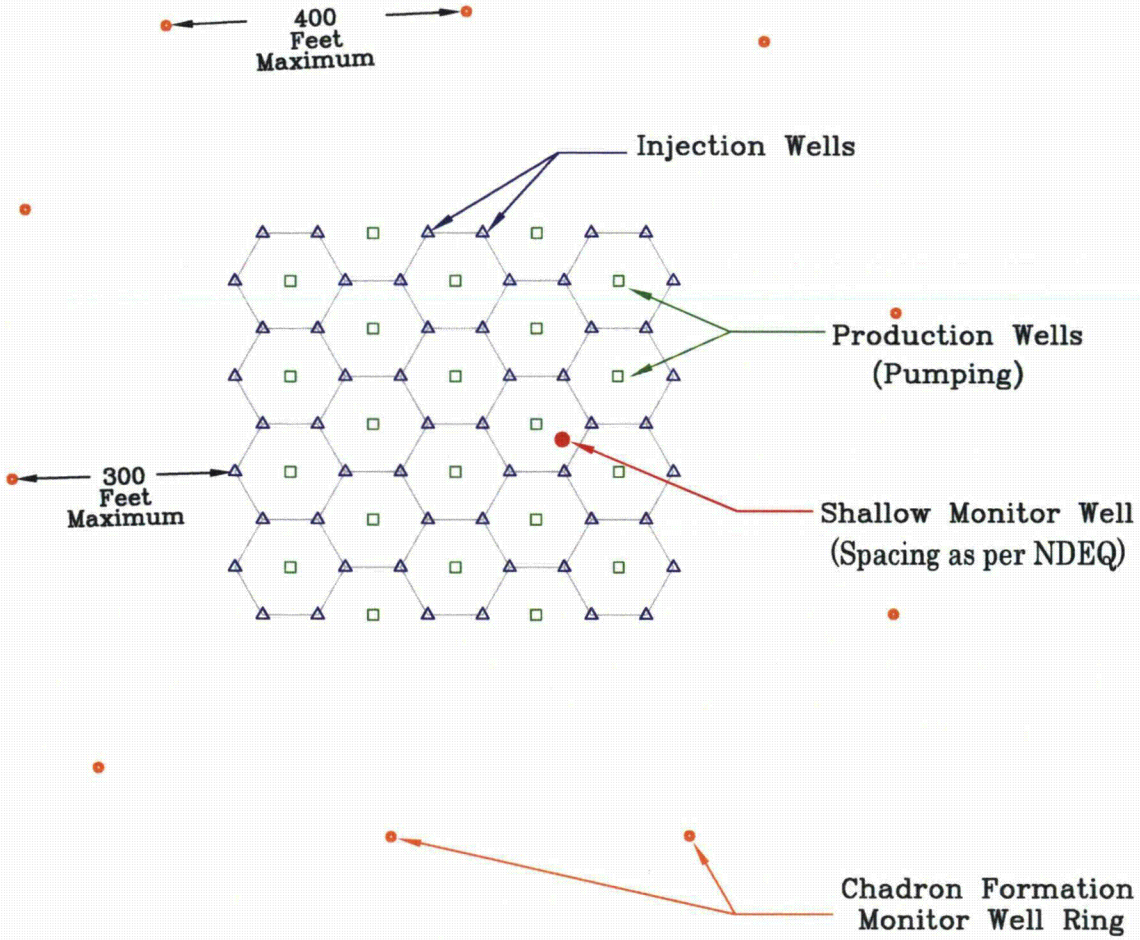
PATH: K:\CBR_\CO001396_ThreeCrow\1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: TechRpt_No3 TIME: 2/2/2010 2:24 PM



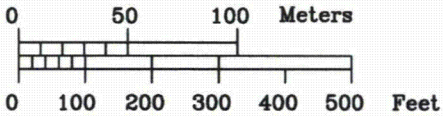


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FIGURE 3.1-4

TYPICAL WELLFIELD LAYOUT

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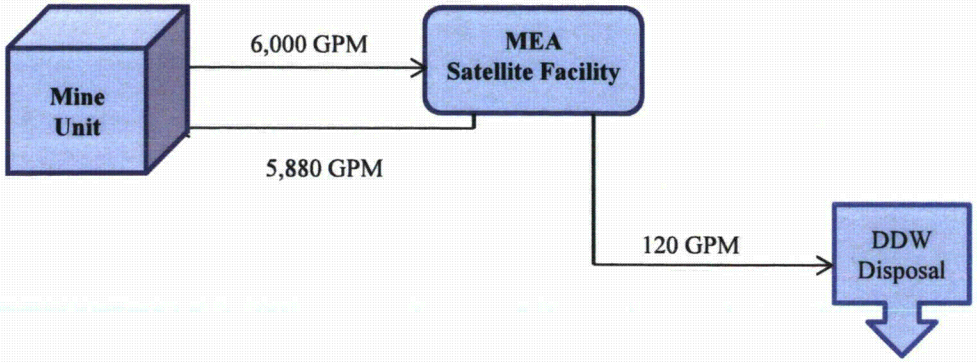
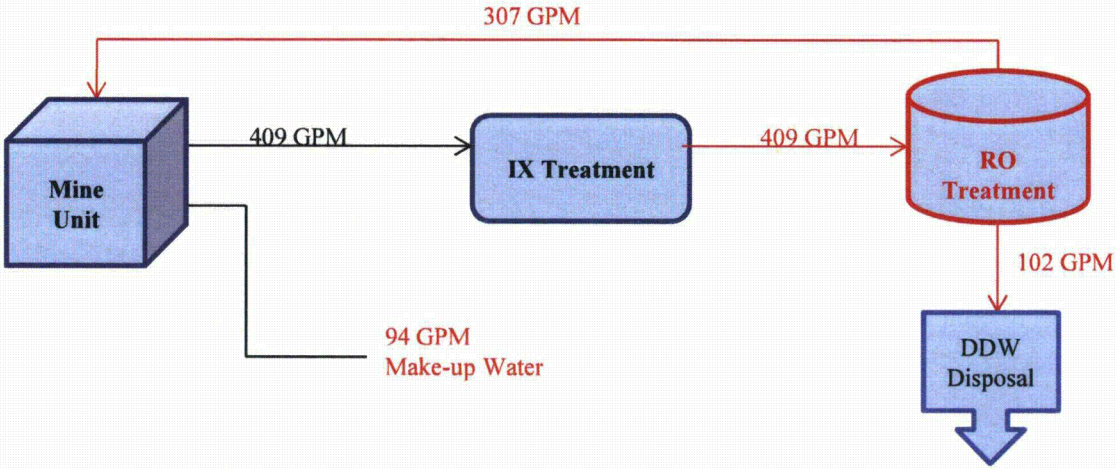
K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 3_1-4 Typical Wellfield Layout.ai @ 10/21/2011 BY: J. CHEN @ Boulder, CO



Water Balance Flow Example for Production



Water balance Flow Example: Restoration – IX Treatment & RO Treatment Phase

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FIGURE 3.1-5
WATER BALANCE FOR MARSLAND FACILITY

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K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 3_1-5 WaterBalance.ai @ 04/06/2012 BY: J.CHEN @ Boulder, CO

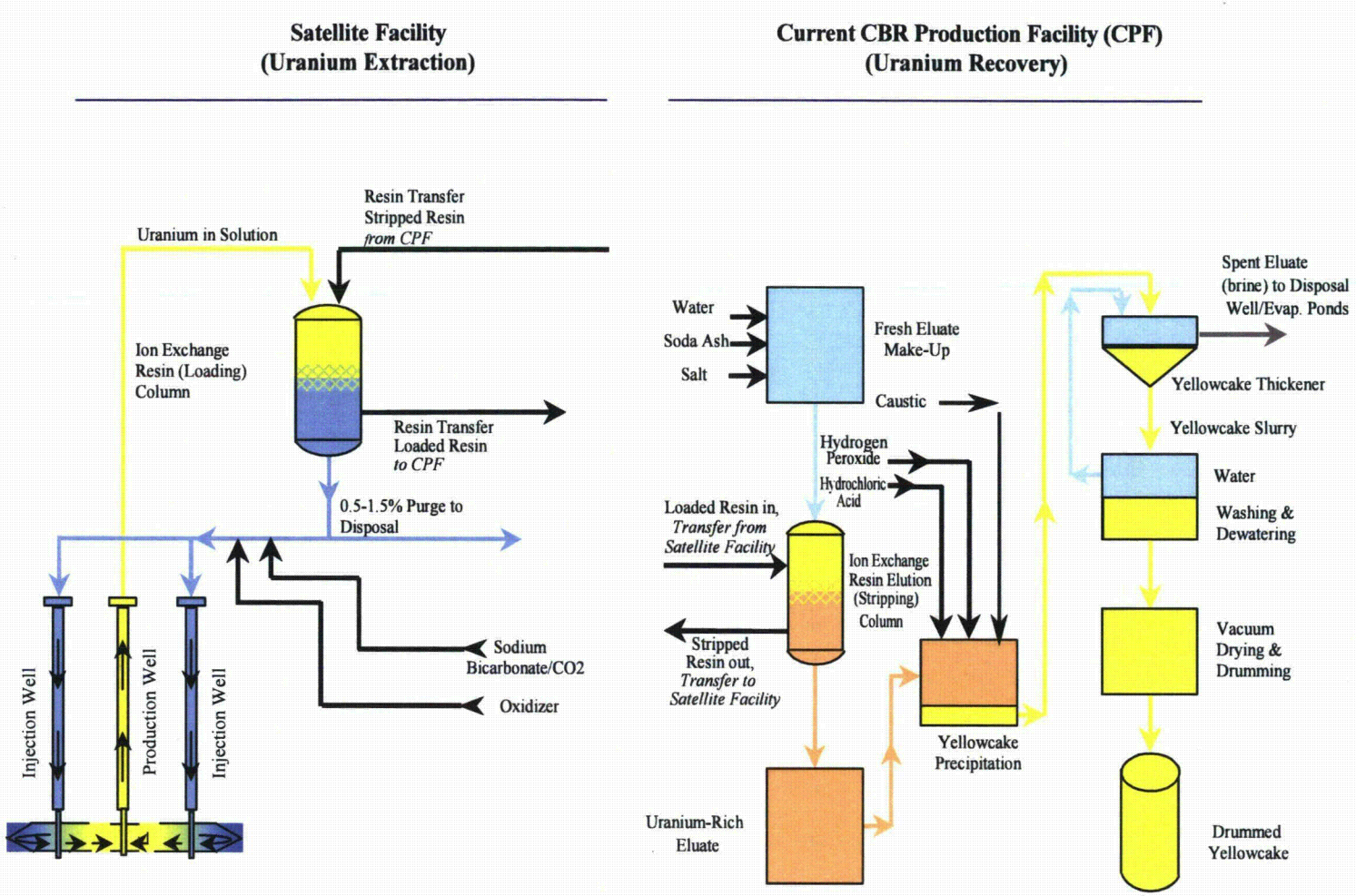

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FIGURE 3.1-6
MARSLAND EXPANSION AREA
SATELLITE FACILITY AND
CURRENT CBR PRODUCTION FACILITY
PROCESS FLOW DIAGRAM

PROJECT: CO001636.00001 MAPPED BY: JC CHECKED BY: JEC

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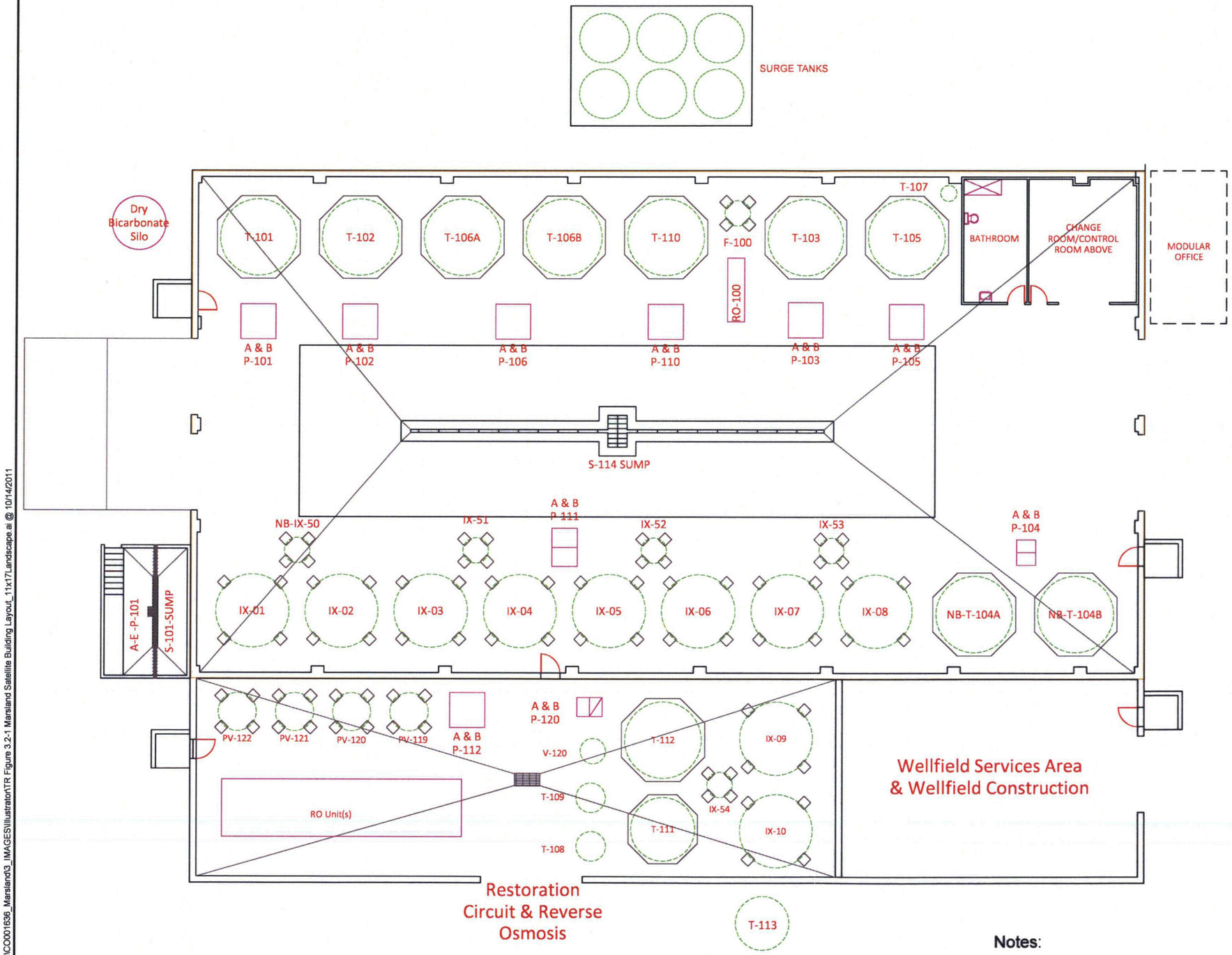
K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 3_6-1 Process Flow Diagram.ai @ 10/21/2011 BY: J.CHEN @ Boulder, CO



Tank (# each)	Size (diameter x height)	Capacity (gallons)	Description
IX-01 through 08	11'-6" x 9'-0"	7,000	Ion Exchange
IX-50 through 54	4'-0" x 7'-6"	625	Ion Exchange Resin Trap
IX-09 through 10	11'-6" x 9'-0"	7,000	Restoration IX Column
T-101	12'-0" x 13'-6"	12,000	Bicarbonate Mix
T-102	12'-0" x 17'-0"	14,500	Bicarbonate Storage
T-103	12'-0" x 17'-0"	14,500	Reverse Osmosis Feed
T-104 A	12'-0" x 21'-9"	16,000	Resin Transfer
T-104 B	12'-0" x 17'-2"	14,500	Resin Transfer
T-105	12'-0" x 17'-0"	14,500	Water Supply/Makeup Water
T-106 A	12'-0" x 21'-9"	16,000	Wastewater
T-106 B	12'-0" x 17'-2"	14,500	Wastewater
T-107	2'-4" x 5'-3"	119	Water Pressure tank
T-108		5,000	Sodium Sulfide Day
T-109		1,000	Sodium Sulfide Mix
T-110	12'-0" x 21'-9"	16,000	Well Work Over Fluid
T-111	10'-0" x 13'-0"	7,500	RO Cleaning Tank
T-112	12'-0" x 17'-0"	14,500	Permeate Tank
T-113	11'-9" x 13'-3"	10,000	HCl Feed Tank
PV-119 through 122	6'-0" x 10'-0" (assumed)		RO Filter
V-120	unknown		Degaser
T-114	12'-0" x 18'-0"	16,000	Waste Water at Disposal Well
Surge Tanks		6 x 50,000	Wastewater Tanks

Notes:

1. Illustration only, not to scale.
2. Adapted from Cameco Resources, 2011.

CROW BUTTE RESOURCES, INC.

FIGURE 3.2-1
MARSLAND
SATELLITE BUILDING LAYOUT

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 3.2-1 Marsland Satellite Building Layout_11x17Landscape.ai @ 10/14/2011

4. EFFLUENT CONTROL SYSTEMS

The proposed MEA Project will generate both radioactive and non-radioactive airborne effluents during construction and/or operations. The effluents of concern at the proposed satellite facility will include the release or potential release of radon gas (radon-222). Yellowcake will be processed and dried nearby at the CPF and not at not at the MEA. Loaded IX resin from the satellite facility will be transported to the CPF for elution, precipitation, drying, and packaging. Effluent control systems will be used at the satellite facility to control the release of radioactive materials to the atmosphere.

The yellowcake drying facilities at the current CPF currently consists of one operational vacuum dryer. A second dryer has been installed but will not be operational until 2012. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the current CPF have been reviewed by NRC and approved in the current license.

4.1 Gaseous and Airborne Particulates

4.1.1 Non-radioactive Airborne Emissions

The operation of internal combustion engines will be the primary source of non-radioactive gaseous airborne emissions. The majority of the combustion emissions are expected to be diesel emissions, which will be limited. Other minor releases may include: drilling rigs and support equipment (e.g., pipe trucks, water trucks, cement units, haul trucks, and pipe and other well completion equipment); maintenance vehicles; wellfield utility vehicles (e.g., workover units, mechanical integrity testing units, and swabbing units); and light vehicles used during operations, construction, and travel to and from the site. Non-radioactive emissions that can be expected from such activities include CO_2, carbon monoxide, nitrogen dioxide, sulfur dioxide, PM_{10}, and total hydrocarbon (THC).

One of the primary non-radioactive emissions will be fugitive dust generated during all project phases (construction, operation and decommissioning). Minor non-radioactive airborne effluents may include: dust from small releases of particulates during delivery and unloading of dry bicarbonate powder to a storage silo; CO_2, O_2, and water vapor vented from process operations; dust generated during cementing operations, building construction activities (e.g., welding fumes and grinding), and various maintenance activities.

Mitigation measures are discussed in Sections 7.1, 7.2 and 7.4.

4.1.2 Radioactive Airborne Emissions

The principal radioactive airborne gaseous radiological effluent at the MEA will be radon-222 gas. Processing at the satellite facility will produce water-based solutions or wet slurry (no yellowcake processing or drying); therefore, airborne uranium concentrations are expected to be at or near local background levels. Airborne releases from uranium ISR facilities normally are radon-222 and its daughters from process fluids and particulates from yellowcake drying and packaging operations (NRC 2001). One process area at the proposed MEA where small quantities of airborne uranium particulates have the potential for occurring is the resin transfer station where minor spills may occur. The loaded IX resin is transferred to a truck for transport

to the CPF for completion of uranium recovery. Spills can occur during resin transfer, and this is where exposure to uranium particulates is possible. All spills will be cleaned up as soon as possible to prevent the wet materials from drying and creating the potential for airborne particulates. Spills associated with resin transfer would involve the impregnated resin itself. The uranium is still bound to the resin at this stage, reducing the potential of employee exposure.

Maintenance activities on piping containing pregnant lixiviant could also result in the release of radon and uranium. Any spills or releases during maintenance of these potential sources would be cleaned up promptly to prevent drying of the material and creation of particulates subject to dispersion. All non-routine operations or maintenance activities where the potential exists for significant exposure to radioactive materials, and for which there is no SOP, require a Radiation Work Permit (RWP). The RWP ensures that the applicable radiological safety measures are used by the workers, and identifies the type of personnel monitoring that would be required for determining radiation exposure (i.e., internal and external radiation).

One stationary sample point would be established near the resin transfer station and sampled monthly for potential airborne uranium particulates. Monitoring activities for routine operations, maintenance activities, and spill cleanups are discussed in Section 5.7.

Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The uranium is then separated from the lixiviant by passing the solution through fixed-bed IX units operated in a pressurized downflow mode. Vessel vents from the individual IX vessels will be directed to a manifold that is exhausted to atmosphere outside the satellite building. Venting any released radon-222 gas to the atmosphere outside the satellite facility via high-volume exhaust fans minimizes employee exposure. Small amounts of radon-222 may be released via solution sampling and spills, filter changes, IX resin transfer, RO system operation during groundwater restoration, and maintenance activities. These are minimal, infrequent radon gas releases. The general building ventilation system in the satellite facility will further reduce employee exposure. The air in the satellite facility is sampled for radon daughters (see Section 5) to ensure that concentration levels of radon and radon daughters are maintained as low as reasonably achievable (ALARA).

Injection wells would generally be closed and pressurized, but periodically vented, releasing radon to the atmosphere. Production wells will be continually vented to the surface, but water levels will typically be low and radon venting will be minimal. All of the well releases would be outside of buildings and directly vented to the atmosphere. Some venting would also occur from the wellhouses. Wellhouses would be vented to remove any radon releases from the building to the surrounding atmosphere. The exhaust fans are located in the wall directly opposite the entryway. Releases to the atmosphere from wells and wellhouses would result in radon emissions dispersing rapidly. Wellfield offgassing is not considered a significant source of radon or a safety issue. This statement is supported by MILDOS-AREA calculations (Section 7.3) and by monitoring at the current CPF. Radon individual exposure levels from 1994 through 2006 for Crow Butte employees ranged from 5 to 16 percent of the occupational exposure limit of 4 working level months. Exposure to radon is reported as working level months, a unit commonly used in occupational environments and refers to exposure to a set concentration of radon and its associated progeny. Exposures at the proposed the satellite facility would be expected to be less than for the current operations due to lack of uranium recovery operation activities such as elution, precipitation, and drying. Radiological exposure pathways are discussed in Section 7.3.

4.1.2.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks that could potentially produce radon (i.e., resin transfer tank and wastewater tanks). Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere by forced-air ventilation. The fans will be designed such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in RG 8.31 (NRC 2002). Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the satellite facility.

A tank ventilation system of this type is used in the existing CPF. Operational radiological in-plant monitoring for radon concentrations has proven this system to be an effective method for minimizing employee exposure.

4.1.2.2 Work Area Ventilation System

The work area ventilation system would be designed to force air to circulate within the satellite facility process areas.

4.1.2.3 Marsland Ventilation System

The ventilation system at the proposed Marsland facilities would be similar to that used at the CPF. Exhaust fans would exhaust air within the building outside to the top of the building, drawing in fresh air. The discharge stacks will be located away from the building ventilation intakes and positioned on the leeward side of the satellite building (based on predominant wind direction) to prevent introducing exhausted emissions into the facility. These exhaust fans would be located at different levels to ensure that areas where radon could accumulate are ventilated sufficiently to prevent radon accumulation. The exhaust fans will create a negative flow, ensuring that air will not enter the process areas from vessels and systems within the satellite building. There will be redundant fans of the same size and capacity, which will operate only when the primary fans are inoperative due to maintenance or repair.

Storage tanks with the potential for radon emissions would also be vented to the outside of the building. Separate and independent local ventilation systems may be used temporarily as needed for non-routine activities such as maintenance. As discussed above for the CPF, radon daughter monitoring at the proposed satellite facility would be used to verify that radon daughters are maintained below the 25 percent DAC action level. Ongoing operations would ensure that the ventilation system operates satisfactorily and as designed through the use of SOPs.

Minor quantities of radon emissions may occur in a wellfield from wellheads and wellhouses. Vents will not be installed on wellhead enclosures, but SOPs will be used when accessing a wellhead enclosure in order to ensure minimal exposures to personnel. Wellhouse buildings will be ventilated with ventilation systems of either a roof- or wall-mounted fan. When the buildings are accessed, the doors will be opened, allowing for additional ventilation of the building prior to

entry by personnel. Radon emissions associated with wellfield operations will quickly disperse into the atmosphere.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. There are no significant amounts of process chemicals that will be used at the satellite facility. There are no significant combustion-related emissions from the process facility, as commercial electrical power is available at the site. The primary types of non-radiological pollutants that could occur during operations at the MEA site are discussed in Section 7.2. The satellite facility operational building would not house combustion devices, except for the propane heaters used for heating the building as needed.

Occupational and public exposures to radon emitted from the mine units and from the satellite processing facility were analyzed using the MILDOS-AREA computer model to ensure that the discharged amount would be within regulatory dose limits. The results of this modeling are presented in Section 7.3.

4.1.3 Response to Emergency Events Associated with Effluent Control Systems

Currently, Crow Butte adheres to requirements in the SHEQMS Volume VIII, Emergency Manual (CBR 2010a), which provides guidance in responding to emergency situations that could occur at the site in the event of effluent system failures. The Marsland project will also be subject to the requirements of this manual. It is understood that this manual is a guideline and that individuals charged with the responsibility of responding to and managing emergencies must use their best judgment when making decisions related to the emergency. The manual is designed to guide the employee on how to properly respond to an emergency.

In the event of a failure of an effluent control device or other mishap that could result in exposure of an individual to elevated quantities of radiation present in gases, liquids, or solids, emergency procedures outlined in the emergency manual and other applicable procedural manuals will be implemented. Guidelines in these manuals, on which employees receive training, will be implemented to minimize individual exposures. The emergency manual addressed emergency situations such as medical emergencies, fires, explosions, radiological emergencies, chemical emergencies, transportation emergencies, natural disasters, and security threats. Appendix A of the SHEQMS Emergency Manual provides detailed instructions for responding to an emergency involving bulk, petrochemical, and compressed gases used at the site. If needed, CBR maintains emergency evacuation procedures that all employees, contractors, and visitors are trained to follow.

CBR also maintains the SHEQMS Volume III, Operating Manual (CBR 2010b), which addresses proper operations of effluent control devices, as well as procedures to follow in the event of non-emergency failures of effluent control devices.

The implementation of the operational and emergency manuals supports CBR efforts to eliminate exposures under both normal and accident conditions. Effluent control techniques are discussed in Subsection 5.7.1.

4.1.4 ALARA Evaluations of Effluent Control Systems

As with the current CBR operations, CBR will operate the effluent controls so that all airborne effluent releases are maintained ALARA. CBR maintains a strict ALARA policy to keep exposures to all radioactive material and other hazardous material as low as possible and to as few personnel as possible, as defined in the SHEQMS Volume IV, Health and Physics Manual (CBR 2010c). The project radiation control program and ALARA program is comprehensively reviewed annually. Such a review would include exposures associated with the effluent control systems.

4.2 Liquids and Solids

4.2.1 Liquid Waste

As a result of ISR mining, there are several sources of liquid waste. The potential wastewater sources that exist at the satellite facility include the following:

4.2.1.1 Water Generated During Well Development

This water is recovered groundwater and has not been exposed to any mining process or chemicals. However, the water may contain elevated concentrations of naturally occurring radioactive material if the development water is collected from the mineralized zone. Well development water will be captured in water trucks specifically labeled for such purpose and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater disposal system (wastewater surge/equalization tanks and DDW). If required, well development water may be transported to the CPF site for disposal in the lined evaporation ponds. Well development water may also be treated with filtration and/or RO and used as plant make-up water.

4.2.1.2 Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed, as previously discussed in Section 3. This bleed will be routed to surge/equalization tanks and then pumped from the tanks to the DDW.

4.2.1.3 Aquifer Restoration Waste

Following mining operations, restoration of the affected aquifer results in the production of wastewater. The current groundwater restoration plan consists of four activities:

1. Groundwater Transfer
2. Groundwater Sweep
3. Groundwater Treatment
4. Wellfield Circulation

Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water would be extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted

water must be sent to the wastewater disposal system during this activity (wastewater surge/equalization tanks and deep well disposal). As has been the case with past operations at Crow Butte, it is anticipated that, during restoration, groundwater at the MEA will be treated using IX and RO. Using this method, there would be no water consumption, and only the bleed has to be disposed, with the rest of the treated water being reinjected.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A RO unit will be used to reduce the TDS in the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system.

4.2.1.4 Stormwater Runoff

Stormwater may be contaminated by contact with industrial materials. Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 (NDEQ 2010a) requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. The design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated stormwater runoff or snowmelt (e.g., tankage diking or curbing outside of the satellite building) will be collected and disposed of in the DDW.

4.2.1.5 Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The septic system will be designed with a capacity sufficient to handle the projected number of employees, contractors, and visitors. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the current license area. A similar permit will be required for the satellite facility.

CBR will employ an estimated 10 to 12 employees at the proposed MEA satellite facility. Assuming 13 gpd for each employee (based on estimate for industrial employees by EPA), a total of approximately 130 to 160 gpd of sanitary waste would be generated (EPA 2002). An assumed additional 50 gpd of miscellaneous sanitary wastewater (e.g., small laboratory and kitchen) would result in approximately 180 to 210 gpd of sanitary wastewater being discharged to the septic system.

The number of temporary construction employees for the proposed satellite facility is estimated at 10 to 15 personnel. An assumed an average of five to 10 full-time employees during construction would result in a total of 15 to 25 employees on site for some periods. This would result in approximately 200 to 325 gpd of sanitary waste generation. During initial construction, portable sanitary units will be used, which will be provided and serviced by a third-party contractor.

The septic system will be designed, constructed, operated, and permitted as per applicable NDEQ Title 124 regulations.

4.2.1.6 Laboratory Waste

Liquid waste from the laboratory will be disposed of in the DDW. Approximately 1,000 gallons per month of non-hazardous liquid waste from the laboratory, composed of sample discards, lab solutions, dish washing wastewater, and lab cleanup wastewater will be disposed of in the DDW via surge/equalization tanks.

4.2.1.7 Liquid Waste Disposal

Disposal of liquid operational wastes for the satellite facility will be via a DDW. Surge/equalization storage tanks will initially receive all wastewater before injection into the DDW. The surge/equalization tanks will be used for wastewaters that would otherwise be discharged to an evaporation pond. No evaporation ponds are planned for the MEA project site. In addition to this disposal method, the NDEQ has issued CBR an NPDES permit for the CPF license area that allows land application of treated wastewater. CBR has not used this waste disposal method at the current operation. At this time, CBR does not intend to apply for an NPDES permit to allow land application at the satellite facility. It is expected that liquid waste generated in the MEA can be satisfactorily managed with the use of the surge/equalization tanks and a DDW. If needed in an emergency situation, contaminated wastewater can be collected and trucked to an approved commercial disposal facility for disposal.

DDW

CBR currently operates two non-hazardous Class I injection wells in the CPF license area for disposal of wastewater. The wells are permitted under NDEQ regulations in Title 122 (NDEQ 2010b) and operated under a Class I UIC Permit. CBR has operated the initial DDW at the current license area for more than 10 years with excellent results and no serious compliance issues. CBR expects that the liquid waste stream at the satellite facility will be chemically and radiologically similar to the waste disposed of in the current DDW. Radiological data for the years 2008 and 2010 for current DDW injection stream are shown in **Table 4.2-1**. The non-radiological data for the DDW injection stream for 2010 are presented in **Table 4.2-2**.

CBR plans to install a DDW at the satellite facility as the primary liquid waste disposal method. CBR has found that permanent deep disposal is preferable to evaporation in ponds. The basic reasons for this position are as follows:

- The potential for human contact while using a deep well is lower because the waste is handled in enclosed systems.
- The potential for emissions from the pond surface is higher than the enclosed deep well disposal system.
- Evaporation ponds carry the potential for leaks and impacts to the environment.
- Use of evaporation ponds creates a larger amount of 11(e)(2) byproduct waste.

The DDW will be located near the satellite building (**Figure 1.7-5**). All tankage, filtration, and process equipment will be located at the main operating satellite facility. Feed from the satellite facility to the DDW will be via a 4-inch PVC/HDPE pipeline. Per NDEQ permitting requirements, CBR will be required to continually monitor and record the injection pressure, injection flowrate and volume, and annual pressure. Any failure of the monitoring system

requires that the DDW be shut down immediately until the potential for a release has been investigated.

All compatible liquid wastes at the satellite facility will be disposed of at the planned onsite Class I UIC DDW. CBR will apply to the NDEQ for the construction and operation of a Class I UIC Permit at the satellite facility. The deep well will be installed in sufficient time to be used for wastewater disposal allowed by the permit. Details of the DDW operations, controls, monitoring, waste management, and spill issues will be addressed in a future NDEQ permit application. No wastewaters will be discharged to the land surface or surface water of the State of Nebraska.

Radioactive liquids not referenced above will be disposed of per NRC License SUA-1534.

4.2.1.8 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the CPF, existing regulatory requirements from the NRC and NDEQ and provisions of the SHEQMS have established a framework that significantly reduces the possibility of a pollution incident. Extensive training of all personnel is standard policy at the existing Crow Butte facility and will be implemented at the satellite facility. Waste management facilities and systems will be inspected frequently. Detailed procedures are included in the SHEQMS, which will be adapted for use at the satellite facility.

Potential sources of pollution include the following:

4.2.1.9 Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal, as the piping will be leak-checked before initial placement into service. Piping from the wellfield will generally be buried, minimizing the possibility of an accident. In addition, the flows through the wellfield the piping and manifold pressure gauges in the wellhouses are monitored 24 hours per day, 7 days per week by control room operators using visual and audible alarms. Flow monitoring systems will alarm in the event of a significant piping failure, which will allow flow to be stopped, preventing any significant migration of process fluids. Wellfield buildings will also be equipped with wet alarms for early detection of leaks.

4.2.1.10 Satellite Facility

The satellite facility will serve as a central hub for the mining operations in the MEA. Therefore, the satellite facility carries the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of solutions due to a piping failure or a process storage tank failure.

The satellite facility building will be designed so that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be designed with a capacity equal to that of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut

down, limiting any release. Liquid inside the building, either from a spill or from washdown water, will be drained through a sump and sent to the liquid waste disposal system.

4.2.1.11 Deep Well Pumphouse and Wellhead

The deep well pumphouse and wellhead will be designed so that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

4.2.1.12 Transportation Vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles transporting IX resin to and from the satellite facility, to the CPF, or transporting radioactive contaminated waste from the satellite facility to an approved disposal site.

All chemicals and products delivered to or transported from the satellite facility will be carried in DOT-approved packaging. In the event of an accident, procedures are currently in place in the SHEQMS Volume VIII, Emergency Manual, to ensure a rapid response.

The uranium-loaded resin will be transported from the satellite facility to the CPF processing building in a specially designed, low profile, 4,000-gallon capacity tanker trailer. The primary access route is approximately 30 miles (48.3 km) long, of which approximately 11.6 miles (18.7 km) are on county or private roads (**Figure 4.2-1**). The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. In the event of an accident, each resin transport vehicle will be equipped with an emergency contingency package whereby the driver could initiate containment of any spilled material. Because the uranium adheres to the resin and the resin is wet when transferred, the radiological and environmental impacts of a spill due to an accident would be minimal. Finally, each resin transfer vehicle will be equipped with a radio for communications with the CPF. This allows quick response and implementation of the emergency response plan for transportation accidents.

4.2.1.13 Spills

Spills can take two forms within an *in-situ* facility. These are surface spills (e.g., pond leaks, piping ruptures) and subsurface releases (e.g., well casing failure, pond liner leak) resulting in a release of waste solutions. Spill contingency plans are discussed in Section 5.7.1.3.

Engineering and administrative controls are in place at the CPF and will be implemented at the satellite facility to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur. The most common form of surface release from *in-situ* mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids from the satellite processing building to the wellfield and back. With the current CBR monitoring system, these release are generally, small, quickly discovered, and promptly mitigated.

In general, piping from the satellite facility to and within the wellfield will be constructed of HDPE with butt-welded joints or equivalent. All pipelines will be pressure-tested before final operation. A break in a buried section of line would be unlikely because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving

over the lines, which is the major cause of failure. Typically, the only exposed pipes will be at the satellite facility, at the wellheads, and in the wellhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for spill detection and process control.

4.2.2 Solid Waste

Any facility or process with the potential to generate industrial waste should practice good housekeeping. This activity generally consists of keeping facilities, equipment, and process areas clean and free of industrial waste or other debris. Good housekeeping includes promptly cleaning any spillage or process residues on floors or other areas that could be spread and collecting solid wastes in designated containers or areas until proper disposal.

Solid waste generated at the satellite facility is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. Solid wastes will be classified as contaminated or non-contaminated waste according to survey results. The solid waste will be segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

The largest volume of solid wastes requiring disposal at the MEA site will be produced during facility decommissioning. Soils would be included in decommissioning surveys, and any soils exceeding NRC release limits at 10 CFR Part 40, Appendix A, Criterion 6 would be removed and disposed of as 11e.(2) byproduct waste. Proposed decommissioning and reclamation activities are discussed in Section 6.

4.2.2.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include trash, piping, valves, instrumentation, equipment, and any other items that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5.

CBR has recently estimated that the CPF produces approximately 1,055 cubic yards (yd^3) of non-contaminated solid waste per year. This estimate is based on the number of collection containers on site and the experience of the contract waste hauler. CBR estimates that the proposed satellite facility would produce approximately 700 yd^3 of non-contaminated solid waste per year. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

4.2.2.2 11(e).2 Byproduct Material

Solid 11e.(2) byproduct wastes consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISR facilities consists of filters, personal protective equipment (PPE), spent resin, piping, and other materials. CBR has recently estimated that the CPF produces approximately 60 to 90 yd^3 of 11(e).2 byproduct material waste per year. This estimate is based on the historical number of shipments to the licensed disposal facilities. CBR estimates that the proposed satellite facility would produce approximately 60 yd^3 of 11(e).2

byproduct materials per year. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a License Condition for SUA-1534. CBR is required to notify NRC in writing within 7 days if the disposal agreement expires or is terminated, and to submit a new agreement for NRC approval within 90 days of the expiration or termination.

If decontamination is possible, surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials have activity levels lower than those specified in NRC guidance (NRC 1987). An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

4.2.2.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. Solid materials collected in septic systems must be disposed of by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124 (NDEQ 2010c).

4.2.2.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128 (NDEQ 2010d). Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator. To date, CBR only generates universal hazardous wastes such as fluorescent light tubes, used waste oil, and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. CBR estimates that the proposed satellite facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in the SHEQMS Volume VI, Environmental Manual, to control and manage these types of wastes.

4.3 References

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CBR. 2010b. *Safety, Health, Environment and Quality Management System. Volume III. Operating Manual.*

CBR. 2010c. *Safety, Health, Environment and Quality Management System. Volume IV. Health Physics Manual.*

Nebraska Department of Environmental Quality (NDEQ). 2010a. Title 119, *Rules and Regulations Pertaining to the Issuance of Permits under the National Pollutant Discharge Elimination System.*

NDEQ. 2010b. Title 122, *Rules and Regulations for Underground Injection and Mineral Production Wells.*

NDEQ. 2010c Title 124, *Rules and Regulations for the Design, Operation, and Maintenance of On-site Wastewater Treatment Systems.*

NDEQ. 2010d. Title 128, *Nebraska Hazardous Waste Regulations.*

U.S. Environmental Protection Agency (EPA). 2002. Onsite Wastewater Treatment Systems Manual. EPA/625/R-00/008. February.

U.S. Nuclear Regulatory Commission. (NRC). 1980. Regulatory Guide 3.11.1, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings* (Revision 1, October 1980).

NRC. 1987. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source or Special Nuclear Material* (May 1987).

NRC. 2001. Regulatory Guide/CR-6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees.* (September 2001).

NRC. 2002. Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

NRC. 2008. Regulatory Guide 3.11, *Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities* (Revision 3, November 2008).

Table 4.2-1 Deep Disposal Well Injection Radiological Data for Crow Butte Central Processing Facility (2008 – 2010)

Month	Total Gallons Injected	Average Natural Uranium (mg/l)[a]	Total Natural Uranium Injected (mg)	Total Natural Uranium Injected (uCi)	Average Radium-226 (uCi/l)[a]	Total Radium-226 Injected (uCi/l)
January 2010	6,934,560	5	1.31E+08	8.89E+04	946	2.48E+04
February 2010	6,582,075	6	1.49E+08	1.01E+05	1,400	3.49E+04
March 2010	7,419,844	7	1.97+08	1.33E+05	1,170	3.29E+04
April 2010	7,129,607	8	2.16E+08	1.46E+05	1,490	4.02E+04
May 2010	7,103,123	7	1.88E+08	1.27E+05	1,660	4.46E+04
June 2010	6,914,870	9	2.36E+08	1.59E+05	1,420	3.72E+04
Semiannual Totals	**42,084,079**	**--**	**1.12E+09**	**7.56E+05**	**--**	**2.15E+05**
July 2010	6,827,844	12	3.10E+08	2.01E+05	1,600	4.14E+04
August 2010	7,485,430	11	3.12E+08	2.11E+05	876	2.48E+04
September 2010	6,979,672	9	2.38E+08	1.61E+05	851	2.25E+04
October 2010	7,360,919	9	2.51E+08	1.70E+05	964	2.69E+04
November 2010	6,484,832	10	2.45E+08	1.66E+05	1,470	3.61E+04
December 2010	6,838,592	14	3.62E+08	2.45E+05	931	2.41E+04
Semiannual Totals	**41,977,289**	**--**	**1.72E+09**	**1.16E+06**	**--**	**1.76E+05**
January 2009	4,656,906	5	8.81E+07	5.97E+04	707	1.25E+04
February 2009	4,208,406	3	4.78E+07	3.24E+04	752	1.20E+04
March 2009	3,849,464	3	4.37E+07	2.96E+04	656	9.56E+03
April 2009	3,761,898	5	7.12E+07	4.82E+04	686	9.77E+03
May 2009	4,821,589	4	7.30E+07	4.94E+04	892	1.63E+04
June 2009	5,634,712	4	8.53E+07	5.78E+04	1,000	2.13E+04
Semiannual Totals	**26,932,975**	**--**	**4.09E+08**	**2.77E+05**	**--**	**8.14E+04**
July 2009	5,467,407	3	6.21E+07	4.20E+04	1,120	2.32E+04
August 2009	5,519,131	6	1.25E+08	8.49E+04	991	2.07E+04
September 2009	5,418,568	5	1.03E+08	6.94E+04	652	1.34E+04
October 2009	5,791,232	4	8.77E+07	5.94E+04	866	1.90E+04

Table 4.2-1 Deep Disposal Well Injection Radiological Data for Crow Butte Central Processing Facility (2008 – 2010)

Month	Total Gallons Injected	Average Natural Uranium (mg/l)[a]	Total Natural Uranium Injected (mg)	Total Natural Uranium Injected (uCi)	Average Radium-226 (uCi/l)[a]	Total Radium-226 Injected (uCi/l)
November 2009	6,060,190	6	1.38E+08	9.32E+04	1,090	2.50E+04
December 2009	6,730,245	7	1.78E+08	1.21E+05	1,250	3.18E+04
Semiannual Totals	**34,986,773**	**--**	**6.94E+08**	**4.70E+05**	**--**	**1.33E+05**
January 2008	5,132,667	3	5.83E+07	3.95E+04	669	1.30E+04
February 2008	3,388,598	4	5.13E+07	3.47E+04	751	9.63E+03
March 2008	2,565,135	5	4.85E+07	3.29E+04	795	7.72E+03
April 2008	3,724,924	3	4.23E+07	2.86E+04	818	1.15E+04
May 2008	3,650,359	4	5.53E+07	3.74E+04	818	1.13E+04
June 2008	3,946,776	3	4.48E+07	3.03E+04	739	1.10E+04
Semiannual Totals	**22,408,459**	**--**	**3.01E+08**	**2.03E+05**	**--**	**6.42 E+04**
July 2008	4,051,240	4	6.13E+07	4.15E+04	698	1.07E+04
August 2008	4,664,934	5	8.83E+07	5.98E+04	775	1.37E+04
September 2008	4,823,374	6	1.10E+08	7.42E+04	753	1.37E+04
October 2008	5,202,468	5	9,85E+07	6.67E+04	693	1.36E+04
November 2008	4,823,009	4	7.30E+07	4.94E+04	763	1.39E+04
December 2008	4,553,541	6	1.03E+08	7.00E+04	741	1.28E+04
Semiannual Totals	**28,118,566**	**--**	**5.34E+08**	**3.62E+05**	**--**	**7.85E+04**

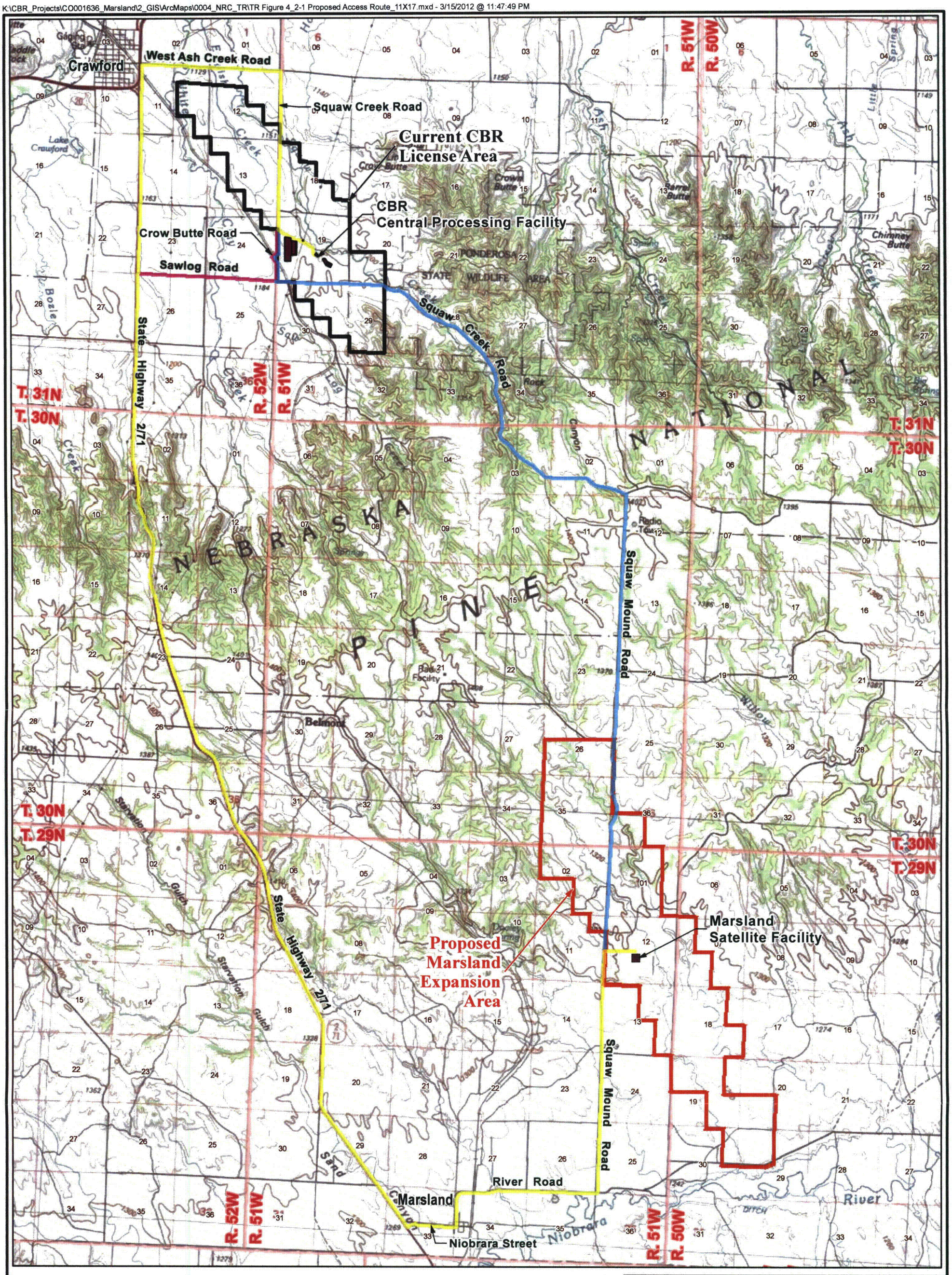
[a] Maximum deep well injection limits: ra-226 – 5,000 uCi/l; U-Natural – 25 mg/l

Table 4.2-2 Deep Disposal Well Injection Non-radiological Data for Current Crow Butte Operations 2010

Parameter	Annual Composite Results		Maximum Injection Level	Laboratory
	mg/l[a]			
	Annual Average	Range		
Sodium	3,388	2,310 – 6,068	40,000	Crow Butte Lab
Calcium	135	105 – 161	Report Only	Crow Butte Lab
Sulfate	1,675	1,389 – 2,084	10,000	Crow Butte Lab
Chloride	2,840	1,507 – 6,205	40,000	Crow Butte Lab
Vanadium	5.83	3.0 – 10.0	100	Crow Butte Lab
Alkalinity	2,007	1,825 – 2,225	4,100	Crow Butte Lab
pH (std. units)	8.28	7.99 – 8.44	5.0 – 9.5	Crow Butte Lab
Arsenic	<0.1	<0.1 – <0.1	5	Energy Lab
Barium	<0.1	<0.1 – <0.1	100	Energy Lab
Cadmium	<0.1	<0.1 – <0.1	1	Energy Lab
Chromium	<0.5	<0.5 – <0.5	5	Energy Lab
Lead	<0.5	<0.5 – <0.5	5	Energy Lab
Mercury	<0.0001	<0.0001 – <0.0001	0.2	Energy Lab
Selenium	<0.1	<0.1 – <0.1	1	Energy Lab
Silver	<0.5	<0.5 – <0.5	5	Energy Lab

[a] mg/l unless noted otherwise.
Note: Reporting data based on 12 monthly samples (January – December 2010)

K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0004_NRC_TR\TR Figure 4_2-1 Proposed Access Route_11X17.mxd - 3/15/2012 @ 11:47:49 PM



LEGEND

- Primary Access Route
- Alternative Route A
- Alternative Route B

N

0 3,500 7,000
Feet

PROJECTION: NAD1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USA TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

FIGURE 4.2-1
PROPOSED ACCESS ROUTE BETWEEN MARSLAND EXPANSION AREA SATELLITE FACILITY AND CROW BUTTE CENTRAL PROCESSING FACILITY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
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Highlands Ranch, CO 80129
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5. OPERATIONS

Required NRC licenses and amendments, as well as surety agreements, are issued in the name of Crow Butte Resources, Inc. All CBR operations conform with applicable laws, regulations, and requirements of the various regulatory agencies. The responsibilities described below have been designed to ensure compliance and further implement CBR policy of providing a safe working environment through cost-effective maintenance of radiation exposures ALARA.

5.1 Corporate Organization and Administrative Procedures

CBR will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. The SHEQMS encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes involvement for all employees from the individual worker to senior management. This SHEQMS will allow CBR to operate efficiently and maintain an effective environment, health, and safety program.

Figure 5.1-1 is a partial organization chart for CBR that illustrates the operation of the CPF and associated operations and identifies the management levels that play a key part in the SHEQMS that will also apply to the satellite facility. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the Safety and Environmental Review Panel (SERP) described in Section 5.2.3.

Specific responsibilities in the organization are described below.

5.1.1 Board of Directors

The Board of Directors for Crow Butte Resources, Inc. has the ultimate responsibility and authority for radiation safety and environmental compliance for CBR. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of CBR.

5.1.2 President

The President of Crow Butte Resources, Inc. is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises the General Manager of Operations. The President is empowered by the Board of Directors with the responsibility and authority for the radiation safety and environmental compliance programs at the Crow Butte facility. The President is responsible for ensuring that CBR operations staff comply with all applicable regulations and permit/license conditions through direct supervision of the General Manager of Operations. The President has overall responsibility for approving the MEA facility design including radiological controls (e.g., ventilation systems) and the manner in which the RSO is integrated into this process.

5.1.3 General Manager

The Crow Butte General Manager of Nebraska is responsible for all uranium production activity at the MEA. The General Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The General Manager is authorized to immediately implement any action to correct or prevent hazards. The General Manager has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity determined to be a threat to employees, public health, or the environment, or potentially a violation of state or federal regulations. The General Manager cannot unilaterally override a decision for suspension, postponement, or modification if that decision is made by the Safety Health Environment and Quality Manager (SHEQ Manager) or the RSO. The General Manager reports directly to the President .

5.1.4 Director of Safety, Health, Environment, and Quality

The Director of Safety, Health, Environment, and Quality reports directly to the President and is responsible for ensuring that personnel comply with industrial safety, radiation safety, and environmental and quality programs as required by NRC regulations and established in the Cameco program. The Director of SHEQ has the responsibility and authority to terminate immediately any activity determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations as indicated in reports from the RSO. The Director of SHEQ may also serve as Corporate Radiation Safety Officer (CRSO) and if doing so, shall meet the RSO qualifications described in Section 5.1.6.

5.1.5 Safety, Health, Environment, and Quality Manager

The SHEQ Manager is responsible for health and safety and environmental programs as stated in the SHEQMS and for ensuring that CBR complies with all applicable regulatory requirements. The SHEQ Manager is located at the offices of site operations. This manager is responsible for drafting, approving, and updating SHEQMS procedures annually. The SHEQ Manager reports directly to the General Manager to ensure that the environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The SHEQ Manager also has the responsibility and authority to suspend, postpone, or modify any activity determined to be a threat to employees, public health, or the environment or potentially a violation of state or federal regulations. As such, the SHEQ Manager has a secondary reporting requirement to the President. The SHEQ Manager has no production-related responsibilities.

5.1.6 Radiation Safety Officer

Reporting directly to the General Manager of Operations and secondarily to the Director of SHEQ, the CBR RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The

RSO works closely with all supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure-related monitoring including data from radiological safety. The RSO recommends improvements to any and all radiological safety-related controls. The RSO has no production-related responsibilities. The RSO has no production-related responsibilities, maintaining independence from operations personnel.

5.1.7 Health Physics Technician

The CBR Health Physics Technician (HPT) assists the RSO with the implementation of the radiological and industrial safety programs. The HPT is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The HPT reports directly to the RSO. Such personnel would be familiar with operations and receive the necessary radiation safety training, including hands-on training (e.g., use of survey instruments for monitoring items removed from the restricted area; see Section 5.7.6 for additional discussions).

5.1.8 ALARA Program Responsibilities

The purpose of the ALARA program is to keep exposures to all radioactive materials and other hazardous material as low as possible, and to expose as few personnel as possible. This program takes into account the state of technology and the economics of improvements in relation to benefits to the public health, safety, and other societal and socioeconomic considerations, and in relation to the use of atomic energy in the public interest.

In order for an ALARA program to correctly function, all individuals, including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.9 Management Responsibilities

Consistent with RG 8.31 (NRC 2002a), CBR senior management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These responsibilities include the following:

1. The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;
2. An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods;
3. A continuing evaluation of the Health Physics Program including adequate staffing and support; and
4. Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.9.1 Radiation Safety Officer ALARA Responsibility

The RSO is responsible for ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO is assigned the following:

1. The responsibility for the development and administration of the ALARA program;
2. Enforcement of regulations and administrative policies that affect any radiological aspect of the SHEQMS;
3. Assistance with the review and approval of new equipment, process changes, or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the SHEQMS;
4. Maintenance of equipment and surveillance programs to ensure continued implementation of the ALARA program;
5. Assistance with conducting an Annual ALARA Audit, as discussed in Section 5.3.2, to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
6. Annual review of all existing operating procedures involving or potentially involving any handling, processing, or storage of radioactive materials to ensure the procedures are ALARA and do not violate any newly established radiation protection practices; and
7. Conductance of (or designate a qualified individual to conduct) daily inspections of pertinent facility areas to confirm that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.1.9.2 Supervisor Responsibility

Supervisors shall be the front line for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. Their responsibilities include:

1. Adequate training to implement the general philosophy behind the ALARA program;
2. Provide direction and guidance to subordinates in ways to adhere to the ALARA program;
3. Enforce rules and policies as directed by the SHEQMS, which implement the requirements of regulatory agencies and company management; and
4. Seek additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.1.9.3 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

1. Adherence to all rules, notices, and operating procedures established by management and the RSO through the SHEQMS;
2. Making suggestions which might improve the radiation protection and ALARA programs;

3. Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an unacceptable increased radiological hazard;
4. Properly using protective equipment; and
5. Properly performing required contamination surveys.

5.2 Management Control Program

5.2.1 Safety Health Environment and Quality Management System

The SHEQMS formalizes the approach to environmental, health, and safety management to ensure consistency across its operations. The SHEQMS is a key element in ensuring that all employees demonstrate "due diligence" in addressing environmental, health, and safety issues and describes how the operations of the facility will comply with the Cameco SHEQ Policy and regulatory requirements. The SHEQ Manager, with assistance from the RSO and Safety Supervisor, is responsible for drafting, approving, and updating (as needed) the SHEQMS site-specific procedures on an annual basis. More frequent updates may be made if site activities and/or conditions warrant such actions.

The SHEQMS:

- Ensures that sound management practices and processes are in place to sustain strong SHEQ performance;
- Clearly sets out and formalizes the expectations of management;
- Provides a systematic approach to the identification of issues and ensures that a system of risk identification and management is in place;
- Provides a framework for personal, site, and corporate responsibility and leadership;
- Provides a systematic approach for the attainment of CBR objectives; and
- Ensures continued improvement of programs and performance.

The SHEQMS has the following characteristics:

- The system is certified to meet the ISO 14001 Environmental Management System Standard.
- The system is straightforward in design and is intended as an effective management tool for all types of activities and operations, and is capable of implementation at all levels of the organization.
- The system is supported by standards that clearly spell out CBR expectations, while leaving the means by which these are attained as a responsibility of line management.
- The system is readily auditable.
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their SHEQ objectives while satisfying CBR government requirements.

The SHEQMS uses a series of standards that align with specific management processes and sets out the minimum expectations for performance. The standards consist of management processes that require assessment, planning, implementation (including training, corrective actions, safe work programs, and emergency response), checking (including auditing, incident investigation,

compliance management, and reporting), and management review. These standards meet the recommendations contained in RG 8.2 (NRC 1973).

5.2.1.1 Operating Procedures

CBR has developed procedures consistent with the corporate policies and standards and regulatory requirements to implement these management controls. The SHEQMS consists of the following standards and operating procedures contained in eight volumes:

Volume 1 – *Standards*
Volume 2 – *Management Procedures*
Volume 3 – *Operating Manual* (SOPs)
Volume 4 – *Health Physics Manual*
Volume 5 – *Industrial Safety Manual*
Volume 6 – *Environmental Manual*
Volume 7 – *Training Manual*
Volume 8 – *Emergency Manual*

Written operating procedures have been developed for all process activities including those activities involving radioactive materials. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including environmental monitoring, health physics procedures, emergency procedures, and general safety.

The procedures enumerate pertinent radiation safety procedures to be followed. A copy of the written procedure will be kept in the area where it is used. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO will also perform a documented annual review of the operating procedures.

5.2.1.2 Radiation Work Permits

When employees are required to conduct activities of a non-routine nature where there is the potential for significant exposure to radioactive materials and for which no operating procedure exists, an RWP will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified facility system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.2.1.3 Record Keeping and Retention

The SHEQMS Volume II, Management Procedures, provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program. The program is consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR §40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents will be maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation, such as descriptions of spills, excursions, contamination events, as well as information related to site and aquifer characterization and background radiation levels will be maintained on site until license termination. Duplicates of all significant records will be maintained in the corporate office or other offsite locations.

5.2.2 Performance Based License Condition

This license application is the basis of the Performance-Based License (PBL) originally issued in 1998. Under that license CBR may, without prior NRC approval or the need to obtain a License Amendment:

1. Make changes to the facility or process, as presented in the license application (as updated);
2. Make changes in the procedures presented in the license application (as updated); and
3. Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval will be necessary prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:

1. Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
2. Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated);
3. Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
4. Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated);
5. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
6. Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated);
7. Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (SER) or the environmental assessment (EA) or technical evaluation reports (TERs) or other analysis and evaluations for license amendments; and

8. For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally, CBR must obtain a license amendment unless the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, EIS, or EA. This would include all supplements and amendments, and TERs, EAs, and EISs issued with amendments to this license.

5.2.3 Safety and Environmental Review Panel

A SERP will determination compliance concerning the conditions discussed in Section 5.2.2. The SERP will consist of a minimum of three individuals. One member of the SERP will have expertise in management and will be responsible for managerial and financial approval for changes, one member will have expertise in operations and/or construction and will have expertise in implementation of any changes, and one member will be the RSO or equivalent. Other members of the SERP may be employed as appropriate to address technical aspects of the change, experiment, or test in several areas, such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP is responsible for monitoring any proposed change in the facility or process, changing procedures, and conducting tests or experiments not contained in the current NRC license. As such, they are responsible for ensuring that any such change results in no degradation in the essential safety or environmental commitments of CBR.

5.2.3.1 Safety and Environmental Review Panel Review Procedures

The SERP will implement the following review procedures for the evaluation of all appropriate changes to the facility operations as outlined in the SHEQMS Volume II, Management Procedures. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with Section 5.2.2 of this chapter. In their documented review of whether a potential change, test, or experiment (hereinafter called the change) is allowed under the PBL (or Performance Based License Condition [PBLC]) without a license amendment, the SERP shall consider the following.

Current NRC License Requirements

The SERP will review the most current NRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment is necessary before initiating the change. This review includes information included in the approved license application.

Ability to Meet NRC Regulations

The SERP will determine if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment is necessary.

Licensing Basis

The SERP will review whether the change, test, or experiment is consistent with NRC conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include the SER and EA prepared in support of the license renewal application (February 1998) and any SERs, TERs, EAs, or EISs prepared to support amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.

Financial Surety

The SERP will review the proposed action to determine if any adjustment to financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly before the change can be approved. The surety estimate must be updated either through a license amendment or through the course of the annual surety update to the NRC. The NRC incorporates the annual surety update by license amendment.

Essential Safety And Environmental Commitments

The SERP will ensure that there is no degradation in the essential safety or environmental commitment in the license application, or as provided by the approved reclamation plan.

5.2.3.2 Documentation of SERP Review Process

After the SERP reviews a proposed action, it will document its findings, recommendations, and conclusions in a written report format. All members of the SERP shall sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why, and what course CBR plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action);
- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified);
- The technical evaluation of the proposed action, including all aspects of the SERP review procedures listed above;
- Conclusions and recommendations;
- Signatory approvals of the SERP members; and
- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the NRC license.

CBR will submit an annual report to the NRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report will include a summary of the SERP evaluation of each change. In addition, CBR will annually submit any pages of the license renewal application to reflect changes to the license renewal application or supplementary information. Each replacement page shall include both a change indicator for the area of change (e.g., bold marking vertically in the margin adjacent to the portion actually changed) and a page change identification (date of change, change number, or both).

5.3 Management Audit and Inspection Program

The following internal inspections, audits, and reports are performed for the Crow Butte Project operations. Similar activities will be performed for the MEA.

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily and Weekly Inspections

The RSO and the facility foreman, or designees, should conduct a weekly inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The RSO, HPT, or qualified designee should conduct a daily walk-through (visual) inspection of all work and storage areas of the facility to ensure proper implementation of good radiation safety procedures, including good housekeeping and cleanup practices that would minimize unnecessary contamination. Problems observed during all inspections should be noted in writing in an inspection logbook or other retrievable record format. The entries should be dated, signed, and maintained on file for at least 1 year. The RSO should review all violations of radiation safety procedures or other potentially hazardous problems with the resident manager or other mine employees who have authority to correct the problem. Also, the RSO should review the daily work order and shift logs on a regular basis to determine that all jobs and operations with a potential for exposing personnel to uranium, especially those RWP jobs that would require a radiation survey and monitoring, were approved in writing by the RSO, the RSO staff, or the RSO designee prior to initiation of work.

5.3.1.2 Monthly Reviews

At least monthly, the RSO should review the results of daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO should provide to the resident manager and all department heads for their review a written summary of the month's significant worker protection activities that contains (1) a summary of the most recent personnel exposure data, including bioassays and time-weighted calculations, and (2) a summary of all pertinent radiation survey records.

In addition, the monthly summary report should specifically address any trends or deviations from the radiation protection and ALARA program, including an evaluation of the adequacy of license conditions regarding radiation protection and ALARA. The summary should describe unresolved problems and the proposed corrective measures. Monthly summary reports should be maintained on file and readily accessible for at least 5 years.

5.3.2 Annual ALARA Audits

CBR will conduct annual audits of the radiation safety and ALARA programs. The Manager of SHEQ may conduct these audits. Alternatively, CBR may employ qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to confirm that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Uranium Project facility. Any outside personnel employed for this purpose will be qualified in radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an audit service, the auditor will meet the same minimum qualifications for education and experience as for the RSO as described in Section 5.4.

The audit of the radiation protection and ALARA program is conducted in accordance with the recommendations contained in RG 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but may not participate in the documentation of conclusions.

The audit report should summarize the following data:

- Employee exposure records (external and time-weighted calculations)
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections
- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC
- Operating procedures that were reviewed during this time period

The report on the annual radiation protection and ALARA audit will specifically discuss the following:

- Trends in personal exposures for identifiable categories of workers and types of operational activities
- Whether equipment for exposure control is being properly used, maintained, and inspected
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA audit report specifically discusses the following:

- Trends in personnel exposures
- Proper use, maintenance, and inspection of equipment used for exposure control
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA audit report is submitted to and reviewed by the President and General Manager. Implementations of the recommendations to further reduce employee exposures, or improvements to the ALARA program, are discussed with the ALARA auditor.

Annual audits will be performed to verify implementation of the quality assurance program, as required by Chapter 2, Section 2.9.4 of CBR's SHEQMS Volume IV Annual ALARA Audits (CBR 2011). The audits are reviewed by facility and corporate management. The Quality Assurance/Quality Control (QA/QC) program is audited annually as per part of CBR's Annual ALARA Audits required by Section 5 of Chapter SHEQ-20 of CBR's Volume II of the SHEQMS manual (CBR 2009)

An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited performs the audit. Results of the QA/QC audit are documented with the ALARA Audit. The RSO has the primary responsibility for the implementation of the radiological QA/QC programs at the Crow Butte Uranium Project facilities. CBR's radiation quality assurance program is discussed in Section 2.9 of Volume IV (Health Physics Manual) of the SHEQMS. The results of the audit, including deficient areas, shall be addressed and appropriate practices implemented to ensure correctness and validity of sampling.

The RSO has the ultimate responsibility for ensuring that the NRC radiological standards are being met at the MEA. The Lead Operator at the satellite facility or wellfield operations would have the responsibility for responding to any spill requiring cleanup. Facility operators and wellfield operators, who have received spill response training, would conduct the cleanup operations.

The proposed management audit and inspection programs for the satellite facility would be sufficient for the type of operations and number and type of employees. CBR has projected that the staffing level for the satellite facility would be 12 full-time CBR staff members to staff three employees per 12-hour shift (one lead operator and two facility operators). These new employees will be needed for the satellite facility, wellfield operations, and maintenance positions. Other staff members working out of the CPF that would occasionally visit the satellite facility and associated wellfield would include the RSO, HPT, Safety Supervisor, SHEQ Manager, as well as various technical and managerial staff members.

5.4 Health Physics Staff Qualifications

CBR project staff is highly experienced in the management of uranium development, mining and operations. The following minimum personnel specifications and qualifications are strictly adhered to.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the RSO are as follows:

- Education: A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium recovery facility radiation protection.

- Health Physics Experience: At least 1 year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actual work with radiation detection and measurement equipment, not strictly administrative or "desk" work.
- Specialized Training: Specialized classroom training in health physics specifically applicable to uranium recovery. In addition, the RSO should attend refresher training on uranium recovery facility health physics every 2 years.
- Specialized Knowledge: A thorough knowledge of the proper application and use of all health physics equipment used in the uranium recovery facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used in the facility and how hazards are generated and controlled during the uranium recovery process.

5.4.2 Health Physics Technician Qualifications

In addition to the RSO, there should be a minimum of one full-time health physics technician at any full-scale operating uranium recovery facility. The health physics technician should have **one** of the following combinations of education, training, and experience:

- Education: An associate degree or 2 or more years of study in the physical sciences, engineering, or a health-related field;
- Training: A total of at least 4 weeks of generalized training (up to 2 weeks may be on-the-job training) in radiation health protection applicable to uranium recovery facilities;
- Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium recovery facility; **OR**
- Education: A high school diploma;
- Training: A total of at least 3 months of specialized training (up to 1 month may be on-the-job training) in radiation health protection relevant to uranium recovery facilities; and
- Experience: Two years of relevant work experience in applied radiation protection.

The health physics technician should demonstrate a working knowledge of the proper operation of health physics instruments used in the uranium recovery facility, surveying and sampling techniques, and personnel dosimetry requirements.

5.5 Radiation Safety Training

All site employees and contractor personnel at the CPF are administered a training program based upon the SHEQMS covering radiation safety, radioactive material handling, and radiological emergency procedures. The CBR Training Program in the SHEQMS Volume VII, Training Manual, provides requirements for radiation safety training. The training program is administered in keeping with standard radiological protection guidelines and the guidance provided in RG 8.29, RG 8.31, and RG 8.13 (NRC 1996, 2002a, and 1999a). The technical content of the training program is under the direction of the RSO. The RSO or an HPT conducts all radiation safety training. CBR will implement this training program for activities at the MEA.

5.5.1 Training Program Content

5.5.1.1 Visitors

Visitors to the site who have not received training are escorted by onsite personnel properly trained and knowledgeable about the hazards of the facility. At a minimum, visitors are instructed specifically on what they should do to avoid possible hazards in the area of the facilities that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at the facilities are given appropriate radiological safety training. Contract workers who will be performing work on heavily contaminated equipment receive the same training normally required of Crow Butte employees as discussed in Section 5.5.1.3.

5.5.1.3 Crow Butte Resources Employees

All CBR employees (and some contractors as noted in Section 5.5.1.2) receive training as radiation workers. The program incorporates the following topics recommended in RG 8.31:

1. Fundamentals of Health Protection
   - The radiologic and toxic hazards of exposure to uranium and its daughters,
   - How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration),
   - Why exposures to uranium and its daughters should be kept ALARA.

2. Personal Hygiene at Uranium Recovery Facilities
   - Wearing protective clothing,
   - Using respiratory protective equipment correctly,
   - Eating, drinking, and smoking only in designated area,
   - Using proper methods for decontamination (i.e., showers).

3. Facility-Provided Protection
   - Ventilation systems and effluent controls,
   - Cleanliness of the work place,
   - Features designed for radiation safety for process equipment,
   - Standard operating procedures,
   - Security and access control to designated areas,
   - Electronic data gathering and storage,
   - Automated processes.

4. Health Protection Measurements
   - Measurement of airborne radioactive materials,
   - Bioassays to detect uranium (urinalysis and in vivo counting),
   - Surveys to detect contamination of personnel and equipment,

- Personnel dosimetry.

5. Radiation Protection Regulations
   - Regulatory authority of NRC, OSHA, and State,
   - Employee rights in 10 CFR Part 19,
   - Radiation protection requirements in 10 CFR Part 20.
6. Emergency Procedures.

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. Instruction is provided in the form of individualized on-the-job training. Retraining is performed annually and documented. Every 2 months, all workers attend a general safety meeting.

Consistent with USNRC RG 8.13, Instruction Concerning Prenatal Radiation Exposure (Revision 3, June 1999), all female workers and those supervisors who will work with them will be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

5.5.2 Testing Requirements

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until the worker understands the correct answer. Workers who fail the exam are retested and test results remain on file.

5.5.3 On-The-Job Training

5.5.3.1 Health Physics Technician

On-the-job training is provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, facility inspections, posting requirements, respirator programs and Health Physics Procedures contained in the SHEQMS Volume IV, Health Physics Manual.

5.5.3.2 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors receive ongoing radiation safety training as part of the annual refresher training and, if determined necessary by the RSO, during monthly safety meetings. This ongoing training is used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends, and other pertinent topics.

5.5.3.3 Training Records

Records of training are kept until license termination for all employees trained as radiation workers (i.e., occupationally exposed employees).

5.6 Security

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in the SHEQMS Volume VIII, Emergency Manual. CBR is committed to:

- Providing employees with a safe, healthful, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transporting of hazardous materials; and
- Managing records and documents that may contain sensitive and confidential information.

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium ["source material"[and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, Storage and Control of Licensed Material, requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material Not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored licensed material at the CPF would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded IX resin removed from the restricted area for transfer to other areas.

At the satellite facility, licensed stored material would typically include loaded IX resin and byproduct waste awaiting disposal. Lixiviant would be found in production piping in the wellfield and wellhouses, production trunkline to the satellite facility, and within piping located in the satellite building. Loaded IX resin would be placed in a transport truck and temporarily stored in the vehicle until the truck is filled and ready for delivery to the CPF.

5.6.1 License Area and Facility Security

5.6.2 MEA Security

Entrance to the MEA will be via Squaw Mound Road west of the facility. The entrance to the site will be posted indicating that permission is required prior to entry. A gate on the access route will be capable of being locked. The satellite facility site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). The primary and alternate access routes to the satellite facility are shown on **Figure 4.2-1** and discussed in Sections 4.2.1.11 and 7.2.1.

The security fence surrounding the satellite facility serves as a control for industrial/property protection purposes with the restricted area noted in red on **Figures 1.7-5 and 5.7-2**. Fencing

around the wellfield will control access and protect industrial property. Appropriate signage will be placed on all fencing advising of access restrictions.

Restricted area at the satellite facility refers to *"...an area where access to is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials"* (10 CFR 20.1003). Proposed restricted areas for the satellite facility are shown on **Figures 5.7-2 and 1.7-5**. Each radiation area will be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA" (10 CFR 20.1902). Radiological warnings are posted based upon actual or likely conditions. Actual conditions are determined through area monitoring. Likely conditions are identified based on professional judgment or experience regarding the probability of a radiological condition. When evaluating the likelihood of specific conditions, normal situations and unique situations that can reasonably be expected to occur will be considered.

All visitors, contractors, or inspectors entering the satellite facility site will be required to register at the facility office and will not be permitted inside the facility or wellfield areas without proper authorization. All visitors needing safety equipment, such as hardhats and safety glasses, will be issued the items by company personnel. Inexperienced visitors will be escorted within the controlled area of the facility unless they are frequent visitors who have been instructed regarding the potential hazards in various site areas. All appropriate and necessary safety or radiological training will be provided and documented by the RSO or designee. Training requirements associated with visitors and contractors are discussed in Section 5.5.

The satellite facility will routinely operate 24 hours per day and 7 days per week, so that CBR employees will normally be on site except for occasional shutdowns. The satellite facility structure will be equipped with locks to prevent unauthorized access. All facility personnel are instructed to immediately report any unauthorized persons to their supervisors. The supervisor will contact the reported unauthorized person and make sure that they have been authorized for entry. If the person is unauthorized, and has no business on the property, they will be escorted to the main entrance for departure.

Access by unauthorized personnel to the stored and non-stored licensed materials (pregnant lixiviant solution, loaded IX resin, and byproduct material awaiting disposal) would be controlled by perimeter access gates with locks and site personnel. This would include piping, process vessels, tankage, and any truck vehicle containing loaded IX resin and parked within or near the satellite facility building.

Wellhouses where pregnant lixiviant solutions would be present in the production piping would be kept locked. Only authorized personnel would have keys to the wellhouses. The production trunk line conveying pregnant lixivant from the wellhouses to the satellite building would be located within perimeter fencing that only authorized personnel would be allowed to enter. Gates associated with perimeter fencing enclosing any operating wellfield would be kept locked when operators and workers are not present (e.g., remote from the satellite facility). Security may be increased by installing continuous video surveillance of outside areas.

CBR maintains and enforces requirements of the SHEQMS, Volume IV Health Physics Manual, that specifies access controls and security issues applicable to visitors, contractors and employees,

radiological posting, and radiological survey and monitoring requirements associated with activities at the site.

Even without consideration of reduced exposures due to the security measures discussed above, the highest estimated total effective dose equivalent (TEDE), as determined using methods described in Section 7.3.3, for a downwind receptor near the MEA is 93 millirems per year (mRem/year). This is based on an occupancy factor of 100 percent or 8,760 hours per year. If the routine visitor were on site for 10 hours per month, the visitor would receive an annual dose of 3 mRem/year. It is unlikely that even frequent visitors to the MEA could receive annual doses near the 100 mRem public dose limit.

5.6.3 Transportation Security

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, Security Plans, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

§172.800(b) (4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;

§172.800(b) (5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;

§172.800(b) (7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to moving IX resin from a satellite facility to the CPF or transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport in a CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;
- Providing the means and methods of protecting the drivers, vehicles, and customer cargo while on the road; and

- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators.
- Offsite tractors will always be secured when left unattended, with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle.
- The vehicle is to be kept visible by an employee at all times when left unattended outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to know and adhere to these guidelines and procedures when performing any load-related activity.

5.7 Radiation Safety Controls and Monitoring

CBR has a strong corporate commitment to and support for the implementation of the radiological control program at the Crow Butte Uranium Project facilities. This corporate commitment to maintaining personnel exposures ALARA has been incorporated into the radiation safety controls and monitoring programs described in the following sections.

To that end, Cameco is procuring instrumentation and other required equipment and has undertaken a sampling program to evaluate a variety of radiation protection issues raised in the context of the Crow Butte license renewal. The sampling plan identifies the sample type, location, equipment frequency/duration, and LLDs. In addition, the sampling plan presents objectives and purposes, components of the dose assessment, and a decision rule/path forward.

In summary, the sampling plan will provide site-specific data to evaluate:

- Dose to public;
- Dose to office workers, lab workers, wellfield workers, and wellfield construction personnel;
- Implications to worker dose from in growth of short-lived beta-emitting isotopes;
- Implication of short-lived beta-emitting isotopes to contamination control, for both personal contamination and for free release of objects;
- Implications of isotope mixtures in establishing the site-specific DAC; and
- Potential to use radium-226 concentrations in pregnant lixiviant as a component of 10 CFR 40.64 effluent reporting.

As elements of the sampling plan are completed, Cameco will provide data and propose program revisions where necessary for NRC consideration. Following deliberation, appropriate license amendments will be prepared. Where needed, these amendments to the base license will be implemented at the MEA. Because the existing program will continue until the various sampling activities are complete and NRC concurs with appropriate program modifications, the following text reflects current practice.

5.7.1 Effluent Control Techniques

5.7.1.1 Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the satellite facility will be the release of radon-222 gas from the production solutions. Uranium product will be eluted and processed at the CPF, where a vacuum dryer is used for drying the yellowcake product. Therefore, there will be no airborne particulate effluent from the satellite facility.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The production flow will be directed to the satellite facility process building for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized downflow IX units. The vents from the individual vessels will be connected to a manifold that will be exhausted outside the satellite facility building through the facility stack.

Venting to the atmosphere outside of the facility building minimizes personnel exposure. Small amounts of radon-222 may be released in the satellite facility building during solution spills, filter changes, IX resin transfer operations, and maintenance activities. The satellite facility building will be equipped with exhaust fans to remove any radon that may be released in the building. No significant personnel exposure to radon gas is expected based on operating experience from similar facilities. Ventilation and effluent control equipment will be inspected for proper operation as recommended in RG 3.56 (NRC 1986). Ventilation and effluent control equipment inspections will be conducted during radiation safety inspections as discussed in Section 5.3.1.

5.7.1.2 Liquid Effluents

The liquid effluents from the satellite facility can be classified as follows:

- Water generated during well development - This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water will be discharged directly to a wastewater surge/equalization tanks, and silt, fines, and other natural suspended matter collected during well development will settle out.
- Liquid process waste - The operation of the satellite facility results in one primary source of liquid waste: a production bleed stream. The production bleed will be disposed of in the DDW permitted under the Nebraska NDEQ Class I UIC Program.
- Aquifer restoration - Restoration of the affected aquifer following mining operations results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater Transfer; 2) Groundwater Sweep; 3) Groundwater Treatment; and, 4) Wellfield Recirculation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water would be extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity (i.e., wastewater surge tanks), followed by deep well disposal injection. Historically Crow Butte has not used groundwater sweep, but this option could be used in the future if warranted. As has been the case with past operations at Crow Butte, it is anticipated that during restoration groundwater at the MEA will be treated using IX and RO. Using this method, there would be no water consumption

activities and only the bleed has to be dealt with for disposal, with the rest of the treated water being reinjected.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit is typically used to reduce the total dissolved solids of the groundwater. The RO unit produces clean water (permeate) and brine. Permeate is normally injected into the formation but, under certain circumstances, may be disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system. There are no plans for land application as an alternate groundwater disposal option.

The existing NRC Source Materials License allows CBR to dispose of wastewater from the CPF by three methods:

- Evaporation from the evaporation ponds;
- Deep well injection; and
- Land application.

At the MEA, CBR proposes to handle liquid effluents from the satellite facility using only deep well injection.

5.7.1.3 Spill Contingency Plans

The RSO is charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Crow Butte Uranium Project facility will assist the RSO in this effort. Basic responsibilities include:

- Assignment of resources and manpower;
- Responsibility for materials inventory;
- Responsibility for identifying potential spill sources;
- Establishment of spill reporting procedures and visual inspection programs;
- Review of past incidents of spills;
- Coordination of all departments in carrying out goals of containing potential spills;
- Establishment of employee emergency response training programs;
- Responsibility for program implementation and subsequent review and updating; and
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an *in-situ* uranium mining facility: 1) surface spills such as tank failures, piping ruptures, transportation accidents, and other incidents; and 2) subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a subsurface release of waste solutions.

Engineering and administrative controls are currently in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur. Where appropriate, similar controls will be instituted for the satellite facility.

Supervisory personnel, satellite facility operators, and wellfield operators receive spill response training for release of radiological and non-radiological materials. In the event of a spill, a designated supervisor (dependent upon location of spill) would take the lead, providing guidance and direction to the facility operators responding to the spill. Supervisory personnel take guidance and direction from the RSO, Safety Supervisor, and SHEQ Manager, as applicable.

Surface Releases

Failure of process tanks - Any failures of process tanks will be contained within the satellite building. The entire building will drain to a sump that will allow transfer of the spilled solutions to appropriate tankage or DDW.

Surface Releases - The most common form of surface releases from ISR mining operations occurs from breaks, leaks, or separations within the piping system that transfers mining fluids between the CPF and the wellfield. These are generally small, short-duration releases because engineering controls detect pressure changes in the piping systems and alert the facility operators through system alarms.

In general, piping from the satellite facility to and within the wellfield will be constructed of PVC or HDPE pipe with butt-welded joints or an equivalent. All pipelines will be pressure-tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which could cause breaks. The only exposed pipes will be at the satellite process facility, the wellheads, and in the wellhouses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQMS Volume VIII, Emergency Manual.

CBR spill control programs have been very effective at limiting surface releases from mining operations. CBR has never had a spill that was reportable under 10 CFR 20 requirements. All spills are analyzed for root causes and contributing factors. Periodically, the CBR SERP meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

Releases Associated With Transportation

The Transportation Emergencies chapter of the SHEQMS Volume VIII, Emergency Manual, provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The chapter provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. This chapter currently includes instructions that specifically address the CBR emergency action plan for responding to a transportation accident involving a shipment of eluent or IX resin en route to or from the CPF. Tanker trailers used for transportation of IX resin between the satellite facility and the CPF will meet or exceed DOT and NRC requirements.

The worst-case transportation accident would involve a failure of the tanker, spilling the entire contents of uranium-loaded resin en route to the CPF. The wet resin with the chemically bonded uranium would be confined to the immediate vicinity of the accident and would not become an

airborne hazard. The close proximity of any accident to the CPF would ensure the rapid response of cleanup crews to contain and retrieve any spilled material.

Sub-Surface Releases

Well Excursions - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with ISR mining.

At the satellite facility, an undetected excursion will be highly unlikely. A ring of perimeter monitor wells located no farther than 300 feet from the wellfield and screened in the ore-bearing Chadron Aquifer will surround all wellfields. Additionally, shallow monitor wells will be placed in the first overlying aquifer above each wellfield segment. These wells will be sampled biweekly. Past experience at the CPF and other ISR mining facilities has shown that this monitoring system effectively detects lixiviant migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying aquifers has also been considered. Several controls are in place to prevent this. CBR will plug all exploration holes to prevent commingling of the Brule and Chadron Aquifers and to isolate the mineralized zone. In addition, mechanical integrity will be tested prior to placing a well in service. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and are capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer will be sampled regularly for the presence of leach solution.

In addition to the spills described above, the accumulation of sediment or erosion of existing soils can lead to potential releases of pollutants. The likelihood of significant sediment or erosion problems is highest during construction activities. If rain (producing runoff) occurs during construction a small amount of the fill may be carried away from the construction area. Significant precipitation during pond and satellite facility construction may produce the same effect. Vegetation cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during mining operations and restoration activities. Site reclamation in the future with backfilling of ponds, grading the facility site, and replacing the topsoil will also expose unsecured soil for suspension in runoff waters. The sediment load as a result of precipitation during future construction or reclamation activities should not significantly affect the quality of any watercourses because the projected satellite facility location is not crossed by any streams.

Runoff from precipitation events should be controlled to minimize any exposure to pollutants on the site. At the satellite facility, runoff should not be a major issue, given the engineering design of the facilities, as well as engineering and administrative controls. Rainwater entering a pond leading to a pond overflow would be the item of greatest concern. The design and operation of the ponds will preclude a runoff-induced overflow as a realistic possibility. Should there be high runoff concurrent with a pipeline failure, some contamination could be spread depending upon the relative saturation of the soils beneath the leaking area. In any event, only minimal releases

of solutions would occur in the event of a pipeline failure, and migration of pollutants due to runoff would be minimal.

5.7.2 External Radiation Exposure Monitoring Program

5.7.2.1 Gamma Surveys

External gamma radiation surveys have been performed routinely at the Crow Butte Uranium Project and will be performed at the satellite facility. The required frequency is quarterly in designated Radiation Areas and semiannually in all other areas of the facility. Surveys will be performed at worker-occupied stations and areas of potential gamma sources such as tanks and filters. CBR establishes a Radiation Area if the gamma survey exceeds the action level of 5.0 mRem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. The probable source is investigated, and survey frequency for areas exceeding 5.0 mRem per hour is increased to quarterly. Records of each investigation are maintained and the corrective action taken. If the results of a gamma survey identify areas where gamma radiation exceeds levels that delineate a "Radiation Area", access to the area is restricted and the area is posted as required in 10 CFR §20.1902 (a). Designated Radiation Areas will be as defined in 10 CFR 20.1003: Radiation Area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 Rem (0.05 milliSeivert [mSv]) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

External gamma surveys are performed with survey equipment that meets the following minimum specifications:

- Range - Lowest range not to exceed 100 microRoentgens per hour (μR/hr) full-scale with the highest range to read at least 5 milliRoentgens per hour (mR/hr) full-scale; and
- Battery-operated and portable.

The Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent meets these requirements. Gamma survey instruments are calibrated at the manufacturer's suggested interval or at least annually and are operated according to the manufacturer's recommendations. Instruments are checked for each day of use.

Gamma exposure rates will be surveyed in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual. Proposed survey locations for the satellite facility are shown on **Figure 5.7-2**. Gamma survey instruments will be checked each day of use in accordance with the manufacturer's instructions. Surveys are performed in accordance with RG 8.30 (NRC 2002b).

To date, beta surveys of specific operations at the CPF that involve direct handling of aged yellowcake as recommended in RG 8.30, Section 1.4 have been performed in accordance with the instructions in SHEQMS Volume IV, Health Physics Manual. Beta evaluations may be substituted for surveys using radiation survey instruments. As noted earlier, Cameco is evaluating the implications of short-lived beta-emitting isotopes at the CPF and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

5.7.2.2 Personnel Dosimetry

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem. Maximum individual annual exposures at the Crow Butte Uranium Project facilities since 1987 have been well below the limit, with a maximum individual external exposure of 495 mRem in 1995.

CBR determines monitoring requirements in accordance with the guidance contained in RG 8.34 (NRC 1992a). CBR believes that it is not likely that any employee working at the satellite facility will exceed 10 percent of the regulatory limit (i.e., 500 mRem/yr). Although monitoring of external exposure may not be required in accordance with §20.1201(a), CBR currently issues dosimeters to all process employees and exchanges them quarterly. The MEA process facility and wellfield operators would be included in this program. Dosimeters are provided by a vendor that is accredited by National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology as required in 10 CFR § 20.1501. The dosimeters have a range of 1 mR to 1,000 R. Dosimeters are exchanged and read quarterly.

Results from personnel dosimetry will be used to determine individual DDE for use in determining TEDE in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual.

CBR has data for other external dose parameters such as Shallow Dose Equivalent (SDE) and Lens Dose Equivalent (LDE) for the existing site. As with the DDE, it can be shown that the external doses are all less than 10 percent of the applicable limits. Extremity monitoring is required when the dose to the extremity is higher than the dose to rest of the body. This would be applicable to beta doses associated with aged yellowcake sources as discussed in Section 5.7.2.1.

Cumulative Exposures

Based on the proposed type of operations (i.e., wet process) and historical exposures at the current operations, no significant increase in risks associated with exposure levels are expected for employees that work at the MEA site and the current main operating CPF. The satellite facility will have a full-time staff dedicated to working at that site. However, there may be some employees who would work at both locations for specified periods of time. Regardless of work locations, all CBR employees would be monitored for occupational external exposure if the exposure is likely to exceed 10 percent of the occupational dose limit appropriate for the individual (e.g., adult or declared pregnant woman), as specified in 10 CFR 20 1201 (a). As stated above, all wellfield and facility personnel at the satellite facility will be included in the dosimetry program. The RSO would be responsible for determining the radiological monitoring requirements for all employees based on the facility radiation levels, worker job locations and tasks, and specific licensing requirements. The RSO would be responsible for reviewing the dosimetry results and comparing them with past data and regulatory exposure limits.

5.7.3 Satellite Facility Airborne Radiation Monitoring Program

The proposed airborne sampling location for the satellite facility is shown on **Figure 2.9-2**. The locations of the sampling points for radon, airborne uranium, and gamma surveys are based on

experience with similar equipment and operations at the current CBR operations. Factors that would be considered are the stage of the process (some areas more prone to exposure than others), potential known release points associated with the equipment and operations, and airflow patterns (based on current CBR operations). The sites selected are expected to carry the highest potential for exposure (**Figure 2.9-2**). Proposed satellite facility survey and sampling locations address potential releases of radiological contaminants (specific release points in the process and resin storage areas) and in areas where sampling would identify any elevated exposure levels due to inadvertent contamination (i.e., office, laboratory, change room, and restroom). Sampling points in the process area are similar to those in other proposed satellite facilities. During the first year of operation, CBR will assess the sampling locations and determine whether these locations provide data representative of the concentrations to which workers would be exposed.

The satellite facility would be subject to requirements of the SHEQMS Volume III, Operating Manual, which has a section on the operation of the ventilation system.

Locations of sample points are based, in part, on a determination of airflow patterns in areas where monitoring is needed. Once the ventilation system is installed and operational, and prior to process operations, a portable anemometer would be used to assess the ventilation patterns (i.e., direction and velocity) in the work areas. Specific attention would be given to areas perceived as having a higher risk for releases. Assessments would be made of any different configurations that may be used for the ventilation system. The RSO would work with those designing the ventilation system to minimize worker exposure and to locate monitors at the optimum locations, drawing upon experience from the current CBR operating facilities.

Once the final design has been completed, the RSO and operations staff would assess the most optimum locations of radiological sampling points. Once the facility is constructed and operational, another assessment would be made of the sampling points and results, the need for any changes to the monitoring points and frequency would be determined.

Monitoring locations and planned surveys would be consistent with RG 8.30. The airborne radiation monitoring program would allow for the determination of concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance, and cleanup. The controls and monitoring program will be sufficient to limit airborne radiation exposures and airborne radioactive releases ALARA and will conform with regulatory requirement identified in 10 CFR Part 20.

5.7.3.1 Airborne Uranium Particulate Monitoring

Airborne particulate levels at ISR facilities that ship loaded IX resin are normally very low because the product is wet. No precipitation, drying, or packaging of source material will be performed at the MEA. Yellowcake will be dried and packaged at the CPF. Therefore, the airborne uranium concentrations should be at or near local background levels. One location near the resin transfer station will be sampled monthly for airborne uranium particulates.

Airborne air particulate area samples will be taken in accordance with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual. The Air Monitoring Chapter implements the guidance contained in RG 8.25 (NRC 1992b). Samples will be taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-1 or equivalent. Sample volume will be adequate to achieve the lower limits of detection (LLD) for uranium in air. The LLD

value for uranium in air would be $5e^{-11}$ µCi/ml, which is 10 percent of the Crow Butte Site-Specific DAC. Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other primary calibration standard. Samplers will be calibrated in accordance with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual.

Breathing zones are sampled to determine individual exposure to airborne uranium during certain operations involving potential airborne exposure. Individual breathing zone monitoring may be required infrequently, at times when engineering controls are impracticable or inoperable (non-routine operations). This would include maintenance activities (e.g., tank entry, disconnection of piping, repair of equipment such as pumps) required to maintain or regain control of normal production activities. An RWP is required for activities that carry the potential for significant exposure to radioactive materials and for which there are no SOPs. The RWPs dictate the proper type of breathing zone monitoring and identifies procedures for protection against radiological hazards during the course of the work activity. Certain SOPs require individual monitoring, such as workers transferring resin beads, changing the bicarbonate mix system filter media, and changing deep disposal filter media.

Sampling is performed with a lapel sampler or equivalent. The air filters are counted and compared to the DAC using the same method described for area sampling. Air samplers are calibrated at the manufacturer's recommended frequency or daily before each use using a primary calibration standard.

Airborne uranium will be measured by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent.

5.7.3.2 CBR Site-Specific DAC

Cameco analyzed the solubility characteristics of Crow Butte yellowcake, and the material was then classified according to the days, weeks, and years (D/W/Y) classification scheme of 10 CFR Part 20. The complete report, provided in **Appendix L** includes a dosimetry interpretation.

This study showed that the yellowcake produced at Crow Butte was primarily of solubility type D with a relatively low type W component. The resulting Annual Limit on Intake (ALI) and DAC values are therefore 1 µCi and $5.0E^{-10}$ µCi/ml.

The expected mix of long-lived radionuclides would be predominantly natural uranium with a lesser amount of radium-226. The DAC for radium-226 is $3x10^{-10}$ µCi/ml. The DAC for the mixture would be between the natural uranium DAC and the radium-226 DAC. As noted earlier, Cameco is evaluating this issue at the CPF and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

An action level of 25 percent of the DAC for soluble natural uranium will be established at the satellite facility. If an airborne uranium sample exceeds the action level of 25 percent of the DAC, the cause will be investigated. If a monthly airborne uranium sample exceeds 25 percent of the action level, the sampling frequency would be increased from monthly to weekly until the airborne uranium levels do not exceed the action level for 4 consecutive weeks. The RSO may initiate corrective actions that may reduce future exposures.

No dose is calculated when comparing the measured airborne uranium concentrations to the natural uranium DAC. The purpose for this comparison is to see if the airborne uranium concentration is higher than the administrative action level of 25 percent DAC, which triggers an investigation. If internal doses are required to be estimated pursuant to 10 CFR 20.1202, methods described in Section 5.7.4 of the application will be used.

Per 10 CFR 20.1201 (e), in addition to the annual dose limits, the intake of soluble uranium by an individual is limited to 10 mg in a week in consideration of chemical toxicity. If exposure to soluble uranium exceeds 25 percent of the weekly allowable intake of 10 mg, which would be 2.5 mg/week, then the RSO would investigate the cause of the occurrence and initiate corrective actions that may reduce future exposures. As with any hazardous material handled on the site, the ALARA program would be applied to such potential chemical exposures as described in Section 2.5 of the SHEQMS Volume III Health Physics Manual.

Any worker likely to receive, in 1 year, an occupational dose in excess of 10 percent of the limits in 10 CFR 20 1201(a) will be monitored. The RSO will use historical and current monitoring and survey data to confirm worker external radiation exposures. The external and internal doses that an individual may be allowed to receive in the current year may be reduced by the amount of occupational dose received or amount of intake while employed by any other person. The record of prior occupational dose that the individual received while performing work involving radiation exposure would be obtained per 10 CFR 20.2104. All new employees would be asked to provide their past radiological exposure history and to sign an Exposure Release Form so previous radiological exposure history may be obtained. If a complete record of the individual's current and previously accumulated occupation dose is not available, the allowable dose limit for the individual would be reduced by 1.25 Rems (12.5 mSv) for each quarter for which records were unavailable and the individual worker engaged in activities that could have resulted in occupational radiation exposure. It would also be assumed that the individual would not be available for planned special exposures. Per 10 CFR 20.2104, CBR would not be required to partition historical data between external dose equivalent(s) and internal committed dose equivalent(s).

5.7.3.3 Radon Daughter Concentration Monitoring

Surveys for radon daughter concentrations will be conducted monthly in the operating areas of the satellite facility. Sampling locations will be determined in accordance with the guidance contained in RG 8.25. Section 3.1 of RG 8.25 states "lapel samplers or samplers located within about 1 foot of the workers head may be accepted as representative without further demonstration that the results are representative." Working Level (WL) measurements will be made using the Modified Kusnetz method (ANSI-N13.8-1973), which involves taking a grab sample, typically every 5 minutes, and analyzing the filter for alpha activity. This grab sample will be taken at locations depicted on **Figure 2.9-2** of the amendment application at a height typical of a worker's breathing zone and within the breathing zone of the worker collecting the sample.

Routine radon daughter monitoring will be performed in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual. Samplers will be calibrated at the manufacturer's suggested interval or daily before use with a digital mass flowmeter or other primary calibration standard. Air samplers will be calibrated in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual.

Results of radon daughter sampling are expressed in WLs where one WL is defined as any combination of short-lived radon-222 daughters in one liter of air without regard to equilibrium that emit 1.3 x 10^5 MeV of alpha energy. The DAC limit from Appendix B to 10 CFR §§ 20.1001 - 20.2402 for radon-222 with daughters present is 0.33 WL. CBR has established an action level of 25 percent of the DAC or 0.08 WL. The LLD for radon measures would be 0.033 WL, which is 10 percent of the DAC limit. Radon daughter results in areas with an average concentration in excess of the action level will result in an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter concentration levels do not exceed the action level for 4 consecutive weeks.

5.7.3.4 Respiratory Protection Program

Respiratory protective equipment has been supplied by CBR for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at Crow Butte Uranium Project is in accordance with the procedures currently set forth in the SHEQMS Volume IV, Health Physics Manual. The respirator program is designed to implement the guidance contained in RG 8.15 (NRC 1999b) and RG 8.31 (NRC 2002a). The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

Because airborne uranium concentrations at the satellite facility during typical operations are not expected to exceed action levels, it is not expected that respirator use will be required for normal operation of the satellite facility. However, any time the potential exists for elevated exposures to employees, respirators could be required. For example, certain maintenance activities (e.g., tank entry, disassembly of potentially contaminated piping and equipment, and welding/grinding on contaminated piping/equipment) and failure of the process building ventilation system could require the use of respirators. The use of respirators at MEA would be determined by SOPs and Radiation Work Permits for specific tasks. The CBR respirator policy and requirements of respirator use are discussed in detail in the SHEQMS.

5.7.4 Exposure Calculations

Employee internal exposure to airborne radioactive materials at the satellite facility will be determined based upon the requirements of 10 CFR § 20.1204 and the guidance contained in RGs 8.30 and 8.7 (NRC 2002b and 1992c). Following is a discussion of the exposure calculation methods and results.

5.7.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium are carried out using the intake method from RG 8.30, Section 3. The intake is calculated using the following equation:

$$I_u = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

where:

I_u = uranium intake, µg or µCi

t_i	=	time that the worker is exposed to concentrations X_i (hr)
X_i	=	average concentration of uranium in breathing zone, $\mu g/m^3$, $\mu Ci/m^3$
b	=	breathing rate, 1.2 m^3/hr
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the week or quarter

The intake for uranium is calculated and recorded. The intakes are totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposures. Exposures during non-routine work are always based upon actual time.

When calculating radiological exposures for the satellite facility, the occupancy time for "routine" operations would be an exposure period based on actual hours worked (12-hour shift period for facility personnel). This would be considered a 100 percent occupancy time. For such routine exposures (i.e., 12-hour shift period), it is assumed that the worker was exposed to the measured "work area" average concentration of uranium for the entire work period (exposure 100 percent of the time). During part of that exposure period, the worker would be expected to spend some time in non-work areas such as the lunch room, office, restroom, hallways, and other areas. The 100 percent occupancy time approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to airborne natural uranium because it does not account for time the employee may have spent outside the work area, as described above.

The measured average airborne uranium concentration is multiplied by the time of worker exposure (12 hours) to obtain the estimated average worker exposure for that time period. Routine operations refer to the facilities operating in a normal fashion with no upsets, maintenance activities, or other activities that may result in non-routine and elevated exposures. If a worker works more than the normal 12-hour shifts, the measured average airborne uranium concentration and the total hours actually worked are used to establish exposure levels.

Measured exposures during non-routine work tasks (e.g., maintenance or cleanup) are based on actual time. The results of breathing zone samples collected during maintenance activities or RWPs are from a specific time period and are added to the calculations of routine employee exposures for a given work period. For example, a worker working under a Radiation Work Permit for 2 hours would have exposures based on measurements taken for that time period (actual time), with the exposures for the remaining 10 hours of routine work based on the measured average concentration of airborne uranium.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in Section 5.7.3.1.

CBR proposes to institute the same internal airborne uranium exposure calculation methods at the satellite facility that have been used to date at the CPF and which are currently described in the SHEQMS Volume IV, Health Physics Manual. Exposures to airborne uranium will be compared to the site-specific Crow Butte Operations DAC developed in response to NRC comments. The information was provided pursuant to a request for confidentiality by email dated March 14, 2011 with further clarifications submitted by email on April 5, 2011 (ML11102020132). The results show that the average ALI for the Crow Butte Operations yellowcake is 0.98μCi and the average DAC is 4.8E-10μCi/ml. For consistency with the convention used to round values in the regulation, an ALI and DAC of 1μCi and 5E-10μCi/ml will be used. Footnote 3 in Table 1 of Appendix B to 10 CFR 20 states "the specific activity for natural uranium is 6.77 E-7 curies per gram U". This is equivalent to 6.77 E^{-7} μCi/μg of natural uranium. This is the specific activity CBR will use to calculate the mass of uranium from an activity measurement and vice versa.

When required by 10 CFR 20.1202, CBR will use methods in RG 8.30 to estimate internal doses. As an example, the Committed Effective Dose Equivalent (CEDE) can be calculated using Equation 2 in RG 8.30 where:

H_{iE}	=	CEDE from radionuclide (rem)
I_i	=	is the intake in μCi of Class D natural uranium as determined by the equation in Section 5.7.4.1 of the application
ALI_{iE}	=	Value of the stochastic inhalation ALI for natural uranium from Column 2 of Table 1 in Appendix B to 10 CFR Part 20 (2 μCi)
5	=	CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 0.5 μCi was determined using the stated equation, the estimate CEDE from this intake would be:

H_{iE} = 5*0.5/2 = 1.25 rem

If an intake (I_i) of 0.5 μg of natural uranium was determined using the stated equation, the estimated CEDE from this intake would be:

H_{iE} = 5*0.5*6.77 E-7/2 = 8.5 E-7 rem

It should be noted that the weekly limit for soluble uranium in 10 CFR 20.1202 (e) due to chemical toxicity is 10 milligrams (10,000 μg), which would be equivalent to a CEDE of 17 mRem per week or 844 mRem per year. The occupational weekly toxicity limit for Class D natural uranium is more restrictive than the radiological limit.

5.7.4.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters are carried out using the intake method from RG 8.30, Section 3. The radon daughter intake is calculated using the following equation:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{W_i \times t_i}{PF}$$

where:

I_r	=	radon daughter intake, working-level months
t_i	=	time that the worker is exposed to concentrations W_i (hr)
W_i	=	average number of working levels in the air near the worker's breathing zone during the time (t_i)
170	=	number of hours in a working month
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the year

The data required to calculate exposure to radon daughters are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposure times. Exposures during non-routine work are always based upon actual time. A clarification of the 100 percent occupancy time is presented in Section 5.7.4.1 for natural uranium exposure. This explanation would also apply to radon daughter exposure.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in Section 5.7.3.2. The WL months (WLMs) for radon daughter exposure are calculated and recorded. The WLMs are totaled and entered onto each employee's Occupational Exposure Record.

CBR proposes to institute the same internal radon daughter exposure calculation methods at the satellite facility that have been used to date and which are currently contained in the SHEQMS Volume IV, Health Physics Manual. Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

The equation above calculates WLMs. If required by 10 CFR 20.1202, CBR can calculate a CEDE from the WLM estimate using Equation 2 in RG 8.30 where:

H_{iE}	=	CEDE from radionuclide (rem)
I_i	=	the intake in WLM of radon-222 and its associated progeny as determined by the equation in this section.
ALI_{iE}	=	Value of the stochastic inhalation ALI for radon-222 with progeny present from Column 2 of Table 1 in Appendix B to Part 20 (4 WLM)
5	=	CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 1 WLM was determined using the stated equation, the estimate CEDE from this intake would be:

$H_{iE} = 5*1/4 = 1.25$ rem

5.7.4.3 Prenatal and Fetal Exposure

Dose Equivalent to an Embryo/Fetus

10 CFR §20.1208 requires that licensees ensure that the dose equivalent to an embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 Rem (5 mSv). Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 Rem limit. The dose equivalent to the embryo/fetus is calculated as the sum of (1) the DDE to the declared pregnant woman; and, (2) the dose equivalent to the embryo/fetus resulting from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman. If the dose equivalent to the embryo is determined to have exceeded 0.5 Rem (5 mSv), or is within 0.05 Rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licenses shall be deemed to be in compliance with 10 CFR 20.1208 if the additional dose equivalent to the embryo/fetus does not exceed 0.05 Rem (0.5 mSv) during the remainder of the pregnancy.

Individual Monitoring of External and Internal Occupational Exposure

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR §20.1502(a)(3) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to receive during the entire pregnancy, from radiation sources external to the body, a DDE in excess of 0.1 Rem (1 mSv). All of the occupational doses in 10 CFR 20.1201 continue to be applicable to the declared pregnant worker as long as the embryo/fetus dose limit is not exceeded. 10 CFR 20.1502(b)(3) requires the monitoring of occupational intake of radioactive material by and assess the committed effective dose equivalent to a declared pregnant woman likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 Rem (1 mSv). Based on this 0.1 Rem threshold, the dose to the embryo/fetus must be determined if the intake is likely to exceed 1 percent of ALI during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR 20.1502. In this case, CBR will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (for example, air monitoring, area monitoring, and bioassay). Exposure calculations will be performed as recommended in RG 8.36 (NRC 1992d).

External Dose to the Embryo/Fetus

The DDE to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of conception and will be based on the methods discussed in Section 5.7.2. External dose to the declared pregnant woman after declaration for the duration of the pregnancy shall be accomplished by personal dosimetry with monthly exchanges.

Internal Dose To The Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception.

The intake for the declared pregnant woman will be determined as discussed in Sections 5.7.3.1 and 5.7.3.2.

5.7.5 Bioassay Program

CBR has implemented a urinalysis bioassay program at the Crow Butte Uranium Project facilities that meets the guidelines contained in RG 8.22 (NRC 1988). The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consists of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is required from all employees.
2. During operations, urine samples are collected from workers quarterly. Employees who have the potential for exposure to dried yellowcake submit bioassay samples monthly or more frequently as determined by the RSO. Samples are analyzed for uranium content by a contract analytical laboratory. Blank and spiked samples are also submitted to the laboratory with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical laboratory is 5 μg/l.
3. Action levels for urinalysis are established based upon Table 1 in RG 8.22.

Elements of the quality assurance requirements for the Bioassay Program are based upon the guidelines contained in RG 8.22. These elements included the following:

1. Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. The control samples are from persons that have not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 μg/l and 40 to 60 μg/l. The results of analysis for these samples are required to be within ± 30 percent of the spiked value.
2. The analytical laboratory spikes 10 to 30 percent of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR.

CBR proposes to continue to implement the Bioassay Program described in this section for operations at the satellite facility. The facility and wellfield operators will be included in a personnel dosimetry (exchanged quarterly) and bioassay program, with urine samples collected quarterly. The program will be implemented in accordance with the guidance contained in RG 8.22 and with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual.

5.7.6 Contamination Control Program

CBR will perform surveys for surface contamination in operating and clean areas of the satellite facility in accordance with the guidelines contained in RG 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 disintegrations per minute (dpm)/100 cm^2 (25 percent of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test

results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving a restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area such as in the wellfield will be required to monitor themselves prior to leaving the area. All personnel receive training in surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 is applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

The RSO, the radiation safety staff, or properly trained employees perform surveys of all items removed from the restricted areas with the exception of small, hand-carried items described above. Due to the distance separating the satellite facility and the CPF where the RSO and radiation staff is officed, it would be more efficient to have properly trained full-time personnel at the MEA site available to perform surveys for releasing items from the restricted area. Such a person would be the Lead Operator or a facility/wellfield operator trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures. These staff members would have received training as operators and the required radiation safety training. They would also be subject to additional hands-on training as to the survey instruments and procedures. The release limits are set by Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials, (NRC 1987).

Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.
2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.
3. Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use with other checks performed weekly. For additional information see Section 3.3.

As recommended in RG 8.30, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. A spot check of the employees assigned to the satellite facility will be conducted, concentrating on facility operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

The contamination control program for the satellite facility will be implemented in accordance with the SHEQMS Volume IV, Health Physics Manual.

As noted earlier, Cameco is evaluating the implications of short-lived beta-emitting isotopes to contamination control, for both personal contamination and for free release of objects at the CPF and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

5.7.7 Airborne Effluent and Environmental Operational Monitoring Programs

The operational baseline monitoring program is presented in **Table 5.7-1**.

5.7.7.1 Air Particulate Monitoring

Composite airborne particulate samples for natural uranium, radium-226, lead-210, and thorium-230 will be obtained quarterly from air monitoring locations MAR-1 through MAR-5. The quality of sample collection and analysis shall be maintained by adhering to quality control (QC) procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.2.4

The air particulate samplers described in Section 2.9.2 will continue to be used for the operational monitoring program.

5.7.7.2 Radon

The radon gas effluent released to the environment from satellite facility will be monitored at the same air monitoring locations (MAR-1 through MAR-5) that were used for baseline determination of radon concentrations as described in Section 2.9.2. Sampling locations are shown on **Figure 2.9-2**. Monitoring will be performed using Track-Etch radon cups. The cups will be exchanged semiannually to achieve the required LLD. SHEQMS Volume IV, Health Physics Manual currently provides the instructions for environmental radon gas monitoring. In addition to the manufacturer's Quality Assurance program, CBR will expose one duplicate radon Track Etch cup per monitoring period. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.2.4.

Monitoring of radon gas releases from the satellite facility building and ventilation discharge points is not deemed to be practicable. Section 3.3 of RG 8.37 indicates that, where monitoring effluent points is not practicable, an estimate can be made of the magnitude of these releases, with such estimated releases used in demonstrating compliance with the annual dose limit. In 10 CFR 20.1302, allowance is made for demonstrating by measurement or calculation that the TEDE to the individual likely to receive the highest dose from licensed operations does not exceed the annual dose limit of 100 mRem.

The satellite facility would use pressurized downflow IX columns, which do not routinely release radon gas except during resin transfer and column backwashing. The design and operation of these systems result in the majority of the radon in the production fluid staying in solution and not being released from the columns. Radon may be released from occasional venting of process vessels and tanks, small leaks in IX equipment, and during maintenance of equipment. Therefore,

releases via the vent stacks would not have a consistent concentration of radon or flow rate, making it impracticable to try to use such data for public exposure estimates.

CBR has used MILDOS-AREA to model the dose from facility operations resulting from releases of radon gas (Savignac 2011a). MILDOS-AREA outputs are presented in **Appendix M-1,** and are discussed in Section 7.3.3. In determining the source term for MILDOS-AREA for the satellite facility, radon gas release was estimated at 25 percent of the radon-222 in the production fluid from the wellfields and an additional 10 percent in the IX circuit in the satellite building. The release of radon-222 at this concentration did not result in significant public dose.

Environmental monitoring and estimated release of radon from process operations will be reported in the semi-annual reports required by 10 CFR § 40.65 and License SUA-1534 License Condition Number 12.1.

5.7.7.3 Surface Soil

Surface soil will be sampled as described in Section 2.9. Surface soil samples will be taken at the monitoring locations (MAR-1 through MAR-5) during operations. Following conclusion of operations, samples will be collected and compared to the results of the preoperational/preconstruction monitoring program. Samples shall be analyzed for natural uranium, radium-226, and lead-210.

Surface soil will also be sampled at the satellite plant location as described in Section 2.9. Surface soil samples will be taken following conclusion of operations and compared to the results of the preoperational/preconstruction monitoring program. The quality of sample collection and analysis shall be maintained by adhering to QC procedures and LLD concentration limits discussed in Section 2.9.6.1.

5.7.7.4 Subsurface Soil

Subsurface soil will be sampled at the facility location as described in Section 2.9. Subsurface soil samples will be taken following conclusion of operations and compared to the results of the preoperational/preconstruction monitoring program. The quality of samples shall be maintained by following QC procedures discussed in Section 5.7.9 and adhering to the LLC concentration limits discussed in Section 2.9.6.1.

5.7.7.5 Vegetation

There are currently no plans to sample vegetation for radiological analyses during operations. In accordance with the provisions of NRC RG 4.14, Footnote (o) to Table 2 requires the following: *Vegetation and forage sampling need to be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 % of the applicable radiation protection standard.* The applicable radiation standard in 10 CFR 20 is 100 mRem/yr. Five percent of 100 mRem/yr is 5 mRem/yr.

This pathway was evaluated by CBR's radiological consultant (Savignac 2011b, **Appendix M-2**). MILDOS calculated the radiation dose to individuals within 50 miles (80 km) of the MEA site from vegetables, meat, and milk as population doses in units of person-Rem/yr. Dividing those doses by the population within 50 miles (80 km) and converting the doses to mRem/yr yields the

doses in **Table 5.7-2.** The total dose in **Table 5.7-2** is the average dose to humans living within 50 miles (80 km) of the MEA uranium recovery operation that results from the consumption of vegetables, meat, and/or milk that might have been impacted by the release of radon and its decay products on vegetation or forage from uranium *in-situ* extraction operations.

Based on the results of the analysis, as presented in **Appendix M-2,** vegetation or forage sampling at the MEA *in-situ* recovery operations should not be required because the radiation dose calculated for those operations is not considered "important" (NRC terminology in RG 4.14). The average radiation dose to people living with 50 miles (80 km) of the MEA from the vegetation pathway was 0.05 mRem/yr. The maximum radiation dose to the nearby residents from the vegetation pathway was 1.5 mRem/yr. RG 4.14 considers doses less than 5 percent of the applicable radiation standard (5 percent of 100 mRem = 5 mRem/yr) as not "important" as a vegetation pathway.

5.7.7.6 Food

Livestock, Crops, and Vegetable Gardens

RG 4.14 recommends that crops, livestock, and other farm products raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest or slaughter. Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Livestock should include a variety of animals present in the area, including cattle, sheep, pigs, fowl, and other farm animals.

There are currently no plans to sample food items (e.g., crops, livestock) for radiological analyses during operations. The basis for not collecting such samples is the results of the dose calculations for the food pathway for Marsland in Section 2.9.5.2. The maximum radiation dose to nearby residents from the vegetation pathway was 1.5 mRem/yr, which is significantly lower than the applicable radiation standard of 5 mRem/yr discussed above. Based on these results, it is highly unlikely that livestock, crops, or vegetable gardens, as part of the food pathway, would accumulate unacceptable levels of radioactive constituents. However, the preoperational/preconstruction baseline plan provides for a survey of a ~1.86-mile (3 km) area around the centerpoint of the satellite facility as to the availability of crops, livestock, fowl, and other applicable sources for sampling. This would determine the types of crops grown in the area, number and types of livestock, availability of gardens, and other applicable data. For available specimens, sampling and analysis of these resources will be conducted per RG 4.14, which will allow for collection of baseline data.

Fish

RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected, sampled, and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

There are currently no plans to collect fish for tissue analysis of radiological constituents. The results of the MILDOS analysis for vegetation uptake discussed in Section 2.9.5.3 indicate that the potential for fish uptake of radiological constituents as part of the food pathway would be highly unlikely. Due to the arid nature of the area in which the MEA is located, the ephemeral

drainages that traverse to MEA license boundary do not carry sufficient water flow to support a fish population. The two major ephemeral drainages eventually connect to the Niobrara River, which is the nearest stream with permanent water. The river is located south of the license boundary, flowing west to east. The Box Butte Reservoir is located on the Niobrara River approximately 3.5 miles (5.6 km) from the southeastern corner of the MEA license boundary. The Marsland operations will not discharge any liquids to the ephemeral drainages or to any other areas of the proposed operations. Any spills that could occur would be contained per the site spill control plans, and it is highly unlikely that any liquid spills would ever reach the Niobrara River. Therefore, operational sampling of fish is not deemed to be of value.

As discussed in Section 2.9, the CBR preoperational/preconstruction monitor plan will provide for collection of fish samples from the Niobrara River per RG 4.14. This sampling and analysis plan will allow for a baseline of radioactive constituent concentrations in fish tissues for the area of the river south of the MEA site.

5.7.7.7 Direct Radiation

Environmental gamma radiation levels will be monitored continuously at the air monitoring stations (MAR-1 through MAR-5) during operations. Gamma radiation will be monitored using environmental dosimeters obtained from an NVLAP certified vendor. Dosimeters will be exchanged quarterly.

5.7.7.8 Sediment

Upstream and downstream sediment samples will be collected annually at the sample locations described in Section 2.9 and shown in **Figure 2.7-4**. Samples will be collected as described in Section 2.9.7 and analyzed for natural uranium, radium-226, thorium-230, and lead-210. The quality of sample collection and analysis shall be maintained by adhering to QC procedures as discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.7.1.

5.7.8 Groundwater/Surface Water Monitoring Program

5.7.8.1 Program Description

During operations at the satellite facility, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. The CBR operational water monitoring program includes the regional evaluation of groundwater, groundwater within the permit or licensed area, and surface water on a regional and site-specific basis. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.3.4.

5.7.8.2 Groundwater Monitoring

The groundwater excursion monitoring program is designed to detect excursions of lixiviant into the ore zone aquifer outside of the wellfield being leached and into the overlying water-bearing strata. The Pierre Shale below the ore zone is more than 1,200 feet thick and contains no water-bearing strata. Therefore, it is not necessary to monitor any water-bearing strata below the ore zone.

Private Well Monitoring

During operations, on a quarterly basis, all active, operational and accessible private wells located within the MEA license boundary and within 0.62 miles (1 km) of the MEA license boundary will be monitored **(Figures 2.7-6 and 2.9-3)**. Groundwater samples are taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual, and samples are analyzed for natural uranium and radium-226. Water well samples will be collected and analyzed as described in Section 2.9.3.1.

Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed no further than 300 feet from the wellfield boundary and no further than 400 feet apart or as required by the NDEQ. After completion, wells are washed out and developed (by air flushing or pumping) until pH and specific conductivity appear stable and consistent with the anticipated quality of the area. After development, wells are sampled to obtain baseline water quality data. For baseline sampling, wells are purged before sample collection to ensure that representative water is obtained. All monitor wells, including ore zone and overlying monitor wells, are sampled three times at least 14 days apart. Samples are analyzed for chloride, conductivity, and total alkalinity as specified in License Condition 10.4. Results from the samples are averaged arithmetically to obtain an average baseline value as well as a maximum value for determination of upper control limits for excursion detection. Wells are developed and sampled in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual.

Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCLs) are set for chemical constituents which would indicate a migration of lixiviant from the wellfield. The constituents chosen for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the IX process (uranium is exchanged for chloride on the IX resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells biweekly and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. License SUA-1534 Condition 11.2 currently requires that monitor wells be sampled no more than 14 days apart except in certain situations. These situations include inclement weather, mechanical failure, holiday scheduling, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment. In these situations, CBR documents the cause and the duration of any delays. In no event is sampling delayed for more than 5 days.

Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second nor third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the NRC Project Manager is notified by telephone or email within 48 hours and notified in writing within 30 days.

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the wellfield area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive 1-week samples.

5.7.8.3 Surface Water Monitoring

If available, surface water samples will be collected as described in Section 2.9. Samples will be collected quarterly and analyzed for dissolved and suspended natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Sample locations are shown on **Figure 2.7-4.** The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.4.5.

Surface water samples will be taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual. Upstream and downstream samples from all locations will be obtained quarterly. Surface water samples are analyzed for the parameters identified in Section 2.9. Surface monitoring results are submitted in the semi-annual environmental and effluent reports submitted to NRC.

5.7.9 Quality Assurance Program

A quality assurance (QA) program is in place at Crow Butte Uranium Project for all relevant operational monitoring and analytical procedures. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QA

program provides assurance to both regulatory agencies and the public that the monitoring results are valid.

The QA program addresses the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided;
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program;
- Written procedures for QA activities. These procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting;
- QC in the laboratory. Procedures cover statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs. Outside laboratory QA/QC programs are included; and
- Provisions for periodic management audits to verify that the QA program is effectively implemented; to verify compliance with applicable rules, regulations, and license requirements; and to protect employees by maintaining effluent releases and exposures ALARA.

The SHEQMS developed by CBR is a critical step to ensuring that QA objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring procedures
2. Testing procedures
3. Exposure procedures
4. Equipment operation and maintenance procedures

5. Employee health and safety procedures
6. Incident response procedures

5.8 References

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Savignac, Noel. 2011a. Radiation Doses from Cameco Resources, Marsland Expansion Area In-Situ Uranium recovery Operation. October 19.

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Table 5.7-1 Marsland Expansion Area Operational Effluent and Environmental Monitoring Plan

Type of Sample	Sample Collection			Sample Analysis		
	Number	Location	Method	Frequency	Frequency	Type of Analysis
AIR						
Particulates	3	At or near site boundaries and in sector(s) having the highest predicted concentrations of airborne particulates[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
	1	At or close to nearest residence(s)[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
	1	Control or background location[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
Radon Gas	5	Same locations as air particulates[a]	Continuous using RadTrak type DRNF	Continuous	Continuous	Rn-222
WATER						
Groundwater	One each	Wells (within license boundary and 2 km radius [c] • Private wells • MEA Brule wells • MEA Ore Zone wells	Grab	Quarterly	Quarterly	Dissolved and suspended Nat-Uranium, Ra-226, Th-230, Pb-210, Po-210
Surface Water	Two from designated ephemeral drainages	Surface waters passing through license area (subject to available flow)[b]	Grab	Quarterly	Quarterly	Suspended and dissolved Nat-Uranium, Ra-226, Th-230, Pb-210
VEGETATION	None	N/A	N/A	N/A	N/A	N/A
FOOD	None	N/A	N/A	N/A	N/A	N/A
FISH	None	N/A	N/A	N/A	N/A	N/A
SOIL AND SEDIMENT						

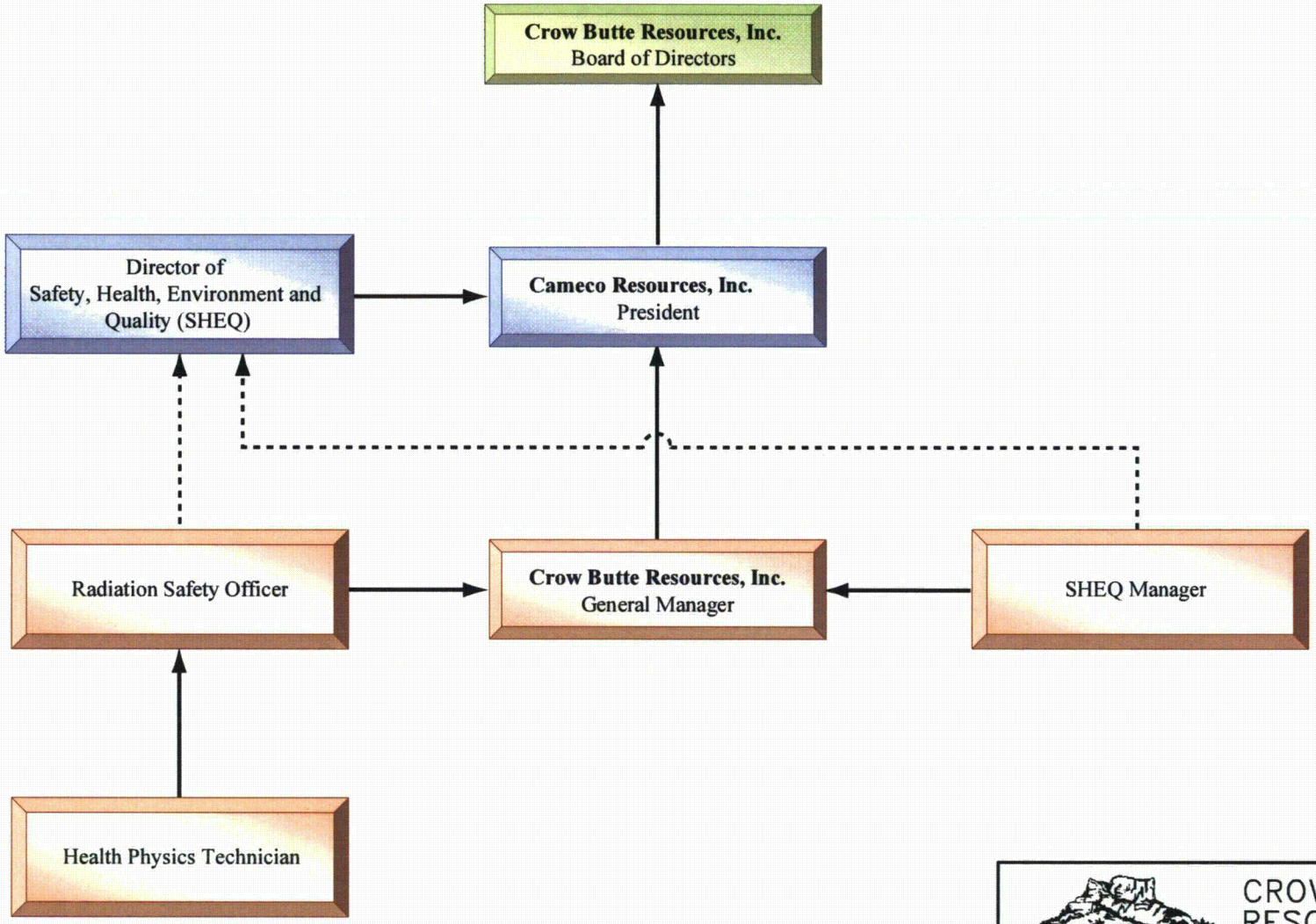
Table 5.7-1 Marsland Expansion Area Operational Effluent and Environmental Monitoring Plan

Type of Sample	Sample Collection			Sample Analysis		
	Number	Location	Method	Frequency	Frequency	Type of Analysis
Soil	5 or more	At same locations used for collection of air particulate samples[a]	Grab (0 to 5 cm)	Annually	Annually	Nat-Uranium, Ra-226, Pb-210
Sediment	1 or 2 from ephemeral drainages	Same as surface water sample locations[b]	Grab (minimum of 3 samples for each sample composite)	Annually	Annually	Nat-Uranium, Ra-226, Th-230, Pb-210
DIRECT RADIATION						
Continuous	One each	Air monitoring stations[a]	Dosimeter	Continuous	Quarterly	Gamma exposure rate, using Sodium Iodide scintillometer

[a] Figure 2.9-2
[b] Figure 2.7-4
[c] Figures 2.2-4 and 2.9-3

Table 5.7-2 Radiation Doses from Vegetation Pathway to Man Within 80 Kilometers of the Marsland In-Situ Uranium Recovery Operation

Pathway	Radiation Dose - mRem/yr
Vegetables	0.045
Meat	0.002
Milk	0.0008
TOTAL	**0.05**



CROW BUTTE RESOURCES, INC.

FIGURE 5.1-1
CAMECO RESOURCES
ORGANIZATIONAL CHART

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

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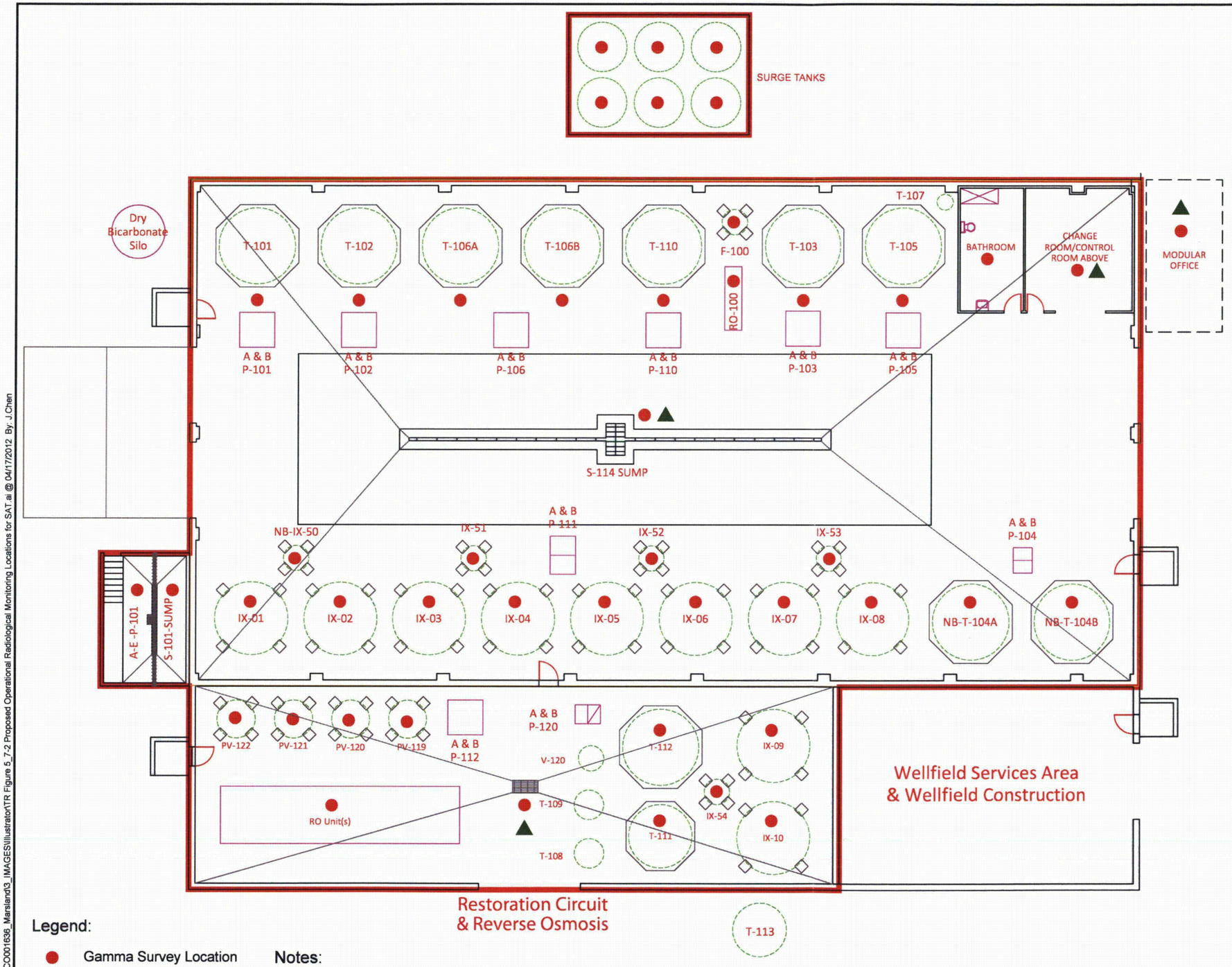


Tank (# Each)	Size (diameter x height)	Capacity (gallons)	Description
IX-01 through 08	11'6"x9'0"	7,000	Ion Exchange
IX-50 through 54	4'0" x7'6"	625	Ion Exchange Resin Trap
IX-09 through 10	11'6" x 9'0"	7,000	Restoration IX Column
T-101	12'0"x13'6"	12,000	Bicarbonate Mix
T-102	12'0"x17'0"	14,500	Bicarbonate Storage
T-103	12'0"x17'0"	14,500	Reverse Osmosis Feed
T-104A	12'0"x21'9"	16,000	Resin Transfer
T-104B	12'0"x17'2"	14,500	Resin Transfer
T-105	12'0"x17'0"	14,500	Water supply/Make-up Water
T-106A	12'0'x21'9"	16,000	Wastewater
T-106B	12'0"x17'2"	14,500	Wastewater
T-107	2'4"x5'3"	119	Water Pressure Tank
T-108	--	5,000	Sodium Sulfide Day
T-109	--	1,000	Sodium Sulfide Mix
T-110	12'0"x21'9"	16,000	Well Work Over Fluid
T-111	10'0"x13'0"	7,500	RO Cleaning Tank
T-112	12'0"x17'0"	14,500	Permeate Tank
T-113	11'9"x13'3"	10,000	HCL Feed Tank
PV-119 through 122	6'0"x10'0" (assumed)	--	RO Filter
V-120	Unknown	--	Degaser
Surge Tanks	--	6 x 50,000	Wastewater Tanks
F-100	--	--	Sock filters
A-E-P-101	--	--	Injection pumps on trunk lines to wellfield

Legend:

- Gamma Survey Location
- Radon Testing Location
- Restricted Area

Notes:

1. Illustration only, not to scale.
2. Adapted from Cameco Resources, 2011.

CROW BUTTE RESOURCES, INC.

FIGURE 5.7-2
PROPOSED OPERATIONAL RADIOLOGICAL MONITORING LOCATIONS FOR SATELLITE FACILITY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

ARCADIS 630 Plaza Drive, Ste. 100 Highlands Ranch, CO 80129 P: 720-344-3500 F: 720-344-3535 www.arcadis-us.com

K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 5_7-2 Proposed Operational Radiological Monitoring Locations for SAT.ai @ 04/17/2012 By: J.Chen

6. GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Groundwater Restoration

The objective of the Restoration and Reclamation Plan is to return the affected ground water and land surface to the uses for which they were suitable before mining. The methods to achieve this objective for both the affected groundwater and the surface are described in the following sections. Before discussing restoration methodologies, the ore body genesis and chemical and physical interactions between the ore body and the lixiviant are discussed.

6.1.1 Ore Body Genesis

The uranium deposit in the MEA is similar to that found in the CPF license area. It is a roll front deposit in fluvial sandstone and is similar to those in the Wyoming such as the Gas Hills, Shirley Basin, and the Powder River Basin. The origin of the uranium in the deposit could lie within the host rock itself from either the feldspar or volcanic ash content of the Chadron Sandstone. The source of the uranium could also be volcanic ash of the Chadron Formation, which overlays the Chadron Sandstone. Regardless of the source of the uranium, it has precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Chadron Sandstone. The Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium-bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing agents are likely H_2S and, to a lesser degree, organic matter and pyrite. More detailed discussions of the geochemical description of the mineralized zone are presented in Section 2.6.1.2.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. Pumping from recovery wells draws the uranium-bearing solution through the mineralized portion of the sandstone. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Because the deposition of the uranium was controlled between clay beds within the Chadron Sandstone, the mining solutions will be confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 Chemical and Physical Interactions of Lixiviant with the Ore Body

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH from 6.5 to 9.0 su. This represents the normal range of operating conditions for the MEA *in-situ* mining operations.

6.1.2.1 Ion Exchange

The principal ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium, and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\ Na^{+}_{solution} = 2\ Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate ($CaCO_3$), and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium IX capacity of the ore in a sodium lixiviant with 3.0 g/L total carbonate strength is 1.21 meq of calcium per 100 grams of ore. This equates roughly to 0.5 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially precipitate. Not all of this calcium, however, will be realized because laboratory testing is run in such a way as to indicate the maximum amount of calcium that can be exchanged. Somewhat less than this amount will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, the lixiviant carbonate concentration and the lixiviant pH are controlled. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system, and IX and/or precipitation will occur until the equilibrium is satisfied. The production bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of 0.5 percent, the effect of the bleed on the IX is small.

6.1.2.2 Precipitation

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH, and temperature. For example, at 15° C, a pH of 7.5 su, and 1 g/L carbonate in lixiviant, the equilibrium solubility of calcium is approximately 40 to 100 parts per million (ppm). Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the IX that is taking place, while the precipitation of calcium is a function of the lixiviant chemistry and the degree of supersaturation observed in the system. As a first approximation, the proportion of calcium precipitation occurring aboveground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is aboveground, as is the case for most ISR operations including those projected for the MEA, then more of the calcium will precipitate underground than aboveground. The calcium precipitation is a function of turbulence in the solution, changes in dissolved CO_2 partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation; at or near the injection or production wellbore where changes in pressure, turbulence, and CO_2 partial pressure are all observed; and on the surface in the filters, in pipes,

and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15 percent of the void space in that ton of ore.

Calcium may be removed from the system in two ways:

- Filters will be routinely backwashed to the MEA wastewater system (i.e., wastewater surge/equalization tanks) and periodically acid cleaned, if necessary, to remove precipitated $CaCO_3$ from the filter housing or filter media; and
- The solution bleed (approximately 0.5 to 1.0 percent) taken to create overproduction and a hydrologic sink in the mining area eliminates some calcium from the system.

Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells may be air lifted, surged, water jetted, or acidified to remove the precipitated calcium. Any water recovered from these wells containing dissolved $CaCO_3$ or particulate $CaCO_3$ is collected and placed into the waste disposal system. Upon decommissioning, $CaCO_3$ from the facility equipment tank residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species that has been identified is iron, which could precipitate as either the hydroxide or the carbonate, causing some fouling. Such fouling is usually evidenced by a reduction in the IX capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Chadron Sandstone, iron precipitation has not been a problem in mining operations to date.

6.1.2.3 Hydrolysis

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0 su, the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system and a possible small increase in the cations associated with the siliceous minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 Oxidation

The oxidant consumers in the basal sandstone of the Chadron Formation are H_2S in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impact of these oxidant consumers on the operation of the facility is a general increase in the oxidant consumption over that which would be required for uranium alone. The second effect is a release of iron and sulfate into solution from the oxidation of pyrite. A third effect is an increase in the levels of some trace metals such as arsenic, vanadium, and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending on its oxidation state. Any vanadium oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium, and could potentially contaminate the precipitated yellowcake product. H_2O_2 precipitation of uranium is used to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species, increasing the concentrations of compounds

such as polythionates, which can foul IX resins. In *in-situ* operations with chemistries similar to the MEA, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 Organics

Organic materials are generally not present in the MEA ore body at levels greater than 0.1 to 0.2 percent. Where present, organic materials effectively increase the oxidant consumption and reduce uranium leaching. On longer flow paths, organic material could potentially re-precipitate uranium should all of the oxidant be consumed and conditions become reducing. Another potential impact of mobilized organics could be the coloring and fouling of leach solutions. As the aquifer is maintained in the pH range of 6.5 to 9.0 su, mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 Basis of Restoration Goals

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to pre-injection baseline values on an MU average as determined by the baseline water quality sampling program. This sampling program is performed for each MU before mining operations commence. Should restoration efforts be unable to achieve baseline conditions after diligent application of the best practicable technology available, CBR commits, in accordance with the Nebraska Environmental Quality Act and NDEQ regulations, to return the groundwater to the restoration values set by the NDEQ in the Class III UIC Permit. These secondary restoration values ensure that the groundwater is returned to a quality consistent with the use, or uses, for which the water was suitable prior to ISR mining. These secondary restoration values are approved by the NDEQ in the individual Notices of Intent (NOIs) for each MU based on the permit requirements and the results of the baseline monitoring program.

EPA groundwater protection standards issued under the authority of the UMTRCA are required to be followed by ISR licenses of the NRC and its Agreement States. The EPA regulations issued under UMTRCA authority provide the principal standards for uranium ISR operations and groundwater protection, while the UIC regulations are considered additional requirements for ISR operations. CBR is required to restore groundwater quality to the standards listed in Criterion 5B (5) of 10 CFR Part 40, Appendix A as required by the UMTRCA, as amended. Under EPA requirements, groundwater restoration at ISR facilities must meet the UMTRCA standards and not those associated with the Safe Drinking Water Act or analogous state regulations.

Under Criterion 5B (5) of 10 CFR Part 40, Appendix A, at the point of compliance (mining zone after restoration), the concentration of hazardous constituent must not exceed:

a. The Commission approved background concentration of that constituent in the groundwater;
b. The respective value given in **Table 6.1-1** for the UMTRCA values if the constituent is listed in the table and of the background level of the constituent is below the value listed; or
c. Alternate concentration limit established by the Commission.

During restoration, sampling and analysis will be conducted in accordance with the operational groundwater monitoring program described in Section 5.7.8 and 5.7.9. Consistent with the Class

III UIC Permit, the specifics of the restoration monitoring are provided in a restoration plan for each MU or group of MUs for submission to the NDEQ.

6.1.3.1 Establishment of Baseline Water Quality

In addition to pre-operational baseline groundwater monitoring, before mining in each MU, the baseline groundwater quality is determined. The baseline data are established in each MU by assigning and evaluating groundwater quality in "baseline restoration wells". A minimum of one baseline restoration well for each 4 acres, but not fewer than six wells total for each MU, are sampled to establish the MU baseline water quality. A minimum of four samples are collected from each well. The samples are collected at least 14 days apart. The samples are analyzed for the parameters listed in **Table 6.1-1**.

Table 2.7-5 is the restoration tables for Mine Unit 1 in the current commercial license area. This is provided as an example of the 11 restoration tables for Mine Units 1 through 11. These tables provide the baseline average and the range for all restoration parameters as well as the NDEQ restoration standard approved for that MU in the NOI. Similar tables will be provided for the MEA mine units at the appropriate time to address restoration activities.

6.1.3.2 Establishment of Restoration Goals

The baseline data are used to establish the restoration standards for each MU. As previously noted, the primary goal of restoration is to return the MU to preoperational/preconstruction water quality condition on an MU average. Because ISR operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

Restoration goals are established by NDEQ to ensure that, if baseline water quality is not achievable after diligent application of best practicable technology (BPT), the groundwater is suitable for any use for which it was suitable before mining. NRC considers these NDEQ restoration goals as the secondary goals. The NDEQ restoration values are established for each MU and are approved with the NOI to Operate submittals according to the following analyses:

- For parameters that have numerical groundwater standards established in Title 118. The restoration goal is based on the Title 1118 Maximum Contaminant Level (MCL).
- If the baseline concentration exceeds the applicable MCL as noted above, the standard is set as the MU baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based on a wellfield average of the preoperational/preconstruction sampling data. Normal statistical procedures will be used to obtain the average.
- The restoration values for the major cations (Ca, Mg, K, and Na) allow the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criterion allows for the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline MU average plus one standard deviation.

The current NDEQ restoration standards are listed in **Table 6.1-1**.

It is anticipated that the Class III UIC Permit issued for the MEA will have similar requirements. Under the provisions of the performance-based license, the CBR SERP reviews and approves the establishment of restoration standards using the review procedures discussed in Section 5. **Table 6.1-1** lists the 27 parameters used at the Crow Butte Project to determine groundwater quality. The current MCLs from Title 118 are listed as well as the restoration standards from the Class III UIC Permit. The restoration value for each MU is based on the current Title 118 standard at the time the NOI is approved by the NDEQ.

Proposals for Alternate Concentration Limits (ACLs) will include consideration of factors listed under Criterion 5B(6) of 10 CFR Part 40, Appendix A and approval by NRC pursuant to Criterion 5B(5)(c).

6.1.4 Groundwater Restoration Methods

6.1.4.1 Introduction

Restoration activities in the current license area have proven that the groundwater can be restored to the appropriate standards following commercial mining activities. As shown in **Table 1.7-1**, MUs 2 through 6 are currently undergoing restoration, with MU 2 undergoing stability monitoring following active restoration. MU 1 groundwater restoration has been approved by the NDEQ and the NRC. On February 12, 2003, the NRC issued the final approval of groundwater restoration in MU 1 at Crow Butte. This approval was the culmination of 3 years of agency reviews including a license amendment to accept the NDEQ restoration standards as the approved secondary goals. MU 1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the CPF. Included within the boundaries of MU 1 were five wells originally mined beginning in 1986 as part of the R & D pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. MU 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

The approved CBR restoration plan consists of four steps:

1. Groundwater transfer
2. Groundwater sweep
3. Groundwater treatment
4. Wellfield recirculation

A reductant may be added at any time during the restoration stage to lower the oxidation potential of the mining zone. A sulfide or sulfite compound will be added to the injection stream in concentrations sufficient to reduce the mobilized species. Safety and handling issues associated with the use of Na_2S are discussed in Section 3.2.2. Instructions and safety precautions on the use of Na_2S are included in the SHEQMS Volume III Operating Manual (Restoration Reductant [Na_2S]).

Although CBR's CSA Class III UIC Permit requires a minimum of 6 months for stability monitoring of an MU to demonstrate the success of restoration (stabilization), for this license, the specified ore zone monitoring wells will be sampled at a frequency of once each quarter. The quarterly monitoring will continue until the data from the most recent four consecutive quarters

indicate no statistically significant increasing trend for all constituents of concern. At that point, stabilization will be deemed complete subject to approval.

Throughout restoration and stabilization, excursion monitoring consistent with Section 5.7.8.2 will continue until NRC determines that groundwater stabilization has been demonstrated. Stability monitoring may continue beyond the 6-month period as necessary. Stability monitoring will conclude, instead, when stabilization samples show that restoration goals on an MU average for monitored constituents are met and there is no significant increasing trend for a minimum of four quarters. At the end of the stabilization period, when restoration parameters have been achieved and there are no significant increasing trends for any of the restoration parameters, a request would be made to the appropriate regulatory agencies. A cone of depression (inward hydraulic gradient) is not maintained during stabilization.

During mining until the start of stabilization, an overall hydrologic bleed will be maintained within the perimeter monitor well ring to prevent lateral migration of mining lixiviant. If a proper hydrologic bleed is not maintained, it is possible for water with chemistry similar to that in **Table 2.7-6** column "Typical Water Quality During Mining at CPF" to begin migrating toward the monitor well ring. The mobile ions, such as chloride and carbonate, would be detected at the monitor well ring, and adjustments would be made to reverse the trend. The maintenance of a hydrologic bleed and the close proximity of the monitor well ring, less than 300 feet from the mining patterns, will ensure control of mining fluid. Vertical migration of fluid is less of a concern than lateral migration due to the underlying and overlying aquitards. The vastly different piezometric heads between the Lower and Middle Chadron, as well as the results of the pumping test, support the conclusion that the Lower Chadron is vertically isolated.

Crow Butte initiated a bioremediation pilot study in MU 4 at the existing CPF on December 17, 2008. If CBR decides to utilize this type of bioremediation in the future, a request for a license amendment will be submitted to the NRC.

6.1.4.2 Restoration Process

Restoration activities include four steps designed to optimize restoration equipment used in treating groundwater and to minimize the number of pore volumes circulated during the restoration stage. The number of pore volumes that would be displaced during groundwater restoration would be as follows: three pore volumes through IX treatment; six pore volumes through the RO; and two pore volumes of recirculation (total of 11 pore volumes for restoration). CBR will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary.

Because the final layout of the MUs has not been defined, the pore volume for the MUs will be calculated as per the following:

Pore Volume (PV) = area x thickness x porosity x flare factor x 7.48 gal/ft^3

The calculated pore volume will be based on the square footage of the potential wellfield area, average under-ream interval of approximately 25 feet and an assumed 29 percent open pore space value, and an assumed flare factor of 20 percent. As additional drilling is performed, these values may be refined for use in calculating surety.

A preliminary calculated pore volume for the first MEA wellfield will be approximately 177,193,095 gallons. This is based on a calculated square footage (3,267,000 ft^2) of the potential wellfield area, an average under-ream interval of 25 feet and an estimated 29% open pore space value.

NUREG-1569 indicates that, for surety purposes, the licensee should include the flare factor in its calculation of the number of pore volumes necessary for groundwater restoration (NRC 2003). The flare factor is defined by the NRC *as a proportionality factor designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the extraction process*. The flare factor is usually expressed as a horizontal and vertical component to account for differences between the horizontal and vertical hydraulic conductivity of an aquifer material (NRC 2003). The horizontal and vertical flares are typically expressed as a multiple of the calculated pore volume. However, R/CR-6870 states that there are zones with low permeabilities that have proven more of a concern than in a wellfield where the balance is maintained. As in the case of the current CBR operations, a wellfield at MEA will be balanced on an individual pattern basis. Within the uranium ISR industry, this is the most effective way to mine an *in-situ* wellfield and restore groundwater (Powertech 2009). During operations, CBR will balance the MEA individual wells daily, a method that will reduce the pore volumes for restoration and minimize excursions beyond the flare zone. CBR bases their projected restoration volumes at the MEA project on historical experience and past successful restoration activities.

Acceptance criteria 2 in Section 6.1.3 of RG-1569 (NRC 2003) states, "Specific flare factors approved in the past vary from 20 to 80 percent and are typically based on experience from research and development pilot demonstrations. CBR's technical basis for the proposed flare factor is operational experience and hydrological modeling at the nearby commercial ISR operation.

Groundwater Transfer

During groundwater transfer, water may be transferred between the MU commencing restoration and an MU commencing mining operations. The higher TDS water from the MU in restoration is recovered and injected into the MU commencing mining. The direct transfer of water will act to lower the TDS in the MU being restored by displacing water affected by the mining with baseline quality water.

The goal of the groundwater transfer step is to blend the water in the two MUs until they become similar in conductivity. The recovered water may be passed through IX columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the groundwater transfer step to occur, a newly constructed MU must be ready to commence mining. If an MU is not available to accept transferred water, groundwater sweep, or other activity will be employed as the first step of restoration. The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the wastewater disposal system during restoration activities.

Groundwater Sweep

During groundwater sweep, water is pumped without injection from the wellfield, causing an influx of baseline quality water from the perimeter of the MU, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The affected water near the edge patterns of the wellfield is also drawn into the boundaries of the MU. The number of pore volumes transferred during groundwater sweep, if any, is dependent upon the presence of other active MU along the MU boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

Groundwater Treatment

Following the groundwater sweep step, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. IX, RO, and/or Electro Dialysis Reversal treatment equipment is generally used during this stage as shown on the generalized restoration flow sheet on **Figure 6.1-1**.

Water recovered from restoration that contains uranium is passed through the IX system. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the restoration wellfield injection to reduce any pre-oxidized minerals. The concentration of reductant injected into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce those minerals solubilized by carbonate complexes to prevent the buildup of dissolved solids, which would increase the time for restoration to be completed.

A portion of the restoration recovery water can be sent to the RO unit. The use of an RO unit: 1) reduces the TDS in the contaminated groundwater; 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits; 3) concentrates the dissolved contaminants in a smaller volume of brine to facilitate waste disposal; and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. **Table 6.1-2** shows typical RO manufacturers specification data for removal of ion constituents. The clean water, called "permeate", will be re-injected, sent to storage for use in the mining process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called "brine", contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the waste system. Makeup water may be added to the wellfield injection stream to control the amount of "bleed" in the restoration areas.

The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any O_2 and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. H_2S, Na_2S, or a similar compound will be added as a reductant. CBR typically uses Na_2S due to the chemical safety issues associated with proper handling of H_2S. A comprehensive reductant use safety plan is implemented.

The number of pore volumes treated and re-injected during the groundwater treatment stage will depend on the efficiency of the RO in removing TDS and the reductant in lowering the uranium and trace element concentrations.

Wellfield Recirculation

At the completion of the groundwater treatment stage, wellfield recirculation may be initiated. To homogenize the aquifer, pumping from the production wells and re-injecting the recovered solution into injection wells may be performed to recirculate solutions.

The sequence of the activities will be determined by CBR based on operating experience and wastewater system capacity. Not all phases of the restoration stage will be used if deemed unnecessary by CBR.

Once the restoration activities are completed, CBR will sample the restoration wells and determine if the MU has achieved the restoration values, on an MU average basis. If so, CBR will notify the regulatory agencies that it is initiating the Stabilization Stage and will submit supporting documentation that the restoration parameters are at or below the restoration standards. If, at the end of restoration activities, the parameters are not at or below the approved values, CBR will either re-initiate certain steps of the restoration plan or submit documentation to the agencies that the best practical technology has been used in restoration. The documentation will include a justification for alternate parameter value(s) including available water quality data and a narrative of the restoration techniques used.

6.1.5 Stabilization Phase

Upon completion of restoration, a groundwater stabilization monitoring program will begin in which the restoration wells and any monitor wells on excursion status during mining operations will be sampled and analyzed for the restoration parameters listed in **Table 6.1-1**. A cone of depression (inward hydraulic gradient) is not maintained during stabilization.

Although CBR's CSA Class III UIC Permit requires one sample a month for a minimum of 6 months for stability monitoring of an MU to demonstrate the success of restoration (stabilization), for this license, the specified ore zone monitoring wells will be sampled at a frequency of once each quarter. The quarterly monitoring will continue until the data from the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern. At that point, stabilization will be deemed complete subject to approval.

Throughout restoration and stabilization, excursion monitoring, consistent with Section 5.7.8.2 will continue until NRC determines that groundwater stabilization has been demonstrated.

The sampling frequency will be one sample every other month for four quarters, and if the six samples show that the restoration values for all wells are maintained during the stabilization period with no significant increasing trends, restoration shall be deemed complete.

Throughout restoration and stabilization, excursion monitoring (consistent with Section 5.7.8.2) will continue until NRC determines that groundwater stabilization has been demonstrated.

6.1.6 Reporting

During the restoration process, CBR will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized and discussed in the Semiannual Radiological Effluent and Environmental Monitoring Report submitted to NRC. This information will also be included in the final report on restoration. In the unlikely event that a well goes on excursion during restoration, the process described in Section 5.7.8.3 of NUREG-1569 will be followed. Excursion monitoring operational procedures will include corrective action and notification plans in the event of an excursion. The NRC will be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation. If any of the wells are still on excursion status when the report is submitted, the report will also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the event of a vertical excursion, the report will contain a projected completion date for the extent of the vertical excursion would be completed.

Upon completion of restoration activities and before stabilization, all designated restoration wells in the MU will be sampled for the constituents listed in **Table 6.1-1**. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the NRC and the NDEQ, CBR will proceed with the stabilization phase of restoration. Groundwater restoration standards for the current CBR operations are established by the NDEQ, with concurrence of the NRC and EPA. This process will be adhered to for the MEA project.

CBR will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. If the analytical results continue to meet the appropriate standards for the MU and do not exhibit significant increasing trends, CBR would request that the MU be declared restored. Following agency approval, wells will be reclaimed, plugged, and abandoned as described in Section 6.2.3. CBR will not remove production or monitoring wells until the stability monitoring is concluded and agency approval is granted. In this way, these wells could be used to correct any excursion.

6.2 Plans for Reclaiming Disturbed Lands

The following section addresses the methods for final decommissioning of disturbed lands including the wellfield, satellite facility areas, wastewater surge/equalization tanks, and diversion ditches that will be used on the Crow Butte Project sites. The section discusses general procedures to be used during final decommissioning as well as the decommissioning of a particular phase or production unit area.

Decommissioning of a wellfield and process facilities will be scheduled after agency approval of groundwater restoration and stability. Decommissioning will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEQ and NRC rules and regulations, permit and license stipulations, and amendments in effect at the time of decommissioning.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 6.2.3.
- Determine appropriate cleanup criteria for structures (Section 6.3) and soils (Section 6.4).
- Conduct radiological surveys and sampling of all facilities, process-related equipment, and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Remove from the site all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocate to an operational portion of the mining operation as discussed in Section 6.3.
- Decontaminate items to be released for unrestricted use to levels consistent with NRC requirements.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.
- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections generally describe the planned decommissioning activities and procedures for the Crow Butte facilities. These activities and procedures will apply to the MEA facilities as well as the current facilities. CBR will, prior to final decommissioning of an area, submit to the NRC and NDEQ a detailed decommissioning plan for their review and approval at least 12 months before final decommissioning. As required by 10 CFR 40.36 (f), records important to MEA decommissioning will be maintained in the office of the onsite RSO. Such information shall meet the criteria of 10 CFR 40.42 (g) (4) and (5).

6.2.1 General Surface Reclamation Procedures

The primary surface disturbances will be the satellite facilities (uranium recovery building, fuel and chemical storage, shop, office, rest rooms, and laboratory), wastewater surge/equalization tanks, and wellfield production areas. Surface disturbances also occur during well drilling, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

The objective of the surface reclamation plan is to return disturbed lands to production compatible with the post-mining land use of equal or better quality than the premining condition. For the Crow Butte area, the reclaimed lands should be capable of supporting livestock grazing and providing habitat for wildlife species. Soils, vegetation, wildlife, and radiological baseline data will be used as guidelines for the design, completion, and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind and water and sedimentation, and to re-establish natural trough drainage patterns.

The following sections provide reclamation procedures for the facility sites, wellfield production units, wastewater surge/equalization tanks, and access and haul roads. Reclamation schedules for wellfield production units will be discussed separately because they are dependent upon the

progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations are discussed in Section 6.6 and include all activities anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite facilities installed. These cost estimates are updated annually to cover work projected for the next year of mining activity.

6.2.1.1 Topsoil Handling and Replacement

In accordance with NDEQ requirements, topsoil is salvaged from building sites (including the satellite buildings) and pond areas. Conventional rubber-tired, scraper-type earth moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfield, which are determined during final wellfield construction activities.

As described in Section 2.6, topsoil thickness varies within the MEA. Topsoil is usually thickest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil stripping depths may vary, depending on location and the type of structure being constructed. In cases where it is necessary to strip topsoil in relatively large areas, such as a major road or building site, field mapping and Soil Conservation Service Soil Surveys will be employed to determine approximate topsoil depths.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles are generally located on the leeward side of hills to minimize wind erosion. Stockpiles are not located in drainage channels. The perimeters of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles are seeded as soon as possible after construction with the permanent seed mix.

During mud pit excavation associated with well construction, exploration drilling, and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When the mud pit is no longer needed, all subsoil is replaced and topsoil is applied. Mud pits generally remain open for a short time. The success of revegetation efforts at the current site shows that these procedures adequately protect topsoil and result in vigorous vegetation growth.

6.2.1.2 Contouring of Affected Areas

Due to the relatively minor nature of disturbances created by *in-situ* mining, there are only a few areas where subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. However, no evaporation ponds are planned for the MEA. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post-mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be temporary during the operating period. These changes will be mitigated by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. Restoration of the original land surface, which is consistent with the pre- and post-mining land use, the blending of affected areas with adjacent topography to approximate original

contours, and the reestablishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

Drainage channels that have been modified by the mine plan for operational purposes such as road crossings will be reestablished by removing fill materials and culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas that have been located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location to allow for controlled surface runoff and eliminate depressions where water could accumulate.

6.2.1.3 Revegetation Practices

Revegetation practices are conducted in accordance with NDEQ requirements. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas, will be seeded with vegetation to minimize wind and water erosion. After placement of topsoil and contouring for final reclamation, an area will normally be seeded with a seed mixture developed in consultation with the Natural Resource Conservation Service as required by the NDEQ.

6.2.2 Process Facility Site Reclamation

Following removal of structures as discussed in Section 6.3, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, as practicable. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, bulldozers, or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Motorgraders may be used to even the spread of backfill materials. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done to establish adequate drainage and the final prepared surface will be left in a roughened condition.

6.2.3 Wellfield Decommissioning

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities discussed below. Surface preparation will be accomplished as needed to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production

feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters, or control fixtures will be salvaged.

- Removal of buried wellfield piping.
- Wells will be plugged and abandoned according to the procedures described below.
- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.
- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.
- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the NRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other contaminated materials will be acid washed or decontaminated with other methods until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at an NRC licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the CPF and at the MEA. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.3.1 Well Plugging and Abandonment

All wells no longer useful to continue mining or restoration operations will be abandoned. These include all injection and production wells, monitor wells, and any other wells within the production unit used for the collection of hydrologic or water quality data or incidental monitoring purposes. The only known exception at this time may be a shallow well that could be transferred to the landowner for domestic or livestock use.

The objective of the Crow Butte well abandonment program is to seal and abandon all wells to protect the groundwater supply and to eliminate any potential physical hazard.

Prior to abandoning a well, data will be gathered (static water level, under-ream interval, casing depth) for use in a well abandonment spreadsheet that accounts for formation pressures, mining injection pressures, static water level, casing depth, materials used, and weight of material used. That information can be used to adjust the amount of bentonite chips used to plug the well screens and to calculate the minimum weight (lbs/gallon) of abandonment mud used to fill the hole to the surface and keep formation and mining pressures from allowing water to rise in the borehole. A pre-packaged bentonite-filled tube is currently used for plugging the well screens. These tubes are placed into the screens by filling the well to the surface with water from a water truck, and then dropping the bentonite tubes down the well. The water is allowed to run while the tubes descend into the screens. The drill rig then trips the drill pipe into the well and tags the bentonite to make sure it has reached the targeted depths. The drill stem is raised approximately 10 feet and an appropriate abandonment mud is mixed. If the weight of the abandonment mud

needs to be increased, barite may be added to increase the weight. Likewise, an appropriate drilling additive may be added to improve the ability of the abandonment mud to carry the barite. In situations where it appears that the operating pressure and formation pressure are great enough to make it difficult to mix heavy mud, cement slurry may be substituted to fill the casing to the surface. All abandoned wells will remain above the surface until the wellfield is reclaimed. This will allow for the continuation of monitoring and observation of the integrity of the abandonment fluid. If needed, abandonment fluids will be added.

The plugging method is approved by the NDEQ and is summarized below:

- A mechanical plug may be placed above the screened interval.
- Thirty to 50 feet of coarse bentonite chips will be added to provide a grout seal.
- A Plug-gel™ or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron formation pressure plus the maximum injection pressure allowed (100 psi).
- The tremie pipe will be removed (when possible) and the casing will be filled to the surface.
- An approved hole plug will be installed.
- The well casing will be cut off below ground level, capped with cement, and the surface disturbance will be smoothed and contoured.
- The hole will be backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. CBR must submit a notarized affidavit to the NDEQ detailing the significant data and the procedure used in connection with each well plugged. The DNR also requires filing a well abandonment notice for all registered wells.

6.2.3.2 Buried Trunklines, Pipes, and Equipment

Buried process-related piping, such as injection and production lines, will be removed from the MU undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill.

6.3 Removal and Disposal of Structures, Waste Materials, and Equipment

CBR would submit a final and detailed decommissioning plan for structures and equipment to the NRC for review and approval at least 12 months before the decommissioning of such structures and equipment. This final decommissioning plan would include a description of structures and equipment to be decommissioned, planned decommissioning activities, methods to be used to ensure protection of workers and the environment against radiation hazards, the planned final radiation survey, and an updated detailed cost estimate.

The procedures to be used for removing and disposing of structures, waste materials, and equipment would meet the following criteria:

- A written program is in place to control residual contamination on structures and equipment.
- Measurements of radioactivity on the interior surface of pipes, drain lines, and duct work would be determined by conducting measurements at all traps and other appropriate access points, provided that such contamination is likely to be representative of contamination on the interior of the pipes, drain lines, and ductwork.
- Any surfaces of premises, equipment, or scrap that would likely be contaminated, but are of such size, construction, or location as to make the surface inaccessible for measurement, would be presumed to be contaminated in excess of the limits.
- Prior to the release of structures for unrestricted use, a comprehensive radiation survey would be made to establish that contamination is within the limits specified in NRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (NRC 1993), and NRC approval would be obtained.
- A contract between CBR and a waste disposal operator would be in place to dispose of 11e.(2) byproduct material.

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to decommissioning the satellite building, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The survey will support the development of procedures for dealing with such hazards prior to decommissioning activities. In general, the contamination control program used during mining operations (as discussed in Section 5.7) will be appropriate for use during decommissioning of structures.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This gross decontamination will generally consist of high-pressure washing of all accessible surfaces with water. In areas where contamination is not readily removed, a decontamination solution (e.g., dilute acid) may be used.

6.3.2 Removal of Process Buildings and Equipment

The majority of the process equipment in the process building will be reusable, as well as the building itself. Alternatives for the disposition of the building and equipment are discussed in this section.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, and other components, will be inventoried, listed, and designated for one of the following removal alternatives:

- Removal to a new location within the Crow Butte site for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or

- Decontamination to meet unrestricted use criteria for release, sale, or other non-restricted use by others.

It is most likely that process buildings will be decontaminated, dismantled, and released for use at another location. If decontamination efforts were unsuccessful, the material would be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a licensed disposal site or properly licensed facility if contaminated.

6.3.2.1 Building Materials, Equipment, and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment, pipe, and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with license conditions contained in SUA-1534 and NRC guidance.

The CBR release limits for alpha radiation are as follows:

- Removable of 1,000 dpm/100cm^2
- Average total of 5,000 dpm/100 cm^2 over an area no greater than 1 square meter
- Maximum total of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2

Monitoring for beta contamination is a current license requirement. This requirement has been eliminated in subsequent ANSI standards, including ANSI/HPS N13.12 (ANSI 1999). In addition, CBR has routinely made these measurements but has never found them limiting.

Decontamination of surfaces will comply with the CBR ALARA policy to reduce surface contamination as far below the limits as practical.

Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to an NRC-licensed facility for disposal. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR 173.427.

6.3.2.2 Disposal at a Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(2) byproduct material, the following procedures may be used.

- Flush inside of tanks, pumps, pipes, and other components, with water or acid to reduce interior contamination as necessary for safe handling.
- Survey the exterior surfaces of process equipment for contamination. If the surfaces are found to be contaminated, the equipment will be washed down and decontaminated to permit safe handling.
- Disassemble the equipment only to the degree necessary for transportation. All openings, pipe fittings, vents, and other components, will be plugged or covered prior to moving equipment from the satellite building.
- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in lined roll-off containers or covered dump trucks or drummed in barrels for delivery to the receiving facility.

- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.
- All other miscellaneous contaminated material will be transported to a licensed disposal facility.

6.3.2.3 Release for Unrestricted Use

If a piece of equipment or structure is to be released for unrestricted use, it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Radioactivity levels would be determined on the interior surfaces of pipes, drain lines, or duct work by making measurements in all traps and other appropriate access points, provided that contamination at these locations would be expected to be representative of contamination on the interior of the pipes, drain lines, or duct work. If the shape, size, or presence of inaccessible surfaces prevents an accurate and representative survey, the material will be assumed contaminated and properly disposed of. Appropriate decontamination procedures will be used to clean any contaminated areas, the equipment will be resurveyed, and documentation of the final survey will be retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. The current release criteria are based on NRC guidelines. The criteria to be used for release to unrestricted use will be the appropriate NRC guidelines at that time. Release surveys will be based on the release methods discussed in Section 5.7.

If a process building is left on site for unrestricted use by a landowner, the following basic decontamination procedures will be used. Actual corrective procedures will be determined by field requirements as defined by radiological surveys.

After the building has been emptied, the interior floors, ceiling, and walls of the building and exterior surfaces at vent and stack locations will be checked for contamination. Any remaining removable contamination will be removed by washing. Areas where contamination was noted will be resurveyed to ensure removal of all contamination to appropriate levels.

Process floor sumps and drains will be washed out and decontaminated using water and, if necessary, acid solutions. If the appropriate decontamination levels cannot be achieved, it may be necessary to remove portions of the sump and floor to disposal.

Excavations necessary to remove trunklines or drains will be surveyed for contaminated earthen material. Earthen material found to be contaminated will be removed to a licensed disposal facility prior to backfilling the excavated areas.

The parking and storage areas around the building will be surveyed for surface contamination after all equipment has been removed.

These areas will be decontaminated as necessary to meet the standards for unrestricted use.

6.3.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed of at a disposal site licensed by the NRC or an Agreement State

to receive 11e.(2) byproduct material. CBR currently maintains agreements with two such facilities located in the States of Utah and Wyoming for disposal of 11e.(2) byproduct materials generated by mining operations. A contract for disposal at a minimum of one facility will be maintained current as required in NRC License SUA-1534.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the DOT Hazardous Materials Regulations (49 CFR Part 173) and the NRC transportation regulations (10 CFR 71).

6.4 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

6.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium.

The proposed limits and ALARA goals for cleanup of soils are summarized in **Table 6.4-1** and described below.

The existing radium-226 criterion in 10 CFR Part 40, Appendix A, was used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct materials. The Benchmark Dose was modeled using the RESRAD code (Version 6.22). The RESRAD runs are shown as Appendix A of the Wellfield Decommissioning Plan for Crow Butte Uranium Project presented in **Appendix N.** The results show that a concentration of 537 pCi/g for natural uranium in the top 15 cm layer of soil for the resident farmer scenario is equivalent to the Benchmark Dose derived from a concentration of 5 pCi/g of radium-226.

ALARA considerations require that an effort be made to reduce contaminants to ALARA levels. The ALARA goals are normally based on a cost-benefit analysis. For the cleanup of gamma-emitting radionuclides, the cost of cleanup becomes excessively high as soil concentrations and/or gamma emission rates become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels along with appropriate field survey and sampling procedures result in near background radium-226 concentrations for the site. In addition, the presence of a mixture of radium-226 and uranium will tend to drive the cleanup to even lower radium-226 concentrations. It is therefore believed that no specific ALARA goal is required for surface radium-226.

CBR proposes an ALARA goal of limiting the natural uranium concentration in the top 15 cm soil layer to 150 pCi/g, averaged more than 100 m^2. According to the RESRAD runs presented in **Appendix N**, the ratio of radium-226 dose rate per pCi/g to the uranium dose rate per pCi/g is 120. It is also shown by calculation that the ratio of radium-226 to uranium emission rates is 30. Therefore, if the action level for pure radium-226 results in cleanup of the site to less than 5 pCi/g, the action level should result in the cleanup of pure uranium to 30 times 5 or 150 pCi/g.

The uranium concentration should be limited to – at most – 230 pCi/g for all soil depths because of chemical toxicity concerns. Using the most conservative daily limit corresponding to the National Primary Drinking Water Standard, a soil limit of 230 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day.

CBR desires to reduce subsurface concentrations to a maximum of two thirds of the proposed limit of 15 pCi/g radium-226. The subsurface uranium goal has not been reduced because it has not been demonstrated that these levels can be detected with readily available field instruments.

Section 2.5 of **Appendix N** demonstrates that spills of process solutions at the CPF are not likely to contain substantial amounts of thorium-230. CBR believes that development of soil cleanup criteria for thorium-230 is not appropriate at this time. In the unlikely event that thorium-230 is present in significant quantities, cleanup criteria will be developed using the radium-226 Benchmark Approach and submitted to the NRC for approval prior to final site decommissioning.

6.4.2 Excavation Control Monitoring

CBR will use 17,900 cpm as its gamma action level, as determined with a Ludlum Model 44-10/2221 NaI detection system or equivalent held at 18 inches above ground surface. The gamma action level, defined as the gamma count rate corresponding to the soil cleanup criterion, will be used in the interpretation of the data. This action level will be used with caution, or until a new action level is developed.

Hand-held and global positioning system (GPS)-based gamma surveys will be used to guide soil remediation efforts. Field personnel will monitor excavations with hand-held detection systems to guide the removal of contaminated material until there is high probability that an area meets the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation.

The 17,900 cpm action level was based on an evaluation of the correlation between gamma count rates and radium-226 concentration in soil using data from the few spill-related contaminated areas that existed at the CPF area. CBR believes that 17,900 cpm is a conservative value because the contaminated areas were small in size. The measured gamma emission rate per unit radium-226 concentration from small areas is normally lower than that which would be measured using large areas, such as a 100 m^2 area. Therefore, cleanup to 17,900 cpm should ensure that each 100 m^2 area meets the radium-226 soil cleanup standard.

Section 6.3 of **Appendix N** discusses the development of the 17,900 cpm action level. It does allow for a revision of the number should it later be determined not appropriate.

6.4.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas, including 10 m buffer zones.

CBR will divide the area systematically into 100 m^2 grid blocks and sample all grid blocks containing gamma count rates exceeding the gamma action level. The samples will be five-point composites, and analyzed at an offsite laboratory for radium-226 and natural uranium.

CBR will sample the remaining grid blocks with average gamma count rates ranking in the top 10 percent.

If any grid blocks within the top 10 percent fail the cleanup criteria, CBR will sample the second 10 percent of grid blocks. This will continue until all grid blocks pass within a 10 percent grouping. To meet the cleanup criterion, each of the sampled grid blocks must satisfy the following inequality:

$$\sum \frac{C_i}{Cc} < 1$$

where C_i is the concentration of the constituent and C_c is the concentration of the constituent that is equivalent to the Benchmark Dose.

CBR will remediate the grid blocks failing this inequality or propose alternatives consistent with Appendix A of 10 CFR 40.

After all sampled grids have met the inequality, an EPA-recommended statistical test will be conducted to determine whether the mean of the equality defined above for all grid blocks is 1 or less at the 95 percent confidence level, using Equation 8-13 of draft NUREG/CR-5849 (NRC 1992). If the mean of the sample concentrations is lower than the criterion but the data fail the statistical test, CBR will follow procedures similar to those recommended in Section 8.6 of draft NUREG/CR-5849 (NRC 1992).

6.4.4 Subsurface Soil Cleanup Verification and Sampling Plan

For subsurfaces, CBR will adopt different survey and sample protocols, depending on the type and size of excavation. CBR will rely more on sampling and analysis of radium-226 and natural uranium over surveying, to verify cleanup of subsurface excavations. The protocols are summarized in site procedures.

6.4.5 Temporary Ditches and Impoundments Cleanup Verification and Sampling Plan

CBR will adopt survey and sample protocols for temporary ditches and surface impoundments on a case-by-case basis. Ditches and impoundments can extend from the surface to the subsurface. For the purpose of decommissioning, the surfaces will be considered as part of adjacent soil surfaces. The subsurfaces will be surveyed and sampled systematically, based on their size and geometry. As with other subsurfaces, CBR will rely more on sampling and analysis of radium-226 and uranium over surveying to verify cleanup of ditches and impoundments. Surveying is applicable in larger impoundments; however, the effects of geometry are not as pronounced, particularly in areas not influenced by adjacent walls.

6.4.6 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The criteria that CBR will use to select the commercial laboratory will follow the guidance published in the Multi-Agency Radiological Laboratory Analytical Protocols Manual (NRC 2004). The commercial laboratory will adhere to a well-defined quality assurance program that addresses the laboratory organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, SOPs, sample receipt, handing, storage, records, and appropriate licenses.

The analytical work performed by the commercial laboratory will adhere to CBR-defined Data Quality Objectives (DQOs). Part of the DQO process is specific analytical sensitivities required by CBR. The minimum sensitivity required for each sample will be 0.5 pCi/g dry weight for each analyte, with an estimated overall error of $\pm$ 0.5 pCi/g.

CBR will expect the reporting equivalent of an EPA Contract Laboratory Program Level 3 data package from the commercial laboratory.

CBR will maintain a laboratory QA file that will include, at a minimum, the laboratory Quality Assurance Manual (QAM) and audit reports.

6.5 Decommissioning Health Physics and Radiation Safety

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels are kept ALARA during decommissioning. This program will ensure that contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public or the environment. The RSO, HPT, or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of RG 8.30 (NRC 2002) or other standards applicable at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC and NDEQ. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of 5 years or as otherwise required by applicable regulations at the time of decommissioning.

6.6 Financial Assurance

6.6.1 Bond Calculations

Cost estimates for the purpose of bond calculations are made annually for the CPF site. The cost assessment includes groundwater restoration, decontamination and decommissioning, and surface reclamation costs for all areas to be affected by the installation and operation of the proposed

mine plan. The detailed calculations used in determining the bonding requirements for the CPF are submitted annually.

6.6.2 Financial Surety Arrangements

CBR maintains an NRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. CBR maintains an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada (New York Branch) in favor of the State of Nebraska in the present (2010) amount of $35,248,294. The surety amount is revised annually in accordance with the requirements of SUA-1534. The surety amount will be revised to reflect the estimated costs of reclamation activities for the MEA as development activities proceed.

6.7 References

American National Standards Institute. (ANSI). 1999. ANSI/HPS N13.12, *Surface and Volume Radioactivity Standards for Clearance.*

Nebraska Department of Environmental Quality. (NDEQ). 2006. *Title 118 – Ground Water Quality Standards and Use Classification*, March 27, 2006.

U.S. Nuclear Regulatory Commission (NRC). 1992. NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination, Draft Report for Comment.* June 1992.

NRC. 1993. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material.* April 1993.

NRC. 2002. Regulatory Guide No. 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, May 2002.

NRC. 2003. Standard Review Plan for In Situ Leach Uranium Extraction License Applications. Final Report. June.

NRC. 2004. Multi-Agency Radiological Laboratory Analytical Protocols Manual. NUREG-1576. July 2004.

Powertech (USA) Inc. 2009. Dewey-Burdock Project Underground Injection Control Permit Application. Prepared for South Dakota Department of Environmental & Natural Resources. April.

Table 6.1-1 NRC and NDEQ Groundwater Restoration Standards

Parameter	NDEQ Title 118 Groundwater Standard	NDEQ Restoration Standard[1]	NRC UMTRCA Groundwater Protection Standards
Ammonium (mg/l)	Not Listed	10.0	--
Arsenic (mg/l)	0.010	0.010	0.05
Barium (mg/l)	2.0	2.0	1.0
Cadmium (mg/l)	0.005	0.005	0.01
Chloride (mg/l)	250	250	--
Chromium (mg/l)	--	--	0.05
Copper (mg/l)	1.3	1.3	--
Fluoride (mg/l)	4.0	4.0	--
Iron (mg/l)	0.3	0.3	--
Mercury (mg/l)	0.002	0.002	0.002
Manganese (mg/l)	0.05	0.05	--
Molybdenum (mg/l)	Reserved	1.0	--
Nickel (mg/l)	Reserved	0.15	--
Nitrate (mg/l)	10.0	10.0	--
Lead (mg/l)	0.015	0.015	0.05
Radium (pCi/l)	5.0	5.0	--
Selenium (mg/l)	0.05	0.05	0.01
Sodium (mg/l)	Reserved	Note 2	--
Sulfate (mg/l)	250	250	--
Uranium (mg/l)	0.030	0.030	--
Ra-226 and Ra-228 (pCi/l)	--	--	5
Vanadium (mg/l)	Reserved	0.2	--
Zinc (mg/l)	5.0	5.0	--
pH (Std. Units)	6.5 – 8.5	6.5 – 8.5	--
Calcium (mg/l)	N/A	Note 2	--
Total Carbonate (mg/l)	N/A	Note 3	--
Potassium (mg/l)	N/A	Note 2	--
Magnesium (mg/l)	N/A	Note 2	--
Total Dissolved Solids (mg/l)	500	Note 4	--

Sources: NDEQ Class III UIC Permit Number NE0122611 (except for NRC UMTRCA Groundwater Protection Standards)
NRC UMTRCA Groundwater Protection Standards (Criterion 5B (5) of 10 CFR Part 40, Appendix A of UMTRCA)

Notes:

[1] NDEQ Restoration Standard based on groundwater standard (MCL) from Title 118. For parameters where the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.

[2] One order of magnitude above baseline is used as the restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.

[3] Total carbonate shall not exceed 50% of the total dissolved solids value.

[4] The restoration value for Total Dissolved Solids (TDS) shall be the baseline mean plus one standard deviation.

Table 6.1-2 Typical Reverse Osmosis Membrane Rejection

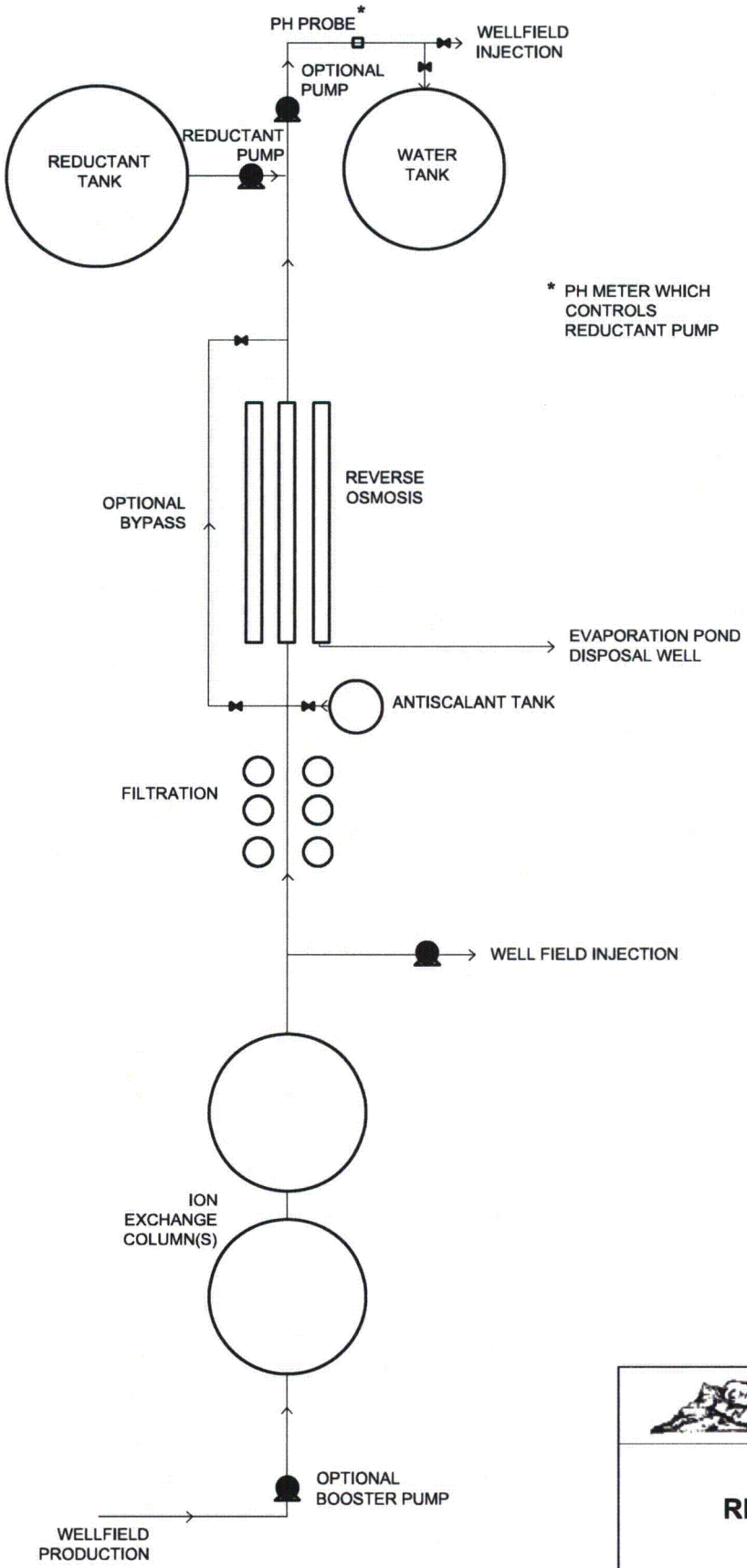
Name	Symbol	Percent Rejection
Cations		
Aluminum	Al^{+3}	99+
Ammonium	NH_4^{+1}	88–95
Cadmium	Cd^{+2}	96–98
Calcium	Ca^{+2}	96–98
Copper	Cu^{+2}	98–99
Hardness	Ca and Mg	96–98
Iron	Fe^{+2}	98–99
Magnesium	Mg^{+2}	96–98
Manganese	Mn^{+2}	98–99
Mercury	Hg^{+2}	96–98
Nickel	Ni^{+2}	98–99
Potassium	K^{+1}	94–96
Silver	Ag^{+1}	94–96
Sodium	Na^{+}	94–96
Strontium	Sr^{+2}	96–99
Zinc	Zn^{+2}	98–99
Anions		
Bicarbonate	HCO_3^{-1}	95–96
Borate	$B_4O_7^{-2}$	35–70
Bromide	Br^{-1}	94–96
Chloride	Cl^{-1}	94–95
Chromate	CrO_4^{-2}	90–98
Cyanide	CN^{-1}	90–95
Ferrocyanide	$Fe(CN)_6^{-3}$	99+
Fluoride	F^{-1}	94–96
Nitrate	NO_3^{-1}	95
Phosphate	PO_4^{-3}	99+
Silicate	SiO_2^{-1}	80–95
Sulfate	SO_4^{-2}	99+
Sulfite	SO_3^{-2}	98–99
Thiosulfate	$S_7O_3^{-2}$	99+

Source: Osmonics, Inc.

Table 6.4-1 Soil Cleanup Criteria and Goals

Layer Depth	Radium-226 (pCi/gm)		Natural Uranium (pCi/gm)	
	Limit	Goal	Limit	Goal
Surface (0 – 15 cm)	5	5	230	150
Subsurface (15 cm layers)	15	10	230	230

pCi/gm – picocuries per gram



CROW BUTTE RESOURCES, INC.

FIGURE 6.1-1
RESTORATION PROCESS FLOW DIAGRAM

PROJECT: CO001396.02 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

PATH: K:\CBR_P...\CO001636_Marsland\1_ACAD\RestorationProcessRevised.dwg LAYOUT: TR DATE/TIME: 3/16/2012 2:18 AM

7. ENVIRONMENTAL EFFECTS

The objective of the mining and environmental monitoring program is to conduct an economically viable and environmentally responsible operation. The environmental monitoring programs used to ensure that the potential sources of land, water, and air pollution are controlled and monitored, are presented in Section 5.7.

This section discusses and describes the short- and long-term impacts associated with operations and the consequences of possible accidents at the CPF and the MEA. Environmental impacts of the proposed satellite facility on scenic resources are discussed in Section 2.4.2.

7.1 Environmental Effects of Site Preparation and Construction

CBR has developed plans for the dcvelopment of the site based largely on the knowledge on the size of the ore body (depth, width and length) and U_3O_8 content arrived at through exploration and delineation work at the MEA site.

It is estimated that a total of approximately 1,753 acres could be affected over the life of the MEA Project. Estimates of acreages have been provided for the currently planned facilities as well as potential additional acreages that could be developed in the future (based on current knowledge of the ore body; **Table 7.1-1**).

Approximately 591 acres will be required for the currently planned facilities, which consist of the satellite building and associated facilities (1.8 acres), the DDW (0.5 acres), access roads to the satellite facility and DDW (1.7 acres) and eleven MUs (587.6 acres). The number of acres associated with roadways located within the MUs is included in the total MU acreage estimates. The number of acres of different types of habitat cover estimated to be impacted by the current planned construction activities are shown in **Table 7.1-1**.

Based on the current knowledge of the MEA ore body, it has been estimated that 1,162 acres in addition to the 591 acres could be disturbed over the life of the project. Estimates of the additional number of acres of different types of habitat cover that may be affected are shown in **Table 7.1-1**. As shown, the major type of habitat that would be affected is mixed grass prairie, which makes up approximately 65 percent of the total 1,753 acres.

The initial site preparation and construction associated with the MEA satellite facility will include the following:

- Construction of a satellite process facility located approximately 11.0 miles (17.7 km) south-southeast of the current process facility. This satellite facility will be housed in a building approximately 130 feet long by 100 feet wide and will contain IX and associated equipment capable of processing 6,000 gpm of production flow and 1,500 gpm of restoration flow.
- Placement of a modular office building.
- Construction of chemical storage facilities, wastewater surge/equalization tanks (six tanks at 30,000 gallons each), and other support facilities.
- Construction of a DDW for disposal of wastewater.
- A deep well injection building and associated facilities.
- Access roads, as required.

Site preparation and construction will include topsoil salvage, building erection, and access road construction. Note that wellfield construction activities and completion of injection, production, and monitor wells are discussed in Section 7.2 because these are ongoing activities at an ISR facility. This section strictly discusses the short-term impacts of initial site preparation and construction where they differ from the impacts of operations.

Environmental impacts of construction of the satellite facility are estimated based on the studies conducted by CBR, which are discussed in Section 2. The impacts are also projected based on experience with the current operation and those that have been associated with this type of construction at the Crow Butte project over the past 17 years of commercial operation by CBR.

As stated above, construction of the satellite facility will require disturbance of an estimated 591 acres for the satellite facility and support facilities such as wastewater surge/equalization tanks, eleven MUs, DDW, and road improvements. Of this total, approximately 1.8 acres will be associated with the satellite facility and approximately 0.5 acres for the DDW; plus additional 1.7 acres of access roads Surface disturbances will include construction of access roads, facility site grading, construction of DDW, and contouring for control of surface runoff. All areas disturbed will be reclaimed during final decommissioning. The planned schedule for construction, production, restoration, and decommissioning was presented in Section 1.

The primary surface disturbances associated with solution mining are the sites containing the processing facilities, associated facilities, and the DDW. Surface disturbances also occur during well drilling, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

Due to the relatively minor nature of disturbances created by ISR mining and the lack of evaporation ponds, no areas will be disturbed to the extent that subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post-mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction.

These surface impacts are unavoidable and will last for the duration of the project until final decommissioning. Mitigation measures for land surface impacts are discussed in Section 6.2.

7.1.1 Air Quality Effects of Construction

Construction activities at the satellite facility would cause minimal effects on local air quality. Effects to air quality would be increased suspended particulates from vehicular traffic on unpaved roads (in addition to existing fugitive dust caused by wind erosion) and diesel emissions from construction equipment. Application of water to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be short-term only, ceasing once the operational phase

begins. NRC estimated fugitive dust emissions during construction of uranium ISR operations are less than 2 percent of the NAAQS for $PM_{2.5}$ and less than 1 percent for PM_{10} (NRC 2009).

There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the satellite facility. This increase will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction are revegetated with the exception of facility pad areas, roads, and parking/storage areas. Of these, the only significant source of TSP is dust emissions from unpaved roads.

Specific regulatory issues associated with air quality impacts of operation are discussed in Section 7.2.1.2.

7.1.2 Land Use Impacts of Construction

The principal land uses for the 591 acres (**Table 7.1-1**) associated with the proposed eleven MUs, processing facility, DDW, and access roads are cropland (71.7 acres) and livestock range (491.2 acres [347.6 acres of mixed grass prairie and 143.6 acres of degraded rangeland]). The entirety of this approximately 591-acre area will be dedicated to the project's needs over the 1-year construction period. As presented previously, livestock and livestock products carry a value of $55.62 per acre, while non-livestock lands carry a value of $14.10 per acre. Based on this information, and assuming all available and suitable acreage within the MEA is currently employed to its greatest efficiency and effect, construction activities in the MEA would result in the lost livestock production of approximately $27,320 per year, and the lost production of crops valued at $1,011 per year. The exclusion of agricultural activities from this area during construction would not have a significant impact on local agricultural production due to the small size of land taken out of production; construction and operation would not have a significant impact on landowners due to the payment of royalties and leases, which will offset the losses from the land being removed from agricultural production.

The long-term principal land uses for an additional 1,162 acres associated with project development will result in a total of 1,753 acres over the life of the project. The main types of habitat cover within the 1,753 acres will include cropland (128.4 acres), livestock range (1,370.7 acres [1,142.7 acres mixed grass prairie and 228 acres degraded rangeland]), and mixed conifer (194.6 acres). The entirety of this approximately 1,753 acres may be dedicated to the project's needs over the life of the project. Using the assumptions above, construction activities over the life of the project could result in the loss livestock production of approximately $76,238.

7.1.3 Geologic and Soil Impacts of Construction

7.1.3.1 Geologic Impacts of Construction

Geologic impacts are expected to be minimal, if any. Impacts to paleontological resources are likely to be significant. Due to the presence of highly sensitive geologic formations within the MEA, surface disturbances that occur during construction of the satellite facility buildings, access roads, and wellfield will likely have direct impacts to paleontological resources, particularly in areas of thin soil cover and bedrock exposure.

7.1.3.2 Soil Impacts of Construction

Construction of the satellite facilities will affect soils. With proper implementation of best management practices (BMPs), effects to soils are not expected to be significant within the MEA.

The severity of soil impacts would depend on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils at the MEA would result from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation of the satellite facility would continue until the area is revegetated.

Wind erosion is possible throughout the MEA. Many soils meet the criteria for high wind erosion hazard (NRCS 1977). These soils include one or more major fine sand or sandy loam constituents that can easily be picked up and spread by wind. Vegetation removal presents the greatest threat to soils with potential for wind erosion. Wind erosion will be controlled by removing vegetation only where necessary, avoiding clearing and grading on erosive areas, surfacing roads with locally obtained gravel, and timely reclamation.

Water erosion is also possible at the MEA, especially in areas disturbed by road and wellfield construction. Various soils meet the criteria for severe water erosion hazard (NRCS 1977). These soils have low permeability and high K-factors, making them susceptible to water erosion. The K-factor describes soil erodibility; it represents both the susceptibility of soil to erosion and the rate of runoff. It is calculated from soil texture, organic matter, and soil structure. Construction and operation would increase soil loss through water erosion. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and promoting gully formation. Soil loss will be reduced substantially by avoiding construction in highly erosive areas such as badlands and steep drainages. Locating roads in areas where cuts and fills would not be required, surfacing roads with gravel, installing drainage controls, and reseeding and installing water bars across reclaimed areas will also aid in reducing soil loss due to water erosion.

An assessment of the potential for flooding or erosion that could impact the proposed in-situ Marsland mining processing facilities and mine units was performed for the MEA. The results of this study are discussed in Section 3.1.3.3. The complete report of the hydrologic and erosion study, including tables and figures, can be found in **Appendix K** (ARCADIS 2011a). The study addressed guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium in-situ facility. The ultimate objective of the MEA study was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented. The results of this study will be used for further analysis, mitigation measures or modification of location of surface facilities, including well locations during the final engineering phase and prior to well installation and construction activities.

Sedimentation in streams and rivers within the MEA and in the Niobrara River immediately to the south could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of area drainages. Installation of appropriate erosion control measures as required by the CBR Construction Stormwater NPDES authorization (see Section 7.1.4) and avoidance of erosive soils will aid in reducing sedimentation.

Activity on the site has the potential to compact soils. Soils sensitive to compaction do exist on the site. Compaction of the soils could decrease infiltration and promote higher runoff. Construction and traffic will be minimized where possible, and soils will be loosened prior to reseeding during reclamation to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific soil conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the Niobrara River. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Satellite facility development would displace topsoil, which would adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This would result in a reduction of natural soil productivity.

A number of erosion and productivity problems resulting from satellite facility construction may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large-scale surface grading and leveling until successful reclamation. Reduction in soil fertility levels and reduced productivity would affect diversity of reestablished vegetative communities. Moisture infiltration would be reduced, creating droughty soil conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials could occur at the satellite facility. If not remediated quickly, these materials have the potential to adversely impact soil resources. To minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan will be implemented. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

Soil Impact Mitigation Measures

BMPs have been included in the project description and will be followed to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will help reduce the effects to soil resources at the MEA. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document. Fundamentally, efforts will be made to preserve existing vegetation where practical.

Sediment Control

- Divert surface runoff from undisturbed areas around the disturbed area.
- Retain sediment within the disturbed area.
- Surface drainage shall not be directed over the unprotected face of the fill.
- Operations and disturbance on slopes greater than 40 percent need special sediment controls and should be designed and implemented appropriately.
- Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.

- Inspect and maintain all erosion control structures.
- Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.
- If BMPs do not result in compliance with applicable standards, modify or improve such BMPs to meet the controlling standard of surface water quality.

Topsoil

- Topsoil should be removed prior to any development activity to prevent loss or contamination.
- When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.
- To the extent possible, directly haul (live handle) topsoil from the site of salvage to concurrent reclamation sites.
- Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes, handling soil while saturated, and scarifying compacted soils.
- Time topsoil redistribution so seeding or other protective measures can be readily applied to prevent compaction and erosion.

Roads

- Restrict the length and grade of roadbeds.
- Surface roads with durable material (i.e., locally obtained native gravel).
- Create cut and fill slopes that are stable.
- Revegetate the entire road prism including cut and fill slopes.
- Create and maintain vegetative buffer strips and construct sediment barriers (e.g., straw bales, wire-backed silt fences, check dams) during the useful life of roads.

Regraded Material

- Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching, and other activities.
- Divert all surface water above regraded material away from the area and into protected channels.
- Shape and compact regraded material to allow surface drainage and ensure long-term stability.
- Concurrently reclaim regraded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and Storm Water Pollution Prevention Plans (SWPPPs) will minimize effects to soils associated with the construction of the satellite facility.

7.1.4 Surface Water Impacts of Construction

When stormwater drains off a construction site, it can carry sediment and other pollutants that can potentially harm lakes, streams, and wetlands. The EPA estimates that 20 to 150 tons of soil per

acre are lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff may need to be controlled by the NDEQ NPDES regulations.

Construction activities at the CBR project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119 (NDEQ 2005). CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in the SHEQMS Volume VI, Environmental Manual and require active engineering measures (such as berms) and administrative measures (such as work activity sequencing) to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEQ under the general permit.

Administrative and engineering controls implemented by CBR during initial site preparation and construction of the satellite facility and related facilities are expected to ensure that surface water impacts are minimal.

7.1.5 Population Impacts of Construction

Construction activities will require the hiring of four to seven temporary construction workers over the estimated one 1-year construction and development period. It is expected that these positions will be filled by local labor from Dawes County or an adjacent county, or by individuals currently employed on other Cameco projects.

7.1.6 Social and Economic Impacts of Construction

The social and economic impacts to the City of Crawford and surrounding areas during the construction of the original Crow Butte facility were slight given the relatively small scale of activities. Given the similar size of the MEA facilities and scope of the project, the impact of MEA-related construction activities will be similarly slight. CBR estimates that four to seven temporary construction workers will be involved in constructing the MEA facility. The social and economic impacts of construction are discussed in more detail in Section 7.6.

7.1.7 Noise Impacts of Construction

The project area is surrounded by agricultural lands and rural residences. The existing ambient noise in the vicinity of the project area is dominated by intermittent noise from the Burlington Northern Santa Fe (BNSF) rail line located approximately 1 mile (1.6 km) west of the MEA boundary at its closest point. Intermittent, low levels of traffic noise from Hollibaugh and River Roads and agricultural equipment also occur. These roads are used primarily to access local residences and agricultural lands. Nebraska SH 2/71 is located about 4.5 miles (7.24 km) west of the MEA boundary. Noise from BNSF trains on the rail line and traffic noise from the roads would be intermittently audible to receptors within and in close proximity to the MEA.

Increased vehicle travel and the operation of construction equipment at the satellite facility during the construction phase of the project would result in a slight increase in noise impacts to residents who live close to the MEA. Potential noise impacts from construction equipment are expected to

occur primarily from operation of drilling rigs during wellfield development. Although noise levels associated with a typical water well drilling rig may reach or exceed 100 A-weighted decibels (dBA) within 2 meters (6.6 feet) of the rig compressor, noise levels decrease to less than 90 dBA within 6 meters (20 feet) (NRC 2009) and 55 dBA at 1,067 meters (3,500 feet) from the source (BLM 2005). Impacts to residences and other sensitive receptors 300 meters (984 feet) or more from the facility would be small (NRC 2009). One occupied residence, located within the MEA, is approximately 200 meters (656 feet) from the proposed wellfield in MU 4. Construction noise impacts at this residence would likely be moderate. All other residences near the MEA boundary are more than 300 meters from the proposed wellfield.

Construction activities would typically occur over an 8-hour work day, 5 days per week. Noise from construction would not be generated during nighttime hours. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise that is intermittently dominated by the BNSF railroad. Noise from construction and construction traffic would be temporary and would briefly add to existing noise levels.

7.2 Environmental Effects of Operations

The major environmental concerns during the operation of the satellite facility will be air quality effects, land use and water quality impacts, ecological impacts, and radiological impacts.

7.2.1 Air Quality Impacts of Operations

The primary new emission source of non-radiological pollutants will be tailpipe emissions of NO_x, CO, SO_2, non-methane-ethane VOCs, and PM_{10} resulting from vehicle traffic at the satellite facility. Approximately six to eight vehicle trips per day (VTPD) are anticipated as part of regular operations. These vehicles are expected to be light-duty pickup style trucks. Heavy equipment in the form of drill rigs, equipment haulers, or water trucks will be used as necessary and are anticipated to average less than one VTPD. These emissions are expected to be minor and should not affect the local ambient air quality.

The operation of the satellite facility will not result in major amounts of these non-radiological emissions and would therefore not be considered a major source of emissions under state permitting regulations, especially because the project will be located in a NAAQS attainment area for all criteria pollutants and there are no PSD issues (see discussions below). This statement would also apply to the construction activities, which pose higher impact risks than the operations phase (see discussions in Section 7.1.1). Other non-radiological emissions occurring during operations would be fugitive dust emissions generated by activities such as onsite traffic related to operations and maintenance, employee traffic to and from the site, resin transfers from the satellite facility to the main CPF, and heavy truck traffic delivering supplies to the site and product from the site. Dust emissions associated with the operational phase will be lower than those associated with the construction phase.

7.2.1.1 Particulate Emissions During Operations

The amount of dust generated during operations can be estimated from the following equation taken from "Supplement No. 8 for Compilation of Air Pollutant Emission Factors" (EPA 1978).

$$E = (0.81s) \times \frac{S}{30} \times \frac{365-w}{365}$$

Where:

E = emission factor, lb TSP per vehicle-mile
s = silt content of road surface material, 40%
S = average vehicle speed, 30 miles (48.3 km) per hour
w = mean number of days with 0.01 inches or more of rainfall, 85

Using the values stated above, the emission factor is equal to 0.25 lb TSP per vehicle-mile. The distance from the City of Crawford to the MEA satellite facility is approximately 25.3 miles (40.7 km) . Approximately 18.2 miles (29.3 km) of this distance is on improved roads and 7.1 miles (11.4 km) is on dirt or trail roads. CBR expects that most employees at the satellite facility will travel from the City of Crawford. Assuming ten employees and a 7-day workweek, there would be 70 round trips per week, and the weekly mileage on dirt or trail roads would be 994 miles (1.600 km). Deliveries and other travel may require up to 50 round trips per week, which would be an additional 710 miles (1,142 km) per week on dirt or trail roads.

The distance from the satellite facility to the CPF is approximately 30 miles (48.3 km) (via primary access route), of which approximately 11.6 miles (18.7 km) are on dirt or trail roads. Assuming two round trips per day for resin transfer and an additional ten round trips per day for facility personnel traveling between the sites, the total mileage on dirt or trail roads will be approximately 1,949 miles (3,137 km) per week. This estimate is based on a 7-day work week.

The total travel on dirt and trail roads for personnel, resin transfer, deliveries, and incidental travel will be approximately 3,653 miles (5,789 km) per week. With an emission factor of 0.25 lb TSP per vehicle-mile, there will be a total dust emission of approximately 23.7 tons per year as a result of increased traffic on dirt and trail roads.

Any increase in fugitive dust emissions resulting from operational activities within the MEA would be minimal. Mitigation measures such as the application of water or dust control chemicals to unpaved roads will be implemented as necessary.

7.2.1.2 Criteria Pollutant Regulatory Compliance Issues

The statements in this section apply to both construction and operations phase of the proposed satellite facility.

The NAAQS for PM_{10} are 150 micrograms per cubic meter ($\mu g/m^3$; 24-hour average), and 50 $\mu g/m^3$ (annual average). The NAAQS standards for other pollutants are presented in **Table 2.5-16**. All counties within the 50-mile (80-km) radius of the project are in attainment of NAAQS. Concentrations of the criteria pollutants from the operations will not be expected to exceed the regulated or "threshold" level for one or more of the NAAQS pollutants within the 50-mile (80-km) radius.

In addition to the NAAQS, there are national standards for the PSD of air quality (see discussions in Section 2.5.5.2). The PSD program is administered by the States of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with

the NAAQS and to prevent degradation of air quality in areas below the standard (designed as clean air areas). The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality. The maximum allowable increments applicable to Nebraska and South Dakota are shown in **Table 2.5-26.**

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e.; National Parks and Wilderness Areas) and allow less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. Class II areas are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The State of South Dakota has two Class I Areas: Badlands and Wind Cave National Parks. The Wind Caves National Park is the closer of the two to the MEA, at a distance of approximately 60 miles (96.6 km). Therefore, no impacts associated with PSD requirements would be expected based on the estimated amount of emissions from the MEA operations.

7.2.2 Land Use Impacts of Operations

The principal land uses for the MEA and the 2.25-mile (3.62-km) AOR is grazing livestock and raising of crops. Rangeland accounts for 82.6 percent of the land use in the MEA and surrounding 2.25-mile (3.62-km) AOR as discussed in Section 2.2. The secondary land use within the MEA license boundary is cropland, which accounted for 8.9 percent of the land use in the MEA and the AOR. Land use was discussed in detail in Section 2.2.

For the proposed disturbance of 591 acres for the proposed MUs, satellite facilities, eleven MUs, and roadways, cropland accounts for 71.7 acres or 12.2 percent of the 591-acre total area. Rangeland accounts for 491.2 acres or 82.0 percent of the total area. Rangeland rehabilitation (6.9 acres), structural biotope (8.9 acres), forest land (5.6 acres), and drainage (7.3 acres) are the only other impacted land uses. **Table 7.1-1** provides the acres disturbed by the MEA satellite facility, MUs, and access routes, and **Figure 2.2-1** shows the land use designations for the MEA AOR.

As a result of site preparation and construction, cattle production will be excluded from the areas that are under development. The total estimated area that will be impacted during the course of currently planned project is the 491.2 acres (mixed grass prairie and degraded rangeland) associated with the satellite facility, wellfield, and roads. As discussed in Section 2.2, livestock and livestock products carry a value of $55.62 per acre, indicating that livestock production on impacted rangeland within the MEA carries a potential value of approximately $27,320.

As a result of site preparation and construction, crop production will be excluded from the areas that are under development. The total estimated cropland area that will be impacted during the course of the project is 71.7 acres associated with the satellite facility, wellfield, and roads. As presented previously, non-livestock lands carry a value of $14.10 per acre. Based on this information, the lost production of crops would be valued at $1,011 per year.

Considering the relatively small size of the area impacted by operations, the exclusion of agricultural activities from this area over the course of the project operation will not significantly impact local or regional agricultural production. The limited impacts are considered temporary

and reversible by returning the land to its former grazing use through post-mining surface reclamation.

The current operations in the licensed area have shown that CBR can successfully restore the land surface following mining operations. Surface reclamation activities, including contouring and revegetation, have been performed routinely following initial MU construction. Additionally, CBR recently completed surface and subsurface reclamation of a significant portion of MU 1 following approval of groundwater restoration. These areas have been successfully recontoured, and revegetation has been completed in accordance with NDEQ requirements.

7.2.3 Geologic and Soil Impacts of Operations

7.2.3.1 Geologic Impacts of Operations

Geologic impacts are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the basal sandstone of the Chadron Formation will be on the order of 1 percent or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10 percent of the available head, or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient. No faults are present within the project area that would be subject to potential reactivation due to fluid injection.

Impacts to paleontological resources due to operations are expected to be minimal.

7.2.3.2 Soil Impacts of Operations

Operational impacts to soils are expected to be minor, and would only occur if BMPs and mitigation measures are not properly constructed, maintained, and monitored. Improper surfacing of access roads could lead to rutting and erosion. Off-road travel could lead to unforeseen vegetation removal, soil compaction, and localized soil loss due to wind and water erosion.

As during construction activities, release of hazardous materials to soils would lead to decreased soil productivity and an increase in soil loss due to erosion. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

7.2.4 Archeological Resources Impacts of Operations

ARCADIS (Graves et al. 2011) completed an intensive pedestrian block cultural resources inventory of approximately 4,500 acres for the MEA during the period from November 2010 to February 2011. The MEA was inventoried for the presence of historic properties (cultural resources that are listed or eligible for listing on the NRHP) and may be impacted by proposed mine development. This inventory recorded 15 newly discovered historic sites and five historic isolated finds and updated the documentation on two previously recorded historic farmstead sites. All of the newly recorded historic sites were recommended not eligible for the NRHP and do not qualify as historic properties. Isolated finds are by definition not eligible for the NRHP. Historic farmstead DWOO-242 is recommended not eligible for the NRHP, but appears to be currently or recently occupied. Site DWOO-243 may have the potential to yield information important in history and may be potentially eligible for the NRHP, but is not recommended eligible based on

the currently available information. Avoidance of these two sites by project actions is recommended. If these recommendations are followed, the proposed project will have no adverse effect on historic properties, and no further cultural resource investigations are recommended.

7.2.5 Groundwater Impacts of Operations

Potential impacts to water resources from mining and restoration activities include the following:

7.2.5.1 Groundwater Consumption

Groundwater impacts and consumption related to the satellite facility operation will be fully assessed in an Industrial Groundwater Permit application required by NDEQ. Information from the existing Groundwater Permit for the current license area indicates that the drawdown from mining operations in the basal sandstone of the Chadron Formation is minimal (e.g., on the order of 10 percent of the available head). Based on drawdown data from years of operation in the current license area, and on the formation characteristics from the MEA pumping test, the drawdown effect on the Chadron aquifer as a result of operations has been and is expected to remain minimal.

Groundwater consumption from the operation is expected to be on the order of 0.5 to 2.0 percent of the total mining flow (6,000 gpm). Consumptive volume (1,500 gpm) will increase during aquifer restoration, especially the groundwater sweep phase. However, it is expected that the net consumption for the entire operation will be on the order of 50 to 100 gpm.

7.2.5.2 Potential Declines in Groundwater Quality

Excursions represent a potential effect on the adjacent groundwater as a result of operations. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Movement of this water out of the wellfield into the monitor well ring results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, and hydrofracturing of the ore zone or surrounding units.

To date, there have been several confirmed horizontal excursions in the basal sandstone of the Chadron Formation in the current license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In the majority of the excursions, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent UCLs. In no case did the excursions threaten the water quality of an underground source of drinking water because the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table 7.2-1** summarizes the excursions reported for the current license area.

7.2.5.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as an uncontrolled release of process liquids due to a wellfield accident. If there should be a wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding

soil, could occur. Wellfield accidents could take the form of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

The satellite building will have curbing around the structure, and the six 30,000-gallon wastewater storage tanks will have diking to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation.

The DDW will receive wastewater from the wastewater surge/equalization tanks located at the satellite processing facility via an underground PVC/HDPE pipeline. Flow rates from the tankage, tank levels, and flow rates are all controlled and monitored to ensure any potential leakage is rapidly detected. All flows and pressures will have limits and alarms programmed in to alert the operator as limits are approached and to control feed pumps. The details of these systems will be addressed in the Class I permit application that will be submitted to the NDEQ as part of the required permitting process. CBR has successfully operated a Class I DDW for approximately 19 years without any significant spills or releases.

Another potential cause of groundwater impacts from accidents could be releases as a result of a spill of injection or production solutions from a wellfield building or associated piping. To control these types of releases, all piping is either PVC, HDPE with butt-welded joints, or equivalent. All piping is leak-tested prior to production flow and following repairs or maintenance.

7.2.6 Surface Water Impacts of Operations

7.2.6.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during ongoing wellfield construction related to operations is regulated by the NDEQ as discussed in Section 7.1.4.

7.2.6.2 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as failure or an uncontrolled release of process liquids due to a wellfield accident. Section 7.1.4 discussed the measures to prevent and control wellfield spills. Wellfield areas are installed with dikes or berms as an additional measure to protect surface water. The berms prevent surface spills from entering all surface water bodies and drainages that connect to surface water bodies and eliminate public dose and contaminant pathways to surface water.

The satellite building will have secondary containment (curbing around the structure, and the six 30,000-gallon wastewater storage tanks will have diking) to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation. In addition, there is a regular program of inspections and preventive maintenance.

7.2.7 Ecological Impacts of Operations

7.2.7.1 Impact Significance Criteria

The following impact significance criteria were used to determine the significance of construction and operation of the proposed project on wildlife and vegetation resources within the project area. These criteria were developed based on professional judgment, involvement in other NEPA projects throughout the West, and state and federal regulations:

- Removal of vegetation such that following reclamation, the disturbed area(s) would not have adequate cover (density) and species composition (diversity) to support pre-existing land uses, including wildlife habitat;
- Unauthorized discharge of dredged or fill materials into, or excavation of, waters of the U.S., including special aquatic sites, wetlands, and other areas subject to the Section 404 of the Clean Water Act, Executive Order 11988 - flood plains, and Executive Order 11990 - wetlands and riparian zones;
- Reclamation is not accomplished in compliance with Executive Order 13112 (Invasive Species);
- Introduction and establishment of noxious or other undesirable invasive, non-native plant species to the degree that such establishment results in listed invasive, non-native species occupying any undisturbed rangeland outside of established disturbance areas or hampers successful revegetation of desirable species in disturbed areas;
- A substantial increase in direct mortality of wildlife caused by road kills, harassment, or other causes;
- Incidental take of a special status species to the extent that such impact would threaten the viability of the local population;
- Elimination or permanent reduction in size of an officially designated critical wildlife habitat, or otherwise rendering such habitat unsuitable;
- Any effect, direct or indirect, resulting in a long-term decline in recruitment and/or survival of a wildlife population; and
- Construction disturbance during the avian breeding season or impacts to reproductive success which could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment, which would violate the regulations prescribed by the Migratory Bird Treaty Act (MBTA).

7.2.7.2 Vegetation

As described in detail in Section 3, a total of 11 mine units, satellite facility, and access roads will be constructed in 2014 with an expected mine life of operation of approximately 7 years. As shown on **Figure 2.8-1**, wellfield development will occur primarily in areas dominated by mixed-grass prairie and degraded rangeland vegetation.

Vegetation removal and soil handling associated with the construction and installation of the mine units, pipelines, access roads, and satellite facilities would affect vegetation resources both

directly and indirectly. Direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) due to soil disturbance and grading activities. Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition and/or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics.

The total number of acres currently identified as having the potential for disturbance within the 4,622.3-acre license area over the long-term operation of the project will be approximately 1,753 acres (**Table 7.1-1**). Initially, the construction of the satellite building(s)/associated facilities, MU No. 1 and needed roadways would have short-term surface disturbances of approximately 78 acres (approximately 2 percent of the total license boundary acreage). The production building and associated facilities would disturb an area of 1.8 acres (area within fence-line of production facilities). **Table 7.1-1** provides a breakdown of the area of disturbance by the type of habitat cover acreage.

Over the life of the project, it is currently estimated that 38 percent of the total license area acreage would be disturbed due to site development and operation. The likelihood of impact is greatest for the primary vegetation cover types of mixed-grass prairie (1,143 acres) and degraded rangeland (228 aces), which occupy approximately 78 percent of the total acreage with the potential for disturbance (1,753 acres). Mixed-grass prairie and degraded rangeland habitat cover (1,143 and 228 acres, respectively) account for 25 percent and 5 percent, respectively, of the total license acreage of 4,622.3 acres. There are no plans to disturb the deciduous streambank forest habitat cover type within the license boundary; other cover types would be subject to minor amounts of disturbance (**Table 7.1-1**).

The majority of new roads are located within the proposed wellfield. A new access road will serve as the entrance roadway to the satellite production facility and offices. Estimated acreage disturbance was based on a 25-foot wide entrance road and 12-foot wide MU roads. Road locations and distances can be seen on **Figure 4.2-1.**

The proposed DDW will be located to the northeast of the fenced-in area of the satellite facilities (**Figure 1.7-5**) located within mixed-grass prairie habitat consisting of an area of approximately 50 x 50 feet. Potential impacts from the DDW are considered minimal, which is based on the operating history of the DDW located at the current CBR operating facilities.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of invasive, non-native species within the MEA. Non-native species invasion and establishment as a result of previous and current disturbance has become an increasingly concern in western states. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the MEA has a relatively high level of noxious weeds and other unwanted invasive, non-native species in the areas adjacent to roads, but to a lesser degree in areas located farther from roads.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to pre-disturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to pre-disturbance conditions would be influenced by factors that are both climatic (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

Previously planted agricultural fields would be recontoured to approximate pre-existing contours and ripped to depths of 12 to 18 inches to relieve compaction. Mixed-grass prairie tracts disturbed by surface activities would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) complete cleanup of the disturbed areas (wellfield and access roads), (2) restoring the disturbed areas to the approximate ground contour that existed before construction, (3) replacing topsoil, if removed, over all disturbed areas, (4) ripping disturbed areas to a depth of 12 to 18 inches, and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

7.2.7.3 Surface Waters and Wetlands

Dooley Spring, Willow Creek, and other ephemeral features are the only potentially available surface waters within the MEA. These features lack defined banks and have no streambed. Generally, these features are dry and they would only be expected to carry water during exceptional precipitation events. Direct disturbance to these features would take place where they would be crossed by access roads. This would occur in several locations, including one location along the main access road to the satellite facility. Culverts will be installed below each road crossing to maintain natural flows. Therefore, there would not be any long-term direct impacts on the integrity of any of the drainages within the MEA.

The Niobrara River is a perennial stream located downstream of the MEA; this river could potentially be indirectly affected by changes in water quality or quantity. Water quantity would not be changed by the proposed project. Hydrologic analysis completed for this project indicates that the MEA generally carries a low potential for erosion (and therefore a low potential for sediment delivery to the Niobrara River). However, there are some small, localized areas within the MEA that carry a moderate to high erosion potential. If wells cannot be placed outside of areas within the wellfield deemed to carry moderate to high erosion risks, mitigation measures (e.g., berms) will be implemented to minimize the potential for flooding and erosion. The mitigation measures will be defined during final engineering and prior to any construction. As a result of these mitigation measures, sediment delivery to the Niobrara River will be negligible.

One wetland site was identified by HWA (2011) within the MEA. This wetland is located outside of the area proposed for disturbance. Therefore, no direct impacts to wetlands are anticipated. Also, for the reasons mentioned above, the potential for sedimentation of wetlands within and near the MEA is anticipated to be minimal due to mitigation measures that would be implemented to reduce erosion risk.

7.2.7.4 Wildlife and Fisheries

The effects on wildlife would be associated with construction and operation of project facilities, which include displacement of individuals of some wildlife species, loss of wildlife habitats, and

an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for poaching, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

7.2.7.5 Big Game Mammals

The principal wildlife impacts likely to be associated within the proposed project include: (1) a direct loss of elk, deer, and pronghorn habitat; (2) the displacement of these big game species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and (4) an increase in the potential for poaching and harassment of wildlife.

Direct removal of habitat used by big game mammals would include 1,143 acres of mixed-grass prairie. Small amounts of drainage (31.2 acres), mixed conifer (194.6 acres), and range rehabilitation (7.1 acres) cover types would also be removed. Because mixed-grass prairie would be the primary vegetation type affected, the proposed project would be more likely to affect big game species that primarily inhabit grassland vegetation (e.g., pronghorn) than big game species that primarily inhabit shrubland, forested, or riparian areas (e.g., elk, deer). The amount of habitat disturbed would decline over time as construction areas not needed for the production phase were reclaimed to their pre-existing contours and vegetation type. Overall, direct loss of habitat would have a minor, short- to long-term impact on big game species using the MEA.

In addition to the direct removal of habitat due to the development of wells and associated satellite facilities, disturbances from drilling activities and traffic would affect wildlife use of the habitat immediately adjacent to these areas. Big game habitat would effectively be reduced by an amount greater than the disturbance footprint acreage, because big game would avoid a wider area than just the infrastructure itself. Big game mammals may adjust their ranges or seasonal migration routes slightly to avoid the new source of disturbance on the landscape. This could result in reduced herd productivity if animals have to expend more energy to travel between seasonal ranges or if adjacent habitats are not of a similar or higher quality to the habitats lost or cannot absorb the additional individuals. If avoidance responses extend out to 0.5 mile (0.8 km) beyond the MEA, this would equate to 1.8 percent of the overlapping elk herd unit, 0.5 percent of the overlapping deer herd unit, and 0.5 percent of the overlapping pronghorn herd unit being affected by the proposed project.

However, big game mammals are adaptable and may adjust over time to non-threatening, predictable human activity. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and (2) the extent of the most intensive activities such as drilling and road building diminishes and the well fields are put into production. By the time the mine units are under full production, construction activities will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact over the long term would be minimal and it is unlikely that big game mammals would be permanently displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available. Forage would be restored once disturbed areas were reclaimed.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue

(although at a reduced rate) throughout all phases of the wellfield operations. To minimize the potential for wildlife collisions, drivers would be required to follow posted speed limits. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals. Vehicle collision impacts and poaching of big game mammals are anticipated to occur infrequently, and no long-term adverse effects on populations are expected.

Based on the foregoing, long-term adverse effects are not expected on any local big game mammal populations.

7.2.7.6 Carnivores and Small Mammals

The direct disturbance of wildlife habitat in the MEA likely would reduce the availability and effectiveness of habitat for a variety of common small mammals and their predators. The initial phases of surface disturbance and noise would result in some direct mortality to small mammals and avoidance of the area by carnivore species that are more sensitive to human disturbance. In addition, a slight increase in mortality from increased vehicle use of roads in the area would be expected.

Carnivores and small mammals inhabiting the mixed-grass prairie and degraded rangeland vegetation types would be more affected by direct habitat loss than carnivores and small mammals inhabiting other vegetation types in the MEA. The temporary disturbances that occur during the construction period would tend to favor generalist wildlife species that are relatively tolerant of human activity, such as ground squirrels and striped skunks, and would have more impact on species that are relatively sensitive to human activity, such as mountain lions. Because of the high reproductive potential of small mammals, they would rapidly repopulate reclaimed areas as habitats become suitable. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated. No black-tailed prairie dog colonies are located within or near the proposed disturbance area, so there would not be any impacts on this species.

Bats have a lower reproductive potential than other small mammals, so the removal of bat roost sites, maternity colonies, or hibernacula could have an adverse effect on local bat populations. However, the majority of habitat that would be affected by the proposed project is open, mixed-grass prairie, which is not generally suitable for bat roosting. There would be only 194.6 acres of impact to any forested habitat (mixed conifer), and no deciduous streambank forest (the most likely bat roosting habitat in the MEA) would be affected.

7.2.7.7 Passerines and Upland Game Birds

Impacts to passerines would include short- and long-term habitat loss, primarily for birds using mixed-grass prairie habitat, and an effective loss of habitat extending beyond the disturbed areas if birds avoid the project facilities due to noise or activity. These effects are likely to attenuate with time as construction areas are reclaimed to the original habitat and as human activity decreases after the construction period ends. Generalist species that are more tolerant of human activity (e.g., mourning doves) are likely to be least affected by the proposed project, while

specialist species that are more sensitive (e.g., grasshopper sparrows) may be affected more. Overall, given the reclamation practices that would be put into place, the minimal long-term surface footprint of the project, and the measures that would be taken to avoid impacting nesting birds, impacts on passerines are anticipated to be minor and not significant at the population level for any species.

The potential effects of the operation and maintenance of project facilities on upland game birds may include direct mortality of eggs or nestlings (if construction were to take place during the nesting season), habitat loss, and nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Other potential effects on upland game birds involve increased public access and subsequent human disturbance that could result from new construction and production activities. These effects will attenuate with time as areas no longer needed for the project are reclaimed and human activity decreases after the construction phase.

No sharp-tailed grouse leks are known to occur within the project area. However, noise related to drilling and production activities may affect sharp-tailed grouse use of leks and/or reproductive success. Reduction of noise levels in areas near leks would minimize this potential impact. If leks are found, surface disturbance will be avoided within 0.25 mile (0.4 km) of leks. If disturbance activities within the 0.25-mile (0.4 km) lek buffer areas are avoided, no impacts are expected. Areas with large tracts of mixed-grass prairie would provide the best quality nesting habitat, 1,143 acres of which would be directly affected by the proposed project. Some of this area would be reclaimed once no longer needed for the production phase. To protect sharp-tailed grouse nesting habitats, construction activities will be limited within a one-mile (1.6-km) radius of an active lek between March 1 and June 30. Significant impacts to leks and subsequent reproductive success are not expected if these guidelines are implemented.

7.2.7.8 Raptors

As noted in Section 2.8.7.3, seven raptor nests were observed within the MEA boundary during the 2011 field survey. The potential impacts to raptors within the MEA include: (1) direct loss of nesting habitat; (2) disturbance to nesting raptors from noise and activity and reduction in nest productivity; (3) temporary reductions in prey populations; and (4) mortality associated with roads.

The proposed project would result in the loss of 1,337 acres of potential raptor nesting habitat in the MEA over the life of the project, which includes mixed-grass prairie and mixed conifer vegetation types. Over time, some of this habitat would be restored through reclamation of areas no longer needed for production. Overall, long-term habitat losses would be minor. The development of wellfield pads and satellite facilities would disturb an estimated 1,143 acres of mixed-grass prairie, a potential habitat for several species of small mammals that serve as prey items for raptors. This impact would affect approximately 8 percent of the total project area, although this is not likely to be a limiting factor of raptor use within this area. The small amount of short-term change in prey base populations created by the construction activities is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals comparable to those of undisturbed

areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the MEA.

There will be no new public roads constructed. However, there will be increased traffic due to site operations on current county roads. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure to public vehicle use for roads located near active raptor nests would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles where they are in danger of being struck and killed. The potential for such collisions would be reduced by requiring drivers to follow all posted speed limits.

7.2.7.9 Reptiles and Amphibians

The primary impacts on reptiles and amphibians would include 1) direct mortality of individuals during the construction period; 2) ongoing mortality of individuals from increased vehicle traffic; 3) short- and long-term loss of terrestrial habitats; 4) changes in water quality in aquatic habitats.

The proposed project has the potential to result in the direct mortality of individual reptiles and amphibians that use terrestrial habitats where construction will take place. Quantifying these changes is not possible because population data are lacking; however, once construction was completed and human activity greatly reduced, the potential for direct mortality would decrease significantly. Mortality could also result from increased vehicle traffic on project roads. This would be a long-term affect but is not likely to result in population-level changes to any amphibian or reptile species.

There would be 1,143 acres of habitat loss for amphibians and reptiles that use native grassland habitats, and 194.6 acres of habitat loss for amphibians and reptiles that use coniferous habitats. Reptiles and amphibians may also use degraded rangeland, drainages, and range rehabilitation habitats in the MEA, of which 228 acres, 31.2 acres, and 7.1 acres would lost, respectively. Some of the construction areas would be reclaimed when no longer needed and could then be re-populated by reptiles and amphibians. Long-term loss of both terrestrial and aquatic habitats would be minimal overall. As described in Section 7.2.7.3, mitigation measures would be used to minimize impacts on surface waters that may be used by reptiles and amphibians, and there would be no direct loss of wetland habitats that could serve as amphibian breeding sites.

7.2.7.10 Fish and Macroinvertebrates

Suitable habitat for fish and macroinvertebrates exists within the Niobrara River and its tributaries. Fish and macroinvertebrates in the Niobrara River could be affected by reductions in water quality as a result of upstream activities. Construction activities could result in runoff carrying sediment into surface waters downstream of the MEA. As discussed in Section 7.2.7.3, the potential for this to occur is low, given the low erosion potential of most the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

7.2.7.11 Threatened and Endangered Species

<u>Black-footed Ferret</u>

Because there are no known black-footed ferret populations in Nebraska, impacts to this species are highly unlikely. Also, there is no suitable habitat for this species (black-tailed prairie dog colonies) within the proposed disturbance area.

Whooping Crane

No impacts to whooping cranes are anticipated to occur as a result of the proposed project, because suitable migration stopover habitat is not present within the MEA.

Gray Wolf

Gray wolves are highly unlikely to occur in the MEA; therefore, impacts on this species would be highly unlikely. If dispersing gray wolves were to pass through the vicinity, these individuals would likely avoid the area due to anthropogenic noise and activity.

Swift Fox

Because swift fox are known to occur within the region, and suitable mixed-grass prairie habitat occurs throughout the MEA, potential impacts to this species may result from project implementation. Construction activities within these mixed-grass prairie habitats could affect potential swift fox denning and foraging habitats. Destruction of swift fox dens could result in direct mortality of adults or pups. If swift fox are denning in the immediate vicinity of a planned project facility, construction activities may displace adults away from the den, at least during daytime periods of construction. Displacement could prevent the adults from securing adequate food for pups or prevent adults for adequately caring for their young. In addition, vehicular traffic associated with the construction and operation of project facilities could result in vehicle collisions resulting in direct mortality.

Because the potential for the mortality and/or displacement of swift fox from construction and operational activities exists within mixed-grass prairie, mitigation measures will be implemented to avoid and/or reduce such incidents. Prior to beginning construction activities in suitable swift fox habitat, CBR will have qualified biologists perform surveys for swift fox dens, and avoidance measures will be implemented to protect any dens that are located. Surveys will be conducted that are consistent with the NGPC standard protocol included in the CBR Mineral Exploration Permit Number NE0210824 as Attachment 1, issued by the NDEQ on August 19, 2009. The procedures in Attachment 1 are specific to drilling of boreholes; therefore, these procedures have been expanded to include Marsland project development activities (e.g., construction, operational activities [e.g., wellfield development, satellite facility facilities, and access roadways] and decommissioning). The modified survey protocol to be used for the swift fox in the MEA is presented in **Appendix O** of Volume II of this application.

Based upon the analysis of the effects of project implementation and the current and potential status of this species in the MEA, it is concluded that the proposed project and planned mitigation measures will result in no adverse population-level effects on the swift fox.

Fish

Three state-listed fish species (the blacknose shiner, northern redbelly dace, and finescale dace) may occur downstream of the MEA and therefore may be affected by the proposed project. No direct effects to these species are anticipated because they do not occur within the MEA.

However, indirect effects may include changes in water quality of the Niobrara River associated with upstream activities. As discussed in Section 7.2.7.3, the potential for sediment delivery to the Niobrara River is low given the low erosion potential of most of the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

7.2.7.12 Cumulative Impacts

Significant cumulative impacts to ecological resources are not anticipated, as no substantive impairment of ecological stability or diminishment of biological diversity within the MEA is expected to occur as a result of the proposed project. The project would add to the effects of other past, present, and future activities occurring in the region, including the effects of other past, present, and future uranium mining operations. When combined with these other activities, the MEA would have minor cumulative effects on ecological resources. The most substantial of these effects would be the loss of 1,143 acres of mixed-grass prairie habitat. However, because the overall long-term surface footprint of the project would minimal, and much of the area proposed for disturbance during the construction phase would be promptly reclaimed to the pre-existing contour and cover type, long-term loss of mixed-grass prairie habitat would have a minor impact on regional ecological resources. Similarly, disturbance to wildlife from noise and activity would initially have a minor cumulative impact on the region's wildlife. This impact would diminish over time as human presence decreases after the construction phase is completed.

7.2.8 Noise Impacts of Operations

Noise sources during operation are expected to increase due to increased vehicle travel and increased numbers of employees traveling to and from the City of Crawford for work and from resin transfer to the CPF. Train usage would not increase as a result of operation. Processing equipment at the MEA would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are expected to be lower than noise levels generated during construction. Therefore, it is expected that noise levels during operation would be barely perceptible over the existing ambient noise that is dominated by the BNSF railroad.

7.3 Radiological Effects

An assessment of the radiological effects of the satellite facility must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The satellite facility will have a production flow capacity of approximately 6,000 gpm and will use fixed-bed downflow IX columns to separate uranium from the pregnant production fluid. The facility will also have a capacity to treat 1,500 gpm of restoration solution. The restoration process will use fixed-bed downflow IX columns to remove the uranium and RO to remove the dissolved solids. Waste disposal at the satellite facility will be via a deep injection well which will receive wastewater from six 30,000-gallon surge/equalization storage tanks. The satellite facility will not have any precipitation equipment. The loaded IX resin will be transferred from the columns to a resin trailer for transport to the CPF for regeneration and stripping. The reclaimed resin will be transported back to the satellite facility and reused in IX columns.

The uranium-bearing regenerant at the CPF is treated in the uranium precipitation circuit. The precipitated uranium is vacuum dried.

The primary airborne radiological emission from the facility will be radon-222 gas (radon). Radon is present in the ore body and is formed from the decay of radium-226. Radon is dissolved in the lixiviant as it travels through the ore body to a production well, where the solution is brought to the surface. The concentration of radon in the production solution is calculated using methods found in RG 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (March 1987). The details of this calculation are found in **Appendix N.**

MILDOS-AREA was used to model radiological impacts on human and environmental receptors (e.g., air and soil) using site-specific radon release estimates, meteorological and population data, and other parameters (Savignac 2011a).

the following sections briefly discuss the assumptions and methods used to estimate the potential radiological impacts of the satellite facility coupled with the CPF. A detailed presentation of the source term and other MILDOS-AREA parameters is included in **Appendix M-1**. The anticipated effects are compared to the naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon gas, comprises the primary radiological impact to the environment in the region surrounding the proposed project.

7.3.1 Exposure Pathways

The proposed satellite is an *in-situ* uranium recovery facility. The only source of planned radioactive emissions from the facility is radon gas, which dissolves in the leaching solution. Radon gas may be released as the solution is brought to the surface and processed in the satellite facility. Unplanned emissions from the site are possible as a result of accidents and engineered structure failure, but are not addressed in the MILDOS-AREA modeling. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented in **Figure 7.3-1.**

The satellite facility will have pressurized downflow IX columns capable of processing 6,000 gpm of production solution. The satellite facility will also have IX and RO equipment with a capacity of 1,500 gpm to process restoration solutions.

Within the pressurized columns, the radon will remain in solution and will be returned to the formation. It will not be released to the atmosphere. There will be minor releases of radon during the air blowdown prior to resin transfer. The air blowdown and the gas released from the vent during column filling will be vented into the exhaust manifold and discharged via the main radon exhaust stack. It is estimated that less than 10 percent of the radon contained in the process solutions will be vented to atmosphere.

In the source term calculation, Cameco estimates that in the absence of evaporation ponds, 25 percent of the contained radon found in the 6,000 gpm flow processed by pressurized downflow IX columns will be released to the environment

After the IX resin is loaded, it will be transferred to a resin trailer. The trailer will transfer the resin to the CPF for additional processing. The stripped and regenerated resin will be transferred

to the trailer, returned to the satellite facility, and transferred into a process column. It is anticipated that two round trips will occur per day.

The injection wells will generally be closed and pressurized, but periodically vented. It is estimated that 25 percent of the radon produced in the production fluids will be released in the wellfield. A sensitivity analysis demonstrated that radiation doses using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite facility did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively (Savignac 2011a). See discussions in Section 7.3.3.3 and **Appendix M-1**.

Atmospheric emissions of radon will lend its presence to all quadrants of the area surrounding the MEA and the CPF. Radon itself impacts human health or the environment marginally, because it is an inert noble gas. Radon has a relatively short half-life (3.8 days), and its decay products are short-lived, alpha emitting, non-gaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. **Figure 7.3-1** shows that all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radon were evaluated using MILDOS-AREA (Savignac 2011a).

7.3.2 Exposures from Water Pathways

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The satellite facility will not have evaporation ponds to store waste solutions, thereby eliminating the potential of releases and exposures via water pathways. In lieu of evaporation ponds, the facility will employ six 30,000-gallon storage tanks for the temporary storage of process wastewater. The storage tanks will be located within spill containment dikes in order to control any spills or releases from the storage tanks.

The wastewater surge/equalization tanks will discharge to a DDW, which will be the primary method of waste disposal at the satellite facility. The deep well will be completed at a depth of approximately 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,500 ft of Pierre Shale. The well will be constructed under a permit from the NDEQ and meet all requirements of the UIC program.

The satellite facility processing building will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and will be pumped to the ponds. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures.

Because no routine liquid discharges of process water are expected, there are no definable water-related pathways.

7.3.3 Exposures from Air Pathways

The only source of radionuclide emissions is radon released into the atmosphere through a vent system or from the wellfield. As shown on **Figure 7.3-1**, atmospheric releases of radon can result in radiation exposure via three pathways: inhalation, ingestion, and external exposure.

Radiation dose rates were determined using the NRC computer code MILDOS for the proposed MEA project (Savignac 2011a). The objective of this evaluation was to:

- Determine the radiation doses to members of the public within a 50-mile (80-km) radius of the MEA using the NRC computer code MILDOS.
- Determine the potential annual dose rate to workers on the site.
- Determine the sensitivity of the MILDOS estimates of radiation dose.

This section summarizes the major findings of the MILDOS evaluation. For more detailed information on assumptions, inputs, outputs, and other elements of the model, the MILDOS report is provided in **Appendix M-1**.

For comparison, naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mRem/yr.

7.3.3.1 MILDOS Output – Radiation Dose Rates

Table 7.3-1 presents the dose rates calculated for the major cities and towns within a 50-mile (80-km) radius of the MEA; eight residences; two unoccupied structures; and for the north, south, east, and west property boundaries. Locations of these receptors are shown on **Figures 7.3-2** and **7.3-3.** The dose rates were calculated using the MEA onsite meteorological data and using an operating purge rate of 44 gpm (to account for the absence of evaporation ponds) for the closed-pressurized uranium extraction circuit used at the MEA site.

Because radon is released from both the mine units wellhouses and from the satellite plant, the doses were proportioned 25 percent from the mine units and 75 percent from the satellite. **Table 7.3-1** presents the total dose from the satellite facility, MEA MUs 1 through 5 and A through F under typical operating conditions from both sources of radon. Conclusions from those dose rates are as follows:

- All dose rates to the public at the property boundaries, the cities and towns within a 50-mile (80-km) radius from the MEA, and at the nearest residence were below the 100 mRem/yr limit specified in 10 CFR 20 (TEDE).
- The highest MEA boundary dose rate was 80 mRem/yr at the south property boundary.
- The highest residential dose rate was 21 mRem/yr at residence 2.
- The highest dose rate at cities and towns within a 50-mile (80-km) radius from the MEA was 0.9 mRem/yr at the town of Hemingford and Marsland.
- The 10 CFR 190 dose rate was 0 mRem/yr which was below the 10 mRem/yr dose limit for emissions that exclude radon and its progeny.
- The population effective dose rate within a 50-mile (80-km) radius from the MEA Project was 1.6 person-Rem/yr and 0 person-Rem/yr beyond 50 miles (80 km).

For comparison naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mRem/yr.

The radiation doses from the production wells and from the wells in restoration are identical. The doses from the new wells are all zero. See **Appendix M-1** for production well doses, restoration well doses, and new well doses. The doses presented in these appendices have not been proportioned between the mine unit emissions and the satellite stack emissions.

7.3.3.2 MILDOS Output – Public and Occupational Radiation Dose Rates

Dose rates for the public apply to delivery personnel, regulatory inspectors, visitors, or other personnel that may spend 10 hours per month on site. Occupational dose rates apply to personnel that may spend an estimated 1,500 hours per year working on site such as company employees or contractors. For example, a water sampling technician who works an estimated 5 days per week, 6 hours per day, 50 weeks per year near the fine fields or satellite plant would spend 1,500 hours on site each year.

Table 7.3.2 shows the MEA public and occupational dose rates. For typical operating conditions, the maximum dose rate to the public was 3 mRem/yr with an average of 2 mRem/yr, and the maximum occupational dose rate to employees and contractors was 35 mRem/yr with an average of 19 mRem/yr.

7.3.3.3 Radon Release Points

The radiation dose rates from typical operations used the following:

- 25 percent radon released from the MU wellhouse
- 75 percent radon released from the satellite plant vent stack

That distribution has been used historically in MILDOS assessments. For comparison, dose rates were calculated using:

- 10 percent radon released from the MU wellhead houses.
- 90 percent radon released from the satellite plant vent stack.

The dose rates from both distributions are presented in **Table 7.3-3**. A comparison of the 25 percent/75 percent distribution of radon in column 2 with the 10 percent/90 percent distribution of radon release in column 3 shows that the averages and standard distributions are nearly identical. That similarity suggests that, within the range of values selected for the radon distribution between releases at the mine units and releases at the satellite plant, the distribution is not important to assessing the doses to people around the MEA site.

A MILDOS sensitivity analysis was conducted. Such an analysis identifies how input parameters affect the calculated radiation dose. Input parameters and variables are discussed in **Appendix M-1.**

The sensitivity analysis demonstrated that:

- When assuming an unrealistic upper bound process purge rate of 222 gpm, neither the occupational or public dose rates exceeded 100 mRem/yr.

- Radiation doses calculated using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite plant did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively.
- Assuming an unrealistic upper bound purge rate, the maximum dose to the public on site 10 hours/month is 3 mRem/yr.
- Assuming an unrealistic upper bound purge rate, the maximum occupational dose rate to employees and contractors on site 1,500 hours/yr is 35 mRem/yr.
- A sensitivity analysis was to identify how input parameters affect the calculated radiation dose.

7.3.4 Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions and accidental spills of radiological containing fluids (e.g., lixiviant).

7.3.4.1 Radon Releases

Radon emissions at satellite uranium *in-situ* facilities such as the proposed satellite facility (i.e., no yellowcake dryer and associated facilities) are considered the primary air contaminant during operations. Radon emissions during normal operations are considered the most important pathway for exposure to flora and fauna due to deposition of radon-222 decay products on surface water, surface soils, and vegetation. The MILDOS-AREA model provides an estimate of surface deposition rate as a function of distance from the source for the radon-222 decay products and calculates surface concentrations.

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987 (Ferret Exploration Company of Nebraska 1987), and the doses were found to be negligible. Based on this evaluation, the proposed MEA, TCEA, and NTEA projects are not expected to have a measurable impact on dose to flora and fauna.

The potential exists for individual mobile fauna (e.g., small mammals and birds) to have contact with higher but short-term contact with concentrations of radon-222 than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that exposure to individuals would be intermittent, as opposed to a constant concentration for the entire year.

There are currently no regulatory dosimetric standards for the protection of flora and fauna, with radiological protection frameworks being traditionally focused on the protection of man. Historically, the International Commission on Radiological Protection (ICRP) has maintained a position towards human health versus non-human species that protection of humans from radiation exposure implicitly ensures an adequate protection of other living organisms and, therefore, the environment (Brechignac 2009 [ICRP 1977 and 1991]). However, the development of a system capable of ensuring adequate protection of the environment against the harmful effects of ionizing radiation is currently being debated (Brechignac 2002). The ICRP has issued a draft report for public comment primarily documenting methods that allow prediction of known concentrations of radionuclides within an organism's habitat (ICRP 2010). This work is still underway.

7.3.4.2 Fluid Discharges

There are currently no planned discharges from the satellite facility, with wastewaters being discharged to a Class I DDW. Therefore, any fluid discharges would be associated with spills (e.g., pipeline break or leak). Spills of this type would be expected to occur within the restricted wellfield areas and between the wellfield and satellite process facility. The satellite processing building, fuel tanks, and chemical tanks would be constructed on pads engineered to contain any spill from a pipe rupture, leaking vessel, or inadvertent spill. Therefore, it is unlikely that any spills in the processing area would reach soils and vegetation. CBR operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to any spill, which would result in cleanup of the spilled material and, if applicable, removal of any contaminated soil and vegetation.

Long-term experience at CBR has shown that single-event spills typically do not cause significant contamination of soil and vegetation.

There is limited potential for wildlife or domestic animals to consume contaminated vegetation or seeds. Other than the potential for accidental spills discussed above, which would be immediately assessed and cleaned up, the satellite facility would not be expected to significantly impact food sources such as vegetation and seeds that local animals depend upon.

7.4 Non-Radiological Effects

Non-radiological effects of site preparation and construction activities are discussed in Section 7.1, including impacts on air quality, land use, surface water, population, social and economic, and noise impacts. Impacts on operational activities are discussed in Section 7.2, including air quality, land use, soil, groundwater, surface water, ecology, and noise impacts.

As discussed in Sections 7.1 and 7.2, overall emissions associated with equipment and facility operations during site preparation, construction and operations would be expected to be minimal and should not affect the local ambient air quality. Non-radiological emissions include NO_x, CO, SO_2, VOC, and particulate matter (operating equipment and fugitive dust due to traffic on unpaved areas). During operations, a gaseous and airborne effluent will consist of air ventilated from the process building ventilation system and from process vessels and tanks. This gaseous effluent would primarily contain radon gas as previously discussed in Sections 4 and 7.3. The gaseous and airborne effluent will not contain any significant non-radiological emissions.

In addition to gaseous and airborne effluents, three types of wastes would be generated at the proposed satellite facility: liquid, solid, and sanitary. The operational-generated liquid wastes would be disposed of through a DDW. Such liquid wastes would consist of: wellfield bleed streams, facility washdown water, groundwater restoration water, laboratory wastewaters, liquids resulting from rainwater/snow fall, and spills within the curbed process areas. Accumulations of rainfall/snowmelt and any spills within the curbed bulk chemical, lubricant storage facility, and the fuel diked area will be removed and disposed of per the site SPCC Plan. Well development water in the wellfield will be collected in dedicated tanker trucks and transported to the main satellite processing facility for disposal in the DDW.

The proposed satellite facility will not use evaporation ponds; therefore, there would be no discharge from these ponds. In lieu of evaporation ponds, CBR will employ six 30,000-gallon

storage tanks for the temporary storage of process wastewater prior to discharge to the DDW. These tanks will be enclosed and emissions controlled through tank vents located on top of the storage tanks.

The DDW will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by the NDEQ. There are currently two DDWs in operation at the CPF. The Class I UIC Permits for these two disposal wells located at the CPF implement injection limits and require monthly monitoring for RCRA metals to ensure that hazardous waste is not injected. Based on the monitoring for the current CPF DDW, there is no non-radiological impact expected due to the liquid effluents from the satellite facility.

Solid wastes generated would consist of waste such as spent resin, resin fines, filters, miscellaneous pipe and fittings, and domestic waste. These wastes are classified as contaminated or non-contaminated waste according to radiological survey results. Byproduct waste that cannot be decontaminated is packaged and stored until it can be shipped to a licensed waste disposal site or licensed mill tailings facility. Non-contaminated solid waste is collected regularly on the site and disposed of in a sanitary landfill permitted by the NDEQ. The CBR estimate of annual quantities of non-contaminated generated solid waste for the Marsland site is presented in Section 4.2.2.1. No significant non-radiological impacts associated with management of relatively small quantities of solid wastes would be expected.

The MEA is expected to only generate a small amount of hazardous waste and is expected to be classified as a Conditionally Exempt Small Quantity Generator. The potential for any adverse impacts due to the handling and disposal of hazardous waste would be minimal due to the small quantities handled and operational procedures in the SHEQMS Volume VI, Environmental Manual. The SHEQMS is reviewed annually and the sections updated as required.

Sanitary liquid waste will be disposed of in an onsite wastewater treatment system (i.e., septic) permitted by the NDEQ under the Class V UIC Regulations. Septic tank solids will be periodically removed by companies or individuals licensed for such activities by the State of Nebraska. There have been no problems associated with operating a similar sanitary system at the CPF, and no problems would be expected for the satellite facility.

For any spill, the free liquids would be recovered and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated. Spills are also discussed in Section 4.2.1.3.

In summary, the design and construction of the satellite facility will concentrate on minimizing the potential for releases of non-radiological waste materials. For example, CBR would use diking or flow cut-off and flow isolation procedures for radiological and non-radiological spill control. A QA/QC system will be used, which would involve pre-operational testing of equipment, periodic testing and regular inspection of equipment (e.g., pipelines, manifolds), and associated monitoring on line flows and pressures with automatic shutdowns in response to flow or pressure changes. Consequently, any spills should be small with little impacts on the environment. For any spill, the free liquids would be recovered and disposed of in the DDW and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated.

7.5 Effects of Accidents

Accidents involving human safety associated with the *in-situ* uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. *In-situ* mining provides a higher level of safety for personnel and neighboring communities compared to conventional mining methods or other energy-related industries. Accidents that may occur would be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur would be easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

NRC has previously evaluated the effects of accidents at uranium milling facilities in NUREG–0706 and specifically at uranium ISR facilities in NUREG/CR-6733 (NRC 1980a, CNWRA 2001). These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures are followed and properly trained personnel are employed. The CBR emergency management procedures contained in the CBR SHEQMS Volume VIII, Emergency Manual, have been developed to implement the recommendations contained in the NRC analyses. Training programs contained in the CBR SHEQMS Volume VII, Training Manual, have been developed to ensure that CBR personnel have been adequately trained to respond to all potential emergencies. The CBR SHEQMS Volume II, Management Procedures, requires periodic testing of emergency procedures and training by conducting drills.

NUREG-0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG-0706 are applicable to ISR facilities, such as transportation accidents; however, many of the analyses do not apply due to the significantly different mining and processing methods. ISR facilities do not handle large quantities of radioactive materials, such as crushed ore and tailings, so the quantity of material that could be affected by an incident is significantly lower than at a mill site.

NUREG/CR-6733 specifically addressed risks at ISR facilities and identified the following "risk insights".

7.5.1 Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. The use of hazardous chemicals at CBR is regulated by the OSHA. CBR is subject to the Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119.

Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none will be used at the satellite facility. The satellite facility will use O_2, CO_2, and $NaHCO_3$ for addition to the injection solution. Na_2S may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the CPF.

Crow Butte construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

7.5.1.1 O_2

O_2 presents a substantial fire and explosion hazard. The O_2 storage facility is typically designed and installed by the O_2 supplier and meets applicable industry standards. As currently practiced at the CPF, CBR will install wellfield O_2 distribution systems at the Marsland site. Combustibles, such as oil and grease, will burn in O_2 if ignited. CBR ensures that all O_2 service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1 (CGA 1996). Construction of O_2 systems in the wellfield is addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill or fire involving O_2 systems are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.1.2 CO_2

The primary hazard associated with the use of CO_2 is concentration in confined spaces, presenting an asphyxiation hazard. Bulk CO_2 facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and CO_2 monitoring at low points is currently performed at the CPF to protect workers from undetected leaks of CO_2. Operation of CO_2 systems is currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a leak involving CO_2 are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.1.3 $NaHCO_3$

$NaCO_3$ is primarily an inhalation hazard. CBR typically uses soda ash and CO_2 to prepare $NaCO_3$ for injection in the wellfield. Soda ash storage and handling systems are designed to industry standards to control the discharge of dry material. Operation of $NaCO_3$ systems is currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill involving $NaCO_3$ or soda ash are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.2 Radiological Risk

7.5.2.1 Tank Failure

A spill of the materials contained in the process tanks at the satellite facility will present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the processing building. O_2, H_2O_2, CO_2, propane, and fuel will be stored in outside storage tanks. The tanks at the satellite facility will contain injection and production solutions and IX resin. Elution, precipitation, and drying will be performed at the CPF. The satellite facility will be designed to control and confine liquid spills from tanks should they occur. The facility building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump system will direct any spilled solutions back into the facility process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for process vessels located outside the satellite building.

All tanks will be constructed of fiberglass or steel. Instantaneous failure of a tank is unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

7.5.2.2 Facility Pipe Failure

The rupture of a pipeline within the satellite processing area would easily visible and could be repaired quickly. Spilled solution will be contained and removed in the same fashion as for a tank failure.

Response procedures for the radiological risk from releases are currently contained in the SHEQMS Volume VIII, Emergency Manual. These procedures also provide instructions for emergency notification including notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

7.5.3 Groundwater Contamination Risk

7.5.3.1 Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the exempted portion of the ore-body aquifer. A vertical excursion is a movement of ISR fluids into overlying or underlying aquifers.

CBR controls lateral movement of lixiviant by maintaining wellfield production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution is either recycled in the processing facility or is sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the MU, the wellfield is said to be balanced.

CBR monitors for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. The current NRC License and NDEQ Class III UIC Permit require that Chadron aquifer monitor wells be located no more than 300 feet from the nearest mineral production wells and no more than 400 feet from each other. These spacing requirements have proven effective for monitoring horizontal excursions CBR and will be employed at the satellite facility or as otherwise provided in the final permit. Monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility. The program was discussed in detail in Section 5.7.8.

Section 7.2.5.2 provided a discussion of horizontal excursions reported at the current Crow Butte operation. The historical experience indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected (NRC 2000).

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. CBR controls vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the NDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing is conducted in accordance with NDEQ regulations contained in Title 122 and methods approved by NRC and NDEQ. Construction and integrity testing methods were discussed in detail in Section 3.1. Well abandonment is conducted in accordance with methods approved and monitored by the NDEQ and discussed in detail in Section 6.2. Procedures for these activities are contained in the SHEQMS Volume III, Operating Manual.

CBR monitors for vertical excursions in the overlying aquifers using shallow monitor wells. These wells are located within the wellfield boundary at a density of one well per 4 acres. Shallow monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility, subject to NRC/NDEQ approval. The program was discussed in detail in Section 5.7.8.

7.5.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the satellite facility, would result in either a release of barren or pregnant lixiviant solution, which would contaminate the ground in the area of the break. All piping from the satellite facility to and within the wellfield will be buried for frost protection. Pipelines are constructed of PVC, HDPE with butt-welded joints, or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each MU will have a number of wellhouses where injection and production wells will be continuously monitored for pressure and flow. With the control system currently employed at CPF, individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the satellite control room via the computer system. In addition, each wellfield building will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective at the current operation in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the wellhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. CBR currently implements a program of continuous wellfield monitoring by roving wellfield operators and required periodic inspections of each well that is in service. Based on experience from the current operation, small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination based on monitoring using field survey instruments and soil samples for radium-226 and uranium. Following repair of a leak, CBR procedures require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

7.5.5 Transportation Accident Risk

Transportation of materials to and from the satellite facility can be classified as follows:

- Shipments of process chemicals or fuel from suppliers to the site
- Shipment of radioactive waste from the site to a licensed disposal facility
- Shipments of uranium-laden resin from the satellite facility to the CPF and return shipments of barren, eluted resin from the CPF back to the satellite facility

The first two types of transportation risks do not represent an increase over the risks associated with operation of the current Crow Butte facility because production from the proposed satellite facility is planned to replace declining production at the current facility. The shipment of loaded IX resin from the satellite and the return of barren, eluted resin represent an additional transportation risk that was not considered for the current operation.

NUREG-0706 concluded that the probability of a truck accident in any year is 11 percent for each uranium extraction facility or mill. This calculation used average accident probabilities (4.0×10^{-7}/km for rural interstate, 1.4×10^{-6}/km for rural two-lane road, and 1.4×10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment (CNWRA 2001). For Marsland, uranium-loaded and barren resin will be routinely transported by tank truck from the satellite facility to the CPF. For the Crown Point ISR site in New Mexico, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC 1997).

Accident risks involving potential transportation occurrences and mitigating measures are discussed below:

7.5.5.1 Accidents Involving Shipments of Process Chemicals

Based on the current production schedule and material balance, it is estimated that approximately 150 bulk chemical deliveries per year will be made to the satellite facility. This averages about one truck per working day for delivery of chemicals throughout the operational life of the project. Types of deliveries include CO_2, O_2, bicarbonate, H_2O_2, and soda ash.

7.5.5.2 Accidents Involving Radioactive Wastes

Low level radioactive 11(e)2 byproduct material or unusable contaminated equipment generated during operations will be transported to an approved licensed disposal site. Because of the low levels of radioactive concentrations involved, these infrequent shipments are considered to have minimal potential impact in the event of an accident.

7.5.5.3 Accidents Involving Resin Transfers

One of the potential additional risks associated with operation of a satellite facility is the transfer of the IX resin to and from the satellite facility.

Resin will be transported to and from the satellite facility in a 4,000-gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility on a daily basis.

The transfer of resin between the satellite facility and the CPF will occur on SH 2/71 and county and private roads. CBR has established a primary access route and an alternate access route. The primary access route will entail approximately 18 miles (28.9 km) of travel on SH 2/71 and approximately 12 miles (19.3 km) on county and private roads (**Figure 4.2-1**). The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. The planned access routes are discussed in more detail in Section 4.2.1.12.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to DOT and NRC regulations. Shipments will be handled as LSA material for both uranium-laden and barren eluted resin. Pertinent procedures include:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.
- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index, and the package identification number.
- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.
- Licensed and trained CBR drivers will transport the resin between the satellite facility and the CPF.
- Crow Butte's current emergency response plan for yellowcake and other transportation accidents to or from the Crow Butte site is contained in the SHEQMS Volume VIII, Emergency Manual. This plan will be expanded to include an emergency resin transfer accident procedure. Personnel at both the satellite facility and the CPF will receive training for responding to a resin transfer transportation accident.

Currently, CBR intends to treat the eluted resin the same as the uranium-loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC regulations will be the primary determining factor.

The worst-case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium-laden resin where the entire tanker contents were spilled. Because the uranium is ionically bonded to the resin, and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, CBR will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each resin hauling truck will be equipped with a radio that can communicate with either the CPF or the satellite facility. In the event of an accident and spill, the driver can radio to both sites to obtain help.
- A check-in and check-out procedure will be instituted where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system will ensure a reasonably quick response time in the case that the driver is incapacitated in the accident.
- Each resin transport vehicle will be equipped with an emergency spill kit that the driver can use to begin containment of any spilled material.
- Both the satellite and central process facilities will be equipped with emergency response packages to quickly respond to a transportation accident.
- Personnel at the satellite and central process facilities, as well as the designated truck drivers, will have specialized training to handle an emergency response to a transportation accident.

7.5.6 Natural Disaster Risk

NUREG/CR-6733 considered the potential risks to an ISR facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. CBR is committed to following these standards.

The project area, along with most of the State of Nebraska, is in seismic risk Zone 1. Most of the central United States is within seismic risk Zone 1, and only minor damage is expected from earthquakes that occur within this area. Seismology was discussed in detail in Section 2.6.

The Crow Butte operation is located in an area subject to tornadoes. CBR emergency procedures currently contained in the SHEQMS Volume VIII, Emergency Manual, provide instructions for response and mitigation of natural disasters and spills or radioactive materials.

Historically, there have been no fires of any significance during CBR commercial operations, and none would be expected to occur at the proposed MEA site. CBR's Emergency Manual maintains procedures for dealing with potential fires, whether associated with man-made events at the operations or associated with wildfires. Wildfires have not been a problem in the area of the MEA and are not considered a major threat to the MEA site.

Flooding is considered a low-risk issue due to the lack of permanent streams or rivers flowing through the MEA project and historical annual rainfalls and snowmelt. CBR personnel are unaware of any historical flooding of the site. CBR conducted an erosion analysis of the MEA site and will use the results of that study in siting assets and providing mitigation measures to prevent any potential damage associated with flooding.

7.6 Economic and Social Effects of Construction and Operation

The preliminary evaluation of socioeconomic impacts of the commercial facility was completed in 1987 as reported in the original commercial license application. The preliminary evaluation was divided into two phases: construction and operation. The evaluation concluded that the construction phase would cause a moderate, positive impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

Since the inception of the operational phase, the overall effect of the current Cameco facility operations on the local and regional economy has been beneficial. Purchases of goods and services by the mine and mine employees contribute directly to the local economy. Local, state, and federal governments benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, are also beneficial. These economic effects further stimulate the economy, resulting in the creation of additional jobs.

The current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County. As discussed in further detail below, CBR currently employs a workforce of approximately 68 employees and 2 contractors employing 14 contractors. The majority of these employees have been hired from the surrounding communities.

In summary, monetary benefits have and continue to accrue to the community from the presence of the existing Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the potential economic impact of the MEA.

7.6.1 Tax Revenues

Table 7.6-1 summarizes the recent tax revenues from the Crow Butte project in U.S. dollars.

Future tax revenues depend on uranium prices, which cannot be forecast with accuracy; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. Spot market values for U_3O_8 peaked at approximately $125 per pound in 2007, and have since fallen to approximately $50 per pound as of August 2011 (UxC 2011). It is likely that market values will not return to the 2007 high in the near future and that future tax revenues will more likely be representative of 2008 and 2009 levels.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $950,000 per year in combined taxes.

Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District.

7.6.2 Temporary and Permanent Jobs

7.6.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County. In 2009, the CBR total payroll was $4,155,000. Of the total Dawes County wage and salary payments of $106,652,000 in 2009, the CBR payroll represented about 4 percent.

Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By way of comparison, the average wage for CBR employees was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonuses, or benefits.

7.6.2.2 Projected Short-Term and Long-Term Staffing Levels

The Marsland Expansion will require 10 to 12 full-time employees, 4 to 7 full-time contractor employees, and 10 to 15 part-time employees and short-term contractors for construction activities. The full- and part-time employees will be needed for the satellite facility and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. It is anticipated that the majority of the proposed MEA full-time and part-time workforce and contractors would be available from the current labor force in Dawes County. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). CBR expects that any new positions will be filled from this pool of available labor. These additional positions should increase payroll by approximately $40,000 per month, or $400,000 to $480,000 per year.

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current CBR staff (less than 5 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal.

Because skills and services required for the proposed MEA project would be available in the existing local labor force, it is not anticipated that the proposed project would require the migration of additional workers into the nearby City of Crawford and City of Chadron, or Dawes County. In the event that proposed project requirements for specialized skills could not be met with the current workforce or local labor force, a small number of workers could be hired from outside of Dawes County. However, any such labor needs would represent a negligible change in the population of Dawes County. It is not anticipated that there would be any change in the local population from implementation of the proposed project.

Because no changes in employment or population are anticipated as a direct result of implementation of the Proposed Action, no impacts to housing availability, including public housing, are expected. There would be no short- or long-term employees that would require temporary housing; therefore, the proposed project would not affect the lodging capacities of nearby communities.

There would be no noticeable increase in the local population from the construction, operation, and maintenance of the proposed project; consequently, there would be no increase in the need for law enforcement and fire safety, medical facilities, public schools, grocery stores, or other community resources in Dawes County.

No increases in existing levels of domestic water usage in Dawes County are expected, nor are effects to existing domestic water facilities anticipated from an increase in population. In addition, the water requirements of the MEA construction and operations would not affect municipal water systems.

Electricity, water, propane and other fuel, sanitary water, and wastewater treatment required for construction and operations will be provided by the utilities that currently provide these services to existing CBR operations. The proposed project may increase the total quantities of electricity, water, propane and other fuel consumed by CBR activities for a limited period of time during operations at MEA because the satellite facility would commence operations as operations in the Crow Butte Permit Area are winding down. Because the scope of production at MEA would be similar to current operations in the Crow Butte Permit Area, it is anticipated that fuel and utility requirements would also be similar. No substantial increases are likely for new operations at the satellite facility over existing operational uses.

It is not anticipated that construction or operational activities would increase costs to other customers supplied by the affected utilities, or increase the requirement for utility services beyond the capacities of the providers. There would be no substantial uses of electricity for construction activities. Fuel would continue to be provided by local suppliers. There would be no interruption of fuel deliveries to other customers from increased propane, diesel, and gasoline usage at MEA construction sites.

The Solid Waste Agency of Northwest Nebraska currently has the capacity for approximately 99 years of service, and would not be affected by the receipt of construction wastes or trash from the satellite facility. Other wastes are managed on site by CBR. Provision of waste services by local waste disposal providers would not be affected, as wastes are managed on site by CBR.

7.6.3 Impact on the Local Economy

It is anticipated than the monetary benefits and costs from the satellite facility would be similar to those associated with current CBR operations. In addition to providing a number of well-paid jobs in the local communities of the Cities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services in the local area.

Total CBR payments made to Nebraska businesses for the past 5 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$8,185,000
2010	$4,330,900

The vast majority of these purchases were made in the City of Crawford and Dawes County. This level of business is expected to continue depending upon CBR project activities in any given year, although not in strict proportion to production. While there are some savings due to some fixed costs, additional expenses are expected to be higher (e.g., wellfield development). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds of uranium produced. Local purchases that will be made annually for the MEA are estimated to be in excess of $1,000,000. Most of these purchases will continue to be made in the City of Crawford and Dawes County. In addition, mineral royalty payments accrue to local landowners. Production royalties of $532,000 were paid to land owners in 2010. Additional royalty payments would be made to MEA landowners. Most of the landowners are residents of Dawes County; therefore, beneficial impacts to county revenues and local businesses will be accrued through the spending and circulation of these dollars in the local economy.

7.6.4 Economic Impact Summary

As discussed in this section, CBR currently provides a positive economic impact to the local Dawes County economy. Development of the MEA would have a positive impact on the local economy as summarized in **Table 7.6-2**. The Proposed Action requires no in-migrating workforce from outside of the local area that currently provides the CBR labor force (primarily communities in Dawes County). Consequently, no increases in housing or community service demands would occur, and existing and planned facilities would not be adversely affected.

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Table 7.1-1 Estimated Acres Disturbed by Marsland Expansion Area Project Development

Disturbed Area	Type of Habitat Cover								Total
	Cultivated	Mixed Grass Prairie	Range Rehabilita-tion	Structure Biotype	Degraded Rangeland	Drainage	Deciduous Streambank Forest	Mixed Conifer	
	Acres								
Initial Acres Disturbed by MEA Satellite Facility, 11 Mine Units, Deep Disposal Well and Access Routes									
Mine Units (11)	71.7	343.7	6.9	8.9	143.6	7.2	0	5.6	587.6
SAT		1.8							1.8
Access Route to SAT		1.6				0.1			1.7
DDW		0.5							0.5
INITIAL DISTURBED ACRES	**71.7**	**347.6**	**6.9**	**8.9**	**143.6**	**7.3**	**0**	**5.6**	**591.6**
Long-Term Acres Disturbed by Additional Site Operations									
All Additional Long-Term Activities [a]	**56.7**	**795.1**	**0.2**	**8.0**	**84.4**	**23.9**	**4.7**	**189.0**	**1,162.0**
TOTAL DISTURBED ACRES	**128.4**	**1142.7**	**7.1**	**16.9**	**228.0**	**31.2**	**4.7**	**194.6**	**1,753.6**

SAT = Satellite Facility

[a]Multiple new activities such as roadways, exploration/delineation drilling, new and expanded MUs, wellhouses, and underground piping.

Table 7.2-1 Crow Butte Resources Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
SM4-5	January 25, 1995	March 9, 1995	Poor well development
SM4-2	April 2, 1995	March 13, 1996	Poor well development
SM4-7	December 27, 1995	March 13, 1996	Poor well development
I-196	March 29, 1996	August 19, 1999	Casing leak
I-752	November 8, 1996	May 7, 1997	Casing leak
SM6-26	March 19, 1998	No record available	High water table
CM6-6	July 1, 1999	September 23, 1999	Excursion of mining solutions
I-567	September 20, 1999	October 12, 1999	Casing leak
PR-15	January 13, 2000	March 23, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM6-18	March 6, 2000	April 11, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
IJ-13	April 20, 2000	July 20, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM7-23	April 27, 2000	January 13, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-28	May 25, 2000	June 22, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-13	May 25, 2000	July 20, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-12	September 8, 2000	November 2, 2000	Surface leak
SM6-13	March 1, 2001	April 12, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM7-23	December 4, 2001	January 9, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
CM5-11	September 10, 2002	June 3, 2003	Excursion of mining solutions
CM6-7	April 4, 2002	April 25, 2002	Excursion of mining solutions
PR-8	December 23, 2003	July 27, 2010	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)

Table 7.2-1 Crow Butte Resources Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
CM5-19	May 2, 2005	July 26, 2005	Excursion of mining solutions
SM6-28	June 16, 2005	July 5, 2005	High water table due to heavy spring rains (unrelated to mining activities)
SM6-12	June 27, 2005	July 26, 2005	High water table due to heavy spring rains (unrelated to mining activities)
CM9-16	August 4, 2005	November 8, 2005	Excursion of mining solutions
CM8-21	January 18, 2006	April 4, 2006	Excursion of mining solutions
PR-15	September 26, 2006	February 4, 2011	See IJ-13 and PR-8
CM9-5	May 15, 2008	June 24, 2008	Excursion of mining solutions
CM9-3	May 30, 2008	July 15, 2008	Excursion of mining solutions
SM6-20	April 27, 2009	August 25, 2009	Excursion of mining solutions
CM9-4	June 11, 2009	July 21, 2009	Excursion of mining solutions
SM6-20	March 16, 2010	July 26, 2011	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM8-6	April 12, 2010	August 31, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-23	June 16, 2010	July 29, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-28	June 16, 2010	July 29, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM8-28	June 16, 2010	July 29, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-21	June 22, 2010	August 10, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM8-5	June 22, 2010	August 3, 2010	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
CM8-12	July 8, 2010	August 19, 2010	Excursion of mining solutions
CM-8	March 15, 2011	June 28, 2011	Excursion of mining solutions
SM6-20	May 23, 2011	July 26, 2011	Excursion of mining solutions
SM8-6	May 24, 2011	August 23, 2011	Excursion of mining solutions
SM6-28	May 26, 2011	July 20, 2011	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM8-28	May 26, 2011	July 20, 2011	Excursion of mining solutions
IJ13P	October 4, 2011	Ongoing	Excursion of mining solutions

Table 7.3-1 Radiation Dose Rates to Receptors Within 80-Kilometer Radius of the Marsland Expansion Area Site

Receptor No.	Description	Distance from MEA Satellite Facility (km)	mRem/y
Cities/Towns			
1	Alliance	54.4	0.3
2	Berea	39.1	0.5
3	Chadron	42.2	0.3
4	Clinton	79.9	0.1
5	Crawford	24.1	0.5
6	Harrison	55.4	0.2
7	Hay Springs	50.7	0.2
8	Hemingford	24.9	0.9
9	Marsland	7.2	0.9
10	Minatare	79.1	0.1
11	Mitchell	77.2	0.1
12	Oelrichs	75.5	0.2
13	Rushville	69.6	0.2
14	Scottsbluff	77.9	0.1
15	Van Tassell	70.7	0.2
16	Whitney	31.4	0.4
Residences, Unoccupied Structures, and License Boundaries			
17	Residence 1	1.0	13.9
18	Residence 2	1.0	20.9
19	Residence 3	2.2	4.8
20	Residence 4	3.5	3.4
21	Residence 5	4.8	3.9
22	Residence 6	5.0	3.4
23	Residence 7	4.2	5.2
24	Residence 8	6.5	1.8
25	Unoccupied 1	2.1	28.1
26	Unoccupied 2	3.3	7.0
27	North Boundary	2.6	18.1
28	East Boundary	1.4	8.5
29	South Boundary	0.5	79.5
30	West Boundary	0.7	51.8

Notes: Total dose from the MEA including satellite facility and Mine Units 1 – 5 and A – F under typical operating conditions (25% from wellfields and 75% from satellite facility).
mRem/yr = millirems per year

Table 7.3-2 Public and Occupational Doses for Marsland Expansion Area

Radon Sources Distribution	Public Dose	Occupational
Location of Dose	**mRem/yr from 10 hrs/month Onsite**	**mRem/yr from 1,500 hrs/yr Onsite**
North Boundary	0.3	3.2
East Boundary	0.1	1.7
South Boundary	1.1	13.5
West Boundary	0.8	10.3
MU-1	1.7	21.6
MU-2	2.8	35.3
MU-3	1.9	23.7
MU-4	2.3	29.2
MU-5	1.7	21.4
Satellite	2.5	31.0
Average	**1.5**	**19.1**

mRem/yr = millirems per year

Table 7.3-3 Radiation Doses Calculated from Different Percentage Releases from the MEA Mine Units and the Satellite Facility

Radiation Sources Distribution Location of Dose	MU-1 through MU-5	MU-1 through MU-5
	0.25/0/75	0.10/0.90
	mrem/yr	
Cities/Towns		
Alliance	0.3	0.3
Berea	0.5	0.5
Chadron	0.3	0.3
Clinton	0.1	0.1
Crawford	0.5	0.5
Harrison	0.2	0.2
Hay Springs	0.2	0.2
Hemingford	0.9	0.9
Marsland	0.9	0.8
Minatare	0.1	0.1
Mitchell	0.1	0.1
Oelrichs	0.2	0.2
Rushville	0.2	0.2
Scottsbluff	0.1	0.1
Van Tassell	0.2	0.2
Whitney	0.4	0.4
Residences, Unoccupied Structures and License Boundaries		
Residence 1	13.9	13.1
Residence 2	20.9	12.9
Residence 3	4.8	4.1
Residence 4	3.4	3.1
Residence 5	3.9	3.5
Residence 6	3.4	3.3
Residence 7	5.2	4.8
Residence 8	1.8	1.7
Unoccupied 1	28.1	12.2
Unoccupied 2	7.0	6.4
North Boundary	18.1	14.1
East Boundary	8.5	5.6
South Boundary	79.5	93.8
West Boundary	51.8	60.5
Average	**6.1**	**8.1**
Standard Deviation	**17.4**	**19.8**

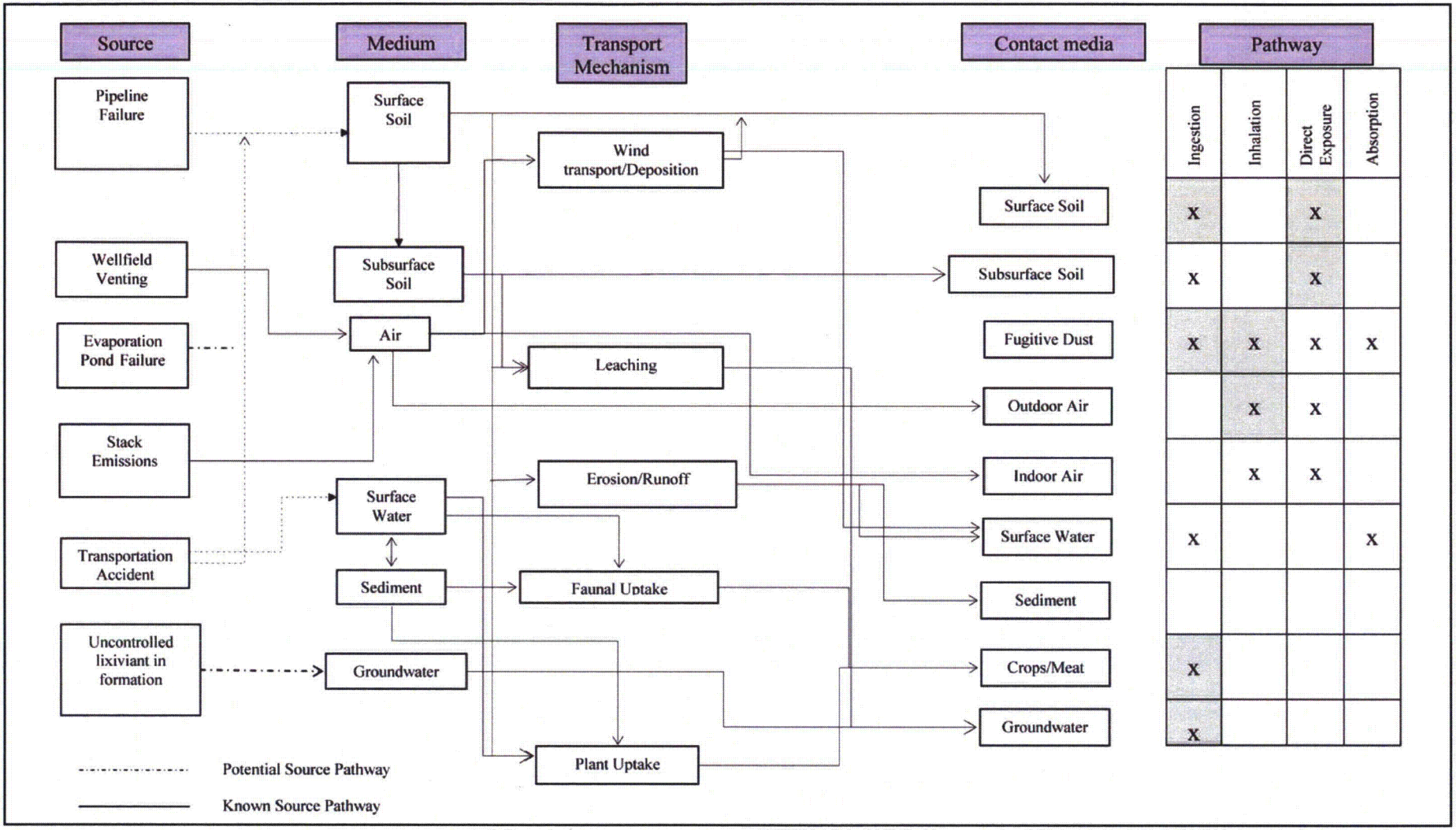
Table 7.6-1 Tax Revenues from the Current Crow Butte Project

Type of Taxes	2010	2009	2008	2007	2006	2005
Property Taxes	$997,000	$914,000	$1,120,000	$1,102,000	$627,000	$351,000
Sales and Use Taxes	$83,000	$136,000	$140,000	$90,000	$238,000	$185,000
Severance Taxes	$292,000	$403,000	$512,000	$1,066,000	$545,000	$338,000
Total	**$1,372,000**	**$1,453,000**	**$1,772,000**	**$2,258,000**	**$1,410,000**	**$874,000**

Table 7.6-2 Current Economic Impact of Crow Butte Uranium Project and Projected Impact from Marsland Expansion Area

Activity	Current Crow Butte Operation	Estimated Economic Impact due to Marsland Expansion Area
Employment		
Full-Time Employees	68	+ 10 to 12
Full-Time Contractor Employees	14	+ 4 to 7
Part-Time Employees and Short-Term Contractors	3	+ 4 to 7**
CBR Payroll, 2010	$4,200,000	+ $400,000 to $480,000
Taxes		
Property Taxes	$997,000	—
Sales and Use Taxes	$83,000	—
Severance Taxes	$292,000	—
Total Taxes	$1,372,000	+ $0.95 million
Production Royalties		
Royalty Payments, 2010	$532,000	+ $325,000
Local Purchases		
Local Purchases, 2010	$4,332,000	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts	**$10,435,000**	**+ $5,325,000 to $6,105,000**

**All construction workers



Contact media	Ingestion	Inhalation	Direct Exposure	Absorption
Surface Soil	X		X	
Subsurface Soil	X		X	
Fugitive Dust	X	X	X	X
Outdoor Air		X	X	
Indoor Air		X	X	
Surface Water	X			X
Sediment				
Crops/Meat	X			
Groundwater	X			

Note: X depicts the pathway that outlines the route which radiological emissions may follow to reach the public.
Gray shading depicts predominant pathway.

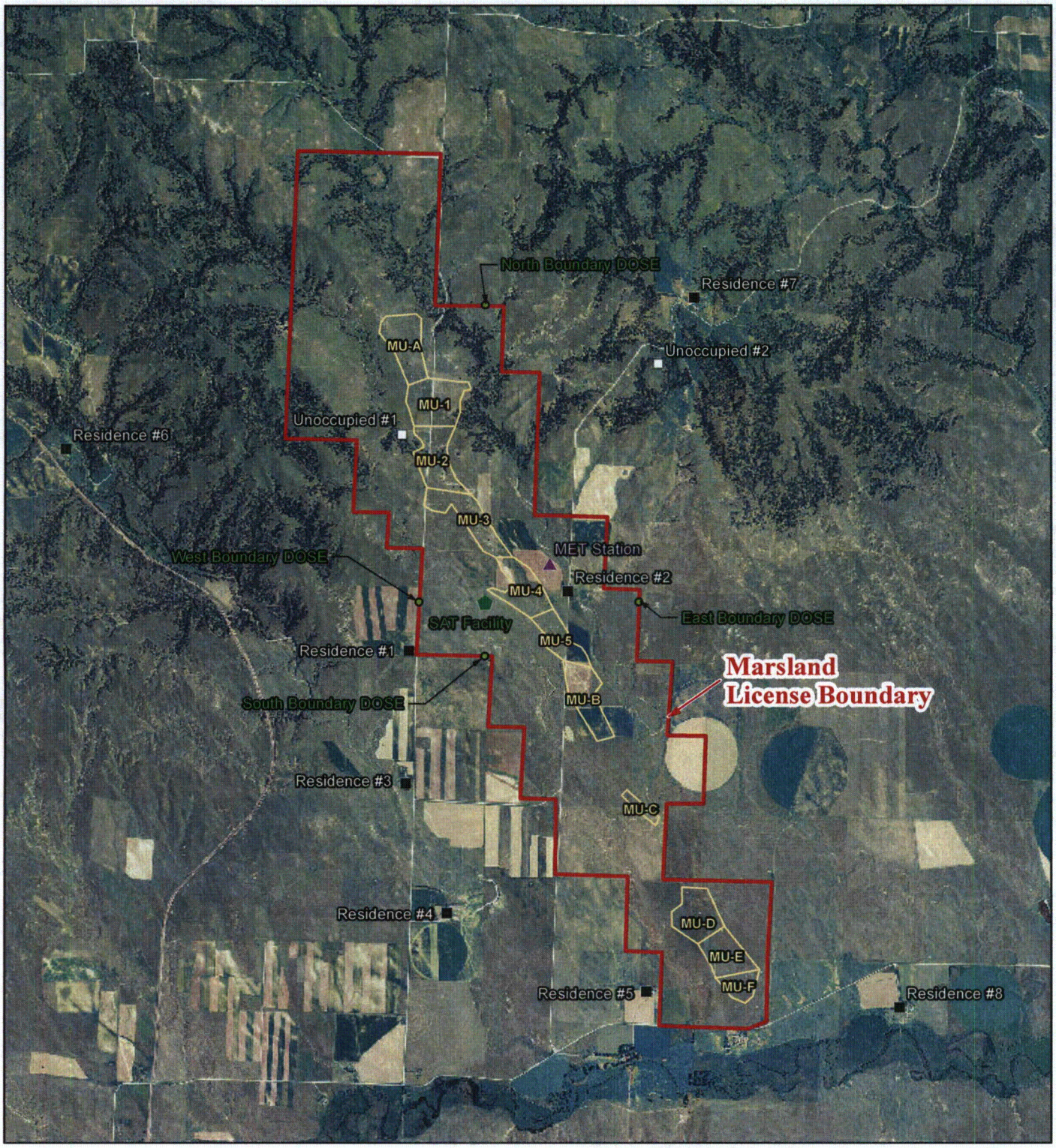
CROW BUTTE RESOURCES, INC.

FIGURE 7.3-1
MARSLAND
HUMAN EXPOSURE PATHWAYS FOR KNOWN AND POTENTIAL SOURCES OF RADIOLOGICAL EMISSIONS

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: LW

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Fig_7_3-1 Human Exposure Pathways.ai @ 01/08/2010



N

0 2,500 5,000

Feet

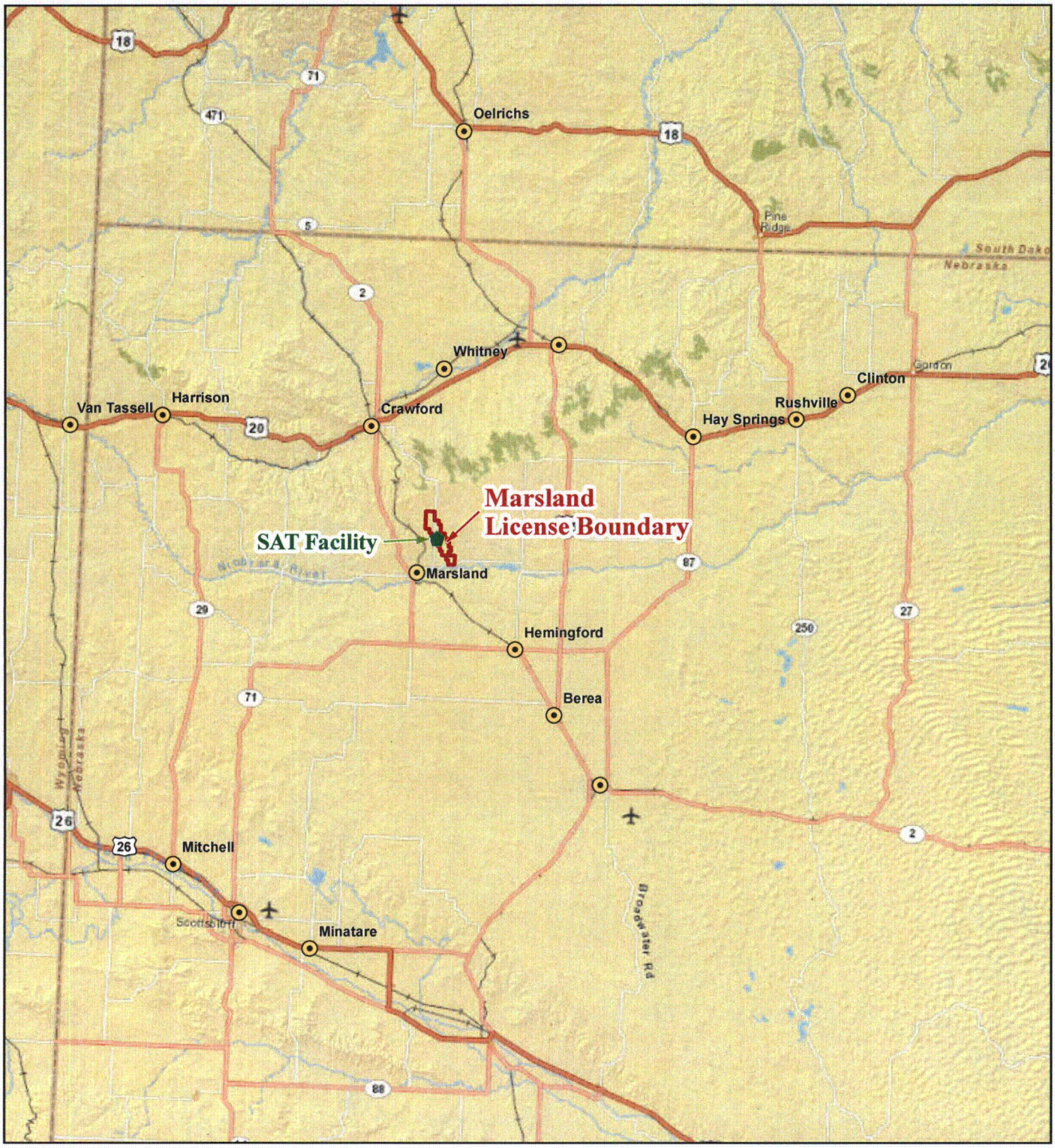
PROJECTION: NAD1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USDA NAIP IMAGERY 2010

CROW BUTTE RESOURCES, INC.

FIGURE 7.3-2
MILDOS RECEPTORS
RESIDENCES AND DESIGNATED MEA
LICENSE BOUNDARY LOCATIONS

PROJECT: CO001636 MAPPED BY: BB CHECKED BY: J. CEARLEY

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com



N

0 7.5 15

Miles

PROJECTION: NAD 1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: WORLD STREET MAP SERVICED
BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

FIGURE 7.3-3
MILDOS RECEPTORS
CITIES AND TOWNS IN REGION
AROUND MEA

PROJECT: CO001636 MAPPED BY: BB CHECKED BY: J. CEARLEY

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

8. ALTERNATIVES TO PROPOSED ACTION

8.1 No-Action Alternative

8.1.1 Summary of Current Activity

CBR currently operates the CPF, a commercial ISR uranium mining operation located approximately 4 miles (6.4 km) southeast of the City of Crawford in Dawes County, Nebraska. Operation is allowed under NRC Source Materials License SUA-1534.

An R&D facility was operated in 1986 and 1987. Construction of the CPF began in 1988, with production beginning in April of 1991. The total original license area is 3,300 acres, and the surface area affected by the current commercial project is approximately 1,100 acres. Facilities include the R&D facility (which now houses the Restoration Circuit), the CPF and office building, solar evaporation ponds, parking, access roads, and the wellfield.

In the current license area, uranium is recovered by *in-situ* leaching from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 percent to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Production is currently in progress in MUs 6 through 11. Groundwater restoration has been completed and regulatory approval has been received in MU 1. Groundwater restoration is currently underway in MUs 2 through 6.

The CPF is operating with a licensed flow rate of 9,000 gpm. Maximum allowable throughput from the facility under SUA-1534 is currently 2,000,000 pounds of U_3O_8 per year.

8.1.2 Impacts of the No-Action Alternative

The no-action alternative would allow CBR to continue mining operations in the CPF license area. Based on current plans and mining schedules discussed in Section 1 (**Table 1.7-1** and **Figure 1.7-1**), CBR could continue production at the current license area until 2014, when reserves are expected to be depleted to the point where commercial production would no longer be economical and would be discontinued. Restoration and reclamation would become the primary activities, with final restoration and reclamation completed in 2025.

When commercially recoverable resources are depleted in the CPF license area, all activities at the site not associated with groundwater restoration and decommissioning will be completed, resulting in the loss of a significant portion of the total employment at the site. In actuality, many of these jobs would be lost well before 2014. For example, the well drilling, installation, and wellfield construction activities would be completed several years before the completion of mining activities, and these positions would no longer be necessary. At the completion of decommissioning activities, all employment opportunities at the mine would be terminated.

In addition to the loss of significant employment opportunities in the City of Crawford and Dawes County, the premature closing of the CPF before commercially viable resources are recovered would adversely affect the economic base of Dawes County. As discussed in further

detail in Section 9, the CPF currently provides a significant economic impact to the local Dawes County economy as shown in **Table 7.6-1**.

If this amendment request is denied, the negative impact on the Dawes County economy would be felt as early as 2013 when employment levels for drilling and construction activities would be cut and purchases of services and materials would diminish.

In addition, a decision to not amend SUA-1534 to allow mining in the proposed MEA would leave a large resource unavailable for energy production supplies. In 2008, total domestic U.S. uranium production was approximately 4,230,000 pounds of U_3O_8, of which more than 700,000 pounds (or approximately 17 percent) was produced at the CPF (EIA 2011a). During the same year, purchases of domestic U.S. uranium by U.S. civilian nuclear power reactors U.S. and foreign suppliers were approximately 47,000,000 pounds of U_3O_8e (equivalent), with approximately 8 percent supplied by domestic producers (EIA 2011b). Foreign-origin uranium accounted for the remaining 92 percent of deliveries. The CPF represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals who have surface leases with CBR and own the mineral rights in the MEA.

8.2 Proposed Action

The proposed MEA MU map and schedule are shown on **Figures 1.7-3** and **1.7-4,** respectively. There will be a total of 11 MUs, with construction for MU-1 to commence in 2014. Production for the project (all MUs) will start in 2015 and terminate in the year 2039. Restoration in designated MUs will commence in the year 2020 and be completed in 2044. Site reclamation will be completed in 2046. The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.17 percent.

The proposed MEA contains a licensed area of approximately 4,622.3 acres. Of this potential licensed area, the total surface area that may be affected over the life of the project will be approximately 1,753 acres for the proposed MUs, processing facility, disposal well, well sites, and access roads. Currently, these areas include cropland (128.4 acres) and livestock range (1,370.7 acres [mixed grass prairie – 1142.7 and degraded rangeland – 228 acres]).

The proposed satellite facility will be located within a 1.8-acre fenced in area in sections 26 and 35 of T30N, R51W; sections 1, 2, 12, and 13 of T29N R51W; and sections 7, 18, 19, 20, 29, and 30 of T29N, R50W. This area will also contain the chemical storage areas and wastewater surge/equalization tanks. The DDW will be located approximately 0.3 mile (0.5 km) north-northwest of the satellite facilities (**Figure 1.7-5**). **Figure 3.2-1** shows the plan view of the satellite facilities.

Figure 1.3-1 shows the location of the current license area and the proposed MEA.

The MEA will be developed and operated by CBR. All land within the proposed license boundary of the MEA is privately owned. CBR has obtained surface and mineral leases from the appropriate landowners necessary to construct and operate the required ISR facilities.

Commercial production at the CPF is expected to extend over the next 10 years with the uranium reserves at both areas largely depleted by 2015. Commercial production at the proposed MEA would occur over 24 years between 2015 and 2024. Aquifer and reclamation will be concurrent with operations, plus an additional period at the end of the project for final decommissioning and surface reclamation. More detailed schedules are provided in Section 1.

The CPF recovers uranium from the basal sandstone of the Chadron Formation. In the MEA, uranium will also be recovered from the basal sandstone of the Chadron Formation. The depth in the MEA ranges from 580 to 940 feet. The width varies from 70 feet to 250 feet.

The satellite facility process structure will be a building approximately 130 feet long by 100 feet wide. The proposed satellite facility equipment will include the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The *in-situ* process consists of an oxidation step and a dissolution step. The oxidants used in the facility are H_2O_2 and/or gaseous O_2. A $NaHCO_3$ lixiviant is used for the dissolution step.

The uranium-bearing solution resulting from the leaching of uranium underground is recovered from the wellfield and piped to the satellite facility for extraction. The satellite facility process employs the following steps:

- Loading of uranium complexes onto an IX resin;
- Reconstitution of the solution by the addition of $NaHCO_3$ and O_2;
- Shipment of loaded IX resin to the CPF; and
- Restoration of groundwater following mining activities.

The satellite facility will be designed for a maximum flow rate, excluding restoration flow, of 6,000 gpm (restoration would account for another 1,500 gpm). Uranium-bearing resin will be transferred to the CPF for elution and packaging of yellowcake.

The operation of the satellite facility results in a number of effluent streams. Airborne effluents are limited to the release of radon-222 gas during the uranium recovery process. Liquid wastes are handled through evaporation and/or deep well injection.

Groundwater restoration activities consist of four steps:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Aquifer recirculation

Groundwater restoration will take place concurrently with development and production. The primary goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions required by 10 CFR 40, Appendix A, Criterion 5(B)(5) [or an approved alternate concentration limit (ACL) under 5(B)(5)(c)]; or, as a secondary goal, to the quality level specified by the NDEQ.

Following groundwater restoration, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the satellite facility, wellfield, and roads. The current estimate of the total acreage to be affected over the life of the MEA project is 1,753 acres.

CBR will maintain financial responsibility for groundwater restoration, facility decommissioning, and surface reclamation. Currently, an irrevocable letter of credit is maintained based on the estimated costs of the aforementioned activities.

The environmental impacts of the requested action will be minimal as discussed in Section 7. The primary radiological air impacts will be from the release of radon gas during production, which will be minimized by the use of pressurized downflow IX columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 4. All drying and packaging will be performed at the CPF using a vacuum drying system, thereby minimizing the potential for radioactive air particulate releases at MEA.

ISR alters the geochemistry and the water quality in the mining zone. CBR has proven in the current licensed area that impacts to groundwater can be controlled through stringent well construction techniques, wellfield operating methodologies that minimize excursions, and the use of best practicable technologies (BPTs) to restore the groundwater to premining baseline or class of use after mining activities are complete.

The impacts discussed in Section 7 include short-term and long-term impacts. However, it should be noted that uranium ISR mining technique allows the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time.

8.3 Reasonable Alternatives

8.3.1 Process Alternatives

8.3.1.1 Lixiviant Chemistry

CBR is employing a $NaHCO_3$ lixiviant that is an alkaline solution. Where the groundwater contains carbonate, as it does at CBR, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the $NaHCO_3$ has proven highly successful to date at the Crow Butte operations. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Consequently, these solutions were excluded from consideration.

8.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in MU-1, and the current restoration activities in MUs 2 through 5 at the current licensed CPF exhibit the effectiveness of the restoration methods. These methods (groundwater sweep, permeate/reductant injection and aquifer recirculation) have been shown to restore groundwater to pre-mining quality. No feasible alternative groundwater restoration method is currently available for the CPF and proposed MEA. The NRC and NDEQ consider the method currently employed at the CPF as the best practicable technology.

8.3.1.3 Waste Management

Liquid wastes generated from production and restoration activities at the CPF are handled by one of three methods: solar evaporation ponds, DDW injection, or land application. All three methods are permitted at the CPF. The use of deep waste disposal wells in conjunction with storage/evaporation ponds to dispose of the high TDS liquid wastes that primarily result from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of wastes. However, only the deep disposal method is planned for use at the MEA. The MEA DDW will be completed at an approximate depth of 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,800 feet of shale (Pierre and Graneros Shales). These discharges must be authorized by the State of Nebraska under a Class I UIC Permit to receive such wastes. CBR considered and rejected using either evaporation ponds or land application as a disposal method at Marsland due to required treatment and monitoring costs and potential environmental impacts.

Alternative pond design and locations for the CPF have been considered. The design is such that any seepage of toxic materials into the subsurface soils or hydrologic system would be prevented.

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Contaminated wastes are shipped to an NRC-approved facility for disposal. Should an NRC (or Agreement State)-licensed disposal facility not be available to CBR at the time of decommissioning, the alternative of onsite burial may be necessary. This alternative could incur long-term monitoring requirements and higher reclamation costs. At this time, CBR believes that offsite disposal of 11(e)2 byproduct material from the MEA at a licensed disposal facility is the best alternative, and there are no plans for onsite disposal.

8.4 Alternatives Considered but Eliminated

As a part of the analysis conducted by CBR, several mining alternatives were considered. Due to the significant environmental impacts and cost associated with these alternative mining methods in relation to the MEA ore body, they were eliminated from further consideration.

8.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to solution mining for the uranium deposits in the project area. Neither of these methods is economically viable for producing the MEA reserves at this time. These alternative methods are not economically feasible for several reasons including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio makes surface mining impractical. Surface mining is commonly undertaken on large, shallow

(less than 300 feet) ore deposits. At the MEA, uranium is recovered from depths ranging from 800 to 1,130 feet.

In addition, the physical characteristics of the deposit and the overlying materials make underground mining infeasible for the MEA or CPF. The costs of mine development, including surface facilities, shaft, subsurface stations, ventilation systems, and drifting would decrease the economic efficiency of the project.

From an environmental perspective, open pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is traditionally much higher in open pit and underground mines than has been the experience at ISR solution mining operations.

Both open pit and underground mining methods would require substantial dewatering to depress the potentiometric surface of the local aquifers to provide access to the ore. The groundwater would contain naturally high levels of radium-226 that would have to be removed prior to discharge, resulting in additional radioactive solids that would have to be disposed. For conventional mining, a mill tailings pond containing 5,000,000 to 10,000,000 tons of solid tailings waste from the uranium mill would also be required.

In a comparison of the overall impacts of uranium ISR with conventional mining, an NRC evaluation (NRC 1982) concluded that environmental and socioeconomic advantages of ISR include the following:

Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much lower.

1. No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by uranium ISR is generally less than 1 percent of that produced by conventional milling methods (more than 948 kg [2,090 lb] of tailings usually result from processing each metric ton [2,200 lb] of ore).
2. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.
3. The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5 percent of the radium in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings and the potential for radiation exposure is significantly lower than that associated with conventional mining and milling.
4. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.
5. Solution mining results in significantly less water consumption than conventional mining and milling.

6. The socioeconomic advantages of uranium ISR include:
    - The ability to mine a lower grade ore;
    - A lower capital investment;
    - Less risk to the miner;
    - Shorter lead time before production begins; and
    - Lower manpower requirements.

Finally, and perhaps most important, because CBR is an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium at Marsland at this time.

8.4.2 Production Facility Alternatives

The option existed for CBR to construct a new yellowcake production facility for the MEA project rather than the proposed satellite facility. The selected option was the construction of a new satellite facility instead because the existing CBR production facility is only approximately 11 miles (17.7 km) to the north-northwest of the proposed MEA site.

The use of the existing facility as a centralized processing facility will allow processing of uranium-loaded resin from the CBR's proposed MEA satellite facility and two other nearby proposed satellite facilities (i.e., NTEA and TCEA). Such a centralized design enhances the economics of uranium production in the region by maximizing production capacity while minimizing further capital expenditures on processing facilities. The construction and operational cost of a satellite facility would be significantly lower than that of a new production facility. The potential for release of radiological particulates would be lower for a satellite facility due to it being a "wet" process because no yellowcake would be produced. Other advantages include: less land disturbance for the operating assets; non-radiological air emissions (e.g., fugitive dust, diesel, and gasoline emissions) during operations would be lower; fewer employees working at the site being potentially exposed to radiation; less byproduct and other types of waste generated that would need to be handled and disposed of; smaller deposits located within the MEA can be mined with the resin trucked to the CPF; and the front end of the "milling" process can be begun independent of the larger CPF. In summary, the construction and operation of a new processing facility was not deemed to be a viable economical alternative and would result in more environmental impacts than a new satellite facility. Transportation of the uranium-loaded resin from the satellite facility to the main processing facility would serve as an additional risk. However, such risk is deemed minimal with the use of trucks designed for hauling resin, trained drivers, required speed of the vehicles, conditions of the roadways, minimal amount of road traffic in the area, and relative short distance between the two facilities.

8.5 Cumulative Effects

8.5.1 Cumulative Radiological Impacts

On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the CPF. License Condition 10.5 of SUA-1534 limited current operation to an annual facility throughput of 5,000 gpm exclusive of restoration flow. CBR

requested an amendment to this license condition to increase the licensed flow to increase production and assist restoration efforts. The production increase was to be accomplished by expanding the existing facility and mining existing wellfield to lower levels of soluble uranium. CBR requested approval to increase the annual facility throughput to 9,000 gpm exclusive of restoration flow. The amendment request did not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year. NRC issued the license amendment on Nov. 30, 2007.

The only environmental impact of the increased flow rate at the current operation is a corresponding increase in the emission of radon-222 from the current operation. The amendment estimated a 22 percent increase in the maximum public dose and that the maximum public dose would remain well below the limit found in 10 CFR § 20.1301.

8.5.2 Future Development

CBR has identified several additional resource areas in the region near the CPF that could conceivably be developed as satellite facilities. Development of these facilities depends on further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR may submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area and the MEA are depleted.

8.6 Comparison of the Predicted Environmental Impacts

Table 8.6-1 summarizes the environmental impacts for the no-action alternative (Section 8.1), the preferred alternative (Proposed Action; Section 8.2), and the process alternatives (Section 8.3.1) and production facility alternatives (Section 8.4.2). The predicted impacts for the mining alternatives discussed in Section 8.4.1 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts were discussed in greater detail in Section 7.

8.7 References

Crow Butte Resources, Inc. (CBR). 2007. Application for Amendment of NRC Source Materials License SUA-1534, North Trend Expansion Area, Technical Report – Volume 1.

U.S. Energy Information Administration (EIA). 2011a. Domestic Uranium Production Report – Annual. Data for 2010. [Web Page]. Located at: http://www.eia.gov/uranium/production/annual/. Accessed on: December 2, 2011.

EIA. 2011b. Nuclear and Uranium. Uranium Marketing Annual Report. [Web Page]. Located at: http://www.eia.gov/uranium/marketing/. Accessed on: December 2, 2011.

U.S. Nuclear Regulatory Commission (NRC). 1982. Draft Environmental Statement Related to the Operation of the Teton Project, NUREG-0925, June 1982. Para. 2.3.5.

Table 8.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Land Surface Impacts	None	Minimal temporary impacts in wellfield areas, significant surface and subsurface disturbance confined to a portion of the ~12-acre satellite facility site.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts from land application of treated wastewater.
Land Use Impacts	None	Loss of crop and cattle production in 562-acre area for duration of project.	Same as Preferred Alternative.	Same as Preferred Alternative plus a potential long-term land use impact from onsite disposal of 11(e)2 byproduct material.
Transportation Impacts	None	Minimal impact on current traffic levels. Estimated additional heavy truck traffic of 500 trips per year; additional 6 to 8 vehicle trips per day light-duty trucks.	Same as Preferred Alternative.	Same as Preferred Alternative.
Geology and Soil Impacts	None	None	None	None
Surface Water Impacts	None	None	None	None
Groundwater Impacts	None	Consumption of Chadron groundwater for control of mining solutions and restoration (estimated at 50 gpm average)	Same as Preferred Alternative. Increased difficulty with groundwater restoration and stabilization.	Same as Preferred Alternative.
Ecological Impacts	None	No substantive impairment of ecological stability or diminishing of biological diversity.	Same as Preferred Alternative.	Same as Preferred Alternative.
Air Quality Impacts	None	Additional 23.7 tons per year of total dust emissions due to vehicle traffic on gravel roads.	Same as Preferred Alternative.	Same as Preferred Alternative.

Table 8.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Noise Impacts	None	Barely perceptible increase over background noise levels in the area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Historic and Cultural Impacts	None	None	None	None
Visual/Scenic Impacts	None	Moderate impact; noticeable minor industrial component in sensitive viewing areas.	Same as Preferred Alternative.	Same as Preferred Alternative plus possible long- term visual and scenic impacts from onsite disposal cell for 11(e)2 byproduct material.
Socioeconomic Impacts	Eventual loss over the next 5 to 10 years of positive economic impact of $10.4 million to the local area as reserves deplete in the current licensed operation.	Extension of the current annual direct economic impact of $10.4 million plus the addition of between $5.3 million and $6.1 million in annual direct economic impact to local area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Non-radiological Health Impacts	None	None	None	None
Radiological Health Impacts	None	The estimated additional maximum dose rate was 1.6 person-rem/yr within 80 km of the MEA and 0 person-rem/yr beyond 80 km.	Same as Preferred Alternative.	Same as Preferred Alternative.
Waste Management Impacts	None	Generation of additional liquid and solid waste for proper disposal.	Same as Preferred Alternative. Mobilization of additional hazardous elements in lixiviant requiring disposal.	Same as Preferred Alternative. Potential additional long- term impact from onsite disposal of 11(e)2 byproduct material.

Table 8.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Mineral Resource Recovery Impacts	Loss of a valuable domestic energy resource. CBR estimated reserves are under development but the current estimated recoverable resource is 9.5 million pounds with a current spot market value (8/2011) of $475 million.	Recovery and use of a domestic energy resource.	Same as Preferred Alternative.	Same as Preferred Alternative.

9. COST-BENEFIT ANALYSIS

9.1 General

The general need for production of uranium is assumed to be an integral part of the nuclear fuel cycle, with the ultimate objective being the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operations required for the fuel cycle are justified in terms of the benefits of energy generation to society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility, such as the CPF and the proposed satellite facility, must be reasonable compared to that typical operation.

9.2 Economic Impacts

Monetary benefits have accrued to the community from the presence of the CPF, such as local expenditures of operating funds and the federal, state, and local taxes paid by the project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community (or for the project) because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date and projects the incremental impacts from operation of the proposed satellite facility.

9.2.1 Tax Revenues

Table 7.6-1 summarizes the tax revenues from the CPF.

Future tax revenues depend on uranium prices, which cannot be accurately forecast; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of approximately $50 per pound of U_3O_8 in August 2011 [UxC 2011]), the production from MEA should contribute to higher tax revenues.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $950,000 per year in combined taxes.

9.2.2 Temporary and Permanent Jobs

9.2.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County.

In 2009, the CBR total payroll was $4,155,000 million. Of the total Dawes County wage and salary payments of $106,652,000 in 2009, the CBR payroll represented approximately 4 percent.

Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By comparison, the average wage for CBR was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonuses, or benefits.

9.2.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of the MEA will provide approximately 10 to 15 temporary construction jobs for up to 1 year. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfield).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than 5 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions required at the current facility and those that will be created by any future expansion will be filled with individuals from the local workforce. Therefore, that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). CBR expects that any new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by 10 to 12 full-time CBR employees. These new employees will be needed for facility operators and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. The majority if not all of these new positions will be filled with local hires.

These additional positions should increase payroll by approximately $40,000 per month, or $400,000 to $480,000 per year.

9.2.3 Impact on the Local Economy

In addition to providing a significant number of well-paid jobs in the local communities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past 4 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$7,838,700
2010	$4,330,900

The vast majority of these purchases were made in the City of Crawford and Dawes County.

This level of business is expected to continue dependent upon CBR project activities in any given year, and should increase somewhat with the addition of expanded production from the proposed MEA and from restoration activities, although not in strict proportion to production. While there are some savings due to some fixed costs, there are additional expenses that are expected to be higher (wellfield development). Therefore, it can be assumed that the overall effect on local purchases will be relatively proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3,650,000 to $4,350,000 per year.

9.2.4 Economic Impact Summary

As discussed in this section, CBR currently provides a significant economic impact to the local Dawes County economy. Approval of the proposed project would have a positive impact on the local economy as summarized **Table 7.6-2**.

9.2.5 Estimated Value of Marsland Resource

CBR continues to develop the reserve estimates for the MEA. Based on the current recoverable resource estimate of 5,667,926 pounds of U_3O_8 and the current market price of uranium ($50 per pound in August 2011 [UxC 2011]), the total estimated value of the energy resources at MEA is approximately $283,396,300. This value will fluctuate as the market price and realized price vary.

9.2.6 Short-Term External Costs

9.2.6.1 Housing Impacts

The available housing resources should be adequate to support short-term needs during facility construction. In 2010, a total of 568 housing units were vacant in Dawes County out of a total housing base of 4,252 units (USCB 2011). Of the vacant units, 168 were available for rent. In addition to this availability of rental housing units, there are two small hotels in the City of Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews. Temporary housing resources have experienced little change in the past two decades.

Recent data for the City of Crawford indicate that in 2010 there were a total of 567 houses in Crawford, with 470 occupied (334 by owners and 136 by renters) (USCB 2011). This indicated that 97 housing units were available for purchase or rent. In 2008, the housing density was 467

houses/condos per square mile. The median rent being asked for vacant rental units in 2008 was $337/month. The median purchase price for a home was $51,856 (City-Data 2010).

9.2.6.2 Noise and Congestion

CBR projects an increase in the noise and congestion in the immediate area of the satellite facility during initial construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which has two minor rural roads (Hollibaugh and River Roads) used primarily for access.

A BNSF rail line is located east of SH 2/71 and is approximately 1.1 miles (1.8 km) from the MEA boundary at the closest point. Noise from the trains on the BNSF rail line would be intermittently audible to receptors within and in close proximity to the MEA. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

9.2.6.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of permanent positions at the MEA will be filled with local hires. As a result of employing the local workforce, the impact on local services should be minimal. In many cases, these services (e.g., schools) are underutilized due to population trends in the area.

9.2.7 Long-Term External Costs

9.2.7.1 Housing and Services

Because of the small number of people who have needed to move into the area to support CBR activities in the past, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of long-term positions that will be created by the MEA project will be filled with individuals from the local workforce. Therefore, there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. As stated earlier, CBR expects that the new positions at the satellite facility will be filled from the local pool of available labor.

9.2.7.2 Noise and Traffic Congestion

CBR projects a minor increase in the long-term noise and traffic congestion in the immediate area of the satellite facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfield. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as O_2 and the shipment of IX resin from the satellite facility to the CPF. Delivery and IX shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility.

The 2008 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of East Belmont Road (NDOR 2010). Secondary and private roads connect with East Belmont

Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. The limited additional traffic related to the MEA operation will not significantly affect these routes.

9.2.7.3 Aesthetic Impacts

The primary visible surface structures proposed for the MEA include wellhead covers, wellhouses, electrical distribution lines, one satellite processing building, and storage tanks. The project will use existing and new roads to access each wellhouse, the DDW building, storage tanks, and the satellite processing building. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture which characterize the existing landscape. The project would primarily affect agricultural land.

In foreground-middleground views, the satellite processing building, storage tanks, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light tan exposed soils in geometrically shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite facility processing building, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Squaw Mound Road and the residence within the license boundary, but would be subordinate in scale to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of these would blend with the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone. However, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

9.2.7.4 Land Access Restrictions

Property owners of land located within the immediate wellfield and facility boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

9.2.8 Most Affected Population

The expected impacts from the proposed MEA can be characterized as an incremental increase in the impacts from current CBR operations. For the most part, the impact from operation of the current Crow Butte Uranium Project has been positive. CBR has provided much-needed well compensated employment opportunities for the local population. Additionally, the policy of purchasing goods and services locally to the extent possible has had a positive economic impact on an area facing economic challenges. Tax expenditures and particularly the recent increases in local property taxes paid due to the increase in the price of uranium have had a positive economic impact on local government-provided services.

Offsetting these positive impacts to the local population are increases in noise, traffic congestion, and aesthetic impacts for residents in and adjacent to the proposed satellite facility. Most residents located in the proposed license area are landowners that have mineral and/or surface leases with CBR and will benefit economically from the presence of the facility.

9.2.9 Satellite Facility Decommissioning Costs

Approval of the proposed satellite facility will result in CBR incurring additional decommissioning liabilities for the installed facilities. The actual estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

This section presents a written estimate of the costs for "environmental protection" deemed to be necessary during and after the cessation of operations. These cost estimates focus on costs associated with the restoration and reclamation (decommissioning) of the MEA in order to ensure that adequate funds are available for permanent closure of the project. The cost estimates address the above-referenced "measures" of concern. The estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

The NRC requires a financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover costs of reclamation activities. Evidence of financial responsibility in the form of a letter of credit or other form satisfactory to the NDEQ in accordance with Title 122, Chapter 13, shall be provided to the NDEQ in an amount equal to or greater than the total costs indicated in the Surety Cost Estimate as required, along with an audit statement from an independent professional auditing firm. CBR will review the cost estimate annually and update in order to ensure adequacy of the dollar amount. The purpose is to ensure that there are sufficient funds available for decontamination, decommissioning, and reclamation of the facility in the event CBR is incapable of performing the tasks. NRC License SUA-1534 requires that CBR continuously maintains an approved surety instrument for Crow Butte Resources, Inc., in favor of the State of Nebraska. CBR is required to ensure that the financial assurance instrument, when authorized by the State of Nebraska, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil and water sample analyses, and groundwater restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual

updates will follow the outline in Appendix C to NUREG-1569, entitled "Recommended Outline for Site-Specific In-Situ Leach Facility Reclamation and Stabilization Cost Estimates."

Groundwater and surface reclamation and restoration methods to be used for the MEA are discussed in Section 6. A decommissioning plan shall be based on factors such as the mine plan, baseline environmental information, and any other factors that will ensure the long-term physical, geotechnical, and geochemical stability of the site. Restoration of a specific MU can be started as soon as mining is completed, hence the importance of integrating the mine plan and the decommissioning plan. Restoration of a specific MU can occur while uranium recovery operations continue at other MUs. Once groundwater restoration has been completed in the final MU and approved by the NDEQ, decommissioning of the satellite processing plant, remaining CPF evaporation ponds, and other structures can be initiated.

The cost estimates presented in this section are based on the cost per year to restore one MU and reclaim one MU (surface and subsurface features). The CBR mine plan calls for sequential restoration and reclamation, and CBR will have approximately two to three MUs in restoration, mining, or reclamation at any one time. The surety cost estimates will be adjusted as necessary when additional MUs are to be brought on line and the proposed operations are better defined. A current and updated surety is required at least 90 days prior to commencement of construction of a new MU or significant expansion.

Cost information is presented in the following tables located in **Appendix P**:

Table P.1-1	Primary Assumptions Serving as the Basis for Surety Cost Estimates Associated with Restoration and Reclamation of One (1) Mine Unit
Table P.1-2	Marsland Total Restoration and Reclamation – 2011 Surety Estimate
Table P.1-3	Marsland Groundwater Restoration – 2011 Surety Estimate
Table P.1-4	Marsland Wellfield Reclamation – 2011 Surety Estimate
Table P.1-5	Marsland Well Abandonment Unit – 2011 Surety Estimate
Table P.1-6	Marsland Satellite Facility Equipment Decommissioning – 2011 Surety Estimate
Table P.1-7	Marsland Building Demolition Cost – 2011 Surety Estimate
Table P.1-8	Marsland Miscellaneous Site Reclamation – 2011 Surety Estimate
Table P.1-9	Marsland Deep Disposal Well Reclamation – 2011 Surety Estimate
Table P.1-10	Marsland Groundwater IX Treatment (GIX) Restoration 9Unit Cost]
Table P.1-11	Marsland Groundwater Reverse Osmosis (RO) Treatment [Unit Cost] – 2011 Surety Estimate
Table P.1-12	Marsland Groundwater Recirculation [Unit Cost] – 2011 Surety Estimate
Table P.1-13	Marsland Well Abandonment [Unit Cost] – 2011 Surety Estimate
Table P.1-14	Five Year Mechanical Integrity Tests (MIT) – 2011 Surety Estimate
Table P.1-15	Marsland Master Cost Basis – 2011 Surety Estimate

Table P.1-1 presents the primary assumptions that serve as the basis for the surety cost estimates associated with restoration and reclamation of one mine unit. **Table P.1-2** provides a summary of the total estimated costs for projected restoration and reclamation activities for MU 1 ($1,641,969), which includes a contract administration and contingency fees of 10 and 15

percent, respectively. The remaining tables further refine the cost estimates and the basis for the tasks and cost estimates. The DDW will operate under a separate Class I UIC Permit, but the reclamation cost estimates for this well have been provided as part of the total surety estimate for the MEA.

9.3 The Benefit-Cost Summary

The benefit-cost summary for a fuel-cycle facility such as the CPF involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater at the CPF during the R&D project and the commercial restoration of MU 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the current and proposed project are small, with all radioactive wastes being transported and disposed of off site. Radiological impacts to air and water are also minimal. Extensive ongoing environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the CPF.

The disturbance of the land for a satellite facility and related activities is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

9.4 Summary

In considering the energy value of the U_3O_8 produced to U.S energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the proposed MEA is favorable, and that amending SUA-1534 is the appropriate regulatory action.

9.5 References

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10. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 Environmental Approvals for the Current Licensed Area

As discussed previously, this is an amendment application for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1998. A license renewal application for continued operation of the CPF was submitted to the NRC on November 27, 2007. NRC approval is pending. A license amendment for the addition of the proposed NTEA satellite facility was submitted to the NRC on May 30, 2007. NRC approval is pending.

All other required permits for the existing CPF have been obtained and maintained as required by applicable regulatory requirements. A summary of the relevant permits and authorizations for the current license area is given in **Table 10.1-1**. License, permits and authorizations anticipated for the Marsland satellite facility are shown in **Table 10.1-2**.

10.1.1 Environmental Approvals and License/Permits

The MEA will be subject licensing and permitting requirements similar to the CPF. **Table 10.1-2** contains a summary list of the type of license, permit or authorization, the granting authority, and the status.

10.1.2 Licensing and Permitting Consultations

During the course of the preparation of this License Amendment application and the NDEQ Class III UIC Application for the MEA, the following agency contacts were consulted:

U.S. Nuclear Regulatory Commission

Mr. Ronald Burrows, Project Manager
Decommissioning and Uranium Recovery Licensing Directorate
Davison of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management
Programs
Mailstop T8-5
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Nebraska Department of Environmental Quality

Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

10.1.3 Environmental Consultations

During the course of the preparation of this license amendment application, several agencies were consulted for information required for various sections of the application:

Uses of Adjacent Lands and Waters (Section 2.2)

Elaine Connelly
Nebraska Maps & More
School Of Natural Resources
101 Hardin Hall
3310 Holdrege Street
Lincoln, NE 68583-0961

Echo Clark
Tax Assessor
Dawes County
451 Main St.
Chadron, NE 69337
308-432-0103

Surface Water (Section 2.7.1)

Assistance was requested in providing available surface water flow and water quality data for the Niobrara River in the proposed project area:

Tom Hayden
Supervisor
Water Field Office Operations
Nebraska Department of Natural Resources
Bridgeport Field Office

Guy H. Lindeman, P.E.
Nebraska Department of Natural Resources
301 Centennial Mall So.
PO Box 94676
Lincoln, NE. 68509

Dave Ihrie
Planning Section, Water Division
Nebraska Department of Environmental Quality
1200 "N" Street, Suite 400
Lincoln, NE 68509-8922
402-471-0283

Bill Peck
U.S. Reclamation Bureau
Field Office
1706 West 3rd St.
McCook, NE 69001

Groundwater Quality Restoration, Surface Reclamation and Facility Decommissioning (Section 6)

Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

Ecology (Section 2.8)

Preparation of the ecology discussion (Section 2.8) required consultations with the following individuals and agencies:

Greg Schenbeck
Wildlife Manager
Pine Ridge Field Office
Nebraska Game and Parks Commission
Chadron, NE

Historic, Scenic, and Cultural Resources (Section 2.4.1)

Preparation of the historic, scenic, and cultural resources discussion required consultations with the following individuals and agencies:

Teresa Fatemi
Nebraska State Historical Society
State Historic Preservation Office
1420 P Street
Lincoln, NE 68508

Trisha Nelson
Archaeological Collections Manager
Nebraska State Historic Society
P.O. Box 82554
Lincoln, NE 68501

Population Distribution (Section 2.3)

Preparation of the population distribution discussion (Section 2.3) required consultations with the following individuals and agencies:

- T. Vogl, School Clerk, Crawford Public Schools

10.1.4 List of Preparers

The following individuals and organizations were involved in the preparation of this Technical Report supporting the amendment request for Source Materials License SUA-1534 to allow development of the MEA:

Crow Butte Resources, Inc.
PO Box 169
Crawford, Nebraska 69339

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Larry Teahon	Manager of Safety Health Environment and Quality
Wade Beins	Senior Geologist
Rhonda Grantham	Supervisor of Radiation Safety & Regulatory Affairs / RSO
Jessica Horwitz	Cameco Staff Geologist
Walter Nelson	Environmental Leadership Coordinator

Cameco Resources
2020 Carey Avenue
Suite 600
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Lee Snowhite	Senior Engineer
John Schmuck	Senior Permitting Manager
Jeff Leftwich	Director Safety Health Environment and Quality
Bryan Soliz	Director of Exploration and Development

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4800 Wadsworth Boulevard
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Wheat Ridge, CO 80033

Bob Lewis	Senior Hydrogeologist

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Laramie, WY 82070

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IML Air Science
555 Absaraka
Sheridan, WY 82801

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Leone Gaston	Senior Hydrology Specialist
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Conrad Mulligan	Senior Scientist
Allison Haraminac	Staff Scientist – Biologist
Carl Spath, Ph.D.	Archeologist
Adam Graves	Principal Investigator
Natalie Graves	Project Archaeologist
Hugh Roberts	Senior Engineer
Shan Zou	Project Engineer
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Debra Ballheim	Technical Editor
Jie Chen	GIS Specialist/CAD Specialist
Matthew Hoefer	Cadd Drafter 3
Clayre Brown	Word Processing

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Table 10.1-1 Environmental Approvals for Crow Butte Project

Issuing Agency	Permit Description
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Materials License SUA-1534 Issued: December 29, 1989 Renewed: February 28, 1998 Source Materials License SUA – 1534 Amendment to Increase Flow Issued: November 30, 2007 Source Material License SUA – 1534 License Renewal request by CBR Submitted: November 27, 2007 NRC Approval: Pending Source Material License SUA – 1534 Amendment for New Satellite Facility: North Trend Expansion Area Submitted: May 30, 2007 NRC Approval: Pending
U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, NW Washington, DC 20460	Aquifer Exemption Approval Effective: June 22, 1990
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Underground Injection Control Class III Authorization NE0122611 Approved: April 24, 1990 Amended to increase flow on August 16, 2007
	Aquifer Exemption Approval Effective: March 23, 1984
	Aquifer Exemption North Trend Expansion Area Submitted: August 15, 2007 Approved: April 18, 2011
	Underground Injection Control Class III Permit Application North Trend Expansion Area Submitted: August 15, 2008 (re-submittal) Approval: August 11, 2011
	Underground Injection Control Class I Authorization NE0206369 Approved: September 9, 1994 Replaced: July 2, 2004
	Underground Injection Control Class I Authorization NE0210825 Additional Class I well Approved: November 24, 2010
	National Pollutant Discharge Elimination System Permit NE0130613 Approved: September 27, 2011
	Mineral Exploration Permit NE0209317 Approved: June 3, 2003 Replaced: August 19, 2009 with NE0210824
	Mineral Exploration Permit NE0210679 Approved: July 16, 2007

Table 10.1-1 Environmental Approvals for Crow Butte Project

Issuing Agency	Permit Description
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Mineral Exploration Permit NE0210678 Approved: July 16, 2007
	Mineral Exploration Permit NE0210680 Approved: July 18, 2007
	Mineral Exploration Permit NE0210824 Approved: August 19, 2009
	Underground Injection Control Class V Authorization NE0207388 Approved: November 6, 2000
	Evaporation Pond Design Approved: July 21, 1988
	Construction Stormwater NPDES General Permit NER 100000 Authorization #NER105203 Approved: December 19, 2006
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509-4676	Industrial Ground Water Permit Approved: August 7, 1991
Nebraska Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln, NE 68509-5007	Class IV Public Water Supply Permit NE3121024 Approved: April 12, 2002

Table 10.1-2 Environmental Approvals for Proposed Marsland Expansion Area

Issuing Agency	Description	Status
U.S. Nuclear Regulatory Commission Washington, DC 20555	Amendment to Source Materials License SUA-1534 (10 CFR 40)	The document containing this table has been submitted as a License Amendment for the Marsland Expansion Area
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW Washington, DC 20460	Aquifer exemption application forwarded to EPA following NDEQ action	Aquifer exemption application will be forwarded to EPA following NDEQ action
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Underground Injection Control Class III Permit (NDEQ Title 122)	Class III UIC Permit application under preparation: expected submittal to NDEQ in first quarter 2012
	Aquifer Exemption (NDEQ Title 122)	Aquifer exemption application under preparation; expected submittal to NDEQ in first quarter 2012
	Underground Injection Control Class I (NDEQ Title 122)	Class I UIC Permit application under preparation; expected submittal to NDEQ in first quarter 2012
	Industrial Stormwater NPDES Permit (NDEQ Title 119)	An Industrial Stormwater NPDES may not be required for a satellite facility depending on processes included and the final facility design. If required, an application will be submitted as per NDEQ requirements.
	Construction Stormwater NPDES Permit (NDEQ Title 119)	Construction Stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. The Notice of Intent will be filed at least 30 days before construction activities begin in accordance with NDEQ requirements.
	Mineral Exploration Permit (NDEQ Title 135)	Mineral Exploration Permit NE0209317 Approved: June 3, 2003 Replaced: July 16, 2007
	Underground Injection Control Class V (NDEQ Title 122)	The Class V UIC Permit will be applied for following installation of an approved site septic system during facility construction
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509-4676	Industrial Ground Water Permit (NDNR Title 456)	The Industrial Groundwater Permit application will be prepared for submittal to NDNR; expected in the first quarter 2012