

Wy 0055751

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**SECTION 20 COMPLIANCE ANALYSIS FOR  
PROPOSED CBNG PRODUCED WATER DISCHARGES BY  
YATES PETROLEUM CORPORATION,  
DEVON ENERGY CORPORATION, AND  
BILL BARRETT CORPORATION TO  
COTTONWOOD CREEK,  
CAMPBELL AND JOHNSON COUNTY, WYOMING**

Prepared for:

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Table 3. Soil chemical analysis results for the Cottonwood Creek site.<sup>14</sup>

Site	Depth inches	pH	Electrical Conductivity at 25°C (EC)	Average EC to a Depth of 48 inches <sup>1</sup>	Calcium mg/L	Magnesium mg/L	Sodium	Sodium Adsorption Ratio (SAR)	Cation Exchange Capacity (CEC)	Exchangeable Sodium	Exchangeable Sodium Percentage (ESP)	Average ESP to a Depth of 48 inches <sup>1</sup>	Line as CaCO <sub>3</sub>
Field 1	0-6	7.6	0.53	0.55	5.0	0.92	0.89	0.57	30	6.40	1.3		5.2
	6-12	7.6	0.55	0.55	2.9	1.1	0.83	0.66	19	0.40	2.1		5.0
	12-24	7.5	0.55	0.55	1.8	5.5	2.9	0.92	21	0.50	2.2		5.1
	24-36	7.4	2.2	1.8	16	6.4	4.5	1.3	17	0.60	3.2	2.9	4.1
	36-48	7.7	1.4	1.4	7.5	2.9	3.8	1.9	10	0.20	4.1		7.5
Field 2	0-6	7.6	0.73	0.67	17	6.9	4.8	1.4	13	0.60	4.7		3.2
	6-12	7.4	0.73	0.67	24	9.1	5.3	1.4	17	0.50	3.0		2.7
	12-24	7.4	0.60	0.67	4.1	1.4	0.90	0.48	33	0.40	1.2		5.6
	24-36	7.6	3.7	3.8	4.1	1.4	1.2	0.70	24	0.40	1.9		5.3
	36-48	7.9	5.0	3.8	22	10	18	4.5	24	1.6	6.8	10.6	5.5
Field 3	0-6	7.6	4.1	5.2	18	18	29	6.7	27	3.0	8.3		5.5
	6-12	7.7	6.2	5.2	20	25	55	12	22	3.0	13.7		4.7
	12-24	7.9	8.6	5.1	19	25	58	12	21	3.1	19		3.7
	24-36	7.9	5.7	5.1	17	21	51	12	20	5.9	30	14.4	5.6
	36-48	7.5	2.9	5.1	30	9.7	12	3.2	19	1.7	2.9		4.6
Field 4	0-6	7.7	3.4	0.51	17	15	15	3.0	19	1.6	3.3		4.5
	6-12	7.7	3.8	0.51	21	11	12	3.0	15	1.6	4.3		6.7
	12-24	7.5	0.58	0.51	4.1	1.3	1.2	0.71	27	0.40	1.1		5.4
	24-36	7.6	0.44	0.51	3.2	1.0	1.3	0.50	30	0.50	1.6		5.4
	36-48	7.5	2.9	2.4	19	7.2	16	4.4	23	1.8	5.8	6.3	4.6
Field 5	0-6	7.7	4.7	3.7	18	13	31	9.3	25	3.5	14		5.7
	6-12	7.7	6.7	3.7	15	21	66	15	29	8.8	30		5.2
	12-24	8.1	6.4	5.4	16	24	62	14	19	6.9	37	12.3	5.5
	24-36	8.3	4.9	5.4	18	16	39	9.4	18	2.3	13		4.9
	36-48	7.9	4.0	5.4	21	14	26	6.4	15	1.4	10		3.6
Field 6	0-6	7.3	3.3	3	6.1	6.1	7.6	5.1	33	3.1	9.5		3.9
	6-12	7.5	1.3	3	7.2	3.5	7.2	5.4	41	1.3	3.6		5.5
	12-24	7.7	3.5	3	13	10	27	9.9	40	4.8	12		5.1
	24-36	8.1	2.4	6.2	18	20	70	16	40	9.4	23		5.3
	36-48	8.2	7.4	6.2	18	27	76	16	33	6.9	21	18.2	5.6
Field 7	0-6	7.5	0.27	1.94	21	18	22	5.1	18	1.5	8.6		4.6
	6-12	7.6	0.27	1.94	24	23	22	5.1	18	1.5	8.6		4.4
	12-24	8.0	6.2	4.9	20	17	55	15	37	3.2	2.3		4.9
	24-36	8.0	6.2	4.9	20	10	53	12	36	4.4	21		4.8
	36-48	7.9	5.1	4.9	17	18	36	8.4	18	2.4	12	13.6	6.2
Average EC:				4.2	19	14	28	6.8	23	1.8	12		4.9
					19	14	28	6.8	23	1.8	12		4.9
													4.8

Notes:  
 1 Samples were collected on December 5-6, 2008 by KC Harvey, Inc. using a Giddings Probe. Samples were analyzed by Energy Laboratories, Inc. Helena, Montana.  
 2 pH, EC, calcium, magnesium, and sodium analytes were conducted using a subsaturated paste extract. Abbreviations used are as follows:  $\mu\text{M}$  = standard units,  $\mu\text{Si}$  = micrograms per liter,  $\text{meq/L}$  = milliequivalents per liter,  $\text{meq/100 g}$  = milliequivalents per 100 grams of soil, and % = percent.  
 3 Average EC and ESP to a depth of 48 inches was calculated by averaging the 0 to 6 and 6 to 12 inch depths to derive a 0 to 12 inch value, then averaging together each 12 inch depth increment to a depth of 48 inches.

Table 4. Expected CBNG produced water quality in the Cottonwood Creek area.<sup>1</sup>

Analyte	Units	Livestock Watering Criteria <sup>2</sup>	Yates <sup>3</sup> Outfall WY0049352-001	Yates <sup>3</sup> Outfall WY0049352-002	Devon <sup>4</sup> Outfall WY0046612	Barrett <sup>5</sup> Outfall WY0046612	Average CBNG Produced Water Quality <sup>6</sup>
pH	s.u.	6.5 to 9	7.3	7.3	7.4	7.4	7.4
Electrical Conductivity (EC)	dS/m	7.5	1.8	1.7	1.3	2.3	1.8
Total Dissolved Solids (TDS)	mg/L	5000	-	-	800	1470	1135
Sodium Adsorption Ratio (SAR)		-	8.5	8.6	6.1	7.8	7.6
<i>Anions</i>							
Bicarbonate	mg/L	-	1300	1200	900	1730	1283
Chloride	mg/L	2000	7.0	6.0	7.0	4.0	6.0
Fluoride	mg/L	4.0	0.80	0.8	-	0.9	0.83
Sulfate	mg/L	3000	<1	1.0	nd	3.0	2.0
<i>Cations</i>							
Calcium	mg/L	-	76	67	59	134	84
Magnesium	mg/L	-	28	24	21	54	32
Potassium	mg/L	-	10	9.0	-	20	13
Sodium	mg/L	-	340	320	220	422	326
<i>Metals<sup>7</sup></i>							
Arsenic	µg/L	20	-	-	0.80	2.2	1.5
Boron	µg/L	5000	-	-	-	-	-
Cadmium	µg/L	50	-	-	nd	<0.1	<0.1
Chromium	µg/L	1000	-	-	-	-	-
Copper	µg/L	500	-	-	nd	<1	<1
Lead	µg/L	100	-	-	nd	<2	<2
Mercury	µg/L	10	-	-	nd	<0.06	<0.06
Selenium	µg/L	50	-	-	nd	<5	<5
Zinc	µg/L	2500	-	-	nd	<10	<10

Notes:

1 Abbreviations used are as follows: s.u. = standard units, dS/m = deciSiemens per meter, mg/L = milligrams per liter, µg/L = micrograms per liter, and, nd = analyte not detected at the given reporting limit. "-" indicates the sample was not analyzed for a given parameter. Samples were analyzed by Energy Laboratories, Inc. Gillette, WY.

2 Livestock watering criteria are from WYDEQ (2006) and National Academy of Sciences (1972 and 1974).

3 Outfall WY0049352-001 was sampled on 7/21/2006, Outfall WY49352-002 was sampled on two occasions, 7/21/2006 and 9/05/2006, average values are listed. All samples were collected by Yates.

4 Outfall WY0046612 is located in the NESE of Section 28 in Township 42 N, Range 75 W. The sample was collected on 9/21/2004 by Devon.

5 Outfall WY0046612 is located in the NESE of Section 28 in Township 42 N, Range 75 W. The sample was collected on 4/17/2006 by Devon.

6 The median pH value is reported.

7 Arsenic and selenium are quantified as total recoverable metals, and, boron, cadmium, chromium, copper, lead, mercury, and zinc are quantified as dissolved metals.

